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Draft A

Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-DV-1 Operable Unit

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Executive Summary

This document presents the work plan for a combined *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[1] (CERCLA) remedial investigation (RI)/feasibility study (FS) and *Resource Conservation and Recovery Act of 1976*[2] (RCRA) facility investigation (RFI)/corrective measures study (CMS) to support the final remedy selection for the 200-DV-1 Operable Unit (OU) at the Hanford Site. This work is being performed under CERCLA and RCRA, as amended by the *Hazardous and Solid Waste Amendments of 1984*.[3]

The purpose of the RI and RFI is to determine the nature and extent of contamination and to select remedies and remedial treatment technologies. This work plan presents the preliminary conceptual site models (CSMs) for the 200-DV-1 OU waste sites and identifies the data needs. Two sampling and analysis plans (SAPs) describing the activities for filling the data needs during the RI and RFI have been prepared and approved. A supplemental SAP is proposed for characterization of the shallow vadose zone. The results will be documented in the RI/RFI report.

The purpose of the FS and CMS is to develop, screen, and evaluate alternative remedial actions. The results will be documented in the FS/CMS report. The FS/CMS report also will provide the basis for the development of a Proposed Plan (PP)/proposed corrective action decision (PCAD) that describes the preferred remedy for each waste site in the 200-DV-1 OU. The PP/PCAD will be issued to the public for review and comment in accordance with 40 CFR 300.430(f)(3), "National Oil and Hazardous Substances Pollution Contingency Plan."[4] Following the receipt of public comments, a Record of Decision (ROD) and corrective action decision (CAD) will be developed by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) in cooperation with the U.S. Department of Energy (DOE). The ROD

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[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.

[2] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

[3] *Hazardous and Solid Waste Amendments of 1984*, Pub. L. 98-616, Nov. 8, 1984, 98 Stat. 3221. Available at: *RCRA Amendment*.

[4] 40 CFR 300.430, "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/ Feasibility Study and Selection of Remedy." Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol27/xml/CFR-2010-title40-vol27-sec300-430.xml.

documents the CERCLA remedial action decision for each waste site. The CAD documents the RCRA corrective action decision for each of the waste sites subject to corrective action. Although the CAD and ROD could be issued separately, a single CAD/ROD document is recommended to ensure that the selected cleanup decisions are compatible for implementation. The CAD/ROD also will contain responses to comments from the public.

Background

In 2009, the DOE 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-DV-1 OU is located in the Inner Area (Figure ES-1).

Figure ES-1. Location of the 200-DV-1 OU within Central Plateau Inner Area

DOE, EPA, and Ecology (together known as the Tri-Parties) initiated the Deep Vadose Zone (DVZ) Project in 2010 to address the challenges of cleaning up the deeper mobile contamination in the Central Plateau. The DVZ Project is addressing the challenge by instituting the following:

- A separate OU (the 200-DV-1 OU) to focus on arriving at cleanup decisions for the DVZ.
- An Applied Field Research Initiative (AFRI) to develop innovative technology alternatives for DVZ challenges in characterization, prediction, remediation, and monitoring. The 200-DV-1 OU coordinates with the AFRI to support the 200-DV-1 OU cleanup decision-making process and to address data needs through technology development and implementation.

The Tri-Parties established the DVZ Project in response to input from the Tribal Nations, the state of Oregon, the Hanford Advisory Board, and stakeholders to place greater focus on DVZ cleanup. The goal of the DVZ Project is to ensure long-term protection of groundwater on the Central Plateau.

The DVZ contamination is a significant issue because it represents a potential source for continued release of mobile contamination to the groundwater. This contamination, which is the result of past waste disposal practices on the Hanford Site's Central Plateau, occurs deep in the subsurface and is not easily remediated by typical surface remedies. The DVZ is defined as the soil below the practical depth of typical surface-based remedies (e.g., excavation or surface engineered barrier influence) and above the water table. The Central Plateau DVZ begins at a depth of approximately 15 m (50 ft) below ground surface (bgs) and extends to the water table at depths ranging from approximately 55 m (180 ft) bgs to approximately 83 m (270 ft) bgs.

The primary DVZ contaminants at the Hanford Site driving long-term risk are technetium-99 and uranium because of their persistence, high inventory in the vadose zone, mobility, difficulty in predicting subsurface behavior, and long half-lives. Additional mobile contaminants of long-term concern are iodine-129, chromium (assumed to be hexavalent), and nitrate.

200-DV-1 Operable Unit

Forty-three wastes sites have been assigned to the 200-DV-1 OU based on (1) the unique remediation challenge of mobile contamination in the DVZ, (2) the complex technical and regulatory challenges of DVZ contamination (e.g., co-mingled plumes, and determining nature and extent), and (3) the geographic proximity to waste management areas (WMAs). The 200-DV-1 OU waste sites are primarily the cribs and trenches adjacent to and associated with the B-BX-BY, T-TX-TY, and S-SX Tank Farm WMAs (Figure ES-2). In this work plan, these three areas are referred to as the B Complex area, the T Complex area, and the S Complex area, respectively. The 200-DV-1 OU includes the vadose zone from the ground surface to the water table at these 43 waste sites. A zone of perched water in the B Complex area is also included in the 200-DV-1 OU and is addressed in this work plan.

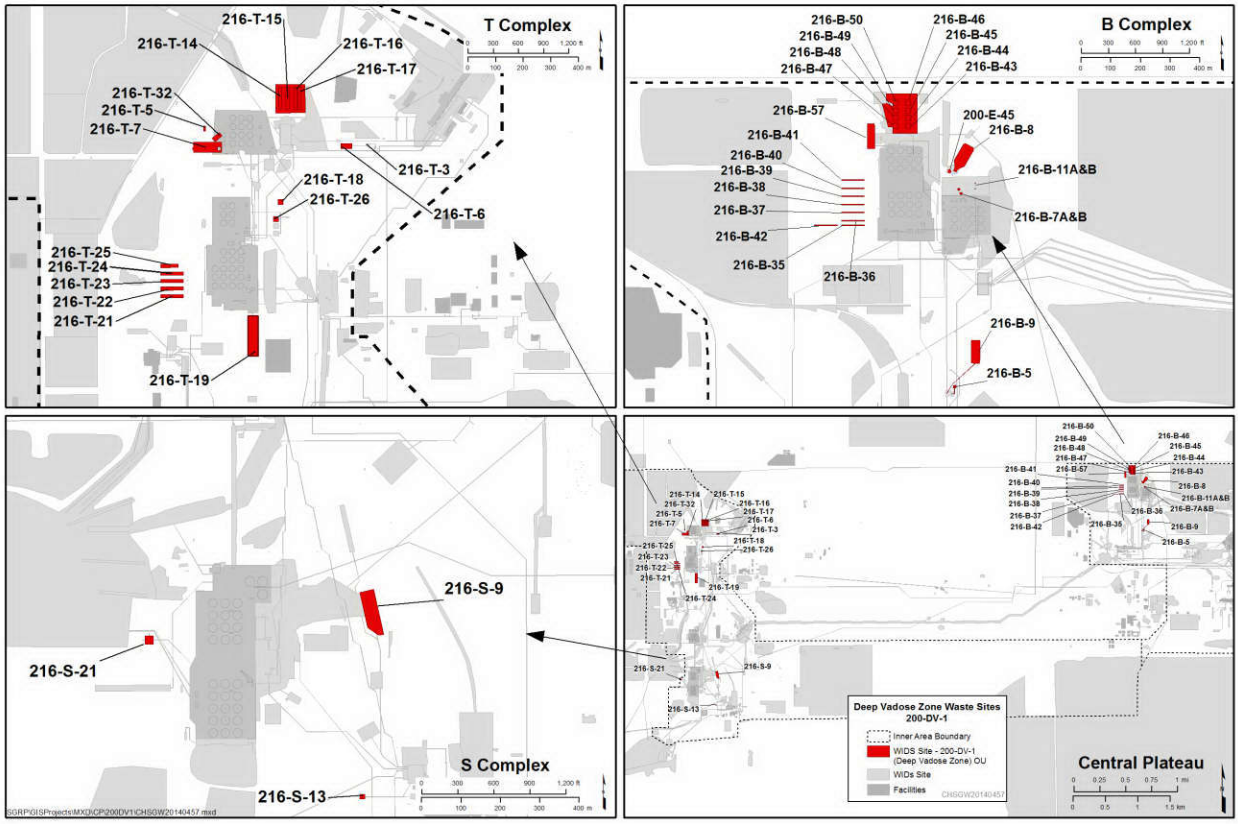

Figure ES-2. Location of 200-DV-1 OU Waste Sites in the Central Plateau Inner Area

The 200-DV-1 OU decision process will include the following:

- Investigate the nature and extent of contamination from the ground surface to the groundwater.

- Evaluate potential impacts to human health and the environment.
- Evaluate potential impacts on groundwater and the Columbia River.
- Evaluate a combination of proven and emerging technologies for characterizing, remediating, and monitoring DVZ contamination.
- Evaluate, select, and implement remedial solutions for contamination in the vadose zone to protect human health, the environment, and groundwater.

The 200-DV-1 OU does not include the groundwater underlying the waste sites.

Characterization to investigate the nature and extent of contamination will be conducted at the 200-DV-1 OU waste sites using either drilled wells or cone penetrometer wells. Soil samples will be collected for laboratory analysis, and the wells will be geophysically logged. In most cases, the well(s) will be installed within the footprint of the waste site being characterized.

Based on the characterization data, a treatability test will be conducted in one of the three areas (anticipated to be the B Complex area) for a 200-DV-1 OU contaminant remediation technology. 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.

Work Plan History

The development of the preliminary CSMs for 200-DV-1 OU waste sites, and the assessment of data needs through the data quality objective (DQO) process, occurred in 2011. In January 2012, the *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*[5] was approved. The characterization activities designed to fill the data needs identified in the 2011 DQO process are described in the SAP. The preliminary CSMs, which were developed in 2011 to support the DQO and SAP, have not been updated in this work plan; they will be updated in the RI/RFI report following collection of the RI/RFI data.

[5] DOE/RL-2011-104, 2012, *Characterization Sampling and Analysis Plan for the 200-DV-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=1202020261.

In January 2014, the *Sampling and Analysis Plan for Perched Water Wells C8914 and C8915 in the 200-DV-1 Operable Unit*[6] was approved. The sampling and analysis activities described in the SAP were completed in fiscal year 2014.

If during the RI/RFI and FS/CMS processes additional data needs are identified to support development of remedial alternatives, then a supplemental DQO and SAP or SAP addendum may be developed.

[6] DOE/RL-2013-52, 2013, *Sampling and Analysis Plan for Perched Water Wells C8914 and C8915 in the 200-DV-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=0081987H.

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Terms

1C	first-cycle (waste)
2C	second-cycle (waste)
AFRI	Applied Field Research Initiative
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BRA	baseline risk assessment
CAD	corrective action decision
CCU	Cold Creek unit
CCU_c	Cold Creek unit (carbonate)
CCU_g	Cold Creek unit (gravel)
CCU_z	Cold Creek unit (silt)
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
CMS	corrective measures study
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-EM	DOE Office of Environmental Management
DS	decision statement
DQO	data quality objective
DVZ	deep vadose zone
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FS	feasibility study
FY	fiscal year

HAB	Hanford Advisory Board
HCP EIS	Hanford Comprehensive Land-Use Plan Environmental Impact Statement
HHE	human health and the environment
HHRA	human health risk assessment
HI	health instrument
HMS	Hanford Meteorological Station
HQ	hazard quotient
ITS	in-tank solidification
K_d	distribution coefficient
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
N/A	not applicable
NCP	National Contingency Plan (40 CFR 300)
NEPA	*National Environmental Policy Act of 1969*
NPL	National Priorities List (40 CFR 300, Appendix B)
ORP	DOE Office of River Protection
OU	operable unit
P&T	pump-and-treat
PCAD	proposed corrective action decision
PNNL	Pacific Northwest National Laboratory
PP	Proposed Plan
PRG	preliminary remediation goal
PSQ	principal study question
PUREX	Plutonium-Uranium Extraction (Plant)
QAPjP	quality assurance project plan
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant)
RFI	RCRA facility investigation
RI	remedial investigation
RL	DOE Richland Operations Office

ROD	Record of Decision
SAP	sampling and analysis plan
SIM	Soil Inventory Model
SMDP	scientific-management decision point
SSL	soil screening level
SST	single-shell tank
TBP	tributyl phosphate
TOD	Tribal Nations, Oregon State, DOE, and Ecology
Tri-Parties	DOE, EPA, and Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and/or disposal
UCL	upper confidence limit
UNH	uranyl nitrate hexahydrate
UPR	unplanned release
WIDS	Waste Information Data System
WMA	waste management area

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1 Introduction

This document presents the work plan for a combined remedial investigation (RI)/feasibility study (FS) and *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation (RFI)/corrective measures study (CMS) to support the final remedy selection for the 200-DV-1 Operable Unit (OU) at the Hanford Site. This work is being performed under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and RCRA, as amended by the *Hazardous and Solid Waste Amendments of 1984*.

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.[7] Each NPL site is divided into multiple OUs, as outlined in the Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). The 200-DV-1 OU is part of the 200 Area NPL site.

In 2009, the U.S. Department of Energy (DOE), Richland Operations Office (RL) 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 approximately 195 km^2 (75 mi^2) and encompasses the 200 Area NPL site. The two major geographic cleanup areas within the Central Plateau include the 170 km^2 (65 mi^2) Outer Area and the 25 km^2 (10 mi^2) Inner Area (Figure 1-1). The 200-DV-1 OU is located in the Central Plateau's Inner Area.

DOE, EPA, and the Washington State Department of Ecology (Ecology) (together known as the Tri-Parties) initiated the Deep Vadose Zone (DVZ) Project in 2010 to address the challenges of cleaning up the deeper contamination in the Central Plateau. The DVZ Project is addressing the challenge by instituting the following:

- A separate OU (the 200-DV-1 OU) to focus on arriving at a cleanup decision for the DVZ.
- An Applied Field Research Initiative (AFRI) to develop innovative remediation alternatives for DVZ challenges in characterization, prediction, remediation, and monitoring. The 200-DV-1 OU coordinates with the AFRI to support the 200-DV-1 OU cleanup decision-making process and to address data needs through technology development and implementation.

The Tri-Parties established the DVZ Project in response to input from the Tribal Nations, the state of Oregon, the Hanford Advisory Board (HAB), and stakeholders to place greater focus on DVZ cleanup. The goal of the DVZ Project is to ensure the long-term protection of groundwater on the Central Plateau. Key components of the strategy for obtaining this goal are as follows:

- Increasing DOE investment in treatability testing of initial candidate technologies
- Increasing DOE investment in evaluating innovative approaches to characterize, remediate, and monitor the DVZ
- Facilitating the transition of scientific research results to applied cleanup solutions

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

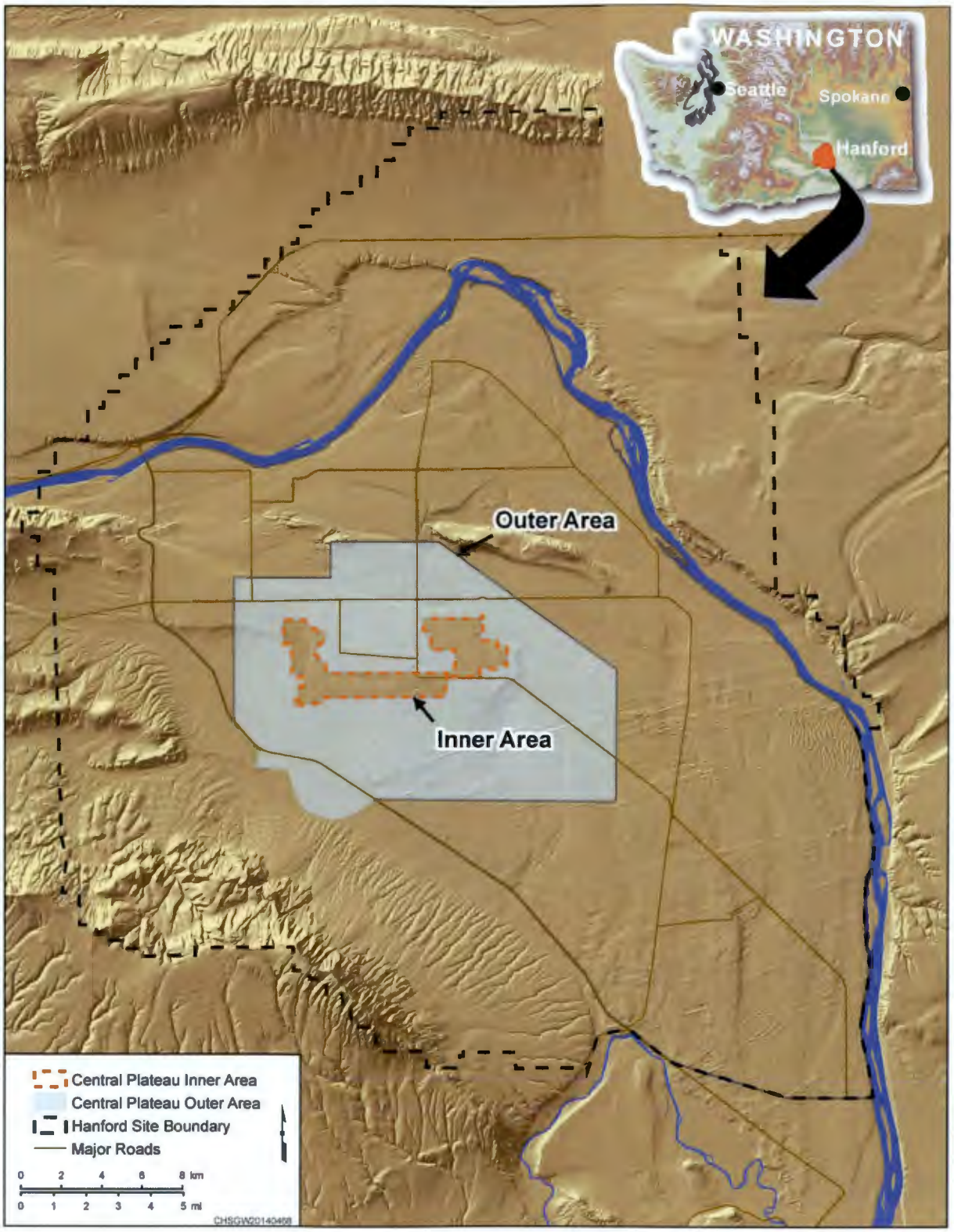

Figure 1-1. Hanford Site

The planning process for the 200-DV-1 OU and the RI/FS and RFI/CMS work plan was initiated in 2010. The Tri-Parties participated in a series of meetings to develop the scope of work for the 200-DV-1 OU and the objectives for the work plan. The results of these scoping meetings are the basis for the scope and objectives presented in Section 1.1.

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*[8]
- EPA/540/G-91/011, *Guidance on RCRA Corrective Action Decision Documents*
- EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4)
- EPA 530/SW-89-031, *Interim Final RCRA Facility Investigation (RFI) Guidance* (four volumes)
- DOE/EH-94007658, *Remedial Investigation/Feasibility Study (RI/FS) Process, Elements, and Techniques*

1.1 Scope and Objectives

The scope of work for the 200-DV-1 OU was developed during Scoping Meeting 3 on January 13, 2011, and was revised on March 28, 2011.

The goal of the 200-DV-1 OU Project is to implement response actions that will protect human health, the environment, and groundwater from contamination associated with the 200-DV-1 OU waste sites.

The 200-DV-1 OU scope is defined in Appendix C of the Tri-Party Agreement (Ecology et al., 1989a). Currently, 43 wastes sites are assigned to the 200-DV-1 OU. These Central Plateau waste sites were assigned to the 200-DV-1 OU based on (1) the unique remediation challenge of mobile contamination in the DVZ, (2) the complex technical and regulatory challenge of DVZ contamination (e.g., co-mingled plumes), and (3) the geographic proximity to waste management areas (WMAs).

The CERCLA RI/FS process will be combined with the RCRA RFI/CMS process. The RI/RFI and FS/CMS reports will present the results of the investigation and alternatives analysis. The CERCLA Proposed Plan (PP)/RCRA proposed corrective action decision (PCAD), the CERCLA Record of Decision (ROD), and the RCRA corrective action decision (CAD) processes will be used for decision-making purposes. The 200-DV-1 OU decision process will include the following:

- Investigate the nature (type) and extent (spatial distribution) of contamination from the surface to the groundwater.
- Evaluate potential impacts to human health and the environment (HHE).
- Evaluate potential impacts on groundwater and the Columbia River.
- Evaluate a combination of proven and emerging technologies for characterizing, remediating, and monitoring DVZ contamination.

[8] Section 6.2.3.7 of EPA/540/G-89/004, 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*.

- Evaluate, select, and implement remedial solutions that protect human health, the environment, and groundwater from contamination in the vadose zone.

The objectives for the work plan were developed during Scoping Meeting 1 on November 15, 2010, and are as follows:

- Document the current state of knowledge and identify the activities needed to determine a preferred remedy (or remedies) for the 200-DV-1 OU.
- Present the rationale and approach for the RI/FS.
- Present the available information on the OU and applicable 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.

The 200-DV-1 OU waste sites are primarily the cribs and trenches adjacent to and associated with the B-BX-BY, T-TX-TY, and S-SX Tank Farms (Figure 1-2). The 200-DV-1 OU also includes a zone of perched water in the vicinity of the B-BX-BY Tank Farms.

The 200-DV-1 OU does not include the groundwater underlying the waste sites. The groundwater on the Central Plateau is addressed through the CERCLA process for the 200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1 OUs.

Submitting this work plan meets Tri-Party Agreement (Ecology et al., 1989a) Milestone M-015-110A: "Submit RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) & Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the 200-DV-1 OU to Ecology. The work plan shall include technology screening that identifies technologies applicable for characterization, treatment, and monitoring of deep vadose zone contaminants." The technology screening that identifies technologies applicable for characterization, treatment, and monitoring of DVZ contaminants is included in this work plan.

The development of the preliminary conceptual site models (CSMs) for 200-DV-1 OU waste sites, and the assessment of data needs through the data quality objective (DQO) process, occurred in 2011. In January 2012, DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*, was approved, which described the characterization activities designed to fill the data needs identified in the 2011 DQO process.

In January 2014, DOE/RL-2013-52, *Sampling and Analysis Plan for Perched Water Wells C8914 and C8915 in the 200-DV-1 Operable Unit*, was approved. The sampling and analysis activities described in the sampling and analysis plan (SAP) were completed in fiscal year (FY) 2014.

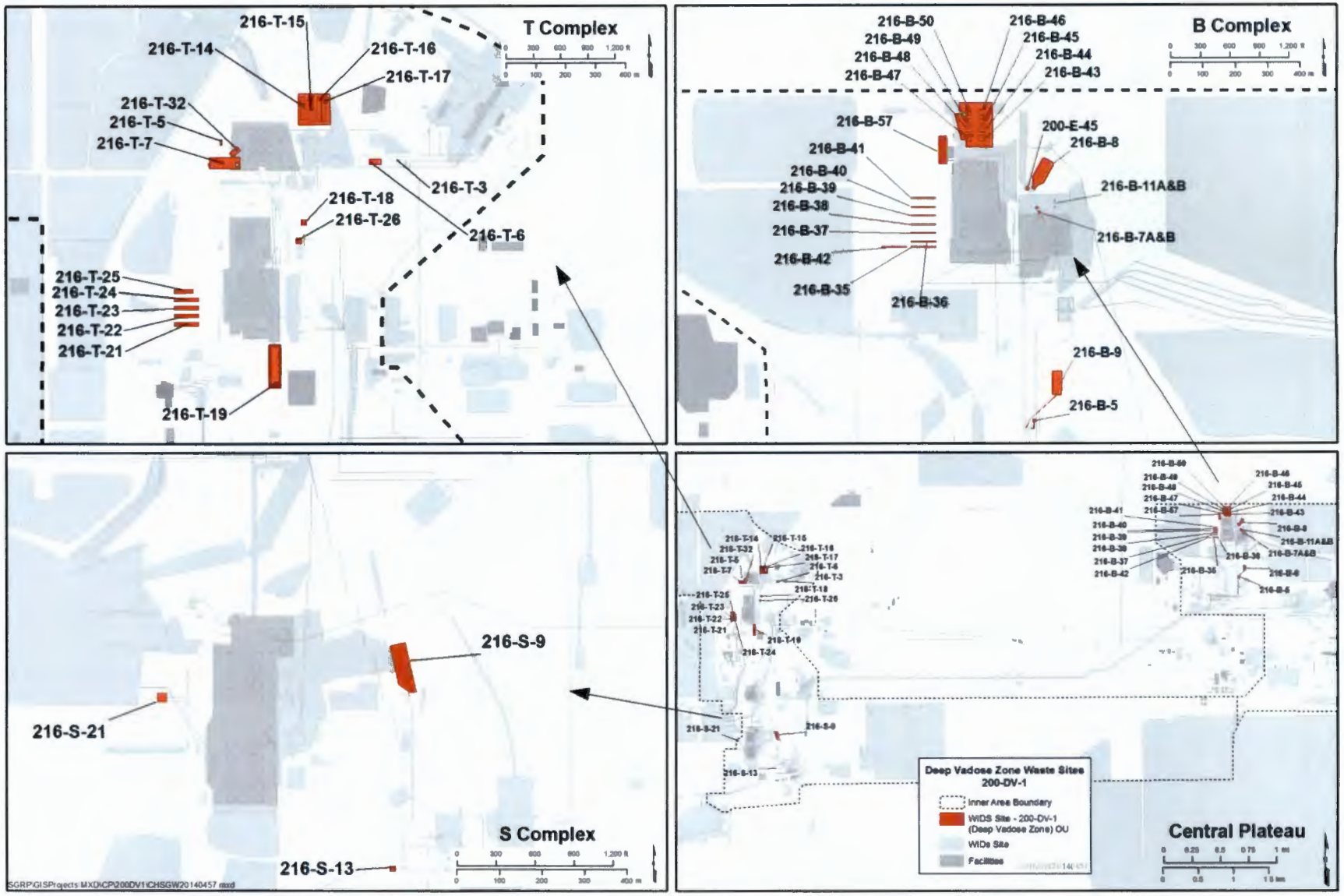

Figure 1-2. Location of 200-DV-1 OU Waste Sites on the Central Plateau

1.2 RCRA-CERCLA Process

The Tri-Party Agreement (Ecology et al., 1989a), which was originally published May 15, 1989, implements the responsibilities of the Tri-Parties under Section 120 of CERCLA to jointly pursue remedial actions on the Hanford Site. The Tri-Party Agreement is a dynamic document that incorporates the 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 Tri-Party Agreement was revised and will continue to be updated, as necessary, per agreements by the Tri-Parties.[9]

The Tri-Party Agreement Action Plan (Ecology et al., 1989b), Section 7.4, describes the combined RCRA and CERCLA Past-Practice Unit Process. The 200-DV-1 OU will follow this process which consists of the following major activities:

- Develop a final RI/FS and RFI/CMS work plan (Tri-Party Agreement Milestone M-015-110A [Ecology et al., 1989a]).
- Implement and complete work needed to complete the RI/FS and RFI/CMS.
- Develop a final RI/RFI report, including a risk assessment.
- Develop a final FS/CMS report (Tri-Party Agreement Milestone M-015-110B [Ecology et al., 1989a]).
- Develop a final PP/PCAD (Tri-Party Agreement Milestone M-015-110B [Ecology et al., 1989a]).
- Provide the public with the opportunity to offer public comments.
- Develop and approve a CAD/ROD.
- Develop a final corrective measures implementation and remedial design/remedial action 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 remedy effectiveness as required by CERCLA and reporting as required by RCRA.

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-DV-1 OU waste sites. After the data have been gathered and analyzed, the CSM updated, and the risk assessment performed, an FS will be completed to identify and evaluate alternatives. A PP/PCAD containing a summary of the investigation and evaluation, and identifying the preferred remedial alternative(s), will be issued for public review and comment. Although the CAD and ROD could be issued separately, a single CAD/ROD document is recommended to ensure that the selected cleanup decisions are compatible for implementation. The CAD/ROD will be signed by the Tri-Parties. The technical requirements of RCRA corrective action are met in the subsequent CERCLA remedial action documentation.

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[9] The most recent version of the Tri-Party Agreement can be found online at www.hanford.gov.

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 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.

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").

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.

Hanford'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 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-DV-1 OU is located within the Inner Area.

1.3.2 Central Plateau Inner Area Cleanup Principles

In 2013-2014, DOE, EPA, and Ecology 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 Tri-Party Agreement.

The overarching goals of the principles are to (1) provide a consistent approach for assessment of risks to human health and the environment 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, baseline risk assessment, cleanup levels, points of compliance, and regulatory strategies are defined below. The principles, as they apply to the 200-DV-1 OU, 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 current 25.9 km^2 (10 mi^2) Inner Area footprint will not be reduced further.

1.3.2.2 Baseline Risk Assessment (BRA)

- BRA will use the default EPA industrial scenario (multiple pathway) to determine need for action at cumulative cancer risk level of 1 in 10,000 and 1 in 100,000 and a hazard index of 1 for non-carcinogenic effects.
- State requirement for cumulative cancer risks under the Model Toxic Control Act (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 Method C industrial cleanup levels for direct contact.
- The only institutional control is industrial land use.
- BRA will not include residential or tribal scenarios.
- BRA will be done on OU-by-OU basis (each work plan).
- DOE will develop RI/FS Work Plan sections that describe the principles and specific parameters on baseline risk assessments 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 Method C (direct contact).
- Approach to ecological cleanup will be the same as for River Corridor, as applied for the 100-D/H area RI/FS (DOE/RL-2010-95).
- 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 the Graded Approach Document (DOE/RL-2011-50). DOE will identify specific parameters in the *Technical Guidance Document for the Tank Closure & Waste Management Environmental Impact Statement* (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 5 unique areas of the Central Plateau.

1.3.2.4 Conditional Point of Compliance for Groundwater

- Feasibility Studies will present an evaluation of groundwater protection at the standard point of compliance (POC) immediately beneath each waste site or facility under consideration. DOE may also choose to perform an analysis in the first Inner Area Feasibility Study to evaluate a conditional point of compliance 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 Feasibility Study, but all OUs will need to justify the decision. The subsequent OU discussions will reference the first 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

- Feasibility Studies 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). DOE may also choose to perform an analysis in first Inner Area Feasibility Study to evaluate a conditional point of compliance at 3 m (10 ft) below ground surface 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 feasibility study, 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 approach 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 Tri-Party Agreement (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 OU and the 200-WA-1 OU. An additional OU, 200-DV-1, was created to include waste sites in the Inner Area with 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 1-3 shows the CERCLA OUs that are currently assigned in the Central Plateau Inner Area. The existing groundwater OUs in the Central Plateau remain unchanged.

The 200-DV-1 OU RI/FS and RFI/CMS 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 are discussed in the following subsections. Specific ongoing sampling, analysis, and remedial action activities that are critical to the 200-DV-1 OU decision process are also discussed.

1.4.1 RCRA-CERCLA Integration

There are no RCRA treatment, storage, and/or disposal (TSD) units in the 200-DV-1 OU. However, the waste sites are adjacent to the single-shell tank (SST) system TSD units in the WMAs for the B-BX-BY, T-TX-TY, and S-SX Tank Farms, resulting in co-mingled DVZ contamination. Remedy selection for the 200-DV-1 OU waste sites will be coordinated with the closure action for the WMAs, as described in Section 1.4.2.

1.4.2 Tank Farm Waste Management Areas

The SSTs are grouped into 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 ROD issued in December 2013 (78 FR 240). The WMAs are not included in the 200-DV-1 OU.

Figure 1-3. OUs in Central Plateau Inner Area

Remedial action alternatives developed in the 200-DV-1 OU FS/CMS report for waste sites adjacent to tank farm WMAs will take into consideration the proximity of the TSD units. The detailed evaluation of alternatives performed in the 200-DV-1 OU FS will determine whether a closure action planned for the nearby TSD units would also be an appropriate remedy for the waste sites.

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 OU and 200-BC-1 OU; 200-PW-1 OU, 200-PW-3 OU, 200-PW-6 OU, and 200-CW-5 OU; 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 1-3.

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*). DOE/RL-88-32, *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit, Hanford Site, Richland, Washington*, was prepared and implemented for the 200-BP-1 OU, which included some of the waste sites (the 216-B-43 through 216-B-50 Cribs and the 216-B-57 Crib) that are now included in the 200-DV-1 OU (Appendix A).

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. During the process-based grouping, most of the waste sites now included in the 200-DV-1 OU were assigned to the 200-TW-1 Scavenged Tank Waste Group OU, the 200-TW-2 Tank Waste Group OU, or the 200-PW-5 Fission Product-Rich Process Waste Group OU (Appendix A).

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 OU and the 200-TW-2 OU (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 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 for the collection of additional data at those waste sites for which existing data were determined to be insufficient for decision-making purposes. The characterization activities described in the SAP approved in 2012 for the 200-DV-1 OU waste sites (DOE/RL-2011-104) replace the characterization activities included for these waste sites in the 2007 supplemental work plan SAP (DOE/RL-2007-02).

The OUs that contain structures or waste sites that are in close physical proximity to 200-DV-1 OU waste sites are described below.

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 Plutonium Finishing Plant process operations. The 200-CW-5 OU received cooling water from the Plutonium Finishing Plant and U Plant. The 200-PW-3 OU waste sites received process water 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 Central Plateau Inner Area. The 200-IS-1 OU also includes the contaminated soil that is the result of previously identified unplanned releases (UPRs) from the pipeline and pipeline components.

1.4.3.3 200-SW-2 Operable Unit Landfills

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 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 (co-located in the 218-W-2A and 281-W-3AE Landfills). The remedial action alternatives for 200-DV-1 OU waste sites adjacent to the burial grounds will take into consideration the proximity of the burial ground.

1.4.3.4 200-EA-1, 200-WA-1, and 200-BC-1 Operable Units

The types of waste sites in the 200-EA-1, 200-WA-1, and 200-BC-1 OUs are diverse but correspond to one of the following general categories: cribs, trenches, reverse wells, French drains, basins, ponds and ditches, vaults, underground storage tanks, septic systems, UPRs, solid waste sites, and process sewers. Most of these sites involve shallow contamination, but some have DVZ contamination and in some cases are adjacent to 200-DV-1 OU sites.

1.4.3.5 Operable Unit Waste Site Interfaces

Part of the coordination of activities across OU waste sites requires an understanding and definition of 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 the soil waste sites and canyons and the 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

No major pipeline boundary interface points are associated with the 200-SW-2 Landfills or the groundwater OUs.

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 the soil waste site. An interface conflict will be considered to exist when either of the following occur:
  - A pipeline[10] is located within the boundary of the soil waste site as defined in the Waste Information Data System (WIDS) database waste site mapping overlay and is not included as being part of the waste site in WIDS.
  - A pipeline is located outside of the boundary of the soil waste and is located within 7.6 m (25 ft)[11] of the boundary. This criterion is inclusive of the segment of pipeline that extends into the waste site.
- Specific coordinates of the interface points will be established and referenced for soil waste sites identified with interface conflicts. 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 will be updated in WIDS.
- DOE does not anticipate any new pipeline or soil waste sites to be created by this process.

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 by historical discharges to 200-DV-1 OU waste sites. The 200-DV-1 OU waste sites are underlain by the 200-ZP-1, 200-UP-1, and 200-BP-5 Groundwater OUs. A groundwater pump-and-treat (P&T) remediation system was constructed to address contaminated groundwater present in the 200-ZP-1

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

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

and 200-UP-1 OUs. A ROD (EPA et al., 2008, *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*) was issued in 2008, and an interim remedial action ROD (EPA et al., 2012, *Record of Decision for Interim Remedial Action, Hanford 200 Area Superfund Site, 200-UP-1 Operable Unit*) was issued in 2012. The RI and FS reports for the 200-BP-5 OU are in preparation.

Carbon tetrachloride, trichloroethene, total and hexavalent chromium, nitrate, technetium-99, iodine-129, and tritium are contaminants of concern (COCs) that were identified in the 200-ZP-1 and 200-UP-1 OUs. In addition, uranium has been identified as a COC in the 200-UP-1 OU. Uranium, technetium-99, and nitrate have been identified as contaminants of potential concern (COPCs) in the 200-BP-5 OU. Chapter 3 discusses the potential contaminant migration from 200-DV-1 OU vadose zone waste sites to the underlying groundwater, which will be more fully evaluated in the 200-DV-1 OU RI/RFI and FS/CMS reports. Chapter 5 presents additional information on the approach that will be used.

1.4.5 Deep Vadose Zone Science and Technology

The DVZ science and technology efforts have included the AFRI for the DVZ, which has been jointly funded by RL and the DOE Office of Environmental Management (DOE-EM) Office of Soil and Groundwater Remediation. The mission of the AFRI for the DVZ is to address the long-term protection of water resources at DOE-EM sites by developing and applying effective solutions for DOE's DVZ challenges in characterization, prediction, remediation, and monitoring. At the Hanford Site, those water resources refer to the unconfined aquifer underlying the DVZ and the Columbia River into which the aquifer discharges groundwater. This work is intended to enhance the fundamental understanding of the DVZ problem and to infuse investments from DOE-EM and RL to develop effective methods to address contaminants in the DVZ at the Hanford Site.

Major programs funded through DOE-EM, RL, the DOE Office of River Protection (ORP), and CH2M HILL Plateau Remediation Company (CHPRC) have included the DVZ treatability test program (DOE/RL-2007-56, *Deep Vadose Zone Treatability Test Plan for the Hanford Central Plateau*), the AFRI for the DVZ (PNNL-20209, *Implementation Plan for the Deep Vadose Zone – Applied Field Research Center*), and the Advanced Simulation Capability for Environmental Management (ASCEM-SITE-2012-01, *Phase II Demonstration*; Freedman et al., 2014, "A High-Performance Workflow System for Subsurface Simulation"). These activities, as well as results from other interim remedial actions on the Central Plateau, provide information and tools applicable to the 200-DV-1 OU RI/FS and RFI/CMS processes.

Through recent efforts, advances have been made in vadose zone remediation and monitoring technology development, including evaluation and testing; research on vadose zone processes; and predictive modeling tool development relevant to vadose zone applications. Remediation technology development has primarily focused on establishing a set of potentially applicable technologies and examining and improving options for in situ remediation. Monitoring technology development has involved testing and developing improved tools (especially tools based on geophysical monitoring), and developing improved approaches for monitoring. Knowledge of hydraulic and biogeochemical processes important for vadose zone transport on the Central Plateau has been refined, including improvements to vadose zone CSMs. Efforts have also included developing new frameworks for evaluating vadose zone contaminant impacts to groundwater, and new predictive modeling tools targeted at providing a modeling system for integrating data, conceptual models, predictive assessments, and visualization into a system that can be applied to facilitate remedy decisions.

Specific elements of science and technology activities relevant to the 200-DV-1 OU are summarized in Appendix B.

2 Operable Unit Background and Environmental Setting

This chapter summarizes the background information and environmental setting for the three 200-DV-1 OU investigation areas: the B Complex area, T Complex area, and S Complex area.

2.1 B Complex Area

In the B Complex area, the 200-DV-1 OU waste sites are located near WMA B-BX-BY.

2.1.1 History of Operations

This section summarizes the historical site operations, activities, processes, waste streams, and contaminant sources in the B Complex area. The B Complex area includes 23 waste sites in the 200-DV-1 OU and three SST farms (Figures 2-1 and 2-2). Other waste sites and facilities in the vicinity are included in the following discussion as needed for completeness.

The following history of operations for the B Complex area was taken from HNF-5231, *Historical Vadose Zone Contamination from B, BX, and BY Tank Farm Operations* (p. 3-10). A timeline for B Complex activities is presented in Figure 2-3.

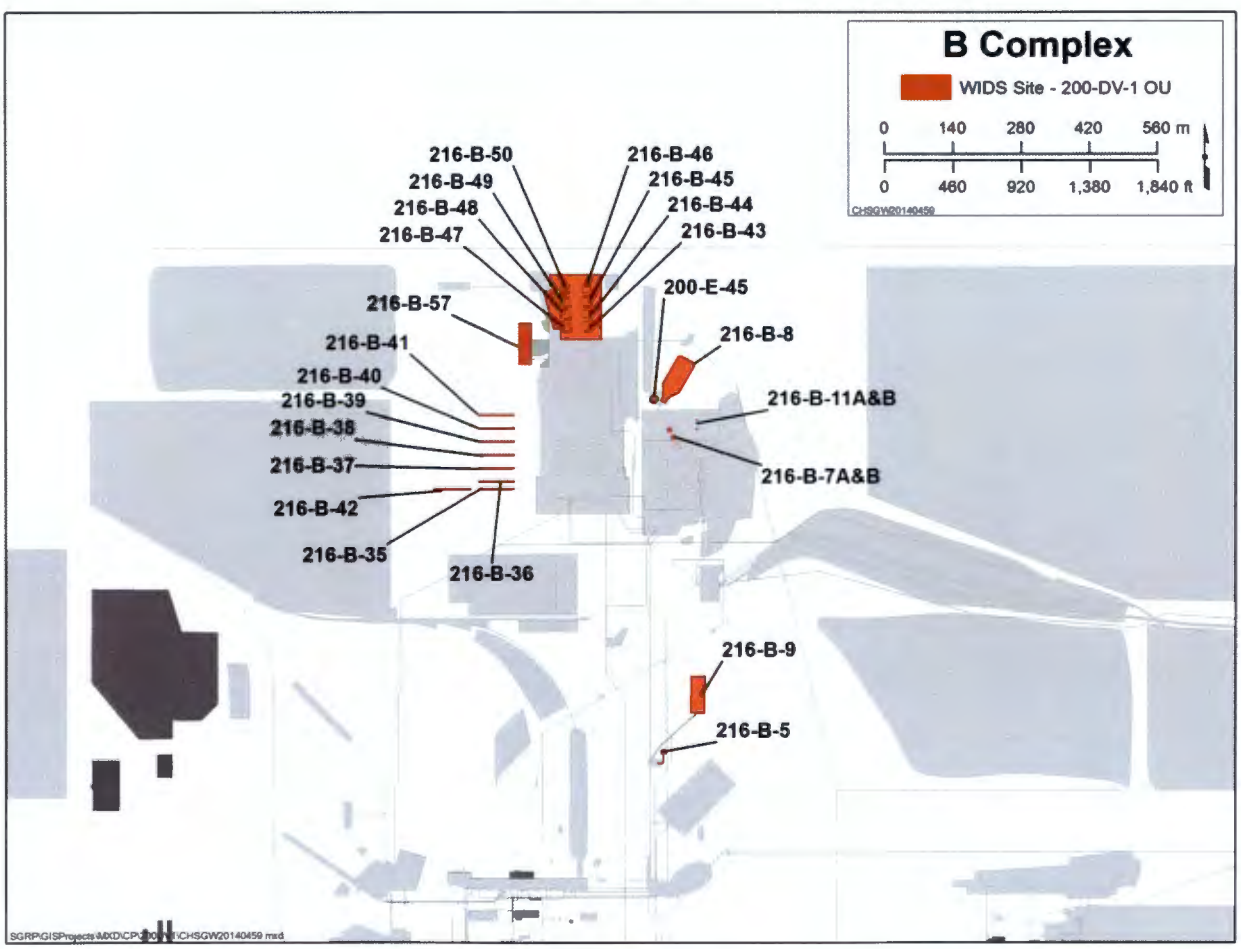
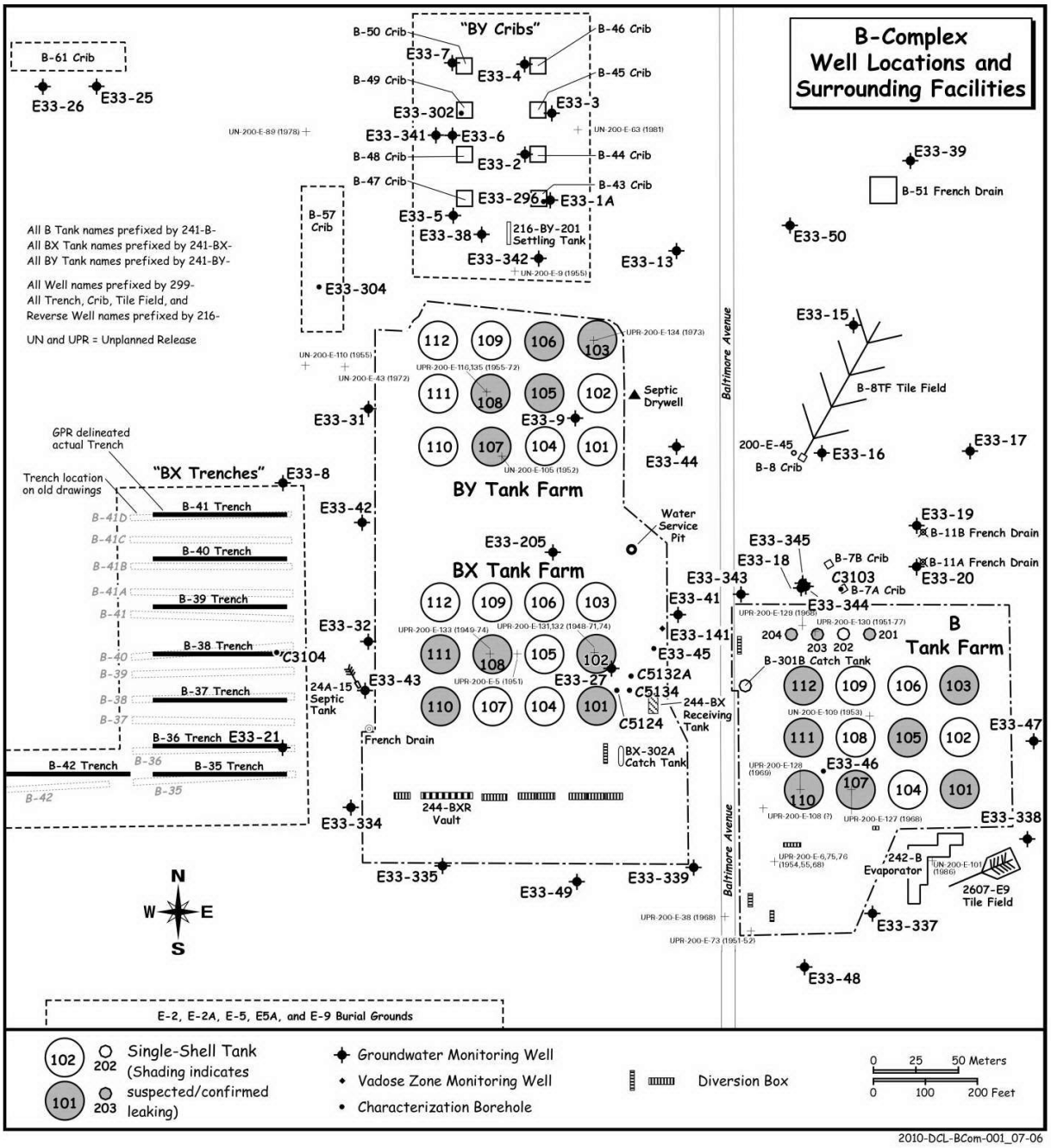
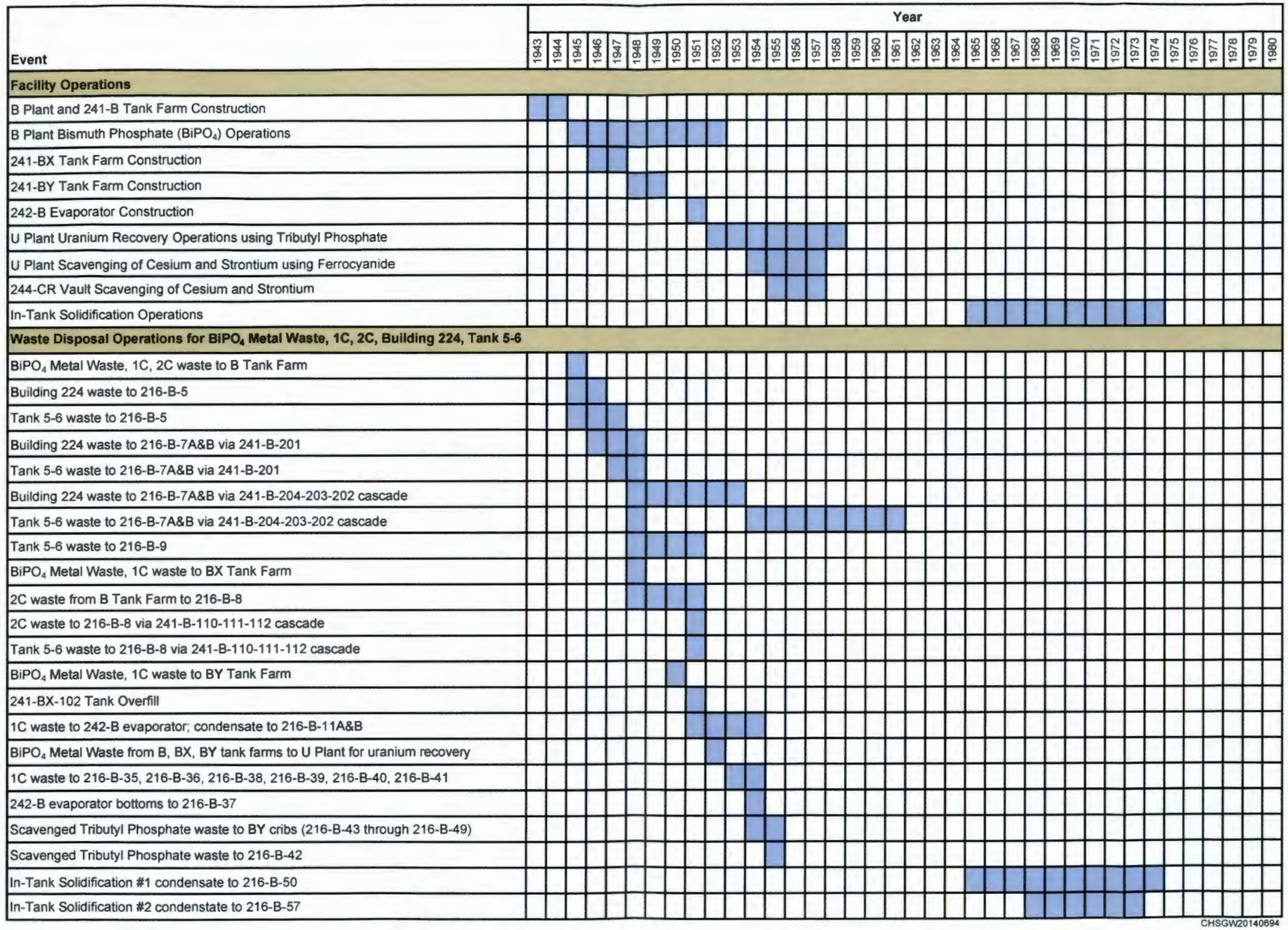


Figure 2-1. Location of 200-DV-1 OU Waste Sites in the B Complex Area



Note: See also Figure 1.1 in PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex.*

Figure 2-2. Location of B-BX-BY Tank Farms in the B Complex Area



Note: This figure is based on Appendix 3 of HNF-5231, *Historical Vadose Zone Contamination from B, BX, and BY Tank Farm Operations*.

Figure 2-3. Historical Timeline for B Complex Area Activities

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The B-BX-BY Tank Farms complex operations that resulted in waste disposal to the 200-DV-1 OU waste sites can be separated into four historical eras:

1. The B Tank Farm was constructed in 1943 and 1944 to provide storage for radioactive liquid waste produced at B Plant. B Plant used the bismuth phosphate process to separate plutonium from irradiated fuel slugs. The bismuth phosphate process produced five waste streams:

    - Bismuth phosphate metal waste was the byproduct from the plutonium-separation phase of the bismuth phosphate process. Bismuth phosphate metal waste contained unfissioned uranium and approximately 90 percent of the fission products of the irradiated fuel. The bismuth phosphate metal waste was stored in tanks at the B Tank Farm.

    - First-cycle waste (referred to as 1C waste) was the byproduct from the first plutonium decontamination cycle of the bismuth phosphate process. This waste contained approximately 10 percent of the fission products of the irradiated fuel. The 1C was stored in tanks at the B Tank Farm.

    - Second-cycle waste (referred to as 2C waste) was the byproduct from the second and last plutonium decontamination cycle of the bismuth phosphate process. This waste contained less than 0.1 percent of the fission products of the irradiated fuel. The 2C waste was stored in tanks at the B Tank Farm.

    - "Building 224 waste" was low-level liquid waste from the 224-B Plutonium Concentrator Building. This waste stream was the primary contributor of plutonium contamination to the soil. The waste was discharged to the 241-B-361 Settling Tank, and the supernate overflowed to the 216-B-5 Reverse Well (Figure 2-1).

    - "Tank 5-6 waste" was low-level liquid waste from individual process cells in B Plant. Drainage from the cells was stored in Tank 5-6. The Tank 5-6 waste was discharged to the 241-B-361 Settling Tank, and the supernate overflowed to the 216-B-5 Reverse Well.

2. From 1946 until 1952 (when B Plant was shut down), the tank farms were expanded and received liquid waste from bismuth phosphate operations. Liquid waste disposal to the soil column through cribs near B Tank Farm was initiated.

    - To increase waste tank storage space, activities were initiated to dispose the relatively low-level 2C waste to the ground, concentrate the intermediate-level 1C waste in an evaporator, recover the unfissioned uranium in the bismuth phosphate metal waste, and build additional waste tanks. The BX Tank Farm was constructed in 1946 and 1947, and the BY Tank Farm was constructed in 1948 and 1949 (Figure 2-2). Facilities for the uranium recovery operations also were built during this time.

    - In 1946, the Building 224 waste was re-routed from the 216-B-5 Reverse Well to tanks in the B Tank Farm (initially Tank 241-B-201 in 1946, and then the Tank 241-B-204-203-202 cascade series in 1948), and the supernate overflowed to the 216-B-7A&B Cribs (Figures 2-1 and 2-2). In 1947, the 216-B-5 Reverse Well was taken out of service, and the Tank 5-6 waste was temporarily combined with the Building 224 waste being discharged through the 216-B-7A&B Cribs. In 1948, the 216-B-9 Crib and Tile Field were built for disposal of Tank 5-6 waste (Figure 2-1).

- Experiments with 2C waste revealed that most of the activity was concentrated on the sludge settling at the tank bottom, leaving a low-activity supernate that met existing criteria for ground disposal. The continuing shortage of tank space led to the decision to begin discharging the 2C waste (after cascading and settling) to the 216-B-8 Crib and Tile Field in 1948 (Figures 2-1 and 2-2). In 1951, when the 216-B-9 Crib and Tile Field reached its radionuclide capacity, the Tank 5-6 waste was combined with the 2C waste being discharged to the 216-B-8 Crib through the 241-B-110-111-112 cascade.

- The 242-B Evaporator was built in 1951 (Figure 2-2). The evaporator received 1C waste from Tank 241-B-106. The evaporator condensate was sent to the 216-B-11A&B French Drains (Figures 2-1 and 2-2). The remaining evaporator "bottoms" were sent to the 241-B-107-108-109 cascade for accumulation as feed for a second pass through the 242-B Evaporator.

- B Plant ceased bismuth phosphate operations in August 1952 and was shut down in October 1952.

- Evaporation of 1C waste was discontinued in August 1953 because the 242-B Evaporator was needed for waste from uranium recovery and fission product scavenging. From February to November 1954, the 1C waste supernate that had not been evaporated was discharged to BX Trenches 216-B-35, 216-B-36, 216-B-38, 216-B-39, 216-B-40, and 216-B-41 (Figures 2-1 and 2-2). The evaporator bottoms were discharged to the 216-B-37 Trench in August 1954.

- One UPR associated with bismuth phosphate operations is UPR-200-E-5, the 1951 overfill event at Tank 241-BX-102 that released bismuth phosphate metal waste containing 20,000 kg of uranium (RPP-RPT-47562, *Hanford BX-Farm Leak Assessments Report*).

3. From 1952 to 1958, high-level waste from the tank farms was sent to U Plant for uranium recovery and fission product scavenging. Scavenged waste was discharged to cribs.

- U Plant was modified in 1951 for uranium recovery operations using the tributyl phosphate (TBP) solvent extraction process. Beginning in 1952, the bismuth phosphate metal waste was removed from the B-BX-BY Tank Farms and transferred to U Plant. The resulting TBP waste (uranium recovery waste) was transferred to the B-BX-BY Tank Farms. Inefficiencies in the process resulted in approximately 2 L (0.5 gal) of TBP waste produced for every 1 L (0.26 gal) of bismuth phosphate metal waste processed.

- To reduce the volume of waste stored in the tanks, the TBP waste was concentrated in the 242-B Evaporator beginning in September 1953. Additionally, a ferrocyanide scavenging process was developed to remove the principal long-lived fission products, cesium-137 and strontium-90, as precipitates from the TBP waste to enable disposal of the TBP waste supernate to cribs. From September 1954 to June 1957, the newly generated TBP waste was scavenged in U Plant to remove cesium-137 and strontium-90. From May 1955 to December 1957, the TBP waste that was being stored in the B-BX-BY Tank Farms from earlier uranium recovery processing was retrieved and scavenged in the 244-CR Vault (referred to as "in-tank-farm" scavenging).

- From scavenging (in U Plant or the 244-CR Vault), waste was sent to the BY Tank Farm for settling. From December 1954 to December 1955, the scavenged TBP supernate was discharged to the ground through BY Cribs 216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, and 216-B-49 and BX Trench 216-B-42 (Figures 2-1 and 2-2). From 1956 to early 1958, the supernate was discharged to the BC Cribs and Trenches (WHC-MR-0227, *Tank Wastes Discharged Directly to the Soil at the Hanford Site*, Section 3.2).

4. From 1965 to 1974, in-tank solidification (ITS) processes were operated to reduce tank volumes. The ITS condensate was discharged to cribs.

   - The ITS process was used to remove liquid waste supernate from SSTs. Two ITS systems were installed in the BY Tank Farm. ITS 1 (heated air circulated through tank waste) was installed for Tanks 241-BY-101 and 241-BY-102 and began operation in 1965. ITS 2 (in-tank heater) was installed for Tanks 241-B-111 and 241-B-112 and began operation in 1968. By 1971, ITS 2 was extended to all remaining BY Tank Farm tanks, and ITS 1 was converted into a cooler for ITS 2. The ITS system was tied into the BX Tank Farm in 1971 and the B Tank Farm in 1973. The ITS system was discontinued in 1974.

   - Condensate from ITS 1 was discharged to the 216-B-50 Crib, and condensate from ITS 2 was discharged to the 216-B-57 Crib (Figures 2-1 and 2-2). The remaining concentrate from the ITS units was discharged to the B-BX-BY Tank Farms.

2.1.2 Description of Tank Farms and Facilities

The B-BX-BY Tank Farms consist of the following:

- **B Tank Farm:** Twelve 2,006,268 L (530,000 gal), 100-series, single-shell underground waste storage tanks (241-B-101 through 241-B-112); and four 208,198 L (55,000 gal), 200-series tanks (241-B-201 through 241-B-204) (Figure 2-2).

- **BX Tank Farm:** Twelve 2,006,268 L (530,000 gal), 100-series SSTs (241-BX-101 through 241-BX-112).

- **BY Tank Farm:** Twelve 2,869,342 L (758,000 gal), 100-series SSTs (241-BY-101 through 241-BY-112).

The 100-series tanks were constructed with 7.6 cm (3 in.) diameter cascade overflow lines in a three-tank series that allowed gravity flow of liquid waste between the tanks. In the B-BX-BY Tank Farms, the tanks cascaded from south to north (e.g., 241-B-101 to 241-B-102 to 241-B-103) (Figure 2-2). The last tank of each south-to-north cascade series in the BX Tank Farm overflowed to the first tank in each south-to-north cascade series in the BY Tank Farm (e.g., Tank 241-BX-103 overflowed to Tank 241-BY-101). The 100-series tanks in the cascade series are arranged with each successive tank sited at a lower elevation (with the receiving tank 0.305 m [1 ft] lower than the feed tank), creating a gradient that allowed fluids to flow from one tank to another as the tanks were filled (RPP-10098, *Field Investigation Report for Waste Management Area B-BX-BY: Volume 1, Main Text and Appendices A-C*, Section 1.2; RPP-RPT-49089, *Hanford B-Farm Leak Assessments Report*, Section 3.1; RPP-RPT-47562, Section 3.1). The B Tank Farm's 200-series tanks and tie lines for cascade tanks 241-B-204, 241-B-203, and 241-B-202 are at the same elevation. This tie line allowed the waste to enter Tank 241-B-204 and to eventually overflow and equalize with Tanks 241-B-203 and 241-B-202 (RPP-RPT-49089, Section B8.1.2).

From the beginning of Hanford Site tank farm operations, the primary leak detection system was the routine monitoring of liquid surface levels within each tank (RPP-RPT-49089, Section 3.2; RPP-RPT-47562, Section 3.2; RPP-RPT-43704, *Hanford BY-Farm Leak Assessments Report*, Section 3.2). Routine monitoring of gross-gamma activity in drywells near the SSTs provided a second leak detection method. The drywells for the B Tank Farm, BX Tank Farm, and BY Tank Farm are identified in RPP-RPT-49089, RPP-RPT-47562, and RPP-RPT-43704.

Past leaks in the B-BX-BY Tank Farms were reassessed in 2011 and documented in leak assessment reports. The reports provide detailed construction information and operating history for each tank.

Table 2-1 indicates the leak status of each tank and provides the reference for the detailed information summary.

Table 2-1. Status of B-BX-BY Tank Farm SSTs

Reference	Assumed to Have Leaked	Classified as Sound
RPP-RPT-49089, *Hanford B-Farm Leak Assessments Report*, Rev. 0	**B Tank Farm SSTs**	
	241-B-101	241-B-102
	241-B-103	241-B-104
	241-B-105	241-B-106
	241-B-107	241-B-108
	241-B-110	241-B-109
	241-B-111	—
	241-B-112	—
	241-B-201	241-B-202
	241-B-203	—
	241-B-204	—
RPP-RPT-47562, *Hanford BX-Farm Leak Assessments Report*, Rev. 0	**BX Tank Farm SSTs**	
	241-BX-101	241-BX-103
	241-BX-102	241-BX-104
	241-BX-108	241-BX-105
	241-BX-110	241-BX-106
	241-BX-111	241-BX-107
	—	241-BX-109
	—	241-BX-112
RPP-RPT-43704, *Hanford BY-Farm Leak Assessments Report*, Rev. 0A	**BY Tank Farm SSTs**	
	241-BY-103	241-BY-101
	241-BY-105	241-BY-102
	241-BY-106	241-BY-104
	241-BY-107	241-BY-109
	241-BY-108	241-BY-110
	—	241-BY-111
	—	241-BY-112

SST = single-shell tank

Each tank farm also includes waste transfer lines, leak detection systems, and tank ancillary equipment. The configuration of these infrastructure elements changed over time. The historical infrastructure for the B-BX-BY Tank Farms is provided in HNF-5231.

2.1.3 Waste Site Descriptions

The 200-DV-1 OU waste sites in the B Complex area were used from 1945 to 1974 for disposal of waste associated with plutonium-separation operations at B Plant, uranium recovery and fission product scavenging at U Plant, and ITS operations at the B-BX-BY Tank Farms. The timeline for use of waste sites for waste disposal is shown in Figure 2-3.

The types of waste sites in the 200-DV-1 OU were designed to percolate wastewater into the ground without exposing the wastewater to the atmosphere. The 200-DV-1 OU waste sites in the B Complex area include the following:

- **Reverse wells (one):** Also known as injection wells, reverse wells were used for the disposal of intermediate-level liquid waste in the early phases of Hanford Site operations. Reverse Well 216-B-5 in the B Complex area of the 200-DV-1 OU consists of a drilled and cased borehole. The lowermost 15 m (50 ft) of casing was perforated to allow liquid to seep into the vadose zone at depths greater than the cribs and French drains (Figure 2-4). The 216-B-5 perforated casing extended approximately 3 m (10 ft) into the groundwater (HW-17088, *The Underground Disposal of Liquid Wastes at the Hanford Works, Washington*, pp. 31–32).

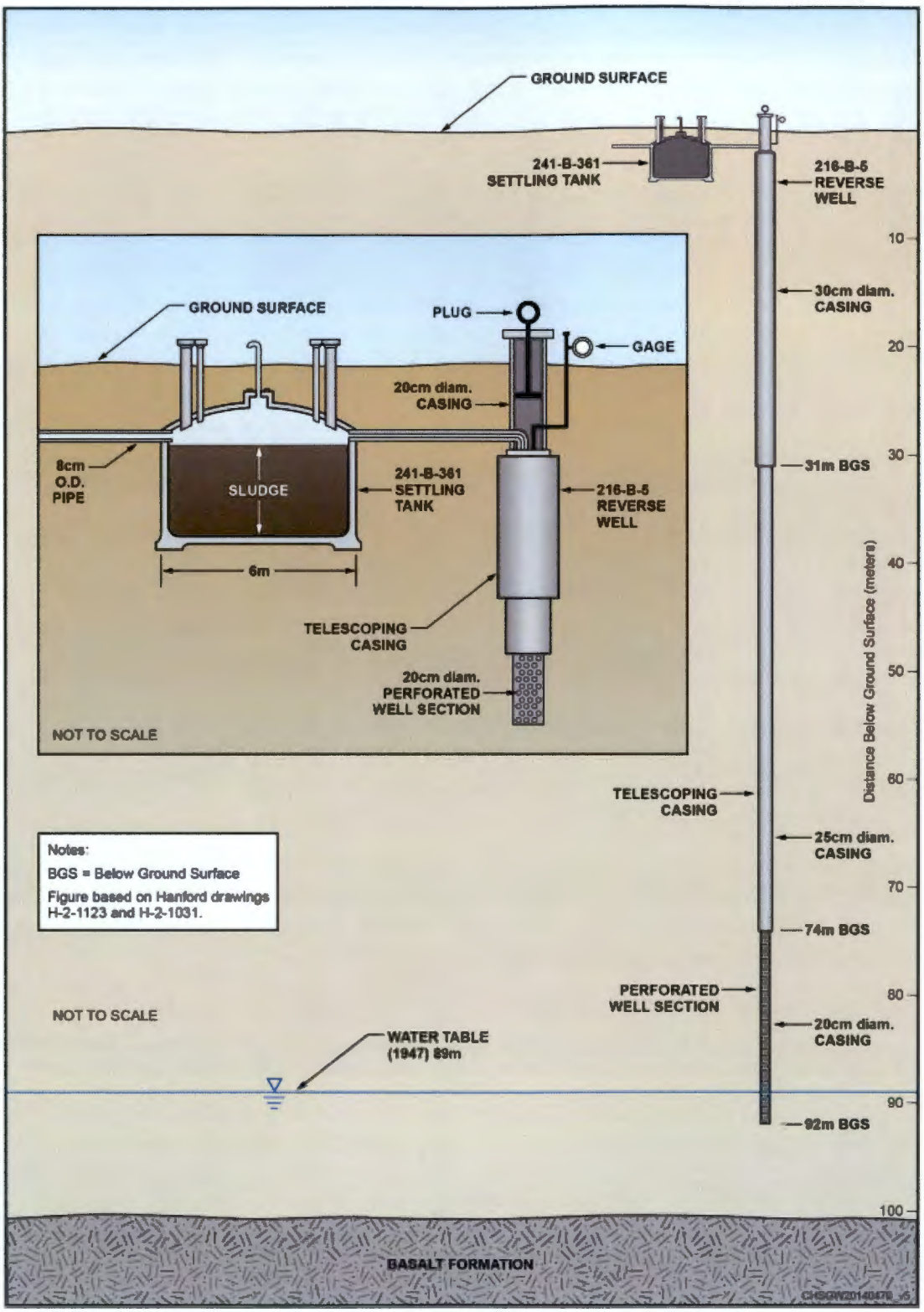
- **Cribs (twelve):** Cribs in the 200-DV-1 OU were relatively shallow excavations (typically less than 10 m [30 ft] deep) that were held open by wood cribbing (216-B-7A&B, 216-B-8, 216-B-9) or concrete culverts (216-B-43 through 216-B-50) or gravel (216-B-57) (Figures 2-5 and 2-6). They were designed to receive liquid via a pipeline from the waste-generating facility on a more or less continuous basis until the unit's specific retention or radionuclide capacity was met. Two of the cribs (216-B-8 and 216-B-9) included tile fields used for waste liquid overflow from the associated cribs.

- **Trenches (eight):** Trenches in the 200-DV-1 OU were relatively shallow excavations (typically less than 10 m [30 ft] deep) that were used to dispose contaminated liquid waste by direct discharge via a temporary, overland pipeline (216-B-35 through 216-B-42) (Figure 2-7). The trenches were typically used on a specific retention basis, with a fixed volume of liquid identified for discharge prior to use.

- **French drains (one):** French Drain 216-B-11A&B in the 200-DV-1 OU was constructed of vertically oriented, large-diameter, steel culverts with open bottoms that were perforated along their lengths (Figure 2-8). The inside of each culvert was open, and the annulus between each culvert and the hole excavated to bury it was filled with gravel.

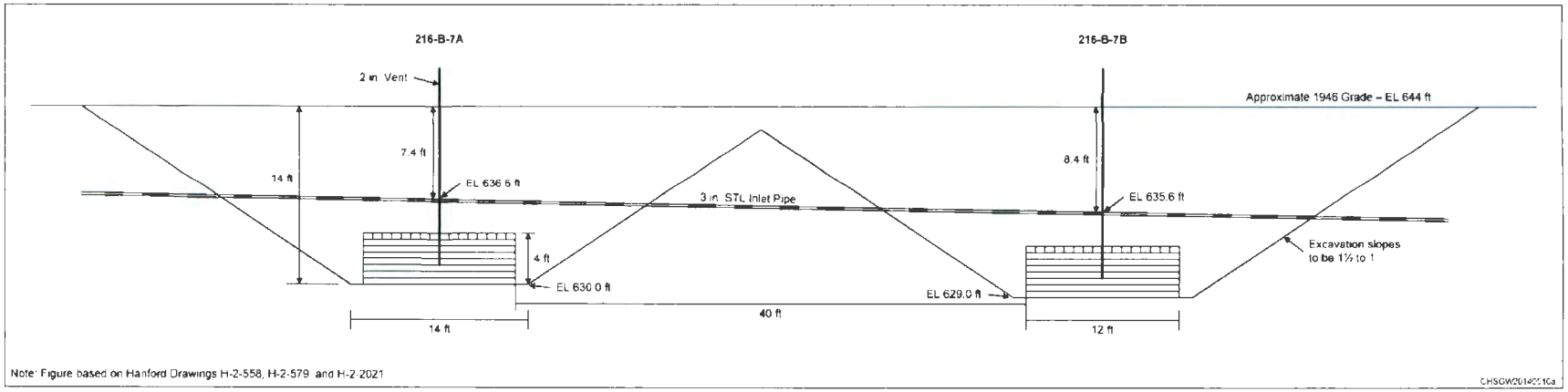
- **Health instrument shafts (one):** Health Instrument (HI) Shaft 200-E-45 in the 200-DV-1 OU was a 2.4 m (8 ft) diameter, 16.8 m (55 ft) deep concrete pipe, with steel laterals installed through holes in the pipe wall for collection of samples beneath the adjacent 216-B-8 Crib (Figure 2-9).

Additional details on the construction and configuration of the waste sites in the 200-DV-1 OU are provided in Table 2-2 and in the tables prepared to support the DQO process (Appendix C).



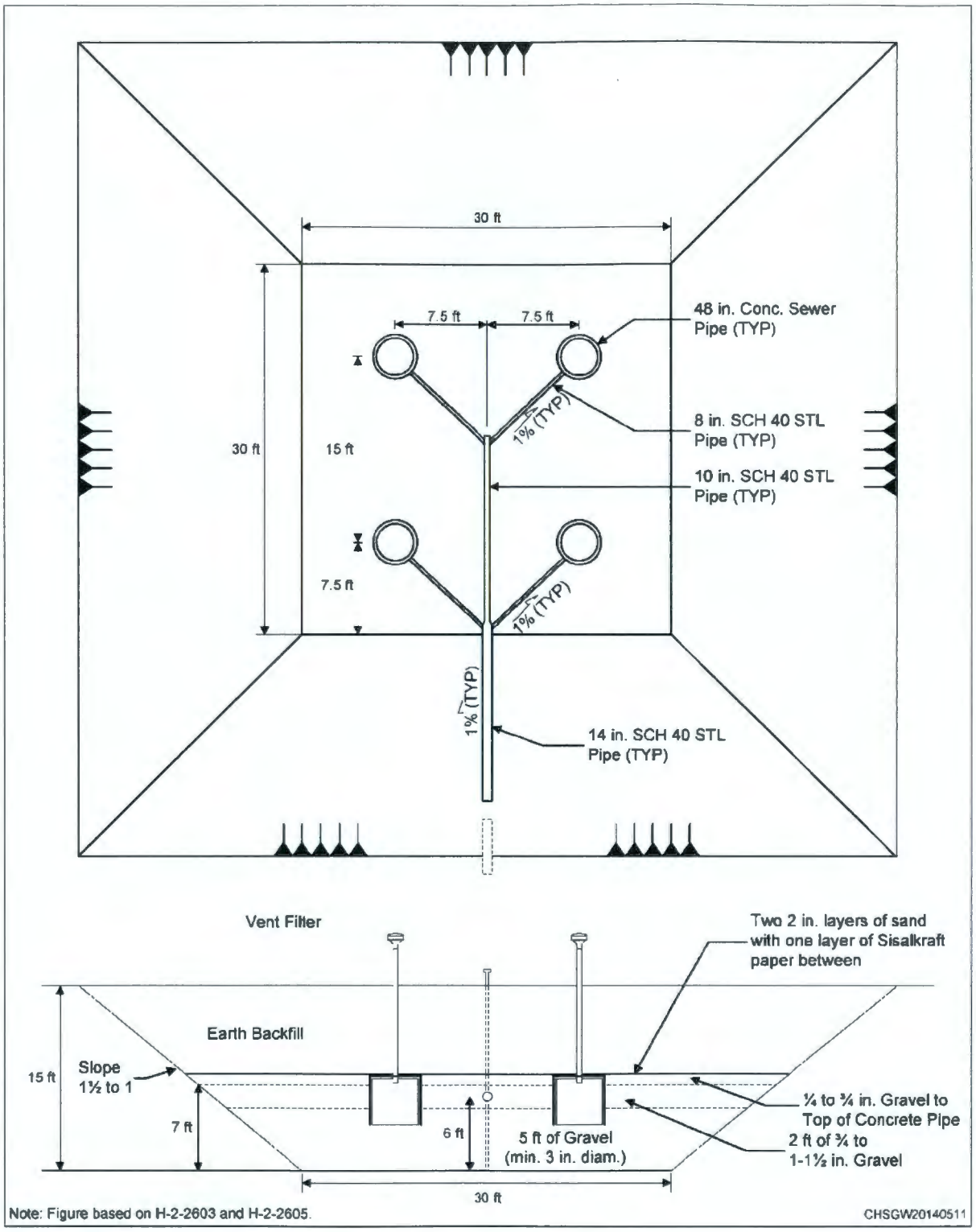
Modified from: Figure 3 in RHO-ST-37, *216-B-5 Reverse Well Characterization Study*.

Figure 2-4. Configuration of the 216-B-5 Reverse Well



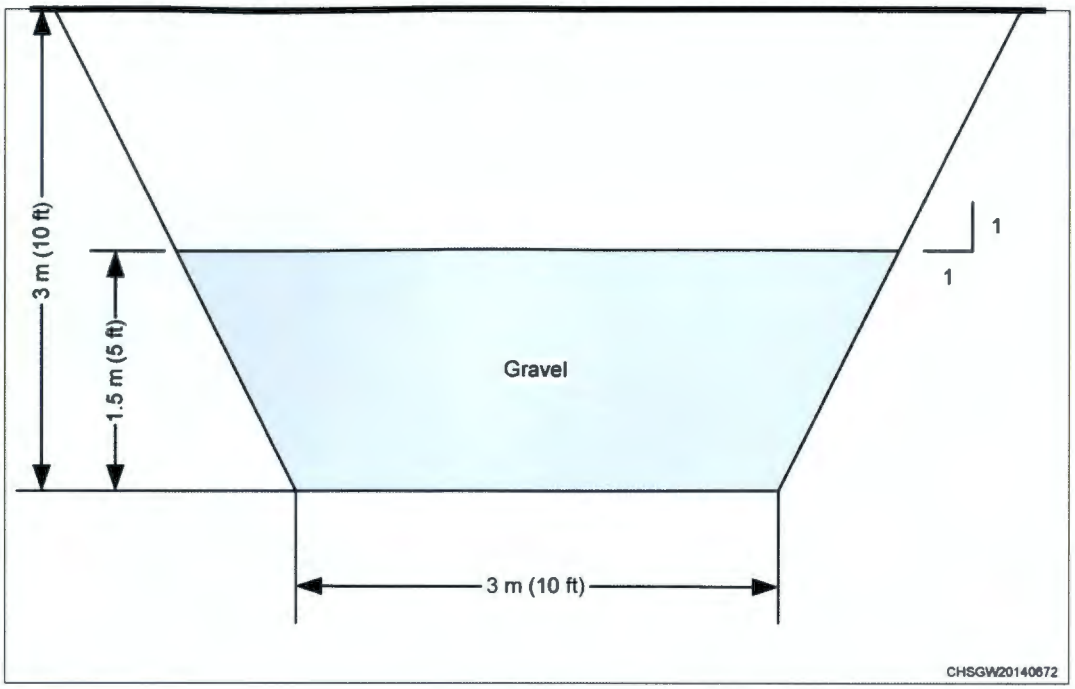
Modified from : Figure AD4 2-2 in DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units, Volume I: Work Plan and Appendices*. See also Figure 2-16 in DOE/RL-2000-38, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan.*

Figure 2-5. Configuration of the 216-B-7A&B Cribs



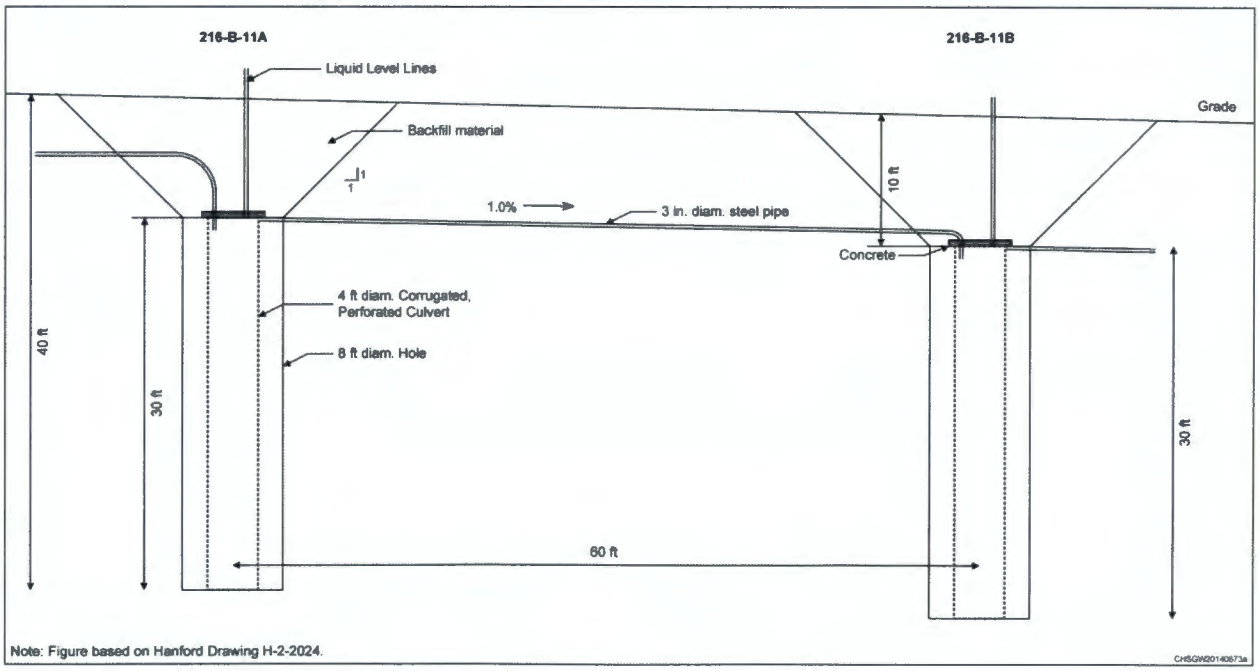
Modified from: Figure 2-15 in DOE/RL-2000-38, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan*.

Figure 2-6. Configuration of the BY Cribs



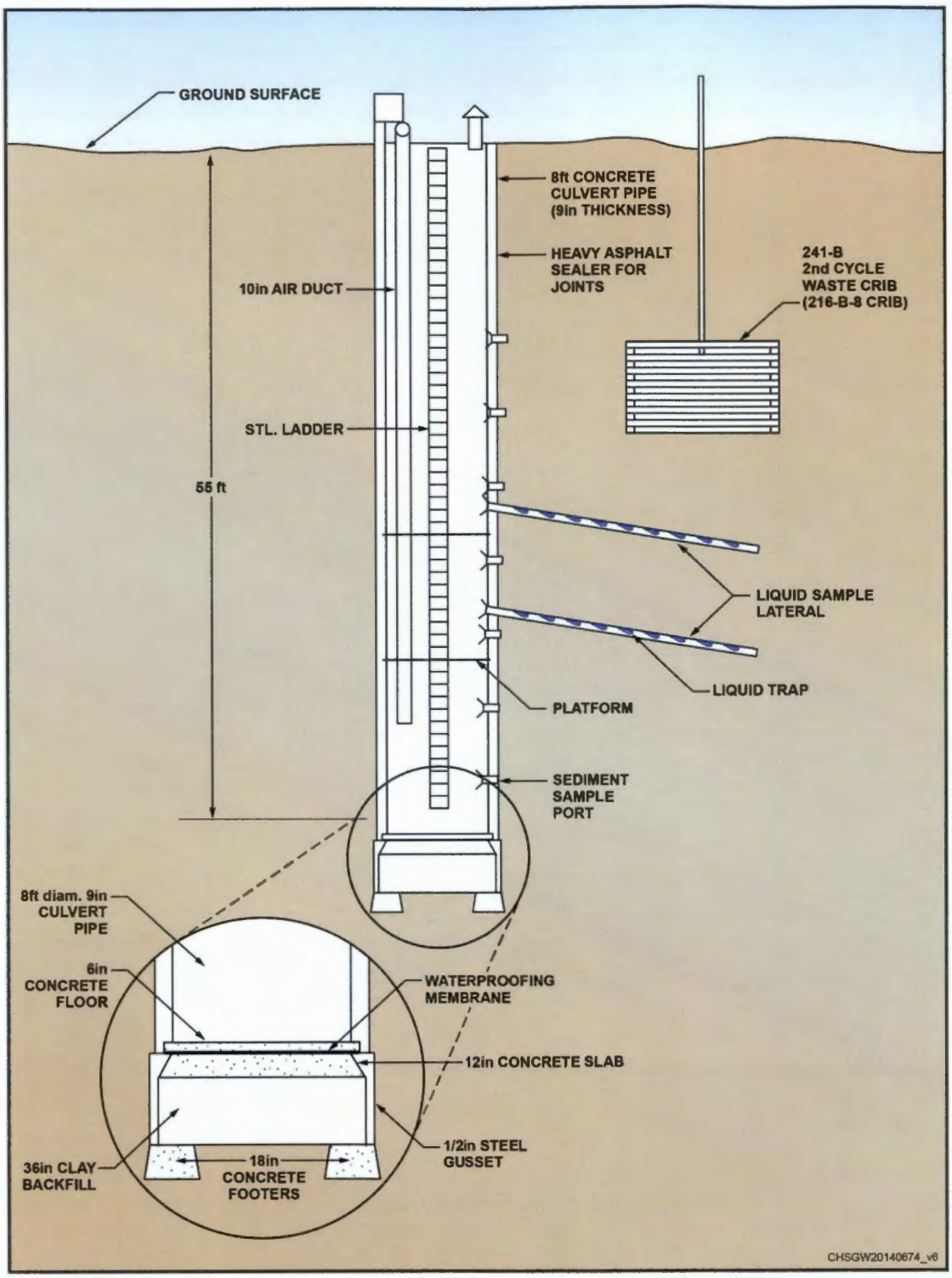
Source: Figure AD3 2-3 in DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units, Volume I: Work Plan and Appendices*.

Figure 2-7. Configuration of the BX Trenches



Note: See HW-55176, *Index of CPD Crib Building Numbers Designs of CPD Radioactive Liquid Waste Disposal Sites*, and drawing H-2-2024.

Figure 2-8. Configuration of the 216-B-11A&B French Drain



Modified from: Figure 6-1 in WHC-EP-0560, *Miscellaneous Underground Radioactive Waste Tanks*.

Figure 2-9. Configuration of the 200-E-45 HI Shaft

Table 2-2. Summary Information for 200-DV-1 OU Waste Sites in the B Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth During Operations[a] (ft bgs)	Influent Pipeline Depth During Operations[d] (ft bgs)	Reason Taken Out of Service[e]	As-Built Drawing Number[b]	Replaced By[d]	Stabilization Date[e]	Stabilization Thickness[e] (ft)
216-B-5	216-B-5 Reverse Well 241-B-361 Reverse Well 241-B-361 Drywell 241-B-5 Drywell 299-E28-29 (C3542)	04/1945 to 09/1947	224-B Building waste and Tank 5-6 waste from 221-B Building supernate overflow from the 241-B-361 Settling Tank	0.67 (HW-17088)	0.67 (HW-17088)	252 – 302 (HW-17088)	12 (RHO-ST-37. p. 3)	Discovery of alpha in groundwater (299-E33-18) 09/19/1947 (HW-17088, p. 31)	H-2-21031 H-2-1123	216-B-7A&B (Building 224 waste and Tank 5-6 waste in 1947) 216-B-9 (Tank 5-6 waste in 1948)	1994	1.5 to 2
216-B-7A&B	216-B-7A&B Cribs 241-B-201 Crib 216-B-7 Crib 216-B-7A Sump 216-B-7B Sump 201-B Tank Crib 224-B Waste Crib 241-B-1&2 Cribs	09/1946 to 05/1967	Overflow from Tanks B-201 to B-204 of second 2C waste, Cell 5/6 drainage, 221-B, 224-B From 1961 to 1967, received decontamination waste from 221-B	12 (crib), 14 (excavation) (H-2-558)	12 (crib), 14 (excavation) (H-2-558)	14 (PNNL-19277)	14 (200-DV-1-DQO)	Effluent flow rate exceeded the infiltration capacity, terminated the reactivation decontamination and cleanup of 221-B Building	H-2-558 H-2-579	216-B-8	1992	1.5 to 2
216-B-8	216-B-8 Crib 241-B-3 Crib 216-B-8TF	04/1945 to 12/1951	2C waste from 221-B Building via blind riser in B Tank Farm, accessible via an over ground line; waste was discharged one month per year, 2C waste from 221-B Building via 110-111-112 Tank cascade, Tank 5-6 waste from 221-B Building via 110-111-112 tank cascade, decontamination waste from 224-B Building	12	12 (PNNL-19277)	14 (PNNL-19277)	16 (200-DV-1-DQO)	Shutdown of B Plant	H-2-579 H-2-738 H-2-2928	216-B-11A&B (WIDS)	1992	1.5
216-B-9	216-B-9 Crib 241-B-361 Crib 5-6 Crib and Tile Field 216-B-361 Crib 216-B-9TF	08/1948 to 07/1951	Tank 5-6 waste from the 221-B Building	180	84 (PNNL-19277)	17 (200-DV-1-DQO)	10 (200-DV-1-DQO)	Reached the radionuclide capacity	H-2-1031 H-2-1123	Tank 5-6 waste was combined with the 2C waste being discharged to 216-B-8 Crib (1951)	1991	2
216-B-11A&B	242-B-1 Crib 216-B-11 Crib 242-B-2 Crib 216-B-11 Crib	12/1951 to 12/1954	Condensate from evaporation of 1C waste in the 242-B Waste Evaporator	4 (diameter)	4 (diameter) (PNNL-19277)	40 (PNNL-19277)	Tops of the culverts were 10 ft bgs (200-DV-1 DQO)	Shutdown of the evaporator	H-2-2021 H-2-2024	Not replaced	1992	1.5 to 2

Table 2-2. Summary Information for 200-DV-1 OU Waste Sites in the B Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth During Operations[a] (ft bgs)	Influent Pipeline Depth During Operations[d] (ft bgs)	Reason Taken Out of Service[e]	As-Built Drawing Number[b]	Replaced By[d]	Stabilization Date[e]	Stabilization Thickness[e] (ft)
216-B-35	216-B-35 Trench 241-BX-1 Grave 216-BX-1 Trench	02/1954 to 03/1954	1C supernate from 221-B Building via 241-BX-110 Tank	252	10 (PNNL-19277)	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-36	216-B-36 Trench 241-BX-2 Grave 216-BX-2 Trench	03/1954 to 04/1954	1C supernate from 221-B Building via 241-BX-111 Tank	252	10 (PNNL-19277)	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-37	216-B-37 Trench 241-BX-3 Grave 216-BX-3 Trench	08/1954 to 08/1954	1C evaporator bottoms from 242-B Building via 241-B-107-108-109 Tanks	252	10	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-38	216-B-38 Trench 241-BX-4 Grave 216-BX-4 Trench	07/1954 to 08/1954	1C supernate from 221-B Building via 241-BY-110 Tank	252	10	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-39	216-B-39 Trench 241-BX-5 Grave 216-BX-5 Trench	12/1953 to 11/1954	1C supernate from 221-B Building via 241-BX-112 Tank (12/1953) and 241-BY-106 Tank (10/1954)	252	10	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-40	216-B-40 Trench 241-BX-6 Grave 216-BX-6 Trench	04/1954 to 07/1954	1C supernate from 221-B Building via 241-BY-110 Tank (08/1954) and 241-BY-106 Tank (11/1954)	252	10	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-41	216-B-41 Trench 241-BX-7 Grave 216-BX-7 Trench	11/1954 to 11/1954	1C supernate from 221-B Building via 241-BY-106 Tank	252	10	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-42	216-B-42 Trench 241-BX-8 Grave 216-BX-8 Trench	01/1955 to 02/1955	Scavenged TBP waste from 221-U Building, batch 4	252	10	10	Waste received via over ground pipelines	Reached the specific retention capacity	H-2-2431 SK-2-2408	Not replaced	1982	2
216-B-43	216-B-43 Crib 216-BY-1 Crib 216-BY-1 Cavern	11/1954 to 11/1954	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2

Table 2-2. Summary Information for 200-DV-1 OU Waste Sites in the B Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth During Operations[a] (ft bgs)	Influent Pipeline Depth During Operations[d] (ft bgs)	Reason Taken Out of Service[e]	As-Built Drawing Number[b]	Replaced By[d]	Stabilization Date[e]	Stabilization Thickness[e] (ft)
216-B-44	216-B-44 Crib 216-BY-2 Crib 216-BY-2 Cavern	11/1954 to 03/1955	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2
216-B-45	216-B-45 Crib 216-BY-3 Crib 216-BY-3 Cavern	04/1955 to 06/1955	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2
216-B-46	216-B-46 Crib 216-BY-4 Crib 216-BY-4 Cavern	09/1955 to 12/1955	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2
216-B-47	216-B-47Crib 216-BY-5 Crib 216-BY-5 Cavern	09/1955 to 09/1955	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2
216-B-48	216-B-48 Crib 216-BY-6 Crib 216-BY-6 Cavern	11/1955 to 07/1957	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2

Table 2-2. Summary Information for 200-DV-1 OU Waste Sites in the B Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth During Operations[a] (ft bgs)	Influent Pipeline Depth During Operations[d] (ft bgs)	Reason Taken Out of Service[e]	As-Built Drawing Number[b]	Replaced By[d]	Stabilization Date[e]	Stabilization Thickness[e] (ft)
216-B-49	216-B-49 Crib 216-BY-7 Crib 216-BY-7 Cavern	11/1955 to 12/157	Received the scavenged TBP supernate waste from 221-U Building	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity; cobalt-60 and cesium-137 breakthrough to groundwater in 1956 (WIDS, 08/23/2010)	H-2-2603 H-2-2605	Not replaced	1991	2
216-B-50	216-BY-8 Cavern 216-BY-8 Crib	01/1965 to 01/1974	Received the waste storage tank condensate from the ITS 1 unit in the BY Tank Farm (RHO-CD-673, Vol. I)	30 (excavation bottom)	30 (excavation bottom)	14	7	Reached the specific retention capacity	H-2-2603 H-2-2605	Not replaced	1991	2
216-B-57	216-B-57 Crib	12/1968 to 06/1973	Received the waste storage tank condensate from the ITS 2 unit in the BY Tank Farm (RHO-CD-673, Vol. I)	200 (ARH-1562)	15 (ARH-1562)	10	7	End of ITS 2 disposal operations	H-2-62406	Not replaced	1991	2

Source: HW-17088, *The Underground Disposal of Liquid Wastes at the Hanford Works, Washington*.

a. Information obtained from RHO-CD-673, *Handbook 200 Areas Waste Sites* (Vol. I), unless otherwise noted.

b. Information obtained from ARH-1562, *200 East and North Areas Radioactive Liquid Waste Disposal Sites*, unless otherwise noted.

c. Information obtained from PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*, unless otherwise noted.

d. Information obtained from the WIDS database, unless otherwise noted.

e. Information obtained from 200-DV-1 OU DQO information tables (Appendix C), unless otherwise noted.

1C = first-cycle waste
2C = second-cycle waste
bgs = below ground surface
DQO = data quality objective
ITS = in-tank solidification
TBP = tributyl phosphate
WIDS = Waste Information Data System

2.1.4 Perched Water

Perched water is present in the DVZ at the B Complex area, north of B Tank Farm and east of the BX-BY Tank Farms (Figure 2-10). The perched zone, which is part of the 200-DV-1 OU, is in the vadose zone above the regional, unconfined aquifer. The unconfined aquifer is in the 200-BP-5 OU. Ongoing extraction to remove the contaminated water before it reaches the unconfined aquifer is summarized in Section 3.2.3.

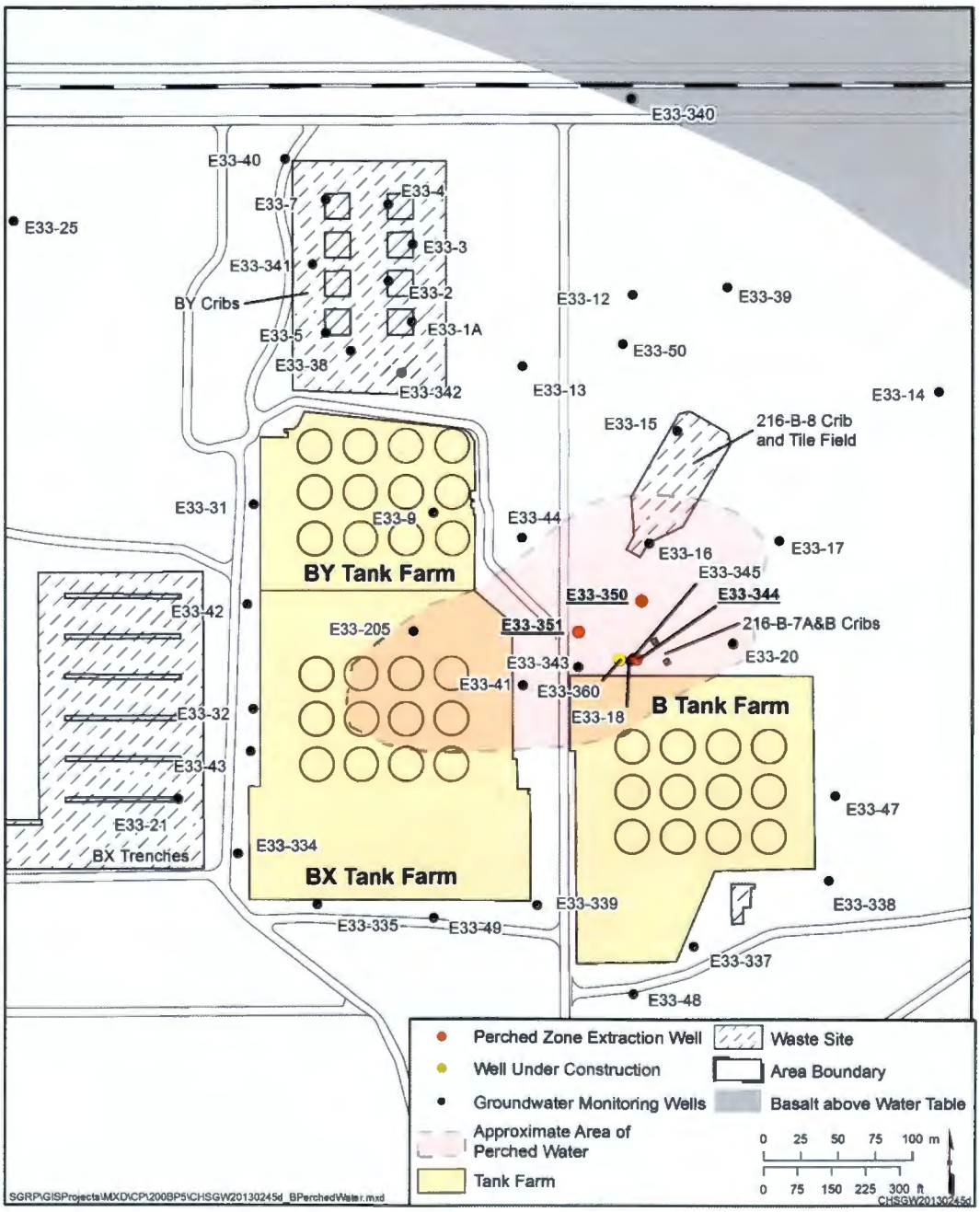


Figure 2-10. Location of Perched Water Zone in the B Complex Area

2.2 T Complex Area

In the T Complex area, most of the 200-DV-1 OU waste sites are located near WMA T-TX-TY.

2.2.1 History of Operations

This section summarizes the historical site operations, activities, processes, waste streams, and contaminant sources in the T Complex area. The T Complex area includes 17 waste sites in the 200-DV-1 OU and three SST farms (Figures 2-11 and 2-12). Other waste sites and facilities in the vicinity are included as needed for completeness. The T Tank Farm consists of twelve 2,006,268 L (530,000 gal), 100-series SSTs (241-T-101 through 241-T-112) and four 208,198 L (55,000 gal), 200-series SSTs (241-T-201 through 241-T-204) (Figure 2-12). The TX Tank Farm consists of eighteen 2,869,342 L (758,000 gal), 100-series SSTs (241-TX-101 through 241-TX-118) (Figure 2-13). The TY Tank Farm consists of six 2,869,342 L (758,000 gal), 100-series SSTs (241-TY-101 through 241-TY-106) (Figure 2-13).

The following history of operations for the T Complex area was taken from RPP-5957, *Historical Vadose Zone Contamination from T, TX, and TY Tank Farm Operations* (p. 3-14). A timeline for T Complex activities is presented in Figure 2-14.

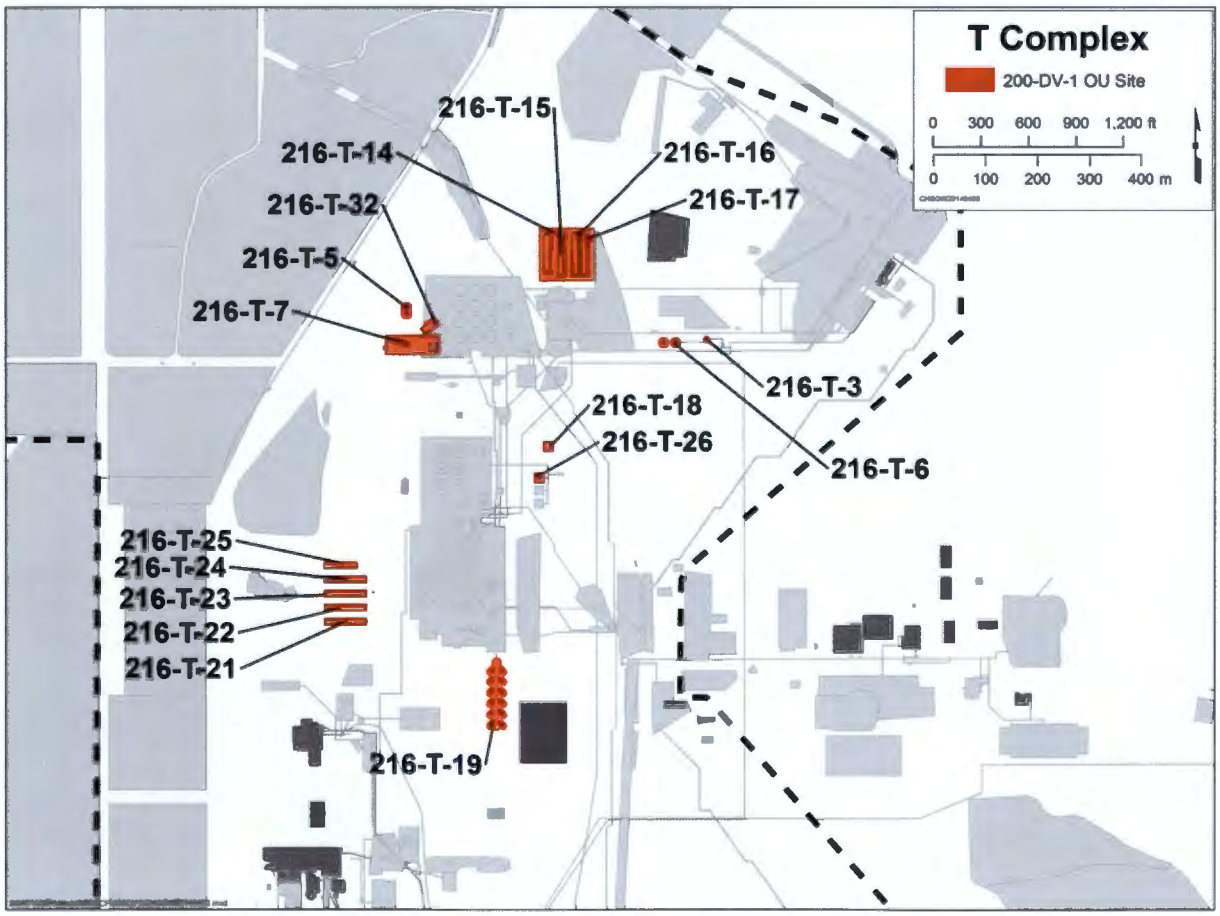
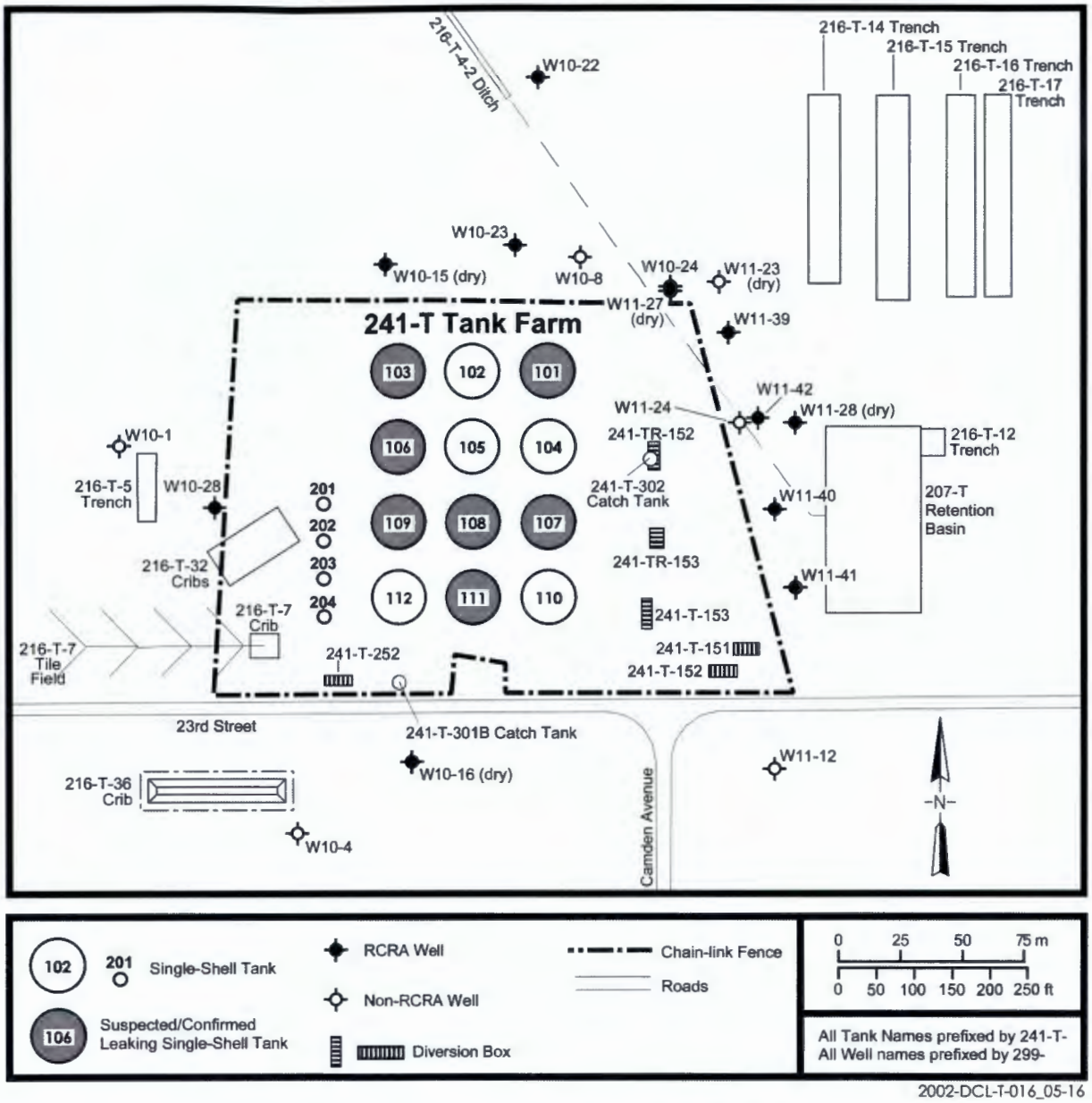
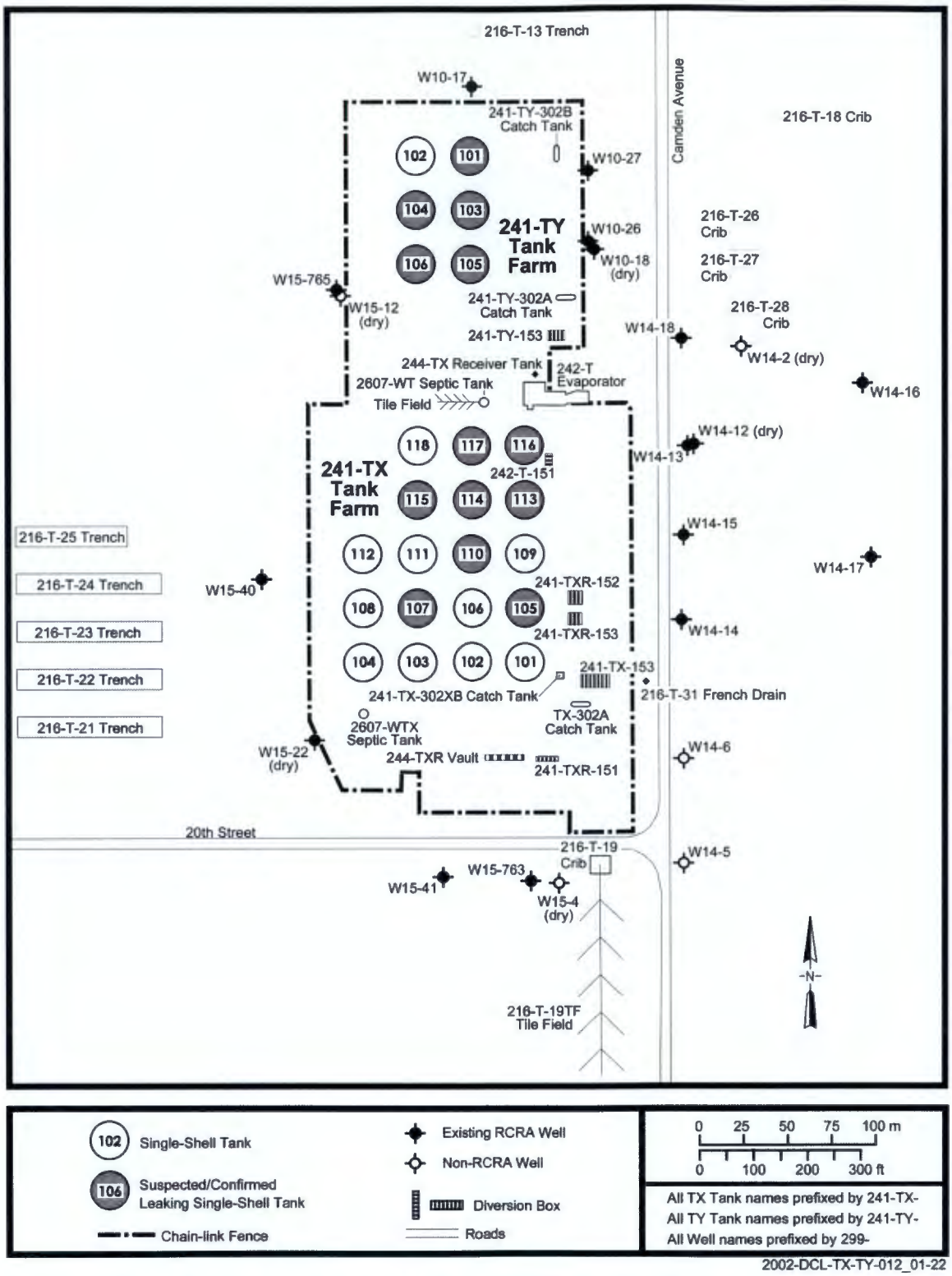


Figure 2-11. Location of 200-DV-1 OU Waste Sites in the T Complex Area



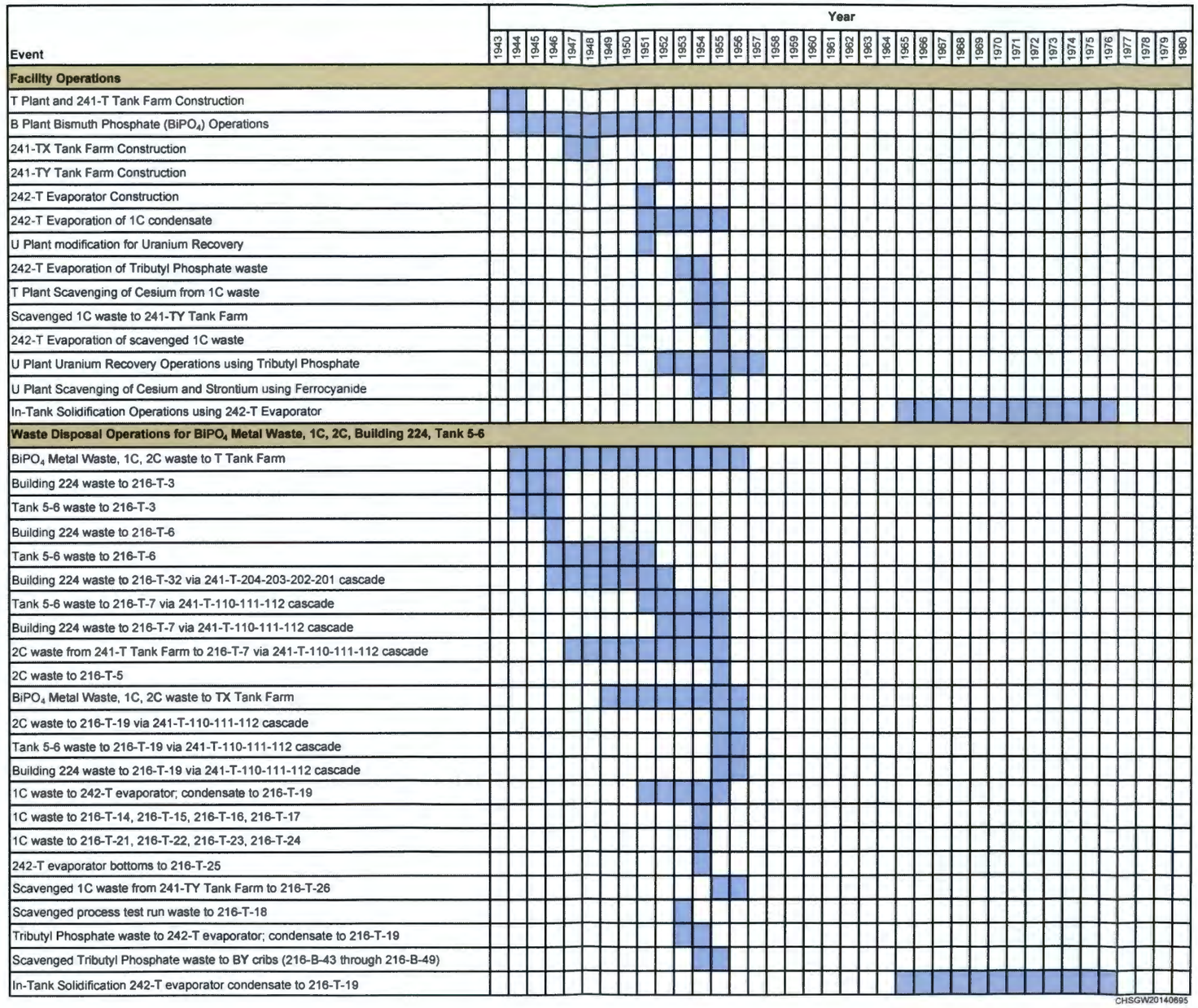
Source: Figure 3-9 in DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*.

Figure 2-12. Configuration of T Tank Farm in the T Complex Area



Source: Figure 3-10 in DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*.

Figure 2-13. Configuration of TX and TY Tank Farms in the T Complex Area



Note: This figure is based on Appendix C of RPP-5957, *Historical Vadose Zone Contamination from T, TX, and TY Tank Farm Operations*.

Figure 2-14. Historical Timeline for T Complex Area Activities

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The T-TX-TY Tank Farm operations that resulted in waste disposal to the 200-DV-1 OU waste sites can be separated into four historical eras:

1. The T Tank Farm was constructed in 1943 and 1944 to provide storage for radioactive liquid waste produced at T Plant. T Plant used the bismuth phosphate process to separate plutonium from irradiated fuel slugs. The bismuth phosphate process at T Plant produced the same five waste streams that were produced at B Plant (Section 2.1.1):

   - Bismuth phosphate metal waste was stored in the T Tank Farm tanks.
   - 1C was stored in the T Tank Farm tanks (RPP-5957 notes that 1C waste also contained coating-removal waste; however, this was not mentioned in HNF-5231).
   - 2C was stored in the tanks in T Tank Farm.
   - "Building 224 waste" was low-level liquid waste from the 224-T Plutonium Concentrator Building. This waste stream was the primary contributor of plutonium contamination to the soil. This waste was discharged to the 241-T-361 Settling Tank, and the supernate overflowed to the 216-T-3 Reverse Well (Figure 2-11).
   - "Tank 5-6 waste" was low-level liquid waste from floor drains in individual process cells in T Plant. This waste was discharged to the 216-T-4 Pond (not a 200-DV-1 OU waste site) during the T Plant startup testing "cold run" but was routed to Tank 5-6 in T Plant when processing of irradiated fuel began in December 1944. Waste stored in Tank 5-6 was discharged to the 241-T-361 Settling Tank, and the supernate overflowed to the 216-T-3 Reverse Well.

2. From 1946 until 1956 (when T Plant was shut down), the tank farms were expanded and received liquid waste from the bismuth phosphate operations. Liquid waste disposal to the soil column through cribs near the T Tank Farm was initiated.

   - To increase waste tank storage space, activities were initiated to dispose the relatively low-level 2C waste to the ground, concentrate the intermediate-level 1C waste in an evaporator, recover the unfissioned uranium in the bismuth phosphate metal waste, and build additional waste tanks. The TX Tank Farm was constructed in 1947, and the TY Tank Farm was constructed in 1952 (Figure 2-12). Facilities for the uranium recovery operations also were built during this time.
   - In August 1946, the Building 224 waste and Tank 5-6 waste continued to be discharged to the 241-T-361 Settling Tank, but the supernate was re-routed from the 216-T-3 Reverse Well to the 216-T-6 Cribs (Figures 2-11 and 2-12). However, the 241-T-361 Settling Tank had filled with sludge and could no longer be used. Consequently, in October 1946, the Tank 5-6 waste line was modified to bypass the 241-T-361 Settling Tank and discharge Tank 5-6 waste directly to the 216-T-6 Cribs without settling. The waste line at the 224 Building was re-routed to the 200-series tanks in the T Tank Farm for settling, and the supernate overflowed to the 216-T-32 Cribs.
   - As occurred at the B Tank Farm (Section 2.1.1), the continuing shortage of tank space resulted in discharge of the 2C supernate waste, after cascading and settling, to the ground through the 216-T-7 Crib and Tile Field from 1947 to 1955 (Figures 2-11 and 2-12). In 1951, the Tank 5-6 waste was combined with the 2C waste being discharged to the 241-T-110-111-112 cascade for settling and supernate overflow to the 216-T-7 Crib. In 1952, the Building 224 waste also was diverted to this cascade when the 200-series tanks filled with sludge. After December 1955, these waste streams were re-routed to the 216-T-19 Crib until T Plant was shut down in 1956.

- One processing run in early 1955 resulted in an unusually high level of activity in 2C waste. Even after cascading and settling, the activity was still too high for discharge to the 216-T-7 Crib. Approximately one-half of this batch was sent to the 216-T-5 Specific Retention Trench in May; the remainder stayed in the 241-T-112 Tank.

- The 242-T Evaporator was built in 1951 to reduce the volume of 1C waste (Figure 2-12). The evaporator received 1C waste from Tank 241-TX-118. The evaporator condensate was sent to the 216-T-19 Crib and Tile Field (Figures 2-11 and 2-12). The remaining evaporator "bottoms" were sent to Tanks 241-TX-113, 241-TX-116, and 241-TX-117 for accumulation as feed for a second pass through the 242-T Evaporator.

- Evaporation of 1C waste was discontinued in June 1953 because the 242-T Evaporator was needed for waste from uranium recovery and fission product scavenging. From January to June 1954, 1C waste supernate that had not been evaporated was discharged to T Trenches 216-T-14, 216-T-15, 216-T-16, and 216-T-17 via an over ground line from the 241-T-106 Tank (Figures 2-11 and 2-12). From June to August 1954, 1C waste supernate that had not been evaporated was discharged to the TX Trenches 216-T-21, 216-T-22, 216-T-23, and 216-T-24 via an over ground line from the 241-TX-110 Tank (Figures 2-11 and 2-12). The evaporator bottoms were discharged to the 216-T-25 Trench in September 1954.

- Evaporation of the uranium recovery waste was discontinued in September 1954 following the development of the ferrocyanide scavenging process. Beginning in October 1954, the ferrocyanide scavenging process was used to remove cesium-137 from the 1C waste to meet crib discharge criteria. As part of the scavenging process, the 242-T Evaporator began evaporating stored 1C waste that had not been discharged to trenches in December 1954 and began evaporating newly generated scavenged 1C waste in March 1955. The evaporator condensate was sent to the 216-T-19 Crib and Tile Field. After 1C waste evaporation was completed in July 1955, scavenged 1C waste was stored in the TY Tank Farm for settling, and the supernate was discharged to the 216-T-26 Crib.

3. From 1952 to1958, high-level waste from the tank farms was sent to U Plant for uranium recovery and fission product scavenging. Scavenged waste was discharged to cribs.

- U Plant was modified in 1951 for uranium recovery operations using the TBP solvent extraction process. Beginning in 1952, the bismuth phosphate metal waste was removed from the T-TX Tank Farms and processed in U Plant to extract uranium. Until T Plant was shut down in 1956, newly generated bismuth phosphate metal waste also was sent to U Plant for uranium recovery. The resulting TBP waste (uranium recovery waste) was returned to the T-TX Tank Farms.

- To reduce the volume of waste stored in tanks, TBP waste from the T Tank Farm was concentrated in the 242-T Evaporator beginning in July 1953. The evaporator condensate was sent to the 216-T-19 Crib. Beginning in September 1954, the TBP waste was scavenged in U Plant to remove cesium-137 and strontium-90 rather than being evaporated. Scavenged waste was sent to the BY Tank Farm for settling, and the supernate was discharged to the BY Cribs and BC Cribs from 1954 to 1957 (Section 2.1.1).

- Waste from a scavenging process test run in late 1953 was pumped from U Plant to the 241-T-101 Tank to settle. Due to poor pH control during the test, only one-half of the waste could be discharged to the ground. This waste was discharged in the 216-T-18 Crib in December 1953.

4. From 1965 to 1974, ITS processes were operated to reduce tank volumes. The ITS condensate was discharged to cribs.

    - The ITS process was used to remove liquid waste supernate from SSTs. The 242-T Evaporator was modified for continuous operation and was restarted in December 1965 as the ITS system. Evaporator condensate was discharged directly to the 216-T-19 Tile Field, bypassing the 216-T-19 Crib.

2.2.2 Description of Tank Farms and Facilities

The T-TX-TY Tank Farms consist of the following (based on RPP-23752, *Field Investigation Report for Waste Management Areas T and TX-TY*, Section 1.2):

- **T Tank Farm:** Twelve 2,025,195 L (535,000 gal), 100-series single-shell underground waste storage tanks (241-T-101 through 241-T-112) and four 208,198 L (55,000 gal), 200-series tanks (241-T-201 through 241-T-204) (Figure 2-12).
- **TX Tank Farm:** Eighteen 2,869,342 L (758,000 gal), 100-series SSTs (241-TX-101 through 241-TX-118) (Figure 2-13).
- **TY Tank Farm:** Six 2,869,342 L (758,000 gal), 100-series SSTs (241-TY-101 through 241-TY-106) (Figure 2-13).

The 100-series tanks were constructed with cascade overflow lines in a two-, three-, or four-tank series (four sets of three tanks in the T Tank Farm, three sets of four tanks, and two sets of three tanks in the TX Tank Farm; three sets of two tanks in the TY Tank Farm) that allowed gravity flow of liquid waste between the tanks (RPP-23752, p. 1-5). In the T-TX-TY Tank Farms, the tanks cascaded from east to west (e.g., 241-T-110 to 241-T-111 to 241-T-112 [Figure 2-12]) (RPP-7123, *Surface Conditions Description of the T-TX-TY Waste Management Area*, Section 2.1.1).

From the beginning of Hanford Site tank farm operations, the primary leak detection system was routine monitoring of liquid surface levels within each tank (RPP-RPT-42296, *Hanford TY-Farm Leak Assessments Report*, Sections 2.1 and 2.2). Routine monitoring of gross-gamma activity in drywells near the SSTs provided a second leak detection method. The drywells for the T-TX-TY Tank Farms are provided in RPP-7123.

The status of the integrity of each tank in the T-TX-TY Tank Farms is provided in HNF-EP-0182, *Waste Tank Summary Report for Month Ending July 30, 2011*. (Note: HNF-EP-0182 is updated monthly with a new revision number.) Past leaks in the TY Tank Farm were reassessed in 2010 and documented in a leak assessment report (RPP-RPT-42296). The leak assessment report provides detailed construction information and operating history for each tank in the TY Tank Farm. Table 2-3 indicates the leak status of each tank in the T Complex and provides the reference for the detailed information summary.

Each tank farm also includes waste transfer lines, leak detection systems, and tank ancillary equipment. The configuration of these infrastructure elements changed over time. The historical infrastructure for the T-TX-TY Tank Farms is provided in RPP-5957.

Table 2-3. Status of T-TX-TY Tank Farm SSTs

Reference	Assumed to Have Leaked	Classified as Sound
HNF-EP-0182, *Waste Tank Summary Report for Month Ending July 31, 2011*, Rev. 280	**T Tank Farm SSTs**	
	241-T-101	241-T-102
	241-T-103	241-T-104
	241-T-106	241-T-105
	241-T-107	241-T-110
	241-T-108	241-T-112
	241-T-109	—
	241-T-111	—
	—	241-T-201
	—	241-T-202
	—	241-T-203
	—	241-T-204
HNF-EP-0182, *Waste Tank Summary Report For Month Ending July 31, 2011*, Rev. 280	**TX Tank Farm SSTs**	
	241-TX-105	241-TX-101
	241-TX-107	241-TX-102
	241-TX-110	241-TX-103
	241-TX-113	241-TX-104
	241-TX-114	241-TX-106
	241-TX-115	241-TX-108
	241-TX-116	241-TX-109
	241-TX-117	241-TX-111
	—	241-TX-112
	—	241-TX-118
RPP-RPT-42296, *Hanford TY-Farm Leak Assessments Report*, Rev. 0	**TY Tank Farm SSTs**	
	241-TY-103	241-TY-101
	241-TY-104	241-TY-102
	241-TY-105	—
	241-TY-106	—

SST = single-shell tank

2.2.3 Waste Site Descriptions

The 200-DV-1 OU waste sites in the T Complex area were used from 1944 through 1976 for disposal of waste associated with plutonium-separation operations at T Plant, uranium recovery and fission product scavenging at U Plant, and ITS operations at the T-TX-TY Tank Farms. The timeline for use of waste sites for waste disposal is shown in Figure 2-14.

The types of waste sites in the 200-DV-1 OU were all designed to percolate wastewater into the ground without exposing the wastewater to the atmosphere. Because the configurations of the 200-DV-1 OU waste sites in the T Complex area are similar to those in the B Complex area (Section 2.1.3), the same figures are used to depict waste sites in both areas. The 200-DV-1 OU waste sites in the T Complex area include the following:

- **Reverse wells (one):** Also known as injection wells, reverse wells were used for the disposal of intermediate-level liquid waste in the early phases of Hanford Site operations. Reverse Well 216-T-3 in the T Complex area of the 200-DV-1 OU consists of a drilled and cased borehole. The lower 29 m (95.5 ft) of casing (from 32 to 62 m [104.5 to 204 ft] bgs) was perforated to allow liquid to seep into the vadose zone at depths greater than the cribs and French drains (Figure 2-4). The 216-T-3 perforated casing extended to approximately 25 m (81 ft) above the 1944 water table (HW-9671, *Underground Waste Disposal at Hanford Works: An Interim Report Covering the 200 West Area*, p. 16; adjusted for length of perforated interval).

- **Cribs (six):** Cribs in the 200-DV-1 OU were relatively shallow excavations (typically less than 10 m [30 ft] deep) that were held open by wood cribbing (216-T-6, 216-T-7, 216-T-19, and 216-T-32) or concrete culverts (216-T-18 and 216-T-26) (Figures 2-5 and 2-6). (Note: The construction of the 216-T-18 Crib is uncertain.) The cribs were designed to receive liquid via a pipeline from the waste generating facility on a more or less continuous basis until the unit's specific retention or radionuclide capacity was met. Two of the cribs (216-T-7 and 216-T-19) included tile fields used for waste liquid overflow from the associated cribs.

- **Trenches (ten):** Trenches in the 200-DV-1 OU were relatively shallow excavations (typically less than 10 m [30 ft] deep) that were used to dispose of contaminated liquid waste by direct discharge via a temporary, overland pipeline (216-T-5, 216-T-14 through 216-T-17, and 216-T-21 through 216-T-25) (Figure 2-7). The trenches were typically used on a specific retention basis, with a fixed volume of liquid identified for discharge prior to use.

Additional details on the construction and configuration of the waste sites in the 200-DV-1 OU are provided in Table 2-4 and in the tables prepared to support the DQO process (Appendix C).

2.3 S Complex Area

In the S Complex area, three 200-DV-1 OU waste sites are located near WMA S-SX.

2.3.1 History of Operations

This section summarizes the historical site operations, activities, processes, waste streams, and contaminant sources in the S Complex area. The S Complex area includes three waste sites in the 200-DV-1 OU and two SST farms (Figures 2-15 and 2-16). Other waste sites and facilities in the vicinity also are included as needed in the discussion for completeness.

The following history of operations for the S Complex area was taken from WHC-SD-WM-ER-560, *Historical Vadose Zone Contamination from S and SX Tank Farms* (p. 4-7), and HNF-4936, *Subsurface*

Physical Conditions Description for the S-SX Waste Management Area (Section 2.1). A timeline for S Complex activities is presented in Figure 2-17. The history and timeline are focused on operations that resulted in waste disposal to the 200-DV-1 OU waste sites.

The Reduction-Oxidation (REDOX) Plant (S Plant) and the S Tank Farm were constructed during 1950 and 1951. The REDOX Plant began startup testing in August 1951. Full production operations began in January 1952 and continued until July 1967. The REDOX process was the second chemical separation process used at the Hanford Site and represented a major increase in efficiency over the previous bismuth phosphate process used at B and T Plants. Methyl isobutyl ketone (hexone) was used to separate plutonium and uranium from the dissolved fuel rod solutions (DOE/RL-98-28, p. H-5). The REDOX process was the first process used at the Hanford Site to recover both plutonium and uranium.

The initial, slightly acidic waste stream contained fission products and large quantities of aluminum nitrate used to promote the extraction of plutonium and uranium. The waste was then neutralized and stored in the SSTs in S-SX Tank Farms.

The REDOX low-level waste (Tank D-1 cell drainage and Tank D-2 redistilled process condensate) was discharged to the 216-S-1 Crib (with overflow to the 216-S-2 Crib) beginning in January 1952. Liquid waste from the 203-S Decontaminated Metal Storage Facility, the 204-S Uranyl Nitrate Hexahydrate (UNH) Lag Storage Facility, and the 276-S Hexone Storage Facility was discharged to the 216-S-13 Crib beginning in January 1952.

In the summer of 1952, some tanks began to boil because of the radioactive decay heat load in the REDOX high-level waste. The S Tank Farm tanks were not designed for self-boiling waste. The SX Tank Farm was constructed during 1953 and 1954. The tanks were specifically designed to accommodate self-boiling waste and to incorporate underground duct headers connected to a common condenser/ventilation system, with condensate routed to the 216-S-21 Crib. The 216-S-21 Crib began receiving condensate from the 241-SX-401 Condenser in November 1954.

In 1956, the REDOX low-level waste was re-routed from the 216-S-1 and 216-S-2 Cribs to the 216-S-7 Crib. The 216-S-7 Crib reached its radionuclide limit and was retired in July 1965. The Tank D-2 condensate waste stream was re-routed to the 216-S-9 Crib.

The REDOX Plant was shut down in 1967. In June 1967, the 216-S-13 Crib stopped receiving waste from the 203-S, 204-S, and 276-S Solvent Storage Facilities and began receiving occasional sump waste from the 204-S UNH Storage Facility.

In January 1969, the 216-S-9 Crib reached its radionuclide limit, and the Tank D-2 condensate waste stream was re-routed to the 216-S-23 Crib. After REDOX separation process operations ceased in 1967, the waste concentrator was used to concentrate decontamination waste from 221-T, N Reactor, 222-S Laboratory, and the 340 Facility. The aqueous waste was discharged to the 216-S-9 and 216-S-23 Cribs after 1967 (DOE/RL-98-28, pp. H-5, H-29/30).

The 216-S-21 Crib was closed in December 1970. The 216-S-13 and 216-S-23 Cribs were removed from service in July 1972.

Table 2-4. Summary Information for 200-DV-1 OU Waste Sites in the T Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth during Operations[c] (ft bgs)	Influent Pipeline Depth during Operations[c] (ft bgs)	Reason Taken Out of Service[d]	As-Built Drawing Number[a]	Replaced By[e]	Stabilization Date[b]	Stabilization Thickness[b] (ft)
216-T-3	241-T-361-A Reverse Well 361-T Reverse Well	06/1945 to 08/1946	Cell drainage from Tank 5-6 in 221-T and waste from 224-T via 241-T-361 Tank	8 in diameter (RHO-CD-673, Vol. II)	8 in diameter (RHO-CD-673, Vol. II)	206	12	Effluent flow rate exceeded the infiltration capacity of the reverse well	H-2-353 H-2-951	Effluent was re-routed to 216-T-6 Crib. Some 224-T waste was directed to 241-T-252 Diversion Box.	1993	N/A (Sinkholes were filled and the ground surface decontaminated and leveled)
216-T-5	216-T-5 Grave 216-T-12 216-T-5 Trench 241-T-5 Trench	05/1955 to 05/1955	2C supernate from 221-T via 241-T-112	50	10	6	Aboveground pipeline	Reached prescribed liquid waste volume for the specific retention trench	H-2-2430 H-2-44510 #3	This trench was only used on a specific retention basis in May 1955 to free up tank space in T Tank Farm.	1992	2
216-T-6	241-T-361 (1&2 Cribs) 216-T-5 361-T-1&2 Cribs	08/1946 to 10/1947	Cell drainage from Tank 5-6 in 221-T and waste from 224-T via 241-T-361 Tank Cell drainage from Tank 5-6 in 221-T	14	14	4	Aboveground with one crib overflowing into the other (WIDS 08/25/2010)	To evaluate the radionuclide disposal characteristics of the crib	H-2-353 H-2-951	216-T-32	1993	N/A (Sinkholes were filled and the ground surface decontaminated and leveled)
216-T-7	216-T-7TF 216-T-7 Tile Field 241-T-3 Tile Field	04/1948 to 11/1955	2C supernate from 221-T via 241-T-105-106-111-112 2C supernate from 221-T via 241-T-112 2C supernate in 221-T, plus cell drainage from Tank 5-6 in 221-T via 241-T-112 2C supernate in 221-T, plus cell drainage from Tank 5-6 in 221-T plus 224-T waste via 241-T-112	12 (crib) 305 (tile field)	12 (crib) 84 (tile field)	26 (crib)	19	Reached the prescribed radionuclide disposal guide limit of the crib and tile field	H-2-578 HW-72182 #1	216-T-19	1992	N/A
216-T-14	241-T-1 Trench 216-T-1 Grave 216-T-13	01/1954 to 01/1954	1C supernate from 221-T via 241-T-104-105-106	220	10	10	5	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409 H-2-36849	242-B and 242-T Evaporators began to concentrate the 1C waste to reduce volume stored in tank farms. This was later discharged via over ground pipelines to specific trenches.	1984	2

Table 2-4. Summary Information for 200-DV-1 OU Waste Sites in the T Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth during Operations[c] (ft bgs)	Influent Pipeline Depth during Operations[c] (ft bgs)	Reason Taken Out of Service[d]	As-Built Drawing Number[a]	Replaced By[e]	Stabilization Date[b]	Stabilization Thickness[b] (ft)
216-T-15	216-T-15 241-T-2 Trench 241-T-2 Grave 216-T-14 216-T-15 Crib	01/1954 to 02/1954	1C supernate from 221-T via 241-T-104-105-106	240	10	10	5	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409 H-2-36849	242-B and 242-T Evaporators began to concentrate the 1C waste to reduce volume stored in tank farms. This was later discharged via over ground pipelines to specific trenches.	1984	2
216-T-16	241-T-3 Trench 241-T-3 Grave 216-T-15 216-T-16 Crib	02/1954 to 02/1954	1C supernate from 221-T via 241-T-104-105-106	240	10	10	5	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409 H-2-36849	242-B and 242-T evaporators began to concentrate the 1C waste to reduce volume stored in tank farms. This was later discharged via over ground pipelines to specific trenches.	1984	2
216-T-17	241-T-4 Trench 216-T-4 Grave 216-T-16	02/1954 to 06/1954	1C supernate from 221-T via 241-T-104-105-106	240	10	10	5	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409 H-2-36849	242-B and 242-T Evaporators began to concentrate the 1C waste to reduce volume stored in tank farms. This was later discharged via over ground pipelines to specific trenches.	1984	2
216-T-18	Test crib for 221-U Building Scavenged TBP waste 216-T-17 241-T-17 Crib	12/1953 to 12/1953	Supernate from the production test of TBP scavenging at U Plant via 241-T-101	10	10	10	Aboveground pipeline	Completed the discharge of waste to the pit	H-2-235 H-2-2733	Not replaced (WIDS).	1990	N/A (Following completion of waste discharge, aboveground piping was removed and crib was backfilled with soil to the ground surface. Surface stabilized in 1990 [0.02 ac area])
216-T-19	216-TX-1 241-TX-153 Crib and Tile Field 241-TX-3 216-T-19TF	09/1951 to 12/1965, 12/1965 to 1976	Process condensate from 242-T Evaporator Cell drainage from Tank 5-6 and 2C supernate from 221-T and waste from 224-T	14 (crib) 390 (tile field)	14 (crib) 85 (tile field)	30.6 (crib)	21.6 (Bechtel drawings)	Shut down the operation of the waste evaporator	H-2-806 H-2-3019	In 1965, the effluent was re-routed around the crib directly into the tile field (WIDS).	1991	N/A
216-T-21	241-TX-1 Trench 216-TX-1 Grave 216-TX-3	06/1954 to 08/1954	1C supernate from 221-T via 241-TX-109-110-111	240	10	10	5 (Bechtel drawings)	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409	N/A	1982	N/A

Table 2-4. Summary Information for 200-DV-1 OU Waste Sites in the T Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth during Operations[c] (ft bgs)	Influent Pipeline Depth during Operations[c] (ft bgs)	Reason Taken Out of Service[d]	As-Built Drawing Number[a]	Replaced By[e]	Stabilization Date[b]	Stabilization Thickness[b] (ft)
216-T-22	241-TX-2 Trench 216-TX-2 Grave 216-TX-4	07/1954 to 08/1954	1C supernate from 221-T via 241-TX-109-110-111	240	10	10	5 (Bechtel drawings)	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409	N/A	1982	N/A
216-T-23	241-TX-3 Trench 216-TX-3 Grave 216-TX-5 241-TX-3 Grave	07/1954 to 08/1954	1C supernate from 221-T via 241-TX-109-110-111	240	10	10	5 (Bechtel drawings)	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409	N/A	1982, 1993, 2000	N/A
216-T-24	241-TX-4 Trench 216-TX-4 Grave 216-TX-6	08/1954 to 08/1954	1C supernate from 221-T via 241-TX-109-110-111	240	10	10	5 (Bechtel drawings)	Reached the prescribed liquid waste volume for the specific retention trench	SK-2-2409	N/A	1982	N/A
216-T-25	241-TX-5 Trench 216-TX-5 Grave 216-TX-7	09/1954 to 09/1954	1C evaporator bottoms from 242-T via 241-TY-101-102	180	10	10	5 (Bechtel drawings)	Completed the discharge of the evaporator bottoms to the trench	H-2-44510 #3	N/A	1982	N/A
216-T-26	216-TY-1 Cavern 216-TY-1 Crib 241-TX-1 Cavern 216-TX-1 Crib	08/1955 to 12/1955	1C scavenged TBP supernate from 221-T via 241-TY-101-103-104	30	30	15	7 (Bechtel drawings)	Discontinued the discharge of the waste to the crib	H-2-2735 H-2-2733 H-2-2913	N/A	1990	In June and July 1975, 6 in. of soil was bladed from affected areas to remediate areas of surface contamination. Ground surface was covered with clean fill dirt back to original level, then surface stabilized.
216-T-32 (1946-1952)	241-T 1&2 Cribs 216-T-6	11/1946 to 05/1952	224-T waste via 241-T-201 Tank	66	14 (includes the 40 ft between the cribs)	26	22 (Bechtel drawings)	Buildup of sludge in 201/204-T tanks resulted in termination of liquid waste disposal to the crib	H-2-558 H-2-578 HW-72182 #1	216-T-7 (WIDS, 08/26/2010)	1992	N/A

Table 2-4. Summary Information for 200-DV-1 OU Waste Sites in the T Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth during Operations[c] (ft bgs)	Influent Pipeline Depth during Operations[c] (ft bgs)	Reason Taken Out of Service[d]	As-Built Drawing Number[a]	Replaced By[e]	Stabilization Date[b]	Stabilization Thickness[b] (ft)
200-W-52(b) (200-W-52 Crib and 216-T-7 Tile Field operated as one waste disposal system and were administratively separated in 1997)	216-T-7 Crib 241-T-3 Crib	04/1948 to 11/1955	2C supernate from 221-T via 241-T-105-106-111-112 2C supernate from 221-T via 241-T-112 2C supernate in 221-T and cell drainage from Tank 5-6 in 221-T via 241-T-112 2C supernate in 221-T and cell drainage from Tank 5-6 in 221-T and 224-T waste via 241-T-112	14	14	26	19.5	N/A	N/A	N/A	N/A	N/A

Source: HW-72182, *Building 241-T Plot Plan.*

a. Information obtained from RHO-CD-673, *Handbook 200 Area Waste Sites* (Vol. II).

b. Information obtained from 200-DV-1 OU DQO information tables (Appendix C), unless otherwise noted.

c. Information obtained from RPP-26744, *Hanford Soil Inventory Model, Rev. 1*, unless otherwise noted.

d. Information obtained from ARH-2155, *Radioactive Liquid Waste Disposal Facilities, 200 West Area.*

e. Information obtained from the WIDS database.

1C = first cycle
2C = second cycle
bgs = below ground surface
DQO = data quality objective
ITS = in-tank solidification
N/A = not applicable
TBP = tributyl phosphate
WIDS = Waste Information Data System

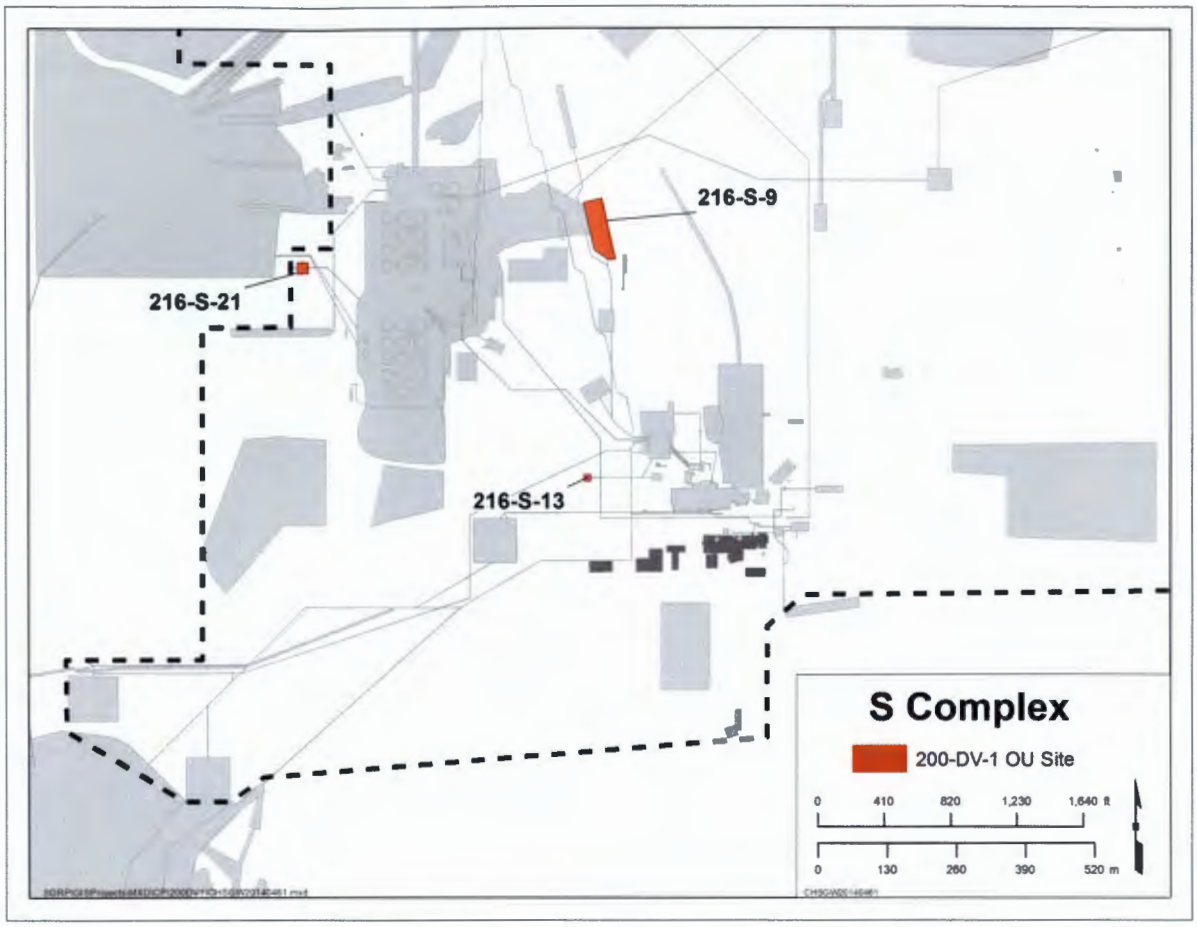


Figure 2-15. Location of 200-DV-1 OU Waste Sites in the S Complex Area

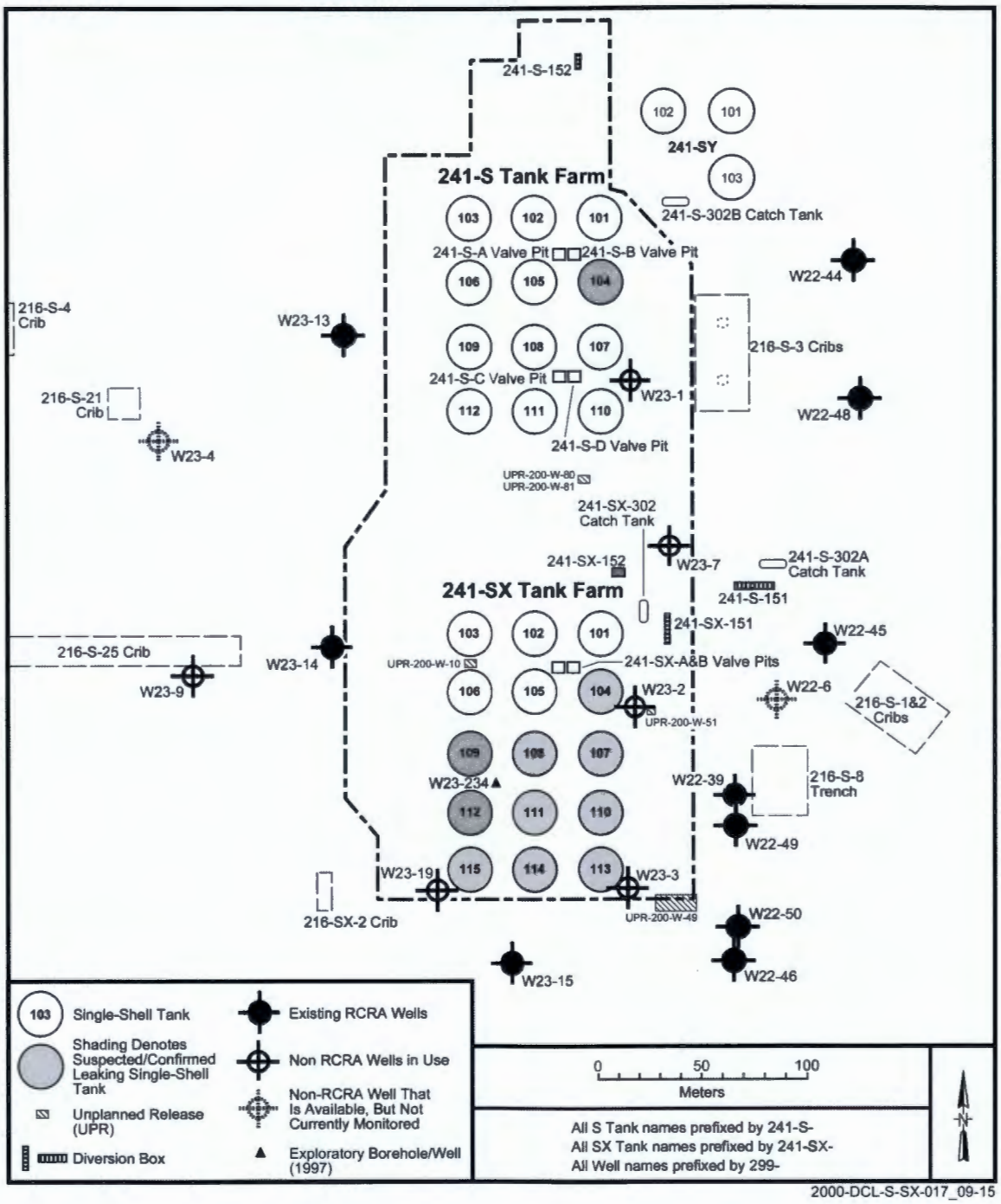
2.3.2 Description of Tank Farms and Facilities

The S-SX Tank Farms consist of the following:

- **S Tank Farm:** Twelve 2,869,342 L (758,000 gal), 100-series, single-shell underground waste storage tanks (241-S-101 through 241-S-112) (RPP-RPT-48589, Section 3.1) (Figure 2-16).
- **SX Tank Farm:** Fifteen 3,785,412 L (1,000,000 gal), 100-series SSTs (241-SX-101 through 241-SX-115) (RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*, Section 4) (Figure 2-16).

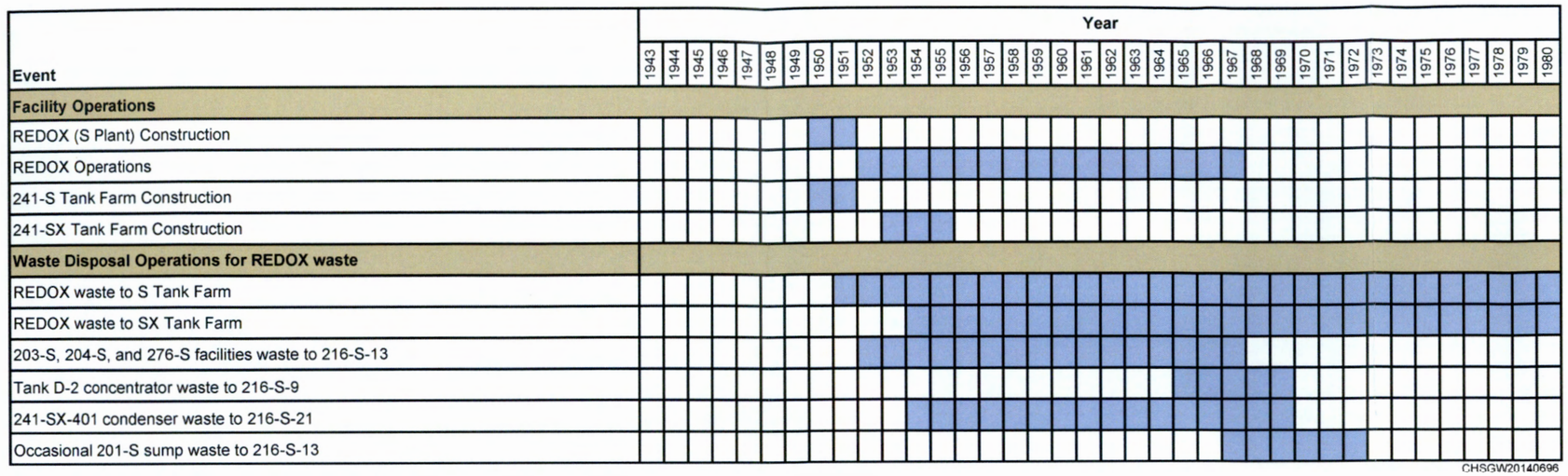
The 100-series tanks were constructed with 7.6 cm (3 in.) diameter cascade overflow lines in three-tank series that allowed gravity flow of liquid waste between the tanks. In the S-SX Tank Farms, the tanks cascaded from east to west (e.g., 241-S-101 to 241-S-102 to 241-S-103) (Figure 2-16). In the S Tank Farm, the 12 tanks are arranged in four three-tank series. In the SX Tank Farm, the 15 tanks are arranged in five three-tank cascade series. The 100-series tanks in the cascade series are arranged with each successive tank sited at a lower elevation (with the receiving tank 0.3 m [1 ft] lower than the feed tank), creating a gradient that allowed fluids to flow from one tank to another as the tanks were filled (WHC-SD-WM-ER-560, p. 4; RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*, Section 3.1; RPP-ENV-39658, Section 4).

From the beginning of Hanford Site tank farm operations, the primary leak detection system was routine monitoring of liquid surface levels within each tank (RPP-RPT-48589, Section 3.2; RPP-ENV-39658, Section 2.1). Routine monitoring of gross-gamma activity in drywells near the SSTs provided a second leak detection method. The drywells for the S Tank Farm and the SX Tank Farm are provided in RPP-RPT-48589 and RPP-ENV-39658, respectively.



Source: Figure 3-8 in DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*.

Figure 2-16. Configuration of S and SX Tank Farms in the S Complex Area



Note: This figure is based on WHC-SD-WM-ER-560, *Historical Vadose Zone Contamination from S and SX Tank Farms*.

Figure 2-17'. Historical Timeline for S Complex Area Activities

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Past leaks in the S-SX Tank Farms were reassessed in 2010 and documented in leak assessment reports. The reports provide detailed construction information and the operating history for each tank. Table 2-5 indicates the leak status of each tank and provides the reference for the detailed information summary.

Each tank farm also includes waste transfer lines, leak detection systems, and tank ancillary equipment. The configuration of these infrastructure elements changed over time. The historical infrastructure for the S-SX Tank Farms is provided in WHC-SD-WM-ER-560.

2.3.3 Waste Site Descriptions

The 200-DV-1 OU waste sites in the S Complex area were used from 1952 to 1972 for disposal of waste associated with REDOX plutonium and uranium separation operations at S Plant and tank vapor condensation processes at the SX Tank Farm. The timeline for use of waste sites for waste disposal is shown in Figure 2-17.

The types of waste sites in the 200-DV-1 OU were all designed to percolate wastewater into the ground without exposing the wastewater to the atmosphere. Because the configurations of the 200-DV-1 OU waste sites in the S Complex area are similar to those in the B Complex area (Section 2.1.3), the same figures are used to depict waste sites in both areas. The 200-DV-1 OU waste sites in the S Complex area include the following:

- **Cribs (three):** Cribs in the 200-DV-1 OU were relatively shallow excavations (typically less than 10 m [30 ft] deep) that were held open by wood cribbing (216-S-13 and 216-S-21) or gravel (216-S-9) (Figure 2-5). They were designed to receive liquid via a pipeline from the waste-generating facility on a more or less continuous basis until the unit's specific retention or radionuclide capacity was met.

Additional details on the construction and configuration of the waste sites in the 200-DV-1 OU are provided in Table 2-6 and in the tables prepared to support the DQO process (Appendix C).

2.4 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-DV-1 OU waste site. This understanding provides the foundation for identifying data needs and investigation approaches to address specific data gaps.

2.4.1 Physiography and Topography

The Hanford Site lies within the Pasco Basin (Figure 2-18). 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 200-DV-1 OU waste sites are located on the Cold Creek bar, a large compound flood bar formed during the Pleistocene Ice Age floods. The elevation (above mean sea level) of the upper surface of the bar ranges from approximately 210 m (700 ft) at B Plant to approximately 221 m (725 ft) along the eastern part of T Plant to approximately 197 m (647 ft) in the western part of U Plant and the REDOX Plant. No natural surface water drainage channels are located within these areas.

Table 2-5. Status of S and SX Tank Farm SSTs

Reference	Assumed to Have Leaked	Classified as Sound
RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*, Rev. 0	**S Tank Farm SSTs**	
	241-S-104	241-S-101
	—	241-S-102
	—	241-S-103
	—	241-S-105
	—	241-S-106
	—	241-S-107
	—	241-S-108
	—	241-S-109
	—	241-S-110
	—	241-S-111
	—	241-S-112
RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*, Rev. 0	**SX Tank Farm SSTs**	
	241-SX-107	241-SX-101
	241-SX-108	241-SX-102
	241-SX-109	241-SX-103
	241-SX-111	241-SX-104
	241-SX-112	241-SX-105
	241-SX-113	241-SX-106
	241-SX-114	241-SX-110
	241-SX-115	—

SST = single-shell tank

2.4.2 Climate and Meteorology

The Pacific Ocean moderates the temperatures throughout the Pacific Northwest. The Cascade Mountains (located approximately 113 km [70 mi] west of the site) generate a rain shadow that limits rain and snowfall in the eastern half of Washington State; the Hanford Site is located within the driest part of that rain shadow. The Cascade Mountains also serve as a source of cold air drainage, which has a considerable effect on the Hanford Site's wind regime. 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.

Table 2-6. Summary Information for 200-DV-1 OU Waste Sites in the S Complex Area

Site Code	Site Names/Aliases[a]	Dates of Operation[a]	Waste Stream[b]	Waste Site Bottom Length/Diameter[c] (ft)	Waste Site Bottom Width/Diameter[c] (ft)	Waste Site Depth During Operations[b] (ft bgs)	Influent Pipeline Depth during Operations[b] (ft bgs)	Reason Taken Out of Service[b]	As-Built Drawing Number[a]	Replaced By[d]	Stabilization Date[b]	Stabilization Thickness[b] (ft)
216-S-9	216-S-9 Crib	07/1965 to 01/1969	Process condensate (acidic) from the D-2 Receiver Tank in the 202-S Building Process, condensate from evaporation and concentration of decontamination waste in the 202-S Building	300	30	24.3	20.3	Reached the subscribed radionuclide disposal guide limit of the crib	H-2-32362 H-2-32363 SK-2-17792	Re-routed D-2 waste to 216-S-23	1995	1.5 – 2
216-S-13	276-S Crib 216-S-6	01/1952 to 06/1967	Liquid waste from the 203-S Decontaminated Metal Storage Facility, the 204-S UNH Lag Storage Facility, and the 276-S Organic Solvent Make-Up Facility Occasional sump waste from the 204-S Facility	40	40	33.5	21.2	Deactivated the 203-S and 276-S Organic-Solvent Make-Up Facility	H-2-5385 H-2-5391 H-2-5640	N/A	1991	N/A
216-S-21	216-SX-1 Cavern or Crib 216-SX-1	11/1954 to 1969)[c]	Condensate from the condensers in the 241-SX-401 Building via the 241-SX-106 Tank	50	50	22.1	9.1	N/A	H-2-39549 H-2-39574 H-2-39579	N/A	1991	N/A

a. Information obtained from RHO-CD-673, *Handbook 200 Area Waste Sites* (Vol. II), unless otherwise indicated.

b. Information obtained from 200-DV-1-DQO information tables (Appendix C).

c. Information from RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

d. Information from ARH-2155, *Radioactive Liquid Waste Disposal Facilities, 200 West Area.*

bgs = below ground surface
DQO = data quality objective
N/A = not applicable
OU = operable unit
UNH = uranyl nitrate hexahydrate

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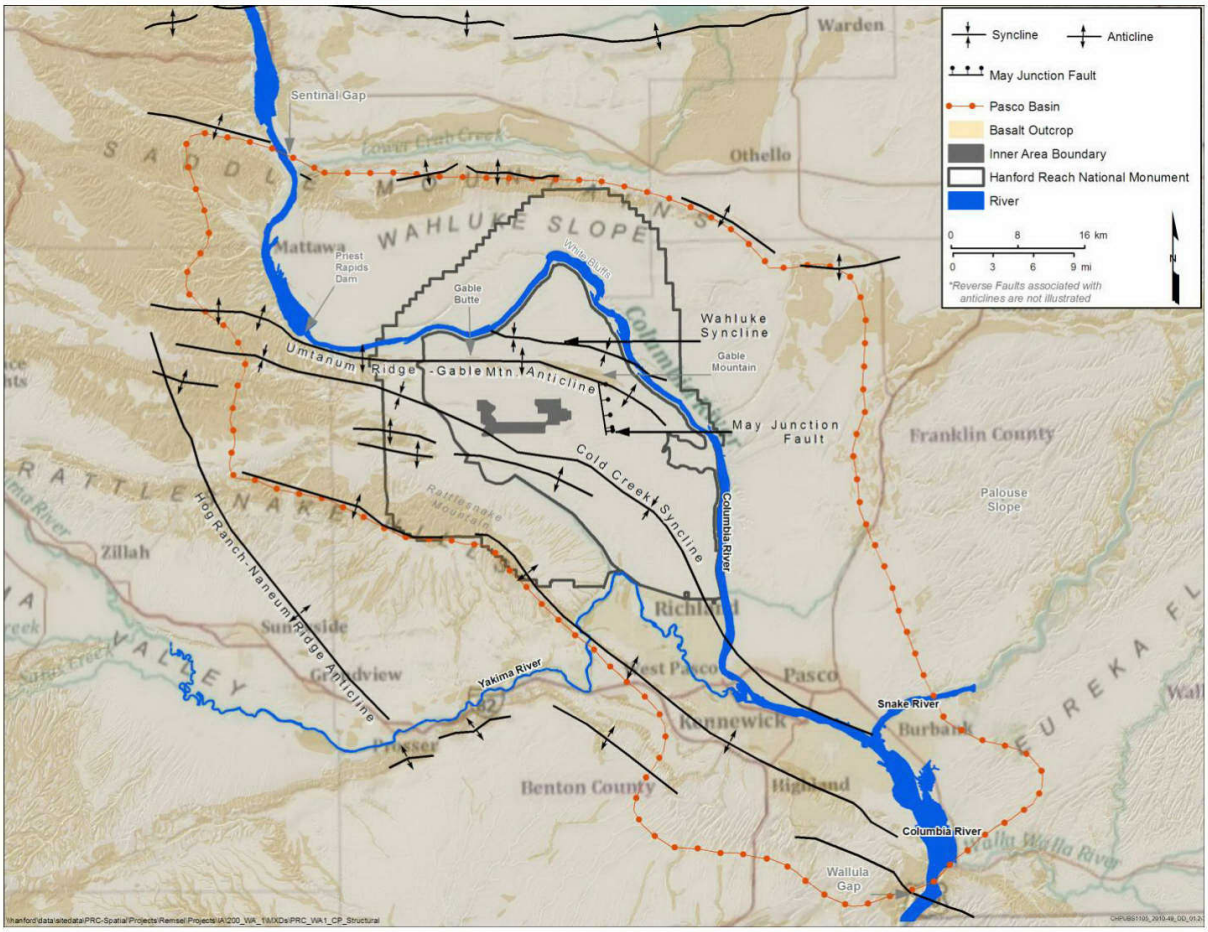


Note: This figure modified from PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*.

Figure 2-18. 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.

2.4.2.1 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 results in a northwest to west-northwest prevailing wind direction. Summertime winds from the northwest frequently exceed 13 m/s (30 mph), although the fastest wind speeds at the HMS are usually associated with flow from the southwest. Monthly average wind speeds of 15 m (50 ft) above the ground were slower during the winter months, averaging 2.7 to 3.1 m/s (6 to 7 mph), and faster during the spring and summer months, averaging 3.6 to 4.0 m/s (8 to 9 mph). The maximum speed of the drainage winds (and their frequency of occurrence) tends to decrease as they move southeast across the Hanford Site.

2.4.2.2 Temperature and Humidity

The average monthly temperatures at the HMS range from a low of -0.7°C (31°F) in January to a high of 24.7°C (76°F) in July, based on data collected from 1946 through 2004. 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.

2.4.2.3 Precipitation

Average annual precipitation at the HMS is 17 cm (6.8 in.). Most precipitation occurs during the late autumn and winter months, with more than one-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.

2.4.3 Geologic Setting

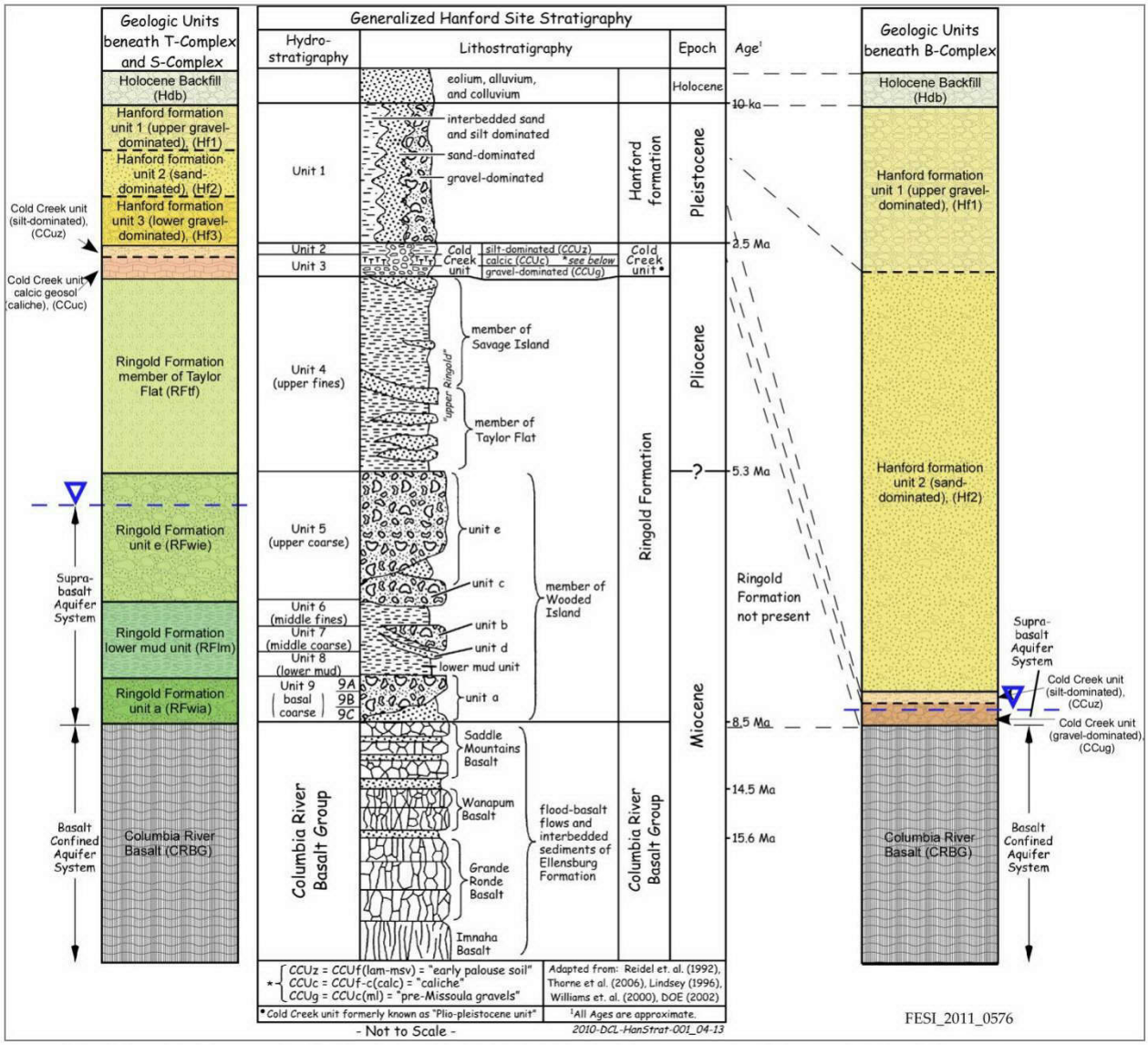
The geology of the Hanford Site has been extensively characterized during previous investigation activities. The Inner Area of the Hanford Site is located in the central portion of the Pasco Basin. Over the last 16 million years, the basin filled with materials that formed bedrock (i.e., volcanic lava flows) and unconsolidated 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 (approximately 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 Basalt of the Saddle Mountains Basalt Formation within 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.

Previous studies containing geologic interpretations, related maps, and cross sections pertaining to the 200-DV-1 OU include the following:

- DOE/RL-92-16, *200 West Groundwater Aggregate Area Management Study Report*
- DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*
- PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and into the Unconfined Aquifer Below the B-Complex*

The hydrogeologic interpretations for the 200-DV-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.*

Figure 2-19 presents stratigraphic columns for the B Complex area, T Complex area, and S Complex area.



Note: This figure has been modified from PNNL-6415, *Hanford Site Environmental Policy Act (NEPA) Characterization*.

Sources:

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

The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-Central Washington and North-Central Oregon (Lindsey, 1996).

PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington* (Williams et al., 2000).

PNNL-14753, *Groundwater Data Package for Hanford Assessments* (Thorne et al., 2006).

WHC-MR-0391, *Field Trip Guide to the Hanford Site* (Reidel et al., 1992).

Figure 2-19. Stratigraphic and Hydrostratigraphic Columns for the B Complex, T Complex, and S Complex Areas

2.4.3.1 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 the 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 western portion of the Hanford Site 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 and is approximately 35 m (115 ft) thick beneath most of the Hanford Site, except in the Gable Gap area near the northern extent of the Central Plateau, where glacial flood waters have eroded through the Elephant Mountain Basalt and have left the underlying Rattlesnake Ridge interbed in contact with the Hanford formation. The Rattlesnake Ridge interbed of the Ellensburg Formation typically occurs 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-DV-1 OU, 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.

2.4.3.2 Ringold Formation

The fluvial-lacustrine Ringold Formation, which overlies basalt over much of the Hanford Site, does not appear to be present in the B Complex area because it was completely eroded away by later cataclysmic flooding. The Ringold Formation is present beneath the T Complex area and the S Complex area as four distinct hydrostratigraphic units informally designated as units 4, 5, 8, and 9. These units generally correspond to Ringold Formation upper unit (silt and sand), fluvial gravel unit E, lower mud unit, and fluvial gravel unit A, respectively (PNNL-13858). The Ringold Formation is described as an unconsolidated to semiconsolidated sedimentary sequence deposited unconformably on the basalt and consists of clay, silt, sand, and granule- to cobble-sized gravel deposited by the ancestral Columbia River (PNNL-12261; PNNL-13858). The lower portion of the vadose zone in the T Complex area and the S Complex area immediately above the water table lies within the Ringold Formation.

2.4.3.3 Cold Creek Unit

The CCU includes several post-Ringold Formation and pre-Hanford formation units beneath portions of the Central Plateau (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*). Three different formations of similar age comprise the CCU. These are a fine-textured silty deposit, a silt to gravel-sized unit that is variably cemented with calcium carbonate (caliche), and a compact gravel unit. The silty and carbonate-cemented units are found in the vadose zone in the western portion of the Central Plateau (including beneath the 200-DV-1 OU waste sites in the T Complex area and the S Complex area). A silt-dominated facies of the CCU occurs locally within the B Complex area. The compact gravel unit is found underlying the eastern portion of the Central Plateau (including beneath the 200-DV-1 OU waste sites in the B Complex area), where it is typically encountered in the saturated zone.

The CCU in the western portion of the Central Plateau is composed of fluvial, eolian (wind deposited), and paleosol (soil) deposits, which are divided into two separate units designated as the lower caliche unit (CCU carbonate unit [CCU_c]) and the overlying silt unit (i.e., formerly "early Palouse soil") (CCU_z). The caliche layer formed during subareal exposure of the upper portions of the underlying sediment (e.g., Ringold Formation unit E or the upper Ringold unit) and extended into overlying CCU_z sediment. The CCU_c deposit is composed of leached calcium carbonate that accumulated in available pore spaces between sediment grains (sand, silt, or gravel). The caliche forms a secondary mineral coating of cement that binds the sediment grains together, forming one or more hardpan layers. The stratigraphic location and amount of calcium carbonate cement are variable, so the physical properties of this unit vary from soil-like to rock-like.

The properties of the CCU underlying the 200-DV-1 OU waste sites are important for two primary reasons: (1) the CCU_z generally exhibits much lower hydraulic conductivity than the overlying Hanford formation and, where present, the underlying Ringold Formation; and (2) the CCU exhibits much higher retention capacity for many contaminants of interest. The hydraulic properties of the CCU_z have historically resulted in accumulation and subsequent lateral spread of perched water within the vadose zone atop this unit and beneath high-volume discharge facilities (e.g., ditches, ponds, and cribs). The high contaminant retention capacity, a function of high ion-exchange capacity (in the silty portion) and precipitation reactions with calcium carbonate (in the cemented portion), have historically resulted in accumulation and retention of certain contaminants. In addition to chemical reactions and exchange properties, the silty and carbonate-cemented elements of the CCU exhibit substantial water-holding capacity. As a result, the vadose zone in some locations is expected to have retained substantial quantities of soluble contaminants within the soil water held by capillary forces in the CCU.

The CCU gravel (CCU_g), formerly known as the pre-Missoula Gravel, forms clast-supported, sandy pebble/cobble gravel that sharply truncates against the underlying Ringold Formation or basalt. This unit consists of post-Ringold deposits presumed to originate from the ancestral Columbia River. This coarse-grained, generally permeable deposit exists primarily within the saturated zone (i.e., beneath the water table) and lower vadose zone underlying the 200-DV-1 OU waste sites in the B Complex area. The CCU_g influences aquifer boundaries and groundwater/contaminant flow throughout the eastern portion of the Central Plateau.

2.4.3.4 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 cataclysmic floodwaters eroded or reworked much of the pre-existing Ringold Formation and CCU sediment across the Gable Gap area and unconformably deposited the sediments as the Hanford formation. The floodwaters deposited a thick sand and gravel bar (Cold Creek bar) that constitutes the Central Plateau. Remnant erosional channels, preserved during waning stages of the paleo-floods, remain visible near the northern extent of the Central Plateau near West Lake and the former Gable Mountain Pond.

The Hanford formation is important because it is the thickest geologic unit (comprising about one-half of the vadose zone thickness in the T Complex area and S Complex area and nearly all of the vadose zone thickness in the B Complex area) and contaminants must pass through the Hanford formation to reach the CCU and groundwater. The Hanford formation consists predominantly of unconsolidated sediments that range from boulder-size gravel to sand, silty sand, and silt. The sorting ranges from poorly sorted (for gravel facies) to well sorted (for fine sand and silt facies). Under the 200-DV-1 OU waste sites, 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 formation sand sequence. Also, gravel deposits do occur within and near the base of the Hanford formation in some areas.

2.4.3.5 Holocene Surficial Deposits

Overlying the Hanford formation are recently deposited surficial deposits of eolian (windblown) silt and sand. These surficial materials, particularly in those areas that constitute most of the 200-DV-1 OU waste sites, have been removed or reworked extensively by construction or operational activities.

2.4.4 Hydrogeology

This section describes the hydrogeology of the Central Plateau, with specific reference to the 200-DV-1 OU waste site areas.

2.4.4.1 Hydrostratigraphy

The hydrostratigraphic units of interest in the 200-DV-1 OU include the following, in descending order: (1) recent surficial deposits and the Hanford formation; (2) the CCU (primary vadose zone perching horizons or perched water zones); (3) the Ringold Formation (unconfined in unit E and unit C gravels with semiconfined and confined water-bearing zones in unit A gravels beneath the lower mud sequence); (4) the Elephant Mountain Basalt Member (confining horizon); and (5) the Rattlesnake Ridge interbed (a confined water-bearing zone) (Figure 2-19). The hydrogeologic designations on the Central Plateau were determined through examination of borehole logs and integration of these data with stratigraphic correlations from existing reports.

2.4.4.2 Vadose Zone

The thickness and stratigraphy of the vadose zone varies across the Central Plateau. The vadose zone thickness ranges from approximately 71 to 78 m (234 to 255 ft) in the T Complex area and from approximately 67 to 73 m (221 to 238 ft) in the S Complex area. In these areas, the vadose zone is composed of the Hanford formation, the CCU_z (silt) and CCU_c (carbonate), the Ringold Formation upper fines, and part of Ringold unit E. The vadose zone at the B Complex area ranges from 70 to 82 m (230 to 270 ft) thick and is composed of the Hanford formation, the CCU_z, and part of the CCU_g. Beneath the 216-B-5 and 216-B-9 waste sites, the vadose zone ranges from 85 to 88 m (280 to 290 ft) thick. The unconfined aquifer water table lies within the Ringold unit E in the T Complex area and S Complex area and within the CCU_g in the B Complex area.

2.4.4.3 Uppermost Aquifer

The uppermost aquifer is important to the assessment of the 200-DV-1 OU because it is the first groundwater to be potentially affected by contaminants originating from the 200-DV-1 OU waste sites. In the T Complex area and S Complex area, the uppermost aquifer is contained within the Ringold Formation and displays unconfined to locally confined or semiconfined conditions. The uppermost aquifer is unconfined in all locations underlying the 200-DV-1 OU waste sites. In the B Complex area, the uppermost aquifer occurs in the CCU_g and Hanford formation.

The saturated thickness of the unconfined aquifer ranges from approximately 102 to 108 m (335 to 355 ft) under the S Complex area, and from 73 to 84 m (240 to 274 ft) under the T Complex area. In the eastern part of the Central Plateau, the saturated thickness of the unconfined aquifer ranges from 61 m (200 ft) in the southern portion to zero in the northeastern portion where the aquifer thins and eventually terminates against the basalt located above the water table. At the B Complex area, the saturated thickness of the

unconfined aquifer ranges from less than 0.3 to 6 m (less than 1 to 20 ft) thick; beneath the 216-B-5 and 216-B-9 waste sites, it ranges from 12 to 15 m (40 to 50 ft) thick.

The water table elevation (and subsequently the groundwater gradient, flow direction, and flow velocity within the uppermost aquifer underlying the 200-DV-1 OU wastes sites) has been historically altered by discharges of large quantities of wastewater to the vadose zone within the Central Plateau. Historically, large groundwater elevation mounds formed beneath high-volume wastewater discharge sites. Although these large-volume discharges have been discontinued, the transient groundwater elevation mounds have not completely dissipated, particularly in the western Central Plateau where the aquifer occurs in the lower hydraulic conductivity deposits of the Ringold Formation. These residual mounds are likely less significant now than are the groundwater mounds and cones of depression created by operation of the 200 West Area P&T system. The groundwater elevation mounds historically present in the eastern Central Plateau (i.e., those associated with B Pond and Gable Mountain Pond), where the water table is typically found within the CCU_g Hanford formation, have generally dissipated.

2.4.5 Surface Water Hydrology

Primary surface water features associated with the Hanford Site are the Columbia and Yakima rivers. Groundwater in the unconfined aquifer beneath the 200-DV-1 OU waste sites eventually discharges to the Columbia River east and southeast of the Central Plateau.

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. 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, *Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*).

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 portion 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 portion of the Hanford Site, forms a small surface stream that flows for about 2.9 km (1.8 mi).

2.4.6 Environmental Resources

Because of the long-standing management practices of DOE, most of the land on the Hanford Site is relatively undisturbed. The Hanford Site is surrounded by agricultural and residential development. Hanford 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 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 in three annual reports (TNC, 1995, *Biodiversity Inventory and Analysis of the Hanford Site, 1994 Annual Report*; TNC, 1996, *Biodiversity Inventory and Analysis of the Hanford Site, 1995 Annual Report*; and TNC, 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*).

- Central Plateau 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*; and PNNL-13745, *Hanford Site Ecological Quality Profile*).
- Characterization of vegetative communities associated with the Central Plateau 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 Site biological resource management plan (using TNC and other characterization reports), identifying four levels of habitat value and appropriate management strategies for the Hanford 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 Site Central Plateau contains a number of plant, mammal, bird, reptile, amphibian, and insect species, as discussed in the following subsections.

2.4.6.1 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 (*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 fire breaks can result in changes to the plant community. DOE's experience with 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-299 (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 also are present, including several sedges

(*Carex* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha latifolia* and *T. angustifolia*), and pond weeds (*Potamogeton* spp.).

2.4.6.2 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 central Hanford (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 (e.g., 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 is the most abundant small mammal, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species. 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.

2.4.6.3 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 that were 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 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.

2.4.6.4 Reptiles and Amphibians

Common reptiles include gopher snakes (*Pituophis melanoleucus*) and sideblotched 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 items of mammalian and avian predators.

2.4.6.5 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 also are common and have been implicated in the uptake of radionuclides from some of the burial grounds in the eastern Central Plateau. 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*). Insects affect the surrounding plant community and serve as the prey base for many species of birds, reptiles, and mammals.

3 Initial Evaluation

This chapter summarizes the current understanding of site conditions for the DVZ and the 200-DV-1 OU waste sites in the B Complex area, the T Complex area, and the S Complex area and the adequacy of the existing information to support remedy decisions. The site descriptions for the waste sites include the nature and extent of contamination. This chapter also summarizes the elements of the preliminary risk assessment evaluated to help develop the scope of the RI. The site descriptions and preliminary risk assessment presented in this chapter were used to identify the data needs (Chapter 4).

3.1 Central Plateau Deep Vadose Zone Contamination

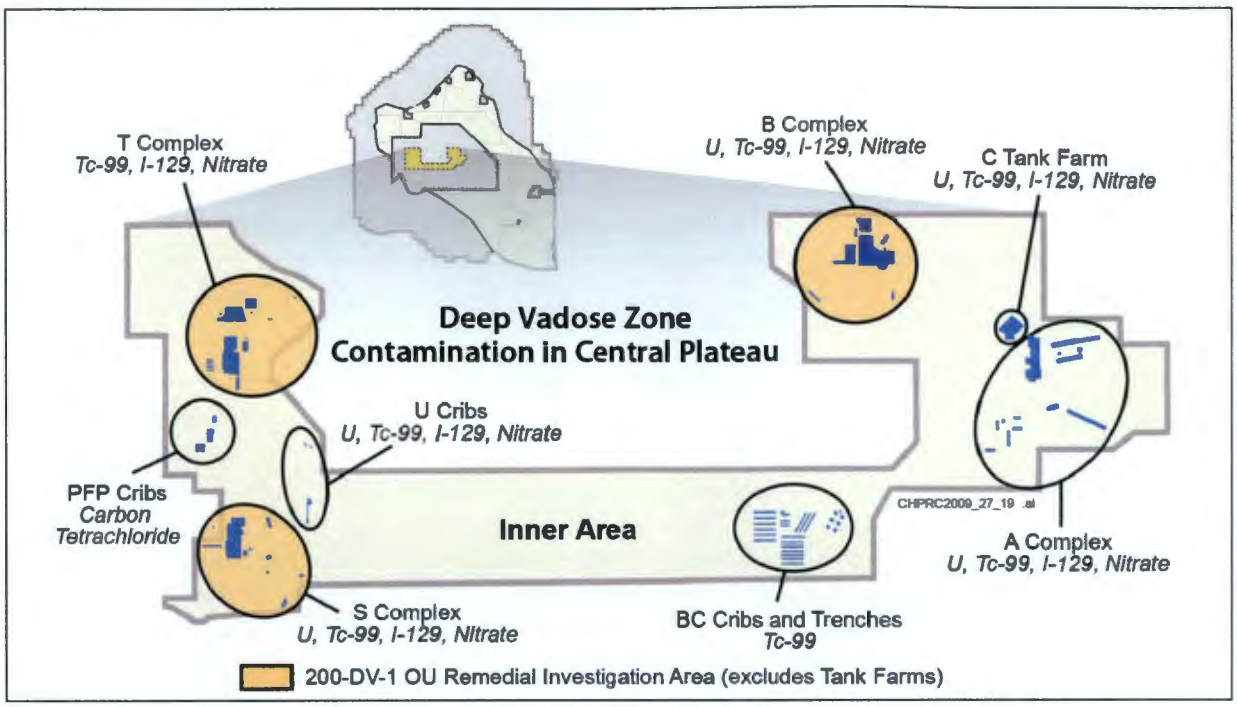
The DVZ contamination is a significant issue because it represents a potential source for continued release of mobile contamination to the groundwater and potentially to surface water and associated receptors. This contamination, which is the result of past waste disposal practices on the Hanford Site's Central Plateau, occurs deep in the subsurface and is not easily remediated by typical surface remedies. The DVZ is defined as the soil below the practical depth of typical surface-based remedies (e.g., excavation or surface engineered barrier influence) and above the water table. The Central Plateau DVZ begins at a depth of approximately 15 m (50 ft) bgs and extends to the water table at depths ranging from approximately 71 to 78 m (234 to 255 ft) bgs in the T Complex area, 67 to 73 m (221 to 238 ft) bgs in the S Complex area, and 70 to 88 m (230 to 290 ft) bgs in the B Complex area.

Cleanup of the DVZ is challenging because contamination is difficult to access; contaminants occur at different depths and in different soil types; conventional, surface-based remedies have limited effectiveness; and remedy performance is difficult to predict, test, and monitor. Typically, remedial technologies for DVZ contamination are less developed than for the shallow soil contamination or saturated groundwater contaminants. In addition, few remediation technologies have been tested in the field, and fewer have been successfully implemented as full remedial actions. These challenges, along with the limited number of potentially applicable remediation technologies, limit the options available in the decision-making process for evaluating and selecting DVZ remedial alternatives.

The primary contaminants at the Hanford Site driving long-term risk are technetium-99 and uranium because of their persistence, high inventory in the vadose zone, mobility, difficulty in predicting subsurface behavior, and long half-lives (Section 1.3 in DOE/RL-2010-89, *Long-Range Deep Vadose Zone Program Plan*). Additional contaminants of long-term concern are iodine-129, chromium (assumed to be hexavalent[12]), and nitrate. Figure 3-1 shows the areas of DVZ contamination in the Central Plateau Inner Area; the three areas shaded in orange include the 200-DV-1 OU waste sites.

The 200-DV-1 OU includes 43 waste sites. As part of the 200-DV-1 OU RI/FS and RFI/CMS process, these waste sites will be evaluated from land surface to groundwater to support remedy decisions for shallow and deep contamination associated with the waste sites. The tank farm WMAs and any subsurface contamination from associated UPRs are not included in the 200-DV-1 OU. However, some of the 200-DV-1 OU waste sites are adjacent to tank farms, potentially resulting in co-mingled contamination in the DVZ. Data for the tank farms are provided to present a comprehensive description of the DVZ in each area of the 200-DV-1 OU waste sites.

[12] In this work plan, chromium is assumed to be hexavalent chromium, unless otherwise noted.



Source: CHPRC-01056-VA, *Hanford Site - Deep Vadose Zone Cleanup Challenge.*

Figure 3-1. DVZ Contamination on the Central Plateau

3.2 B Complex Area

Environmental impacts in the B Complex area occurred as a result of facility processes, waste disposal practices, and accidental spills (UPRs).

3.2.1 200-DV-1 Operable Unit Waste Sites in the B Complex Area

The primary contaminant source for the 200-DV-1 OU waste sites in the B Complex area was liquid process waste that was generated during facility operations (e.g., B Plant, U Plant, 242-B Evaporator, and ITS) and intentionally released to the environment through engineered waste site structures such as cribs and trenches. In some cases, liquid waste that was initially sent to the tank farms was later discharged to the waste sites. In some cases, liquid waste was initially sent to settling tanks (SSTs in the tank farms) designed to allow the supernate liquid to overflow to the waste sites. The process waste was aqueous and contained relatively high concentrations of known process-related contaminants (e.g., radionuclides or chemicals). Table 3-1 lists the primary sources of contamination for the 200-DV-1 OU waste sites.

The 200-DV-1 OU waste sites will be evaluated from the land surface to groundwater to support remedy decisions. The chemical and/or radionuclide contaminants in the shallow soils (up to 4.6 m [15 ft]) at the individual waste sites will be used to determine whether each waste site exceeds acceptable risk levels for HHE. Relatively immobile contaminants such as cesium-137 and strontium-90 are most likely to be retained near the point of discharge, which for some waste sites was in the upper 4.6 m (15 ft) of the subsurface. The inventory of cesium-137 and strontium-90 at the 200-DV-1 OU waste sites is provided in Table 3-2.

Table 3-1. Sources of Contamination for 200-DV-1 OU Waste Sites in the B Complex Area

Waste Site	Service Dates	Primary Sources of Contamination
216-B-5	04/1945to 09/1946	Tank 5-6 waste from the 221-B Building and liquid waste from the 224-B Building via 241-B-361 Settling Tank
	09/1946 to 10/1947	Tank 5-6 waste from the 221-B Building via 241-B-361 Settling Tank
216-B-7A&B	09/1946 to 10/1947	224-B Building liquid waste via 241-B-201 Tank
	10/1947to 08/1948	224-B Building liquid waste and 221-B Building Tank 5-6 waste via 241-B-201 Tank
	08/1948 to 10/1948	224-B Building liquid waste via 241-B-201 Tank
	10/1948 to 12/1954	224-B Building liquid waste via 241-B-204-203-202 Tank cascade
	12/1954 to 09/1958	Tank 5-6 waste from the 221-B Building and the liquid waste from the 224-B Building during reactivation decontamination and cleanup in the 221-B Building
	09/1958 to 10/1961	Occasional Tank 5-6 waste from the 221-B Building
	10/1961 to 05/1967	Decontamination and construction waste from the 221-B Building
216-B-8	03/1948 to 05/1951	2C waste from the 221-B Building via blind riser in B Tank Farm
	05/1951 to 12/1951	2C waste from the 221-B Building via 241-B-110-111-112 Tank cascade
	07/1951 to 12/1951	Tank 5-6 waste from the 221-B Building via 241-B-110-111-112 Tank cascade
	12/1951 to 12/1952	Decontamination waste from the 224-B Building
216-B-9	08/1948 to 07/1951	Tank 5-6 waste from the 221-B Building
216-B-11A&B	12/1951 to 12/1954	Condensate from evaporation of 1C waste in the 242-B Evaporator
216-B-35	02/1954 to 02/1954	1C supernate from the 221-B Building via 241-BX-110 Tank
216-B-36	04/1954 to 04/1954	1C supernate from the 221-B Building via 241-BX-111 Tank
216-B-37	08/1954 to 09/1954	1C evaporator bottoms from the 242-B Building via 241-B-107-108-109 Tanks

Table 3-1. Sources of Contamination for 200-DV-1 OU Waste Sites in the B Complex Area

Waste Site	Service Dates	Primary Sources of Contamination
216-B-38	07/1954 to 07/1954	1C supernate from the 221-B Building via 241-BY-110 Tank
216-B-39	12/1953 to 10/1954	1C supernate from the 221-B Building via 241-BX-112 Tank (12/53) and 241-BY-106 Tank (10/54)
216-B-40	08/1954 to 11/1954	1C supernate from the 221-B Building via 241-BY-110 Tank (08/1954) and 241-BY-106 tank (11/1954)
216-B-41	10/1954 to 10/1954	1C supernate from the 221-B Building via 241-BY-106 Tank
216-B-42	02/1955 to 02/1955	Scavenged TBP waste from the 221-U Building, batch 4
216-B-43	11/1954 to 11/1954	Scavenged TBP waste from the 221-U Building, batch 1
216-B-44	12/1954 to 03/1955	Scavenged TBP waste from the 221-U Building, batches 2, 3, and 5
216-B-45	04/1955 to 06/1955	Scavenged TBP waste from the 221-U Building, batches 7 and 10
216-B-46	08/1955 to 12/1955	Scavenged TBP waste from the 221-U Building, batches 13, 16, and 20
216-B-47	09/1955 to 09/1955	Scavenged TBP waste from the 221-U Building, batches 14 and 15
216-B-48	11/1955 to 11/1955	Scavenged TBP waste from the 221-U Building, batches 11 and 17
216-B-49	11/1955 to 12/1955	Scavenged TBP waste from the 221-U Building, batches 12, 18, and 19
216-B-50	01/1965 to 01/1974	Waste storage tank condensate from the ITS 1 unit
216-B-57	02/1968 to 06/1973	Waste storage tank condensate from the ITS 2 unit
200-E-45	Late 1950s through early 1970s	Water to support testing contaminated pumps from the B-BX-BY Tank Farms
Perched water*	Not applicable	Liquid discharges to 200-DV-1 OU waste sites (e.g., 216-B-7A&B, 216-B-8) and an unplanned release (tank overfill) at 241-BX-102 in 1951

Table 3-1. Sources of Contamination for 200-DV-1 OU Waste Sites in the B Complex Area

Waste Site	Service Dates	Primary Sources of Contamination

* The zone of perched water is not considered a waste site, but it is included in the 200-DV-1 Operable Unit.

Note: The following definitions are from HNF-5231, *Historical Vadose Zone Contamination from B, BX, and BY Tank Farm Operations* (p. 4):

- "1C" (first-cycle waste) was the byproduct from the first plutonium decontamination cycle of the bismuth phosphate process in B Plant. This waste contained about 10 percent of the fission products of the irradiated fuel.
- "2C" (second-cycle waste) was the byproduct from the second and last plutonium decontamination cycle of the bismuth phosphate process in B Plant. This waste contained less than 0.1 percent of the fission products of the irradiated fuel.
- "Building 224 waste" was low-level waste from the 224-B Plutonium Concentrator Facility. This waste stream was the primary contributor to plutonium contamination of the soil.
- "Tank 5-6 waste" was low-level waste from individual process cells in B Plant. Drainage from the cells was stored in Tank 5-6 before being discharged.
- "Scavenged TBP waste" was low-level waste that had been generated during the uranium recovery process in U Plant (which used TBP and then was treated using the ferrocyanide process in U Plant to remove (scavenge) the cesium-137 and strontium-90.

TBP = tributyl phosphate
ITS = in-tank solidification

The chemical and/or radionuclide contaminants will be used to determine whether the vadose zone exceeds acceptable risk levels for groundwater. Relatively mobile contaminants such as technetium-99, uranium, iodine-129, and nitrate are most likely to have migrated deeper in the vadose zone and pose a current and/or future risk to groundwater. The inventories of selected mobile contaminants discharged to 200-DV-1 OU waste sites in the B Complex area are listed in Table 3-2.

The volumes of liquid waste discharged and the inventories of radionuclides and chemicals in the waste discharged to the 200-DV-1 OU waste sites are based on the Soil Inventory Model (SIM) results (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*). The SIM was developed, using a probabilistic approach, to estimate the inventory of contaminants that were released to the soil within the Central Plateau during the Hanford Site production mission. Input data were obtained from historical records, including the various plutonium/uranium processing facilities. The SIM also updated previous efforts to quantify the contaminant inventories in Hanford Site waste storage tanks using results from high-level waste tanks and process control data in historical waste management documents.

The SIM (published in 2005) used 196 waste streams applied at 377 liquid waste disposal sites, UPRs, and tank leaks. The SIM contains inventory and uncertainty estimates for 46 radionuclides and 29 chemicals. The inventories are calculated in 1-year increments over the operating lifetime of the waste sites (from 1944 to 2001). The radionuclides are decayed to January 1, 2001. The complete list of contaminant inventories for the 200-DV-1 OU waste sites is provided in RPP-26744.

The volumes of liquid waste discharged to the 200-DV-1 OU waste sites in the B Complex area and released from SST 241-BX-102 are compared in Figure 3-2. In general, the BX Trenches (216-B-35 through 216-B-42) and BY Cribs (216-B-43 through 216-B-49) received the smallest volumes of liquid waste. Five waste sites (216-B-57 Crib, 216-B-50 Crib, 216-B-7A&B, 216-B-8, and 216-B-11A&B) received 80 percent of the liquid volume discharged to the 200-DV-1 OU waste sites in the B Complex area.

The inventories of technetium-99 and uranium for each of the 200-DV-1 OU waste sites are shown in Figures 3-3 and 3-4, respectively. The mean values for the inventories of technetium-99 and uranium are

compared in Figures 3-5 and 3-6, respectively. The technetium-99 inventory data indicate that the most significant sources of technetium-99 are the seven BY Cribs (216-B-43 through 216-B-49) that received the scavenged TBP waste. The uranium inventory data indicate that the most significant source of uranium is the tank overfill event at SST 241-BX-102.

3.2.2 B-BX-BY Tank Farms Data

The B-BX-BY Tank Farms, and any subsurface contamination from associated UPRs, are not included in the 200-DV-1 OU. However, some of the 200-DV-1 OU waste sites in the B Complex area are adjacent to the B-BX-BY Tank Farms, potentially resulting in co-mingled contamination in the DVZ. Data for the B-BX-BY Tank Farms are provided to present a comprehensive description of the B Complex area.

The primary sources of contamination for the B-BX-BY Tank Farms were bismuth phosphate waste from plutonium extraction at B Plant (1945 to 1952), TBP waste from the uranium recovery operations at U Plant (1952 to 1958), scavenged TBP waste following ferrocyanide treatment at U Plant (1954 to 1958), and scavenged TBP waste following ferrocyanide treatment in the 244-CR Vault (1955 to 1958).

Leaks of waste fluids from the tanks and/or ancillary equipment and losses (UPRs) of waste fluids during waste transfers (e.g., overfilling a tank) contributed contamination from the tanks to the subsurface. Leaks from raw and potable water lines likely contributed to tank waste migration in the vadose zone, as cited in HNF-5507, *Subsurface Conditions Description for the B-BX-BY Waste Management Area* (Section 2.1.2).

Selected tank leak and UPR estimates (volumes and inventories) were reassessed and updated, as needed, in 2011 for the B-BX-BY Tank Farms. The reassessment results for the B-BX-BY Tank Farms are documented in RPP-RPT-49089, RPP-RPT-47562, and RPP-RPT-43704; current SIM estimates (RPP-26744) have not been updated to reflect the revised estimates in these reports.

The most significant tank waste loss event, in terms of volume and inventory released, was the 1951 release from Tank 241-BX-102. This release contributed the largest amount of uranium contamination to the vadose zone in the B Complex area (BX Tank Farm on Figure 3-6). The volume and inventory for the 241-BX-102 leak is provided in Table 3-2, based on the data in the SIM (RPP-26744). The 2011 reassessment concluded that the inventory estimates in the SIM appear to be reasonable for the 1951 release from 241-BX-102 (RPP-RPT-47562).

3.2.3 Previous Investigations, Monitoring, and Remediation Activities in the B Complex Area

A timeline of the most significant previous investigations, monitoring, and remediation activities at the 200-DV-1 OU waste sites in the B Complex area is presented in Figure 3-7. The nature and extent of contamination are provided in Section 3.2.4.

3.2.3.1 200-DV-1 Operable Unit Waste Sites

The earliest investigations of waste sites in the B Complex area were conducted from 1947 to 1950 (Figure 3-7). Field investigations were conducted at the 216-B-5, 216-B-7A&B, 216-B-8, and 216-B-9 waste sites to evaluate the fate and transport of radionuclides contained in waste liquids discharged to the ground. The results demonstrated that plutonium and most of the fission products bound to the soil within a relatively short distance from the waste sites and that uranium and certain fission products (e.g., ruthenium) were the most likely to remain in solution and to travel the farthest from the point of injection (HW-17088, p. 7). The results of these sampling activities are documented in HW-17088 and are summarized in the information tables prepared to support the DQO process (see Tables C-2, C-3, C-4, and C-5 in Appendix C).

Table 3-2. Volumes and Inventories Discharged to 200-DV-1 OU Waste Sites in the B Complex Area

Waste Site	Volume Discharged[a] (million L)	Total Waste Inventory[a]												
		Nitrate (kg)	Fluoride (kg)	Uranium (total) (kg)	Chromium[b] (kg)	Ferrocyanide (kg)	Cesium-137[c] (Ci)	Strontium-90[c] (Ci)	Plutonium-239[c] (Ci)	Plutonium-240[c] (Ci)	Cobalt-60[c] (Ci)	Iodine-129[c] (Ci)	Technetium-99[c] (Ci)	Tritium[c] (Ci)
216-B-5 (1945-1947)	3.21E+01	9.50E+05	5.63E+04	1.05E+01	3.79E+03	0	8.67E+00	7.55E+00	3.72E+01	2.51E+00	5.28E-03	1.88E-06	4.25E-03	1.07E-04
216-B-7A&B (1946-1954, 1966-1967)	4.46E+01	2.71E+06	1.62E+05	1.97E+02	1.16E+04	0	3.73E+02	1.64E+03	2.17E+01	6.84E+00	3.61E-01	6.67E-04	9.47E-02	7.81E-03
216-B-8[d,e]/200-E-45 (no waste generated at 200-E-45) (1948-1953)	3.53E+01	1.94E+06	1.05E+05	1.91E+02	6.23E+03	0	1.68E+02	1.46E+02	1.26E+02	9.74E+00	8.72E-02	2.67E-05	8.00E-02	1.32E-02
216-B-9[e] (1948-1951)	3.60E+01	1.71E+05	9.53E+03	1.23E+01	6.41E+02	0	1.24E+01	1.07E+01	8.08E+00	7.17E-01	7.59E-03	1.32E-06	5.74E-03	1.68E-03
216-B-11A&B (1952-1954)	2.96E+01	2.45E+02	3.60E+00	4.21E-02	4.72E-01	0	9.66E+00	3.04E+00	6.61E-03	7.87E-04	3.12E-04	4.54E-06	3.25E-03	1.59E+01
216-B-35 (1954)	1.06E+00	1.14E+05	3.97E+03	3.63E+01	3.80E+02	0	4.85E+02	7.62E+01	4.28E-01	6.10E-02	3.37E-01	1.87E-03	2.14E-01	6.46E+00
216-B-36 (1954)	1.94E+00	2.08E+05	7.27E+03	6.64E+01	6.95E+02	0	8.87E+02	1.40E+02	7.85E-01	1.11E-01	6.16E-01	3.42E-03	3.92E-01	1.18E+01
216-B-37 (1954)	4.32E+00	4.63E+05	1.62E+04	1.48E+02	1.55E+03	0	1.98E+03	3.11E+02	1.75E+00	2.47E-01	1.37E+00	7.62E-03	8.73E-01	2.63E+01
216-B-38 (1954)	1.43E+00	1.53E+05	5.36E+03	4.90E+01	5.12E+02	0	6.54E+02	1.03E+02	5.79E-01	8.19E-02	4.54E-01	2.52E-03	2.89E-01	8.72E+00
216-B-39 (1953-1954)	1.54E+00	1.65E+05	5.77E+03	5.27E+01	5.52E+02	0	7.04E+02	1.11E+02	6.22E-01	8.82E-02	4.89E-01	2.72E-03	3.11E-01	9.39E+00
216-B-40 (1954)	1.64E+00	1.76E+05	6.14E+03	5.62E+01	5.87E+02	0	7.50E+02	1.18E+02	6.63E-01	9.37E-02	5.21E-01	2.89E-03	3.32E-01	1.00E+01
216-B-41 (1954)	1.44E+00	1.54E+05	5.39E+03	4.93E+01	5.16E+02	0	6.59E+02	1.04E+02	5.82E-01	8.23E-02	4.57E-01	2.54E-03	2.91E-01	8.78E+00
216-B-42 (1954)	1.5E+00	2.98E+05	6.08E+03	4.65E+01	2.58E+02	0	5.27E+01	2.01E+02	1.19E+00	1.29E-01	2.82E-01	7.31E-03	5.70E+00	9.35E+00
216-B-43 (1954)	2.12E+00	4.21E+05	8.59E+03	6.58E+01	3.65E+02	0	7.44E+01	2.84E+02	1.69E+00	1.82E-01	3.98E-01	1.03E-02	8.05E+00	1.32E+01
216-B-44 (1954-1955)	5.60E+00	1.11E+06	2.27E+04	1.74E+02	9.63E+02	0	1.97E+02	7.50E+02	4.46E+00	4.80E-01	1.05E+00	2.73E-02	2.13E+01	3.49E+01
216-B-45 (1955)	4.92E+00	9.77E+05	1.99E+04	1.65E+02	8.46E+02	5.15E+01	6.08E+02	1.03E+03	4.00E+00	4.31E-01	9.24E-01	2.40E-02	1.87E+01	3.07E+01
216-B-46 (1955)	6.70E+00	1.33E+06	2.71E+04	2.08E+02	1.15E+03	0	2.35E+02	8.97E+02	5.33E+00	5.75E-01	1.26E+00	3.26E-02	2.55E+01	4.18E+01

Table 3-2. Volumes and Inventories Discharged to 200-DV-1 OU Waste Sites in the B Complex Area

Waste Site	Volume Discharged[a] (million L)	Total Waste Inventory[a]												
		Nitrate (kg)	Fluoride (kg)	Uranium (total) (kg)	Chromium[b] (kg)	Ferrocyanide (kg)	Cesium-137[c] (Ci)	Strontium-90[c] (Ci)	Plutonium-239[c] (Ci)	Plutonium-240[c] (Ci)	Cobalt-60[c] (Ci)	Iodine-129[c] (Ci)	Technetium-99[c] (Ci)	Tritium[c] (Ci)
216-B-47 (1955)	3.68E+00	7.32E+05	1.49E+04	1.14E+02	6.33E+02	0	1.29E+02	3.29E+02	2.93E+00	3.16E-01	6.92E-01	1.79E-02	1.40E+01	2.29E+01
216-B-48 (1955)	4.09E+00	8.12E+05	1.66E+04	1.27E+02	7.03E+02	0	1.44E+02	5.48E+02	3.25E+00	3.51E-01	7.69E-01	1.99E-02	1.55E+01	2.55E+01
216-B-49 (1955)	6.70E+00	1.33E+06	2.71E+04	2.08E+02	1.15E+03	0	2.35E+02	8.98E+02	5.33E+00	5.75E-01	1.26E+00	3.27E-02	2.55E+01	4.18E+01
216-B-50 (1965-1974)	5.47E+01	1.11E+02	7.59E+00	2.88E-02	1.48E+01	0	5.49E+01	1.52E+00	1.77E-02	4.02E-03	8.01E-03	9.34E-05	6.60E-02	1.26E+02
216-B-57 (1968-1973)	8.43E+01	2.76E+02	1.27E+01	5.94E-02	2.42E+01	0	1.64E+02	3.55E+00	2.97E-02	6.78E-03	2.40E-02	2.80E-04	1.97E-01	1.95E+02
241-BX-102[f]	3.47E-01	3.80E+03	1.31E-05	1.01E+04	6.05E+01	0	4.64E+03	2.36E+03	1.33E+00	9.01E-02	4.99E-02	1.01E-03	2.27E+00	3.85E+00

a. Total waste volume and inventory values are based on the sum value of the mean concentrations taken from SIM results (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*).

b. The SIM does not provide speciation information for chromium. All chromium inventories are assumed to be hexavalent unless other information is available.

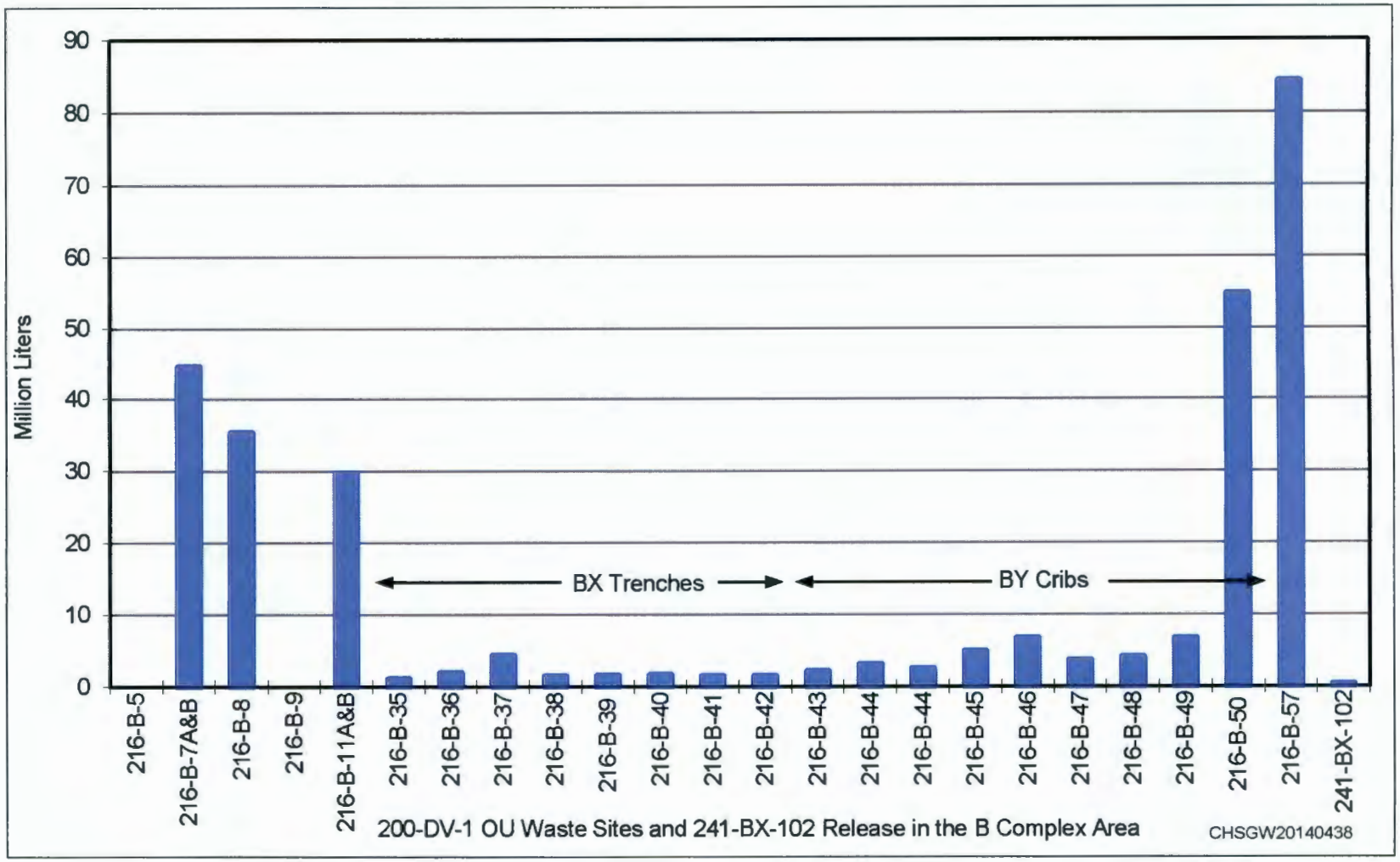
c. Radiological constituents decayed to January 1, 2001.

d. The SIM does not include the inventory in the sludge that was inadvertently jetted to 216-B-8 from Tank 241-B-104 in August 1948 (HW-17088, *The Underground Disposal of Liquid Wastes at the Hanford Works, Washington*, p. 59).

e. The SIM does not include the addition of acid used to attempt to clear the cribs of sludge to maintain operations (HW-17088, pp. 51 and 59).

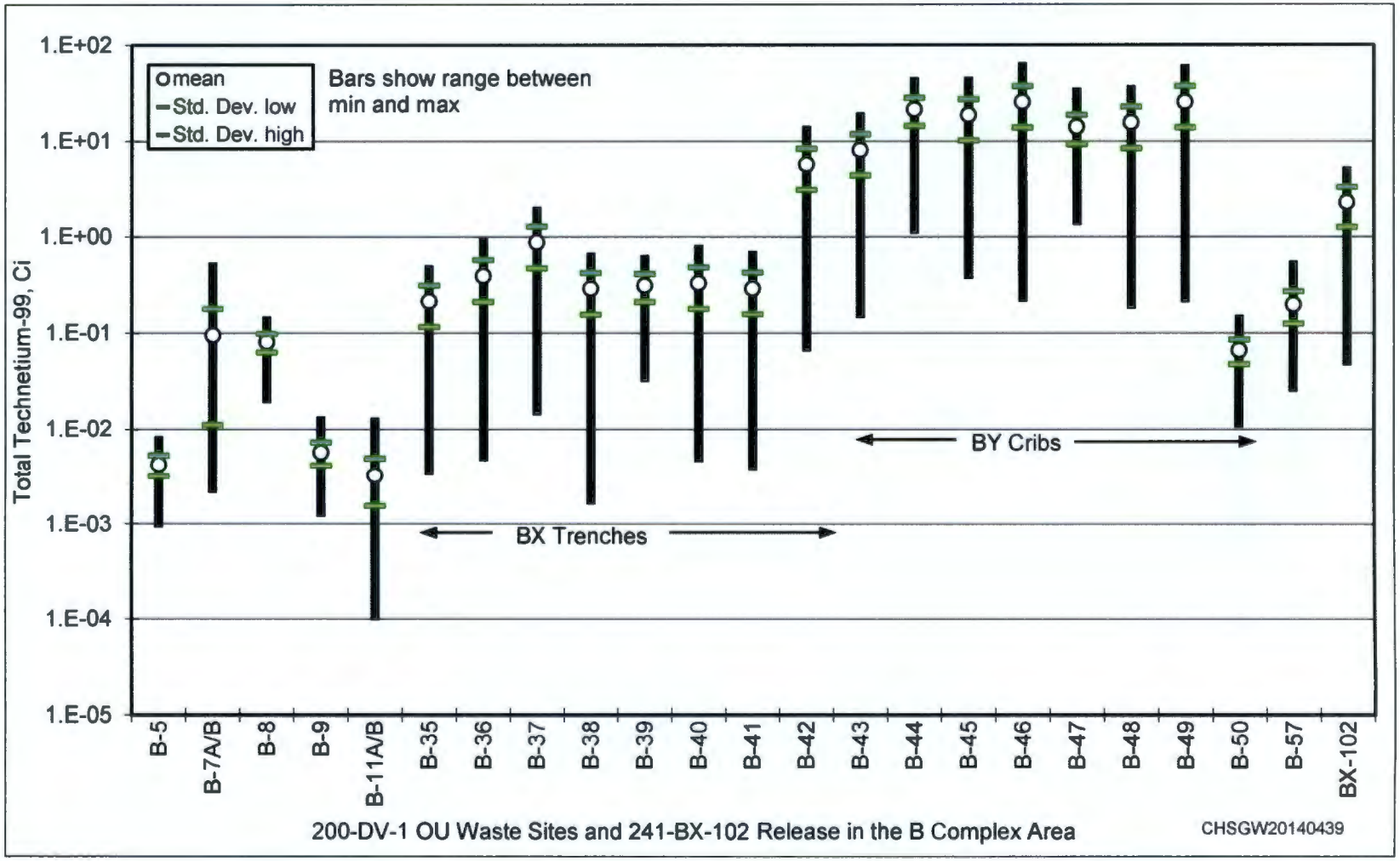
f. Volume and inventory in the 1951 unplanned release.

SIM = Soil Inventory Model



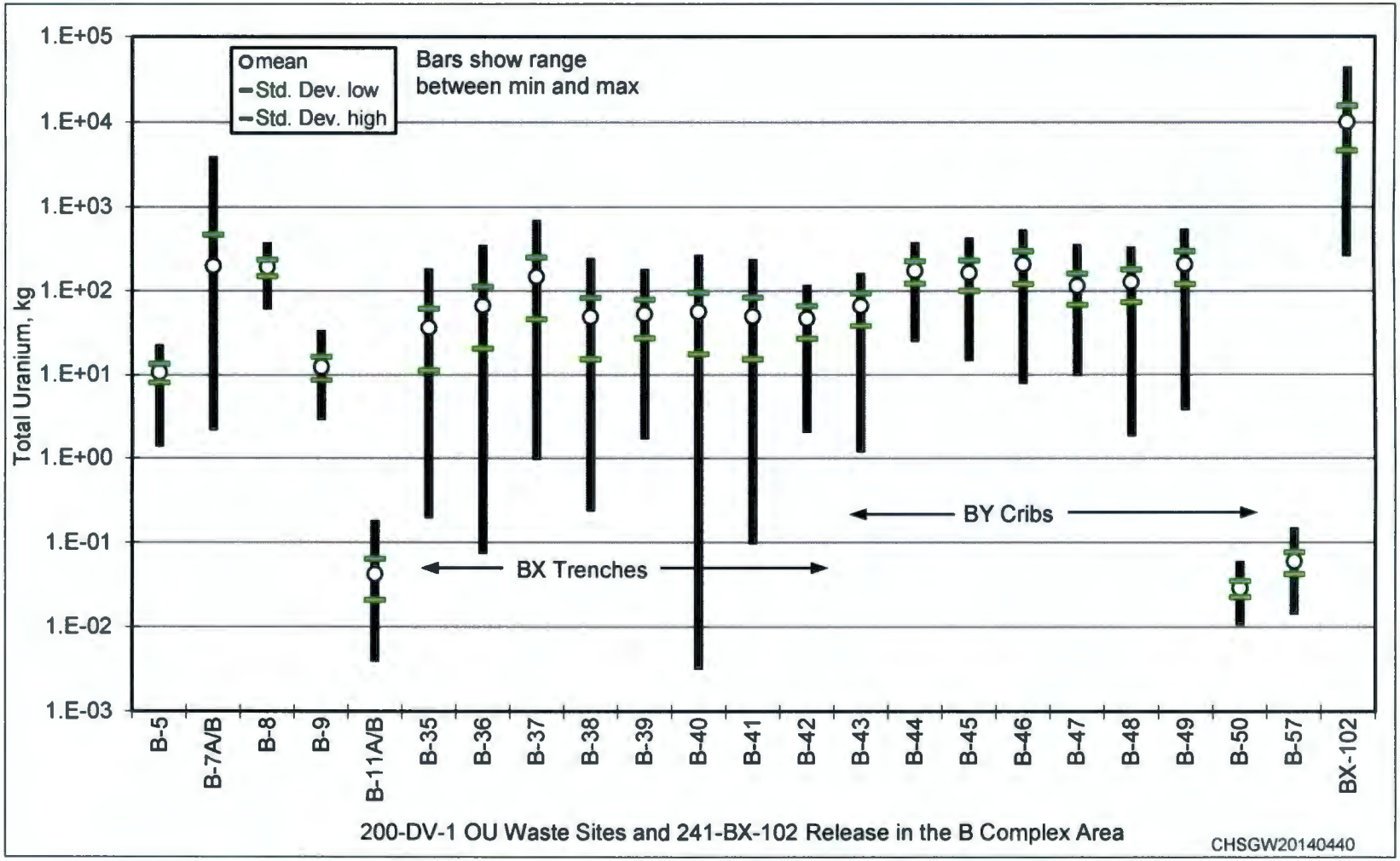
Source: RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

Figure 3-2. Volumes of Liquid Waste Discharged to 200-DV-1 OU Waste Sites and Released from SST 241-BX-102 in the B Complex Area



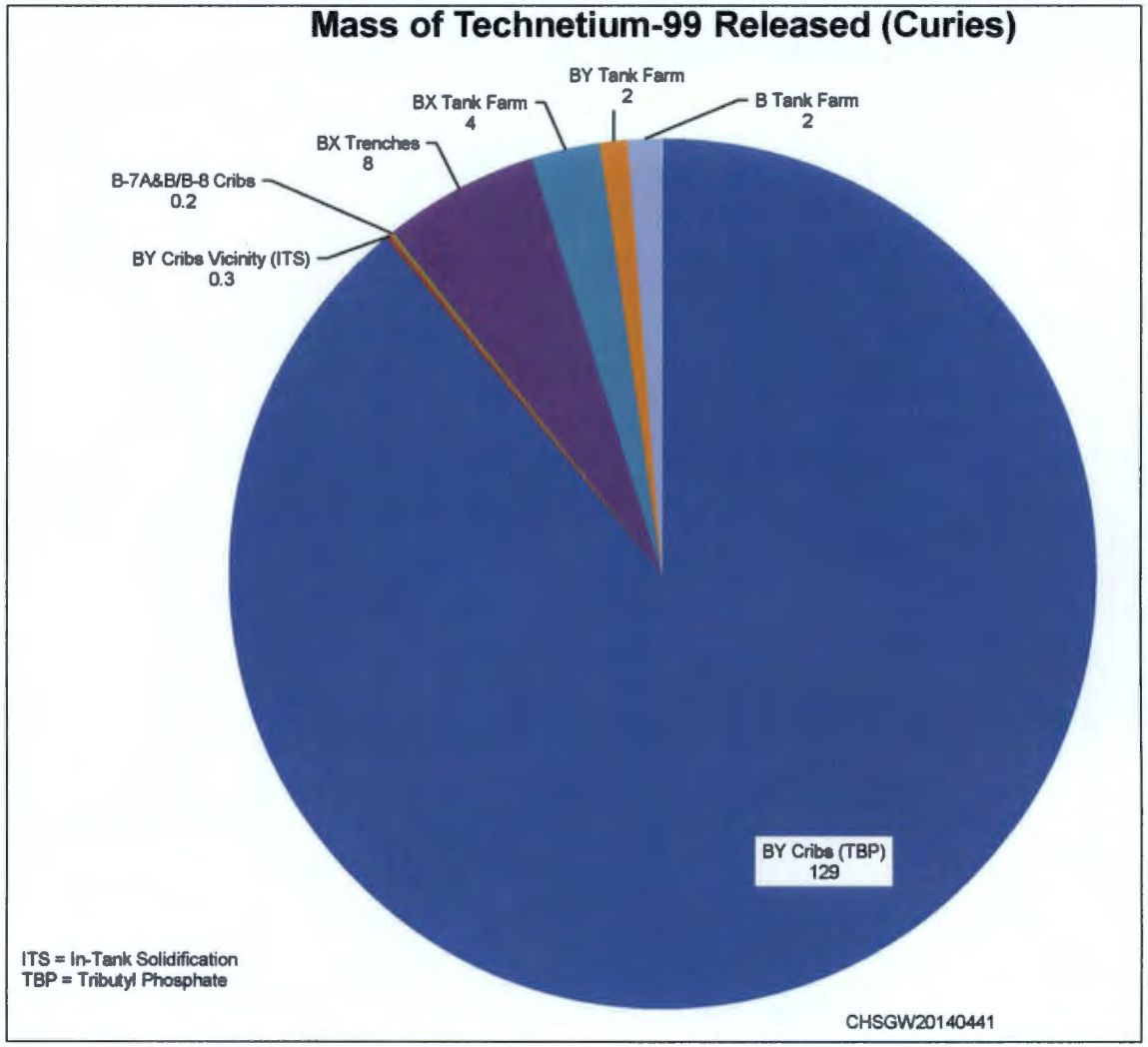
Note: This figure is based on data from RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

Figure 3-3. Technetium-99 Inventory Discharged to 200-DV-1 OU Waste Sites and Released from SST 241-BX-102 in the B Complex Area



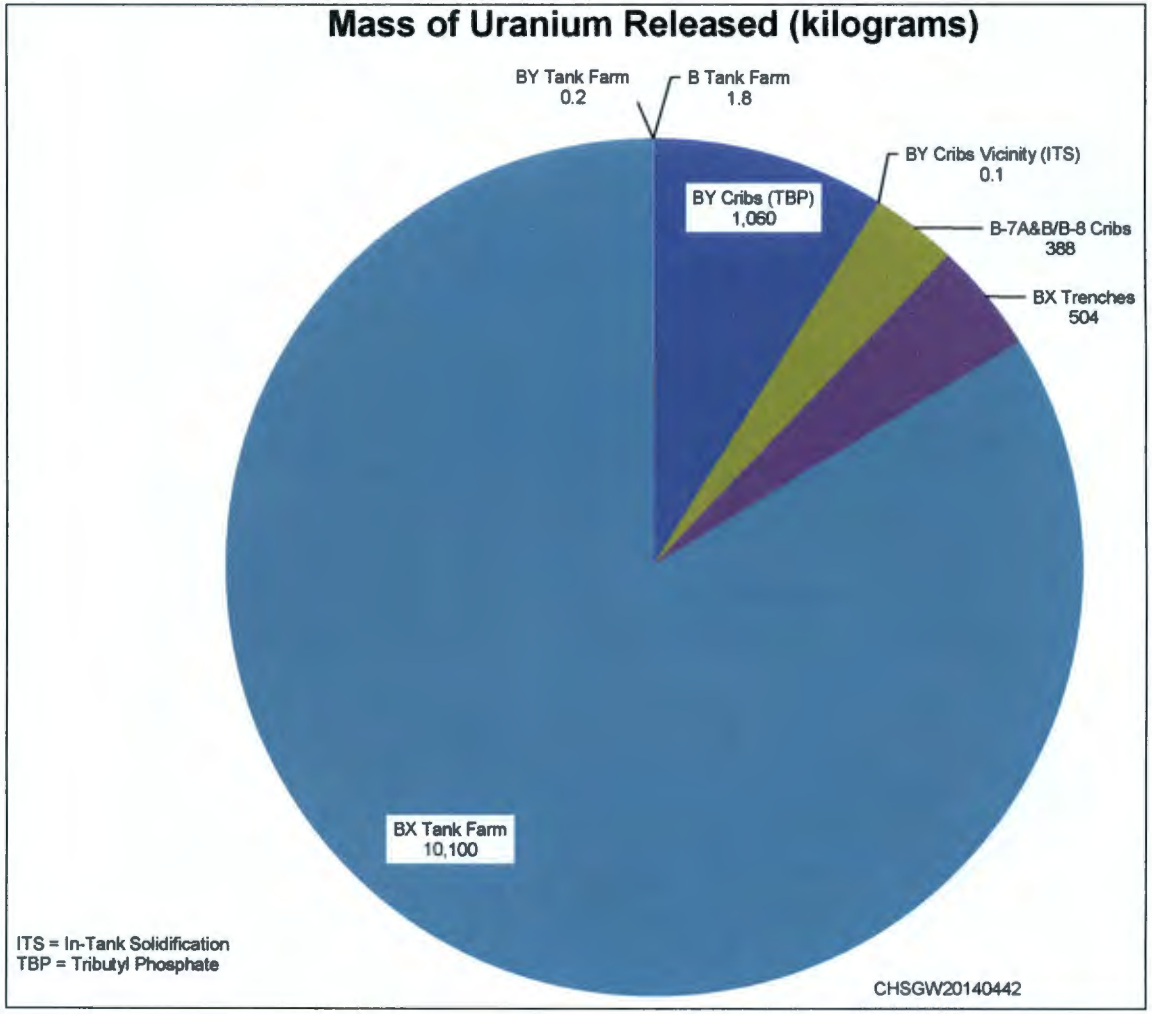
Note: This figure is based on data from RPP-26744, *Hanford Soil Inventory Model, Rev. 1*.

Figure 3-4. Uranium Inventory Discharged to 200-DV-1 OU Waste Sites and Released from SST 241-BX-102 in the B Complex Area



Note: This figure is based on mean values provided in RPP-26744, *Hanford Soil Inventory Model, Rev. 1*.

Figure 3-5. Mass of Technetium-99 Released to the Vadose Zone through 200-DV-1 OU Waste Sites and B-BX-BY Tank Farms in the B Complex Area



Note: This figure is based on mean values provided in RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

Figure 3-6. Mass of Uranium Released to the Vadose Zone through 200-DV-1 OU Waste Sites and B-BX-BY Tank Farms in the B Complex Area

In 1990, the 200-BP-1 OU RI/FS work plan (DOE/RL-88-32) was prepared and implemented for the geographic-based 200-BP-1 OU, which included the BY Cribs (216-B-43 through 216-B-50 Cribs) and the 216-B-57 Crib.

In 2001, an RI/FS work plan (DOE/RL-2000-38) was prepared for the process-based 200-TW-1 OU and 200-TW-2 OU. The RI/FS work plan included characterization of the 216-B-7A Crib and the 216-B-38 Crib, which were representative sites for the 200-TW-2 OU in the B Complex area.

Surface geophysics surveys were conducted over most of the 200-DV-1 OU waste sites in the B Complex area in 2007. The primary geophysical technique used was electrical resistivity. The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods. The results of the surface geophysical surveys are documented in RPP-34690, *Surface Geophysical Exploration of the B, BX, and BY Tank Farms at the Hanford Site*, and summarized in the information tables prepared to support the DQO process (Appendix C).

216-B-5 Reverse Well Investigations

In 1979 and 1980, a field investigation was conducted at the 216-B-5 Reverse Well to determine the spatial distribution of radionuclides sorbed on the sediments (RHO-ST-37, *216-B-5 Reverse Well Characterization Study*, p. iii). Three wells were drilled to basalt and another well was deepened to basalt, and then sampling and analysis were conducted for plutonium-239/240, cesium-137, and strontium-90. The results showed that plutonium-239/240 and strontium-90 exceeding 10 nCi/g were limited to within 6 m (19.7 ft) of the reverse well (RHO-ST-37, p. v). The cesium-137 distribution indicated that cesium-137 moved laterally away from the reverse well in a silt layer in the unsaturated sediment, at the position of the 1948 water table, and within the aquifer at the basalt surface.

A treatability test to evaluate P&T technology for remediation of 200-BP-5 OU groundwater was conducted from August 1994 through May 1995 (DOE/RL-95-59, *200-BP-5 Operable Unit Treatability Test Report*). One pilot-scale treatability test system was set up in close proximity to the 216-B-5 Reverse Well because the associated strontium-90, cesium-137, and plutonium-239/240 concentrations were identified as candidates for an interim response measure (DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*). Well 299-E28-23 was the extraction well, and Wells 299-E28-7 and 299-E28-25 were the injection wells. Aquifer pumping at the 216-B-5 site provided substantial quantities of groundwater containing significant concentrations of cesium-137 and strontium-90 and lesser quantities of plutonium-239/240, which had adsorbed to the sediments (Section 3.5 of DOE/RL-2010-74, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*).

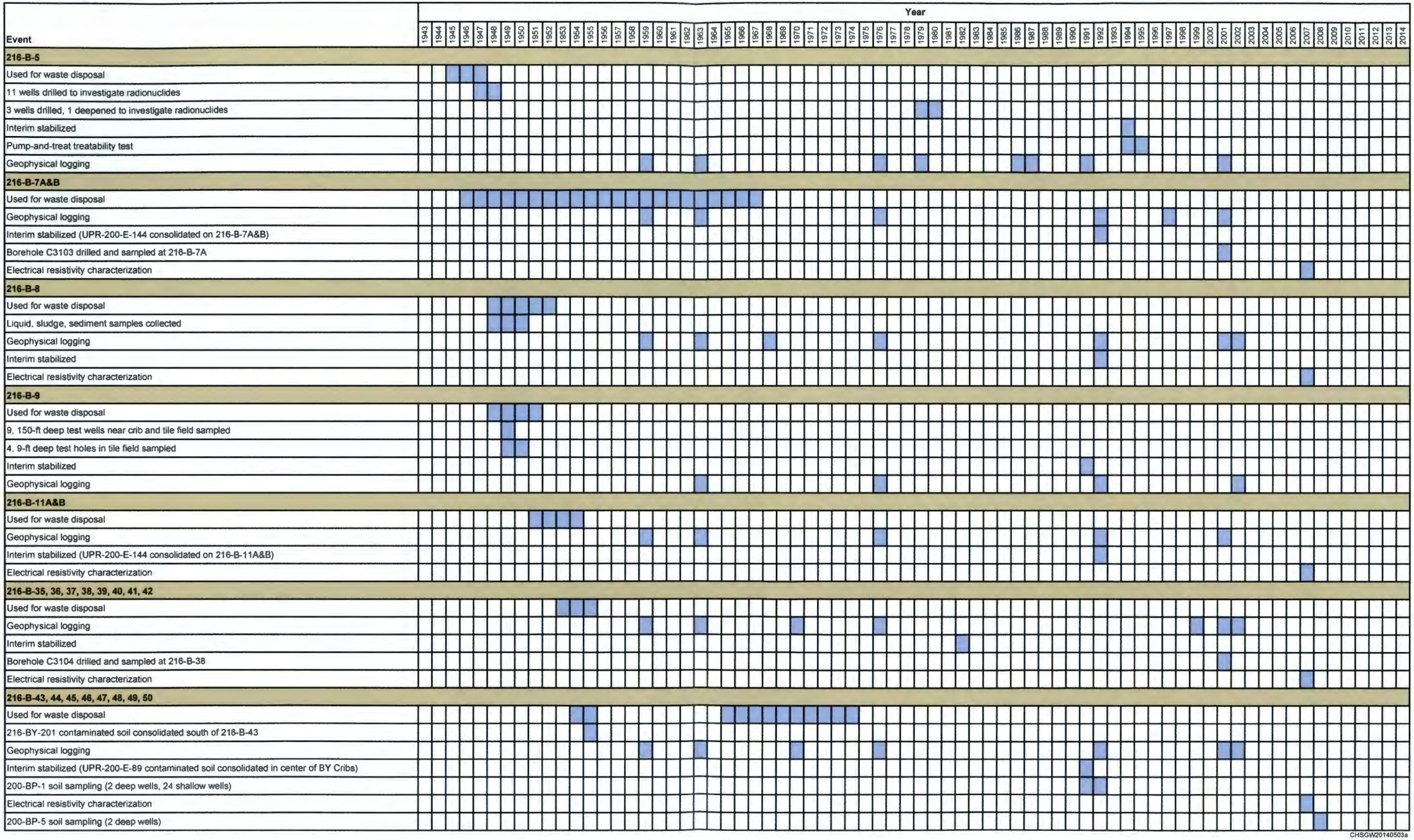


Figure 3-7. Timeline for B Complex Area Remediation and Monitoring Activities, 1943–2015 (sheet 1 of 2)

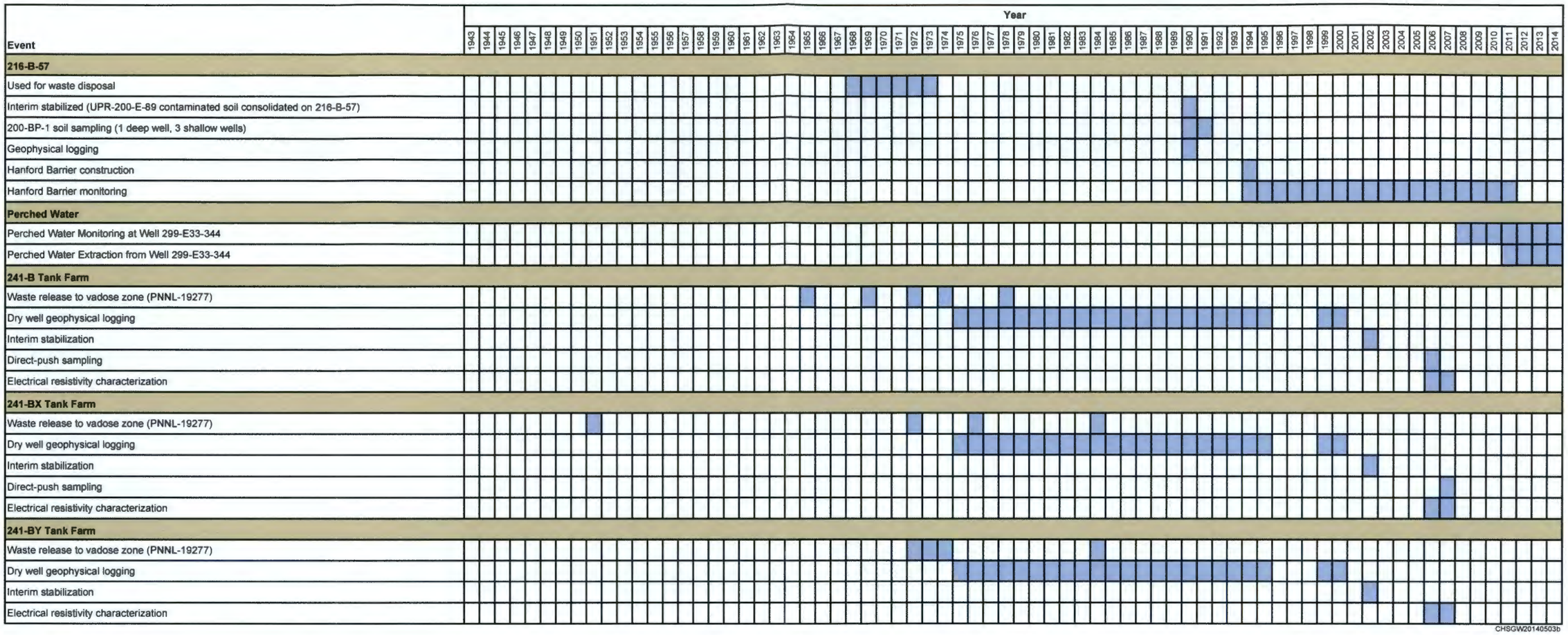


Figure 3-7. Timeline for B Complex Area Remediation and Monitoring Activities, 1943–2015 (sheet 2 of 2)

BY Cribs and 216-B-57 Crib Investigations

The BY Cribs (216-B-43 through 216-B-50 Cribs) and the 216-B-57 Crib were characterized in 1991 and 1992 in accordance with the 200-BP-1 OU RI/FS work plan (DOE/RL-88-32). Three boreholes were drilled and sampled in each of the eight BY Cribs to approximately 9 m (30 ft). Three boreholes were drilled and sampled through the 216-B-57 Crib to approximately 15 m (50 ft). Three of the wells (one at the 216-B-43 Crib, one at the 216-B-49 Crib, and one at the 216-B-57 Crib) were then deepened to approximately 70 m (230 ft) bgs, nearly to the water table. The rationale for drilling the deep wells in these three cribs is as follows (DOE/RL-88-32, Section 5.1.4):

> *Boreholes will be drilled through cribs 216-B-43, 216-B-49, and 216-B-57 to the water table (approximately 230 feet) ... It is anticipated that boring through vadose zone soils below these cribs will be adequate to represent soils below the other cribs that received waste effluents.*
>
> *The cribs were selected based on waste disposal history and location. Cribs 216-B-43 and 216-B-49 both received TBP supernatant waste. Crib 216-B-43 was selected because it was used for a brief period of time and received the smallest volume of waste (560,000 gallons). It should represent the lower limits of contaminant levels. Crib 216-B-49 received 1,770,000 gallons of waste and should represent the upper limits of contaminant levels. Crib 216-B-57 was selected because it received a larger volume of ITS condensate waste than did crib 216-B-50. The borehole locations selected will also provide three-dimensional information on subsurface stratification.*

The results of the 200-BP-1 OU RI at the BY Cribs and the 216-B-57 Crib are documented in DOE/RL-92-70, *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit*, and summarized in the information tables prepared to support the DQO process (Tables C-8 and C-9 in Appendix C).

Two groundwater wells (299-E33-341 and 299-E33-342) were drilled near, but outside the footprint of, the BY Cribs in 2008 as part of the 200-BP-5 OU RI because concentrations of technetium-99 and other co-contaminants in the groundwater beneath the BY Cribs had been increasing (Section 3.1.2 of PNNL-19277). The wells were drilled from ground surface to the water table and then down to the top of the basalt. During drilling, grab and core samples (more than 160 samples at each borehole) were retrieved, and selected samples were used for geochemical, hydrologic, and physical characterization. The results are documented in PNNL-19277 and were used to evaluate the lateral extent of vadose zone contamination associated with the BY Cribs in the information tables prepared to support the DQO process (Table C-8 in Appendix C).

The results indicate that mobile contaminants in waste fluids discharged to the 216-B-49 Crib migrated vertically to groundwater and laterally along fine-grained lenses within the Hanford formation sand (PNNL-19277, pp. 3.15 and 3.16). Mobile contaminants in the waste fluids discharged to the 216-B-43 Crib likely reached the water table in the past and are continuing to be a source today (PNNL-19277, p. 3.20).

BX Trenches Investigations

The 216-B-38 Trench was characterized in 2001 in accordance with the 200-TW-2 OU work plan (DOE/RL-2000-38). One well (C3104) was drilled through the eastern end of the 216-B-38 Trench to the water table at a depth of approximately 80 m (263 ft). Samples were collected at 10 intervals between 1.4 and 80.8 m (4.5 and 265 ft). The borehole location was chosen based on the results of spectral gamma logging at five direct-push locations. The five direct-push holes were placed along the center axis of the trench, distributed along the length of the trench, and pushed to approximately 18 m (60 ft). The gamma

logging showed that the three boreholes on the eastern half of the trench contained high concentrations of gamma emitters, but the two westernmost boreholes contained no detectable manmade gamma activity, except very near the ground surface (PNNL-19722, p. 3.54). The inlet to the trench was on the eastern end of the trench, and most of the disposed fluids percolated into the ground before reaching the far end of the trench.

The results of the 200-TW-2 OU RI at the 216-B-38 Trench are documented in DOE/RL-2002-42 and are summarized in the information tables prepared to support the DQO process (Table C-7 in Appendix C).

Based on sampling Well C3104, the bulk of the nitrate and the disposed fluids is found above 45.7 m (150 ft) bgs. The nitrate concentration in the sample at 60.5 m (198.75 ft) bgs, approximately 20.2 m (66.3 ft) above the water table, also was higher than Hanford background levels (PNNL-19722, p. 3.54).

216-B-7A&B Cribs Investigations

The 216-B-7A Crib was characterized in 2001 in accordance with the 200-TW-2 OU work plan (DOE/RL-2000-38). One borehole (C3103) was drilled through the approximate center of the 216-B-7A Crib to a depth of approximately 68 m (222.5 ft), approximately 7 m (23 ft) above the water table. Drilling was terminated when high moisture contents were encountered in a thick silt lens in the CCU. Sediment samples were collected at 10 depths, between 5.6 and 67.5 m (18.5 and 221.5 ft) bgs.

The results of the 200-TW-2 OU RI at the 216-B-7A Crib are documented in DOE/RL-2002-42 and are summarized in the information tables prepared to support the DQO process (Table C-3 in Appendix C). Additional analytical data for Borehole C3103 is provided in PNNL-14128, *Characterization of Vadose Zone Sediment: Borehole C3103 Located in the 216-B-7A Crib and Selected Samples from Borehole C3104 Located in the 216-B-38 Trench Near the BX Tank Farm*. The 216-B-7B Crib was not characterized.

The sediment characterization data show that the mobile and partially mobile constituents nitrate and fluoride are present within the Hanford formation below the 216-B-7A Crib, from 18 to 49 m (60 to 160 ft) and 9 to 29 m (30 to 95 ft) bgs, respectively. Both constituents show a sharp increase in concentration at 66.5 m (218 ft) bgs in the CCU_z. There is little to no technetium-99 in the sediments below the 216-B-7A Crib, and acid- and water-leachable uranium was found only at shallow depths in the sediment profile (PNNL-19277, p. 3.65).

Monitoring

Geophysical logging has been conducted since 1959 in vadose zone wells and boreholes associated with the 200-DV-1 OU waste sites in the B Complex area (Figure 3-7). The logging provides a vertical profile of subsurface gamma activity and is used to identify zones of contamination and changes in stratigraphy. Total gamma logs that record gamma activity were used until the early 1990s; spectral gamma logs, which identify individual gamma-emitting species, have been in use since then. Geophysical logging at 200-DV-1 OU waste sites in the B Complex area is summarized and interpreted in the following four waste site summary reports (Table 3-3):

- GJO-2002-322-TAR, *Hanford 200 Areas Spectral Gamma Baseline Characterization Project 216-B-35 to -42 Trenches Waste Site Summary Report* (for the 216-B-35 through 216-B-42 Trenches)
- GJO-2002-343-TAR, *Hanford 200 Areas Spectral Gamma Baseline Characterization Project 216-B-8 Crib and Adjacent Sites Waste Site Summary Report* (for the 216-B-7A&B Crib, 216-B-8 Crib and Tile Field, and 216-B-11A&B French Drains)

Table 3-3. Key Previous Documents for 200-DV-1 OU Waste Sites in the B Complex Area

Document Number	Document Title	Date Issued	Summary
HW-17088	*The Underground Disposal of Liquid Wastes at the Hanford Works, Washington*	February 1950	Describes the results of field investigations of the 216-B-5, 216-B-7A&B, 216-B-8, and 216-B-9 waste sites from 1947 to 1950.
RHO-ST-37	*216-B-5 Reverse Well Characterization Study*	November 1980	Describes the results of 1979 and 1980 characterization activities for the 216-B-5 Reverse Well.
DOE/RL-88-32, Rev. 1	*Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit, Hanford Site, Richland, Washington*	March 1990	Provides the plan for the characterization activities to be implemented in 1991 and 1992 at the BY Cribs and the 216-B-57 Crib, which at that time were located in the 200-BP-1 OU.
DOE/RL-92-70, Rev. 0	*Phase I Remedial Investigation Report for 200-BP-1 Operable Unit*	September 1993	Provides the results of the 1991-1992 RI at the BY Cribs and the 216-B-57 Crib, which at that time were in the 200-BP-1 OU.
DOE/RL-95-59, Rev. 0	*200-BP-5 Operable Unit Treatability Test Report*	June 1996	Summarizes the results of the 1994–1995 pilot-scale pump-and-treat treatability test conducted in groundwater contaminated by discharges to the 216-B-5 Reverse Well.
BHI-01356, Rev. 0	*Remedial Investigation Data Quality Objectives Summary Report for the 200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Units*	June 2000	Provides the results of the DQO process conducted for the 200-TW-1 and 200-TW-2 OU waste sites.
DOE/RL-2000-38, Rev. 0	*200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan*	February 2001	Provides the plan for characterization activities to be implemented in 2001 and 2002 at the 200-TW-1 and 200-TW-2 OU waste sites.
GJO-2002-322-TAR	*Hanford 200 Areas Spectral Gamma Baseline Characterization Project 216-B-35 to -42 Trenches Waste Site Summary Report*	May 2002	Provides data on gamma-emitting radionuclide contamination based on geophysical logging in wells at the 216-B-35 through 216-B-42 Trenches (BX Trenches).

Table 3-3. Key Previous Documents for 200-DV-1 OU Waste Sites in the B Complex Area

Document Number	Document Title	Date Issued	Summary
GJO-2002-343-TAR	*Hanford 200 Areas Spectral Gamma Baseline Characterization Project 216-B-8 Crib and Adjacent Sites Waste Site Summary Report*	August 2002	Provides data on gamma-emitting radionuclide contamination based on geophysical logging in wells at the 216-B-7A&B Cribs, the 216-B-8 Crib and Tile Field, and the 216-B-11A&B Reverse Wells.
GJO-2002-358-TAC	*Hanford 200 Area Spectral Gamma Baseline Characterization Project 216-B-5 Injection Well and 216-B-9 Crib and Tile Field Waste Site Summary Report*	November 2002	Provides data on gamma-emitting radionuclide contamination based on geophysical logging in wells at the 216-B-5 Reverse Well and 216-B-9 Crib and Tile Field.
GJO-2003-458-TAC	*Hanford 200 Areas Spectral Gamma Baseline Characterization Project 216-B-43 to -50, -57, and -61 Cribs and Adjacent Sites Waste Site Summary Report*	August 2003	Provides data on gamma-emitting radionuclide contamination based on geophysical logging in wells at the 216-B-43 through 216-B-50 Cribs (BY Cribs) and the 216-B-57 Crib.
PNNL-14128	*Characterization of Vadose Zone Sediment: Borehole C3103 Located in the 216-B-7A Crib and Selected Samples from Borehole C3104 Located in the 216-B-38 Trench Near the BX Tank Farm*	December 2002	Contains the results of geochemical and physical characterization conducted by Pacific Northwest Laboratory on vadose zone sediment samples recovered from Borehole C3103 (in the 216-B-7A Crib) and a few sediment samples from Borehole C3104 (in the 216-B-38 Trench).
DOE/RL-2002-42, Rev. 0	*Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*	April 2003	Contains the analytical results for sediment samples collected from Borehole C3102 in the 216-T-26 Crib, Borehole C3103 in the 216-B-7A Crib, and Borehole C3104 in the 216-B-38 Trench as part of the RI in 2001 for the 200-TW-1 and 200-TW-2 OUs.
DOE/RL-2003-64, Draft A Reissue	*Feasibility Study for the 200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product Rich Waste Group Operable Units*	March 2004	Provides the draft results of the feasibility study for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites.

Table 3-3. Key Previous Documents for 200-DV-1 OU Waste Sites in the B Complex Area

Document Number	Document Title	Date Issued	Summary
DOE/RL-2004-10, Draft A Reissue	*Proposed Plan for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product Rich Waste Group Operable Units*	March 2004	Provides the draft Proposed Plan for the 200-TW-1, 200-TW-2, and 200-PW-5 OU waste sites.
RPP-26744, Rev. 0	*Hanford Soil Inventory Model, Rev. 1*	September 2005	Describes the SIM, a probabilistic approach used to estimate the inventory of contaminants that were released to the soil during the Hanford Site production mission. The SIM generated inventory and uncertainty estimates for 46 radionuclides and 29 chemicals at the 200-DV-1 OU waste sites.
RPP-34690, Rev. 0	*Surface Geophysical Exploration of the B, BX, and BY Tank Farms at the Hanford Site*	September 2007	Documents the results of surface geophysical exploration activities performed during FY 2007 for the B-BX-BY Tank Farms and surrounding areas (referred to as B Complex).
DOE/RL-2007-02, Rev. 0	*Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units*	November 2007	Provides the detailed sampling plans for collecting additional characterization data at waste sites on the Central Plateau. The sampling plans were developed following a supplemental DQO process conducted by the Tri-Parties in FY 2005 and FY 2006. The waste sites evaluated in the supplemental DQO process included all of the 200-DV-1 OU waste sites in the B Complex area.
PNNL-19277	*Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*	July 2010	Provides the conceptual models that describe the migration of contaminants from sources in the B Complex area that impact groundwater. The waste sites evaluated in the report included all but two (216-B-5, 216-B-9) of the 200-DV-1 OU waste sites in the B Complex area. The conceptual models are based on a thorough review of available data on disposal history, waste site construction, vadose zone sediment and pore water data, groundwater plume information, borehole geophysical logging results, and field electrical resistivity information. This report, and by reference all of the supporting reports and data, is considered the primary reference for the 200-DV-1 OU waste sites in the B Complex area.

Table 3-3. Key Previous Documents for 200-DV-1 OU Waste Sites in the B Complex Area

Document Number	Document Title	Date Issued	Summary
SGW-46352, Rev. 0	*Data Quality Assessment Report for Vadose Zone Samples Collected during Drilling of Wells 299-E24-25, 299-E28-30, 299-E29-54, 299-E33-205, 299-E33-342, 299-E33-343, and 299-E33-344 in the 200 East Area*	September 2010	Provides the analytical data for vadose zone soil samples collected from seven boreholes (including Borehole 299-E33-342 near the 216-B-43 Crib and Borehole 299-E33-344 near the 216-B-7A Crib) drilled during the RI for the 200-BP-5 OU. The report also summarizes the data validation and data quality assessment activities associated with these analyses.
DOE/RL-2011-40, Rev.0	*Field Test Plan for the Perched Water Pumping/Pore Water Extraction Treatability Test*	December 2011	Describes the methodologies that will be used to evaluate perched water pumping/pore water extraction as a potential remedy for protecting groundwater from deep vadose zone contamination.
PNNL-22499	*Perched-Water Evaluation for the Deep Vadose Zone Beneath the B, BX, and BY Tank Farms Area of the Hanford Site*	June 2013	Provides an assessment of the perched water in terms of estimating flux from the perched water zone to the groundwater.
DOE/RL-2013-37, Rev. 0	*Engineering Evaluation/Cost Analysis for Perched Water Pumping/Pore Water Extraction*	January 2014	Evaluates alternatives for extraction of perched water as a non-time-critical removal action.
SGW-53604, Rev. 1	*Path Forward Recommendations Report for the Uranium Contamination in the B Area*	December 2013	Provides the conceptual site model for the perched water zone and summarizes the results of perched water extraction. The report also provided recommendations for additional characterization and remediation of the perched water zone as part of the 200-DV-1 OU RI.
DOE/RL-2014-34, Rev. 0	*Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*	December 2014	Documents the decision to transition the perched water pumping from a treatability test to a non-time-critical removal action.

DQO = data quality objective
FY = fiscal year
OU = operable unit
RI = remedial investigation
SIM = Soil Inventory Model (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*)
Tri-Parties = U.S. Department of Energy, Washington State Department of Ecology, and U.S. Environmental Protection Agency

- GJO-2002-358-TAC, *Hanford 200 Area Spectral Gamma Baseline Characterization Project 216-B-5 Injection Well and 216-B-9 Crib and Tile Field Waste Site Summary Report* (for the 216-B-5 Injection Well and 216-B-9 Crib and Tile Field)

- GJO-2003-458-TAC, *Hanford 200 Areas Spectral Gamma Baseline Characterization Project 216-B-43 to -50, -57, and -61 Cribs and Adjacent Sites Waste Site Summary Report* (for the 216-B-43 through 216-B-50 Cribs and the 216-B-57 Crib)

The data are summarized in the information tables prepared to support the DQO process (Appendix C).

Remediation

All of the 200-DV-1 OU waste sites in the B Complex area have been interim stabilized. The BX Trenches were stabilized in 1982; the other waste sites were stabilized between 1991 and 1994 (Figure 3-7). Interim stabilization typically included covering the site with 46 to 61 cm (18 to 24 in.) of uncontaminated soil. At some waste sites (e.g., 216-B-7, 216-B-11, and the BY Cribs) nearby contaminated surface soil was consolidated on the surface of the waste site before the uncontaminated soil cover was added.

In 1994, the Hanford prototype barrier was installed over the 216-B-57 Crib. The barrier is 105 m (340 ft) long, 64 m (210 ft) wide, and 7.9 m (26 ft) thick. The barrier was constructed as a treatability test to obtain information on the cost and performance of the barrier (DOE/RL-2003-64, *Feasibility Study for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product Rich Waste Group Operable Units*, p. 2-63; PNNL-19277, p. 3.27).

Extraction of contaminated perched water from the perched water zone north of B Tank Farm and east of the BX-BY Tank Farms began in August 2011 using a perched water extraction system installed in Well 299-E33-344. Perched water pumping from Well 299-E33-344 has continued in accordance with DOE/RL-2011-40, *Field Test Plan for the Perched Water Pumping/Pore Water Extraction Treatability Test*. As of September 30, 2014, approximately 882,000 L (233,000 gal) of perched water containing approximately 49 kg of uranium, 1.7 g of technetium-99, and 471 kg of nitrate have been removed from the perched zone (SGW-58147, *Annual Performance Report for the 200-DV-1 Operable Unit Perched Water Extraction, Fiscal Year 2014*). The perched water zone, which is part of the 200-DV-1 OU, is in the vadose zone above the main water table aquifer. The aquifer is in the 200-BP-5 OU. Under the treatability test plan, contaminated water is being treated at the Effluent Treatment Facility. The treatability test has been successful, and perched water extraction is being transitioned to a non-time-critical removal action to continue the removal of contaminated water before it reaches the groundwater.

3.2.3.2 B-BX-BY Tank Farms

The subsurface conditions description for WMA B-BX-BY, provided in HNF-5507 and HNF-2603, *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination*, summarizes the available investigation and monitoring information for the B-BX-BY Tank Farms as of 2000 (Table 3-4). This historical information was used in a set of DQO processes to identify data gaps. The data gaps were filled by field investigations conducted in 2001 and 2002 in accordance with RPP-6072, *Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA B-BX-BY*. The results of these field investigations are documented in RPP-10098. Major field investigations included drilling and sampling a new borehole (299-E33-45) east of Tank BX-102 through a known uranium plume; drilling and sampling a new borehole (299-E33-46) northeast of Tank B-110 through a suspected strontium-90 plume; collecting samples from the CERCLA RI boreholes installed in the 216-B-38 Trench and the 216-B-7A Crib; collecting supplemental vadose zone characterization samples during installation of RCRA groundwater

monitoring Well 299-E33-338 at the southeast corner of the B Tank Farm; and performing vadose zone flow and transport experiments at the 299-E24-111 experimental test well (Sisson and Lu site), approximately 1.61 km (1 mi) southeast of the B-BX-BY Tank Farms (RPP-10098, p. vii).

The results of additional field investigations and analyses conducted between 2002 and 2007 are provided in DOE/ORP-2008-01, *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*.

Surface geophysical exploration was performed across the B-BX-BY Tank Farms and adjacent waste sites between October 2006 and September 2007. Inside the tank farms, fieldwork included ground-penetrating radar surveys to confirm the location of subsurface features, as well as resistivity surveys. The results were documented in RPP-34690 (DOE/ORP-2008-01, Section 6.3.1).

Direct-push probes in the B and BX Tank Farms were advanced in June and July 2006 and in January 2007, respectively, using the hydraulic hammer unit and were placed to investigate the 1951 BX-102 Tank overfill release, a contaminated region identified by spectral gamma logging around the BX-110 Tank, and the subsurface around the diversion boxes in the B Tank Farm. Geophysical logging results for the borings in the B and BX Tank Farms are documented in RPP-34622. *Small Diameter Geophysical Logging in the 241-B Tank Farm*, and RPP-34623, *Small Diameter Geophysical Logging in the 241-BX Tank Farm*, respectively. Results for the laboratory analyses of sediment samples collected from the direct pushes are provided in PNNL-17162, *Characterization of Direct-Push Vadose Zone Sediments from the 241-B and 241-BX Tank Farms*. As part of the investigation, electrodes were placed at depth to support the subsequent surface geophysical exploration investigation (DOE/ORP-2008-01, Section 6.3.2).

As part of the 200-BP-5 OU RI, Wells 299-E33-343, 299-E33-344, and 299-E33-345 were drilled and sampled in 2008 to provide additional information on the lateral extent and source of localized uranium contamination in the DVZ and to characterize the low-permeability zones in the vadose zone that might influence vertical and lateral spreading of contamination (DOE/RL-2007-18, *Remedial Investigation/ Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit*, Section 5.2.1). All three wells are located north of the B Tank Farm, between the BX Tank Farm and the 216-B-7A&B Cribs. The sampling results and uranium isotopic signatures indicate that uranium from the 241-BX-102 release has migrated northeast from the tank to the locations of these wells (Sections 3.4.2, 3.4.3, 9.3, and 9.8 of PNNL-19277). Well 299-E33-344 is being used to remove perched water from the DVZ (Section 3.2.3.1 in this report).

Vadose zone boreholes, commonly referred to as dry monitoring boreholes, were used to remotely monitor the contamination in the soils at the B-BX-BY Tank Farms. From 1975 to 1995, detectors that measured only the total amount of gamma (or gross) radiation were used. Analyses of the gross-gamma logs for drywells in the B-BX-BY Tank Farms are provided in HNF-5433, *Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-B Tank Farm – 200 East*; HNF-3531, *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm*; and HNF-3532, *Analysis of Historical Gross Gamma Logging Data from BY Tank Farm*. In the late 1990s, the measurement of gamma radiation in the boreholes was resumed using spectral gamma detectors.

Table 3-4. Key Previous Documents for B-BX-BY Tank Farms in the B Complex Area

Document Number	Document Title	Date Issued	Summary
GJO-96-2-TAR/ GJO-HAN-6	*Vadose Zone Characterization Project at the Hanford Tank Farms: BY Tank Farm Report*	February 1997	Provides analyses of the spectral gamma logs for drywells in the BY Tank Farm.
GJO-98-40-TAR/ GJO-HAN-19	*Vadose Zone Characterization Project at the Hanford Tank Farms: BX Tank Farm Report*	August 1998	Provides analyses of the spectral gamma logs for drywells in the BX Tank Farm.
GJO-99-113-TAR/ GJO-HAN-28	*Vadose Zone Characterization Project at the Hanford Tank Farms: B Tank Farm Report*	March 1999	Provides analyses of the spectral gamma logs for drywells in the B Tank Farm.
HNF-3531, Rev. 0	*Analysis of Historical Gross Gamma Logging Data from BX Tank Farm*	October 1999	Provides analyses of the gross gamma logs for drywells in the BX Tank Farm.
HNF-3532, Rev. 0	*Analysis of Historical Gross Gamma Logging Data from BY Tank Farm*	October 1999	Provides analyses of the gross gamma logs for drywells in the BY Tank Farm.
HNF-5433, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-B Tank Farm – 200 East*	June 2000	Provides analyses of the gross gamma logs for drywells in the B Tank Farm.
HNF-2603, Rev. 0	*A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination*	December 1998	Presents the 1998 conceptual understanding of impacts of unplanned releases of tank waste into the vadose zone as a basis for developing more detailed conceptual models during site-specific planning activities.
HNF-5231, Rev. 0	*Historical Vadose Zone Contamination from B, BX, BY Tank Farm Operations*	September 1999	Compiles historical information regarding radioactive contamination of the soil surface and vadose zone for tank farms, liquid waste disposal sites, and unplanned releases near the B-BX-BY Tank Farms.

Table 3-4. Key Previous Documents for B-BX-BY Tank Farms in the B Complex Area

Document Number	Document Title	Date Issued	Summary
HNF-5507, Rev. 0	*Subsurface Conditions Description for the B-BX-BY Waste Management Area*	March 2000	Discusses subsurface conditions relevant to the occurrence and migration of contamination from the B-BX-BY Tank Farms to the underlying groundwater. The report, which summarizes the available investigation and monitoring information for the B-BX-BY Tank Farms as of 2000, was used during the data quality objective process to identify data gaps for the Phase 1 RFI/CMS work plan (RPP-6072).
RPP-6072, Rev. 1	*Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA B-BX-BY*	September 2000	Provides the plan for the characterization activities to be implemented in 2001 and 2002 at the B-BX-BY Tank Farms to support RFI/CMS decision making.
RPP-10098, Rev. 0	*Field Investigation Report for Waste Management Area B-BX-BY*	December 2002	Provides the results of the characterization activities implemented in 2001 and 2002 at the B-BX-BY Tank Farms to support RFI/CMS decision making.
RPP-34622, Rev. 0	*Small Diameter Geophysical Logging in the 241-B Tank Farm*	April 2007	Provides the geophysical logging results for the direct-push probes advanced in the B Tank Farm in January 2007.
RPP-34623, Rev. 0	*Small Diameter Geophysical Logging in the 241-BX Tank Farm*	April 2007	Provides the geophysical logging results for the direct-push probes advanced in the BX Tank Farm in June and July 2006.
PNNL-17162	*Characterization of Direct-Push Vadose Zone Sediments from the 241-B and 241-BX Tank Farms*	December 2007	Provides the geochemical analytical results and interpretation for sediment samples collected from the direct-push probes advanced in the BX Tank Farm in June and July 2006 and in the B Tank Farm in January 2007.
RPP-34674, Rev. 0	*Surface Geophysical Exploration of the B, BX, and BY Tank Farms at the Hanford Site: Results of Background Characterization with Ground-Penetrating Radar*	September 2007	Documents the results of ground-penetrating radar surveys conducted as part of the surface geophysical exploration activities performed during FY 2007 for the B-BX-BY Tank Farms.
RPP-34690, Rev. 0	*Surface Geophysical Exploration of the B, BX, and BY Tank Farms at the Hanford Site*	September 2007	Documents the results of surface geophysical exploration activities performed during FY 2007 for the B-BX-BY Tank Farms and surrounding areas (referred to as B Complex).

Table 3-4. Key Previous Documents for B-BX-BY Tank Farms in the B Complex Area

Document Number	Document Title	Date Issued	Summary
DOE/ORP-2008-01, Rev. 1	*RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*	July 2009	Integrates the results of data-gathering activities and evaluations for all Hanford Site single-shell tank WMAs with conclusions and recommendations, including data and information obtained after the publication of the field investigation report for WMA B-BX-BY.
RPP-RPT-43704, Rev. 0A	*Hanford BY-Farm Leak Assessments Report*	February 2011	Documents reassessment of past leaks in the BY Tank Farm.
RPP-RPT-47562, Rev. 0	*Hanford BX-Farm Leak Assessments Report*	February 2011	Documents reassessment of past leaks in the BX Tank Farm.
RPP-RPT-49089, Rev. 0	*Hanford B-Farm Leak Assessments Report*	September 2011	Documents reassessment of past leaks in the BY Tank Farm.

CMS = corrective measures study
FY = fiscal year
RFI = RCRA facility investigation
WMA = waste management area

Analyses of the spectral gamma logs for drywells in the B Tank Farm are provided in GJO-99-113-TAR/GJO-HAN-28, *Vadose Zone Characterization Project at the Hanford Tank Farms B Tank Farm Report*. Analyses of the spectral gamma logs for drywells in the BX Tank Farm are provided in GJO-98-40-TAR/GJO-HAN-19, *Vadose Zone Characterization Project at the Hanford Tank Farms BX Tank Farm Report*. Analyses of the spectral gamma logs for drywells in the BY Tank Farm are provided in GJO-96-2-TAR/GJO-HAN-6, *Vadose Zone Characterization Project at the Hanford Tank Farms BY Tank Farm Report* (DOE/ORP-2008-01, Section 5.2.3).

Past leaks in the B-BX-BY Tank Farms were reassessed in 2011 and are documented in the leak assessment reports (RPP-RPT-49089, RPP-RPT-47562, and RPP-RPT-43704).

Previous investigations at the tank farms also included laboratory studies to improve the understanding of the fate of radionuclides during waste processing and, as a result, during waste disposal. During bismuth phosphate operations, it was assumed that 90 percent of the technetium went with the metal waste stream (which was sent to SSTs), and 10 percent went with the 1C and 2C waste streams (which were discharged to cribs and trenches). This assumption was based on gross-beta analyses of batches of the various waste streams and the assumption that all beta emitters would act similarly during the process steps. Based on simulations of the bismuth phosphate process at Pacific Northwest National Laboratory (PNNL) in 2007 (PNNL-14120, *Laboratory-Scale Bismuth Phosphate Extraction Process Simulation to Track Fate of Fission Products*), greater than 97 percent of the technetium would have been in the metal waste solutions sent to the SSTs, and 1 percent or less would have been in the waste streams sent directly to cribs and trenches (DOE/ORP-2008-01, Section 5.4.5).

Tanks at the B-BX-BY Tank Farms were interim stabilized beginning in 1975 (HNF-5231). During interim stabilization, all supernate and as much drainable liquid as possible were removed. Beginning in 1980, the tanks at the B-BX-BY Tank Farms were interim isolated by establishing at least one physical barrier between the tank contents and the environment to preclude inadvertent addition of liquid. Interim isolation was accomplished by cutting and blanking all process piping to and from the tanks, blanking all risers, and equipping the tanks with filtered ventilation systems.

Interim measures to minimize infiltration and migration to groundwater were evaluated and implemented at the B-BX-BY Tank Farms in 2002. Active water lines were leak tested. A valve associated with the Hanford barrier test plot was repaired and returned to service. No leaks in the tank farm area were detected. Other lines were determined not to be needed and were abandoned, effectively removing them as sources of inadvertent recharge (RPP-10098, p. xv and Section 5.1.1). Existing drywells were capped to prevent water intrusion (RPP-10098, p. xv). Design and construction of run-on control structures were implemented adjacent to the B-BX-BY Tank Farms. Berms were placed to redirect surface water away from the tank farm surface, and curbs and gutters were placed to redirect anticipated run-off from the paved road (Baltimore Avenue) (RPP-10098, Section 5.1.3).

3.2.4 Nature and Extent of Contamination in the B Complex Area

This section describes the current understanding of the nature and extent of contamination as it exists in the B Complex area. The nature and extent of contamination are evaluated on a site-by-site basis to support assessment of potential risks, to support initial identification and evaluation of potential remedial alternatives for each waste site, and to identify data needs. Using waste site-specific information and the physical site data, this section provides a preliminary understanding and estimate of the locations of contaminants that may have migrated from a waste site. Data needs for the 200-DV-1 OU waste sites will be addressed during the RI in accordance with this work plan and associated SAP. The preliminary understanding of the nature and extent of contamination will be refined in the RI report using the information collected during the investigation.

For each waste site, the nature and extent of contamination is evaluated for two zones: (1) the upper 4.6 m (15 ft) bgs to support assessment of risk to HHE, and (2) the vadose zone to support assessment of groundwater risk to HHE. The results of these evaluations are summarized below based on the information tables prepared to support the DQO process (Appendix C). Table 3-5 identifies the vertical location of contamination at each waste site with respect to the upper 4.6 m (15 ft) of the vadose zone, 4.6 m (15 ft) bgs to groundwater, and groundwater.

Table 3-5. Vertical Contamination at 200-DV-1 OU Waste Sites in the B Complex Area

Waste Site	Contamination in Upper 4.6 m (15 ft)	Contamination from 4.6 m (15 ft) to Groundwater	Contamination in Groundwater
216-B-5	No	Yes	Yes
216-B-7A&B	Yes	Yes	Yes
216-B-8	Yes	Yes	Yes
216-B-9	Yes	Yes	No
216-B-11A&B	Yes	Yes	Yes
216-BX Trenches	Yes	Yes	No
216-BY Cribs	Yes	Yes	Yes
216-B-57	No*	Yes	No

Source: 200-DV-1 Operable Unit data quality objectives summary report (Appendix C).

* The barrier constructed over the 216-B-57 Crib is greater than 4.6 m (15 ft) thick.

Cesium-137, a gamma-emitting radionuclide, is a common and relatively immobile contaminant in the liquids discharged to the 200-DV-1 OU waste sites. It can be identified and quantified in the subsurface adjacent to boreholes using downhole spectral gamma logging instruments. Because borehole logging data have been collected from 0 to 4.6 m (0 to 15 ft) at many waste sites, the presence of elevated cesium-137 concentrations near the surface is an initial indicator of the likelihood that a remedial action could be needed for the shallow vadose zone at these waste sites.

Mobile contaminants discharged to the 200-DV-1 OU waste sites in the B Complex include technetium-99, cobalt-60, chromium, uranium, and nitrate. In general, the presence of elevated concentrations of these contaminants in the DVZ is an indicator of the likelihood that an action will be needed to remediate the DVZ at the waste sites. The evaluation of the mobile contaminants at the 200-DV-1 OU waste sites in the B Complex (with the exception of the 216-B-5 Reverse Well and the 216-B-9 Crib and Tile Field) is taken from PNNL-19277.

The likelihood that contaminants from the 200-DV-1 OU waste sites have affected groundwater in the past or may be affecting groundwater currently and/or in the future is summarized in Table 3-6. The perched water is currently affecting groundwater.

Table 3-6. Impact of 200-DV-1 OU Waste Sites in the B Complex Area on Underlying Groundwater

200-DV-1 OU Waste Site	Past Groundwater Impact Likely?	Current Groundwater Impact Likely?	Future Groundwater Impact Likely?
216-B-5 Reverse Well	●	○	○
216-B-7A&B Cribs	●	●	●
216-B-8 Crib and Tile Field	●	●	●
216-B-9 Crib and Tile Field	○	○	○
216-B-11A&B French Drains	●	○	○
216-BX Trenches	○	○	○
216-BY Cribs	●	●	●
216-B-57 Crib	○	○	○

Note: This table is based on PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex.*

○ = groundwater impact unlikely
● = groundwater impact likely
OU = operable unit

216-B-5 Reverse Well

Because the perforations in the 216-B-5 Reverse Well begin at 76.8 m (252 ft) bgs, contamination release from the 216-B-5 waste site is unlikely in the upper 4.6 m (15 ft) of the subsurface. Low levels (less than 1 pCi/g) of cesium-137 that were detected in the upper 4.6 m (15 ft) at two wells (299-E28-7 and 299-E28-25) within 22.8 m (75 ft) of the 216-B-5 Reverse Well do not appear related to reverse well discharges. The contamination is believed to occur inside one of the casing strings and was likely "dragged up" during well drilling (GJO-2002-358-TAC, p. 24).

Contamination from the 216-B-5 Reverse Well is present in the sediments in the DVZ and unconfined aquifer at depths corresponding to the depths of the perforated interval in the reverse well (RHO-ST-37). Analytical results for plutonium-239/240, americium-241, cesium-137, and strontium-90 are available for sediment samples collected in 1980 from four wells within 22.8 m (75 ft) of the 216-B-5 Reverse Well (RHO-ST-37, Appendix A). Of the four wells, Well 299-E28-23 is the closest to the 216-B-5 Reverse Well, located approximately 1.8 m (6 ft) to the southeast. The maximum concentrations were detected in samples from Well 299-E28-23 (Table 3-7). The lateral and vertical extent of plutonium-239/240 is shown in Figure 3-8.

During use of the reverse well from 1945 to 1947, the perforated interval extended into the unconfined aquifer. Waste discharges to 216-B-5 Reverse Well have resulted in contamination of the groundwater by relatively immobile contaminants such as plutonium-239/240, strontium-90, and cesium-137.

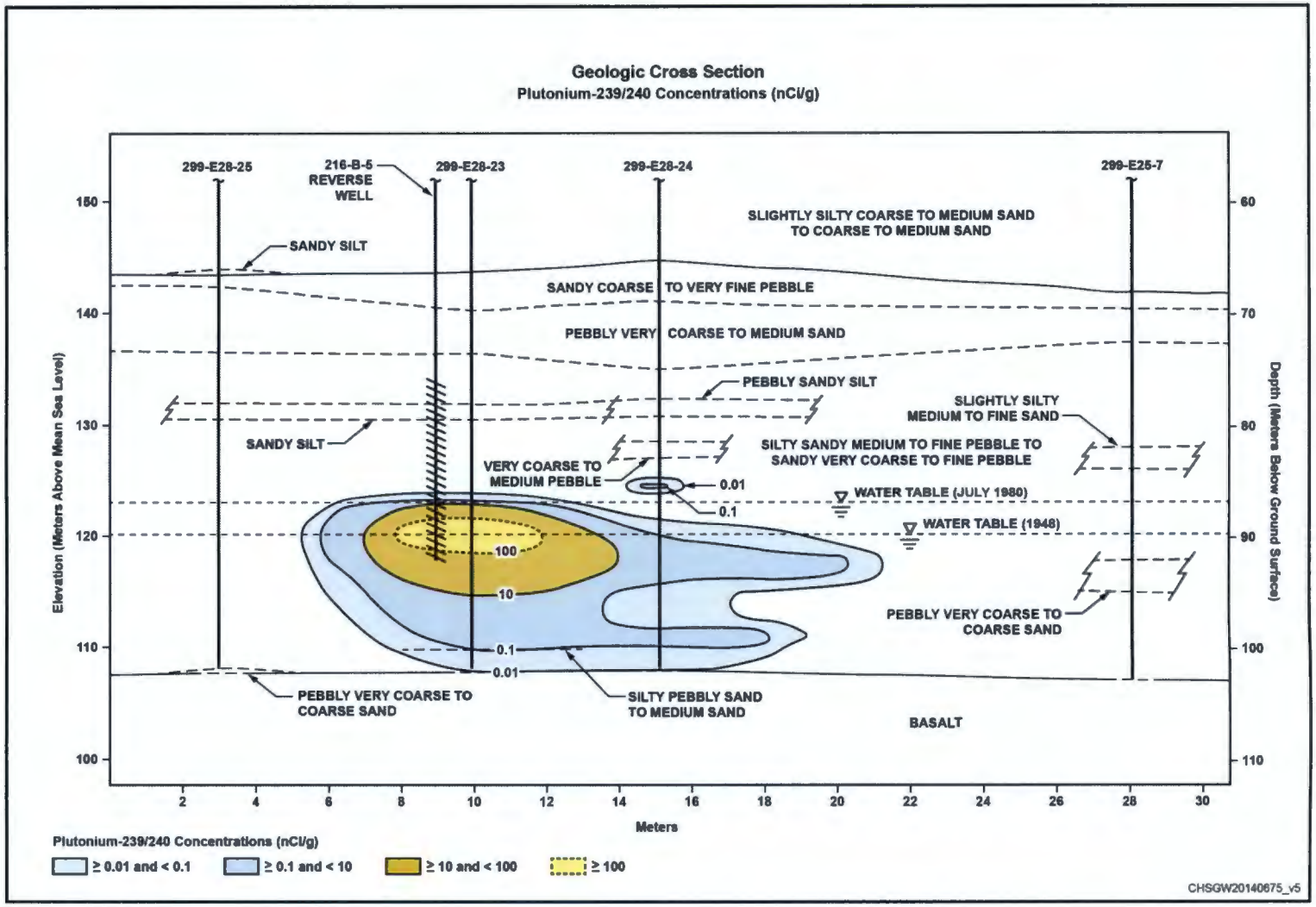
Table 3-7. Nature and Vertical Extent of Contamination at the 216-B-5 Reverse Well

Contaminant	Maximum Depth Observed (m [ft] bgs)	Concentration at Maximum Depth (nCi/g)	Location of Maximum Depth	Maximum Concentration Observed (nCi/g)	Depth of Maximum Concentration (m bgs)	Location of Maximum Concentration
Cesium-137	103.6 [400]	1.36E-02	299-E28-7	5.13E+01	86.6 [284]	299-E28-23
Strontium-90	100.6 [300]	1.45E-03	299-E28-7	6.03E+01	86.6 [284]	299-E28-23
		9.05E-02	299-E28-23			
Plutonium-239/240	102.1 [335]	1.84E-03	299-E28-7	7.50E+01	88.1 [289]	299-E28-23
Americium-241	102.1 [335]	5.83E-05	299-E28-7	2.54E+00	89.5 [294]	299-E28-23

Source: RHO-ST-37, *216-B-5 Reverse Well Characterization Study*, Appendix A.

Note: Depth to water in Well 299-E28-23 was 88.37 m (290 ft) bgs on January 6, 2011.

bgs = below ground surface



Source: RHO-ST-37, *216-B-5 Reverse Well Characterization Study*, Figure 22.

Figure 3-8. Lateral and Vertical Extent of Plutonium-239/240 Contamination at the 216-B-5 Reverse Well

216-B-7A&B Cribs

Borehole C3103 was drilled and sampled near the center of the 216-B-7A Crib in 2001 (Figure 3-9). The maximum soil concentration for cesium-137 in the upper 4.6 m (15 ft) was 42.5 pCi/g in the sample from 1.7 to 2.4 m (5.5 to 8 ft) (DOE/RL-2002-42). Based on geophysical logging, the maximum cesium-137 concentration in the upper 4.6 m (15 ft) was approximately 40 pCi/g at Borehole C3103 (216-B-7A) and approximately 50 pCi/g at Well 299-E33-75 (216-B-7B) (BHI-01607, *Borehole Summary Report for Boreholes C3103 and C3104, and Drive Casings C3340, C3341, C3342, C3343, and C3344, in the 216-B-38 Trench and 216-B-7A Crib, 200-TW-2 Tank Waste Group Operable Unit*; GJO-2002-343-TAR) (Figure 3-9). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the 216-B-7A&B Cribs.

Contamination from the 216-B-7A&B Cribs is present in the sediments in the DVZ. At the 216-B-7A Crib, Borehole C3103 was drilled to 67.8 m (222.5 ft) bgs, approximately 7 m (23 ft) above the water table (drilling was terminated when high-moisture contents were encountered in a thick silt lens in the CCU). Sediment samples were collected at 10 depths between 5.6 and 67.5 m (18.5 and 221.5 ft) bgs. Analytical data for Borehole C3103 are provided in DOE/RL-2002-42 and PNNL-14128. The maximum sediment concentrations and maximum observed depths for key constituents are summarized in Table 3-8 (based on data from Tables C-12, C-13, and C-14 in DOE/RL-2002-42).

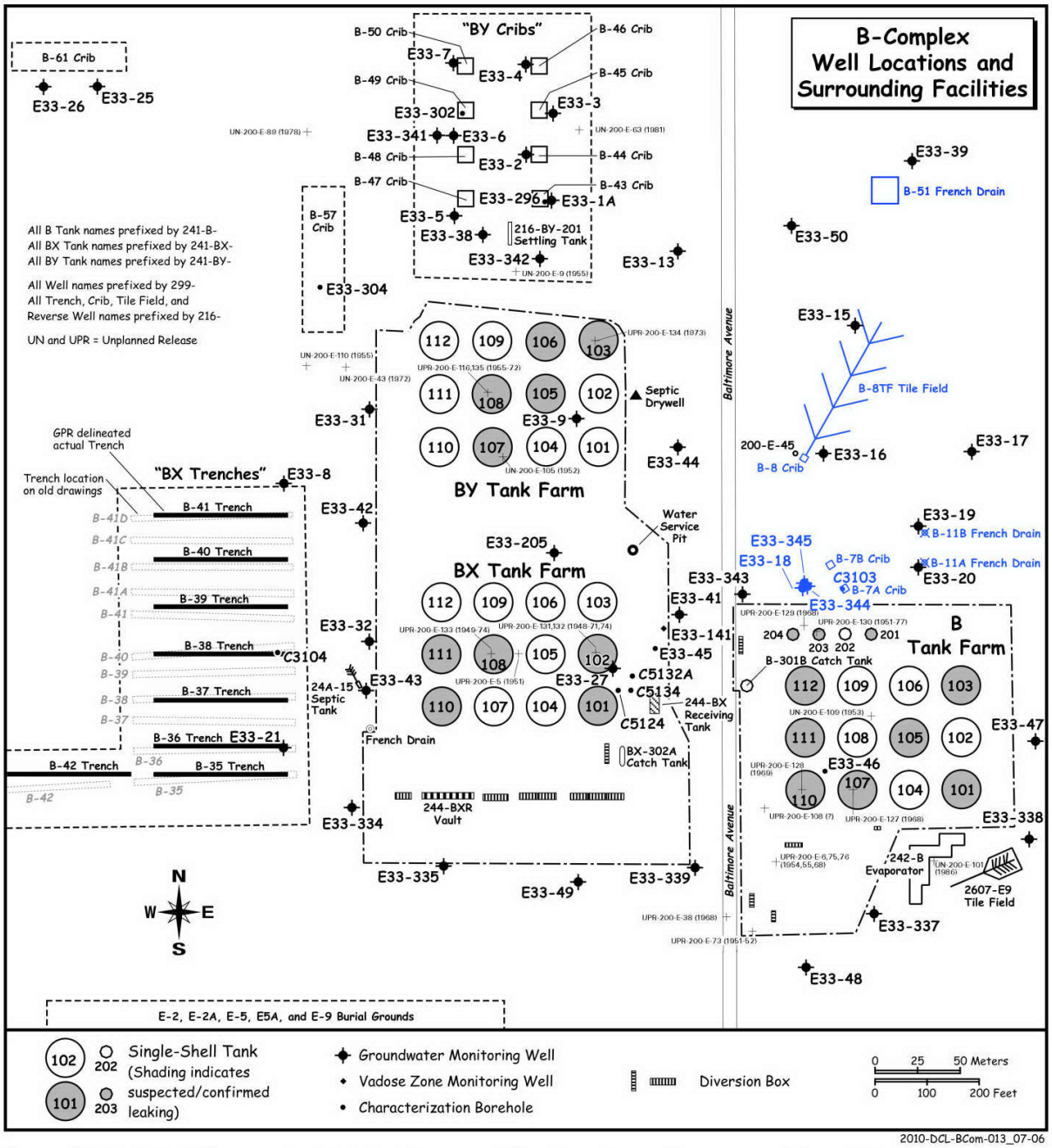
Liquid waste disposed to the 216-B-7A&B Cribs reached the groundwater soon after the beginning of disposal operations in 1946, and it is currently a source for some of the contamination found in the CCU. The observed fluoride and chromium in the CCU_z pore water, and the chromium in the vicinity groundwater, indicate that wastewater from the 216-B-7A&B Crib (and/or the 216-B-8 Crib and Tile Field) is present in the CCU_z. The uranium isotopic data suggest that 216-B-7A&B is not a significant contributor to uranium found in the groundwater (PNNL-19277, pp. 9.8 and 9.9).

Fluoride is present at elevated concentrations in the CCU sediments southwest of the 216-B-7A&B Cribs at Wells 299-E33-344 and 299-E33-345 (PNNL-19277, p. 9.9) (Figure 3-9). Cesium-137 contamination was detected at boreholes to the north (299-E33-75), to the east (299-E33-58), and to the south (299-E33-60) (GJO-2002-343-TAR, p. 26 and Figure 8). Based on these well locations, the lateral extent of contamination is approximately 32 m (105 ft) north-south and 25 m (82 ft) east-west.

216-B-8 Crib and Tile Field and 200-E-45 Health Instruments Shaft

There are no vadose zone boreholes located within the 216-B-8 Crib and no sediment sample analyses within the 216-B-8 Tile Field (PNNL-19277, p. 3.78). Based on geophysical logging, the maximum cesium-137 concentration in the upper 4.6 m (15 ft) was 300 pCi/g at Well 299-E33-73 in the tile field (GJO-2002-343-TAR, Figure 11). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the 216-B-8 Crib and Tile Field and the 200-E-45 HI Shaft.

Samples (105 liquid, 4 sludge, and 7 sediment) were collected at depths of 3 and 6.1 m (10 and 20 ft) beneath the bottom of the 216-B-8 Crib (9.9 and 13 m [32.5 and 42.5 ft] bgs) using access from the HI shaft (HW-17088, p. 58). Liquid samples showed fission products activity at both depths and sediment samples showed beta-gamma activity at 12.3 m (40.5 ft) bgs. Very little plutonium penetrated to a depth greater than 9.9 m (32.5 ft) bgs, except for plutonium contained in the inadvertent discharge of sludge from Tank 241-B-104 to the crib. Some of the sludge was washed to a depth of at least 13 m (42.5 ft) bgs, and some of the sludge was washed into the HI shaft.



Source: PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*, Figure 3.30.

Figure 3-9. Location Map for 216-B-7A&B Cribs, 216-B-8 Crib and Tile Field, and 216-B-11A&B French Drains and Vicinity Boreholes/Wells

Table 3-8. Nature and Vertical Extent of Contamination at the 216-B-7A&B Cribs

Contaminant	Concentration Units	Maximum Depth		Maximum Concentration	
		Maximum Depth Observed* (m [ft] bgs)	Concentration at Maximum Depth	Maximum Concentration Observed	Depth of Maximum Concentration* (m [ft] bgs)
Uranium	µg/kg	67.13 [220]	1.80E+03	3.46E+05	9.53 [31]
Technetium-99	pCi/g	8.38 [27]	1.56E+00 (J)	3.29E+01	6.02 [20]
Nitrate	µg/kg	67.13 [220]	2.63E+05	4.93E+05	45.34 [149]
Fluoride	µg/kg	67.13 [220]	1.01E+05	2.05E+05	11.05 [36]
Chromium (total)	µg/kg	67.13 [220]	4.42E+04	1.42E+05 (J)	6.02 [20]

Source: Tables C-12, C-13, and C-14 in 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).*

* Depth is the average for a 0.8 m (2.5 ft) long split-spoon sample interval.

bgs = below ground surface

J = estimated result

Based on geophysical logging, an interval of elevated cesium-137 contamination was detected from approximately 6.1 to 44.8 m (20 to 147 ft) bgs. The maximum concentration was approximately 150,000 pCi/g in Borehole 299-E33-67 near the 216-B-8 Crib (GJO-2002-343-TAC).

The lateral extent of contamination is based on results of the surface resistivity surveys conducted in the vicinity of the 216-B-8 Crib and Tile Field in 2007 (RPP-34690, pp. 4-13 to 4-19). The surveys indicated an anomalous zone (low resistivity) at 50 m (164 ft) in depth. The anomalous zone is approximately 110 m (361 ft) east-west by 140 m (459 ft) north-south (including the 216-B-11 area). The base of the anomalous zone is estimated at approximately 60 m (197 ft) in depth.

Based on gamma-logging data, the large volumes of liquids disposed to the 216-B-8 Crib and Tile Field, and historical groundwater data, the liquids discharged to 216-B-8 likely did reach groundwater no later than 1959. Groundwater plume maps show that the 216-B-8 Crib is a continuing source of chromium, sodium, and likely nitrate contamination to the groundwater today (PNNL-19277, p. 9.9).

216-B-9 Crib and Tile Field

Four test holes were drilled in 1948 for checking the drainage of the 216-B-9 Tile Field and were bottomed at the same elevation as the tile field (HW-17088, p. 49). The test holes were 2.7 m (9 ft) deep. Samples (59 sediment and 12 liquid) were collected in 1949 and 1950 (HW-17088, p. 52). Liquid and sediment samples from the two wells closer to the crib had detections of fission products and alpha activity (HW-17088, p. 50). Fission product contamination in the sediments from the two test holes that are 45.7 m (150 ft) downstream from the crib was much lower (HW-17088, p. 50).

Based on geophysical logging, the maximum cesium-137 concentration in the upper 4.6 m (15 ft) was approximately 20,000 pCi/g in Well 299-E28-53 at the southeast corner of the crib (GJO-2002-358-TAC, Figure 13). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-B-9 Crib and Tile Field.

Nine 45.7 m (150 ft) deep test wells were drilled near the crib and in the tile field in 1948 prior to initiation of waste discharges to the site. Well 299-E28-53 was drilled at an angle and bottomed directly beneath the crib (HW-17088, p. 51). Sediment samples obtained in October 1949 from the bottom of all of the 45.7 m (150 ft) deep wells (except 299-E28-53) showed no significant alpha or beta-gamma contamination at that depth (HW-17088, p. 52). The casing of Well 299-E28-53 was corroded and filled with sediments, implying that some waste liquids had been introduced into the subsurface at a depth of 45.7 m (150 ft) (i.e., through the bottom of the well), or within 45.7 m (150 ft) of the water table. No evidence had been found as of January 1950 from groundwater Wells 299-E28-1, 299-E28-2, 299-E28-5, and 299-E28-7 that the waste had reached groundwater (HW-17088, p. 54).

Based on geophysical logging, the maximum cesium-137 concentration was approximately 84,000 pCi/g at 6.1 m (20 ft) bgs in Borehole 299-E28-53 near the 216-B-9 Crib (GJO-2002-358-TAC, Figure 13). The maximum cesium-137 concentration in the tile field below 4.6 m (15 ft) ranged from 1,000 to 4,000 pCi/g, from 6.9 to 8.9 m (22.5 to 28.5 ft) bgs, at Well 299-E28-57 on the west side of the tile field.

Evaluation of the 1963 scintillation probe profiles and the 2002 spectral gamma logging results suggests that contaminants from the 216-B-9 Crib and Tile Field did not break through to groundwater. The deepest contamination recognized on any of the scintillation probe profiles was 43 m (141 ft) in the 1963 profile of Well 299-E28-58. The contamination profiles indicate that significant site-related contamination generally is not detected below 18.2 m (60 ft) bgs (GJO-2002-358-TAC, p. 32).

The lateral extent of contamination, based on the area stabilized in 1991, is approximately 75 m (246 ft) north-south by 30 m (98 ft) east-west. The vertical extent of contamination, based on this 1963 gross-gamma logging, is 43 m (141 ft). However, waste liquids may have migrated deeper than 45.7 m (150 ft) if the corroded Well 299-E28-53 provided a preferential pathway.

216-B-11A&B French Drains

Based on geophysical logging, the maximum cesium-137 concentration in the upper 4.6 m (15 ft) was approximately 90 pCi/g at Well 299-E33-19 (216-B-11B) and approximately 40 pCi/g at Well 299-E33-20 (216-B-11A) (GJO-2002-343-TAR) (Figure 3-9). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the 216-B-11A&B Cribs.

Vadose zone sediment characterization studies have not been performed within or close to the 216-B-11A&B French Drains (PNNL-19277, p. 3.81). Based on geophysical logging, cesium-137 contamination is detected intermittently in the vadose zone and just above the current groundwater level at Wells 299-E33-19 and 299-E33-20 (GJO-2002-343-TAR) (Figure 3-9). Both boreholes indicate minor amounts of cobalt-60 contamination just above the current groundwater level.

Based on historical geophysical logs from Well 299-E33-20, contamination introduced to the 216-B-11A French Drain may have entered the groundwater prior to 1959. The contamination is not as extensive in Well 299-E33-19. The majority of the contamination probably entered the 216-B-11A French Drain (GJO-2002-343-TAR, p. 28; PNNL-19277, p. 3.81). The currently observed low concentrations of cobalt-60 and cesium-137 right above the water table in Well 299-E33-19 are likely adsorbed contaminants inside the rusted borehole casing and are not indicative of current groundwater contamination (PNNL-19277, p. 3.82).

The 216-B-11A&B French Drains likely had an impact on groundwater in the past but, based on the low inventory of key contaminants (uranium and technetium-99), are not considered a current or future source of significant contamination to groundwater (PNNL-19277, p. 3.82).

The lateral extent of contamination is based on results of the surface resistivity surveys conducted in the vicinity of the 216-B-11A&B French Drains in 2007 (RPP-34690, pp. 4-13 to 4-19). The surveys indicate anomalous zones (low resistivity) at 30 m (98 ft) depth and 50 m (164 ft) depth. The deeper anomalous zone is broader region of approximately 110 m (361 ft) east-west by 140 m (459 ft) north-south (including the 216-B-8 area). The depth slice at 50 m (164 ft) suggests northwest movement from the north side of 216-B-11B. The base of the anomalous zone is estimated at approximately 60 m (197 ft) in depth.

BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42)

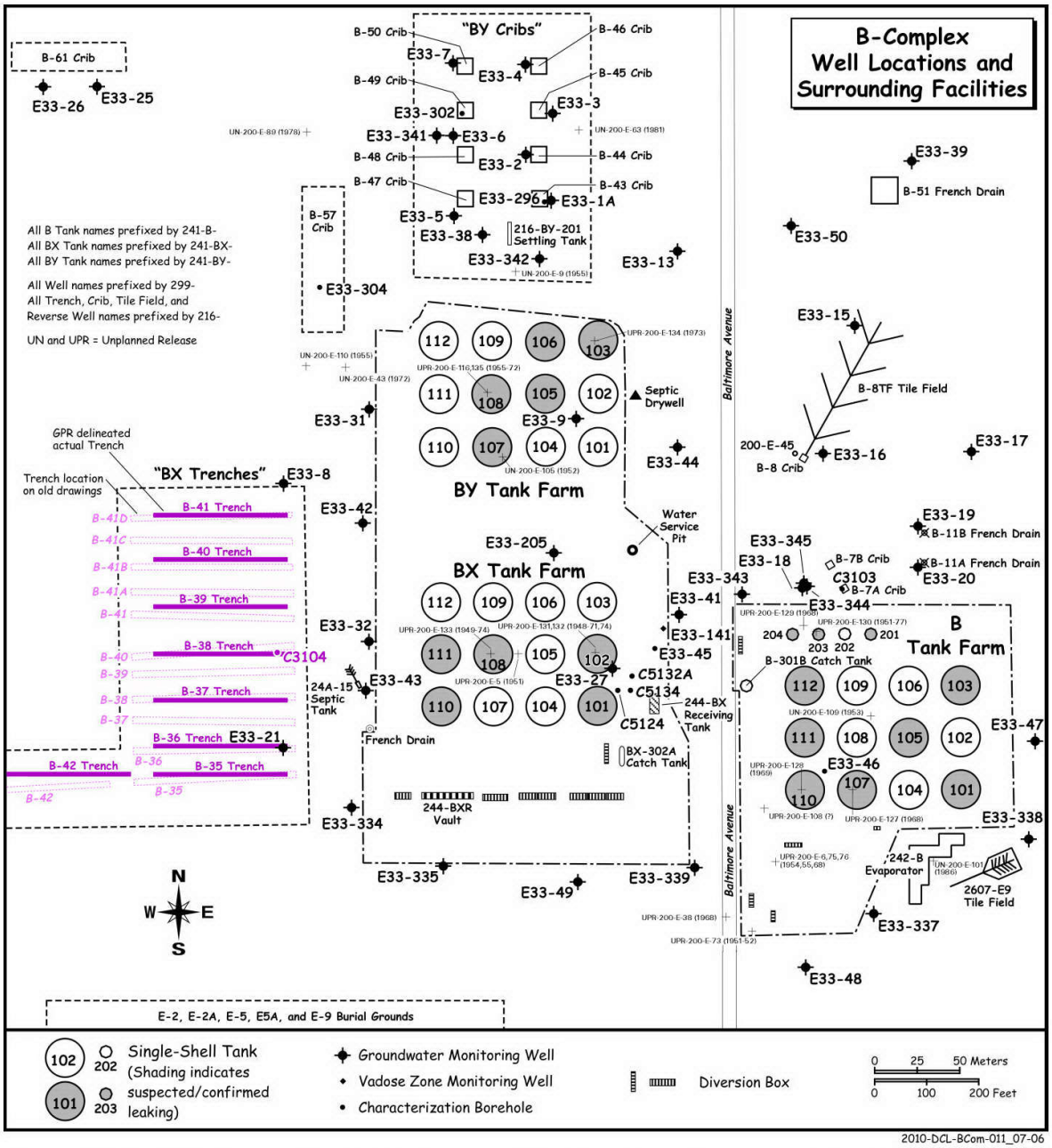
Borehole C3104 was drilled and sampled near the east end of the 216-B-38 Trench in 2001 (Figure 3-10). The maximum soil concentration for cesium-137 in the upper 4.6 m (15 ft) was 226,000 pCi/g in the sample from 4.4 to 4.7 m (14.5 to 15.5 ft) (DOE/RL-2002-42). Based on geophysical logging, the maximum cesium-137 concentration in the upper 4.6 m (15 ft) was approximately 10,000 pCi/g at the east end of the 216-B-38 Trench (BHI-01607; GJO–2002–322–TAR). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the trenches.

At the 216-B-38 Trench, Borehole C3104 was drilled to the water table and sampled at 10 intervals, between 1.4 m and 80.8 m (4.5 ft and 265 ft) bgs (DOE/RL-2002-42; PNNL-14128). Contamination from the 216-B-38 Trench is present in the sediments in the DVZ. The maximum sediment concentrations and maximum observed depths for key constituents are summarized in Table 3-9 (based on data from Tables C-8, C-9, and C-10 in DOE/RL-2002-42).

The available data indicate that the BX Trench waste has not reached groundwater based on the 216-B-38 Trench data (PNNL-19277, Section 3.2.3). The lateral extent of contamination is based on results of the surface resistivity surveys conducted in the vicinity of the BX Trenches in 2007 (RPP-34690, pp. 4-4 to 4-13). The surveys indicate anomalous zones (low resistivity) are spatially consistent with the trenches at the 30 and 50 m (98 and 164 ft) depth slices. The maximum extent is approximately 130 m (427 ft) east-west by 200 m (656 ft) north-south. The vertical extent of contamination, based on the distribution of nitrate, is approximately 47.5 m (150 ft) and no deeper than 54.9 m (180 ft) (PNNL-19277, Figure 3.28).

BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)

During the RI of the 200-BP-1 OU, three boreholes were drilled through each of the BY Cribs to approximately 9.1 m (30 ft) bgs (DOE/RL-92-70, pp. 2-2 and 4-25). The maximum detected concentrations of cesium-137 and strontium-90 from samples in the upper 4.6 m (15 ft) were 5.59 pCi/g and 13 pCi/g, respectively (DOE/RL-92-70, Table 4-16). Based on geophysical logging results, the highest cesium-137 concentrations detected in the upper 4.6 m (15 ft) at wells drilled through the cribs were approximately 10,000 pCi/g (GJO-2003-458-TAC). Well 299-E33-22, located approximately 4.9 m (16 ft) south of the 216-B-45 Crib, had relatively high cesium-137 concentrations (approximately 50,000 to 2,500,000 pCi/g) at depths from 1.5 to 3 m (5 to 10 ft) bgs This contamination may have been placed at this location from removal of contaminated soil from UPR-200-E-89 or UPR-200-E-9 (GJO-2003-458-TAC, p. 23). The lateral extent of contamination in the upper 4.6 m (15 ft) is assumed to coincide with the lateral extent of the bottoms of the BY Cribs.



Source: PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*, Figure 3.25.

Figure 3-10. Location Map for the BX Trenches

During the RI for the 200-BP-1 OU, two of the 9.1 m (30 ft) deep boreholes were extended to approximately 70.1 m (230 ft) bgs, nearly to the water table. Well 299-E33-296 was drilled in the 216-B-43 Crib, and Well 299-E33-302 was drilled in the 216-B-49 Crib (DOE/RL-92-70) (Figure 3-11). Two wells were drilled to groundwater near the BY Cribs in 2008 during the RI for the 200-BP-5 OU. Well 299-E33-341 was drilled approximately 10.7 m (35 ft) west of the western sides of the 216-B-48 and 216-B-49 Cribs and Well 299-E33-342 was drilled approximately 22.9 m (75 ft) south of the southern side of the 216-B-43 Crib (PNNL-19277, p. 3.6).

Table 3-9. Nature and Vertical Extent of Contamination at the 216-B-38 Trench

Contaminant	Concentration Units	Maximum Depth		Maximum Concentration	
		Maximum Depth Observed* (m [ft] bgs)	Concentration at Maximum Depth	Maximum Concentration Observed	Depth of Maximum Concentration* (m [ft] bgs)
Uranium	µg/kg	80.70 [265]	7.90E+02	3.25E+04	5.87 [19]
Technetium-99	pCi/g	45.34 [149]	8.88E-01 (J)	1.93E+00 (J)	16.23 [53]
Nitrate	µg/kg	80.70 [265]	1.48E+03	3.18E+06	45.34 [149]
Fluoride	µg/kg	11.81 [39]	3.29E+04 (B)	3.34E+04 (B)	9.22 [30]
Chromium (total)	µg/kg	80.70 [265]	1.4E+04	1.45E+04	45.34 [149]

Source: Tables C-8, C-9, and C-10 in 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)*.

* Depth is the average for a 0.8 m (2.5 ft) long split-spoon sample interval.

B = estimated result

bgs = below ground surface

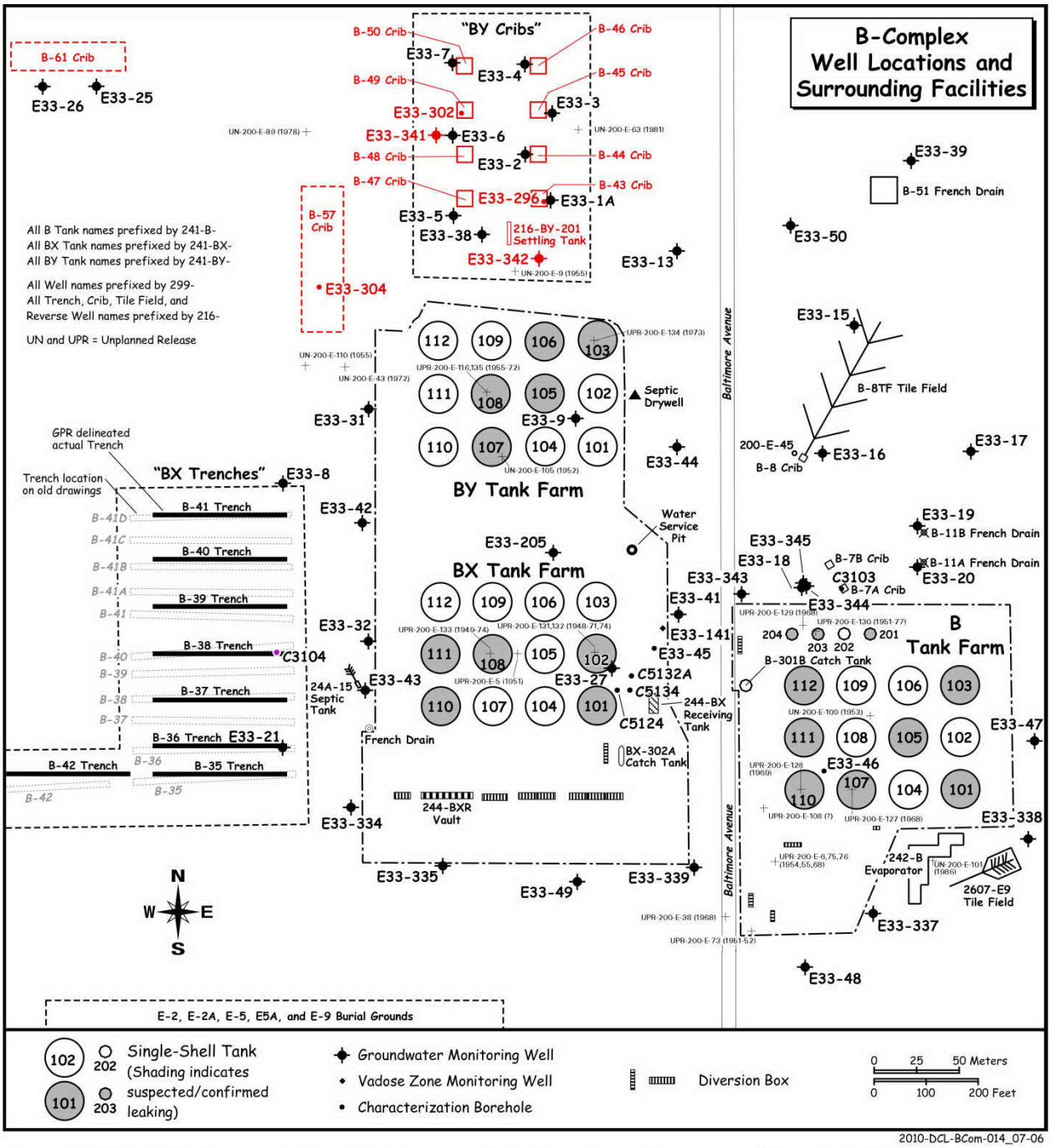
J = estimated result

The data from Borehole 299-E33-302 in the 216-B-49 Crib indicate that mobile contaminants such as technetium-99, nitrate, sulfate, cyanide, and sodium from waste liquids discharged to the 216-B-49 Crib reached groundwater. The DVZ pore water below the footprint of the 216-B-49 Crib from approximately 15.2 to 70.1 m (50 to 230 ft) bgs contain elevated concentrations of these mobile species (PNNL-19277, p. 3.15).

Technetium-99 and nitrate data from Well 299-E33-341, approximately 18.3 m (60 ft) west of the 216-B-49 Crib, indicate lateral spreading of the waste liquids from the BY Cribs, especially along fine-grained lenses within the Hanford formation sand. The sulfate distributions suggest that sulfate has spread laterally at the contact between the Hanford formation and the CCU (PNNL-19277, pp. 3.15 and 3.16).

The data from Borehole 299-E33-296 in the 216-B-43 Crib show elevated concentrations of technetium-99, nitrate, sodium, and to a lesser extent cyanide in the DVZ. The elevated concentrations in the DVZ sediments at 299-E33-296 likely indicate that mobile contaminants in the waste liquids reached the water table in the past and are continuing to be a source today (PNNL-19277, p. 3.20).

The concentrations of these mobile constituents in the sediments at Well 299-E33-342, 30.5 m (100 ft) south of the 216-B-43 Crib, are much lower than those within the footprint of the crib and also lower than in the sediments from Borehole 299-E33-341. The lower concentrations at 299-E33-342 reflect that this well is farther from the BY Cribs and that the 216-B-43 Crib received a smaller volume of liquid than the 216-B-49 Crib (PNNL-19277, p. 3.21).



Source: PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*, Figure 3.1.

Figure 3-11. Location Map for the BY Cribs

The DVZ below the BY Cribs is currently contributing technetium-99, cyanide, nitrate, and perhaps cobalt-60 to the groundwater. The distribution of technetium-99 is shown in Figure 3-12. Although uranium is present in the groundwater beneath the BY Cribs, it does not appear to be associated with waste liquids discharged to the BY Cribs because water-extractable uranium in the vadose zone sediment below the BY Cribs is found only in shallow sediments far from the water table (PNNL-19277, pp. 3.25 and 9-8).

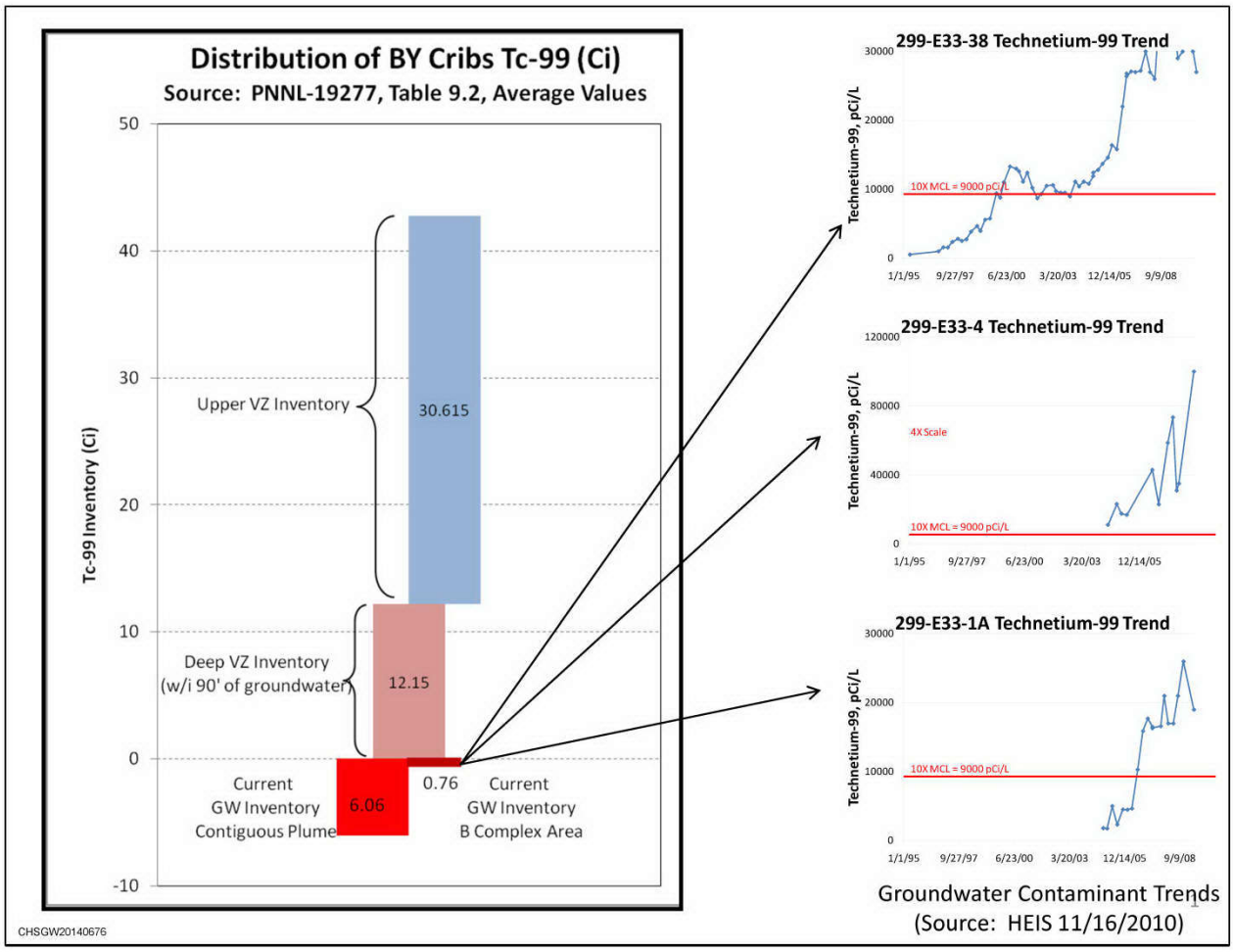


Figure 3-12. Distribution of Technetium-99 from Discharges to the BY Cribs

The estimated lateral extent of contamination at the BY Cribs is shown in Figure 3-13. A 150 m (492 ft) east-west by 110 m (361 ft) north-south anomalous region (low-resistivity) is spatially co-located with the BY Cribs, with the zone of lowest resistivity centered to the east of the 216-B-44, 216-B-45, and 216-B-46 Cribs (RPP-34690, Figures 4-19 and 4-20). The horizontal dimensions remain consistent from 30 to 50 m (98 to 164 ft) in depth. The top of the anomalous zone occurs in the 15 to 20 m (49 to 66 ft) depth range. The base of the anomalous zone is estimated to be about 60 m (197 ft) in depth. Cobalt-60 was detected laterally 53.3 m (175 ft) northwest of the center of the 216-B-50 Crib and 50.3 m (165 ft) southeast of the 216-B-43 Crib (GJO-2003-458-TAC, p. 32).

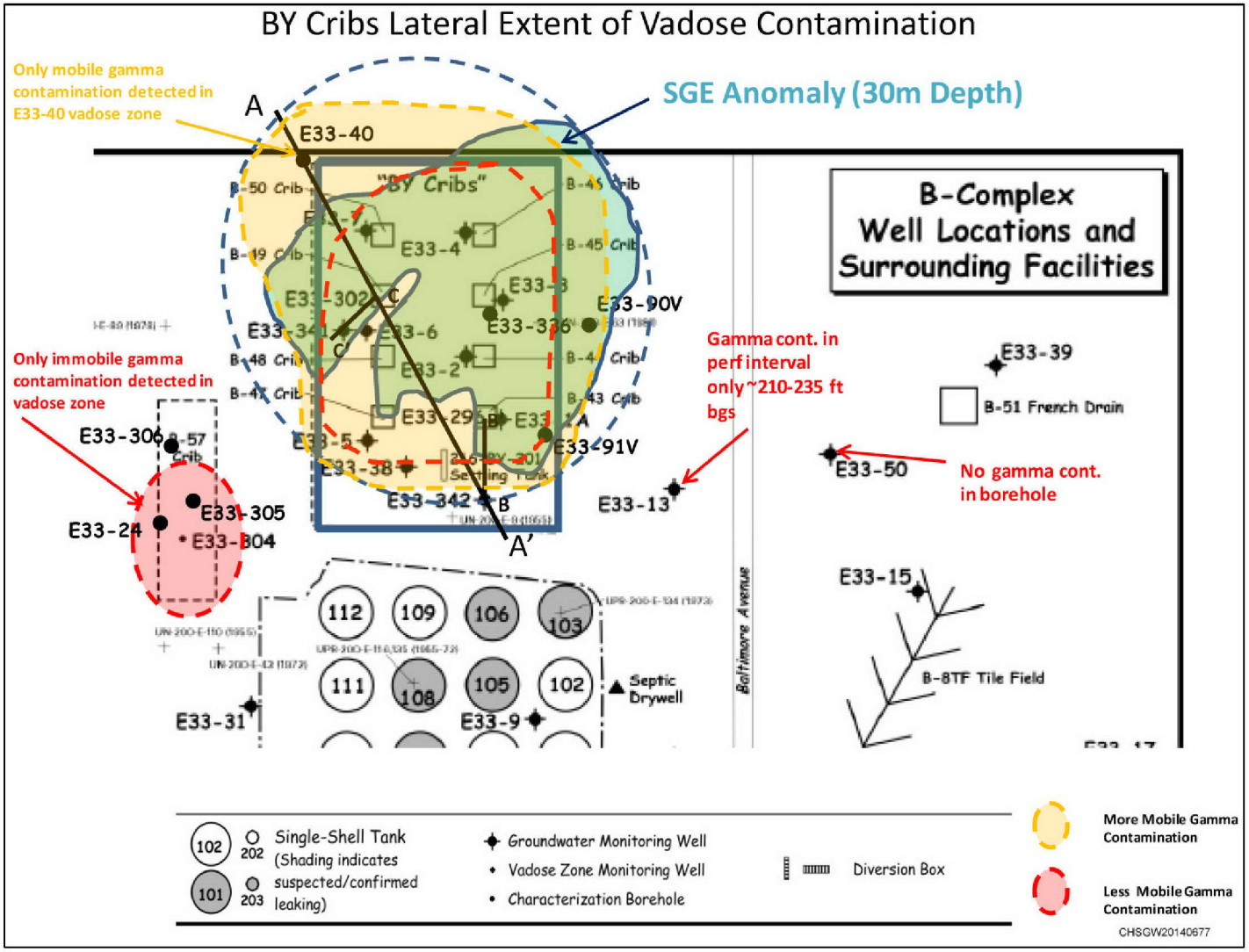


Figure 3-13. Lateral Extent of Vadose Zone Contamination at the BY Cribs

216-B-57 Crib

During the RI of the 200-BP-1 OU, three boreholes were drilled through the 216-B-57 Crib to approximately 15.2 m (50 ft) bgs (based on ground surface before barrier emplacement) (DOE/RL-92-70, pp. 2-2 and 4-25). The maximum detected concentrations of cesium-137 and strontium--90 from samples in the upper 4.6 m (15 ft) of the original land surface were 0.7 pCi/g and 0.25 pCi/g, respectively (DOE/RL-92-70, Table 4-16). The thickness of the prototype barrier overlying the 216-B-57 Crib is greater than 4.6 m (15 ft).

During the RI for the 200-BP-1 OU, one of the 15.2 m (50 ft) deep boreholes was extended to approximately 70.1 m (230 ft) bgs (based on ground surface before barrier emplacement), nearly to the water table. Well 299-E33-304 was drilled through the southern end (influent end) of the 216-B-57 Crib (DOE/RL-92-70) (Figure 3-11). At Well 299-E33-304, sediment samples were collected at 11 depths, between 4.6 and 72 m (15 and 235.5 ft) bgs (based on ground surface before barrier emplacement) (DOE/RL-92-70; PNNL-19277, Table 3.4). The maximum sediment concentrations and maximum observed depths for key constituents are summarized in Table 3-10 (based on data from DOE/RL-92-70, pp. A-43 to A-45, A-78 to A-80, and A-100).

Table 3-10. Nature and Vertical Extent of Contamination at the 216-B-57 Trench

Contaminant	Concentration Units	Maximum Depth		Maximum Concentration	
		Maximum Depth Observed* (m [ft] bgs)	Concentration at Maximum Depth	Maximum Concentration Observed	Depth of Maximum Concentration* (m [ft] bgs)
Uranium	µg/kg	9.60 [31]	1.05E+03	1.05E+03	9.60 [31]
Technetium-99	pCi/g	71.40 [234]	3.2E-01 (J)	6.0E+01 (J)	9.60 [31]
Nitrate	µg/kg	Not analyzed			
Fluoride	µg/kg	Not analyzed			
Chromium (total)	µg/kg	71.40 [234]	3.9E+03 (J)	6.2E+03 (J)	68.96 [226]

Source: DOE/RL-92-70, *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit*, Vols. 1 and 2, pp. A-43 to A-45, A-78 to A-80, and A-100.

* Depth is the average for a 0.8 m (2.5 ft) long split-spoon sample interval.

bgs = below ground surface

J = estimated result

Based on geophysical logging, a high-contamination zone dominated by cesium-137 was detected from approximately 9.1 to 27.4 m (30 to 90 ft) (based on ground surface before barrier emplacement) (GJO-2003-458-TAC). The maximum cesium-137 contamination (approximately 80,000 pCi/g) was found in Well 299-E33-304.

Based on the inventory estimates for the 216-B-57 Crib, and the fact that sediments under the 216-B-57 Crib footprint do not contain cyanide and contain only minor amounts of uranium and only about 0.1 percent of the total technetium-99 mass in the BY Cribs region, it does not appear that this facility has contaminated groundwater. It is also unlikely that the 216-B-57 Crib will be a significant contributor to groundwater contamination in the future because the mobile contaminants do not appear to

have migrated more than approximately 18 m (60 ft) bgs, and it has been covered by a barrier since 1994 (PNNL-19277, p. 3.28).

Based on the geophysical surveys in the two deep boreholes, significant breakthrough to groundwater did not occur below this crib (GJO-2003-458-TAC, p. 27).

Perched Water

The integration and interpretation of borehole hydrogeologic, geochemical, and geophysical data sets were used to resolve the nature of the perching horizon and the location and extent of the contaminated perched water within the perching zone (SGW-53604, *Path Forward Recommendations Report for the Uranium Contamination in the B Area*). The resulting CSM indicates that the contaminated perched water is contained within a localized sand lens deposited in a structural low on top of a low permeability paleosol (silt) layer (CCU_z) in the CCU (Figure 3-14). The top of the sand lens is defined at approximately 67 m (220 ft) bgs based on geophysical logs; the maximum thickness of the sand lens is approximately 4.6 m (15 ft). The lateral and vertical extent of the perched water is limited to the region containing the sand lens and underlying silt zone; the bottom of the perched sand lens is approximately 4.6 m (15 ft) above the unconfined aquifer at its lowest point. The underlying silt layer forms a natural barrier that slows contaminant migration from the sand layer to the aquifer. Liquid waste containing uranium, technetium-99, and nitrate has migrated vertically and laterally in the subsurface and accumulated within the sand lens. The major sources of the contaminated water are considered the nearby 200-DV-1 OU waste sites (216-B-7A&B and 216-B-8 Cribs), which were used for subsurface infiltration of liquid waste, and the 241-BX-102 SST, which released liquid waste to the subsurface when it was inadvertently overfilled. SGW-53604 and SGW-58147 provide detailed information on the CSM. The perched water is a continuing source of contamination to the underlying groundwater.

B Tank Farm

The B Tank Farm has not been a significant contributor to DVZ contamination or a significant source of mobile contaminants to the groundwater under current conditions based on sediment characterization around Tank 241-B-110, the estimates of volumes of waste released, the estimated masses of mobile contaminants present in the released waste, the available spectral gamma logs of drywells within the B Tank Farm, and the groundwater plume maps (PNNL-19277, Section 6.5).

BX Tank Farm

Correlation of the stratigraphy, spectral gamma logging results, and uranium isotopic ratio signatures portray a large area and deep vertical penetration of Hanford-processed uranium into the vadose zone east and northeast of Tank 241-BX-102. The mass-balance estimates for uranium show that the total uranium currently found in the vadose zone sediments to the northeast of Tank 241-BX-102 ranges from approximately 6,400 to 7,200 kg and that approximately 24 percent of this mass is readily mobilized by water. Furthermore, the estimated mass of total uranium within 27.4 m (90 ft) of the water table is substantial (3,050 to 3,910 kg), and about 45 percent of this mass is readily mobilized by water (Figure 3-15). These mass estimates for residual uranium within the vadose zone sediments are much larger than the total uranium (22.3 kg) currently in the groundwater plume, which is mainly below the B Complex area. The sum of total uranium that can be accounted for in the vadose zone plus groundwater plume varies from 63 to 72 percent of the mass released from the 241-BX-102 overfill. It is hypothesized that the uranium from the 1951 overfill event required about 40 to 45 years to reach the water table. This hypothesis is based on the lack of elevated uranium concentrations in the groundwater until 1994, when concentrations were reported at 63.9 µg/L at Well 299-E33-18, followed by a large influx to groundwater below the B Complex in 1996 (PNNL-19277, Section 6.4).

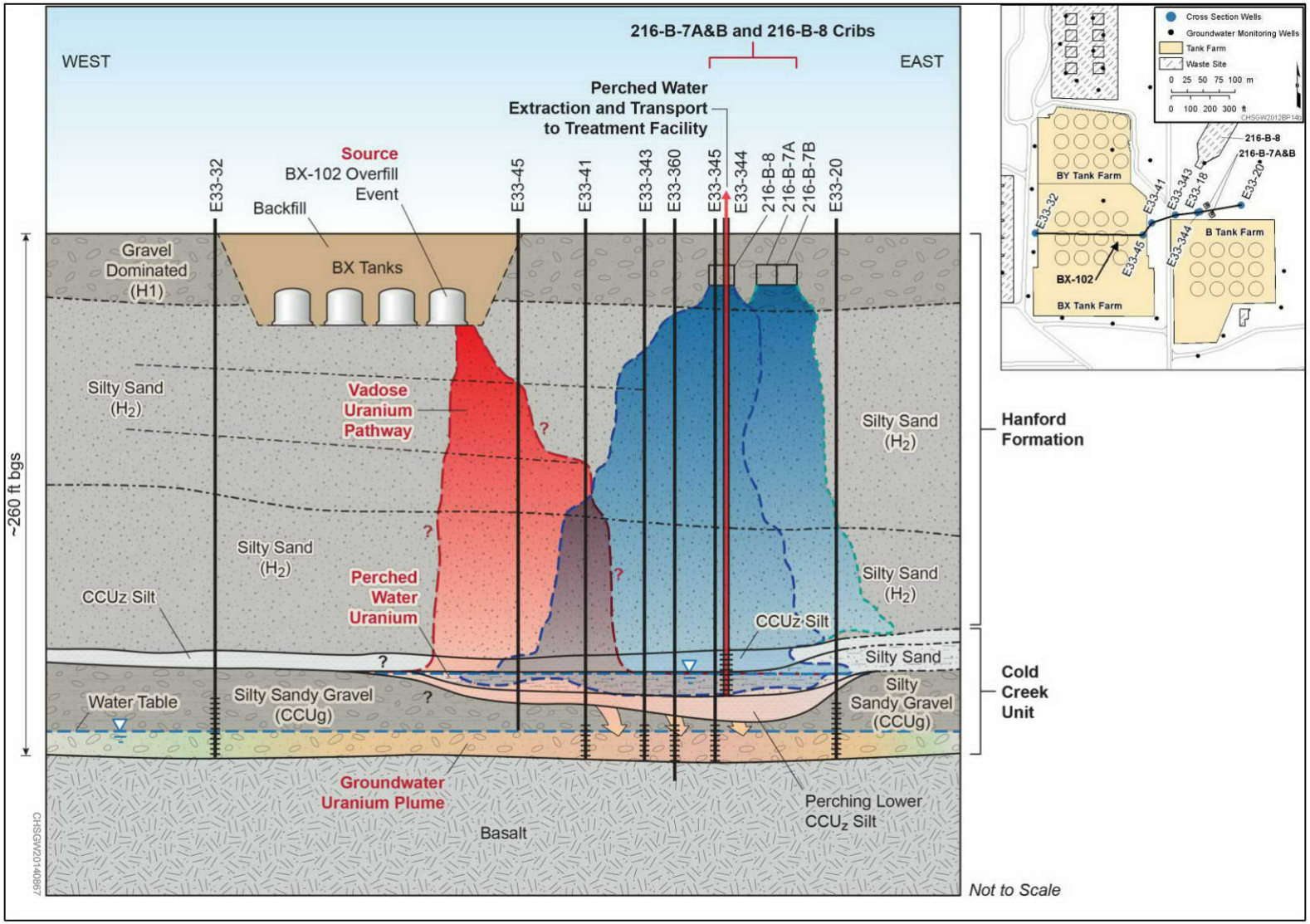


Figure 3-14. CSM of the CCU Perching Zone

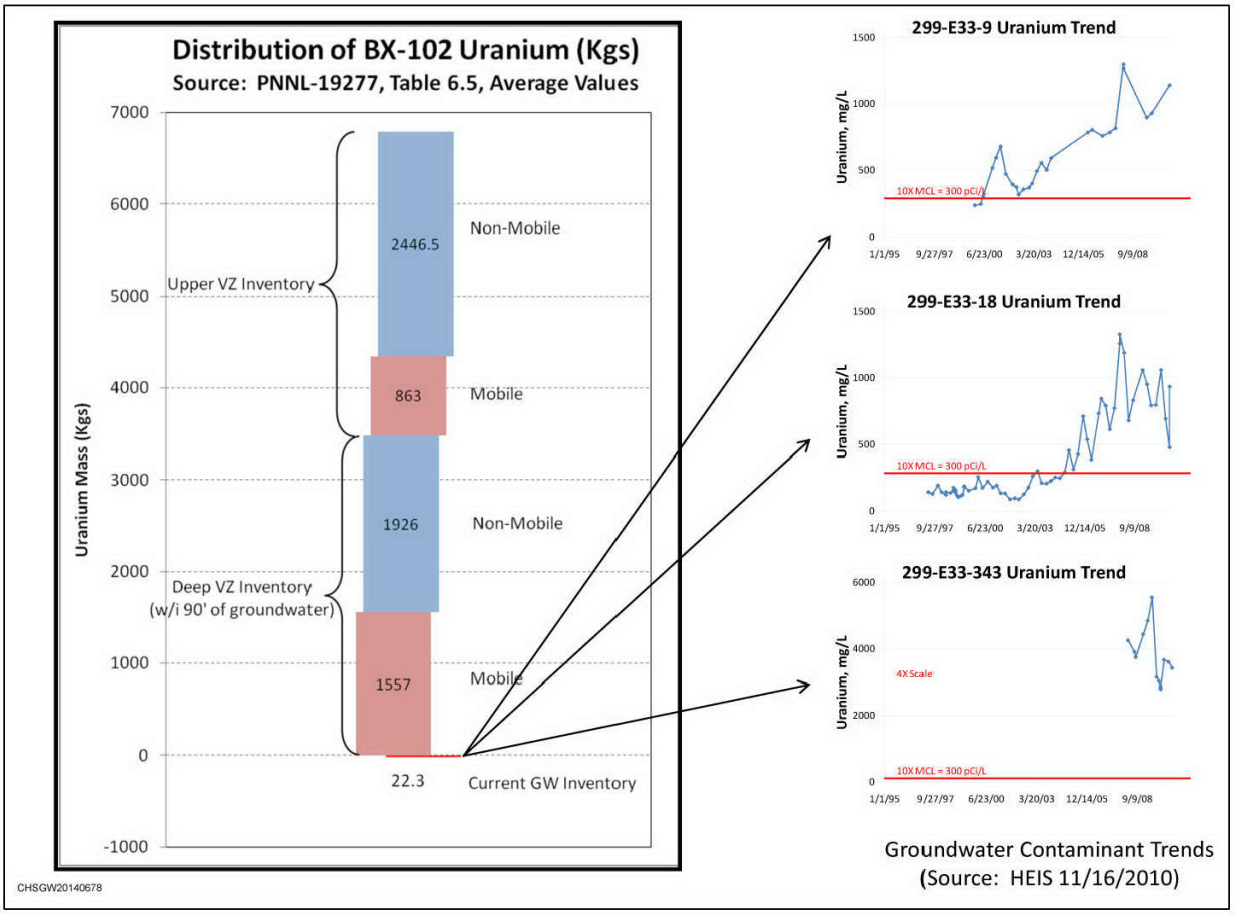


Figure 3-15. Distribution of Uranium from 241-BX-102 Overfill Event in 1951

BY Tank Farm

Based on the available information, it is hypothesized that the BY Tank Farm is not a significant contributor to DVZ contamination or to the groundwater plumes under the B Complex under current conditions (PNNL-19277, Section 6.4).

3.2.5 Groundwater Contamination beneath the B Complex Area

The 200-DV-1 OU waste sites, the perched water zone, and the tank farms in the B Complex area overlie groundwater in the 200-BP-5 OU. Contamination in the 200-BP-5 OU will be addressed through a separate RI/FS process. The primary groundwater contaminants currently underlying the B Complex are nitrate, technetium-99, cyanide, chromium, iodine-129, and uranium (DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010*). The groundwater at the 216-B-5 Reverse Well is locally contaminated with plutonium-239/240, strontium-90, and cesium-137 as a result of direct discharges to the aquifer through the well perforations.

From 1956 through at least the mid-1960s, a large, high-concentration groundwater plume was present below the B Complex that contained mobile fission products such as ruthenium-106; mobile activation products such as cobalt-60; and chemicals such as nitrate, cyanide, and sodium. The early plume likely contained tritium and technetium-99, which were mobile contaminants contained in the waste discharges. Because the gross-beta (mainly ruthenium-106 and cobalt-60) species have relatively short half-lives (i.e., 1 year and 5.7 years, respectively), they are no longer useful for tracking the migration of the

original groundwater plumes that were present near the end of the active disposal period. The only two species that do not rapidly decay that were sometimes measured in the mid-1950s to mid-1960s are nitrate and uranium (PNNL-19277, Section 5.1).

3.2.5.1 Nitrate

The liquid release volumes, large nitrate inventories disposed, and vadose zone depth-discrete sediment measurements below the BY Cribs suggest that the entire area below the BY Cribs is currently contributing nitrate to the water table (Figure 3-16). Based on time-series maps of nitrate contamination, increasing concentrations of nitrate were observed after 2006 in the groundwater below the B Complex, primarily from the BY Cribs (DOE/RL-2008-01, Figure 32.10-20). Nitrate from the 216-B-7A&B/ 216-B-8 Cribs region and the 241-BX-102 UPR has impacted, and most likely continues to impact, groundwater along the north side of the B Tank Farm based on the groundwater data supported by the liquid release volumes, large nitrate inventories disposed to these waste sites, and soil electrical resistivity survey results (PNNL-19277, Section 5.2; DOE/RL-2011-01, Section 9.1.1).

3.2.5.2 Iodine-129

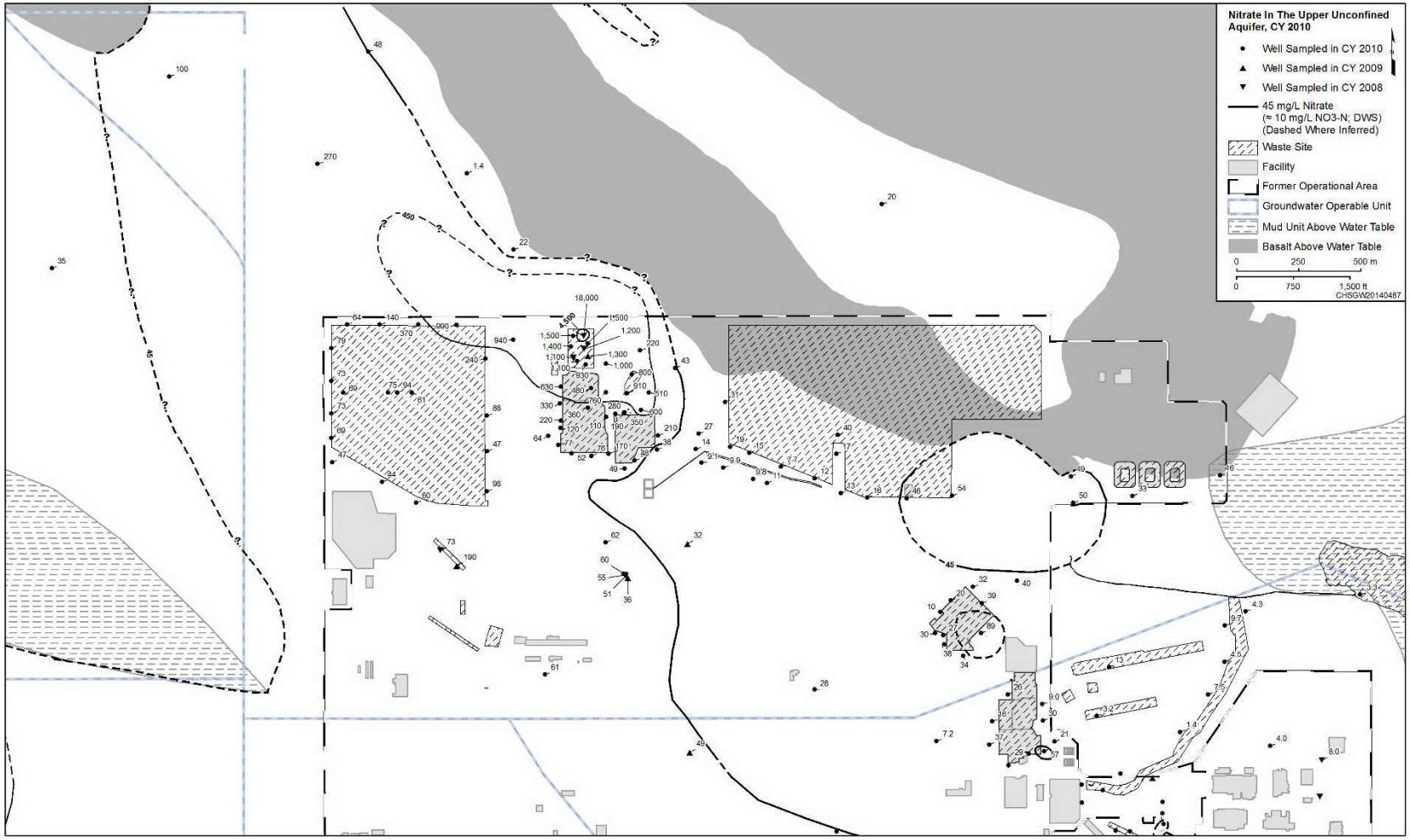
In 2010, the highest iodine-129 activity in groundwater below the B Complex area was detected in Well 299-E33-343, adjacent to the northwest corner of the B Tank Farm and northeast of the 241-BX-102 UPR. The majority of the iodine-129 is considered to be from past sources south of the 200-BP-5 OU. The 241-BX-102 UPR may also be contributing iodine-129 based on the iodine-129 activity in the perched water zone and the inventory associated with the 241-BX-102 waste (DOE/RL-2011-01, Section 9.1.2.5).

3.2.5.3 Technetium-99

The source of the technetium-99 in the groundwater below the B Complex is primarily from below the BY Cribs (Figure 3-17). A secondary source in the vicinity of Well 299-E33-343, adjacent to the northwest corner of the B Tank Farm and northeast of the 241-BX-102 UPR, has also been supplying technetium-99 to the groundwater at least since 2003 (assuming that the technetium-99 arrived at the water table at this location at the same time as uranium) (Figure 2.10-21 in DOE/RL-2008-01). Some of the technetium-99 is from the 241-BX-102 overfill event, but other possible sources include the B or BY Tank Farms or, less likely, the 216-B-7A&B Cribs and 216-B-8 Crib and Tile Field or contamination from the BY Cribs that migrated within horizontal spreading layers to the CCU near Borehole 299-E33-343 (PNNL-19277, Section 5.3).

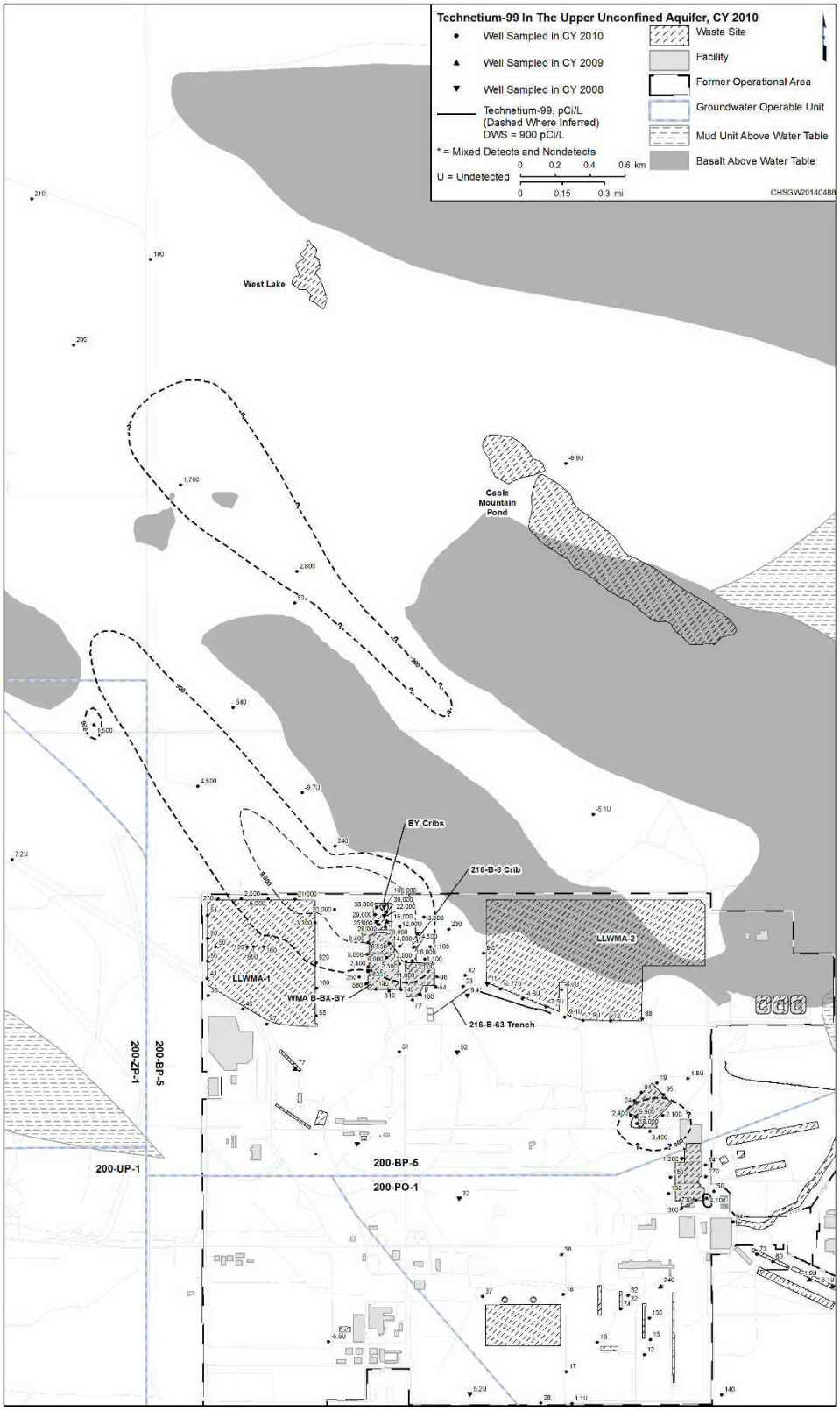
3.2.5.4 Uranium

In 2010, the highest uranium concentration in groundwater below the B Complex area was detected in Well 299-E33-343, adjacent to the northwest corner of the B Tank Farm and northeast of the 241-BX-102 UPR (DOE/RL-2011-01, Section 9.1.4.1) (Figure 3-18). Uranium isotopic ratios for samples from the vadose zone and the groundwater indicate that the 241-BX-102 UPR is the primary source of this uranium (PNNL-19277, Section 5.7). Based on the high concentrations of uranium in the 299-E33-343 vadose zone pore water extracted from the sediments in the CCU_z layer, uranium from this silt-dominated layer is migrating down through the gravel-dominated CCU_g layer into the water table very near to this well.



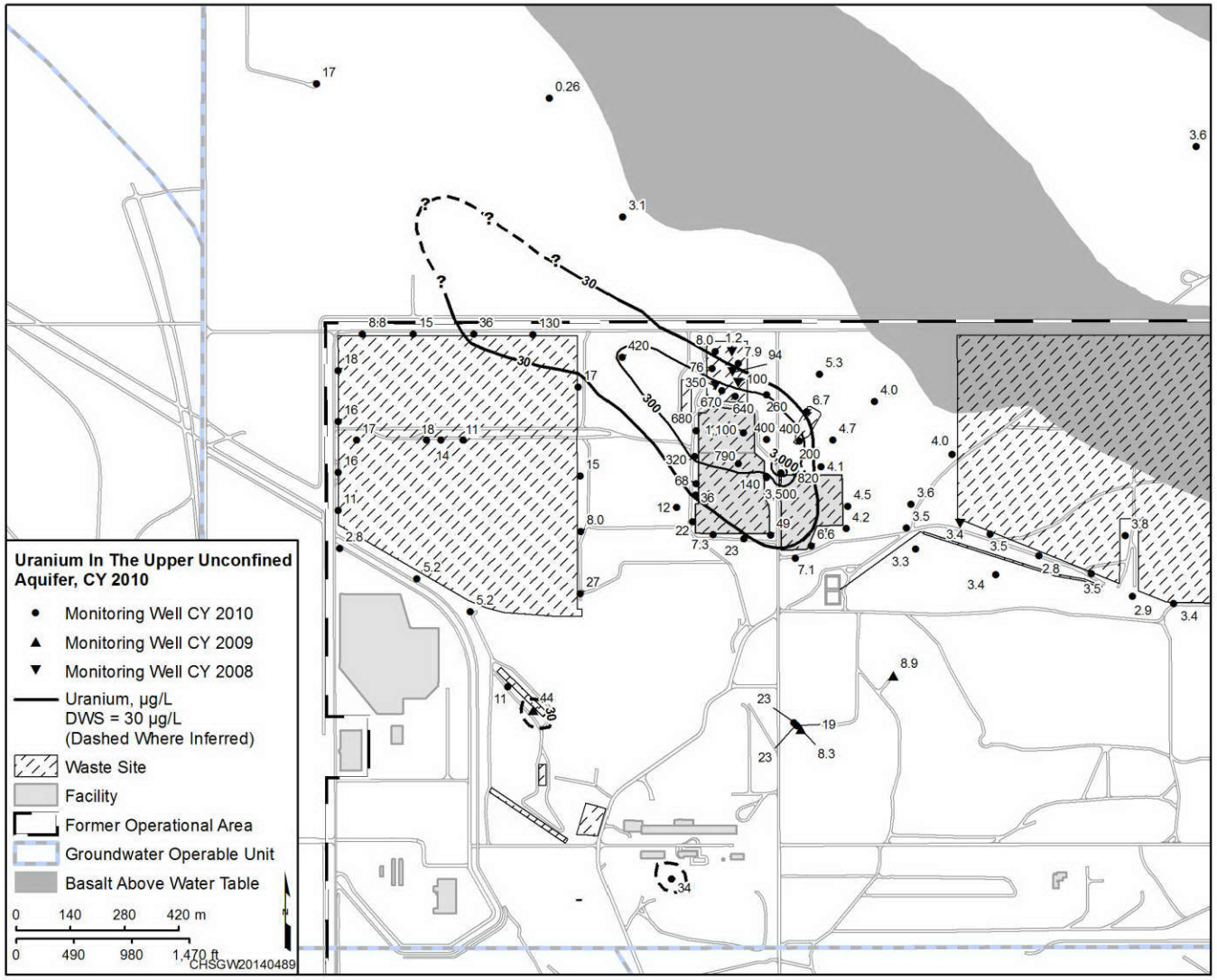
Source: DOE/RL-2011-01, *Hanford Site Groundwater Monitoring and Performance Report for 2010*.

Figure 3-16. Map of Nitrate Groundwater Plume in the in the B Complex Area



Source: DOE/RL-2011-01, *Hanford Site Groundwater Monitoring and Performance Report for 2010*.

Figure 3-17. Map of Technetium-99 Groundwater Plume in the B Complex Area



Source: DOE/RL-2011-01, *Hanford Site Groundwater Monitoring and Performance Report for 2010*.

Figure 3-18. Map of Uranium Groundwater Plume in the B Complex Area

The overall uranium plume below the B Complex has been increasing since 1996, with rapid increases in some years (2006) and localized rapid increases in the vicinity just north of the northwest corner of the B Tank Farm fence (the location of 299-E33-343) (Figures 5.41 through 5.44 in PNNL-19277). The mass of uranium present in the groundwater plume below the B Complex area has increased over the last decade, from 3.4 to 22.3 kg. This mass is a very small fraction of the uranium estimated to have been released (10,100 kg) in the 1951 overfill event at 241-BX-102. The mass of uranium currently in the groundwater is also a very small fraction of the uranium that is estimated to still be present in the vadose zone between Tank 241-BX-102 and the vicinity of Well 299-E33-343 north of the B Tank Farm (PNNL-19277, Section 5.6).

3.2.5.5 Cyanide

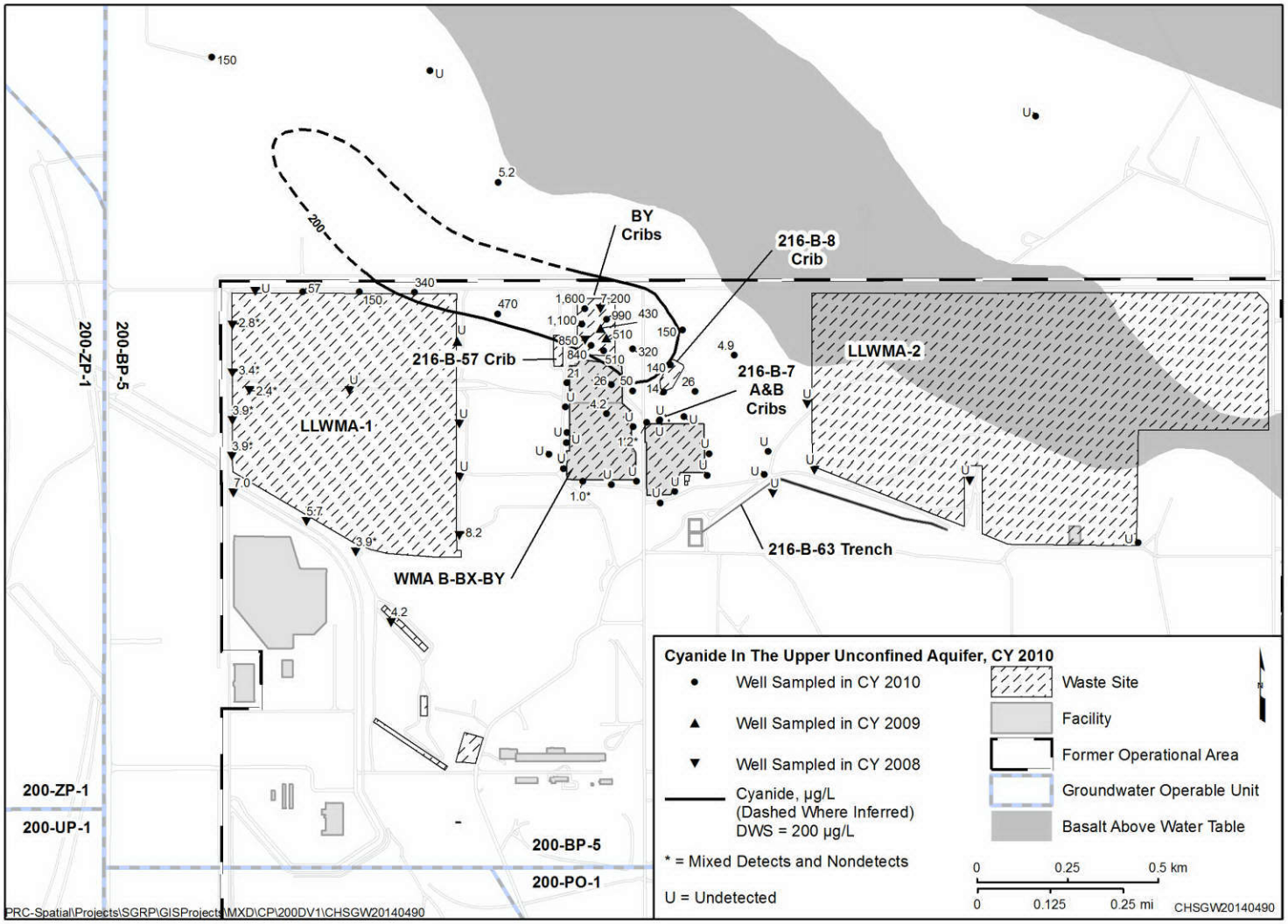
Along with technetium-99 and nitrate, the likely source of the cyanide is the DVZ sediments below the BY Cribs (Figure 3-19). Cyanide has been reaching the groundwater at increasing concentrations in the last decade in the region below the BY Cribs (Figures 5.25 through 5.28 in PNNL-19277). The sediments in the two 1991 boreholes (299-E33-296 and 299-E33-302, drilled in the footprints of the 216-B-43 and 216-B-49 Cribs) and in the two 2008 boreholes (299-E33-341 and 299-E33-342), show elevated cyanide, technetium-99, nitrate, and sulfate concentrations. Thus, the DVZ sediments below the BY Cribs are a major source for these contaminants in the underlying groundwater. No other waste site in the B Complex area received significant masses of cyanide, so the available vadose zone sediment and groundwater cyanide data consistently indicate that the BY Cribs are the primary (and most likely the sole) source of the cyanide in the groundwater below and to the north of the B Complex area (PNNL-19277, Section 5.4).

3.2.5.6 Chromium

The source of chromium in the groundwater appears to be the 216-B-8 Crib and Tile Field. The 216-B-7A&B Cribs may also be contributing chromium, or the chromium plume may be migrating south toward the 216-B-7A&B Cribs when there is reduced groundwater flow to the northwest. The increased concentration of chromium in the groundwater in 2001 and 2008 (compared to 2004) may indicate a transient influx of contamination from the DVZ below the 216-B-8 Crib and Tile Field/216-B-7A&B Cribs subregion (Figures 5.30, 5.32, and 5.24 in PNNL-19277). The 216-B-8 Crib and the 216-B-7A&B Cribs received significant quantities of chromium, and both facilities received sufficient volumes of waste to drive contaminants deep into the vadose zone to the aquifer (PNNL-19277, Section 5.5).

3.2.5.7 Plutonium-239/240, Strontium-90, and Cesium-137

The highest plutonium-239/240 concentration detected in groundwater in 2010 was in Well 299-E28-23, 1 m (3 ft) from the 216-B-5 Reverse Well (DOE/RL-2011-01, Section 9.1.8). Detectable low activities have been reported in the three wells within 5 to 7 m (16 to 23 ft) of 216-B-5 site since routine groundwater sampling began in 1986 and 1987. The highest strontium-90 concentration detected in 2010 was also Well 299-E28-23 (DOE/RL-2011-01, Section 9.1.5). Samples from the three wells within 5 to 7 m (16 to 23 ft) of the 216-B-5 site were the only samples in the 200-BP-5 OU with detectable activities of cesium-37 in 2010 (DOE/RL-2011-01, Section 9.1.7). The highest cesium-137 activity was detected in Well 299-E28-23.



Source: DOE/RL-2011-01, *Hanford Site Groundwater Monitoring and Performance Report for 2010*.

Figure 3-19. Map of Cyanide Groundwater Plume in the B Complex Area

3.3 T Complex Area

This section describes the current understanding of the nature and extent of contamination in the T Complex area. The nature and extent of contamination are evaluated on a site-by-site basis to support the risk assessment, the evaluation of remedial alternatives for each waste site, and the identification of data needs. Using waste site-specific information and the physical site data, this section provides a preliminary estimation of locations where contamination may have migrated from a waste site. Data needs for the 200-DV-1 OU waste sites will be addressed during the RI in accordance with this work plan and associated SAPs. The preliminary understanding of the nature and extent of contamination will be refined in the RI report using the information collected during the RI.

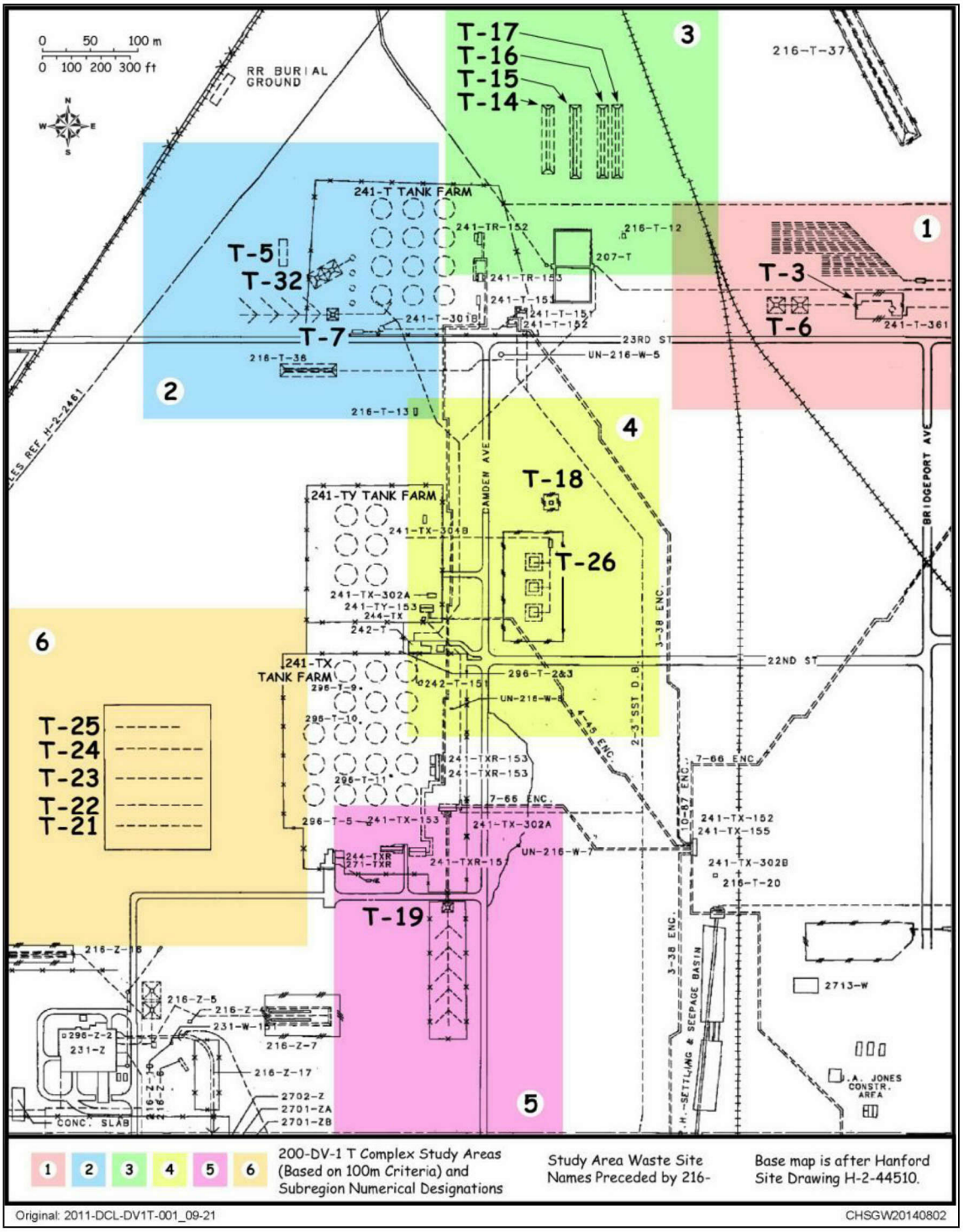
At the T Complex area, environmental impacts occurred as a result of facility processes, waste disposal practices, and accidental spills (UPRs). The impacts from the waste sites and SST operations to the vadose zone and groundwater are discussed below.

3.3.1 200-DV-1 Operable Unit Waste Sites in the T Complex Area

The 200-DV-1 OU waste sites in the T Complex area are grouped into six subregions (Figure 3-20). The primary contaminant source for the 200-DV-1 OU waste sites in the T Complex area was liquid process waste that was generated during facility operations (e.g., T Plant and 242-T Evaporator). The process waste was aqueous and contained relatively high concentrations of contaminants (e.g., radionuclides or chemicals). Process waste was intentionally released to the environment through engineered waste site structures such as cribs, trenches, and reverse wells. In some cases, liquid waste that was initially sent to the tank farms was later discharged to the waste sites. In other cases, liquid waste was sent to settling tanks, designed to allow the supernate liquid to overflow to the waste sites. Table 3-11 lists the waste sites and their primary waste sources.

The 200-DV-1 OU T Complex waste sites will be evaluated from the land surface to groundwater to support remedy decisions. The chemical and/or radionuclide contaminants in the shallow soils (up to 4.6 m [15 ft]) at the individual waste sites will be used to determine whether each waste site exceeds acceptable risk levels for HHE. Relatively immobile contaminants such as cesium-137 and strontium-90 are most likely to be retained near the point of discharge, which for some waste sites was in the upper 4.6 m (15 ft) of the subsurface. The chemical and/or radionuclide contaminants will be used to determine whether the vadose zone exceeds acceptable risk levels for groundwater. Relatively mobile contaminants such as technetium-99, uranium, iodine-129, and nitrate most likely migrated deeper in the vadose zone and pose a current and/or future risk to groundwater. The inventories of selected, mobile contaminants discharged to the T Complex waste sites are listed in Table 3-12. The complete list of inventories for the waste sites is provided in the SIM (RPP-26744).

The volumes, inventories, and concentration of the waste discharged to the 200-DV-1 OU waste sites are based on the RPP-26744. The SIM was developed, using a probabilistic approach, to estimate the inventory of contaminants that were released to the soil within the Central Plateau during the Hanford Site production mission. Input data were obtained from historical records, including the various plutonium/uranium-processing facilities. The SIM also updated previous efforts to quantify the contaminant inventories in the Hanford Site waste storage tanks using results from high-level waste tanks and process control data in historical waste management documents.



Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-20. T Complex Area Subregions in the 200-DV-1 OU

Table 3-11. Sources of Contamination for 200-DV-1 OU Waste Sites in the T Complex Area

Waste Site	Service Dates[a]	Primary Waste Sources
216-T-3	1945 to 1946	Cell drainage from Tank 5-6 in 221-T and waste from 224-T via 241-T-361 Tank
216-T-5	1955	2C supernate from 221-T via 241-T-112
216-T-6	1946 to 1947	Cell drainage from Tank 5-6 in 221-T and waste from 224-T via 241-T-361 Tank, cell drainage from Tank 5-6 in 221-T
216-T-7	1947 to 1955	2C supernate from 221-T via 241-T-105, 106, 111, 112 2C supernate from 221-T via 241-T-112 2C supernate in 221-T plus cell drainage from Tank 5-6 in 221-T via 241-T-112 2C supernate in 221-T plus cell drainage from Tank 5-6 in 221-T plus 224-T waste via 241-T-112
216-T-14	1954	1C supernate from 221-T via 241-T-104, 105, 106
216-T-15	1954	1C supernate from 221-T via 241-T-104, 105, 106
216-T-16	1954	1C supernate from 221-T via 241-T-104, 105, 106
216-T-17	1954	1C supernate from 221-T via 241-T-104, 105, 106
216-T-18	1953	Supernate from the production test of TBP scavenging at U Plant via 241-T-101
216-T-19	1951-1956, 1965-1976	Process condensate from 242-T Evaporator Cell drainage from Tank 5-6 and 2C supernate from 221-T and waste from 224-T
216-T-21	1954	1C supernate from 221-T via 241-TX-109, 110, 111
216-T-22	1954	1C supernate from 221-T via 241-TX-109, 110, 111
216-T-23	1954	1C supernate from 221-T via 241-TX-109, 110, 111
216-T-24	1954	1C supernate from 221-T via 241-TX-109, 110, 111
216-T-25	1954	1C evaporator bottoms from 242-T via 241-TY-101, 102
216-T-26	1955-1956	1C scavenged TBP supernate from 221-T via 241-TY-101, 103, 104
216-T-32	1946-1952	224-T waste via 241-T-201 Tank
200-W-52[b]	1948-1955	2C supernate from 221-T via 241-T-105, 106, 111, 112 2C supernate from 221-T via 241-T-112 2C supernate in 221-T plus cell drainage from Tank 5-6 in 221-T via 241-T-112 2C supernate in 221-T plus cell drainage from Tank 5-6 in 221-T plus 224-T waste via 241-T-112

Table 3-11. Sources of Contamination for 200-DV-1 OU Waste Sites in the T Complex Area

Waste Site	Service Dates[a]	Primary Waste Sources

a. Information obtained from 200-DV-1 Operable Unit data quality objectives summary report (Appendix C).

b. The 216-T-7 Crib and Tile Field operated as one waste disposal system. They were administratively separated in 1997 because the crib is inside the T Tank Farm. At that time, the crib was assigned a separate Waste Information Data System site code (200-W-52) and assigned to Waste Management Area T. Because these two sites operated as one disposal system, the 200-W-52 Crib is included in discussions of the 216-T-7 Tile Field in this work plan.

1C = first cycle

2C = second cycle

TBP = tributyl phosphate

The SIM (published in 2005) (RPP-26744) used 196 waste streams at 377 liquid waste disposal sites, UPRs, and tank leaks. The SIM contains inventory and uncertainty estimates for 46 radionuclides and 29 chemicals. The inventories are calculated in one-year increments over the operating lifetime of the waste sites (from 1944 to 2001). The radionuclides are decayed to January 2001.

The volumes of liquid waste discharged to the 200-DV-1 OU waste sites in the T Complex area are compared in Figure 3-21. In general, the T Trenches (216-T-14 through 216-T-17) and TX Trenches (216-T-21 through 216-T-25) received the smallest volumes of liquid waste. Two sets of crib and tile field (216-T-7/200-W-52 and 216-T-19) received 77 percent of the liquid volume discharged to the 200-DV-1 OU waste sites in the T Complex area.

The inventories of technetium-99 and uranium in each subregion are illustrated in Figures 3-22 and 3-23, respectively. The inventories of nitrate, uranium, technetium-99, and iodine-129 for each of the 200-DV-1 OU waste sites are shown in Figures 3-24, 3-25, 3-26, and 3-27, respectively. The nitrate inventory data indicate that the most significant sources of nitrate are at 216-T-7 Crib and Tile Field and the 216-T-32 Crib. The uranium inventory data indicate that the most significant source of uranium is at the 216-T-26 Crib. The iodine-129 and technetium-99 inventory data indicate that the most significant sources are from tank 241-T-106.

3.3.2 T-TX-TY Tank Farms Data

The T-TX-TY Tank Farms, and any subsurface contamination from associated UPRs, are not included in the 200-DV-1 OU. However, some of the 200-DV-1 OU waste sites in the T Complex area are adjacent to the T-TX-TY Tank Farms, potentially resulting in co-mingled contamination in the DVZ. Data for the T-TX-TY Tank Farms are provided to present a comprehensive description of the T Complex area.

The primary waste sources for the T-TX-TY Tank Farms were bismuth phosphate metal waste, 1C waste, 2C waste, Building 221 waste, Building 224 waste, and Tank 5-6 waste from bismuth phosphate operations at T Plant (1945 to 1956); TBP waste and low-level waste from uranium recovery operations at U Plant (1952 to 1958); and decontamination/laboratory waste from T Plant (1958 to 1970).

Leaks of liquid waste from the tanks and/or ancillary equipment (UPRs) during waste transfers (e.g., overfilling a tank) contributed contamination from the tanks to the subsurface. Leaks from raw and potable water lines likely contributed to tank waste migration deeper into the vadose zone.

Table 3-12. Volumes and Inventories Discharged to 200-DV-1 OU Waste Sites in the T Complex Area

Waste Site	Volume Discharged[a] (million L)	Total Waste Inventory[a]												
		Nitrate (kg)	Fluoride (kg)	Uranium (total) (kg)	Chromium[b] (kg)	Ferrocyanide (kg)	Cesium-137[c] (Ci)	Strontium-90[c] (Ci)	Plutonium-239[c] (Ci)	Plutonium-240[c] (Ci)	Cobalt-60[c] (Ci)	Iodine-129[c] (Ci)	Technetium-99[c] (Ci)	Tritium[c] (Ci)
216-T-3 (1945-1946)	1.13E+01	6.47E+05	3.86E+04	2.01E+00	2.65E+03	0	1.95E+00	1.70E+00	1.66E+01	1.12E+00	1.96E-03	4.24E-07	9.57E-04	2.02E-05
216-T-5 (1955)	3.15E+00	2.42E+05	1.31E+04	2.42E+01	1.21E+03	0	3.43E+01	2.94E+01	1.65E+01	2.09E+00	2.54E-02	0	1.50E-02	8.77E-03
216-T-6 (1946-1947)	4.50E+01	2.30E+05	1.26E+04	2.08E+01	6.83E+02	0	1.60E+01	1.40E+01	1.51E+01	1.02E+00	7.03E-03	3.49E-06	7.87E-03	2.13E-04
216-T-7, 200-W-52 (1947-1955)	1.07E+02	6.55E+06	3.73E+05	3.39E+02	2.81E+04	0	4.26E+02	3.66E+02	2.36E+02	2.64E+01	3.12E-01	1.49E-05	1.90E-01	9.16E-02
216-T-14 (1954)	1.01E+00	1.08E+05	3.77E+03	3.44E+01	3.60E+02	0	4.60E+02	7.23E+01	4.07E-01	5.8E-02	3.19E-01	1.78E-03	2.03E-01	6.13E+00
216-T-15 (1954)	1.04E+00	1.12E+05	3.90E+03	3.57E+01	3.73E+02	0	4.77E+02	7.50E+01	04.21E-01	6.0E-02	3.31E-01	1.84E-03	2.11E-01	6.35E+00
216-T-16 (1954)	1.02E+00	1.09E+05	3.82E+03	3.49E+01	3.65E+02	0	4.67E+02	7.34E+01	4.13E-01	5.85E-02	3.24E-01	1.80E-03	2.06E-01	6.22E+00
216-T-17 (1954)	7.85E-01	8.41E+04	2.94E+03	2.69E+01	2.81E+02	0	3.59E+02	5.65E+01	3.18E-01	4.50E-02	2.49E-01	1.39E-03	1.59E-01	4.79E+00
216-T-18 (1953)	9.69E-01	3.28E+04	4.21E+03	5.52E+01	1.01E+02	1.44E+02	4.22E+01	3.96E+01	3.24E+00	2.19E-01	6.14E-02	1.48E-03	1.54E-01	2.36E-01
216-T-19 (1951-1956, 1965-1976)	4.55E+02	2.41E+05	1.37E+04	1.28E+01	1.13E+03	0	1.92E+01	2.46E+01	8.35E+00	1.06E+00	1.41E-02	0	7.91E-03	5.12E+03
216-T-21 (1954)	4.63E-01	4.96E+04	1.73E+03	1.58E+01	1.66E+02	0	2.12E+02	3.33E+01	1.87E-01	2.65E-02	1.47E-01	8.17E-04	9.36E-02	2.82E+00
216-T-22 (1954)	1.54E+00	1.65E+05	5.77E+03	5.27E+01	5.51E+02	0	7.04E+02	1.11E+02	6.20E-01	8.82E-02	4.89E-01	2.72E-03	3.01E-01	9.39E+00
216-T-23 (1954)	1.48E+00	1.59E+05	5.57E+03	5.09E+01	5.32E+02	0	6.80E+02	1.07E+02	6.02E-01	8.50E-02	4.72E-01	2.62E-03	3.11E-01	9.06E+00
216-T-24 (1954)	1.54E+00	1.65E+05	5.77E+03	5.27E+01	5.52E+02	0	7.04E+02	1.11E+02	6.24E-01	8.83E-02	4.89E-01	2.72E-03	3.11E-01	9.39E+00
216-T-25 (1954)	2.99E+00	3.20E+05	1.12E+04	1.02E+02	1.07E+03	0	1.37E+03	2.15E+02	1.21E+00	1.71E-01	9.49E-01	5.27E-03	6.04E-01	1.82E+01
216-T-26 (1955-1956)	1.11E+01	3.75E+05	4.82E+04	6.33E+02	1.16E+03	1.63E+03	4.81E+02	4.54E+02	3.69E+01	2.51E+00	7.02E-01	1.70E-02	1.76E+00	2.70E+00
216-T-32 (1946-1952)	2.90E+01	2.50E+06	1.49E+05	5.90E-01	1.03E+04	0	2.93E+00	2.52E+00	5.42E+00	5.48E-01	1.09E-02	2.28E-07	1.33E-03	2.18E-04

a. Total waste volume and inventory values based on the sum value of the mean concentrations taken from the SIM (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*).

b. The Soil Inventory Model (RPP-26744) does not provide speciation information for chromium. All chromium inventories are assumed to be hexavalent unless other information is available.

c. Radiological constituents decayed to January 1, 2001.

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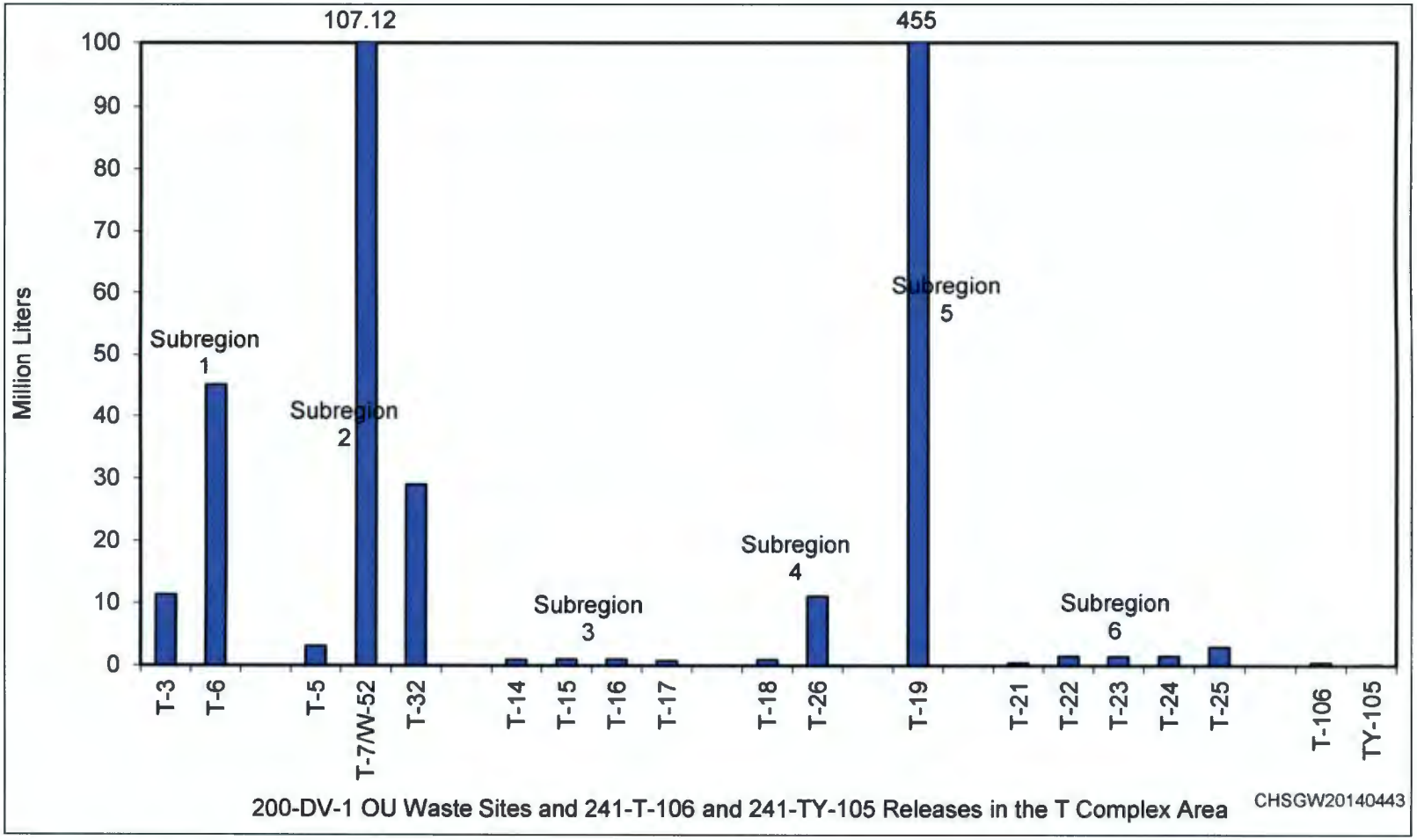


Figure 3-21. Volume of Liquid Waste Discharged to 200-DV-1 OU Waste Sites and Released from SSTs 241-T-106 and 241-TY-105 in the T Complex Area

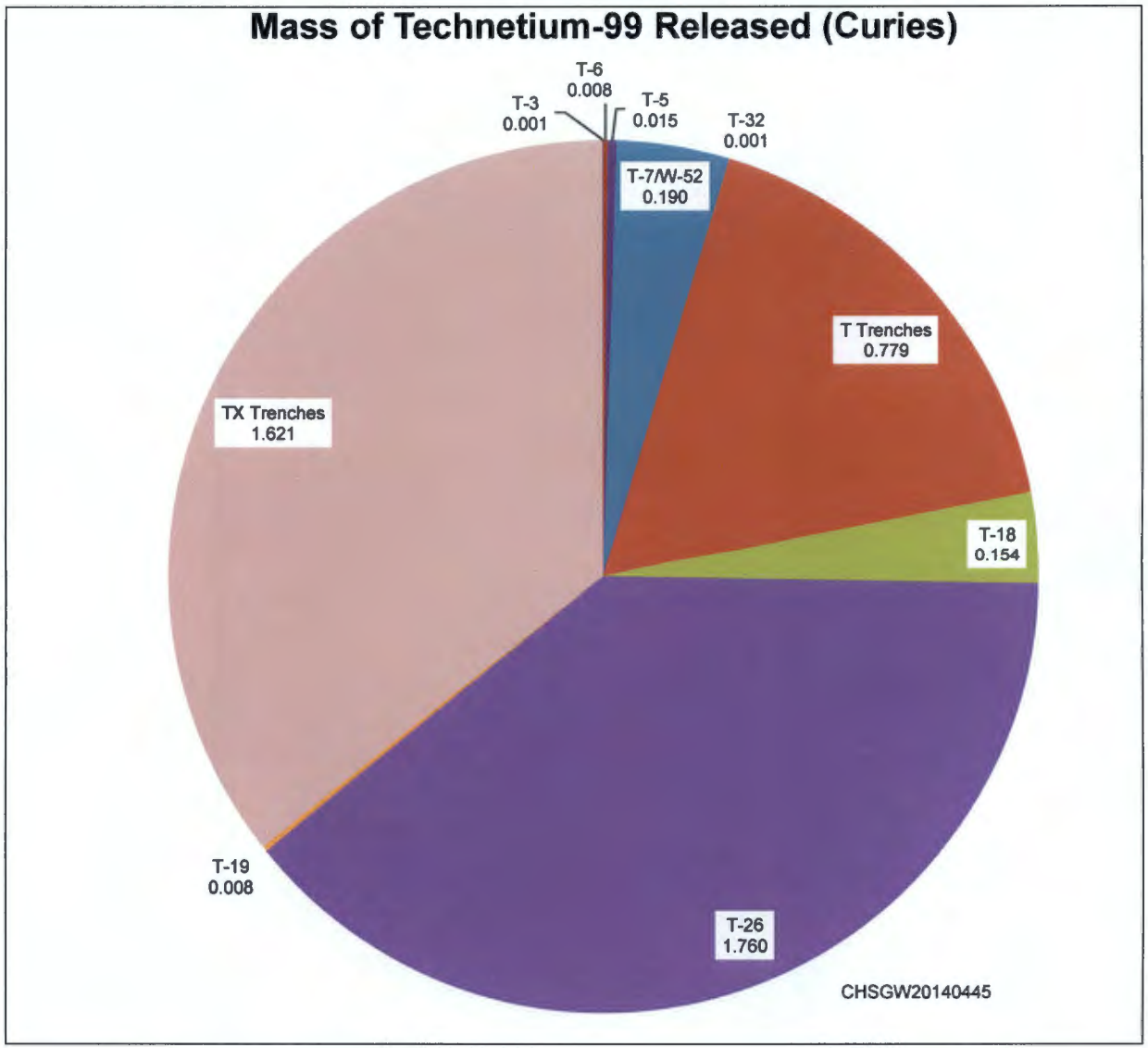


Figure 3-22. Mass of Technetium-99 Released to the Vadose Zone through 200-DV-1 OU Waste Sites in the T Complex Area

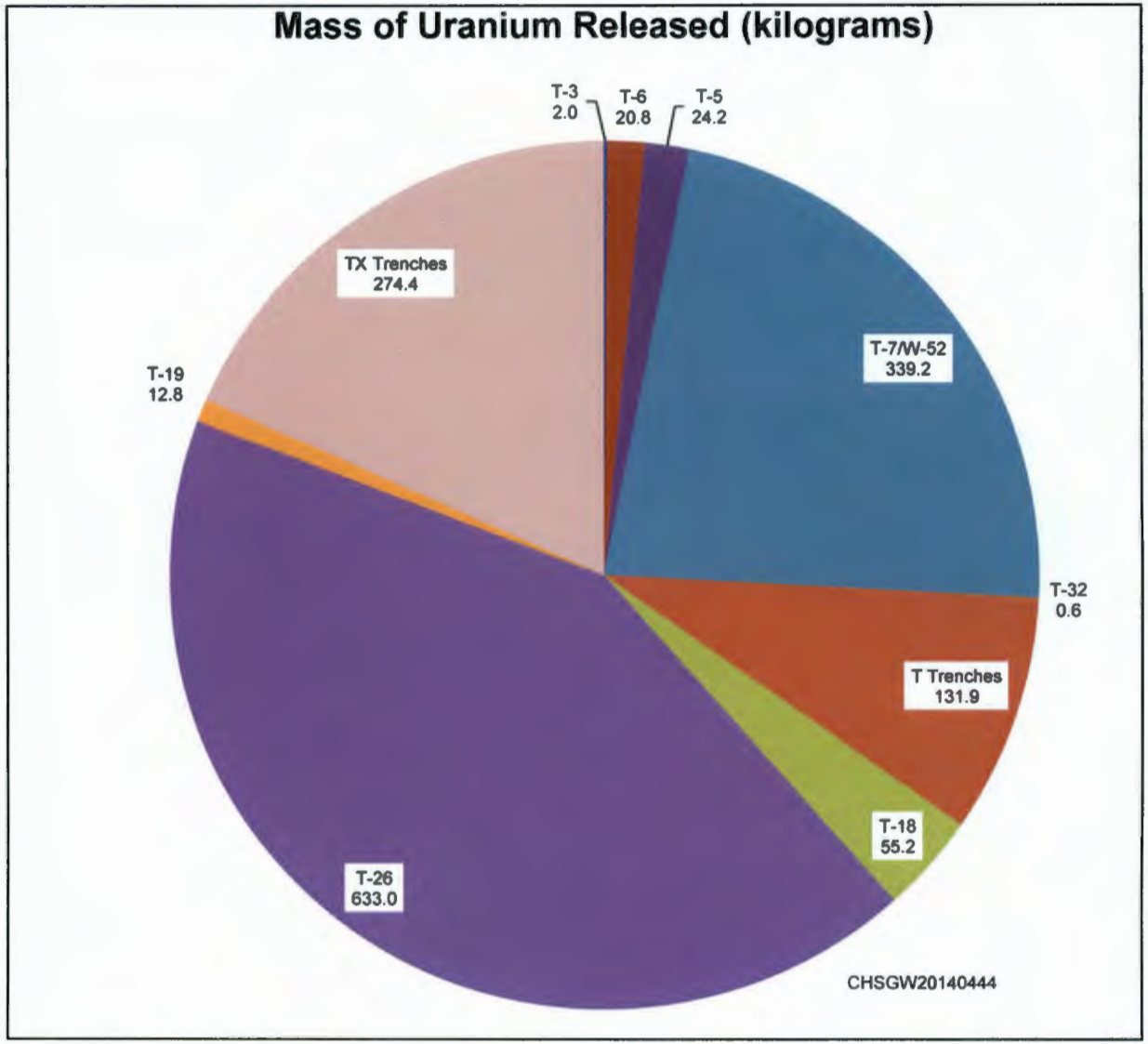


Figure 3-23. Mass of Uranium Released to the Vadose Zone through 200-DV-1 OU Waste Sites in the T Complex Area

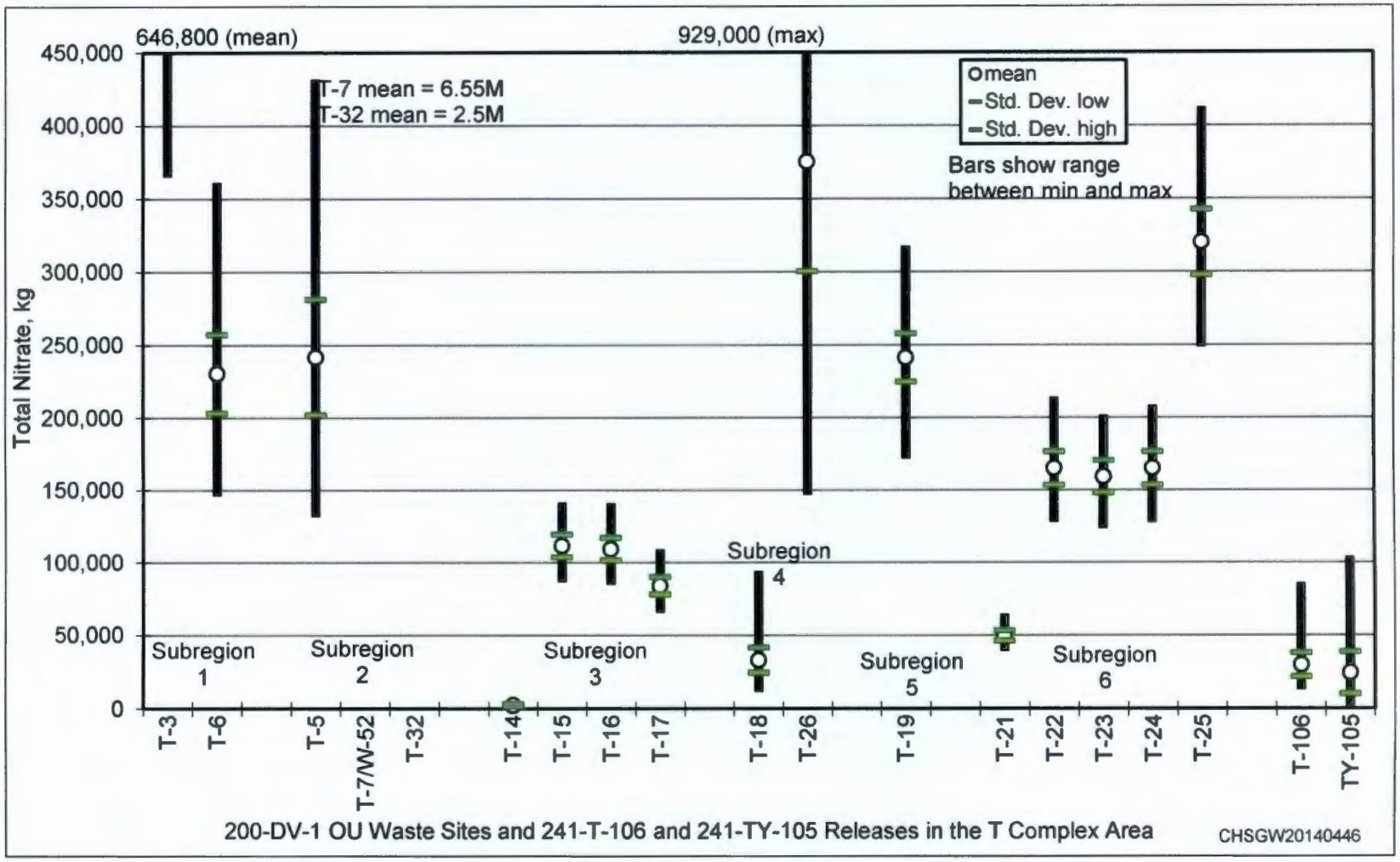


Figure 3-24. Nitrate Inventory Discharged to 200-DV-1 OU Waste Sites and Released from SSTs 241-T-106 and 241-TY-105 in the T Complex Area

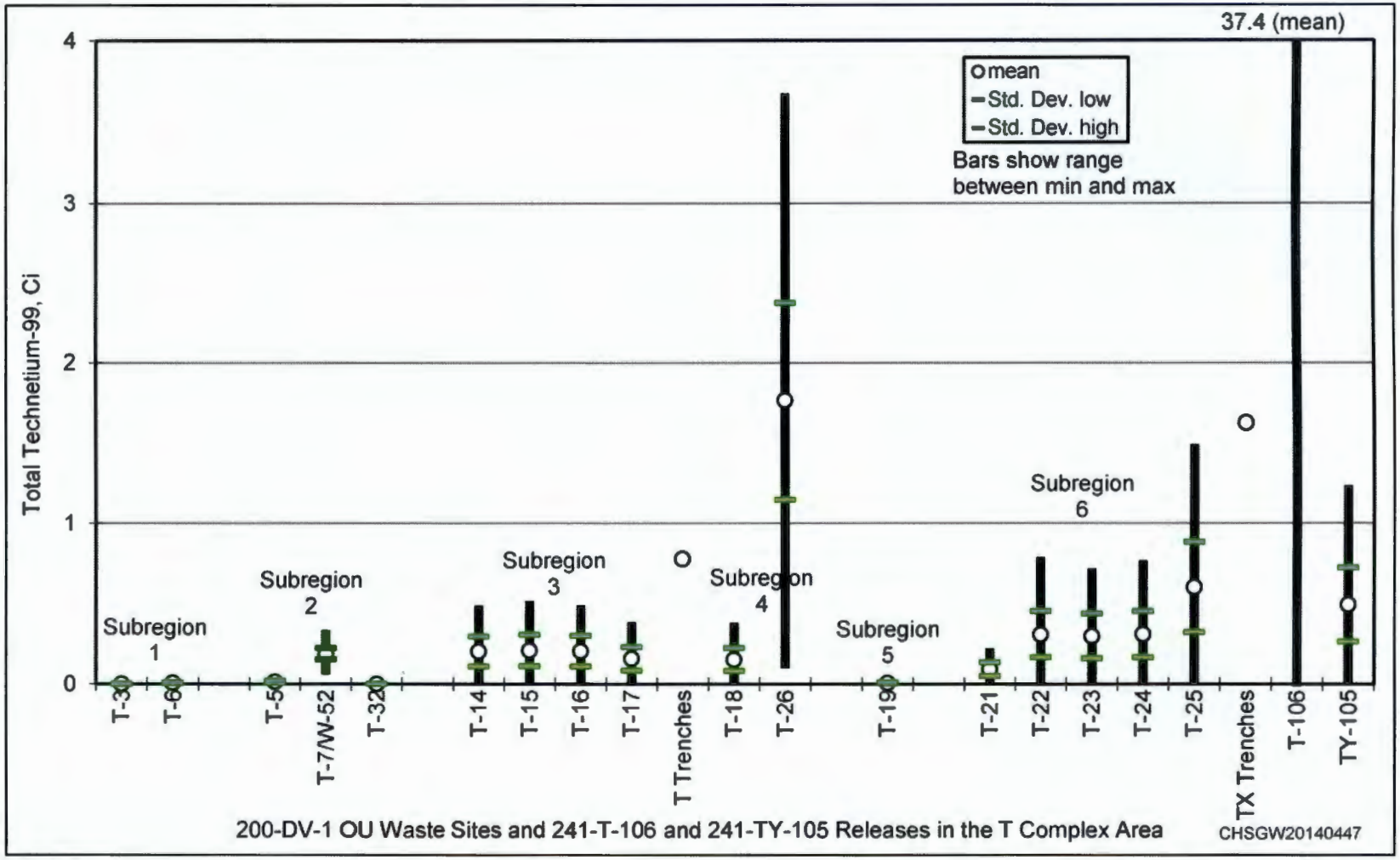


Figure 3-25. Technetium-99 Inventory Discharged to 200-DV-1 OU Waste Sites and Released from SSTs 241-T-106 and 241-TY-105 in the T Complex Area

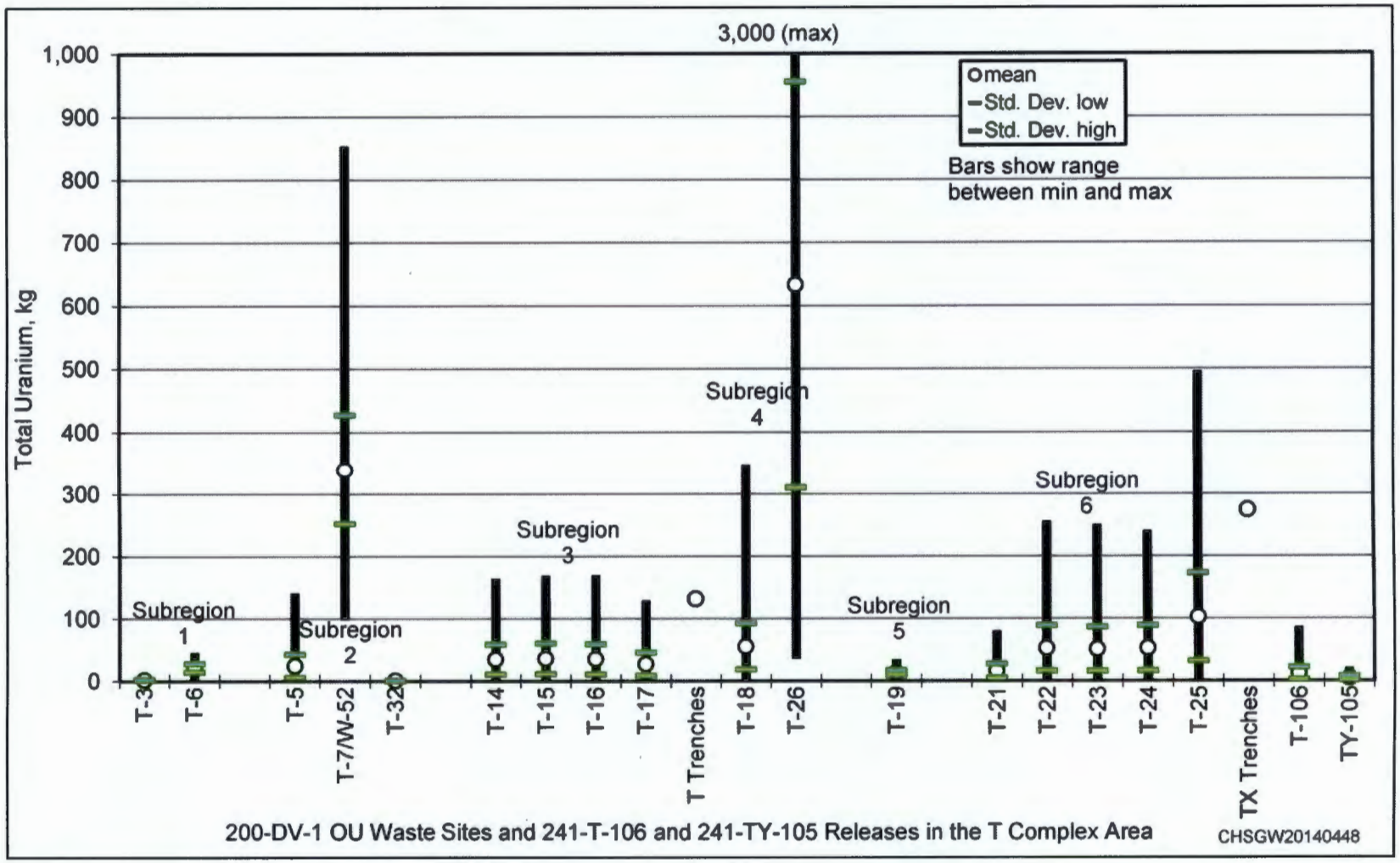


Figure 3-26. Uranium Inventory Discharged to 200-DV-1 OU Waste Sites and Released from SSTs 241-T-106 and 241-TY-105 in the T Complex Area

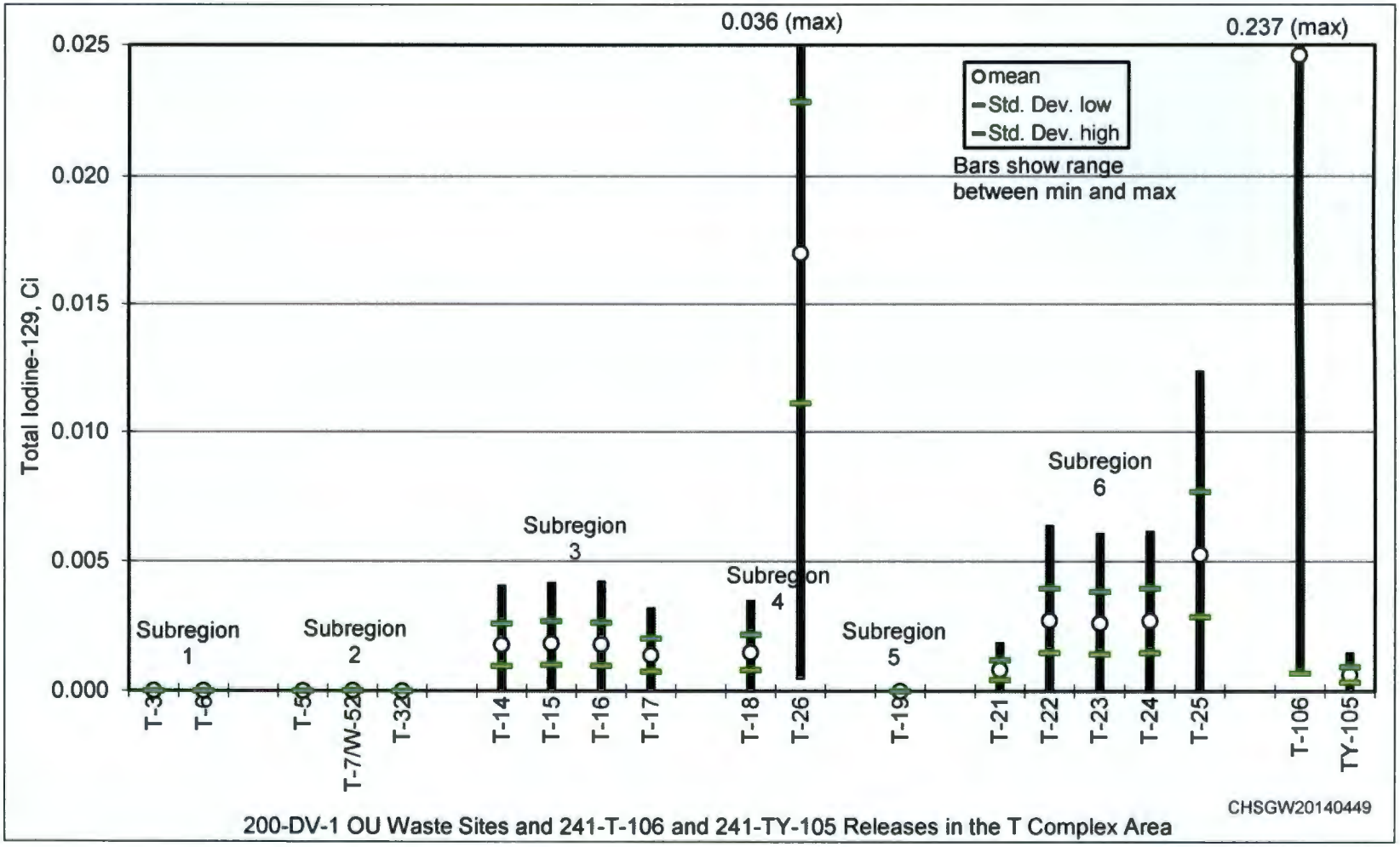


Figure 3-27. Iodine-129 Inventory Discharged to 200-DV-1 OU Waste Sites and Released from SSTs 241-T-106 and 241-TY-105 in the T Complex Area

Selected tank leak and UPR estimates (volumes and inventories) were reassessed and updated in 2010 for the SSTs in the TY Tank Farm. The reassessment result is documented in the RPP-RPT-42296. Current SIM estimates (RPP-26744) have not been updated to reflect the revised estimates in this report. The leaks at T and TX Tank Farms will be reassessed in the future.

The most significant tank waste loss event was the leak of 435,000 L (114,915 gal) from Tank 241-T-106 in May 1973. This leak released approximately 40,000 Ci of cesium-137; 14,000 Ci of strontium-90, 6 Ci of plutonium; and 297,000 Ci of various fission products to the soil. The complete volume and inventory for the 241-T-106 leak is documented in RPP-RPT-42296.

3.3.3 Previous Investigations, Monitoring, and Remediation Activities in the T Complex Area

A timeline of the most significant previous investigations, monitoring, and remediation activities at the 200-DV-1 OU waste sites in the T Complex area is presented in Figure 3-28. Tables 3-13 and 3-14 provide lists of key source documents that were used to support the investigation of 200-DV-1 OU waste sites and the T-TX-TY Tank Farms in the T Complex area. The nature and extent of contamination are discussed in Section 3.3.4.

Geophysical logging has been conducted in wells and boreholes associated with the 200-DV-1 OU waste sites in the T Complex area. The logging provides a vertical profile of subsurface gamma activity and is used to identify zones of contamination and changes in stratigraphy. Total gamma logs that record gamma activity were used until the early 1990s. Spectral gamma logs, which identify individual gamma-emitting species, have been in use since then. Geophysical logging at 200-DV-1 OU waste sites in the T Complex area is summarized and interpreted in SGW-49498, *Geophysical Logging Report for 200-DV-1 Operable Unit Waste Sites in the T Complex Area*. The data are summarized in the information tables prepared to support the DQO process (Tables C-10 through C-17 in Appendix C).

Surface geophysics surveys were conducted over most of the 200-DV-1 OU waste sites in the T Complex area in the past. The primary geophysical technique used was electrical resistivity. Electrical resistivity methods were deployed to identify and delineate subsurface zones of low resistivity (high conductivity) typically associated with high-salt waste residues (i.e., high nitrate waste).The results of the surface geophysical surveys are documented in SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*, and are summarized in the information tables prepared to support the DQO process (Appendix C).

All of the 200-DV-1 OU waste sites in the T Complex area have been interim stabilized. Interim stabilization typically included covering the site with 46 to 61 cm (18 to 24 in.) of uncontaminated soil. At some waste sites, contaminated soil from surrounding area was pushed onto the surface of the waste site before the uncontaminated soil cover was added.

RPP-5957 summarizes the available investigation and monitoring information for the T-TX-TY Tank Farms as of the year 2000. This historical information was used in the DQO process to identify data gaps. The data gaps were filled by field investigations conducted in 2001 and 2002 in accordance with RPP-7578, *Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA T and TX-TY*. The results of these field investigations are documented in the field investigation report (RPP-23752).

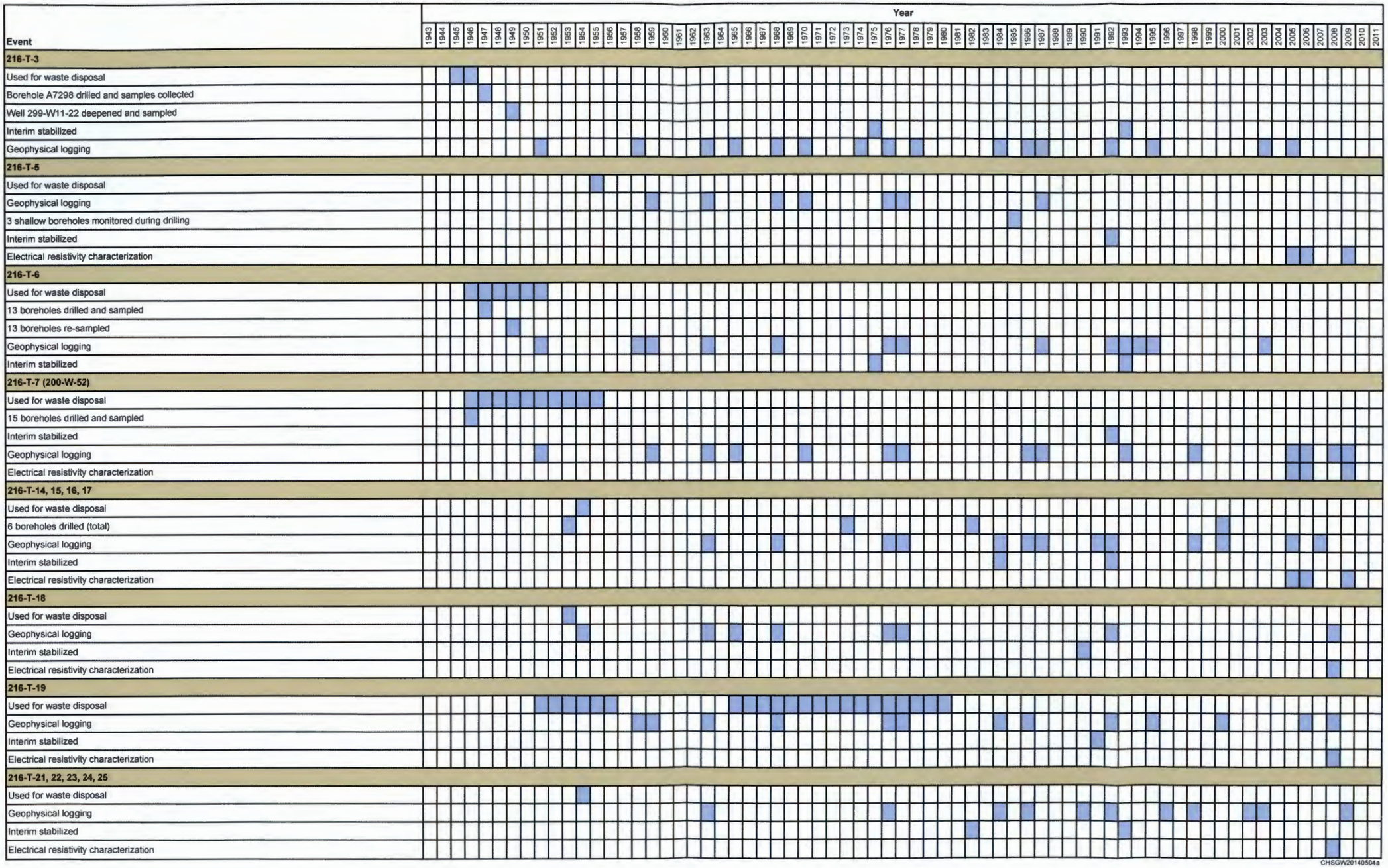


Figure 3-28. Operational Timeline for T Complex Area Waste Sites (sheet 1 of 2)

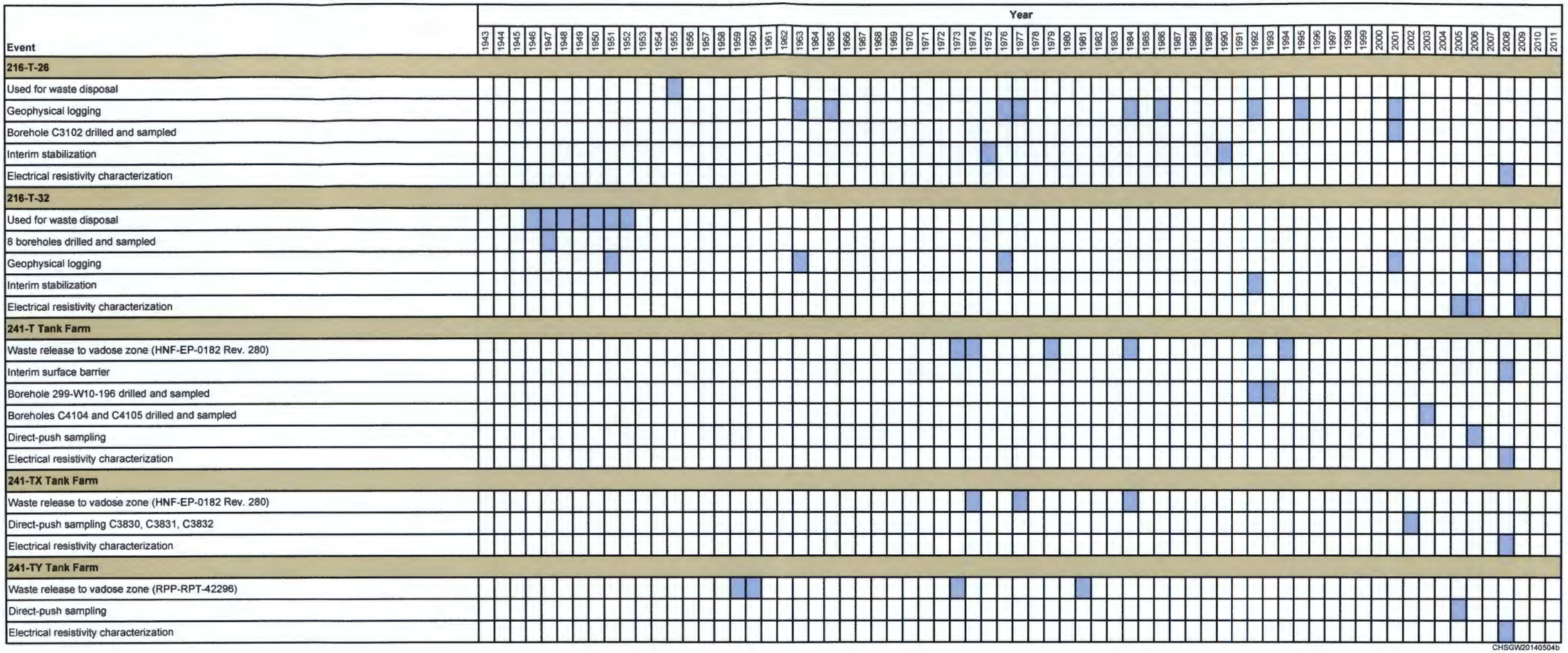


Figure 3-28. Operational Timeline for T Complex Area Waste Sites (sheet 2 of 2)

Table 3-13. Key Previous Documents for 200-DV-1 OU Waste Sites in the T Complex Area

Document Number	Document Title	Date Issued	Summary
HW-9671	*Underground Waste Disposal at Hanford Works: An Interim Report Covering the 200 West Area*	1948	Describes the results of a field investigation of the 216-T-3 Reverse Well, 216-T-6 Cribs, 216-T-7/200-W-52 Crib and Tile Field, and 216-T-32 Cribs.
HW-17088	*The Underground Disposal of Liquid Wastes at the Hanford Works, Washington*	1950	Updates the information in HW-9671 and describes the results of additional field investigation of the 216-T-3 Reverse Well, 216-T-6 Cribs, 216-T-7/200-W-52 Crib and Tile Field, and 216-T-32 Cribs.
ARH-1562	*200 East and North Areas Radioactive Liquid Waste Disposal Sites*	January 1970	Consolidates previously documented information on the liquid waste disposal sites within or near the eastern Central Plateau.
ARH-2155	*Radioactive Liquid Waste Disposal Facilities, 200 West Area*	August 1971	Lists the liquid waste disposal facilities within or near the western Central Plateau. Identifies the waste released in each facility and describes the current facility status.
RHO-CD-673	*Handbook 200 Area Waste Sites*	April 1979	Was written as a handbook of radioactive waste sites and associated radiation areas within the Central Plateau and related environment. It does not include those sites within the confines of the tank farms.
WIDS	Waste Information Data System	Varies	Provides detailed waste site information.
RPP-26744, Rev. 0	*Hanford Soil Inventory Model, Rev. 1*	2005	Provides data on major chemical inventories disposed by year for each facility, in addition to waste stream and waste density information.
SGW-49498, Rev. 0	*Geophysical Logging Report for 200-DV-1 Operable Unit Waste Sites in the T Complex Area*	August 2011	Assembles and presents the interpreted extent of gamma-emitting contamination for available geophysical logging data for the 200-DV-1 OU waste sites in the T Complex area.
RPP-RPT-38320, Rev. 0	*Surface Geophysical Exploration of the TX and TY Tank Farms at the Hanford Site*	August 2008	Documents the results of surface geophysical characterization activities performed during FY 2008 for the TX-TY Tank Farms and the surrounding areas.

Table 3-13. Key Previous Documents for 200-DV-1 OU Waste Sites in the T Complex Area

Document Number	Document Title	Date Issued	Summary
RPP-5957, Rev. 0	*Historical Vadose Zone Contamination from T, TX and TY Tank Farm Operations*	March 2000	Provides a collection of historical information regarding radioactive contamination of the soil surface and vadose zone near the T-TX-TY Tank Farms.
RPP-7123, Rev. 0	*Subsurface Conditions Description of the T and TX-TY Waste Management Areas*	January 2001	Describes the subsurface conditions relevant to the occurrence and migration of contaminants in the groundwater underlying the T-TX-TY Tank Farms.
DOE/RL-2002-42, Rev. 0	*Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*	2003	Provides the analytical results for sediment samples collected from Borehole C3102 in the 216-T-26 Crib, Borehole C3103 in the 216-B-7A Crib, and Borehole C3104 in the 216-B-38 Trench as part of the RI in 2001 for the 200-TW-1 and 200-TW-2 OUs.
PNNL-16649	*Characterization of Direct Push Vadose Zone Sediments from the T and TY Waste Management Areas*	2007	Contains geochemical and selected physical characterization data collected on vadose zone sediment recovered from direct-push characterization holes emplaced near Tanks 241-T-101 and 241-T-104 (in the T Tank Farm) and near Tanks 241-TY-105 and 241-TY-106 (in the TY Tank Farm).
DOE/RL-2007-02	*Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units*	2007	Provides the detailed sampling plans for collecting additional characterization data at waste sites on the Central Plateau. The sampling plans were developed following a supplemental DQO process conducted by the Tri-Parties in FY 2005 and FY 2006. The waste sites evaluated in the supplemental DQO process included all of the 200-DV-1 OU waste sites. Supplemental characterization data were identified for 12 waste sites in the 200-DV-1 OU.
WMP-28389, Rev. 0	*T-Area Technetium-99 Data Quality Objectives Summary Report*	2007	Presents the process history, data, and conceptual site models for the presence of relatively high concentrations of technetium-99 approximately 30 ft below the water table near the northeast corner of the T Tank Farm.

Table 3-13. Key Previous Documents for 200-DV-1 OU Waste Sites in the T Complex Area

Document Number	Document Title	Date Issued	Summary
RPP-RPT-42844, Rev. 0	*Reanalysis of Surface Geophysical Exploration Resistivity Data for the 241-T Tank Farm*	2009	Presents the results of a reanalysis of electrical resistivity data collected during 2005 and 2006 for the T Tank Farm and surrounding area (referred to along with the TX-TY Tank Farm areas as the "T Complex").
SGW-50056, Rev. 0	*Resistivity Characterization of 216-C-1, A Complex, B Plant, PUREX, S Complex, T Plant, and 216-Z-16 Trench Project Sites*	August 2011	Geophysical profiling using the two-dimensional resistivity method was conducted to interrogate the vadose zone subsurface beneath these waste sites using a noninvasive technique to determine whether past waste disposal and/or handling activities have left a measureable electrical signature.
SGW-49924, Rev. 0	*Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*	January/ February 2015	Evaluates and documents the current understanding (i.e., conceptual model) of the distribution and behavior of key mobile contaminants beneath specific waste sites assigned to the 200-DV-1 OU in the T Complex area.

DQO = data quality objective
FY = fiscal year
OU = operable unit
Tri-Parties = U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology

Table 3-14. Key Previous Documents for T-TX-TY Tank Farms in the T Complex Area

Document Number	Document Title	Date Issued	Summary
RPP-5957, Rev. 0	*Historical Vadose Zone Contamination from T, TX and TY Tank Farm Operations*	March 2000	Compiles information on liquid waste discharged to the vadose zone within and around the T-TX-TY Tank Farms. Planned discharged and unplanned releases are considered. Discharges are presented chronologically and placed in the context of tank farm operations.
RPP-23752, Rev. 0-A	*Field Investigation Report for Waste Management Areas T and TX-TY*	August 2005	Compiles and presents the 2005 comprehensive assessment of information to understand the nature and extent of past major releases from single-shell tanks in the T-TX-TY Tank Farms.
RPP-7578, Rev. 2	*Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs T and TX-TY*	July 2002	Outlines the investigation efforts for collection of field characterization data in and near Waste Management Areas T and TX-TY. The data was used to support RCRA field investigation/corrective measures study decision-making process.
RPP-RPT-42296, Rev. 0	*Hanford TY-Farm Leak Assessments Report*	April 2010	Reassesses and updates selected tank leak estimates (volumes and inventories) in the TY Tank Farm.
RPP-7123, Rev. 0	*Subsurface Conditions Description of the T and TX-TY Waste Management Areas*	January 2001	Describes the subsurface conditions relevant to the occurrence and migration of contaminants in the groundwater underlying the T-TX-TY Tank Farms.

RCRA = *Resource Conservation and Recovery Act of 1976*

Interim measures to minimize infiltration and mitigate migration to groundwater were evaluated and implemented at the T-TX-TY Tank Farms. Active water lines were leak tested. Existing drywells were capped to prevent water intrusion. Design and construction of run-on control structures were implemented. Berms were placed to redirect surface water away from the tank farm surface, and curbs and gutters were placed to redirect anticipated run-off from the paved road. The investigation, monitoring, and remediation activities for each T Complex area subregion are summarized below. Additional information is provided in the information tables prepared to support the DQO process (Appendix C).

3.3.3.1 Subregion 1: 216-T-3 Reverse Well and 216-T-6 Cribs

Characterization data from three wells within 9.1 m (30 ft) of the 216-T-3 waste site were evaluated. Relatively high concentrations of cesium-137 are shown at approximately 4.6 m (15 ft) bgs in all three boreholes. The maximum concentration of cesium-137 is 46,000 pCi/g between 4.6 and 4.9 m (15 and 16 ft) bgs in Well 299-W11-79, approximately 8.2 m (27 ft) southeast of 216-T-3. This shallow interval of contamination is most likely related to the 241-T-361 Setting Tank, or the pipelines between the settling tank and the 216-T-3 Reverse Well, or between the 216-T-3 Reverse Well and the 216-T-6 Cribs (SGW-49498, pp. A-42 and A-57). Two of the boreholes indicate contamination throughout the sediments to the approximate top of the CCU, where the perforations begin in the 216-T-3 Reverse Well. All three boreholes indicate increases in cesium-137 concentrations at a level equivalent to the top of the perforations.

At 216-T-6 Cribs, geophysical logging data were evaluated at 15 boreholes near the cribs. A zone of elevated concentrations was identified from approximately 6.1 to 18.2 m (20 to 60 ft) bgs, with the highest cesium-137 concentrations between 6.1 to 12.2 m (20 to 40 ft) bgs. Because the base of the cribs was 6.1 m (20 ft) bgs, this shallower contamination is likely from the pipeline between the two cribs. The plutonium contamination was summarized as being contained within 6.1 m (20 ft) below the 216-T-6 Cribs, with a lateral spread of 13.7 m (45 ft). Fission product contamination was summarized as extending to 32.6 m (107 ft) below the cribs; with a 29 m (95 ft) lateral spread (HW-9671, p. 17). Additional sediment samples were collected in October 1949. Approximately 0.08 μCi of beta-gamma activity per kilogram of sediment was detected in each sample. No significant alpha contamination was detected in any of the sediment samples. Samples from the bottom of the six boreholes penetrating through the silt-clay bed (likely the CCU_z layer) showed no evidence of contamination (HW-17088, p. 66).

In August 1975, the aboveground piping was removed at the 216-T-3 site and the sinkholes were filled. The ground surface was decontaminated and leveled at both 216-T-3 and 216-T-6 waste sites (RHO-CD-673 II.NE, *Handbook 200 Areas Waste Sites*). The 241-T-361 Settling Tank, 216-T-3 Reverse Well, and 216-T-6 Cribs were again surface stabilized in 1993 (WIDS; WHC-SP-1149, *Status of Outdoor Radioactive Contamination at the Hanford Site*, p. B-9).

3.3.3.2 Subregion 2: 216-T-5, 216-T-32, and 216-T-7

A borehole was drilled northwest of the 216-T-5 Crib in 1947. Although gamma-emitting contamination was detected beginning at 3.1 m (10 ft) bgs in this well in 1959, the contamination had decayed to background levels by 1968. In 1985, three shallow boreholes were drilled in the northwest section of the crib. Geophysical logging data do not exist for these boreholes. According to driller's logs, each borehole encountered contamination at 3.4 or 3.7 m (11 or 12 ft) bgs, with maximum concentration found at 3.7 and 4 m (12 and 13 ft) bgs.

Eight boreholes surrounding the 216-T-7 Crib, and five more boreholes within the excavated area at 216-T-32 Crib 1, were drilled in 1947. Contamination from the 216-T-32 Crib 1 had migrated laterally to the southwest, contaminating sediment beneath the 216-T-7 Crib and Tile Field (HW-9671,

pp. 21 and 68, Plate 6). HW-9671 (Plates 7 and 8) and SGW-49498 (p. A-67) suggest that the plutonium may have been 10.4 m (34 ft) bgs rather than below the cribs. At the 216-T-32 Cribs, detections of cesium-137, europium-154, and plutonium begin approximately at 10.7 m (35 ft) bgs. The contaminated zone ranges in thickness from approximately 4.6 m (15 ft) near Crib 1 to approximately 1.5 m (5 ft) southeast of Crib 2 at a location below the 216-T-7 Tile Field. The concentrations of cesium-137 and europium-154 are relatively minor, suggesting that the fission product plume described in HW-9671 primarily contained the short-lived, gamma-emitting radionuclides. Geophysical logging suggests that the plutonium, cesium-137, and europium-154 contamination from 216-T-32 migrated laterally to the southwest within a dipping, silty-sandy geologic subunit and is contained within this unit.

In 1948, four shallow test boreholes were drilled in the 216-T-7 Tile Field. No contamination was found in sediment samples obtained from the bottom of the crib, and no liquid was found in any of these boreholes (HW-17088, p. 74). The plutonium contamination was summarized as being contained within 10.4 m (34 ft) below the cribs, with a lateral spread of 60 m (197 ft). Fission product contamination was summarized as extending to 8.5 m (28 ft) below the crib, with an 85.3 m (280 ft) lateral spread (HW-9671, pp. 15 and 17). At the 216-T-7/200-W-52 Crib, contamination generally begins near the bottom of the crib in the four boreholes closest to the crib and at approximately 12.2 m (40 ft) bgs in the four boreholes further from the crib. Historical (1951) contamination detected at the 216-T-7 Tile Field at 12.2 m (40 ft) bgs had decayed by 1976 and appears likely to have originated from the 216-T-32 Cribs. Contamination below 24.4 m (80 ft) bgs appears to have originated from the 216-T-7 Crib and Tile Field system. Borehole 299-W10-73, approximately 21.3 m (70 ft) north of the 216-T-7 Crib, appears to have been contaminated from 216-T-7. At this borehole, cesium-137 is detected to the bottom of the borehole near groundwater. Boreholes 299-W10-70 and 299-W10-71 at the western end both indicate no contamination at any time, suggesting that this portion of the tile field received very little effluent overflowing from the 216-T-7 Crib and no lateral migration of contaminants at these locations from the 216-T-32 or 216-T-5 Cribs.

In 1992, surface contamination was identified in the vicinity of 216-T-5 and the T Tank Farm. Both areas were covered with 0.6 m (2 ft) of clean dirt. The surface of the 216-T-32 Crib was also stabilized with gravel, along with the remainder of the T Tank Farm (WIDS).

3.3.3.3 Subregion 3: 216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches (T Trenches)

Previous investigations were performed at the T Trenches. SGW-49498 (pp. A-95 to A-96) summarizes geophysical logging results for six wells surrounding the T Trenches.

- At Borehole 299-W11-69, west of 216-T-14 (33.5 m [110 ft] deep), cesium-137 was detected in 2005 from 0 to 3.4 m (0 to 11 ft) bgs, with a maximum activity of 16 pCi/g at 1.7 m (5.5 ft) bgs. This shallow contamination may be associated with the contaminated soil placed on the west slope of the T Trenches in 1992. No contamination was detected between 9.1 and 12.2 m (30 and 40 ft).

- At Borehole 299-W11-23, further west of 216-T-14 (76.8 m [252 ft] deep), cesium-137 was detected in 1998 from 0 to 12.8 m (0 to 42 ft) and from 18.2 to 42.7 m (60 to 140 ft) bgs, with a maximum concentration of 74 pCi/g at 0.5 m (1.5 ft) bgs.

- At Borehole 299-W11-39, cesium-137 was detected from 0 to 0.3 m (0 to 1 ft) and again at 6.4 m (21 ft) bgs in 2000, with a maximum of 2 pCi/g at the ground surface.

- At Borehole 299-W11-68 (30.5 m [100 ft] deep), high gross-gamma activity (about 500,000 counts per minute) was detected in 1968 from 9.1 and 12.2 m (30 to 40 ft) bgs and was still higher than background in 1987. In 2005, cesium-137 was detected in from 0 to 2.4 m (0 to 8 ft) bgs, with a maximum activity of 230 pCi/g at 1.2 m (4 ft) bgs.

- At Borehole 299-W11-80 (15.8 m [52 ft] deep), northeast corner of 216-T-16, cesium-137 was detected in 2005 from 0 to 3.7 m (0 to 12 ft) bgs, with a maximum activity of 1 pCi/g at 3.1 m (10 ft) bgs. No gross gamma activity was detected in 1984 or 1986.

- At Borehole 299-W11-81 (15.8 m [52 ft] deep), near the southeast corner of 216-T-17, gross-gamma activity at 4.6 to 4.9 m (15 to 16 ft) bgs saturated the logging tool in 1984, 1986, and 1992. The count rates increased at the bottom of the borehole. In 1992, cobalt-60 was identified from 4.9 to 14.6 m (16 to 48 ft) bgs, with a maximum of 2 pCi/g at 5.5 m (18 ft) bgs. In 2005, cesium-137 was detected from 0 to 15.8 m (0 to 52 ft) bgs, with a maximum activity of 13,000 pCi/g at 4.6 m (15 ft) bgs. Cobalt-60 was identified from 6.7 to 9.1 m (22 to 30 ft), with a maximum of 0.2 pCi/g at 8.5 m (28 ft).

The 216-T-14 through 216-T-17 Trenches were interim stabilized with 0.6 m (2 ft) of clean soil in 1984. The trenches were posted as "Surface Contamination" and included in the UPR-200-W-166 (alias UN-216-W-31) area in 1989. Subsequent surveys showed that a large portion of the site had low but detectable near-surface contamination (shine) and was probably not surface contaminated (WHC-SD-DD-AP-013, *UN-216-W-31 Unplanned Release Site Interim Stabilization Plan and Alternatives Evaluation*, p. 3). In 1992, the original stabilized area of the T Trenches was covered with an additional 0.2 to 0.3 m (0.5 to 1 ft) of clean soil to provide an additional barrier over the near-surface contamination. The posting was changed from "Surface Contamination" to "Underground Radioactive Material" (WHC-SD-DD-AP-013, p. 7). In 1992, radiologically contaminated soil from UPR-200-W-166, north of the T Tank Farm and west of the T Trenches, was scraped and consolidated onto the west slope of the T Trenches. The contaminated soil was covered with 0.5 to 0.6 m (1.5 to 2 ft) of clean dirt (WHC-SD-DD-AP-013, p. 7; WHC-SP-0098-7, *Routine Environmental Monitoring Schedule, Calendar Year 1996*, p. B-8).

3.3.3.4 Subregion 4: 216-T-18 and 216-T-26 Cribs

SGW-49498 (pp. A-112 to A-113) summarizes the geophysical logging results for the 216-T-18 Crib.

Well 299-W11-11 was logged periodically from 1954 until 1992. The log profiles detected activity to 25.6 m (84 ft) bgs at the top of the CCU. By 1992, cesium-137 and cobalt-60 were the only detectable gamma-emitting radionuclides. The maximum cesium-137 concentration is approximately 10,000 pCi/g at 9.1 m (30 ft) bgs, and the maximum cobalt-60 concentration is approximately 0.6 pCi/g at 22.9 m (75 ft) bgs. Low levels of cobalt-60 are also detected in the Ringold Formation. Three direct-push holes were installed at 216-T-18 and logged in 2008 as part of the supplemental characterization. The maximum cesium-137 concentration in the upper 4.6 m (15 ft) was approximately 1,000 pCi/g at 4.6 m (15 ft) bgs.

In 2001, Borehole C3102 was drilled through the center of the 216-T-26 to the groundwater and sampled at 10 intervals between 3.1 and 69.2 m (10 ft and 227 ft). DOE/RL-2002-42 provides analytical data for Borehole C3102. The maximum soil concentrations from Borehole C3102 are provided in Table 3-15.

Remnants of cobalt-60 are also found at the above depths in Borehole C3102. It appears that contamination resides primarily in the southern portion of the crib (SGW-49498, pp. A-113 to A-115).

Following completion of waste discharge to the 216-T-18 Crib, the aboveground piping was removed and the crib was backfilled with soil to the ground surface (HW-33591, *Summary of Liquid Radioactive Wastes Discharged to the Ground – 200 Areas, July 1952 through June 1954*, p. 27; ARH-2155, *Radioactive Liquid Waste Disposal Facilities, 200 West Area*, p. B-26; RHO-CD-673 II.NE). The crib was surface stabilized again in 1990.

Table 3-15. Maximum Detected Values of Selected Analytes from Borehole C3102 Samples

Analyte	Maximum Concentration	Depth of Maximum Concentration (bgs)
Total uranium	61,100 µg/kg	10.4 to 11.3 m (34 to 36.5 ft)
Technetium-99	4.87 pCi/g	28 to 28.8 m (92 to 94.5 ft)
Iodine-129	NA	NA
Cobalt-60	0.074 pCi/g	28 to 28.8 m (92 to 94.5 ft)
Tritium	2,650 pCi/g	28 to 28.8 m (92 to 94.5 ft)
Plutonium-239	6,320 pCi/g	10.4 to 11.3 m (34 to 36.5 ft)
Nitrate	3,070 mg/kg	28 to 28.8 m (92 to 94.5 ft)
Fluoride	168 mg/kg	10.4 to 11.3 m (34 to 36.5 ft)
Cyanide	7.9 mg/kg	28 to 28.8 m (92 to 94.5 ft)
Chromium (hexavalent)	4.2 mg/kg	10.4 to 11.3 m (34 to 36.5 ft)

Source: Tables C-1, C-2, and C-3 in 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).*

bgs = below ground surface

NA = not analyzed

In May 1975, spotty surface contamination was found at the 216-T-26 Crib. In June and July 1975, 15.2 cm (6 in.) of surface-contaminated soil was bladed from the affected areas. The ground surface was then covered with clean fill dirt back to its original level (RHO-CD-673 II.NE). The 216-T-26, 216-T-27, and 216-T-28 Cribs and the 216-TY-201 flush tank were surface stabilized as one unit in 1990 (WIDS) (WHC-SP-1149, p. B-9).

3.3.3.5 Subregion 5: 216-T-19 Crib and Tile Field

SGW-49498 (pp. A-139 to A-140) summarizes the geophysical logging results for the 216-T-19 Crib and Tile Field.

Four boreholes are located within the area of the 216-T-19 Crib and Tile Field. These logs show no evidence of cesium-137 contamination greater than 1 pCi/g in the upper 4.6 m (15 ft) near the tile field. Waste entered the 216-T-19 Crib and Tile Field approximately 7 m (23 ft) bgs. Contamination is not anticipated for the upper 4.6 m (15 ft) bgs.

- Borehole 299-W14-51, nearest to the crib, indicates possible contamination to 22.9 m (75 ft) bgs (total depth).
- Borehole 299-W15-4, located approximately 37.1 m (122 ft) southwest of the crib and outside of the tile field, encountered radiological contamination above 12.2 m (40 ft) bgs when it was drilled in 1956, suggesting extensive lateral migration if 216-T-19 was the source. Elevated gamma activity was detected between 10.7 and 15.2 m (35 and 50 ft) bgs on all logs run between 1958 and 1995.

- Well 299-W15-762 encountered radiological contamination at 11.3 m (37 ft) bgs when it was drilled in 2000.
- Well 299-W15-763 encountered no radiological contamination when it was drilled in 2000.

After the 1956 cave-in, a bypass line was installed to route the waste directly to the 216-T-19 Tile Field. In 1991, the tile field was interim stabilized (WHC-SP-1149, p. B-9).

3.3.3.6 Subregion 6: 216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 (TX Trenches)

SGW-49498 (pp. A-150 to A-151) summarizes the geophysical logging results for the TX Trenches.

Five boreholes are investigated in the general vicinity of the TX Trenches, and none were drilled through the base of a trench. Cesium-137 was detected in all five boreholes between 0 and 4.6 m (0 and 15 ft) bgs. The maximum cesium-137 concentration was approximately 30 pCi/g at 0.9 m (3 ft) bgs. Cesium-137 was detected with the predominant contamination occurring at approximately 8.5 m (28 ft) bgs. The maximum cesium-137 concentration detected is approximately 100,000 pCi/g at 10.1 m (33 ft) bgs in Well 299-W15-209. The deepest cesium-137 contamination was detected at 30.5 m (100 ft) bgs in Well 299-W15-210 (total depth of the borehole).

When each trench reached specific retention capacity, the aboveground piping was removed and the trench was backfilled (ARH-2155, pp. B-30 through B-34; RHO-CD-673 II.NW). All of the trenches were interim stabilized as one unit in 1982 (WHC-SP-1149, p. B-9). An area of backfill on the northeast corner was expanded to the north and east (approximately 30.5 m by 18.3 m [100 ft by 60 ft]) in 1993 (WIDS). An underground contamination site, approximately 1.8 m by 1.5 m (6 ft by 5 ft), east of the 216-T-23 Trench, was stabilized in 1993 and included with 216-T-23 in 2000 (WIDS).

3.3.4 Nature and Extent of Contamination in the T Complex Area

This section summarizes the nature and extent of contamination associated with each of the T Complex area subregions. Table 3-16 identifies the vertical location of contamination at each subregion with respect to the upper 4.6 m (15 ft) of the vadose zone, 4.6 m (15 ft) bgs to groundwater, and groundwater.

Table 3-16. Vertical Contamination at 200-DV-1 OU Waste Sites in the T Complex Area

Subregion	Waste Site	Contamination in Upper 4.6 m (15 ft)[a]	Contamination From 4.6 m (15 ft) to Groundwater[b]	Contamination in Groundwater[a]
1	216-T-3	No	Yes	Yes
	216-T-6	Yes	Yes	Yes
2	216-T-5	Yes	Yes	Yes
	216-T-7	No	Yes	Yes
	216-T-32	No	Yes	No[c]
3	216-T-14	Yes	Yes	No
	216-T-15	Yes	Yes	No
	216-T-16	Yes	Yes	No
	216-T-17	Yes	Yes	No

Table 3-16. Vertical Contamination at 200-DV-1 OU Waste Sites in the T Complex Area

Subregion	Waste Site	Contamination in Upper 4.6 m (15 ft)[a]	Contamination From 4.6 m (15 ft) to Groundwater[b]	Contamination in Groundwater[a]
4	216-T-18	Yes	Yes	Yes
	216-T-26	Yes	Yes	Yes
5	216-T-19	No	Yes	Yes
6	216-T-21	Yes	Yes	No
	216-T-22	Yes	Yes	No
	216-T-23	Yes	Yes	No
	216-T-24	Yes	Yes	No
	216-T-25	Yes	Yes	No

a. 200-DV-1 Operable Unit data quality objectives summary report (Appendix C).

b. SGW-49498, *Geophysical Logging Report for 200-DV-1 Operable Unit Waste Sites in the T Complex Area.*

c. May be contributing to groundwater plume to the east (via 216-T-7).

Table 3-17 summarizes the likelihood that contaminants from the 200-DV-1 OU waste sites have affected groundwater in the past or may be affecting groundwater currently and/or in the future.

3.3.4.1 Subregion 1: 216-T-3 Reverse Well and 216-T-6 Cribs

Because the perforations in the 216-T-3 Reverse Well begin at 31.9 m (104.5 ft) bgs, contamination release from the 216-T-3 waste site is unlikely in the upper 4.6 m (15 ft) of the subsurface. The vertical extent of contamination likely extends at least to 62.2 m (204 ft) bgs, the lowermost depth of the perforations (SGW-49924, Figure 3-14). The lateral extent of contamination is approximately 14 m (45 ft) radially from the well, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-13).

At the 216-T-6 Cribs, the vertical extent of contamination likely extends at least to 45.7 m (150 ft) bgs to the Ringold Formation (SGW-49924, Figure 3-14). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the cribs. In the DVZ, the area of contamination is an ellipse with a northwest-southeast axis approximately 75 m (246 ft) long and a northeast-southwest axis approximately 45.1 m (148 ft) long, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-13). The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex CSM report (SGW-49924, Chapter 4).

Based on the evaluation of geophysical logging data for wells near these waste sites, it appears that contaminants have possibly affected groundwater at both waste sites (SGW-49498, p. A-9).
The contaminant conceptual model for the 216-T-3 Reverse Well and 216-T-6 Cribs (as 216-T-6-1 and 216-T-6-2) is provided in Figure 3-29.

Table 3-17. Impact of 200-DV-1 OU Waste Sites in the T Complex Area on Underlying Groundwater

Subregion	200-DV-1 OU Waste Site	Past Groundwater Impact Likely?	Current Groundwater Impact Likely?	Future Groundwater Impact Likely?
1	216-T-3 Reverse Well	●	○	○
	216-T-6 Cribs	●	○	○
2	216-T-5 Trench	○	○	○
	216-T-7 Tile Field (and 200-W-52 Crib in Waste Management Area T)	●	●	●
	216-T-32 Cribs	●	●	●
3	216-T Trenches	○	○	○
4	216-T-18 Crib	●	○	○
	216-T-26 Crib	●	●	○
5	216-T-19 Crib and Tile Field	●	○	○
6	216-TX Trenches	○	○	○

Note: This table is based on SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington.*

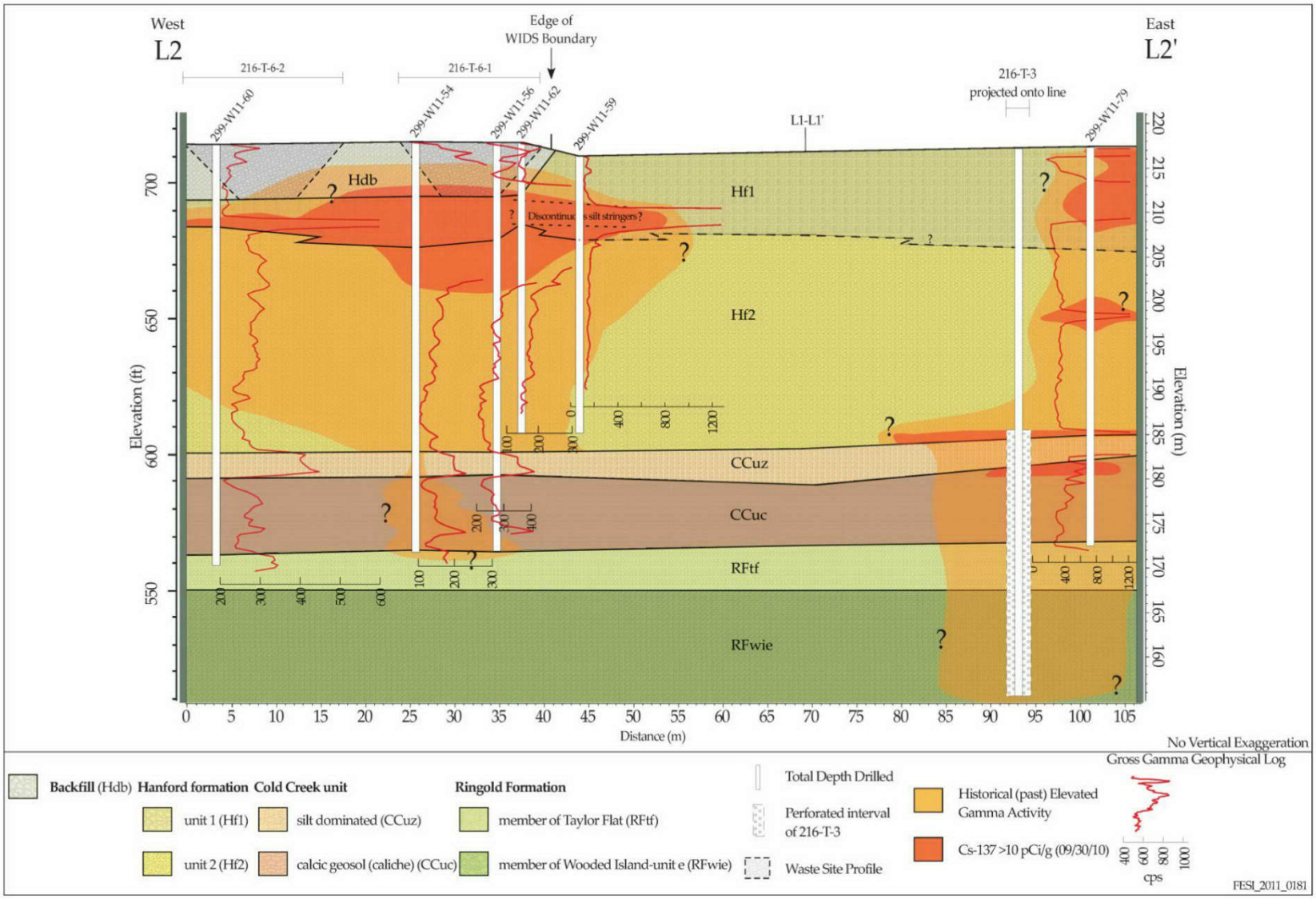
○ = groundwater impact unlikely
● = groundwater impact likely
OU = operable unit

3.3.4.2 Subregion 2: 216-T-5 Trench, 216-T-32 Crib, 216-T-7 Tile Field, and 200-W-52 Crib (in Waste Management Area T)

At 216-T-5 Trench, the lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the trench. In the DVZ, the area of contamination is estimated to be encompassed by a circle with an approximately 50 m (164 ft) diameter based on historical detectable mobile gamma contamination and recent resistivity surveys (SGW-49924, Figure 3-33). The vertical extent of contamination at 216-T-5 is uncertain but appears to co-mingle with contamination from 216-T-7 and 216-T-32 sites based on the resistivity surveys.

Waste from the 216-T-7/200-W-52 and 216-T-32 sites appears to be co-mingled based on the geophysical logging and the resistivity surveys (SGW-49924, Figure 3-32 and p. C-28). Based on the waste site construction dimensions and soil concentrations from geophysical logging, there is no contamination in the upper 4.6 m (15 ft) at the 216-T-7 and 216-T-32 sites.

At the 216-T-7 Tile Field and 200-W-52 Crib, the lateral extent of contamination is estimated to be encompassed by an ellipse that is approximately 120.1 m (394 ft) northeast-southwest and 95.1 m (312 ft) northwest-southeast based on historical detectable mobile gamma contamination and recent resistivity surveys (SGW-49924, Figure 3-33). The vertical extent of contamination at 216-T-7 is likely the groundwater.



Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-29. T Complex Area Subregion 1: Contaminant Conceptual Model, West to East Cross Section

At the 216-T-32 Cribs, the lateral extent of contamination is estimated to be encompassed by an ellipse that is approximately 85 m (279 ft) northeast-southwest and 50 m (164 ft) northwest-southeast based on historical detectable mobile gamma contamination and recent resistivity surveys (SGW-49924, Figure 3-33).

The vertical extent of contamination at 216-T-32 is likely the CCU (SGW-49924, p. C-28). Figures 3-30, 3-31, and 3-32 illustrate the contamination profiles at the 216-T-5, 216-T-32, and 216-T-7/200-W-52 Cribs, respectively.

3.3.4.3 Subregion 3: 216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches (T Trenches)

All of the T Trenches are considered as one unit because of the close proximity. The vertical extent of contamination likely extends to at least 24 m (80 ft) bgs, the top of the CCU (SGW-49924, pp. C-41 and C-42, and Figure 3-54). The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the T Trenches. In the DVZ, the area of contamination is estimated to be encompassed by a circle with a 145.1 m (476 ft) diameter based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-53). Figures 3-33 and 3-34 illustrate the contamination profiles at the T Trenches.

3.3.4.4 Subregion 4: 216-T-18 and 216-T-26 Cribs

The lateral extent of contamination will be assumed to coincide with the lateral extent of the bottom of the 216-T-18 Crib. In the deeper vadose zone, the lateral extent of contamination is estimated to be encompassed by an ellipse that is approximately 39.9 m (131 ft) northeast-southwest and 29.9 m (98 ft) northwest-southeast based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-77). The vertical extent of contamination likely extends at least 29 m (95 ft) bgs, into the CCU (SGW-49498, Figure 7-4).

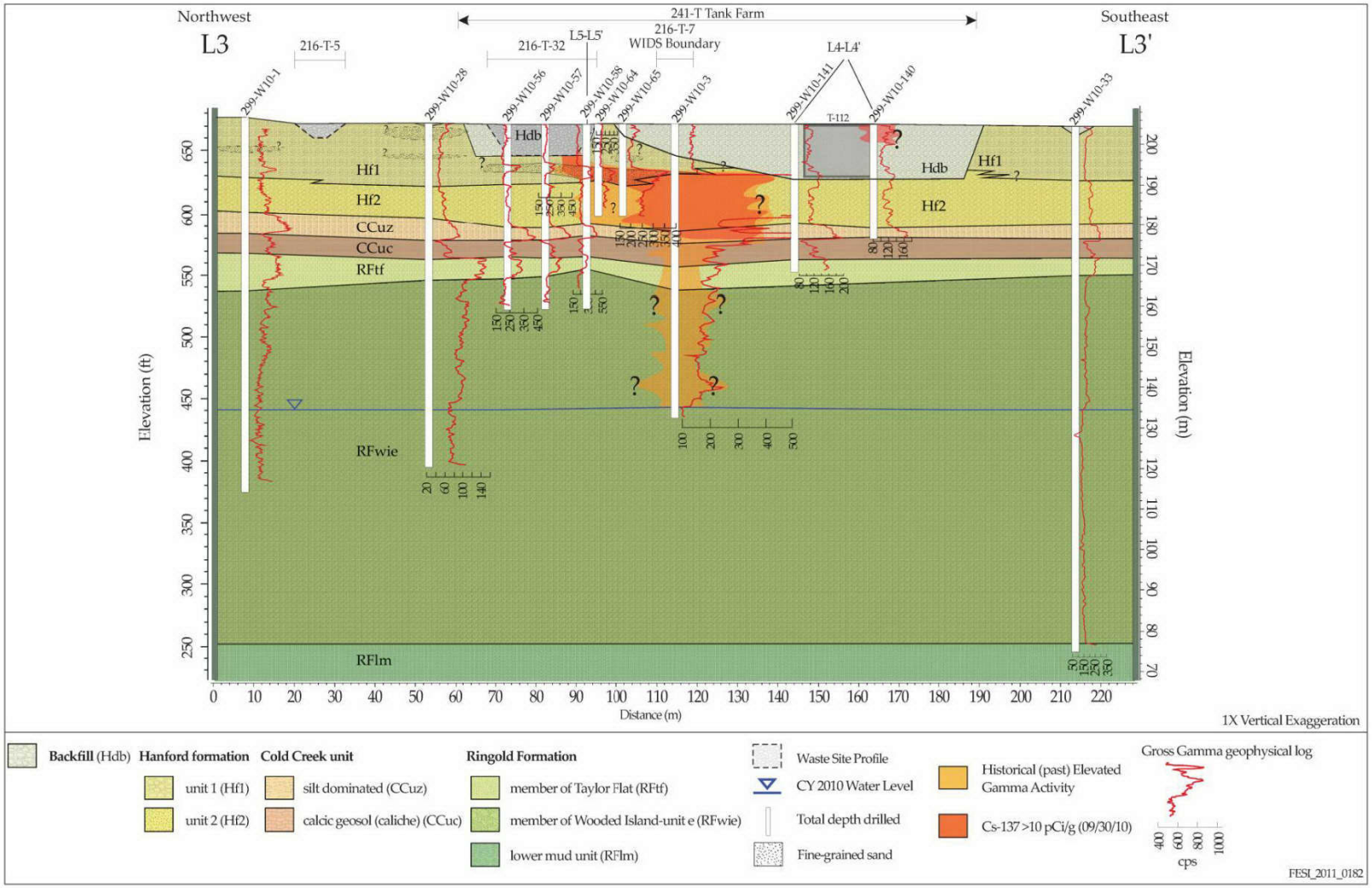
The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-T-26 Crib. In the deeper vadose zone, the lateral extent of contamination is estimated to be encompassed by an ellipse that is approximately 79.9 m (262 ft) northeast-southwest and 60 m (197 ft) northwest-southeast, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-77). The vertical extent of contamination likely extends to the water table (SGW-49924, Figure 3-79). Figure 3-35 illustrates the contamination profile at the 216-T-26 Crib.

3.3.4.5 Subregion 5: 216-T-19 Crib and Tile Field

Based on the 216-T-19 Crib and Tile Field construction dimensions and data from geophysical logging, soil contamination is unlikely in the upper 4.6 m (15 ft) at the 216-T-19 site. The lateral extent of contamination is estimated to be encompassed by a circle with a diameter of approximately 125 m (410 ft) based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-93). The vertical extent of contamination likely extends to groundwater (SGW-49924, Figure 3-94). Figure 3-36 illustrates the contamination profile at the 216-T-19 Crib and Tile Field.

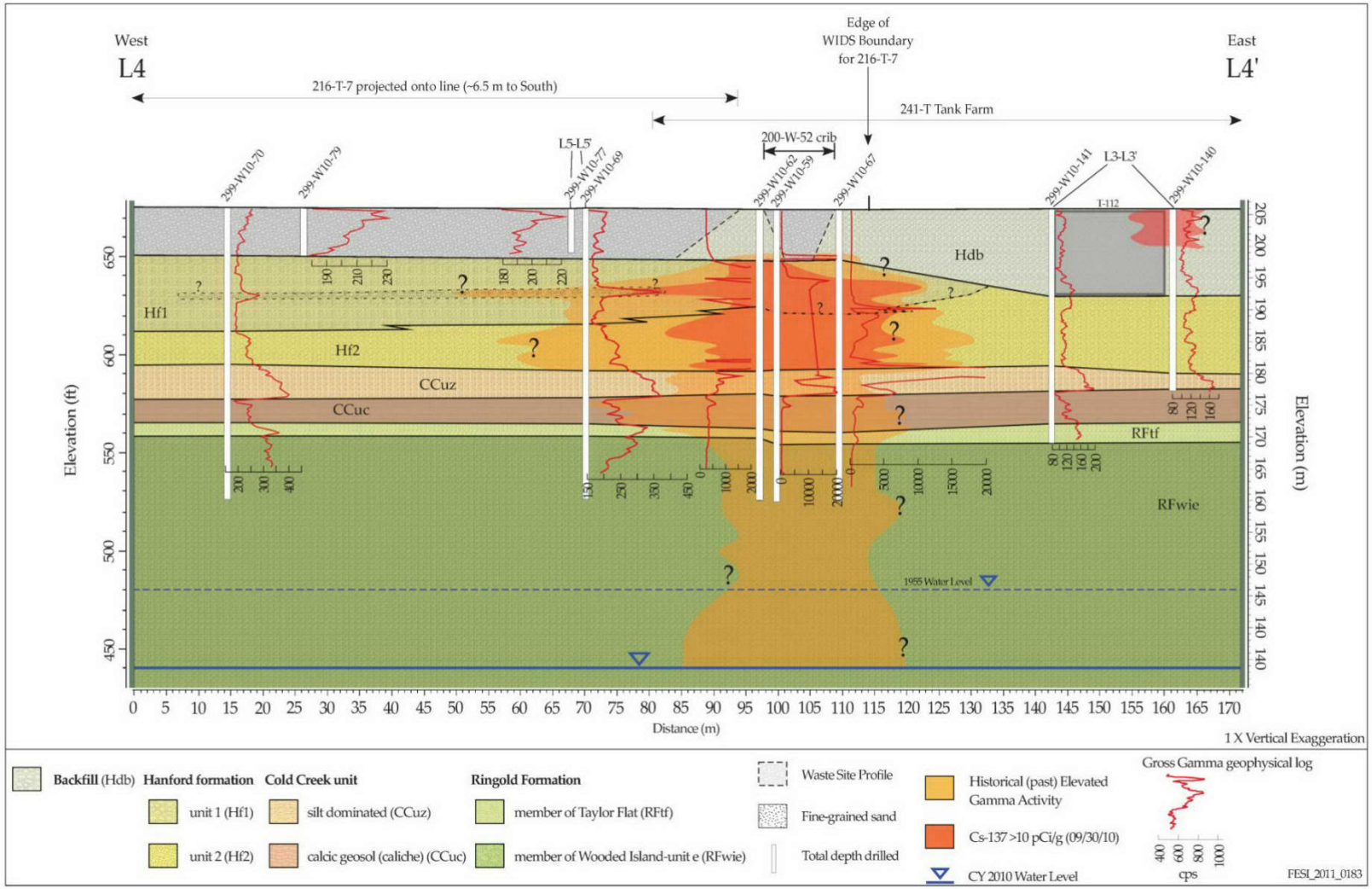
3.3.4.6 Subregion 6: 216-T-21, 216 -T-22, 216-T-23, 216-T-24, and 216-T-25

At the TX Trenches, the lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the TX Trenches. The lateral extent of contamination is estimated to be approximately 139.9 m (459 ft) north-south by 100 m (328 ft) east-west based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-105). The vertical extent of contamination likely extends at least to 33.5 m (110 ft) bgs, the top of the CCU (SGW-49924, Figure 3-106). Figure 3-37 illustrates the contamination profile at TX Trenches.



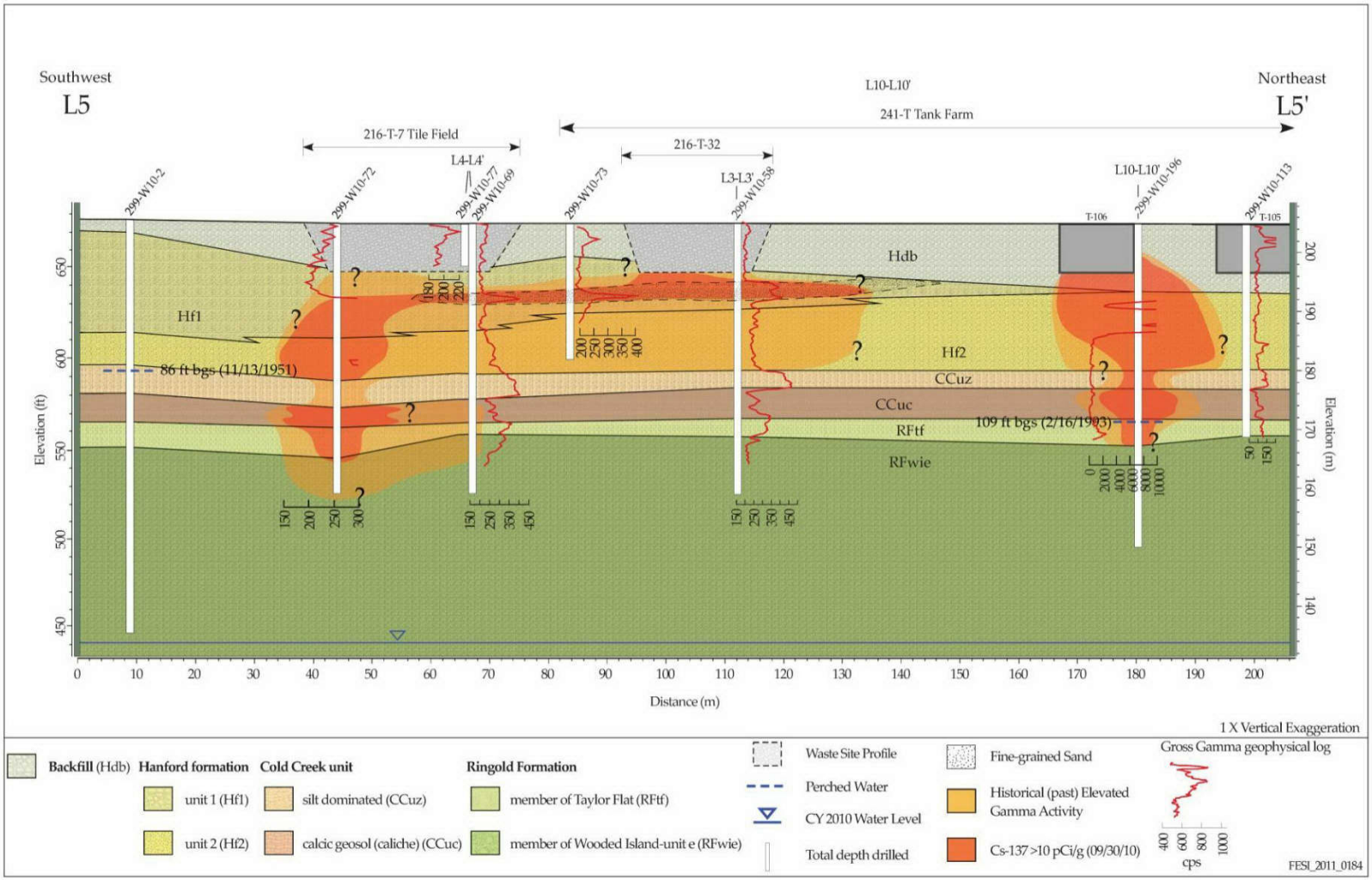
Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-30. T Complex Area Subregion 2: Contaminant Conceptual Model, Northwest to Southwest Cross Section



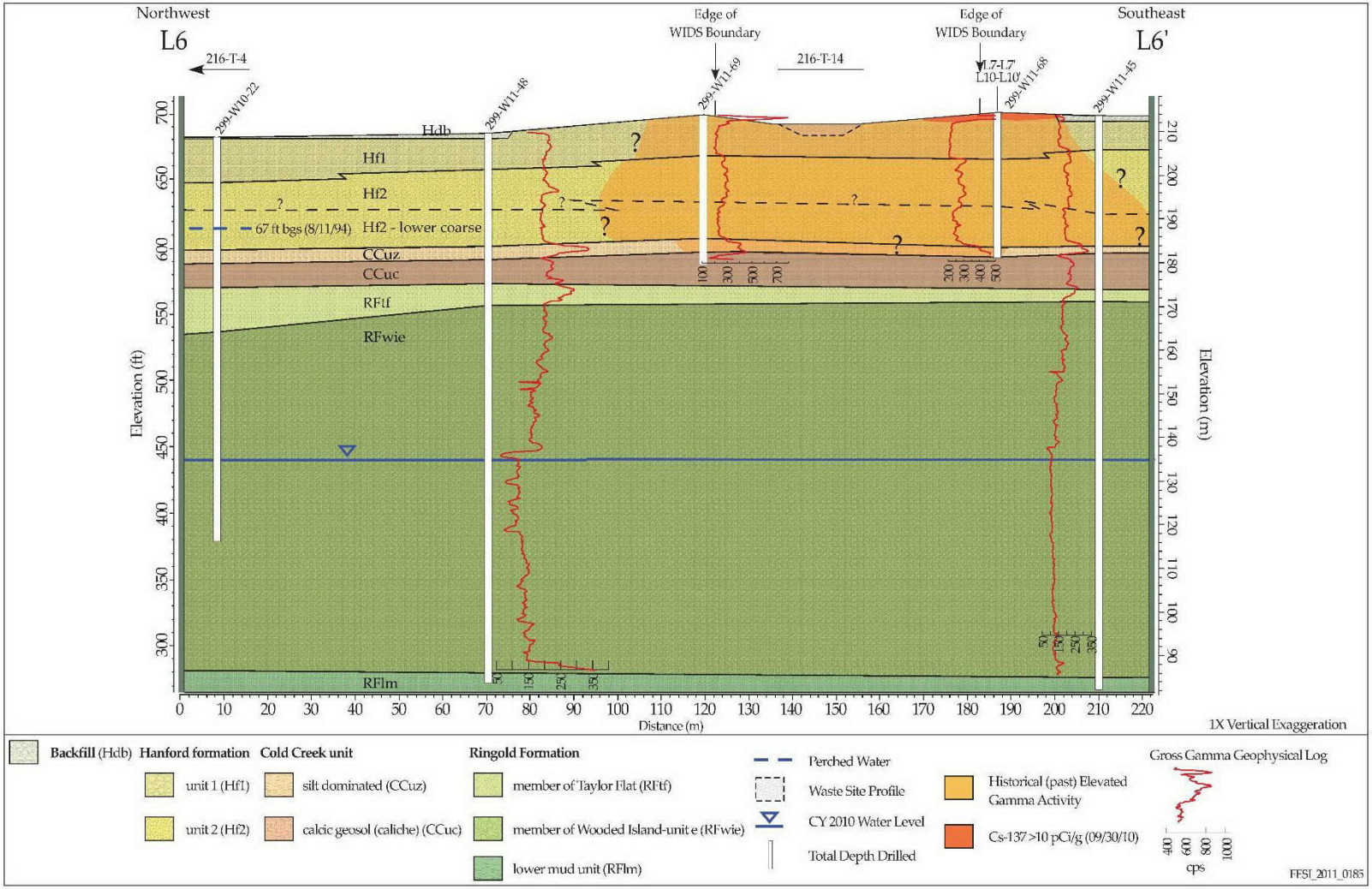
Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-31. T Complex Area Subregion 2: Contaminant Conceptual Model, West to East Cross Section



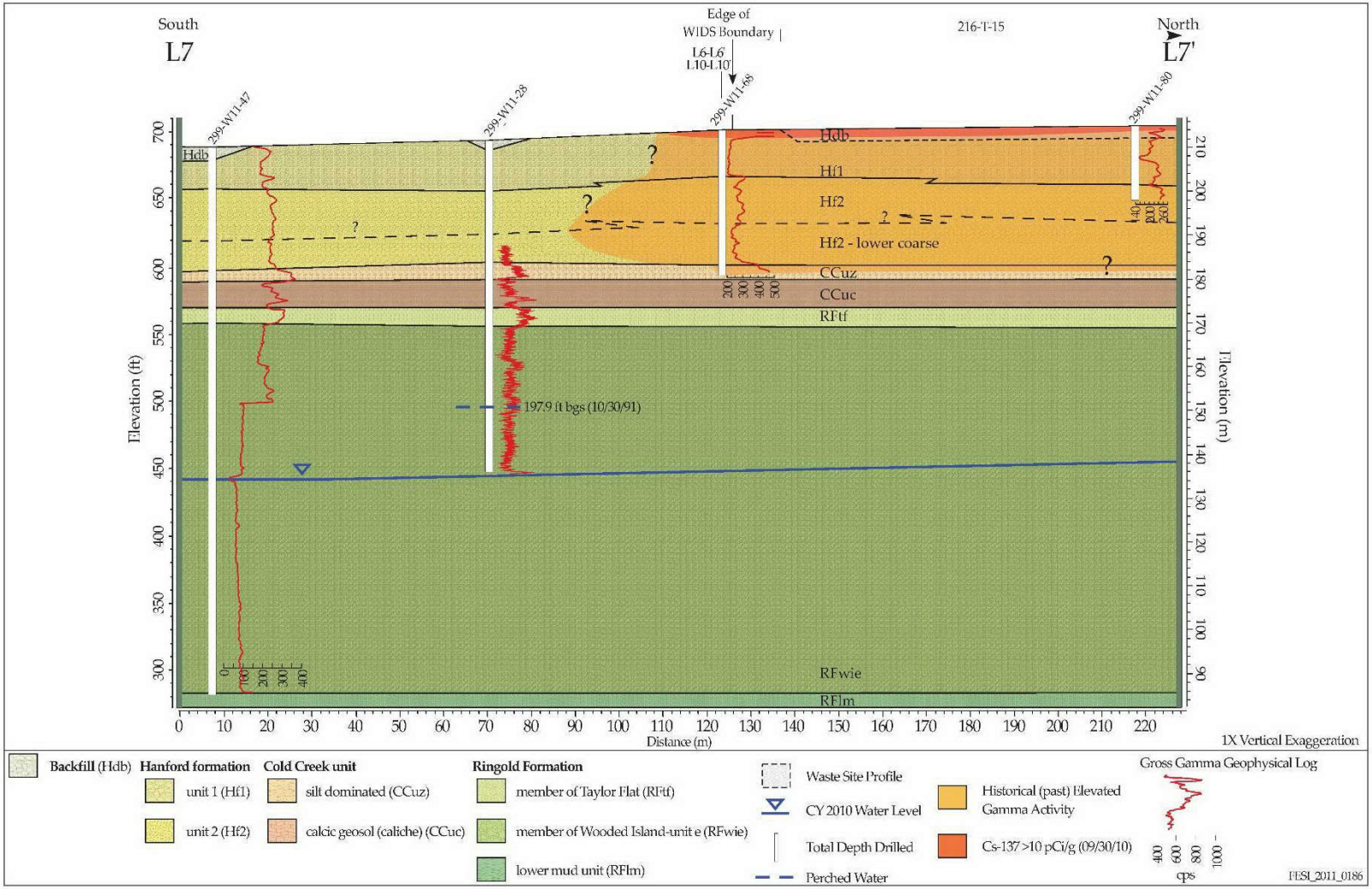
Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-32. T Complex Area Subregion 2: Contaminant Conceptual Model, Southwest to Northeast Cross Section



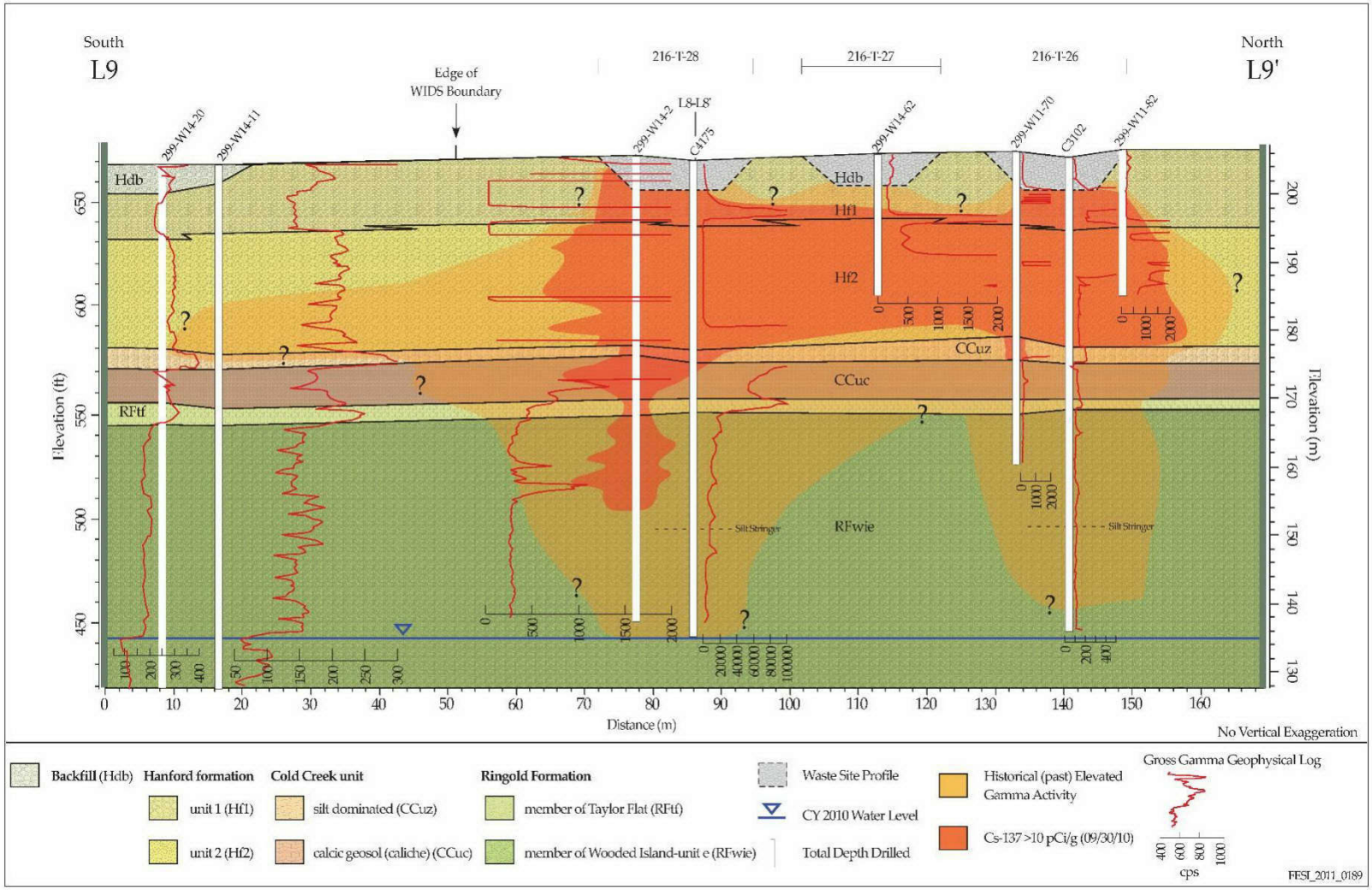
Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-33. T Complex Area Subregion 3: Contaminant Conceptual Model, Northwest to Southeast Cross Section



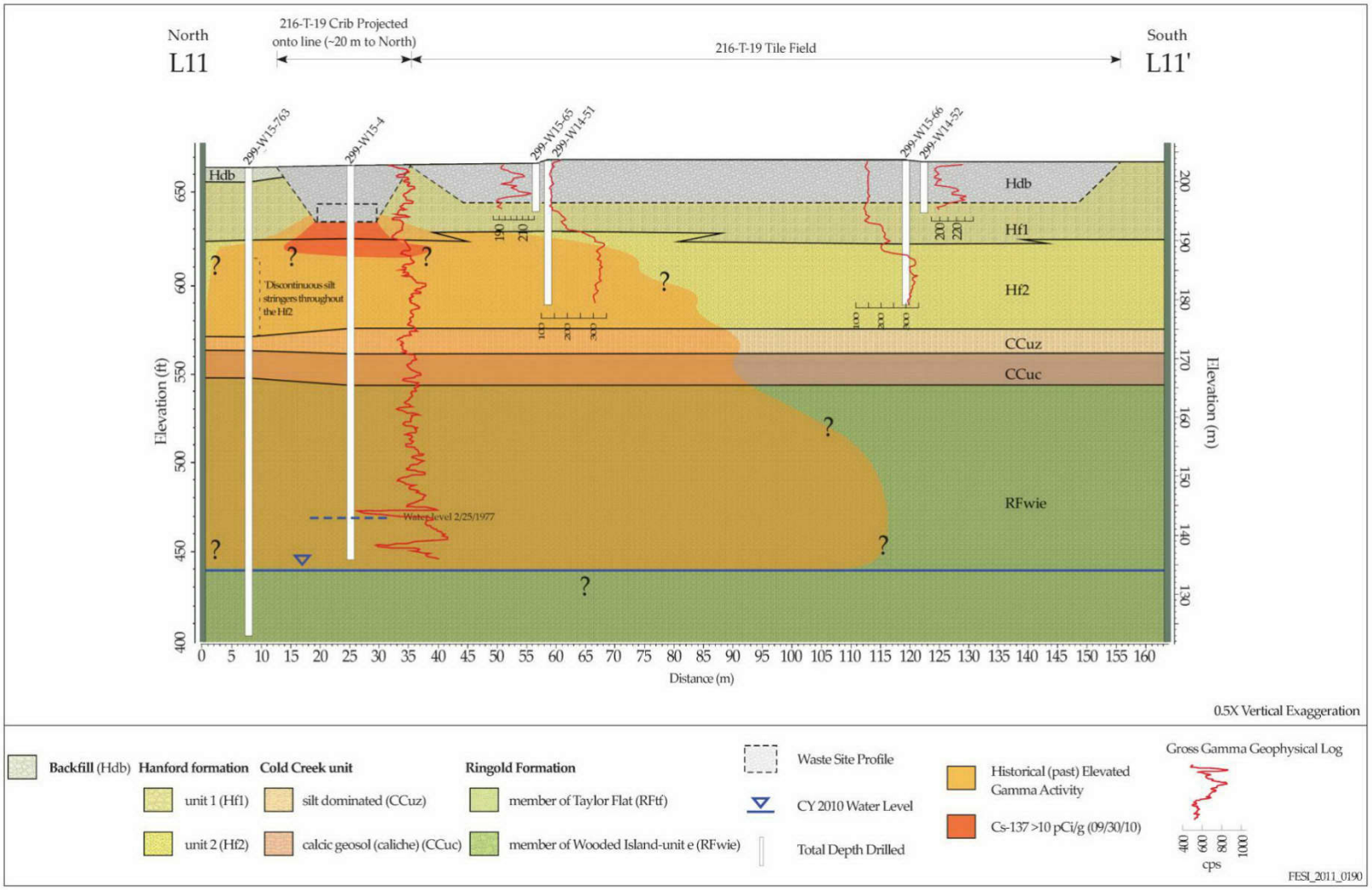
Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-34. T Complex Area Subregion 3: Contaminant Conceptual Model, South to North Cross Section



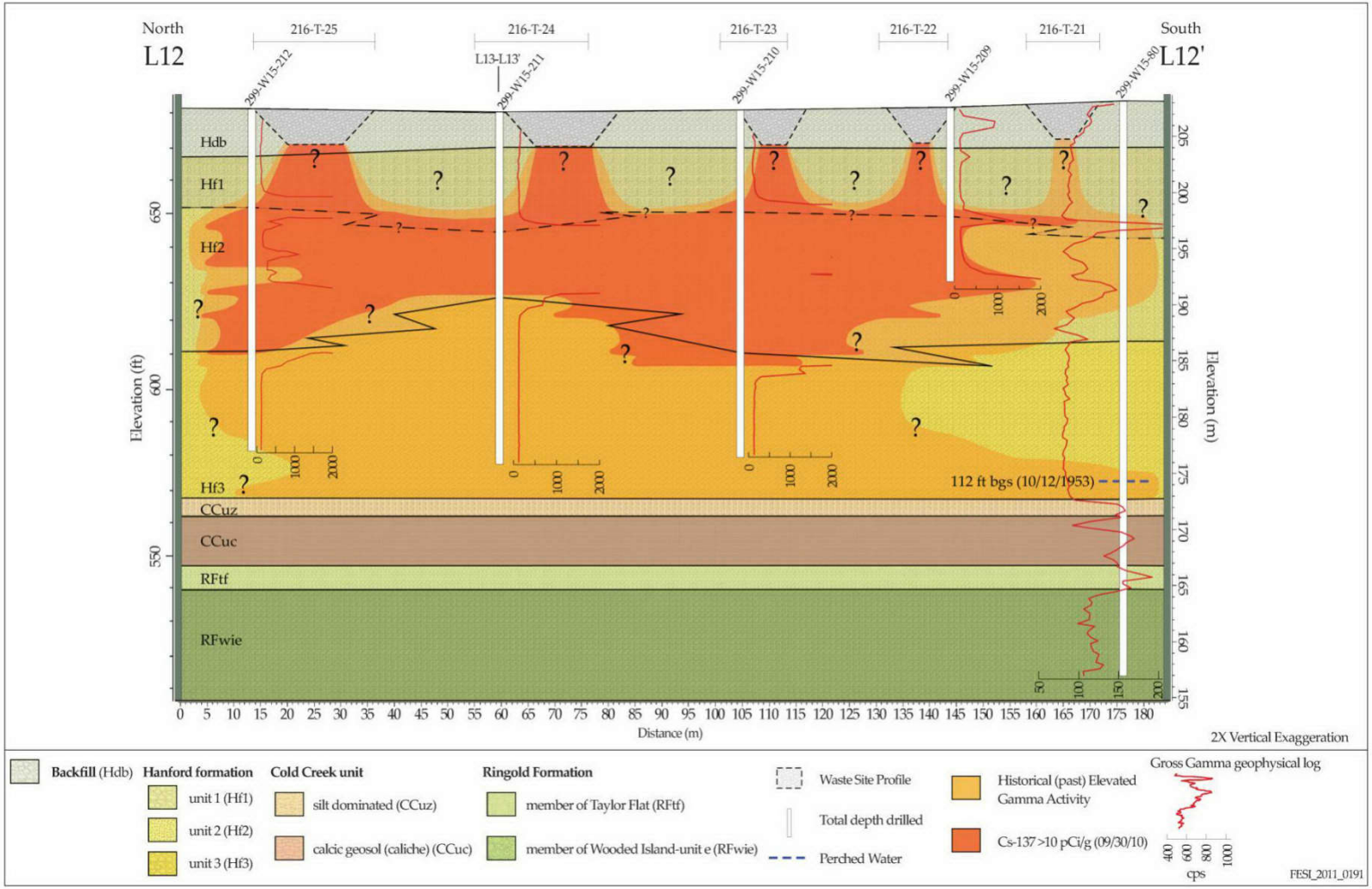
Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-35. T Complex Area Subregion 4: Contaminant Conceptual Model, South to North Cross Section



Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-36. T Complex Area Subregion 5: Contaminant Conceptual Model, North to South Cross Section



Source: SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-37. T Complex Area Subregion 6: Contaminant Conceptual Model, North to South Cross Section

3.3.5 Groundwater Contamination beneath the T Complex Area

The T Complex area overlies the 200-ZP-1 Groundwater OU, and carbon tetrachloride is the primary COC in the OU. The primary source of this contaminant is not from the T Complex area, but it is attributed to Plutonium Finishing Plant waste discharges to the 216-Z Cribs and Trenches. Other major contaminants in the 200-ZP-1 OU include trichloroethene, nitrate, total chromium, hexavalent chromium, tritium, iodine-129, and technetium-99. Three plumes that extend across or beyond several subregions include nitrate, tritium, and iodine-129. The extents of these regional plumes are discussed in DOE/RL-2011-01 and are shown in Figures 3-38, 3-39, and 3-40, respectively. Historical plume data and maps are provided in SGW-49924.

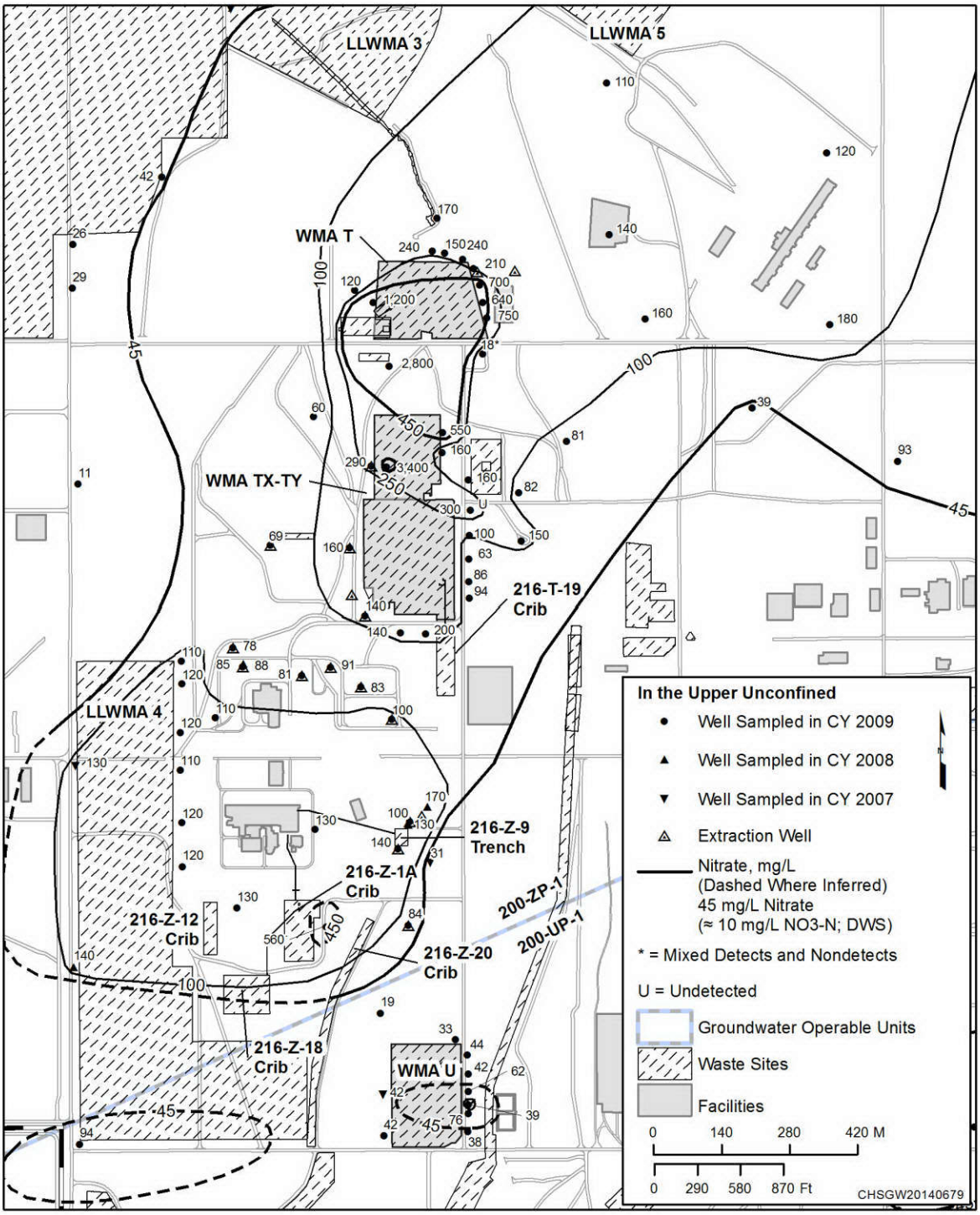
3.4 S Complex Area

Vadose zone and groundwater impacts in the S Complex area occurred as a result of facility processes, waste storage and disposal practices, and accidental spills (UPRs). The following subsections discuss impacts from these activities on both the shallow and the deep vadose zones.

3.4.1 200-DV-1 Operable Unit Waste Sites in the S Complex Area

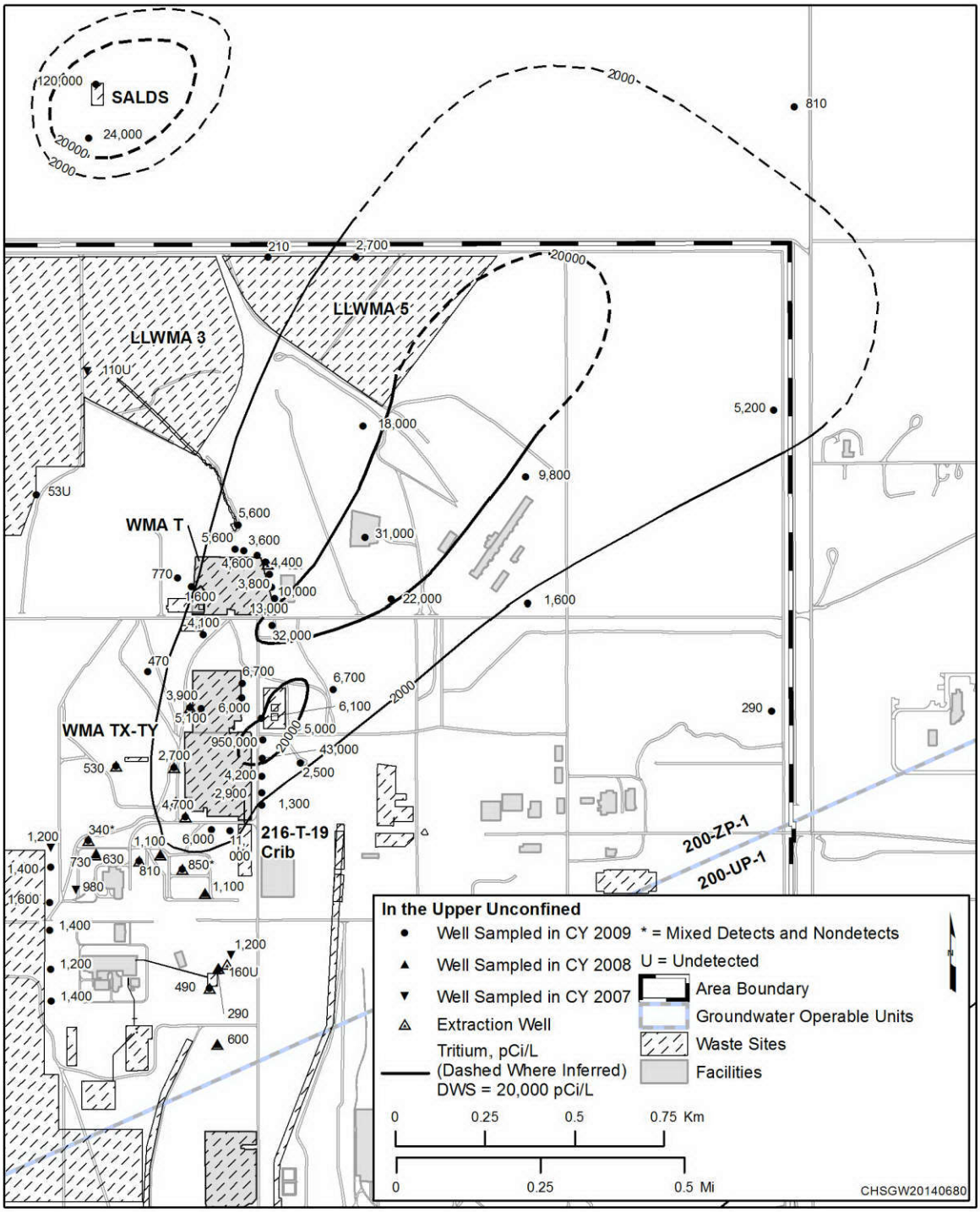
The 200-DV-1 OU waste sites in the S Complex area are grouped into three subregions. Figure 3-41 depicts these waste sites presented as Subregion 1, Subregion 2, and Subregion 3, along with the S-SX Tank Farms and S Plant (REDOX). The primary contaminant source for these waste sites in the S Complex area was liquid process waste that was generated during facility operations (e.g., S Plant and 242-S Evaporator) and intentionally released to the environment through engineered waste site structures such as cribs and trenches. In some cases, liquid waste was initially sent to settling tanks (including SSTs in the tank farms) that were designed to allow the supernate liquid to overflow to the waste sites. The process waste was aqueous and contained relatively high concentrations of known process-related contaminants (e.g., radionuclides or chemicals). Table 3-18 lists the primary sources of contamination for S Complex area waste sites.

To support the 200-DV-1 OU RI, the S Complex area waste sites will be evaluated from the land surface to groundwater to support shallow and DVZ remedy decisions. The chemical and/or radionuclide contaminants in the shallow soils (up to 4.6 m [15 ft]) at the subregion waste sites will be used to determine whether each waste site exceeds acceptable risk levels for HHE and ecological receptors. Relatively immobile contaminants such as cesium-137 and strontium-90 are most likely to be retained near the point of discharge, which for some waste sites was in the upper 4.6 m (15 ft) of the subsurface. The chemical and/or radionuclide contaminants will be used to determine whether the vadose zone exceeds acceptable risk levels for groundwater. Relatively mobile contaminants such as technetium-99, uranium, iodine-129, and nitrate are most likely to have migrated deeper in the vadose zone and may pose a current and/or future risk to groundwater. The inventories of selected mobile contaminants discharged to 200-DV-1 OU waste sites are listed in Table 3-19. The complete list of inventories for the waste sites is provided in the SIM (RPP-26744).



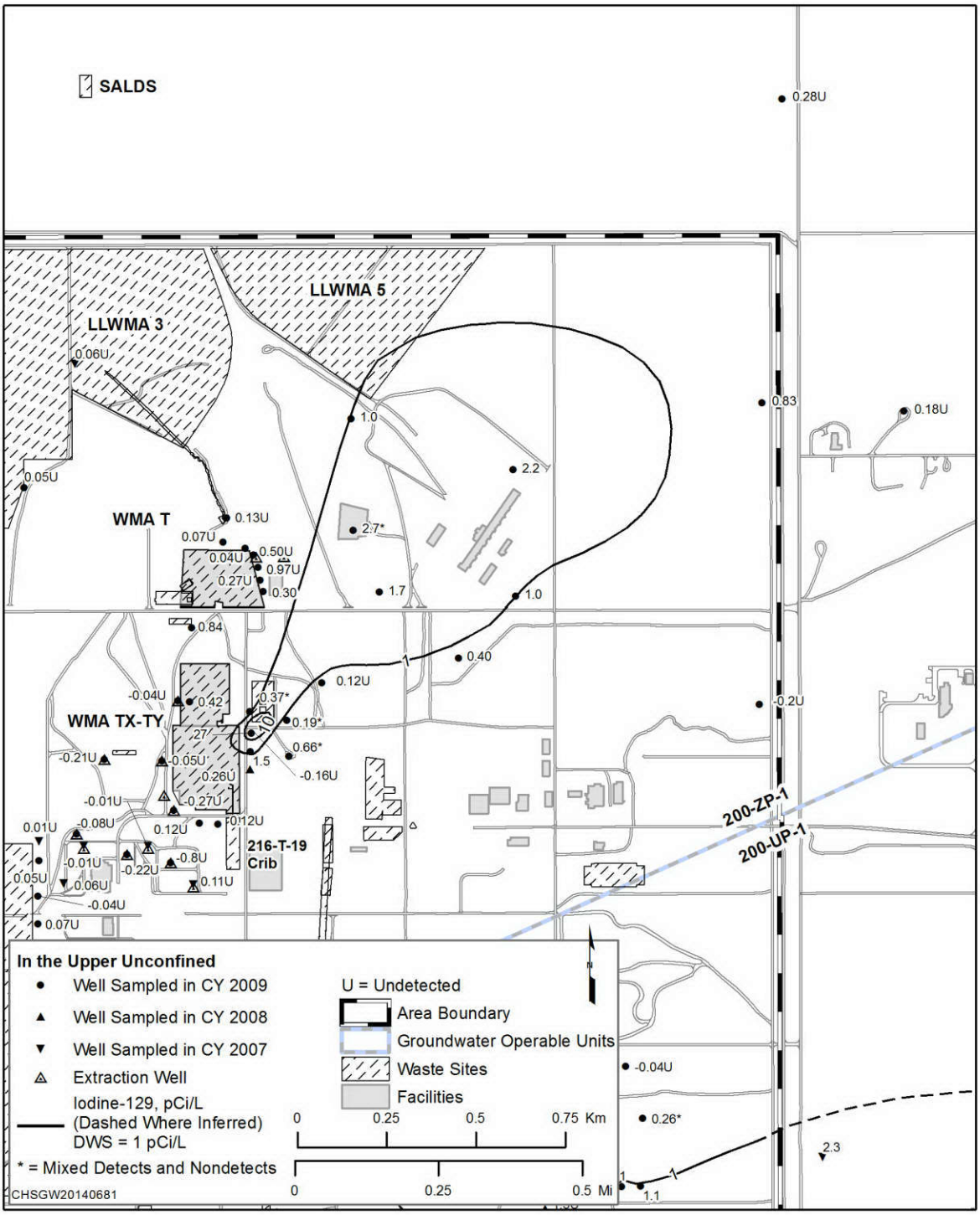
Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*.

Figure 3-38. Map of Nitrate Groundwater Plume in the T Complex Area



Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2.*

Figure 3-39. Map of Tritium Groundwater Plume in the T Complex Area



Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2.*

Figure 3-40. Map of Iodine-129 Groundwater Plume in the T Complex Area

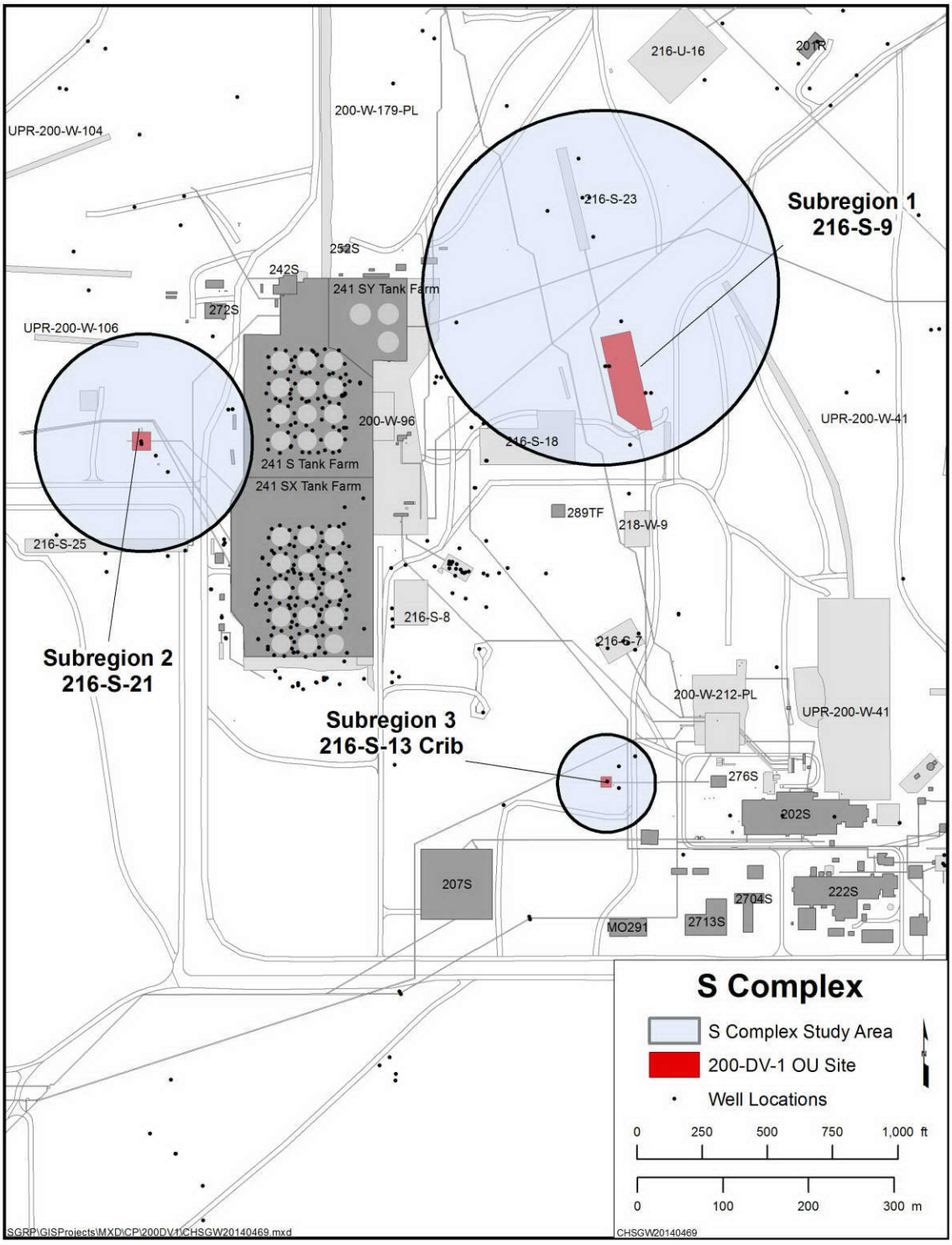


Figure 3-41. 200-DV-1 OU S Complex Area Subregions and Surrounding Facilities

Table 3-18. Sources of Contamination for 200-DV-1 OU Waste Sites in the S Complex Area

Waste Site	Service Dates*	Primary Sources of Contamination*
216-S-9	07/1965 to 01/1969	Process condensate (acidic) from the D-2 Receiver Tank in the 202-S Building process, condensate from evaporation and concentration of decontamination waste in the 202-S Building.
216-S-13	01/1952 to 06/1967	Liquid waste from the 203-S Decontaminated Metal Storage Facility, the 204-S UNH Lag Storage Facility, and the 276-S Organic Solvent Make-Up Facility. Occasional sump waste from the 204-S Facility.
216-S-21	11/1954	Condensate from the condensers in the 241-SX-401 Building via the 241-SX-106 tank

* Information obtained from 200-DV-1-Operable Unit data quality objectives summary report (Appendix C).

The volumes of liquid waste discharged to the 200-DV-1 OU waste sites in the S Complex area are presented in Figure 3-42. The two cribs comprising Subregion 2 (216-S-21 and 216-S-25) received the majority (approximately 81 percent) of the volume discharged in the S Complex area. Subregion 1 (216-S-9 and 216-S-23) received 18 percent of the discharged volume, while Subregion 3 (216-S-13) received the remaining 1 percent of the discharged volumes of liquid waste. (Note that the 216-S-23 Crib and 216-S-25 Crib are not 200-DV-1 OU waste sites. However, they were included in Subregion 1 and Subregion 2, respectively, during development of the CSMs in SGW-50280, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the S Complex Area, Central Plateau, Hanford, Washington*, and this work plan in 2011.)

The inventories of nitrate, uranium, technetium-99, and iodine-129 for each of the 200-DV-1 OU waste sites are shown in Figures 3-43, 3-44, 3-45, and 3-46, respectively. The nitrate inventory data indicate that the most significant source of nitrate is the 216-S-25 Crib. The uranium and iodine-129 inventory data indicate that the most significant source of these contaminants is the 216-S-9 Crib. The technetium-99 inventory data indicate that the most significant source is the 216-S-13 Crib.

3.4.2 S-SX Tank Farms Data

The S-SX Tank Farms, and any subsurface contamination from associated UPRs, are not included in the 200-DV-1 OU. However, some of the 200-DV-1 OU waste sites in the S Complex area are adjacent to the S-SX Tank Farms, potentially resulting in co-mingled contamination in the DVZ. Data for the S-SX Tank Farms are provided to present a comprehensive description of the S Complex area.

The S Tank Farm was constructed from 1950 to 1951 and consists of twelve 22.9 m (75 ft) diameter tanks, with a nominal 2,840,000 L (750,000 gal) capacity. The primary waste source for the S Tank Farm was process waste from the REDOX Plant operations at S Plant and solids from the 242-S Evaporator. Only one tank in the S Tank Farm (Tank 241-S-104) is assumed to have leaked. The S Tank Farm tanks were removed from service in the late 1970s and early 1980s.

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Table 3-19. Volumes and Inventories Discharged to 200-DV-1 OU Waste Sites in the S Complex Area

Waste Site	Volume Discharged[a] (million L)	Total Waste Inventory[a]												
		Nitrate (kg)	Fluoride (kg)	Uranium (total) (kg)	Chromium[b] (kg)	Ferrocyanide (kg)	Cesium-137[c] (Ci)	Strontium-90[c] (Ci)	Plutonium-239[c] (Ci)	Plutonium-240[c] (Ci)	Cobalt-60[c] (Ci)	Iodine-129[c] (Ci)	Technetium-99[c] (Ci)	Tritium[c] (Ci)
216-S-9 (1965–1969)	4.96E+01	4.18E+04	0	2.76E+02	0	0	6.04E+01	1.19E+02	2.90E+00	6.77E-01	1.12E-02	2.95E-02	1.04E-01	1.17E+03
216-S-13 (1951–1966)	5.0E+00	3.48E+04	4.79E+01	3.05E+00	1.21E+01	0	1.45E+02	4.20E-01	7.04E-01	1.58E-01	1.85E-03	0	4.40E-01	4.31E+01
216-S-21 (1954–1969)	8.71E+01	4.91E+02	2.19E+01	1.06E-01	5.08E+01	0	6.28E+02	6.63E+00	5.99E-02	1.34E-02	3.36E-02	3.23E-04	2.11E-01	2.54E+03

a. Total waste volume and inventory values based on the sum value of the mean concentrations taken from the Soil Inventory Model (SIM) (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*).

b. The SIM does not provide speciation information for chromium. All chromium inventories are assumed to be hexavalent unless other information is available.

c. Radiological constituents decayed to January 1, 2001.

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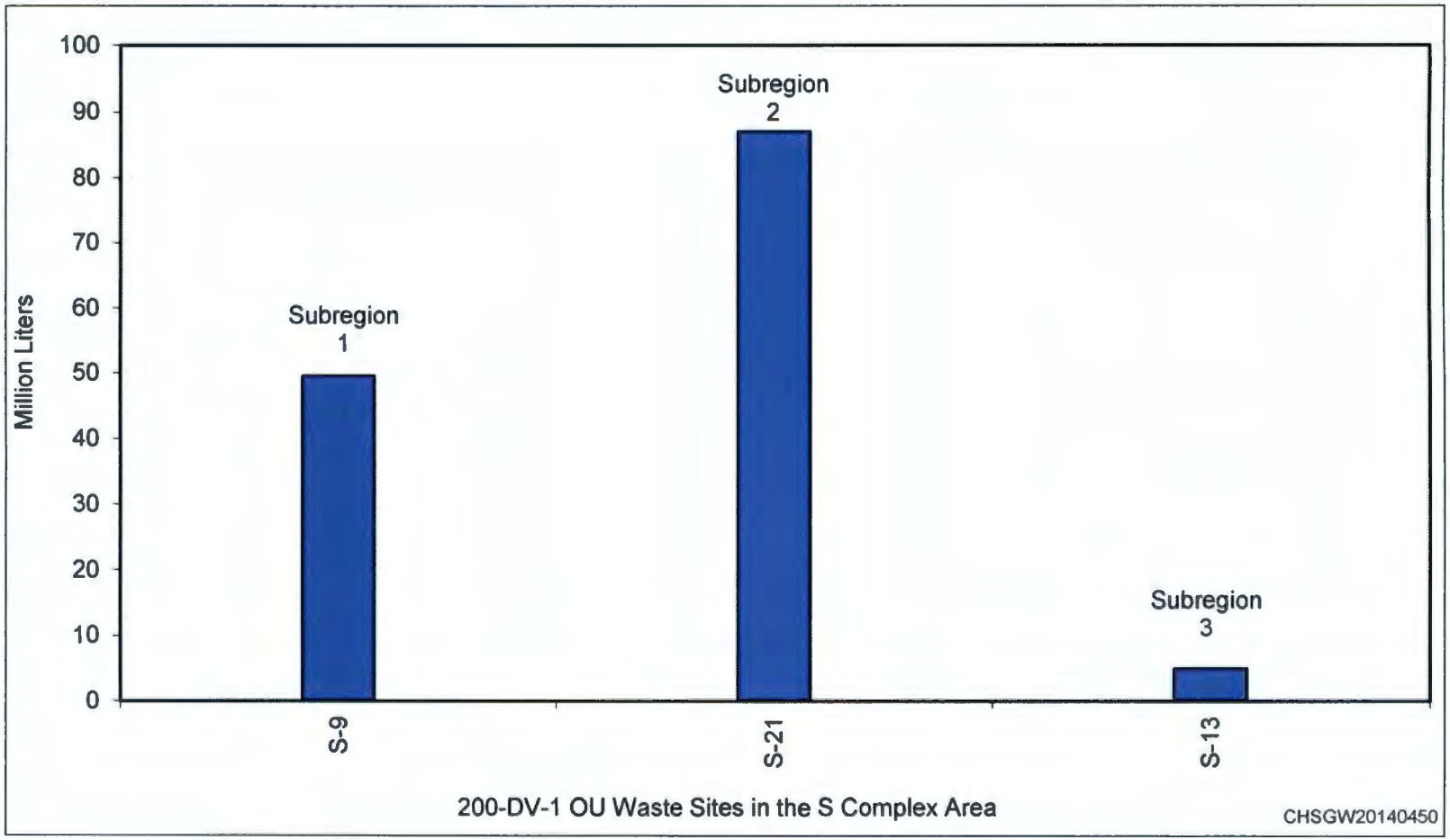

Figure 3-42. Volume of Liquid Waste Discharged to 200-DV-1 OU Waste Sites in the S Complex Area

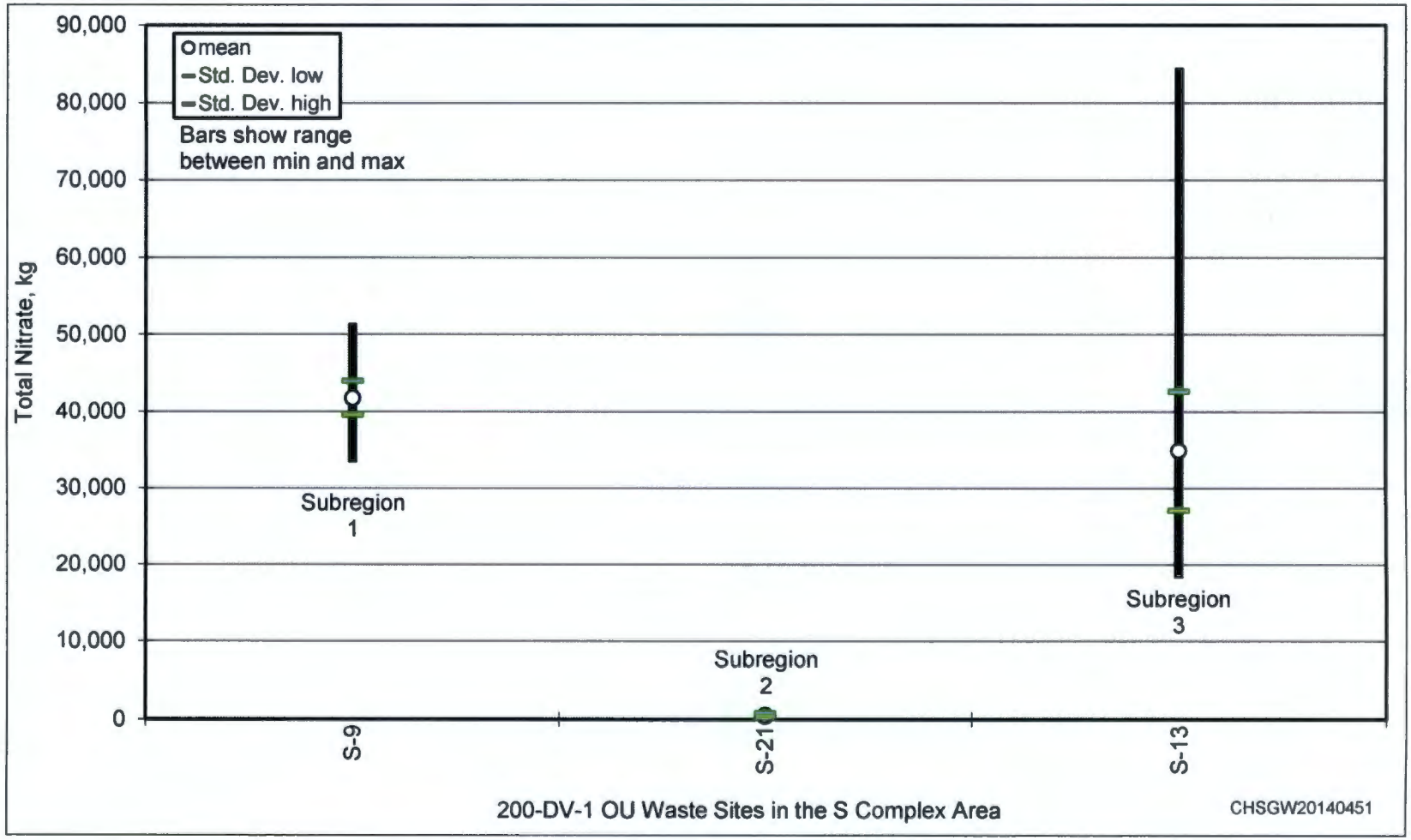

Figure 3-43. Nitrate Inventory Discharged to 200-DV-1 OU Waste Sites in the S Complex Area

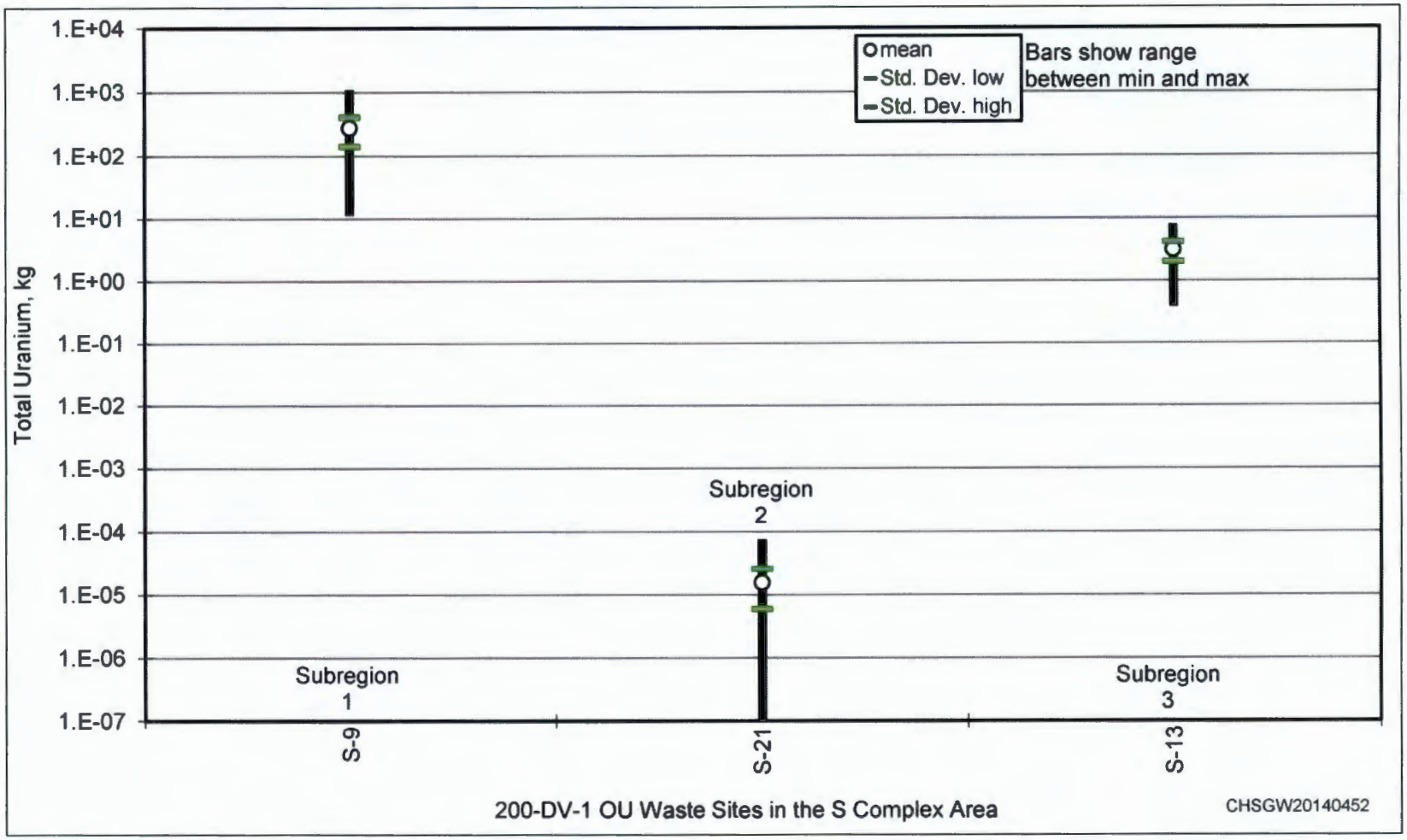

Figure 3-44. Uranium Inventory Discharged to 200-DV-1 OU Waste Sites in the S Complex Area

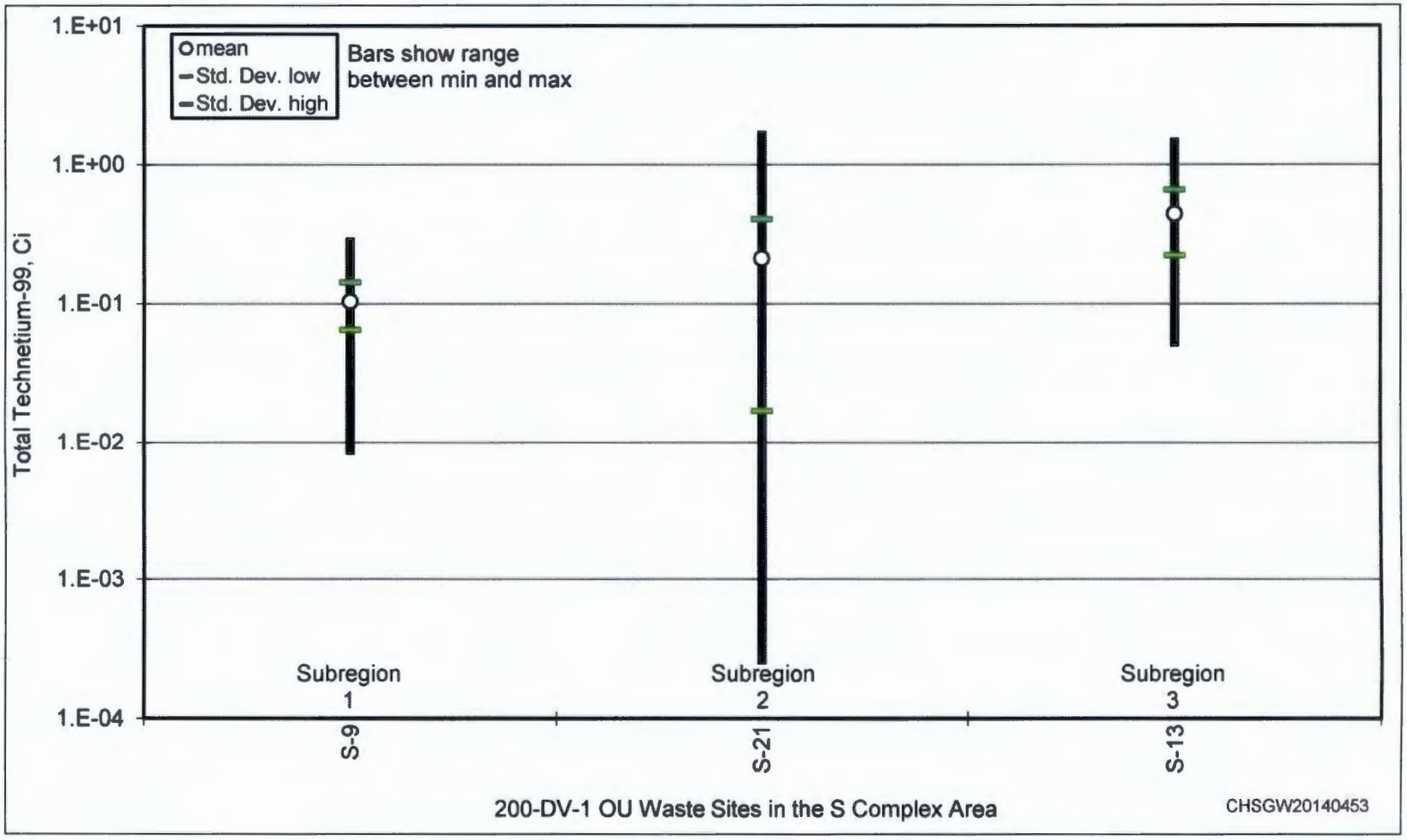

Figure 3-45. Technetium-99 Inventory Discharged to 200-DV-1 OU Waste Sites in the S Complex Area

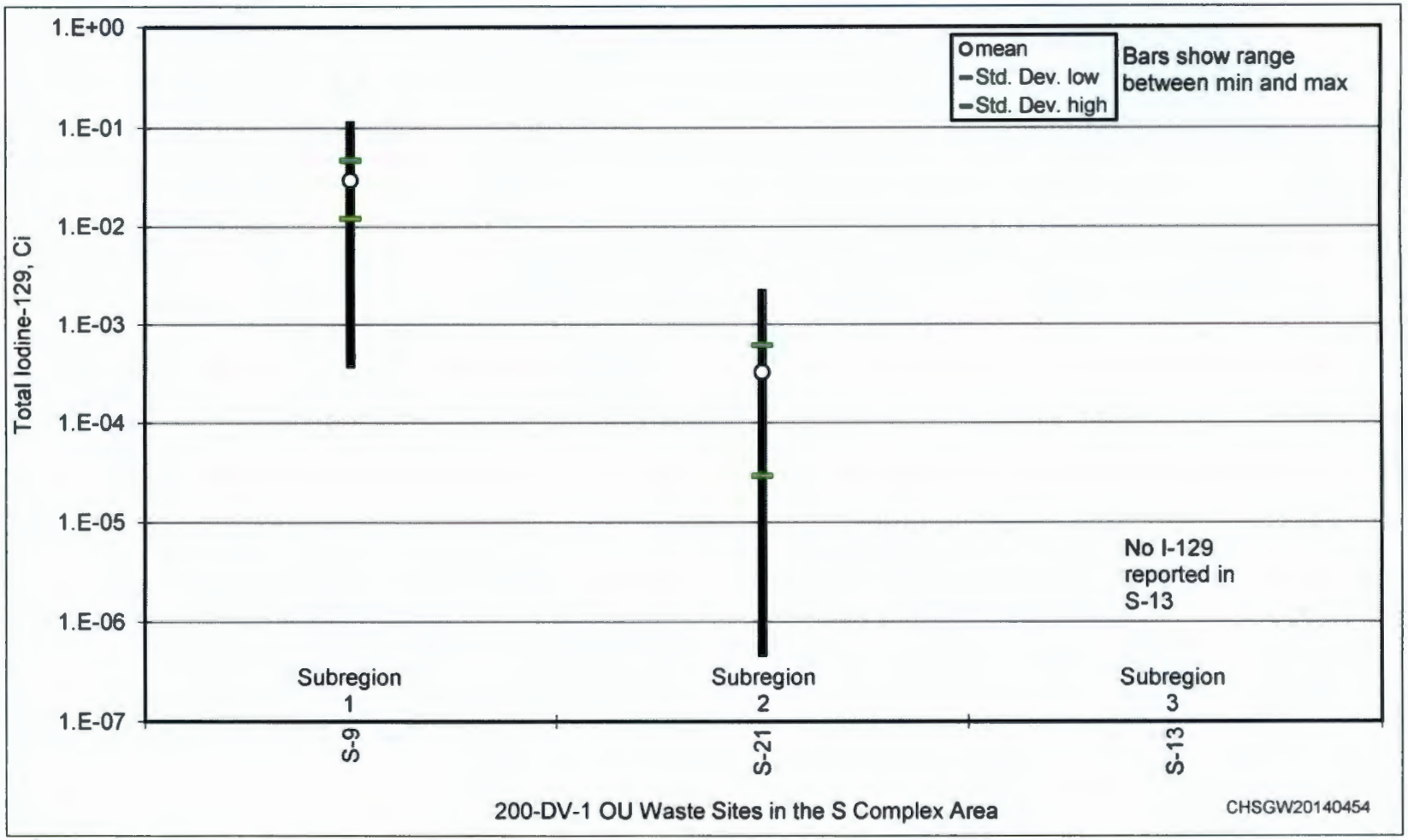

Figure 3-46. Iodine-129 Inventory Discharged to 200-DV-1 OU Waste Sites in the S Complex Area

The SX Tank Farm is comprised of 15 SSTs, each with a nominal 3.9 million L (1 million gal) storage capacity. The SX Tank Farm was constructed from 1953 and 1954, and the first six tanks began receiving waste from the REDOX Plant in 1954. In 1955, the remaining six SX Tank Farm tanks began to receive waste. Tanks 241-SX-105 and 241-SX-107 through 241-SX-115 were designed to handle REDOX high-level boiling waste. All nine of these tanks that operated as boiling waste tanks are confirmed or suspected leakers.

Leaks of liquid waste from the tanks and/or ancillary equipment (UPRs) during waste transfers (e.g., overfilling a tank) contributed contamination from the tanks to the subsurface. Leaks from adjacent raw and potable water lines likely contributed to tank waste migration into deeper vadose zone.

Selected tank leak and UPR estimates (volumes and inventories) were reassessed and updated in 2010 for SSTs in the SX Tank Farm, as documented in RPP-ENV-39658. In 2011, the S Tank Farm leak assessment report (RPP-RPT-48589) was released. The most significant tank waste loss events were the leaks of 91,000 L (24,000 gal) from Tank 241-S-104 in the S Tank Farm and 189,000 L (50,000 gal) from Tank 241-SX-115 in the SX Tank Farm. Current SIM estimates (RPP-26744) have not been updated to reflect the revised estimates in this report.

3.4.3 Previous Investigations, Monitoring, and Remediation Activities in the S Complex Area

A timeline of the most significant previous investigations, monitoring, and remediation activities at the 200-DV-1 OU waste sites in the S Complex area is presented in Figure 3-47. Table 3-20 lists key documents and reports pertaining to the S Complex area. The investigation, monitoring, and remediation activities for each subregion are summarized below. Additional information is provided in the information tables prepared to support the DQO process (Tables C-18 through C-20 in Appendix C). The waste site investigations and geophysical data are summarized from SGW-50194, *Geophysical Logging Report for 200-DV-1 Operable Unit Waste Sites in the S Complex Area*. The nature and extent of contamination are provided in Section 3.4.4.

3.4.3.1 Subregion 1: 216-S-9 and 216-S-23

In 1969, during the tie-in of the 216-S-9 Pipeline to the 216-S-23 Pipeline, a break in the pipeline was encountered at the junction of the two feed lines. The leak is identified as UPR-200-W-108. Site investigation activities concluded that there was no way to determine how long the line had been leaking or how much waste had been discharged to the ground.

In 1992, contaminated soil from the location of UPR-216-W-30 was consolidated on the surface of the 216-S-23 Crib. Later, in 1995, additional contaminated soil from that UPR was consolidated on the surface of the 216-S-9 Crib. Both sites were then covered with 0.5 to 0.6 m (18 to 24 in.) of uncontaminated soil as an interim stabilization measure, increasing the elevation of the ground surface by approximately 1.5 m (5 ft) (BHI-00257, *UN-216-W-24 and UN-216-W-30 Interim Stabilization Final Report*).

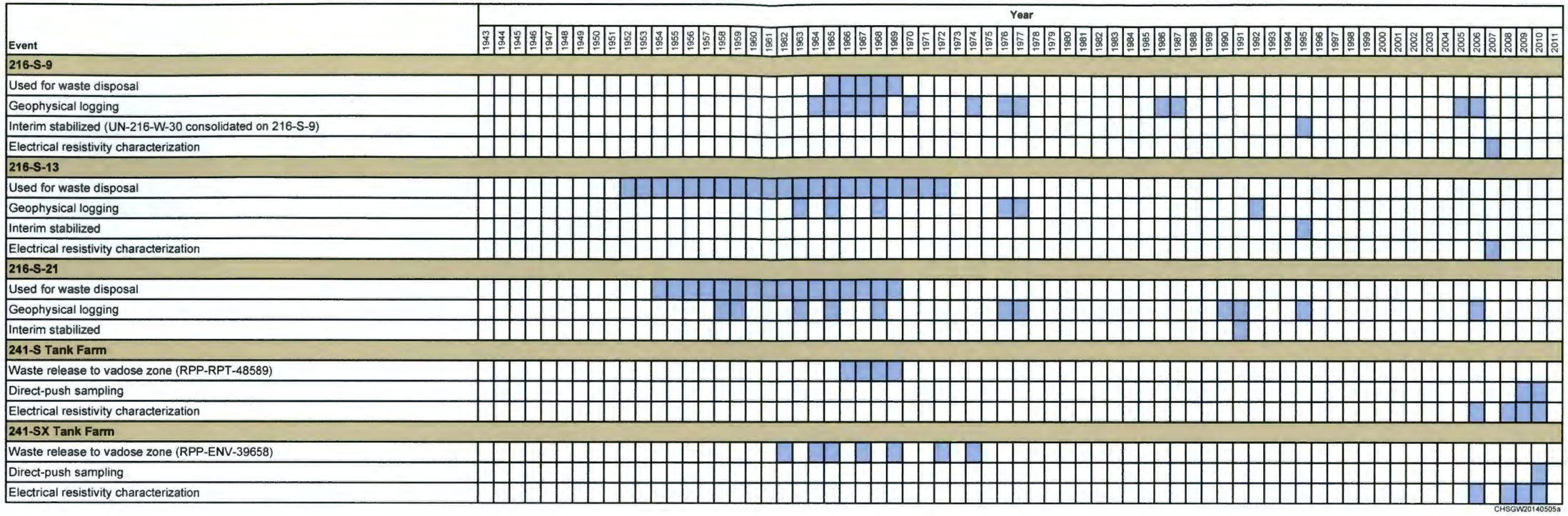

Figure 3-47. Timeline for S–SX Complex Subregion Waste Sites

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Table 3-20. Key Previous Documents for 200-DV-1 OU Waste Sites in the S Complex Area

Document Number	Document Title	Date Issued	Summary
ARH-2155	*Radioactive Liquid Waste Disposal Facilities, 200 West Area*	August 1971	Lists the liquid waste disposal facilities in or near the western Central Plateau. It identifies the waste released in each facility and describes the current facility status.
RHO-CD-673	*Handbook 200 Area Waste Sites*	April 1979	This document is a handbook of radioactive waste sites and associated radiation areas within the Central Plateau and related environment. It does not include those sites within the confines of the tank farms.
RPP-7884, Rev. 0	*Field Investigation Report for Waste Management Area S-SX*	2002	Provides an assessment of existing and new information to clarify the current understanding of the nature and extent of past releases in the S and SX Tank Farms.
RPP-RPT-47851, Rev. 0	*Three-Dimensional Surface Geophysical Exploration of S/SX Tank Farm*	November 2010	Documents the surface geophysical exploration activities completed within a 96 m by 90 m area in the region between the S and SX Tank Farms at the Hanford Site in FY 2010.
RPP-26744, Rev. 0	*Hanford Soil Inventory Model, Rev. 1*	2005	Provides major chemical inventories disposed by year for each facility, in addition to waste stream and waste density information.
RPP-RPT-30976, Rev. 0	*Surface Geophysical Exploration of S Tank Farm at the Hanford Site*	2006	Documents the results of resistivity surveys using surface-based two-dimensional profiling from FY 2006 through FY 2008 for the S Tank Farm and surrounding area (referred to, with the SX Tank Farm area, as the S Complex).
DOE/RL-2007-02, Rev. 0	*Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units*	2007	Provides the detailed sampling plans for collecting additional characterization data at waste sites on the Central Plateau. The sampling plans were developed following a supplemental DQO process conducted by the Tri-Parties in FY 2005 and FY 2006. The waste sites evaluated in the supplemental DQO process included all of the 200-DV-1 OU waste sites. Supplemental characterization data were identified for 12 waste sites in the 200-DV-1 OU.
RPP-RPT-42513, Rev. 0	*Surface Geophysical Exploration of SX Tank Farm at the Hanford Site*	2009	Documents the results of resistivity surveys using well-to-well measurements for the S and SX Tank Farms and surrounding area, including the 216-S-25 Crib (referred to as the S Complex).

Table 3-20. Key Previous Documents for 200-DV-1 OU Waste Sites in the S Complex Area

Document Number	Document Title	Date Issued	Summary
DOE/RL-2007-46, Rev. 0	*Resistivity Characterization of 216-C-1, A-Complex, B-Plant, PUREX, S-Complex, T-Plant, and 216-Z-16 Trench Project Sites*	2008	Documents the results of resistivity surveys using surface-based, two-dimensional profiling from FY 2006 through FY 2008 for selected waste sites in the Central Plateau, including the 216-S-9 and 216-S-13 Cribs.
DOE/RL-2002-42, Rev. 0	*Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*	2003	Contains the analytical results for sediment samples collected from Borehole C3102 in the 216-T-26 Crib, Borehole C3103 in the 216-B-7A Crib, and Borehole C3104 in the 216-B-38 Trench as part of the remedial investigation in 2001 for the 200-TW-1 and 200-TW-2 OUs.
SGW-50056, Rev. 0	*Resistivity Characterization of 216-C-1, A Complex, B Plant, PUREX, S Complex, T Plant, and 216-Z-16 Trench Project Sites*	August 2011	Geophysical profiling using the two-dimensional resistivity method was conducted to interrogate the vadose zone subsurface beneath these waste sites using a noninvasive technique to determine whether past waste disposal and/or handling activities have left a measureable electrical signature.
RPP-RPT-38322, Rev. 0	*Surface Geophysical Exploration of the S and SX Tank Farms at the Hanford Site*	September 2008	Documents initial geophysical exploration activities completed at the S and SX Tank Farms at the Hanford Site in FY 2008 (August through September 2008).
SGW-50194, Rev. 0	*Geophysical Logging Report for 200-DV-1 Operable Unit Waste Sites in the S Complex Areas*	September 2011	Assembles and presents the interpreted extent of gamma-emitting contamination for available geophysical logging data for the 200-DV-1 OU waste sites in the S Complex area.
SGW-50280, Rev. 0	*Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the S Complex Area, Central Plateau, Hanford, Washington*	December 2014	Evaluates and documents the current understanding (i.e., conceptual model) of the distribution and behavior of key mobile contaminants beneath specific waste sites assigned to the 200-DV-1 OU in the S Complex area.

DQO = data quality objective
FY = fiscal year
OU = operable unit
TBD = to be determined
Tri-Parties = U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology

SGW-50194 summarizes the geophysical logging results from the 216-S-9 Crib. Three boreholes are located in the immediate vicinity of the crib with geophysical logging data of the upper vadose zone, none of which were drilled through the bottom of the crib. The boreholes indicate no gamma contamination between 0 and 4.6 m (0 and 15 ft) bgs. Only two of the boreholes have been logged since the 1995 interim stabilization activity. Two wells were monitored weekly in 1965 to obtain field data on the performance of the new crib disposal site. It is recorded that radionuclides penetrated to a depth of 18.9 m (62 ft) three weeks following the initial disposal at the site. Gamma activity was detected throughout the vadose zone to groundwater in February 1966. Spectral gamma logging in 2007 to 2008 indicated cesium-137 (and possibly cobalt-60) contamination from 9.1 to 18.2 m (30 to 60 ft) bgs. Low levels of these radionuclides were also found from 54.9 to 73.2 m (180 to 240 ft) bgs.

SGW-50194 also summarizes the geophysical logging activities for the 216-S-23 Crib. Four vadose zone boreholes are located in the immediate vicinity of the crib with geophysical logging data, none of which were drilled through the bottom of the crib. During 1968, the geophysical logs from the monitoring wells indicated no contamination in the vadose zone prior to the use of the crib. During logging in 2003, sporadic cesium-137 contamination was detected outside the crib boundaries between 0 and 3.1 m (0 and 10 ft) bgs at concentrations less than 2 pCi/g. Logging in the boreholes indicated no contamination prior to 1992, when the interim stabilization was completed. Gamma-emitting contaminants were detected in two wells from approximately 21.9 to 63.1 m (72 to 207 ft) bgs; however, by 1976, the gamma activity had decayed to near background levels. During spectral gamma logging throughout the vadose zone in 2003, no contamination was detected deeper than 3.1 m (10 ft) bgs.

3.4.3.2 Subregion 2: 216-S-21 and 216-S-25 Cribs

The 216-S-21 Crib was interim stabilized in 1991 (WHC-SP-1149) and again in 1991. The surface of the 216-S-25 Crib was about 0.3 m (1 ft) above grade (BHI-00174, *U Plant Aggregate Area Management Study Technical Baseline Report*).

SGW-50194 summarizes the geophysical logging results from the 216-S-21 Crib. Two boreholes are located in the immediate vicinity of the crib with geophysical logging data of the upper vadose zone, one of which was drilled through the bottom of the crib to 15.2 m (50 ft) bgs. Cesium-137 was detected in the upper 4.6 m (15 ft) of that borehole at concentrations ranging from 0.2 to 1,000 pCi/g, with the maximum value at 4.6 m (15 ft) bgs. Contamination was found in the DVZ in both wells from the bottom of the crib to 18.2 m (60 ft) bgs, with cesium-137 activity to 45,000,00 pCi/g at 7.5 m (24.5 ft) bgs directly beneath the crib. Remnant cobalt-60 was found to at least 50.3 m (165 ft) bgs.

SGW-50194 also summarizes the geophysical logging activities for the 216-S-25 Crib. Two monitoring wells are located in the immediate vicinity of the crib with geophysical logging data, neither of which was within the excavated area of the crib. When these wells were last logged in 1976 and 1981, no contamination was detected.

3.4.3.3 Subregion 3: 216-S-13 Crib

The 216-S-13 Crib was interim stabilized in 1991 (WHC-SP-1149).

The nearest well is located approximately 14.9 m (49 ft) from the center of the crib. Geophysical logging of the well between 1963 and 1968 detected radioactive contaminants from 8.2 to 33.5 m (27 to 110 ft) bgs. By 1976, radioactivity had decreased to low levels. No measurable migration of radionuclides has been detected in the sediments since the discharges to the crib were terminated. Based on the geophysical logging, breakthrough to the groundwater has not occurred at this site.

3.4.4 Nature and Extent of Contamination in the S Complex Area

Table 3-21 summarizes the vertical location of contamination at each 200-DV-1 OU waste site with respect to the upper 4.6 m (15 ft) of the vadose zone, 4.6 m (15 ft) bgs to groundwater, and groundwater.

Table 3-22 summarizes the likelihood that contaminants from the 200-DV-1 OU waste sites have affected groundwater in the past or may be affecting groundwater currently and/or in the future.

Table 3-21. Vertical Contamination at 200-DV-1 OU Waste Sites in the S Complex Area

Subregion	Waste Site	Contamination in Upper 4.6 m (15 ft)[a]	Contamination from 4.6 m (15 ft) to Groundwater[a]	Contamination in Groundwater[a]
1	216-S-9	No	Yes	Yes
2	216-S-21	Yes	Yes	No
3	216-S-13	No[b]	Yes	No

a. 200-DV-1 Operable Unit data quality objectives summary report (Appendix C).

b. Soil concentration data are not available for the upper 4.6 m (15 ft) of soil in the crib.

Table 3-22. Impact of 200-DV-1 OU Waste Sites in the S Complex Area on Underlying Groundwater

Subregion	200-DV-1 OU Waste Site	Past Groundwater Impact Likely?	Current Groundwater Impact Likely?	Future Groundwater Impact Likely?
1	216-S-9 Crib	●	●	●
2	216-S-21 Crib	●	○	○
3	216-S-13 Crib	○	○	○

Note: This table is based on SGW-50280, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the S Complex Area, Central Plateau, Hanford, Washington.*

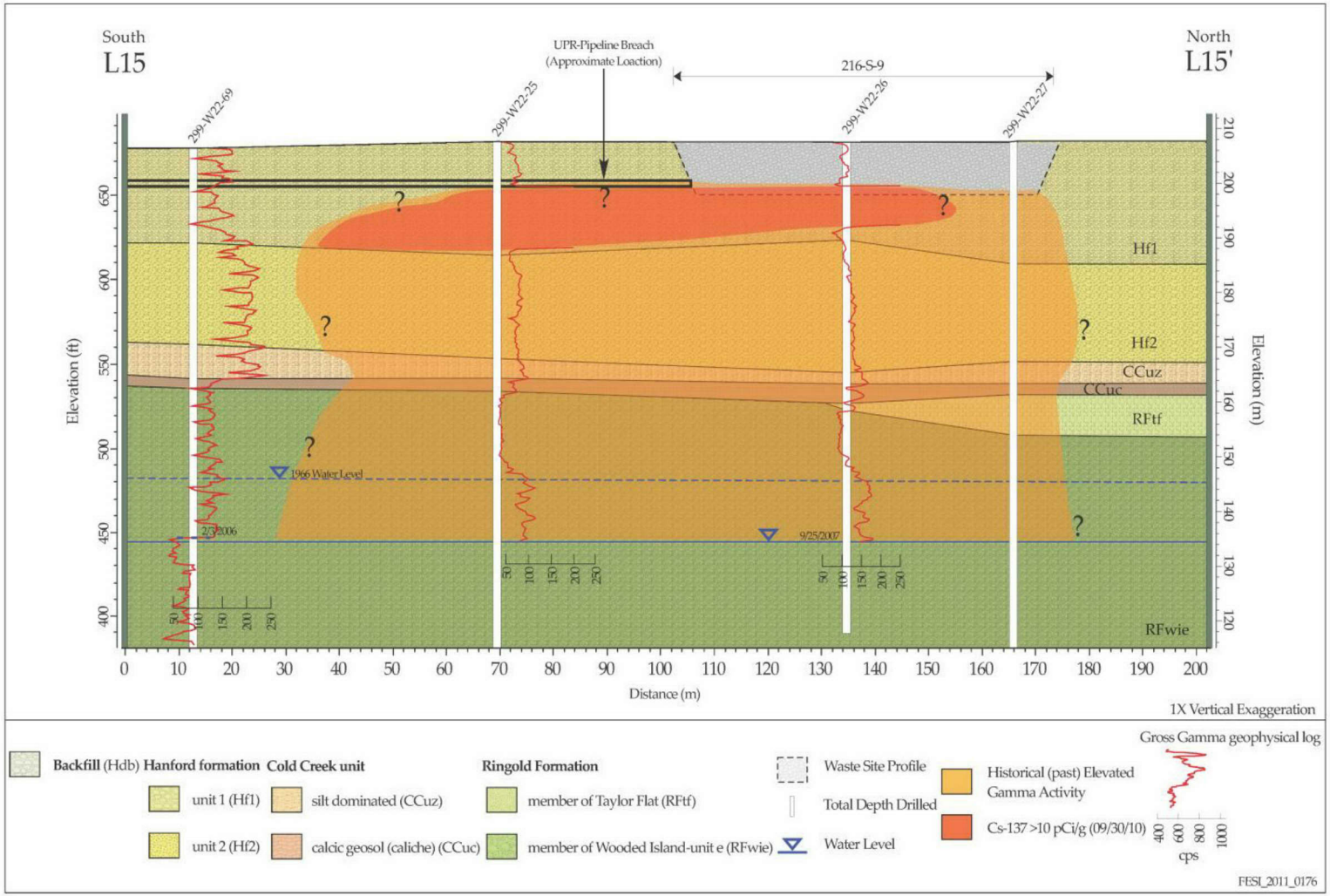
○ = groundwater impact unlikely

● = groundwater impact likely

OU = operable unit

3.4.4.1 Subregion 1: 216-S-9 Crib

Based on the waste site construction dimensions and soil concentrations from the geophysical logging, there is no gamma-emitting contamination in the upper 4.6 m (15 ft) at the 216-S-9 Crib. Electrical resistivity surveys indicate a zone of relatively low to intermediate resistivity near the south end of the crib. The lateral extent of contamination, based on historical detectable mobile gamma contamination, is an ellipse centered near the south end of the crib, with a northwest-southeast axis approximately 170 m (559 ft) long and a northeast-southwest axis approximately 100 m (328 ft) long (SGW-50280, Figure 3-8). The historical vertical extent of contamination extends to the 2007 water table approximately 73 m (240 ft) bgs (SGW-50820, Figure 3-9). Figure 3-48 illustrates the contamination profile at the 216-S-9 Crib.



Source: SGW-50280, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the S Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-48. S Complex Area Subregion 1: Contaminant Conceptual Model, South to North Cross Section

3.4.4.2 Subregion 2: 216-S-21 Crib

The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-S-21 Crib. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft) of the 216-S-21 Crib. The lateral extent of contamination at depth is circular, approximately centered on the crib, with a diameter of approximately 84 m (274 ft), based on historical detectable mobile gamma contamination (SGW-50280, Figure 3-18). The historical vertical extent of vadose zone contamination is not likely to have extended below the CCU (SGW-50280, Figure 3-18). Figure 3-49 illustrates the contamination profile at the 216-S-21 Crib.

3.4.4.3 Subregion 3: 216-S-13 Crib

Based on the waste site construction dimensions, there is no contamination in the upper 4.6 m (15 ft) at the 216-S-13 Crib.

The resistivity surveys did not provide coverage of the 216-S-13 Crib. However, based on historical detectable mobile gamma contamination at Well 299-W22-21, the lateral extent of contamination is estimated to be encompassed by a circle with a radius of at least 14.9 m (49 ft) (ARH-ST-156, *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells*). The vertical extent of contamination is estimated to be approximately 33.5 m (110 ft) based on historical geophysical logging.

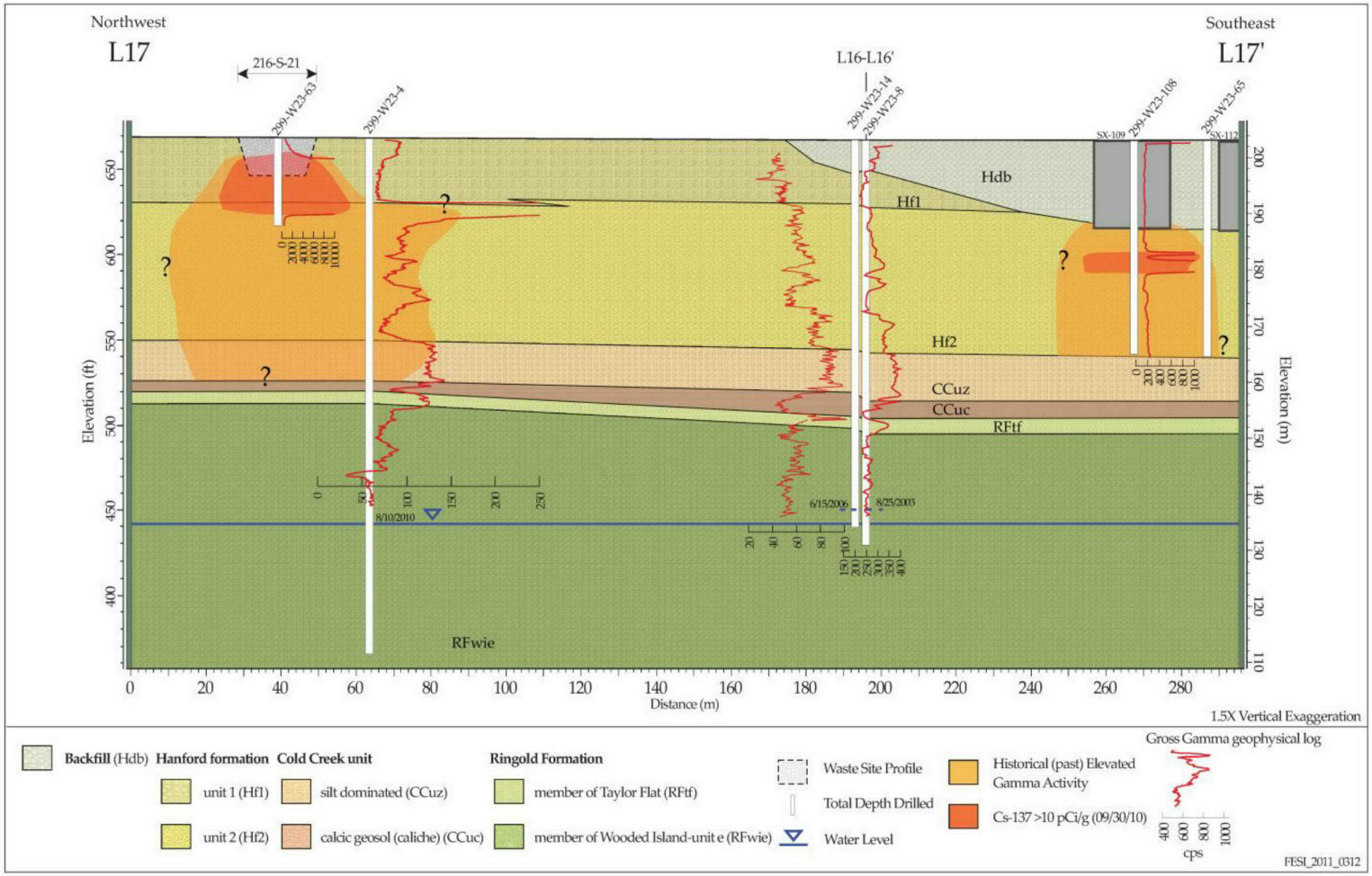
3.4.5 Groundwater Contamination beneath the S Complex Area

The S Complex area overlies the 200-UP-1 Groundwater OU. Radionuclides (uranium, iodine, and technetium) and nitrate are the primary COCs in southern portion of this OU. The primary sources of these COCs are not the 200-DV-1 OU waste sites in the S Complex area, but are instead the discharges to tank leaks at adjacent facilities. Other major contaminants in the 200-UP-1 OU include trichloroethene, total chromium, hexavalent chromium, and tritium. The four extensive COC plumes near the S Complex area include nitrate, uranium, technetium-99, and iodine-129. Maps showing the regional extent of these plumes in 2009 are provided in Figures 3-50, 3-51, 3-52, and 3-53, respectively.

3.5 Identification of Contaminants of Potential Concern

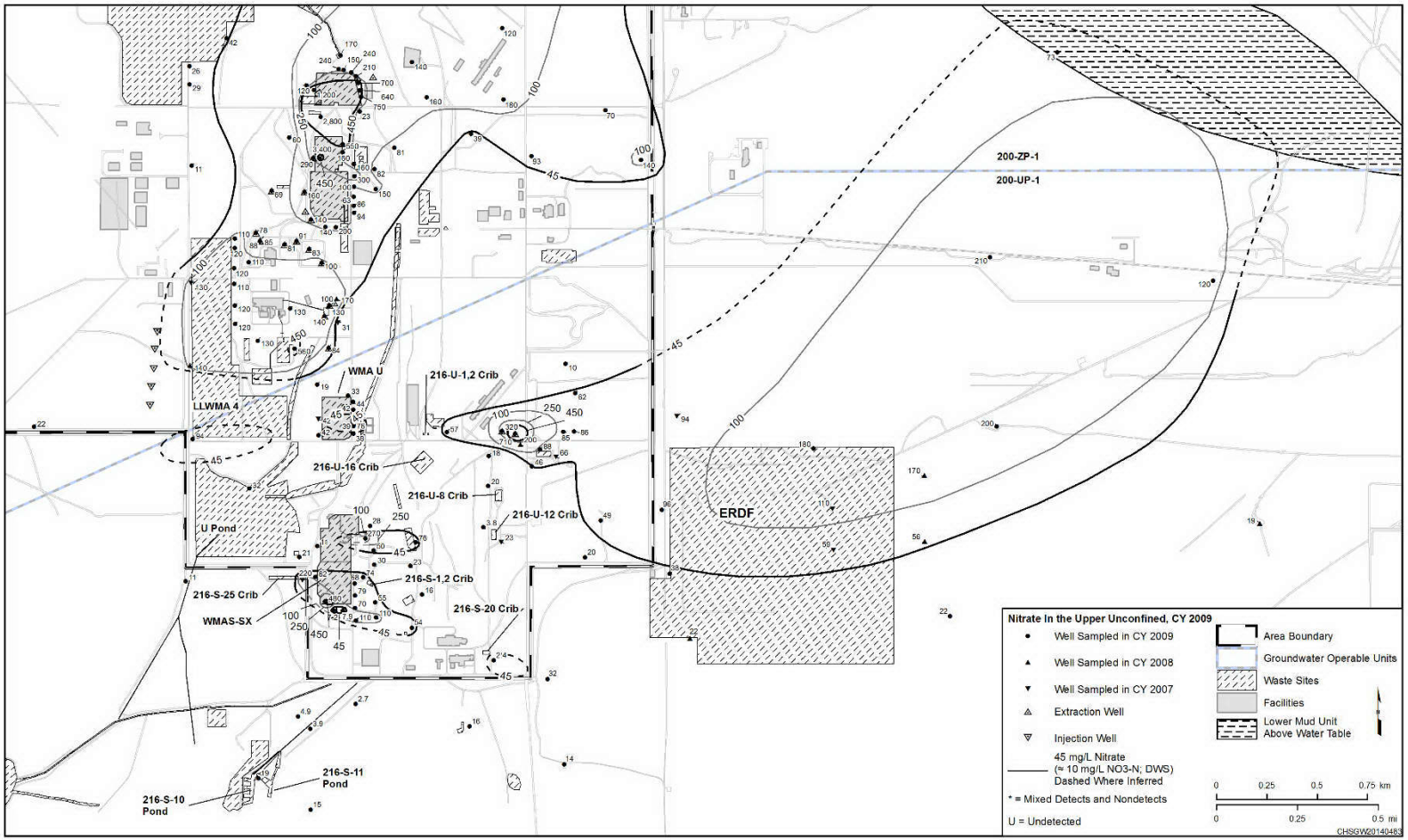
COPCs have been identified for the 200-DV-1 OU waste sites through three separate DQO processes. The sites previously assigned to the 200-TW-1 and the 200-TW-2 OUs were evaluated as part of the 200-TW-1 OU and 200-TW-2 OU RI DQO (BHI-01356, *Remedial Investigation Data Quality Objectives Summary Report for the 200-TW-1 Scavenged Waste Group and the 200-TW-2 Tank Waste Group Operable Units*). The list of COPCs was revisited and confirmed during the DQO process conducted to support development of the Central Plateau supplemental work plan (DOE/RL-2007-02). The final list of COPCs was revised during the 2011 DQO for the 200-DV-1 OU.

The initial list of COPCs was developed based on a thorough review of process, operational, and waste discharge information. Process knowledge indicates that the waste streams discharged to these waste sites were predominantly liquid effluent discharges from the B, BX, BY, T, TX, and TY Tank Farms. This resulted in a preliminary listing of 68 radioactive, 123 inorganic, and 12 organic constituents for the previous 200-TW-1 OU waste sites. For the waste sites in the previous 200-TW-2 OU, 59 radioactive, 120 inorganic, and 6 organic constituents were identified. In 2002, the 200-PW-5 OU waste sites were consolidated with these OUs based upon similarities between contaminant sources.



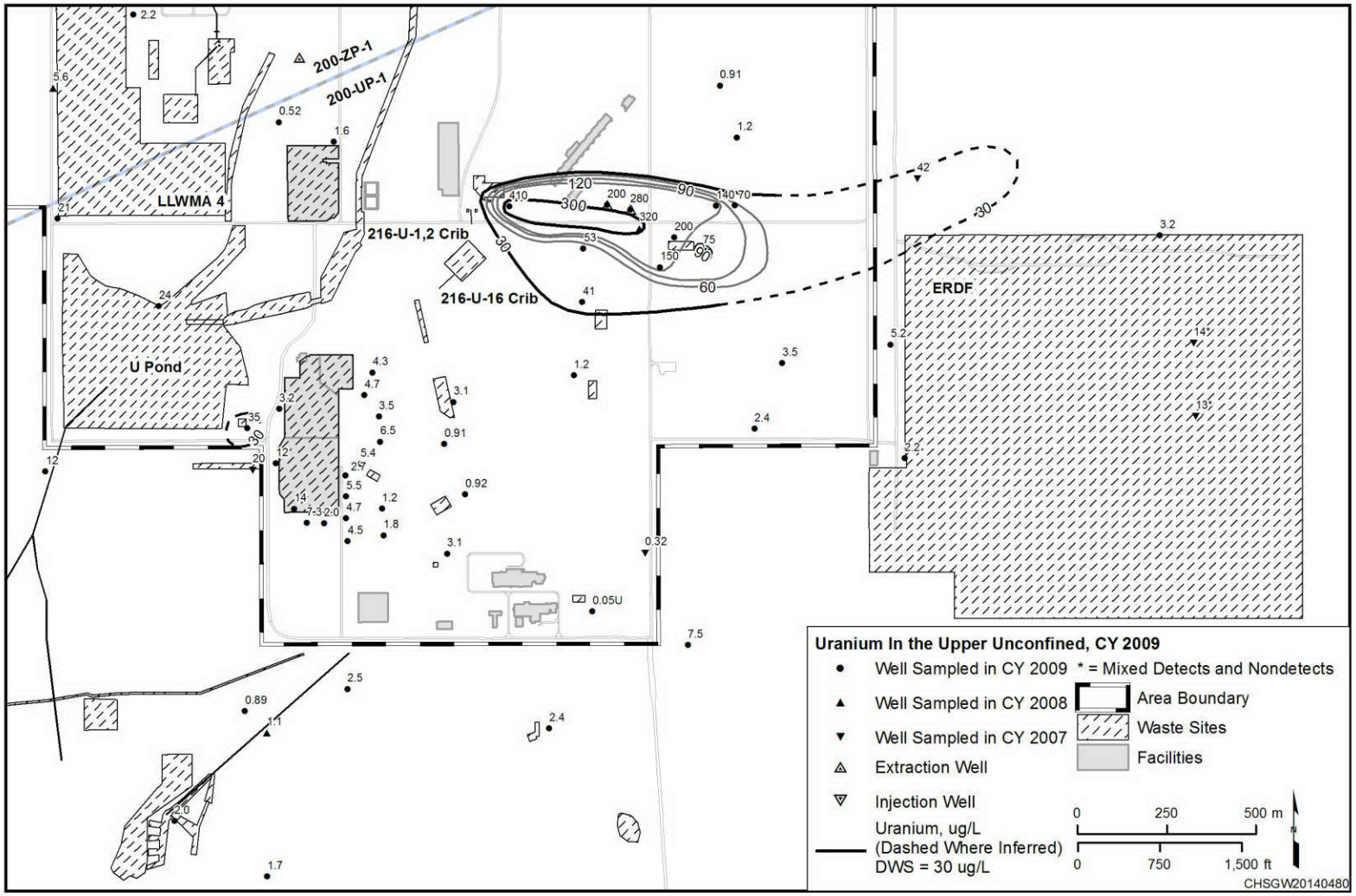
Source: SGW-50280, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the S Complex Area, Central Plateau, Hanford, Washington*.

Figure 3-49. S Complex Area Subregion 2: Contaminant Conceptual Model, Northwest to Southeast Cross Section



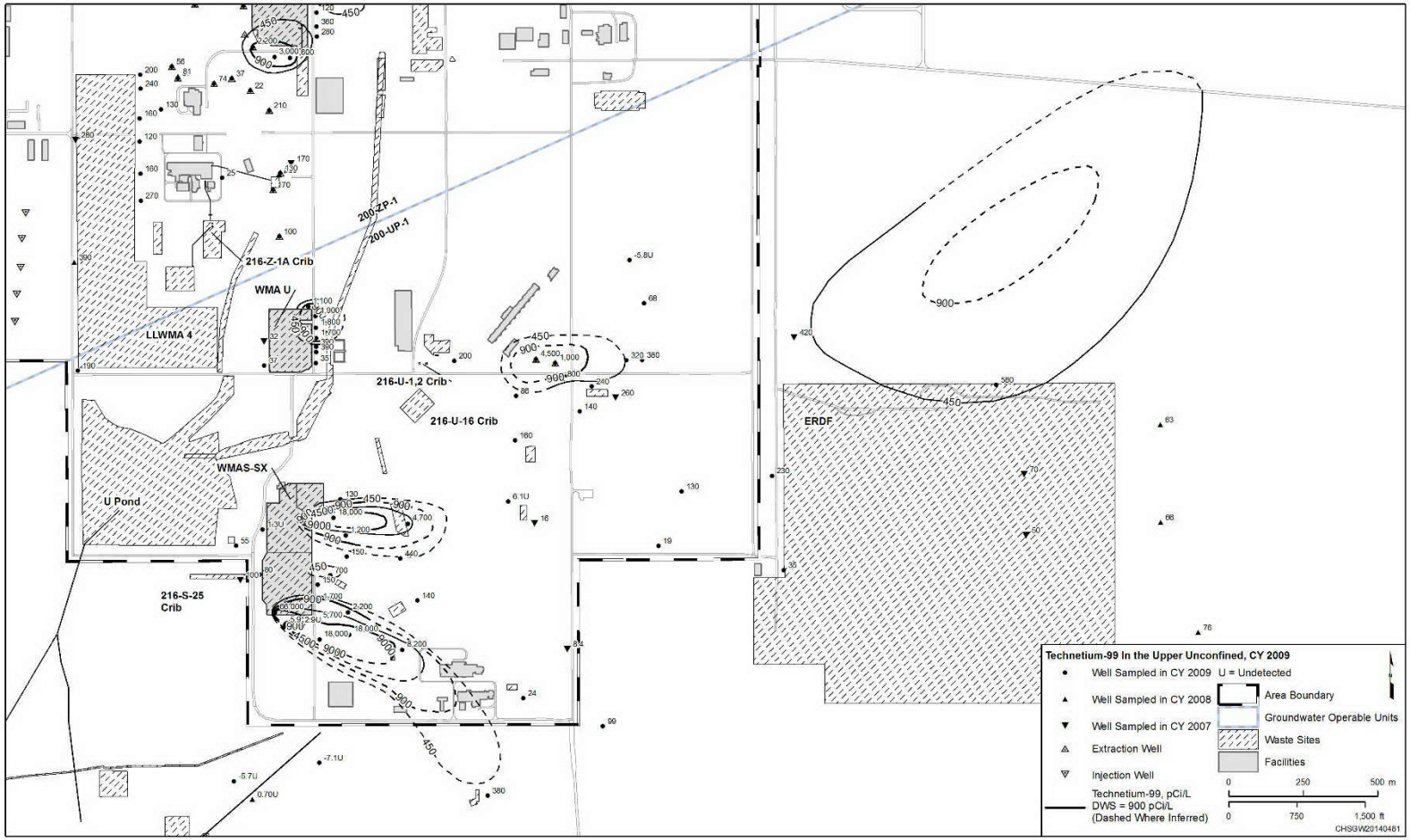
Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*.

Figure 3-50. Map of Nitrate Groundwater Plume in the S Complex Area



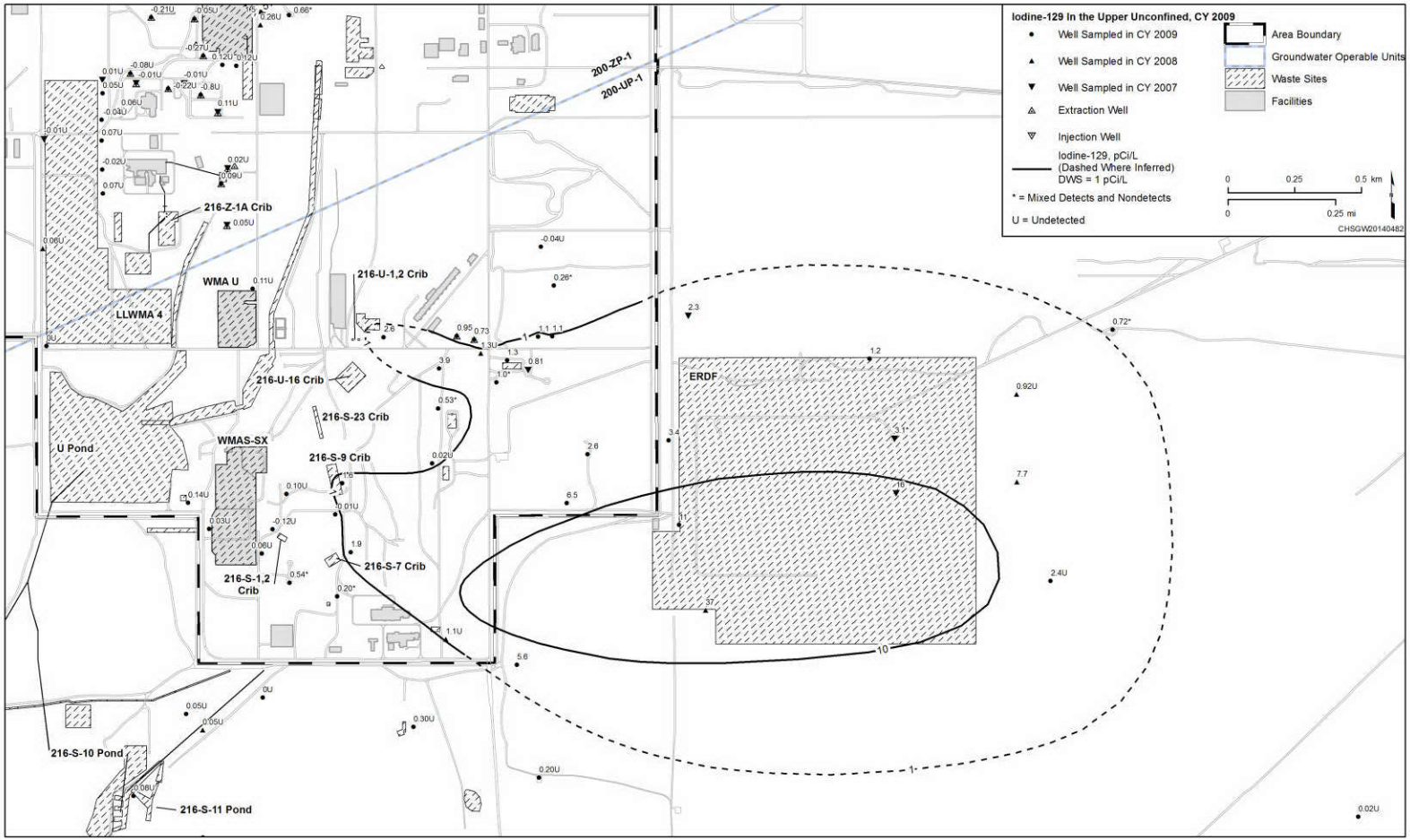
Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2.*

Figure 3-51. Map of Uranium Groundwater Plume in the S Complex Area



Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2.*

Figure 3-52. Map of Technetium-99 Groundwater Plume in the S Complex Area



Source: DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2.*

Figure 3-53. Map of Iodine-129 Groundwater Plume in the S Complex Area

The preliminary list of COPCs was then evaluated, and constituents were removed based on a series of criteria, resulting in the list of COPCs (BHI-01356). Criteria for removal of a constituent, the individual constituent exclusions, and the associated justifications are provided in the 200-TW-1/200-TW-2 RI DQO summary report (BHI-01356). This list of COPCs was also carried forward in the Central Plateau OUs supplemental RI/FS work plan (DOE/RL-2007-02).

The list of COPCs was revised during the 2011 DQO for the 200-DV-1 OU. Five additional COPCs identified in the 200-TW-1/200-TW-2/200-PW-5 draft PP (DOE/RL-2004-10, *Proposed Plan for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product Rich Waste Group Operable Units*) were added. During the DQO process, DOE and Ecology agreed that a methods-based approach would be employed. This approach will involve instructing the laboratory to report results for all constituents determined through multi-constituent analysis methods (e.g., ion chromatography, inductively coupled plasma, inductively coupled plasma/mass spectroscopy, gamma energy analysis, gas chromatography/mass spectrometry), regardless of whether they are COPCs. The list of COPCs for the 200-DV-1 OU waste sites is provided in Table 3-23.

Table 3-23. COPCs for 200-DV-1 OU Waste Sites

Radiological Constituents			
Americium-241	Europium 154	Plutonium-238	Technetium-99
Carbon-14	Europium-155	Plutonium-239/240	Thorium-232
Cesium-137	Tritium	Radium-226	Uranium-234
Cobalt-60	Neptunium-237	Radium-228	Uranium-235
Europium-152	Nickel-63	Strontium-90	Uranium-238
Iodine-129[a,e]			Uranium-233[e]
Inorganic Constituents			
Cadmium	Lead	Ammonia/ammonium	Nitrate/nitrite
Chromium (total)	Mercury	Chloride	Phosphate
Chromium (hexavalent)	Nickel	Cyanide	Sulfate
Copper	Silver	Fluoride	Aluminum[b]
Antimony[b]	Manganese[b]	Selenium[b]	Uranium (total)[b]
Arsenic[d,e]	Barium[e]		
Organic Constituents (BY Cribs, 216-B-42, 216-T-18, 216-T-19, 216-S-9, 216-S-13, and 216-S-21 Waste Sites Only)[f]			
Tributyl phosphate[g]	Normal paraffin hydrocarbon (kerosene)[c]		
Organic Constituents (216-T-19 Waste Site Only)[d]			
1,1-Dichloroethane	1,2-Dichloroethane	cis-1,2-Dichloroethylene	trans-1,2-Dichloroethylene
1,1,1-Trichloroethane	Acetone	Benzene	n-Butyl benzene
Carbon tetrachloride	Chlorobenzene	Trichloromethane (chloroform)	Dichloromethane (methylene chloride)
Ethyl benzene	Methyl ethyl ketone	Methyl isobutyl ketone (hexone)	Phenol
Polychlorinated biphenyls	Tetrachloroethylene	Toluene	Trichloroethene

Table 3-23. COPCs for 200-DV-1 OU Waste Sites

Xylene	
Organic Constituents (216-S-13 Waste Site Only)[e]	
Methyl isobutyl ketone (hexone)	Polychlorinated biphenyls

a. Not identified for the 200-TW-1 or 200-TW-2 OUs but included on waste site-specific basis for the 200-DV-1 OU.

b. Identified as a contaminant of concern in Table 2 of DOE/RL-2004-10, *Proposed Plan for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product Rich Waste Group Operable Units*.

c. Analyzed as kerosene total petroleum hydrocarbons.

d. Identified as a COPC for 216-T-19 waste site only, in accordance with DOE/RL-2007-02-VOLII-ADD3, *Site-Specific Field-Sampling Plans for the 216-B-42 Trench, 216-S-13 Crib, 216-S-21 Crib, 216-T-18 Crib and 216-T-19 Crib and Tile Field in the 200-TW-1/200-PW-5 Operable Units*, Section AD3-6.0.

e. Included for previous 200-PW-3 OU waste sites only (216-S-13), in accordance with DOE/RL-2007-02-VOLII-ADD3, Section AD3-3.0.

f. Included for previous 200-TW-1/200-PW-5 OU and 200-PW-1 OU waste sites only (216-B-42, BY Cribs, 216-T-18, 216-T-19, 216-S-9, 216-S-13, 216-S-21), in accordance with DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units, Volume I: Work Plan and Appendices*.

g. Analyzed as tributyl phosphate only.

COPC = contaminant of potential concern

OU = operable unit

3.6 Land and Groundwater Use

This section describes the current and future land use and groundwater use for the Inner Area, consistent with the Central Plateau cleanup completion strategy, the Inner Area Cleanup principles (Section 1.3.2), and the 200-ZP-1 OU ROD (EPA et al., 2008). Reasonably anticipated future land use for the Inner Area is industrial. It is recognized that some areas are dedicated to long-term waste management; the Tri-Parties anticipate that these waste units will be managed in perpetuity. Further, the Tri-Parties have defined the smallest practical area on the Central Plateau for waste management as the Inner Area. Land use and groundwater use will be consistent with the 200-WA-1 and 200-EA-1 OU BRAs.

Groundwater beneath the Central Plateau is currently contaminated and undergoing active remediation; withdrawal is prohibited as a result of institutional controls emplaced by DOE. Under current Hanford Site use conditions, there are no complete human or ecological exposure pathways, except when groundwater discharges to the Columbia River, which is located few miles downgradient. Furthermore, regardless of land use designations for surface soils, groundwater within the Central Plateau is not anticipated to become a future source of drinking water until cleanup criteria are met and groundwater is restored to its highest beneficial use.

3.6.1 Current Land Use

The current land-use activities in the Inner Area are industrial in nature. Several waste management facilities continue to operate on the Central Plateau, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility, low-level radioactive waste burial grounds, and mixed waste trenches permitted by RCRA. Construction of tank waste treatment facilities on the Central Plateau began in 2002. The Integrated Disposal Facility is the planned disposal location for the vitrified low-activity tank waste. Non-Hanford Site DOE organizations and the U.S. Department of the Navy use the TSD units on the Central Plateau. In addition, U.S. 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.

3.6.2 Reasonably Anticipated Future Land Use

The reasonably anticipated future land use for the portion of the Central Plateau where the 200-DV-1 OU sites are located (Inner Area) 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 that report, DOE issued DOE/EIS-0222F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (HCP EIS), and 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 implications 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 supplement 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 Future Site Uses Working Group report (Drummond, 1992) 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 required for permanent waste management and containment of residual contamination.

3.6.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated cities of Richland, West Richland, Kennewick, Pasco, and numerous other smaller communities within Benton and Franklin counties. No residences are located on the Hanford Site. The inhabited residences nearest to the Central Plateau are farmhouses on land approximately 16 km (10 mi) north across the Columbia River. The City of Richland corporate boundary is approximately 27 km (17 mi) to the south (PNNL-6415, *Hanford Site Environmental Policy Act (NEPA) Characterization*).

3.6.4 Groundwater Use

The groundwater underlying the Central Plateau is contaminated and is not currently 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.

3.7 Potential Applicable or Relevant and Appropriate Requirements

A preliminary identification of potential applicable or relevant and appropriate requirements (ARARs) and to-be-considered information in the scoping phase of the RI/FS and RFI/CMS process 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 and RFI/CMS process, ARAR identification continues throughout the RI/FS and RFI/CMS as a better understanding is gained of site conditions and remedial action alternatives.

ARARs may be categorized as (1) chemical-specific requirements that may define acceptable exposure levels and, therefore, be used in establishing PRGs; (2) location-specific requirements that may set restrictions on activities within specific locations such as floodplains or wetlands; and (3) action-specific, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous waste. Detailed information on identifying and complying with ARARs is provided in EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*.

Appendix D provides a table of potential ARARs and to-be-considered information for the 200-DV-1 OU.

3.8 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-DV-1 OU waste sites and includes a discussion of the exposure areas.

3.8.1 Exposure Pathways and Routes

Potentially complete exposure pathways and associated exposure routes for human and ecological receptors will be defined for the risk assessment approach detailed in Sections 3.10.1 and 3.10.2. Human health risks will be assessed using an industrial worker exposure scenario. The exposure pathways, exposure routes, exposure assumptions, and toxicity values that will be used for the industrial worker scenario are described in Section 3.10.1.

Ecological risks will be assessed for terrestrial receptors on the Central Plateau as described in Section 3.10.2. The ecological receptors, exposure pathways, exposure parameters, and toxicity reference values that will be used to conduct the assessment are also described in Section 3.10.2.

Human health and ecological BRAs will not evaluate direct contact risk below the standard point of compliance (0 to 4.6 m [0 to 15 ft] bgs). However, a conditional point of compliance may be proposed for soil depth to evaluate direct contact for human and ecological receptors. This conditional point of compliance would represent the biologically active zone and would be evaluated as an alternative in the FS/CMS.

The methods and parameters outlined in Sections 3.10.1 and 3.10.2 support the Central Plateau Inner Area cleanup principles and are based on guidance from EPA and the regulations promulgated by Ecology. These methods and parameters also are consistent with baseline risk assessments previously conducted at the Hanford Site that have been reviewed and approved by EPA and Ecology.

3.8.2 Contaminant Fate and Transport

The groundwater protection modeling approach will be based on the process defined in the graded approach document (DOE/RL-2011-50). The modeling approach is detailed in Section 3.10.3.

3.9 Preliminary Conceptual Site Model

This section presents the preliminary CSMs for the B Complex area, the T Complex area, and the S Complex area. Each CSM describes contamination from all waste sources in the B, T, and S Complex areas to develop a comprehensive understanding. The CSMs provided in this section are from two 200-DV-1 OU SAPs (DOE/RL-2011-104; DOE/RL-2013-52).

3.9.1 Conceptual Site Model for the B Complex Area

The CSM for the 200-DV-1 OU waste sites in the B Complex area is primarily provided in PNNL-19277. The CSM for the perched water zone is provided in SGW-53604. Data on contamination in the upper 4.6 m (15 ft) of the waste sites are summarized in Appendix C.

To facilitate the DQO process, the 24 waste sites in the B Complex area have been combined into eight waste site groups based on similar construction, operating history, and location (Figure 3-54). The eight waste site groups and the associated highlights from the key reference documents include the following:

- **216-B-5, consisting of 216-B-5 Reverse Well:** The 216-B-5 Reverse Well was used from 1945 to 1947 for disposal of 32.1 million L (8.5 million gal) of process waste from bismuth phosphate fuel reprocessing in the 221-B Building (B Plant) and from plutonium concentration processes in the 224-B Building (224-B Concentration Facility) via the 241-B-361 Settling Tank. The bottom 15.2 m (50 ft) of the well was perforated and the waste discharged into the lower 12.2 m (40 ft) of the vadose zone and the upper 3 m (10 ft) of the aquifer. Wells were drilled in 1947 and 1948 to investigate radionuclide distributions in groundwater, and wells were drilled and sampled in 1979 to investigate radionuclide distributions on sediments. A treatability test to evaluate P&T technology for remediation of 200-BP-5 OU groundwater was conducted in 1994 and 1995 at the site. Geophysical logging results are available for six wells at the site. Because the perforations in the 216-B-5 Reverse Well begin at 76.8 m (252 ft) bgs, contamination release from the 216-B-5 waste site is unlikely in the upper 4.6 m (15 ft) of the subsurface. No contamination was detected in samples collected in the upper 3 m (10 ft) bgs in 1979. Low levels (less than 1 pCi/g) of cesium-137 that were detected in the upper 4.6 m (15 ft) at two wells within 23 m (75 ft) of the 216-B-5 reverse well do not appear related to reverse well discharges. The available data suggest that the 216-B-5 Reverse Well contributed cesium-137, strontium-90, plutonium-239/240, and americium-241 directly to groundwater and the DVZ in the past. No additional data collection is planned.

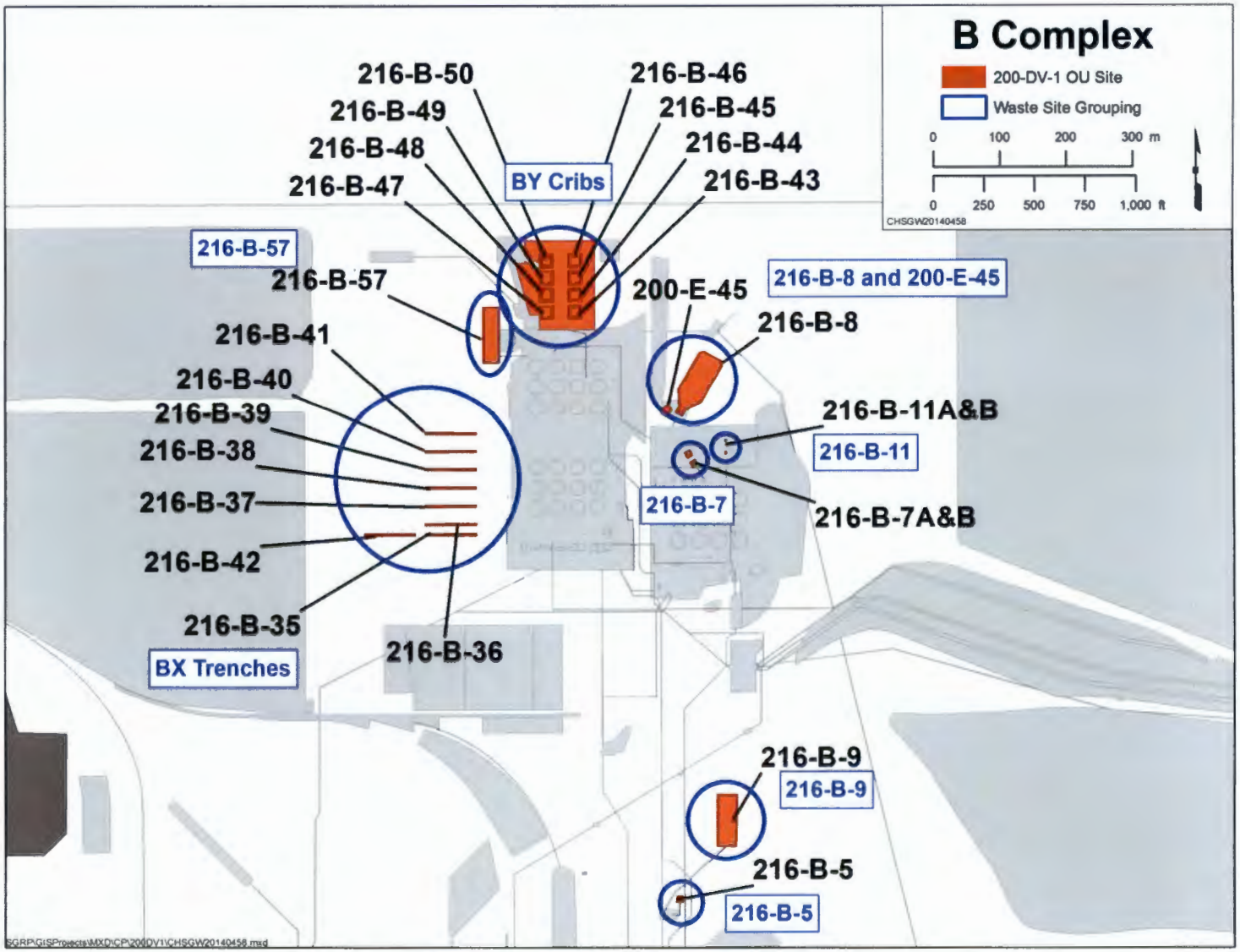


Figure 3-54. Location of 200-DV-1 OU Waste Sites in the B Complex Area

- **216-B-7A&B, consisting of 216-B-7A&B Cribs:** The 216-B-7A&B Cribs were used from 1946 to 1967 for disposal of 44.6 million L (11.8 million gal) of process waste from bismuth phosphate fuel reprocessing in the 221-B Building (B Plant) and plutonium concentration waste generated in the 224-B Building (224-B Concentration Facility) via the 241-B-201, 241-B-202, 241-B-203, and 241-B-204 Settling Tanks. During the RI for the 200-TW-2 OU in 2001, a characterization borehole was drilled through the 216-B-7A Crib nearly to the groundwater. Selected vadose zone sediment samples were collected and analyzed. Geophysical logging results are available for six wells at the site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs through analysis of soil samples and by geophysical logging. The available data suggest that the 216-B-7A&B Cribs have contaminated groundwater in the past and that the cribs are likely a source for fluoride and chromium found in the DVZ CCU. Additional data collection is planned to confirm/refine this CSM.

- **216-B-8, consisting of 216-B-8 Crib and Tile Field and 200-E-45 HI Shaft:** The 216-B-8 Crib and Tile Field were used from 1948 to 1952 for disposal of 35.3 million L (9.3 million gal) of tank waste supernate from the 2C bismuth phosphate fuel separation process. Sediment, liquid, and sludge samples were collected beneath the 216-B-8 Crib in 1948 and 1949 using access from the 200-E-45 HI Shaft. From the late 1950s through the mid-1970s, the HI shaft was used intermittently to test contaminated tank farm pumps that had been repaired. A resistivity survey was conducted in 2007 over the crib and tile field. Geophysical logging results are available for 16 wells at the site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that the 216-B-8 Crib contaminated groundwater in the past and is likely a continuing source of chromium, sodium, and likely nitrate contamination to the groundwater today. Additional data collection is planned to confirm/refine this CSM.

- **216-B-9, consisting of 216-B-9 Crib and Tile Field:** The 216-B-9 Crib and Tile Field was used from 1948 to 1951 for disposal of 36 million L (9.5 million gal) of process waste from bismuth phosphate fuel reprocessing in the 221-B Building (B Plant). Wells and test holes were drilled in 1948 and sampled in 1949 to investigate the distribution of radionuclides. Geophysical logging results are available for 13 wells at the site. Fission products and alpha activity were detected in soil samples from the upper 4.6 m (15 ft) bgs in 1949. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that contaminants from the 216-B-9 Crib and Tile Field are unlikely to have reached groundwater in the past and are unlikely to reach groundwater in the future. Additional data collection is planned to confirm/refine this CSM.

- **216-B-11A&B, consisting of 216-B-11A&B French Drains:** The 216-B-11A&B French Drains were used from 1951 to 1954 for the disposal of 29.6 million L (7.8 million gal) of condensate produced during evaporation of 1C bismuth phosphate fuel separation waste. A resistivity survey was conducted in the vicinity of the waste site in 2007. Geophysical logging results are available for two wells within 4.6 m (15 ft) of the waste site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that the 216-B-11A&B French Drains likely contaminated groundwater in the past but are not considered a current or future source of significant contamination to the groundwater. No additional data collection is planned.

- **BX Trenches, consisting of 216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42 Trenches:** The BX Trenches were used in 1954 and 1955 for disposal of 14.9 million L (3.9 million gal) of liquid waste from the following three sources: (1) tank waste supernate from the 1C bismuth phosphate fuel separation process, (2) waste evaporator bottoms from the concentration of 1C bismuth phosphate tank waste, and (3) tank waste supernate from scavenged TBP uranium recovery waste. During the RI for the 200-TW-2 OU in 2001, a characterization borehole was drilled through the 216-B-38 Trench to groundwater. Selected vadose zone sediment

samples were collected and analyzed. A resistivity survey was conducted in 2007 over the trenches. Geophysical logging results are available for 14 wells at the site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs through analysis of soil samples and by geophysical logging. The available data suggest that the BX Trench waste may have migrated as deep as 54.9 m (180 ft) bgs but has not reached groundwater and is not a likely source of future groundwater contamination. Additional data collection is planned to confirm or refine this CSM.

- **BY Cribs, consisting of 216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs:** Seven of the BY Cribs (216-B-43 through 216-B-49) were used in 1954 and 1955 for the disposal of 33.8 million L (8.9 million gal) of tank waste supernate from scavenged TBP uranium recovery waste. The eighth BY Crib (216-B-50) was used from 1965 to 1974 for disposal of 54.7 million L (14.5 million gal) of liquid condensate waste from the ITS process at the B-BX-BY Tank Farms. During the RI for the 200-BP-1 OU in 1991, three characterization boreholes were drilled through each of the BY Cribs to 9.1 m (30 ft); two boreholes were deepened nearly to groundwater. During the RI for the 200-BP-5 OU in 2008, two wells were drilled to groundwater near the BY Cribs. Selected vadose zone sediment samples were collected and analyzed from these wells. A resistivity survey was conducted in 2007 over the cribs. Geophysical logging results are available for 32 wells at the site. Cesium-137 and strontium-90 were detected in the upper 4.6 m (15 ft) bgs through analysis of soil samples, and cesium-137 also was detected by geophysical logging. The available data suggest that the BY Cribs have contaminated groundwater in the past and that the DVZ below the BY Cribs is currently contributing technetium-99, cyanide, nitrate, and perhaps cobalt-60 to the groundwater. Additional data collection is planned to confirm/refine this CSM.

- **216-B-57, consisting of 216-B-57 Crib:** The 216-B-57 Crib was used from 1968 to 1973 for the disposal of 84.4 million L (22.3 million gal) of liquid condensate waste from the ITS process at the B-BX-BY Tank Farms. During the RI for the 200-BP-1 OU in 1991, three characterization boreholes were drilled through the 216-B-57 Crib: two boreholes to 15.2 m (50 ft), and one borehole nearly to groundwater. Selected vadose zone sediment samples were collected and analyzed. Geophysical logging results are available for three wells at the site. In 1994, the Hanford prototype barrier was constructed over the crib. Prior to construction of the barrier, cesium-137 and strontium-90 were detected in the upper 4.6 m (15 ft) bgs at concentrations less than 1 pCi/g through analysis of soil samples, and cesium-137 also was detected by geophysical logging. Because the barrier is 15 m (49 ft) thick, this contamination is no longer within the upper 4.6 m (15 ft) bgs. The available data suggest that the crib has not contaminated groundwater and is unlikely to be a significant contributor to groundwater contamination in the future. No additional data collection is planned.

- **B Complex Area perched water:** Perched water, containing contaminants from historical releases from Tank 241-BX-102 and discharges from several nearby facilities used to dispose liquid process waste, is a significant and persistent contaminant source to the underlying unconfined aquifer. The current CSM and ongoing interim remedial actions (SGW-53604) are based on limited hydrogeologic, physical, and chemical characterization data from the perched water interval. Additional data are needed to characterize the perched water, support well completion design requirements for two perched water extraction wells, and refine the CSM.

3.9.2 Conceptual Site Model for the T Complex Area

The CSM for the 200-DV-1 OU waste sites in the T Complex area is primarily provided in SGW-49924. Data on contamination in the upper 4.6 m (15 ft) of the waste sites is summarized in Appendix C.

The seventeen 200-DV-1 OU waste sites (plus one non-200-DV-1 OU waste site) in the T Complex area have been combined into six waste site groups based on similar construction, operating history, and location (Figure 3-55). The six waste site groups include the following:

- **216-T-3 and 216-T-6, consisting of 216-T-3 Reverse Well and 216-T-6 Cribs:** The 216-T-3 Reverse Well was used from 1945 to 1946 for disposal of 11.3 million L (3 million gal) of supernate, via the 241-T-361 Settling Tank, from process waste from bismuth phosphate fuel reprocessing in the 221-T Building (T Plant) and plutonium concentration waste generated in the 224-T Building (224-T Concentration Facility). A well was drilled near the 216-T-3 waste site in 1944 and was later deepened and sampled in 1949. Surface resistivity surveys were conducted in 2005 and 2006. Geophysical logging data are available for the three boreholes near the 216-T-3 site. Because the perforations in the 216-T-3 Reverse Well begin at 32 m (104.5 ft) bgs, contamination release from the 216-T-3 waste site is unlikely in the upper 4.6 m (15 ft) of the subsurface. However, the subsurface at least 8.2 m (27 ft) laterally from 216-T-3 is contaminated from ground surface to 4.6 m (15 ft) bgs. The available data suggest that the 216-T-3 Reverse Well likely impacted groundwater in the past and may contribute nitrate and/or chromium to groundwater in the future (Figure 3-29). Additional data collection is planned to confirm/refine this CSM.

  The 216-T-6 Cribs were used from 1946 to 1951 for disposal of 45 million L (11.9 million gal) of process waste from bismuth phosphate fuel reprocessing in the 221-T Building (T Plant). Thirteen boreholes were drilled at the 216-T-6 Cribs in 1947 and then sampled in 1947 and 1949 to determine the nature and extent of contamination. Surface resistivity surveys were conducted in 2005 and 2006. Geophysical logging data are available for the 15 boreholes near the 216-T-6 site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that the 216-T-6 Cribs likely affected groundwater in the past and may contribute nitrate and/or chromium to groundwater in the future (216-T-6-1 and 216-T-6-2 on Figure 3-29). Additional data collection is planned to confirm/refine this CSM.

- **216-T-5, 216-T-7/200-W-52, and 216-T-32, consisting of 216-T-5 Crib, 216-T-7 Tile Field, 200-W-52 Crib (in WMA T), and 216-T-32 Crib:** The 216-T-32 Crib was used from 1946 to 1952 for disposal of 29 million L (7.7 million gal) of plutonium concentration waste generated in the 224-T Building (224-T Concentration Facility) via the 241-T-201 Settling Tank. The 200-W-52 Crib and 216-T-7 Tile Field were used from 1947 to 1955 for disposal of 107 million L (28.3 million gal) of tank waste supernate from the 2C bismuth phosphate fuel separation process and process waste from bismuth phosphate fuel reprocessing in the 221-T Building (T Plant). Eight boreholes were drilled at the 216-T-32 Crib and fifteen boreholes were drilled at the 216-T-7 Crib (200-W-52) in 1947, and soil samples were collected to determine the nature and extent of contamination. Four shallow test wells were drilled at the 216-T-7 Tile Field in 1948 and sampled in 1949. Surface resistivity surveys were conducted in 2005 and 2006. Geophysical logging results are available for 8 wells at the 216-T-32 site and 15 wells at the 216-T-7/200-W-52 site. Based on the waste site construction dimensions for 216-T-32 and 216-T-7/200-W-52, contamination is not anticipated in the upper 4.6 m (15 ft) bgs. Geophysical logging detected cesium-137 at concentrations less than 1 pCi/g at the ground surface at 216-T-32 and within the upper 1.8 m (6 ft) bgs at the 216-T-7 Tile Field. Contamination from these two waste sites appears to be co-mingled in the vadose zone. The available data suggest that the 216-T-32 and 216-T-7/200-W-52 waste sites impacted groundwater in the past, are currently contributing to the groundwater plume below the T Trenches to the east, and may be continuing sources of technetium-99, chromium, uranium, and nitrate contamination in the future (Figures 3-30, 3-31, and 3-32). Additional data collection at the 216-T-7 Tile Field is planned to confirm/refine this CSM.

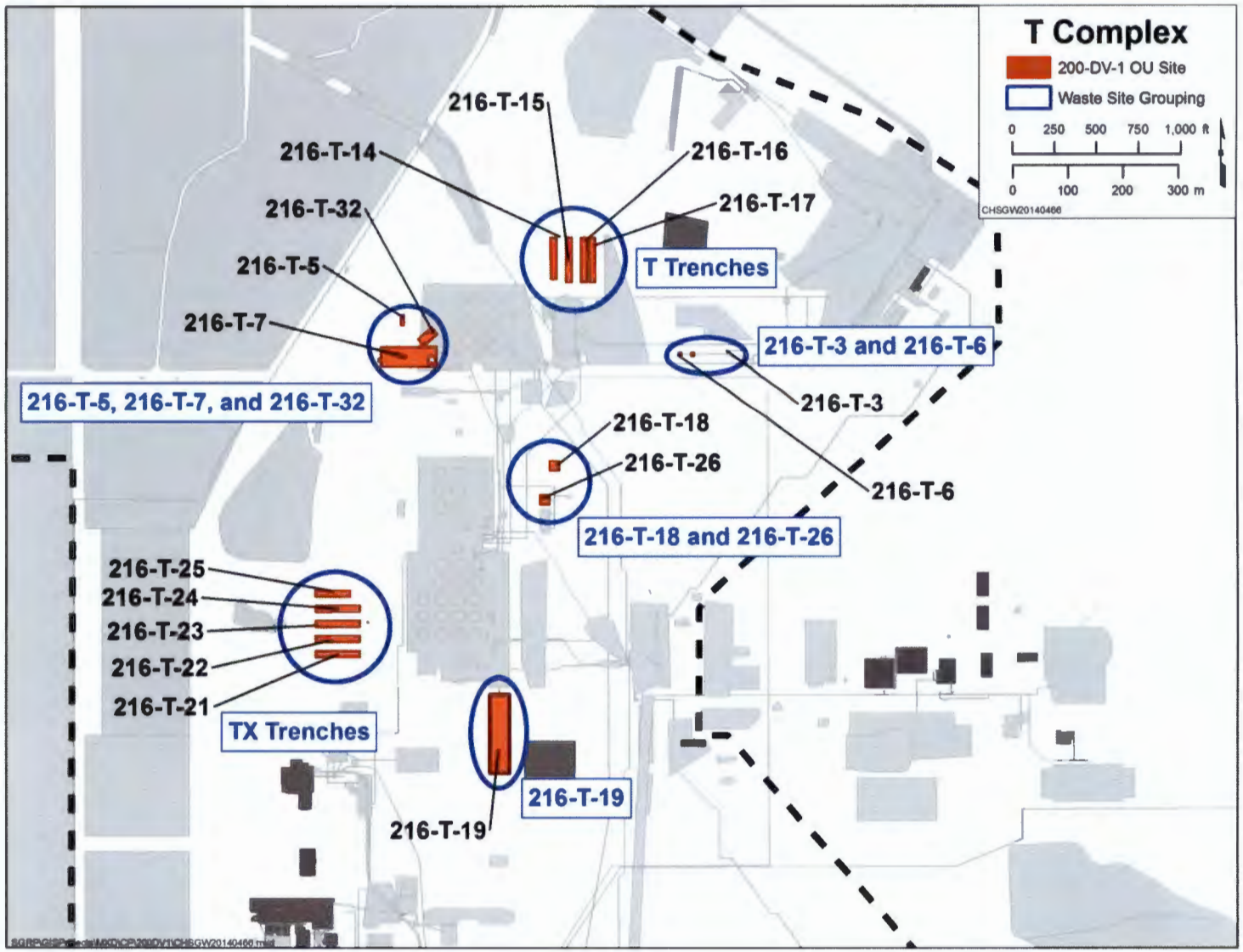


Figure 3-55. Location of 200-DV-1 OU Waste Sites in the T Complex Area

The 216-T-5 Trench was used in 1955 for disposal of 3.2 million L (0.8 million gal) of tank waste supernate from a 2C bismuth phosphate fuel separation processing run that had an unusually high level of activity. Drilling logs are available for three shallow (less than 9.1 m [30 ft]) boreholes that were drilled in 1985. Surface resistivity surveys were conducted in 2005 and 2006. Geophysical logging results are available for the one well near the site. According to the drilling logs, contamination was encountered in the upper 4.6 m (15 ft) bgs in each of the 1985 boreholes. The available data suggest that contaminant breakthrough to the groundwater from the 216-T-5 Trench did not occur (Figure 3-30). Additional data collection is planned to confirm/refine this CSM.

- **T Trenches, consisting of 216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches:** The T Trenches were used in 1954 for disposal of 3.9 million L (1 million gal) of tank waste supernate from the 1C bismuth phosphate fuel separation process in the 221-T Building (T Plant) via the 241-T-104, 241-T-105, 241-T-106 Tanks. Surface resistivity surveys were conducted in 2005 and 2006. Geophysical logging results are available for five wells at the site and six wells to the west and southwest of the site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that contaminants from the T Trenches are unlikely to have reached groundwater in the past and are unlikely to reach groundwater in the future (Figures 3-33 and 3-34). Additional data collection is planned to confirm/refine this CSM.

- **216-T-18 and 216-T-26, consisting of 216-T-18 and 216-T-26 Cribs:** The 216-T-18 Crib was used in 1953 for disposal of 1 million L (0.3 million gal) of tank supernate from the production test of the TBP scavenging process at the 221-U Building (U Plant). Three direct-push boreholes were installed in 2008. Surface resistivity surveys were conducted in 2008. Geophysical logging results are available for the four boreholes at the site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that contaminant breakthrough to the groundwater from the 216-T-18 Crib may have occurred in the past but is unlikely to occur in the future. Additional data collection is planned to confirm/refine this CSM.

  The 216-T-26 Crib was used in 1955 for disposal of 11.1 million L (2.9 million gal) of tank waste supernate from the 1C bismuth phosphate fuel separation process via the 241-TY-101, 241-TY-103, and 241-TY-104 Tanks. During the RI for the 200-TW-1 OU in 2001, a characterization borehole was drilled through the 216-T-26 Crib to groundwater. Selected vadose zone sediment samples were collected and analyzed. Surface resistivity surveys were conducted in 2008. Geophysical logging results are available for three wells at the site. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that contaminants from the 216-T-26 Crib may have reached groundwater in the past and may be a continuing source in the future. No additional data collection is planned.

- **216-T-19, consisting of 216-T-19 Crib and Tile Field:** The 216-T-19 Crib and Tile Field was used from 1951 to 1980 for disposal of 455 million L (120.2 million gal) of liquid waste from the following sources: (1) process and steam condensate from the 242-T Evaporator, (2) supernate from the 2C bismuth phosphate fuel separation process in the 221-T Building (T Plant), (3) process waste from bismuth phosphate fuel reprocessing in the 221-T Building (T Plant); and (4) plutonium concentration waste generated in the 224-T Building (224-T Concentration Facility). Surface resistivity surveys were conducted in 2008. Geophysical logging data are available for the seven boreholes near the 216-T-19 site. Based on the waste site construction dimensions for 216-T-19, contamination is not anticipated in the upper 4.6 m (15 ft) bgs. Geophysical logging shows no evidence of cesium-137 at concentrations greater than 1 pCi/g in the upper 4.6 m (15 ft). The available data suggest that the 216-T-19 Crib and Tile Field likely was a source of mobile contaminants, especially tritium, to groundwater in the past but that it does not appear to be a likely

contributor to groundwater currently or in the future (Figure 3-36). Additional data collection is planned to confirm/refine this CSM.

- **TX Trenches, consisting of 216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 Trenches:** The TX Trenches were used in 1954 for disposal of 8 million L (2.1 million gal) of liquid waste from the following two sources: (1) tank waste supernate from the 1C bismuth phosphate fuel separation process in the 221-T Building (T Plant), and (2) waste evaporator bottoms from the concentration of 1C bismuth phosphate tank waste in the 242-T Evaporator. Surface resistivity surveys were conducted in 2008. Geophysical logging data is available for the five boreholes near the TX Trenches. Cesium-137 was detected in the upper 4.6 m (15 ft) bgs by geophysical logging. The available data suggest that contaminants from the T Trenches are unlikely to have reached groundwater in the past and are unlikely to reach groundwater in the future (Figure 3-37). Additional data collection is planned to confirm/refine this CSM.

3.9.3 Conceptual Site Model for the S Complex Area

The CSM for the 200-DV-1 OU waste sites in the T Complex area is primarily provided in SGW-50280. Data on contamination in the upper 4.6 m (15 ft) of the waste sites is summarized in Appendix C.

The three 200-DV-1 OU waste sites in the S Complex area have been treated as three separate waste site groups (Figure 3-56). The three waste site groups include the following:

- **216-S-9, consisting of 216-S-9 Crib:** The 216-S-9 Crib was used from 1965 to 1969 for disposal of 49.6 million L (13.1 million gal) of process condensate from the REDOX Plant solvent extraction separation operation (1965 to 1967) and from evaporation and concentration of decontamination waste (1967 to 1969) in the 202-S Building (REDOX Plant). Surface resistivity surveys were conducted in 2006 through 2008. Geophysical logging data are available for five wells near the 216-S-9 waste site. Based on the waste site construction dimensions, contamination is not anticipated in the upper 4.6 m (15 ft), and gamma-emitting contaminants were not detected in this zone by geophysical logging. The available data suggest that the 216-S-9 Crib likely affected groundwater in the past and may be contributing iodine-129 to groundwater currently and in the future (Figure 3-48). Additional data collection is planned to confirm/refine this CSM.

- **216-S-21, consisting of 216-S-21 Crib:** The 216-S-21 Crib was used from 1954 to 1969 for disposal of 87.1 million L (23 million gal) of condensate from the condensers in the 241-SX-401 Building (241-SX-401 Condenser Shielding Waste Disposal Condenser House); the condensers were used to condense warm vapor from Tank 241-SX-106. Geophysical logging data are available for two wells near the 216-S-21 waste site. Cesium-137 was detected in the upper 4.6 m (15 ft) by geophysical logging. The available data suggest that contaminants from the 216-S-21 waste site may have reached groundwater in the past, but are unlikely to be a future source of contamination (Figure 3-49). Additional data collection is planned to confirm/refine this CSM.

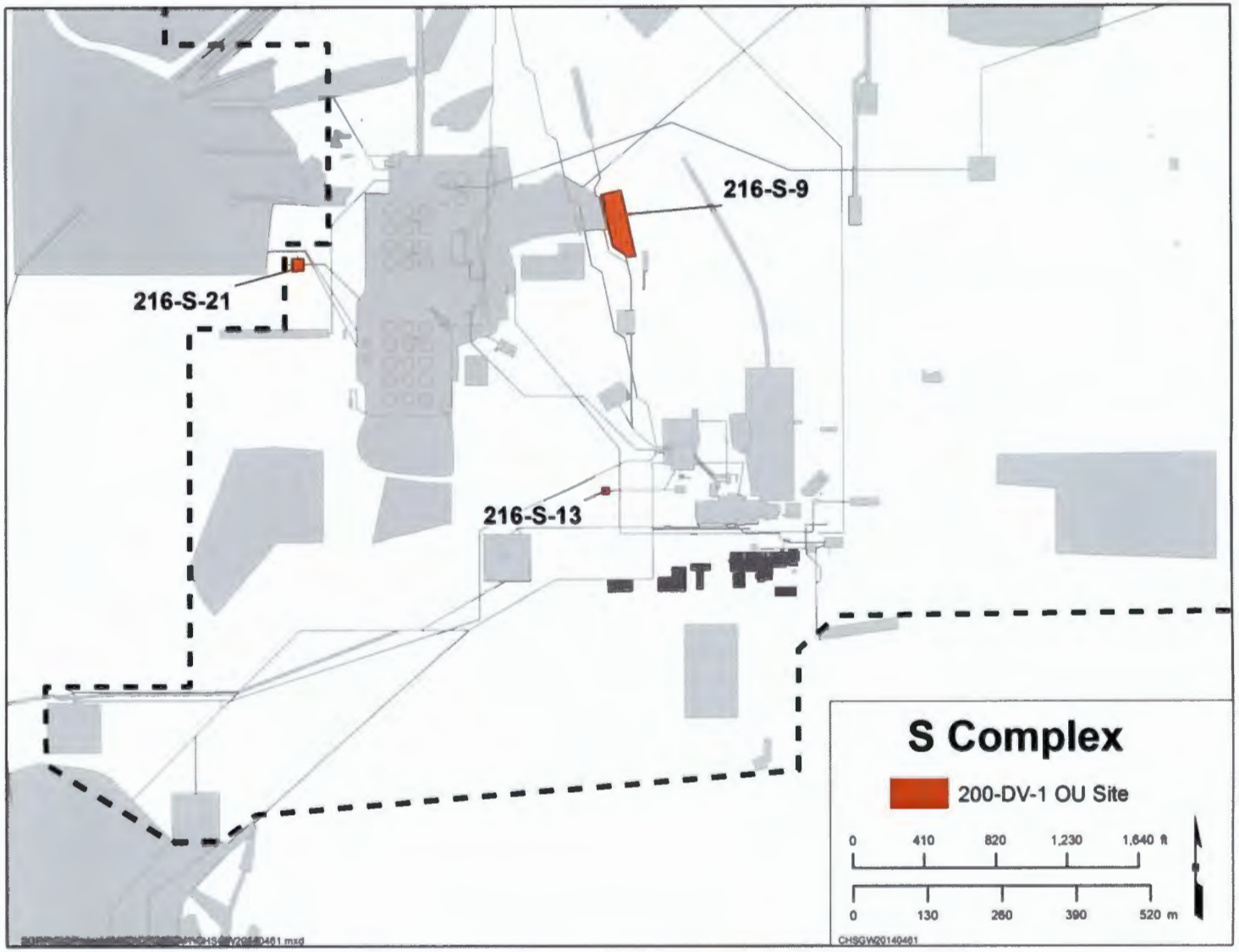


Figure 3-56. Location of 200-DV-1 OU Waste Sites in the S Complex Area

- **216-S-13, consisting of 216-S-13 Crib:** The 216-S-13 Crib was used from 1952 to 1972 for disposal of 5 million L (1.3 million gal) of liquid waste from the 203-S Decontaminated Metal Storage Facility, the 204-S UNH Lag Storage Facility, and the 276-S Organic Solvent (methyl isobutyl ketone) Make-Up Facility. Geophysical logging data is available for the one borehole near the 216-S-13 waste site. Based on the waste site construction dimensions, contamination is not anticipated in the upper 4.6 m (15 ft); gamma-emitting contaminants were not detected in this zone by geophysical logging of the nearest well, 15 m (49 ft) from the center of the crib. The available data suggest that contaminants from the 216-S-13 waste site are unlikely to have reached groundwater in the past and are unlikely to contaminate groundwater in the future. Additional data collection is planned to confirm/refine this CSM.

3.10 Preliminary Risk Assessment

The purposes of a BRA are 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 Clay, 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 general methodology for conducting the BRA is described in the following sections.

3.10.1 Human Health Risk Assessment Approach

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

3.10.1.1 Definition of Human Exposure Scenario

Human health risks in the Inner Area will be assessed using an industrial worker exposure scenario. The basis for the industrial worker scenario will be drawn from EPA's Regional Screening Level guidance (EPA, 2014a, *Regional Screening Levels for Chemical Contaminants at Superfund Sites*) for chemicals, and from EPA's Radionuclide PRG guidance (EPA, 2014b, *Preliminary Remediation Goals for Radionuclides*) for radionuclides. Key assumptions are as follows:

- Exposure pathways selected for the industrial worker scenario are based on the assumption that direct contact exposure is potentially complete to contaminants in soil.
  - Exposure pathways for chemicals include soil ingestion, inhalation of dust and volatiles, and dermal contact with soil.

- Exposure pathways for radionuclides include soil ingestion, inhalation of dust, and direct (external) exposure.

- Exposure point concentrations (EPCs) for soil will include the standard point of compliance (i.e., 4.6 m [15 ft]) based on the 2007 MTCA and may include a conditional point of compliance proposed by DOE in the FS/CMS.

The exposure parameters for the industrial scenario for radionuclides and nonradionuclides are described in Table 3-24.

3.10.1.2 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. The basis for action for chemicals is one in 100,000 cancer risk or a hazard index of one for noncancer hazards based on 2007 MTCA Method C. Ecological risk and groundwater protection will also be considered to establish a basis for action.

3.10.1.3 Identification of Contaminants of Potential Concern

For protection of human health (direct contact), a COPC is defined as 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, and 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 3-25.

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: (1) radionuclides with a half-life of less than 3 years; (2) essential trace elements; (3) soil physical property measurements; and (4) 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.

Table 3-24. Summary of Industrial Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Nonradiological	
			Value	Source	Value	Source
Excess lifetime cancer risk	Risk	unit-less	Analyte-specific	Calculated	Analyte-specific	Calculated
Hazard quotient	HQ	unit-less	N/A	N/A	Analyte-specific	Calculated
Chronic daily intake	CDI	mg/kg-day, pCi, mg/m^3, or $\mu g/m^3$	Analyte-specific	Calculated	Analyte-specific	Calculated
Soil concentration	Cs	mg/kg or pCi/g	Analyte-specific	Measured value	Analyte-specific	Measured value
Averaging time – carcinogens	ATc	days	N/A	—	25,550	Default; EPA/540/1-89/002
Averaging time - noncarcinogens	ATnc	days	N/A	—	9,125	Default; EPA/540/1-89/002
Body weight – adult	BW_a	kg	80	Clay, 2011 (OSWER Directive 9355.0-30), Table 8-2	80	EPA, 2011, Table 8-2
Exposure frequency	EF_{IW}	days/year	250	Default; Clay, 1991 (OSWER Directive 9355.0-30)	250	Default; Clay, 1991 (OSWER Directive 9355.0-30)
Exposure duration	ED_{IW}	year	25	Default; Clay, 1991 (OSWER Directive 9355.0-30)	25	Default; Clay, 1991 (OSWER Directive 9355.0-30)
Soil ingestion rate	IRS_{IW}	mg/day	50	Default; Clay, 1991 (OSWER Directive 9355.0-30)	50	Default; Clay, 1991 (OSWER Directive 9355.0-30)
Unit correction factor 1	CF1	g/mg	0.001	Calculated	N/A	N/A
Unit correction factor 2	CF2	kg/mg	N/A	N/A	0.000001	Calculated

Table 3-24. Summary of Industrial Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Nonradiological	
			Value	Source	Value	Source
Unit correction factor 3	CF3	year/day	0.00274	Calculated	N/A	N/A
Unit correction factor 4	CF4	g/kg	1,000	Calculated	N/A	N/A
Unit correction factor 5	CF5	day/hour	N/A	N/A	0.0417	Calculated
Unit correction factor	CF6	µg/mg	N/A	N/A	1,000	Calculated
Area correction factor	ACF	unit-less	Isotope-specific	Eckerman, 2007	N/A	N/A
Indoor exposure time	ET_{IW-i}	unit-less	0.171	Site-specific[a]	N/A	N/A
Outdoor exposure time	ET_{IW-o}	unit-less	0.056	Site-specific[b]	N/A	N/A
Gamma shielding factor	GSF	unit-less	0.4	EPA, 2000	N/A	N/A
Dermal absorption fraction	ABSd	unit-less	N/A	N/A	Analyte-specific	EPA, 2004
Worker skin surface area	SA_{IW}	cm^2	N/A	N/A	3,470	EPA, 2011, Table 7-2
Worker soil adherence factor	AF_{IW}	mg/cm^2-day	N/A	N/A	0.12	EPA, 2011, Table 7-20
Gastrointestinal absorption factor	ABSGI	unit-less	N/A	N/A	Analyte-specific	EPA/540/R/99/005
Inhalation rate – adult	INHa	m^3/day	20	Default; OSWER Directive 9285.6-03	N/A	N/A
Worker air exposure time	ET_{IW-a}	hours/day	N/A	N/A	8	Stalcup, 2015 (OSWER Directive 9200.1-120)
Particulate emission factor	PEF	m^3/kg	7.30E+10	EPA, 2002	7.30E+10	OSWER 9355.4-24
Volatilization factor	VF	m^3/kg	N/A	N/A	Analyte-specific	EPA[c]
Carcinogenic slope factor for soil ingestion	SFsi	Risk/pCi	Analyte-specific	EPA, 2001	N/A	N/A
Carcinogenic slope factor for external exposure	SFx	Risk/pCi	Analyte-specific	EPA, 2001	N/A	N/A

Table 3-24. Summary of Industrial Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Nonradiological	
			Value	Source	Value	Source
Carcinogenic slope factor for inhalation	SFinh	Risk/pCi	Analyte-specific	EPA, 2001	N/A	N/A
Oral carcinogenic slope factor	SFo	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	Analyte-specific	EPA[c]
Oral reference dose	RfDo	(mg/kg-day)	N/A	N/A	Analyte-specific	EPA[c]
Unit risk factor	IUR	$(\mu g/m^3)^{-1}$	N/A	N/A	Analyte-specific	EPA[c]
Reference concentration	RfC	mg/m^3	N/A	N/A	Analyte-specific	EPA[c]
Decay constant	λ	unit-less	0.693	EPA, 2000	N/A	N/A
Time	t	years	25	Default; OSWER Directive 9285.6-03	N/A	N/A

Sources:

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

Clay, 1991, "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30).

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

EPA, 2001, *Health Effects Assessment Summary Tables database, "April 16, 2001 Update: Radionuclide Toxicity."*

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

EPA, 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*, EPA/540/R/99/005 (OSWER 9285.7-02EP).

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.*

Stalcup, 2014, "Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors" (OSWER Directive 9200.1-120).

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

a. Based on 6 hr/d × 250 day/yr (1,500 hr/yr)/(8,760 hr/yr)$^{-1}$.

b. Based on 2 hr/d × 250 day/yr (500 hr/yr)/(8,760 hr/yr)$^{-1}$.

c. Values will be obtained from the sources described in Section 3.10.1.5.

EPA = U.S. Environmental Protection Agency

HQ = hazard quotient

N/A = not applicable

Table 3-25. 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, Rev. 0
Cobalt-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12, Rev. 0
Europium-154	RAD	pCi/g	0.033	0.079	DOE/RL-96-12, Rev. 0
Europium-155	RAD	pCi/g	0.054	0.098	DOE/RL-96-12, Rev. 0
Gross beta	RAD	pCi/g	23	25	DOE/RL-96-12, Rev. 0
Plutonium-238	RAD	pCi/g	0.0038	0.019	DOE/RL-96-12, Rev. 0
Plutonium-239/240	RAD	pCi/g	0.025	0.033	DOE/RL-96-12, Rev. 0
Radium-228	RAD	pCi/g	1.8	2.3	DOE/RL-96-12, Rev. 0
Strontium-90	RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Thorium-228	RAD	pCi/g	1.4	1.6	DOE/RL-96-12, Rev. 0
Total beta radiostrontium	RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Naturally Occurring Radionuclides					
Potassium-40	RAD	pCi/g	17	20	DOE/RL-96-12, Rev. 0
Radium-226	RAD	pCi/g	0.82	1.2	DOE/RL-96-12, Rev. 0
Thorium-232	RAD	pCi/g	1.3	1.6	DOE/RL-96-12, Rev. 0
Uranium-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-235	RAD	pCi/g	0.11	0.39	DOE/RL-96-12, Rev. 0
Uranium-238	RAD	pCi/g	1.1	1.2	DOE/RL-96-12, Rev. 0
Metals					
Aluminum	METAL	mg/kg	11,800	28,800	DOE/RL-92-24, Vol. 1, Rev. 4
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, Rev. 4
Barium	METAL	mg/kg	132	480	DOE/RL-92-24, Vol. 1, Rev. 4
Beryllium	METAL	mg/kg	1.51	10	DOE/RL-92-24, Vol. 1, Rev. 4
Boron	METAL	mg/kg	3.89	5.86	ECF-HANFORD-11-0038
Cadmium	METAL	mg/kg	0.563	2.98	ECF-HANFORD-11-0038

Table 3-25. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Calcium	METAL	mg/kg	17,200	105,000	DOE/RL-92-24, Vol. 1, Rev. 4
Chromium	METAL	mg/kg	18.5	320	DOE/RL-92-24, Vol. 1, Rev. 4
Cobalt	METAL	mg/kg	15.7	110	DOE/RL-92-24, Vol. 1, Rev. 4
Copper	METAL	mg/kg	22	61	DOE/RL-92-24, Vol. 1, Rev. 4
Iron	METAL	mg/kg	32,600	68,100	DOE/RL-92-24, Vol. 1, Rev. 4
Lead	METAL	mg/kg	10.2	74.1	DOE/RL-92-24, Vol. 1, Rev. 4
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, Rev. 4
Manganese	METAL	mg/kg	512	1,110	DOE/RL-92-24, Vol. 1, Rev. 4
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, Rev. 4
Potassium	METAL	mg/kg	2,150	7,900	DOE/RL-92-24, Vol. 1, Rev. 4
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, Rev. 4
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, Rev. 4
Zinc	METAL	mg/kg	67.8	366	DOE/RL-92-24, Vol. 1, Rev. 4
Ammonia	ANIONS	mg/kg	9.23	26.4	DOE/RL-92-24, Vol. 1, Rev. 4
Chloride	ANIONS	mg/kg	100	1,480	DOE/RL-92-24, Vol. 1, Rev. 4
Fluoride	ANIONS	mg/kg	2.81	73.3	DOE/RL-92-24, Vol. 1, Rev. 4
Nitrate	ANIONS	mg/kg	52	906	DOE/RL-92-24, Vol. 1, Rev. 4
Phosphate	ANIONS	mg/kg	0.785	225	DOE/RL-92-24, Vol. 1, Rev. 4
Sulfate	ANIONS	mg/kg	237	12,600	DOE/RL-92-24, Vol. 1, Rev. 4

Table 3-25. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value

Sources:

DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*.

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

ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

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

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.

3.10.1.4 Exposure Assessment

The exposure assessment will address (1) methods for developing EPCs in soil, (2) methods for calculating concentrations in air from EPCs in soil using EPA's screening models, and (3) 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 (up to a depth of 4.6 m [15 ft]). 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. Soil samples obtained from soil borings will include only those sample intervals up to a depth of 4.6 m (15 ft).

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-07/038, 2010, *ProUCL Version 4.00.05 User Guide (Draft)*—if all recommended methods to calculate the UCL provide a value that exceeds the maximum concentration, then the maximum concentration in an exposure area will be used as the EPC. The flow chart 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 volatile organic compounds (when appropriate) will be calculated in accordance with EPA guidance (OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*).

3.10.1.5 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 subsections.

Toxicity Values for Nonradionuclides

For nonradionuclides, the analyte-specific toxicity values are determined using the recommended reference hierarchy as described in Cook, 2003, *Human Health Toxicity Values in Superfund Risk Assessments* (OSWER Directive 9285.7-53). The hierarchy is the same as used in the baseline risk assessments for the River Corridor OUs and is summarized below.

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

Tier 1 – IRIS. The preferred source of toxicity data is the EPA *Integrated Risk Information System (IRIS)* database (EPA, 2014c). Expert toxicologists at EPA have derived the values in this database, and the values have undergone thorough review and validation both within and outside of the 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 – PPRTVs. 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 not available to the general public, but is accessible to EPA risk assessors via the EPA intranet. These values are also published at the EPA Regional Screening Levels website (EPA, 2014a). 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 (OEHHA, 2014) 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.
- Toxicity values in EPA 540-R-97-036, *Health Effects Assessment Summary Tables (HEAST), FY 1997 Update*.

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 are used. These values can be found in the Risk Assessment Information System (ORNL, 2014).

Toxicity Values for Radionuclides

The cancer slope factors for radionuclides will be obtained from EPA, 2001, *Health Effects Assessment Summary Tables database, "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.

3.10.1.6 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 identifies the COPCs that are risk drivers.

3.10.1.7 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.

3.10.1.8 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 3.10.1.1, as well as the toxicity values identified in Section 3.10.1.5. The EPA PRG calculator[13] will be used to obtain the radionuclides PRGs. 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. Table 3-24 provides the exposure parameters that will be used. PRGs corresponding to a 10^{-4} acceptable cancer risk level that will be used for radionuclides. The methodology used to calculate soil PRGs for radionuclides is consistent with the methodology used for the baseline risk assessments 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 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 3.10.1.5. The PRGs will be developed based on a 10^{-5} acceptable cancer risk level or a noncancer hazard quotient of 1. MTCA 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.

3.10.2 Ecological Risk Assessment Approach

The ecological risk assessment (ERA) approach will follow EPA guidance and the terrestrial ecological evaluation procedures developed by Ecology (MTCA). The ERAs will include, as appropriate, explanations of how the methodology conforms to guidance and requirements identified in MTCA. The ERA approach is the same as that used in the baseline risk assessments in the River Corridor OUs.

3.10.2.1 Identification of Contaminants of Potential Concern

COPCs will be identified using the same process developed for the HHRA (Section 3.10.1.3) but will consider ecological pathways and screening levels.

3.10.2.2 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*. Although not specifically referred to as a CSM, these same elements are also part of the simplified terrestrial ecological evaluation procedures (WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures") and site-specific terrestrial ecological evaluation procedures under MTCA. 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

[13] EPA's PRG calculator is available online at http://epa-prgs.ornl.gov/radionuclides/.

(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*).

3.10.2.3 Evaluation of Biointrusion

The ERA 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 point of compliance for soil depth is proposed, both the standard point of compliance and the alternative point of compliance will be presented as remedial action alternatives in the FSs (and CMSs, as applicable).

3.10.2.4 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 ERAs in the River Corridor OUs. Estimation of EPCs in soil will use the same data and parallel the methods as presented for the HHRA.

3.10.2.5 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 Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site*, and CHPRC-00784.

3.10.2.6 Risk Characterization

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

- 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 (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, characterization of lateral extent of contamination)
- Data quality (presence of qualifiers, adequacy of detection limits)
- Frequency that risk based thresholds are exceeded and the location(s) of those exceedances
- Chemical-specific properties of each COC (potential to biomagnify, persistence)

- Ecological receptors specific details
- Feeding guild that is affected (plants, insects, or omnivorous, herbivorous, insectivorous, 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 PRG
- Evaluation of PRG (level of confidence, basis, relation to other PRGs such as those for human health or groundwater protection)

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

3.10.2.7 Methods for Calculating Ecological Cleanup Levels

PRGs have been developed for individual feeding guilds (for birds and mammals) and for plants and invertebrates. The 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).

The PRGs for radionuclides are developed using the methods presented in DOE's graded approach document (DOE/RL-2011-50), using as a protective threshold a dose limit of 0.1 rad/d for birds and mammals and 1.0 rad/d for plants and invertebrates.

3.10.3 Contaminant Fate and Transport

The evaluation of groundwater protection will be based on the graded approach document (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 also 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 the graded approach document 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-DV-1 OU), 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/yr 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/yr. 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/yr.

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 cross walk for waste sites applicable across the Central Plateau will be developed. This crosswalk will follow the structure documented in 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 the *Washington Administrative Code* requirements are met.

3.10.3.1 Basis for Calculation of Screening Levels and Preliminary Remediation Goals

The evaluation of groundwater protection approach 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 impact groundwater above pre-defined levels. Consistent with the graded approach document (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 SSLs calculation, these soil concentrations would not impact groundwater concentrations above the lowest value from the following:

- 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 impact groundwater concentrations above the lowest value from the following:

- The federal and state maximum contaminant level values, where available
- EPA screening levels for radionuclides for which no maximum contaminant level is available; groundwater cleanup level is calculated using the tap water scenario at an individual target risk level of 1×10^{-4}
- MTCA Method B cleanup level for groundwater based on carcinogenic effects calculated at target risk level of 1×10^{-6}, as applicable
- MTCA Method B cleanup level for groundwater based on noncarcinogenic effects calculated at a hazard quotient value of 1, as applicable

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

An alternative can be developed in the FS (and CMS, as applicable) that considers an alternative point of compliance 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 the Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391). The following considerations will be defined for this evaluation:

- The alternative point of compliance 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 3-57. This proposed boundary encompasses all of 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.

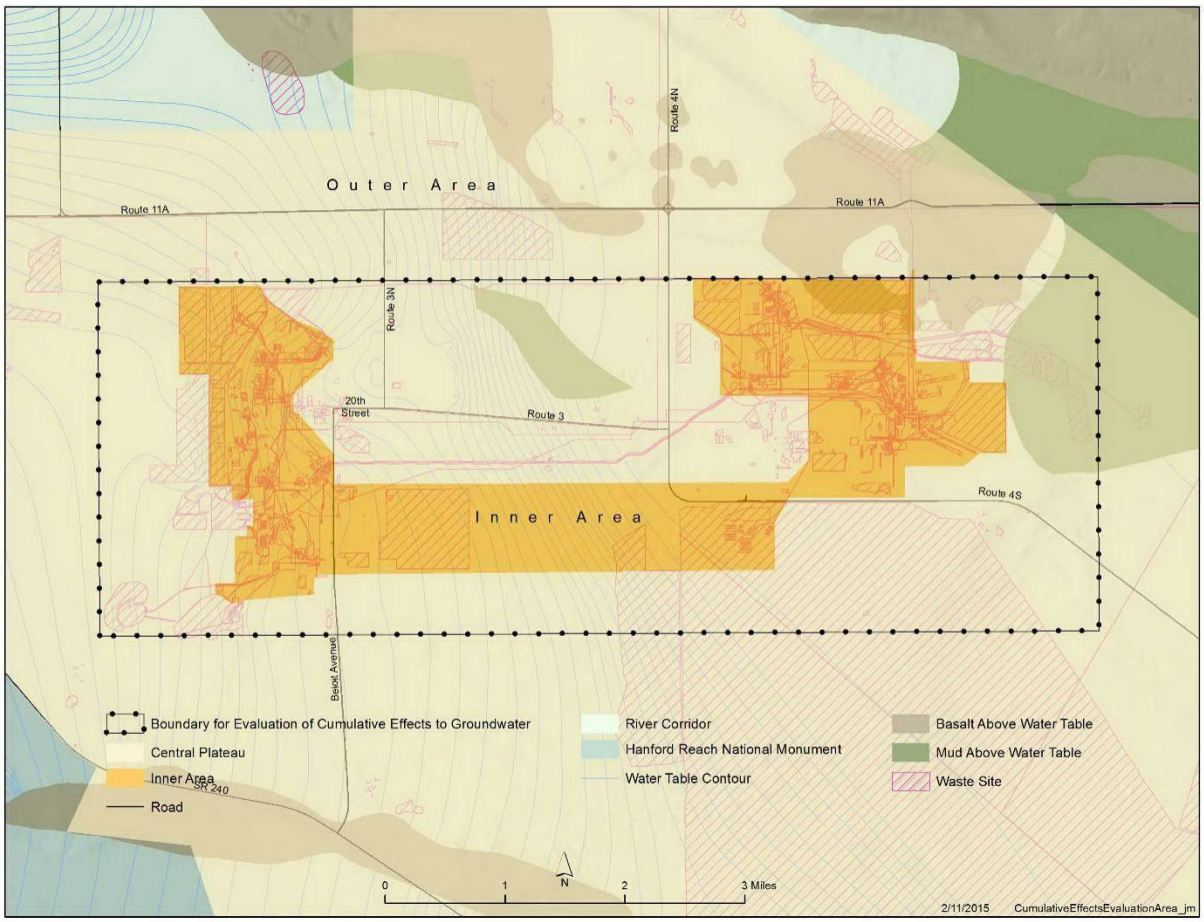


Figure 3-57. Boundary Proposed for the Evaluation of Alternative Point of Compliance for Groundwater Protection

- Inventory estimates for waste sites will include measurements for surface soils and the vadose zone, as well as the following sources:

- **Liquid disposal sites:** SIM mean values (PNNL-16940, *Hanford Soil Inventory Model (SIM) Rev. 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 farms 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*, which will be updated to reflect the current decisions and response actions that have already been implemented 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 Tri-Party Agreement (Ecology et al., 1989a) document. 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 remedial investigation 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, Chg. 1, *Radioactive Waste Management*) will reference the same application document, evaluate any necessary changes and demonstrate the performance metrics required under this DOE order.

3.11 Preliminary Remedial Action Objectives

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

The RAOs listed below 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.

3.12 Preliminary Remediation Goals

For human health direct contract, the PRGs will be developed as described in Section 3.10.1.8. Ecological PRGs are described in Section 3.10.2.7. For groundwater protection, development of PRGs will be based on the process defined in DOE's graded approach document (DOE/RL-2011-50). Section 3.10.3 provides the implementation details for this approach.

3.13 Preliminary Remedial Technologies and Treatability Studies

Potentially applicable remedial technologies were identified and screened in 2011 to develop a list of promising technologies for further evaluation during the RI/FS and RFI/CMS activities. This screening was performed in accordance with EPA/540/R-92/071a, *Guide for Conducting Treatability Studies under CERCLA Final*. This early screening of technologies for the 200-DV-1 OU provides an opportunity to identify promising remediation technologies that require further treatability testing to determine potential feasibility, or those that are mature enough to be carried forward and evaluated during the FS. Appendix E describes the technology screening process and results. Additional details on the technology screening and the evaluation process are provided in SGW-50339, *Remediation Technologies Screening Report for the Deep Vadose Zone, Hanford's Central Plateau*.

The results of this technology screening will help aid in the planning and implementation of possible treatability testing associated with the RI/RFI field activities for the DVZ contamination. The results of the 2011 technology screening and evaluation will be reviewed and updated, as needed, based on recent technology evaluations by the AFRI for the DVZ and on recent treatability test results (e.g., pore water extraction), as a task under this work plan (Section 5.3).

4 Remedial Investigation/RCRA Facility Investigation and Feasibility Study/Corrective Measures Study Data Needs

This chapter presents the data needs based on the initial evaluations described in Chapter 3 (Sections 3.2, 3.3, 3.4, and 3.13). The field and analytical tasks necessary to fulfill the identified data needs are presented in Chapter 5.

The initial assessment of data needs occurred in 2011 through the DQO process (Appendix C). The characterization activities designed to fill the data needs identified in the 2011 DQO process are described in the SAP (DOE/RL-2011-104). This chapter of the work plan describes these data needs and examines additional data needs associated with meeting the work plan objectives and supporting the FS/CMS. If during the RI/FS and RFI/CMS process additional data needs are identified to support development of remedial alternatives, then a supplemental DQO and SAP will be developed.

4.1 Strategy for Defining Data Needs

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

- **Decision stage:** Data are collected during the RI/RFI and FS/CMS to support the following actions:
  - Identify contaminant sources.
  - Evaluate the nature and extent of contaminants in environmental media.
  - Evaluate potential risks to HHE.
  - Determine the need for action through the BRA.
  - Support remedy treatability testing and the development and evaluation of remedial action alternatives to mitigate unacceptable risks.
  - Support establishing performance metrics for vadose zone remedies (e.g., defining the extent and time frame for reduction in recharge or contaminant flux that will meet groundwater remediation goals) that will support remedy alternative development.
- **Remedial design stage:** Additional field data may be collected to support remedial design. For example, additional data may be collected to refine quantification of natural attenuation, to refine targets for remedy actions in order to obtain performance goals, or to evaluate appropriate sequencing of remedy elements as for an adaptive approach.
- **Remedy implementation stage:** Additional confirmation or verification data may be obtained to support remedy implementation, transition between stages of a remedy, and/or remedy optimization. Data collection and monitoring during remedy implementation may be progressive and tied to the stages of remediation. Monitoring implementation builds on the conceptual model established during the decision and remedial design stages and can be tailored to focus on diagnostic elements of the hydrologic and contaminant system as remediation progresses from initial implementation and performance assessments toward longer term management.
- **Remedy completion stage:** Data may be collected during this stage 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 available data to determine data needs. Information concerning the nature and extent of contamination at waste sites was assessed to determine whether sufficient data exist to evaluate risks and consequently develop an appropriate remedial decision. Based on the data collected during the RI/RFI, a treatability test may be conducted for a 200-DV-1 OU contaminant mitigation technology.

4.2 Data Quality Objectives Evaluation

The Tri-Parties conducted a supplemental DQO evaluation in 2005 and 2006 to review all process and characterization data available for the Central Plateau waste sites and to identify residual data needs. The elements of the supplemental DQO were integrated into the supplement work plan (DOE/RL-2007-02), which was issued in 2007. The supplemental work plan included a SAP for the collection of additional data at those waste sites for which existing data were determined to be insufficient for decision-making purposes.

In early 2011, DOE and Ecology met with Hanford Site technical experts for a series of facilitated DQO sessions. These sessions reviewed the current state of knowledge for the 200-DV-1 OU sites and developed principal study questions (PSQs), decision statements (DSs), alternative actions, and other data objectives and requirements. The data needs were then determined on a site-by-site basis to address the PSQs. The sampling and analysis recommendations in the existing Central Plateau supplemental work plan (DOE/RL-2007-02) were then modified as needed to address the 200-DV-1 OU data needs. Through this process, a final set of data requirements was derived. The 200-DV-1 OU data needs and the results of the completed DQO process for the 200-DV-1 OU waste sites are provided in Appendix C of this work plan. This DQO was used to develop the agency-approved SAP (DOE/RL-2011-104).

4.3 Data Needs for 200-DV-1 Operable Unit Waste Sites

A summary of the data needs for the 200-DV-1 OU waste sites is presented in Table 4-1. The data needs are based on the outcome of the DQO evaluation (Appendix C). The data needs presented in this chapter represent specific data gaps with respect to the CSM for each site (or site group) and primarily focus on establishing nature and extent of contaminants in support of the PSQs. The data also provide baseline data that will be needed to support an assessment of the groundwater potential exposure pathway (PSQ 2). However, the method of assessing impact to groundwater may require some additional information as part of fully addressing PSQ 2. Initial efforts under the work plan will include defining the assessment approach, anticipated to include estimating the temporal profile of contaminant flux to groundwater and linking this assessment to potential exposure path and compliance considerations.

4.4 Data Needs for 200-DV-1 Operable Unit Perched Water

A summary of the data needs for the 200-DV-1 OU perched water wells installed in 2014 is presented in Table 4-2.

Table 4-1. Summary of Data Needs for the 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Data Need	Rationale
B Complex Area		
216-B-5 Reverse Well	None	Sufficient data are available.
216-B-7A&B Cribs	Vertical distribution of contaminants between the 216-B-7A and 216-B-7B Cribs on the east side	Based on geophysical logging, the thickest zone of cesium-137 is east of 216-B-7A (Well 299-E33-58). The 200-DV-1 OU characterization is needed to refine the estimates of the extent of contamination based on existing data and geophysical logging. The new data will be used to confirm the CSM that the 216-B-7-A&B Cribs have contaminated groundwater in the past and that the cribs are currently a source for fluoride and hexavalent chromium found in the deep vadose zone Cold Creek unit.
216-B-8 Crib and Tile Field/ 200-E-45 HI shaft	Vertical distribution of contaminants between the 216-B-8 Crib and the HI shaft	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys. The new data will be used to confirm the CSM that the 216-B-8 site contaminated groundwater in the past and is currently a continuing source of hexavalent chromium, sodium, and likely nitrate to groundwater. The contaminant inventory does not include the inadvertent discharge of sludge to 216-B-8; this data need will be filled using existing data.
216-B-9 Crib and Tile Field	Vertical distribution of contaminants near Well 299-E28-57 and near Well 299-E28-53	Well 299-E28-57 is the location of the deepest contamination recognized on any of the scintillation probe profiles, and Well 299-E28-53 is corroded and may have provided a preferential pathway. The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging. The new data will be used to confirm the CSM that contaminants from the 216-B-9 site are unlikely to have reached groundwater in the past and are unlikely to reach groundwater in the future.
216-B-11A&B French Drains	None	Sufficient data are available.

Table 4-1. Summary of Data Needs for the 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Data Need	Rationale
BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42)	Vertical distribution of technetium-99 at the 216-B-42 Trench Vertical distribution of contaminants at the 216-B-37 Trench	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys and on sediment sampling from Borehole C3104, which was drilled through the 216-B-38 Trench in 2001. Drilling at 216-B-42 Trench, which received a higher inventory of technetium-99 than the other BX Trenches, will ensure that the vertical extent of the technetium-99 contamination in the subsurface at this location is characterized. Characterization of the 216-B-37 Trench, which received the largest disposal volume of all the BX Trenches, will be used to confirm the CSM that contaminants from the BX Trenches have not reached groundwater and are not a likely source of future groundwater contamination.
BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)	Vertical distribution of mobile contaminants at the 216-B-46 Crib Extent of mobile contaminants northeast of the 216-B-46 Crib Vertical distribution of mobile contaminants in the center of the BY Cribs Vertical distribution of mobile contaminants northwest of the 216-B-50 Crib	The 200-DV-1 OU characterization is needed to refine the estimates of the lateral and vertical extents of contamination based on existing geophysical logging, resistivity surveys, and sediment sampling from boreholes drilled through the BY Cribs in 1991 and 1992 and near the BY Cribs in 2008. • The 216-B-46 Crib has the highest technetium-99 and hexavalent chromium inventory of the BY Cribs. The soil resistivity survey indicates that the highest conductive region is in the vicinity of this crib, and the highest technetium-99 concentrations in groundwater are in the vicinity of this crib. Deep analytical data are not available for this area. • The soil resistivity survey indicates that the highest conductive region is in the vicinity of the 216-B-46 Crib, and the highest technetium-99 concentrations in groundwater are in the vicinity of this crib. • The center of the BY Cribs (near both the 216-B-46 and the 216-B-49 Cribs) is anticipated to have the highest concentrations based on the likely co-mingling of discharged wastes; the 216-B-46 and 216-B-49 Cribs received the highest discharge inventories. • Borehole gamma logging at Well 299-E33-40 northwest of the BY Cribs indicates mobile contaminants from approximately 100 to 200 ft bgs. The new data will be used to confirm the CSM that the BY Cribs have contaminated groundwater in the past and that the deep vadose zone below the BY Cribs is currently contributing technetium-99, cyanide, nitrate, and perhaps cobalt-60 to the groundwater.

Table 4-1. Summary of Data Needs for the 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Data Need	Rationale
216-B-57 Crib	None	Sufficient data are available.
T Complex Area		
216-T-3 Reverse Well	Vertical distribution of contaminants at the 216-T-3 Reverse Well	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing data, geophysical logging, and resistivity surveys. The new data will be used to confirm the CSM that the 216-T-3 reverse Well likely impacted groundwater in the past and may contribute nitrate and/or hexavalent chromium to groundwater in the future.
216-T-5 Trench	Vertical distribution of contaminants at the north and south ends of the 216-T-5 Trench	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys. The new data will be used to confirm the CSM that contaminant breakthrough to the groundwater from the 216-T-5 Trench did not occur. Both ends of the trench were selected to reduce uncertainty regarding the location of the discharge point.
216-T-6 Crib	Vertical distribution of contaminants at the 216-T-6 Crib	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing data, geophysical logging, and resistivity surveys. The new data will be used to confirm the CSM that the 216-T-6 Crib likely impacted groundwater in the past and may contribute nitrate and/or hexavalent chromium to groundwater in the future.
216-T-7 Tile Field	Vertical distribution of contaminants near the 216-T-7 Tile Field central distribution pipe and as close to the influent end of the tile field as possible without entering WMA T	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing data, geophysical logging, and resistivity surveys. The new data will be used to confirm that CSM that co-mingled wastes in the vadose zone from the 216-T-32 and 216-T-7/200-W-52 waste sites impacted groundwater in the past, are currently contributing to the groundwater plume below the T Trenches to the east, and may be continuing sources of technetium-99, hexavalent chromium, uranium, and nitrate in the future.

Table 4-1. Summary of Data Needs for the 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Data Need	Rationale
T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)	Vertical distribution of contaminants at the 216-T-14 Crib Vertical distribution of contaminants at the 216-T-15 Crib	The 216-T-14 Trench received the highest pore volume liquid because it has a shorter length than the other three T Trenches. Among the four T Trenches, the 216-T-15 Trench received the largest volume of waste liquid and the largest inventory of contaminants. The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys. The new data will be used to confirm the CSM that contaminants from the T Trenches are unlikely to have reached groundwater in the past and are unlikely to reach groundwater in the future.
216-T-18 Crib	Vertical distribution of plutonium near the center of the 216-T-18 Crib	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys and to supplement previous geophysical logging of drive points with samples for laboratory analysis. The new data will be used to confirm the CSM that contaminant breakthrough to the groundwater from the 216-T-18 Crib may have occurred in the past but is unlikely in the future.
216-T-19 Crib and Tile Field	Vertical distribution of contaminants at the location of the point of discharge to the 216-T-19 Tile Field	The highest volume of waste was discharged at the influent end of the tile field. The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys. The new data will be used to confirm the CSM that the 216-T-19 Crib and Tile Field likely was a source of mobile contaminants, especially tritium, to groundwater in the past but that it does not appear to be a likely contributor to groundwater currently or in the future.

Table 4-1. Summary of Data Needs for the 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Data Need	Rationale
TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)	Vertical distribution of contaminants at the 216-T-23 Trench Vertical distribution of contaminants at the 216-T-25 Trench	The deepest gamma-emitting contamination based on geophysical logging results was detected at the 216-T-23 Trench. Of the five TX Trenches, the 216-T-25 Trench received the largest volume and inventory. The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys. The new data will be used to confirm the CSM that contaminants from the T Trenches are unlikely to have reached groundwater in the past and are unlikely to reach groundwater in the future.
216-T-26 Crib	None	Sufficient data are available.
216-T-32 Crib	None	Sufficient data are available.
S Complex Area		
216-S-9 Crib	Vertical distribution of contaminants near the influent end of the crib and near the leak of contaminated liquid waste discovered in 1969	The 200-DV-1 OU characterization is needed to refine the estimates of the vertical extent of contamination based on existing geophysical logging and resistivity surveys. The new data will be used to confirm the CSM that the 216-S-9 Crib likely impacted groundwater in the past and may be contributing iodine-129 to groundwater currently and in the future. In 2013, Well 299-W22-95 was drilled at the northern end of the 216-S-9 Crib in support of groundwater remediation. The geophysical logging of the well in July 2013 is expected to provide additional characterization data.
216-S-13 Crib	Vertical distribution of contaminants near influent side of 216-S-13 Crib and evaluation of uncertainty regarding total and hexavalent chromium inventory	The 200-DV-1 OU characterization is needed to refine the estimate of the vertical extent of contamination based on existing geophysical logging and to evaluate uncertainty regarding the total and hexavalent chromium inventory. The new data will be used to confirm the CSM that contaminants from the 216-S-13 waste site are unlikely to have reached groundwater in the past and are unlikely to contaminate groundwater in the future. In 2011, Well 299-W22-92 was drilled at the northern end of the 216-S-13 Crib in support of groundwater remediation. The geophysical logging of the well in April 2011 is expected to provide additional characterization data.*

Table 4-1. Summary of Data Needs for the 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Data Need	Rationale
216-S-21 Crib	Vertical distribution of contaminants near influent side of 216-S-21 Crib	The 200-DV-1 OU characterization is needed to refine the estimate of the vertical extent of contamination based on existing geophysical logging. The new data will be used to confirm the CSM that contaminants from the 216-S-21 waste site may have reached groundwater in the past but are unlikely to be a future source of contamination.

* Geophysical logging conducted during 2011 at Well 299-W22-92 has been completed and indicates no manmade contamination within the borehole. The data were not available for inclusion at the time the CSM was completed for this work plan but will be included when the CSM is updated following collection of the characterization data described in this work plan.

Sources:

DOE/RL-91-60, *S Plant Aggregate Area Management Study Report.*

DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units, Volume 1: Work Plan and Appendices.*

RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

bgs = below ground surface

CSM = conceptual site model

OU = operable unit

WMA = waste management area

Table 4-2. Data Needs for the 200-DV-1 OU Perched Water Wells

Well	200-DV-1 OU Data Need	Rationale
C8914 (299-E33-350)	Vertical distribution of contaminants in vadose zone and perched water zone; and local stratigraphy	The vertical profiles will improve understanding of the sources of contamination in the perched water. The local stratigraphy will improve understanding of the configuration of the perched zone.
C8915 (299-E33-351)	Vertical distribution of contaminants in vadose zone and perched water zone; and local stratigraphy	The vertical profiles will improve understanding of the sources of contamination in the perched water. The local stratigraphy will improve understanding of the configuration of the perched zone.

OU = operable unit

4.5 Data Needs for Deep Vadose Zone Science and Technology Development Supporting Remedy Selection

Significant advances have been made recently under programs funded through DOE-EM, RL, ORP, and CHPRC, including the technology development and application conducted as part of 200-DV-1 OU treatability testing, the DVZ Treatability Test Program, the AFRI for the DVZ, and Advanced Simulation Capability for Environmental Management. These programs were initiated to (1) address limitations associated with existing approaches for characterizing and monitoring the DVZ, (2) address the need for improved approaches to quantify contaminant fate and transport and impacts to groundwater, and (3) provide additional remedy technology options and improved information about these options. This 200-DV-1 OU work plan approach recognizes that there will be continued efforts related to DVZ science and technology that need to be integrated with work plan activities as part of developing the foundation for the FS. This section describes the data needs associated with applying DVZ science and technology to enhance implementation of work plan activities and provide improved information for subsequent remedy evaluation and selection in the FS.

Additional data needs to integrate improved science and technology into work plan activities are associated with (1) evaluating improved characterization approaches; (2) enabling the effective evaluation of emerging candidate DVZ remediation technologies in the FS; (3) improving modeling with respect to DVZ technology evaluation, selection, and implementation; and (4) identifying and evaluating improved long-term monitoring approaches and tools. These data needs are discussed in the following subsections.

A DVZ technical forum, held in July 2010 to kick off the AFRI for the DVZ, identified research and technology development categories. The forum included broad participation from a variety of organizations, including the public; interest groups; the HAB; state agencies; DOE; and representatives from the Tribal Nations, Hanford Site contractors, national laboratories, universities, and regulatory agencies. The four categories developed at the forum included controlling processes, remedial design, predictive modeling and data integration, and monitoring (DOE/RL-2010-89), which are discussed in the following subsections. An information exchange for DVZ remediation technologies was held in June 2011 as part of the 200-DV-1 OU technology screening and provided candidate technologies for consideration with respect to data needs discussed in this section.

4.5.1 Characterization

Characterization includes the use of standard techniques associated with borehole sampling and analysis, geologic logging, and geophysical logging. To support evaluation of contaminant behavior, characterization results need to be incorporated into a CSM.

Current and recent science and technology efforts are focused on providing enhanced characterization relevant to developing improved conceptual models that provide a context for estimating the temporal profile of contaminant flux to groundwater and linking this assessment to exposure path and compliance considerations. The goal of these efforts is to enable more effective identification of the features and processes that control contaminant discharge from the vadose zone to the groundwater. This information, in turn, supports more effective predictive assessment of impact to groundwater and selection of appropriate remedies. Targeted enhancements included (1) extending characterization beyond boreholes (e.g., through geophysics and tracers); (2) performing sample analyses linked to key fate and transport elements (e.g., sequential uranium extractions, biogeochemical indicators); and (3) using in situ monitoring applied as a characterization tool and as a link to subsequent remediation and monitoring efforts (e.g., in situ sensors, geophysical assessment tools). For the 200-DV-1 OU, data needs include field testing of enhanced characterization tools in conjunction with planned characterization to provide a basis for evaluating the implementability, as well as data quality for these tools in relation to providing enhanced data in support of work plan objectives. It is anticipated that evaluating improved tools in early work plan tasks will enable their use in streamlining subsequent activities. Work plan implementation will include an assessment of candidate tools as part of planning for individual characterization (e.g., borehole) campaigns. The SAP will be appended as needed based on this assessment. Candidate tools include the following:

- Geophysical assessment tools
- Mass flux/mass discharge measurements
- Bioassessment characterization
- Biogeochemical surrogates and indicators
- Tracers
- Sequential extractions
- Sensors
- Perturbation characterization approaches

4.5.2 Remediation

The 2011 information exchange for DVZ remediation technologies addressed DVZ contamination in the Central Plateau, challenges associated with remediation, and technology evaluation and screening. For the 200-DV-1 OU, data needs include providing characterization data that support evaluation of candidate technologies with respect to applicability at the site being characterized, especially for those technologies scoring high in the technology screening effort. These data needs will be evaluated as part of planning for individual characterization (e.g., borehole) campaigns. The SAP will be appended, as needed, based on this assessment. The data needs also include treatability testing of a technology in addition to those tested under the DVZ Treatability Test Program (DOE/RL-2007-56), which were planned over 6 years ago, to account for new technology options that have arisen recently or that were not included as a detailed treatability test within the DVZ Treatability Test Program scope. This work plan approach anticipates that the DVZ Treatability Test Program will, at minimum, complete the ongoing desiccation field test and conduct a test for gas-phase treatment of uranium in the vadose zone as previously planned (DOE/RL-2007-56). The technology for treatability testing under the work plan will be selected based on a review of

candidates from the previous technology screening and from results of current DVZ technology development efforts (see Appendix B). Candidate treatability test technologies include the following:

- Gas-phase treatment for uranium
- Phosphate sequestration
- Infiltration control
- Pore water extraction
- Refined desiccation testing

4.5.3 Long-Term Monitoring

Similar to characterization tools, data needs associated with long-term monitoring for the 200-DV-1 OU include field testing of enhanced monitoring tools in conjunction with planned characterization to provide a basis for evaluating the implementability and data quality for these tools. Monitoring for the vadose zone and complex sites such as the Hanford Site is recognized as a challenge requiring development and testing of improved monitoring approaches (PNNL-21379, *Scientific Opportunities for Monitoring at Environmental Remediation Sites (SOMERS): Integrated Systems-Based Approaches to Monitoring*). Because monitoring will be an integral part of vadose zone remedies, information of the effectiveness and implementability of monitoring is needed for the FS and is therefore incorporated into this work plan. Testing and implementation of monitoring approaches are anticipated to improve the quality of data for remedy selection by providing a mechanism to (1) collect temporal data important to interpreting contaminant fate and transport, (2) establish baseline monitoring data from which remedy performance can be evaluated, and (3) establish field-scale information to evaluate integration of monitoring with remediation technology design. Work plan implementation will include an assessment of candidate tools as part of planning for individual characterization (e.g., borehole) campaigns. The SAP will be appended as needed based on this assessment. Candidate monitoring tools include the following:

- Surrogates and systems-based indicators
- Geophysical assessment tools
- Sensors
- Mass flux/mass discharge measurements
- Bioassessment monitoring
- Perturbation monitoring approaches

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5 Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Tasks

This chapter describes the 12 tasks that will be completed during the RI/FS and RFI/CMS process. These descriptions incorporate the RI/RFI 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 and RFI/CMS. Figure 5-1 illustrates the typical relationships among the CERCLA RI/FS tasks and the RCRA RFI/CMS tasks.

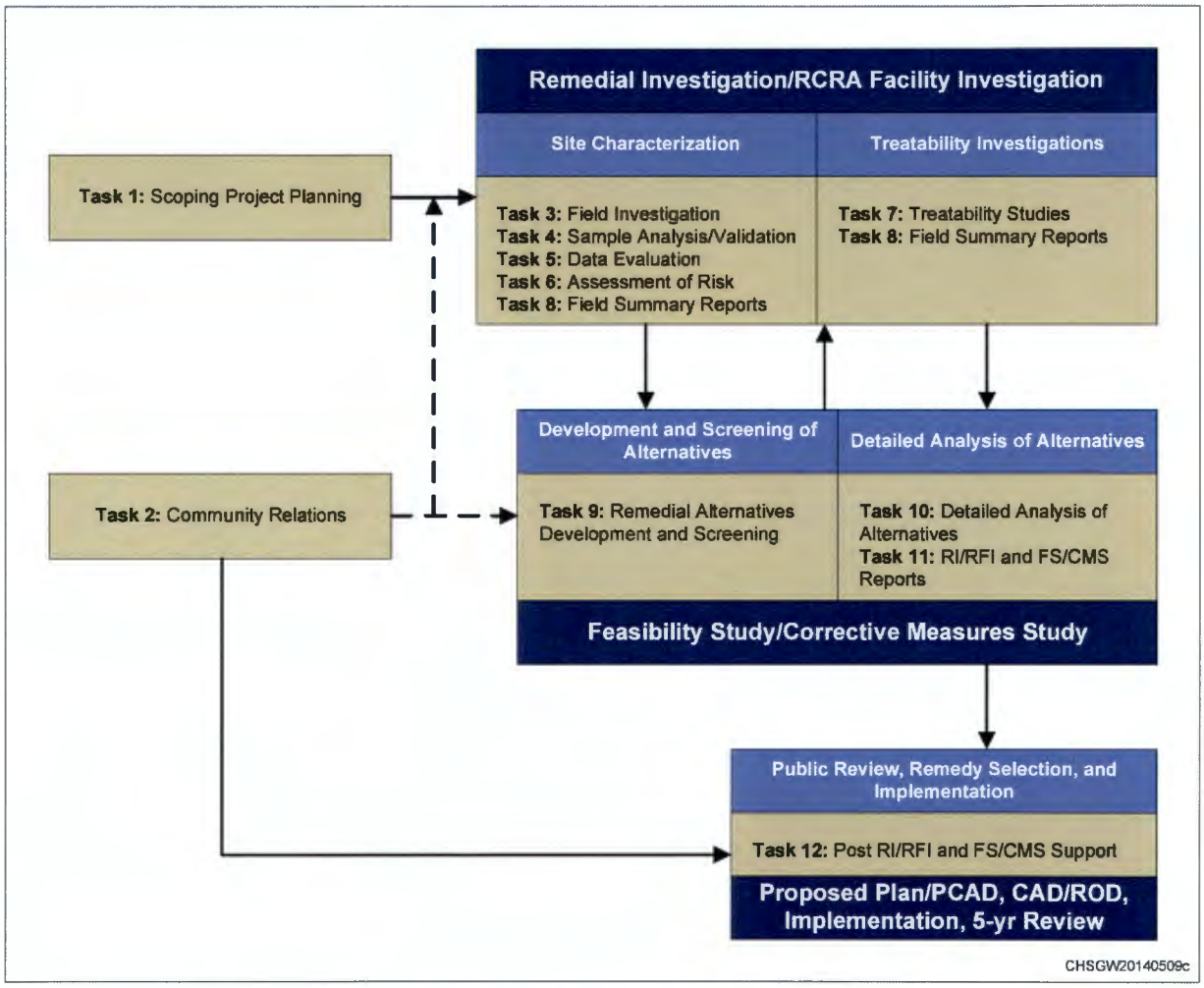

Figure 5-1. RCRA-CERCLA Tasks

5.1 Task 1 – Project Planning

Project planning for the 200-DV-1 OU RI/FS and RFI/CMS was initiated in 2010. A series of meetings was held with Ecology, EPA, RL, PNNL (AFRI for the DVZ), WRPS (Tank Farms Project), and CHPRC (200-DV-1 OU Project) to develop the expectations for the 200-DV-1 OU work plan and to facilitate integration of project needs and data (Table 5-1).

Table 5-1. 200-DV-1 OU Scoping Meetings Timeline

Session	Scope	Date
200-DV-1 OU Kick-Off	Kick-off meeting	08/24/2010
Scoping Meeting Session 1	200-DV-1 OU scope	11/15/2010
Scoping Meeting Session 2	200-DV-1 OU scope	12/07/2010
Scoping Meeting Session 3	200-DV-1 OU scope	01/13/2011
Scoping Meeting Session 4	Technology binning/tables	01/31/2011
Scoping Meeting Session 5	Waste site DQO approach	02/16/2011
Scoping Meeting Session 6	Technology screening	03/14/2011
Scoping Meeting Session 7	Waste site DQO kick-off	03/23/2011
Waste Site DQO	DQO initial discussions	03/28/2011
Waste Site DQO	B Complex data needs	05/10/2011
Waste Site DQO	B Complex comments	05/31/2011
Technology Screening	DVZ technologies public information exchange	06/07/2011
Waste Site DQO	T Complex data needs	06/14/2011
Waste Site DQO	B Complex comment responses	07/18/2011
Waste Site DQO	T Complex comments	07/18/2011
Waste Site DQO	S Complex data needs	07/27/2011
Waste Site DQO	BY Cribs strategy	07/27/2011
Waste Site DQO	BY Cribs conceptual site model	08/03/2011
Waste Site DQO	T Complex comment responses	08/16/2011
Technology Screening	Technology screening	08/16/2011
TOD Meeting	BY Cribs site visit	10/19/2011
TOD Presentation	BY Cribs characterization	01/18/2012
TOD Presentation	200-DV-1 OU sampling and analysis plan	03/21/2012

DQO = data quality objective
DVZ = deep vadose zone
OU = operable unit
TOD = Tribal Nations, Oregon State, U.S. Department of Energy, and Washington State Department of Ecology

The RI/FS and RFI/CMS activities for the 200-DV-1 OU will be integrated with those of the AFRI for the DVZ and the characterization and the remediation activities conducted on the Central Plateau for waste sites, tank farms, and groundwater.

Project planning activities for the 200-DV-1 OU have produced the following documents:

- CSM reports for the B Complex area (PNNL-19722), T Complex area (SGW-49924), and S Complex area (SGW-50280), which are the initial evaluations of existing data used in Chapter 3 of this work plan. Each CSM report contains hydrogeologic descriptions for each area; background information summarizing waste disposal history, waste site dimensions, estimated waste constituent inventory, and results of previous investigations; CSMs for vadose zone contaminant distributions and potential sources of groundwater contamination; hydrologic properties of the sedimentary layers; and preliminary evaluations of the potential for future groundwater impacts.
- The DQO summary report for 200-DV-1 OU waste sites (Appendix C of this work plan), which was developed to identify data needs described in Chapter 4 of this work plan.
- This RI/FS and RFI/CMS work plan, which identifies the scope and objectives of the planned work.
- Two SAPs (DOE/RL-2011-104; DOE/RL-2013-52) that describe the collection of required measurements and observations to fill data needs identified in Chapter 4 of this work plan. Each SAP consists of a field sampling plan and a quality assurance project plan (QAPjP) that provide specific details of data collection.
- A list of promising technologies, based on identification and screening of potentially applicable remedial technologies, for further evaluation during the RI/FS and RFI/CMS activities (SGW-50339 and Appendix E of this work plan).
- A project schedule that defines project activity sequences and identifies delivery of enforceable milestone documents (Chapter 6 of this work plan).

5.2 Task 2 – Community Relations

A public involvement plan (Ecology 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 (Ecology 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 RL Public Involvement Manager.

5.2.1 Tribal Nations Involvement

Interactions between the Tribal Nations and DOE are usually facilitated through the RL Tribal Program Manager or the RL Cultural Resources Manager. 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, *DOE 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*. 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, RL and ORP briefings will be held on groundwater and vadose zone issues for the Tribal Nations. 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 (Ecology 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 Investigations and Analytical Tasks

Field investigations and analytical tasks will be conducted for the 200-DV-1 OU RI/FS and RFI/CMS to supplement existing data. The field investigations and data analysis activities will address the data needs defined in Chapter 4. The data needs were identified through the DQO process that was completed for the 200-DV-1 OU waste sites (Section 4.2 and Appendix C).

The scope of the field investigations are described in two SAPs associated with this work plan. Each SAP provides the QAPjP and the field sampling plan for the characterization activities.

The sampling activities for the 200-DV-1 OU waste sites are summarized in Table 5-2, and additional details are provided in the 200-DV-1 OU characterization SAP (DOE/RL-2011-104). The SAP describes the types of analyses to be performed; the samples to be analyzed; and the precision, accuracy, representativeness, completeness, and comparability parameters to be used in order to obtain a sufficient representation of conditions at the site. The BY Cribs in the B Complex area are anticipated to be the focus of the initial characterization activities.

Table 5-2. Summary of Vadose Zone Sampling Activities for 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Characterization	Rationale
B Complex Area		
216-B-5 Reverse Well	Characterization adequate	Previous investigation drilled and sampled boreholes at the 216-B-5 Reverse Well (RHO-ST-37).
216-B-7A&B Cribs	One direct-push borehole to refusal, with sampling for contaminants	Use sample results to confirm the conceptual model that the vadose zone between approximately 15 m (50 ft) bgs and the CCU is relatively uncontaminated, as shown by the existing data from Borehole C3103 at 216-B-7A.
216-B-8 Crib and Tile Field/ 200-E-45 Health Instruments Shaft	One direct-push borehole to refusal, with sampling for contaminants.	Evaluate vertical distribution of contaminants.
216-B-9 Crib and Tile Field	Two direct-push boreholes to refusal, with sampling for contaminants	Evaluate vertical distribution of contaminants.
216-B-11A&B French Drains	Characterization adequate	The 216-B-11A&B French Drains are not considered a current or future source of significant contamination to groundwater (PNNL-19277, p. 3.82).
BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42)	One drilled borehole to groundwater with split-spoon samples at the 216-B-42 Trench One direct-push borehole to refusal at the 216-B-37 Trench, with sampling for contaminants	Drilling at the 216-B-42 Trench will ensure that the vertical extent of the technetium-99 contamination in the subsurface at this location is characterized. Use sample results from the 216-B-37 Trench to confirm the conceptual model, which is based on the C3104 borehole at the 216-B-38 Trench, that contaminants have not reached groundwater.
BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)	Phase I: 4 direct push boreholes to refusal, with sampling for contaminants. Evaluate extent of existing surface geophysical data Phase II: target characterization, depending on the results from Phase I	Cost effectively characterize the BY Cribs area during Phase I to better understand the distribution of mobile contamination and moisture. Additional boreholes, if needed, would be used to evaluate the vertical extent of mobile contamination in key locations identified by the Phase I results.
216-B-57 Crib	Characterization adequate	Previous investigation drilled and sampled boreholes at 216-B-57 (DOE/RL-92-70). Prototype Hanford barrier constructed over the 216-B-57 Crib.

Table 5-2. Summary of Vadose Zone Sampling Activities for 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Characterization	Rationale
T Complex Area		
216-T-3 Reverse Well	One drilled borehole to groundwater, with sampling for contaminants	Evaluate vertical distribution of contaminants.
216-T-5 Trench	Three direct-push boreholes to refusal, with geophysical logging at two and sampling for contaminants at one	Evaluate vertical distribution of contaminants.
216-T-6 Crib	Three direct-push boreholes to refusal, with geophysical logging at two and sampling for contaminants at one	Evaluate vertical distribution of contaminants.
216-T-7 Tile Field	One drilled borehole to groundwater, with sampling for contaminants	Evaluate vertical distribution of contaminants.
T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)	Three direct-push boreholes to refusal, with geophysical logging at two and sampling for contaminants at one	Evaluate vertical distribution of contaminants.
216-T-18 Crib	One direct-push borehole to refusal, with sampling for contaminants	Supplement previous geophysical logging of drive points with samples for laboratory analysis.
216-T-19 Crib and Tile Field	One drilled borehole to groundwater, with sampling for contaminants	Evaluate vertical distribution of contaminants.
TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)	Three direct-push boreholes to refusal, with geophysical logging at two and sampling for contaminants at one	Evaluate vertical distribution of contaminants.
216-T-26 Crib	Characterization adequate	Previous remedial investigation drilled and sampled borehole (C3102) at the 216-T-26 Crib.
216-T-32 Crib	Characterization adequate	Existing boreholes show no contamination below the CCU.
S Complex Area		
216-S-9 Crib	One direct-push borehole, with sampling for contaminants	Evaluate vertical distribution of contaminants.
216-S-13 Crib	One drilled borehole to groundwater, with sampling for contaminants	Evaluate vertical distribution of contaminants and evaluate uncertainty regarding total and hexavalent chromium inventory.

Table 5-2. Summary of Vadose Zone Sampling Activities for 200-DV-1 OU Waste Sites

Waste Site/Group	200-DV-1 OU Characterization	Rationale
216-S-21 Crib	One direct-push borehole to refusal, with sampling for contaminants.	Evaluate vertical distribution of contaminants.

Note: This table is based on Table 3-1 from DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

Sources:

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

PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex.*

RHO-ST-37, *216-B-5 Reverse Well Characterization Study.*

bgs = below ground surface
CCU = Cold Creek unit
OU = operable unit
WMA = waste management area

The sampling activities for the 200-DV-1 OU perched water wells are summarized in Table 5-3. The details are provided in the SAP for perched water Wells C8914 and C8915 (DOE/RL-2013-52). The sampling and analysis activities described in DOE/RL-2013-52 were completed in FY 2014.

Table 5-3. Summary of Vadose Zone and Perched Water Sampling Activities for the 200-DV-1 OU Perched Water Wells

Well	200-DV-1 OU Characterization	Rationale
C8914 (299-E33-350)	One drilled borehole to perched water, with sampling for contaminants	Evaluate vertical distribution of contaminants in vadose zone and perched water zone; improve knowledge of local stratigraphy.
C8915 (299-E33-351)	One drilled borehole to perched water, with sampling for contaminants	Evaluate vertical distribution of contaminants in vadose zone and perched water zone improve knowledge of local stratigraphy.

OU = operable unit

The sampling activities presented in Table 5-2 are designed to fill specific data gaps with respect to the CSM for each site (or site group). An initial work plan task will be the development of an approach for establishing the nature and extent of contamination and estimating the temporal profile of contaminant flux to groundwater.

The tables of potential remediation technologies for DVZ contamination provided in Appendix E of this work plan were developed in 2011 during the initial preparation of this work plan. The list of technologies will be reviewed and updated based on recent technology evaluations by the AFRI for the DVZ and on recent treatability test results (e.g., pore water extraction).

5.4 Task 4 – Sample Analysis/Validation

The SAPs for the 200-DV-1 OU (DOE/RL-2011-104; DOE/RL-2013-52) identify 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 QAPjPs in the SAPs.

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 and RFI/CMS planning phase have been achieved. Data validation will be based on EPA functional guidelines, and 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 level of data validation is specified in the QAPjPs in the SAPs. The QAPjP in DOE/RL-2011-104 states that Level C validation will be performed on at least 5 percent of the data by matrix and analyte group. The QAPjP in DOE/RL-2013-52 states that Level C data validation will be performed on at least 5 percent of the perched water data for each 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 data quality assessment 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 SAPs for the 200-DV-1 OU will be evaluated, reduced, and presented in tabular and graphic format for subsequent use in the risk assessment, the fate and transport evaluation, and the FS/CMS, and for preparation of RI/RFI and FS/CMS reports. The results of the measurement data review and validation presented in the data quality assessment 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 preliminary CSMs 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 SAPs for the 200-DV-1 OU and by other projects, as applicable. For each waste site or group of waste sites, a data summary will be prepared describing information that will be used to evaluate site risk, assess potential threats to groundwater, and develop and evaluate remedial alternatives. The results of the evaluation will be reported in the RI/RFI report.

5.6 Task 6 – Assessment of Risk

The BRA will be conducted as part of the RI/RFI 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 3.10. Cleanup levels (i.e., PRGs) will also be developed as part of this task, as described in Section 3.12.

Additional characterization could be needed for the shallow vadose zone in order to provide quantitative risk characterization for the top 3 or 4.6 m (10 or 15 ft) of the vadose zone.

5.7 Task 7 – Treatability Studies

Treatability studies for DVZ remediation 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.

An initial list of potential technologies for DVZ remediation is provided in Appendix E. This list of potential technologies will be updated as an early task under this work plan (Section 5.3). Following the characterization of waste sites in each area (B Complex area, T Complex area, and S Complex area), the updated list of candidate technologies will be evaluated to identify potential technology/technologies that could enhance future remediation efforts. A decision will be made at that time whether to conduct a treatability test to support remedy selection.

The 200-DV-1 OU treatability studies for waste sites will consider the context of existing programs and activities. The DVZ treatability test plan for the Central Plateau (DOE/RL-2007-56) defined a program of technology testing and evaluation for the DVZ (Appendix B). DOE/RL-2007-56 identified soil desiccation and gas-phase remediation technologies as the highest priority for development and testing at the field scale. The Hanford prototype barrier was constructed over the 216-B-57 waste site, which is now in the 200-DV-1 OU, in 1994 as a treatability test (DOE/RL-93-27, *Treatability Test Plan for the 200-BP-1 Prototype Surface Barrier*). Monitoring of the barrier has continued since 1994. A comprehensive report to summarize the performance of the Hanford prototype barrier is in progress as part of the AFRI for the DVZ (Appendix B).

5.8 Task 8 – Field Summary Reports

As the field investigations and treatability studies are completed, field summary reports will be prepared for each waste site or group of waste sites to summarize the activities performed and the information collected in the field. The reports will 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 geophysical logging results. The field reports support the preparation of the RI/RFI report and the FS/CMS report.

5.9 Task 9 – Remedial Alternatives Development and Screening

Potentially applicable remedial technologies were identified and screened in 2011 to develop a list of promising technologies for further evaluation during the 200-DV-1 OU RI/FS and RFI/CMS activities (Section 3.14). This screening was performed in accordance with EPA's guidance for conducting treatability studies under CERCLA (EPA/540/R-92/071a). The technologies were grouped into four general response action categories to aid in the pre-screening process (Appendix E): (1) containment, (2) removal, (3) ex situ treatment and disposal, and (4) in situ treatment. The 2011 technology screening and evaluation will be reviewed and updated as needed as a task under this work plan (Section 5.3). This early screening of technologies for the 200-DV-1 OU provides an opportunity to identify promising remediation technologies that require further treatability testing to determine potential feasibility or those that are mature enough to be carried forward and evaluated during the FS/CMS.

The goal and objectives for the technology pre-screening conducted during the RI/FS and RFI/CMS scoping stage differ from the goal and objectives used for the selection of remedial alternatives conducted during the FS/CMS. In the FS/CMS, technology screening is conducted to narrow down the number of viable technologies from which remedial alternatives are assembled and evaluated with respect to their effectiveness, implementability, and cost. In contrast, technology screening conducted during the initial RI/FS and RFI/CMS scoping is focused primarily on identifying potentially applicable technologies that may require further evaluation through treatability studies and/or additional data searches. Technologies that have been demonstrated or proven as viable in remediating DVZ contamination and do not require

additional evaluation or testing during RI/RFI activities will be carried forward to the FS/CMS (SGW-50339).

The screening and formulation of initial alternatives will be refined in the FS/CMS based on new data and emerging technologies that become available after preparation of this work plan

The screening is used to identify and distinguish any differences among the various alternatives and to evaluate each alternative for effectiveness, implementability, and cost. The result of this task is a refined list of remedial alternatives judged as the best or most promising based on these evaluation factors. The list is retained for a more detailed analysis (Section 5.10).

It is anticipated that the remedial alternatives development and screening for 200-DV-1 OU waste sites may differ among waste sites or groups of waste sites based on the contaminant of interest.

5.10 Task 10 – Detailed Analysis of Alternatives

During the detailed analysis, the alternatives that passed screening (Section 5.9) are further refined and analyzed. Alternatives will be developed in the FS/CMS that provide a range of options and sufficient information to adequately compare alternatives. For source control options, the following types of alternatives will be developed to the extent practicable (EPA/540/G-89/004):

- A number of treatment alternatives ranging from one that would eliminate or minimize, to the extent feasible, the need for long-term management (including monitoring) at a site to one that would use treatment as a primary component of an alternative to address the principal threats at the site. Alternatives within this range typically will differ in the type and extent of treatment used and the management requirements of treatment residuals or untreated wastes.
- One or more alternatives that involve containment of waste with little or no treatment but protect HHE by preventing potential exposure or reducing the mobility of contaminants.
- An alternative for no action.

The FS/CMS will provide more detailed explanations of each alternative.

The alternatives are analyzed in detail in the FS/CMS by applying the two threshold criteria and the five balancing criteria of the nine CERCLA evaluation criteria. Each alternative is evaluated, but the alternatives are not compared to each other. Each alternative must meet the two threshold criteria:

- Overall protection of HHE
- Compliance with ARAR

To satisfy RCRA corrective action technical requirements, the analysis of alternatives also must consider whether they attain media cleanup objectives and control the source of release (e.g., treating the principal threat).

The comparative analysis of alternatives that meet threshold criteria is based on the five balancing criteria:

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

RCRA corrective action also includes community acceptance and state involvement as "balancing criteria."

For waste sites in the 200-DV-1 OU, the detailed analysis of alternatives will include an evaluation of remedy effectiveness for groundwater protection using a fate and transport assessment based on the graded approach (DOE/RL-2011-50), site data, and the conceptual site models.

If alternatives evaluating conditional points of compliance are included in the FS/CMS, a disproportionate cost analysis may be included in this section to consider the value of risk reduction achieved for the potential additional actions associated with meeting the standard point of compliance. If determined to be appropriate for this OU, the methodology for application of a plug-in approach for remedial alternatives to waste sites identified in the future will be discussed.

5.11 Task 11 – Remedial Investigation/RCRA Field Investigation and Feasibility Study/Corrective Measures Study Reports

The final RI/RFI report presents the collection of data and evaluations that characterize waste site conditions, determines the nature and extent of contamination for each waste site, and assesses risk from each waste site to HHE and to ecological receptors. The field summary reports (Section 5.8) address these RI/RFI elements for individual field investigation activities and are discussed overall within the final RI/RFI report. The FS/CMS report presents the RAOs, the results of the remedial technology screening process, and the detailed evaluation of remedial alternatives. The results of treatability studies also are presented, if available. The RI/RFI report and FS/CMS report may be combined into one report.

The final RI/RFI and FS/CMS reports consider all information available at the time of report preparation, including information from activities conducted outside of this work plan. Key among those activities are the products of research being conducted under the AFRI for the DVZ, RCRA closure/treatment, storage, and disposal unit decisions for RCRA sites in the vicinity of 200-DV-1 OU waste sites, remedial decisions for CERCLA sites in the vicinity of 200-DV-1 OU waste sites, and updated CSMs and remedy decisions for the underlying groundwater OUs.

5.12 Task 12 – Post Remedial Investigation/RCRA Field Investigation and Feasibility Study/Corrective Measures Study Support

The 200-DV-1 OU RI/RFI and FS/CMS reports are subject to Ecology review and approval. Following this approval, the PP/PCAD will be prepared. The PP/PCAD is the primary subject of the public comment period. The RI/RFI report, FS/CMS report, PP/PCAD, and other final project deliverables are publically available in the Tri-Party Agreement (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 CAD/ROD contains the responsiveness summary reflecting all of the public comments received and the regulatory agencies' responses to each of the comments. Additional information concerning the PP/PCAD and the CAD/ROD is presented in the following sections.

5.12.1 Proposed Plan/Proposed Corrective Action Decision

The PP/PCAD is the mechanism by which the Tri-Parties present 200-DV-1 OU site information and the preferred remedy to the public for review. The document describes site background, the risks associated with each waste site, and the remedial alternatives evaluated in the RI/RFI and FS/CMS. The PP/PCAD includes the comparative analysis of the alternatives, in which the alternatives are compared to each other based on the threshold CERCLA/corrective action criteria and the balancing CERCLA criteria. Based on the results of the comparative analysis, the preferred remedial alternative is identified in the PP/PCAD.

The PP/PCAD provides the public with the opportunity to comment on the alternatives and to participate in selection of the final remedial alternative. Following public review and comment, a responsiveness summary is prepared that presents significant comments and new/relevant information received during the public comment process. The responsiveness summary is incorporated into the final CAD/ROD.

5.12.2 Record of Decision and Corrective Action Decision

Following final comments from the public and any final comments from supporting regulatory agencies, a remedy is selected and documented in a CAD/ROD. State acceptance and community acceptance are evaluated following the public comment period and are addressed in the CAD/ROD. The CAD/ROD documents the cleanup action 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*), consistent with EPA Corrective Action Guidance (EPA, 2014d).

- A legally enforceable document that certifies the remedy selection process was performed 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 that outlines the RAOs and cleanup levels for the selected remedy.
- A key communication tool for the public that explains the contamination problems that the remedy seeks to address and the rationale for its selection.
- The CAD documents the RCRA corrective action plan for each of the waste sites subject to corrective action. The CAD serves as the legally enforceable document for RCRA corrective action and is made through a modification of the Hanford Facility RCRA Permit.

5.12.3 Post-Record of Decision and Corrective Action Decision Activities

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

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

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

Modification to the CAD will follow the permit modification requirements in WAC 173-303-830, "Dangerous Waste Regulations," "Permit Changes."

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.

The schedule includes Tri-Party Agreement (Ecology et al., 1989a) milestones, field activities, and due dates. Any revisions to the project schedule will be in accordance with Section 11.4 of the Tri-Party Agreement.

Preparation of the 200-DV-1 OU work plan was initiated in 2010. The Tri-Parties agreed in 2011 to delay completion of the work plan but to proceed with preparation of the 200-DV-1 OU SAP for characterizing waste sites (DOE/RL-2011-104). The 200-DV-1 OU SAP for drilling and characterizing two perched water wells has also been completed (DOE/RL-2013-52) prior to completion of the work plan.

Evaluation of the alternative point of compliance (discussed in Sections 1.3.2 and 5.6) requires the development of a supplemental shallow characterization SAP for 200-DV-1 OU waste sites. Draft A of this supplemental SAP will be developed by September 2015.

Table 6-1. Project Schedule for the 200-DV-1 Operable Unit

Activity	Period or Completion Date
DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*	January 2012
DOE/RL-2013-52, *Sampling and Analysis Plan for Perched Water Wells C8914 and C8915 in the 200-DV-1 Operable Unit*	January 2014
200-DV-1 OU perched water wells drilling and characterization	September 2014
DOE/RL-2013-37, *Engineering Evaluation/Cost Analysis for Perched Water Pumping/Pore Water Extraction*	January 2014
DOE/RL-2014-34, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*	December 2014
DOE/RL-2014-37, *Removal Action Work Plan for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*	August 2015 (planned)
200-DV-1 OU Waste Site Shallow Characterization Sampling and Analysis Plan, Draft A	September 2015 (planned)
DOE/RL-2011-102, Draft A, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-DV-1 Operable Unit*	March 2015 (planned)
Tri-Party Agreement Milestone M-015-110A (a)	March 31, 2015
200-DV-1 OU RI/FS and RFI/CMS work plan approval	6 months
200-DV-1 OU waste sites characterization	24 months after NTP
200-DV-1 OU waste sites characterization report	12 months after characterization completion

Table 6-1. Project Schedule for the 200-DV-1 Operable Unit

Activity	Period or Completion Date
Possible treatability test plan	12 months after characterization completion
Possible treatability test	18 months after treatability test plan approval
Possible treatability test report and post-test monitoring	12 months after treatability test completion
200-DV-1 OU Draft A RI/RFI report, Draft A FS/CMS report, and Draft A Proposed Plan/Proposed CAD submitted to Ecology	66 months after NTP*
TPA Milestone M-015-110B(b)**	September 30, 2015

* Schedule does not include the possible treatability test

** Tri-Party Agreement Milestone M-015-110B will require revision.

CAD = corrective action decision

Ecology = Washington State Department of Ecology

NTP = notice to proceed

OU = operable unit

RCRA = *Resource Conservation and Recovery Act of 1976*

RI/FS = remedial investigation/ feasibility study

RFI/CMS = RCRA facility investigation/corrective measures study

Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)

(a) Submit RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) & Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the 200-DV-1 OU to Ecology. The work plan shall include technology screening that identifies technologies applicable for characterization, treatment, and monitoring of deep vadose zone contaminants.

(b) Submit Corrective Measures Study & Feasibility Study Report and Proposed Plan/Proposed Corrective Action Decision for the 200-DV-1 OU to Ecology.

7 Project Management Considerations

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 the RI/FS and RFI/CMS. Problems are resolved at the lowest possible level, with higher levels of project oversight engaged to resolve the issues.

7.1 Project Organization

RL is responsible for cleanup on the Central Plateau. The RL contractor implements the cleanup for RL and is responsible for planning, coordinating, and executing the RI/FS and RFI/CMS activities. The lead regulatory agency (Ecology) 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-DV-1 OU.

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

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

The RL Contracting Officer is responsible for authorizing the Central Plateau remediation contractor to perform the RI/FS and RFI/CMS tasks for the 200-DV-1 OU.

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

7.1.2 Regulatory Agency Oversight Organization

Ecology is the lead regulatory agency for the 200-DV-1 OU. Ecology has assigned a project manager who is responsible for overseeing various RI/FS and RFI/CMS activities. The project manager is responsible for working with RL to resolve issues and approve the documents in accordance with Article XIV through Article XVI of the Tri-Party Agreement (Ecology et al., 1989a).

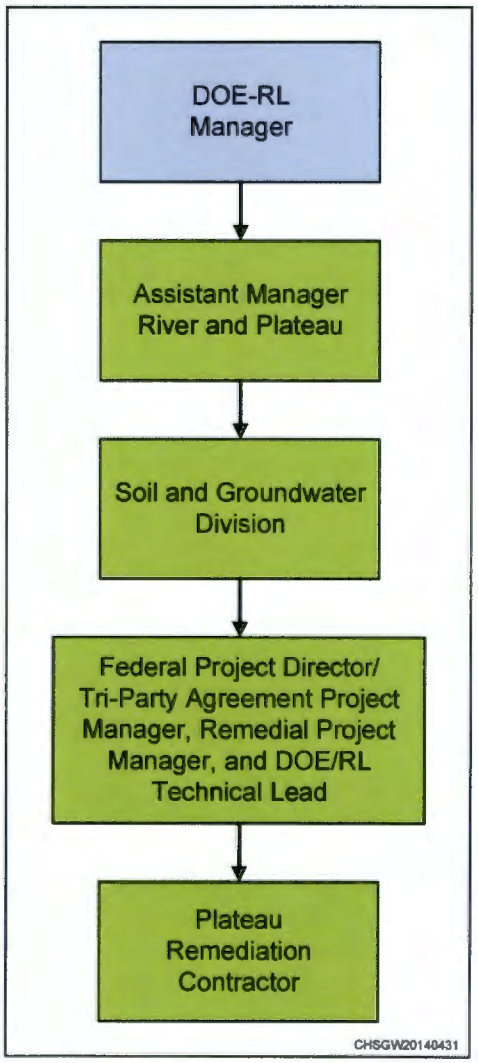

Figure 7-1. Project Organization for Cleanup of the 200-DV-1 OU

As a participating agency, EPA's regulatory responsibilities include providing assistance if requested by the lead regulatory agency (Ecology), approving the final

remedy, approving completion of construction, and proposing sites for deletion from the NPL (40 CFR 300, Appendix B).

7.1.3 Contractor Organization

The RI/FS and RFI/CMS activities are being conducted by CHPRC under DE-AC06-08RL14788, *CH2M HILL Plateau Remediation Company Plateau Remediation Contract*. CHPRC is responsible for integrating and executing the full scope of RI/FS and RFI/CMS activities on the Central Plateau.

7.1.4 Integration Teams

The RL/ORP Groundwater/Vadose Zone Executive Council was formed in 2006 to integrate Hanford Site groundwater, vadose zone, and risk assessment/modeling activities. The Executive Council may periodically charter integrated project teams on specific topics of interest as necessary to provide a forum for multiple projects and contractors with related activities to focus on day-to-day coordination issues and opportunities (e.g., field sampling, data communication, and data interpretation). There are no current integrated project teams for DVZ activities.

7.2 Project Coordination, Decision Making, and Documentation

Coordination among Ecology, EPA, the lead agency (DOE), and the contractors is essential for successful execution of the RI/FS and RFI/CMS. 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 200-DV-1 OU 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, depending on the nature of the change in accordance with Section 9.3 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*). Changes that affect the Tri-Party Agreement (Ecology et al., 1989a) are documented using change control forms in accordance with Section 12 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b). The class or level of the change (i.e., signatory, executive management, or project management) is noted and the description, justification, and impact of the change are documented.

Dispute resolution is handled in accordance with Article XVI of the Tri-Party Agreement (Ecology et al., 1989a). The Tri-Parties are to make reasonable attempts to resolve all disputes informally at the project manager level. Disputes that cannot be resolved informally are submitted in writing to, and resolved by, the Interagency Management Integration Team at the executive manager level. If resolution is not achieved at this level, the dispute is forwarded to higher levels of management. As a last resort, the dispute resolution process outlined in Article XXVI of the Tri-Party Agreement (Ecology et al., 1989a) is used. To promote dispute avoidance, potential problems will be identified early in the RI/FS and RFI/CMS process, and associated contingency/variance plans will be developed.

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Appendix A

History of Operable Unit Assignments for the Waste Sites in the 200-DV-1 Operable Unit

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A1 History of Operable Unit Assignments

In 1989, waste sites on the Central Plateau initially were grouped into 42 operable units (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 U.S. Department of Energy, Washington State Department of Ecology, and U.S. Environmental Protection Agency (also known as 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. During the process-based grouping, most of the waste sites now included in the 200-DV-1 OU were assigned to the 200-TW-1 Scavenged Tank Waste Group OU, the 200-TW-2 Tank Waste Group OU, or the 200-PW-5 Fission Product-Rich Process Waste Group OU. 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 OU and the 200-TW-2 OU. In 2010, waste sites in the 200-TW-1, 200-TW-2, and 200-PW-5 OUs were transferred to the new 200-DV-1 OU.

Table A-1 provides the history of OU assignments for the waste sites in the 200-DV-1 OU.

Table A-1. History of OU Assignments for Waste Sites in the 200-DV-1 OU

200-DV-1 OU Waste Site (2010 to present)	Process-Based OU (1997 to 2010)	Geographic-Based OU (1989 to 1997)
B Complex Area		
216-B-5	200-TW-2	200-BP-6
216-B-7A&B	200-TW-2	200-BP-4
216-B-8	200-TW-2	200-BP-4
216-B-9	200-TW-2	200-BP-6
216-B-11A&B	200-PW-5	200-BP-4
216-B-35	200-TW-2	200-BP-3
216-B-36	200-TW-2	200-BP-3
216-B-37	200-TW-2	200-BP-3
216-B-38	200-TW-2	200-BP-3
216-B-39	200-TW-2	200-BP-3
216-B-40	200-TW-2	200-BP-3
216-B-41	200-TW-2	200-BP-3
216-B-42	200-TW-1	200-BP-3
216-B-43	200-TW-1	200-BP-1
216-B-44	200-TW-1	200-BP-1
216-B-45	200-TW-1	200-BP-1
216-B-46	200-TW-1	200-BP-1
216-B-47	200-TW-1	200-BP-1

Table A-1. History of OU Assignments for Waste Sites in the 200-DV-1 OU

200-DV-1 OU Waste Site (2010 to present)	Process-Based OU (1997 to 2010)	Geographic-Based OU (1989 to 1997)
216-B-48	200-TW-1	200-BP-1
216-B-49	200-TW-1	200-BP-1
216-B-50	200-PW-5	200-BP-1
216-B-57	200-PW-5	200-BP-1
200-E-45	200-TW-2	Not applicable
T Complex Area		
216-T-3	200-TW-2	200-TP-4
216-T-5	200-TW-2	200-TP-1
216-T-6	200-TW-2	200-TP-3
216-T-7*	200-TW-2	200-TP-1
216-T-14	200-TW-2	200-TP-3
216-T-15	200-TW-2	200-TP-3
216-T-16	200-TW-2	200-TP-3
216-T-17	200-TW-2	200-TP-3
216-T-18	200-TW-1	200-TP-2
216-T-19	200-TW-1, 200-PW-1	200-TP-2
216-T-21	200-TW-2	200-TP-1
216-T-22	200-TW-2	200-TP-1
216-T-23	200-TW-2	200-TP-1
216-T-24	200-TW-2	200-TP-1
216-T-25	200-TW-2	200-TP-1
216-T-26	200-TW-1	200-TP-2
216-T-32	200-TW-2	200-TP-1
S Complex Area		
216-S-9	200-PW-5	200-RO-2
216-S-13	200-PW-5, 200-PW-3	200-RO-2
216-S-21	200-PW-5	200-RO-1

* The 216-T-7 Crib and Tile Field operated as one waste disposal system. They were administratively separated in 1997 because the crib is inside the T Tank Farm. At that time, the crib was assigned a separate Waste Information Data System database site code (200-W-52) and was assigned to Waste Management Area T. Because these two sites operated as one disposal system, the 200-W-52 Crib is included in discussions of the 216-T-7 Tile Field in this work plan.

OU = operable unit

A2 Reference

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Appendix B

Deep Vadose Zone Science and Technology Advances

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Contents

B1 Deep Vadose Zone Science and Technology Advances B-1

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Terms

CHPRC	CH2M HILL Plateau Remediation Company
DOE	U.S. Department of Energy
DVZ	deep vadose zone
ERT	electrical resistivity tomography
ORP	DOE Office of River Protection
OU	operable unit
PNNL	Pacific Northwest National Laboratory
RL	DOE Richland Operations Office
STOMP	Subsurface Transport Over Multiple Phases
WRPS	Washington River Protection Solutions

B1 Science and Technology Advances

This appendix summarizes specific elements of science and technology activities relevant to the 200-DV-1 Operable Unit (OU).

Published in 2008, DOE/RL-2007-56, *Deep Vadose Zone Treatability Test Plan for the Hanford Central Plateau*, defined a program of technology testing and evaluation for the deep vadose zone (DVZ). The following elements of the DVZ treatability test plan (DOE/RL-2007-56) have been completed:

- A DVZ ***remediation technology review***, which was included as part of the DVZ treatability test plan (DOE/RL-2007-56), identified soil desiccation and gas-phase remediation technologies as the highest priority for development and testing at the field scale. The review also identified efforts needed to evaluate (1) the role of surface infiltration barriers for DVZ contaminants, (2) soil flushing as an extraction technique, and (3) in situ grouting of vadose zone contaminants.
- A treatability test of ***desiccation*** was initiated on the Central Plateau, and the following elements of the test have been completed:
  - The following laboratory and modeling assessments of the desiccation process and design elements have been completed:
    - Oostrom et al., 2009, "Desiccation of Unsaturated Porous Media: Intermediate-Scale Experiments and Numerical Simulation"
    - Oostrom et al., 2011, "Determination of Water Saturation in Relatively Dry and Desiccated Porous Media Using Gas-Phase Partitioning Trace Tests"
    - Oostrom et al., 2012a, "Sensor and Numerical Simulator Evaluation by Porous Medium Desiccation and Rewetting at the Intermediate Laboratory Scale"
    - Oostrom et al., 2012b, "Effects of Porous Medium Heterogeneity on Vadose Zone Desiccation: Intermediate-Scale Laboratory Experiments and Simulations;"
    - PNNL-20146, *Laboratory and Modeling Evaluations in Support of Field Testing for Desiccation at the Hanford Site*
    - PNNL-17274, *Experimental and Numerical Investigations of Soil Desiccation for Vadose Zone Remediation: Report for Fiscal Year 2007*
    - PNNL-20507, *Pore-Water Extraction Intermediate-Scale Laboratory Experiments and Numerical Simulations*
    - Truex et al., 2012b, "Technical Basis for Gas-Phase Vadose Zone Remediation Technologies at Hanford: A Review – 12186"
  - The active portion of desiccation field testing has been completed, as described in the following publications:
    - PNNL-18800, *Characterization of Sediments from the Soil Desiccation Pilot Test (SDPT) Site in the BC Cribs and Trenches Area*
    - PNNL-21369, *Deep Vadose Zone Treatability Test for the Hanford Central Plateau: Soil Desiccation Pilot Test Results*

    - Truex et al., 2012a, "Field-Scale Assessment of Desiccation Implementation for Deep Vadose Zone Contaminants"
    - DOE/RL-2010-04, *Field Test Plan for the Soil Desiccation Pilot Test*
  - About 2 years of long-term performance monitoring of field testing have been completed (PNNL-22826, *Deep Vadose Zone Treatability Test for the Hanford Central Plateau: Interim Post-Desiccation Monitoring Results*).
  - Electrical resistivity tomography and ground-penetrating radar methods for remedy monitoring were tested as part of the desiccation field test (PNNL-21369; Truex et al., 2013, "Monitoring Vadose Zone Desiccation with Geophysical Models").
  - In situ sensors for remedy monitoring were tested as part of the desiccation field test (Oostrom et al., 2012a; PNNL-21369).
  - Numerical modeling using Subsurface Transport Over Multiple Phases (STOMP) code was applied for remedy design (PNNL-21369).
- A ***uranium sequestration laboratory investigation*** was conducted to evaluate candidate techniques, with continued development of ammonia vapor treatment as the most promising approach. Two reports and one journal article describing the laboratory results have been published (PNNL-18879, *Remediation of Uranium in the Hanford Vadose Zone Using Gas-Transported Reactants: Laboratory-Scale Experiments*; PNNL-20004, *Remediation of Uranium in the Hanford Vadose Zone Using Ammonia Gas: FY 2010 Laboratory-Scale Experiments*; Szecsody et al., 2012, "Geochemical and Geophysical Changes During NH3 Gas Treatment of Vadose Zone Sediments for Uranium Remediation").
- ***Uranium sequestration field test*** planning draft documents were prepared targeting a 216-U-8 Crib field test.
- A ***soil flushing assessment*** was completed, including a review of potential flushing solution formulations and modeling of the process relevant to application in the Central Plateau (PNNL-19938, *Evaluation of Soil Flushing for Applications to the Deep Vadose Zone in the Hanford Central Plateau*).
- An assessment of ***in situ grouting*** was completed, including a review of injectable grouting materials and techniques to estimate injection performance (PNNL-20051, *Evaluation of In Situ Grouting as a Potential Remediation Method for the Hanford Central Plateau Deep Vadose Zone*).
- A review of ***surface barrier applicability*** and data gaps for DVZ contaminants was conducted (PNNL-18661, *Technical Basis for Evaluating Surface Barriers to Protect Groundwater from Deep Vadose Zone Contamination*).
- In response to observations from the desiccation field testing, initial development and testing of two technologies (***pore water extraction*** using applied vacuum, and ***soil wicking*** using super absorbent polymers) that have the potential to extract contaminated water from the vadose zone have been initiated. Proof-of-principle evaluations were conducted by Pacific Northwest National Laboratory (PNNL) in collaboration with the U.S. Department of Energy (DOE), Richland Operations Office (RL); CH2M HILL Plateau Remediation Company (CHPRC); DOE Office of River Protection (ORP); and Washington River Protection Solutions (WRPS) (Oostrom et al., 2011; Oostrom et al., 2012c, "Vadose Zone Soil Moisture Wicking Using Super Absorbent Polymers").

The DVZ Applied Field Research Initiative has been jointly funded by RL and the DOE Office of Environmental Management, Office of Soil and Groundwater Remediation.

- A review of DVZ remediation was competed and published in the *Environmental Science and Technology* journal as a critical review article (PNNL-18114, *Remediation of Deep Vadose Zone Radionuclide and Metal Contamination: Status and Issues*; Dresel et al., 2011, "Review: Technical and Policy Challenges in Deep Vadose Zone Remediation of Metals and Radionuclides").

- The ***impact of disposed waste chemistry on the fate of uranium*** in the vadose zone was evaluated with important ramifications in assessing the potential future impact to groundwater (Szecsody et al., 2013, "Influence of Acidic and Alkaline Waste Solution Properties on Uranium Migration in Subsurface Sediments").

- A ***contaminant flux/natural attenuation-based remedy evaluation approach*** for the vadose zone was developed as a means to structure the assessment of vadose zone contamination to support remedy decisions for protection of groundwater (PNNL-21815, *Remedy Evaluation Framework for Inorganic, Non-Volatile Contaminants in the Vadose Zone*).

- An ***analysis of the B Complex perched water system*** was conducted to support the evaluation of future contaminant flux to groundwater and related monitoring approaches (PNNL-22499, *Perched-Water Evaluation for the Deep Vadose Zone Beneath the B, BX, and BY Tank Farms Area of the Hanford Site*; Oostrom et al., 2013, "Perched-Water Analysis Related to Deep Vadose Zone Contaminant Transport and Impact to Groundwater").

- ***Pore water extraction*** technologies were evaluated, and experiments and modeling were performed to support a WRPS-led field test at the SX Tank Farm in collaboration with ORP/WRPS (PNNL-21882, *Pore-Water Extraction Scale-Up Study for the SX Tank Farm*; Truex et al., 2013; PNNL-22662, *Field Test Design Simulations of Pore-Water Extraction for the SX Tank Farm*; and Oostrom et al., 2014, "Pore-Water Extraction from Unsaturated Porous Media: Intermediate-Scale Laboratory Experiments and Simulations"). The field test results will be documented by WRPS in fiscal year 2014.

- A ***technetium sequestration*** laboratory investigation was conducted to evaluate candidate techniques, with continued development of combined hydrogen sulfide and ammonia vapor treatment as the most promising approach (Szecsody et al., 2014, "Influence of Alkaline Co-Contaminants on Technetium Mobility in Vadose Zone Sediments"). This is the subject of continued efforts.

- ***Iodine speciation and biogeochemistry*** has been evaluated (SRNL-STI-2012-00592, *Laboratory report on iodine (^{129}I and ^{127}I) speciation, transformation and mobility in Hanford groundwater, suspended particles and sediments*; SRNL-STI-2012-00425, *Biogeochemical Considerations Related to the Remediation of ^{129}I Plumes*; Kaplan et al., 2014, "Radioiodine Biogeochemistry and Prevalence in Groundwater;" PNNL-18139, *The Geochemistry of Technetium: A Summary of the Behavior of an Artificial Element in the Natural Environment*; Icenhower et al., 2010, "The Biogeochemistry of Technetium: Review of the Behavior of an Artificial Element in the Natural Environment"; PNNL-SA-94653, *An Evaluation of Radioiodine Transformation and Migration in the Subsurface of Hanford Site*) and is the subject of continued efforts. This work includes evaluation of the effect of dissolved organic material (e.g., humic and fulvic acids) and the presence and function of microbial populations on iodine speciation. This knowledge is critical to developing accurate conceptual site models, predictions of contaminant fate and transport, and effective remedial strategies for iodine immobilization at the Hanford and Savannah River Sites.

- ***Technetium speciation and biogeochemistry*** has been evaluated (Szecsody et al., 2014) and is the subject of continued efforts to evaluate the effect of microbial processes on the transport and fate of technetium. This knowledge is critical to developing accurate conceptual site models, predictions of contaminant fate and transport, and effective remedial strategies for technetium immobilization at the Hanford Site.

- Monitoring data at the ***Hanford prototype barrier*** are being processed, and a comprehensive report to summarize the ***performance of the Hanford prototype barrier*** is in progress.

- An ***improved electrical resistivity tomography (ERT) software*** for subsurface characterization and monitoring has been completed by PNNL. Aspects of this effort include the following:

  - The software (E4D) was tested and documented to NQA-1 Level B safety software standards in 2014 and released with an open source license (see https://e4d.pnnl.gov).

  - A new capability to account for subsurface metallic infrastructure is included in the software (Johnson and Wellman, 2014, "Parallel Modeling and Inversion of Electrical Resistivity Data in the Presence of Metallic Infrastructure"), which enables effective imaging in the presence of tanks, pipes, and well casings.

  - The software is designed to operate on supercomputers to optimize ERT imaging and time-lapse monitoring capabilities.

  - Methods to quantify and monitor moisture content distribution in the vadose zone to identify zones impacted by waste discharges and to determine the rate of contaminated water movement toward the groundwater (Johnson et al., 2013, "Determination of Water Saturation Using Gas Phase Partitioning Tracers and Time-Lapse Electrical Conductivity Measurements").

  - A refined approach for characterization of contaminant extent within the vadose zone (PNNL-22520, *Re-Inversion of Surface Electrical Resistivity Tomography Data from the Hanford Site B-Complex*; Johnson et al., 2011, "Characterization and Monitoring of Subsurface Processes Using Parallel Computing and Electrical Resistivity Imaging").

- A document defining a ***framework for improved monitoring technologies and approaches*** (including the vadose zone) was published in support of DOE Headquarters, with the collaboration of scientists across the DOE complex (PNNL-21379, *Scientific Opportunities for Monitoring at Environmental Remediation Sites (SOMERS) Integrated Systems-Based Approaches to Monitoring*). The collaboration between CHPRC, RL, and PNNL is establishing the technical basis for transition of Hanford Site groundwater monitoring plans from point-source-based monitoring to systems-based monitoring, accounting for integration with expected plume behavior and remedy characteristics.

- ***Foam delivery technology*** was evaluated as a method to deliver remedial amendments into vadose zone environments. However, some key limitations were identified (Zhong et al., 2009, "Foam Delivery of Calcium Polysulfide to the Vadose Zone for Chromium(VI) Immobilization: A Laboratory Evaluation;" Zhong et al., 2010, "Foam Delivery of Amendments for Vadose Zone Remediation: Propagation Performance in Unsaturated Sediments;" Zhang et al., 2012b, "Experimental Investigation of the Effective Foam Viscosity in Unsaturated Porous Media").

- State of the knowledge reviews were published defining the biogeochemical and hydrogeophysical processes controlling iodine, technetium, plutonium, americium, and iodine at the Hanford Site. These reviews provide the scientific and technical basis for supporting ***risk-informed decisions*** for Hanford Site cleanup and closure.

Remedy activity support includes the following:

- CHPRC is expanding efforts to ***pump water from a perched water zone*** within the Cold Creek unit at the B Complex. This effort includes characterization and monitoring to improve understanding of the perched water system and remedy performance.

- ***Interim surface infiltration barriers*** have been installed and are being monitored to examine impact on vadose zone flow (PNNL-19772, *T-TY Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring Plan*; PNNL-20144, *T-TY Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring FY10 Report*). A method to evaluate the performance of a surface barrier was developed in collaboration with ORP/WRPS (Zhang et al., 2012a, "Evaluating the Performance of a Surface Barrier for Reducing Soil-Water Flow").

- Development of the Advanced Simulation Capability for Environmental Management toolset (ASCEM-SITE-2012-01, *Phase II Demonstration*) is continuing toward a regulatory release in 2015. The toolset will be applied to evaluate DVZ contamination, including the BC Cribs and Waste Management Area C.

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Appendix C

Data Quality Objectives Summary Report for the 200-DV-1 Operable Unit Waste Sites

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Terms

1C	first-cycle
2C	second-cycle
bgs	below ground surface
CCU	Cold Creek unit
CCU_z	Cold Creek unit silt
COPC	contaminant of potential concern
cpm	counts per minute
CSM	conceptual site model
dpm	disintegrations per minute
DPT	direct-push technology
DQO	data quality objective
DOE	U.S. Department of Energy
DR	decision rule
DS	decision statement
DVZ	deep vadose zone
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FY	fiscal year
HI	health instrument
ID	identification
ITS	in-tank solidification
OU	operable unit
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
PSQ	principal study question
REDOX	Reduction-Oxidation (S Plant)
RI	remedial investigation
SAP	sampling and analysis plan

SDLS	small-diameter logging system
SGE	surface geophysical exploration
SIM	Soil Inventory Model
TBP	tributyl phosphate
Tri-Parties	U.S. Department of Energy, Washington State Department of Ecology, and U.S. Environmental Protection Agency
UCL	upper confidence level
WIDS	Waste Information Data System
WMA	waste management area

C1 Summary

The data quality objective (DQO) process is a strategic planning approach based on the scientific method and is used to prepare for a sampling data collection activity (EPA/600/R-96-055, *Guidance for the Data Quality Objectives Process* [EPA QA/G-4]). The process provides a systematic procedure for defining the criteria that the data collection design should satisfy, including when to collect samples, where to collect samples, and how many samples to collect.

By using the DQO process, the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. In addition, resources will not be committed to data collection efforts that do not support a defensible decision.

The DQO process ensures that characterization activities address identified data needs. However, although the DQO process is intended to limit redundant or unnecessary activities, it will not preclude additional characterization activities that may be prompted by new information or technological advances.

C2 Background

The 200-DV-1 Operable Unit (OU) waste sites are located in the vicinities of Waste Management Area (WMA) B-BX-BY, WMA T-TX-TY, and WMA S-SX in the Inner Area on the Hanford Site's Central Plateau. These three areas, each of which include waste sites and tank farms, are referred to in this report as the B Complex area, the T Complex area, and the S Complex area, respectively.

The 200-DV-1 OU was created in 2010 to support remedy selection for waste sites with deep vadose zone (DVZ) contamination. In general, DVZ contamination is considered to be contamination that poses a potential threat to groundwater and cannot be remediated using standard surface-based remedies.

Between 1989 (when Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*, was signed) and 2010, the 200-DV-1 OU waste sites were included in other OUs (see Table A-1 in Appendix A of this document). In 1989, waste sites on the Central Plateau initially were grouped into 42 OUs (32 source OUs, 6 tank farm OUs, and 4 groundwater OUs), which were primarily geographically based (DOE/RL-96-67, *200 Areas Soil Remediation Strategy – Environmental Restoration Program*). A work plan (DOE/RL-88-32, *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit Hanford Site, Richland, Washington*) was prepared and implemented for the 200-BP-1 OU, which included some of the waste sites now included in the 200-DV-1 OU.

In 1997, the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) (known collectively as the Tri-Parties) regrouped the waste sites for characterization purposes according to discharge type (e.g., tank waste and process water) followed by waste site type (e.g., crib or ditch). This process-based grouping reduced the number of source OUs from 32 to 23. During the process-based grouping, most of the waste sites now in the 200-DV-1 OU were assigned to the 200-TW-1 Scavenged Tank Waste Group OU, the 200-TW-2 Tank Waste Group OU, or the 200-PW-5 Fission Product-Rich Process Waste Group OU (see Table A-1 in Appendix A).

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*. A work plan was prepared 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) (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*). 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 (DOE/RL-92-70, *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit*).

In 2002, the Tri-Parties agreed to consolidate the 23 process-based source OUs into 12 OU groups based on similarities between contaminant sources. This modification allowed one OU group, consisting of one or more OUs, to be investigated using a single remedial investigation (RI)/feasibility study (FS) process. As a result, the 200-PW-5 OU was consolidated with the 200-TW-1 and 200-TW-2 OUs in the RI report issued in 2003 (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 DQO evaluation in 2005 and 2006 to review all of the process and characterization data available for the Central Plateau waste sites, to identify residual data needs, and to reach agreement on a path forward for supplemental data collection that would augment the RI and the data that had previously been collected. The elements of the DQO evaluation 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 sampling and analysis plan (SAP) for the collection of additional data at those waste sites for which existing data were determined to be insufficient for decision making purposes.

In 2011, the waste sites now mapped to the new 200-DV-1 OU were the subject of an independent DQO evaluation, as described in this appendix. New detailed conceptual site models (CSMs) for the waste sites were available or were in process, and specific sampling and analysis elements were developed to address the data needs for the 200-DV-1 OU. The sampling and analysis recommendations in the supplemental work plan (DOE/RL-2007-02) were modified as needed to address the 200-DV-1 OU data needs (Section 4.3 in main text discussion). The analogous waste site approach, which was only used during the original 200-TW-1 and 200-TW-2 OUs investigation in 2001, was not used during the DQO development for the supplemental characterization (DOE/RL-2007-02) or the 200-DV-1 OU waste sites (this appendix). The DQO process for the 200-DV-1 OU waste sites was developed, completed, and approved in 2011. The data needs and results of the completed DQO process are provided in this appendix.

The agreements made during the 200-DV-1 OU DQO sessions have been incorporated in DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*. The characterization activities described in the 200-DV-1 OU SAP (DOE/RL-2011-104) replace the characterization activities included for these waste sites described in DOE/RL-2007-02.

C3 Step 1 – State the Problem

The purpose of this DQO process is to support decision-making activities as they pertain to remediation of the 200-DV-1 OU waste sites. The objective of DQO Step 1 is to use the information gathered from the DQO scoping process, as well as other relevant information, to clearly and concisely state the problem to be resolved.

C3.1 Describe the Problem

The waste sites in the 200-DV-1 OU received liquid waste streams from Hanford Site chemical and radiological processes. These liquids percolated through the soil column, and the associated chemical and radiological waste contaminants migrated with the percolating water, interacting to some degree with the surrounding soil. Residual radiological and chemical constituents remain within the soil column underneath each of the sites. Any contaminant concentrations that exist in amounts posing an unacceptable risk to human or ecological health, or that present a current or future source of unacceptable groundwater contamination, will be identified and characterized sufficiently to determine the need for and the selection of a proper remedial action.

C3.2 Conceptual Site Model

The goal of the DQO process is to develop a sampling design that will either confirm or refine the CSM, which is continuously refined as additional data become available. The CSM, including the nature and extent of contamination and a discussion of uncertainty, for the B Complex area is primarily provided in PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*. The CSMs, including the nature and extent of contamination and a discussion of uncertainty, for the T Complex area and S Complex area were developed in 2011 to support this DQO process. The S Complex area CSMs were issued in 2014 (SGW-50280, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the S Complex Area, Central Plateau, Hanford Site*), and the T Complex area CSMs were issued in 2015 (SGW-49924, *Conceptual Site Models for the 200-DV-1 Operable Unit Waste Sites in the T Complex Area, Central Plateau, Hanford Site)*.

Note: In this appendix, chromium is assumed to be hexavalent chromium unless otherwise noted.

C3.2.1 B Complex Area Waste Sites

To facilitate the DQO process, the 23 waste sites in the B Complex area have been combined into eight waste site groups based on similar construction, operating history, and location (Figure C-1). The eight waste site groups and associated highlights from key reference documents include the following:

- **216-B-5, consisting of the 216-B-5 Reverse Well:** When the 216-B-5 Reverse Well was receiving contaminated liquid waste, the perforated interval extended through the deepest 15 m (50 ft) of the vadose zone and the upper 3 m (10 ft) into the unconfined aquifer. Contaminants detected in the subsurface include cesium-137, strontium-90, plutonium-239/240, and americium-241 (RHO-ST-37, *216-B-5 Reverse Well Characterization Study* [Figures 21, 22, and 23]).

- **216-B-7A&B, consisting of the 216-B-7A&B Cribs:** Contaminated liquid waste discharged to the 216-B-7A&B Cribs reached groundwater during the cribs' active period and currently is a source for some of the contamination found in the DVZ Cold Creek unit silt (CCU_z). The observed water-extractable fluoride and chromium in the CCU_z pore water and the chromium in groundwater in nearby wells support the conclusion that liquid waste from the 216-B-7A&B Cribs and/or 216-B-8 Crib and Tile Field is present in the pore water in the CCU_z unit. However, uranium isotopic signature data suggest that fluids from the 216-B-7A Crib are not a significant contributor to the uranium found in the groundwater in the vicinity (PNNL-19277, p. 9-9).

- **216-B-8, consisting of the 216-B-8 Crib and Tile Field and 200-E-45 Health Instrument Shaft:** Liquids discharged to the 216-B-8 Crib likely did reach groundwater no later than 1959. The 216-B-8 Crib is currently a continuing source of chromium, sodium, and likely nitrate contamination to the groundwater (PNNL-19277, p. 9-9).

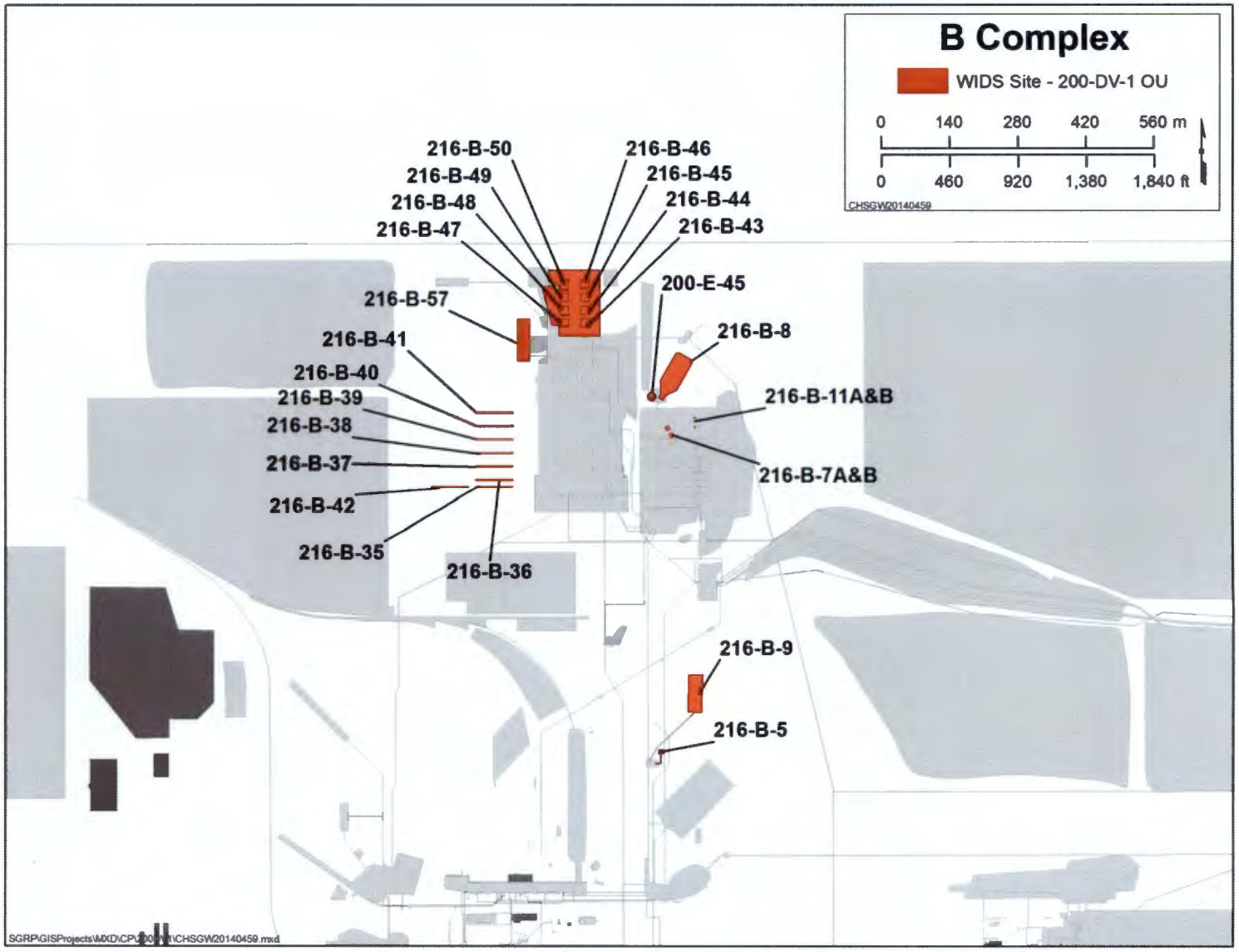

Figure C-1. Location of 200-DV-1 OU Waste Sites in the B Complex Area

- **216-B-9, consisting of the 216-B-9 Crib and Tile Field:** Geophysical logging data suggest that contaminant breakthrough to groundwater in the vicinity of the 216-B-9 Crib and Tile Field did not occur. The contamination profiles for the 216-B-9 Crib and Tile Field indicate that significant site-related contamination generally is not detected below 18 m (60 ft) from the ground surface (GJO-2002-358-TAC, *Hanford 200 Area Spectral Gamma Baseline Characterization Project 216-B-5 Injection Well and 216-B-9 Crib & Tile Field Waste Site Summary Report*, p. 32).

- **216-B-11A&B, consisting of the 216-B-7A&B Cribs and 216-B-11A&B French Drains:** The 216-B-11A&B French Drains are a likely contributor to the historical groundwater plume, but based on the low inventory of key contaminants (only 0.04 kg of uranium and 0.003 Ci of technetium-99), this facility is not considered a current or future source of significant contamination to the groundwater (PNNL-19277, p. 3-82).

- **BX Trenches, consisting of the 216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42 Trenches:** Waste liquids discharged to the 216-B-38 Trench likely have not reached the groundwater. Based on this observation, it was concluded that the entire BX Trenches subregion also has not impacted the groundwater to any significant extent (PNNL-19277, p. 9-10).

- **216-BY Cribs, consisting of the 216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs:** The DVZ below the BY Cribs is currently contributing technetium-99, cyanide, nitrate, and perhaps cobalt-60 to the groundwater. However, it does not appear that the DVZ below the BY Cribs is contributing much (if any) uranium to the groundwater at this time, and water-extractable uranium in the vadose zone sediment below the BY Cribs is found only in shallow sediments far from the water table (PNNL-19277, p. 9-8).

- **216-B-57, consisting of the 216-B-57 Crib:** The 216-B-57 Crib vadose zone sediment contaminant data are sparse but suggest comparatively low concentrations and relatively shallow distributions for all constituents. Under current conditions, this facility appears not to be a past, present, or significant future contributor to groundwater risk (PNNL-19277, p. 9-8).

- **216-T-5, 216-T-7/200-W-52, and 216-T-32, consisting of the 216-T-5 Crib, 216-T-7 Tile Field, 200-W-52 Crib, and 216-T-32 Crib (preliminary assessment):** There is a commingled contamination region in the vadose zone below and between the 216-T-32 Crib and the 216-T-7 Crib and Tile Field that contains the majority of the residual nitrate (75 percent), chromium (69 percent), and some of the residual uranium (16 percent) released to the vadose zone at the T Complex. This vadose zone region appears to be currently contributing to the groundwater plume below the T Trenches subregion to the east.

Table 3-3 in Chapter 3 of this work plan presents a list of the key references that were reviewed as part of the scoping process for the B Complex area waste sites, as well as a summary of the pertinent information contained within each reference.

C3.2.2 T Complex Area Waste Sites

To facilitate the DQO process, the seventeen 200-DV-1 OU waste sites within the T Complex area have been combined into six waste site groups based on similar construction, operating history, and location (Figure C-2). The six waste site groups include the following:

- **216-T-3 and 216-T-6, consisting of the 216-T-3 Reverse Well and 216-T-6 Crib (preliminary assessment):** The 216-T-6 Crib and 216-T-3 Reverse Well likely impacted groundwater during the 1940s through 1960s, but there currently is no indication that wastes from the vadose zone are contributing significant masses of the mobile contaminants. Based on the conceptual model for the vadose zone in this subregion, there is the potential that large enough inventories of nitrate and chromium exist to eventually impact groundwater in the future.

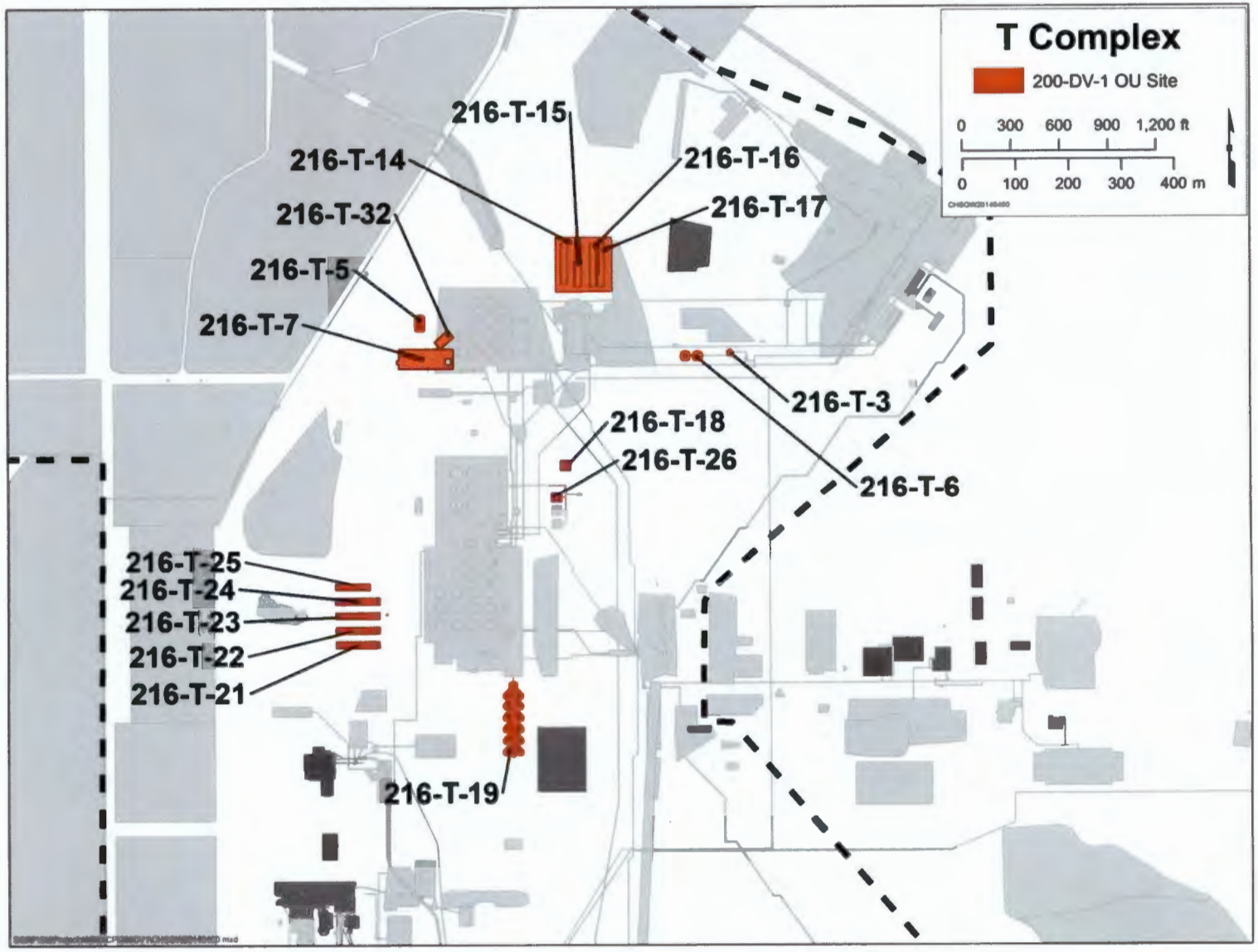

Figure C-2. Location of 200-DV-1 OU Waste Sites in the T Complex Area

- **216-T-5, 216-T-7/200-W-52, and 216-T-32, consisting of 216-T-5 Crib, 216-T-7 Tile Field, 200-W-52 Crib (in WMA T), and 216-T-32 Crib (preliminary assessment):** A commingled contamination region in the vadose zone below and between the 216-T-32 Cribs, the 216-T-7 Tile Field, and the 200-W-52 Crib in this subregion contains the majority of the residual nitrate (73 percent) and chromium (66 percent) and some of the residual uranium (16 percent) compared to the masses disposed of to the T Complex Area facilities. This vadose zone region is currently contributing to the groundwater plume below the T Trenches subregion to the east. The mass released to the 216-T-5 Crib appears to be retained in the vadose zone.

- **T Trenches, consisting of the 216-T-14, 216-T-15, 216-T-16, 216-T-17 Trenches (preliminary assessment):** The specific retention trenches in the T Trenches (216-T-14 through 216-T-17) subregion do not appear to be a future threat to groundwater because the disposed wastes are retained relatively shallow in the vadose zone, despite the fact that they received about 9 percent of the iodine-129, 6 percent of the uranium, 3 percent of the nitrate, 2 percent of the chromium, and 2 percent of the technetium-99 released from the waste sites and tanks in the T Complex.

- **216-T-18 and 216-T-26, consisting of the 216-T-18 and 216-T-26 Cribs (preliminary assessment):** The vadose zone below the 216-T-18 and 216-T-26 Cribs subregion is estimated to contain sufficient nitrate, chromium, uranium, technetium-99, and iodine-129 to impact groundwater.

- **216-T-19, consisting of the 216-T-19 Crib and Tile Field (preliminary assessment):** The 216-T-19 Crib and Tile Field does not appear to be impacting groundwater at present but likely was a source of mobile contaminants, especially tritium, in the past. It appears that the high-volume releases of very dilute waste during the 1960s may have flushed much of the earlier, more concentrated wastes out of the vadose zone.

- **TX Trenches, consisting of the 216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 Trenches (preliminary assessment):** The specific retention trenches in the TX Trenches (216-T-21 through 216-T-25) subregion do not appear to be a future threat to groundwater because the disposed wastes are retained relatively shallow in the vadose zone, despite the fact that they received about 19 percent of the iodine-129, 0.5 percent of the uranium, 7 percent of the nitrate, 5 percent of the chromium, and 3 percent of the technetium-99 released from the waste sites and tanks in the T Complex.

Table 3-13 in Chapter 3 of this work plan presents a list of key references that were reviewed as part of the scoping process for the T Complex area waste sites, as well as a summary of the pertinent information contained within each reference.

C3.2.3 S Complex Area Waste Sites

To facilitate the DQO process, the three 200-DV-1 OU waste sites (plus two non-200-DV-1 OU waste sites) within the S Complex area have been combined into three waste site groups based on similar construction, operating history, and location (Figure C-3). The three waste site groups include the following:

- **216-S-9 and 216-S-23, consisting of the 216-S-9 Crib and 216-S-23 Crib (preliminary assessment):** The vadose zone below the 216-S-9 Crib may still contain a significant inventory of nitrate, uranium, and iodine-129 in comparison to the other S Complex area facilities. Iodine-129 may be impacting groundwater at detectable concentrations below this crib. The 216-S-23 Crib is a 200-WA-1 OU waste site.

- **216-S-21 and 216-S-25, consisting of the 216-S-21 Crib and 216-S-25 Crib (preliminary assessment):** Because the waste type disposed to the 216-S-21 Crib was not particularly concentrated in any of the five mobile contaminants and the lateral spread was not particularly large, the mass of residual contaminants in the vadose zone is not significant. Comparatively, the 216-S-21 Crib sediments may contain about 1 percent of the total chromium released to the S Complex Area but less than 0.2 percent of any of the other mobile contaminants. The 216-S-25 Crib is a 200-WA-1 OU waste site.

- **216-S-13, consisting of the 216-S-13 Crib (preliminary assessment):** The 216-S-13 Crib is unlikely to have impacted groundwater based on geophysical logging. However, there is uncertainty regarding the inventory of chromium disposed to this site.

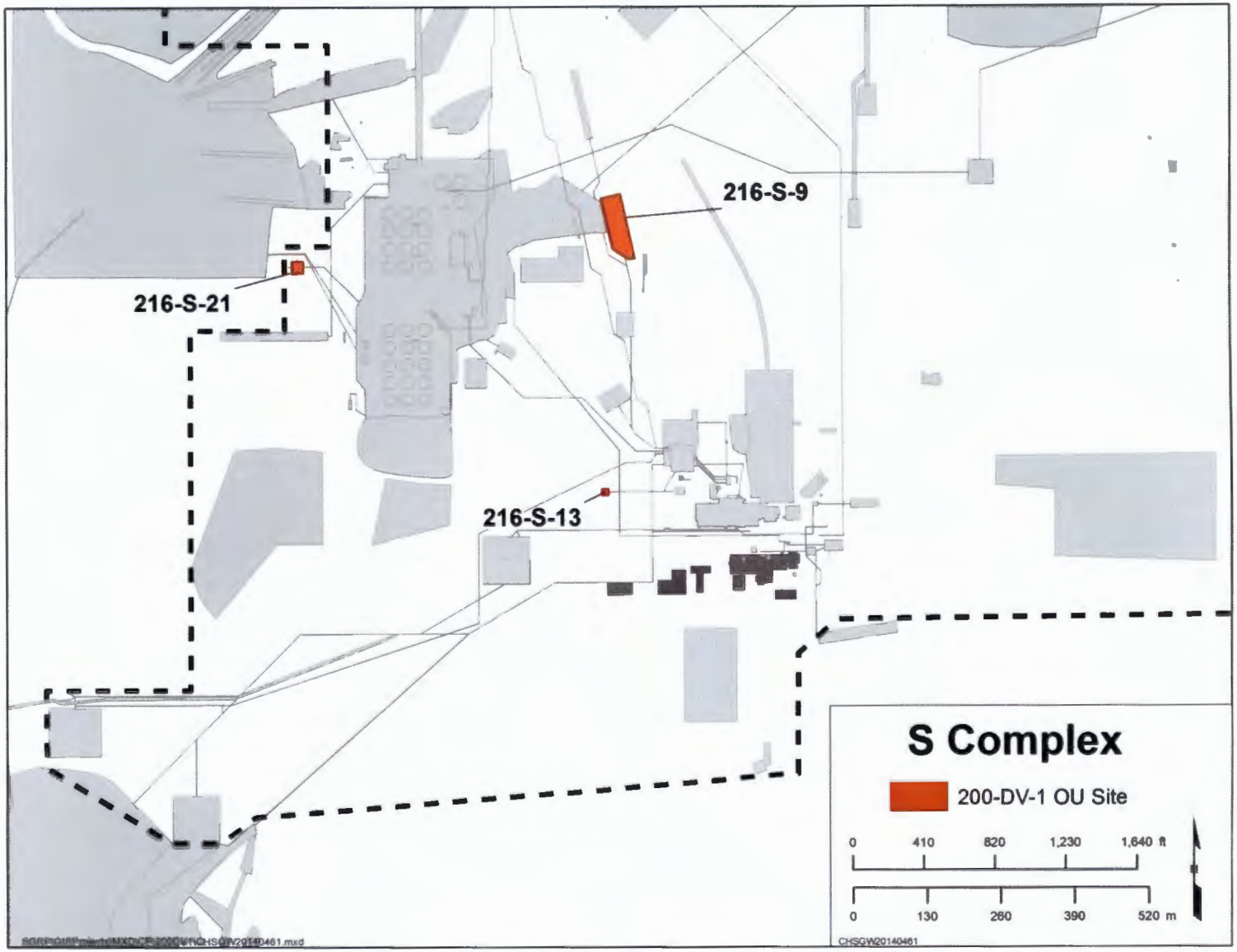

Figure C-3. Location of 200-DV-1 OU Waste Sites in the S Complex Area

Table 3-20 in Chapter 3 of this work plan presents a list of key references that were reviewed as part of the scoping process for the S Complex area waste sites, as well as a summary of the pertinent information contained within each reference.

C3.2.4 Contaminants of Potential Concern

Contaminants of potential concern (COPCs) have been identified for the 200-DV-1 OU waste sites through three separate DQO processes. The sites previously assigned to the 200-TW-1 and the 200-TW-2 OUs were evaluated as part of BHI-01356, *Remedial Investigation Data Quality Objectives Summary Report for the 200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Units*. The list of COPCs was revisited and confirmed in the Central Plateau supplemental characterization work plan (DOE/RL-2007-02). The list of COPCs was revised during the 2011 DQO for the 200-DV-1 OU. Section 3.5 of this work plan describes how the list of COPCs was developed and provides the list of COPCs for the 200-DV-1 OU waste sites.

C4 Step 2 – Identify the Goals of the Study

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be resolved to address the problem identified in DQO Step 1 and the alternative actions that would result from the resolution of the PSQs. The PSQs and alternative actions are then combined into decision statements (DSs) that typically express a choice among alternative actions.

Two PSQs were developed for the 200-DV-1 OU waste sites. Table C-1 lists the PSQs, alternative actions, and resulting DSs used for the 200-DV-1 OU DQO evaluation in 2011.

Table C-1. Summary of DQO PSQs and DSs for 200-DV-1 OU Waste Sites

PSQ #1	Alternative Actions
Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?	No action.
	Remediate waste site to reduce risk to acceptable levels.
DSs	
DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.	
DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.	
PSQ #2	**Alternative Actions**
Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?	No action.
	Remediate contamination to reduce risk to acceptable levels.

Table C-1. Summary of DQO PSQs and DSs for 200-DV-1 OU Waste Sites

DSs
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.

bgs = below ground surface OU = operable unit
DS = decision statement PSQ = principal study question

C5 Step 3 – Identify Information Inputs

The purpose of DQO Step 3 is to identify the type of data needed to resolve each of the DSs identified in DQO Step 2. The data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., practical quantitation limit [PQL] requirements, precision, and accuracy) are also provided in this step for any new data that need to be collected.

C5.1 Information Required to Resolve Decision Statements

Tables C-2 through C-20 specify, for each of the waste site groups in the 200-DV-1 OU, the information (data) input to resolve each of the DSs identified in Table C-1 and identify whether the data already exist. For the existing data, the source references for the data are provided with a qualitative assessment regarding whether the data are of sufficient quality to resolve the corresponding DS. The qualitative assessment of the existing data was based on the evaluation of the corresponding quality control data (e.g., spikes, duplicates, and blanks), detection limits, and data collection methods. Tables C-2 through C-20 begin on page C-13.

Tables C-2 through C-9 provide the information input for the eight waste site groups in the B Complex, and a summary is provided in Table C-21.

Tables C-10 through C-17 provide the information input for the six waste site groups in the T Complex, and a summary is provided in Table C-22.

Tables C-18 through C-20 provide the information input for the three waste site groups in the S Complex, and a summary is provided in Table C-23.

Note: The Soil Inventory Model (SIM) (RPP-26744, *Hanford Soil Inventory Model, Rev. 1*) does not provide speciation information for chromium. All chromium inventories provided in Tables C-2 through C-20 from the SIM are assumed to be hexavalent unless other information is available.

C5.2 Analytical Performance Requirements

The analytical performance requirements for the new data that need to be collected are specified in the 200-DV-1 OU characterization SAP (DOE/RL-2011-104).

C6 Step 4 – Define the Boundaries of the Study

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and identify any practical constraints (i.e., hindrances or obstacles) that must be taken into consideration in the sampling design. Implementing this step ensures that the sampling design will result in the collection of data that accurately reflect the true condition of the site under investigation.

C6.1 Geographic Boundaries

Limiting the geographic boundaries of the study area ensures that the investigation does not expand beyond the original scope of the task. For the investigations relative to the 200-DV-1 OU waste sites, the geographic boundaries are the physical boundaries of the sites laterally and the vertical extent of that site footprint from the ground surface to the top of the groundwater. Where soil contamination has migrated laterally beyond the footprint of the waste site, the entire contaminated soil volume is also considered within the geographic boundary of the study area.

C6.2 Practical Constraints

Practical constraints that may impact the data collection effort include physical barriers, difficult sample matrices, high radiation areas, or any other condition that will need to be taken into consideration in the design and scheduling of the sampling program. One 200-DV-1 OU waste site (216-T-32 Crib) is within the T Tank Farm. The 216-T-7 Crib and Tile Field were operated as one disposal unit but were administratively separated in 1997 because the 216-T-7 Crib is within the T Tank Farm. The 216-T-7 Crib was designated as waste site 200-W-52 and was assigned to WMA T.

C7 Step 5 – Develop a Decision Rule

The purpose of DQO Step 5 is initially to define the statistical parameter of interest (e.g., mean or 95 percent upper confidence level [UCL]) that will be used for comparison against the action level. The statistical parameter of interest specifies the characteristic or attribute that the decision maker would like to know about the population. The action level for the contaminants is also identified in DQO Step 5. When this is established, a decision rule is developed for each DS in the form of an "IF…THEN…" statement that incorporates the parameter of interest, the scale of decision making, the action level, and the alternative action(s) that would result from resolution of the decision. Note that the scale of decision making and alternative actions were identified earlier in DQO Steps 4 and 2, respectively.

C7.1 Decision Statements

Table C-24 presents the DSs identified in Section C4.

C7.2 Decision Rules

Table C-25 presents the decision rules that correspond to each of the DSs. Decision rules are combined "IF…THEN" statements that incorporate the parameter(s) of interest, scale of the decision making, action level, and resulting actions.

C8 Step 6 – Specify Tolerable Limits on Decision Errors

Because analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). For this reason, the primary objective of DQO Step 6 is to determine which DSs (if any) require a statistically based sample design. For those DSs requiring a statistically based sample design, DQO Step 6 defines tolerable limits on the probability of making a decision error.

The sampling design for the 200-DV-1 OU waste sites is judgmental (nonstatistically based).

C9 Step 7 – Optimize the Design

The objective of DQO Step 7 is to present alternative data collection designs that meet the minimum data quality requirements specified in DQO Steps 1 through 6. A selection process is then used to identify the most resource-effective data collection design that satisfies all of the data quality requirements. Table 6-3 in Chapter 6 of this work plan differentiates between those DSs that require a statistical sampling design from those that may be resolved using a nonstatistical design.

The data collection designs are specified in 200-DV-1 OU characterization SAP (DOE/RL-2011-104).

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Table C-2. Required Information for Waste Site/Group 216-B-5 Reverse Well

216-B-5

PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?
DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.
DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.

Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 216-B-5 Reverse Well was drilled in 1944 as a 20 cm (8 in.) diameter well to a depth of 92 m (302 ft). The bottom 15 m (50 ft) of the well was perforated. The well received supernate overflow from the 241-B-361 Settling Tank through a pipe that entered the well approximately 3.7 m (12 ft) bgs (HW-17088, pp. 31-33; RHO-CD-673 I.NE; RHO-ST-37, pp. 3-5). Historical drawings H-2-1031 and H-2-1123 (ARH-1562, pp. 63-64; additional drawings listed in BHI-00179, Table B-5; HW-55176, Part VI, Appendix C-6). Historical photographs (BHI-00179, Table B-5). The area around the well was interim-stabilized in 1994 with 46 cm (18 in.) to 61 cm (24 in.) of crushed concrete from the demolished 190-B Facility (WIDS). The total stabilized area was approximately 0.004 ha (0.01 ac) (WHC-SP-1149).	Yes	None
Waste inventory	1-1	The 216-B-5 Reverse Well received the following waste stream (HW-17088, pp. 31-33; RHO-CD-673 I.NE; RHO-ST-37, pp. 3-5; ARH-1562, p. 63; HW-28121, Table 3; HW-33591, Table 1): **Waste Site** / **Service Dates** / **Waste Stream** 216-B-5 / 04/1945 to 09/1946 / Tank 5-6 waste from the 221-B Building and liquid waste from the 224-B Building 09/1946 to 10/1947 / Tank 5-6 waste from the 221-B Building The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-B-5 Reverse Well was 32.1 million L (8.5 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **Analyte** / **Inventory (Mean Values)** Cesium-137 / 8.67E+00 Ci Strontium-90 / 7.55E+00 Ci Waste from the 241-B-361 Settling Tank entered the 216-B-5 Reverse Well through a pipe approximately 3.7 m (12 ft) bgs (RHO-ST-37, p. 3). The well was perforated from 77 m (252 ft) to 92 m (302 ft) bgs to allow distribution of the waste into the subsurface (HW-17088, p. 31).	Yes	None

Table C-2. Required Information for Waste Site/Group 216-B-5 Reverse Well

216-B-5				
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	Eleven wells were drilled from November 1947 to May 1948 to determine the distribution of radionuclides in the groundwater around the 216-B-5 Reverse Well. No contamination was detected on the sediments in any of the wells, including Well 299-E28-7 (361-B-9), 15 m (50 ft) from the 216-B-5 Reverse Well (HW-17088, p. 32). In 1979, three wells were drilled and one well was deepened within 23 m (75 ft) of the 216-B-5 Reverse Well to determine the distribution of radionuclides sorbed on the sediments. Sediment samples were collected 3 m (10 ft) bgs in Well 299-E28-23 (approximately 2 m [6 ft] southeast of 216-B-5) and 1.5 m (5 ft) bgs in Well 299-E28-25 (approximately 6 m [20 ft] northwest of 216-B-5). No contamination was detected in these shallow samples (RHO-ST-37, Appendix A). GJO-2002-358-TAC summarizes the geophysical logging results for the four wells (299-E28-7, E28-23, 299-E28-24, and 299-E28-25) that are located within 23 m (75 ft) of the 216-B-5 Reverse Well. Cesium-137 was detected in the upper 4.6 m (15 ft) at Well 299-E28-25 at concentrations ranging from approximately 0.25 to 0.75 pCi/g and at Well 299-E28-7 at a concentration of approximately 0.5 pCi/g. The contamination is believed to occur inside one of the casing strings and was probably "dragged up" during well drilling (GJO-2002-358-TAC, p. 24).	Yes	None
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-B-5 Reverse Well. Sample data and geophysical logging will be used to determine the vertical extent of contamination in the upper 4.6 m (15 ft).	Yes	None
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:	Yes	None

Analyte	Inventory (Mean Values)
Uranium (total)	1.05E+01 kg
Technetium-99	4.25E-03 Ci
Iodine-129	1.88E-06 Ci
Cobalt-60	5.28E-03 Ci
Tritium	1.68E-03 Ci
Plutonium-239	3.72E+01 Ci
Nitrate	9.50E+05 kg
Ferrocyanide	0.00E+00 kg
Fluoride	5.63E+04 kg
Chromium	3.79E+03 kg

Table C-2. Required Information for Waste Site/Group 216-B-5 Reverse Well

216-B-5				
		The SIM estimate appears to be for the waste liquids discharged to the 241-B-361 Settling Tank (RPP-26744, Table A5-21). In 1979, the 241-B-361 Settling Tank was sampled to determine the radionuclide concentrations in the sludge. The sample results indicate that about one-half of the estimated 4.3 kg of plutonium discharged to the system was retained in the 241-B-361 Settling Tank and that the remainder overflowed into the 216-B-5 Reverse Well. The data also indicate that a larger portion of the cesium-137 inventory overflowed to the reverse well than the strontium-90 inventory (RHO-ST-37, p. 41).		
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	Eleven wells were drilled from November 1947 to May 1948 to determine the distribution of radionuclides in the groundwater around the 216-B-5 Reverse Well. No contamination was detected on the sediments in any of the wells, including Well 299-E28-7 (361-B-9), 15 m (50 ft) from 216-B-5 (HW-17088, p. 32). In 1979, three wells were drilled and one well was deepened within 23 m (75 ft) of the 216-B-5 Reverse Well to determine the distribution of radionuclides sorbed on the sediments. The four wells were drilled to basalt. Sediment samples were analyzed for plutonium-239/240, americium-241, cesium-137, and strontium-90 (RHO-ST-37, Appendix A). Of the four wells, 299-E28-23 is the closest to the 216-B-5 Reverse Well, located approximately 2 m (6 ft) to the southeast. Well 299-E28-24 is approximately 6 m (20 ft) southeast of the reverse well. The contaminant concentrations detected in samples from these wells were associated with depths corresponding to the perforated interval in the 216-B-5 Reverse Well. The maximum vadose zone concentrations in Well 299-E28-23 (RHO-ST-37, Appendix A) were as follows: **Analyte** / **Maximum Concentration** / **Depth bgs (m [ft])** / **Distance above 1980 Water Table (m [ft])** Cesium-137 / 1,800 pCi/g / 85.3 [280] / 1.2 [4] Plutonium-239/240 / 26.5 pCi/g / 85.3 [280] / 1.2 [4] Americium-241 / 0.175 pCi/g / 83.8 [275] / 2.7 [9] Strontium-90 / 209 pCi/g / 82.0 [269] / 4.6 [15] The maximum vadose zone concentrations in Well 299-E28-24 (RHO-ST-37, Appendix A) were as follows: **Analyte** / **Maximum Concentration** / **Depth bgs (m [ft])** / **Distance above 1980 Water Table (m [ft])** Cesium-137 / 5,270 pCi/g / 82.6 [271] / 4.0 [13] Plutonium-239/240 / 149 pCi/g / 82.0 [269] / 4.6 [15] Americium-241 / 10.4 pCi/g / 82.0 [269] / 4.6 [15] Strontium-90 / 1,620 pCi/g / 85.6 [281] / 0.9 [3] A treatability test to evaluate pump-and-treat technology for remediation of groundwater was conducted in 1994 and 1995 in close proximity to the 216-B-5 Reverse Well (DOE/RL-95-59). Well 299-E28-23 was the extraction well, and Well 299-E28-7 was the injection well. Aquifer pumping at the 216-B-5 site provided substantial quantities of groundwater containing significant concentrations of cesium-137 and strontium-90 and lesser quantities of plutonium-239/240, which had adsorbed to the sediments. GJO-2002-358-TAC summarizes geophysical logging results for the four wells (299-E28-7, 299-E28-23, 299-E28-24, and 299-E28-25), which are located within 23 m (75 ft) of the 216-B-5 Reverse Well. The distribution of cesium-137 based on geophysical logging is consistent with the distribution reported in RHO-ST-37 (GJO-2002-358-TAC, p. 26). The highest concentration of cesium-137 detected at Well 299-E28-23 was a few feet above the 2002 water table at about 3,200 pCi/g. The highest concentration detected at Well 299-E28-24 was 3,300 pCi/g, about 3 m (10 ft) above the 2002 water table (GJO-2002-358-TAC, Table 4-1, p. 50).	Yes	None

Table C-2. Required Information for Waste Site/Group 216-B-5 Reverse Well

216-B-5				
		Note: The 1949 water table elevation was 118 m (388 ft); the 1980 water table elevation was 123.5 m (405 ft); and the 2002 water table elevation was 122.5 m (402 ft) (GJO-2002-358-TAC, Table 4-1, p. 26). The supplemental characterization SAP concludes that sufficient information is available for the 216-B-5 Reverse Well.		
Extent of contamination	2-2	Contamination from the 216-B-5 Reverse Well is present in the DVZ and unconfined aquifer at depths corresponding to the depths of the perforated interval in the reverse well. During use of the reverse well from 1945 to 1947, the perforated interval extended into the unconfined aquifer.	Yes	None
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
DS = decision statement
DVZ = deep vadose zone
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model
WIDS = Waste Information Data System

Table C-3. Required Information for Waste Site/Group 216-B-7A&B Cribs

216-B-7A&B				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 216-B-7A and 216-B-7B Cribs were each approximately 3.7 m (12 ft) wide by 3.7 m (12 ft) long by approximately 1.2 m (4 ft) high, wooden timbered cribs placed at the bases of two 4.3 m (14 ft) by 4.3 m (14 ft) excavations that were 5.5 m (18 ft) deep and subsequently backfilled. The centers of the two cribs are 16 m (52 ft) apart (12 m [40 ft] from edge to edge). The southeast Crib 216-B-7A may have overflowed to the northwest Crib 216-B-7B, or the two cribs may have been fed in parallel. The inlet pipe was 4.3 m (14 ft) bgs (ARH-1562, pp. 66-71; HW-55176, Part VI, Appendices C-9 and C-10; RHO-CD-673 I.NE; PNNL-19277). Historical drawings H-2-558 and H-2-579 (ARH-1562, pp. 66-71; additional drawings listed in BHI-00179, Table B-4; HW-55176, Part VI, Appendices C-9 and C-10). Historical photographs (BHI-00179, Table B-4). In 1992, an area of contaminated soil from UPR-200-E-144 was removed and consolidated into a spoil pile covering the 216-B-7A&B Cribs. The maximum depth of the contaminated soil was approximately 3 m (10 ft). About 46 cm (18 in.) to 61 cm (24 in.) of uncontaminated soil was placed over the contaminated soil (WHC-SD-DD-TI-078, p. 18). 216-B-7A Crib geophysical investigations (BHI-01607, Appendix C).	Yes	None

Table C-3. Required Information for Waste Site/Group 216-B-7A&B Cribs

<table>
<tr><th colspan="6">216-B-7A&B</th></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The 216-B-7A&B Cribs received the following waste streams (HW-17088, p. 55; HNF-5231, p. 5; HW-38562, Table IV; ARH-1562, pp. 66-71; RHO-CD-673 I.NE):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td rowspan="7">216-B-7A&B</td><td>09/1946 to 10/1947</td><td>Supernate from the 224-B Building liquid waste via the 241-B-201 Tank</td></tr>
<tr><td>10/1947 to 08/1948</td><td>Supernate from the 224-B Building liquid waste and 221-B Building Tank 5-6 waste via the 241-B-201 Tank</td></tr>
<tr><td>08/1948 to 10/1948</td><td>Supernate from the 224-B Building liquid waste via the 241-B-201 Tank</td></tr>
<tr><td>10/1948 to 12/1954*</td><td>Supernate from the 224-B Building liquid waste via the 241-B-204-203-202 Tank cascade</td></tr>
<tr><td>12/1954 to 09/1958</td><td>Tank 5-6 waste from the 221-B Building and the liquid waste from the 224-B Building during reactivation decontamination and cleanup in the 221-B Building</td></tr>
<tr><td>09/1958 to 10/1961</td><td>Occasional Tank 5-6 waste from the 221-B Building</td></tr>
<tr><td>10/1961 to 05/1967</td><td>Decontamination and construction waste from the 221-B Building</td></tr>
</table>
* ARH-1562, p. 67 indicates cribs inactive 07/1951 to 12/1954; HNF-5231, Appendix 1 indicates cribs active through 12/1954; HW-33591, Table 1, and HW-38562, Table IV, indicate cribs received 224-B waste from 10/1946 to 03/1953 and 221-B 5-6 waste from 10/1947 to 08/1948 and 12/1954 to current (1955). The SIM continues from 1946 through 1954 and from 1966 through 1967.

The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-B-7A&B Cribs was 44.6 million L (11.8 million gal).

The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>3.73E+02 Ci</td></tr>
<tr><td>Strontium-90</td><td>1.64E+03 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15ft)</td><td>1-1</td><td>At the 216-B-7A Crib, Borehole C3103 was drilled in 2001 to 68 m (222.5 ft) bgs, about 7 m (23 ft) above the water table (drilling was terminated when high moisture contents were encountered in a thick silt lens in the CCU). Samples were collected at five intervals in the upper 4.6 m (15 ft): 0 to 0.2 m (0 to 0.5 ft), 0.8 to 1.5 m (2.5 to 5 ft), 1.7 to 2.4 m (5.5 to 8 ft), 3 to 3.8 m (10 to 12.5 ft), and 3.8 to 4.6 m (12.5 to 15 ft). DOE/RL-2002-42 provides analytical data for Borehole C3103. The maximum soil concentration from C3103 for cesium-137 in the upper 4.6 m (15 ft) was 42.5 pCi/g in the sample from 1.7 to 2.4 m (5.5 to 8 ft).

BHI-01607 provides borehole geophysical logging results for the 216-B-7A Crib (C3103). GJO-2002-343-TAR summarizes geophysical logging results for Borehole C3103 and Wells 299-E33-58, 299-E33-59, 299-E33-60, and 299-E33-75 at the 216-B-7A&B Cribs. The maximum cesium-137 concentration in the upper 4.6 m (15 ft) was about 40 pCi/g at C3103 (216-B-7A) and about 50 pCi/g at 299-E33-75 (216-B-7B).

The shallow contamination above the base of the cribs is likely from the spoil pile of contaminated soil from UPR-200-E-144. This contamination is cesium-137 and is generally on the order of 10 pCi/g with a profile 1.5 to 3 m (5 to 10 ft) thick (GJO-2002-343-TAR, p. 27).</td><td>Yes</td><td>None

The supplemental characterization SAP recommended installing drive points at 216-B-7A (two) and 216-B-7B (one) to 12 m (40 ft) bgs for geophysical logging to reduce the uncertainty associated with the extent and volume of plutonium released at these cribs (DOE/RL-2007-02-VOLII-ADD4, p. AD4 2-1). However, plutonium was analyzed for, and not detected, in the four samples collected from 2.5 to 4.6 m (8 to 15 ft) bgs at C3103 (DOE/RL-2002-42, Table C-12). On this basis, the supplemental characterization was recommended for the sediments deeper than 4.6 m (15 ft) bgs.</td></tr>
</table>

Table C-3. Required Information for Waste Site/Group 216-B-7A&B Cribs

<table>
<tr><th colspan="6">216-B-7A&B</th></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-B-7A&B Cribs. Geophysical logging and the analytical results from C3103 will be used to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
<tr><td colspan="6">PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Waste inventory</td><td>2-1</td><td>The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:
<table>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Uranium (total)</td><td>1.97E+02 kg</td></tr>
<tr><td>Technetium-99</td><td>9.47E-02 Ci</td></tr>
<tr><td>Iodine-129</td><td>6.67E-04 Ci</td></tr>
<tr><td>Cobalt-60</td><td>3.61E-01 Ci</td></tr>
<tr><td>Tritium</td><td>7.81E-03 Ci</td></tr>
<tr><td>Plutonium-239</td><td>2.17E+01 Ci</td></tr>
<tr><td>Nitrate</td><td>2.71E+06 kg</td></tr>
<tr><td>Ferrocyanide</td><td>0.00E+00 kg</td></tr>
<tr><td>Fluoride</td><td>1.62E+05 kg</td></tr>
<tr><td>Chromium</td><td>1.16E+04 kg</td></tr>
</table>
The 216-B-7A&B Cribs received about one-third more nitrate and almost twice as much chromium as 216-B-8 Crib and Tile Field.
The 216-B-7A&B Cribs and the 216-B-8 Crib and Tile Field received about three times as much fluoride and chromium as the BY Cribs. Thus, elevated groundwater fluoride and chromium concentrations in this area are good indicators of waste impact to groundwater from one or both of these facilities (PNNL-19277, p. 3.60).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-3. Required Information for Waste Site/Group 216-B-7A&B Cribs

<table>
<tr><th colspan="5">216-B-7A&B</th></tr>
<tr>
<td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td>
<td>2-1, 2-2</td>
<td>At 216-B-7A, Borehole C3103 was drilled in 2001 to 68 m (222.5 ft) bgs, about 7 m (23 ft) above the water table (drilling was terminated when high moisture contents were encountered in a thick silt lens in the CCU). Sediment samples were collected at 10 depths between 5.6 and 67.5 m (18.5 and 221.5 ft) bgs. DOE/RL-2002-42 and PNNL-14128 provide analytical data for Borehole C3103. The maximum sediment concentrations from C3103 (DOE/RL-2002-42) were as follows:
<table>
<tr><th>Analyte</th><th>Maximum Concentration</th><th>Depth bgs (m [ft])</th></tr>
<tr><td>Uranium (total)</td><td>346,000 µg/kg</td><td>9.1 to 9.9 [30 to 32.5]</td></tr>
<tr><td>Technetium-99</td><td>32.9 pCi/g</td><td>5.6 to 6.4 [18.5 to 21]</td></tr>
<tr><td>Iodine-129</td><td>Not analyzed</td><td></td></tr>
<tr><td>Nitrate</td><td>493 mg/kg</td><td>45.0 to 45.7 [147.5 to 150]</td></tr>
<tr><td>Fluoride</td><td>205 mg/kg</td><td>10.7 to 11.4 [35 to 37.5]</td></tr>
<tr><td>Chromium (total)</td><td>142 mg/kg</td><td>5.6 to 6.4 [18.5 to 21]</td></tr>
</table>
Chemical analysis by PNNL included strong acid extraction and deionized water extraction of the sediments (PNNL-14128; PNNL-19277, Table 3.12).

The sediment characterization data show that the mobile and partially mobile constituents nitrate and fluoride are present within the Hanford formation below 216-B-7A from 18 to 49 m (60 to 160 ft) and 9 to 29 m (30 to 95 ft) bgs, respectively (PNNL-19277, p. 3.65). Both constituents show a sharp increase in concentration at 66.5 m (218 ft) bgs in the CCU silt (PNNL-19277, p. 3.65). There is little to no technetium-99 in the sediments below 216-B-7A, and acid- and water-leachable uranium was found only shallow in the sediment profile (PNNL-19277, p. 3.65).

Characterization Wells 299-E33-344 and 299-E33-345 were drilled within 3 m (10 ft) of Well 299-E33-18 during the remedial investigation for the 200-BP-5 OU. Sediment samples from 299-E33-344 were collected from 12.7 to 72.4 m (41.5 to 237.5 ft) bgs (PNNL-19277, Table 3.13; SGW-46352, Appendices A through F). Sediment samples from 299-E33-345 were collected from about 66 to 79 m (216 to 260 ft) (below the water table at 77.3 m [253.3 ft]) bgs (PNNL-19277, Table 3.13). Both new wells show no signs of elevated concentrations of typical waste constituents through the Hanford formation, but both show indications of waste impacts in the CCU silt (PNNL-19277, p. 3.65).

BHI-01607 provides borehole geophysical logging results for the 216-B-7A Crib (C3103). GJO-2002-343-TAR summarizes geophysical logging results for Borehole C3103 and Wells 299-E33-58, 299-E33-59, 299-E33-60, 299-E33-75, and 299-E33-18 at the 216-B-7A&B Cribs. Cesium-137, cobalt-60, uranium-235, uranium-238, and europium-154 were detected while logging. Cesium-137 was measured at higher concentrations at depths of 4.9 to 24.4 m (16 to 80 ft) bgs in every borehole except 299-E33-18. The maximum cesium-137 concentration was 218,000 pCi/g, measured at C3103 at a depth of 7 m (23 ft) bgs. The thickest interval (25.3 m [83 ft]) of cesium-137 contamination (with a maximum concentration of 4,000 pCi/g) is east of the cribs (Borehole 299-E33-58), and the thinnest interval (8.8 m [29 ft]) of cesium-137 contamination (with a maximum concentration of 1,000 pCi/g) is west of the cribs (Borehole 299-E33-59). The maximum cesium-137 concentration south of C3103 is 4,000 pCi/g (Borehole 299-E33-60). At Borehole 299-E33-75 (18.3 m [60 ft] north of 216-B-7B), the maximum cesium-137 concentration is about 10,000 pCi/g, with the major contaminant zone beginning at 10.7 m (35 ft) bgs. Borehole 299-E33-18, about 23 m (75 ft) west of the 216-B-7A&B Cribs, does not appear to exhibit contamination from the cribs in the upper vadose zone. Uranium-235 and uranium-238 were detected northeast of C3103 from 12.5 to 16.2 m (41 to 53 ft) bgs at 299-E33-59.</td>
<td>No</td>
<td>None

However, the supplemental characterization SAP recommended installing drive points at 216-B-7A (two) and 216-B-7B (one) to 12 m (40 ft) bgs for geophysical logging to reduce the uncertainty associated with the extent and volume of plutonium released at these cribs (DOE/RL-2007-02-VOLII-ADD4, p. AD4 2-1). The maximum plutonium concentration detected at C3103 (216-B-7A) was 153,000 pCi/g in the sample from 18.5 to 21 ft bgs. Plutonium concentrations did not exceed 100,000 pCi/g in any other samples, including the samples from 6.9 m (22.5 ft) to 25 ft bgs and 25 to 27.5 ft bgs. The concentrations at 216-B-7B would not be expected to exceed the concentrations at 216-B-7A. Therefore, the plutonium concentrations are sufficiently characterized for remedy decisions.

For the 200-DV-1 OU, one DPT between 216-B-7A and 216-B-7B is recommended on the east side with sampling to look for contaminants, rather than implementing the three DPTs to 12 m (40 ft) with geophysical logging. The recommended DPT will be used to confirm the conceptual model that the vadose zone between about 15 m (50 ft) bgs and the CCU is relatively uncontaminated, as indicated by the chromium, fluoride, nitrate, and technetium-99 data from Borehole C3103, which was drilled near the center of 216-B-7A. Based on geophysical logging, the thickest zone of cesium-137 is east of 216-B-7A (b 299-E33-58) (GJO-2002-343-TAR, p. 26).</td>
</tr>
</table>

Table C-3. Required Information for Waste Site/Group 216-B-7A&B Cribs

216-B-7A&B				
Extent of contamination	2-2	Waste liquids disposed to the 216-B-7A&B Cribs reached groundwater soon after the start of disposal operations in 1946 and are currently a source for some of the contamination found in the CCU. The observed water-extractable fluoride and chromium in the CCU silt pore water, and chromium in the vicinity groundwater, support the conclusion that wastewater from 216-B-7A&B (and/or 216-B-8 Cribs and Tile Field) is present in the CCU silt. The uranium isotopic data suggest that 216-B-7A&B is not a significant contributor to uranium found in the groundwater (PNNL-19277, pp. 9.8 and 9.9). Elevated water-extractable fluoride is present at elevated concentrations in the CCU sediments at Wells 299-E33-344 and 299-E33-345 (PNNL-19277, p. 9.9). Cesium-137 contamination was detected at Boreholes 299-E33-75 to the north, 299-E33-58 to the east, and 299-E33-60 to the south (GJO-2002-343-TAR, p. 26). Based on these well locations, the lateral extent of contamination is about 32 m (105 ft) north-south and 25 m (82 ft) east-west. The gamma contamination in boreholes at 216-B-7A&B, 216-B-8, and 216-B-11A&B do not appear to correlate with depth; thus, it is unlikely that wastes from each facility have commingled in the vadose zone above the historical high water table (PNNL-19277, p. 3.80). The waste liquids are likely to be commingled in the CCU silt, which appears to act as an effective lateral spreading zone (p. 3.65).	No	The planned supplemental characterization, as modified by the recommendation described above, is needed to refine these estimates based on existing data and geophysical logging.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
CCU = Cold Creek unit
DPT = direct-push technology
DS = decision statement
OU = operable unit
PNNL = Pacific Northwest National Laboratory
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model

Table C-4. Required Information for Waste Site/Group 216-B-8 Crib and Tile Field and 200-E-45 Health Instruments Shaft

216-B-8 Crib and Tile Field and 200-E-45 Health Instruments (HI) Shaft				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 216-B-8 Crib is 3.7 m (12 ft) wide by 3.7 m (12 ft) long by about 2 m (7 ft) high. This wooden timbered crib was placed in an excavation that was 6.9 m (22.5 ft) deep. The inlet pipe entered the crib at 5 m (16 ft) bgs. The crib overflowed to the 216-B-8 Tile Field. The overflow pipe from the crib was 5.2 m (17 ft) bgs at the crib end of the tile field and about 3.7 m (12 ft) bgs at the far end of the tile field. A 30.5 cm (12 in.) diameter, vitrified clay central distribution pipe extends 91.5 m (300 ft) down the center of the tile field. Four pairs of 20 cm (8 in.) diameter, 21.4 m (70 ft) long lateral pipes join the central pipe at 45-degree angles on both sides of the central pipe. Based on the configuration of the lateral pipes, the tile field is 30.2 m (99 ft) wide. The center of the HI shaft is 6.4 m (20.9 ft) northwest of the center of the crib. The shaft is 2.4 m (8 ft) in diameter. The base of the shaft is 16.8 m (55 ft) bgs, underlain by 1.2 m (4 ft) of clay backfill. Steel laterals, 15.2 cm (6 in.) in diameter and 6.7 m (22 ft) long, were installed through holes in the wall of the shaft to collect samples from 3 m (10 ft) and 6 m (20 ft) beneath the crib. Openings in the tops of the laterals permitted liquid to enter and collect in sample cups (HW-55176, Part VI, Appendices C-11 and C-12; HW-17088, pp. 53-59; H-2-579). Historical drawings H-2-579, H-2-738, and H-2-2928 (ARH-1562, p. 72; additional drawings listed in BHI-00179, Table B-4; HW-55176, Part VI, Appendices C-11 and C-12). Historical photographs (BHI-00179, Table B-4). In 1992, the 216-B-8 Crib and 200-E-45 HI shaft were interim-stabilized with 46 cm (18 in.) of uncontaminated soil, and the 216-B-8 Tile Field was surface-decontaminated (WHC-SD-DD-TI-078, p. 18).	Yes	None
Waste inventory	1-1	The 216-B-8 Crib and Tile Field received the following waste streams (WHC-SD-WM-ER-575, pp. 11-12; HNF-5231, p. 15; HW-33591, Table 1; HW 17088, p. 56; ARH-1562, p. 72, RHO-CD-673 I.NE): **Waste Site** / **Service Dates** / **Waste Stream** 216-B-8 / 03/1948 to 05/1951 / 2C waste from the 221-B Building via blind riser in B Tank Farm, accessible via an over ground line; waste was discharged one month per year 05/1951 to 12/1951 / 2C waste from the 221-B Building via 110-111-112 Tank cascade 07/1951 to 12/1951 / 5-6 waste from the 221-B Building via 110-111-112 Tank cascade 12/1951 to 12/1952 / Decontamination waste from the 224-B Building The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-B-8 Crib and Tile Field was 35.3 million L (9.3 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **Analyte** / **Inventory (Mean Values)** Cesium-137 / 1.68E+02 Ci Stronium-90 / 1.46E+02 Ci	Yes	None

Table C-4. Required Information for Waste Site/Group 216-B-8 Crib and Tile Field and 200-E-45 Health Instruments Shaft

216-B-8 Crib and Tile Field and 200-E-45 Health Instruments (HI) Shaft				
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	GJO-2002-343-TAR summarizes geophysical logging results for 16 vadose zone boreholes and eight groundwater wells at the 216-B-8 site. Wells 299-E33-66, 299-E33-67, 299-E33-68, 299-E33-69, 299-E33-70, 299-E33-71, 299-E33-89, and 299-E33-16 are at the 216-B-8 Crib, and Wells 299-E33-79, 299-E33-73, 299-E33-74, 299-E33-81, 299-E33-82, 299-E33-15, and 299-E33-76 are at the 216-B-8 Tile Field. The maximum cesium-137 concentration in the upper 4.6 m (15 ft) was 300 pCi/g at 299-E33-73 in the tile field.	Yes	None
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-B-8 Crib and Tile Field and the 200-E-45 HI shaft. Geophysical logging will be used to determine the vertical extent of contamination in the upper 4.6 m (15 ft).	Yes	None
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following: **Analyte** — **Inventory (Mean Values)** Uranium (total) — 1.91E+02 kg Technetium-99 — 8.00E-02 Ci Iodine-129 — 2.67E-05 Ci Cobalt-60 — 8.72E-02 Ci Tritium — 1.32E-02 Ci Plutonium-239 — 1.26E+02 Ci Nitrate — 1.94E+06 kg Ferrocyanide — 0.00E+00 kg Fluoride — 1.05E+05 kg Chromium — 6.23E+03 kg In August 1948, sludge was inadvertently jetted to the 216-B-8 Tank from the 241-B-104 Tank (HW-17088, p. 59). The plutonium activity in the sludge was 990 µg/kg of sludge, about 1,000 times as high as the supernate. The fission products activity was 9,000 mCi/kg of sludge, about 5,000 times as high as the fission products in the supernate. Citric and hydrochloric acid were used to help clear the crib, but the results were not significantly successful. The tile field was therefore put into service receiving the overflow of waste liquids from the crib (HW-17088, p. 59). At some point in the late 1950s, the HI shaft was used to test repaired; contaminated B, BX, and BY Tank Farms pumps; and later, contaminated the sluicing pumps (WHC-EP-0560, p. 6-1). Water was likely added to the shaft to support the pump tests. This use continued intermittently through the early to mid-1970s. The facility has not been used since April 1973. In 1990, the liquid level in the shaft was measured at 1.5 m (4.9 ft). No sludge or equipment was observed in the shaft when the liquid level was measured.	Yes	It appears that the SIM did not include the inadvertent discharge of sludge from the 241-B-104 Tank to 216-B-8. Existing data (e.g., HW-17088 or data from the tank farm) will be used to re-create the likely sludge inventory.

Table C-4. Required Information for Waste Site/Group 216-B-8 Crib and Tile Field and 200-E-45 Health Instruments Shaft

216-B-8 Crib and Tile Field and 200-E-45 Health Instruments (HI) Shaft				
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	There are no vadose zone boreholes within the 216-B-8 Crib, and no sediment sample analyses from boreholes associated with the 216-B-8 Tile Field (PNNL-19277, p. 3.78). The base of the 216-B-8 Crib was 6.9 m (22.5 ft) bgs (HW-55176, Part VI, Appendix C-12; H-2-738). Samples (105 liquid, 4 sludge, and 7 sediment) were collected at depths of 3 m (10 ft) and 6 m (20 ft) beneath the bottom of the 216-B-8 Crib using access from the HI shaft (HW-17088, p. 58). The HI shaft was installed 6 m (20 ft) from the crib. Steel laterals 6.7 m (22 ft) long were installed from the shaft to beneath the crib. Openings in the tops of the laterals permitted liquid to enter and be collected in sample cups. Other holes were made in the shaft wall facing the crib so that sediment samples could be collected (HW-17088, p. 58). Liquid samples from 3 m (10 ft) and 6 m (20 ft) below the crib had about the same fission product activity (0.5 mCi/L) and showed no increase in activity during jetting from each tank, except when sludge from Tank 241-B-104 was inadvertently jetted to the crib in 1948 (HW-17088, p. 59). Some of the sludge was washed to a depth of at least 6 m (20 ft) beneath the crib, based on the small amount that was collected in the sample cups at that depth. Considerable sludge was obtained from the upper lateral cups, and some sludge was washed into the shaft (HW-17088, p. 59). Based on four sludge samples from the shaft, the beta activity of the sludge ranged from 4,900 to 9,000 mCi/L, and the alpha activity ranged from 50,000,000 to 90,000,000 dpm/L (HW-17088, p. 29, Table 2). The average alpha contamination of the supernate jetted to the crib was about 135,000 dpm/L. Sixty-four of the liquid samples obtained from the shaft laterals prior to the jetting of the sludge had less than 1,000 dpm/L alpha activity, and the average alpha activity of the other four samples was 17,500 dpm/L (based on 10 mL samples). Very little plutonium therefore penetrated to a depth greater than 3 m (10 ft) below the crib, except in the sludge. The horizontal spread of plutonium was probably not greater than 6 m (20 ft) from the disposal unit. The fission products activity decreased by a factor of 3.4 within 3 m (10 ft) of the bottom of the crib and showed no appreciable decrease within the next 3 m (10 ft) (HW-17088, p. 60). The sediments 5.5 m (18 ft) beneath the crib showed an increase in beta-gamma activity from 0.13 to 0.33 mCi/kg between the 1,930,000 and 5,090,000 L discharge of radioactive wastes. No alpha contamination was detected on the sediments (HW-17088, p. 60). GJO-2002-343-TAR summarizes geophysical logging results for boreholes at the 216-B-8 site. An interval of elevated cesium-137 contamination was detected from approximately 6 to 44.8 m (20 to 147 ft) bgs. The maximum concentration was about 150,000 pCi/g in Borehole 299-E33-67 at the 216-B-8 Crib. Borehole 299-E33-89 exhibits a major interval of cesium-137 contamination from about 6 m (20 ft) bgs to the bottom of the borehole at 44.2 m (145 ft) bgs (PNNL-19277, p. 3.78). Well 299-E33-16 is the deepest borehole in the vicinity of the crib and exhibits almost continuous cesium-137 contamination (but very low concentrations below 32 m [105 ft] bgs) down to the water table. Boreholes northeast of the crib but within the far end of the tile field exhibit only near-surface gamma contamination. The apparent horizontal spread of contamination in the vadose zone generally following the vadose zone stratigraphic dip (northeast). The horizontal spread reaches only about two-thirds the distance of the tile field and does not reach Well 299-E33-17 (about 90 m [295 ft] east of the crib) or Well 299-E33-15 at the northwest corner of the tile field (PNNL-19277, p. 3.78). Historical logs at Borehole 299-E33-16 show contamination probably entered the groundwater sometime prior to 1959 (GJO-2002-343-TAR, p. 29).	No	Analytical data are not available for the 216-B-8 site. The supplemental characterization SAP recommends one borehole to 21.4 m (70 ft) bgs between the 216-B-8 Crib and the HI shaft. For the 200-DV-1 OU, the supplemental investigation is recommended to be implemented as planned but that the DPT should be extended to the bottom of the contamination or to refusal. The deeper samples will be used to evaluate whether the 216-B-8 site is currently, or will be in the future, a source of uranium and/or chromium contamination to groundwater.
Extent of contamination	2-2	Based on gamma-logging data, the large volumes of liquids disposed to 216-B-8 and historical groundwater data, liquids discharged to 216-B-8 likely did reach groundwater no later than 1959. The time-series groundwater plume maps show that the 216-B-8 Crib is currently a continuing source of chromium, sodium, and likely nitrate contamination to the groundwater (PNNL-19277, p. 9.9). Based on the resistivity survey, the lateral extent of contamination is about 140 m (459 ft) north-south by 110 m (361 ft) east-west (RPP-34690, Figures 4-14 and 4-15). The gamma contamination in boreholes at 216-B-7A&B, 216-B-8, and 216-B-11A&B do not appear to correlate with depth; thus, it is unlikely that wastes from each facility have commingled in the vadose zone above the historical high water table (PNNL-19277, p. 3.80). RPP-34690 (pp. 4-13 to 4-19) provides results of surface resistivity surveys conducted in the vicinity of the 216-B-8 Crib and Tile Field. The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods. Results for the 216-B-8 Crib and Tile Field indicate an anomalous zone (low resistivity) at 30 m (98.4 ft) deep, It is unclear whether the north-south oriented anomalous zone at 30 m (98.4 ft) deep correlates with a buried utility or pipe or is associated with the 216-B-7A&B Cribs further to the south. At 50 m (164 ft) deep, the anomalous zone is a broader region of about 110 m (361 ft) east-west by 140 m (459 ft) north-south (including the 216-B-11 area). The base of the anomalous zone is estimated at about 60 m (197 ft) deep.	No	The planned supplemental characterization, as modified by the recommendations described above, is needed to refine these estimates based on geophysical logging and resistivity surveys.

Table C-4. Required Information for Waste Site/Group 216-B-8 Crib and Tile Field and 200-E-45 Health Instruments Shaft

216-B-8 Crib and Tile Field and 200-E-45 Health Instruments (HI) Shaft				
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

2C = second-cycle (waste)
bgs = below ground surface
dpm = disintegrations per minute
DPT = direct-push technology
DS = decision statement
HI = health instruments
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model

Table C-5. Required Information for Waste Site/Group 216-B-9 Crib and Tile Field

216-B-9				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 216-B-9 Crib is 4.3 m (14 ft) wide by 4.3 m (14 ft) long and 2 m (7 ft) high, placed in an excavation that was 5.2 m (17 ft) below the original ground surface. The inlet effluent pipe bypassed the 241-B-361 Settling Tank (which was nearly filled with sludge from use with the 216-B-5 Reverse Well) and entered the crib about 3 m (10 ft) bgs. The crib overflowed to the 216-B-9 Tile Field. The overflow pipe was about 3.7 m (12 ft) bgs at the crib end of the tile field and about 2.7 m (9 ft) bgs at the center of the tile field. A 15.2 cm (6 in.) diameter clay central distribution pipe extends 55 m (180 ft) down the center of the tile field. Three pairs of 18 m (60 ft) long lateral pipes join the central pipe at 45-degree angles on both sides of the central pipe. The eastern laterals were installed downstream one pipe length from the opposite western laterals. Based on the configuration of the lateral pipes, the tile field is 26 m (85 ft) wide (HW-33305, p. 9; H-2-1031; H-2-1123; HW-17088, p. 48). Historical drawings H-2-103 and H-2-1123 (ARH-1562, p. 73; additional drawings listed in BHI-00179, Table B-5; HW-55176, Part VI, Appendices C-13 and C-14). Historical photographs (BHI-00179, Table B-5). The crib and tile field was covered with 0.61 m (2 ft) of clean fill in 1991. The area was planted with rye grass in 1992 (WIDS).	Yes	None

Table C-5. Required Information for Waste Site/Group 216-B-9 Crib and Tile Field

<table>
<tr><th colspan="6">216-B-9</th></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The 216-B-9 Crib and Tile Field received the following waste stream (HW-17088, pp. 48-52; RHO-CD-673 I.NE; ARH-1562, p. 73; HW-28121, Table 3; HW-33591, Table 1):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td>216-B-9</td><td>08/1948 to 07/1951</td><td>Tank 5-6 waste from the 221-B Building</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-B-9 Crib and Tile Field was 36.0 million L (9.5 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>1.24E+01 Ci</td></tr>
<tr><td>Strontium-90</td><td>1.07E+01 Ci</td></tr>
</table>
The 216-B-9 Crib was used as a combination settling tank and crib. Sludge in the wastes rapidly decreased the capacity of the crib, and acid was added to the unit to keep it in operation. Eventually the crib became sealed with sludge, and overflow into the tile field began in November 1948 after about 4 million L of waste had been discharged to the crib (HW-17088, pp. 48-49).</td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>Four test holes for checking the drainage of the tile field were drilled in October 1948 and bottomed at the same elevation as the tile field (HW-17088, p. 49). The test holes were 2.7 m (9 ft) deep. Test holes 1 and 2 are on the west and east sides, respectively, of the central distribution pipe, closer to the southern end of the tile field (i.e., closer to the crib). Test holes 3 and 4 are on the east and west sides, respectively, of the central distribution pipe, closer to the northern end of the tile field (i.e., further from the crib). The nearest borehole to each test hole is as follows:
<table>
<tr><th>Test Hole</th><th>Borehole</th></tr>
<tr><td>1</td><td>299-E28-57</td></tr>
<tr><td>2</td><td>299-E28-56</td></tr>
<tr><td>3</td><td>299-E28-56 and 299-E28-58</td></tr>
<tr><td>4</td><td>299-E28-57 and 299-E28-59</td></tr>
</table>
From the initial sampling in January 1949 to January 1950, a total of 59 sediment samples and 12 liquid samples were obtained from the test holes and analyzed for contamination (HW-17088, p. 52).
Liquid or radioactivity were not found in the test holes until April 1949, at which time 18 cm (7 in.) of liquid was found in test hole 2 (HW-17088, p. 50). A sample of this liquid contained 11.5 mCi/L of fission products and 9,000 dpm/L of alpha activity. Liquid was found in test hole 2 at all inspections between April 1949 and October 6, 1949. The maximum fission products and alpha activity of the liquid was 51 mCi/L and 12,400 dpm/L, respectively. A sediment sample collected at test hole 2 on October 20, 1949, when it was dry, had 152 mCi/kg of fission products and 943,000 dpm/kg of alpha activity (HW-17088, p. 50).
Liquid was found in test hole 1 one time in May 1949. A sample of the liquid contained 1.3 mCi/L of fission product activity and 2,200 dpm/L of alpha activity. The maximum fission products and alpha contamination in sediment samples from test hole 1 was 1.2 mCi/kg and 35,400 dpm/kg, respectively (HW-17088, p. 50).
Fission products contamination in the sediments from test holes 3 and 4, which are 46 m (150 ft) downstream from the crib, was less than 1.0 mCi/L (HW-17088, p. 50).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-5. Required Information for Waste Site/Group 216-B-9 Crib and Tile Field

216-B-9				
		GJO-2002-358-TAC summarizes geophysical logging results for Wells 299-E28-53, 299-E28-54, 299-E28-55, and 299-E28-61 at the corners of the 216-B-9 Crib; Wells 299-E28-62, 299-E28-57, 299-E28-67, 299-E28-68, 299-E28-56, and 299-E28-50 in the center of the 216-B-9 Tile Field; and Wells 299-E28-59, 299-E28-60, and 299-E28-58 at the further downstream (north) end of the 216-B-9 Tile Field. The highest cesium-137 concentration detected in the upper 4.6 m (15 ft) was about 20,000 pCi/g in Well 299-E28-53 at the southeast corner of the crib. The maximum cesium-137 concentration in the tile field was about 7,000 pCi/g at 3.7 m (12 ft) bgs in Well 299-E28-57 on the west side of the tile field. Uranium-238 was detected at 4.6 m (15 ft) bgs at an activity of 13.7 pCi/g at Well 299-E28-56. U-235 was detected at 2.9 m (9.5 ft) bgs at a concentration of about 1 pCi/g at Well 299-E28-59.		
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-B-9 Crib and Tile Field. Geophysical logging will be used to determine the vertical extent of contamination in the upper 4.6 m (15 ft).	Yes	None
PSQ #:2 Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following: **Analyte** — **Inventory (Mean Values)** Uranium (total) — 1.23E+01 kg Technetium-99 — 5.74E-03 Ci Iodine-129 — 1.32E-06 Ci Cobalt-60 — 7.59E-03 Ci Tritium — 1.68E-03 Ci Plutonium-239 — 8.08E+00 Ci Nitrate — 1.71E+05 kg Ferrocyanide — 0.00E+00 kg Fluoride — 9.53E+03 kg Chromium — 6.40E+02 kg	Yes	None

Table C-5. Required Information for Waste Site/Group 216-B-9 Crib and Tile Field

<table>
<tr><th colspan="6">216-B-9</th></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>Nine 46 m (150 ft) deep test wells were drilled near the crib and in the tile field in 1948 prior to initiation of waste discharges to the site.
<table>
<tr><th>Well Name</th><th>Well ID</th><th>Original Name</th></tr>
<tr><td>299-E28-53</td><td>A6804</td><td>361-B-13</td></tr>
<tr><td>299-E28-54</td><td>A6805</td><td>361-B-14</td></tr>
<tr><td>299-E28-55</td><td>A6806</td><td>361-B-15</td></tr>
<tr><td>299-E28-56</td><td>A6807</td><td>361-B-16</td></tr>
<tr><td>299-E28-57</td><td>A6808</td><td>361-B-17</td></tr>
<tr><td>299-E28-58</td><td>A6809</td><td>361-B-18</td></tr>
<tr><td>299-E28-59</td><td>A6810</td><td>361-B-19</td></tr>
<tr><td>299-E28-60</td><td>A6811</td><td>361-B-20</td></tr>
<tr><td>299-E28-61</td><td>A6812</td><td>361-B-12</td></tr>
</table>
Well 299-E28-53, located 3.9 m (12.7 ft) from the center of the crib, was drilled at an angle of 85 degrees toward the center and bottomed directly beneath the crib (HW-17088, p. 49). This well was found filled with sediments to within 7.3 m (24 ft) of the surface in April 1949. Acid used to clear sludge from the crib corroded the casing and permitted wastes discharged to the crib to wash sediments into the well. A sample of the sediment from this well had 1,830 mCi/kg of fission products and 14,800,000 dpm/kg of alpha contamination (HW-17088, p. 51).
The observation that the well casing was corroded and filled with sediments implied that some waste liquids had been introduced into the subsurface at a depth of 46 m (150 ft) (i.e., through the bottom of the well), or within 46 m (150 ft) of the water table. No evidence had been found as of January 1950 from Groundwater Wells 299-E28-1, 299-E28-2, 299-E28-5, and 299-E28-7 that the waste had reached groundwater (HW-17088, p. 52).
Sediment samples obtained in October 1949 from the bottom of all of the 46 m (150 ft) deep wells, except 299-E28-53 showed no significant alpha or beta-gamma contamination at that depth (HW-17088, p. 52).
GJO-2002-358-TAC summarizes geophysical logging results for Wells 299-E28-53, 299-E28-54, 299-E28-55, and 299-E28-61 at the corners of the 216-B-9 Crib; Wells 299-E28-62, 299-E28-57, 299-E28-67, 299-E28-68, 299-E28-56, and 299-E28-50 in the center of the 216-B-9 Tile Field; and Wells 299-E28-59, 299-E28-60, and 299-E28-58 at the downstream (north) end of the 216-B-9 Tile Field. The highest cesium-137 concentration detected was about 84,000 pCi/g at 6 m (20 ft) bgs in Well 299-E28-53 at the southeast corner of the crib. The maximum cesium-137 concentration in the tile field below 4.6 m (15 ft) ranged from 1,000 to 4,000 pCi/g from 6.9 m (22.5 ft) to 8.7 m (28.5 ft) bgs at Well 299-E28-57 on the west side of the tile field.
The 2002 spectral gamma logging detected uranium-235 and uranium-238 at activities near their minimal detectable levels. At the 216-B-9 Crib, the maximum concentration of uranium-235 was 1.7 pCi/g detected at 11.4 m (37.5 ft) bgs in Well 299-E28-61. Uranium-238 was detected with a concentration of about 17 pCi/g at 17 m (56.5 ft) and 20 to 20.1 m (65.5 to 66 ft) bgs in Well 299-E28-54. At the 216-B-9 Tile Field, the maximum uranium-235 concentration was 2 pCi/g detected at 5.6 to 5.8 m (18.5 to 19 ft) bgs in Well 299-E28-57. The maximum uranium-238 concentration was 29 pCi/g detected at the location.
The supplemental characterization SAP concludes that sufficient information is available for 216-B-9.</td><td>No</td><td>For the 200-DV-1 OU, two DPTs are recommended: one near Well 299-E28-57 (location of the deepest contamination recognized on any of the scintillation probe profiles), and one near Well 299-E28-53 (where corroded Well 299-E28-53 may have provided a preferential pathway). The DPTs would be pushed to refusal, and samples would be analyzed for contaminants.</td></tr>
<tr><td>Extent of contamination</td><td>2-2</td><td>The zone of soil with cesium-137 contamination greater than 100 pCi/g trends from the 216-B-9 Crib northwest to Well 299-E28-57.
Well 299-E28-57 is located in the thickest area of contaminated soil. The waste liquids from the crib may have migrated along a sedimentary contact (Hanford formation H1/H2 contact) or may have been discharged primarily to the tile field lateral immediately south of Well 299-E28-57.
The maximum extent of the vadose zone contamination is unknown west of the crib and tile field and south of the crib (GJO-2002-358-TAC, pp. 27-28, 31).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-5. Required Information for Waste Site/Group 216-B-9 Crib and Tile Field

216-B-9				
		Evaluation of the 1963 scintillation probe profiles and the 2002 spectral gamma logging results suggests that contaminants from the 216-B-9 Crib and Tile Field did not break through to groundwater. The deepest contamination recognized on any of the scintillation probe profiles was 43 m (141 ft) on the 1963 profile of Well 299-E28-58. The contamination profiles indicate that significant site-related contamination generally is not detected below 18.3 m (60 ft) from the ground surface (GJO-2002-358-TAC, p. 32). The lateral extent of contamination, based on the area stabilized in 1991, is about 75 m (246 ft) north-south by 30 m (98.4 ft) east-west. The vertical extent of contamination, based on this 1963 gross gamma logging, is 43 m (141 ft). However, waste liquids may have migrated deeper than 46 m (150 ft) if the corroded Well 299-E28-53 provided a preferential pathway.		
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
dpm = disintegrations per minute
DPT = direct-push technology
DS = decision statement
ID = identification
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model
WIDS = Waste Information Data System

Table C-6. Required Information for Waste Site/Group 216-B-11A&B French Drains

216-B-11A&B				
PSQ #1 Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1 – Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2 – For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 216-B-11A and 216-B-11B French Drains are 1.2 m (4 ft) diameter, 9 m (30 ft) long corrugated culverts placed vertically in 2.4 m (8 ft) diameter holes. The tops of the culverts were 3 m (10 ft) bgs during operations. The corrugated culverts were perforated with 1.3 cm (0.5 in.) holes 15.2 cm (6 in.) off-center horizontally and 30.5 cm (12 in.) off-center vertically starting 15.2 cm (6 in.) from the bottom. The excavation was backfilled. The centers of the two culverts are 18.3 m (60 ft) apart. Waste from the southern 216-B-11A overflowed to northern 216-B-11B (HW-55176, Part VI, Appendices C-17 and C-18; RHO-CD-673 I.NE). Historical drawings H-2-2021 and H-2-2024 (ARH-1562, pp. 77-78; additional drawings listed in BHI-00179, Table B-4; HW-55176, Part VI, Appendices C-17 and C-18). Historical photographs (BHI-00179, Table B-4). In 1992, an area of contaminated soil from UPR-200-E-144 was removed and consolidated into a spoil pile covering the 216-B-11A&B French Drains. The maximum depth of the contaminated soil was about 3 m (10 ft). About 46 cm (18 in.) to 61 cm (24 in.) of uncontaminated soil was placed over the contaminated soil (WHC-SD-DD-TI-078, p. 18).	Yes	None

Table C-6. Required Information for Waste Site/Group 216-B-11A&B French Drains

216-B-11A&B				
Waste inventory	1-1	The 216-B-11A&B French Drains received the following waste streams (WHC-SD-WM-ER-575, p. 12; HNF-5231, p. 15; ARH-1562, p. 77; RHO-CD-673 I.NE): **Waste Site** / **Service Dates** / **Waste Stream** 216-B-11A&B / 12/1951 to 12/1954 / Condensate from evaporation of 1C waste in the 242-B waste evaporator The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-B-11A&B French Drains was 29.6 million L (7.8 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **Analyte** / **Inventory (Mean Values)** Cesium-137 / 9.66E+00 Ci Strontium-90 / 3.04E+00 Ci	Yes	None
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	The 216-B-11A&B French Drains are metal culverts that are 9 m (30 ft) long and buried vertically from 3 m (10 ft) to 12 m (40 ft) bgs. They are perforated with 1.3 cm (0.5 in.) holes (15.2 cm [6 in.] on center horizontally and 30.5 cm [12 in.] on center vertically) along the entire length of the culvert. There are no data from within the footprint of the culverts. GJO-2002-343-TAR summarizes geophysical logging results for nearby Wells 299-E33-19, located about 4.6 m (15 ft) northwest of the 216-B-11B site, and 299-E33-20, located about 4.6 m (15 ft) southwest of the 216-B-11A site. The highest cesium-137 concentration detected in the upper 4.6 m (15 ft) at Well 299-E33-19 was 90 pCi/g at 3.1 m (10.2 ft) bgs. The highest cesium-137 concentration detected in the upper 4.6 m (15 ft) at Well 299-E33-20 was 40 pCi/g at 1.5 m (5 ft) ft bgs (GJO-2002-343-TAR). The shallow contamination above the tops of the French drains is likely from UPR-E-144, an area of contaminated soil that was removed, consolidated into a spoil pile overlying 216-B-11A&B, and covered with uncontaminated soil. This contamination is cesium-137 and is generally on the order of 10 pCi/g with a profile 1.5 to 3 m (5 to 10 ft) thickness (GJO-2002-343-TAR, p. 27).	Yes	None
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-B-11A&B French Drains. Geophysical logging will be used to determine the vertical extent of contamination in the upper 4.6 m (15 ft).	Yes	None

Table C-6. Required Information for Waste Site/Group 216-B-11A&B French Drains

<table>
<tr><th colspan="5">216-B-11A&B</th></tr>
<tr><td colspan="5">PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Waste inventory</td><td>2-1</td><td>The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:
<table>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Uranium (total)</td><td>4.21E-02 kg</td></tr>
<tr><td>Technetium-99</td><td>3.25E-03 Ci</td></tr>
<tr><td>Iodine-129</td><td>4.54E-06 Ci</td></tr>
<tr><td>Cobalt-60</td><td>3.12E-04 Ci</td></tr>
<tr><td>Tritium</td><td>1.59E+01 Ci</td></tr>
<tr><td>Plutonium-239</td><td>6.61E-03 Ci</td></tr>
<tr><td>Nitrate</td><td>2.45E+02 kg</td></tr>
<tr><td>Ferrocyanide</td><td>0.00E+00 kg</td></tr>
<tr><td>Fluoride</td><td>3.60E+00 kg</td></tr>
<tr><td>Chromium</td><td>4.72E-01 kg</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>There have been no vadose zone sediment characterization studies within or close to the 216-B-11A&B French Drains (PNNL-19277, p. 3.81).
GJO-2002-343-TAR summarizes geophysical logging results for Wells E33-19 and E33-20 at the 216-B-11-A&B site. Thin zones of cesium-137 contamination were detected at 32 m (105 ft) bgs (10 pCi/g) and 26 m (85 ft) bgs (40 pCi/g) in Wells 299-E33-19 and 299-E33-20, respectively. Cesium-137 was detected intermittently between 56.7 and 59.2 m (186 and 194 ft) bgs in Well 299-E33-20. Both boreholes indicate cesium-137 contamination just above the current groundwater level. Cobalt-60 was detected at intermittent depth intervals between approximately 35.4 and 40 m (116 and 130 ft) bgs in Well 299-E33-19 and 67 m (221 ft) bgs in Well 299-E33-20. Both boreholes indicate minor amounts of cobalt-60 contamination just above the current groundwater level.
On the basis of historical logs from Well 299-E33-20, contamination introduced to the 216-B-11A French Drain may have entered the groundwater prior to 1959. The contamination is not as extensive in Well 299-E33-19. The majority of the contamination likely entered the 216-B-11A French Drain (GJO-2002-343-TAR, p. 28; PNNL-19277, p. 3.81). The currently observed low concentrations of cobalt-60 and cesium-137 right above the water table in Well 299-E33-19 are likely adsorbed contaminants inside the rusted borehole casing and not indicative of current groundwater (PNNL-19277, p. 3.82).
The supplemental characterization SAP concludes that sufficient information is available for 216-B-11A&B.</td><td>Yes</td><td>None</td></tr>
</table>

Table C-6. Required Information for Waste Site/Group 216-B-11A&B French Drains

216-B-11A&B				
Extent of contamination	2-2	The 216-B-11A&B French Drains likely had an impact on groundwater in the past, but based on the low inventory of key contaminants (uranium and technetium-99) is not considered a current or future source of significant contamination to groundwater (PNNL-19277, p. 3.82). The gamma contamination in boreholes at 216-B-7A&B, 216-B-8, and 216-B-11A&B do not appear to correlate with depth; thus, it is unlikely that wastes from each facility have commingled in the vadose zone above the historical high water table (PNNL-19277, p. 3.80). The waste liquids are likely to be commingled in the CCU silt, which appears to act as an effective lateral spreading zone (PNNL-19277, p. 3.65). RPP-34690 (pp. 4-13 to 4-19) provides results of surface resistivity surveys conducted in the vicinity of the 216-B-11A&B French Drains. The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods. Results for the 216-B-11A&B French Drains indicate an anomalous zone (low resistivity) at 30 m (98.4 ft) deep. At 50 m (164 ft) deep, the anomalous zone is a broader region of about 110 m (361 ft) east-west by 140 m (459 ft) north-south (including the 216-B-8 area). The depth slice at 50 m (164 ft) suggests northwest movement from the north side of 216-B-11B. The base of the anomalous zone is estimated at about 60 m (197 ft) deep.	Yes	None
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

1C = first-cycle (waste)
bgs = below ground surface
CCU = Cold Creek unit
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model

Table C-7. Required Information for Waste Site/Group BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42 Trenches)

BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, and 216-B-41, 216-B-42)				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Physical layout	1-1, 1-2	The bases of the BX Trenches were 3 m (10 ft) wide, 3 m (10 ft) deep, and 77 m (252 ft) long. The centerline of the 216-B-36 Trench is 15 m (50 ft) north of the centerline of the 216-B-35 Trench; the spacing between the centerlines of the 216-B-36 through 216-B-40 Trenches is 27.5 m (90 ft). The centerline of the 216-B-41 Trench is 33.5 m (110 ft) north of the centerline of the 216-B-40 Trench. The eastern edge of the 216-B-42 Trench excavation is 15 m (50 ft) west of the western edge of the 216-B-35 Trench excavation (ARH-1562, pp. 103-110; HW-55176, Part VI, Appendices C-31 and C-32; SK-2-2408; RHO-CD-673 I.NW). Historical drawings H-2-2431 and SK-2-2408 (ARH-1562, pp. 103-110; additional drawings listed in BHI-00179, Table B-3; HW-55176, Part VI, Appendices C-31 and C-32). Historical photographs (BHI-00179, Table B-3; BHI-01607, Appendix C). When each trench reached specific retention capacity, the aboveground piping was removed and the trench was backfilled (ARH-1562, pp. 103-110; RHO-CD-673 I.NW). The BX Trenches were stabilized in 1982 with 0.61 m (2 ft) of topsoil (0200X-CA-V0007, p. 9).	Yes	None

Table C-7. Required Information for Waste Site/Group BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42 Trenches)

<table>
<tr><th colspan="6">BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, and 216-B-41, 216-B-42)</th></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The BX Trenches received the following waste streams (HNF-5231, Appendices 5 and 6; HW-38562; ARH-1562, pp. 103-110; RHO-CD-673 I.NW):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td>216-B-35</td><td>02/1954 to 02/1954</td><td>1C supernate from the 221-B Building via the 241-BX-110 Tank</td></tr>
<tr><td>216-B-36</td><td>04/1954 to 04/1954</td><td>1C supernate from the 221-B Building via the 241-BX-111 Tank</td></tr>
<tr><td>216-B-37</td><td>08/1954 to 09/1954</td><td>1C evaporator bottoms from the 242-B Building via the 241-B-107, -108, and -109 Tanks</td></tr>
<tr><td>216-B-38</td><td>07/1954 to 07/1954</td><td>1C supernate from the 221-B Building via the 241-BY-110 Tank</td></tr>
<tr><td>216-B-39</td><td>12/1953 to 10/1954</td><td>1C supernate from the 221-B Building via the 241-BX-112 Tank (12/1953) and 241-BY-106 Tank (10/1954)</td></tr>
<tr><td>216-B-40</td><td>08/1954 to 11/1954</td><td>1C supernate from the 221-B Building via the 241-BY-110 Tank (08/1954) and 241-BY-106 Tank (11/1954)</td></tr>
<tr><td>216-B-41</td><td>10/1954 to 10/1954</td><td>1C supernate from the 221-B Building via the 241-BY-106 Tank</td></tr>
<tr><td>216-B-42</td><td>02/1955 to 02/1955</td><td>Scavenged tributyl phosphate waste from the 221-U Building, batch 4</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-BX Trenches was 14.9 million L (3.9 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>6.17E+03 Ci</td></tr>
<tr><td>Strontium-90</td><td>1.16E+03 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>At the 216-B-38 Trench, Borehole C3104 was drilled in 2001 to the water table and sampled at four intervals in the upper 4.6 m (15 ft): 0 to 0.2 m (0 to 0.5 ft), 1 to 1.5 m (3.5 to 5 ft), 2.9 to 3.7 m (9.5 to 12 ft), and 4.4 to 4.7 m (14.5 to 15.5 ft). DOE/RL-2002-42 provides analytical data for Borehole C3104. The maximum soil concentration from C3104 for cesium-137 was 226,000 pCi/g in the sample from 4.4 to 4.7 m (14.5 to 15.5 ft).
BHI-01607 provides borehole geophysical logging results for the 216-B-38 Trench (C3104, plus five push locations). GJO-2002-322-TAR summarizes geophysical logging results for BX Trenches. The maximum concentration of cesium-137 in the upper 4.6 m (15 ft) was about 10,000 pCi/g at the east end of the 216-B-38 Trench.</td><td>Yes</td><td>None</td></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the trenches. Geophysical logging and the analytical results from C3104 is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-7. Required Information for Waste Site/Group BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42 Trenches)

BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, and 216-B-41, 216-B-42)				
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following: **Analyte** — **Inventory (Mean Values)** Uranium (total) — 5.04 E+02 kg Technetium-99 — 8.40 E+00 Ci Iodine-129 — 3.09 E-02 Ci Cobalt-60 — 4.53 E+00 Ci Tritium — 9.09E+01 Ci Plutonium-239 — 6.60E+00 Ci Nitrate — 1.73E+06 kg Fluoride — 5.62E+04 kg Ferrocyanide — 0.00E+00 kg Chromium — 5.05E+03 kg	Yes	None

Table C-7. Required Information for Waste Site/Group BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, 216-B-41, and 216-B-42 Trenches)

<table>
<tr><th colspan="6">BX Trenches (216-B-35, 216-B-36, 216-B-37, 216-B-38, 216-B-39, 216-B-40, and 216-B-41, 216-B-42)</th></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>At the 216-B-38 Trench, Borehole C3104 was drilled in 2001 to the water table and sampled at 10 intervals between 1.4 and 80.8 m (4.5 and 265 ft). DOE/RL-2002-42 and PNNL-14128 provide analytical data for Borehole C3104. The maximum soil concentrations from C3104 (DOE/RL-2002-42) were as follows:
<table>
<tr><th>Analyte</th><th>Maximum Concentration</th><th>Depth bgs (m [ft])</th></tr>
<tr><td>Uranium (total)</td><td>32,500 µg/kg</td><td>5.5 to 6.2 [18 to 20.5]</td></tr>
<tr><td>Technetium-99</td><td>1.93(J) pCi/g</td><td>15.8 to 16.6 [52 to 54.5]</td></tr>
<tr><td>Iodine-129</td><td>Not analyzed</td><td></td></tr>
<tr><td>Cobalt-60</td><td>0.06 pCi/g</td><td>15.8 to 16.6 [52 to 54.5]</td></tr>
<tr><td>Tritium</td><td>29 pCi/g</td><td>15.8 to 16.6 [52 to 54.5]</td></tr>
<tr><td>Nitrate</td><td>3,180,000 µg/kg</td><td>45.0 to 45.7 [147.5 to 150]</td></tr>
<tr><td>Fluoride</td><td>33,400(B) µg/kg</td><td>8.8 to 9.6 [29 to 31.5]</td></tr>
<tr><td>Cyanide</td><td>420 µg/kg</td><td>6.7 to 7.8 [22 to 25.5]</td></tr>
<tr><td>Chromium (total)</td><td>14.5 mg/kg</td><td>45.0 to 45.7 [147.5 to 150]</td></tr>
</table>
BHI-01607 provides borehole geophysical logging results for the 216-B-38 Trench (C3104, plus five push locations). GJO-2002-322-TAR summarizes geophysical logging results for 11 vadose zone boreholes and three groundwater wells in the vicinity of the BX Trenches. The only gamma-emitting radionuclides detected were cesium-137, cobalt-60, and antimony-125. Activities of cesium-137 exceeding 1,000 pCi/g were generally detected between 3.7 and 16.8 m (12 and 55 ft) bgs, with the highest activities (greater than 10,000 pCi/g) about 7 m (23 ft) below the bases of the trenches. The maximum cesium-137 activity detected was about 20,000 pCi/g at 5 m (16.5 ft) bgs at the east end of the 216-B-38 Trench. Cobalt-60 was detected in the interval from 9 to 22 m (30 to 72 ft) at activities ranging from 0.1 to 0.6 pCi/g.

RPP-34690 (pp. 4-4 to 4-13) summarizes the surface geophysics for the BX Trenches. The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods. Observed anomalous zones (low-resistivity) are spatially consistent with the trenches for both the 30 and 50 m (98.4 and 164 ft) deep slices. The maximum extent is about 200 m (656 ft) north-south by about 130 m (426.5 ft) east-west. The anomalous zone narrows with depth and remains centered beneath the trench locations. The top of the anomalous zone occurs at about 20 m (65.6 ft) deep and the base is estimated at about 60 m (197 ft) deep.</td><td>No</td><td>The supplemental characterization SAP recommended a deep borehole at the 216-B-42 Trench with nine sampling intervals and geophysical logging. For the 200-DV-1 OU, implementing is recommended as planned.
The drilled borehole is recommended for 216-B-42 because 216-B-42 received a higher inventory of technetium-99 than the other BX Trenches. Drilling will ensure that the vertical extent of the technetium-99 contamination in the vadose zone at this location is characterized.

The 216-B-37 Trench received the largest disposal volume of all the BX Trenches. Also, the 216-B-37 Trench received a different waste stream than any of the other BX Trenches or BY Cribs. Based on the drilling at the 216-B-38 Trench, contaminants have not reached the groundwater (PNNL-19277, Section 3.2.3). For the 200-DV-1 OU, a direct-push borehole is recommended through the 216-B-37 Trench, with sampling for contaminants, to evaluate this conceptual model. Characterization of the 216-B-37 Trench was recommended by PNNL-19277 and GJO-2002-322-TAR. Because all of the BX Trenches were of similar construction and received relatively similar inventories, the data from 216-B-42 and 216-B-37, and the existing characterization data will be sufficient for a remedy decision for BX Trenches.</td></tr>
<tr><td>Extent of contamination</td><td>2-2</td><td>Based on the resistivity survey, the lateral extent of contamination is about 200 m (656 ft) north-south by 130 m (426.5 ft) east-west (RPP-34690, Figure 4-8). The vertical extent of contamination, based on the distribution of nitrate, is about 46 m (150 ft) and no deeper than 55 m (180 ft) (PNNL-19277, Figure 3.28). The available data indicate that the BX Trench wastes have not reached groundwater, based on the 216-B-38 Trench data (PNNL-19277, Section 3.2.3).</td><td>No</td><td>The planned supplemental characterization, as modified by the recommendations described above, is needed to refine these estimates based on existing data and geophysical logging.</td></tr>
<tr><td>Contaminant fate and transport parameters</td><td>2-1, 2-2</td><td>The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).</td><td>Yes</td><td>None</td></tr>
</table>

Note: The references cited in this table are included in the References section of this appendix.

IC = first-cycle (waste)
bgs = below ground surface
DS = decision statement
OU = operable unit
PSQ = principal study question
SIM = Soil Inventory Model

Table C-8. Required Information for Waste Site/Group BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs)

216-BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)

PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?

DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.

DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.

Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The BY Cribs consist of eight individual cribs arranged in two north-south rows of four cribs each. The base of the excavation for each crib was 9 m (30 ft) wide by 9 m (30 ft) long and about 4.6 m (15 ft) below the original ground surface. The excavation was backfilled with a 1.5 m (5 ft) layer of gravel into which four 122 cm (48 in.) diameter, 1.2 m (4 ft) long concrete culvert pipes were embedded vertically in a 4.6 m (15 ft) square pattern. Additional gravel was added to the tops of the culvert pipes. The excavation was backfilled to grade with existing material. Each crib was fed by a 35.6 cm (14 in.) diameter steel pipe, with a 20 cm (8 in.) diameter steel pipe in a chevron pattern feeding each culvert pipe. The pipe to each crib connects to a 35.6 cm (14 in.) diameter steel pipe running south from the 216-BY-201 Flush Tank. Valves were provided to isolate each crib (WHC-SD-WM-ER-575, pp. 12-14; HW-55176, Part VI, Appendix C-33; RHO-CD-673 I.NW). Historical drawings H-2-2603 and H-2-2605 (ARH-1562, pp. 111-118; additional drawings listed in BHI-00179, Table B-1; HW-55176, Part VI, Appendix C-33). Historical photographs (BHI-00179, Table B-1). In 1955, waste liquids overflowed from the 216-BY-201 Flush Tank associated with the BY Cribs (UPR-200-E-9). Most of the contaminated soil was excavated and placed in a shallow pit south of the 216-B-43 Crib and covered with 0.61 m (2 ft) of clean soil. The remaining contaminated area near the flush tank was reported to be covered with 3 m (10 ft) of clean soil (BHI-00179, p. 3-9). In 1991, an area of contaminated soil from UPR-200-E-89 was removed. Some of the contaminated soil was placed in the low area in the center of the BY Cribs. About 46 cm (18 in.) to 61 cm (24 in.) of uncontaminated soil was placed over the contaminated soil (WHC-SD-DD-TI-064, p. 14). During characterization for the 200-BP-1 OU remedial investigation in 1991 and 1992, the depths to the crib tops and bottoms were observed during drilling activities. The tops of the cribs (top of infiltration gravel) were generally encountered from about 3 to 4.3 m (10 to 14 ft) bgs. The gravels averaged 2.1 m (6.8 ft) thick. The crib depths observed during drilling are generally 0.61 to 2 m (2 to 6 ft) deeper than suggested in the drawings. This may be due, at least in part, to the interim stabilization activities that were performed for the UPR-200-E-89 (also known as UN-200-E-89) unplanned release (DOE/RL-92-70, p. 3-2, Table 2-2).	Yes	None
Waste inventory	1-1	The BY Cribs received the following waste streams (WHC-SD-WM-ER-575, pp. 12-14; HNF-5231, Appendix 6; ARH-1562, pp. 111-118; RHO-CD-673 I.NW):	Yes	None

Waste Site	Service Dates	Waste Stream
216-B-43	11/1954 to 11/1954	Scavenged TBP waste from the 221-U Building, batch 1
216-B-44	12/1954 to 03/1955	Scavenged TBP waste from the 221-U Building, batch 2, 3, 5
216-B-45	04/1955 to 06/1955	Scavenged TBP waste from the 221-U Building, batch 7, 10
216-B-46	08/1955 to 12/1955	Scavenged TBP waste from the 221-U Building, batch 13, 16, 20
216-B-47	09/1955 to 09/1955	Scavenged TBP waste from the 221-U Building, batch 14, 15
216-B-48	11/1955 to 11/1955	Scavenged TBP waste from the 221-U Building, batch 11, 17
216-B-49	11/1955 to 12/1955	Scavenged TBP waste from the 221-U Building, batch 12, 18, 19
216-B-50	01/1965 to 01/1974	Waste storage tank condensate from the ITS 1 unit

Table C-8. Required Information for Waste Site/Group BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs)

216-BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)				
		The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the BY Cribs was 33.8 million L (8.9 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **Analyte** — **Inventory (Mean Values)** Cesium-137 — 1.68E+03 Ci Strontium-90 — 4.74E+03 Ci		
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	During the remedial investigation of the 200-BP-1 OU, three boreholes were drilled through each of the BY Cribs to about 9 m (30 ft) bgs (DOE/RL-92-70, pp. 2-2, 4-25). The maximum detected concentrations of cesium-137 and strontium-90 from samples in the upper 4.6 m (15 ft) were 5.59 and 13 pCi/g, respectively (DOE/RL-92-70, Table 4-16). GJO-2003-458-TAC summarizes geophysical logging results for wells at the BY Cribs. The highest cesium-137 concentration detected in the upper 4.6 m (15 ft) at wells drilled through the cribs was about 10,000 pCi/g. Well 299-E33-22, located about 5 m (16 ft) south of the 216-B-45 Crib, had relatively high cesium-137 concentrations (about 50,000 to 2,500,000 pCi/g) at depths from 1.5 to 3 m (5 ft to 10 ft) bgs. This contamination may have been placed at this location from removal of contaminated soil from UPR-200-E-89 or UPR-200-E-9 (GJO-2003-458-TAC, p. 23).	Yes	None
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the BY Cribs. Soil sample results and geophysical logging will be used to determine the vertical extent of contamination in the upper 4.6 m (15 ft).	Yes	None

Table C-8. Required Information for Waste Site/Group BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs)

216-BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)

PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.

Information Input		Existing Data	Data Sufficient?	Data Needs
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following: **Analyte** — **Inventory (Mean Values)** Uranium (total) — 1.06E+03 kg Technetium-99 — 1.29E+02 Ci Iodine-129 — 1.65E-01 Ci Cobalt-60 — 6.39E+00 Ci Tritium — 3.37E+02 Ci Plutonium-239 — 2.70E+01 Ci Nitrate — 6.71E+06 kg Ferrocyanide — 1.89E+04 kg Fluoride — 1.35E+05 kg Chromium (total) — 5.83E+03 kg	Yes	None
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	During the remedial investigation for the 200-BP-1 OU, two of the 9 m (30 ft) deep boreholes were extended to about 70 m (230 ft) bgs, nearly to the water table. Well 299-E33-296 was drilled in the 216-B-43 Crib, and Well 299-E33-302 was drilled in the 216-B-49 Crib (DOE/RL-92-70). The data are provided in DOE/RL-92-70. The analyses of the anions, which were extracted using a water leach, also are provided in PNNL-19277, Tables 3.2 and 3.3. Two wells were drilled to groundwater in the vicinity of the BY Cribs during the remedial investigation for the 200-BP-5 OU. Well 299-E33-341 was drilled about 10.7 m (35 ft) west of the western sides of the 216-B-48 and 216-B-49 Cribs, and Well 299-E33-342 was drilled about 23 m (75 ft) south of the southern side of the 216-B-43 Crib (PNNL-19277, p. 3.6). The data for vadose zone samples from Well 299-E33-342 are provided in SGW-46352. Analyses of water and acid extracts are provided in PNNL-19277, Tables 3.2 and 3.3. At Well 299-E33-296, sediment samples were collected at 10 depths between 5.6 and 69.4 m (18.5 and 227.5 ft) bgs. At Well 299-E33-302, sediment samples were collected at 9 depths between 5.2 and 67 m (17 and 219.5 ft) bgs. In general, the contaminant concentrations were higher in samples from 299-E33-296. The maximum sediment concentrations from 299-E33-296 (DOE/RL-92-70) were as follows:	No	For the 200-DV-1 OU, additional characterization is recommended to be performed to better understand the distribution of contamination beneath the BY Cribs to facilitate remedy selection. Characterization will be accomplished using the following phased approach: • **Area Characterization (Phase 1):** Characterize the extent of contamination using four DPTs pushed to refusal and collect soil samples for analyses. • **Target Characterization (Phase II):** Depending on the results from Phase I, additional boreholes may be used to characterize hot spots.

Table C-8. Required Information for Waste Site/Group BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs)

216-BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)

Analyte	Maximum Concentration	Depth bgs (ft)
Uranium (total)	30,800 µg/kg	5.6 to 6.4 [18.5 to 21]
Technetium-99	210 pCi/g	48.0 to 48.8 [157.5 to 160]
Cobalt-60	2 pCi/g	48.0 to 48.8 [157.5 to 160]
Iodine-129	Not analyzed	
Tritium	71 pCi/g	5.6 to 6.4 [18.5 to 21]
Nitrate	Not analyzed	
Fluoride	Not analyzed	
Cyanide	3.4 mg/kg	48.0 to 48.8 [157.5 to 160]
Chromium	119 mg/kg	68.0 to 69.3 [223 to 227.5]
Sodium	3,070 mg/kg	48.0 to 48.8 [157.5 to 160]

GJO-2003-458-TAC summarizes geophysical logging results for wells at the BY Cribs. At Well 299-E33-296 in the 216-B-43 Crib, the highest cesium-137 concentrations (10,000 to 20,000 pCi/g) were detected from about 3 to 14.3 m (10 to 47 ft) bgs. Cesium-137 is detected to about 29 m (95 ft) bgs. From 33.5 m (110 ft) to the bottom of the borehole at 68.6 m (225 ft) bgs, cobalt-60 is the dominant radionuclide and is measured continuously in this interval. The spectral gamma logging did not identify uranium-238 contamination in this borehole (GJO-2003-458-TAC, p. 21). In Borehole 299-E33-1A, about 4.3 m (14 ft) east of 216-B-43, the distribution of cobalt-60 is similar to that in 299-E33-296, but the shallowest cesium-137 contamination begins 9 m (30 ft) deeper than it does in the borehole within the crib. It is likely that the cobalt-60 continues to impact the groundwater at the 216-B-43 Crib (GJO-2003-458-TAC, p. 22).

At Well 299-E33-302 in the 216-B-49 Crib, the highest cesium-137 concentrations (greater than 100 pCi/g) were detected from 3 to 9 m (10 to 30 ft) bgs and from 13.7 to 15 m (45 to 50 ft) bgs. From 30.5 m (100 ft) to the bottom of the borehole at 67 m (220 ft) bgs, cesium-137 is detected intermittently and cobalt-60 is detected continuously. It is likely that the cobalt-60 continues to impact the groundwater at the 216-B-49 Crib (GJO-2003-458-TAC, p. 26).

Uranium contamination was not detected in the vadose zone by any spectral gamma logging at the BY Cribs. (In the high activity zones just below the cribs, the minimum detection limit for uranium is increased and may not be detected at the concentrations detected in the soil samples.) There is no evidence of vadose zone uranium contamination near the groundwater (GJO-2003-458-TAC, p. 37).

The supplemental characterization SAP concludes that sufficient information is available for the BY Cribs.

The lateral extent of the vadose contamination at the BY Cribs is shown on Figure C-4. Four DPT locations are proposed at the BY Cribs. The rationale for each DPT is as follows:

- **BYcrib-1:** Evaluate vertical distribution of mobile contaminants at the 216-B-46 Crib.

  The 216-B-46 Crib has the highest technetium-99 (25.5 Ci) and Cr (1.150 kg) inventories.

  The soil resistivity survey indicates that the highest conductive region is in the vicinity of 216-B-46.

  The highest technetium-99 concentrations in groundwater are in the vicinity of 216-B-46.

  No deep analytical data are available for this area.
- **BYcrib-2:** Help to establish the northeastern extent of mobile contaminants.

  The soil resistivity survey indicates that the highest conductive region is in the vicinity of 216-B-46.

  The highest technetium-99 concentrations in groundwater are in the vicinity.
- **BYcrib-3:** Evaluate vertical distribution of mobile contaminants in the center of the BY Cribs.

  Area anticipated to have the highest concentrations based on the likely commingling of discharged wastes.

  Near both the 216-B-49 and 216-B-46 Cribs (highest discharge inventories based on the SIM).
- **BYcrib-4:** Establish the northwestern extent of mobile contaminants.

  Well 299-E33-40 indicates mobile contaminants from about 30.5 to 61 m (100 to 200 ft) based on borehole gamma logging.

  Validate the discharges to the 216-B-50 Crib.

Table C-8. Required Information for Waste Site/Group BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50 Cribs)

216-BY Cribs (216-B-43, 216-B-44, 216-B-45, 216-B-46, 216-B-47, 216-B-48, 216-B-49, and 216-B-50)				
Extent of contamination	2-2	Based on geophysical logging, cobalt-60 contamination was found to have moved laterally in the vadose zone and reached the groundwater. There is some indication that migration of cobalt-60 continued to occur at least between 1992 and 2001 (GJO-2003-458-TAC, pp. 37-38). Cobalt-60 was detected laterally 53.4 m (175 ft) northwest of the center of the 216-B-50 Crib and 50.3 m (165 ft) southeast of the 216-B-43 Crib (GJO-2003-458-TAC, p. 32). The full extent of contamination cannot be determined because of the relatively sparse distribution of boreholes. The geophysical logging data suggest no commingling in the vadose zone with contaminants from the 216-B-57 Crib to the west (GJO-2003-458-TAC, p. 37). The data at Borehole 299-E33-302 in the 216-B-49 Crib provide evidence that mobile contaminants such as technetium-99, nitrate, sulfate, cyanide, and sodium from waste fluids discharged to the 216-B-49 Crib reached groundwater. The DVZ pore water below the footprint of 216-B-49 from about 15 to 70 m (50 to 230 ft) bgs contain elevated concentrations of these mobile species (PNNL-19277, p. 3.15). Technetium-99 and nitrate data from Well 299-E33-341, about 18.3 m (60 ft) west of the 216-B-49 Crib, indicate lateral spreading of the waste fluids from the BY Cribs, especially along fine-grained lenses within the Hanford formation sand. The sulfate distributions suggest that sulfate has spread laterally at the contact between the Hanford formation and the CCU (PNNL-19277, pp. 3.15 and 3.16). The data at Borehole 299-E33-296 in the 216-B-43 Crib show elevated concentrations of technetium-99, nitrate, sodium, and to a lesser extent cyanide in the DVZ. The elevated concentrations in the DVZ sediments at 299-E33-296 are likely an indication that mobile contaminants in the waste fluids reached the water table in the past and are continuing to be a source today (PNNL-19277, p. 3.20). The concentrations of these mobile constituents in the sediments at Well 299-E33-342 (30.5 m [100 ft] south of the 216-B-43 Crib) are much lower than those within the footprint of the crib and also lower than in the sediments from Borehole 299-E33-341. The lower concentrations at 299-E33-342 reflect that this well is farther from the BY Cribs and that 216-B-43 received a lower volume of liquid than 216-B-49 (PNNL-19277, p. 3.21). Although uranium is present in the groundwater beneath the BY Cribs, it does not appear to be associated with waste fluids discharged to the BY Cribs. This conclusion is based on the lack of significantly elevated sediment uranium concentrations in the sediments from the four deep boreholes below and adjacent to the BY Crib footprints at depths deeper than 12 m (40 ft) bgs. The lack of mobile uranium deep in the vadose zone below the BY Cribs region is strongly supported by the water-extractable uranium concentrations in Boreholes 299-E33-341 and 299-E33-342 (PNNL-19277, p. 3.25). RPP-34690 (pp. 4-20 to 4-27) provides the results of surface resistivity surveys conducted in the vicinity of the BY Cribs. The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods. A 150 m (492 ft) east-west by 110 m (361 ft) north-south anomalous region (low resistivity) is spatially co-located with the BY Cribs, with the zone of lowest resistivities centered to the east of Cribs 216-B-44, 216-B-45 and 216-B-46 (RPP-34690, Figures 4-19 and 4-20). The horizontal dimensions remain consistent, from 30 to 50 m (98.4 to 164 ft) deep. The top of the anomalous zone occurs in the 15 to 20 m (49 to 65.6 ft) depth range. The base of the anomalous zone is estimated to be about 60 m (197 ft) deep.	No	The planned 200-DV-1 OU characterization, as described above, is needed to refine these estimates based on existing data, geophysical logging, and resistivity surveys.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
CCU = Cold Creek Unit
DPT = direct-push technology
DS = decision statement
DVZ = deep vadose zone
ITS = in-tank solidification
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model
TBP = tributyl phosphate

Table C-9. Required Information for Waste Site/Group 216-B-57 Crib

216-B-57				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The base of the 216-B-57 Trench was 61 m (200 ft) long and 4.6 m (15 ft) wide and about 3 m (10 ft) below the original ground surface. A perforated, 30.5 cm (12 in.) diameter, corrugated distribution pipe ran the length of the crib, about 2 m (7 ft) below the original ground surface and 0.91 m (3 ft) above the bottom in a 1.2 m (4 ft) bed of gravel (RHO-CD-673 I. NW; H-2-62406). Historical drawing H-2-62406 (ARH-1562, p. 126; additional drawings listed in BHI-00179, Table B-1). Historical photographs (BHI-00179, Table B-1). In 1991, an area of contaminated soil from UPR-200-E-89 was removed. Some of the contaminated soil was placed over the surface of the 216-B-57 Crib. The approximate 46 cm (18 in.) to 61 cm (24 in.) of uncontaminated soil was placed over the contaminated soil (WHC-SD-DD-TI-064, p. 14). During characterization for the 200-BP-1 OU remedial investigation in 1991 and 1992, the depths to the crib top and bottom were observed during drilling activities. The 216-B-57 Crib appears to have been constructed from 2 to nearly 2.7 m (6.5 to 9 ft) deeper than indicated on the as-built drawing for the crib (DOE/RL-92-70, p. 3-2, Table 2-2). In 1994, the 216-B-57 Crib was covered with an engineered barrier known as the Hanford prototype barrier. The barrier is about 105 m (344 ft) long, 64 m (210 ft) wide, and 15 m (49 ft) tall. The total surface area of the barrier is 2.5 ha (6.2 ac) (DOE/RL-94-76). The objectives of this barrier treatability study were to evaluate performance and construction costs (DOE/RL-93-27).	Yes	None
Waste inventory	1-1	The 216-B-57 Trench received the following waste stream (WHC-SD-WM-ER-575, p. 14; HNF-5231 Appendix 1; RPP-RPT-43704, p. 5-16; RHO-CD-673 I.NW): **Waste Site** / **Service Dates** / **Waste Stream** 216-B-57 / 02/1968 to 06/1973 / Waste storage tank condensate from the ITS 2 unit The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-B-57 Crib was 84.4 million L (22.3 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **Analyte** / **Inventory (Mean Values)** Cesium-137 / 1.64E+02 Ci Strontium-90 / 3.55E+00 Ci	Yes	None

Table C-9. Required Information for Waste Site/Group 216-B-57 Crib

216-B-57				
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	During remedial investigation of the 200-BP-1 OU, three boreholes were drilled through the 216-B-57 Crib to approximately 15 m (50 ft) bgs (based on ground surface before barrier emplacement) (DOE/RL-92-70, pp. 2-2, 4-25). The maximum detected concentrations of cesium-137 and strontium-90 from samples in the upper 4.6 m (15 ft) of the original land surface were 0.7 and 0.25 pCi/g, respectively (DOE/RL-92-70, Table 4-16). GJO-2003-458-TAC summarizes geophysical logging results for wells at the 216-B-57 Crib. The highest cesium-137 concentrations detected in the upper 4.6 m (15 ft) (based on ground surface before barrier emplacement) at a well drilled through the crib was about 10 pCi/g.	Yes	None
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the 216-B-57 Crib. The thickness of the prototype barrier overlying the 216-B-57 Crib is greater than 4.6 m (15 ft) thick.	Yes	None

PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?

DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.

DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.

Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:	Yes	None

Analyte	Inventory (Mean Values)
Uranium (total)	5.94E-02 kg
Technetium-99	1.97E-01 Ci
Iodine-129	2.80E-04 Ci
Cobalt-60	2.40E-02 Ci
Tritium	1.95E+02 Ci
Plutonium-239	2.97E-02 Ci
Nitrate	2.76E+02 kg
Ferrocyanide	0.00E+00 kg
Fluoride	1.27E+01 kg
Chromium (total)	2.42E+01 kg

Table C-9. Required Information for Waste Site/Group 216-B-57 Crib

<table>
<tr><th colspan="6">216-B-57</th></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>During the remedial investigation for the 200-BP-1 OU, one of the 15 m (50 ft) deep boreholes was extended to about 70 m (230 ft) bgs (based on ground surface before barrier emplacement), nearly to the water table. Well 299-E33-304 was drilled through the southern end (influent end) of the 216-B-57 Crib (DOE/RL-92-70). The data are provided in DOE/RL-92-70. The analyses of the anions, which were extracted using a water leach, also are provided in PNNL-19277, Table 3.4.
At Well 299-E33-304, sediment samples were collected at 11 depths, between 4.6 and 71.8 m (15 and 235.5 ft) bgs (based on ground surface before barrier emplacement). The maximum sediment concentrations (DOE/RL-92-70) were as follows:
<table>
<tr><th>Analyte</th><th>Maximum Concentration</th><th>Depth bgs (ft)</th></tr>
<tr><td>Uranium (total)</td><td>1,050 µg/kg</td><td>9.1 to 10.1 [30 to 33]</td></tr>
<tr><td>Technetium-99</td><td>60 pCi/g</td><td>9.1 to 10.1 [30 to 33]</td></tr>
<tr><td>Cobalt-60</td><td>Not detected</td><td></td></tr>
<tr><td>Iodine-129</td><td>Not analyzed</td><td></td></tr>
<tr><td>Tritium</td><td>Not analyzed</td><td></td></tr>
<tr><td>Nitrate</td><td>Not analyzed</td><td></td></tr>
<tr><td>Fluoride</td><td>Not analyzed</td><td></td></tr>
<tr><td>Cyanide</td><td>Not detected</td><td></td></tr>
<tr><td>Chromium</td><td>6.2 mg/kg</td><td>68.6 to 69.3 [225 to 227.5]</td></tr>
<tr><td>Sodium</td><td>212 mg/kg</td><td>71.0 to 71.7 [233 to 235.5]</td></tr>
</table>
No cyanide or significantly elevated uranium concentrations were observed in any of the sediments analyzed. Technetium-99 at a concentration of 60 pCi/g was found at a depth of about 9.4 m (31 ft) bgs, suggesting that this mobile contaminant migrated about 9 m (30 ft) below the crib bottom.
GJO-2003-458-TAC summarizes geophysical logging results for wells at the 216-B-57 Crib. A high contamination zone dominated by cesium-137 was detected from about 9 and 27.5 m (30 and 90 ft) bgs (based on ground surface before barrier emplacement). The cesium-137 contamination is highest (about 80,000 pCi/g) in Well 299-E33-304 at the southern (influent) end of the crib. In Borehole 299-E33-24, west of the center of the crib, the high contamination zone extends from about 9 and 18.3 m (30 to 60 ft) bgs, with a maximum cesium-137 concentration of about 10,000 pCi/g (GJO-2003-458-TAC, p. 27).
The supplemental characterization SAP concludes that sufficient information is available for the 216-B-57 Crib.</td><td>Yes</td><td>None</td></tr>
<tr><td>Extent of contamination</td><td>2-2</td><td>Based on the inventory estimates for the 216-B-57 Crib, and the fact that sediments under the 216-B-57 Crib footprint do not contain cyanide, contain only minor amounts of uranium, and only about 0.1 percent of the total technetium-99 mass in the BY Cribs region, it does not appear that this facility has contaminated groundwater. It is also unlikely that the 216-B-57 Crib will be a significant contributor to groundwater contamination in the future because the mobile contaminants do not appear to have migrated more than about 18.3 m (60 ft) bgs, and it has been covered by a barrier since 1994 (PNNL-19277, p. 3.28).
On the basis of the geophysical surveys in the two deep boreholes, significant breakthrough to groundwater did not occur below this crib (GJO-2003-458-TAC, p. 27).
Boreholes in the vicinity of the 216-B-57 Crib suggest no commingling in the vadose zone of contaminants from the BY Cribs to the east (GJO-2003-458-TAC, p. 37).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-9. Required Information for Waste Site/Group 216-B-57 Crib

216-B-57				
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the four stratigraphic units in the B Complex conceptual model report (PNNL-19277, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
DS = decision statement
ITS = in-tank solidification
OU = operable unit
PSQ = principal study question
SIM = Soil Inventory Model

Table C-10. Required Information for Waste Site/Group 216-T-3 Reverse Wells and 216-T-6 Cribs

216-T-3 and 216-T-6

PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?
DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.
DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.

Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 216-T-3 waste site is a reverse well with telescoped casing starting with a 30.5 cm (12 in.) diameter and ending with a 2 cm (8 in.) diameter casing that was drilled in October 1944 to a depth of 62.8 m (206 ft) bgs (about 24 m [79 ft] above the 1944 water table) (HW-9671, p. 16). The well was perforated from 32 to 62 m (104.5 ft to 204 ft) bgs (HW-17088, p. 69). The inlet pipe entered at about 3.7 m (12 ft) bgs (based on 216-B-5, RHO-ST-37, p. 3). The 216-T-6 waste site consists of two cribs, 18 m (62 ft) apart. Each crib is 3.7 m (12 ft) by 3.7 m (12 ft) and was constructed with wooden timber in an excavation that is 4.3 by 4.3 m (14 by 14 ft). The bottom depth of the two cribs was about 6.4 m (21 ft) bgs. The inlet pipeline was about 3 m (10 ft) bgs. The easternmost Crib 1 was designed to overflow into Crib 2 to the west (RHO-CD-673 II.NE, H-2-353). Historical drawings (ARH-2155, pp. B-6, and B-12 through B-13; additional drawings listed in BHI-00177, Tables B-3 and B-4; HW-55176, Part 5, Appendices C-3 and C-5). Historical photographs (BHI-00177, Tables B-3 and B-4). The aboveground piping was removed at the 216-T-3 site and the sinkholes were filled and the ground surface was decontaminated and leveled at the 216-T-3 and 216-T-6 sites during August 1975 (RHO-CD-673 II.NE). The 241-T-361 Settling Tank and 216-T-3 Reverse Well were surface stabilized in 1993. At ground surface, the stabilized area is 0.12 ha (0.3 ac). The 216-T-6 Cribs were surface stabilized at the same time. At ground surface, the stabilized area is 0.05 ha (0.12 ac) (WIDS; WHC-SP-1149, p. B-9).	Yes	None
Waste inventory	1-1	The 216-T-3 and 216-T-6 sites received the following waste streams (ARH-2155, pp. B-6, and B-12 to B-13):	Yes	None

Waste Site	Service Dates	Waste Stream
216-T-3	06/1945 to 08/1946	Cell drainage from Tank 5-6 in 221-T and waste from 224-T via 241-T-361 Tank
216-T-6	08/1946 to 10/1946	
	10/1946 to 06/1951	Cell drainage from Tank 5-6 in 221-T

Table C-10. Required Information for Waste Site/Group 216-T-3 Reverse Wells and 216-T-6 Cribs

<table>
<tr><th colspan="5">216-T-3 and 216-T-6</th></tr>
<tr><td></td><td></td><td>The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-T-3 Reverse Well was 11.3 million L (3.0 million gal).
The total volume discharged to the 216-T-6 Cribs was 45.0 million L (11.9 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">216-T-3</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>1.95E+00 Ci</td></tr>
<tr><td>Strontium-90</td><td>1.70E+00 Ci</td></tr>
<tr><th colspan="2">216-T-6</th></tr>
<tr><td>Cesium-137</td><td>1.60E+01</td></tr>
<tr><td>Strontium-90</td><td>1.40E+01</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>SGW-49498 summarizes geophysical logging results for the 216-T-3 Reverse Well. The three closest wells are within 9 m (30 ft) of 216-T-3. Relatively high concentrations of cesium-137 are shown at about 4.6 m (15 ft) bgs in all three boreholes. The maximum concentration of cesium-137 is 46,000 pCi/g between 4.6 and 5 m (15 and 16 ft) bgs in Well 299-W11-79, about 8.2 m (27 ft) southeast of 216-T-3. The shallow interval of contamination is most likely related to the 241-T-361 Setting Tank, the pipelines between the settling tank and the 216-T-3 Reverse Well, or between 216-T-3 and the 216-T-6 Cribs (SGW-49498, pp. A-42 and A-57).
SGW-49498 summarizes geophysical logging results for the 216-T-6 Cribs. Of the 15 boreholes in the vicinity of the 216-T-6 Cribs, the highest cesium-137 concentration in the upper 4.6 m (15 ft) is about 300 pCi/g at Well 299-W11-54 at 3 m (10 ft) bgs (SGW-49498, p. A-60). Because the base of the cribs was 6 m (20 ft) bgs, this shallower contamination is likely from the pipeline between the two cribs.</td><td>Yes</td><td>None</td></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>Because the perforations in the 216-T-3 Reverse Well begin at 32 m (104.5 ft) bgs, contamination release from the 216-T-3 waste site is unlikely in the upper 4.6 m (15 ft) of the subsurface. However, the subsurface at least 8.2 m (27 ft) laterally from 216-T-3 is contaminated from ground surface to 4.6 m (15 ft) bgs.
At the 216-T-6 Cribs, the lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the cribs. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-10. Required Information for Waste Site/Group 216-T-3 Reverse Wells and 216-T-6 Cribs

216-T-3 and 216-T-6				
PSQ #2 Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:	Yes	None

216-T-3	
Analyte	**Inventory (Mean Values)**
Uranium (total)	2.01E+00 kg
Technetium-99	9.57E-04 Ci
Iodine-129	4.24E-07 Ci
Cobalt-60	1.96E-03 Ci
Tritium	2.02E-05 Ci
Plutonium-239	1.66E+01 Ci
Nitrate	6.47E+05 kg
Fluoride	3.86E+04 kg
Ferrocyanide	0.00E+00 kg
Chromium	2.65E+03 kg
216-T-6	
Uranium (total)	2.08E+01 kg
Technetium-99	7.87E-03 Ci
Iodine-129	3.49E-06 Ci
Cobalt-60	7.03E-03 Ci
Tritium	2.13E-04 Ci
Plutonium-239	1.51E+01 Ci
Nitrate	2.30E+05 kg
Fluoride	1.26E+04 kg
Ferrocyanide	0.00E+00 kg
Chromium	6.83E+02 kg

Table C-10. Required Information for Waste Site/Group 216-T-3 Reverse Wells and 216-T-6 Cribs

216-T-3 and 216-T-6				
		The inventory for the 216-T-3 Reverse Well represents the inventory discharged to the 241-T-361 Settling Tank and 216-T-3 Reverse Well system. Some of the inventory is expected have been retained in the settling tank sludge.		
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	Well 299-W11-22 (originally named Well 241-T-361) was drilled 8.2 m (27 ft) northeast of 216-T-3 in 1944. The well was re-opened in October 1949, cleaned out, and deepened from 2 m (7 ft) above the 1949 water table to 14.3 m (47 ft) below the water table. No contamination was found in the sediments, but alpha and beta-gamma activity above the background level of activity was found in the groundwater samples. Water samples analyzed by fluorophotometer indicated that all the alpha activity in the well was due to uranium (HW-17088, pp. 70-71). Thirteen boreholes were drilled at the 216-T-6 Cribs in 1947, and soil samples were collected to determine the nature and extent of contamination (HW-9671, p. 15). The plutonium contamination was summarized as being contained within 6 m (20 ft) below the 216-T-6 Cribs, with a lateral spread of 13.7 m (45 ft). Fission product contamination was summarized as extending to 32.6 m (107 ft) below the cribs, with a 29 m (95 ft) lateral spread (HW-9671, p. 17). Additional sediment samples were collected in October 1949 from the bottoms of the 13 boreholes drilled in 1947. Contamination was found only in two sediment samples: one sample from 299-W11-58 at 23 m (75 ft) bgs, and one sample from 299-W11-62 at 31 m (102 ft) bgs. About 0.08 mCi of beta-gamma activity/kg of sediment was detected in each sample (detection limit of 0.05 mCi/kg). No significant alpha contamination was detected in any of the sediment samples obtained in October 1949. Samples from the bottom of the six boreholes penetrating through the silt-clay bed (likely the CCU silt layer) showed no evidence of contamination (HW-17088, p. 66). SGW-49498 summarizes the geophysical logging results for the 216-T-3 Reverse Well and the 216-T-6 Cribs. Based on the geophysical log data evaluation for wells near these waste sites, it appears that contaminants have possibly impacted groundwater at both sites (SGW-49498, p. A-9). The three closest wells are within 9 m (30 ft) of the 216-T-3 Reverse Well. Relatively high concentrations of cesium-137 are shown at about 4.6 m (15 ft) bgs in all three boreholes. Two of the boreholes indicate contamination throughout the sediments to the approximate top of the CCU, where the perforations begin in the 216-T-3 Reverse Well. All three boreholes indicate increases in cesium-137 concentrations at a level equivalent to the top of the perforations. All three boreholes exhibit cesium-137 contamination below the CCU interval that continues into the upper Ringold Formation. The highest concentration of cesium-137 was 46,000 pCi/g at 4.6 to 5 m (15 ft to 16 ft) bgs in Well 299-W11-79, about 8.2 m (27 ft) southeast of the reverse well (SGW-49498, p. A-42). At the 216-T-6 Cribs, cesium-137 contamination was detected in all 15 boreholes. A zone of elevated concentrations was identified from about 6 to 18.3 m (20 to 60 ft) bgs, with the highest cesium-137 concentrations between 20 to 12 m (40 ft) bgs. The highest cesium-137 concentrations are located adjacent to Crib 1, but significant gamma contamination does not appear to exceed 21.4 m (70 ft) bgs. The maximum concentration of cesium-137 was 9,600 pCi/g at 10.4 m (34 ft) bgs in 299-W11-54. The uranium-238 at a concentration of 34 pCi/g was also identified in this borehole at 13.7 m (45 ft) bgs. At the only borehole (299-W11-60) near Crib 2, the maximum cesium-137 concentration was 10 pCi/g. The current gamma profiles are generally consistent with the 1948 profiles in HW-9671. Comparison of the data suggests that shorter lived contaminants existed at greater depths and lateral extent in 1948, but that the currently detectable cesium-137 has not migrated deeper at any appreciable amounts into the vadose zone over the past 60 years. Spectral gamma logging in 2003 did not detect plutonium; the maximum detectable limit for plutonium-239 is about 10 nCi/g (SGW-49498, pp. A-43 to A-44).	No	For the 216-T-3 Reverse Well, the supplemental characterization SAP includes a borehole to groundwater with nine split-spoon samples. For the 200-DV-1 OU, implementing this borehole as planned is recommended, but adding two or three samples above the CCU, including one above 4.6 m (15 ft) bgs, to help characterize the shallow contamination. For the 216-T-6 Cribs, the supplemental characterization SAP includes four direct-push boreholes to 12 m (40 ft) bgs with geophysical logging. Based on the latest conceptual site model, 200-DV-1 OU instead recommends two direct-push boreholes to the CCU (about 27.5 m [90 ft] bgs) with geophysical logging and sampling at one direct-push borehole for contaminants.
Extent of contamination	2-2	At the 216-T-3 Reverse Well, the lateral extent of contamination is about 14 m (45 ft) radially from the well, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-13). The vertical extent of contamination likely extends at least to 62 m (204 ft) bgs, the lowermost depth of the perforations (SGW-49924, Figure 3-14). At the 216-T-6 Cribs, the lateral extent of contamination is an ellipse with a northwest-southeast axis about 75 m (246 ft) long and a northeast-southwest axis about 45 m (147.6 ft) long, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-13). The vertical extent of contamination likely extends at least to 46 m (150 ft) bgs to the Ringold Formation (SGW-49924, Figure 3-14).	No	The planned supplemental characterization, as modified by the recommendations described above, is needed to refine these estimates based on geophysical logging.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
CCU = Cold Creek unit
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan

Table C-11. Required Information for Waste Site/Group 216-T-5 Trench

216-T-5				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.5 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS#1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Physical layout	1-1, 1-2	The base of the 216-T-5 Trench is 15 m (50 ft) long, 3 m (10 ft) wide, and 3.7 m (12 ft) deep. The waste was discharged to the trench using an aboveground pipeline (HW-43121, p. 16; RHO-CD-673 II.NW). Historical drawings (ARH-2155, p. B-11; additional drawings listed in BHI-00177, Table B-1; HW-55176, Part 5, Appendix C-4). Historical photographs (BHI-00177, Table B-1). When the 216-T-5 Trench reached specific retention capacity, the aboveground piping was removed and the trench was backfilled (ARH-2155, p. B-11; RHO-CD-673 II.NW). In 1992, two areas of surface contamination were identified in the vicinity of 216-T-5. One contaminated area generally followed the outline of the 216-T-5 Trench. The other contamination was in a 3 by 3 m (10 by 10 ft) area near the northwest corner of the T Tank Farm. Both areas were covered with 0.61 m (2 ft) of clean dirt to remediate an area of surface contamination (WIDS). The stabilized area is 0.49 ha (1.2 ac) (WHC-SP-1149, p. B-9).	Yes	None
Waste inventory	1-1	The 216-T-5 Trench received the following waste streams (HW-43121, p. 16; ARH-2155, p. B-11): **Waste Site** / **Service Dates** / **Waste Stream** 216-T-5 / 05/1955 to 05/1955 / 2C supernate from 221-T via 241-T-112 The 216-T-5 Trench was used for disposal of 2C waste from one processing run in early 1955 that resulted in an unusually high level of activity. The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-T-5 Trench was 3.2 million L (0.8 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **216-T-5** **Analyte** / **Inventory (Mean Values)** Cesium-137 / 3.43E+01 Ci Strontium-90 / 2.94E+01 Ci	Yes	None
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	SGW-49498 summarizes the borehole geophysical logging results for the 216-T-5 Trench (p. A-67). Three shallow boreholes were drilled in the northwest section of the trench excavation in 1985. There are no geophysical log data for these boreholes. According to driller's logs, each borehole encountered contamination at 3.3 or 3.7 m (11 or 12 ft) bgs. The maximum concentration measured was 100,000 cpm at 3.7 m (12 ft) and 3.9 m (13 ft) bgs in Well 299-W10-191. Borehole 299-W10-1 was drilled northwest of 216-T-5 in 1947. Although gamma-emitting contamination was detected starting at 3 m (10 ft) bgs in this well in 1959, the contamination had decayed to background levels by 1968.	Yes	None

Table C-11. Required Information for Waste Site/Group 216-T-5 Trench

<table>
<tr><th colspan="6">216-T-5</th></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-T-5 Trench. Driller's logs are available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
<tr><td colspan="6">PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Waste inventory</td><td>2-1</td><td>The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:
<table>
<tr><th colspan="2">216-T-5</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Uranium (total)</td><td>2.42E+01 kg</td></tr>
<tr><td>Technetium-99</td><td>1.50E-02 Ci</td></tr>
<tr><td>Iodine-129</td><td>0.00E+00 Ci</td></tr>
<tr><td>Cobalt-60</td><td>2.54E-02 Ci</td></tr>
<tr><td>Tritium</td><td>8.77E-03 Ci</td></tr>
<tr><td>Plutonium-239</td><td>1.65E+01 Ci</td></tr>
<tr><td>Nitrate</td><td>2.42E+05 kg</td></tr>
<tr><td>Ferrocyanide</td><td>0.00E+00 kg</td></tr>
<tr><td>Fluoride</td><td>1.31E+04 kg</td></tr>
<tr><td>Chromium</td><td>1.21E+03 kg</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>SGW-49498 summarizes the borehole geophysical logging results for the 216-T-5 Trench (p. A-67).
Three shallow boreholes were drilled in the northwest section of the trench excavation in 1985. There are no geophysical log data for these boreholes. According to the driller's logs, each borehole encountered contamination at 3.3 or 3.7 m (11 or 12 ft) bgs. In Well 299-W10-189, the deepest of the three, contamination at 8.8 m (29 ft) bgs (total depth) was 9,000 cpm.
Borehole 299-W10-1 was drilled northwest of 216-T-5 in 1947. Although gamma-emitting contamination was detected possibly to 49 m (160 ft) in this well in 1959, the contamination had decayed to background levels by 1968.
Surface and well-to-well resistivity surveys were conducted in FY 2005 and FY 2006 at the T Tank Farm and were extended to cover associated waste sites, including 216-T-5 (RPP-RPT-28955). During FY 2009, the data were reanalyzed using newer model codes and lessons learned from past modeling (RPP-RPT-42844). The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods.
The FY 2009 well-to-well modeling indicates the presence of an east-west elongated zone of extremely low resistivity (3 to 10 ohm-m) north of the 216-T-7 Tile Field, south of the 216-T-5 Trench, and beneath the southwestern half of the 216-T-32 Cribs. This zone measures about 100 m (328 ft) (east-west) by 35 m (114.8 ft) (north-south).</td><td>No</td><td>For the 216-T-5 Crib, the supplemental characterization SAP includes four direct-push holes to 12 m (40 ft) with geophysical logging. Instead, 200-DV-1 recommends two direct-push holes to the CCU (about 27.5 m [90 ft] bgs) with geophysical logging: one at the north end, and one at the south end. The direct-push hole at the location with the highest contamination, based on geophysical logging, would be sampled to evaluate contaminants. The basis for the recommended change is that analytical data on constituents is a higher priority than characterizing the lateral extent of plutonium using geophysical logging.</td></tr>
</table>

Table C-11. Required Information for Waste Site/Group 216-T-5 Trench

216-T-5				
		The FY 2009 three-dimensional modeling indicated a zone of moderately low resistivity (50 to 80 ohm-m) north of the 216-T-7 Tile Field; the 38 m (124.7 ft) deep slice represents the maximum horizontal extent of this anomaly. The 80 ohm-m contour (yellow outline on Figure 3-32 in SGW-49924) indicates an anomalous region that is about 80 m (262.5 ft) (north-south) by 60 m (197 ft) (east-west). The top of this zone occurs at about 20 m (65.6 ft) bgs and the base extends to at least 56 m (183.7 ft) bgs.		
Extent of contamination	2-2	At the 216-T-5 Trench, the lateral extent of contamination is estimated to be encompassed by a circle with an approximate 50 m (164 ft) diameter, based on historical detectable mobile gamma contamination and recent resistivity surveys (SGW-49924, Figure 3-33). The vertical extent of contamination at 216-T-5 is uncertain but appears to commingle with contamination from 216-T-7 and 216-T-32 sites in the deeper vadose zone, based on the resistivity surveys.	No	The planned supplemental characterization, as modified by the recommendations described above, will refine these estimates based on geophysical logging and electrical resistivity.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

2C = second-cycle (waste)
bgs = below ground surface
CCU = Cold Creek unit
cpm = counts per minute
DS = decision statement
FY = fiscal year
OU = operable unit
PSQ = principal study question
SIM = Soil Inventory Model
WIDS = Waste Information Data System

Table C-12. Required Information for Waste Site/Group 216-T-7/200-W-52 (WMA T) Crib and Tile Field and 216-T-32 Cribs

216-T-7/200-W-52 (WMA T) and 216-T-32				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The 200-W-52 Crib and 216-T-7 Tile Field operated as one waste disposal system. They were administratively separated in 1997 because the crib is located inside the T Tank Farm. At that time, the crib was assigned a separate WIDS site code (200-W-52). The 216-T-7/200-W-52 Crib is 3.7 m (12 ft) wide by 3.7 m (12 ft) long and was constructed using wooden timbers. The base of the crib was 8 m (26 ft) bgs. The pipeline discharged waste to the crib approximately 5.8 m (19 ft) bgs. The crib overflowed to the 216-T-7 Tile Field through a pipe at about 6.4 m (21 ft) bgs. The tile field consisted of a trunk line with four laterals on each side. The trunk line was 30.5 cm (12 in.) diameter vitrified clay pipe and was 93 m (305 ft) long. The laterals were 25.4 cm (10 in.) diameter, were spaced 21.4 m (70 ft) apart, and met the trunk line at a 45-degree angle. The laterals on the southern side were 12 m (40 ft) long; the laterals on the north side were 24.4 m (80 ft) long. The tile field was 25.6 m (84 ft) wide (HW-55176, Part 5, Appendices C-7 and C-8). The 216-T-32 Cribs are each 3.7 m (12 ft) wide by 3.7 m (12 ft) long by about 1.2 m (4 ft) high. Each was placed in a 4.3 by 4 m (14 by 14 ft) excavation that was 8 m (26 ft) deep and subsequently backfilled. The centers of the two cribs are 16 m (52 ft) apart (12 m [40 ft] from edge to edge). The northeast Crib 1 overflows to the southwest Crib 2. Historical drawings (ARH-2155, pp. B-14 through B-15, and B-43; additional drawings listed in BHI-00177, Table B-1; HW-55176, Part 5, Appendices C-7, C-8, and C-21). Historical photographs (BHI-00177, Table B-1).	Yes	None

Table C-12. Required Information for Waste Site/Group 216-T-7/200-W-52 (WMA T) Crib and Tile Field and 216-T-32 Cribs

216-T-7/200-W-52 (WMA T) and 216-T-32				
		In 1992, the 216-T-7 Tile Field showed no surface contamination. The surface of the 216-T-32 Cribs was stabilized with gravel, along with the remainder of the T Tank Farm, in 1992 (WIDS).		
Waste inventory	1-1	The 216-T-7 Crib and Tile Field and the 216-T-32 Cribs received the following waste streams (RPP-5957; ARH-2155, pp. B-14, B-15, and B-43): **Waste Site** / **Service Dates** / **Waste Stream** 216-T-7 / 09/1947 to 07/1948 / 2C supernate from 221-T via 241-T-105, 106, 111, 112 216-T-7 / 04/1948 to 06/1951 / 2C supernate from 221-T via 241-T-112 216-T-7 / 06/1951 to 06/1952 / 2C supernate in 221-T, plus cell drainage from Tank 5-6 in 221-T via 241-T-112 216-T-7 / 06/1952 to 11/1955 / 2C supernate in 221-T, plus cell drainage from Tank 5-6 in 221-T, plus 224-T waste via 241-T-112 216-T-32 / 11/1946 to 05/1952 / 224-T waste via 241-T-201 Tank The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-T-7 Crib and Tile Field was 107.0 million L (28.3 million gal). The total volume discharged to the 216-T-32 Cribs was 29.0 million L (7.7 million gal). The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **216-T-7/200-W-52** **Analyte** / **Inventory (Mean Values)** Cesium-137 / 4.26E+02 Ci Strontium-90 / 3.66E+02 Ci **216-T-32** Cesium-137 / 2.93E+00 Ci Strontium-90 / 2.52E+00 Ci	Yes	None
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	Waste entered the 216-T-7 Crib and Tile Field at approximately 5.8 m (19 ft) bgs; the base of the crib was 8 m (26 ft) bgs. The effluent pipe to the tile field was 6.4 m (21 ft) bgs. The bases of the 216-T-32 Cribs were 8 m (26 ft) bgs. Contamination is not anticipated for the upper 4.6 m (15 ft) bgs at these waste sites. SGW-49498 summarizes the borehole geophysical logging results for the 216-T-7 Crib and Tile Field and the 216-T-32 Cribs (pp. A-67 to A-69). Eight boreholes surround the 216-T-7/200-W-52 Crib. Four boreholes are within 5.5 m (18 ft) of the center of the crib. On the east inlet side, gamma-emitting contaminants were detected as shallow as 5.5 m (18 ft) bgs in 1976. Cesium-137 was detected at ground surface in two wells in 2008. Five wells are used to monitor the 216-T-7 Tile Field. At the tile field, cesium-137 was detected within the upper 1.8 m (6 ft) bgs at one well in 2006 at a concentration less than 1 pCi/g. Five boreholes were drilled within the excavated area at 216-T-32 Crib 1. In 2008, spectral gamma logging detected cesium-137 near the ground surface at concentrations less than 1 pCi/g.	Yes	None
Extent of contamination	1-2	Based on the waste site construction dimensions and soil concentrations from geophysical logging, contamination is not present in the upper 4.6 m (15 ft) at the 216-T-7 and 216-T-32 sites.	Yes	None

Table C-12. Required Information for Waste Site/Group 216-T-7/200-W-52 (WMA T) Crib and Tile Field and 216-T-32 Cribs

216-T-7/200-W-52 (WMA T) and 216-T-32				
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS#2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:	Yes	None

216-T-7/200-W-52	
Analyte	**Inventory (Mean Values)**
Uranium (total)	3.39E+02 kg
Technetium-99	1.90E-01 Ci
Iodine-129	1.49E-05 Ci
Cobalt-60	3.12E-01 Ci
Tritium	9.16E-02 Ci
Plutonium-239	2.36E+02 Ci
Nitrate	6.55E+06 kg
Ferrocyanide	0.00E+00 kg
Fluoride	3.73E+05 kg
Chromium	2.81E+04 kg

Table C-12. Required Information for Waste Site/Group 216-T-7/200-W-52 (WMA T) Crib and Tile Field and 216-T-32 Cribs

216-T-7/200-W-52 (WMA T) and 216-T-32				
		216-T-32 **Analyte** — **Inventory (Mean Values)** Uranium (total) — 5.90E-01 kg Technetium-99 — 1.33E-03 Ci Iodine-129 — 2.28E-07 Ci Cobalt-60 — 1.09E-02 Ci Tritium — 2.14E-04 Ci Plutonium-239 — 5.42E+00 Ci Nitrate — 2.50E+06 kg Ferrocyanide — 0.00E+00 kg Fluoride — 1.49E+05 kg Chromium — 1.03E+04 kg		
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	Eight boreholes were drilled at the 216-T-32 Crib 1, 15 boreholes were drilled at the 216-T-7 Crib in 1947, and soil samples were collected to determine the nature and extent of contamination. The plutonium contamination was summarized as being contained within 10.4 m (34 ft) below the 216-T-32 and 216-T-7 Cribs, with a lateral spread of 60 m (197 ft). Fission product contamination was summarized as extending to 8.5 m (28 ft) below the cribs, with an 85 m (280 ft) lateral spread (HW-9671, pp. 15 and 17). Contamination from the 216-T-32 Crib 1 migrated laterally to the southwest, contaminating sediment beneath the 216-T-7 Crib and Tile Field (HW-9671, pp. 21 and 68, Plate 6). (HW-9671 [Plates 7 and 8] and SGW-49498 [p. A-67], suggest that the plutonium may have been 10.4 m [34 ft] bgs rather than below the cribs.) By 1949, waste liquids had seeped through perforations in Wells 299-W10-59, 299-W10-60, 299-W10-61, and 299-W10-68 at the 216-T-7 Crib. The wells that contained liquids indicated that the waste liquids at 216-T-7 also were moving in a southwest direction (HW-17088, p. 74). No contamination was found on sediment samples obtained from the bottom of four shallow test boreholes that were drilled in 1948 in the 216-T-7 Tile Field; no liquid was found in any of these holes (HW-17088, p. 74). SGW-49498 summarizes the borehole geophysical logging results for the 216-T-7 Crib and Tile Field and the 216-T-32 Cribs (pp. A-67 to A-69). At the 216-T-7/200-W-52 Crib, contamination generally begins near the bottom of the crib in the four boreholes closest to the crib, and at about 12 m (40 ft) bgs in the four boreholes further from the crib. Historical (1951) contamination detected at the 216-T-7 Tile Field at 12 m (40 ft) bgs had decayed by 1976 and appears likely to have originated from the 216-T-32 Cribs. Contamination below 24.4 m (80 ft) bgs appears to have originated from the 216-T-7 Crib and Tile Field system. Borehole 299-W10-73, approximately 21.4 m (70 ft) north of the 216-T-7 Crib, appears to have been contaminated from 216-T-7. At this borehole, cesium-137 is detected to the bottom of the borehole near groundwater. Boreholes 299-W10-70 and 299-W10-71 at the western end both indicate no contamination at any time, suggesting that this portion of the tile field received very little effluent overflowing from the 216-T-7 Crib and no lateral migration of contaminants at these locations from the 216-T-32 or 216-T-5 Cribs. At the 216-T-32 Cribs, detections of cesium-137, europium-154, and plutonium begin at about 10.7 m (35 ft) bgs. The contaminated zone ranges in thickness from about 4.6 m (15 ft) near Crib 1 to about 1.5 m (5 ft) southeast of Crib 2 at a location below the 216-T-7 Tile Field. The concentrations of cesium-137 and europium-154 are relatively minor, suggesting that the fission product plume described in HW-9671 primarily contained short-lived gamma-emitting radionuclides. Geophysical logging suggests that the plutonium, cesium-137, and europium-154 contamination from 216-T-32 migrated laterally to the southwest within a dipping, silty-sandy geologic subunit and is contained within this unit. Near the 216-T-7 Tile Field, most of the cesium-137 contamination exhibits much higher concentrations and extends to much greater depths.	No	For the 216-T-32 Cribs, the supplemental characterization SAP includes geophysical logging at three existing boreholes at Crib 1 and one direct-push borehole to 12 m (40 ft) with geophysical logging at Crib 2. The existing boreholes were geophysically logged in 2008. 200-DV-1 recommends that the direct-push borehole at Crib 2 is not needed, based on the recently completed logging at Crib 1. The existing boreholes show no contamination beneath the CCU. For the 216-T-7 Tile Field, the supplemental characterization SAP includes one borehole to groundwater with nine split-spoon samples. 200-DV-1 recommends adding two samples in the Ringold Formation to evaluate contaminants.

Table C-12. Required Information for Waste Site/Group 216-T-7/200-W-52 (WMA T) Crib and Tile Field and 216-T-32 Cribs

216-T-7/200-W-52 (WMA T) and 216-T-32				
		Surface and well-to-well resistivity surveys were conducted in FY 2005 and FY 2006 at the T Tank Farm and were extended to cover associated waste sites, including 216-T-5 (RPP-RPT-28955). During FY 2009, the data were reanalyzed using newer model codes and lessons learned from past modeling (RPP-RPT-42844). The primary driver for using the resistivity method was that past waste streams contained ionic compounds (e.g., nitrate) whose residue within the vadose zone serves to increase the electrical conductivity (decrease the electrical resistivity) of the subsurface and can be traced using surface based electrical geophysical methods. The FY 2009 well-to-well modeling indicates the presence of an east-west elongated zone of extremely low resistivity (3 to 10 ohm-m) north of the 216-T-7 Tile Field, south of the 216-T-5 Trench, and beneath the southwestern half of the 216-T-32 Cribs. This zone measures about 100 m (328 ft) (east-west) by 35 m (114.8 ft) (north-south). The FY 2009 three-dimensional modeling indicated a zone of moderately low resistivity (50 to 80 ohm-m) north of the 216-T-7 Tile Field; the 38 m (124.7 ft) deep slice represents the maximum horizontal extent of this anomaly. The 80 ohm-m contour (yellow outline on Figure 3-32 in SGW-49924) indicates an anomalous region that is about 80 m (262.5 ft) (north-south) by 60 m (197 ft) (east-west). The top of this zone occurs at about 20 m (65.6 ft) bgs and the base extends to at least 56 m (183.7 ft) bgs.		
Extent of contamination	2-2	At the 216-T-7 Crib and Tile Field, the lateral extent of contamination is estimated to be encompassed by an ellipse that is about 120 m (394 ft) northeast-southwest and 95 m (312 ft) northwest-southeast, based on historical detectable mobile gamma contamination and recent resistivity surveys (SGW-49924, Figure 3-33). At the 216-T-32 Cribs, the lateral extent of contamination is estimated to be encompassed by an ellipse that is about 85 m (280 ft) northeast-southwest and 50 m (164 ft) northwest-southeast, based on historical detectable mobile gamma contamination and recent resistivity surveys (SGW-49924, Figure 3-33). The vertical extent of contamination at 216-T-7 is likely the groundwater; the vertical extent of contamination at 216-T-32 is likely the CCU (SGW-49924, p. C-24). Wastes from the 216-T-7 and 216-T-32 sites appear to be commingled, based on the geophysical logging and the resistivity surveys (SGW-49924, p. C-24 and Figure 3-32).	No	The planned supplemental characterization, as modified by the recommendations described above, will refine these estimates based on geophysical logging and electrical resistivity.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

2C = second-cycle (waste)
bgs = below ground surface
CCU = Cold Creek unit
DS = decision statement
FY = fiscal year
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model
WIDS = Waste Information Data System

Table C-13. Required Information for Waste Site/Group 216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches)

216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The base of the 216-T-14 Trench was 3 m (10 ft) wide and 61 m (200 ft) long. The bases of the 216-T-15, 216-T-16, and 216-T-17 Trenches were 3 m (10 ft) wide and 73 m (240 ft) long. All four trenches were 3 m (10 ft) deep (RHO-CD-673 II.NE). The centerlines of the 216-T-14, 216-T-15, and 216-T-16 Trenches are 27.5 m (90 ft) apart; the centerlines of the 216-T-16, and 216-T-17 Trenches are 15 m (50 ft) apart (H-2-36849). Historical drawings (ARH-2155, pp. B-22 through B-25; additional drawings listed in BHI-00177, Table B-3; HW-55176, Part 5, Appendix C-13). Historical photographs (BHI-00177, Table B-3). When each trench reached specific retention capacity, the aboveground piping was removed and the trench was backfilled (RHO-CD-673, II.NE). The 216-T-14 through 216-T-17 Trenches were interim-stabilized with 0.61 m (2 ft) of clean soil in 1984. The trenches were posted "Surface Contamination" and included in the UPR-200-W-166 (also known as UN-216-W-31) area in 1989. Subsequent surveys showed that a large portion of the site had low but detectable near-surface contamination (shine) and was probably not surface contaminated (WHC-SD-DD-AP-013, p. 3). In 1992, the original stabilized area of the T Trenches was covered with an additional 0.15 to 0.3 m (0.5 to 1 ft) of clean soil to provide an additional barrier over the near-surface contamination. The posting was changed from surface contamination to underground radioactive material. This area covers about 1.25 ha (3.1 ac) (WHC-SD-DD-AP-013, p. 7). In 1992, radiologically contaminated soil from UPR-200-W-166, north of the T Tank Farm and west of the T Trenches, was scraped and consolidated onto the west slope of the T Trenches. The contaminated soil was covered with 0.45 to 0.61 m (1.5 to 2 ft) of clean dirt (WHC-SD-DD-AP-013, p. 7; WHC-SP-0098-7, p. B-8).	Yes	None

Table C-13. Required Information for Waste Site/Group 216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches)

<table>
<tr><th colspan="6">216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)</th></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The T Trenches received the following waste streams (HW-38562):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td>216-T-14</td><td>01/1954 to 01/1954</td><td rowspan="4">1C supernate from 221-T via 241-T-104, 105, 106</td></tr>
<tr><td>216-T-15</td><td>01/1954 to 02/1954</td></tr>
<tr><td>216-T-16</td><td>02/1954 to 02/1954</td></tr>
<tr><td>216-T-17</td><td>02/1954 to 06/1954</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the T Trenches was 3.9 million L (1.0 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>1.76E+03 Ci</td></tr>
<tr><td>Strontium-90</td><td>2.77E+02 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>SGW-49498 summarizes geophysical logging results for the T Trenches (pp. A-95 and A-96).
At Borehole 299-W11-69, west of 216-T-14, cesium-137 was detected in 2005 from 0 to 3.3 m (0 to 11 ft) bgs, with a maximum activity of 16 pCi/g at 1.7 m (5.5 ft) bgs. This shallow contamination may be associated with the contaminated soil placed on the west slope of the T Trenches in 1992 because elevated gamma was detected from 9 to 13.7 m (30 to 45 ft) bgs when this borehole was first logged in 1963. The deeper contamination appears to have decayed away by 1976.
At Borehole 299-W11-23, further west of 216-T-14, cesium-137 was detected in 1998 from 0 to 42 ft and from about (60 to 140 ft) bgs, with a maximum concentration of 74 pCi/g at 0.5 m (1.5 ft) bgs. At Well 299-W11-39, which is 21 m (69 ft) to the south-southeast of 299-W11-23, Cesium-137 was detected from 0 to 0.3 m (0 to 1 ft) and at 6.4 m (21 ft) bgs in 2000, with a maximum of 2 pCi/g at ground surface.
At Borehole 299-W11-68, south of 216-T-15, cesium-137 was detected in 2005 from 0 to 2.4 m (0 to 8 ft) bgs, with a maximum activity of 230 pCi/g at 1.2 m (4 ft) bgs.
At Borehole 299-W11-80, at the northeast corner of 216-T-16, cesium-137 was detected in 2005 from 0 to 3.7 m (12 ft) bgs, with a maximum activity of 1 pCi/g at 3 m (10 ft) bgs.
At Borehole 299-W11-81, near the southeast corner of 216-T-17, cesium-137 was detected in 2005 from 0 to 4.6 m (15 ft) bgs, with a maximum activity of 13,000 pCi/g at 4.6 m (15 ft) bgs.</td><td>Yes</td><td>None</td></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the T Trenches. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-13. Required Information for Waste Site/Group 216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches)

<table>
<tr><th colspan="5">216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)</th></tr>
<tr><td colspan="5">PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Waste inventory</td><td>2-1</td><td>The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:
<table>
<tr><th colspan="2">216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Uranium (total)</td><td>1.32E+02 kg</td></tr>
<tr><td>Technetium-99</td><td>7.79E-01 Ci</td></tr>
<tr><td>Iodine-129</td><td>6.80E-03 Ci</td></tr>
<tr><td>Cobalt-60</td><td>1.22E+00 Ci</td></tr>
<tr><td>Tritium</td><td>2.35E+01 Ci</td></tr>
<tr><td>Plutonium-239</td><td>1.56E+00 Ci</td></tr>
<tr><td>Nitrate</td><td>4.13E+05 kg</td></tr>
<tr><td>Ferrocyanide</td><td>0.00E+00 kg</td></tr>
<tr><td>Fluoride</td><td>1.44E+04 kg</td></tr>
<tr><td>Chromium</td><td>1.38E+03 kg</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>SGW-49498 summarizes geophysical logging results for the T Trenches (pp. A-95 and A-96).
At Borehole 299-W11-69 (110 ft deep), west of 216-T-14, elevated gamma was detected in 1963 from 9 to 13.7 m (30 to 45 ft) bgs, which appears to have decayed away by 1976. No contamination was detected between 9 and 12 m (30 and 40 ft) in 2005, although cesium-137 was detected from 0 to 3.3 m (0 to 11 ft) bgs, with a maximum activity of 16 pCi/g at 1.7 m (5.5 ft) bgs.
At Borehole 299-W11-23 (77 m [252 ft] deep), further west of 216-T-14, cesium-137 contamination was detected in 1998 from 0 to 12.8 m (0 to 42 ft) bgs and from 18.3 to 42.7 m (60 to 140 ft) bgs, with a maximum of 74 pCi/g at 0.46 m (1.5 ft) bgs. At Well 299-W11-39, which is 21 m (69 ft) to the south-southeast of 299-W11-23, cesium-137 was detected from 0 to 0.35 m (0 to 1 ft) and at 6.4 m (21 ft) bgs in 2000, with a maximum of 2 pCi/g at ground surface.
At Borehole 299-W11-68 (30.5 m [100 ft] deep), south of 216-T-15, high gross-gamma activity (about 500,000 cpm) was detected in 1968 from 9 to 12 m (30 to 40 ft) bgs. In 1987, count rates were still higher than background. No gamma-emitting contamination was detected in 2005.
At Borehole 299-W11-80 (16 m [52 ft] deep), at the northeast corner of 216-T-16, gross gamma activity was not detected in 1984 or 1986.
At Borehole 299-W11-81 (16 m [52 ft] deep), near the southeast corner of 216-T-17, gross-gamma activity at 4.6 m to 5 m (15 to 16 ft) bgs saturated the logging tool in 1984, 1986, and 1992, and count rates increased at the bottom of the borehole. In 1992, cobalt-60 was identified from 5 to 14.6 m (16 to 48 ft) bgs with a maximum of 2 pCi/g at 5.5 m (18 ft) bgs. In 2005, cobalt-60 was identified from 6.7 to 9 m (22 to 30 ft), with a maximum of 0.2 pCi/g at 8.5 m (28 ft). In 2005, cesium-137 was identified from 0 to 16 m (0 to 52 ft).</td><td>No</td><td>The supplemental characterization SAP recommended three DPTs to 15 m (50 ft) with geophysical logging, and one DPT to sample based on contamination results from first three, at the 216-T-15 Trench. 200-DV-1 recommends attempting to reach the CCU (about 27.5 m [90 ft] bgs) to obtain a deeper sample to evaluate constituents.</td></tr>
</table>

Table C-13. Required Information for Waste Site/Group 216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17 Trenches)

216-T Trenches (216-T-14, 216-T-15, 216-T-16, and 216-T-17)				
Extent of contamination	2-2	At the T Trenches, the lateral extent of contamination is estimated to be encompassed by a circle with a 145 m (476 ft) diameter, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-53). The vertical extent of contamination likely extends at least to 24.4 m (80 ft) bgs, the top of the CCU (SGW-49924, Figure 3-54 and p. C-42).	No	The planned supplemental characterization, as modified by the recommendations described above, is needed to refine these estimates based on geophysical logging.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

1C = first-cycle (waste)
bgs = below ground surface
cpm = counts per minute
DPT = direct-push technology
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model

Table C-14. Required Information for Waste Site/Group 216-T-18 Crib

216-T-18

PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?
DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.
DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.

Information Input		Existing Data	Data Sufficient?	Data Needs
Type	DS #			
Physical layout	1-1, 1-2	The 216-T-18 Crib was a 3 m (10 ft) wide by 3 m (10 ft) long by 3 m (10 ft) deep "hole in the ground" (HW-33591, p. 27). Wastes were discharged to this site using an aboveground pipe. Historical drawings (ARH-2155, p. B-26; additional drawings listed in BHI-00177, Table B-2; HW-55176, Part 5, Appendix C-14). Historical photographs (BHI-00177, Table B-2). Following completion of waste discharge to the 216-T-18 Crib, the aboveground piping was removed and the crib was backfilled with soil to the ground surface (HW-33591, p. 27; ARH-2155, p. B-26; RHO-CD-673 II.NE). The 216-T-18 Crib was surface stabilized in 1990; the area at ground surface is 0.008 ha (0.02 ac) (WHC-SP-1149, p. B-9).	Yes	None
Waste inventory	1-1	The 216-T-18 Crib received the following waste streams (HW-33591, WHC-MR-0227): **Waste Site** / **Service Dates** / **Waste Stream** 216-T-18 / 12/1953 to 12/1953 / Supernate from the production test of TBP scavenging at U Plant via 241-T-101 The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-T-18 Crib was 1.0 million L (0.3 million gal).	Yes	None

Table C-14. Required Information for Waste Site/Group 216-T-18 Crib

216-T-18				
		The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following: **216-T-18** **Analyte** / **Inventory (Mean Values)** Cesium-137 / 4.22E+01 Ci Strontium-90 / 3.96E+01 Ci		
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	SGW-49498 summarizes geophysical logging results for the 216-T-18 Crib (pp. A-112 and A-113). Well 299-W11-11 is 3 m (10 ft) south of 216-T-18 (HW-33591, p. 28). Three direct-push holes were installed at 216-T-18 and logged in 2008 as part of the supplemental characterization. The maximum cesium-137 concentration (decayed to 09/30/2010) in the upper 4.6 m (15 ft) was about 1,000 pCi/g at 4.6 m (15 ft) bgs in Well 299-W11-11.	Yes	None
Extent of contamination	1-2	The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-T-18 Crib. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).	Yes	None
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following: **216-T-18** **Analyte** / **Inventory (Mean Values)** Uranium (total) / 5.52E+01 kg Technetium-99 / 1.54E-01 Ci Iodine-129 / 1.48E-03 Ci Cobalt-60 / 6.14E-02 Ci Tritium / 2.36E-01 Ci Plutonium-239 / 3.24E+00 Ci Nitrate / 3.28E+04 kg Ferrocyanide / 1.44E+02 kg Fluoride / 4.21E+03 kg Chromium / 1.01E+02 kg	Yes	None

Table C-14. Required Information for Waste Site/Group 216-T-18 Crib

216-T-18				
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	SGW-49498 summarizes geophysical logging results for the 216-T-18 Crib (pp. A-112 and A-113). Well 299-W11-11 is 3 m (10 ft) south of 216-T-18 (HW-33591, p. 28). Three direct-push holes were installed at 216-T-18 and logged in 2008 as part of the supplemental characterization. Well 299-W11-11 was logged periodically from 1954 until 1992. The log profiles detected activity to 25.6 m (84 ft) bgs at the top of the CCU. By 1992, cesium-137 and cobalt-60 were the only detectable gamma-emitting radionuclides. The maximum cesium-137 concentration (decayed to 09/30/2010) is about 10,000 pCi/g at 9 m (30 ft) bgs, and the maximum cobalt-60 concentration (decayed to 09/30/2010) is about 0.6 pCi/g at 23 m (75 ft) bgs. Low levels of cobalt-60 are detected in the Ringold Formation.	No	None The supplemental characterization SAP includes three DPTs to 30.5 m (100 ft) with geophysical logging, and one DPT to sample based on plutonium results from first three. The first three DPTs were installed and logged in 2008, and Stoller issued a report (HGLP-LDR-309, Rev. 0) summarizing the results of the geophysical logging. The logging was performed in three small-diameter, direct-push boreholes, using the SDLS, which are configured to operate inside steel casing with a minimum inner diameter of 4.4 cm (1.75 in.). Bismuth germanate, neutron moisture, and passive neutron logs were run in all three boreholes. Using the SDLS, the detection level for plutonium is at or near 100 nCi/g. There were no apparent detections of plutonium in any of the boreholes. Given the relatively high detection level for plutonium from the small-diameter borehole, for the 200-DV-1 OU, it is recommended that one DPT be located near the crib be sampled as identified in the supplemental characterization field sampling plan.
Extent of contamination	2-2	At the 216-T-18 Crib, the lateral extent of contamination is estimated to be encompassed by an ellipse that is about 40 m (131 ft) northeast-southwest and 30 m (98.4 ft) northwest-southeast, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-77). The vertical extent of contamination likely extends at least 29 m (95 ft) bgs, into the CCU (SGW-49924, Figure 3-67).	Yes	None
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
CCU = Cold Creek unit
DPT = direct-push technology
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SDLS = small-diameter logging system
TBP = tributyl phosphate

Table C-15. Required Information for Waste Site/Group 216-T-19 Crib and Tile Field

<table>
<tr><th colspan="5">216-T-19</th></tr>
<tr><td colspan="5">PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?
DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.
DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Physical layout</td><td>1-1, 1-2</td><td>The 216-T-19 Crib consists of a 3.7 m (12 ft) wide by 3.7 m (12 ft) long by 2.7 m (9 ft) high timber crib installed in a 9 m (30 ft) deep excavation, which was subsequently backfilled. A 15.2 cm (6 in.) diameter steel pipe from the 241-TX-153 Diversion Box discharged wastes near the top of the crib. Overflow from the crib discharged to the 216-T-19 Tile Field through a 20 cm (8 in.) diameter vitrified clay trunk line located 7 m (23 ft) bgs and extending 120 m (394 ft) to the south. Ten 15.2 cm (6 in.) diameter vitrified clay laterals are arranged in a 45-degree chevron pattern at intervals of 21.4 m (70 ft). Each lateral is 18.3 m (60 ft) long. A 1 percent grade was maintained on the trunk line and laterals. The drainage area of the tile field is 119 m (390 ft) long and 26 m (85 ft) wide. After a cave-in to the crib in 1956, a bypass pipeline was installed in 1973 to route the wastes directly to the tile field (SGW-49498, p. A-137; RHO-CD-673 II.NW; HW-55176, Part 5, Appendix C-15; RPP-5957, p. 13).
Historical drawings (ARH-2155, pp. B-27 and B-28; additional drawings listed in BHI-00177, Table B-2; HW-55176, Part 5, Appendix C-15).
Historical photographs (BHI-00177, Table B-2).
The 216-T-19 site was interim-stabilized in 1991; the surface area is 0.4 ha (1.0 ac) (WHC-SP-1149, p. B-9).</td><td>Yes</td><td>None</td></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The 216-T-19 Crib and Tile Field received the following waste streams (ARH-2155, p. B-27 and B-28; RPP-5957, Appendix E; BHI-00177):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td rowspan="2">216-T-19 Crib and Tile Field</td><td>05/1951 to 07/1955</td><td>Process condensate from 242-T Evaporator</td></tr>
<tr><td>12/1955 to 08/1956</td><td>Cell drainage from Tank 5-6 and 2C supernate from 221-T and waste from 224-T</td></tr>
<tr><td rowspan="2">216-T-19 Tile Field</td><td>12/1965 to 04/1976</td><td>Process condensate and steam condensate from 242-T Evaporator</td></tr>
<tr><td>04/1976 to 07/1980</td><td>Cold cell drainage</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-T-19 Crib and Tile Field was 455.0 million L (120.2 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>1.92E+01 Ci</td></tr>
<tr><td>Strontium-90</td><td>2.46E+01 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>Waste entered the 216-T-19 Crib and Tile Field at approximately 7 m (23 ft) bgs. Contamination is not anticipated for the upper 4.6 m (15 ft) bgs.
SGW-49498 summarizes geophysical logging results for the 216-T-19 Crib and Tile Field (pp. A-139 and A-140). Four boreholes are located within the area of the tile field. Boreholes 299-W14-52 and 299-W15-65 are 9 m (30 ft) deep; Boreholes 299-W14-51 and 299-W15-66 are 23 m (75 ft) and 24.4 m (80 ft) deep, respectively. These logs show no evidence of cesium-137 contamination greater than 1 pCi/g in the upper 4.6 m (15 ft) in the vicinity of the tile field.</td><td>Yes</td><td>None</td></tr>
</table>

Table C-15. Required Information for Waste Site/Group 216-T-19 Crib and Tile Field

216-T-19				
Extent of contamination	1-2	Based on the waste site construction dimensions and soil concentrations from geophysical logging, there is no contamination in the upper 4.6 m (15 ft) at the 216-T-19 site.	Yes	None
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following: **Analyte** / **Inventory (Mean Values)** Uranium (total) — 1.28E+01 kg Technetium-99 — 7.91E-03 Ci Iodine-129 — 0.00E+00 Ci Cobalt-60 — 1.41E-02 Ci Tritium — 5.12E+03 Ci Plutonium-239 — 8.35E+00 Ci Nitrate — 2.41E+05 kg Ferrocyanide — 0.00E+00 kg Fluoride — 1.37E+04 kg Chromium — 1.13E+03 kg	Yes	None
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	SGW-49498 summarizes geophysical logging results for the 216-T-19 Crib and Tile Field (pp. A-139 and A-140). Borehole 299-W14-51, nearest to the crib, indicates possible contamination to 23 m (75 ft) bgs (total depth). Borehole 299-W15-4, located about 37 m (122 ft) southwest of the crib and outside of the tile field, encountered radiological contamination above 12 m (40 ft) bgs when it was drilled in 1956, suggesting extensive lateral migration if 216-T-19 was the source. Elevated gamma activity was detected between 10.7 and 15 m (35 and 50 ft) bgs on all logs run between 1958 and 1995. Well 299-W15-762, drilled about 3.8 m (12.5 ft) northwest of 299-W15-4, encountered radiological contamination at 11.3 m (37 ft) bgs when it was drilled in 2000. Well 299-W15-763, drilled about 17 m (56 ft) west of 299-W15-4, did not encounter radiological contamination when it was drilled in 2000.	No	For the 216-T-19 Crib and Tile Field, the supplemental characterization SAP includes one borehole to groundwater with nine split-spoon samples. 200-DV-1 recommends adding one or two samples below the CCU.
Extent of contamination	2-2	At the 216-T-19 Crib and Tile Field, the lateral extent of contamination is estimated to be encompassed by a circle with an approximate 125 m (410 ft) diameter, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-93). The vertical extent of contamination likely extends to groundwater (SGW-49924, Figure 3-94).	No	The planned supplemental characterization, as modified by the recommendations described above, is needed to refine these estimates based on geophysical logging.

Table C-15. Required Information for Waste Site/Group 216-T-19 Crib and Tile Field

216-T-19				
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

2C = second-cycle (waste)
bgs = below ground surface
CCU = Cold Creek unit
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan

Table C-16. Required Information for Waste Site/Group 216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 Trenches)

216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Physical layout	1-1, 1-2	The bases of the 216-T-21. 216-T-22, 216-T-23, and 216-T-24 Trenches were 3 m (10 ft) wide and 73 m (240 ft) long. The base of the 216-T-25 Trench was 3 m (10 ft) wide and 55 m (180 ft) long (ARH-2155, pp. B-30 through B-34). All five trenches were 3 m (10 ft) deep. The centerlines of the trenches are 27.5 m (90 ft) apart (RHO-CD-673 II.NW). Historical drawings (ARH-2155, pp. B-30 through B-34; additional drawings listed in BHI-00177, Table B-1; HW-55176, Part 5, Appendix C-17; RHO-CD-673 II.NW). Historical photographs (BHI-00177, Table B-1). When each trench reached specific retention capacity, the aboveground piping was removed and the trench was backfilled (ARH-2155, pp. B-30 through B-34, RHO-CD-673 II.NW). The TX Trenches were interim-stabilized as one unit in 1982; the surface area is 1.2 ha (3.0 ac) (WHC-SP-1149, p. B-9). An area of backfill on the northeast corner was expanded to the north and east (about 30.5 m by 18.3 m [100 ft by 60 ft]) in 1993 (WIDS). An underground contamination site, about 2 m (6 ft) by 1.5 m (5 ft), east of the 216-T-23 Trench was stabilized in 1993 and included with 216-T-23 in 2000 (WIDS).	Yes	None

Table C-16. Required Information for Waste Site/Group 216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 Trenches)

<table>
<tr><th colspan="6">216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)</th></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The TX Trenches received the following waste streams (HW-38562):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td>216-T-21</td><td>06/1954 to 06/1954</td><td rowspan="4">1C supernate from 221-T via 241-TX-109, 110, 111</td></tr>
<tr><td>216-T-22</td><td>07/1954 to 07/1954</td></tr>
<tr><td>216-T-23</td><td>07/1954 to 08/1954</td></tr>
<tr><td>216-T-24</td><td>08/1954 to 08/1954</td></tr>
<tr><td>216-T-25</td><td>09/1954 to 09/1954</td><td>1C evaporator bottoms from 242-T via 241-TY-101, 102</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the TX Trenches was 8.0 million L (2.1 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>3.67E+03 Ci</td></tr>
<tr><td>Strontium-90</td><td>5.77E+02 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>SGW-49498 summarizes geophysical logging results for the TX Trenches (pp. A-150 and A-151).
Five boreholes are in the general vicinity of the TX Trenches. Cesium-137 was detected in all five boreholes between 0 to 4.6 m (0 to 15 ft) bgs. The maximum cesium-137 concentration was about 30 pCi/g at 0.91 m (3 ft) bgs in Well 299-W15-209.</td><td>Yes</td><td>None</td></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottoms of the TX Trenches. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-16. Required Information for Waste Site/Group 216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 Trenches)

<table>
<tr><th colspan="5">216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)</th></tr>
<tr><td colspan="5">PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?
DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Waste inventory</td><td>2-1</td><td>The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:
<table>
<tr><th colspan="2">TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Uranium (total)</td><td>2.74E+02 kg</td></tr>
<tr><td>Technetium-99</td><td>1.62E+00 Ci</td></tr>
<tr><td>Iodine-129</td><td>1.41E-02 Ci</td></tr>
<tr><td>Cobalt-60</td><td>2.55E+00 Ci</td></tr>
<tr><td>Tritium</td><td>4.89E+01 Ci</td></tr>
<tr><td>Plutonium-239</td><td>3.25E+00 Ci</td></tr>
<tr><td>Nitrate</td><td>8.59E+05 kg</td></tr>
<tr><td>Ferrocyanide</td><td>0.00E+00 kg</td></tr>
<tr><td>Fluoride</td><td>3.00E+04 kg</td></tr>
<tr><td>Chromium</td><td>2.87E+03 kg</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in the vadose zone</td><td>2-1, 2-2</td><td>SGW-49498 summarizes geophysical logging results for the TX Trenches (pp. A-150 and A-151).
Five boreholes are in the general vicinity of the TX Trenches; none were drilled through the base of a trench. Cesium-137 was detected in all five boreholes, with the dominant contamination occurring at about 8.5 m (28 ft) bgs. The maximum cesium-137 concentration detected is about 100,000 pCi/g at 10 m (33 ft) bgs in Well 299-W15-209. The deepest cesium-137 contamination was detected at 30.5 m (100 ft) bgs in Well 299-W15-210 (total depth of the borehole).</td><td>No</td><td>For the TX Trenches, the supplemental characterization SAP found the existing characterization adequate. For the 200-DV-1 OU, two direct-push boreholes are recommended to the CCU (about 33.5 m [110 ft] bgs): one at the 216-T-23 Trench (deepest gamma-emitting contamination), and one at the 216-T-25 Trench (received largest volume and inventory). Based on geophysical logging at these two locations, one DPT would be sampled at the location with the highest contamination to evaluate constituents.</td></tr>
</table>

Table C-16. Required Information for Waste Site/Group 216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25 Trenches)

216-TX Trenches (216-T-21, 216-T-22, 216-T-23, 216-T-24, and 216-T-25)				
Extent of contamination	2-2	At the TX Trenches, the lateral extent of contamination is estimated to be about 140 m (459 ft) north-south by 100 m (328 ft) east-west, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-105). The vertical extent of contamination likely extends at least to 33.5 m (110 ft) bgs, the top of the CCU (SGW-49924, Figure 3-106).	No	The characterization recommended above is needed to refine these estimates based on geophysical logging.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

1C	=	first-cycle (waste)	OU	=	operable unit
bgs	=	below ground surface	PSQ	=	principal study question
CCU	=	Cold Creek unit	SAP	=	sampling and analysis plan
DPT	=	direct-push technology	SIM	=	Soil Inventory Model
DS	=	decision statement	WIDS	=	Waste Information Data System

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Table C-17. Required Information for Waste Site/Group 216-T-26 Crib, 216-T-27 Crib (200-WA-1), and 216-T-28 Crib (200-WA-1)

216-T-26, 216-T-27 (200-WA-1), 216-T-28 (200-WA-1)				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The bases of the 216-T-26, 216-T-27, and 216-T-28 Cribs were each 9 m (30 ft) wide by 9 m (30 ft) long in a 4.6 m (15 ft) deep excavation. The excavation was backfilled with a 1.5 m (5 ft) layer of gravel into which four 122 cm (48 in.) diameter, 1.2 m (4 ft) long concrete culvert pipes were embedded vertically in a 4.6 m (15 ft) square pattern. Additional gravel was added to the tops of the culvert pipes. The excavation was backfilled to grade with existing material. Each crib was fed from the east by a 35.5 cm (14 in.) diameter steel pipe, with a 20 cm (8 in.) diameter steel pipe in a chevron pattern feeding each culvert pipe. The pipe to each crib connects to a 35.5 cm (14 in.) diameter steel pipe running south from the 216-TY-201 Flush Tank. Valves were provided to isolate each crib (SGW-49498, pp. A-109 and A-110; ARH-2155, Appendix C-20; RHO-CD-673 II.NE). Historical drawings (ARH-2155, pp. B-35 to B-39; additional drawings listed in BHI-00177, Table B-2; HW-55176, Part 5, Appendices C-19 and C-20). Historical photographs (BHI-00177, Table B-2). 216-T-26 Crib geophysical investigations (BHI-01606, Appendix C). A radiation survey in May 1975 revealed spotty surface contamination to a maximum of 30,000 cpm at the 216-T-26, 216-T-27, and 216-T-28 Cribs. In June and July 1975, 15.2 cm (6 in.) of soil was bladed from the affected areas to remediate the areas of surface contamination. The ground surface was then covered with clean fill dirt back to its original level (RHO-CD-673 II.NE). The 216-T-26, 216-T-27, and 216-T-28 Cribs and the 216-TY-201 Flush Tank were surface stabilized as one unit in 1990 (WIDS); the area at ground surface is 0.65 ha (1.6 ac) (WHC-SP-1149, p. B-9).	Yes	None

Table C-17. Required Information for Waste Site/Group 216-T-26 Crib, 216-T-27 Crib (200-WA-1), and 216-T-28 Crib (200-WA-1)

<table>
<tr><th colspan="6">216-T-26, 216-T-27 (200-WA-1), 216-T-28 (200-WA-1)</th></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The 216-T-26, 216-T-27, and 216-T-28 Cribs received the following waste streams (ARH-2155, pp. B-35 to B-39):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td>216-T-26</td><td>08/1955 to 12/1955</td><td>1C scavenged TBP supernate from 221-T via 241-TY-101, -103, -104</td></tr>
<tr><td>216-T-27</td><td>09/1965 to 11/1965</td><td>300 Area laboratory waste from the 340 Facility</td></tr>
<tr><td>216-T-28</td><td>02/1960 to 02/1963</td><td>Steam condensate, decontamination waste, and miscellaneous waste from 221-T via 241-T-112</td></tr>
<tr><td></td><td>02/1963 to 09/1963</td><td>Same waste from 221-T, plus decontamination waste from 2706-T</td></tr>
<tr><td></td><td>09/1963 to 07/1964</td><td>Same wastes from 221-T and 2706-T, plus 300 Area laboratory waste from the 340 Facility</td></tr>
<tr><td></td><td>07/1964 to 05/1966</td><td>Same waste from 221-T and the 340 Facility</td></tr>
<tr><td></td><td>05/1966 to 12/1966</td><td>Same waste from 221-T via 241-T-112</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-T-26 Crib was 11.1 million L (2.9 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">216-T-26, 216-T-27, and 216-T-28</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>6.32E+02 Ci</td></tr>
<tr><td>Strontium-90</td><td>5.82E+02 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>At the 216-T-26 Crib, Borehole C3102 was drilled in 2001 to the water table and sampled at two intervals in the upper 4.6 m (15 ft): 0 to 1.5 m (0 to 0.5 ft), and 3 to 3.8 m (10 to 12.5 ft). DOE/RL-2002-42 provides analytical data for Borehole C3102. Cesium-137 was analyzed for in only the 3 m (10 ft) to 3.8 m (12.5 ft) sample and was not detected.
At the 216-T-28 Crib, Borehole C4175 was drilled in 2004 to the water table. However, incomplete soil recovery prevented samples from being collected from 0 to 4.6 m (0 to 15 ft) bgs (DOE/RL-2005-61).
SGW-49498 summarizes geophysical logging results for the 216-T-26, 216-T-27, and 216-T-28 Cribs (pp. A-113 to A-115). Six boreholes have been drilled within the areas excavated for construction of the cribs, an additional two boreholes are on the margins of cribs, and a ninth borehole is just west of 216-T-28. The maximum cesium-137 concentration detected in the upper 4.6 m (15 ft) was about 3,000,000 pCi/g at 4.6 m (15 ft) bgs in Well 299-W14-2 in the southern part of the excavation for 216-T-28.</td><td>Yes</td><td>None</td></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-T-26, 216-T-27, and 216-T-28 Cribs. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft).</td><td>Yes</td><td>None</td></tr>
</table>

Table C-17. Required Information for Waste Site/Group 216-T-26 Crib, 216-T-27 Crib (200-WA-1), and 216-T-28 Crib (200-WA-1)

216-T-26, 216-T-27 (200-WA-1), 216-T-28 (200-WA-1)				
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants includes the following:	Yes	None

216-T-26, 216-T-27, and 216-T-28	
Analyte	**Inventory (Mean Values)**
Uranium (total)	1.14E+03 kg
Technetium-99	1.80E+00 Ci
Iodine-129	1.70E-02 Ci
Cobalt-60	1.09E+00 Ci
Tritium	2.96E+00 Ci
Plutonium-239	7.52E+01 Ci
Nitrate	5.65E+05 kg
Ferrocyanide	1.63E+03 kg
Fluoride	4.82E+04 kg
Chromium	8.41E+03 kg

Table C-17. Required Information for Waste Site/Group 216-T-26 Crib, 216-T-27 Crib (200-WA-1), and 216-T-28 Crib (200-WA-1)

216-T-26, 216-T-27 (200-WA-1), 216-T-28 (200-WA-1)				
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	At the 216-T-26 Crib, Borehole C3102 was drilled in 2001 to the water table and sampled at 10 intervals between 3 and 69 m (10 and 227 ft). DOE/RL-2002-42 provides analytical data for Borehole C3102. The maximum soil concentrations from C3102 (DOE/RL-2002-42) were as follows:	Yes	None

Analyte	Maximum Concentration	Depth bgs (ft)
Uranium (total)	61,100 µg/kg	10.4 to 11.1 [34.0 to 36.5]
Technetium-99	4.87 pCi/g	28.0 to 28.8 [92.0 to 94.5]
Iodine-129	Not analyzed	
Cobalt-60	0.074 pCi/g	28.0 to 28.8 [92.0 to 94.5]
Tritium	2,650 pCi/g	28.0 to 28.8 [92.0 to 94.5]
Plutonium-239	6,320 pCi/g	10.4 to 11.1 [34.0 to 36.5]
Nitrate	3,070 mg/kg	28.0 to 28.8 [92.0 to 94.5]
Fluoride	168 mg/kg	10.4 to 11.1 [34.0 to 36.5]
Cyanide	7.9 mg/kg	28.0 to 28.8 [92.0 to 94.5]
Chromium (hexavalent)	4.2 mg/kg	10.4 to 11.1 [34.0 to 36.5]

At the 216-T-28 Crib, Borehole C4175 was drilled in 2004 to the water table and sampled at 10 intervals between 5.3 and 68.9 m (17.5 and 226 ft). DOE/RL-2005-61 provides analytical data for Borehole C4175. The maximum soil concentrations from C4175 (DOE/RL-2005-61) were as follows:

Analyte	Maximum Concentration	Depth bgs (ft)
Uranium (total)	125,000 µg/kg	6.9 to 7.6 [22.5 to 25.0]
Technetium-99	18.6 pCi/g	6.9 to 7.6 [22.5 to 25.0]
Iodine-129	Not analyzed	
Cobalt-60	1.77 pCi/g	6.9 to 7.6 [22.5 to 25.0]
Tritium	19,000 pCi/g	27.4 to 28.2 [90.0 to 92.5]
Plutonium-239	1,110 pCi/g	5.3 to 6.1 [17.5 to 20.0]
Nitrate	245 mg/kg	27.4 to 28.2 [90.0 to 92.5]
Fluoride	39.6 mg/kg	27.4 to 28.2 [90.0 to 92.5]
Cyanide	Not detected	
Chromium (hexavalent)	1.5 mg/kg	27.4 to 28.2 [90.0 to 92.5]

Table C-17. Required Information for Waste Site/Group 216-T-26 Crib, 216-T-27 Crib (200-WA-1), and 216-T-28 Crib (200-WA-1)

216-T-26, 216-T-27 (200-WA-1), 216-T-28 (200-WA-1)				
		SGW-49498 summarizes geophysical logging results for the 216-T-26, 216-T-27, and 216-T-28 Cribs (pp. A-113 to A-115). Six boreholes have been drilled within the areas excavated for construction of the cribs, an additional two boreholes are on the margins of cribs, and a ninth borehole is just west of 216-T-28. At Well 299-W11-70, in the southern portion of the 216-T-26 excavation, the high gamma-emitting activity from 4.6 to 30.5 m (15 to 100 ft) has saturated the logging detector since 1963. Cesium-137 concentrations are underestimated by up to three orders of magnitude. This zone likely contains cobalt-60, europium-154, and europium-152. Cesium-137 and cobalt-60 were detected in the CCU and underlying Ringold Formation. Remnants of cobalt-60 are also found at these depths in Borehole C3102, which was drilled through the center of the 216-T-26 excavation. It appears that contamination resides primarily in the southern portion of the crib. The borehole at 216-T-27 indicated gamma activity from 9 to 30.5 m (30 to 100 ft) bgs (total depth) in 1963. After the crib was activated in 1965, additional contamination that saturated the detection system was observed between 3 and 9 m (10 and 30 ft) bgs. The borehole was deepened in 1983; current logging shows cobalt-60 to 46 m (150 ft) bgs (total depth). Log profiles in the boreholes at 216-T-28 indicate that contamination reached groundwater between 1963 and 1970. The boreholes at 216-T-26 and 216-T-27 are not deep enough to evaluate whether contamination from those cribs reached groundwater. Contamination from 216-T-26 and 216-T-27 has likely commingled with contamination from 216-T-28 in the deeper vadose zone. Boreholes 299-W14-1 and 299-W14-13, located about 38 m (125 ft) southeast and 61 m (200 ft) southwest, respectively, of 216-T-28 appear to show evidence of lateral spreading from 216-T-28 into, along, and below the CCU.		
Extent of contamination	2-2	At the 216-T-26 Crib, the lateral extent of contamination is estimated to be encompassed by an ellipse that is about 80 m (262.5 ft) northeast-southwest and 60 m (197 ft) northwest-southeast, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-77). The vertical extent of contamination likely extends to the water table (SGW-49924, Figure 3-79). At the 216-T-27 and 216-T-28 Cribs, the lateral extent of contamination is estimated to be encompassed by an ellipse that is about 135 m (443 ft) northeast-southwest and 95 m (312 ft) northwest-southeast, based on historical detectable mobile gamma contamination (SGW-49924, Figure 3-77). The vertical extent of contamination likely extends to the water table (SGW-49924, Figure 3-79).	Yes	None
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the T Complex conceptual model report (SGW-49924, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

1C = first-cycle (waste)
bgs = below ground surface
CCU = Cold Creek unit
DS = decision statement
OU = operable unit
PSQ = principal study question
SIM = Soil Inventory Model
TBP = tributyl phosphate
WIDS = Waste Information Data System

Table C-18. Required Information for Waste Site/Group 216-S-9 Crib and 216-S-23 Crib (200-WA-1)

216-S-9 and 216-S-23				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input				
Type	**DS #**	**Existing Data**	**Data Sufficient?**	**Data Needs**
Physical layout	1-1, 1-2	The base of the 216-S-9 waste site excavation was 91.5 m (300 ft) long, 9 m (30 ft) wide, and about 7.4 m (24.3 ft) deep bgs. The waste flowed through a 7.6 cm (3 in.) diameter Schedule 10 steel pipe from the 202-S Building to the 216-S-9 Crib inlet. At the inlet, the steel pipe fed two parallel, 15.2 cm (6 in.) diameter, perforated vitrified clay pipes that were 4.6 m (15 ft) apart and extended 90 m (295 ft) along the length of the crib. The two distribution pipes were 6.2 m (20.3 ft) bgs during operation of the crib. Gravel was placed in the excavation from 7.4 to 5.8 m (24.3 to 19 ft) bgs (i.e., extending about 0.24 m [0.8 ft] above the distribution pipes). A polyethylene barrier was placed on top of the gravel before backfilling the remainder of the excavation (H-2-32363). The base of the 216-S-23 waste site excavation was 109.8 (360 ft) long, 3 m (10 ft) wide, and about 8.5 m (28 ft) deep (RHO-CD-673 II.SE). The 7.6 cm (3 in.) diameter steel pipe to the 216-S-9 Crib was diverted to a 15.2 cm (6 in.) diameter ductile iron pipe that was routed to the 216-S-23 Crib (H-2-46111). Within the crib, the 15.2 cm (6 in.) diameter distribution pipe was about 0.30 m (1 ft) above the bottom of the excavation (8.2 m [27 ft] bgs) and followed the centerline of the excavation (H-2-46112). The bottom 0.61 m (2 ft) of the excavation was filled with gravel (i.e., extending about 0.15 m [0.5 ft] above the distribution pipe). A membrane barrier was placed on top of the gravel, a 10 cm (4 in.) thick sand cover was placed on top of the barrier, and the excavation was backfilled to grade. In 1969, during the tie-in of the 216-S-9 Pipeline to the 216-S-23 Pipeline, contaminated water was encountered coming from a break at the junction of the two crib lines at the south end of the 216-S-9 Crib (SGW-502080, Figure 3-8). Further excavation disclosed a severe expansion buckle in the line at that point with a similar buckle 2 m (6 ft) up the line toward the 202-S Building. There was no way to determine how long the line had been leaking or how much waste had been discharged to the ground. The dose rate at the bottom of the waste line was 40 R/hr. The leak is UPR-200-W-108 (previously called UN-200-W-108) (BHI-00176, p. 5-12; PNL-6456, Vol. 3, p. 216). Historical drawings (ARH-2155, pp. A-12 and A-31; additional drawings listed in BHI-00176, Table B-2). Historical photographs (BHI-00176, Table B-2). In 1992, contaminated soil from the northern portion of unplanned release UN-216-W-30 was excavated and consolidated on the surface of the 216-S-23 Crib. In 1995, contaminated soil from the southern portion of UN-216-W-30 was excavated and consolidated on the surface of the 216-S-9 Crib (BHI-00257, pp. 11-12). Both sites were covered with 46 5o 61 cm (18 to 24 in.) of uncontaminated soil. At both sites, the elevation of the ground surface increased by about 1.5 m (5 ft) (BHI-00257, Figures 1-2, 1-3, 3-1, and 3-7). In anticipation of the grade changes, groundwater wells associated with the 216-S-9 and 216-S-23 Cribs were extended as part of site preparations (BHI-00257, p. 10).	Yes	None Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.

Table C-18. Required Information for Waste Site/Group 216-S-9 Crib and 216-S-23 Crib (200-WA-1)

<table>
<tr><th colspan="6">216-S-9 and 216-S-23</th></tr>
<tr>
<td>Waste inventory</td>
<td>1-1</td>
<td>
The 216-S-9 and 216-S-23 sites received the following waste streams; 216-S-1&2 and 216-S-7 are included for information (ARH-2155, pp. A-12 and A-31; RHO-CD-673 II.SE; DOE/RL-98-28, p. H-5; ARH-329):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td>216-S-1&2 (160.43 ML)</td><td>01/1952 to 01/1956</td><td>Cell drainage from D-1 Receiver Tank and process condensate from D-2 Receiver Tank in 202-S Building</td></tr>
<tr><td>216-S-7 (389.90 ML)</td><td>01/1956 to 07/1965</td><td>Cell drainage from D-1 Receiver Tank, process condensate from D-2 Receiver Tank, and condensate from H-6 Condenser (until 04/1959) in 202-S Building</td></tr>
<tr><td rowspan="2">216-S-9 (49.58 ML)</td><td>07/1965 to 06/1967</td><td>Process condensate (acidic) from the D-2 Receiver Tank in the 202-S Building</td></tr>
<tr><td>07/1967 to 01/1969</td><td>Process condensate from evaporation and concentration of decontamination wastes in the 202-S Building</td></tr>
<tr><td>216-S-23 (34.10 ML)</td><td>01/1969 to 07/1972</td><td>Process condensate (neutral/basic) from evaporation and concentration of decontamination wastes in the 202-S Building</td></tr>
</table>
The REDOX solvent extraction separation process operated from 1951 through 1967. The process used acidified methyl isobutyl ketone/hexone solvent to separate plutonium and uranium from the dissolved fuel rod solutions. The aqueous process waste stream was concentrated in the waste concentrator, and the aqueous waste was discharged to 216-S-1&2, 216-S-7, and 216-S-9. The waste concentrator was active at REDOX until 1973.
After REDOX separation process operations ceased, the waste concentrator was used to concentrate decontamination waste from 221-T, N Reactor, 222-S Laboratory, and the 340 Facility. The aqueous waste was discharged to 216-S-23 (DOE/RL-98-28, pp. H-5, H-29, and H-30).
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-S-9 Crib was 49.6 million L (13.1 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">216-S-9</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>6.04E+01 Ci</td></tr>
<tr><td>Strontium-90</td><td>1.19E+02 Ci</td></tr>
<tr><th colspan="2">216-S-23</th></tr>
<tr><td>Cesium-137</td><td>5.88E-02</td></tr>
<tr><td>Strontium-90</td><td>1.15E-03</td></tr>
</table>
</td>
<td>Yes</td>
<td>None
Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.</td>
</tr>
</table>

Table C-18. Required Information for Waste Site/Group 216-S-9 Crib and 216-S-23 Crib (200-WA-1)

216-S-9 and 216-S-23				
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	SGW-50194 summarizes geophysical logging results for the 216-S-9 Crib. There are three boreholes in the immediate vicinity of 216-S-9 with geophysical logging data (one on the northwest side and two on the southeast side) and one borehole about 30 m (98.4 ft) south of the inlet near UPR-200-W-108; none were drilled through the crib bottom. The boreholes indicate no gamma contamination between 0 and 4.6 m (0 to 15 ft) bgs, consistent with the depth of the distribution pipes. Only two of the boreholes were logged after 1995, when the interim stabilization was completed. SGW-50194 summarizes geophysical logging results for the 216-S-23 Crib. There are four boreholes in the immediate vicinity of 216-S-23 with geophysical logging data (all on the east side) and one borehole about 30 m (98.4 ft) west of the distribution pipe; none were drilled through the crib bottom. During logging in 2003, sporadic cesium-137 contamination was detected outside the crib boundaries between 0 and 3 m (0 and 10 ft) bgs at concentrations less than 2 pCi/g. Logging in these boreholes indicated no contamination prior to 1992, when the interim stabilization was completed.	Yes	None Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.
Extent of contamination	1-2	Based on the waste site construction dimensions and soil concentrations from geophysical logging, there is no gamma-emitting contamination in the upper 4.6 m (15 ft) at the 216-S-9 Crib. Based on the waste site construction dimensions and soil concentrations from geophysical logging, there is no cesium-137 contamination exceeding 2 pCi/g in the upper 4.6 m (15 ft) at the 216-S-23 Crib.	Yes	None Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.

PSQ #2 Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use?

DS #2-1 Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.

DS #2-2 For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.

Information Input		Existing Data	Data Sufficient?	Data Needs
Type	DS #			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total volumes and mass of constituents discharged to the waste sites; 216-S-1&2 and 216-S-7 are included for information. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants include the following:	Yes	None Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.

216-S-9	
Analyte	**Inventory (Mean Values)**
Uranium (total)	2.76E+02 kg
Technetium-99	1.04E-01 Ci
Iodine-129	2.95E-02 Ci
Cobalt-60	1.12E-02 Ci
Tritium	1.17E+03 Ci
Plutonium-239	2.90E+00 Ci
Nitrate	4.18E+04 kg
Fluoride	0.00E+00 kg
Ferrocyanide	0.00E+00 kg
Chromium	0.00E+00 kg

Table C-18. Required Information for Waste Site/Group 216-S-9 Crib and 216-S-23 Crib (200-WA-1)

216-S-9 and 216-S-23				
		216-S-23 Analyte: Inventory (Mean Values) Uranium (total): 1.57E-05 kg Technetium-99: 1.86E-05 Ci Iodine-129: 2.93E-08 Ci Cobalt-60: 3.39E-06 Ci Tritium: 4.24E-05 Ci Plutonium-239: 2.57E-06 Ci Nitrate: 1.91E+03 kg Fluoride: 0.00E+00 kg Ferrocyanide: 0.00E+00 kg Chromium: 1.28E-03 kg		
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	In 1965, two wells at the 216-S-9 Crib were monitored weekly using an in-well gamma scintillation instrument to obtain field data on behavior of a new crib disposal site. Radionuclides were first detected in the soil near Well 299-W22-26 (located about 19.8 m [65 ft] from the crib) at a depth of 18.9 m (62 ft), 3 weeks following the initial disposal. About 10 days later, radioactivity was detected at a depth of 29 m (95 ft) in Well 299-W22-26 and at a depth of 12 m (40 ft) in Well 299-W22-25 (located about 30 m [98.4 ft] south of the inlet). Later measurements, within 6 weeks of the initial disposal, indicated a thickening of the contaminated zones adjacent to both wells and the appearance of radioisotopes (likely ruthenium-103/106) at a depth of 29.5 m (97 ft) near Well 299-W22-25. Neutron probe (moisture content) results were in good agreement with the scintillation results (BNWC-8-8-C, pp. C-4 and C-5). Within the first 6 months of 216-S-9 operations (July through December 1965), the scintillation monitoring indicated that the highest contamination near Well 299-W22-26 extended from 18.3 to 25.9 m (60 to 185 ft) (7.6 m [25 ft] deeper than the previous month). The position of contamination adjacent to Well 299-W22-25 had not changed. These results were interpreted to indicate that lateral migration had stabilized while downward migration continued (BNWC-8-12-C, p. C-6). Gamma activity was detected throughout the vadose zone to groundwater by February 1966 at Well 299-W22-26 and by February 1968 at Well 299-W25-25. Significant decay between 19.8 m (65 ft) and the water table had occurred by 1976, suggesting short-lived fission products such as Ru-106 as the dominant radionuclide (SGW-50194, Executive Summary and Section 4.4.1). Spectral gamma logging at 216-S-9 in 2007-2008 indicated cesium-137 contamination from about 9 to 18.3 m (30 to 60 ft) bgs (a stratigraphic contact in the Hanford formation), with a maximum concentration of 46,000 pCi/g at 10 m (33 ft) in Well 299-W22-25. Cobalt-60 also may be present in this interval. Low levels of both cesium-137 and cobalt-60 were detected from 55 to 73 m (180 to 240 ft) in 299-W22-25. This deeper contamination may be associated with historical contamination in the groundwater that left a "bathtub ring" when it receded. Europium-154 was detected from 9.4 to 14 m (31 to 46 ft) in Well 299-W25-26, with a maximum concentration of 2 pCi/g at 12 m (39 ft). No gamma-emitting contaminants were detected in Well 299-W22-69, about 86 m (282 ft) south of the inlet (SGW-50194, Executive Summary, Section 4.4.1, Table 4-1, and Section 4.5).	No	The supplemental characterization SAP found that the existing data for 216-S-9 are sufficient. For the 200-DV-1 OU, one DPT is recommended at the southern end of the crib, pushed to refusal with samples. Additional information for the northern end of the crib will be provided by the driller's log and geophysical logging of Well 299-W22-95 being drilled in 2011 (DOE/RL-2010-90). Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.

Table C-18. Required Information for Waste Site/Group 216-S-9 Crib and 216-S-23 Crib (200-WA-1)

216-S-9 and 216-S-23				
		At the 216-S-23 Crib, geophysical logging in 1968 during drilling of five new monitoring wells indicated no contamination in the vadose zone prior to use of the crib. Gamma-emitting contaminants were detected at two wells, 299-W19-5 and 299-W19-6, in 1970 from about 22 to 63 m (72 to 207 ft) (groundwater). By 1976, the gamma activity had decayed to near background levels. During spectral gamma logging throughout the vadose zone in 2003, no contamination was detected deeper than 3 m (10 ft) bgs (SGW-50194, Section 4.4.2, Table 4-1). The source of the iodine-129 groundwater plume underlying this area appears to be the 216-S-1, 216-S-2, 216-S-7, and 216-S-9 Cribs (DOE/RL-2009-122, pp. vii and 4-37).		
Extent of contamination	2-2	At the 216-S-9 Crib, electrical resistivity surveys indicated a zone of relatively low-to-intermediate resistivity (180 to 280 ohm-m) near the southern end of the crib (SGW-50280, Figure 3-7). The lateral extent of contamination is an ellipse, centered near the southern end of the crib, with a northwest-southeast axis about 170 m (559 ft) long and a northeast-southwest axis about 100 m (328 ft) long, based on historical detectable mobile gamma contamination (SGW-50280, Figure 3-8). The historical vertical extent of contamination extended to the 2007 water table (SGW-50280, Figure 3-9). The resistivity surveys did not provide coverage of the 216-S-23 Crib. At the 216-S-23 Crib, the lateral extent of contamination is a circle at the southern end of the crib with a diameter approximately 75 m (246 ft) long, based on historical detectable mobile gamma contamination (SGW-50280, Figure 3-8). The historical vertical extent of contamination is not likely to have extended to the 2007 water table (SGW-50280, p. B-20).	No	At the 216-S-9 Crib, the planned supplemental characterization, as modified by the recommendations described above, will help define the extent of contamination. Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the S Complex conceptual model report (SGW-50280, Chapter 4).	Yes	None Note: The 216-S-23 Crib is a 200-WA-1 OU waste site.

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
DPT = direct-push technology
DS = decision statement
OU = operable unit
PSQ = principal study question
REDOX = Reduction-Oxidation (Plant)
SAP = sampling and analysis plan
SIM = Soil Inventory Model

Table C-19. Required Information for Waste Site/Group 216-S-13 Crib

<table>
<tr><th colspan="5">216-S-13</th></tr>
<tr><td colspan="5">PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use?
DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.
DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.</td></tr>
<tr><th colspan="2">Information Input</th><th rowspan="2">Existing Data</th><th rowspan="2">Data Sufficient?</th><th rowspan="2">Data Needs</th></tr>
<tr><th>Type</th><th>DS #</th></tr>
<tr><td>Physical layout</td><td>1-1, 1-2</td><td>The base of the 216-S-13 Crib excavation is 12 m (40 ft) long, 12 m (40 ft) wide, and 33.5 ft deep. The wooden crib structure is 3.7 m (12 ft) long, 3.7 m (12 ft) wide, and 2.7 m (9 ft) high. The base of the crib was placed in the center of the excavation on a 1.2 m (4 ft) thick bed of crushed stone. The crushed stone layer above the crib bottom was 2 m (6 ft) thick. The upper 7.2 m (23.5 ft) of the excavation was backfilled. The 15.2 cm (6 in.) diameter, vitrified clay inlet pipe discharge to the eastern side of the crib at 6.4 m (21.2 ft) bgs (HW-55176 Part 3, Appendices C-18 and C-19).
Historical drawings (ARH-2155, p. A-17; additional drawings listed in BHI-00176, Table B-2; HW-55176, Part 3, Appendices C-18 and C-19).
Historical photographs (BHI-00176, Table B-2).
The 216-S-13 Crib was interim-stabilized in 1991. The surface area is 0.36 ha (0.09 ac) (WHC-SP-1149, p. B-8).
In 2008, in preparation for drilling the supplemental characterization borehole (C6408) through the crib, a camera was lowered into a vent riser and indicated a void space. About 29 m (95 ft) of control density fill was added to the crib void space through the vent riser (WIDS). The borehole was not drilled.</td><td>Yes</td><td>None</td></tr>
<tr><td>Waste inventory</td><td>1-1</td><td>The 216-S-13 Crib received the following waste streams (ARH-2155, p. A-17):
<table>
<tr><th>Waste Site</th><th>Service Dates</th><th>Waste Stream</th></tr>
<tr><td rowspan="2">216-S-13
(5.00 ML)</td><td>01/1952 to 06/1967</td><td>Liquid waste from the 203-S Decontaminated Metal Storage Facility, the 204-S UNH Lag Storage Facility, and the 276-S Organic Solvent Make-Up Facility</td></tr>
<tr><td>06/1967 to 07/1972</td><td>Occasional sump waste from the 204-S Facility; deactivated the 203-S and 276-S Facilities during shutdown of production operations at REDOX</td></tr>
</table>
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-S-13 Crib was 5.0 million L (1.3 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">216-S-13</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>1.45E+02 Ci</td></tr>
<tr><td>Strontium-90</td><td>4.20E-01 Ci</td></tr>
</table></td><td>Yes</td><td>None</td></tr>
</table>

Table C-19. Required Information for Waste Site/Group 216-S-13 Crib

216-S-13				
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	The nearest well, 299-W22-21, is about 15 m (49 ft) from the center of the 216-S-13 Crib. Soil concentration data are not available for the upper 4.6 m (15 ft) of soil in the crib.	Yes	None
Extent of contamination	1-2	Based on the waste site construction dimensions, there is no contamination in the upper 4.6 m (15 ft) at the 216-S-13 Crib.	Yes	None
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total volumes and mass of constituents discharged to the waste sites; 216-S-1&2 and 216-S-7 are included for information. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants include the following: **216-S-13** **Analyte** — **Inventory (Mean Values)** Uranium (total) — 3.05E+00 kg Technetium-99 — 4.40E-01 Ci Iodine-129 — 0.00E+00 Ci Cobalt-60 — 1.85E-03 Ci Tritium — 4.31E+01 Ci Plutonium-239 — 7.04E-01 Ci Nitrate — 3.48E+04 kg Ferrocyanide — 0.00E+00 kg Fluoride — 4.79E+01 kg Chromium — 1.21E+01 kg The 216-S-13 Crib received 10,000 kg of hexone and 10,000 kg of sodium dichromate (DOE/RL-2007-02-VOLII-ADD3, p. AD3 3-5). The inventory of sodium dichromate based on historical documents differs from the inventory in the table above based on the SIM (RPP-26744).	Yes	None

Table C-19. Required Information for Waste Site/Group 216-S-13 Crib

216-S-13				
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	Well 299-W22-21 was drilled in 1957. Geophysical logging of Well 299-W22-21 between 1963 and 1968 detected radioactive contaminants from 8.2 to 33.5 m (27 to 110 ft) bgs (ARH-ST-156, p. 42). By 1976, radioactivity had decreased to low levels. Measurable migration of radionuclides has not been detected in the sediments since the discharges to the crib were terminated. Based on the geophysical logging, breakthrough to groundwater has not occurred at this site.	No	For the 216-S-13 Crib, the supplemental characterization SAP includes a borehole near the center of the crib to be drilled to groundwater, sampled at seven intervals, and geophysically logged. For the 200-DV-1 OU, implementing the supplemental characterization as planned is recommended. Additional information will be provided by the driller's log and geophysical logging of Well 299-W22-92, being drilled in 2011 near the northeast corner of the crib (DOE/RL-2010-90).
Extent of contamination	2-2	The resistivity surveys did not provide coverage of the 216-S-13 Crib. Based on historical detectable mobile gamma contamination at Well 299-W22-21, the lateral extent of contamination is estimated to be encompassed by a circle with a radius of at least 15 m (49 ft) (ARH-ST-156). Based on historical geophysical logging, the vertical extent of contamination is estimated to be about 33.5 m (110 ft).	No	The planned supplemental characterization, as described above, will help define the extent of contamination.
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the S Complex conceptual model report (SGW-50280, Chapter 4).	Yes	None

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model
WIDS = Waste Information Data System

Table C-20. Required Information for Waste Site/Group 216-S-21 Crib and 216-S-25 Crib (200-WA-1)

216-S-21 and 216-S-25				
PSQ #1: Do chemical and/or radiological contaminants in the shallow (0 to 4.6 m [0 to 15 ft] bgs) vadose zone at 200-DV-1 OU waste sites pose an unacceptable risk to human health and the environment under current and/or potential future land use? **DS #1-1: Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.** **DS #1-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Physical layout	1-1, 1-2	The base of the 216-S-21 Crib excavation was 15 m (50 ft) wide, 15 m (50 ft) long, and 6.7 m (22.1 ft) deep. The crib, which was constructed with 20 cm (8 in.) thick timbers, is 5 m (16 ft) wide, 5 m (16 ft) long, and 3 m (9.8 ft) deep. The base of the crib was placed in the center of the excavation on a 1.2 m (4 ft) thick bed of gravel. The gravel layer above the crib bottom was 2 m (6 ft) thick. The upper 3.7 m (12 ft) of the excavation was backfilled. The inlet and outlet pipes were 20 cm (8 in.) diameter Schedule 40 steel. The inlet pipe entered the eastern side of the crib at 2.7 m (9.1 ft) bgs. The overflow pipe exited the western side of the crib 2.9 m (9.7 ft) bgs; it extended 15 m (50 ft) to the west and was capped (HW-55176, Part 3, Appendices C-29, C-30, and C-30a; RHO-CD-673 II.SW). Well 299-W23-63 was drilled through the center of the excavation before installation of the crib structure. The well was physically decommissioned on 03/27/2007. The base of the 216-S-25 Crib was 175 m (575 ft) long, 3 m (10 ft) wide, and 3 m (10 ft) deep (RHO-CD-673 III.S-200W). The bottom 1.2 m (4 ft) of the crib was filled with gravel. The 15.2 cm (6 in.) diameter, perforated steel, central distribution pipe was placed 0.91 m (3 ft) above the crib floor, 2 m (7 ft) bgs (H-2-46292). Historical drawings (ARH-2155, p. A-29 [216-S-21]; BHI-00176, Table B-1 [216-S-25]; BHI-00174, Section 11.2 [216-S-21]; HW-55176, Part 3, Appendices C-29, C-30, and C-30a [216-S-21]). Historical photographs (BHI-00176, Table B-1 [216-S-25]; BHI-00174, Appendix A [216-S-21]). The 216-S-21 Crib was interim-stabilized in 1991. The surface area is 0.9 ha (0.23 ac) (WHC-SP-1149, p. B-8). In 1991, the surface of the 216-S-25 Crib was about 0.30 m (1 ft) above grade (BHI-00174, p. 4-9).	Yes	None Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.
Waste inventory	1-1	The 216-S-21 and 216-S-25 Cribs received the following waste streams (ARH-2155, p. A-29 [216-S-21]; DOE/RL-91-60, p. 2-16 [216-S-25]; WHC-EP-0133, p. 5-6 [216-S-25]): **Waste Site** / **Service Dates** / **Waste Stream** 216-S-21 (87.14 ML) / 11/1954 to 02/1969 / Condensate from the condensers in the 241-SX-401 Building via the 241-SX-106 Tank 216-S-25 (288.0 ML) / 11/1973 to 11/1980 / 242-S Evaporator process and steam condensate 11/1980 to 1992 / SX Tank Farm cooling water 1984 / Pipeline from the 241-SX-402 Building was tied into the 216-S-25 Pipeline (WIDS) 06/1985 to 11/1985 / Effluent (treated using ion exchange to remove uranium) from 216-U-1&2 pump-and-treat operation 1992 / 241-SX Sludge Cooler Steam Heater was shut off because of leaking tubes (WIDS)	Yes	None Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.

Table C-20. Required Information for Waste Site/Group 216-S-21 Crib and 216-S-25 Crib (200-WA-1)

<table>
<tr><th colspan="5">216-S-21 and 216-S-25</th></tr>
<tr><td></td><td></td><td>The 241-SX-401 Building (also known as the 241-SX-401 Condenser Shielding Waste Disposal Condenser House) and the 241-SX-402 Building (also known as the 241-SX-402 Waste Disposal Condenser House) were used to remove warm vapor from Tank 241-SX-106, condense the condensable materials, and route the condensate to a crib (DOE/RL-91-60, p. 2-7; RPP-6925, Rev. 1, p. 1-3).
The SIM (RPP-26744) provides estimates of the yearly and total volumes discharged to the waste sites. The total volume discharged to the 216-S-21 Crib was 87.1 million L (23.0 million gal).
The SIM (RPP-26744) provides estimates of the yearly and total masses of constituents discharged to the waste sites. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory (mean values) for key contaminants associated with the direct exposure pathway includes the following:
<table>
<tr><th colspan="2">216-S-21 Crib</th></tr>
<tr><th>Analyte</th><th>Inventory (Mean Values)</th></tr>
<tr><td>Cesium-137</td><td>6.28E+02 Ci</td></tr>
<tr><td>Strontium-90</td><td>6.63E+00 Ci</td></tr>
<tr><th colspan="2">216-S-25 Crib</th></tr>
<tr><td>Cesium-137</td><td>2.30E-05 Ci</td></tr>
<tr><td>Strontium-90</td><td>4.85E-05 Ci</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)</td><td>1-1</td><td>SGW-50194 summarizes geophysical logging results for the 216-S-21 Crib. There are two boreholes in the immediate vicinity of the crib. Borehole 299-W23-63 extends to 15 m (50 ft) bgs through the middle of the crib, and Well 299-W23-4 extends to groundwater at the southeast corner of the excavated area. Cesium-137 was detected in the upper 4.6 m (15 ft) in Borehole 299-W23-63 at concentrations ranging from 0.2 to 1,000 pCi/g, with the maximum value at 4.6 m (15 ft) bgs.
SGW-50194 summarizes geophysical logging results for the 216-S-25 Crib. Well 299-W23-9 is about 5 m (16.4 ft) south of the eastern end of the crib, and Well 299-W23-10 is about 23 m (75 ft) south of the middle of the crib; neither well is within the excavated area. When these wells were last logged (299-W23-9 in 1976, and 299-W23-10 in 1981), no contamination was detected.</td><td>Yes</td><td>None
Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.</td></tr>
<tr><td>Extent of contamination</td><td>1-2</td><td>The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-S-21 Crib. Geophysical logging is available to determine the vertical extent of contamination in the upper 4.6 m (15 ft) of the 216-S-21 Crib.
The lateral extent of contamination in the upper 4.6 m (15 ft) will be assumed to coincide with the lateral extent of the bottom of the 216-S-25 Crib. Although geophysical logging indicated no gamma-emitting contamination at the 216-S-25 Crib, the upper 4.6 m (15 ft) is assumed to potentially contain chemical contamination at undetermined concentrations.</td><td>Yes</td><td>None
Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.</td></tr>
</table>

Table C-20. Required Information for Waste Site/Group 216-S-21 Crib and 216-S-25 Crib (200-WA-1)

216-S-21 and 216-S-25				
PSQ #2: Do chemical and/or radiological contaminants in the vadose zone from 200-DV-1 OU waste sites pose an unacceptable groundwater risk to human health and the environment under current and/or potential future land use? **DS #2-1: Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.** **DS #2-2: For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.**				
Information Input		**Existing Data**	**Data Sufficient?**	**Data Needs**
Type	**DS #**			
Waste inventory	2-1	The SIM (RPP-26744) provides estimates of the yearly and total volumes and mass of constituents discharged to the waste sites; 216-S-1&2 and 216-S-7 are included for information. (Note: In RPP-26744, radionuclides are decayed to January 1, 2001.) The waste inventory for key mobile contaminants include the following:	Yes	None Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.

216-S-21 Crib	
Analyte	**Inventory (Mean Values)**
Uranium (total)	1.06E-01 kg
Technetium-99	2.11E-01 Ci
Iodine-129	3.23E-04 Ci
Cobalt-60	3.36E-02 Ci
Tritium	2.54E+03 Ci
Plutonium-239	5.99E-02 Ci
Nitrate	4.91E+02 kg
Ferrocyanide	0.00E+00 kg
Fluoride	2.19E+01 kg
Chromium	5.08E+01 kg

Table C-20. Required Information for Waste Site/Group 216-S-21 Crib and 216-S-25 Crib (200-WA-1)

216-S-21 and 216-S-25				
		216-S-25 Crib Analyte / Inventory (Mean Values) Uranium (total) 6.89E-01 kg Technetium-99 0.00E+00 Ci Iodine-129 0.00E+00 Ci Cobalt-60 2.33E-04 Ci Tritium 3.62E+03 Ci Plutoniium-239 1.38E-01 Ci Nitrate 2.23E+05 kg Ferrocyanide 0.00E+00 kg Fluoride 4.27E+02 kg Chromium 1.40E+02 kg The SIM data indicate that 216-S-25 received liquid discharges from 1973 through 1980 and in 1985.		
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	SGW-50194 summarizes geophysical logging results for the 216-S-21 Crib. In Well 299-W23-63 in the center of the crib, cesium-137 was detected to about 14.3 m (47 ft) bgs in 2006; the maximum value was 45,000,000 pCi/g at 7.5 m (24.5 ft). Europium-154, cobalt-60, and tin-126 were detected in the bottom 3 to 3.7 m (10 to 12 ft) of the well (11.8 to 15.5 m [39 to 41 ft] bgs), where cesium-137 concentrations were lower. It is likely that these contaminants are present in the high-activity cesium-137 interval but could not be detected because of the cesium-137 activity. In Well 299-W23-4 at the southeast corner of the 216-S-21 Crib, cobalt-60 was detected in 1995 from about 11 to 18 m (36 to 60 ft) bgs, with intermittent detections to about 50.3 m (165 ft) bgs. The existence of remnant cobatl-60 in current logs to a depth of at least 50.3 m (165 ft) bgs suggests that relatively short-lived radionuclides earlier may have reached this depth in the vadose zone. SGW-50194 summarizes geophysical logging results for the 216-S-25 Crib. Well 299-W23-9 is about 5 m (16.4 ft) south of the eastern end of the crib, and Well 299-W23-10 is about 23 m (75 ft) south of the middle of the crib. Neither is within the excavated area. When these wells were last logged (i.e., 299-W23-9 in 1976, and 299-W23-10 in 1981), contamination was not detected.	No	The supplemental characterization SAP recommended one DPT to30.5 m (100 ft) with two soil samples at the 216-S-21 Crib. 200-DV-1 recommends attempting to reach the CCU (about 37 m [120 ft] bgs) to obtain a deeper sample to evaluate constituents. Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.
Extent of contamination	2-2	At the 216-S-21 Crib, the lateral extent of contamination is a circle approximately centered on the crib with a diameter about 84 m (274 ft) long, based on historical detectable mobile gamma contamination (SGW-50280, Figure 3-18). The historical vertical extent of contamination is not likely to have extended below the CCU (SGW-50280, Figure 3-19). Resistivity modeling results for 216-S-25 do not indicate a strong electrical signature that can be correlated with past waste streams. A subtle zone of low to intermediate resistivity (90 to 150 ohm-m) is imaged on profiles 0E and 1E beneath the location of the 216-S-25 Crib (SGW-50280, p. B-26). At the 216-S-25 Crib, the lateral extent of contamination is an ellipse associated with the eastern three-fourths of the crib with an east-west axis about 540 m (1,772 ft) long and a north-south axis about 60 m (197 ft) long, based on historical detectable mobile gamma contamination (SGW-50280, Figure 3-18). The historical vertical extent of contamination is not likely to have extended below the CCU (SGW-50280, Figure 3-20).	No	At the 216-S-21 Crib, the planned supplemental characterization, as modified by the recommendations described above, will help define the extent of contamination. Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.

Table C-20. Required Information for Waste Site/Group 216-S-21 Crib and 216-S-25 Crib (200-WA-1)

216-S-21 and 216-S-25				
Contaminant fate and transport parameters	2-1, 2-2	The hydraulic and transport parameter values for the vadose zone and unconfined aquifer are provided for the stratigraphic units in the S Complex conceptual model report (SGW-50280, Chapter 4).	Yes	None Note: The 216-S-25 Crib is a 200-WA-1 OU waste site.

Note: The references cited in this table are included in the References section of this appendix.

bgs = below ground surface
CCU = Cold Creek unit
DPT = direct-push technology
DS = decision statement
OU = operable unit
PSQ = principal study question
SAP = sampling and analysis plan
SIM = Soil Inventory Model
WIDS = Waste Information Data System

Table C-21. Summary of Data Sufficiency for 200-DV-1 OU Waste Sites in the B Complex Area

Required Information		200-DV-1 OU Waste Sites in the B Complex Area							
PSQ #1 Information Input		**216-B-5**	**216-B-7**	**216-B-8**	**216-B-9**	**216-B-11**	**216-BX**	**216-BY**	**216-B-57**
Type	**DS#**	**Table C-2**	**Table C-3**	**Table C-4**	**Table C-5**	**Table C-6**	**Table C-7**	**Table C-8**	**Table C-9**
Physical layout	1-1, 1-2	●	●	●	●	●	●	●	●
Waste inventory	1-1	●	●	●	●	●	●	●	●
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	●	●	●	●	●	●	●	●
Extent of contamination	1-2	●	●	●	●	●	●	●	●
PSQ #2 Information Input									
Type	**DS#**								
Waste inventory	2-1	●	●	○	●	●	●	●	●
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	●	○	○	○	●	○	○	●
Extent of contamination	2-2	●	○	○	○	●	○	○	●
Contaminant fate and transport parameters	2-1, 2-2	●	●	●	●	●	●	●	●

○ = data not sufficient
● = data sufficient
DS = decision statement
OU = operable unit
PSQ = principal study questions

Table C-22. Summary of Data Sufficiency for 200-DV-1 OU Waste Sites in the T Complex Area

Required Information		200-DV-1 OU Waste Sites in the T Complex Area									
PSQ #1 Information Input		**216-T-3**	**216-T-5**	**216-T-6**	**216-T-7**	**216-T**	**216-T-18**	**216-T-19**	**216-TX**	**216-T-26**	**216-T-32**
Type	**DS#**	**Table C-10**	**Table C-11**	**Table C-10**	**Table C-12**	**Table C-13**	**Table C-14**	**Table C-15**	**Table C-16**	**Table C-17**	**Table C-12**
Physical layout	1-1, 1-2	●	●	●	●	●	●	●	●	●	●
Waste inventory	1-1	●	●	●	●	●	●	●	●	●	●
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	●	●	●	●	●	●	●	●	●	●
Extent of contamination	1-2	●	●	●	●	●	●	●	●	●	●
PSQ #2 Information Input											
Type	**DS #**										
Waste inventory	2-1	●	●	●	●	●	●	●	●	●	●
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	○	○	○	○	○	○	○	○	●	●
Extent of contamination	2-2	○	○	○	○	○	○	○	○	●	●
Contaminant fate and transport parameters	2-1, 2-2	●	●	●	●	●	●	●	●	●	●

○ = data not sufficient
● = data sufficient
DS = decision statement
OU = operable unit
PSQ = principal study question

Table C-23. Summary of Data Sufficiency for 200-DV-1 OU Waste Sites in the S Complex Area

Required Information		200-DV-1 Operable Unit Waste Sites in the S Complex Area		
PSQ #1 Information Input		**216-S-9**	**216-S-13**	**216-S-21**
Type	**DS#**	**Table C-18**	**Table C-19**	**Table C-20**
Physical layout	1-1, 1-2	●	●	●
Waste inventory	1-1	●	●	●
Soil concentration (actual or estimated) for target analytes in upper 4.6 m (15 ft)	1-1	●	●	●
Extent of contamination	1-2	●	●	●
PSQ #2 Information Input				
Type	**DS #**			
Waste inventory	2-1	●	●	●
Soil concentration (actual or estimated) for target analytes in the vadose zone	2-1, 2-2	○	○	○
Extent of contamination	2-2	○	○	○
Contaminant fate and transport parameters	2-1, 2-2	●	●	●

○ = data not sufficient
● = data sufficient
DS = decision statement
OU = operable unit
PSQ = principal study question

Table C-24. Decision Statements

DS #	Decision Statement
1-1	Determine whether the chemical and/or radiological contaminants within the upper 4.6 m (15 ft) at the 200-DV-1 OU waste sites exceed acceptable risk levels for human health and the environment.
1-2	For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination within the upper 4.6 m (15 ft) sufficiently for remedy selection.
2-1	Determine whether the chemical and/or radiological contaminants in the vadose zone exceed acceptable risk levels for groundwater.
2-2	For the 200-DV-1 OU waste sites requiring remediation, determine the extent of chemical and/or radiological contamination in the vadose zone sufficiently for remedy selection.

DS = decision statement
OU = operable unit

Table C-25. Decision Rules

DS #	DR #	Decision Rule
1-1	1-1	If the chemical and/or radiological contaminants in the top 4.6 m (15 ft) of the soil at the sites represent an unacceptable risk to human health and the environment, based upon the highest observed contaminant concentrations in soil samples from the waste site or applicable similar waste site, then proceed with selection and description of a remedial alternative within a feasibility study/correction measures study and proposed plan/proposed corrective action decision, otherwise propose no further action.
1-2	1-2	If the chemical and/or radiological contaminants in the top 4.6 m (15 ft) of the soil at the sites require remediation, then then gather additional physical, geophysical, and/or sample analytical information, otherwise proceed to evaluate remedial alternatives within the feasibility study/ correction measures study and proposed plan/proposed corrective action decision.
2-1	2-1	If the chemical and/or radiological contaminants in the vadose zone at the sites represent an unacceptable risk to human health and the environment, based upon the highest observed contaminant concentrations in soil samples from the waste site or applicable similar waste site, then proceed with selection and description of a remedial alternative within a feasibility study/correction measures study and proposed plan/proposed corrective action decision, otherwise propose no further action.
2-2	2-2	If the chemical and/or radiological contaminants in the vadose zone at the sites require remediation, then then gather additional physical, geophysical, and/or sample analytical information, otherwise proceed to evaluate remedial alternatives within the feasibility study/correction measures study and proposed plan/proposed corrective action decision.

DR = decision rule
DS = decision statement

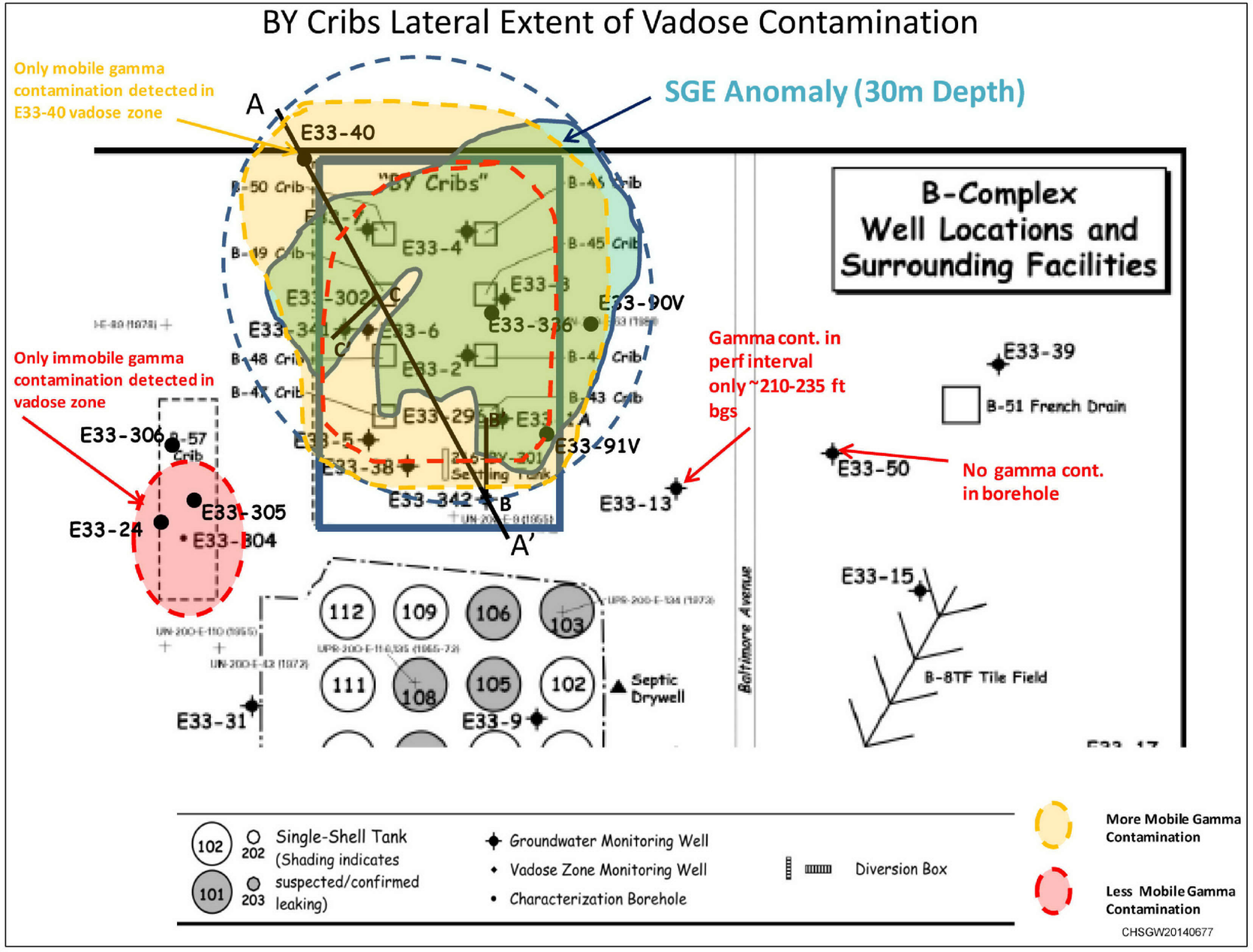

Figure C-4. BY Cribs Lateral Extent of Vadose Contamination

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Appendix D

Identification of Potential Applicable or Relevant and Appropriate Requirements and To-Be-Considered Criteria for the 200-DV-1 Operable Unit

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Terms

ACM	asbestos-containing material
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BACT	best available control technology
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Eco-SSLs	ecological risk-based soil screening levels
EPA	U.S. Environmental Protection Agency
FEM	federal equivalent method
FRM	federal reference method
FS	feasibility study
IDW	investigation-derived waste
OU	operable unit
PCB	polychlorinated biphenyl
PM-10	particles less than 10 μm in diameter
PM_{10}	particles less than 10 μm in diameter
ppm	parts per million
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
RTD	removal, treatment, and disposal
TBC	to-be-considered
TSD	treatment, storage, and disposal

D1 Introduction

This appendix presents potential applicable or relevant and appropriate requirements (ARARs) that may apply to 200-DV-1 Operable Unit (OU) remediation activities. Table D-1 presents potential federal ARARs and to-be-considered (TBC) criteria. Table D-2 presents potential Washington State ARARs and TBC criteria.

Table D-1. Identification of Potential Federal ARARs and TBCs for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
Chemical-Specific ARARs and TBCs – Vadose Zone Soil				
OSWER Directive 9285.7-55, *Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)*	Provides a set of Eco-SSLs for several soil contaminants that are of ecological concern for terrestrial plants and animals at hazardous waste sites. Also describes the process used to derive these levels and provides guidance for their use.	Target analytes detected in soil and vadose zone soil include constituents that could pose ecological risks.	TBC	Assistance in the identification of areas, contaminants, and conditions that may require further RI.
"Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2010)	Provides a set of risk-based screening levels; the regional screening levels provide tables of human health risk-based screening levels calculated using the latest toxicity values, default exposure assumptions, and physical and chemical properties. Risk-based screening levels may help determine whether levels of contamination found at CERCLA hazardous waste sites may warrant further investigation or site cleanup, or whether no further investigation or action may be required.	Target analytes detected in soil and vadose zone soil includes constituents that could pose risks to human health.	TBC	Assistance in the identification of areas, contaminants, and conditions that may require further RI.
***Toxic Substances Control Act of 1976*; 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions"**				
40 CFR 61.140, "National Emission Standards for Hazardous Air Pollutants," "Applicability"	Establishes general PCB disposal requirements for the storage and disposal of PCB wastes including liquid PCB wastes, PCB items, PCB remedial waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations greater than 50 ppm.	PCB wastes greater than 50 ppm may be encountered or generated during the RI and subsequent remediation.	ARAR	Soil and vadose zone soil excavation and RI; equipment and debris handling and disposal; IDW management and disposal of PCB wastes greater than 50 ppm.

Table D-1. Identification of Potential Federal ARARs and TBCs for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
40 CFR 761.60(a), (b), and (c), "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," "Disposal Requirements"	Establishes requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, or containers may be encountered or generated during the RI and subsequent remediation.	ARAR	Equipment and debris handling, storage, and disposal; IDW management and disposal.
40 CFR 761.61, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," "PCB Remediation Waste"	Provides cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation wastes may be encountered or generated during remedial actions for 200-WA-1 or 200-BC-1.	ARAR	Soil remediation; RTD; and IDW management and disposal.
***Clean Air Act of 1977*; 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants"**				
40 CFR 61.140, "National Emission Standards for Hazardous Air Pollutants," "Applicability" 40 CFR 61.145, "National Emission Standards for Hazardous Air Pollutants," "Standard for Demolition and Renovation"	Defines regulated ACM and regulated removal and handling requirements. Specifies sampling, inspection, handling, and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of ACM.	Encountering ACM (e.g., on pipelines or buried asbestos) is possible during the RI or during remedial activities.	ARAR	Site investigation and remedial activities that include demolition or renovation and associated handling, packaging, and transportation of ACM including IDW management and disposal.
40 CFR 61.150, "National Emission Standards for Hazardous Air Pollutants," "Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations"	Identifies requirements for the removal and disposal of asbestos from demolition and renovation activities.	Encountering ACM on pipelines or buried asbestos is possible during the RI or during remedial activities.	ARAR	Site investigation and remedial activities that include demolition or renovation and associated handling, packaging, and transportation of ACM, including IDW management and disposal.

Table D-1. Identification of Potential Federal ARARs and TBCs for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
Radionuclide ARAR Dose Compliance Concentrations for Superfund				
"Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" (Luftig and Weinstock, 1997) OSWER Directive 9200.4-31P, *Radiation Risk Assessment at CERCLA Sites: Q & A*	This memorandum presents clarification for establishing protective cleanup levels in media for radioactive contamination at CERCLA sites. EPA has determined that the dose limits established in 62 FR 39058, "Radiological Criteria for License Termination" (25 mrem/yr, which is equivalent to 5×10^{-4} increase lifetime risk), will not provide a protective basis for establishing PRGs under CERCLA. Instead, EPA has identified a 15 mrem/yr effective dose (approximately equivalent to 3×10^{-4} increased lifetime risk), which is preferred as the maximum dose limit for humans. (However, depending upon the radionuclide involved, a 15 mrem/yr effective dose equivalent could represent a significantly higher or lower lifetime cancer risk than 3×10^{-4}.) In the final guidance, EPA further clarifies that 15 mrem/yr is not a presumptive cleanup level under CERCLA. Rather, site decision makers should continue to use the CERCLA risk range when ARARs are not used to set cleanup levels because using dose-based guidance would result in unnecessary inconsistency in how radiological and nonradiological (chemical) contaminants are addressed at CERCLA sites.	Target analytes detected in soil and vadose zone soil include constituents that would constitute radionuclides regulated as hazardous air pollutants (National Emission Standards for Hazardous Air Pollutants).	TBC	Development of media cleanup levels for remediation and verification.

Table D-1. Identification of Potential Federal ARARs and TBCs for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
Location-Specific ARARs and TBCs				
Archeological and Historic Preservation Act of 1974				
Archeological and Historic Preservation Act of 1974 (16 USC 469a-1 – 469a-2[d])	Provides for the preservation of historical and archaeological data that might be otherwise irreparably lost or destroyed as a result of alterations of terrain caused by any federal construction project. This act mandates preservation of data; it does not require protection of the actual site or facility.	Archaeological and historic sites have been identified within 200-DV-1.	ARAR	Investigation and remedial activities that occur in or near archaeological or historical sites.
National Historic Preservation Act of 1966				
36 CFR 800, "Protection of Historic Properties" 36 CFR 65, "National Historic Landmarks Program" 36 CFR 60, "National Register of Historic Places"	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, and mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within 200-DV-1.	ARAR	Investigation and remedial activities that affect cultural or historical sites. Regulations implementing Section 106 of the *National Historic Preservation Act* will be met as required.
***Native American Graves Protection and Repatriation Act of 1990*; 43 CFR 10, "Native American Graves Protection and Repatriation Regulations"**				
43 CFR 10, "Native American Graves Protection and Repatriation Regulations"	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony. Requires Native American Tribal consultation in the event of discovery.	Native American archaeological, cultural, and historic sites have been identified within 200-DV-1; Native American remains and associated objects may be present.	ARAR	Investigation and remedial activities that affect Native American archaeological and cultural areas, and historic sites that contain associated remains and objects.

Table D-1. Identification of Potential Federal ARARs and TBCs for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
		Endangered Species Act of 1973		
50 CFR 402, "Interagency Cooperation—Endangered Species Act of 1973, as Amended"	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species, in order to protect the resource.	Federal endangered and/or threatened species including plants and animals are found within 200-DV-1.	ARAR	Remedial actions and investigation activities that occur within critical habitats or designated buffer zones of federally listed species.
		Migratory Bird Treaty Act of 1918		
Migratory Bird Treaty Act of 1918 (16 USC 703-712)	Implements various treaties and conventions for the protection of migratory birds. Under this act, taking, killing, or possessing migratory birds is unlawful.	Migratory birds occur within 200-DV-1.	ARAR	Investigation and remediation activities that have the potential to kill migratory birds or destroy their eggs or nests.
		Land Use and Exposure Scenarios		
Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (DOE/EIS-0222-F) and *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-SA-01)	Establishes the future land use projections for the Inner Area.	Land use as stated in the Hanford Comprehensive Land Use Plan for the Inner Area of the Central Plateau is industrial exclusive.	TBC	

Note: The acronyms used in this table are presented in the "Terms" front matter portion of this appendix. References listed in this table are cited in Chapter D2 of this appendix.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
Chemical-Specific ARAR				
WAC 173-340-745(5) and (8), "Model Toxics Control Act—Cleanup," "Soil Cleanup Standards for Industrial Properties"	Establishes soil chemical cleanup levels where industrial land use represents the reasonable maximum exposure under both current and future site use conditions. Cleanup standards require specification of the following: hazardous chemical substance concentrations that protect human health and the environment (cleanup levels), the location of the site where cleanup levels must be attained (points of compliance), and other regulatory requirements that apply to the cleanup action because of the type of action or location of the site. These requirements are specified in the applicable state and federal laws and are generally established in conjunction with the selection of a specific cleanup action.	Soil in 200-DV-1 contains chemical contaminants that require remediation. The human health conceptual exposure model for these areas is considered industrial land use.	ARAR	Soil chemical cleanup actions where concentrations of hazardous substances in the soil exceed Method C cleanup levels.
WAC 173-340-747(3) and (8), "Model Toxics Control Act—Cleanup," "Deriving Soil Concentrations for Groundwater Protection"	Establishes soil chemical concentrations that will not cause contamination of groundwater at levels that exceed the groundwater cleanup levels established under WAC 173-340-720, "Groundwater Cleanup Standards."	Soil in 200-DV-1 contains chemical contaminants that require remediation to protect groundwater. The requirements corresponding to soil cleanup levels may be used to calculate cleanup levels to ensure protection of groundwater. Although groundwater is not currently used for drinking water, it is a potential drinking water source.	ARAR	Soil cleanup actions where concentrations of hazardous chemical substances in the soil exceed soil concentrations for protection of groundwater. As allowed, WAC 173-340-747(8), alternative fate and transport models (one of the seven allowable methods under WAC 173-340-747) will be used to determine appropriate cleanup levels.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-340-7490(4)(b), "Model Toxics Control Act—Cleanup," "Terrestrial Ecological Evaluation Procedures" WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures" WAC 173-340-7494, "Priority Contaminants of Ecological Concern"	Defines goals and procedures for determining whether a release of hazardous substances to soil and vadose zone soil may pose a threat to the terrestrial environment; characterizes existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil and vadose zone soil; and establishes site-specific cleanup standards for the protection of terrestrial plants and animals. WAC 173-340-7494 provides for numeric concentrations of hazardous substances determined to persist, bioaccumulate, or be highly toxic to terrestrial ecological receptors.	Soil and vadose zone soil in 200-DV-1 contain contaminants that require evaluation to determine whether ecological exposures have the potential to cause significant adverse effects.	ARAR	Soil and vadose zone soil remedial activities (e.g., containment or RTD) that may pose risks to terrestrial ecological plants and animals.
Action-Specific ARARs				
RCW 70.105, "Hazardous Waste Management"; WAC 173-303, "Dangerous Waste Regulations"				
WAC 173-303-016, "Dangerous Waste Regulations," "Identifying Solid Waste" WAC 173-303-017, "Dangerous Waste Regulations," "Recycling Processes Involving Solid Waste"	Establishes criteria for solid and recycled solid wastes.	Solid wastes and/or recycled solid wastes may be generated during the RI/FS.	ARAR	Investigative and remedial activities that generate solid wastes, (e.g., drums, barrels, tanks, containers, bulk wastes, debris, contaminated soil and vadose zone soil).
WAC 173-303-070, "Dangerous Waste Regulations," "Designation of Dangerous Waste"	Establishes the method for determining whether a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste may be generated during the RI/FS.	ARAR	Investigative and remedial (including waste treatment) activities that generate solid wastes that may be dangerous waste.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-303-071, "Dangerous Waste Regulations," "Excluded Categories of Waste"	Lists waste categories that are excluded from management in accordance with the requirements of WAC 173-303.	Excluded wastes may be generated during the RI/FS.	ARAR	Potential for generating materials during the cleanup of waste sites and decommissioning of industrial buildings/structures that would qualify for management under the substantive provisions of these regulations.
WAC 173-303-073, "Dangerous Waste Regulations," "Conditional Exclusion of Special Wastes"	Establishes the conditional exclusion and the management requirements of special wastes, as defined in WAC 173-303-040, "Definitions."	Special wastes may be generated during the RI/FS.	ARAR	Investigative and remedial activities (disposal, storage, recycling, and onsite treatment) that manage special wastes consistent with the requirements of the *Washington Administrative Code*.
WAC 173-303-077, "Dangerous Waste Regulations," "Requirements for Universal Waste"	Identifies those wastes exempted from regulation under WAC 173-303-140, "Land Disposal Restrictions," and WAC 173-303-170, "Requirements for Generators of Dangerous Waste" through WAC 173-303-9907, "Reserved" (excluding WAC 173-303-960, "Special Powers and Authorities of the Department"). These wastes are subject to regulation under WAC 173-303-573, "Standards for Universal Waste Management."	Universal wastes may be generated during the RI/FS.	ARAR	Investigative and remedial activities (disposal, storage, recycling, and onsite treatment) that manage universal wastes consistent with the requirements of the *Washington Administrative Code*.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-303-120(3) and (5), "Dangerous Waste Regulations," "Recycled, Reclaimed, and Recovered Wastes"	These regulations define the requirements for the recycling of materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Recycled, reclaimed, and recovered wastes may be generated during the RI/FS.	ARAR	RI/FS recycling activities consistent with the requirements of the *Washington Administrative Code* and are not otherwise subject to CERCLA as hazardous substances.
WAC 173-303-140, "Dangerous Waste Regulations," "Land Disposal Restrictions"	This regulation establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates, by reference, (in WAC 173-303-140[2][a]) the federal land disposal restrictions of 40 CFR 268, "Land Disposal Restrictions," that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3).	Onsite land disposal may be a selected remedy for dangerous waste and debris.	ARAR	Investigative and remedial wastes destined for onsite land disposal.
WAC 173-303-170, "Dangerous Waste Regulations," "Requirements for Generators of Dangerous Waste"	Establishes the requirements for dangerous waste generators. WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste On-Site," by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Use and Management of Containers," and WAC 173-303-640, "Tank Systems," by reference. Specifically, the substantive standards for management of dangerous or mixed waste are relevant and appropriate to the management of dangerous waste that will be generated during the remedial action.	Dangerous wastes may be generated from the RI/FS.	ARAR	IDW and remedial wastes (e.g., contaminated soil, vadose zone soil, groundwater, IDW, treatment chemicals, etc.).
WAC 173-303-200, "Dangerous Waste Regulations," "Accumulating Dangerous Waste On-Site"	Establishes the requirements for accumulating wastes onsite. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630 and WAC 173-303-640, by reference.	Dangerous waste may be generated from the RI/FS.	ARAR	Management of dangerous waste during remedial and investigative actions.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-303-64610, "Dangerous Waste Regulations," "Purpose and Applicability" WAC 173-303-64620(4)(a) through (g), "Dangerous Waste Regulations," "Requirements"	Establishes closure requirements applicable to all TSD units dangerous waste facilities and post-closure care requirements applicable to all regulated units (as defined in WAC 173-303-040) where dangerous wastes will remain after closure (including tank systems, landfills, surface impoundments, waste piles, and miscellaneous units). RCW 70.105D, "Hazardous Waste Cleanup—Model Toxics Control Act," as amended, and its implementing regulations may be used to fulfill corrective action responsibilities.	Dangerous wastes may remain at TSD units after closure. The RI/FS process will also meet the requirements of RCRA corrective action to the extent practicable. The substantive requirements of the specified subsections are used to ensure the corrective action requirements are being considered during the remedial actions.	ARAR	These requirements are applicable to the closure of RCRA TSD units. The substantive requirements ensure corrective action requirements are considered where appropriate.
WAC 173-303-610(2)(b)(ii), "Dangerous Waste Regulations," "Closure and Post-Closure"	Establishes closure requirements applicable to all dangerous waste facilities and post-closure care requirements applicable to all regulated units (as defined in WAC 173-303-040) where dangerous wastes will remain after closure (including tank systems, landfills, surface impoundments, waste piles, and miscellaneous units).	Dangerous wastes may remain after closure.	ARAR	Remedial design and operation of regulated units that contain dangerous wastes and that will remain after closure of a TSD unit.
WAC 173-303-665(6), "Dangerous Waste Regulations," "Landfills"	Specifies closure and post-closure requirements for landfills.	Land disposal may be proposed as a containment remedy.	ARAR	Design and operation of an engineered landfill cover.
RCW 18.104, "Water Well Construction"; WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"				
WAC 173-160-460, "Minimum Standards for Construction and Maintenance of Wells," "What Is the Decommissioning Process for Resource Protection Wells?"	Identifies the decommissioning process for resource protection wells.	Groundwater monitoring and treatment wells and borings may occur in 200-WA-1 or 200-BC-1.	ARAR	Investigative and remedial activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 246-272A-0300, "On-Site Sewage Systems," "Abandonment"				
WAC 246-272A-0300 , "On-Site Sewage Systems," "Abandonment"	Identifies the abandonment requirements for onsite sewage systems.	Inactive septic systems need to be abandoned.	ARAR	Remedial actions that require the abandonment of septic systems.
RCW 70.95, "Solid Waste Management—Reduction and Recycling"; WAC 173-350, "Solid Waste Handling Standards"				
WAC 173-350-025, "Solid Waste Handling Standards," "Owner Responsibilities for Solid Waste" WAC 173-350-040, "Solid Waste Handling Standards," "Performance Standards" WAC 73-350-300, "Solid Waste Handling Standards," "On-Site Storage, Collection and Transportation Standards" WAC 173-350-900, "Solid Waste Handling Standards," "Remedial Action"	Establishes minimum functional performance standards for the proper handling and disposal of solid waste materials originating from residences; commercial, agricultural, and industrial operations; and other sources, and identifies those functions necessary to ensure effective solid waste handling programs at the state and local level.	Solid, nondangerous waste will be generated during the implementation of the RI/FS.	ARAR	Investigative and remedial actions that generate solid, nondangerous waste.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
RCW 70.94, "Washington Clean Air Act"; WAC 173-400, "General Regulations for Air Pollution Sources"				
WAC 173-400, "General Regulations for Air Pollution Sources"	Defines methods of control to be employed to minimize the release of air pollutants associated with fugitive emissions resulting from materials handling, construction, demolition, or other operations. Emissions are to be minimized through application of BACT.	Soil and vadose zone soil remedial actions implemented in 200-WA-1 or 200-BC-1 have the potential to emit air pollutants because contaminants detected in 200-WA-1 or 200-BC-1 include regulated pollutants subject to these standards.	ARAR	Actions performed such as decontamination, demolition, and excavation activities that have the potential to emit visible, particulate, fugitive, or gaseous forms of hazardous criteria, and toxic or nuisance air pollutants.
WAC 173-400-040, "General Regulations for Air Pollution Sources," "General Standards for Maximum Emissions"	All sources and emissions units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emissions detrimental to health and property, sulfur dioxide, and fugitive dust.	Soil and vadose zone soil remedial actions implemented have the potential to emit air pollutants because contaminants detected in 200-WA-1 or 200-BC-1 include regulated pollutants subject to these standards.	ARAR	Remedial actions that have the potential to release air pollutants subject to these regulations.
WAC 173-400-075, "General Regulations for Air Pollution Sources," "Emission Standards for Sources Emitting Hazardous Air Pollutants"	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, 40 CFR 61 and appendices.	Soil and vadose zone soil remedial actions implemented have the potential to emit air pollutants because contaminants detected in 200-WA-1 or 200-BC-1 include regulated pollutants subject to these standards.	ARAR	Actions performed that could result in the emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during the RI/FS that have the potential to release air pollutants subject to these regulations.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
RCW 70.94, "Washington Clean Air Act"; WAC 173-460, "Controls for New Sources of Toxic Air Pollutants"				
WAC 173-460-010, "Controls for New Sources of Toxic Air Pollutants," "Purpose" WAC 173-460-030, "Controls for New Sources of Toxic Air Pollutants," "Applicability" WAC 173-460-060, "Controls for New Sources of Toxic Air Pollutants," "Control Technology Requirements" WAC 173-460-070, "Controls for New Sources of Toxic Air Pollutants," "Ambient Impact Requirement" WAC 173-460-080, "Controls for New Sources of Toxic Air Pollutants," "First Tier Review" WAC 173-460-150, "Controls for New Sources of Toxic Air Pollutants," "Table of ASIL, SQER and de Minimis Emission Values"	Establishes control of new sources emitting toxic air pollutants to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality as will protect human health and safety. Toxic air pollutants include carcinogens and noncarcinogens listed in WAC 173-460-150, "Table of ASIL, SQER and de Minimis Emission Values." Three major requirements of this regulation include implementation of BACT for toxics, quantification of toxic air pollutant emissions, and health and safety protection demonstration.	Hazardous contaminants detected in soil and groundwater in 200-WA-1 or 200-BC-1 include constituents that would constitute toxic air pollutants if released to the air.	ARAR	Groundwater and soil remediation activities such as treatment systems that have the potential to emit toxic air emissions and would be considered a new source.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
RCW 70.94, "Washington Clean Air Act"; WAC 173-476, "Ambient Air Quality Standards"				
WAC 173-476-100(1), "Ambient Air Quality Standards," "Ambient Air Quality Standard for PM-10," "Standard for PM-10"	Sets maximum acceptable levels for particulate matter in the ambient air at 150 $\mu g/m^3$ over a 24-hour period more than one time per year, on at 3-year average.	Particulates and dust can be generated during the remedial actions. Ambient air quality standards for particulate matter will be considered if the remedial actions raise emissions above the standard.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, containment) that have the potential to emit particulate matter above maximum acceptable levels.
WAC 173-476-100(2), "Ambient Air Quality Standards," "Ambient Air Quality Standard for PM-10," "Measurement Method"	The levels of PM-10 in the ambient air must be measured by: (a) An FRM based on 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards," Appendix J, "Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere, and designated according to 40 CFR 53, "Ambient Air Monitoring Reference and Equivalent Methods"; or (b) An FEM designated according to 40 CFR 53	Particulates and dust can be generated during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, containment) that have the potential to emit particulate matter above maximum acceptable levels.
RCW 70.94, "Washington Clean Air Act"; WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides"				
WAC 173-480-040, "Ambient Air Quality Standards and Emission Limits for Radionuclides," "Ambient Standard"	Requires that emissions of radionuclides in the air will not cause a maximum effective dose equivalent of more than 10 mrem/yr to the whole body to any member of the public.	Hazardous contaminants detected in soil and groundwater in 200-WA-1 or 200-BC-1 include radionuclides that could be emitted to ambient air during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-480-050, "Ambient Air Quality Standards for Particulate Matter," "General Standards for Maximum Permissible Emissions"	At a minimum, all emission units will make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas, ALARA* control equipment of sites operating under ALARA will be defined as reasonably available control technology and ALARA control technology.	The potential for fugitive and diffuse emissions resulting from demolition, excavation, and related activities will require efforts to minimize those emissions. This requirement is action specific.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.
WAC 173-480-070, "Ambient Air Quality Standards for Particulate Matter," "Emission Monitoring and Compliance Procedures"	Requires that procedures specified in WAC 246-247, "Radiation Protection—Air Emissions," or approved specifically by the regulatory agency will be used to determine emissions compliance with the 10 mrem/yr standard for dose to any member of the public. Compliance is determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	Hazardous contaminants detected in soil and groundwater in 200-WA-1 or 200-BC-1 include radionuclides that could be emitted to unrestricted areas during remedial actions and, therefore, could require monitoring.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, and vacuuming/exhaust) that have the potential to emit radionuclides to the ambient air.
WAC 173-480-060, "Ambient Air Quality Standards for Particulate Matter," "Emission Standards for New and Modified Emission Units"	Requires that construction, installation, or establishment of a new air emission control units will use best available retrofit control technology.	Hazardous contaminants detected in soil and groundwater in 200-WA-1 or 200-BC-1 include radionuclides that could be emitted to the ambient air during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, and vacuuming/exhaust) that require air pollution control equipment or other methods to best control emissions and have the potential to emit airborne radionuclides.

Table D-2. Identification of Potential Washington State ARARs TBC Criteria for the 200-DV-1 OU

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
RCW 70.98, "Nuclear Energy and Radiation"; WAC 246-247, "Radiation Protection—Air Emissions"				
WAC 246-247-035(1)(a)(ii), "Radiation Protection—Air Emissions," "National Standards Adopted by Reference for Sources of Radionuclide Emissions"	Establishes emission standards for radionuclides equivalent to 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," by reference. Combined Hanford Site radionuclide airborne emissions will be controlled so as not to exceed amounts that would cause an exposure to any member of the public of greater than 10 mrem/yr effective dose equivalent.	Substantive requirements of this standard are applicable because the remedial action may include activities such as excavation, decontamination, and stabilization of contaminated areas that many provide airborne emissions of radioactive.	ARAR	Investigative and remedial activities.
WAC 246-247-040(3) and (4), "Radiation Protection—Air Emissions," "General Standards"	Requires that emissions be controlled to ensure ALARA-based and BACT standards are not exceeded.	Hazardous contaminants detected in soil and groundwater include radionuclides that could be emitted and require controls during remedial actions.	ARAR	Investigative and remediation activities (e.g., RTD, excavation, demolition, ventilation).
WAC 246-247-075, "Radiation Protection—Air Emissions," "Monitoring, Testing and Quality Assurance"	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Emissions from nonpoint and fugitive sources of airborne radioactive material will be measured. Measurement techniques may include but are not limited to sampling, calculation, smears, or other reasonable methods for identifying emissions as determined by the lead agency.	Hazardous contaminants in 200-WA-1 or 200-BC-1 waste sites include radionuclides that could be emitted as airborne radioactive material during remedial actions.	ARAR	Investigative and remediation activities (e.g., RTD, excavation, demolition, ventilation) that could emit airborne radionuclides.

Note: Acronyms used in this table are presented in the "Terms" front matter portion of this appendix. References listed in this table are cited in Chapter D2 of this appendix.

* "ALARA" means as low as reasonably achievable, making every reasonable effort to maintain exposures to radiation as far below the 10 mrem/yr dose standard as practical, consistent with the purpose for which the activity is undertaken, taking into account the state of technology, the economics of improvements in relation to the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other socioeconomic considerations, and in relation to the use of nuclear energy, ionizing radiation, and radioactive materials in the public interest.

D2 References

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Appendix E

Potential Remediation Technologies for Deep Vadose Zone Contamination

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Terms

COPC	contaminant of potential concern
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DVZ	deep vadose zone
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FS	feasibility study
OU	operable unit
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI/CMS	RCRA field investigation/corrective measures study
RI	remedial investigation
SERDP	Strategic Environmental Research and Development Program

E1 Potential Remediation Technologies for Deep Vadose Zone Contamination

In 2011, potentially applicable remedial technologies were identified and screened to develop a list of promising technologies for further evaluation during the 200-DV-1 Operable Unit (OU) remedial investigation (RI)/feasibility study (FS) activities. This screening was performed in accordance with U.S. Environmental Protection Agency (EPA) guidance for conducting treatability studies (EPA/540/R-92/071a, *Guidance for Conducting Treatability Studies under CERCLA, Final*) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The EPA guidance document identifies technology pre-screening, to be conducted early in the planning and scoping phase of the RI/FS, as an important first step in the identification of potentially applicable remediation technologies and the need for treatability testing. This early screening of technologies for the 200-DV-1 OU provides an opportunity to identify promising remediation technologies that require further treatability testing to determine potential feasibility or those that are mature enough to be carried forward and evaluated during the FS.

An initial list of 59 potentially applicable technologies for remediating contamination in the deep vadose zone (DVZ) was developed from a variety of sources, including the following:

- Remediation approaches from similar sites across the country
- Research and development activities performed within the U.S. Department of Energy (DOE) and the U.S. Department of Defense
- Past technology research and development occurring at the Hanford Site
- Solicited input from DOE, EPA, the Washington State Department of Ecology, and stakeholders

Information was then collected on each of the technologies, including the general description, state of development, contaminant applicability, maturity level, and limitations/development needs for full-scale deployment.

The technologies were grouped into four general response action categories to aid in the pre-screening process. This initial search for potentially applicable technologies identified 7 containment technologies (Table E-1), 18 removal technologies (Table E-2), 8 ex situ treatment and disposal technologies (Table E-3), and 26 in situ treatment technologies (Table E-4).

The technologies were then screened into different bins based on their readiness for full-scale implementation. The technology screening bins include the following:

- Technologies that are FS-ready
- Technologies that need additional remedy selection information
- Technologies that need field demonstration to prove
- Technologies for no further evaluation

Eleven technologies were considered ready for evaluation in the FS. These technologies primarily consist of commonly used remediation methods such as soil vapor extraction, perched water removal, or landfill disposal. Twenty-one technologies were considered to benefit from the collection of additional information on remedy performance and/or implementation cost prior to evaluation in the FS. The technologies in this category primarily include a variety of containment/barrier methods and deep excavation techniques for contaminant removal.

Twenty-two technologies were identified that are not ready for immediate deployment and would require further evaluation before use, including possible treatability testing. These technologies are primarily associated with in situ treatment methods (from soil flushing through contaminant sequestration) and include a variety of different delivery techniques to get the reagents to the contamination. Finally, five technologies were identified for no further evaluation at this time. These technologies are either not applicable to the contaminants of concern or will not be ready for full-scale implementation in the near term.

Additional details on this technology screening and the evaluation process are provided in SGW-50339-FP, *Remediation Technologies Screening Report for the Deep Vadose Zone, Hanford's Central Plateau*. Results of the 2011 technology screening and evaluation will be reviewed and updated, as needed, based on recent technology evaluations by the DVZ Applied Field Research Initiative and recent treatability test results (e.g., pore water extraction) as a task under this work plan (see Section 5.3 in the main text discussion).

E2 References

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Table E-1. General Response Action — Containment Remediation Technologies To Be Considered for the 200-DV-1 OU

Technology Type	Technology	Description	COPC Applicability	State of Development	Maturity Level[a]	Limitations/Development Needs[b]
Surface barriers	Asphalt/concrete cap	Asphalt-concrete caps consist of asphalt and aggregate that are heated, mixed, and then placed to form a surface barrier between waste area and the environment.	All contaminants	Technology is well established. Asphalt/concrete caps are simple to construct.	Additional remedy selection information	Effective depth of the asphalt/concrete cap has not been fully evaluated; need to determine how deep the effect of surface infiltration control extends into the vadose zone as function of the areal extent of the surface barrier. Also, need to determine extent of horizontal flow and migration beneath an asphalt/concrete cap.
	Modified RCRA Subtitle C barrier	A multilayer surface barrier that generally consists of an upper vegetative (topsoil) layer, a drainage layer, and a low-permeability layer consisting of a synthetic liner over compacted clay.	All contaminants	Technology is well established. Multiple barrier designs have been developed and implemented.	Additional remedy selection information	Effective depth of the RCRA C barrier has not been fully evaluated; need to determine how deep the effect of surface infiltration control extends into the vadose zone as function of the areal extent of the surface barrier. Also, need to determine extent of horizontal flow and migration beneath a RCRA C barrier.
	Hanford barrier	A prototype multilayer earthen barrier constructed in 1994 over an existing waste site to provide long-term protection of radioactive wastes in a semiarid environment.	All contaminants	Technology is well established, although its use has been limited to the Hanford Site.	Additional remedy selection information	Effective depth of the Hanford barrier has not been fully evaluated; need to determine how deep the effect of surface infiltration control extends into the vadose zone as function of the areal extent of the surface barrier. Also, need to determine extent of horizontal flow and migration beneath a Hanford barrier.
	Vegetative cap (evapotranspiration cap/ cover)	A capillary barrier consisting of a fine-grained soil layer overlying a relatively coarse-grained soil layer, creating a distinct textural interface that increases the water-holding capacity of the fine-grained soil over that associated with unimpeded vertical drainage.	All contaminants	Technology is well established. Vegetative caps are simple to construct.	Additional remedy selection information	Effective depth of the evapotranspiration cover has not been fully evaluated; need to determine how deep the effect of surface infiltration control extends into the vadose zone as function of the areal extent of the surface barrier. Also, need to determine extent of horizontal flow and migration beneath an evapotranspiration cover.
Subsurface barriers	Jet grouting	Jet grouting is the injection of a grout mixture at very high pressures and velocities into the pore space of the soil or rock through small orifices located in the drill pipe above drill bit.	All contaminants	Field-scale application is fully deployable and has been performed to depths of 91 m (300 ft). There are issues over radius of influence.	Additional remedy selection information	Large debris or stone (e.g., cobbles) may inhibit effective application. Soils with low permeability to grout flow must be addressed. The impact of grout and fluid injection on the vadose zone surrounding the targeted area must be evaluated.
	Permeation grouting (molten wax injection)	Permeation grouting is the injection of a liquid grout that fills the natural porosity of unsaturated soils and then gels to form a solid, void-filling material (e.g., hot molten wax).	All contaminants	Development has occurred over the last several years at Idaho National Laboratory in radiologically contaminated environments.	Field testing to prove	Additional research and development need to be conducted to evaluate effectiveness of grout formulations, including identification of appropriate grouting configuration and evaluation of wax penetration in DVZ sediments.
	Soil freezing	Frozen soil barriers (or cryogenic barriers) are constructed by freezing the soil pore water.	All contaminants	Proven application for temporary containment for dewatering during construction. Could potentially be used as containment barrier for environmental remediation.	Additional remedy selection information	The long-term effectiveness and durability of the barrier must be evaluated. Technology has not been proven at depths necessary for use in DVZ. The presence of gravels and cobbles may make access and deployment more difficult.

a. Maturity levels for the technology in DVZ applications and Hanford Site conditions.

- **Feasibility study ready:** Proven and fully developed; ready to evaluate in the RI/FS without additional needs during the RI/FS and RFI/CMS work plan.
- **Additional remedy selection information:** Well tested and deployed; additional evaluation with site-specific conditions may be needed during the RI/FS and RFI/CMS work plan.
- **Field testing to prove:** Field tested; additional site-specific testing or data collection likely needed.
- **No further evaluation:** Limited field testing performed; additional science and technology and/or field tests needed to prove technology.

b. Limitations/development needs to advance the technology to a higher maturity level for effective application at the Hanford Site DVZ.

COPC = contaminant of potential concern
DVZ = deep vadose zone
RCRA = *Resource Conservation and Recovery Act of 1976*
RI/FS = remedial investigation/feasibility study
RFI/CMS = RCRA field investigation/corrective measures study

Table E-2. General Response Action — Removal Remediation Technologies To Be Considered for the 200-DV-1 OU

Technology Type[a]	Technology	Description	COPC Applicability	State of Development	Maturity Level[b]	Limitations/Development Needs[c]
Excavation	Deep excavation with sloping and/or benching (open-pit mining)	Sloping and benching support systems cut back the excavation walls at such an angle to maintain the stability of the side walls.	All contaminants	Excavation with sloping and/or benching is a fully mature technology. Significant laybacks or a combination of innovative and mature technologies are required for deep excavations.	Additional remedy selection information	Practicability of deep excavation using sloping and benching support systems decreases as the depth of excavation increases. Utilities, structures, and other infrastructure may restrict the ability to implement this technique.
	Deep excavation using dragline excavators	Dragline excavators use large buckets and cables to move large volumes of loose material. Used as a primary excavating method in many surface mining operations.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Utilities, structures, and other infrastructure require protection. Cannot practically be combined with shoring. Potential to excavate effectively to the desired depth must be assessed. Significant volume of uncontaminated soil must be processed; increased volume of contaminated soil generated due to cross contamination.
	Deep excavation using drilling and soil replacement	Drilling and soil replacement involves constructing hollow spaces using drilling techniques and then replacing the existing soil with filling materials.	All contaminants	Drilling and soil replacement is a standard technique used in the construction industry throughout the world. Large-diameter borings have been drilled to over 61 m (200 ft) at sites that included large cobbles.	Additional remedy selection information	Practicability of using drilling and soil replacement for removal of contaminated soils in the DVZ decreases as the depth and extent of excavation increases. Cobbles make any drilling much more difficult.
	Deep excavation using sheet piling or sheet pile walls	Sheet pile walls are thin steel sections with interlocked watering grooves at the sides that are driven into soil by hammering or vibrating to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Cobbles/gravels will greatly limit the ability to drive sheet piling to required depth. The ability to drive the pile walls to the depth required for remediation would have to be evaluated. Maximum effective depth is about 15 m (50 ft).
	Deep excavation using soldier pile and lagging wall	Soldier piles are steel "H"- or "I"-shaped piles that are driven into the ground to support lagging walls for side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Soil conditions and the depth of the excavation may require tie-backs that consist of steel strand cables placed in holes drilled with power auger horizontally (up to 15 m [50 ft]) into the banks of the excavation. Types of lagging and strut support will be limited due to depth of excavation. Maximum effective depth is about 30 m (100 ft).
	Deep excavation using diaphragm walls	Diaphragm walls are underground structures formed by filling trenches with slurry that solidifies to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Slurry makes the work somewhat "sloppy." Slurries may be chemically attacked by soils. Wide corridors (23 to 30 m [75 to 100 ft]) required along wall alignment. Diaphragm walls have not been used for removal of contaminated soils. Maximum effective depth is about 61 m (200 ft).
	Deep excavation using soil nail walls	Soil nail walls use steel bars, wire mesh, and concrete installed in the side of the excavation to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Lack of cohesive soils will reduce implementability. Given the potential for contamination, remote techniques may be required to place formwork and establish walls. Technology has not been used for remediation. Maximum effective depth is about 12 m (40 ft).
	Deep excavation using secant/tangent pile wall	Secant/tangent pile walls are formed by drilling boreholes and constructing overlapping, reinforced concrete piles to provide side-slope stability. Tangent pile walls are a variation of secant pile walls but with no overlap of the piles to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Cobbles can affect the ability to ensure vertical alignment of piles. Neither secant nor tangent pile walls have been used solely for removal of contaminated soils. Tangent piles are also not meant to overlap, which may increase the degree of difficulty to implement. Maximum depth for a single stage is about 15 m (50 ft).
	Deep excavation using caissons	Caisson is an open-ended concrete cylinder that is lowered into position during excavation to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Caissons can hang on boulders and cobbles. Methods for soil removal at the bottom of the caisson will also need to be determined. Maximum practical depth is about 24 m (80 ft).
	Deep excavation using jet grout walls	Jet grout walls are retaining walls that are constructed by single to triple row of jet grout columns or deep mixed columns to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Variation in stratigraphy and the presence of boulders/cobbles may affect grout permeability and the ability to transport grout into the DVZ. Vertical control is critical and becomes more difficult with increasing depth and rocky soils. Maximum depth for a single stage is about 15 m (50 ft).

Table E-2. General Response Action — Removal Remediation Technologies To Be Considered for the 200-DV-1 OU

Technology Type[a]	Technology	Description	COPC Applicability	State of Development	Maturity Level[b]	Limitations/Development Needs[c]
Excavation (continued)	Deep excavation using deep mixed walls	Deep mixed walls are constructed by mixing in situ soils with cement to increase strength, control deformation, and reduce permeability of unconsolidated sediments.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Generates substantial volumes of excess material due to bulk swell and fluid injection. Vertical control and panel overlap can be difficult. Deep mixed wall use is limited in soils containing boulders and sites with multiple underground obstructions such as utilities, subways, or other underground structures. Maximum practical depth is about 15 m (50 ft).
	Deep excavation using reinforced concrete walls	Reinforced concrete walls are staged excavation walls that are usually supported by ground anchors to provide side-slope stability.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Cohesive soils are necessary to maintain the excavation face. Remote techniques may be required to establish walls and place soil nails.
	Deep excavation using cofferdams	Cofferdams are temporary earth-retaining structures to enable excavation during construction activities, typically used near water bodies.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site.	Additional remedy selection information	Wall is much thicker since it relies on gravity instead of anchors to prevent overturning. Technology has not been used for removal of contaminated soils. Maximum depth is about 12 m (40 ft).
	Deep excavation using tunneling	Tunneling is a completely enclosed excavation with opening for egress.	All contaminants	Fully mature technology in the construction industry that may require detailed evaluation of applicability at each specific site. Large cobbles and boulders will affect the selection of tunneling equipment/techniques.	Additional remedy selection information	Structures and other infrastructure must be protected during tunneling. Excavation of unconsolidated materials can be difficult since material is not self-supporting.
Contaminated water removal	Perched water removal	Water that is perched within the vadose zone is pumped to the surface before it migrates to the regional water table.	Mobile COPCs	Technology is well developed. Currently planned to be deployed in the B Complex at the Hanford Site.	Feasibility study ready	Although perched water extraction is fairly well understood, the distribution and location of perched water must be determined in order to deploy the technology effectively. Perched water can be ephemeral (transitory).
	Pore water extraction	Subsurface water within the unsaturated zone containing mobile contaminants is extracted using high vacuum to overcome capillary forces.	Mobile COPCs	Technology is still being developed for full-scale field operation. Currently being pilot tested at the Hanford Site for mobile contaminants.	Field testing to prove	Technology is still in the pilot testing stage. Need to optimize recovery rates and determine the effectiveness in removing pore water held in tighter formations.
Soil flushing and contaminant recovery	Soil flushing vadose zone with water/chemicals	Mobilization of contaminants with water so they can be removed and treated or disposed. The addition of chemicals (e.g., surfactants) can be used to enhance mobilization of contaminants with lower solubility.	Contaminants with high to moderate solubility, such as uranium and technetium-99	Mature technology, in situ field deployment for shallow vadose zone has taken place. Use of chemicals has been subjected to limited study.	Field testing to prove	Challenges in applying this technology at significant depth and heterogeneous hydrogeologic conditions will need to be addressed. The ability to capture the flushed contaminants needs to be evaluated. Most research has targeted saturated conditions. Technology not yet fully field deployable for unsaturated conditions.
	In situ uranium recovery	In situ leaching, sometimes termed in situ recovery or "solution mining." consists of injecting a leaching solution into an ore zone, dissolving uranium, pumping the uranium-bearing solution out of the aquifer, and processing the solution to recover uranium.	Uranium	This technology is currently being deployed in the uranium mining industry in the United States, Kazakhstan, and Australia under saturated conditions.	Field testing to prove	Requires saturated sediment to distribute and contact the targeted uranium. Successful in situ leaching has not been achieved in vadose zone strata above the water table.

a. All soil removal technologies require ex situ treatment and disposal

b. Maturity levels for the technology in DVZ applications and Hanford Site conditions.

- **Feasibility study ready:** Proven and fully developed; ready to evaluate in the RI/FS without additional needs during the RI/FS and RFI/CMS work plan.
- **Additional remedy selection information:** Well tested and deployed; additional evaluation with site-specific conditions may be needed during the RI/FS and RFI/CMS work plan.
- **Field testing to prove:** Field tested; additional site-specific testing or data collection likely needed.
- **No further evaluation:** Limited field testing performed; additional science and technology and/or field tests needed to prove technology.

c. Limitations/development needs to advance the technology to a higher maturity level for effective application at the Hanford Site DVZ.

COPC = contaminant of potential concern
DVZ = deep vadose zone
RCRA = *Resource Conservation and Recovery Act of 1976*
RI/FS = remedial investigation/feasibility study
RFI/CMS = RCRA field investigation/corrective measures study

Table E-3. General Response Action — Ex Situ Treatment and Disposal Remediation Technologies To Be Considered for the 200-DV-1 OU

General Response Action	Technology Type	Technology	Description	COPC Applicability	State of Development	Maturity Level[a]	Limitations/Development Needs[b]
Ex situ treatment	Thermal treatment	Ex situ vitrification	Process that converts excavated soil and other materials into stable glass substances using high temperatures.	All contaminants	Uses furnaces that have evolved from the glass industry. Implementability is higher than for in situ application given use of proven technology.	Feasibility study ready	Treated waste must still be disposed in a landfill. Large material (e.g., cobbles) must be screened out of the waste to be treated.
	Physical/chemical treatment	Solidification/stabilization	Treatment process that eliminates or minimizes the mobility of inorganic and organic contaminants by physical or chemical retention.	Mobile to semimobile contaminants (uranium and technetium-99)	Well established technology. Site-specific studies need to be completed to evaluate equipment required and appropriate solidification.	Feasibility study ready	Mixtures of contaminants with varying characteristics and heterogeneous soils require complex solidification/stabilization formulations and treatment trains.
		Soil washing	Water-based treatment technology for excavated soils that removes contaminants by dissolving or suspending the contaminants in the wash solution or by concentrating the soil particles by size.	Possibly uranium, technetium-99, iodine-129, and nitrate	Conventional aggregate washing and screening technology is used to separate soil particles. Mobile contaminants are captured in the wash water.	Feasibility study ready	Mixtures of contaminants with varying characteristics and heterogeneous soils require complex soil-washing formulations and treatment trains.
		Soil sorting/screening	Clean soil is separated from contaminated soil based upon radioactive energy emissions from the soil.	Radionuclides	Fully functional prototype has been developed and deployed.	Additional remedy selection information	Further testing of prototype with similar soil and contaminants should be performed, depending upon the application.
		Molecular sieves	Industrial effluent and other liquid waste streams are passed through molecular sieves, which function as an ion-exchange media. Sieves can be heated to create a stable disposal form.	Hexavalent chromium	Laboratory-scale tests are being performed by Sandia National Laboratories.	No further evaluation	Limited to water treatment only. Technology evaluation has been limited to laboratory tests; need for field testing.
Disposal	Onsite	Backfill treated soil	Excavation and ex situ treatment of soil followed by onsite disposal of the treated soil (backfill).	All contaminants that can be treated ex situ	Fully mature technology.	Feasibility study ready	Backfill must meet the specifications established for restoration of the site.
		Onsite landfill	Disposal of excavated soil at onsite landfill (e.g., ERDF).	All contaminants depending on concentrations	Fully mature technology.	Feasibility study ready	Onsite waste disposal in the ERDF is a common practice at the Hanford Site. Limits on waste volumes and contaminant concentrations and radioactivity must be considered.
	Offsite	Offsite landfill/repository	Disposal of excavated soil at offsite landfill. Required for wastes for which onsite disposal is not acceptable.	All contaminants depending on concentrations	Fully mature technology.	Feasibility study ready	Limits on waste volumes and contaminant concentrations and radioactivity must be considered.

a. Maturity levels for the technology in DVZ applications and Hanford Site conditions.

- **Feasibility study ready:** Proven and fully developed; ready to evaluate in the RI/FS without additional needs during the RI/FS and RFI/CMS work plan.
- **Additional remedy selection information:** Well tested and deployed; additional evaluation with site-specific conditions may be needed during the RI/FS and RFI/CMS work plan.
- **Field testing to prove:** Field tested; additional site-specific testing or data collection likely needed.
- **No further evaluation:** Limited field testing performed; additional science and technology and/or field tests needed to prove technology.

b. Limitations/development needs to advance the technology to a higher maturity level for effective application at the Hanford Site DVZ.

COPC = contaminant of potential concern
DVZ = deep vadose zone
ERDF = Environmental Restoration Disposal Facility
RCRA = *Resource Conservation and Recovery Act of 1976*
RI/FS = remedial investigation/feasibility study
RFI/CMS = RCRA field investigation/corrective measures study

Table E-4. General Response Action – In Situ Treatment Remediation Technologies To Be Considered for the 200-DV-1 OU

Technology Type		Technology	Description	COPC Applicability	State of Development	Maturity Level[a]	Limitations/Development Needs[b]
Thermal treatment		In situ vitrification	Solidification process that uses high temperatures to melt and convert waste materials into glass crystalline products.	All contaminants	In situ vitrification has been subjected to several pilot studies to test its effectiveness.	Field testing to prove	The practical limit on depth for this technology is not known. Issues with deployment in large material (e.g., cobbles) and offgas capture must be addressed. The technology is complex to implement.
		In situ thermal desorption	In situ thermal treatment that uses direct application of heat to increase the temperature of soil and destroy or volatilize organic compounds.	Organics	DOE has developed and tested several thermally enhanced remediation systems combining soil vapor extraction.	Field testing to prove	The practical limit on depth for this technology is not known. Technically challenging to implement. Offgas capture must also be addressed.
In situ physical/ chemical treatment	Delivery method	Gas-phase delivery	Gas-phase delivery uses vertical or horizontal injection wells and extraction wells to introduce and draw a gaseous mixture of chemical reagents through the vadose zone.	Reactant/contaminant dependent	Studies for gas-phase reagents are planned for the Hanford Site. Gaseous electron donor vadose zone demonstration and validation are ongoing under SERDP (DOD) support.	Field testing to prove	Technology evaluation has been limited to laboratory-scale and preliminary field tests. Soil heterogeneity will result in preferential flow and limit treatment effectiveness in lower permeability soil. Radius of influence needs to be determined.
		Foam delivery	Foam, which is a dispersed phase of gas in a liquid, can be used for lateral flushing or delivery of liquid chemical reagents through the vadose zone.	Reactant/contaminant dependent	Microfoam formulas applicable for DVZ delivery and tank-scale testing are being conducted in coordination with corresponding modeling and monitoring development. Under research and development by DOE-Environmental Management DVZ Applied Field Research Initiative.	Field testing to prove	Technology evaluation has been limited to laboratory-scale tests. The stability of the foam (i.e., how far will the foam migrate before the bubbles breakdown), which will dictate the well spacing, is unknown. Reagent would comprise a small percentage of foam, requiring higher injection volumes.
		Shear thinning fluid injection	A shear thinning fluid, which decreases in viscosity with increasing rate of shear stress, will move more easily in the vadose zone and distribute amendments further.	Reactant/contaminant dependent	Tested primarily for groundwater applications. Can be used during periods of rising groundwater table and rewetting of contaminated areas near the groundwater table. Development activities supported by SERDP (DOD).	No further evaluation	Implementation in unsaturated conditions has not been demonstrated. Use would be limited to near water table and perched water applications.
		Jet grouting	Jet grouting is the injection of a grout mixture, at very high pressures and velocities, into the pore space of the soil or rock through small orifices in the drill pipe located above the drill bit.	Reactant/contaminant dependent	Field-scale application is fully deployable and has been performed to depths of 91 m (300 ft). There are issues over radius of influence.	Field testing to prove	Soils with low permeability to grout flow must be addressed. Limited radius of influence. The impact of grout and fluid injection on the vadose zone surrounding the targeted area must be evaluated.
		Surface infiltration	Surface infiltration uses drip irrigation, trenches, and shallow basin systems to apply reagent to the ground surface to treat contaminants within the underlying vadose zone.	Reactant/contaminant dependent	Technology is well proven for shallow depths but would need to additional testing to make it applicable to the deeper vadose zone.	Field testing to prove	Challenges in applying this technology at significant depth and heterogeneous hydrogeologic conditions must be addressed.
		Deep soil mixing	Deep soil mixing uses large-diameter augers, or horizontally rotating mechanical or hydraulic mixing tools, to blend in reactants and homogenize soil.	Reactant/contaminant dependent	Technology is proven for shallow deployment in fairly homogeneous soils. May be effective in combination with other technologies (e.g., excavation).	Field testing to prove	Implementation is challenging in gravelly and cobbly lithologies. Although deep soil mixing has been performed to depths of 30 m (100 ft), most field applications have been limited to approximately 15 m (50 ft).
	Access method	Injection/extraction wells (horizontal)	Horizontal wells are typically directionally drilled and can be used to extract soil vapor and groundwater; or to inject water, chemical reagents, or biological substrates into contaminated regions.	Reactant/contaminant dependent	Technology is well proven at shallow depths and certain geological conditions.	Field testing to prove	Implementation is challenging in gravelly and cobbly lithologies. Pilot testing at moderate depths (23 m [75 ft]) has encountered significant challenges in strata containing cobbles.

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Technology Type		Technology	Description	COPC Applicability	State of Development	Maturity Level[a]	Limitations/Development Needs[b]
In situ physical/ chemical treatment (cont.)	Access method (cont.)	Injection/extraction wells (vertical)	Vertical wells are used to extract soil vapor and groundwater; or to inject water, chemical reagents, or biological substrates into contaminated regions.	Reactant/contaminant dependent	Technology is well proven. Distribution of liquid amendments can be highly ineffective due to presence of gravelly and cobbly lithologies.	Feasibility study ready	Injection in unsaturated conditions can be more challenging compared with saturated conditions. Gravelly and cobbly lithologies make injection amendment distribution challenging, although injection effectiveness is a function of the substrate (i.e., foam or gas).
	Reagent approach	Chemical oxidation	Chemical oxidation uses reduction/oxidation reactions to chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert.	Organics	Technology is proven for shallow deployment in fairly homogeneous soils. Chemical oxidants can be delivered using soil mixing, horizontal injections wells, or vertical injection wells.	Feasibility study ready	Challenges in applying this technology at significant depth and heterogeneous hydrogeologic conditions must be addressed.
		Soil vapor extraction	Soil vapor extraction applies a vacuum to the soil to induce a controlled flow of air for the removal of volatile and some semivolatile contaminants from the soil.	Volatile organics	Technology is proven for remediating soils contaminated by volatile organics.	Feasibility study ready	Challenges in applying this technology at significant depth and heterogeneous hydrogeologic conditions must be addressed.
		Biological reductive dechlorination	Biological reductive dechlorination uses microorganisms to sequentially replace chlorine atoms with hydrogen, forming nonhazardous or less toxic compounds.	Carbon tetrachloride	Pilot-scale and laboratory bench-scale testing have been performed for reduction of carbon tetrachloride.	Field testing to prove	Generally limited to use in saturated conditions. Effective delivery methods for unsaturated soils must be developed. Other vadose zone limitations include adequate moisture content, delivery of substrate, and ability to control reactions.
		Electrokinetic mobilization and recovery	Electrokinetic mobilization and recovery uses electrodes to create a low-voltage, direct-current electric field across contaminated soil to help mobilize contaminants.	Uranium and nitrate	Method has been implemented in selected shallow vadose zone contaminant areas.	Field testing to prove	Most effective in low-permeability soils with higher moisture content. Challenges in dry unsaturated soils must be overcome for wider deployment.
		Hybrid electrokinetic delivery of treatment chemicals	Using the electrokinetic remediation process described above, this technology mobilizes the fluids to target areas by application of electric fields.	Depends on the type of treatment chemicals being applied	Laboratory testing performed for reduction of chromate. Control of subsurface chemical conditions is critical.	No further evaluation	Most effective in soils with higher moisture content. Use in dry unsaturated soils has not been demonstrated.
		Sodium dithionite	Sodium dithionite is injected into the subsurface to chemically reduce contaminants into a less mobile and/or less toxic form.	Hexavalent chromium	Application to the vadose zone has not been demonstrated. Effective delivery is a challenge.	Field testing to prove	Use in unsaturated conditions has not been demonstrated.
		Sulfide salts and minerals	Calcium polysulfide is injected into the subsurface to chemically reduce contaminants into a less mobile and/or less toxic form.	Hexavalent chromium, uranium, and technetium(VII)	Field deployment for hexavalent chromium remediation has taken place at a number of sites, including the Hanford Site.	Field testing to prove	Generally limited to use in saturated conditions. Strong reducing conditions can mobilize other constituents. Reoxidation of uranium and technetium is possible. Effective delivery methods for unsaturated soils must be developed.
		Ferrous iron	Liquid ferrous iron is injected into the subsurface to reduce mobile contaminants such as hexavalent chromium and other contaminants to less mobile forms.	Hexavalent chromium and technetium(VII)	Treatments have been effective on source plumes in the saturated zone.	Field testing to prove	Generally limited to use in saturated conditions. Delivery methods need to be developed to enable liquid iron(II) to contact the DVZ prior to oxidation by soil oxygen, and without mobilizing the contaminants at the liquid front. Reoxidation of contaminants also needs to be considered.
		Gaseous reductant	Gaseous reduction uses a gaseous reagent in the subsurface to reduce contaminants to a less mobile and/or less toxic form.	Uranium and technetium-99	Field-scale demonstration of hexavalent chromium remediation in the vadose zone has been successful.	Field testing to prove	Transport of gas within the vadose zone (including containment of injected gas) needs further development. Reoxidation of contaminants must be considered. Technology evaluation has been limited to laboratory tests; need for field testing.

Table E-4. General Response Action – In Situ Treatment Remediation Technologies To Be Considered for the 200-DV-1 OU

Technology Type		Technology	Description	COPC Applicability	State of Development	Maturity Level[a]	Limitations/Development Needs[b]
In situ physical/ chemical treatment (cont.)	Reagent approach (cont.)	Gaseous ammonia	An ammonia gas mixture is injected into the subsurface to increase the pH sufficiently to dissolve silica. During the subsequent decrease in pH, the aluminosilicates will precipitate and will coat or bind the mobile contaminants.	Mobile COPCs	Effectiveness is being studied as part of a laboratory-scale investigation. Field testing is being planned for the Hanford Site.	Field testing to prove	Transport of gas within the vadose zone (including containment of injected gas) needs further development. Technology evaluation has been limited to laboratory tests; need for field testing.
		Phosphate sequestration (apatite)	Phosphate sequestration is used to stabilize metals by chemically binding them into new stable phosphate mineral phases (apatite minerals) and other relatively insoluble phases in the soil.	Mobile COPCs; uranium, technetium-99, and hexavalent chromium	Field-scale testing for sequestration of uranium in phosphate phases (apatite) is being performed in saturated conditions at the Hanford Site.	Field testing to prove	Effective methods for emplacing phosphate solution and maximizing distribution beyond delivery point need to be explored. Uncertainty on long-term stability of sequestered metals.
		Carbonate sequestration	Carbonate sequestration is used to stabilize contaminants by substituting the metals into the carbonate mineral phases to reduce their mobility.	Uranium and chromium	Substitution of strontium, uranium, and chromium into carbonates has been shown but not developed into remediation technology.	No further evaluation	Carbonate sequestration proof-of-concept testing in the laboratory is needed to evaluate contaminant substitution into calcium or iron carbonates using Hanford Site vadose zone samples.
		Nanoparticles	Injected nanoparticles of zerovalent iron (sometimes in combination with catalysts) provide large surface areas relative to their volume, creating enhanced chemical and biological reactivity.	Hexavalent chromium, technetium-99, and uranium	Field treatability testing has been performed in saturated conditions at the Hanford Site.	No further evaluation	Generally limited to use in saturated conditions. Delivery methods and effectiveness in unsaturated conditions must be demonstrated.
	Other	Soil desiccation	Soil desiccation removes water from the vadose zone to create a horizontal capillary barrier.	Mobile COPCs	A pilot test is being performed at the Hanford Site.	Field testing to prove	Basic concepts are well proven, and the technology is currently being tested at Hanford Site.
Biological treatment		In situ biological reduction	Reduction of contaminants may occur during in situ biological metabolic processes that will result in a less mobile and/or less toxic form.	Uranium, technetium-99, hexavalent chromium, and nitrate	Field-scale application has occurred for some of the target contaminants in the saturated zone. DOE-Office of Science supporting effort to study the long-term stability of uranium sequestration by sulfate reducing bacteria.	Field testing to prove	Basic technology is well understood; effective delivery methods must be developed and undesirable byproducts must be mitigated. Other vadose zone limitations include adequate moisture content, delivery of substrate, and ability to control reactions.
Natural attenuation		Monitored natural attenuation	Monitored natural attenuation relies on natural processes to achieve remediation objectives within a designated time frame and uses monitoring to track progress and ensure that contamination does not spread or increase.	COPCs are dependent on time frame to reach remediation objectives	Mature technology.	Feasibility study ready	Effective approach when combined with a comprehensive monitoring strategy.

a. Maturity levels for the technology in DVZ applications and Hanford Site conditions.

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b. Limitations/development needs to advance the technology to a higher maturity level for effective application at the Hanford Site DVZ.

COPC = contaminant of potential concern
DOD = U.S. Department of Defense
DOE = U.S. Department of Energy
DVZ = deep vadose zone
RCRA = *Resource Conservation and Recovery Act of 1976*
RI/FS = remedial investigation/feasibility study
RFI/CMS = RCRA field investigation/corrective measures study
SERDP = Strategic Environmental Research and Development Program

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