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Richland Operations Office
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10-AMCP-0176

JUN 29 2010

Ms. J. A. Hedges, Program Manager
Nuclear Waste Program
State of Washington
Department of Ecology
3100 Port of Benton
Richland, Washington 99354

Dear Ms. Hedges:

GROUNDWATER QUALITY ASSESSMENT PLAN FOR THE SINGLE-SHELL TANK WASTE MANAGEMENT AREA C, DOE/RL-2009-77, REVISION 0

This letter transmits the Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C, DOE/RL-2009-77, Revision 0 for your information. Comments provided by the State of Washington Department of Ecology to Draft A have been incorporated.

This plan describes the interim-status groundwater quality assessment activities to meet requirements of Washington Administrative Code (WAC) 173-303-400 (and by reference Code of Federal Regulations 40 CFR 265, Subpart F).

If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:RDH

Attachment

cc: See Page 2

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DOE/RL-2009-77
Revision 0

Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2009-77
Revision 0

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Date Published
May 2010

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

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

P.O. Box 550
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Executive Summary

Waste Management Area (WMA) C is being placed in groundwater quality assessment monitoring under interim status *Resource Conservation and Recovery Act of 1976*[1] (RCRA) regulations (*Washington Administrative Code* [WAC] 173-303-400[2] and 40 *Code of Federal Regulations* [CFR] 265, Subpart F[3]) because of exceedance of the critical mean for the indicator parameter of specific conductance. The dangerous constituent cyanide has been found in groundwater beneath WMA C, and no upgradient source for cyanide has been identified.

The WMA C, which incorporates the C Tank Farm, is regulated via Washington State's "Hazardous Waste Management Act"[4] and the implementing requirements of WAC 173-303-400. The Washington State Department of Ecology (Ecology) has been authorized by the U.S. Environmental Protection Agency[5] to conduct its hazardous waste regulatory program in lieu of RCRA, including the requirements of 40 CFR 265, Subpart F. The WMA C is also subject to the *Hanford Federal Facility Agreement and Consent Order*,[6] with Ecology identified as the lead regulatory agency for all single-shell tank farms.

This document presents the WMA C groundwater assessment plan to determine whether dangerous constituents (as defined in WAC 173-303-645[4][7]) are associated with past releases from WMA C. The plan describes the WMA C facility and operating history, waste characteristics, hydrogeology, previous monitoring at the WMA, groundwater and vadose zone contamination associated with the WMA, and the conceptual model. The plan addresses (1) the adequacy of the wells monitoring groundwater for WMA C; (2) the sampling requirements and schedule; (3) the constituents, groundwater parameters, and analytical methods necessary to determine whether past releases from WMA C are

---

1 *Resource Conservation and Recovery Act of 1976*, 42 U.S.C. 6901, et seq.

2 WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," *Washington Administrative Code*.

3 40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Groundwater Monitoring," *Code of Federal Regulations*.

4 RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*.

5 *Authorized State Hazardous Waste Programs*, 42 U.S.C. 6926, et seq.

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

7 WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units," *Washington Administrative Code*.

affecting groundwater quality; (4) the procedures for evaluating groundwater quality data; and (5) reporting requirements.

This document replaces *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site* (PNNL-13024[8] and subsequent interim change notices[9,10,11,12,13]) to address changes in the groundwater quality at WMA C and to update the groundwater monitoring project management organization.

This groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at WMA C.

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[8] PNNL-13024, 2001, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

[9] PNNL-13024-ICN-1, 2002, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Interim Change Notice 1, Pacific Northwest National Laboratory, Richland, Washington.

[10] PNNL-13024-ICN-2, 2003, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Interim Change Notice 2, Pacific Northwest National Laboratory, Richland, Washington.

[11] PNNL-13024-ICN-3, 2003, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Interim Change Notice 3, Pacific Northwest National Laboratory, Richland, Washington.

[12] PNNL-13024-ICN-4, 2004, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Interim Change Notice 4, Pacific Northwest National Laboratory, Richland, Washington.

[13] PNNL-13024-ICN-5, 2007, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, Interim Change Notice 5, Pacific Northwest National Laboratory, Richland, Washington.

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Terms

bgs	below ground surface
CFR	*Code of Federal Regulations*
DOE	U.S Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
PUREX	plutonium-uranium extraction
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UPR	unplanned release
WAC	*Washington Administrative Code*
WMA	waste management area

1 Introduction

This document provides the groundwater assessment plan for Waste Management Area (WMA) C. The WMA C contains the 241-C Tank Farm (C Tank Farm) and is located in the east-central portion of the Hanford Site's 200 East Area (Figure 1-1). This dangerous waste management unit provided interim storage of radioactive mixed waste, primarily from the bismuth-phosphate process, the plutonium-uranium extraction (PUREX) process, and the uranium extraction process. The WMA is regulated under *Washington Administrative Code* (WAC) 173-303 ("Dangerous Waste Regulations") and the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989).

This document supersedes the previous groundwater monitoring plan, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site* (PNNL-13024, as revised by subsequent interim change notices), to respond to changes that have occurred in groundwater at WMA C and to incorporate changes to project management for groundwater monitoring. This plan implements the requirements of WAC 173-303-400(3) ("Interim Status Facility Standards"), incorporating by reference 40 *Code of Federal Regulations* (CFR) 265.92(d) ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis"), documenting the assessment-level groundwater program for WMA C. The primary objective is to determine whether dangerous waste or dangerous waste constituents have entered the groundwater from this treatment, storage, and disposal unit. The scope of this plan is to acquire data of sufficient quantity and quality to meet specific regulatory requirements and the stated objective.

The most significant change at WMA C is the recent exceedance of the critical mean by the indicator parameter of specific conductance. Furthermore, the dangerous constituent cyanide has been found in groundwater beneath WMA C, and no upgradient source for cyanide has been identified.

This plan evaluated past WMA C investigations and groundwater monitoring reports as part of the data quality objectives (DQO) process. Chapter 2 presents a summary of information about the facility and the waste characteristics, conceptual model, contaminants of potential concern, and previous groundwater monitoring results, with references to sources of more detailed information. The information is then evaluated relative to the regulatory requirements to provide site-specific decision statements. Chapter 3 provides the logic for dangerous waste or dangerous waste constituent selection and the construction of additional monitoring wells. Chapter 4 uses the DQO decision statements to develop the logic for dangerous waste or dangerous waste constituent determinations. Chapter 4 also discusses the process for evaluating the monitoring network and the reporting requirements. Chapter 5 provides references, and the quality assurance project plan (QAPjP) is included as Appendix A.

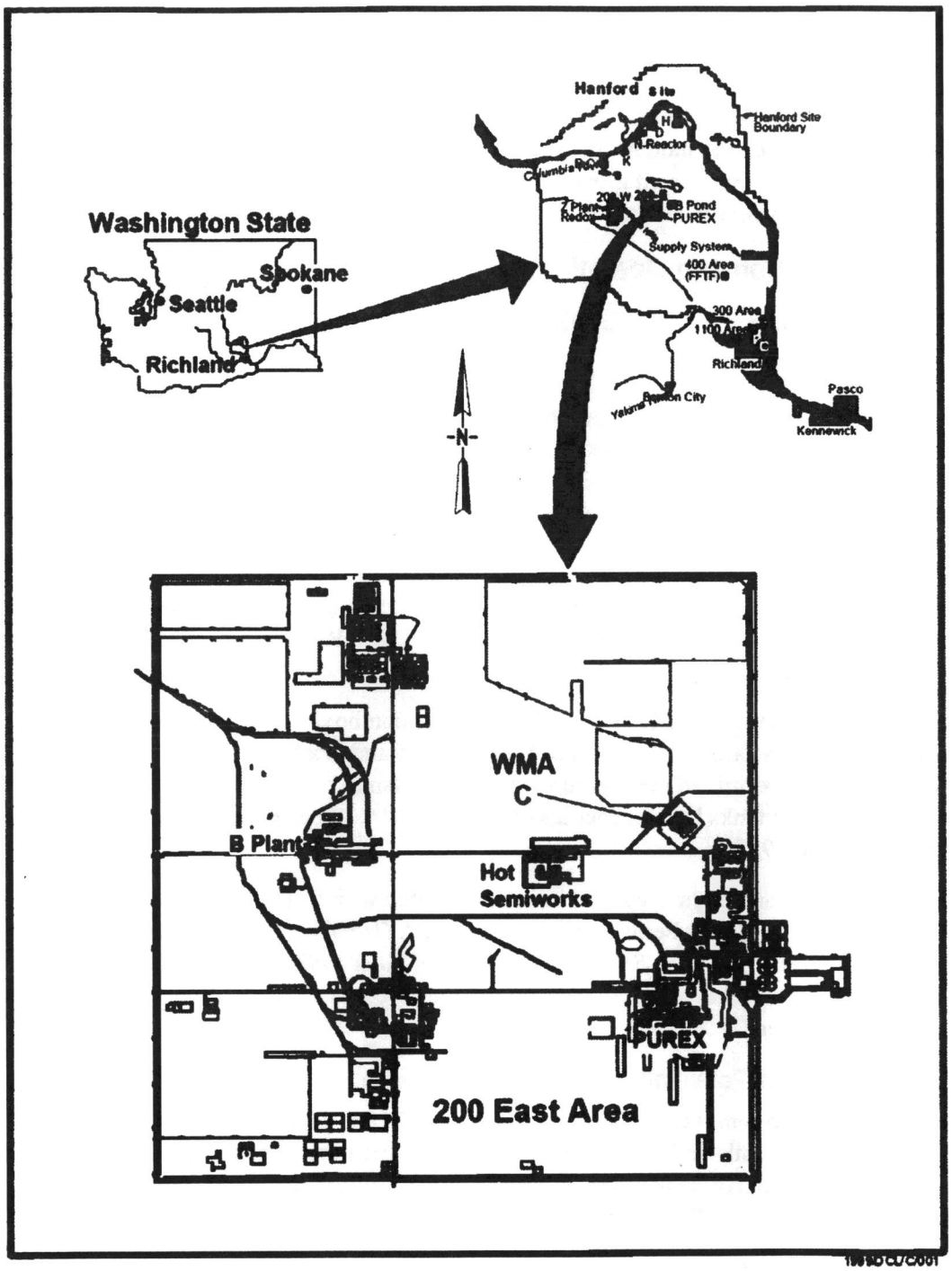

Figure 1-1. Location of Waste Management Area C

2 Background

This chapter provides an overview of WMA C, including a brief account of the facility's operational history and a general description of the tank wastes. The stratigraphic framework is provided, along with the nature and various conceptual models of vadose zone contaminant migration. This chapter also provides a summary of past and present groundwater monitoring status, and it also describes the DQO process for responding to a significant increase of specific conductance in well 299-E27-14.

2.1 Facility Description and Operational History

A discussion of WMA C and its operational history is provided in this section.

2.1.1 Facility Description

The WMA C is located in the east-central portion of the 200 East Area, which includes the C Tank Farm. In general, the fence line surrounding the tank farm constitutes the *Resource Conservation and Recovery Act of 1976* (RCRA) site boundary (Figure 2-1) of the WMA. The C Tank Farm contains 16 single-shell tanks (SSTs) of the "100" series and SSTs of the "200" series, all constructed in 1943 and 1944. The 100-series tanks are 22.9 m (75 ft) in diameter and have an operating capacity of 1,892,500 L (530,000 gal) each. The 200-series tanks are 6.1 m (20 ft) in diameter and have a capacity of 208,000 L (55,000 gal) each. All of the tanks are entirely below grade with at least 2.1 m (7 ft) of soil cover. Each of these SSTs was removed from service between 1970 and 1980 (RPP-PLAN-39114, *RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C*).

The WMA C also includes the 244-CR vault and eight diversion boxes. The 244-CR vault is located in southern portion of the tank farm. The vault was built in 1946 and is a below-grade, reinforced-concrete structure that houses four permitted underground tanks. Two tanks have capacities of 170,343 L (45,000 gal) each, and two tanks have capacities of 55,494 L (14,700 gal) each. The 244-CR vault was removed from service in 1988.

In 1996, the transfer lines and eight diversion boxes associated with C Tank Farm were added as part of the WMA in the Dangerous Waste Permit Application Part A (*Hanford Facility Dangerous Waste Part A Permit Application, Form 3, Revision 8, for the Single-Shell Tank [SST] System* [DOE-ORP 2003]). All of the diversion boxes used in the C Tank Farm are inactive and are currently isolated or covered as protection from the weather.

2.1.2 Facility Conditions Potentially Impacting Groundwater

Retrievable waste has been removed from tanks 241-C-103, 241-C-106, 241-C-108, and 241-C-109, as well as the four 200-series tanks at WMA C, in order to meet the requirements for tank waste retrieval in Appendix H of the Tri-Party Agreement (HNF-EP-0182, Rev. 249, *Waste Tank Summary Report for Month Ending December 31, 2008*). The remaining volume of waste for each of the tanks is as follows:

- Tank 241-C-103: 9,573.3 L (2,529 gal)
- Tank 241-C-106: 10,489.4 L (2,771 gal)
- Tank 241-C-108: 29,147.7 L (7,700 gal)
- Tank 241-C-109: 32,554.5 L (8,600 gal)
- Tank 241-C-201: 545.1 L (144 gal)
- Tank 241-C-202: 537.5 L (142 gal)
- Tank 241-C-203: 526.2 L (139 gal)
- Tank 241-C-204: 518.6 L (137 gal)

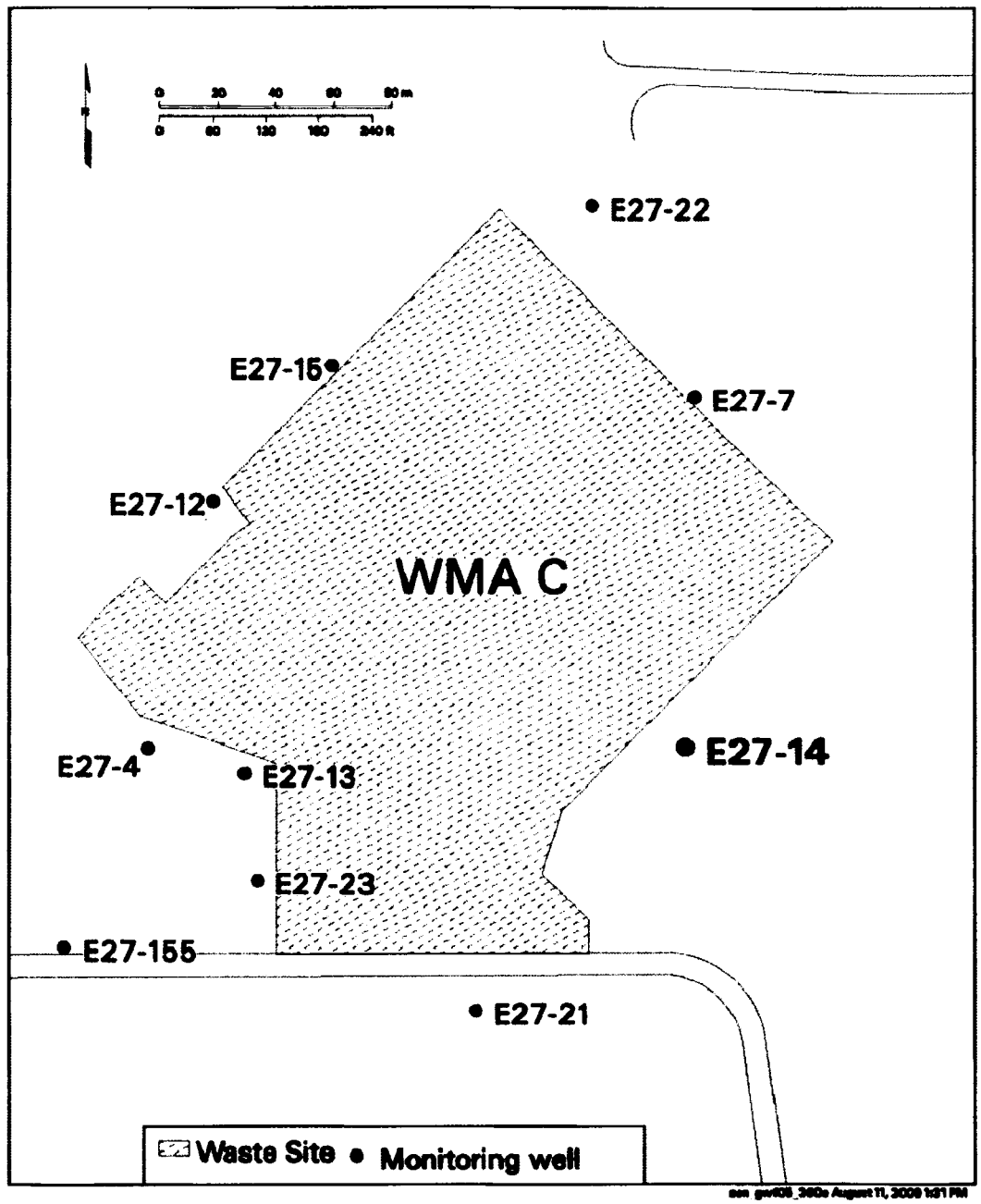

Figure 2-1. Waste Management Area C and Monitoring Well Network

Waste retrieval was declared to have retrieved to the limit of modified sluicing technology on April 27, 2009, at tank 241-C-110. As of April 27, 2009, the tank had a total solid waste volume of 64,345 L (17,000 gal) based on *Waste Tank Summary Report For Month Ending February 28, 2010* (HNF-EP-0182, Rev. 263). The remaining tanks at WMA C have undergone interim stabilization.

During interim stabilization, the supernatant liquid and salt cake were removed at the C Tank Farm. Thus, the tanks' total remaining waste volume is primarily sludge, with generally a small percentage (i.e., less than 10 percent) of drainable liquid remaining. Table 2-1 provides the total remaining waste volume,

sludge waste volume, and drainable liquid remaining for the interim stabilized tanks per HNF-EP-0182, Rev. 263.

Table 2-1. Volumes of Remaining Waste, Sludge, and Drainable Liquid in Interim Stabilized Tanks at C Tank Farm

Interim Stabilized Tank	Total Remaining Waste	Sludge	Drainable Liquid
241-C-101	88,000 gal	88,000 gal	4,000 gal
241-C-102	316,000 gal	316,000 gal	62,000 gal
241-C-104	125,000 gal	111,000 gal	0 gal
241-C-105	132,000 gal	132,000 gal	10,000 gal
241-C-107	247,000 gal	247,000 gal	30,000 gal
241-C-111	58,000 gal	57,000 gal	4,000 gal
241-C-112	104,000 gal	104,000 gal	6,000 gal

Seven of the 16 SSTs in WMA C are confirmed or assumed to have leaked (RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report: 241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases*): 241-C-101, 241-C-110, 241-C-111, 241-C-201, 241-C-202, 241-C-203, and 241-C-204. The combined total of the estimated tank leak volumes is 110,700 L (29,000 gal). Additional sources of unplanned releases (UPRs) include waste loss from spare inlet nozzles or cascade lines, additional pipeline leaks, and surface releases. Significant uncertainty is associated with the extent of contaminant migration from both the SSTs and UPRs. Investigations are ongoing to better understand the extent of contamination in the vadose zone and groundwater associated with the assumed or confirmed tank leaks (listed above), as well as the other areas of concern identified in RPP-PLAN-39114. The following provides a brief summary of the site knowledge for the areas of concern with larger volume releases and/or observed vertical migration. Section 2.5 discusses the recent investigation results presented in the *Field Investigation Report for Waste Management Areas C and A-AX* (RPP-35484). Figure 2-2 depicts the Phase 2 planned characterization locations provided in RPP-PLAN-39114.

The largest confirmed tank leak is associated with tank 241-C-101, which was categorized as a confirmed leaking tank in 1980, with an approximate leak volume of 75,700 L (20,000 gal) (RPP-ENV-33418). Gross-gamma measurements in adjacent dry wells appear to be consistent with a contaminant leak. Further investigation is planned in this area (see location "B" in Figure 2-2) (RPP-PLAN-39114).

Tank 241-C-111 was categorized as a suspect leaker in late 1973, with an approximate leak volume of 20,820 L (5,500 gal) (RPP-ENV-33418); however, various assessment methods (e.g., borehole gamma-spectral logging and electrical resistivity) provided little evidence of this volume of a leak. Further investigation is planned in this area (see locations "V" and "K" in Figure 2-2) (RPP-PLAN-39114).

Another tank listed as an assumed leaker is 241-C-110. Although the release from this tank is small (less than 7,570 L [2,000 gal)]) (RPP-ENV-33418), past spectral gamma results reported cesium-137 at depths greater than 18.3 m (60 ft) bgs. Further investigation is planned in this area (see location "V" in Figure 2-2) (RPP-PLAN-39114).

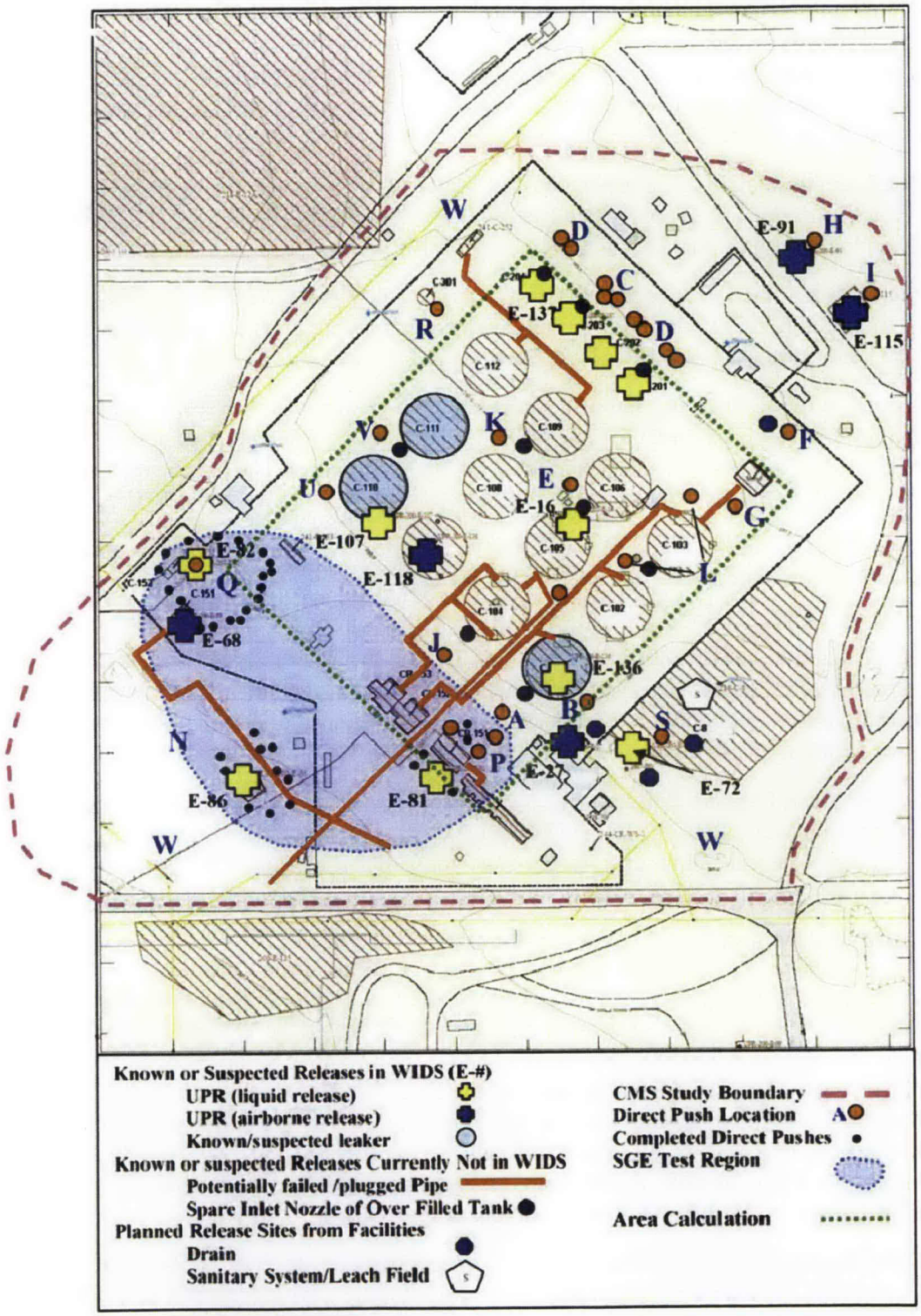

Figure 2-2. Waste Management Area C, Phase 2 Vadose Zone Characterization Sample Locations

Although tank 241-C-108 is not officially identified as an official leaker, it is located near a zone of low electrical resistivity thought to be associated with a transfer line leak (RPP-PLAN-39114). Past gross-gamma geophysical logging results indicated contaminant migration (WHC-SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*). Further investigation is planned in this area (see location "K" in Figure 2-2) (RPP-PLAN-39114).

Past dry well spectral gamma results near tank 241-C-103 (GJO-HAN-18, *Hanford Tank Farms Vadose Zone, C Tank Farm Report*) suggest some type of release in the area. Further investigation is planned in this area (see locations "G" and "L" in Figure 2-2) (RPP-PLAN-39114).

Four of the tanks assumed to have leaked are 200-series tanks, which were categorized as small releases (less than about 2,000 L [530 gal] each). Further investigations are planned in this area (see locations "C" and "D" in Figure 2-2) (RPP-PLAN-39114).

Contamination in the vadose zone has also been attributed to known and/or suspected surface releases and piping system leaks in WMA C. Three of the largest defined liquid releases are defined as UPR-200-E-81, UPR-200-E-82, and UPR-200-E-86 (see Figure 2-2). The conclusions to date, based on Phase 1 investigation results at these UPR sites, are provided in Section 2.5.

The largest surface area release site was northeast of WMA C, which was subject to water from an equipment decontamination station located inside the tank farm. Further investigation is planned (see location "H" in Figure 2-2) (RPP-PLAN-39114).

The 216-C-8 french drain received at least 120,665 L (31,880 gal) of research wastes of unknown compositions. Spectral gamma logging in well 299-E27-14 indicated lateral and vertical vadose zone contaminant migration, possibly associated with the 216-C-8 french drain.[14] Further investigation is planned (see location "S" in Figure 2-2) (RPP-PLAN-39114).

The 241-C-801 Cask Loading Building may have released waste to a dry well approximately 27.4 m (90 ft) to the southeast of well 299-E27-7 (RPP-PLAN-39144). Spectral gamma logging results in well 299-E27-7 indicate lateral and vertical vadose zone contaminant migration.[15] Further investigation is planned (see location "F" in Figure 2-2) (RPP-PLAN-39114).

2.2 Regulatory Basis

In May 1989, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed the Tri-Party Agreement (Ecology et al. 1989). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes the SST WMAs. As part of the WAC 173-303 regulatory process implementing RCRA, an interim status Dangerous Waste Permit Application Part A and the *Single-Shell Tank Closure Work Plan* (DOE/RL-89-16) were submitted to Ecology for the SSTs. In 1996, the Washington State Attorney General determined that the effective date of mixed waste in Washington State was August 19, 1987.

Groundwater monitoring is conducted at WMA C in accordance with WAC 173-303-400(3) and, by reference, 40 CFR 265, Subpart F ("Ground-Water Monitoring"), which requires monitoring to determine whether dangerous waste or dangerous waste constituents from the waste site have entered

[14] HGLP-LDR-068, *299-E27-14 (A4812) Log Data Report*, Rev. 0, dated March 28, 2007, S.M. Stoller, Richland, Washington.

[15] HGLP-LDR-174, *299-E27-07 (A4816) Log Data Report*, Rev. 0, dated January 1, 2008, S.M. Stoller, Richland, Washington.

the groundwater. A RCRA groundwater monitoring program for WMA C was initiated in 1989 (WHC-SD-EN-AP-012, *Interim Status Groundwater Monitoring Plan for the Single-Shell Tanks* [Rev. 0, followed by Rev. 1 in 1991]). Since 2001, monitoring has been conducted in accordance with PNNL-13024 (and subsequent interim change notices). In July 2009, the indicator parameter of specific conductance was verified as exceeding the critical mean in well 299-E27-14. Furthermore, cyanide (a dangerous constituent) has been detected in groundwater beneath WMA C. No upgradient source of cyanide has been identified; therefore, the groundwater assessment program for WMA C will meet the regulatory requirements specified in 40 CFR 265.93(d)(7), "Preparation, Evaluation, and Response."

2.3 Waste Characteristics

During the period of Hanford Site operations, wastes routed to tanks in the C Tank Farm were derived from several production processes. Appendix A of PNNL-13024 lists the chemical constituent inventories in each of the sixteen 241-C tanks and provides an evaluation of the chemical and radioactive species derived from the processes run at B Plant, U Plant, PUREX Plant, and the Hot Semiworks Facility, citing the following references, and also in any RCRA permit:

- HNF-SD-WM-TI-740, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*
- LA-UR-96-3860, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*
- WHC-MR-0132, *A History of the 200 Area Tank Farms*

WHC-MR-0132 provides the approximate chemical compositions for the major waste types sent to the SSTs, and the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744) includes detailed estimates for chemical and radioisotope concentrations for each tank leak in WMA C.

Table 2-2 lists the dangerous wastes specified in the SST Dangerous Waste Permit Application Part A Form.

2.4 Geology and Hydrogeology

This section summarizes the geology and hydrogeology in the vicinity of WMA C. Additional discussion is provided in the *Geology Data Package for the Single-Shell Tanks Waste Management Areas at the Hanford Site* (PNNL-15955); *Revised Hydrostratigraphy for the Suprabasalt Upper Aquifer System, 200 East Area, Hanford Site, Washington* (PNNL-12261); *Data Package for Past and Current Groundwater Flow and Contamination Beneath Single-Shell Tank Waste Management Areas* (PNNL-15837); and PNNL-13024.

The geology beneath WMA C consists of basalt overlain by four sedimentary sequences. The sedimentary sequences, in ascending order, are as follows (see Figure 2-3).

- Undifferentiated Hanford-Cold Creek unit-Ringold gravels (H3/CCU/R): This sequence is a new nomenclature based on evaluations provided in PNNL-15955. This sequence consists of predominantly sandy, pebble- to cobble-sized gravel with occasional boulders. The total thickness is estimated at approximately 32 m (105 ft) in well 299-E27-23 and thins to the east and north. Details pertaining to the new nomenclature are not provided in this document; however, PNNL-15955 provides information for the basis of this change.

Table 2-2. Dangerous Wastes in the Single-Shell Tank System Dangerous Waste Permit Application Part A Form

Dangerous Waste Code	Contaminant Description	Dangerous Waste Code	Contaminant Description
D001	Ignitable waste	D029	1,1-dichloroethylene
D002	Corrosive waste	D030	2,4-dinitrotoluene
D003	Reactive waste	D033	Hexachlorobutadiene
D004	Arsenic	D034	Hexachloroethane
D005	Barium	D035	Methyl ethyl ketone
D006	Cadmium	D036	Nitrobenzene
D007	Chromium	D038	Pyridine
D008	Lead	D039	Tetrachloroethylene
D009	Mercury	D040	Trichloroethylene
D010	Selenium	D041	2,4,5-trichlorophenol
D011	Silver	D043	Vinyl chloride
D018	Benzene	WP01	Extremely hazardous waste/ persistent dangerous waste
D019	Carbon tetrachloride	WP02	Dangerous waste/persistent dangerous waste
D022	Chloroform	WT01	Extremely hazardous waste/toxic dangerous waste
D028	1,2-dichloroethane	WT02	Dangerous waste/toxic dangerous waste
F001	Spent halogenated solvents	F004	Spent non-halogenated solvents
F002	Spent halogenated solvents	F005	Spent non-halogenated solvents
F003	Spent non-halogenated solvents		

- Hanford formation sand sequence: This sequence is variably bedded silty sand, sand, and slightly gravelly to gravelly sand. The sediments contain a higher proportion of gravel in the west and southwest portion of WMA C. The thickness of the Hanford formation sand sequence averages approximately 58 m (190 ft).
- Hanford formation upper gravel sequence: This sequence consists of interbedded sandy gravels, gravelly sands, and sands. It averages about 10 m (32 ft) in thickness in the vicinity of WMA C.
- Holocene eolian sediments and/or backfill material: Areas outside of the C Tank Farm have up to 4.5 m (15 ft) of Holocene eolian sediment. Within the tank farm, the upper 12 m (40 ft) of material is backfill consisting of mixed gravel, sand, and silt excavated from the Hanford formation during construction of the tank farm. Clastic dikes were detected during the construction of the tank farm (PNNL-15955).

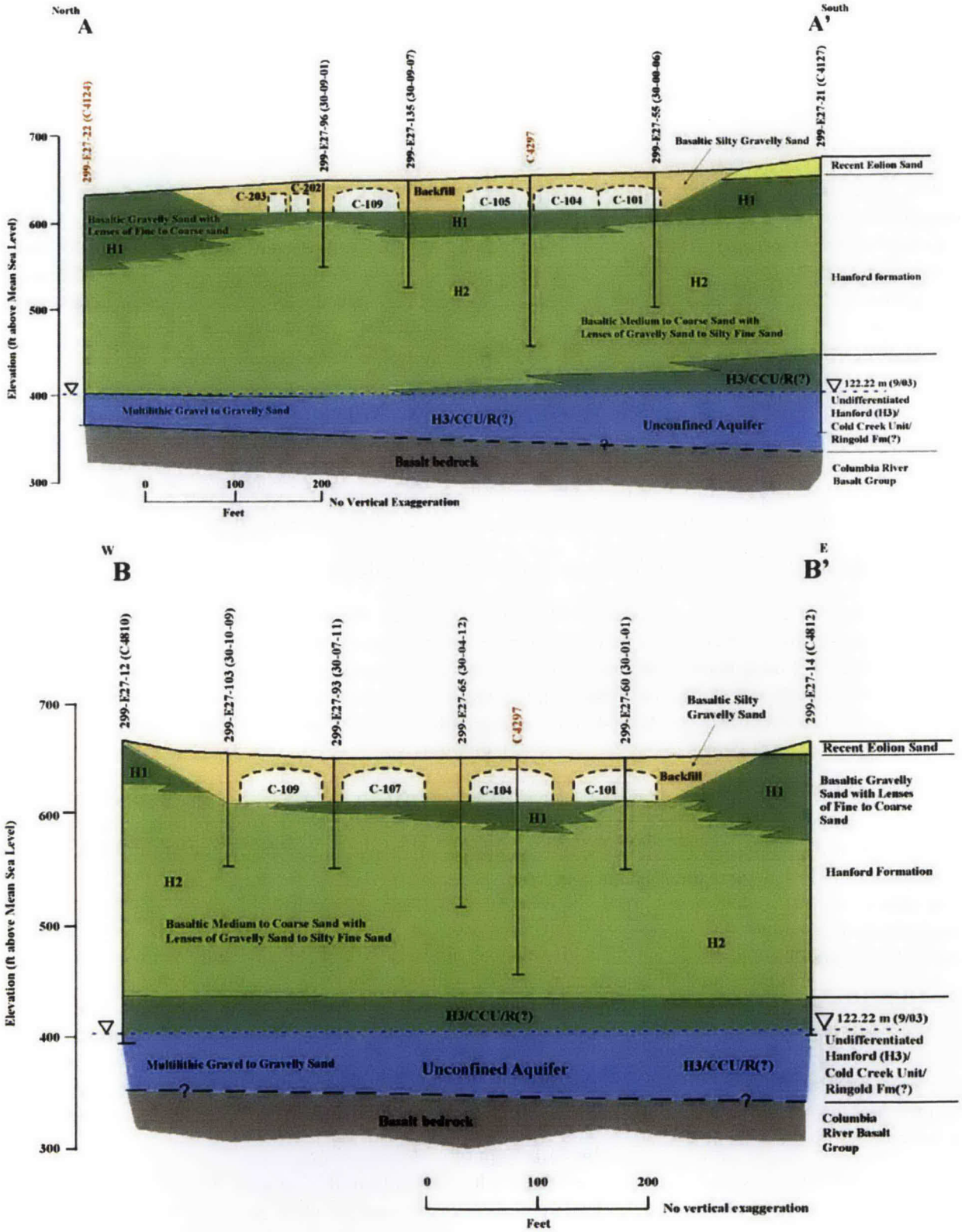

Figure 2-3. Cross-Section Through Waste Management Area C

Currently, the water table beneath WMA C lies at approximately 122 m (400 ft) above sea level, with roughly 77 m (255 ft) of vadose zone above. The rate of water table decline was approximately 5 cm/year (1.97 in./year) in fiscal year 2007, although water table elevations in all RCRA wells at WMA C showed an increase (as much as 0.11 m [0.36 ft]) in 2007, prior to dropping back to near 122 m (400 ft). Based on a least-squares regression fit to the water table, wells in the network may not require replacement for over 15 years.

The aquifer thickness (based on the groundwater elevation and top of basalt contacts in wells 299-E27-7, 299-E27-22, and 299-E27-155) ranges from 11 to 16.6 m (36.1 to 54.6 ft). The measured hydraulic conductivity beneath WMA C ranges from 0.04 to 6,900 m/day (0.13 to 22,638 ft/day) (PNNL-15837). The low value is likely not representative of bulk aquifer properties, based on the specific test conditions. Although the hydraulic conductivity is considered high in this area, the flow rate is uncertain because the gradient is low and the hydraulic conductivity is variable. Groundwater flow rate was estimated to be 0.09 m/day (0.3 ft/day) by evaluating contaminant migration (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*). This is much less than previous Darcy calculations (0.7 to 2.4 m/day [2.3 to 7.9 ft/day]) (PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*). Groundwater flow direction has predominantly been reported over the past decade as southwest, based on the groundwater gradient. More recently, however, groundwater flow was reported as southwest to south-southwest based on contaminant migration. The determination of flow direction is based on contaminant migration, considered local hydrographs, in situ flow measurement data, groundwater chemistry, and nitrate-to-technetium-99 ratios (DOE/RL-2008-01).

2.5 Summary of Previous Vadose Zone Investigations

As part of the corrective action process for WMA C, the Phase 1 characterization effort was focused primarily on sample collection and analyses in areas where specific gamma-emitting contaminants (e.g., cesium-137) have been identified. Four areas were characterized for non-gamma-emitting mobile tank waste contaminants during the Phase 1 investigations. A summary of the conclusions for the UPR-200-E-81, UPR-200-E-82, UPR-E-86, and a possible transfer line leak between tanks 241-C-104 and 241-C-105 (as noted in Section 2.1) is provided below and the locations are shown in Figure 2-2.

For UPR-200-E-81 (a PUREX cladding waste), an estimated 136,260 L (36,000 gal) were lost near diversion box 241-C-151 (RPP-35484). Based on the depth and concentration of mobile constituents reported from the analytical results on samples collected in this area, contaminant contributions to the groundwater below are not likely. This conclusion is further vetted by the three-dimensional data acquisition of electrical-resistivity data acquired using 332 surface electrodes and two pairs of depth-discrete electrodes near this release (RPP-RPT-41236, *Surface Geophysical Exploration of UPR-200E-81 Near the C Tank Farm*).

For UPR-200-E-82 (the cesium-137 recovery process feed solution pipeline leak), an estimated 9,992 L (2,640 gal) were lost near diversion box 241-C-152 (PNNL-15617, *Characterization of Vadose Zone Sediments from C Waste Management Area: Investigation of the C-152 Transfer Line Leak*). Although elevated water-extractable mobile contaminants were found at depths greater than expected, the estimated volume lost during the leak event from this UPR and subsequent natural recharge did not appear sufficient to have contaminated the groundwater, at least by the end of 2007 (RPP-35484).

For UPR-200-E-86 (a transfer line leak of PUREX waste near monitoring well 299-E27-4), an estimated 79,102 L (17,400 gal) were lost (RPP-37625, *Completion Report for UPR-200-E-86 Direct Push Drilling and Sampling*). Based on the depth and concentration of mobile constituents reported from laboratory results on samples collected in this area, contaminant contributions to the groundwater below is not likely.

The most extensive WMA C vadose zone contamination area is the suspect transfer line leak between tanks 241-C-104 and 241-C-105. Two reports (GJO-HAN-82, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank C-103*; and *Investigation of Dry-Well 30-03-09 in the C-Tank Farm with High Resolution Gamma Ray Spectroscopy* [Ulbricht 1987]) associate a large cobalt-60 vadose zone plume with this release. One vertical characterization borehole (C4297) was driven to approximately 59.9 m (196.5 ft) bgs. Analyses of soil samples showed no clear relationship between the porewater and the groundwater contamination; therefore, groundwater contamination was considered to be influenced by fluids from nearby cribs and trenches (PNNL-15503, *Characterization of Vadose Zone Sediments Below the C Tank Farm: Borehole C4297 and RCRA Borehole 299-E27-22*).

2.6 Vadose Zone Conceptual Model

As part of the *RCRA Facility Investigation/Corrective Measures Study Work Plan for WMA C* (RPP-PLAN-39114), several alternative conceptual models were developed to integrate the relationships of important parameters such as the contamination source, driving force, and migration pathway. The conceptual models were developed from knowledge of previous releases in WMA C and past characterization results for large leaks. According to RPP-PLAN-39114, observable migration has been limited to non-reactive to slightly reactive contaminants (mostly nitrate and technetium-99, and to a lesser extent cobalt-60, chromium, and uranium [where present]). Recent porewater extract analyses from borehole C4297, located between tanks 241-C-104 and 241-C-105 within WMA C provided a near-continuous profile of these constituents with depth in the vadose near the point of one of the largest suspect releases (Figure 2-3). Based on the data from this borehole, the bulk of the inventory may still reside in the vadose zone, approximately 21 to 46 m (70 to 150 ft) above the unconfined aquifer (Figure 2-4). However, because the data are only one dimensional, contamination may have also been diverted horizontally and vertically, and a considerable amount of contamination may have reached groundwater (Figures 2-5 and 2-6). From the initial data, three conceptual models have been developed, which are discussed in RPP-PLAN-39114. The following discussion on the conceptual models is taken from RPP-PLAN-39114.

In *Conceptual Models of Flow and Transport in the Fractured Vadose Zone* (NRC 2001), the National Resource Council defines a conceptual model as "...an evolving hypothesis identifying the important features, processes, and events controlling fluid flow and contaminant transport of consequence at a specific field site in the context of a recognized problem." Furthermore, Dr. Eileen Poerter (Colorado School of Mines), while giving the 2006 Darcy Lecture for the National Groundwater Association, recommended using "multiple working hypotheses" (alternative conceptual models) when studying complex geohydrologic systems. This section provides an overview of the alternative conceptual models supporting the DQO process for the Phase 2 characterization data needed for the WMA C corrective measures study. As additional data are collected during Phase 2 characterization activities, these conceptual models will be updated and revised as necessary.

With regard to the unintentional discharge of waste from SST farm infrastructure into the subsurface at various waste management areas on the Central Plateau, the nature and extent of contaminant release and subsequent migration have been conceptualized in terms of the source term properties (e.g., contaminant inventory and release mechanisms), the driving forces that move contaminants (e.g., recharge rates), and the properties of the medium through which contaminants move (e.g., subsurface stratigraphy). The following discussion emphasizes the variability of key factors over time (e.g., the local water flux controlling contaminant migration can vary by orders of magnitude when considering the leak event, operational recharge events, and long-term recharge through an engineered cover). Similarly, some critical factors may differ depending on the location (e.g., variability in operational fluid discharges at one WMA versus another that contact and move contaminants in the subsurface).

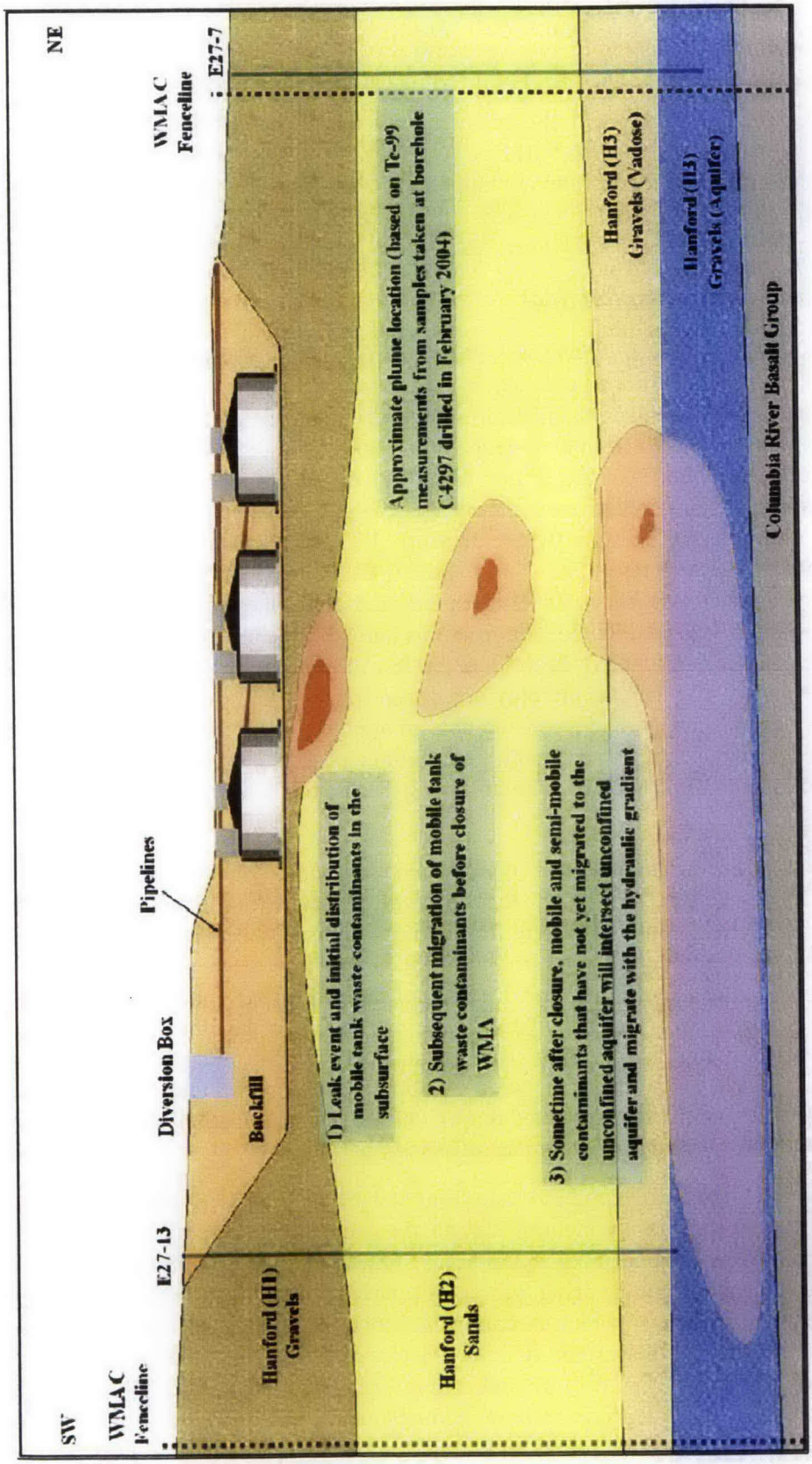

Figure 2-4. Vadose Zone Contaminant Transport Conceptual Model Alternative 1

2.6.1 Alternative 1: Phase 1 Conceptual Model

This model is documented in Chapter 16 and Appendix A of DOE/ORP-2008-01 and was derived from process records, gross gamma-logging information collected from the 1960s through the 1990s,[16] spectral gamma data collected in the late 1990s to early 2000s,[17] and the data collected during the Phase 1 characterization efforts conducted from 2000 to 2007.[18] One of the primary goals of the Phase 1 characterization effort was to understand the relationship of the inventory of contaminants (that adversely impact groundwater) observed in the vadose zone to the concentrations of those contaminants in the groundwater. To accomplish this, the Phase 1 characterization effort collected soil samples at major leaks within a WMA with known high cesium-137 concentrations (10,000,000 pCi/g) in the nearby soils to find depth of the mobile contaminants (i.e., technetium-99, nitrate, etc.) based on the relationship between cesium-137 and technetium-99 in the fission process (i.e., if high cesium-137 is present, then technetium-99 should also be present, but deeper, because technetium-99 does not adsorb onto the soil).

The complete Phase 1 conceptual model is described in DOE/ORP-2008-01 (Appendix A). Rather than evaluating individual leaks sequentially, the summary discussion in Appendix A is oriented toward comparisons of similar information related to several leak events where possible, particularly the larger leaks that are more completely characterized. The purpose of these comparisons is to emphasize and describe those key characteristics and processes that are common to all leak events and, therefore, are indicative of systematic behavior. At the same time, it is important to keep in mind that each tank waste release site is unique in some way and that site-specific factors not emphasized in this general discussion may provide significant impacts to contaminant behavior in the subsurface. These factors, which must be determined from site-specific evaluation, may result in more refined or alternative conceptual models that are most appropriate for a given site.

At a summary level, the following key characteristics and processes discussed in Sections 2.6.1.1 through 2.6.1.4 are concluded to be the primary components of the conceptual model and common to all major tank leak events.

2.6.1.1 Initial Leak Period

Unintentional discharges of tank waste were events that occurred because waste transfer pipelines and storage tanks were compromised and allowed waste releases to the subsurface. The primary degrading waste storage conditions of tanks were overheating and overfilling.

Following release into the vadose zone, waste fluids increased ambient moisture content and perturbed the local geochemical conditions at the point of entry and beyond. Natural physical and chemical processes sometime after the leak event began to eliminate these perturbations.

Waste fluids were distributed rapidly over limited areas of the vadose zone until ambient moisture contents were essentially restored. Key characteristics and processes were unsaturated flow and lateral

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[16] See reports on analysis of historical gross-gamma data: HNF-3136, HNF-3531, HNF-3532, HNF-3831, HNF-4220, HNF-5433, RPP-6088, RPP-6353, RPP-7729, RPP-8321, RPP-8820, and RPP-8821.

[17] See DOE's Grand Junction Office reports and associated addendum for the Vadose Zone Characterization Project at the Hanford tank farms: DOE/ID/12584-268, DOE/ID/12584-268A, GJO-96-2-TAR, GJO-96-2-TARA, GJO-97-13-TAR, GJO-97-13-TARA, GJO-97-14-TAR, GJO-97-14-TARA, GJO-97-1-TAR, GJO-97-1-TARA, GJO-97-30-TAR, GJO-97-30-TARA, GJO-97-31-TAR, GJO-97-31-TARA, GJO-98-39-TAR, GJO-98-39-TARA, GJO-98-40-TAR, GJO-98-40-TARA, GJO-98-64-TAR, GJO-98-64-TARA, GJO-99-101-TAR, GJO-99-101-TARA, GJO-99-113-TAR, and GJO-99-113-TARA.

[18] See field investigation reports RPP-7884; RPP-10098; RPP-23752; DOE/ORP-2008-01, Appendices L and M; RPP-35484; and RPP-35485.

migration that resulted from hydrogeologic controls. Consequently, waste contacted an expanded vadose zone volume compared to the initial volume of the released waste.

Chemical reactions between tank waste fluid and the vadose zone soil/water system occurred as waste fluids were distributed in the vadose zone. Key characteristics and processes were moderation of the local elevated pH conditions typical of tank waste fluids and sorption/precipitation/desorption of reactive contaminants onto soil surfaces. In some cases, tank waste chemistry altered the reactivity of specific contaminants relative to their behavior under ambient conditions (notably, for waste with high sodium content [SX-108], cesium-137 mobility was temporarily enhanced). By the time the ambient moisture content was essentially re-established, contaminants were variably distributed in the vadose zone volume contacted by tank waste, depending on their reactivity. Maximum distribution occurred for non-reactive constituents (e.g., ruthenium-106, technetium-99, and nitrate).

2.6.1.2 Current Conditions

Following the initial waste fluid release and distribution into the vadose zone, lateral and vertical waste migration continued, but the controlling physical and chemical processes changed in some respects. Migration was driven by local recharge conditions that were dictated by the permeability of the gravel/sand fill that covers the SST system in the tank farm. Chemical reactions continued that were primarily controlled by the ambient environment.

To date, observable migration has occurred only for non-reactive to slightly reactive contaminants (mostly nitrate and technetium-99, and to a lesser extent cobalt-60, chromium, and uranium, where present). The exception to this observation is at the SX-108 leak, where enhanced cesium-137 mobility occurred due to the presence of high sodium concentrations in the tank waste (RPP-10098, *Field Investigation Report for Waste Management Area B-BX-BY*). Under these conditions, sodium sorbs preferential on soil phase sorption sites.

Under natural recharge conditions through a gravel cover, vertical migration rates of 0.3 to 0.9 m/year (1 to 3 ft/year) in the Hanford formation of the vadose zone for cobalt-60 have been observed at a few of the dry wells in WMAs C and B-BX-BY, most notably at drywells 22-03-09, 22-06-05 (HNF-3532, *Analysis of Historical Gross Gamma Logging Data from BY Tank Farm*), and 30-08-02 (RPP-8321, *Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-C Tank Farm – 200 East Area*).

A total of 11 characterization boreholes were installed during Phase 1 characterization activities. Technetium-99 was found approximately between 25.9 m and 45.7 m (85 ft and 150 ft) bgs for the 200 West Area WMAs and 39.6 m to 51.8 m (130 ft to 170 ft) bgs for the 200 East Area WMAs (DOE/ORP-2008-01). Drilling depths ranged from 35.1 m (115 ft) bgs in the TX Tank Farm to 80.4 m (264 ft) bgs in the B Tank Farm and were sufficient to reach, and in some cases pass through, a maximum concentration zone where technetium-99 concentrations at the deepest location were one or more orders of magnitude below the highest recorded values in the borehole. Based on these analyses, the bulk of the inventory for technetium-99 is inferred to still reside in the vadose zone, approximately 21.3 to 45.7 m (70 to 150 ft) above the unconfined aquifer. However, mobile tank waste contaminants (e.g., technetium-99 and nitrate) have impacted groundwater, as indicated by groundwater monitoring well analysis.

The lower Cold Creek unit is present in the 200 West Area but not in the 200 East Area.

2.6.1.3 Future Conditions

Future migration rates are expected to diminish if an engineered barrier is installed. If installed, the engineered barrier is expected to reduce recharge rates from approximately 100 mm/year to much less than 1.0 mm/year for some time (PNNL-14744, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*). This rate may experience an eventual small increase with barrier degradation. Ambient chemical conditions will be maintained, and only highly mobile or slightly retarded contaminants (distribution coefficient of less than 0.6 mL/g) will reach the unconfined aquifer in a period of several thousand years. For those mobile contaminants currently in the shallow vadose zone, significant increases in travel time and reductions in peak groundwater concentrations relative to current conditions are projected.

For those contaminants deeper in the vadose zone, the engineered barrier is less effective, and if no remedial actions take place, the inventory of non-reactive contaminants in the vadose zone will continue to migrate to the unconfined aquifer, causing the ground concentrations to rise and peak over the maximum contaminant level sometime in the future (RPP-7884, *Field Investigation Report for Waste Management Area S-SX*; RPP-10098; RPP-23752, *Field Investigation Report for Waste Management Areas T and TX-TY*; DOE/ORP-2005-01).

These general periods are shown as different plume locations in Figure 2-4. The depicted plumes can be considered as the distribution of highly mobile contaminants that always migrate with the waste fluid. The data and analytical results collected during Phase 1 characterization indicate that the bulk of the contaminant inventory remains in the vadose zone.

2.6.1.4 Importance of Water as a Driving Force

Despite the measurement of the highest levels of non-reactive to slightly reactive contaminants (e.g., technetium-99, chromium, nitrate, and cyanide) in the vadose zone, approximately 21.3 to 36.6 m (70 to 120 ft) above the water table, groundwater monitoring data from wells near WMA fence lines indicate that some tank waste has reached the aquifer in discrete locations, notably on the southern side of SX Tank Farm, the east side of S Tank Farm, the northeastern corner of T Tank Farm, east of BX Tank Farm, and south of C Tank Farm. These sites are noted for high technetium-99 concentrations (above the maximum contaminant level of 900 pCi/L) in nearby groundwater monitoring wells and high uranium concentrations (above the maximum contaminant level of 30 μg/L) at the BX Tank Farm. If these contaminants were initially present in leaked tank waste, the conceptual model described above must be expanded to include these observations.

Examination of site-specific conditions at the WMAs suggests a mechanism that explains these observations. This mechanism is enhanced recharge of raw water or wastewater by one or more of the following: (1) localized unintentional releases from leaking pipelines; (2) flooding of the tank farm due to rapid snowmelt; and/or (3) intentional releases from nearby cribs, trenches, and ditches. The following provides specific examples of known enhanced recharge within the WMAs.

- At the southeastern corner of the SX Tank Farm, a several-year period of steady water loss from an operating raw water pipeline (note that pipes are not routinely monitored, and normal construction specifications allow minimal leakage rates) in the early 1990s was indicated by sustained growth of a tree at that location. Also, during field characterization, the moisture content in sediments retrieved from a nearby borehole was anomalously high, suggesting recent local additions of water to the vadose zone (RPP-7884). Enhanced recharge (RPP-7884, Appendix E and Attachment E3; DOE/ORP-2005-01) through a vadose zone area previously contaminated by tank waste would accelerate the migration rate of mobile contaminants in the vadose zone and in several instances has

apparently driven these contaminants completely through the vadose zone and into the nearby unconfined aquifer (see Figure 2-5).

- Water losses of several gallons per minute for several years above a vadose zone contaminated by tank waste could result in effective recharge rates well above the average recharge rates from precipitation of about 100 mm/year (4 in./year). For example, if a pipe joint leak occurs at the rate of 1.89 L/min (0.5 gal/min), the yearly volume output is 994,806.2 L (262,800 gal). If this fluid volume migrates through a flux plane of 100 m^2 (1,076.4 ft^2), the equivalent annual volume discharge from ambient recharge of 100 mm/year would be 10,001 L (2,642 gal). Thus, the leak recharge rate is effectively 100 times the ambient recharge rate. This differential can quickly increase with higher leak rates and/or distribution over smaller flux planes.

- At the T Tank Farm, a large snow melt event occurred in February 1979, which created temporary ponding over the tank farm, followed by rapid infiltration into the subsurface. At that time, the dry wells were not grouted to 27.4 m (90 ft) and could have provided preferential pathways for vertical migration to that depth (RPP-23752). Flooding events probably occurred at other tank farms in the past during site operations. In 2001 and 2002, interim measures were conducted to mitigate flooding at the tank farms.

- Large, intentional discharges of raw water or wastewater occurred in cribs, trenches, and ditches close to WMAs B-BX-BY and U. WMA B-BX-BY is bounded on the west and north by cribs that have received approximately 113.5 million L (30 million gal) of liquid effluent. At this location, a perched water table is observed approximately 67.1 to 73.2 m (220 to 240 ft) bgs. As the tank waste travels through the vadose zone, if it encounters a perched water table, the perched water table will impact when and where contaminants from the vadose zone will enter the unconfined aquifer. At WMA U, the 216-U-14 Trench is located to the east and the 216-Z-20 Trench is located to the west. Large volumes of water (approximately 1.3 billion L [346 million gal]) were discharged to these trenches during their operational lifetime. Perching occurred on top of the Cold Creek unit, and elevated moisture content was observed in the vadose zone at WMA U (DOE/ORP-2008-01, Appendix M; RPP-35485, *Field Investigation Report for Waste Management Area U*). Intentional discharges to cribs, ditches, and trenches ceased in the mid-1990s.

It is inferred from these observations that when enhanced recharge encounters pre-existing tank waste in the vadose zone, the pre-existing tank waste can be transported to the unconfined aquifer. Because of the detrimental impact of enhanced recharge in the tank farms, a series of interim corrective actions have been implemented to prevent enhanced recharge.

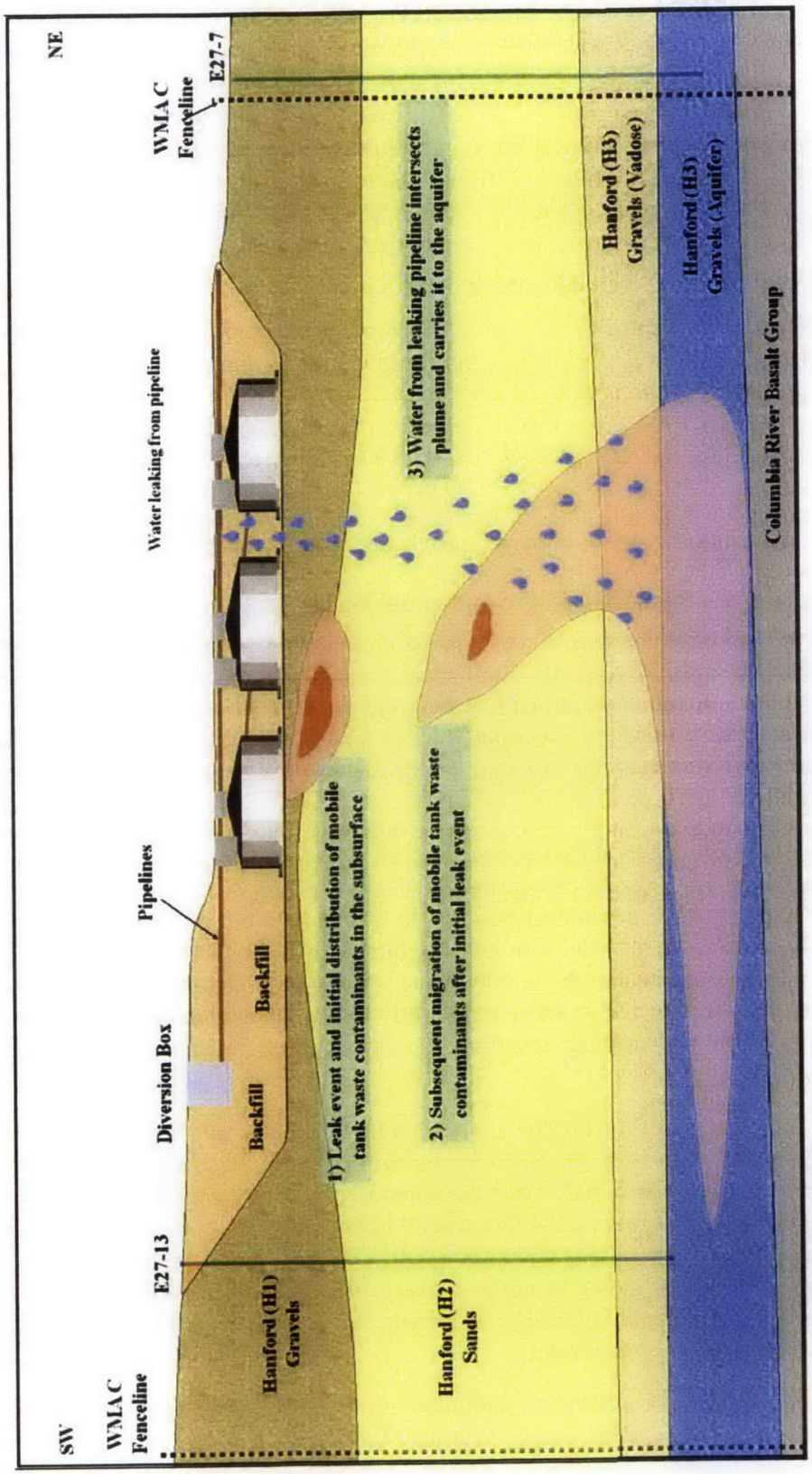

Figure 2-5. Vadose Zone Expanded Contaminant Transport Conceptual Model Alternative 1 Accounting for Artificial Recharge Due to Pipeline Leak

2.6.2 Alternative 2: Movement of Contaminants Down Stratigraphic Dip Conceptual Model

Dr. Stan Sobczyk has provided an updated depiction of the 2007 conceptual model (Figure 2-6). Dr. Sobczyk bases this conceptual model on the following.

- Tank and/or pipelines leak.
- Tank waste migrates primarily vertically through backfill and H1 gravels.
- Tank waste and moisture migrates primarily laterally through the H2 sands following stratigraphic dip.
- Tank waste migrates primarily vertically through the coarser material in the lower H2 and H3 gravels until it reaches groundwater.
- Tank waste is denser than groundwater and sinks in the aquifer as it is transported to the southwest under the tank farm.

Dr. Sobczyk has suggested a similar conceptual model for the release from the BX-102 tank for the movement of uranium from the BX-102 tank overfill event. The conceptual model provided by Dr. Sobczyk is being used in the DQO process for the Phase 2 characterization efforts at WMA C, which will include sampling to assess this conceptual model.

2.6.3 Alternative 3: Preferential Pathways Conceptual Model

Preferential pathways have been hypothesized as a method of moving contaminants through the vadose zone. The preferential pathways are typically small-scale features with physical properties that can enhance the movement of contaminants vertically downward through the vadose zone. Those cited most frequently at the Hanford Site are poorly constructed wells and/or clastic dikes. Of these two features, a poorly constructed well would likely be associated with larger void spaces and, therefore, allow a greater migration rate.

Poorly constructed wells might allow the contaminant to move vertically downward between the casing and the surrounding media. However, at tank farms, the depth of nearly all of the dry wells within the tank farms is 30.5 m (100 ft) bgs, while groundwater is 70.1 to 91.4 m (230 to 300 ft) bgs. Therefore, it is unlikely that a poorly constructed dry well within a tank farm is providing a preferential pathway all the way to groundwater. On the other hand, in some locations, nearby groundwater monitoring wells extend to the aquifer and could have provided a sufficient pathway for aquifer contamination. This may have occurred in WMA B-BX-BY, where some of technetium-99 and uranium from the BX-102 tank leak may have reached the unconfined aquifer.

Clastic dikes are common structures that occur in many geologic units in the Pasco Basin and vicinity (BHI-01103, *Clastic Injection Dikes of the Pasco Basin and Vicinity – Geologic Atlas* Series). Clastic dikes are tabular and tapered intrusive bodies that are composed of continental clastic sediments. BHI-01103 contains a photograph (Figure 9-44 on page 9-55) of irrigation on top of a clastic dike. In this photograph, water can be seen moving down the clastic dike until reaching the bottom of the dike, at which point the water begins spreading laterally and vertically. This photograph illustrates the potential for clastic dikes to become preferential pathways. However, it should be noted that BHI-01103 noted the following in its description of this clastic dike.

- The highest observed hydraulic infiltration within an infilling unit was in a random occurrence dike network located in Lind Coulee, east of Warden, Washington (32 km [186 mi] north of the Pasco Basin).

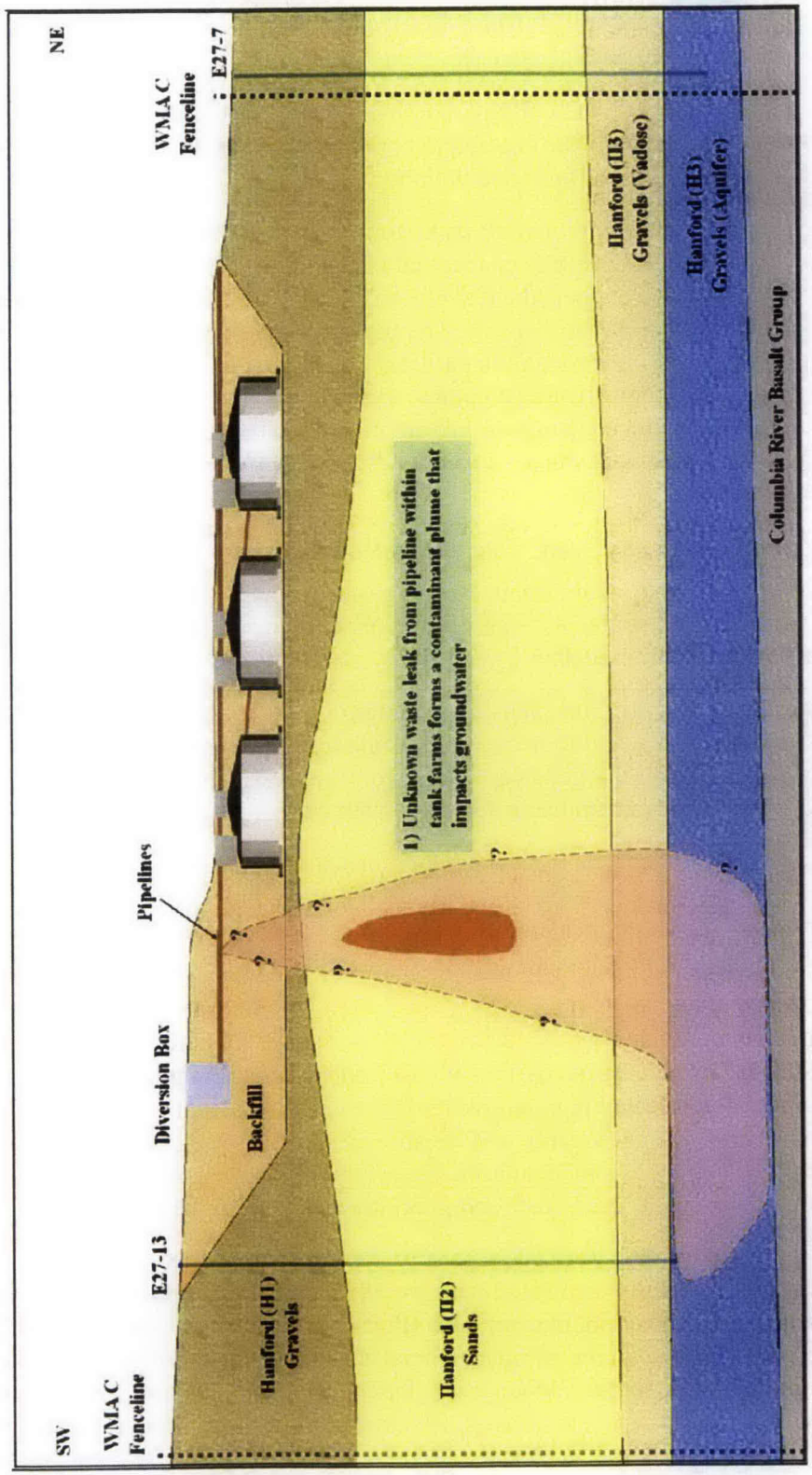

Figure 2-6. Vadose Zone Contaminant Transport Conceptual Model Alternative 2

- The rate of moisture movement was not measured, but water could be observed moving down the dike at rates estimated at least 10 times the rates observed in other dikes in this study. The clastic dike acted as a conduit to transmit soil moisture downward through a preferential pathway to the base of the dike before spreading out into the host sediments.
- The very high moisture velocity in the infilling unit that was observed is due to the unconsolidated, well-sorted nature of the sediments. The characteristics of this infilling unit are unique compared to infilling units observed in the Pasco Basin and vicinity.

Clastic dikes have been noted in the vicinity of all tank farms. However, due to the small-scale nature of these features, it is not possible to address this conceptual model in the DQO process for Phase 2 characterization, but movement down a hypothetical clastic dike can be captured in the corrective measures study assessment of groundwater impacts. The likelihood of effectively locating, retrieving, and analyzing clastic dike materials is too small to successfully execute a dedicated characterization effort. Instead, modeling analyses must be relied upon to evaluate the significance of this conceptual model as a mechanism for enhancing contaminant migration through the vadose zone. Figure 9-44 (on page 9-55) in BHI-01103 was used to develop a conceptualization of contaminant movement down a clastic dike (Figure 2-7).

2.6.4 Alternative 4: Unknown Leak Event Conceptual Model

Another possibility that could occur within a tank farm is a waste pipeline leak that did not manifest itself at the surface. The transport of contaminants from a new source, such as an unknown leak event, would follow one of the previous transport models.

Each WMA contains miles of pipeline; it is plausible that one or more of these pipelines leaked without knowledge of such a leak. These leaks, if they occurred, could lead to large volumes (i.e., greater than 113,562 L [30,000 gal]) of waste discharged over a period of years, resulting in localized volumes of soil with elevated levels of tank waste contaminants. Figure 2-8 shows this conceptualization.

If it can be demonstrated that surface geophysical exploration can discriminate subsurface anomalies in the tank farm environment, it may be possible to target specific areas that may be representative of this model. A final determination of the application of surface geophysical exploration to help locate unknown leaks will be made following the confirmation testing around UPR-81, UPR-82, and UPR-86.

2.7 Contaminants of Potential Concern

The indicator parameter, specific conductance, recently exceeded the critical mean in well 299-E27-14. Furthermore, cyanide has been detected in groundwater in the unconfined aquifer beneath WMA C. Because of the indicator parameter exceedance and because cyanide is a dangerous constituent, groundwater monitoring will change from an interim status indicator parameter evaluation program to an interim status groundwater quality assessment program in order to meet the requirements of 40 CFR 265.93(7).

The contaminants of potential concern associated with the SSTs have been derived through various Hanford Site documents. The previous monitoring plan (PNNL-13024) completed a study of the chemical and radiological species derived from process runs associated with WMA C, which was derived from LA-UR-96-3860. A more recent analytical strategy was based on analyzing major constituent categories associated with specific SST constituents to address risk assessment and performance criteria (RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*). By comparison, the more recent list from RPP-23403 is significantly more extensive.

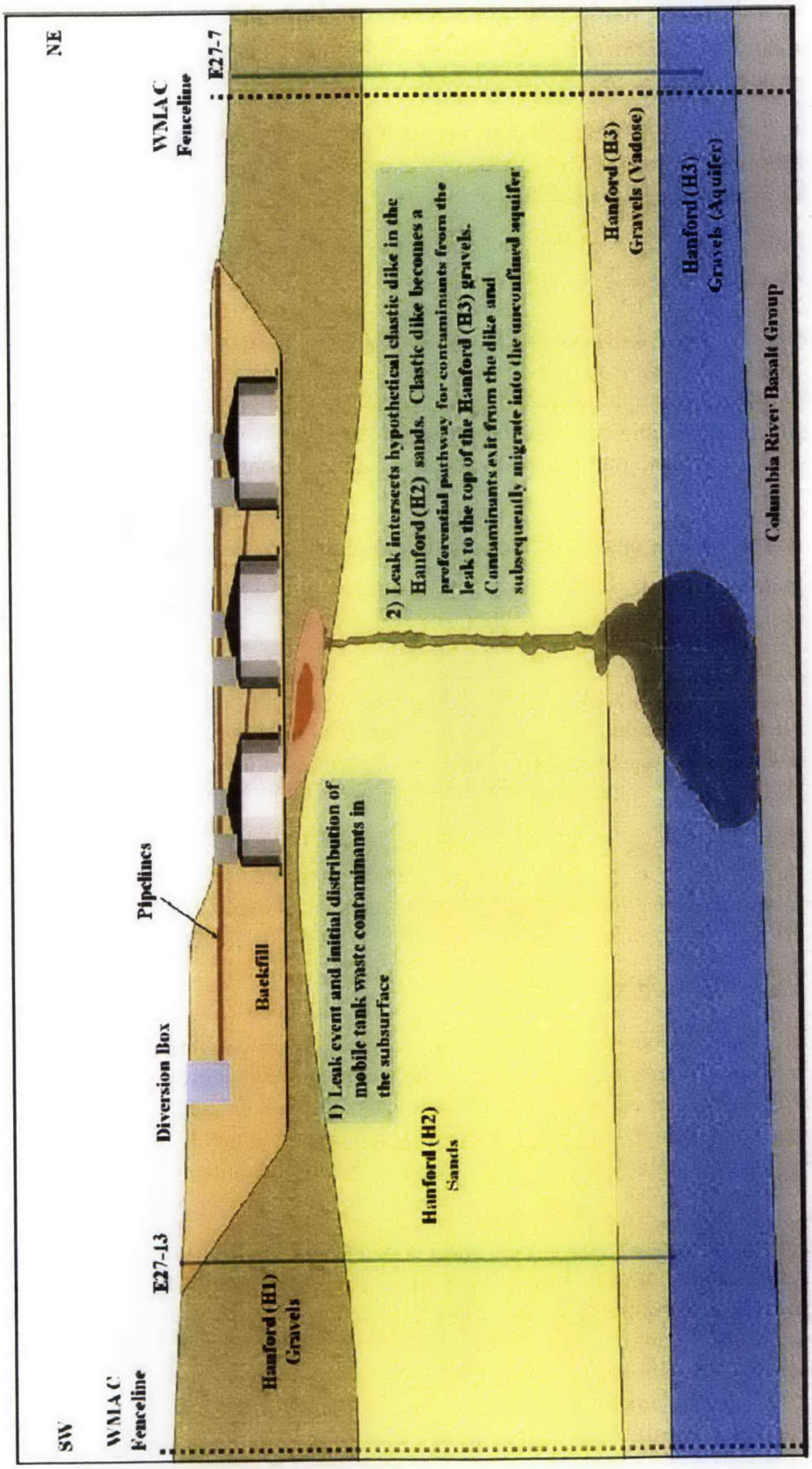

Figure 2-7. Vadose Zone Contaminant Transport Conceptual Model Alternative 3

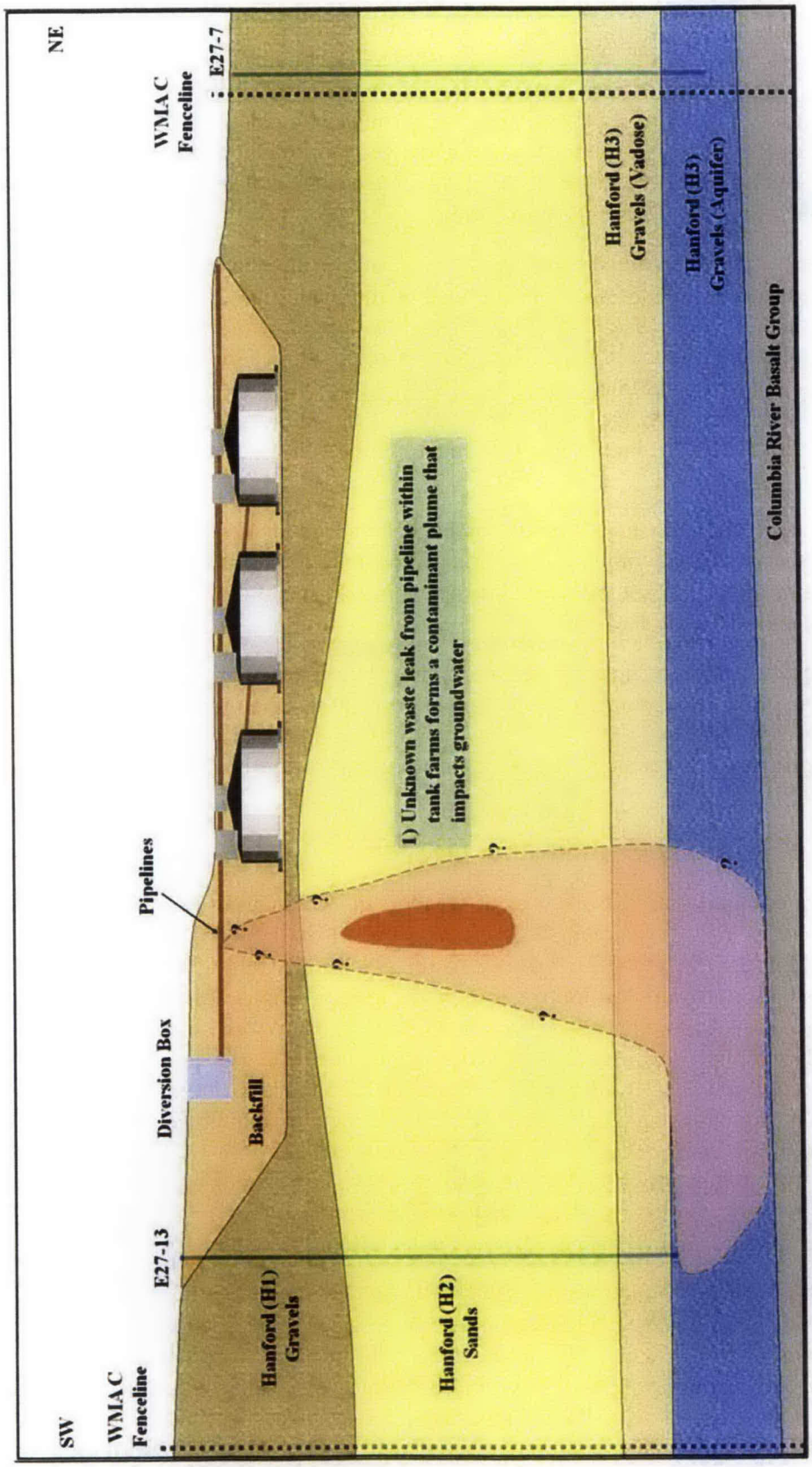

Figure 2-8. Vadose Zone Contaminant Transport Conceptual Model Alternative 4

This monitoring plan strategy includes a common subset of constituents from two sources to determine if dangerous waste or dangerous waste constituents have impacted the groundwater: (1) RPP-23403, and (2) Appendix IX of 40 CFR 264 ("Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring List"). The common subset of these constituents is discussed in Section 3.1 (see Tables 3-2 through 3-4). The lists of constituents will be used to determine the concentration and extent of potential dangerous waste or dangerous waste constituents in the groundwater. Any dangerous waste or dangerous waste constituent determined to have impacted the groundwater will be retained for subsequent analysis.

It is likely that only the more mobile dangerous waste or dangerous waste constituents may be determined as impacting groundwater from WMA C. This is based on the conclusion that not all of the chemical species in tank waste are mobile (PNNL-13024). Depending on solubility and concentration, some species are more likely to have leaked from a tank and migrated through the subsurface to the groundwater. Thus, it is important to consider the chemistry and fate of the waste routed to the SSTs in WMA C. Nitrate, sulfate, and chloride are the most likely anionic constituents to be detected in the groundwater, although these constituents are not dangerous constituents identified in 40 CFR 264, Appendix IX.

Inorganic complexes (namely, the ferrocyanide complex associated with in-farm scavenging) are the most significant complexes associated with WMA C. Iron and cyanide are the most obvious constituents associated with this type of complex, and cyanide present in the groundwater is likely associated with the scavenging process completed at WMA C.

The organic components, if not completely degraded, should be detected by the analyses described in Section 3.1. Because of the lack of organics reported in groundwater monitoring results for the 200-BP-5 Operable Unit, it seems unlikely that any organics would be detected, other than common laboratory contaminants (e.g., acetone, 2-butanone, methylene chloride, bis[2-ethylhexyl]phthalate, and 2-butoxyethanol).

2.8 Summary of Previous Groundwater Monitoring

Quarterly groundwater monitoring was initiated at WMA C in 1992 in accordance with the *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks* (WHC-SD-EN-AP-012). The initial well network consisted of five wells: 299-E27-7, 299-E27-12, 299-E27-13, 299-E27-14, and 299-E27-15. These wells were used for quarterly groundwater monitoring beginning in March 1992 and continued until the fall of 1993. In the spring of 1994, semiannual sampling began for indicator parameter evaluation. Monthly sampling began in June 1998 as a prerequisite to retrieval of tank 241-C-106. Monthly sampling was scaled back to every other month in 2000 and then returned to quarterly sampling in 2001. In 2001, a new monitoring plan (PNNL-13024) was initiated and required additional wells to ensure adequate monitoring network coverage for WMA C. Wells 299-E27-4, 299-E27-21, 299-E27-22, and 299-E27-23 were subsequently added to the network. (Note that although a quarterly sampling frequency was not initially identified in PNNL-13024, quarterly sampling of indicator parameters and certain groundwater quality parameters has been maintained from inception of the sampling.)

The initial groundwater detection monitoring plan (WHC-SD-EN-AP-012) included indicator parameters and groundwater quality parameters to determine if possible releases from WMA C facilities were impacting the groundwater. The indicator parameters included pH, specific conductivity, total organic carbon, and total organic halides. The groundwater quality parameters included cations, anions, phenols, organochlorides, and some additional metals (e.g., arsenic, lead, mercury, radium, and selenium). The organochlorides and additional metals were discontinued in 1994. Upon review of the Hanford Environmental Information System database, these results were either below detection limits or

background concentrations (i.e., filtered metals). Although the organochlorides were discontinued, they were covered by phenol analyses. The more recent groundwater monitoring plan (PNNL-13024) continued all of the analyses from the original plan (WHC-SD-EN-AP-012), with the exception of organochlorides and additional metals.

The only indicator parameter that has approached the critical mean at WMA C is specific conductance. The elevated specific conductance is considered to be associated with regional increases in nitrate and sulfate, but recent steeply increasing sulfate concentrations indicate a potential source from WMA C. These regional increases have required annual statistical adjustments for the critical mean evaluations. As a result, a statistically significant increase had not occurred until the June 2009 sampling event. The critical mean has been derived for WMA C by upgradient wells 299-E27-7 and 299-E27-22. The upgradient positions of these wells have been determined based on historic groundwater flow.

2.9 Current Groundwater Monitoring Data Evaluation

Nitrate and sulfate concentrations recently reported in WMA C monitoring well 299-E27-14 were higher than all of the other wells in the northeastern section of the 200 East Area. As a result, the detection monitoring indicator parameter of specific conductance in well 299-E27-14 exceeded the critical mean comparison value calculated from the upgradient well results. In addition, cyanide has been detected in groundwater beneath WMA C. The following discussion includes the recent groundwater quality parameters for nitrate, sulfate, and cyanide.

A comparison of nitrate trends among wells 299-E26-10, 299-E27-10, 299-E27-7, and 299-E27-14 is provided in Figure 2-9. Nitrate concentrations in downgradient well 299-E27-14 have recently been reported as higher than the nitrate concentrations in upgradient wells 299-E27-10, 299-E26-10, and 299-E27-7. This suggests that either some additional source of nitrate from WMA C is contributing to the concentrations reported in well 299-E27-14, or the current upgradient wells do not sufficiently represent background conditions relative to well 299-E27-14.

Figure 2-10 shows that sulfate concentrations in well 299-E27-14 have recently exceeded the concentrations in wells 299-E27-10, 299-E26-10, and 299-E27-7. Again, either some WMA C source appears associated with the elevated sulfate in well 299-E27-14 or the current upgradient wells do not sufficiently represent background conditions.

Cyanide has also been detected periodically in all of the monitoring wells adjacent WMA C. Although this constituent is associated with some of the tank waste in WMA C, none of the reported tanks associated with cyanide inventory (241-C-108, 241-C-109, 241-C-111, and 241-C-112) are suspect or confirmed to have leaked. In addition, the highest historic groundwater concentrations reported (44.6 μg/L) have been associated with upgradient well 299-E27-7, although the results have been highly variable. Results from well 299-E27-14 have been lower but more consistent, with a general upward trend for the past 3 years.

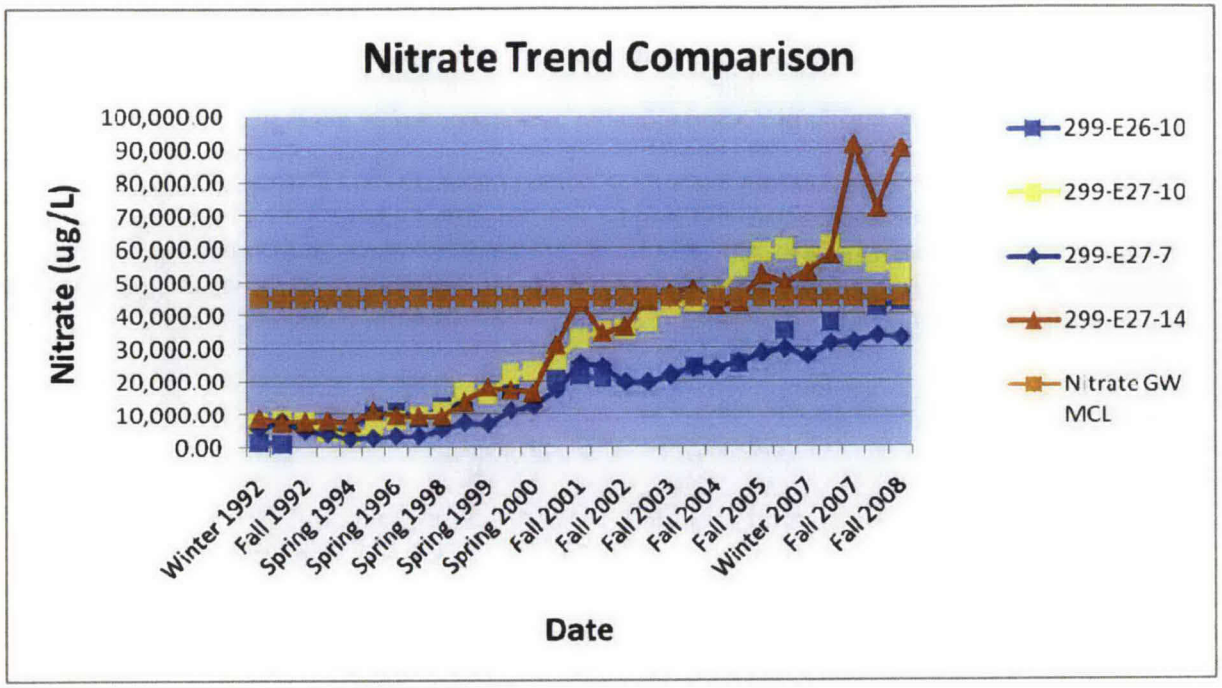

Figure 2-9. Regional Nitrate Concentration Trend in Wells 299-E26-10, 299-E27-10, 299-E27-7, and 299-E27-14

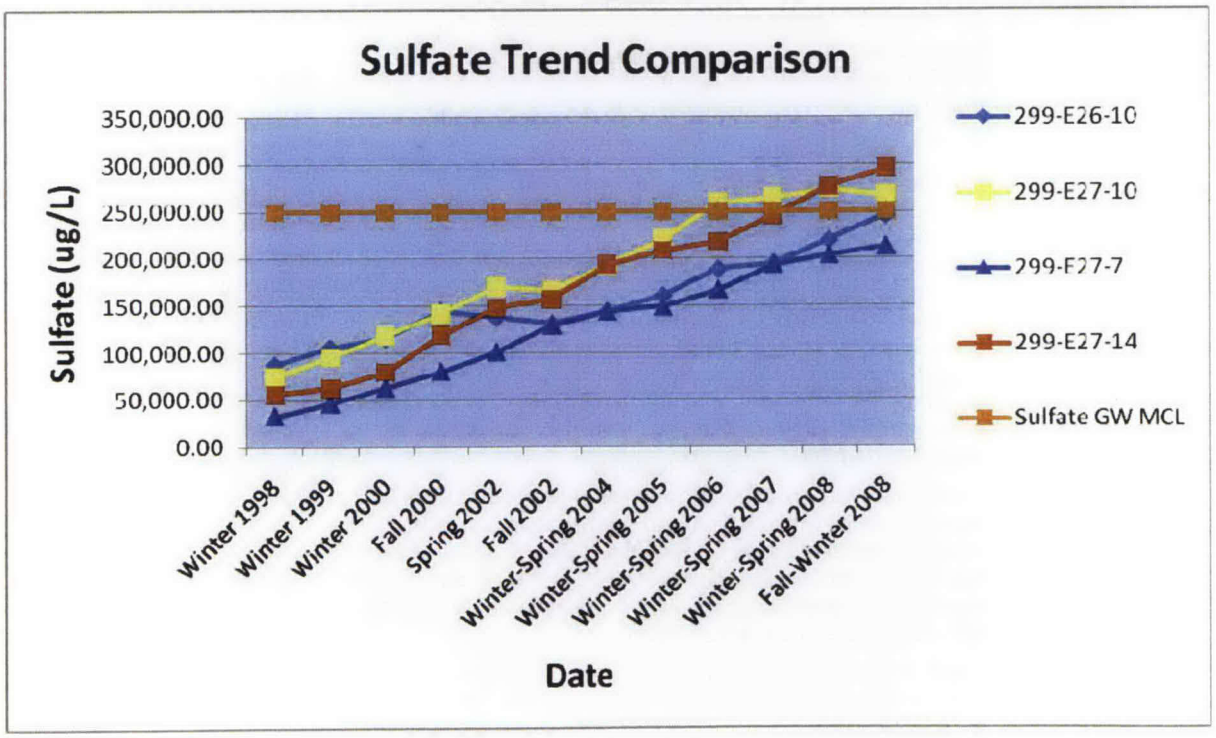

Figure 2-10. Regional Sulfate Concentration Trend in Wells 299-E26-10, 299-E27-10, 299-E27-7, and 299-E27-14

2.10 Data Quality Objectives

To define the required information for groundwater quality assessment, the DQO process is used to ensure that the data gathered during this assessment are of the appropriate quantity and quality to meet specific objectives. The DQO decision statements listed below are based on the requirements of 40 CFR 265.93(d)(7).

- If dangerous waste or dangerous waste constituents are suspected to be in the groundwater, then determine the appropriate constituents and analytical methods for determining which dangerous waste or dangerous waste constituents are present in the unconfined aquifer beneath WMA C.
- If dangerous waste or dangerous waste constituents are determined to be in the groundwater, determine the concentration.
- If dangerous waste or dangerous waste constituents are determined to be in the groundwater, then determine if the number, location, and depth of network monitoring wells are appropriate to determine the extent and rate of migration of the dangerous waste or dangerous waste constituents in groundwater.

The DQO parameters, regulatory interim status requirements, and associated reports supporting the regulatory requirements are outlined in Table 2-3.

Table 2-3. Data Quality Objective Parameters, Associated Regulatory Requirements, and Documentation for Waste Management Area C

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Scope	**40 CFR 265, Subpart F, incorporated by reference in WAC 173-303-400(3)(a), as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v)** **40 CFR 265.93 Preparation, Evaluation, and Response.** (a) Within one year after the effective date of these regulations, the owner or operator must prepare an outline of a ground-water quality assessment program. The outline must describe a more comprehensive ground-water monitoring program capable of determining: (1) whether dangerous waste or dangerous waste constituents have entered the ground-water; (2) the rate and extent of migration of dangerous waste or dangerous waste constituents in the ground-water; and (3) the concentration of dangerous waste or dangerous waste constituents in the ground-water. (d)(3) The plan...must specify (i) the number, location, and depth of wells; (ii) sampling and analytical methods for those dangerous waste or dangerous waste constituents in the facility; (iii) evaluation procedures, including any use of previously gathered ground-water quality information; and (iv) a schedule of implementation. (d)(4) The owner or operator must implement the ground-water quality assessment plan which...at a minimum, determine: (i) the rate and extent of migration of dangerous waste or dangerous waste constituents in the ground-water; (ii) the concentration of the dangerous waste constituents in the ground-water.	This plan, Chapters 3 and 4, and Appendix A PNNL-13024, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*, as modified by interim change notice Future report, if needed

Table 2-3. Data Quality Objective Parameters, Associated Regulatory Requirements, and Documentation for Waste Management Area C

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
	(d)(5) The owner or operator must make his first determination under paragraph (d)(4) of this section as soon as technically feasible, and prepare a report containing an assessment of ground-water quality. This report must be placed in the facility operating record and be maintained until closure of the facility. A copy of the report must be submitted to the department within 15 days. (d)(6) If the owner or operator determines, based on the results of the first determination... that no dangerous waste or dangerous waste constituents from the facility have entered the ground-water, then the owner or operator may reinstate the indicator evaluation program...through notification of the department in the report submitted under (d)(5)... (d)(7) If the owner or operator determines, based on the first determination...that hazardous waste or hazardous waste constituents from the facility have entered the ground-water, then owner or operator: (1) must continue to make the determinations...on a quarterly basis until final closure of the facility, if the ground-water quality (i) Must continue to make the determinations required under paragraph (d)(4) of this section...	
Number and location of wells	**40 CFR 265, Subpart F, incorporated by reference in WAC 173-303-400(3)(a), as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v)** **40 CFR 265.93 Preparation, Evaluation, and Response.** (d)(4) The owner or operator must implement the ground-water quality assessment plan that satisfies the requirements of paragraph (d)(3) of this section, and, at a minimum, determine: (i) The rate and extent of migration of the hazardous waste or hazardous waste constituents in the ground-water; and (ii) The concentrations of the hazardous waste or hazardous waste constituents in the ground-water.	This plan, Chapters 3 and 4
Well configuration (depth and length of screened interval; well construction)	**40 CFR 265.91 Ground-Water Monitoring System.** (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated, and packed with gravel or sand where necessary; to enable sample collection at depths where appropriate aquifer flow zones exist. The annular space (i.e., the space between the borehole and well casing) above the sampling depth must be sealed with a suitable material (e.g., cement grout or bentonite slurry) to prevent contamination of samples and the ground-water.	This plan, Section 3.2 PNNL-13024, *RCRA Groundwater Monitoring Plan for Single–Shell Tank Waste Management Area C at the Hanford Site*, as modified by interim change notice

Table 2-3. Data Quality Objective Parameters, Associated Regulatory Requirements, and Documentation for Waste Management Area C

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Frequency of sampling Types of analysis or measurement Method detection limits or accuracy and precision Methods used to evaluate the collected data	**40 CFR 265.93 Preparation, Evaluation, and Response.** (d)(4) The owner or operator must implement the ground-water quality assessment plan which satisfies the requirements of paragraph (d)(3) *[see scope in first row of this table]* of this section, and, at a minimum, determine: (i) The rate and extent of migration of the hazardous waste or hazardous waste constituents in the ground-water; and (ii) The concentrations of the hazardous waste or hazardous waste constituents in the ground-water (d)(7) If the owner or operator determines...that hazardous waste or hazardous waste constituents from the facility have entered the ground-water, then the owner or operator: (i) Must continue to make the determinations required under paragraph (d)(4) of this section on a quarterly basis until final closure of the facility, if the ground-water quality assessment plan was implemented prior to final closure of the facility; or (ii) May cease to make the determinations required under paragraph (d)(4) of this section, if the ground-water quality assessment plan was implemented during the post-closure care period.	This plan, Chapter 3 Future reports, if needed

PNNL-13024, *RCRA Groundwater Monitoring Plan for Single–Shell Tank Waste Management Area C at the Hanford Site.*

CFR = *Code of Federal Regulations*

DQO = data quality objective

WAC = *Washington Administrative Code*

An initial assumption regarding WMA C is that the groundwater has been impacted by dangerous waste and dangerous waste constituents, which is based on the following:

- Exceeded critical mean for specific conductivity in well 299-E27-14
- History of cyanide, a constituent appearing on the 40 CFR 264, Appendix IX groundwater monitoring list, which is linked with scavenging waste at WMA C and reported in WMA C monitoring wells
- Lack of cyanide inventory in upgradient past-practice waste sites in accordance with RPP-26744

The dangerous waste or dangerous waste constituent selection and associated analytical methods are discussed in Section 3.1, and the initial well monitoring network is discussed in Section 3.2. Chapter 4 discusses the evaluation process.

Any dangerous waste or dangerous waste constituent determined to have impacted the groundwater will be retained for subsequent analyses on a quarterly basis in accordance with 40 CFR 265.93(d)(7)(i). Subsequent to this determination, the well monitoring network will be evaluated to determine if additional wells are required to establish the extent and rate of migration of any dangerous waste or dangerous waste constituent from WMA C. Annual reports will be provided including the results of the

groundwater quality assessment program until final closure in accordance with 40 CFR 265.94(b)(2), "Recordkeeping and Reporting."

A new upgradient well is planned to further assess groundwater migrating into WMA C (see Figure 3-1 in Chapter 3) and will be drilled in accordance with applicable Tri-Party Agreement milestones. Section 3.2 provides the rationale for the location of this well.

Because cyanide is assumed to have originated from WMA C, a well is planned south of well 299-E27-14 to further evaluate the potential horizontal and vertical extent of dangerous waste or dangerous waste constituents in accordance with 40 CFR 265.93(d)(4)(i) (Figure 3-1). The rationale for the location of this well is provided in Section 3.2.

3 Groundwater Monitoring

This chapter lists the wells monitored, constituents analyzed, and sampling frequency. The quality assurance and quality control requirements are provided in Appendix A.

3.1 Constituent List and Sampling Frequency

The WMA C will be monitored in accordance with this groundwater quality assessment plan. Monitoring wells and parameters that are to be sampled quarterly for this assessment are listed in Table 3-1. In addition (as described in Section 2.7), a common subset of constituents from two requirements is used to determine if dangerous waste or dangerous waste constituents have impacted the groundwater (RPP-23403, and Appendix IX of 40 CFR 264), and the lists are provided in Tables 3-2, 3-3, and 3-4. The initial groundwater samples for this assessment will be collected during the December 2009 quarterly sampling event. In accordance with 40 CFR 265.93(d)(7), if through the evaluation process (Section 4.2) dangerous waste or dangerous waste constituents are determined to have impacted the groundwater, the constituents will be retained for quarterly sample collection. Because sample results may not be available in time for planning the March 2010 sampling event, the same list of constituents will be sampled during March 2010. Based on the evaluation process described in Section 4.2, constituents will be either retained or excluded.

Table 3-1. Groundwater Monitoring Schedule for Waste Management Area C

Well Name	Purpose	Well Construction Standard	pH	Specific Conductance	Alkalinity	Anions	Cyanide	Metals*, (Unfiltered, Filtered)	Water Level
299-E27-4	Downgradient	C	Q	Q	Q	Q	Q	Q	Q-
299-E27-7	Upgradient	N	Q	Q	Q	Q	Q	Q	Q
299-E27-12	Cross-gradient	C	Q	Q	Q	Q	Q	Q	Q
299-E27-13	Downgradient	C	Q	Q	Q	Q	Q	Q	Q
299-E27-14	Downgradient	C	Q	Q	Q	Q	Q	Q	Q
299-E27-15	Cross-gradient	C	Q	Q	Q	Q	Q	Q	Q
299-E27-21	Downgradient	C	Q	Q	Q	Q	Q	Q	Q
299-E27-22	Upgradient	C	Q	Q	Q	Q	Q	Q	Q-
299-E27-23	Downgradient	C	Q	Q	Q	Q	Q	Q	Q
299-E27-155	Downgradient	C	SA	SA	SA	SA	SA	SA	SA
Proposed upgradient well	Upgradient	C	Q	Q	Q	Q	Q	Q	Q
Proposed well south of 299-E27-14	Cross-gradient/ downgradient(?)	C	Q	Q	Q	Q	Q	Q	Q

Table 3-1. Groundwater Monitoring Schedule for Waste Management Area C

Well Name	Purpose	Well Construction Standard	pH	Specific Conductance	Alkalinity	Anions	Cyanide	Metals*, (Unfiltered, Filtered)	Water Level

Water levels are measured in all wells before sampling; the frequency for measurements is provided.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

* Metals for groundwater quality include iron, manganese, and sodium.

C = well constructed as a WAC 173-160 resource protection wells

N = well constructed before the requirements of WAC 173-160 were applicable at the Hanford Site

Q = quarterly

SA = semiannually

WAC = *Washington Administrative Code*

Table 3-2. Groundwater Assessment Volatile Organic Compound Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
1,1-Dichloroethane	75-34-3	X	X	X	X	X	X	X	X	X	X	X	X
1,1-Dichloroethylene	75-35-4	X	X	X	X	X	X	X	X	X	X	X	X
1,1,1-Trichloroethane	71-55-6	X	X	X	X	X	X	X	X	X	X	X	X
1,1,2,2-Tetrachloroethane	79034-5	X	X	X	X	X	X	X	X	X	X	X	X
1,1,2-Trichloroethane	79-00-5	X	X	X	X	X	X	X	X	X	X	X	X
1,2-Dibromoethane	106-93-4	X	X	X	X	X	X	X	X	X	X	X	X
1,2-Dichloroethane	107-06-2	X	X	X	X	X	X	X	X	X	X	X	X
1,2-Dichloropropane	78-87-5	X	X	X	X	X	X	X	X	X	X	X	X
1,2,4-Trichlorobenzene	120-82-1	X	X	X	X	X	X	X	X	X	X	X	X
1,4-Dichlorobenzene	106-46-7	X	X	X	X	X	X	X	X	X	X	X	X
1,4-Dioxane	123-91-1	X	X	X	X	X	X	X	X	X	X	X	X
2-Butanone (MEK)	78-93-3	X	X	X	X	X	X	X	X	X	X	X	X

Table 3-2. Groundwater Assessment Volatile Organic Compound Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
2-Hexanone	591-78-6	X	X	X	X	X	X	X	X	X	X	X	X
2-Propanone (Acetone)	67-64-1	X	X	X	X	X	X	X	X	X	X	X	X
3-Chloropropene	107-05-1	X	X	X	X	X	X	X	X	X	X	X	X
4-Methyl-2-petanone	108-10-1	X	X	X	X	X	X	X	X	X	X	X	X
Acetonitrile	75-05-8	X	X	X	X	X	X	X	X	X	X	X	X
Acrolein	107-02-8	X	X	X	X	X	X	X	X	X	X	X	X
Acrylonitrile	107-13-1	X	X	X	X	X	X	X	X	X	X	X	X
Benzene	71-43-2	X	X	X	X	X	X	X	X	X	X	X	X
Bromomethane	74-83-9	X	X	X	X	X	X	X	X	X	X	X	X
Carbon disulfide	75-15-0	X	X	X	X	X	X	X	X	X	X	X	X
Carbon tetrachloride	56-23-5	X	X	X	X	X	X	X	X	X	X	X	X
Chlorobenzene	108-90-7	X	X	X	X	X	X	X	X	X	X	X	X
Chloroethene	75-01-4	X	X	X	X	X	X	X	X	X	X	X	X
Chloroform	67-66-3	X	X	X	X	X	X	X	X	X	X	X	X
Chloromethane	74-87-3	X	X	X	X	X	X	X	X	X	X	X	X
Cis-1,3-dichloropropene	10061-01-5	X	X	X	X	X	X	X	X	X	X	X	X
Dichlorodifluoro-methane	75-71-8	X	X	X	X	X	X	X	X	X	X	X	X
Dichloromethane	75-09-2	X	X	X	X	X	X	X	X	X	X	X	X
Ethylbenzene	100-41-4	X	X	X	X	X	X	X	X	X	X	X	X
Ethyl cyanide	107-12-0	X	X	X	X	X	X	X	X	X	X	X	X
Methacrylonitrile	126-98-7	X	X	X	X	X	X	X	X	X	X	X	X
Styrene	100-42-5	X	X	X	X	X	X	X	X	X	X	X	X
Tetrachloroethene	127-18-4	X	X	X	X	X	X	X	X	X	X	X	X
Toluene	108-88-3	X	X	X	X	X	X	X	X	X	X	X	X

Table 3-2. Groundwater Assessment Volatile Organic Compound Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
Trans-1,3-dichloropropene	10061-02-6	X	X	X	X	X	X	X	X	X	X	X	X
Trichloroethylene	79-01-06	X	X	X	X	X	X	X	X	X	X	X	X
Trichlorofluoro-methane	75-69-4	X	X	X	X	X	X	X	X	X	X	X	X
Xylenes	1330-20-7	X	X	X	X	X	X	X	X	X	X	X	X

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

a. Constituents will be collected and analyzed for during the December 2009 sampling event. Constituents considered to be dangerous constituents, as defined in WAC 173-303-645(4) and based on the logic discussed in Section 4.2, will be retained for quarterly sampling for the first year, semiannual sampling in the second year, and annually thereafter, or until no longer required.

b. Wells will be sampled for constituents in the December sampling event if sample-ready; otherwise, the wells will be sampled in March.

CAS = Chemical Abstract Services

WAC = *Washington Administrative Code*

Table 3-3. Groundwater Assessment Semivolatile Organic Compound Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
1,2-Dichlorobenzene	95-50-1	X	X	X	X	X	X	X	X	X	X	X	X
1,3-Dichlorobenzene	541-73-1	X	X	X	X	X	X	X	X	X	X	X	X
2-Chlorophenol	95-57-8	X	X	X	X	X	X	X	X	X	X	X	X
2-Methylphenol	95-48-7	X	X	X	X	X	X	X	X	X	X	X	X

Table 3-3. Groundwater Assessment Semivolatile Organic Compound Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
2-Nitrophenol	88-75-5	X	X	X	X	X	X	X	X	X	X	X	X
2-sec-Butyl-4,6-dinitrophenol	88-85-7	X	X	X	X	X	X	X	X	X	X	X	X
2,4-Dinitrotoluene	121-14-2	X	X	X	X	X	X	X	X	X	X	X	X
2,4,5-Trichlorophenol	95-95-4	X	X	X	X	X	X	X	X	X	X	X	X
2,4,6-Trichlorophenol	88-06-2	X	X	X	X	X	X	X	X	X	X	X	X
3-Methylphenol	108-39-4	X	X	X	X	X	X	X	X	X	X	X	X
4-Methylphenol	106-44-5	X	X	X	X	X	X	X	X	X	X	X	X
Acenaphthene	83-32-9	X	X	X	X	X	X	X	X	X	X	X	X
Acetophenone	98-86-2	X	X	X	X	X	X	X	X	X	X	X	X
Aldrin	309-00-2	X	X	X	X	X	X	X	X	X	X	X	X
Alpha-BHC	319-84-6	X	X	X	X	X	X	X	X	X	X	X	X
Benzo[a]pyrene	50-32-8	X	X	X	X	X	X	X	X	X	X	X	X
Beta-BHC	319-85-7	X	X	X	X	X	X	X	X	X	X	X	X
Butylbenzylphthalate	85-68-7	X	X	X	X	X	X	X	X	X	X	X	X
Dibenzene[a,h] anthracene	53-70-3	X	X	X	X	X	X	X	X	X	X	X	X
Dieldrin	60-57-1	X	X	X	X	X	X	X	X	X	X	X	X
Di-n-butylphthalate	84-74-2	X	X	X	X	X	X	X	X	X	X	X	X
Diphenylamine	122-39-4	X	X	X	X	X	X	X	X	X	X	X	X
Endrin	72-20-8	X	X	X	X	X	X	X	X	X	X	X	X
Fluoranthene	206-44-0	X	X	X	X	X	X	X	X	X	X	X	X
Gamma-BHC	58-89-9	X	X	X	X	X	X	X	X	X	X	X	X
Heptachlor	76-44-8	X	X	X	X	X	X	X	X	X	X	X	X
Hexachlorobenzene	118-74-1	X	X	X	X	X	X	X	X	X	X	X	X
Hexachlorobutadiene	87-68-3	X	X	X	X	X	X	X	X	X	X	X	X
Hexachloroethane	67-72-1	X	X	X	X	X	X	X	X	X	X	X	X

Table 3-3. Groundwater Assessment Semivolatile Organic Compound Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
Isodrin	465-73-6	X	X	X	X	X	X	X	X	X	X	X	X
Naphthalene	91-20-3	X	X	X	X	X	X	X	X	X	X	X	X
Nitrobenzene	98-95-3	X	X	X	X	X	X	X	X	X	X	X	X
N-Nitrosodi-methylamine	62-75-9	X	X	X	X	X	X	X	X	X	X	X	X
N-Nitrosodi-propylamine	62164-7	X	X	X	X	X	X	X	X	X	X	X	X
n-Nitrosomorpholine	59-89-2	X	X	X	X	X	X	X	X	X	X	X	X
p-Chorol-m-cresol	59-50-7	X	X	X	X	X	X	X	X	X	X	X	X
Pentachloronitro-benzene	82-68-8	X	X	X	X	X	X	X	X	X	X	X	X
Pentachlorophenol	87-86-5	X	X	X	X	X	X	X	X	X	X	X	X
Phenol	108-95-2	X	X	X	X	X	X	X	X	X	X	X	X
Pyrene	129-00-0	X	X	X	X	X	X	X	X	X	X	X	X
Pyridine	110-86-1	X	X	X	X	X	X	X	X	X	X	X	X
Toxaphene	8001-35-2	X	X	X	X	X	X	X	X	X	X	X	X

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

a. Constituents will be collected and analyzed for during the December 2009 sampling event. Constituents considered dangerous constituents, as defined in WAC 173-303-645(4) and per the logic discussed in Section 4.2, will be retained for quarterly sampling for the first year, semiannual sampling in the second year, and annually thereafter, or until no longer required.

b. Wells will be sampled for constituents in the December sampling event if sample-ready; otherwise, the wells will be sampled in March.

CAS = Chemical Abstract Services

WAC = *Washington Administrative Code*

Table 3-4. Groundwater Assessment Inorganic Constituent Monitoring at Waste Management Area C

Dangerous Waste Constituent Name[a]	CAS No.	Wells											
		299-E27-4	299-E27-7	299-E27-12	299-E27-13	299-E27-14	299-E27-15	299-E27-21	299-E27-22	299-E27-23	299-E27-155	Proposed Upgradient Well[b]	Proposed Downgradient Well[b]
Antimony	7440-36-0	X	X	X	X	X	X	X	X	X	X	X	X
Arsenic	7440-38-2	X	X	X	X	X	X	X	X	X	X	X	X
Barium	7440-39-3	X	X	X	X	X	X	X	X	X	X	X	X
Beryllium	7440-41-7	X	X	X	X	X	X	X	X	X	X	X	X
Cadmium	7440-43-9	X	X	X	X	X	X	X	X	X	X	X	X
Chromium	7440-47-3	X	X	X	X	X	X	X	X	X	X	X	X
Cobalt	7440-48-4	X	X	X	X	X	X	X	X	X	X	X	X
Copper	7440-50-8	X	X	X	X	X	X	X	X	X	X	X	X
Cyanide	57-12-5	X	X	X	X	X	X	X	X	X	X	X	X
Lead	7439-92-1	X	X	X	X	X	X	X	X	X	X	X	X
Mercury	7439-97-6	X	X	X	X	X	X	X	X	X	X	X	X
Nickel	7440-02-0	X	X	X	X	X	X	X	X	X	X	X	X
Selenium	7782-49-2	X	X	X	X	X	X	X	X	X	X	X	X
Silver	7440-22-4	X	X	X	X	X	X	X	X	X	X	X	X
Sulfide	18496-25-8	X	X	X	X	X	X	X	X	X	X	X	X
Thallium	7440-28-0	X	X	X	X	X	X	X	X	X	X	X	X
Tin	7440-31-5	X	X	X	X	X	X	X	X	X	X	X	X
Vanadium	7440-62-2	X	X	X	X	X	X	X	X	X	X	X	X
Zinc	7440-66-6	X	X	X	X	X	X	X	X	X	X	X	X

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

a. Constituents will be collected and analyzed for during the December 2009 sampling event. Constituents considered dangerous constituents, as defined in WAC 173-303-645(4) and according to the logic discussed in Section 4.2, will be retained for quarterly sampling for the first year, semiannual sampling in the second year, and annually thereafter, or until no longer required.

b. Wells will be sampled for constituents in the December sampling event if sample-ready; otherwise, the wells will be sampled in March.

CAS = Chemical Abstract Services

WAC = *Washington Administrative Code*

3.2 Well Network

The well locations and proposed well locations are shown in Figure 3-1. PNNL-13024 contains as-built diagrams with construction details for wells 299-E27-7, 299-E27-12, 299-E27-13, 299-E27-14, and 299-E27-15. PNNL-13024-ICN-4 contains figures depicting borehole lithology and construction information for wells 299-E27-4, 299-E27-21, 299-E27-22, and 299-E27-23. Well construction specifications for new wells will be documented separately.

Table 3-1 lists the current and planned wells in the WMA C groundwater assessment network, provides the functional location for each well, and indicates if the existing wells meet the well construction standards found in WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Table 3-5 summarizes the well construction information and provides March 2009 depth-to-water measurements. The depth-to-water measurements were revised based on March 2009 survey results to establish a quantifiable groundwater gradient for the northeastern portion of the 200 East Area. All WMA C wells were included in the survey, except well 299-E27-13. Since well 299-E27-13 was not included in the resurvey work, the values reflect the 2001 survey. The depth to estimated basalt and the estimated percentage of the unconfined aquifer incepted by the well screen are also provided in Table 3-5.

Wells installed since the promulgation of WAC 173-160 have stainless-steel casings and screen, sand pack in the screened interval, and full annular seal above (including surface seal). Well 299-E27-7, which was installed before implementation the WAC 173-160 requirements, has a carbon-steel casing and a perforated interval rather than a screened interval. The use of the older well permits continuity with historical data.

At present, the monitoring well network at WMA C includes two upgradient and seven downgradient wells. One downgradient well potentially could be cross-gradient (299-E27-14). Based on current trends in water table elevation, none of these wells are expected to go dry in the near future.

Two new wells are scheduled to be drilled in fiscal year 2010 as part of the Tri-Party Agreement (Ecology et al. 1989) Milestone M-24 process. The well locations are shown in Figure 3-1. One of the wells is located to the northeast of well 299-E27-14 (C7571/299-E27-25). This well location was selected as an upgradient well for WMA C because it may be more representative of groundwater unaffected by the WMA. A well (C7570/299-E27-24) is also planned south of well 299-E27-14 to investigate the vertical and horizontal extent of dangerous waste or dangerous waste constituents. The well will be located approximately 61 m (200 ft) south of well 299-E27-14, with this distance based on travel time for comparable cyanide increases between wells 299-E27-7 and 299-E27-14. Cyanide should be present in this well if the groundwater is flowing to the south. The vertical extent of contamination will be investigated by depth-discrete groundwater samples collected during drilling of this new well.

Well 299-E27-155, located to the southwest, will be added to the monitoring network. This well was initially installed as part of the 200-BP-5 Operable Unit remedial investigation. At this well, significant concentrations of nitrate and technetium-99 were found throughout the entire vertical extent of the unconfined aquifer. Well 299-E27-155 was screened in the lower portion of the aquifer where the highest nitrate and technetium-99 concentrations were found. This well will be used to evaluate the extent of potential dangerous waste or dangerous waste constituents in the lower portion of the aquifer.

3.3 Sampling and Analysis Protocol

Sampling and analysis protocols for the activities identified in Tables 3-1 through 3-5 follow the conventions of the project and are further addressed in Appendix A.

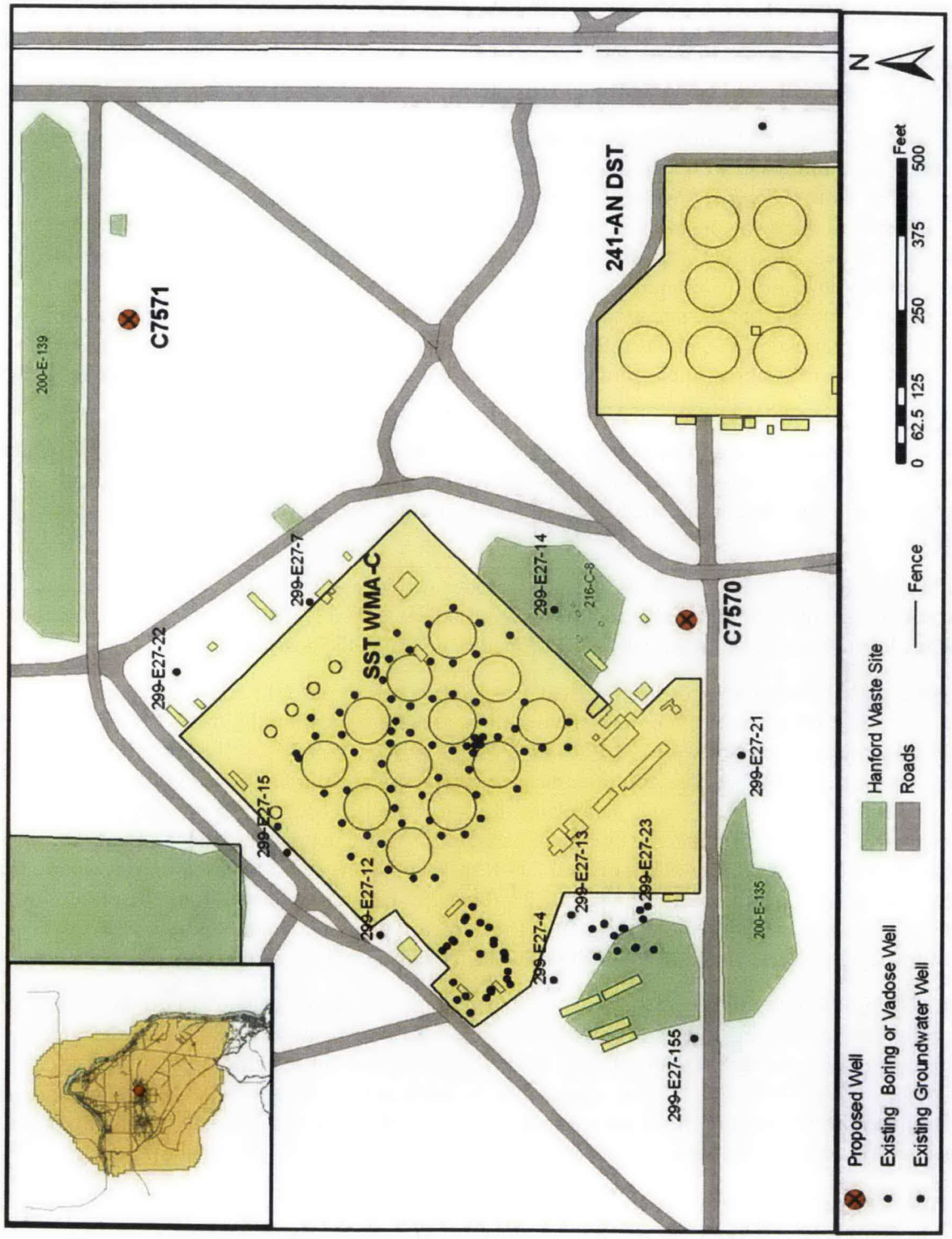

Figure 3-1. RCRA Groundwater Monitoring Wells for Waste Management Area C

Table 3-5. Waste Management Area C Groundwater Monitoring Well Attributes

Well Name	Construction Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Water-Level Date	Depth to Water (ft bgs)	Screened Water Column (ft)	Estimated Depth to Basalt (ft bgs)	Percentage of Screen in Aquifer
299-E27-4	2003	270.3	305.3	3/30/09	271.1	32.6	321	68.5
299-E27-7	1982	241.0	281.0	3/30/09	236.8	44.2	287	80
299-E27-12	1989	246.5	267.6	3/24/09	260.7	6.9	305	15.8
299-E27-13	1989	253.6	274.7	3/13/08	269.4	5.3	317	16.4
299-E27-14	1989	245.8	266.8	3/24/09	258.5	8.4	312	15.7
299-E27-15	1989	238.0	259.0	3/30/09	253.5	5.9	294	14.5
299-E27-155	2007	380.4	345.4	3/09/09	281.2	35.0	336*	61.4
299-E27-21	2003	271.4	306.4	3/30/09	272.2	34.2	329	60.2
299-E27-22	2003	228.1	268.0	3/30/09	231.1	36.9	268*	100
299-E27-23	2003	273.5	308.5	3/30/09	274.4	34.1	328	63.6

* Actual depth based on drilling depth to basalt.

bgs = below ground surface

4 Data Evaluation and Reporting

This chapter addresses the data evaluation and reporting requirements for WMA C.

4.1 Data Review

Data review, validation, and verification are discussed in the QAPjP (Appendix A).

4.2 Interpretation

The groundwater assessment at WMA C is designed to determine the rate and extent of contaminant migration in the groundwater beneath WMA C. The DQO process, as described in *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4 (EPA/240/B-06/001), was used to develop a logic-driven assessment based on the requirements of 40 CFR 265.93(d)(4) and 40 CFR 265.93(d)(5), as discussed in Section 2.10.

The fundamental questions from the DQO process regarding interpretation for this assessment are as follows.

- Determine the appropriate constituents and analytical methods for determining which dangerous waste or dangerous waste constituents will be analyzed in the unconfined aquifer beneath WMA C.
- Determine whether the analytical results are acceptable for the evaluation of current groundwater conditions.
- Determine if the number, location, and depth of network monitoring wells are appropriate to determine the extent and rate of migration of the dangerous waste or dangerous waste constituents in groundwater throughout the aquifer.

The determination for the appropriate constituents and analytical methods is provided in Section 3.1. All potential dangerous waste or dangerous waste constituents will be evaluated by the process outlined in the steps below and as shown in Figure 4-1.

A. Is the upgradient concentration higher than the downgradient concentration?

   i. If yes, do not consider the reported constituent to be associated with WMA C; however, proceed as follows:

      - Is the groundwater flow direction such that the upgradient well is representative of the downgradient well in which the constituent was detected?

        – If so, exclude the constituent from further consideration.

        – If not, retain the constituent and re-evaluate the monitoring network.

   ii. If no, proceed to step B.

B. Is the downgradient concentration higher or equal to the upgradient concentration? If yes, proceed to step i below. If no, proceed to step C.

   i. Are there any laboratory issues with the analysis?

      - If yes, do not consider the constituent to be associated with WMA C; however, include the constituent for the next quarterly sampling event.

      - If no, proceed to step ii below.

ii. Is the result below sitewide background concentrations?

- If yes, exclude the constituent from further consideration.
- If no, proceed to step iii below.

iii. Are there similar characteristics of the groundwater quality that indicate the same plume with the major source of contamination now past the upgradient well?

- If yes, do not consider the constituent to be associated with WMA C; however, retain the constituent for further analysis. If three consecutive results concur with migration of a plume through the well, then exclude the constituent.
- If no, consider the reported constituent to be associated with WMA C.

C. Is the result for the constituent non-detect?

i. If yes, excluded from further analyses.

ii. If no, start the logic process again.

In step B(ii) of the logic process, the following interpretative techniques will be used to determine if similar groundwater quality characteristics are present.

- Hydrographs: Graph water levels versus time to determine the decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- Water table maps: Use water table elevations from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential.
- Trend plots: Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.
- Plume maps: Map distributions of chemical or radiological constituents in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of flow.
- Stiff diagrams: Provide mass equivalent relationship of groundwater quality parameters for comparison between wells. Can be helpful in differentiating between background and contaminated groundwater or multiple groundwater sources.

It is likely that only a few (if any) dangerous waste or dangerous waste constituents will be determined to be impacting groundwater from WMA C. Therefore, the list provided in Table 3-1 will remain intact for continued evaluation. Constituents that are excluded based on the evaluation process will be listed in the annual report. Conversely, the constituents determined to be dangerous waste or dangerous waste constituents will also be defined in the annual report and will be retained for further evaluation. Finally, any constituent that is undetermined will be retained for further evaluation and will be reported as such in the annual report.

The third evaluation was previously discussed in Section 3.2. Based on the results of the assessment, further activities may be required to determine the full extent of dangerous waste or dangerous waste constituents in groundwater from WMA C.

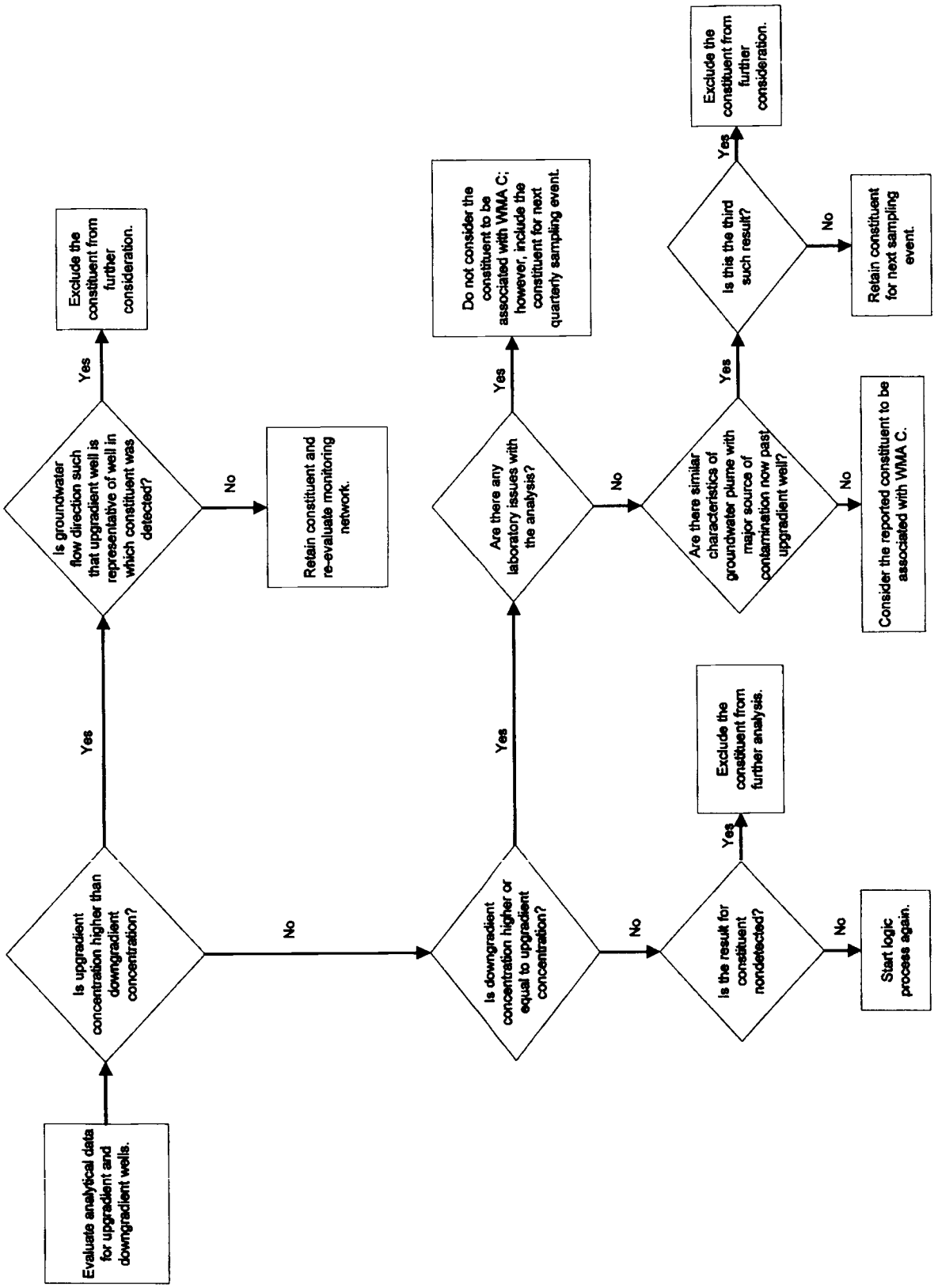

Figure 4-1. Groundwater Sample Result Evaluation Flow Chart

Records of the analyses and evaluations discussed in this section will be maintained throughout the active life of the facility. The results of laboratory analyses are stored in the Hanford Environmental Information System database.

4.3 Evaluation and Reporting

The RCRA groundwater assessment monitoring requirements include quarterly determinations of the extent and rate of migration of the dangerous waste or dangerous waste constituents in accordance with 40 CFR 265.93(d)(4). The results will be discussed in annual reports that will provide the basis for the extent of contamination. To determine the rate of migration, water-level measurements and/or contaminant interpretative methods will be used, as further discussed below.

Water-level measurements are corrected, if needed, to account for borehole deviation from vertical. The results are used to determine the corrected groundwater elevation from which groundwater flow rate and direction are calculated (using Darcy's Law). In addition, contaminant plume configuration and contaminant trend ratios are compared with water-level measurements for consistency. If the groundwater gradient is too small to be determined, then contaminant trends, stiff diagrams, and contaminant contouring are compared with past results to derive the estimated groundwater flow rate and direction. The adequacy of the monitoring network to meet the objectives of this plan will be reviewed annually. If the monitoring network is not adequate to provide the extent and concentration of dangerous waste or dangerous waste constituents, then additional well(s) will be considered.

4.4 Reporting and Notification

Assessment monitoring results are reported annually, in accordance with the requirements of 40 CFR 265.94(b), in annual Hanford Site groundwater monitoring reports (e.g., DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). The annual report will provide results and identify proposed constituents to be excluded, constituents to be retained for further evaluation, and constituents determined to be dangerous waste or dangerous waste constituents based on the evaluation process discussed in Section 4.2. As required by 40 CFR 265.94(b), the extent and rate of migration will also be provided.

5 References

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Appendix A

Quality Assurance Project Plan

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Terms

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DQO	data quality objective
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FTB	full trip blank
FXR	field transfer blank
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HEIS	Hanford Environmental Information System
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy, Richland Operations Office
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*

A Quality Assurance Project Plan

The contractor's quality assurance (QA) program describes the contractor's QA structure, requirements, implementation methods, and responsibilities. The contractor's environmental QA program plan provides the requirements for collecting and assessing environmental data in accordance with the following:

- 10 *Code of Federal Regulations* (CFR) 830, Subpart A, "Nuclear Safety Management," "Quality Assurance Requirements"
- DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD)
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5
- U.S. Department of Energy (DOE) O 414.1C, *Quality Assurance*

This quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection including the planning, implementation, and assessment of sampling, field measurements, and laboratory analyses. Section 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989a), Attachment 2, "Action Plan," require that QA/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal (TSD) units, as well as for past-practice processes. The HASQARD requirements (DOE/RL-96-68) also apply to this work.

The content of this QAPjP is patterned after the QA elements of EPA/240/B-01/003. The QAPjP demonstrates conformance to the Part B requirements of *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use* (ANSI/ASQ E4). This QAPjP is divided into four sections (designated in EPA/240/B-01/003) that describe the quality requirements and controls applicable to this investigation. This QAPjP is intended to supplement the contractor's environmental QA program plan.

A1 Project Management

This section addresses the basic aspects of project management and will ensure that the project has defined goals, that the participants understand the goals and the approaches used, and that the planned outputs are appropriately documented.

A1.1 Project/Task Organization

The project organization in regard to planning, sampling, analysis, and data assessment is described in the following subsections and is shown in Figure A-1. For each functional primary contractor role, there is a corresponding oversight role within DOE.

A1.1.1 Regulatory Project Manager

The Washington State Department of Ecology (Ecology) project manager is responsible for oversight of the work being performed under this groundwater monitoring plan. Ecology will work with the DOE Richland Operations Office (RL) to resolve concerns regarding the work as described in this QAPjP. Ecology can request this plan during a regulatory compliance inspection for review.

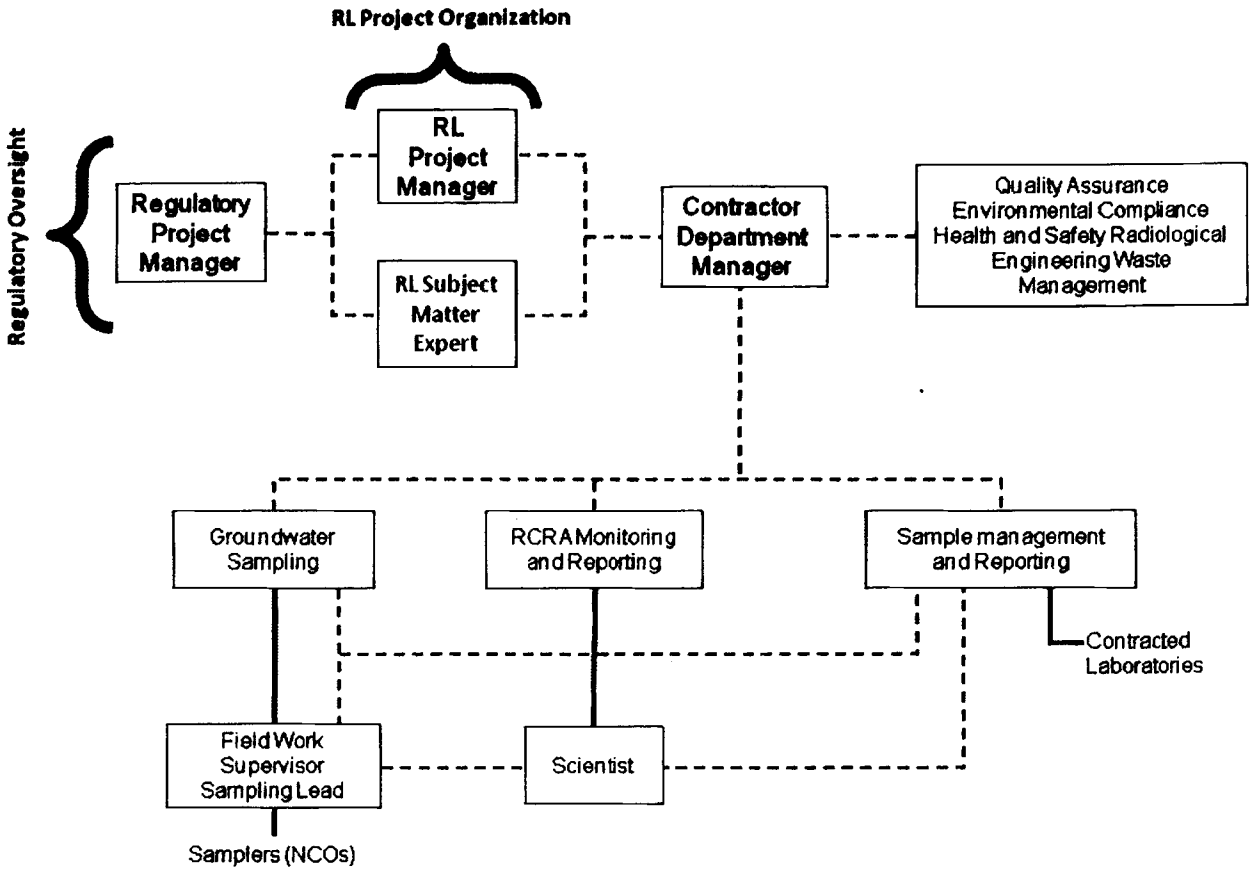

Figure A-1. Project Organization

A1.1.2 U.S. Department of Energy, Richland Operations Office Project Manager

Hanford Site cleanup is the responsibility of RL. The RL project manager is responsible for authorizing the contractor to perform activities under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; the *Resource Conservation and Recovery Act of 1976* (RCRA); the *Atomic Energy Act of 1954*; and the Tri-Party Agreement for the Hanford Site.

A1.1.3 U.S. Department of Energy, Office of River Protection

The management of single-shell tank operations and remediation is the responsibility of the DOE Office of River Protection.

A1.1.4 U.S. Department of Energy, Richland Operations Office Subject Matter Expert

The RL subject matter expert is responsible for day-to-day oversight of the contractor's performance of workscope, for working with the contractor and the regulatory agencies to identify and work through issues, and for providing technical input to the RL project manager.

A1.1.5 Contractor Groundwater Remediation Department Manager

The contractor groundwater remediation department manager provides oversight for all activities and coordinates with DOE, the regulators, and primary contractor management in support of sampling and reporting activities. The remediation department manager also provides support to the RCRA Monitoring and Reporting manager to ensure that work is performed safely and cost effectively.

A1.1.6 Groundwater Sampling Operations

Groundwater sampling operations is responsible for planning and coordinating field sampling resources and provides the field work supervisor for routine groundwater sampling operations. The field work supervisor directs the samplers, who collect groundwater samples in accordance with the sampling and analysis plan, and corresponding standard procedures and work packages. The samplers also complete the field logbook and chain-of-custody forms, including any shipping paperwork, and ensure delivery of the samples to the analytical laboratory.

A1.1.7 RCRA Monitoring and Reporting

The RCRA Monitoring and Reporting manager is responsible for direct management of activities performed to meet RCRA TSD monitoring requirements. The RCRA Monitoring and Reporting manager coordinates with and reports to DOE and primary contractor management regarding RCRA TSD monitoring requirements. The RCRA Monitoring and Reporting manager assigns scientists to provide technical expertise.

A1.1.8 Sample Management and Reporting Organization

The Sample Management and Reporting organization coordinates laboratory analytical work to ensure that laboratories conform to HASQARD requirements (or their equivalent), as approved by DOE, the U.S. Environmental Protection Agency (EPA), and Ecology. Sample Management and Reporting receives analytical data from the laboratories, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation. Sample Management and Reporting is responsible for informing the RCRA Monitoring and Reporting manager of any issues reported by the analytical laboratories.

A1.1.9 Contract Laboratories

The contract laboratories analyze samples in accordance with established procedures and provide necessary sample reports and explanations of results to support data validation. The laboratories must meet site-specific QA requirements and must have an approved QA plan in place.

A1.1.10 Quality Assurance

The QA point of contact is matrixed to the subject matter expert and is responsible for QA issues on the project. Responsibilities include overseeing implementation of the project QA requirements; reviewing project documents, including data quality objective (DQO) summary reports, sampling and analysis plans, and the QAPjP; and participating in QA assessments on sample collection and analysis activities, as appropriate. The QA point of contact must be independent of the unit generating the data.

A1.1.11 Environmental Compliance Officer

The environmental compliance officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work, and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

A1.1.12 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or by internal primary contractor work requirements.

A1.1.13 Waste Management

Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

A1.2 Problem Definition/Background

The problem definition, as required by *Washington Administrative Code* (WAC) 173-303-400 ("Dangerous Waste Regulations," "Interim Status Facility Standards") and 40 CFR 265, Subpart F ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Groundwater Monitoring"), is outlined in the main text discussion of this monitoring plan. The background is also provided in the monitoring plan.

A1.3 Project/Task Description

The project description is provided in Chapters 3 and 4 of this monitoring plan and includes the selection of appropriate dangerous waste or dangerous waste constituents, collection and analyses of groundwater from the monitoring network, interpretation of analytical results, evaluation of the monitoring network, and reporting.

The target analytes, along with the monitoring wells and frequency of sampling, are provided in Chapter 3.

A1.4 Quality Objectives and Criteria

The quality objectives and criteria for groundwater monitoring are defined in the tables provided in this QAPjP in order to meet the evaluation requirements stated in the monitoring plan.

A1.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility of collecting and transporting groundwater samples in accordance with the requirements of WAC 173-303-330, "Personnel Training." The field work supervisor, in coordination with line management, will ensure that all field personnel meet training requirements.

A1.6 Documents and Records

The project scientist is responsible for ensuring that the current version of the groundwater monitoring plan is used and for providing any updates to field personnel. Version control is maintained by the administrative document control process. Significant changes to the plan that affect DQOs will be reviewed and approved by DOE and the regulatory agency prior to implementation. Table A-1 defines the types of changes that may be made to the sampling design and the documentation requirements.

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for the logbooks shall be identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The HEIS database will be identified as a data repository for the Hanford Facility Operating Record unit file. Records may be stored in either electronic or hardcopy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement will be managed in accordance with the requirements therein.

Assessment monitoring results are reported annually in accordance with the requirements of 40 CFR 265.94, "Recordkeeping and Reporting." The reports will be part of the annual Hanford Site groundwater monitoring report (e.g., DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*).

Table A-1. Actions and Documentation for Regulatory Notification

Type of Change	Action	Documentation
Temporary addition of wells or constituents, or increased sampling frequency	RCRA Monitoring and Reporting manager approval; notify regulatory agency, if appropriate	Project's schedule tracking system
Unintentional impact to groundwater monitoring plan including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, loss of samples in transit, etc.	Electronic notification	RCRA annual report
Planned change to groundwater monitoring activities, including addition or deletion of constituents or wells, change of sampling frequency, etc.	Revise monitoring plan	Revised RCRA groundwater monitoring plan
Anticipated unavoidable changes (e.g., dry wells)	Electronic notification; revise monitoring plan	RCRA annual report and revised groundwater monitoring plan

RCRA = *Resource Conservation and Recovery Act of 1976*

A2 Data Generation and Acquisition

This section addresses data generation and acquisition to ensure that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented.

A2.1 Sampling Process Design (Experimental Design)

The sampling design is based on regulatory requirements and judgmental sampling.

A2.1.1 Regulatory Requirements

The groundwater protection regulations of WAC 173-303-400 dictate the groundwater sampling and analysis requirements applicable to interim status TSD units.

A2.1.2 Judgmental Sampling

The selection of sampling and analysis requirements is based on knowledge of the feature or condition under investigation and is also based on professional judgment. The TSD monitoring is based on professional judgment. Conclusions depend on the validity and accuracy of professional judgment.

A2.2 Sampling Methods

Sampling is described in the contractor's environmental QA program plan, including the following:

- Field sampling methods
- Sample preservation, containers, and holding times
- Corrective actions for sampling activities
- Decontamination of sampling equipment

The groundwater sampling operations supervisor must ensure that situations that may impair the usability of samples and/or data are documented in field logbooks or on nonconformance report forms in accordance with internal corrective action procedures, as appropriate. The groundwater sampling operations supervisor will note any deviations that occur from the standard procedures for sample collection, contaminants of potential concern, sample transport, or monitoring. The groundwater sampling operations supervisor is also responsible for coordinating all activities related to the use of field monitoring equipment (e.g., dosimeters and industrial hygiene equipment). Field personnel will document in the logbook all noncompliant measurements taken during field sampling. Ultimately, the groundwater sampling operations supervisor is responsible for developing, implementing, and communicating corrective action procedures; for documenting all deviations from procedure; and for ensuring that immediate corrective actions are applied to field activities. Problems with sample collection, custody, or data acquisition that adversely impact data quality or impair the ability to acquire data or failure to follow procedure will be documented in accordance with internal corrective action procedures, as appropriate.

A2.3 Sample Handling and Custody

A sampling and data tracking database is used to track samples from the point of collection through the laboratory analysis process. Laboratory analytical results are entered and maintained in the HEIS database. Each sample is identified and labeled with a unique HEIS sample number. The contractor's environmental QA program plan specifies sample handling information, including the following:

- Container requirements
- Container labeling and tracking process
- Sample custody requirements
- Shipping and transportation

Sample custody during laboratory analysis is addressed in the applicable laboratory's standard operating procedures. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process. Storage of samples at the laboratory will be consistent with laboratory instructions prepared by the Sample Management and Reporting organization.

A2.4 Analytical Methods

Information on analytical methods is provided in Tables A-2 and A-3. These analytical methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary contractor participates in oversight of offsite analytical laboratories to qualify the laboratories for performing Hanford Site analytical work.

Table A-2. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Continuing Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
Metals Analyzed by Inductively Coupled Plasma Method – Unfiltered/Filtered			
Calcium	P, HNO_3 to pH <2	SW-846[d] Method 6010B/C, SW-846 Method 6020[e], or EPA/600 Method 200.8[e]	1,000
Chromium			10
Sodium			500
Manganese			5
Potassium			4,000
Iron			50
Magnesium			750
Anions by Ion Chromatography			
Chloride	P, none	EPA/600 Method 300.0[f]	200
Nitrate			250
Nitrite			250
Sulfate			500
Other			
Alkalinity	G/P, none	Standard Method[g] 2320, EPA/600 Method 310.1 EPA/600 Method 310.2	5,000
Conductivity, field	N/A	Instrument/meter	1 µohm
Cyanide	P, NaOH to pH >12	SW-846 Method 9012, Standard Method[g] 4500, EPA/600 Method 335.2	5
pH, field measurement	N/A	Instrument/meter	0.1
Temperature	Field measurement	Instrument/meter	0.2°C

a. All samples will be collected in plastic (P) or glass (G) containers and will be cooled to 4°C upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. Detection limit units, unless otherwise indicated.

d. SW-846, *Methods for Evaluation of Solid Waste: Physical/Chemical Methods.*

e. SW-846 Method 6010 is the preferred method; however, Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

f. Analytical method adapted from Method 300.0, *Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography* (EPA-600/4-84-017).

g. *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 2005).

EPA = U.S. Environmental Protection Agency

N/A = not applicable

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
Metals Analyzed by the Inductively Coupled Plasma Method — Unfiltered/Filtered			
Barium	P, HNO_3 to pH <2	SW-846[d] Method 6010B/C SW-846 Method 6020[e] or EPA/600 Method 200.8[f]	20
Beryllium			5
Cadmium			5
Chromium			10
Cobalt			20
Copper			10
Nickel			40
Silver			10
Tin			100
Vanadium			25
Zinc			10
Trace Metals – Unfiltered/Filtered			
Antimony	P, HNO_3 to pH <2	SW-846 Method 6020 or EPA/600 Method 200.8	6
Arsenic			10
Lead			5
Selenium			10
Thallium			5
Trace Metals – Unfiltered/Filtered			
Mercury	G, HNO_3 to pH <2	SW-846 Method 7470A, EPA/600 Method 200.8	50
Volatiles by Gas Chromatography/Mass Spectrometry			
1,1-Dichloroethane	G, no headspace	SW-846 Method 8260B	10
1,1-Dichloroethylene			10
1,1,1-Trichloroethane			5
1,1,2,2-Tetrachloroethane			5
1,1,2-Trichloroethane			5
1,2-Dibromoethane			5
1,2-Dichloroethane			5
1,2-Dichloropropane			5

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
1,2,4-Trichlorobenzene			10
1,4-Dichlorobenzene			5
1,4-Dioxane			500
2-Butanone			10
2-Hexanone			20
2-Propanone			20
3-Chloropropene			10
4-Methyl-2-petanone			10
Acetonitrile			100
Acrolein			100
Acrylonitrile			100
Benzene			5
Bromomethane			10
Carbon disulfide			5
Carbon tetrachloride			5
Chlorobenzene			5
Chloroethene			10
Chloroform			5
Chloromethane			10
Cis-1,3-dichloropropene			5
Dichlorodifluoromethane			10
Dichloromethane			5
Ethylbenzene			5
Ethyl cyanide			10
Methacrylonitrile			10
Styrene			5
Tetrachloroethene			5
Toluene			5
Trans-1,3-dichloropropene			5

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
Trichloroethylene			5
Trichlorofluoromethane			10
Xylene			10
Semivolatiles by Gas Chromatography/Mass Spectrometry			
1,2-Dichlorobenzene	AG, cool ~4°C	SW-846 Method 8270D	10
1,3-Dichlorobenzene			10
2-Chlorophenol			10
2-Methylphenol			10
2-Nitrophenol			20
2-sec-Butyl-4,6-dinitrophenol			10
2,4-Dinitrotoluene			10
2,4,5-Trichlorophenol			10
2,4,6-Trichlorophenol			10
3-Methylphenol			20
4-Methylphenol			10
Acenaphthene			10
Acetophenone			10
Benzon[a]pyrene			10
Butylbenyphthalate			10
Di-n-butylphthalate			10
Dibenzene[a,h]anthracene			10
Diphenylamine			20
Fluoranthene			10
Hexachlorobenzene			10
Hexachlorobutadiene			10
Hexachloroethane			10
Isodrin			20
N-Nitrosodimethylamine			10
N-Nitrosodipropylamine			10
n-Nitrosomorpholine			10

Table A-3. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits for Assessment Constituents

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Method Quantitation Limit (µg/L)[c]
Naphthalene			10
p-Chloro-m-cresol			10
Pentachloronitrobenzene			50
Pentachlorophenol			10
Phenol			10
Pyrene			10
Pyridine			20
Pesticides by Gas Chromatography/Electron Capture Detector			
Aldrin	AG, cool ~4°C	EPA Method 8081[d]	0.05
Alpha-BHC			0.05
Beta-BHC			0.05
Dieldrin			0.1
Endrin			0.1
Gamma-BHC			0.05
Heptachlor			0.05
Toxaphene			5
Other			
Cyanide	P, NaOH to pH >12	SW-846 Method 9012 Standard Method[g] 4500 EPA/600 Method 335.2	5
Sulfide	G ,P, 2 mL 2 N zinc acetate and NaOH pH >9; cool 4°C	Sulfides - 9030	500

a. All samples will be collected in plastic (P,) glass (G), or amber glass (AG) containers and will be cooled to 4°C upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. Detection limit units, unless otherwise indicated.

d. SW-846, *Methods for Evaluation of Solid Waste: Physical/Chemical Methods.*

e. SW-846 Method 6010 is the preferred method; however, Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

f. Analytical method adapted from Method 300.0, *Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography* (EPA-600/4-84-017).

g. *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 2005).

EPA = U.S. Environmental Protection Agency

Laboratories providing analytical services in support of this QAPjP will report errors to the Sample Management and Reporting project coordinator, who will then initiate a sample disposition record. The error-reporting process is intended to document analytical errors and the resolution of those errors with the project scientist. The corrective action program addresses the following:

- Evaluation of impacts of laboratory QC failures on data quality
- Root-cause analysis of QC failures
- Evaluation of recurring conditions that are adverse to quality
- Trend analysis of quality-affecting problems
- Implementation of a quality improvement process
- Control of nonconforming materials that may affect quality

A2.5 Quality Control

The QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to field variability. Field QC for sampling will require the collection of field replicates (duplicates), trip or field blanks, and equipment blanks. Laboratory QC samples estimate the precision and bias of the analytical data. Field and laboratory QC samples are summarized in Table A-4.

A2.5.1 Field Quality Control Samples

Field QC samples will be collected to evaluate the potential for cross-contamination and field sampling performance. The QC samples and the required frequency for collection are described in this section.

Full trip blanks (FTBs) are prepared by the sampling team prior to traveling to the sampling site. The FTB is filled with high-purity reagent water. The bottles are sealed and transported, unopened, to the field in the same storage containers used for samples collected that day. Collected FTBs are analyzed for the same constituents as the samples. The FTBs are used to evaluate potential contamination of the samples due to the sample bottles, preservative, handling, storage, or transportation.

Field transfer blanks (FXRs) are preserved volatile organic analysis sample bottles that are filled at the sample collection site with high-purity reagent water that has been transported to the field. After collection, FXR bottles are sealed and placed in the same storage containers with the samples from the associated sampling event. The FXR samples are analyzed for volatile organic compounds only. The FXRs are used to evaluate potential contamination caused by conditions in the field.

Equipment blanks (EBs) are samples in which high-purity reagent water is passed through the pump or placed in contact with the sampling surfaces of the equipment to collect blank samples identical to the sample set that will be collected. The EB bottles are placed in the same storage containers with the samples from the associated sampling event. The EB samples are analyzed for the same constituents as the samples from the associated sampling event. The EBs are used to evaluate the effectiveness of the cleaning process to ensure that samples are not cross-contaminated from previous sampling events.

For the field blanks (i.e., FTBs, FXRs, and EBs), results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the method detection limit.

Table A-4. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC		
Full trip blank	Contamination from containers or transportation	1 per 20 well trips
Field transfer blank	Contamination from sampling site	1 each day; volatile organic compounds sampled
Equipment blank	Contamination from non-dedicated equipment	As needed[a]
Replicate/duplicate samples	Reproducibility	1 per 20 well trips
Laboratory QC		
Method blanks	Laboratory contamination	1 per batch
Laboratory duplicates	Laboratory reproducibility	See footnote[b]
Matrix spikes	Matrix effect and laboratory accuracy	See footnote[b]
Matrix spike duplicates	Laboratory reproducibility/accuracy	See footnote[b]
Surrogates	Recovery/yield	See footnote[b]
Laboratory control samples	Method accuracy	1 per batch

a. For portable Grundfos® (registered trademark of Grundfos Pumps Corporation, Colorado Springs, Colorado) pumps, equipment blanks are collected 1 per 10 well trips. Whenever a new type of non-dedicated equipment is used, an equipment blank shall be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. As defined in the laboratory contract or quality assurance plan, and/or analysis procedures.

QC = quality control

Field duplicates, also known as replicates, are two samples that are collected as close as possible to the same time and same location, and they are intended to be identical. Field duplicates are stored and transported together and are analyzed for the same constituents. The field duplicates are used to determine precision for both sampling and laboratory measurements. The results of the field duplicates must have precision within 20 percent, as measured by the relative percent difference. Only field duplicates with at least one result greater than five times the method detection limit or minimum detectable activity are evaluated.

Double-blind samples contain a concentration of analyte known to the supplier but unknown to the analyzing laboratory. The laboratory is not informed that the samples are QC samples. The project submits double-blind samples to assess analytical precision and accuracy.

A2.5.2 Laboratory Quality Control Samples

The laboratory QC samples (e.g., method blanks, laboratory control sample/blank spikes, and matrix spikes) are defined in Chapter 1 of SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, and will be run at the frequency specified in that reference, unless superseded by agreement.

A2.5.3 Quality Control Requirements

Table A-5 lists the acceptance criteria for QC samples, and Table A-6 lists the acceptable recovery limits for the double-blind standards. These samples are prepared by spiking Hanford Site background well water with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Investigations shall be conducted for double-blind standards that are outside of acceptance limits. The results from these standards are used to determine the acceptability of the associated parameter data.

Table A-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity Chemical oxygen demand Conductivity pH	MB[b]	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	≤20% RPD[c]	Data reviewed[d]
	MS[e]	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Ammonia and Anions			
Ammonia Anions by IC Cyanide	MB	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	≤20% RPD[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Metals			
Arsenic Cadmium Chromium Lead Mercury Selenium Thallium ICP metals ICP/MS metals	MB	<CRDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	MSD	≤20% RPD[c]	Data reviewed[d]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"

Table A-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
Volatile Organic Compounds			
Volatiles by GC/MS Total petroleum hydrocarbons by GC	MB	<MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB, FXR	<2 times MDL[h]	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Semivolatile Organic Compounds			
Herbicides by GC PCBs by GC Pesticides by GC Phenols by GC Semivolatiles by GC/MS	MB	<2 times MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed[d]
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB	<2 times MDL[h]	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"

a. Refer to Tables A-2 and A-3 for specific analytical methods.

b. Does not apply to pH.

c. Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect ("Y" flag) or rejected ("R" flag).

e. Applies to total organic carbon and total organic halides only.

f. Applies only in cases where one or both results are greater than five times the detection limit.

g. Determined by the laboratory based on historical data. Control limits are reported with the data.

h. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is less than five times the MDL.

Data flags:

B, C = possible laboratory contamination (analyte was detected in the associated method blank)

N = result may be biased (associated matrix spike result was outside the acceptance limits)

Q = problem with associated field QC sample (blank and/or duplicate results were out of limits)

Table A-5. Field and Laboratory Quality Control Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action

Abbreviations:

CRDL = contract-required detection limit
DUP = laboratory matrix duplicate
EB = equipment blank
FTB = full trip blank
FXR = field transfer blank
GC = gas chromatography
IC = ion chromatography
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PCB = polychlorinated biphenyls
QC = quality control
RPD = relative percent difference
SUR = surrogate

Table A-6. Blind Standard Constituents and Schedule

Constituents	Frequency	Accuracy (%)	Precision (% RSD)*
Chloride	Quarterly	±25%	≤25%
Cyanide	Semiannually	±25%	≤25%
Fluoride	Quarterly	±25%	≤25%
Nitrate as nitrogen	Quarterly	±25%	≤25%
Nitrite as nitrogen	Quarterly	±25%	≤25%
Arsenic	Annually	±20%	≤20%
Barium	Annually	±20%	≤20%
Cadmium	Semiannually	±20%	≤20%
Carbon tetrachloride	Quarterly	±25%	≤25%
Chloroform	Quarterly	±25%	≤25%
Chromium (total)	Quarterly	±20%	≤20%

Table A-6. Blind Standard Constituents and Schedule

Constituents	Frequency	Accuracy (%)	Precision (% RSD)*
Cobalt	Semiannually	±20%	≤20%
Copper	Semiannually	±20%	≤20%
Hexavalent chromium	Quarterly	±20%	≤20%
Iron	Semiannually	±20%	≤20%
Magnesium	Annually	±20%	≤20%
Manganese	Annually	±20%	≤20%
Nickel	Annually	±20%	≤20%
Potassium	Annually	±20%	≤20%
Silver	Annually	±20%	≤20%
Sodium	Annually	±20%	≤20%
Trichloroethylene	Quarterly	±25%	≤25%
Vanadium	Annually	±20%	≤20%
Zinc	Annually	±20%	≤20%

* If the results are less than five times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

RSD = relative standard deviation

Holding time is the elapsed time period between sample collection and analysis. The contractor's environmental QA program plan provides a table with holding times. Exceeding the required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in SW-846 or *Methods of Chemical Analysis of Water and Wastes* (EPA/600/4-79/020). Data associated with exceeded holding times are flagged with an "H" in the HEIS database. Data that exceed the holding time shall be maintained but potentially may not be used in statistical analyses.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. The groundwater project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems from occurring. Audit results are used to improve performance, and the summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

Failure of QC will be determined and evaluated during data validation and the data quality assessment process. Data will be qualified, as appropriate.

A2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to minimize measurement system

downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and the onsite organization's QA plan or operating procedures, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with SW-846, or with auditable HASQARD and contractual requirements. Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use.

A2.7 Instrument/Equipment Calibration and Frequency

Specific field equipment calibration information is provided in the environmental QA program plan. Standards used for calibration will be certified and traceable to nationally recognized performance standards. Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratory's QA plan.

A2.8 Inspection/Acceptance of Supplies and Consumables

Supplies and consumables used to support sampling and analysis activities are procured in accordance with internal work requirements and processes that describe the contractor's acquisition system and the responsibilities and interfaces necessary to ensure that items procured/acquired for contractor meet the specific technical and quality requirements. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

Supplies and consumables that are procured by the analytical laboratories are procured, checked, and used in accordance with the laboratory's QA plan.

A2.9 Non-Direct Measurements

Non-direct measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. If evaluation includes data from historical sources, whenever possible such data will be validated to the same extent as the data generated as part of this effort. All data used in evaluations will be identified by source.

A2.10 Data Management

The Sample Management and Reporting organization, in coordination with the RCRA Monitoring and Reporting manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements that govern data management procedures. Electronic data access, when appropriate, will be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hardcopies will be provided in accordance with Section 9.6 of the Tri Party Agreement Action Plan (Ecology et al. 1989b). The HEIS database will be identified as a data repository for the Hanford Facility Operating Record unit file.

All field activities will be recorded in the field logbook.

Laboratory errors are reported to the Sample Management and Reporting organization on a routine basis. For reported laboratory errors, a sample disposition record will be initiated in accordance with contractor procedures. This process is used to document analytical errors and to establish resolution of the errors with the RCRA Monitoring and Reporting manager. Sample disposition records become a permanent part of the analytical data package for future reference and for records management.

A3 Assessment and Oversight

The elements discussed in this section address the activities for assessing the effectiveness of project implementation and the associated QA and QC activities. The purpose of the assessment is to ensure that the QAPjP is implemented as prescribed.

A3.1 Assessments and Response Actions

The contractor management, Regulatory Compliance, Quality, and/or Health and Safety organizations may conduct random surveillances and assessments to verify compliance with the requirements outlined in this QAPjP.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratory's QA plan. The primary contractor conducts oversight of offsite analytical laboratories to qualify the laboratories for performing Hanford Site analytical work.

A3.2 Reports to Management

Reports to management on data quality issues will be made if and when these issues are identified. Issues reported by the laboratories are communicated to the Sample Management and Reporting organization, which initiates a sample disposition record in accordance with contractor procedures. This process is used to document analytical or sample issues and to establish resolution with the RCRA Monitoring and Reporting manager.

A4 Data Validation and Usability

The elements in this section address the QA activities that occur after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying project objectives. These elements are further discussed in the contractor's environmental QA program plan.

A4.1 Data Review, Verification, and Validation

The criteria for verification may include review for completeness (e.g., all samples were analyzed as requested), use of the correct analytical method/procedure, 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.

A4.2 Verification and Validation Methods

The work activities shall follow documented procedures and processes for data validation and verification, as summarized below. Validation of groundwater data consists of assessing whether the data collected and measured truly reflect aquifer conditions. Verification means assessing data accuracy, completeness, consistency, availability, and internal control practices to determine overall reliability of the data collected. Other DQOs that shall be met include proper chain-of-custody, sample handling, use of proper analytical techniques as applied for each constituent, and the quality and acceptability of the laboratory analyses conducted.

Groundwater monitoring staff perform checks on laboratory electronic data files for formatting, allowed values, data flagging (i.e., qualifiers), and completeness. Hardcopy results are verified to check for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems

encountered during analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to correct the problem found during the analysis.

The data validation process provides the requirements and guidance for validating groundwater data that are routinely collected. Validation is a systematic process of reviewing verified data against a set of criteria (listed in Table A-4) to determine whether the data are acceptable for their intended use.

Results of laboratory and field QC evaluations, double-blind sample results, laboratory performance evaluation samples, and holding-time criteria are considered when determining data usability. Staff review the data to identify whether observed changes reflect changes in groundwater quality or potential data errors, and they may request data reviews of laboratory, field, or water-level data for usability purposes. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the data reviews are used to flag the data appropriately in the HEIS database (e.g., "R" for reject, "Y" for suspect, or "G" for good) and/or to add comments.

A4.3 Reconciliation with User Requirements

The data quality assessment process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet project DQOs. The RCRA Monitoring and Reporting manager is responsible for determining if data quality assessment is necessary and for ensuring that, if required, one is performed. The results of the data quality assessment will be used in interpreting the data and determining if the objectives of this activity have been met.

A5 References

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