

CH2M HILL DOCUMENT RELEASE FORM

(1) Document Number: RPP-PLAN-39114 (2) Revision Number: 0 (3) Effective Date: 11/2008

(4) Document Type: Digital Image Hard copy PDF Video (a) Number of pages (including the DRF) or number of digital images: 258

(5) Release Type: New Cancel Page Change Complete Revision

(6) Document Title: RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C

(7) Change/Release Description: Initial Release

(8) Change Justification: NA



(9) Associated Structure, System, and Component (SSC) and Building Number: (a) Structure Location: NA (b) System Designator: NA (c) Building Number: EDMC (d) Equipment ID Number (EIN): N/A

(10) Impacted Documents:	(a) Document Type	(b) Document Number	(c) Document Revision
	N/A		

(11) Approvals:

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(d) Reviewer (Optional, Print/Sign): Date:

(12) Distribution:

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J. W. Badden	H6-03	P. N. Seeley	H9-05	

(13) Clearance (a) Cleared for Public Release: Yes No (b) Restricted Information?: Yes No (c) Restriction Type:

(14) Clearance Review (Print/Sign): J. D. Aardal / Janis Aardal Date: 11/20/2008

attached to: 0079690

RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C

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U.S. Department of Energy Contract DE-AC27-08RV14800

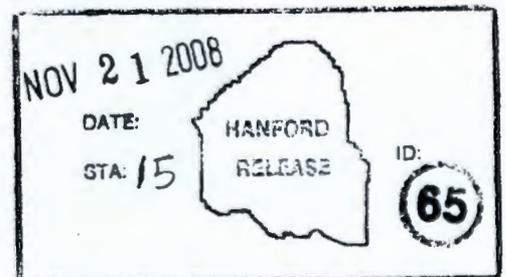
EDT/ECN: UC:
Cost Center: 2FF00 Charge Code:
B&R Code: Total Pages: 758

Key Words: ecology, geology, vadose zone, groundwater WMA C, contamination releases, soils conceptual models, human health, risk assessment, contaminants, stratigraphic dip, leak, data, site selection, surface geophysical exploration, loggin, tissue, sampling, field, investigation, performance, treatability, corrective measures, study, closure, project management, program integration, recharge

Abstract: This work plan describes the field work necessary to collect the data identified in RPP-RPT-38152, Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C Corrective Measures Study, and supports the Phase 2 Resource Conservation and Recovery Act of 1976 facility investigation/corrective measures study work plan and sampling and analysis plan activities for the single-shell tank Waste Management Area C.

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A. E. Aardal 11/20/08
Release Approval Date



Release Stamp

Approved For Public Release

RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C

M. P. Connelly
Washington River Protection Solutions LLC

Date Published
November 2008



Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-08RV14800

EXECUTIVE SUMMARY

This work plan describes the field work necessary to collect the data identified in RPP-RPT-38152, *Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C Corrective Measures Study*, and supports the Phase 2 *Resource Conservation and Recovery Act of 1976 (RCRA) facility investigation/corrective measures study (RFI/CMS) work plan and sampling and analysis plan activities for the single-shell tank (SST) Waste Management Area (WMA) C (Figure 1-1)*. As discussed in the *Hanford Federal Facility Agreement and Consent Order (HFFACO) Action Plan (Ecology et al. 1989)*, the RFI/CMS work plan is prepared to present information on how the Phase 2 RFI/CMS processes will be conducted and eventually lead to proposed remedies for WMA C fulfilling HFFACO Milestone M-45-60 (Ecology and DOE 2007, *Federal Facility Agreement and Consent Order Change Control Form Change No. M-45-06-03, Modifications of Tank Farm Corrective Measures and Interim Measures Milestone*). This work plan also integrates with RPP-PLAN-37243, *Phase 2 RCRA Facility Investigation/Corrective Measures Study Master Work Plan for Single-Shell Tank Waste Management Areas*, as described in HFFACO Milestone M-45-58 and Appendix I, section 2.3 (Ecology and DOE 2007). The RFI/CMS uses the framework established in RPP-PLAN-37243, *Single-Shell Tank Phase 2 Resource Conservation and Recovery Act of 1976 Facility Investigation/ Corrective Measures Study Master Work Plan*, which is the implementation plan for integrating the RCRA treatment, storage, and disposal (TSD) unit closure process with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) groundwater and operable unit remedial investigation/feasibility study (RI/FS) process including the groundwater program*. The integration of these two regulations will be implemented through management project teams as defined in DOE/RL-2007-20, *Hanford Integrated Groundwater and Vadose Zone Management Plan*.

For this work plan, site characterization will be performed at the 23 sites listed in Table ES-1 and shown on Figure ES-1. These characterization activities include the following:

- a. Soil collection and analysis through direct push technology.
- b. Tissue sampling for ecological risk assessment.
- c. Drywell and groundwater monitoring well geophysical logging.
- d. Surface geophysical exploration (SGE).

Table ES-1 includes the sampling method, implementation design, and objective. Not shown in Table ES-1 or in Figure ES-1 is the development of a geophysical logging tool that can detect beta emitters, which is also included in this work plan.

Soil samples for chemical analysis will be collected using direct push technology at 18 of the 23 selected sites. The number of sampling direct pushes ranges from one to three at each site for a total of up to 29 direct pushes. Furthermore, a demonstration of SGE with deep electrodes is also planned at site N. Following the demonstration, if SGE is successful at site N, a plan would be developed to deploy SGE to encompass the WMA C data quality objectives boundary based on lessons-learned from the demonstration. Additionally, new spectral gamma and moisture logging would be performed at tanks 241-C-103, 241-C-104, 241-C-106, and 241-C-108 through 241-C-112. This work is contingent on available funding and that direct push installation schedule is consistent with other schedule priorities.

Table ES-1. Sample Plan WMA C Phase 2 Characterization for RFI/CMS (3 sheets)

Map Design.	Group ^a	Location	Deployment	Number of Holes	Average Number of Samples	Known or Suspected Event	Objective	Access Availability	Ecology/ Stakeholder Interest
A	G3	Spare inlet 241-C-101	Direct push, slant	1-2	8	Tank over fill. Loss through spare inlet	Characterize C-101 release and refine conceptual models 1, 2, and 4	Fair	High
B	G2	241-C-101, south side	Direct push, vertical or slant	1	8	Tank release	Characterize C-101 release and refine conceptual models 1 and 2	Good	High
C	G4	241-C-203	Direct push, slant	3	3: 0-15 ft 15: >15 ft	Tank leak and/or tank over fill. Loss through spare inlet	Determine if C-200 actually leaked and refine conceptual models 1, 2, and 4	Fair	Moderate to high
D	G4	241-C-201 ^b 241-C-202 241-C-204	Direct push, slant	1-2/tank	8	200 series tank leaks	Determine if C-200 actually leaked and refine conceptual models 1, 2, and 4	Fair	Moderate, depending on C-203 results
E	G2	Between 241-C-106 and 200-C-109	Direct push, vertical	1	8	Suspected release	Assess ⁶⁰ Co and refine conceptual models 1, 2, and 4	Fair	High
F	G2	Bldg C-801 chemical drain	Direct push, vertical	1	8	Suspected release site	Assess release of PUREX waste, ¹³⁷ Cs and ⁹⁹ Tc, and ⁶⁰ Co and refine conceptual models 1, 2, and 4	Good	Moderate to high
G	G2	Between Bldg C-801 and 241-C-103	Direct push, vertical	1	8	Suspected transfer line release site	Assess release and ⁶⁰ Co and refine conceptual models 1, 2, and 4	Good	High
H	G5	Northeast side of E-91	Direct push, vertical	1	8	Surface release	Surface exposures and assess ⁶⁰ Co and surface release conceptual Model	Good	High
I	G5	Northeast side of E-115	Direct push, vertical or slant	1	8	Surface release	Surface exposures and assess ⁶⁰ Co and surface release conceptual model, refine conceptual models 1, 2, and 4	Good	High
J	G3	241-C-104	Direct push, slant	1	8	Tank release	Assess suspected release and refine conceptual models 1, 2, and 4	Fair	High
K	G2	241-C-108	Direct push, vertical or slant	1	8	Transfer line leak, hot dry well (09-02)	Assess suspected release and refine conceptual models 1, 2, and 4	Poor	High
L	G2	241-C-103 and 241-C-106	Drywell logging and direct push, vertical	2 / log drywells	8	Potential transfer line leak and tank over fill	Update logging data for ⁶⁰ Co, ¹³⁷ Cs, uranium, and moisture and assess potential release and refine conceptual models 1, 2, and 4	Fair	Moderate

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Table ES-1. Sample Plan WMA C Phase 2 Characterization for RFI/CMS (3 sheets)

Map Design.	Group ^a	Location	Deployment	Number of Holes	Average Number of Samples	Known or Suspected Event	Objective	Access Availability	Ecology/ Stakeholder Interest
M	G7	241-C-104, 108, 109, 110, 111, and 112	Drywell logging	N/A	N/A		Update logging data for ⁶⁰ Co, ¹³⁷ Cs, uranium, and moisture	Fair to good	Moderate
N	G8	UPR-86, UPR-82 and UPR-81	SGE	N/A	N/A		Test SGE, define plume at unplanned releases (UPR)-82 and -86; refine conceptual models 1, 2, and 4	Good	High
O	G9	WMA C	SGE	N/A	N/A		3-D vision of suspected releases – may lead to supplemental sample locations	Good	High
P	G1	UPR-81	Balance of direct pushes to complete characterization	3	8	Known release site	Characterize release and refine conceptual models 1, 2, and 4	Good	High
Q	G6	UPR-82	Direct push through center of UPR-82	1	8	Known release site	Penetrate center of mass, and refine conceptual models 1, 2, and 4	Good	High
R	G2	241-C-301 Catch Tank	Direct push vertical	1	8	Unlined concrete catch tank	Assess potential catch tank release and refine conceptual models 1, 2, and 4	Good	Moderate to high
S	G5	UPR-72 and C-8 Drain	Direct push vertical	1	8	Buried radioactive material and French drain from 241 CR Building are in this area	Assess presence of buried material and potential releases to C-8 drain and refine conceptual models 1, 2, and 4	Good	Moderate to high
T	TBD	TBD, based on SGE data for entire WMA	TBD, direct push vertical and/or slant	TBD	TBD	Previously unknown release sites	TBD	TBD	Moderate to high
U	G3	C-110	Direct push, slant	1	8	Tank leak and/or tank over fill. Loss through spare inlet	Characterize C-110 release and conceptual models 1, 2, and 4	Fair	High

Table ES-1. Sample Plan WMA C Phase 2 Characterization for RFI/CMS (3 sheets)

Map Design.	Group ^a	Location	Deployment	Number of Holes	Average Number of Samples	Known or Suspected Event	Objective	Access Availability	Ecology/ Stakeholder Interest
V	G2	C-111	Direct push vertical	1	8	Tank leak and/or tank overflow. Loss through spare inlet	Characterize C-111 release and conceptual conceptual models 1, 2, and 4	Good	High
W	G9	299-E27-4, 299-E27-12, 299-E27-13, 299-E27-14, 299-E27-15	Log groundwater monitoring wells outside of WMA C				Log wells to collect data on U, ⁶⁰ Co, ¹³⁷ Cs, and moisture	Good	High

^a Group refers to the expected work package associated with the characterization effort broadly defined as follows:

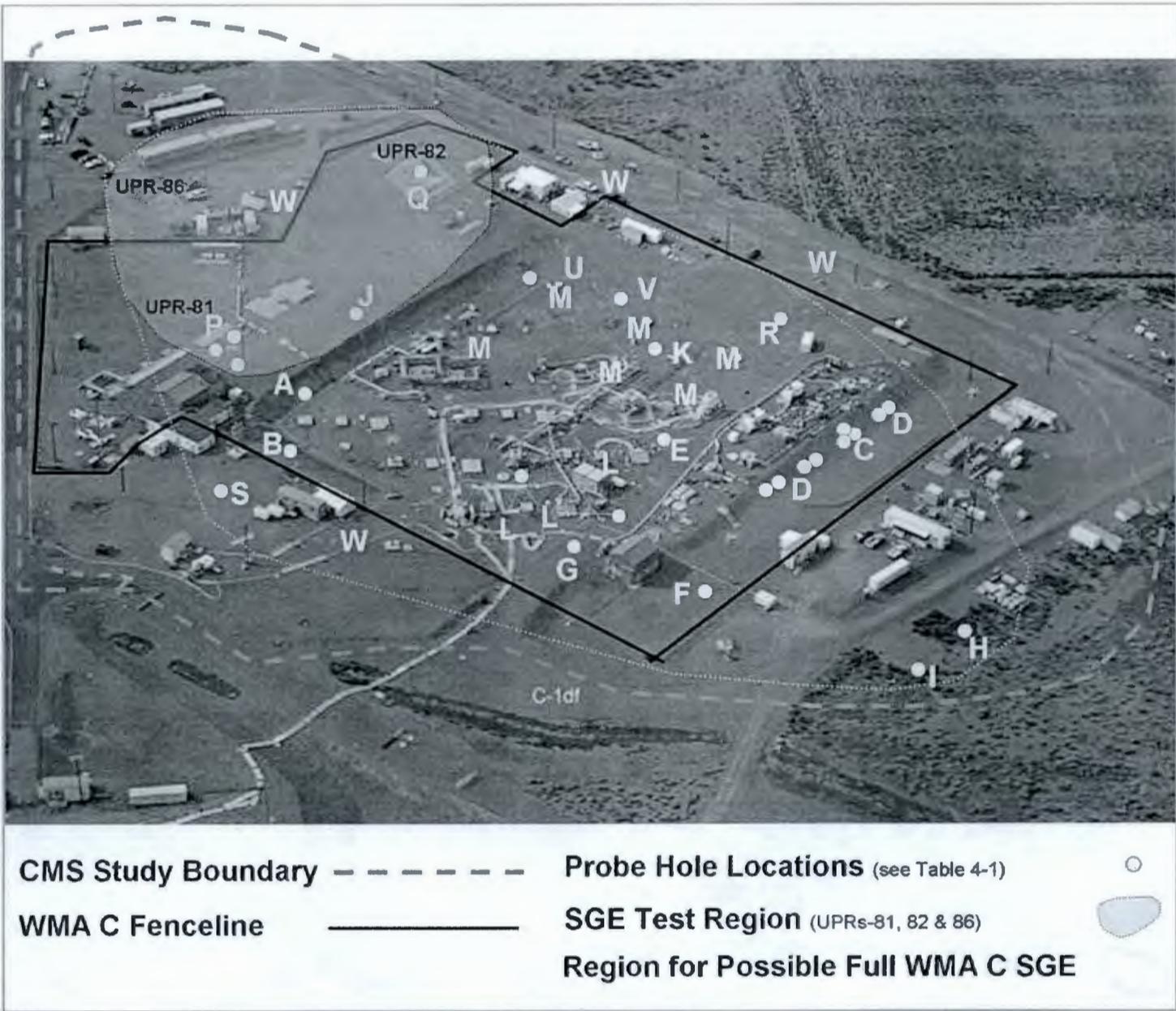
- G1 = Direct push at UPR-81 (covered by existing work package).
- G2 = Vertical direct pushes at nine investigative sites around the 100-series SSTs.
- G3 = Slant direct pushes at three investigative sites around the 100-series SSTs.
- G4 = Slant direct push at the C-200 Series tanks.
- G5 = Outside the WMA, vertical direct push at the investigative sites.
- G6 = Vertical direct push through gunite at UPR-82.
- G7 = Drywell logging at select dry wells.
- G8 = Three separate SGE areas at the following locations: UPR-81, UPR-82, and UPR-86.
- G9 = Deploy SGE at WMA C taking into account the results from testing at site N.

^b Sampling the vadose zone around these three tanks will be dependent on the result of C-203. If there is no indication of a release from C-203, samples will not be collected at these three tanks.

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1	HLW	high-level waste
2	HMS	Hanford Meteorological Station
3	HRR	high-resolution resistivity
4	HWMA	<i>Hazardous Waste Management Act</i>
5	IAEA	International Atomic Energy Agency
6	IX	ion exchange
7	LLW	low-level waste
8	MCL	maximum contaminant level
9	MTCA	<i>Model Toxics Control Act of 1989</i>
10	NCRP	National Council on Radiation Protection and Measurements
11	NEPA	<i>National Environmental Policy Act of 1969</i>
12	NRC	U.S. Nuclear Regulatory Commission
13	ORP	U.S. Department of Energy, Office of River Protection
14	OWW	organic wash waste from PUREX Plant
15	PAS	PUREX acidified sludge
16	PCB	polychlorinated biphenyls
17	PNG	Pacific Northwest Geophysics
18	PNNL	Pacific Northwest National Laboratory
19	PUREX	plutonium uranium extraction (plant)
20	QAPD	<i>Quality Assurance Program Description</i>
21	RCAP	RCRA Corrective Action Program
22	RCBRA	River Corridor Baseline Risk Assessment
23	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
24	RCW	Revised Code of Washington
25	REDOX	reduction-oxidation (plant)
26	RFI/CMS	RCRA facility investigation/corrective measures study
27	RI/FS	remedial investigation/feasibility study
28	RL	U.S. Department of Energy, Richland Operations Office
29	SAP	sampling and analysis plan
30	SDWA	<i>Safe Drinking Water Act</i>
31	SGE	surface geophysical exploration
32	SST	single-shell tank
33	TBP	Tributyl Phosphate
34	TFPC	241-A Tank Farm Process Condensate
35	TOC	Tank Operations Contractor
36	TSD	treatment, storage, and disposal
37	UPR	unplanned release
38	WAC	<i>Washington Administrative Code</i>
39	WIDS	Waste Information Data System
40	WMA	waste management area

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METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>	<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>
Length			Length		
Inches	25.4	millimeters	millimeters	0.039	inches
Inches	2.54	centimeters	centimeters	0.394	inches
Feet	0.305	meters	meters	3.281	feet
Yards	0.914	meters	meters	1.094	yards
Miles	1.609	kilometers	kilometers	0.621	miles
Area			Area		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			Mass (weight)		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			Volume		
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
gallons	3.8	liters			
Temperature			Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			Radioactivity		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

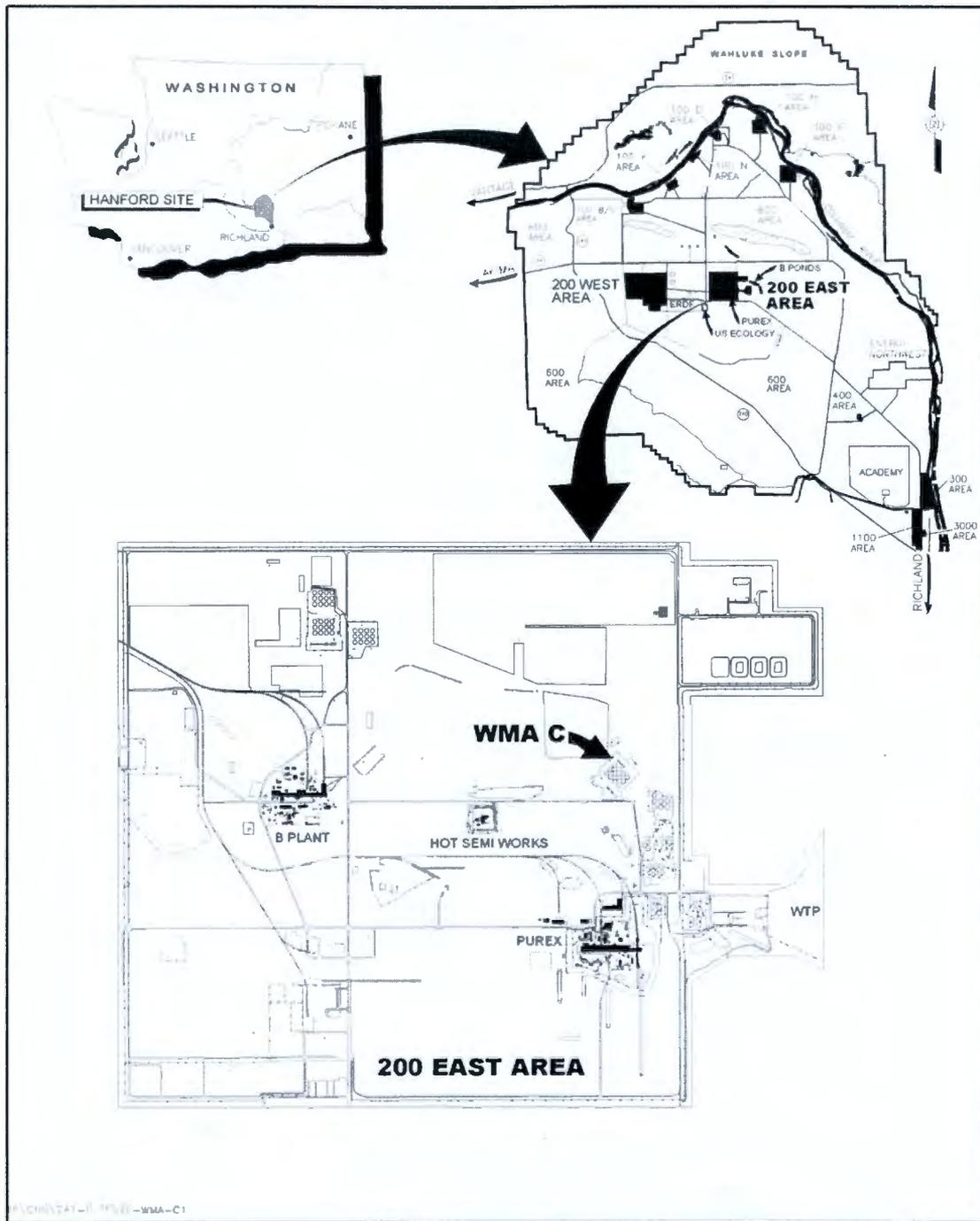
1. INTRODUCTION

This work plan describes the field work necessary to collect the data identified in RPP-RPT-38152, *Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C Corrective Measures Study*, and supports the Phase 2 Resource Conservation and Recovery Act of 1976 (RCRA) Facility Investigation/Corrective Measures Study (RFI/CMS) work plan and sampling and analysis plan activities for the single-shell tank (SST) Waste Management Area (WMA) C (Figure 1-1). The content and structure of this work plan follow the RCRA RFI/CMS work plan format established in OSWER Directive 9902.3-2A, *RCRA Corrective Action Plan – Final*, with modifications to concurrently satisfy the additional Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requirements in accordance with Appendix I of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO).

As discussed in the HFFACO Action Plan (Ecology et al. 1989), the RFI/CMS work plan is prepared to collect characterization data under the Phase 2 RFI/CMS process that eventually leads to proposed remedies for WMA C. This document fulfills the requirements of HFFACO Milestone M-045-60 (Ecology and DOE 2007). This work plan also integrates with the Phase 2 master work plan as described in HFFACO Milestone M-045-58 and Appendix I, section 2.3 (Ecology and DOE 2007). The RFI/CMS process uses the framework established in RPP-PLAN-37243, *Single-Shell Tank Phase 2 Resource Conservation and Recovery Act of 1976 Facility Investigation/ Corrective Measures Study Master Work Plan*, which is the implementation plan for integrating the RCRA treatment, storage, and disposal (TSD) unit closure process with the CERCLA groundwater and operable unit remedial investigation/feasibility study (RI/FS) process including the groundwater program. The integration between vadose zone program and the groundwater program is described in Chapter 5 of the Phase 2 Master Work Plan (RPP-PLAN-37243).

The U.S. Department of Energy (DOE), and Washington State Department of Ecology (Ecology) recently concluded negotiations on HFFACO milestone changes for completing the Phase 1 RFI/CMS process with HFFACO Milestone M-45-55. These negotiations also included the development of a clear vision for the planning and execution of Phase 2 final RCRA RFI/CMS process which also takes into account integration with other site groundwater and vadose zone cleanup efforts on the Hanford Central Plateau (Ecology and DOE 2007, *Federal Facility Agreement and Consent Order Change Control Form Change No. M-45-06-03, Modifications of Tank Farm Corrective Measures and Interim Measures Milestones*). The modification (M-45-55, M-045-58 and M-045-60) and additional milestones (M-045-61 and M-45-62) will establish a framework for completion of corrective measures within WMA C (M-45-60 through M-045-62) and a Phase 2 Tank Farm Corrective Action Master Work Plan (M-45-58 and amended HFFACO Appendix I, Section 2.3) to define the overall corrective action completion approach and sequence for other tank farms or WMAs (Ecology and DOE 2007). Modifications to the M-45 series of HFFACO (Ecology et al. 1989) milestones for *Tank Farm Corrective Measures and Interim Measures* approved in December 2007 (Ecology and DOE 2007) contains modifications to M-45-55, M-45-58, and M-45-60, and added milestones M-45-61 and M-45-62. The modifications combined M-45-55-T04 with M-45-55 and M-45-55, which completed Phase 1, and the schedule of completion was moved out to January 31, 2008, which was met.

1 **Figure 1-1. Location Map of WMA C in the 200 East Area at the DOE Hanford Site**



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Related to this work plan, the Phase 2 WMA C RFI/CMS is moved to M-45-61 and replaced with a master work plan describing the approach for all WMAs in M-45-58. A revised milestone is added for submittal of WMA C Phase 2 RFI/CMS work plan and sampling and analysis plan (SAP) (M-45-60; this work plan and SAP). A new milestone is added for submittal of the Phase 2 RFI/CMS for WMA C (M-45-61). A new milestone is added for submittal of the WMA C Corrective Measures Implementation Plan (M-45-62). Finally, HFFACO Appendix I,

1 Section 2.3, was modified to describe the contents of RPP-PLAN-32743 that provides the
2 conceptual process and sequencing approach for all SST farms and selection criteria for
3 implementing Phase 2 RCRA corrective action.

4
5 Where information regarding treatment, management, and disposal of radioactive source,
6 byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic*
7 *Energy Act of 1954*) is incorporated into this document, it is not incorporated for the purpose of
8 regulating the radiation hazards of such components under the authority of the Revised Code of
9 Washington (RCW) 70.105, "Hazardous Waste Management Act," and its implementing
10 regulations, but is provided for information purposes only.

11 **1.1 PURPOSE, SCOPE, AND OBJECTIVES**

12 This work plan presents background information, existing contaminant distribution data, and the
13 approach that will be used for characterization and corrective action decision-making for
14 WMA C. The potentially applicable technologies and the need for treatability studies are
15 discussed in Chapter 5.

16
17 This work plan addresses only WMA C and its surrounding vicinity as defined in RPP-RPT-
18 38152. WMA C, which is a RCRA WMA, includes the C Farm that consists of the following:

- 19 a. Twelve 100-series SSTs, each with 535,000-gal capacity.
- 20 b. Four 200-series SSTs, each with 55,000-gal capacity.
- 21 c. Waste transfer lines.
- 22 d. Multiple drywells around each 100-series SST used as leak detection systems.
- 23 e. Tank ancillary equipment, including diversion boxes, catch tanks, and related structures.
- 24 f. Associated unplanned releases (UPR) to the soil.

25
26
27 This work plan contains SAPs for the Phase 2 corrective action process (Appendixes A and B).
28 The soil SAP includes a quality assurance project plan and the sampling specifications for the
29 characterization activities in the field (Appendix A). Previous characterization efforts
30 (RPP-35484, *Field Investigation Report for Waste Management Areas C and A-AX*) and
31 historical information (RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report:*
32 *241-C-101, 241-C-110, 241-C-111, 241-C-105, and Unplanned Waste Releases*) associated with
33 WMA C was used in the development of this work plan. Data-gathering activities included
34 compiling and reviewing existing process-knowledge information. WMA C site characterization
35 data also have been gathered and evaluated. This existing information and the new
36 characterization data that will be acquired as part of this Phase 2 sampling approach for this work
37 plan will be used in the Phase 2 RFI/CMS report for WMA C presently due to Ecology on
38 December 31, 2010 (Ecology and DOE 2007). However, the length of time to collect the
39 characterization data extends beyond the HFFACO Milestone M-45-61 date for the CMS report
40 and may need to be renegotiated.

41
42 The results from sampling and other characterization activities will be used to update the
43 contaminant distribution models as needed and to support the CMS decision-making process.
44 This work plan focuses on identifying and gathering the characterization information that will be
45 needed for evaluating the selection of the preferred remedy(ies) from the CMS alternatives.

1 Results of the characterization activities will be used for evaluating risk to potential receptors
2 and for the CMS alternative analyses.

3
4 To focus the activities needed for future remedy selection for WMA C, this Phase 2 RFI/CMS
5 work plan has incorporated the following.

- 6
7 a. Information-gathering activities are continuing, including location and characterization of
8 releases, throughout the RFI/CMS process. As characterization results become available,
9 they will be compared with information concerning operational history and construction
10 details. This approach will allow for any subsequent data collection needs to be adapted
11 as needed. Data gathering requirements are tailored to accommodate the characteristics
12 of the entire WMA C and integration with the groundwater program, tank closure, and
13 adjacent operable units, as appropriate.
- 14
15 b. Potential corrective measures alternatives (CMA) are identified and described. Potential
16 remedies associated with WMA C initially are identified in the work plan. Corrective
17 measures alternatives analysis will be completed in the Phase 2 RFI/CMS report for
18 WMA C (HFFACO Milestone M-45-61) using data collected from both Phase 1 and 2
19 field characterization and risk evaluation activities.

20
21 Following approval of this work plan, the major elements (RFI/CMS steps) are requirements that
22 are not expected to change; therefore, the work plan should not change. Specific work scope
23 elements might require modification or refinement as the work progresses. Changes that do not
24 affect the overall intent of the approved work plan or schedule can be made in the field and
25 documented in the daily log books that are maintained in the field as stated in Section 12.4 of the
26 HFFACO Action Plan (Ecology et al. 1989). Alternatively, and if agreed to by the U.S.
27 Department of Energy, Office of River Protection (ORP) and the lead regulatory agency, unit
28 managers' meetings or predecessor primary documents requiring ORP and lead regulatory
29 agency approval also can be used to document changes. Changes to the project schedule that
30 affect assigned HFFACO M-045 interim milestones will require approval through the HFFACO
31 (Ecology et al. 1989) change control process.

32
33 Supporting characterization data acquired during the field investigation that will be used for
34 corrective measures decision-making for WMA C will be presented in the Phase 2 RFI/CMS
35 report.

36 **1.2 DATA QUALITY OBJECTIVES PROCESS FOR WMA C**

37 EPA/240/B-06/001, *Guidance on Systematic Planning Using Data Quality Objectives Process*,
38 was used to identify the data needs described in this work plan. The primary participants in this
39 process were the Tank Operations Contractor (TOC), Ecology, and ORP. However, to ensure
40 integration with other activities within the 200 East Area (RPP-PLAN-37243, Chapter 5), U.S.
41 Environmental Protection Agency (EPA); U.S. Department of Energy, Richland Operations
42 Office (RL); and Plateau Remediation Contractor also participated in the process but did not
43 attend every workshop. This DQO process established the assumptions and global issues
44 associated with Phase 2 characterization activities at WMA C. The Tribal Nations and Oregon
45 stakeholders were provided informational meetings and sent the data quality objectives (DQO)

1 for their review. The Phase 2 WMA C DQO summary report (RPP-RPT-38152) summarizes the
2 outcome of the DQO process for WMA C during the Phase 2 RFI/CMS process.

3 1.3 DOCUMENT STRUCTURE

4 This Phase 2 RFI/CMS work plan is organized to present information as follows:

- 5
- 6 • **Chapter 1** – *Introduction*
- 7 • **Chapter 2** – *Background and Setting*
- 8 • **Chapter 3** – *Waste Management Area C Site Characterization Efforts*
- 9 • **Chapter 4** – *Work Plan Rationale and Approach*
- 10 • **Chapter 5** – *RCRA Facility Investigation/Corrective Measures Study Process*
- 11 • **Chapter 6** – *Schedule*
- 12 • **Chapter 7** – *Project Management and Program Integration*
- 13 • **Chapter 8** – *References*
- 14

15 Appendix A contains the SAP for the Phase 2 characterization activities for soils planned for the
16 vadose zone in WMA C, while Appendix B contains the sampling and analysis instructions for
17 collecting tissue samples from small mammals. The sampling and analysis tasks presented in
18 this sampling and analysis instructions guide are specific to small mammal collection and
19 analysis to obtain data for use in dietary exposure modeling in the ecological risk assessment for
20 WMA C. Attachments 1 through 4 support Appendixes A and B with the quality assurance
21 program description (Attachment 1), general health and safety plan (Attachment 2), information
22 management overview (Attachment 3), and waste management plan (Attachment 4).

23 1.4 QUALITY ASSURANCE

24 The TOC document, TFC-PLN-02, *Quality Assurance Program Description (QAPD)*, is
25 provided in Attachment 1 of this work plan. It establishes the quality requirements for
26 environmental data collection, including sampling and analysis, in support of the *SST Resource*
27 *Conservation and Recovery Act of 1976 (RCRA) Corrective Action Program (RCAP)*. This
28 QAPD applies specifically to field and laboratory activities associated with evaluating
29 subsurface contaminant impacts involving 200 Areas SST WMAs releases to the environment.
30 The QAPD complies with the requirements of DOE O 414.1C, *Quality Assurance*; Title 10,
31 *Code of Federal Regulations*, Part 830.120, “Quality Assurance Requirements” (10 CFR
32 830.120), “Quality Assurance Requirements”; EPA/240/B-01/003, *EPA Requirements for*
33 *Quality Assurance Project Plans*; DOE/RL-96-68, *Hanford Analytical Services Quality*
34 *Assurance Requirements Documents (HASQARD)*; and ASME NQA-1, *Quality Assurance*
35 *Requirements for Nuclear Facility Applications*, as applied. The QAPD also identifies technical
36 procedural requirements that will describe field data collection and sampling and analysis
37 requirements to be implemented during the investigation. Technical procedures will be
38 identified in the SAP to address the requirements of the HASQARD (DOE/RL-96-68). The
39 purpose of Attachment 1 is to provide a framework of the general requirements that apply to
40 RCAP characterization and remedial efforts.
41

1

2. BACKGROUND AND SETTING

This section provides background and site setting information relevant to SST WMA C. A thorough review of the documents relevant to SST WMA C process history, waste inventory, vadose zone studies, and groundwater studies was conducted as part of the DQO process and is presented in the Phase 2 WMA C DQO summary report (RPP-RPT-38152).

Figure 2-1 shows the location of WMA C and its surrounding facilities. Previous field investigation of borehole C4297 is also noted in Figure 2-1. Section 3.2.1 and RPP-35484 provide additional field characterization results for Phase 1.

2.1 GEOGRAPHIC SETTING

This section describes the topography, climate, demography, and ecology of the Hanford Site, specifically the Central Plateau that includes 200 East Area where SST WMA C is located.

2.1.1 Topography

The WMAs were always located downhill from the waste generating facilities to allow gravity flow in the pipelines from the facilities to the tanks. Figure 2-2 provides a topographic map of WMA C along with two topographic profiles (C-101 to C-103 and C-110 to C-112). These profiles show a stair-step elevation drop trending from the higher elevations in the southwest to lower elevations in the northeast.

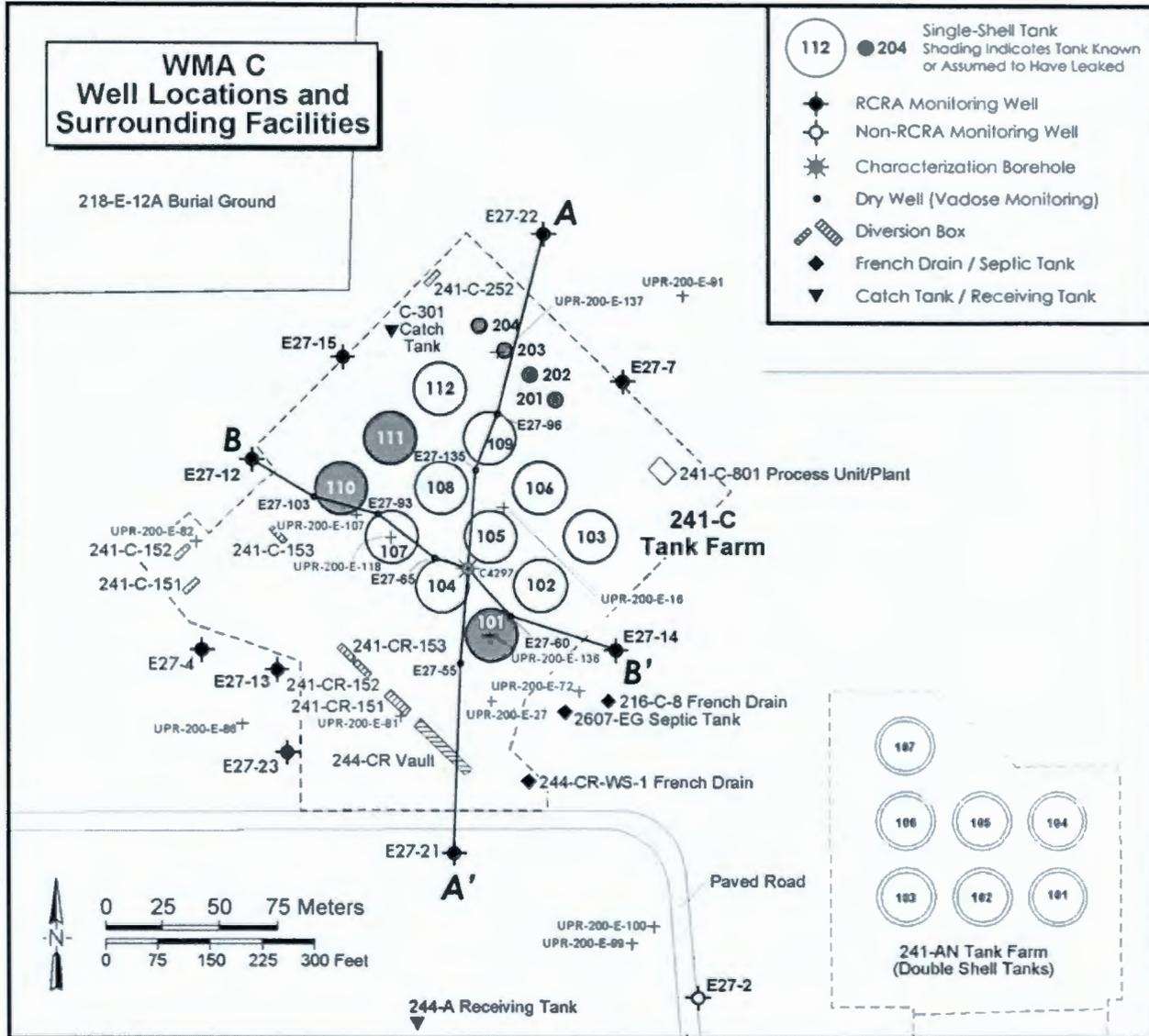
2.1.2 Climate

The information in this section is a summary; additional detail can be found in the annual climatological data summary reports, which have been issued since 1993. The most recent report is PNNL-15160, *Hanford Site Climatological Data Summary 2004 with Historical Data*. Additional information can be found in PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*.

The climate at the Hanford Site can be classified as either mid-latitude semiarid or mid-latitude desert, depending on which climatological classification system is used. Large diurnal temperature variations are common, resulting from intense solar heating and nighttime cooling. Daytime high temperatures in June, July, and August can exceed 100°F. Winters are cool with occasional precipitation that makes up about 44% of the yearly total. During the winter, outbreaks of cold air associated with modified arctic air masses can reach the area and cause temperatures to drop below 0°F. Overcast skies and fog occur predominately during the late fall and winter months.

Weather conditions are monitored and recorded at the Hanford Meteorological Station (HMS), located between the 200 East and 200 West Areas at about 733 ft elevation. Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the 200 Areas. Real-time and historical data from the HMS can be obtained on the Internet at <http://hms.pnl.gov/hms.htm>.

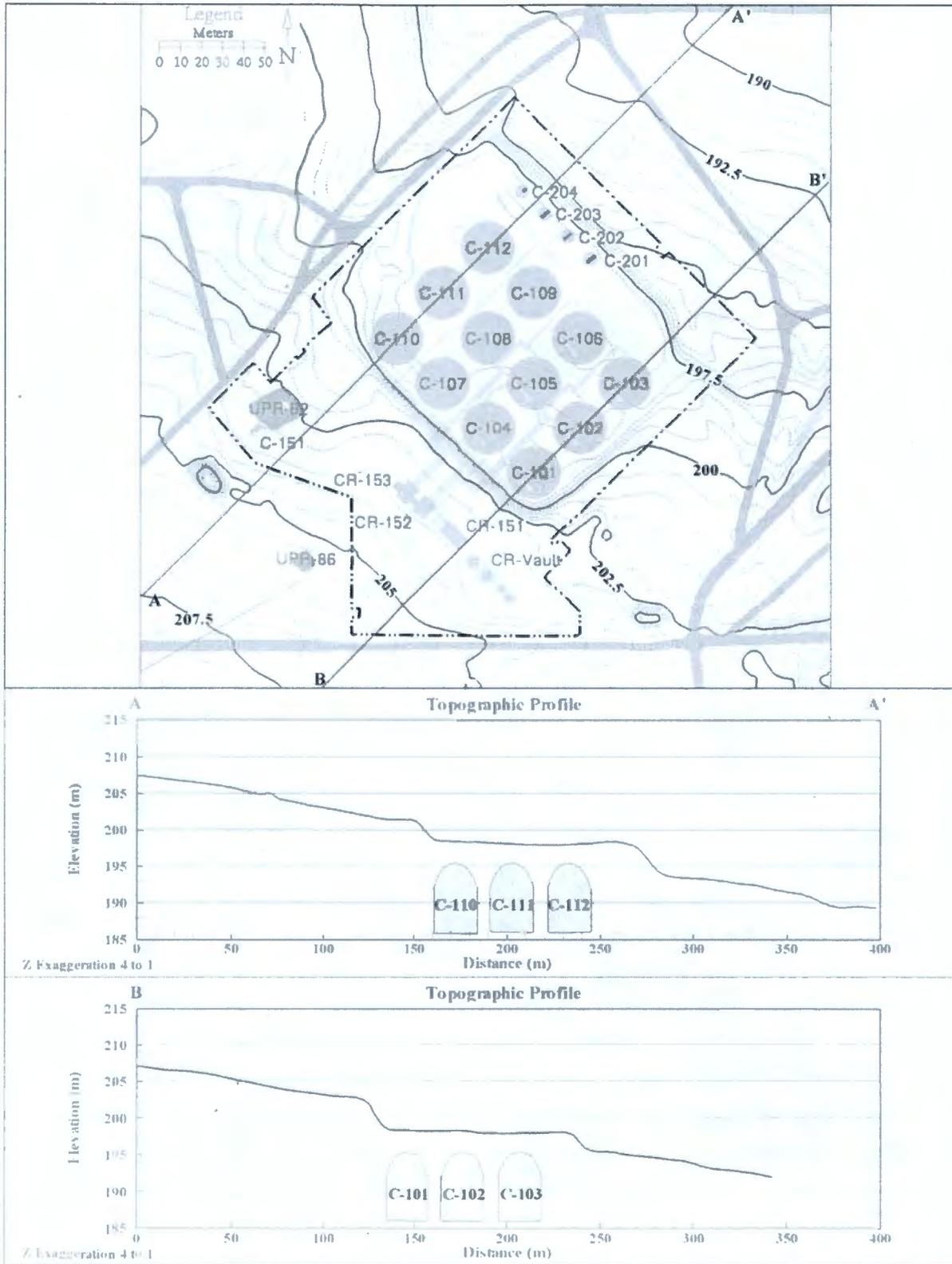
Figure 2-1. WMA C and Nearby Facilities



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Figure 2-2. Elevation Contour Map of WMA C with Topographic Profiles Running through WMA C



3

1
2 The Cascade Range to the west of the Hanford Site greatly affects the temperature, wind, and
3 precipitation in the region. Air masses that reach the Pasco Basin are changed as they pass over
4 the region's relatively complex topography. The mountains limit the maritime influence of the
5 Pacific Ocean, making the climate of eastern Washington drier and with greater temperature
6 extremes than the coastal region. In addition to this rain shadow effect, the Cascade Mountains
7 are a source of cold air drainage, which has a considerable effect on the wind regime of the site.
8

9 Daily maximum temperatures vary from a normal maximum of 35°F in late December and early
10 January to 96°F in late July. On the average, 52 days during the summer months have maximum
11 temperatures of 90°F or higher and 12 days with maxima of 100°F or higher. From
12 mid-November through early March, average daily minimum temperatures are below freezing
13 ($\leq 32^{\circ}\text{F}$), with the daily minima in late December and early January averaging 21°F. During the
14 winter, on average, 3 days have minimum temperatures of 0°F or lower; however, only about one
15 winter in two experiences such temperatures. The record maximum temperature is 113°F, and
16 the record minimum temperature is -23°F .
17

18 Between 1946 and 2007, annual precipitation at the HMS averaged 17.3 cm (6.81 in.) and varied
19 between 7.6 cm (3 in.) and 31.3 cm (12.3 in.). The wettest season on record was the winter of
20 1996–1997 with 14.1 cm (5.4 in.) of precipitation; the driest season was the summer of 1973
21 when only 0.1 cm (0.03 in.) of precipitation was measured. Most precipitation occurs during the
22 late autumn and winter, with more than half of the annual amount occurring from November
23 through February. Days with more than 1.3 cm (0.50 in.) precipitation occur on average less
24 than once each year. Rainfall intensities of 1.3 cm/hr (0.5 in./hr) persisting for 1 hour are
25 expected once every 10 years. Rainfall intensities of 2.5 cm/hr (1.0 in./hr) for 1 hour are
26 expected only once every 500 years.
27

28 About 38% of the precipitation during December through February falls as snow. Winter
29 monthly average snowfall ranges from 0.5 in. in March to 5.0 in. in January. Only one winter in
30 four is expected to accumulate as much as 5.9 in. of snow on the ground. During these winters,
31 4 days, on average, have 6.0 in. (or more) of snow on the ground. However, the 1964–1965
32 winter had 35 days with snow on the ground, 32 of which were consecutive.
33

34 Prevailing wind direction on the 200 Area plateau is from the northwest in all months of the year.
35 Secondary maxima occur for southwesterly winds. Summaries of wind direction indicate that
36 winds from the northwest quadrant occur most often during the winter and summer. During the
37 spring and fall, the frequency of southwesterly winds increases with a corresponding decrease in
38 northwest flow. Winds blowing from other directions (e.g., northeast) display minimal variation
39 from month to month. Monthly average wind speeds are lowest during the winter months,
40 averaging 6 to 7 mph, and highest during the summer, averaging 8 to 9 mph.
41

42 Wind speeds that are well above average are usually associated with southwesterly winds.
43 However, the summertime drainage winds are generally northwesterly and frequently reach
44 30 mph. These winds are most prevalent over the northern portion of the Hanford Site.

2.1.3 Demography

An estimated total of 155,100 people lived in Benton County and 57,000 lived in Franklin County during 2004, totaling 212,100, an increase of almost 11% from the Census 2000 figure (OFM 2008a, *Population of Cities, Towns and Counties: April 1, 2000 to April 1, 2008*). According to the 2000 Census, population totals for Benton and Franklin counties were 142,475 and 49,347, respectively (U.S. Census 2001, *Poverty Thresholds in 2000, by Size of Family and Number of Related Children Under 18 Years.*). Both Benton and Franklin counties grew at a faster pace than Washington as a whole during the 1990s. The population of Benton County grew 26.6%, up from 112,560 during 1990. The population of Franklin County grew 31.7%, up from 37,473 during 1990 (U.S. Census 2001).

The distribution of the 2004 Tri-Cities population by city is as follows: Richland, 42,660; Pasco, 40,840; and Kennewick, 58,970. The combined populations of Benton City, Prosser, and West Richland totaled 17,640 during 2004. The unincorporated population of Benton County was 35,830. In Franklin County, incorporated areas other than Pasco had a total population of 3855. The unincorporated population of Franklin County was 12,305 (OFM 2008a).

During 2004, Benton and Franklin counties accounted for 3.4% of Washington's population. The population demographics of Benton and Franklin counties are quite similar to those found within Washington. In general, the population of Benton and Franklin counties is somewhat younger than that of Washington as a whole. The 0- to 14-year-old age group accounts for 24.6% of the total bi-county population compared with 20.4% for Washington. The population in Benton and Franklin counties under the age of 35 is 51.9%; it is 48.2% for the state of Washington (OFM 2008b, *Intercensal and Postcensal Estimates of April 1 County Population by Age and Sex: 1980-2008*).

Additional Hanford area demographic data are available from PNNL-14428, *Hanford Area 2000 Population*. This document includes 2000 Census estimates for the resident population by distance and compass direction within an 80-km (50-mi) radius of the Hanford Site. Population distributions are reported relative to five reference points centered on meteorological stations within major operating areas of the Hanford Site: the 100-F, 100-K, 200, 300, and 400 Areas. Data are presented in both graphical and tabular format and are provided for total populations residing within 80 km (50 mi) of the reference points, as well as for Native American, Hispanic and Latino, total minority, and low-income populations.

2.2 ECOLOGY

This section summarizes the ecology of the Hanford Site (Section 4.4 of PNNL-6415), emphasizing plant and animal activities that may affect exposure pathways. The primary impact would be through roots penetrating and animals burrowing through surface barriers into a disposal facility. Secondarily, the types of plants and animals and their density can affect net groundwater recharge, which is greatly influenced by surface vegetation and burrowing.

PNNL-6415 details both the terrestrial and aquatic ecology of the Hanford Site and presents extensive listings of plant and animal species, while this section considers only terrestrial ecological effects because all SSTs are not located near significant aquatic ecological systems.

1 The Hanford Site consists of primarily undeveloped land. Chemical processing facilities,
2 shutdown nuclear reactors, and supporting facilities occupy only about 6% of the site. Most of
3 the Hanford Site has not experienced tillage or agricultural grazing since the early 1940s.
4

5 The Hanford Site is characterized as a shrub-steppe ecosystem that is adapted to the mid-latitude
6 semiarid climate of the region. These ecosystems are typically dominated by a shrub overstory
7 with a grass understory. In the early 1800s, dominant plants in the area were big sagebrush
8 (*Artemisia tridentata*) and an understory consisting of perennial Sandberg's bluegrass (*Poa*
9 *sandbergii*) and bluebunch wheatgrass (*Pseudoregneria spicata*). Other species included
10 threepoint sagebrush, bitterbrush, gray rabbitbrush, spiny hopsage, bluebunch wheatgrass,
11 needle-and-thread grass, Indian rice grass, and prairie June grass.
12

13 With the advent of settlement, livestock grazing and agricultural production contributed to
14 colonization by non-native vegetation species that currently dominate portions of the landscape.
15 Although agriculture and livestock production were the primary subsistence activities at the turn
16 of the century, these activities ceased when the Hanford Site was designated in 1943. No
17 farming has occurred on the Hanford Site since the government took control of the site.
18

19 The dominant non-native species, cheatgrass, is an aggressive colonizer and has become well
20 established across the site. Over the past decade, several knapweed species also have become
21 persistent invasive species in areas not dominated by shrubs. Range fires that historically burned
22 through the area during the dry summers eliminate fire-intolerant species (e.g., big sagebrush)
23 and allow more opportunistic and fire-resistant species to establish. Of the 590 species of
24 vascular plants recorded for the Hanford Site, approximately 20% are non-native. Wildfires are
25 frequent on the Hanford Site. Three large wildfires in the past two decades have burned over
26 15% of the site.
27

28 All WMAs in the tank farm system are actively managed to prevent vegetation, insects, and
29 wildlife from using the WMA as habitat, including WMA C. Herbicides and pesticides are used
30 on a regular basis and fences are placed around the perimeter to keep larger animals out.
31 Without a source of food within the WMA, smaller animals are less likely to enter. PNNL-6415
32 provides a more complete description of the plant, insect, and animal life outside the WMAs.

33 2.3 GEOLOGY AND HYDROGEOLOGIC CONDITIONS

34 Since the Hanford Site started operating in the early 1940s, a large volume of information on the
35 geology, seismology, and volcanology of the site has been collected and evaluated. As part of
36 DOE/ORP 2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford*
37 *Site*, a geologic data package (RPP-23748, *Geology, Hydrogeology, Geochemistry, and*
38 *Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford*
39 *Site*) was prepared that describes the geology, hydrology, and geochemistry of the region, site,
40 and WMAs. Most of the data included in the geologic data package were collected by (or used
41 by) several projects between about 1980 and the present. Those projects include the Basalt
42 Waste Isolation Project, the Skagit Hanford Nuclear Project, the Energy Northwest safety
43 analysis, several performance assessments, and numerous regulatory driven geologic and
44 hydrologic characterizations, assessments, and monitoring projects.
45

1 The technical aspects of all of these projects, and thus the data, interpretations of the data, and
 2 conclusions, have been scrutinized by one or more regulatory agencies and stakeholder groups
 3 including the U.S. Nuclear Regulatory Commission (NRC), the National Academy of Sciences,
 4 the Defense Nuclear Facilities Safety Board, the EPA, the U.S. Geological Survey, the
 5 Washington State Departments of Ecology and Health, the Oregon Department of Energy, and
 6 the Yakama, Nez Perce, and Wanapum Indian Nations, and the Confederated Tribes of the
 7 Umatilla Indian Reservation. For additional information relating to geology, hydrology, and
 8 geochemistry of the Hanford Site, see RPP-23748 and PNNL-15955, *Geology Data Package for*
 9 *the Single-Shell Tank Waste Management Areas at the Hanford Site*. More information specific
 10 to WMA C is available in RPP-35484.

11
 12 The descriptions in these reports were brought up to date by WHC-SD-EN-TI-012, *Geologic*
 13 *Setting of the 200 East Area: An Update*. In addition, DOE/RL-2002-39, *Standardized*
 14 *Stratigraphic Nomenclature for Post-Ringold Formation Sediments within the Central Pasco*
 15 *Basin*, provides the new standardized nomenclature that was applied to this investigation.
 16 Post-basalt strata beneath the tank farm include (in descending order): (1) recent deposits,
 17 (2) Hanford formation, and (3) Cold Creek unit (CCU) and/or Ringold Formation. The most
 18 recent and comprehensive investigations on the interpreted geology of C Farm includes those
 19 reported in RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste*
 20 *Management Area*, RPP-18290, *241-C Tank Farm Geologic and Stratigraphic Analysis*;
 21 RPP-23748, PNNL-15955, and RPP-35484. This document follows the standardized
 22 stratigraphic nomenclature recommended in DOE/RL-2002-39; therefore, the names for
 23 post-Ringold Formation stratigraphic units may differ from the terminology used in previous
 24 reports.

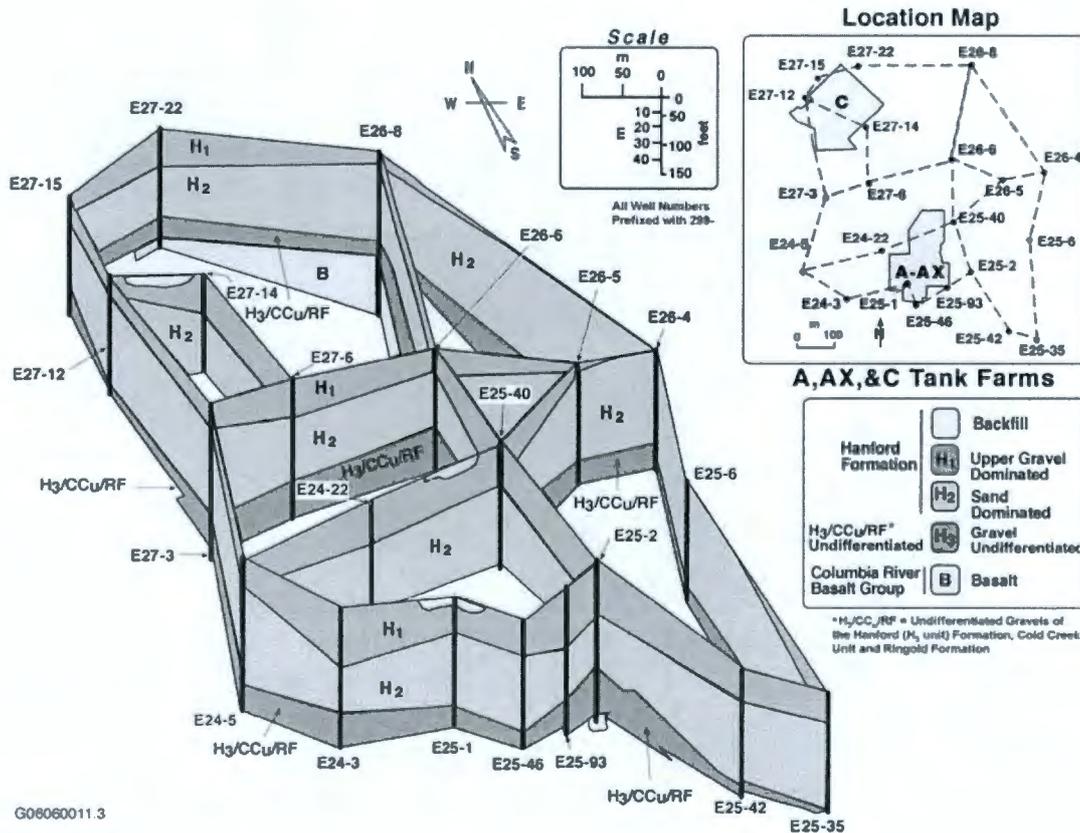
25 **2.3.1 Geology**

26 The geology of the major stratigraphic units underlying the C Farm and vicinity is well
 27 understood as a result of several decades of site characterization activities. It has been described
 28 in numerous reports (HW-61780, *Subsurface Geology of the Hanford Separation Areas*;
 29 ARH-LD-132, *Geology of the 241-C Tank Farm*; RPP-14430, and RPP-35484. The main source
 30 of information about the geologic strata underlying the Hanford Site and the tank farms is data
 31 from the drilling of boreholes and the analyses of the sediments and contaminants within them
 32 (e.g., PNNL-14656, *Borehole Data Package for Four CY 2003 RCRA Wells 299-E27-4,*
 33 *299-E27-21, 299-E27-22, and 299-E27-23 at Single-Shell Tank, Waste Management Area C,*
 34 *Hanford Site, Washington*). More detailed discussion of the borehole-specific geologic and
 35 geochemical characteristics of WMA C vadose zone are provided in RPP-23748 and
 36 PNNL-15955.

37
 38 Three major stratigraphic units underlie the C Farm, including (in ascending order) the igneous
 39 Columbia River Basalt Group, and two sedimentary units, the undifferentiated H3 unit of the
 40 Hanford formation/Cold Creek unit/Ringold Formation (H3/CCU/RF) and the Hanford
 41 formation. Figure 2-3 shows a fence diagram of these units underlying WMAs C and A-AX.
 42 Figure 2-4 shows the cross sections through WMA C as located on Figure 2-1. The
 43 undifferentiated H3/CCU/RF unit directly above the Columbia River Basalt Group is labeled as
 44 undifferentiated because two or three major stratigraphic units may have commingled, and clear
 45 distinctions between them cannot be made. These include the H3 subunit of the Hanford

1 formation, the Cold Creek unit, and the Ringold Formation's Wooded Island member. The water
 2 table occurs within the H3/CCU/RF. Finally, backfill materials consisting of poorly sorted
 3 cobbles, pebbles, and coarse to medium sand derived from the H1 subunit of the Hanford
 4 formation, are distributed around the tanks and tank infrastructure. Overall, the vadose zone is
 5 approximately 250 ft thick at WMA C.

7 **Figure 2-3. Fence Diagram Showing Cross Sections through WMA A-AX and C**



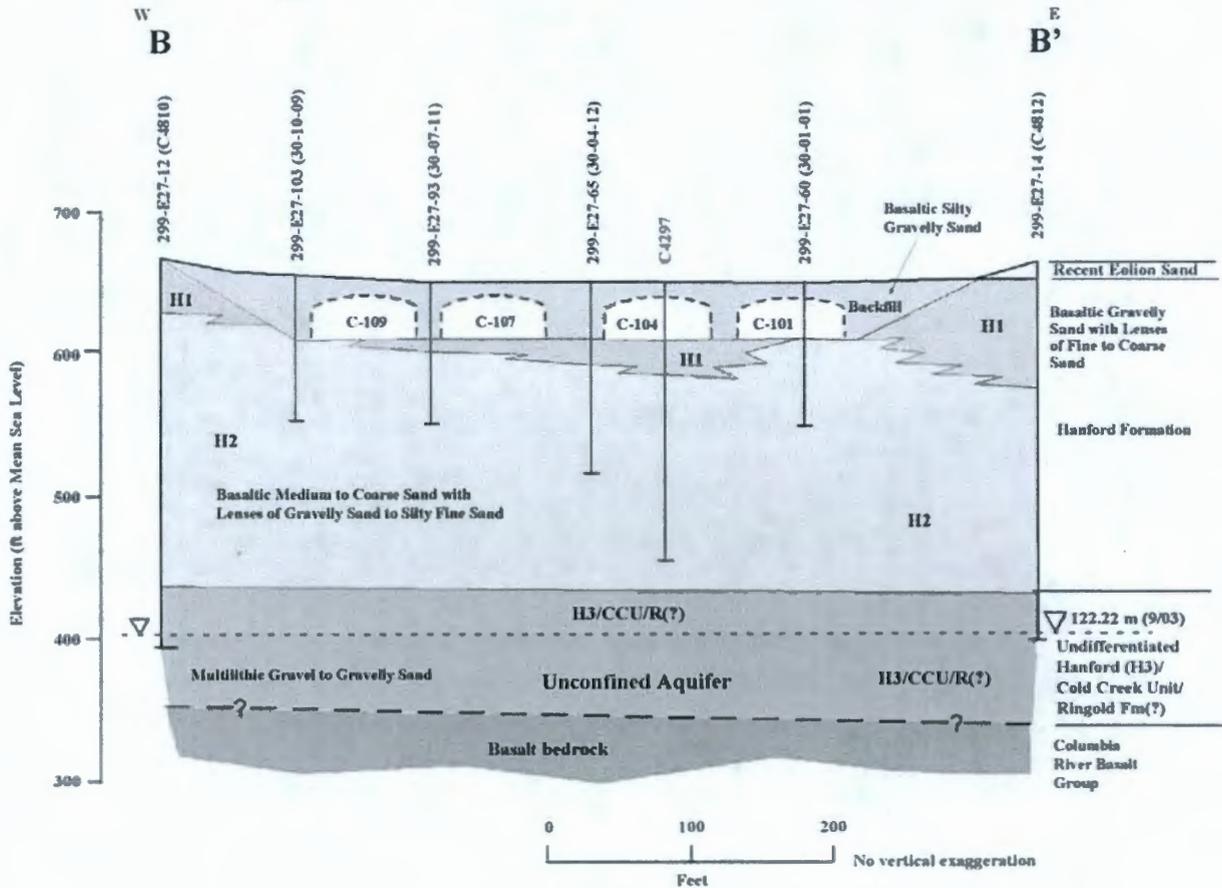
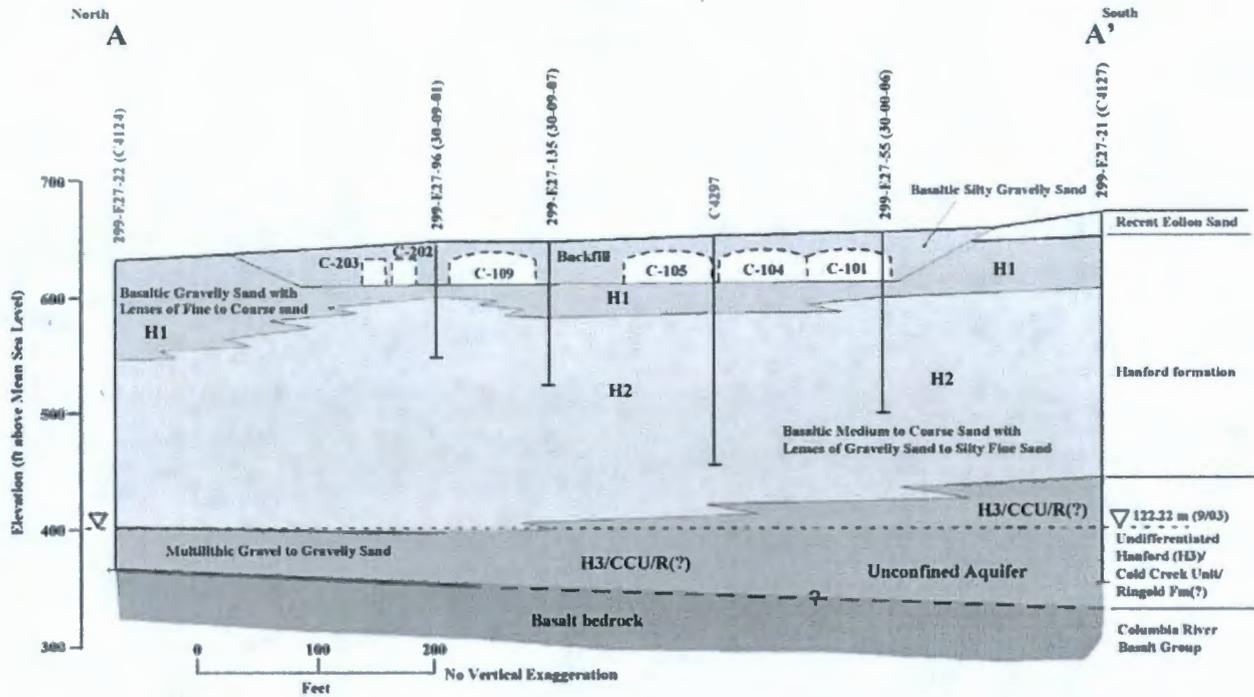
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9 from PNNL-15955

10
 11
 12
 13 Of these, the backfill, Hanford formation, and the undifferentiated H3/CCU/RF make up the
 14 vadose zone. The unconfined aquifer is generally contained within the undifferentiated
 15 H3/CCU/RF. All major stratigraphic units are inferred to be essentially continuous in this area,
 16 although unit thicknesses vary and some subunits are not continuous. General characteristics of
 17 each sedimentary unit descending from the surface down beneath WMA C are as follows:

18
 19 **Hanford Formation.** The Hanford formation is a cataclysmic flood deposit that is between
 20 140 and 240 ft thick and thickens slightly toward the south and west. It consists of three subunits
 21 (H1, H2, and H3) that are distinguished by a change in the dominant particle-size distribution.
 22 The upper unit, H1, deposited in a high-energy environment, is loose sandy gravel to gravel sand
 23 and composed of poorly sorted basaltic, sandy gravels to silty sandy gravels. It is between
 24 30 and 100 ft thick in the area, thinning concentrically toward the middle of A Farm and
 25

1 **Figure 2-4. Cross Sections A-A' and B-B' Through WMA C (Cross-Section Locations on**
 2 **Figure 2-1)**



1 generally thinning toward the north (e.g., at C Farm)(RPP-14430 and RPP-35484). The H2 unit
2 deposited in a lower-energy environment is predominantly a sand-dominated sequence composed
3 of mostly horizontal to tabular cross-bedded sands to gravelly sands. Thin silt lenses are
4 occasionally present that occur on a scale too small to correlate between boreholes. The H2 unit
5 is between 95 and 200 ft thick in the area and generally thickens to the west with localized
6 minimums on the west side of A Farm and the east side of AX Farm. RPP-18290 and PNNL-
7 14656 identified a third unit (H3) of the Hanford formation, which is usually reserved for a clast-
8 supported, gravel-dominated facies at the base of the Hanford formation (DOE/RL-2002-39).
9 However, at C Farm, the overall texture of this unit is still predominantly sand, with only a minor
10 component of pebbly to slightly pebbly sand. The H3 unit of RPP-18290 and PNNL-14656 does
11 not contain appreciably more gravel than the H2 unit. Otherwise, thicknesses increase toward
12 the east up to a maximum of approximately 50 ft on the east side of AX Farm. At C Farm, the
13 H3 unit may be present as part of the undifferentiated H3/CCU/RF.

14
15 **Undifferentiated Hanford Formation/Cold Creek Unit/Ringold Formation.** WMAs A-AX
16 and C lie along the edge of a paleochannel that eroded much or all of the Ringold Formation
17 during CCU and/or Hanford time. Because of the difficulty in distinguishing reworked Ringold
18 Formation gravels and pre-Missoula mainstream Columbia River gravels from original Ringold
19 Formation gravels, these units are undifferentiated here (H3/CCU/R).

20
21 Gravelly facies immediately overlying basalt within most of the study area belong to the
22 H3/CCU/R. The H3/CCU/R consists of predominantly sandy pebble- to cobble-sized gravel
23 with occasional boulders. Mineralogically, the sand fraction consists of 15 to 60% basalt grains
24 with generally less than 1 wt% calcium carbonate. The total thickness of this unit is less than
25 27 m (90 ft), based on a limited number of boreholes where the upper and lower boundaries are
26 represented. The top of H3/CCU/R ranges from about 120 to 130 m (390 to 425 ft) elevation
27 above mean sea level.

28 2.3.2 Vadose Zone

29 The geology of the vadose zone underlying WMA C forms the media through which the
30 contaminants move and provides the basis with which to interpret and extrapolate the physical
31 and geochemical properties that control the migration and distribution of contaminants. Of
32 particular interest are the interrelationships between the coarser- and finer-grained facies, and the
33 degree of contrast in their physical and geochemical properties. While the exact distribution of
34 these alternating units is not known, their contrast appears to have a strong influence on the
35 distribution of leak and recharge waters and dissolved tank waste constituents.

36
37 Natural recharge from meteoric water (precipitation and snowmelt) and vadose zone hydrology
38 are among the most important factors that control contaminant movement to the groundwater.
39 The state of knowledge on recharge, matric potential, moisture content, and vadose zone
40 hydraulic properties is discussed in the following sections. The section concludes with a
41 discussion of the unconfined aquifer properties for WMA C. A determination of the unsaturated
42 flow characteristics in the region of these WMAs was based on the information in Section 3.1.3
43 of RPP-35484.

2.3.3 Recharge

Moisture movement through the vadose zone is important because it is the driving force for migration of most contaminants to the groundwater. Radioactive and hazardous wastes in the soil column from liquid-waste disposals, unplanned leaks, solid waste burial, and underground tank storage are potential sources of continuing and future vadose zone and groundwater contamination. Contaminants may continue to move downward for long periods [tens to hundreds of years depending on recharge rates and the distribution coefficient (K_d) of the contaminant] after termination of liquid waste disposal.

The WMAs were constructed with a gravelly sand surface layer that has been maintained free of vegetation with the use of herbicides. These conditions promote higher rates of infiltration of meteoric water that are expected to continue until the time of WMA closure. Interim measures to control infiltration have been implemented at the WMAs and an evaluation of accelerated corrective measures is being conducted under a RCRA corrective action program. Tank farm surfaces are covered with gravelly sand to provide radiation shielding for site workers and sprayed with herbicides to prevent vegetation growth. Bare gravel surfaces, however, enhance the net infiltration of meteoric water compared to undisturbed, naturally vegetated surfaces. Infiltration is further enhanced in the tank farms by the effect of percolating water being diverted by the impermeable, sloping surface of the tank domes. An umbrella effect is created by the buried tank domes, which for the larger 100-series tanks at WMA C, are 75 ft in diameter. Water that is shed from the tank domes flows down the tank walls into the underlying sediments. Sediments adjacent to the tanks, while remaining unsaturated, can attain elevated moisture levels (WHC-SA-2680-FP, *Effect of Moisture-Dependent Anisotropy and Enhanced Recharge Around Underground Storage Tanks*). Other sources of recharge include unintentional surface spills, infiltration of surface runoff, leaking waterlines, and leaks from ancillary tank-related equipment.

Natural recharge can vary greatly, depending on factors such as climate, vegetation, surface condition, and soil texture. Studies conducted at the Hanford Site suggest that recharge rates can range from less than 0.1 mm/yr on a variety of soil and vegetative combinations to greater than 130 mm/yr on bare basalt outcrops or bare, gravel-covered waste sites ("Variations in Recharge at the Hanford Site," Gee et al.). Data from experimental sites, such as the Field Lysimeter Test Facility and the prototype Hanford barrier (crib B-57), suggest that recharge through gravels can range from 15 to 70% of precipitation, with the lower amount occurring under vegetated conditions (PNNL-11367, *Hanford Prototype-Barrier Status Report: FY 1996*; PNL-10285, *Estimated Recharge Rates at the Hanford Site*; and "Estimating Recharge Rates for a Groundwater Model Using a GIOS" (Fayer et al. 1996). With a long-term annual average precipitation of 160 mm, the higher percentage translates into a recharge rate of approximately 100 mm/yr and was observed on sandy gravels that were kept free of vegetation (PNNL-14744, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*). Drainage is approximately 70 mm/yr from bare sand and approximately 100 mm/yr from sandy gravel under Hanford Site climatic conditions. There has been no direct measurement of recharge on tank farm gravels, which are known to contain a larger amount of fines compared to clean gravels. Thus, it is likely that the tank farms experience a recharge rate that ranges between that observed for bare sand and the rate for clean gravels (i.e., 70 to 100 mm/yr).

1 Recharge estimates based on environmental tracer techniques [Open File Report 94-514, *Using*
2 *Chloride and Chlorine-36 as Soil-Water Tracers to Estimate Deep Percolation at Selected*
3 *Locations on the US Department of Energy Hanford Site, Washington*; and “Geochemical
4 Estimates of Paleorecharge in the Pasco Basin: Evaluation of the Chloride Mass Balance
5 Technique” (Murphy et al. 1996)] are generally consistent with those based on lysimeter studies.
6 However, the tracer techniques are not applicable to disturbed sites such as the tank farms.

7 **2.3.4 Groundwater**

8 The Hanford Groundwater Protection Program has extensively monitored the groundwater in and
9 around WMA C as part of the 200-BP-5 operable unit. At WMA C, the unconfined aquifer is
10 found within the undifferentiated H3/CCU/RF unit. Both water level and general direction of
11 groundwater flow in this region have been altered many times throughout Hanford Site
12 operations history by high-volume wastewater discharges to various ponds (DOE/RL-2008-01,
13 *Hanford Site Groundwater Monitoring for Fiscal Year 2007*; PNNL-16439, *Hanford Site*
14 *Groundwater Monitoring for Fiscal Year 2006*).

15
16 In the 1980s, a groundwater mound in this area was maintained by liquid discharge to B Pond
17 north of WMA C, elevating the water table and imposing a southwestern trend in groundwater
18 flow under WMA C (PNNL-15837, *Data Package for Past and Current Groundwater Flow*
19 *Contamination beneath Single-Shell Tank Waste Management Areas*).

20
21 The aquifer properties beneath WMA C, including hydraulic properties, aquifer thickness,
22 current flow directions, and flow rates are discussed in this section. The discussion focuses on
23 the unconfined aquifer that extends from the water table to the top of basalt. Most of the
24 information in this section is from PNNL-15837, PNNL-13024, *RCRA Groundwater Monitoring*
25 *Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*; PNNL-16439,
26 DOE/RL-2008-01, and RPP-23748.

27
28 Between 1944 and the mid 1990s, the volume of artificial recharge from Hanford Site operations
29 wastewater disposal was significantly greater than recharge from precipitation. An estimated
30 1.68×10^{12} L (4.44×10^{11} gal) of liquid was discharged to disposal ponds, trenches, and cribs
31 during this period. Wastewater discharge has decreased since 1984 and currently contributes a
32 volume of recharge in the same range as the estimated natural recharge from precipitation.
33 Because of the reduction in discharges, groundwater levels are falling, particularly around the
34 operational areas (PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*).

35
36 Several wells extend through the unconfined aquifer in the 200 East Area to the top of the basalt
37 and can be used to determine the thickness of the aquifer. RPP-23748 contains a list of wells
38 near the 200 East Area SST WMAs that penetrate through the entire unconfined aquifer and have
39 water level measurements from March 2005. In FY 2008 a new well, 299-E27-155, was drilled
40 to basalt and installed southwest of WMA C. Based on local and regional data the thickness of
41 the uppermost aquifer increases from north to south as the top of basalt dips into the Cold Creek
42 syncline. The unconfined aquifer thickness ranges from 29 to 55 ft beneath WMA C (Table 2-1).
43

Table 2-1. Thickness of the Unconfined Aquifer Beneath WMA C

Well Name	Elevation of Top of Basalt ^{a,b} (m amsl)	Elevation of Water Table ^c (m amsl)	Aquifer Thickness (m)
WMA C			
299-E26-8	113.02	122.00	8.98
299-E27-22	112.38 ^d	122.18	9.80

(after PNNL-15837 and RPP-23748)

^a Elevation of top of basalt, except where noted.

^b Top of basalt elevation from PNNL-13024, *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site*; PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200 East Area and Vicinity, Hanford Site, Washington*; RPP-14430, and Hanford Well Inventory System.

^c March 2005 data, except where noted.

^d July 2005.

amsl = above mean sea level.

1
2 Current general groundwater flow directions and general flow rates are given in Table 2-2 for
3 WMA C (PNNL-15670, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*). The
4 general flow rate has been unchanged since FY 2005. The most current groundwater flow
5 direction is southwest to south-southwest with a flow rate of 0.09 m/day, based on contaminant
6 migration of sulfate (DOE/RL-2008-01)(see Section 3.2.2). The water table is very flat over all
7 of the 200 East Area; the flow directions given in Table 2-3 were estimated using in-situ methods
8 and plume tracking in addition to interpreting water level data on a local scale (PNNL-15837).
9 No recent published results of detailed hydrologic testing (e.g., tracer dilution tests, constant-rate
10 pumping tests) are available for wells at WMAs C and A-AX. However, recent data are
11 available from slug testing at several wells (see Table 2-3).

12
13 The range of velocities for WMA C is the same in Tables 2-2 and 2-3 because the same
14 hydraulic conductivity values were used.

15
16 Multi-stress slug tests have been done at specific depth intervals in one well at WMA C. The
17 results of those tests (Table 2-3) indicate the ranges in hydraulic conductivity that can be
18 expected within a single well. The data show that the hydraulic conductivity and the calculated
19 flow velocity can be expected to vary by several orders of magnitude within a single well. One
20 similar test was performed at WMA T in the 200 West Area in a well for the Ringold Formation
21 (member of Wooded Island unit E) sediments. The range of hydraulic conductivity in that well
22 was 0.73 to 8.21 m/d. The aquifer for WMA C is in the undifferentiated H3/CCU/RF unit, and
23 the magnitude and range of the hydraulic conductivities is much larger than that found for the
24 Ringold Formation.

25
26 Several slug tests were completed prior to 1997 in wells near the 200 East Area SST farms. The
27 hydraulic conductivities obtained from the earlier slug test ranged from 7 to 119 m/d and were
28 generally lower than those measured in the more recent tests (PNNL-15837). The differences
29 are the result of different testing and analysis methods used over time; different assumed values
30 for certain parameters, such as effective porosity; and natural variation in lithologic properties
31 that affect the hydraulic properties.

Table 2-2. General Groundwater Flow Directions and Flow Rates for Single-Shell Tank WMA C in the 200 East Area

Waste Management Area	Groundwater Flow Direction	Gradient	Groundwater Flow Rate ^{a,b} (m/day)
C	SW - SSW	0.0001	0.7 to 2.4

(from PNNL-15670)

^a Groundwater flow rates are calculated using the Darcy equation.^b The multi-stress slug test was used for the calculation of groundwater flow rate for WMA C.

1

Table 2-3. Results from Slug Testing of Wells at WMA C

Well	Hydraulic Conductivity (m/d)	Calculated Groundwater Flow Rate (m/d)
WMA C		
299-E27-22 ^{a,b} (75.1 – 75.9)	1900 – 2100 ^c	0.7 ^d
299-E27-22 ^{a,b} (76.8 – 77.4)	0.04 ^c	0.00003 ^d
299-E27-22 ^{a,b} (81.4 – 81.7)	6000 – 6900 ^c	2.3 ^d
299-E27-23 ^c	100 – 108 ^c	0.036 ^d

(after PNNL-15837)

^a PNNL-14656.^b Numbers in parentheses are depth intervals tested (meters below ground surface).^c High K (oscillatory) analysis method.^d Estimated, using maximum hydraulic conductivity from this table and effective porosity of 0.3 and hydraulic gradient of 0.0001 from PNNL-15670.^e PNNL-13378, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 1999*; PNNL-13514, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000*; PNNL-14186, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2002*; PNNL-14804, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2003*.

2

3 After the beginning of Hanford Site operations during 1943, the water table rose about 27 m
4 (89 ft) under the U Pond disposal area in the 200 West Area and about 9.1 m (30 ft) under B and
5 Gable Mountain disposal ponds near the 200 East Area. The volume of water that was
6 discharged to the ground at the 200 West Area was actually less than that discharged at the 200
7 East Area. However, the lower hydraulic conductivity of the aquifer near the 200 West Area
8 inhibited groundwater movement in this area resulting in a higher groundwater mound.

9

10 The presence of the groundwater mounds locally affected the direction of groundwater
11 movement, causing radial flow from the discharge areas. PNL-5506, *Hanford Site Water Table
12 Changes, 1950 Through 1980 – Data Observations and Evaluation*, documented changes in
13 water table elevations between 1950 and 1980. Until about 1980, the edge of the mounds
14 migrated outward from the sources over time. Groundwater levels have declined over most of
15 the Hanford Site since 1984 because of decreased wastewater discharges (PNNL-14548, *Hanford
16 Site Groundwater Monitoring for Fiscal Year 2003*; DOE/RL-2008-01).

17

1 Horizontal hydraulic conductivities of sand and gravel facies within the Ringold Formation
2 generally range from about 1 to 100 m/day, compared to 10 to 3000 m/day for the Hanford
3 formation and the coarse-grained multilithic facies of the CCU (pre-Missoula gravels)
4 (DOE/RW-0164, *Consultation Draft: Site Characterization Plan, Reference Repository*
5 *Location, Hanford Site, Washington*; PNNL-13641, 2001. *Uncertainty Analysis Framework –*
6 *Hanford Site-Wide Groundwater Flow and Transport Model*; PNNL-14058, *Prototype Database*
7 *and User's Guide of Saturated Zone Hydraulic Properties for the Hanford Site*). Because the
8 Ringold Formation sediments are more consolidated and partially cemented, they are about 10 to
9 100 times less permeable than the sediments of the overlying Hanford formation. Before
10 wastewater disposal operations at the Hanford Site, the uppermost aquifer was mainly within the
11 Ringold Formation, and the water table extended into the Hanford formation at only a few
12 locations [*Geology and Ground-Water Characteristics of the Hanford Reservation of the*
13 *U.S. Atomic Energy Commission, Washington* (Newcomb et al. 1972)]. However, wastewater
14 discharges raised the water table elevation across the site. The general increase in groundwater
15 elevation caused the unconfined aquifer to extend upward into the Hanford formation over a
16 larger area, particularly near the 200 East Area. This resulted in an increase in groundwater
17 velocity because of both the greater volume of groundwater and the higher permeability of the
18 newly saturated Hanford formation sediments.

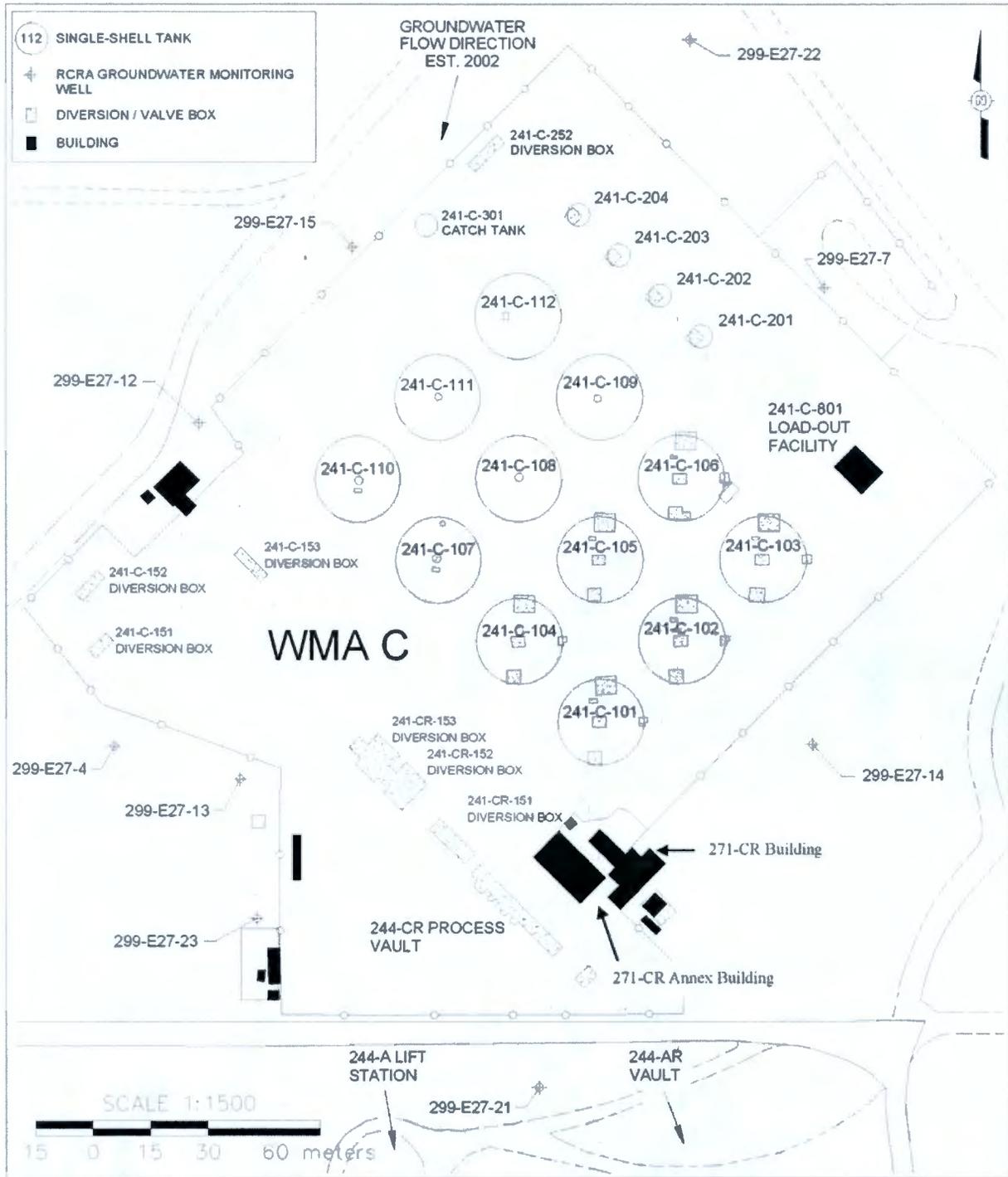
19 **2.4 WMA C DESCRIPTION**

20 Since the Hanford Site started operating in the early 1940s, a large volume of information related
21 to WMA C operations has been collected and evaluated. WMA C encompasses the C Farm
22 located in the east central portion of the 200 East Area (Figure 1-1 and Figure 2-5) including soil
23 and groundwater contaminated by C Farm operations. C Farm was constructed from 1944 to
24 1945, and began operations in the late 1940s. In general, the WMA C boundary is represented
25 by the fenceline surrounding the C Farm.

26
27 The C Farm contains twelve 100-series tanks and four 200-series tanks. The 100-series tanks are
28 23 m (75 ft) in diameter, have a 5-m (15 ft) operating depth, and have an operating capacity of
29 1,892,700 L (530,000 gal) each. The 200-series tanks are 6 m (20 ft) in diameter with a 7.32-m
30 (24 ft) operating depth and an operating capacity of 208,000 L (55,000 gal) each. Typical tank
31 configuration and dimensions are shown in Figure 2-6. Only tanks 241-C-101 (C-101) through
32 241-C-106 (C-106) have the concrete pits as shown in Figure 2-6. The other 100-series tanks are
33 equipped with centrally located saltwell pump pits. The tanks sit below grade with at least 2 m
34 (7 ft) of soil cover to provide shielding from radiation exposure to operating personnel. Tank
35 pits are located on top of the tanks and provide access to the tank, pumps, and monitoring
36 equipment.
37
38
39

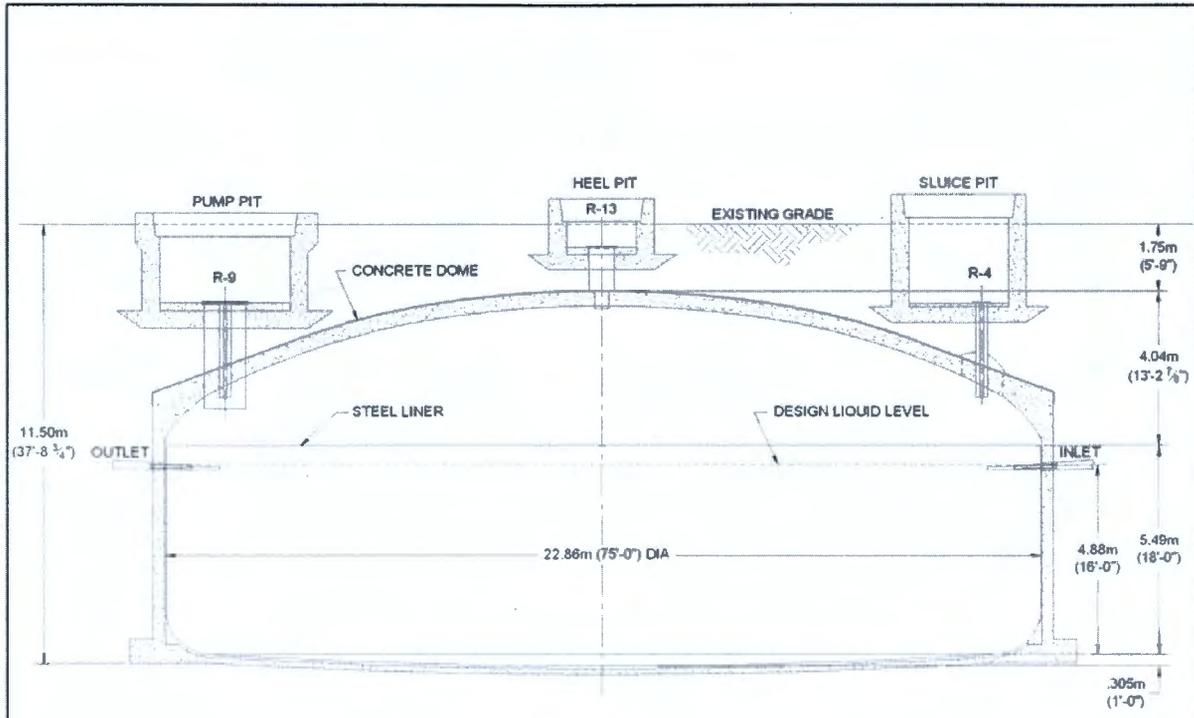
1
2

Figure 2-5. Location Map of WMA C and Surrounding Area

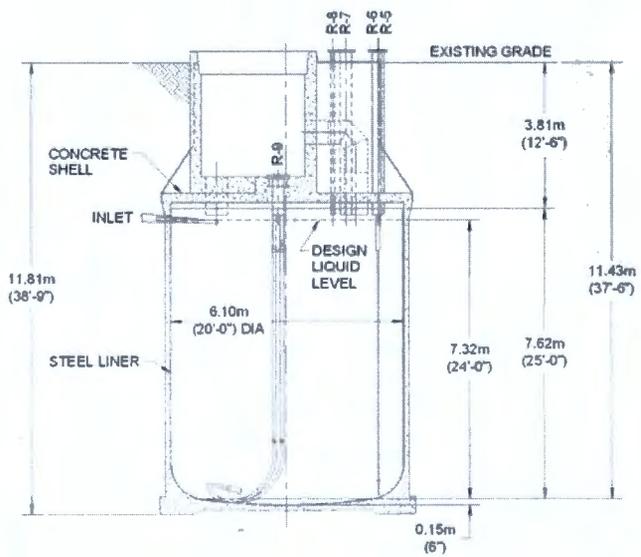


WULPHD\241-C_TF\2F-WMA-C2A

Figure 2-6. Typical Configuration and Dimensions of SSTs in WMA C



241-C-100 SERIES SST
530,000 GALLON CAPACITY

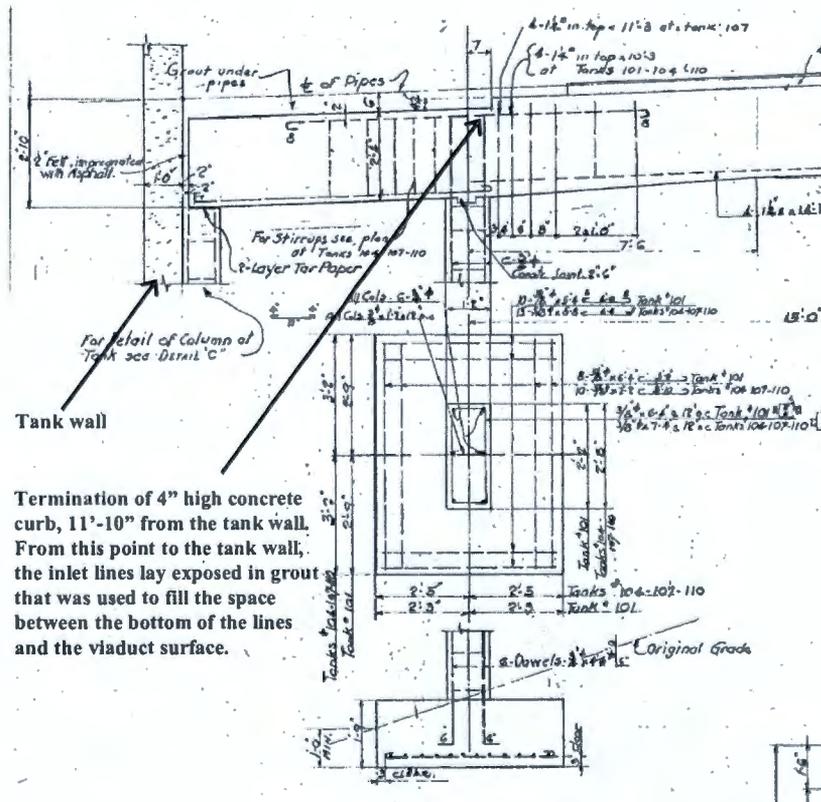


241-C-200 SERIES SST
55,000 GALLON CAPACITY

H:\CHG\241-C TF\2E-WMA-021

1 The SSTs were constructed in place with 3/8-in.-thick carbon steel (ASTM A283 Grade C)
 2 lining the bottom and 1/4-in.-thick carbon steel lining the sides of a reinforced-concrete shell.
 3 The tanks have concave bottoms (center of tanks lower than the perimeter) and a curving
 4 intersection of the sides and bottom, where the carbon steel plate is 5/16-in. thick. The inlet and
 5 outlet lines are located near the top of the liners (Figure 2-6). There are four inlet lines on each
 6 tank, which are also known as nozzles. Pipelines from the diversion boxes to tanks C-101,
 7 C-104, C-107, C-108, C-110, and C-111 are support by concrete viaducts, as shown in
 8 Figure 2-7. The viaduct has a 4-in. high curb running along both edges. The curbing stops about
 9 11 ft 10 in. from the tank wall. At about 9 ft 10 in. from the tank wall, the viaduct surface steps
 10 down and the void space between the pipes and the viaduct surface is grouted. At this point the
 11 viaduct begins fanning out from 2 ft 8 in. wide to 7 ft 4 in. wide to support the spread placement
 12 of the fill lines through the tank wall. The concrete viaduct terminates 2 in. from the tank wall;
 13 the void space is filled with 2-in. asphalt-impregnated felt (drawing W-74108, *Hanford Engineer
 14 Works Building No. 241-T-U-B & C Concrete Details of Pipe Supports*).
 15

16 **Figure 2-7. Concrete Viaduct Supporting Pipelines**



17
 18 Tanks C-101, C-104, C-107, and C-110 each have one outlet line to the next tank in series.
 19 Tanks C-102, C-105, C-108, and C-111 each have one additional inlet line and one outlet line.
 20 Tanks C-103, C-106, C-109, and 241-C-112 (C-112) each have one additional inlet line from the

1 previous tank in the series. The lines connecting each tank are also referred to as "cascade" lines
2 since they allowed transfer of fluids between tanks using gravity flow.

3
4 To support the transfer and storage of waste within WMA C SSTs, there is a complex waste
5 transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, and other
6 miscellaneous structures. Collectively, these are referred to as ancillary equipment, as shown in
7 Figure 2-8.

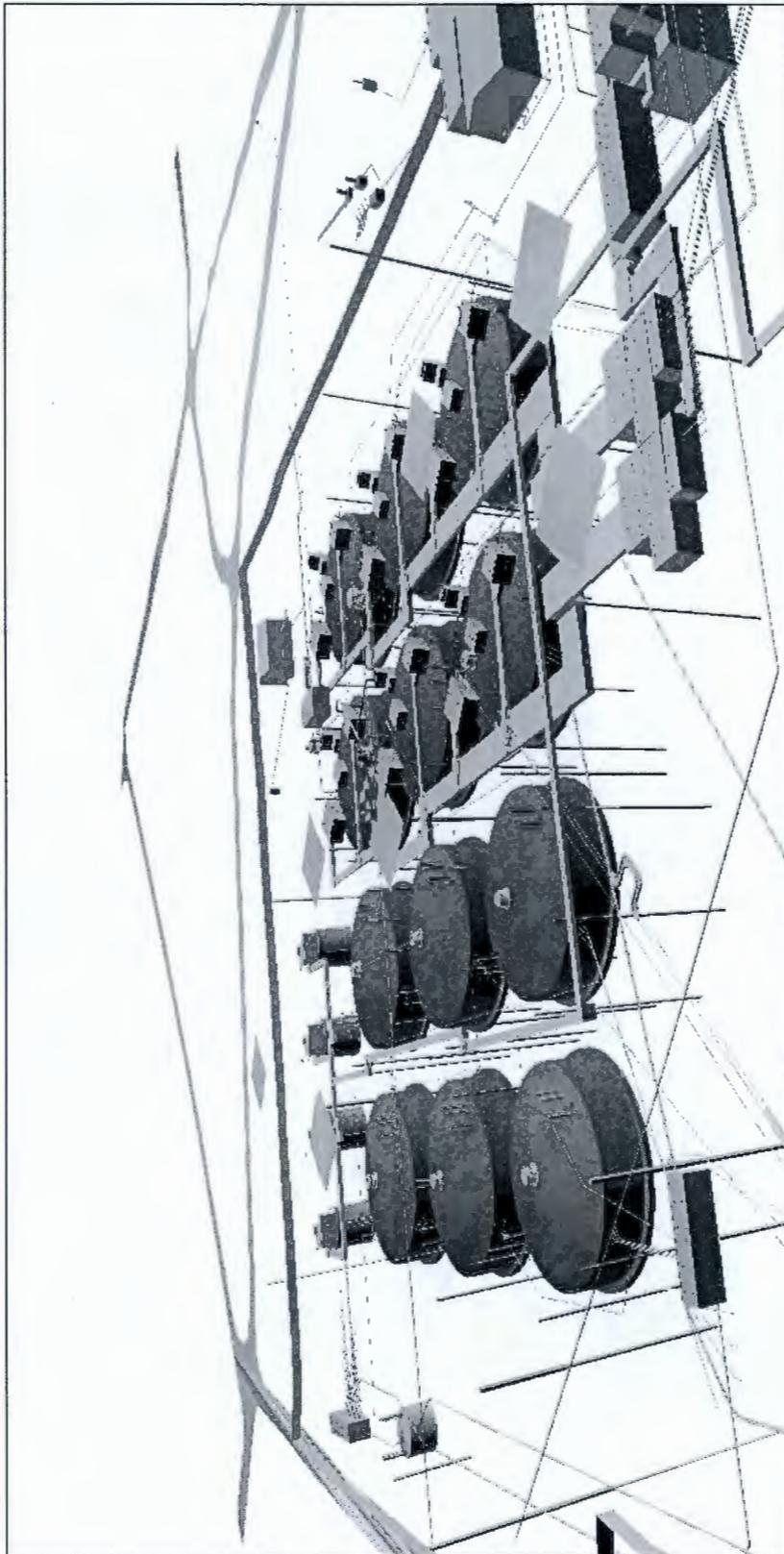
8
9 The 244-CR vault is located south of the tanks. The vault is a two-level, multi-cell, reinforced-
10 concrete structure constructed below grade (DOE/RL-92-04, *PUREX Source Aggregate Area*
11 *Management Study Report*), which contains four underground tanks along with overhead piping
12 and equipment. Two tanks (TK-CR-001 and TK-CR-011) have a capacity of 170,343 L
13 (45,000 gal) each. The other two tanks (TK-CR-002 and TK-CR-003) have capacities of
14 55,494 L (14,700 gal) each. This vault and associated diversion boxes 241-CR-151,
15 241-CR-152, and 241-CR-153 were constructed in 1951 and ceased operating in 1988.
16 A schematic of the 244-CR vault is shown in Figure 2-9.

17
18 The routing of liquid waste from the operations buildings to the tank farms was accomplished
19 using underground transfer lines, diversion boxes, and valve pits. The diversion boxes housed
20 jumpers (remote pipeline connectors) where waste could be routed from one transfer line to
21 another. The diversion boxes are below-ground, reinforced-concrete boxes that were designed to
22 contain any waste that leaked from the HLW transfer line connections. The interior surfaces of
23 diversion boxes were coated with a chemically resistant paint (INDC-356-Vol3, *Construction*
24 *Hanford Engineering Work U.S. Contract Number W-7412-ENG-1 Du Pont Project 9536*
25 *History of the Project Volume III*, page 923). If waste leaked into a diversion box, it generally
26 drained by gravity to nearby catch tanks where any spilled waste was stored and then pumped to
27 SSTs (DOE/RL-92-04). Figure 2-10 shows a schematic of a typical diversion box. There are
28 seven diversion boxes labeled 241-C-151, 241-C-152, 241-C-153, 241-C-252, 241-CR-151,
29 241-CR-152, and 241-CR-153 located in the C Farm. An eighth diversion box, 241-C-154, is
30 located across from the C Farm at the former 201-C Hot (or Strontium) Semiworks site.

31
32 There are three valve boxes and one valve pit in the C Farm. A fourth valve box is located at the
33 former 201-C Hot (or Strontium) Semiworks site. The valve boxes and pit contained valve
34 assemblies that were used for routing the liquid waste through transfer lines. There is a valve
35 box associated with the C-801 load-out facility with a drain to a drywell on the north side of
36 C Farm (H-2-4581, *Valve Pit liner Arrangement*). There is a valve box located on the south side
37 of C-112 at the 6 o'clock position and a valve box located on the south side of C-111 at the
38 6 o'clock position (H-2-2909, *Piping Arrangement & Details First Cycle Waste Scavenging*
39 *241-C Tank Farm*). These two valve boxes drained directly to the soil. There is one valve pit in
40 the C Farm located at about the 9 o'clock position next to C-103 (H-2-73876, *Piping plan*
41 *241-C Tank Farm*). This valve pit is a below-ground culvert with a reinforced-concrete floor
42 with a drain to C-103.

1

Figure 2-8. Tank Infrastructure at WMA C



2

Figure 2-9. Schematic of the 244-CR Vault in WMA C.

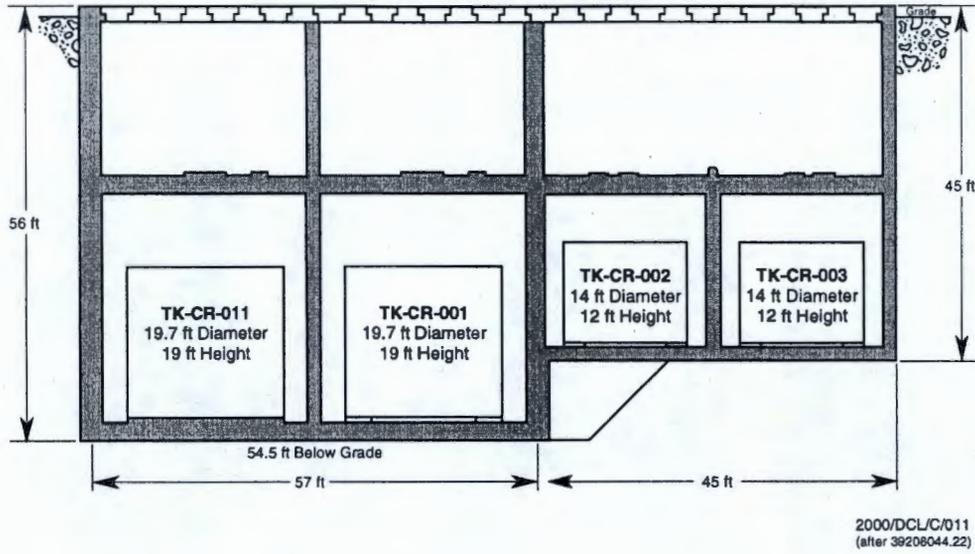
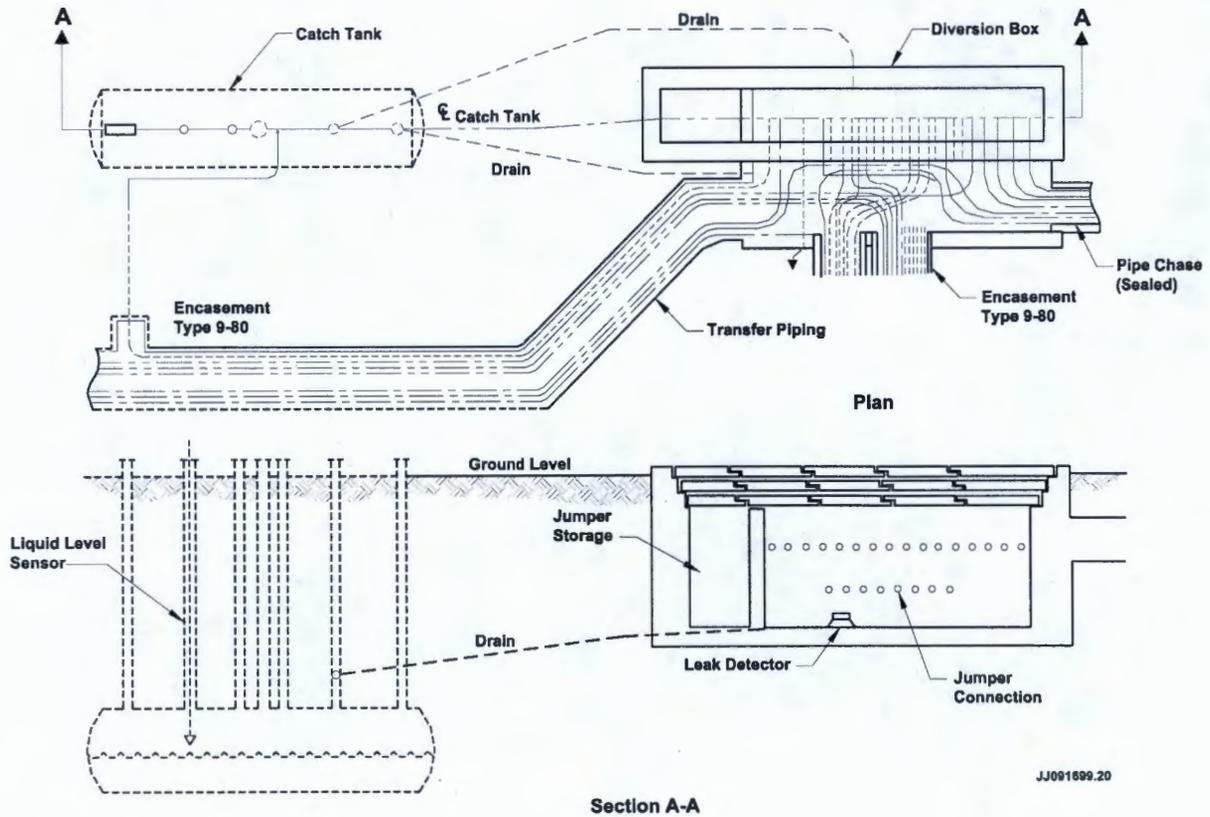


Figure 2-10. Schematic of a Typical Diversion Box Transfer System.



2.4.1 History of WMA C

WMA C was constructed from 1944-1945 and originally consisted of the twelve 100-series tanks, four 200-series tanks, catch tank 241-C-301, four diversion boxes (241-C-151, 241-C-152, 241-C-153, and 241-C-252) and interconnecting pipelines. WMA C was originally designated to receive waste from the planned 221-C Bismuth Phosphate Plant. However, the 221-C Bismuth Phosphate Plant was canceled shortly after excavating the plant foundation. To utilize the tanks in the WMA C, diversion box 241-B-154 was installed to enable connections from the 221-B Bismuth Phosphate Plant to either the 241-B or C Farms (HW-10475-C, *Hanford Technical Manual Section C*, page 906 and 910). Two pipelines (8902 and V130) were installed in late 1945 from diversion box 241-B-154 to diversion boxes 241-C-151 and 241-C-152 to enable use of the tanks in WMA C (H-2-432, *Piping Between 241B and 241C*). Construction of WMA C was completed and turnover of the tank farm structures to operations occurred on February 10, 1945 (HW-7-1388-DEL, *Hanford Engineering Works Monthly Report February 1945*, page 16, and INDC-356-VOL3, page 840).

Following completion of construction, the tanks in the WMA C were not utilized until March 1946, starting with receipt of waste into the 100-series tanks, and receipt of waste in the 200-series tanks in September 1947. The operating history of the 100-series and 200-series tanks in WMA C is uniquely different and discussed separately in Sections 2.4.1.1 and 2.4.1.2. Additional facilities were constructed in WMA C in 1951-1952 and are also discussed in Sections 2.4.1.1 and 2.4.1.2.

2.4.1.1 100-Series Tanks

Bismuth Phosphate Plant Wastes: The 100-series tanks in WMA C began to receive metal waste from the bismuth phosphate process conducted in the 221-B Plant starting on March 12, 1946 (HW-7-3751-DEL, *Hanford Engineering Works Monthly Report March 1946*, page 20). By November 1947, tanks C-101 through C-106 were filled with bismuth phosphate metal waste (HW-8267-DEL, *Hanford Works Monthly Report November 1947*, page 29). Tanks C-107 through C-112 received first cycle decontamination waste mixed with cladding removal waste (designated as 1C/CW) from the 221-B Plant starting on April 24, 1946 (HW-7-4004-DEL, *Hanford Engineering Works Monthly Report April 1946*, page 20) and were filled by September 14, 1948 (HW-11226-DEL, *Hanford Works Monthly Report September 1948*, page 32).

Precipitation of some components (e.g., phosphate, plutonium, and aluminum) in the 1C/CW waste occurred while this waste was stored in tanks 241-C-107 through 241-C-112. Floating head suction pumps were installed in these SSTs, and waste transfer pipelines and jumpers were installed in 1951 to enable removal of the 1C/CW supernatant (H-2-2021 sheet 2, *First Cycle Evaporation 200 East Plot Plan*, and H-2-2076, *First Cycle Evaporation 241 B, C, BX & BY Tank Pump Arrangement & Details*). The floating head suction pump allowed the 1C/CW supernatant to be transferred from these tanks, while leaving the 1C/CW sludge in the tank. The 1C/CW supernatant contained in tanks C-107 through C-112 was transferred to tank 241-B-106 and then processed in the 242-B Evaporator from April 1952 (HW-27838, *Waste Status Summary, Planning and Scheduling Group Waste Control Manufacturing Department, April, May, June 1952*, page 9) to August 1952 (HW-27839, *Waste Status Summary, Planning and*

1 *Scheduling Group Waste Control Manufacturing Department, July, August, September 1952,*
 2 page 20). The concentrated 1C/CW supernatant generated in the 242-B Evaporator was stored in
 3 tanks 241-B-105, 241-B-107, 241-B-108 and 241-B-109. Removal of the 1C/CW supernatant
 4 left some 1C/CW solids in each tank. The supernatant was removed from tanks C-107 through
 5 C-112 to enable the use of these tanks for storage of waste from the 221-U Tributyl Phosphate
 6 (TBP) Plant.

7
 8 New facilities were constructed in WMA C in 1951–1952 to allow removal of the stored metal
 9 waste in C-101 through C-106 (and C-201 through C-204 as discussed in Section 2.3.1.2). New
 10 pump pits, sluice pits, and heel pits were constructed atop of these SSTs for installing waste
 11 retrieval equipment through tank risers. The 244-CR Process Tank Vault was installed for
 12 acidification, dissolution of solids, and blending the retrieved metal waste slurries. Diversion
 13 boxes 241-CR-151, 241-CR-152, and 241-CR-153 along with concrete-encased pipelines were
 14 installed for transferring metal wastes from the SSTs to the 244-CR vault. A control room, the
 15 271-CR building, was also constructed for operation of the 244-CR vault equipment.

16
 17 Beginning in October 1952, the metal waste supernates and solids stored in tanks C-101 through
 18 C-106 were sluiced to the 244-CR vault for acidification, dissolution of solids, blending, and
 19 transfer through the cross-site transfer pipelines to the 241-WR Diversion Station Vault in the
 20 200 West Area (HW-26047-DEL, *Hanford Works Monthly Report for October 1952*, page Ed-4).
 21 Some metal waste supernates from tank BY-109 (241-BY farm metal waste supernate receiver
 22 tank) were also transferred periodically from May 1954 (HW-32110, *Waste- Status Summary;*
 23 *Separations Section, Planning and Scheduling Separations – Operations*, page 4) through
 24 November 1954 (HW-33904, *Waste- Status Summary; Separations Section, Separations –*
 25 *Projects and Personnel Development Sub-section, November 30, 1954*, page 4) to C-104 for
 26 blending in the 244-CR vault. From the 241-WR Vault, the acidic metal waste solutions were
 27 processed in the 221-U TBP Plant for uranium extraction and nitric acid recovery (HW-19140,
 28 *Uranium Recovery Technical Manual*, chapters II and XIII). Nitric acid recovered in the TBP
 29 Plant was returned to the 241-WR Vault and transferred to the 244-CR (and 244-BXR,
 30 244-TXR, and 244-UR) Vaults for use in acidifying and dissolving metal waste slurries retrieved
 31 from the single-shell tanks. Metal waste removal from C-101 through C-106 was completed in
 32 April 1955 (SD-WM-TI-302, *Hanford Waste Tank Sluicing History*, page 84).

33
 34 **Tributyl Phosphate Plant Waste:** Tanks C-101 through C-112 were refilled with waste from
 35 the 221-U TBP Plant as the 1C/CW and metal waste was removed from these tanks. The TBP
 36 Plant waste began to be received in these tanks in November 1952 (HW-27840, *Waste Status*
 37 *Summary Separations Section Period 10/1952 thru 12/1952*, page 20). With the exception of
 38 tank 241-C-104, all of the 11 other 100-series tanks were reported to be filled with TBP Plant
 39 waste by early 1954. Tank C-104 received TBP Plant waste from C-112 in October 1955
 40 (HW-39850, *Waste- Status Summary; Separations Section, Separations – Projects and*
 41 *Personnel Development Subsection*, page 4), since this tank was being used for metal waste
 42 storage until late 1954.

43
 44 In November and December 1955 (HW-40208, *Waste- Status Summary; Separations Section,*
 45 *Separations – Projects and Personnel Development Subsection, November 30, 1955*, page 4; and
 46 HW-40816, *Waste- Status Summary; Separations Section, Separations – Projects and Personnel*

1 *Development Subsection, December 31, 1955, page 4*), TBP Plant supernatant waste was
2 transferred from C-109 to the 244-CR vault for precipitation of cesium and strontium using
3 ferrocyanide (so-called In Farm scavenging).¹ In late December 1955, TBP Plant supernatant
4 waste was transferred from C-101 to the 244-CR vault for In Farm scavenging. The TBP Plant
5 waste along with the ferrocyanide (FeCN) precipitate was discharged to C-109 for settling of the
6 precipitate, with the supernatant then transferred to 216-BC-4 crib (HW-44784, *Radioactive*
7 *Contamination in Liquid Wastes Discharged to Ground at Separations Facilities Through June*
8 *1956, page 20*). Tank C-101 was then refilled with TBP Plant supernatant waste from C-104 in
9 January 1956 (HW-41038, *Waste- Status Summary; Separations Section, Separations – Projects*
10 *and Personnel Development Subsection, January 31, 1956, page 4*).

11
12 In January 1956, TBP Plant supernatant waste was transferred from C-111 to 244-CR vault for
13 In-Farm scavenging of ¹³⁷Cs and ⁹⁰Sr. Tank C-111 then served primarily as one of the settling
14 tanks for FeCN (designated as waste type TFeCN) resulting from in-farm scavenging operations
15 conducted in the 244-CR vault (HW-41812, *Waste Status Summary; Separations Section,*
16 *Separations – Projects and Personnel Development Sub-Section, page 4*). In February 1956, the
17 TBP Plant supernatant waste was transferred from C-108 and C-110 to 244-CR vault for
18 ferrocyanide scavenging of cesium and strontium (HW-41812, page 4). In March and April
19 1956, the TBP Plant supernatant waste was transferred from C-112 and C-105 to 244-CR vault
20 for In-Farm scavenging, and then C-112 was used to receive TFeCN waste (HW-42394, *Waste*
21 *Status Summary; Separations Section, Separations – Projects and Personnel Development*
22 *Sub-Section, February 29, 1956, page 4, and HW-42993, Separations Section Waste- Status*
23 *Summary for April 1956, page 4*).

24
25 In September and October 1956, TBP Plant supernatant was transferred from C-101 to
26 244-CR vault for In Farm scavenging (HW-45738, *Waste- Status Summary; Chemical*
27 *Processing Department, Production Operation – Chemical Processing Department, September*
28 *30, 1956, page 4, and HW-46382, Waste- Status Summary; Chemical Processing Department,*
29 *Planning and Scheduling – Production Operation, October 1956, page 4*). The TBP Plant waste
30 along with the ferrocyanide precipitate (designated as TFeCN waste) was discharged to
31 tank 241-C-112 for settling of the precipitate with the supernatant then transferred to 216-BC-10
32 crib (HW-48518, *Radioactive Contamination in Liquid Wastes Discharged to Ground at*
33 *Separations Facilities Through December 1956, page 19*). In October 1956, part of the TBP
34 Plant supernatant waste in C-107 was In-Farm scavenged (HW-46382, page 4). The TBP Plant
35 supernatant wastes in C-102, C-103, and C-106 were In-Farm scavenged in April and May 1957
36 (HW-50127, *Waste- Status Summary; Chemical Processing Department, Planning and*
37 *Scheduling – Production Operation, April 30, 1957, page 4 and HW-50617, Waste- Status*
38 *Summary; Chemical Processing Department, Planning and Scheduling – Production Operation,*
39 *May 31, 1957, page 4*).

40
41 Tank C-101 continued to be used through 1957 as the feed tank to the In Farm scavenging
42 process conducted in the 244-CR vault. Tank C-101 received TBP Plant supernatant and
43 242-B Evaporator bottoms wastes from the tanks listed in Table 2-4. The scavenged waste was
44 transferred to C-108, C-109, C-111, and C-112 for settling of the TFeCN precipitate before

¹ The 241-C tanks were sometimes referred to as tank 241-CR tanks when used in conjunction with the 244-CR vault for In Farm scavenging operations.

1 discharge to the 216-BC trenches and cribs. The In Farm scavenging of TBP Plant wastes was
 2 completed in January 1958.

3
**Table 2-4. TBP Plant Supernatant and 242-B Evaporator Bottoms Wastes
 Transferred to Tank 241-C-101**

Tank	Volume (gal)	Date	Reference
241-BY-101	455,000	June 1957	HW-51348, ^a page 5
241-BY-102	717,000	June 1957	HW-51348, page 5
241-BY-101	227,000	July 1957	HW-83906-C RD, ^b pages 64
241-BY-103	551,000	July 1957	HW-83906-C RD, pages 64
241-BY-103	162,000	August 1957	HW-83906-C RD, pages 72
241-B-101	228,000	August 1957	HW-83906-C RD, pages 72
241-B-102	424,000	August 1957	HW-83906-C RD, pages 72
241-B-103	297,000	August 1957	HW-83906-C RD, pages 72
241-B-107	265,000	September 1957	HW-83906-C RD, page 80
241-B-108	399,000	September 1957	HW-83906-C RD, page 80
241-B-109	403,000	September 1957	HW-83906-C RD, page 80
241-B-106	379,000	October 1957	HW-83906-C RD, page 88
241-B-112	495,000	October 1957	HW-83906-C RD, page 88
241-BX-110	88,000	October 1957	HW-83906-C RD, page 88
241-BX-110	113,000	November 1957	HW-83906-C RD, page 97
241-BX-111	511,000	November 1957	HW-83906-C RD, page 97
241-BX-108	484,000	November 1957	HW-83906-C RD, page 97
241-BX-109	243,000	December 1957	HW-83906-C RD, page 104

4 ^aHW-51348, *Waste- Status Summary; Chemical Processing Department, Planning and Scheduling – Production*
 5 *Operation June 1, 1957 – June 30, 1957.*

6 ^bHW-83906, *Chemical Processing Dept 200 W Area Tank Farm Inventory & Waste Reports 01/1957 Thru 12/1958.*

7
 8 **PUREX, B Plant, REDOX, and Miscellaneous Wastes:** Following the period of TBP waste
 9 storage, the C-100 series were used to store a wide variety of waste types as indicated by
 10 Table 2-5. The calendar year each waste types were received into each tank is listed in
 11 Table 2-5.

12
 13 Waste receipt into each tank was intermittent. The following is a simplified description of the
 14 waste types received into the C-100 series tanks from 1956 through 1978 (WHC-MR-0132,
 15 *A History of the 200 Area Tank Farms*).

16
 17 With the exception of C-103 and C-106, coating waste from the PUREX Plant was generally
 18 received by all of the C-100 series tanks during 1956-1962. Tank C-102 continued to receive
 19 coating waste from the PUREX Plant until 1968 and also received waste from the thorium
 20 recovery process conducted at the PUREX Plant in 1966. Waste from washing the solvent in the
 21 PUREX Plant (OWW) was generally received into C-102 (1968-1969), C-103 (1973), and C-104
 22 (1969-1972); however, C-110 and C-111 also received OWW in 1956. Tank C-104 also
 23 received waste from the thorium recovery process conducted at the PUREX Plant in 1970. The
 24 OWW contained normal paraffin hydrocarbon, tributyl phosphate, monobutyl phosphate, and
 25 dibutyl phosphate organic compounds. The supernatant fraction of the CW and OWW wastes

Table 2-5. Waste Types Received into 241-C 100-Series Tanks (1956-1978)

Year	C-101	C-102	C-103	C-104	C-105	C-106	C-107	C-108	C-109	C-110	C-111	C-112
1956	TFeCN			CW	CW					OWW	OWW	TFeCN
1957			PSN	CW	CW	PSN/ OWW		TFeCN	TFeCN		CW/ TFeCN	TFeCN
1958				CW	CW							
1959					CW				CW		CW	
1960	CW	CW	CW		CW			CW			CW	CW
1961		CW					CW	CW			CW	HS
1962		CW					CW		HS		HS	HS
1963	PSN	CW	PSN		PSN	PSN					HS	
1964	PSN	CW					HS		HS		HS	
1965		CW	PSN				HS	HS	HS			
1966		TH / CW	PSN				BNW/HS		HS			
1967		CW					HS					
1968		CW/ OWW			PSN							
1969		OWW		OWW	PSN	PSS						
1970			IX	TH/ OWW/ PSN	PSN/ RSN	PSS	IX	OWW/ IX	IX	IX		IX
1971			IX	CW/ OWW	PSS	PSS						
1972			CW/ OWW	CW/ OWW	PSS					IX		
1973			Misc	Misc	PSS		Misc	Misc				
1974			Misc	Misc	PSS	BL						
1975			Misc	Misc	PSS	BL						
1976			Misc	Misc	PSS	BL						
1977						BL						
1978						BL						

Definitions:

Colors in table are used to highlight each waste type

BL B Plant strontium processing wastes and misc. wastes

CW coating waste from PUREX or REDOX Plants

HS 201-C Hot Semiworks waste

IX cesium denuded waste from ion exchange process in B Plant

Misc Sources may include research waste from Battelle Northwest (i.e., BNW) which is now PNNL, reactor decontamination waste, etc.

OWW Organic Wash Waste from PUREX Plant

PSN PUREX HLW supernatant

PSS PUREX Sludge Supernatant derived from washing PUREX HLW sludges in 244-AR Vault or 241-A and 241-AX tanks

RSN REDOX HLW Supernatant

TFeCN Ferrocyanide waste from 244-CR vault treatment of TBP waste

TH Thorium process waste from PUREX Plant

1 were transferred via tanks in the 241-BX Farm to the 241-BY Farm for evaporation in the In-
 2 Tank Solidification system. Settled solids from the CW and OWW wastes accumulated in the
 3 C-100-series tanks.

4
 5 Waste from the 201-C Hot Semiworks (aka Strontium Semiworks) building was received into
 6 C-107, C-108, C-109, C-111, and C-112 from 1961 through 1967. The Hot Semiworks
 7 separated strontium from rare earth fission products from 1960–1967 and in 1967 conducted a
 8 campaign to separate the rare earth elements from a high-level waste (HLW) stream. After
 9 radiolytic decay of the rare earth fission products, the Hot Semiworks wastes were transferred
 10 via tanks in the 241-C and 241-BX Farms to the 241-BY Farm for evaporation in the In-Tank
 11 Solidification system.

12
 13 Tanks C-101 (1963-1964), C-103 (1957, 1963-1966), C-105 (1963, 1968-1970), and C-106 (1957
 14 and 1963) were used to store PUREX HLW supernatant (PSN) from 241-A and 241-AX tanks.
 15 Tanks C-105 (1971 – 1976) and C-106 (1969 – 1971) also received PUREX sludge wash
 16 supernatant (PSS) from 244-CR vault and from 241-A and 241-AX tanks. Tank C-105 also
 17 received REDOX HLW supernatant (RSN) from 241-SX and 241-TX tanks (1970–1971). The
 18 PSN, PSS, and RSN wastes were transferred to B Plant for ion exchange (IX) processing to
 19 separate cesium. Tanks C-107 through C-112 (1970) received waste from the B Plant IX process.
 20 Tank C-106 also received waste from the B Plant strontium separation process (1974-1978).

21
 22
 23 Several other miscellaneous waste streams were routed to tanks C-103 (1973-1976), C-104
 24 (1973-1976), C-107 (1973), and C-108 (1973). These include N Reactor decontamination waste
 25 and waste from research activities at the Hanford 300-Area Laboratories (HLO waste type), also
 26 known as Battelle Northwest (BNW waste type). The Hanford 300-Area Laboratories is now the
 27 Pacific Northwest National Laboratory (PNNL).
 28

29 **2.4.1.2 200-Series Tanks**

30 The operating history of the 200-series tanks is detailed in RPP-15408, *Origin of Wastes C-200*
 31 *Series Single-Shell Tanks*, and briefly summarized here.

32
 33 In September 1947, construction activities were completed to permit utilization of the 200-series
 34 tanks for storage of metal waste from the 221-B Bismuth Phosphate Separations plant
 35 (HW-7795-DEL, *Hanford Works Monthly Report September 1947*, page 26). Prior to this date,
 36 these tanks were empty. Tanks 241-C-201(C-201) through 241-C-204 (C-204) began to receive
 37 metal waste from the 221-B Plant in November 1947 (HW-8267-DEL, page 29) with these tanks
 38 reported as filled in January 1948 (HW-8931-DEL, *Hanford Works Monthly Report January*
 39 *1948*, page 27 and 28, and RPP-15408). In 1951-1952, jet pump pits and concrete-encased
 40 transfer pipelines to the 241-CR-151 master diversion box were installed on tanks C-201 through
 41 C-204 for retrieval of metal waste from these tanks. From December 1953 through February
 42 1955, the metal waste supernatant and sludges present in C-201 through C-204 were
 43 intermittently retrieved and transferred to 244-CR vault and eventually to the 241-WR Vault.
 44 Tanks C-203 and C-204 received cold uranium (i.e., uranium that had not been irradiated in a
 45 reactor) waste from the 202-A PUREX Plant startup testing in November 1955. The cold
 46 uranium waste was removed from C-203 and C-204 in December 1955 and discharged to the

1 216-A-19 ditch (HW-40763, *Separations Section Radiation Monitoring Subsection Monthly*
2 *Progress Report December 1955*, page 6). Tanks C-201 through C-204 were then used from
3 May 1955 through October 1956 to receive and store waste originating from research and
4 development activities conducted at the 201-C Hot Semiworks facility in the 200 East Area of
5 the Hanford Site. The cold uranium waste was removed from C-203 and C-204 before transfers
6 of Hot Semiworks waste into these tanks was conducted.

7
8 Tanks C-201 through C-204 were not used to receive waste after being filled with waste from the
9 Hot Semiworks. The liquid in C-201, C-202, and C-204 was transferred to SST C-104 in 1970.
10 The liquid in C-203 was transferred to SSTs C-104 and 241-C-109 in 1970. Residual liquids
11 were subsequently transferred from these tanks into C-106 in 1980.

12 **2.4.2 Components of WMA C**

13 The components included in WMA C are listed in Table 2-6. This list is extracted from
14 Addendum 1 of RPP-13774, *Single-Shell Tank System Closure Plan*, which incorporates units
15 listed on the RCRA Part A, Form 3, Rev. 8 permit application (DOE W-28/RL-88-21,
16 *Dangerous Waste Permit Application, Form 3*), in addition to RCRA Past Practice (RPP),
17 CERCLA Past Practice (CPP), and miscellaneous storage tank units. The list was modified to
18 correct errors in the dates for the construction of some components as well as their description
19 and was verified using essential drawing H-14-104175, *Waste Transfer Piping Diagram*
20 *200 East Area*. While most WMA C components are physically located within the C Farm
21 fenceline (also the WMA C boundary), some components extend beyond the fenceline (e.g.,
22 pipelines and groundwater) or are located outside the fenceline (e.g., 241-C-154 diversion box).

23 **2.4.3 Process Operations**

24 The waste storage activities in WMA C are discussed in Section 2.4.1. Process operations
25 conducted in WMA C include metal waste retrieval (Section 2.4.3.1), ferrocyanide treatment of
26 tanks wastes (Section 2.4.3.2), strontium/rare earth (Sr/RE) fission products processing
27 (Section 2.4.3.3), PUREX acidified sludge (PAS) processing (Section 2.4.3.4), 241-A tank farm
28 process condensate treatment testing (Section 2.4.3.5), and cesium and technetium recovery in
29 the 241-C-801 Cask Loading Building (Section 2.4.3.6). The 244-CR vault played a pivotal role
30 in all of these process operations except for loading casks in the 241-C-801 Cask Loading
31 Building. In addition, the 244-CR vault was used to collect the supernate and interstitial liquids
32 removed during interim stabilization of tanks in the 241-C Farm (RPP-6029, *244-CR Vault*
33 *Interim Stabilization Project Plan*) as well as supernate and sludge removal from tank
34 241-CX-70 (SD-WM-TI-302, section 4.3). These wastes were transferred from 244-CR vault
35 tanks to double-shell tanks (DST).

Table 2-6. WMA C Components. (7 sheets)

Single-Shell Tanks			
Tank 241-	Constructed	Removed from Service	Constructed Operating Capacity L (gal)
C-101	1943-1944	1970	2,000,000 (530,000)
C-102	1943-1944	1976	2,000,000 (530,000)
C-103	1943-1944	1979	2,000,000 (530,000)
C-104	1943-1944	1980	2,000,000 (530,000)
C-105	1943-1944	1979	2,000,000 (530,000)
C-106	1943-1944	1979	2,000,000 (530,000)
C-107	1943-1944	1978	2,000,000 (530,000)
C-108	1943-1944	1976	2,000,000 (530,000)
C-109	1943-1944	1976	2,000,000 (530,000)
C-110	1943-1944	1976	2,000,000 (530,000)
C-111	1943-1944	1978	2,000,000 (530,000)
C-112	1943-1944	1976	2,000,000 (530,000)
C-201	1943-1944	1977	210,000 (55,000)
C-202	1943-1944	1977	210,000 (55,000)
C-203	1943-1944	1977	210,000 (55,000)
C-204	1943-1944	1977	210,000 (55,000)
Diversion boxes			
Unit 241-	Constructed	Removed from Service	Description
C-151	1944	1985	Interconnected 241-C-152, -153, and CR-151 diversion boxes
C-152	1944	1985	Interconnected 241-B-154 and -153 and C farm, associated with 241-C-301 catch tank
C-153	1944	1985	Interconnected 241-C-151 and -152 diversion boxes
C-154	1965-66	1985	Interconnected B-Plant to Building 201-C Hot Semiworks. Box located at Hot Semiworks (H-2-32887, <i>Promethium Transfer Line Diversion Box Plan, Sections & Det's</i>)
C-252	1944	1985	Interconnected 241-C-151 diversion box and C Farm
CR-151	1952	1985	Interconnected 244-CR vault and C Farm
CR-152	1942	1985	Interconnected 244-CR vault and C Farm
CR-153	1942	1985	Interconnected 244-CR vault and C Farm
244-CR Vault (contains four tanks)			
Tank 244-	Constructed	Removed from Service	Description
CR-011	1951-1952	1988	Transfer of waste solutions from processes and decontamination operations.
CR-001	1951-1952	1988	
CR-002	1951-1952	1988	
CR-003	1951-1952	1988	

Table 2-6. WMA C Components. (7 sheets)

Miscellaneous Tanks	
Facility Number	Description
241-C-301	Catch tank; 36,000-gal capacity 20-ft radius by 20.25-ft tall reinforced-concrete interior painted with two coats of Amercoat Paint (INDC-356-Vol 3, page 923 and W-72903, <i>Hanford Engineering Works – Bld #241 T-U-B 20'-0" Catch Tank Arrangement and Concrete</i>)
CR-003-TK/SMP	Tank/Sump
Miscellaneous Structures	
Facility Number	Description
241-C-801	Cesium loadout facility
Valve Pit/Boxes	
Facility Number	Description
241-C	Valve pit located at 9-o'clock position adjacent to tank C-103
Unknown	Valve box located at 6-o'clock position south of tank C-112
Unknown	Valve box located at 6-o'clock position south of tank C-111
Unknown	Valve box located adjacent to C-801 building
Tank Pits	
Facility Number¹	Description
241-C-01A	Pump pit
241-C-01B	Heel pit
241-C-01C	Sluice pit
241-C-02A	Pump pit
241-C-02B	Heel pit
241-C-02C	Sluice pit
241-C-03A	Pump pit
241-C-03B	Heel pit
241-C-03C	Sluice pit
241-C-04A	Pump pit
241-C-04B	Heel pit
241-C-04C	Sluice pit
241-C-05A	Pump pit
241-C-05B	Heel pit
241-C-05C	Sluice pit
241-C-06A	Pump pit
241-C-06B	Heel pit
241-C-06C	Sluice pit

¹ The pump pits, heel pits, and sluice pits are sometimes labeled as 241-CR-XX-YYY in documentation.

Table 2-6. WMA C Components. (7 sheets)

Tank Pits		
Facility Number²	Description	
241-C-07	No pit, covered saltwell caisson pump pit	
241-C-08	No pit, covered saltwell caisson pump pit	
241-C-09	No pit, covered saltwell caisson pump pit	
241-C-110	No pit, covered saltwell caisson pump pit	
241-C-111	No pit, covered saltwell caisson pump pit	
241-C-112	No pit, covered saltwell caisson pump pit	
Tank Pits		
Facility Number	Description	
241-C-201	Jet pump pit	
241-C-201	Condenser pit	
241-C-202	Jet pump pit	
241-C-202	condenser pit	
241-C-203	Jet pump pit	
241-C-203	Condenser pit	
241-C-204	Jet pump pit	
241-C-204	Condenser pit	
Transfer Lines³		
Line Number	Connecting Facilities	
4012	241-CR-153-U4A	241-AX-151 D, E, F, and G-Cell
4013	241-AX-151 D, E, F, and G-Cell	241-CR-152-U3A
8002	241-C-103-03A-U1	241-CR-152-L13
8006	241-C-102-02A-U1	241-CR-152-L12
8010	241-C-101-01A-U1	241-CR-152-L11
8012	241-CR-152-U9,-U11,-U12	241-CR-151-U4
8014	241-C-103-03C-U1	241-CR-152-L10
8017	241-C-102-02C-U1	241-CR-152-L7
8020	241-C-101-01C-U1	241-CR-152-L9
8025	241-CR-152-U10	241-CR-151-U11
8031	241-C-101-01A-U3	241-CR-152-L14
8032	241-C-103-03A-U2	241-CR-152-U6
8035	241-C-103-03C-U2	241-CR-152-U5
8037	241-C-102-02A-U3	241-CR-152-L15
8038	241-C-102-02A-U2	241-CR-152-U4
8041	241-C-102-02C-U2	241-CR-152-U3

² The pump pits, heel pits, and sluice pits are sometimes labeled as 241-CR-XX-YYY in documentation.

³ Does not include temporary hose-in-hose transfer pipelines.

Table 2-6. WMA C Components. (7 sheets)

Transfer Lines (continued)		
Line Number	Connecting Facilities	
8044	241-C-101-01A-U2	241-CR-152-U2
8047	241-C-101-01C-U2	241-CR-152-U1
8053	241-C-101-01C-U6	3-in. drain from 241-CR-152
8056	241-C-103-03B-U2	Connects to line 8002
8063	241-C-102-02B-U2	Connects to line 8006
8070	241-C-101-01B-U1	Connects to line 8010
8107	241-CR-152-L8	V844/241-CR-151-L8
8114	241-C-101-01B-U3	Capped nearby heel pump pit 241-C-101-01B formerly to C-103
8121	241-C-102-02C-U3	Former saltwell pumping line
8202	241-C-106-06A-U1	241-CR-153-L13
8206	241-C-105-05A-U1	241-CR-153-L12
8210	241-C-104-04A-U1	241-CR-153-L11
8212	241-CR-151-U3	241-CR-153-U9, U11, U12
8214	241-C-106-06C-U1	241-CR-153-L10
8217	241-C-105-05C-U1	241-CR-153-L7
8220	241-C-104-04C-U1	241-CR-153-L9
8225	241-CR-153-U10	241-CR-151-U10
8231	241-C-104-04A-U3	241-CR-153-L14
8232	241-C-106-06A-U2	241-CR-153-U6
8235	241-C-106-06C-U2	241-CR-153-U5
8237	241-C-105-05A-U3	241-CR-153-L15
8238	241-C-105-05A-U2	241-CR-153-U4
8241	241-C-105-05C-U2	241-CR-153-U3
8244	241-C-104-04A-U2	241-CR-153-U2
8247	241-C-104-04C-U2	241-CR-153-U1
8256	241-C-106-06B-U2	Connects to line 8235
8263	241-C-105-05B-U2	Connects to line 8206
8270	241-C-104-04B-U2	Connects to line 8210
8552	241-C-201,-202,-203,-204-U1	241-CR-151-U2
8555	241-CR-151-U5	241-C-201,-202,-203,-204-U2 and U-3
8601	241-CR-151-L1	244-CR-Tank-001
8603	244-CR-Tank-003	244-CR-Tank-001-U2
8609	244-CR-Tank-002-U2	244-CR-Tank-011
8613	244-CR-Tank-003-U2	244-CR-Tank-011
8616	241-CR-151-L5	244-CR-Tank-011-U1
8622	241-CR-151-L3	244-CR-Tank 001-U3

Table 2-6. WMA C Components. (7 sheets)

Transfer Lines (continued)		
Line Number	Connecting Facilities	
8624	241-CR-152-U8	241-CR-151-U7
8625	241-CR-153-U8	241-CR-151-U6
8630	241-CR-152-L1,-2,-3,-4,-5,-6	241-CR-151-U9
8631	241-CR-153-L1,-2,-3,-4,-5,-6	241-CR-151-U8
8644	241-CR-151-U12,-U13,-U15	241-CR-151-U12,-U13,-U15
8647	241-CR-151-L4	244-CR-Tank-003-U1
8648	241-CR-151-L6	244-CR-Tank-002-U1
8656	241-AX-151 connects to header for E thru G Cells	244-CR-Tank-003
8900	201-C Hot Semiworks Valve Box	244-CR-Tank-003-U10
8901/8649/V108/V837	221-B	244-CR-Tank-003-U11
8636/V105	241-CR-151-U1	241-C-151-L6
8653/8618	241-ER-151-L9	241-CR-151-U14
A4013	241-CR-152-U3A	241-AX-151-Washdown Connects to Header for E thru G Cells
Drain Line	241-C-102-02B-U3	241-C-Valve Pit-L1
Drain Line	241-C-103	241-C-Valve Pit
8253 Drain Line	241-C-104-04C-U6	241-CR-153
Drain Line	241-C-104-04B-U3	241-C-Valve Pit-L2
Drain Line	Cut and capped nearby 241-C-107-U1	241-C-Valve Pit-L3
Drain Line	Cut and capped nearby 241-C-108 Saltwell Pump Pit	Capped by 241-C-Valve Pit
Drain Line	Cut and capped nearby 241-C-109 Saltwell Pump Pit	Capped by 241-C-Valve Pit
Drain	241-C-110 Saltwell Pump Pit-U1	241-C-Valve Pit-L4
Drain	241-C-112 Saltwell Pump Pit-U1	241-C-Valve Pit-L5
Drain Line	244-CR-Tank-002	241-CR-151
Drain-301	241-C-106-06C-U8	Metal Filter Drain
Drain-302	241-C-106-06C-U9	Process Building Floor Drain
Drain	241-C-106-06A-U8	SL-100 encasement
SL-100	241-C-106-06A-U9	241-AY-102-02A
SN-200	241-C-106-06C-U6	241-AY-102-02A
Drain	241-C-106-06C-U7	SN-200 encasement
PAS-244	241-ER-153-9	244-CR-Tank-003-U13

Table 2-6. WMA C Components. (7 sheets)

Transfer Lines (continued)		
Line Number	Connecting Facilities	
SN-275	241-C-VP-U1,-U2,-U3,-U4,-U5,-U6	244-CR-Tank-003-U15
Cascade line	241-C-101-N5	241-C-102-B
Cascade line	241-C-102-A	241-C-103-B
Cascade line	241-C-104-A	241-C-105-B
Cascade line	241-C-105-A	241-C-106-B
Cascade line	241-C-107-A	241-C-108-B
Cascade line	241-C-108-A	241-C-109-B
Cascade line	241-C-110-A	241-C-111-N2
Cascade line	241-C-111-N1	241-C-112-B
Unknown	241-C-103-03B-U1	241-C-Valve Pit-L6
Unknown	241-C-104-04B-U3	241-C-Valve Pit-L2
Unknown	241-C-105-05B-U3	Capped by 241-C Valve Pit
Unknown	244-CR-Tank-002	244-CR-Tank-001-U1
V050	241-A-152-L7	241-C-104-R2
V051	241-A-152-L8	241-C-104-R2
V100	241-C-151-L1	241-C-153-U9
V1000	241-CR-152-U1A	244-CR-Tank-003-U14
V1001	241-CR-152-U4A	241-CR-153-U3A
V1002	241-CR-152-U6A	241-CR-153-U1A
V101	241-C-151-L2	241-C-104-04A-U4
V102	241-C-101-N3	241-C-151-L4
V103	241-C-105-N1	241-C-151-L3
V104	241-C-101-N4	241-C-151-L5
V105/8636	241-C-151-L6	241-CR-151-U1
V107	241-C-252-U4	241-C-151-L8
V108/812	241-C-151-U1	244-AR-Tank-002-T9
V109	241-C-151-U2	241-A-101-01A-U2
V110	241-C-151-U3	244-CR-Tank-003-U12
V113	241-C-151-U6	241-AX-101-01A
V113	241-C-151-U6	241-AX-103-03A-1
V-114 Drain Line	241-C-153, 241-C-152 and 241-C-151	241-C-301 Catch Tank
V115	241-C-105-05A-U8	241-C-152-L1
V118	241-C-152-L4	241-C-153-U6
V119	241-C-152-L5	241-C-153-U5

Table 2-6. WMA C Components. (7 sheets)

Transfer Lines (continued)		
Line Number	Connecting Facilities	
V120	241-C-152-L6	241-C-153-U4
V121	241-C-152-L7	Capped
V122	241-C-105-05A-U4	241-C-152-L8
V130	241-B-154-L8	241-C-152-U4
V136	241-C-153-L1	None identified
V137	241-C-111-N6	241-C-153-L2
V138	241-C-110-C3	241-C-153-L3
V139	241-C-110-C2	241-C-153-L4
V140	241-C-110-C1	241-C-153-L5
V141	241-C-153-L6	Capped
V142	241-C-153-L7	Capped
V143	241-C-107-C3	241-C-153-L8
V144	241-C-107-C2	241-C-153-L9
V145	241-C-107-C1	241-C-153-L10
V147	241-C-153-L12	None identified
V148	241-C-104-N3	241-C-153-L13
V149	241-C-104-N2	241-C-153-L14
V150	241-C-104-N1	241-C-153-L15
V-155 Drain Line	241-C-252	241-C-301 Catch Tank
V156	241-C-201-N4	241-C-252-L1
V157	241-C-201-N3	241-C-252-L2
V158	241-C-202-N4	241-C-252-L3
V159	241-C-202-N3	241-C-252-L4
V160	241-C-203-N4	241-C-252-L5
V161	241-C-203-N3	241-C-252-L6
V162	241-C-204-N4	241-C-252-L7
V163	241-C-204-N3	241-C-252-L8
V172	241-C-252-U1	Formerly connected to valve boxes and 241-C-104-R6, 241-C-107-R6, 241-C-108-R6, 241-C-109-R5, 241-C-110-R6, 241-C-111-R6 and 241-C-112-R5
V175	241-C-252-U5	201-C-Hot Semiworks Valve Box
V210/V111	241-B-154-L10	241-C-151-U4
V228	241-CR-153-U6A	241-ER-153-7
V843	241-CR-151-L9	241-C-102-R2
V844	241-CR-151-L8	241-C-102-R2

2.4.3.1 Metal Waste Retrieval

The 244-CR vault, diversion boxes 241-CR-151, -152, and 153, concrete-encased pipelines, and concrete pits atop tanks 241-C-101 through 241-C-106 (heel jet, pump, and sluicing pits) were constructed from 1951-1952 in WMA C. These WMA C facilities were part of other facilities constructed in 241-U, 241-T, 241-TX, 241-B, 241-BX, and 241-BY tanks farms, as well as major modifications of the 221-U Plant, that were used to retrieve and process metal wastes to recover uranium (HW-19140, *Uranium Recovery Technical Manual*). The pits atop of the tanks connect via concrete-encased underground pipelines to the 241-CR-152 and 241-CR-153 cascade diversion boxes, which have underground piping connections to the 241-CR-151 master diversion box (see Section 2.4.2). The 241-CR-151 master diversion box has concrete-encased underground pipelines connecting to the 244-CR vault (see Section 2.4.2).

The 244-CR vault contains a sludge accumulation tank (TK-CR-001), two sludge dissolution tanks (TK-CR-002 and TK-CR-003), and a process pump tank (TK-CR-011). An aboveground nitric acid tank (TK-CR-004) was used to add nitric acid to tanks TK-CR-002 and TK-CR-003 for acidifying sludge. Tank TK-CR-004 was relocated into the 271-CR annex building in 1963 (see Section 2.4.3.5). The 244-CR vault was originally equipped with an air supply and exhaust system that included a glass wool filter, exhaust fan, and stack (291-CR). A control house, building 271-CR, was also constructed to contain instrumentation, motor control centers, air compressors, ventilation, and operations and administrative facilities for operation of the 244-CR vault and metal waste retrieval equipment.

Metal waste sluicing in the C Farm started in October 1952 and completed in April 1955. Supernate was first removed from the tank to be sluiced using a transfer pump. The metal waste supernate was transferred to tank TK-CR-001 in 244-CR vault and then to the 241-WR vault to expose the sludge in the tank to be sluiced. Metal waste supernate was then transferred from tank TK-CR-001 back through two sluice nozzles that were installed in the tank being sluiced. The transfer pump was used to transfer the sludge slurry back to tank TK-CR-001. All waste transfers used the installed underground pipelines and the three diversion boxes, 241-CR-151, 241-CR-152, and 241-CR-153.

When sufficient sludge accumulated in the sludge accumulation tank (TK-CR-001), the sluicing was halted. Accumulated slurry was transferred from tank TK-CR-001 to one of the two sludge dissolution tanks (TK-CR-002 and TK-CR-003) in the 244-CR vault for dissolution with nitric acid. Sluicing could then be resumed to TK-CR-001 until the C Farm tank was emptied or sluicing operations were no longer able to effectively remove sludge. Then, a heel jet pump (installed in the heel jet pit) was used to remove the residual metal waste slurry from the tank to TK-CR-001. A periscope optical system was used to inspect tanks to verify sufficient metal waste sludge made been removed. Sluicing operations were repeated if the periscope inspection revealed significant sludge present in the tank.

The dissolved sludge was transferred from tanks TK-CR-002 and TK-CR-003 to a process pump tank (TK-CR-011). From TK-CR-011, the acidified waste was transferred through an underground stainless-steel pipeline connecting to the 241-CR-151, 241-ER-151, and 241-UX-154 diversion boxes to the 241-WR Vault in 200-West Area. The acidified waste was then transferred from the 241-WR Vault into the 221-U TBP Plant for uranium recovery. Nitric

1 acid recovered at the 221-U TBP Plant was transferred back to the 244-CR vault through a
2 separate underground stainless steel pipeline connecting to the aforementioned diversion boxes.
3 The recovered nitric acid solution was received into TK-004 located above ground at the
4 244-CR vault and was used for acidification of subsequent sludge batches.

5
6 The retrieval and processing of metal waste from the C-200-series tanks was similar to the
7 100-series tanks with the exception of the retrieval equipment. From December 1953 through
8 February 1955, the metal waste supernatant and sludges present in tanks 241-C-201 (C-201)
9 through 241-C-204 (C-204) was intermittently retrieved and transferred to 244-CR vault. A jet
10 pump and a sluicer were installed in each of the C-200-series tanks for removal of the stored
11 metal waste supernate and sludge. Metal waste supernate was used to activate this jet and
12 transfer supernate and sludge from each of the C-200-series tanks to sludge accumulation tank in
13 the 244-CR vault. Once the sludge was exposed in the C-200-series tank, the sluicer was
14 activated using supernate from the slurry accumulation tank in the 244-CR vault. Processing of
15 the metal waste slurry in the 244-CR vault was the same as for the metal waste slurries retrieved
16 from the 100-series tanks.

17 **2.4.3.2 Ferrocyanide Treatment of Tank Wastes**

18 The 244-CR vault, which was previously used for metal waste recovery, was reused for
19 precipitation of ^{137}Cs , ^{90}Sr , and ^{60}Co from TBP wastes. A new chemical make-up facility, the
20 241-C-601 building, was constructed adjacent to the 241-CR-271 control room building.
21 Underground transfer piping to the 244-CR vault and necessary jumpers in diversion boxes also
22 were installed (HW-34487, *Scavenging of Stored TBP Waste*). The 241-C-601 building has
23 since been removed from WMA C. Inside the 241-C-601 building were chemical storage tanks
24 for sodium hydroxide, nickel sulfate, sodium ferrocyanide, and calcium nitrate (HW-38223,
25 *Project CG-603 – 4X Program Design Criteria for Calcium Nitrate Addition Facilities for the*
26 *Scavenging of Stored TBP Wastes*). Strontium nitrate was sometimes substituted for calcium
27 nitrate (HW-38955-REV, *"In-Farm Scavenging" Operating Procedure and Control Data*). The
28 reaction of nickel sulfate and potassium ferrocyanide at pH ~9 with the TBP wastes in the
29 244-CR vault resulted in the precipitation of cesium nickel ferrocyanide. The addition of
30 calcium nitrate (or strontium nitrate) to the TBP wastes resulted in the precipitation of ^{90}Sr .
31 Later, sodium sulfide was also added to some waste batches in the 244-CR vault to promote ^{60}Co
32 precipitation (WHC-MR-0089, *Status of TBP Scavenged Waste August 1955 to October 1957*,
33 and WHC-MR-0110, *Cribbing of Scavenged Waste 200 West Area*).

34
35 Ferrocyanide precipitation processing in the 244-CR vault is reported to have started on
36 November 9, 1955 (HW-38955-REV), and completed in January 1958. The ferrocyanide treated
37 TBP waste, referred to as TFeCN waste, was transferred from 244-CR vault to tanks 241-C-108
38 (C-108), 241-C-109 (C-109), 241-C-111 (C-111), and 241-C-112 (C-112) for settling of the
39 precipitates before discharge to the 216-BC trenches and cribs.

40 **2.4.3.3 Sr/RE Fission Products Processing**

41 The 244-CR vault, the head-end section of the 202-A PUREX Plant, and the 201-C Strontium
42 Semiworks building were used in 1961 through 1963 to recover ^{90}Sr from HLW solutions
43 (HW-66297, *Strontium-90 – Recovery and Lag Storage Interim Program*, and HW-72666, *Hot*
44 *Semiworks Strontium -90 Recovery Program*). Beginning in August 1963, B Plant was used in

1 conjunction with the former three facilities to separate ^{90}Sr and rare earth fission products (^{144}Ce
2 and ^{147}Pm) from HLW solutions. The Sr/RE processing activities were conducted from August
3 1963 through February 1967 (RPP-16015, *Origin of Wastes in Single-Shell Tanks 241-B-110 and*
4 *241-B-111*). None of the SSTs in C Farm received wastes from the Sr/RE processing conducted
5 in PUREX and B Plants. However, C-107, C-108, C-109, C-111, and C-112 did receive waste
6 from the Sr/RE purification processing conducted in the 201-C Strontium Semiworks building
7 (see Section 2.3.1.1).

8
9 The PUREX facility generated a first cycle raffinate solution from the solvent extraction
10 reprocessing of irradiated reactor fuel (i.e., HLW). The first cycle raffinate solution was highly
11 acidic and contained most of the fission products (e.g., $^{89/90}\text{Sr}$, ^{144}Ce , ^{147}Pm , and ^{137}Cs) that were
12 separated from the uranium and plutonium during the reprocessing of irradiated reactor fuel.
13 The acidity of the first cycle raffinate solution was reduced by addition of sugar and digestion at
14 elevated temperature to decompose the nitric acid solution. In a section of the PUREX facility
15 known as the head-end, first cycle raffinate solution was reacted with sodium sulfate and lead
16 nitrate to precipitate strontium and rare earth (i.e., cerium and promethium) fission products
17 (HW-63051, *The Recovery of Fission Product Rare Earth Sulfates from PUREX IWW*, and
18 HW-69534, *Laboratory Development of a Carrier Precipitation Process for the Recovery of*
19 *Strontium from PUREX Wastes*). Lead co-precipitated with strontium and increased the amount
20 of strontium precipitated from the first cycle raffinate solution. The resulting strontium and rare
21 earth precipitate was centrifuged and washed to separate the supernatant, which contained
22 soluble fission products such as ^{137}Cs , $^{95}\text{Zr-Nb}$, and $^{106}\text{Ru-Rh}$. The supernatant containing the
23 soluble fission products (e.g., ^{137}Cs , $^{95}\text{Zr-Nb}$, and $^{106}\text{Ru-Rh}$) was neutralized and transferred to
24 underground storage tanks. The strontium and rare earth precipitate was metathesized to soluble
25 carbonates by addition of sodium carbonate. The strontium and rare earth carbonate precipitates
26 were then dissolved in nitric acid and transferred to B-Plant via 244-CR vault for further
27 processing.

28
29 In B-Plant, the strontium nitrate/rare earth nitrate solutions were processed to form separate
30 solutions containing strontium and rare earths (HW-77016, *B-Plant Phase I Information*
31 *Manual*). The strontium nitrate/rare earth nitrate solution was reacted with oxalic acid to
32 precipitate the rare earths along with lead, leaving strontium in solution. The precipitate was
33 centrifuged to separate the strontium solution from the rare earth precipitate. The strontium
34 solution was stored in B-Plant and transferred periodically to the 201-C Strontium Semiworks
35 building via the 244-CR vault for purification. The rare earth precipitate was dissolved in nitric
36 acid and stored in B-Plant for further processing.

37
38 Lead was removed from the rare earth solution by adding sodium hydroxide solution to form
39 soluble plumbite and insoluble rare earth hydroxide precipitates (HW-81373, *Removal of Lead*
40 *from B-Plant Cerium and Rare Earth Fraction*; RL-SEP-197, *Chemical Processing Department*
41 *Monthly Report December 1964*, page G-2, and HAN-90907, *Monthly Status and Progress*
42 *Report for February 1965*, page 21). The plumbite was separated from the rare earth hydroxide
43 precipitate by centrifugation and discarded to the SSTs. The rare earth hydroxide precipitate was
44 washed with sodium hydroxide solution to remove soluble lead and the wash solution was also
45 discarded to the SSTs. The rare earth hydroxide precipitate was dissolved in nitric acid, stored in
46 B-Plant, and eventually transferred to the 201-C Strontium Semiworks building via 244-CR vault
47 for purification.

1
2 Processing of strontium and rare earth solutions within B-Plant continued until June 1966
3 (HAN-95105-DEL, *Monthly Status and Progress Report for June 1966*, page 15). Separations of
4 strontium and rare earths from the first cycle raffinate solution continued to be conducted in the
5 head-end section of the PUREX facility through February 8, 1967 (HAN-96805-DEL, *Monthly*
6 *Status and Progress Report for February 1967*, page AIII-4). The strontium and rare earth
7 solution was transferred from PUREX to the 244-CR vault for storage from July 1966 through
8 February 1967 while equipment modifications were conducted at B-Plant.

9 **2.4.3.4 PAS Processing**

10 The sludges stored in the 241-A and 241-AX Farms contained high concentrations of ^{90}Sr that
11 required removal to reduce the heat load in these tanks. The sludges in these tanks were sluiced
12 from 1968 through 1978 (SD-WM-TI-302, section 3), with the sludge collected in the
13 244-AR Vault. The ^{90}Sr bearing sludge was washed to remove soluble salts and ^{137}Cs then
14 dissolved in nitric acid in the 244-AR Vault. The dissolved sludge, designated as PAS solution
15 was transferred to the 244-CR vault. From the 244-CR vault, the PAS solution was transferred
16 to B Plant for centrifugation and ^{90}Sr processing using solvent extraction (ARH-CD-691,
17 *Strontium Recovery from PUREX Acidified Sludge*).

18 **2.4.3.5 241-A Tank Farm Process Condensate Treatment Testing**

19 A micro-pilot plant was installed in the 271-CR building and was operated from January 1960
20 through April 1963 to evaluate activated carbon and ion exchange materials for separating
21 organics and fission products from the 241-A Tank Farm Process Condensate (TFPC). The
22 micro-pilot plant was shut down in April 1963 and replaced by an engineering-scale pilot plant
23 that was constructed from 1962 through September 1963 in an annex building adjacent to the
24 271-CR building. The engineering-scale pilot-plant in the 271-CR annex was operated from
25 September 1963 through March 1965 and included a steam stripper, a vertical leaf filter, an
26 electro dialysis unit and a thin bed ion exchanger (Letter 7G420-MEJ-06-007, "Waste Discharged
27 to the 216-C-8 Crib").

28
29 Floor and process drains in the 271-CR and 271-CR annex buildings connected to an
30 underground vitrified clay pipeline that discharged to the 216-C-8 French drain. Letter
31 7G420-MEJ-06-007 summarizes the analyses of the TFPC waste stream located in reference
32 documents as well as the various tests conducted in the 271-CR and 271-CR annex buildings.
33 Although process records are incomplete, a minimum of 31,780 gal of treated TFPC was
34 discharged to the French drain 216-C-8 from January 1960 through March 1965.

35 **2.4.3.6 241-C-801 Cask Loading Building**

36 In 1962, building 241-C-801 was constructed to enable recovery of ^{137}Cs from PUREX HLW
37 solutions. The 241-C-801 building was used from 1963 through 1968 to load cesium and
38 occasionally technetium onto casks containing ion exchange material [Letter
39 7G400-03-SMM-003, "Shipment of Cesium-137 and Strontium-90 from the Hanford Site (1961
40 through 1977)"].
41

1 A cask would be staged in the 241-C-801 building and connected to waste transfer piping at a
 2 shielded enclosure within the 241-C-801 building. Tank waste (PUREX P1 and P2 waste types)
 3 was transferred from C-103 through underground piping to a valve pit located inside 241-C-801.
 4 The tank waste would then flow into the cask, the target radionuclide would be absorbed by the
 5 ion exchange material (Decalso^{®4}), and then waste would flow back to C-102.

6
 7 The 201-C Strontium Semiworks building was also used in conjunction with the C-801 cask
 8 station to demonstrate the separation of ⁹⁹Tc from alkaline HLW solutions. Approximately 1 kg
 9 of ⁹⁹Tc was separated from HLW that was stored in C-Farm SSTs in October 1963
 10 (HW-79377-C, *Chemical Laboratory Monthly Report October 1963*, page C-7; and HW-79480,
 11 *Chemical Processing Department Monthly Report for October 1963*, page G-2). The HLW
 12 solution was passed through a shielded cask in the 241-C-801 building that contained Decalso[®]
 13 ion exchange material to separate cesium. The effluent solution from the cesium cask was then
 14 passed through a separate shielded cask in the 241-C-801 building that contained IRA-401^{®5} ion
 15 exchange material, which adsorbed technetium from the waste solution. The Strontium
 16 Semiworks received the cask that was loaded with technetium in November 1963, eluted and
 17 concentrated the technetium, which was then loaded into a smaller cask for transfer to the
 18 Hanford Laboratories located in the 300 Area (HW-79768, *Chemical Processing Department*
 19 *Monthly Report for November 1963*, page G-2). A second campaign to recover an additional
 20 1 kg of ⁹⁹Tc from HLW stored in C Farm was conducted in August through September 1964 in
 21 the same manner as the first campaign (HW-83876, *Chemical Processing Department Monthly*
 22 *Report for August 1964*, page B-2 and HW-84354, page B-1).

23
 24 The cask loading area within the 241-C-801 building has a drain line connecting to the valve pit.
 25 The valve pit and cask loading area have separate drain lines connecting to a drywell located
 26 outside of the tank farm fence (drawings H-2-4573, *Engineering Flow Diagram, Cesium*
 27 *Loadout Facility*, and H-2-4554, *Plot Plan – Roads Drawing Schedule, Cesium Loadout*
 28 *Facility*). This drywell is located approximately 23 m (75 ft) north of the 241-C-801 building,
 29 outside the tank farm fence (DOE/RL-88-30, *Hanford Site Waste Management Units Report*,
 30 rev. 16, page 659). No record was located that provides information on the volume and types of
 31 wastes potentially discharged to this drywell. An unknown amount of PUREX P1 and P2 waste
 32 types along with decontamination solutions may have been discharged to this drywell as a result
 33 of operations conducted at the 241-C-801 building.

34 2.4.4 Unplanned Releases

35 Fourteen UPRs have occurred within or adjacent to WMA C. The following brief descriptions of
 36 the UPRs are summarized from the Waste Information Data System (WIDS) General Summary
 37 Reports (DOE/RL-88-30) and represent the best information available on the nature and extent
 38 of releases. There is substantial uncertainty in the volume and content of UPRs from
 39 components within the WMA C. The UPR sites will be addressed as potentially contributing
 40 sources to the soil component and will be part of the soil component investigation and cleanup.
 41

⁴ Decalso[®] is a synthetic, sodium aluminosilicate gel manufactured by the Permutit Company, New York.

⁵ IRA-401[®] is a styrene, di-butyl benzene ion exchange bead manufactured by the Rohm and Haas Company, Philadelphia, Pennsylvania.

- 1 a. UPR-200-E-16 is a surface spill that resulted from a leak in an overground transfer
2 pipeline between tanks C-105 and C-108. The surface spill associated with this release is
3 located approximately 18 m (60 ft) northeast of tank C-105 and occurred in 1959. The
4 spilled liquid was classified as coating waste from the PUREX process and was an
5 estimated 50 gal.
- 6 b. UPR-200-E-27 is located just east of the 244-CR vault and extends east beyond the tank
7 farm fenceline. DOE/RL-92-04 indicates the surface contamination was deposited in
8 1960, but does not identify the source(s) of the contamination. However, the November
9 1960 monthly report for the Tank Farm Contractor states the particulate contamination
10 was due to work in 241-C Farm diversion boxes and 244-CR vault (HW-67459,
11 *Chemical Processing Department Monthly Report for November 1960*, pages B-2 and
12 B-3). Since the UN-200-E-27 release consisted of airborne particulate contamination, the
13 impact was limited to the ground surface.
- 14 c. UPR-200-E-68 is wind-borne surface contamination spread from the 241-C-151
15 diversion box. The release occurred in 1985 and was subsequently decontaminated to
16 background radiation levels or covered with clean soil for later decontamination (the
17 source document is inconclusive). Sometime after the release, the 241-C-151 diversion
18 box was opened, flushed, and sprayed with Turco Fabriform⁶ to physically fix
19 contamination to the structure surface.
- 20 d. UPR-200-E-72 occurred in 1985 and is located south of WMA C near the 216-C-8 crib.
21 The source of the contamination was buried contaminated waste. The waste posed little
22 release potential because the contamination was fixed in place with Turco Fabriform. The
23 source of the contamination was determined to be from the burial of previously
24 undocumented contaminated material. The area was surrounded with a chain and posted
25 as a Surface Contamination Area; however, the site is no longer marked or posted. No
26 information regarding the buried material was given in the WIDS report; it is assumed
27 that the contamination extends to the depth of the buried material, but the aerial extent
28 and depth are not known. The volume of contamination was not specified.
- 29 e. UPR-200-E-81 is located northeast of the 244 CR vault near the 241-CR-151 diversion
30 box. It occurred as a result of a leak in an underground transfer pipeline in October 1969.
31 The estimated 36,000 gal of waste leaked from the pipeline consisted of PUREX coating
32 waste. The site was covered with 0.5 m (18 in.) of backfill and clean gravel.
- 33 f. UPR-200-E-82 occurred in December 1969. The source was determined to be the feed
34 line running between tank C-105 and the 221-B building. The leak was discovered near
35 the 241-C-152 diversion box. The liquid release, an estimated 2600 gal, flowed from the
36 vicinity of the 241-C-152 diversion box to the northeast, downgrade, until it pooled into
37 an area measuring approximately 0.46 m² (5 ft²) outside the WMA C fence. The
38 contaminated site was covered with 2 ft of dirt in 1969 (RPP-RPT-29191, *Supplemental*
39 *Information Hanford Tank Waste Leaks*, pages 128-129). The WIDS report states that
40 additional decontamination of the area was performed in 1985. A gunite cap was
41 subsequently installed on the soil surface above this leak location.

⁶ Turco Fabriform is a registered trademark of Turco Products, Westminster, California.

- 1 g. UPR-200-E-86 is a spill that resulted from a leak in a pipeline used to transfer waste from
2 the 244-AR vault to WMA C. The depth of the leaking pipeline was approximately 2 m
3 (8 ft) below ground surface (bgs). The release occurred in March 1971 near the
4 southwest corner of WMA C, outside the fence. The spill consisted of 25,000 Ci of ¹³⁷Cs
5 in an estimated 17,385 gal of waste (RHO-CD-673, *Handbook 200 Areas Waste Sites*).
6 The soils surrounding the pipeline were sampled, and it was determined the
7 contamination had not penetrated below 6 m (20 ft). The contamination plume volume
8 was estimated at 37 m³ (1300 ft³). The surface of the release site has been stabilized with
9 "shotcrete." The release site is demarcated with concrete AC-540 marker posts and signs
10 indicating "Underground Radioactive Material." A gunite cap was subsequently installed
11 on the soil surface above this leak location.
- 12 h. UPR-200-E-91 is located approximately 30 m (100 ft) from the northeast side of the tank
13 farm. It resulted from surface contamination that migrated from WMA C. The date of
14 the occurrence, its areal extent, and the nature of the contamination are not specified.
15 DOE/RL-92-04 states that the contaminated soil was removed, and the area was released
16 from radiological controls.
- 17 i. UPR-200-E-99 is surface contamination that resulted from numerous piping changes
18 associated with the 244-CR vault. It is located south of 7th Street, directly south of the
19 244-CR vault, and was established as a release site in 1980, although the actual
20 occurrence date is unknown. A radiological survey conducted in support of herbicide
21 applications in 1981 found no detectable contamination in the release area. As a result of
22 the radiological survey, surface contamination postings were removed on March 5, 1981,
23 and the area was released from the radiation zone designation.
- 24 j. UPR-200-E-100 is a surface spill of unknown volume and constituents that occurred in
25 1986. It is located about 60 m (197 ft) and east of WMA C and surrounds the 244-A lift
26 station.
- 27 k. UPR-200-E-107 is a surface spill located north of the 244-CR vault inside WMA C.
28 DOE/RL-92-04 states that a spill occurred on November 26, 1952, when a pump
29 discharged an estimated 5 gal of liquid to the ground surface during a pump installation.
30 The spilled waste was TBP waste from 221-U building. Decontamination of the ground
31 and equipment was reported to have been immediately undertaken. "Due to the
32 magnitude of the ground contamination, it was decided to excavate a hole and blade the
33 contamination earth into the hole" (RPP-RPT-29191 page 103).
- 34 l. UPR-200-E-118 is located in the northeast portion of the tank farm and extends north up
35 to about 300 m (1000 ft) beyond the fenceline. It was the result of an airborne release
36 from C-107 that occurred in April 1957. The highest exposure rate was estimated at
37 50 mrem/hour at the ground surface (DOE/RL-92-04).
- 38 m. UPR-200-E-136 is a release in 1969 of 64,345 to 90,840 L (17,000 to 24,000 gal) of
39 waste from C-101. The quantity and type of waste released from C-101 is uncertain
40 (RPP-ENV-33418).

1 n. UPR-200-E-137 occurred when, as stated in WIDS, “water entered tank C-203, migrated
2 through the saltcake, and either became entrained in the saltcake or leaked out of the
3 tank.” The leak was 1514 L (400 gal) of PUREX HLW. The waste in C-203 was
4 subsequently determined to be sludge and was retrieved to a DST in 2006.

5 In addition to the documented UPRs, there are additional events that potentially have resulted in
6 the UPR of wastes within WMA C. Potential sources of additional unplanned waste releases in
7 WMA C include waste losses through spare inlet nozzles or cascade lines and additional pipeline
8 leaks not previously reported in WIDS. These potentially new UPRs were identified through
9 review of the operational history for C Farm (RPP-ENV-33418) and are summarized in the
10 following.

11 The SSTs in WMA C are equipped with horizontal inlet nozzles. Process waste transfer
12 pipelines were inserted through the inlet nozzle and protruded into the tank. As discussed in
13 RPP-ENV-33418, a loose seal was installed around the process waste transfer pipeline at the
14 nozzle. The 100-series tanks are also arranged in four cascades of three tanks each. After filling
15 the first tank in the cascade, waste then flows to the second and once filled, the waste flows to
16 the third and final tank in the cascade.

- 17
- 18 a. Tank waste may have been discharged from the tank inlet nozzles if the waste elevation
19 in the tank exceeded the elevation of the inlet nozzles. Cascade lines which lie below the
20 spare inlets in elevation are also submerged when the waste level exceeds the spare inlet
21 level. The cascade lines consist of a 4-in. schedule 80 pipe welded to the steel liners in
22 the SSTs. The 4-in. pipe is encased inside an 8-in. schedule 80 pipe when traversing
23 between SSTs, but the outer pipe is not sealed to the inner pipe and waste leakage could
24 occur if the inner pipe is breached. When the waste exceeds the operating capacity of the
25 tank, it would appear the waste must find an outlet over the top of the tank liner, breach a
26 weak spot in the cascade line (perhaps where it exits or enters the tank liner), or breach
27 the spare inlet lines. Dates and waste types present in WMA C tanks that filled with
28 waste above the elevation of the spare inlet nozzles are summarized in Table 2-7.
- 29 b. Additional pipeline failures that may have resulted in the loss of tank waste within the
30 C Farm are summarized in Table 2-8. Insufficient information was available to estimate
31 the volume of tank waste potentially discharged to the soil from the spare inlet nozzles or
32 newly identified pipeline failures.

Table 2-7. Potential Waste Losses Through Spare Inlets on WMA C Tanks

Tank	Date	Waste Type Present in Tank
C-101	June 1965–December 1967	Received waste from CR vault. Tank contains CR vault waste (28 kgal), PUREX P2 (452 kgal), and Coating Waste (CWP2) (94 kgal).
C-103	October 1953–March 1957	TBP waste
C-103	June 1961–December 1961	PUREX CWP2
C-104	August 1958	PUREX CWP1
C-104	June 1965–March 1966	After receiving 15,000 gal of unknown waste type (likely PUREX CWP2 based on RL-SEP-332, page B-2) from 244-CR vault, the tank was filled above the spare inlets. Majority of waste in tank is PUREX CWP2
C-105	Pre-October 1967	Waste type unknown; soil contamination found beneath spare inlet nozzles during excavation in October 1967
C-106	November 1951	Water added to metal waste (MW2)
C-106	December 1965–March 1966	PUREX P2 HLW supernate
C-109	June 1961–December 1961	PUREX CWP2
C-109	June 1965–March 1968	Tank received 19,000 gal from 201-C Sr Semiworks (HS). Tank contains 112,000 gal of evaporator bottoms (BT-SltCk), 300,000 gal of PUREX CWP2, and 142,000 gal of Sr Semiworks waste (HS).
C-111	May 1957	TBP waste
C-111	September 1957	Scavenged 242-B BT-SltCk waste (i.e., concentrated 1C/CW and TBP wastes)
C-201	December 1955 – January 1956 June 1961–June 1963	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: This is not waste type HS).
C-202	January 1957–March 1957 June 1957–October 1958 June 1961–December 1963	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: This is not waste type HS). Last waste transferred into tank was 201-C building flush solutions.
C-204	March 1968–March 1970	201-C Hot Semiworks waste from PUREX flowsheet tests (Note: This is not waste type HS) and 201-C building flush solutions.

1

2

Table 2-8. Potential Pipeline Failures Not Previously Reported in DOE/RL-88-30 (2 sheets)

Date	Waste Type	Event Description from RPP-ENV-33418
6-1964	HS - 201C Strontium Semiworks Waste	"The underground process line from the 252-C diversion box to 112 tank, C Tank farm, failed. The failed pipeline was isolated. Jumpers were fabricated and installed to establish a new process route." The failed pipeline is line V172.
11-1964	Cesium Depleted PUREX HLW Supernate (P1)	Installation was completed on an alternative effluent return route from the C-801 (801-C) Cesium Loadout Building to Tank 103-C. See drawing H-2-4574, <i>Process & Service Piping Tanks to Loadout Station</i> for details of this piping. A three-way ball valve was inserted in the C-801 (801-C) effluent return line to SST C-102 to enable routing waste to SST C-103 or C-102.
2-1965	PUREX CWP2	"On February 18, 1965, the 244-CR Vault was found flooded up to approximately the level of the tank tops. Immediate steps were taken to reduce the liquid level by jetting the solution to the 011 Tank. Partial cause of the flooding is attributed to a failure in the coating waste line which enters the 151-CR diversion box. Drainage from this diversion box collects in the 002-CR vault sump. Water from a sampler flush line and drainage from rain and snow contributed to the liquid level in the vault. To date, the 001, 002, and 003 sumps have been emptied, and the 011 sump is being emptied, to the 011 Tank. This liquid is being pumped from the 011 Tank to Tank 103-A in the 241-A Tank Farm. In trying to establish a coating waste routing from the PUREX Plant to the 241-C Tank Farm a leak was also discovered in the underground line adjacent to the 152-A Diversion Box. Because of the two apparent leaks in this line it has been abandoned as being unusable."
3-1965	PUREX CWP2	"A liquid level rise in Tank 103-C, the cesium feed tank, was apparently caused by a failed line in the encasement between the 152-CR diversion box and Tank 102-C which permitted coating waste from the PUREX Plant to leak into the encasement and drain to Tanks 101-C, 102-C, and 103-C via the tank pump pits. Coating waste has been routed through a spare line to Tank 102-C and no further leaks have been detected. The coating waste solution accumulated in Tank 103-C did not significantly affect cesium loading capability as a cask was loaded normally following the incident." Note: Pipeline 8041 is inside a concrete encasement was used to route the PUREX CW to SST C-102 (see drawing H-2-44501, sheet 92). This encasement traverses from diversion box 241-CR-152 along the west side of SSTs C-101, C-102, and C-103. In order for the PUREX CW to drain into SSTs C-101, C-102, and C-103, the encasement containing the failed transfer pipeline must have partially filled with waste. The integrity of this encasement is unknown and may have leaked waste to the soil. Drawing H-2-2338, sheet 45 indicates pipeline 8041 is out of service. Pipeline 8041 connects from nozzle U-3 in the 241-CR-152 diversion box and nozzle U-2 in pit 02C atop SST C-102.
5-1966	PUREX CWP2	"A leak in the PUREX coating waste route (152-CR diversion box) was detected by an abnormal liquid level increase of the 002CR vault sump. The leaking flexible jumper in the 152CR diversion box was replaced." Note: Diversion box 241-CR-152 and 244-CR Vault sump are concrete structures with painted surfaces. It is uncertain whether leaked waste was contained inside diversion box 241-CR-152 and 244-CR Vault sump.

Table 2-8. Potential Pipeline Failures Not Previously Reported in DOE/RL-88-30 (2 sheets)

Date	Waste Type	Event Description from RPP-ENV-33418
Pre-1988	PUREX P2 supernate	<p>Pipeline V-103 - "Earlier investigations of the extremely high levels of contamination found between Tanks 104-C and 105-C (Environmental Protection Deviation Report 87-10). The following observations were documented at the time and were the bases for the conclusion that both tanks were sound:</p> <p>The fill line V-103 was stated to have been abandoned at an earlier date due to pipeline leakage, and the activity noted in DW 30-03-02 could have been due to migration of pre-existing contamination that was first seen in the exploratory scans. This line was part of the old PUREX supernate (PSN) transfer route from Tank 241-AX-101. The material was thermally hot, and water injection was required to maintain a temperature below 60°C. The cause of failure was believed to have been due to thermal shock induced by the intermittent transfers.</p> <p>In-tank photographs failed to show any evidence that either tank was unsound. However, the Tank 241-C-105 photos indicated that the tank had been filled to a level above that of the cascade and sidefill pipelines. The possibility of leakage through the wall penetration seals was discussed.</p> <p>The liquid levels in Tank 241-C-105 and -104 remained at a high level for almost six months after the first exploratory well scans, and the observed activities, including that in DW 30-03-02, had remained stable throughout, whereas seepage from either tank would normally have been seen as steadily increasing radiation at the 35 to 41 feet farm excavation depth. The activity at this depth however has diminished in all wells since 1974."</p>
Unknown	Unknown	Line V112 is identified as a leaker adjacent to diversion box 241-C-151. The date and amount of waste leaker from this pipeline is unknown.

1
2

3. WASTE MANAGEMENT AREA C SITE CHARACTERIZATION EFFORTS

This chapter provides a summary evaluation of sources and current contaminant distribution in the vadose zone and groundwater underlying WMA C. It also identifies potential corrective action objectives and requirements. The information on known and suspected contamination is presented in section 3.1 of RPP-14430 and in RPP-35484. Additional data to support improved understanding of the nature and extent of contamination at WMA C will be collected during the field investigation described in this work plan.

Limited characterization of the soils was completed during the Phase 1 RCRA corrective action process from 2004 to 2007. The characterization effort focused on sites with the highest observed ^{137}Cs contamination (on the order of 10^7 - 10^8 pCi/g). This approach was taken because high inventory levels of mobile contaminants (e.g., ^{99}Tc and nitrate) are invariably associated with high ^{137}Cs content). The results of the Phase 1 characterization efforts are documented in RPP-35484. Additional field characterization activities have been undertaken since the publication of RPP-35484. These activities are described in RPP-35169, *Near Term Data Quality Objectives for Vadose Zone Characterization Waste Management Area C*, and Appendix D of RPP-PLAN-35341, *Work Plan for Near-Surface Vadose Zone Characterization Utilizing the Hydraulic Hammer/Direct Push Technology for 35 Direct Pushes in FY08*. The near-term DQO supports characterization efforts that have been conducted at UPR-86 and UPR-81 at WMA C.

This chapter contains information that could be used for portions of the RCRA TSD closure plans, including the nature and extent of contamination, facility description, and current RCRA interim status groundwater monitoring requirements.

3.1 KNOWN AND SUSPECTED CONTAMINATION

A summary of available data and conditions is needed to effectively develop a characterization plan designed to collect data to support a determination of the presence of contamination at a site caused by a given event or activity. A summary of available WMA C data regarding source, sediments, and groundwater contamination is presented in the following subsections and RPP-ENV-33418 and RPP-35484.

When considering the data in Sections 3.1.1 and 3.1.2, it is important to note the amount of radioactive decay that has taken place since the data were gathered. For example, the half-life of ^{137}Cs is 30.2 years, approximately the time between 1968 and 1998. Thus, ^{137}Cs levels would, in 1998, have been approximately half of their 1968 values. Where possible, the dates for radionuclide inventories have been given, but calculations of the decayed inventories through the present time have not been made.

3.1.1 Sources

The source terms for WMA C are dependent on nuclear and chemical aspects of the processes that generated the waste. The inventory of chemicals and radionuclides lost to the vadose zone in WMA C is a function of the waste types stored in the tanks and other facilities over their decades of use. Because of its long operational history, C Farm received waste generated by all

1 of the major processes as discussed in Section 2.4.3. Best estimates of specific sources for each
2 leak event are provided in RPP-ENV-33418.

3
4 Sources of releases include fluid discharges, tank waste through tank leaks, ancillary equipment
5 leaks, and failures (e.g., diversion boxes, transfer and cascade pipelines). These releases
6 impacted the sediments. These releases are discussed in detail in RPP-ENV-33418.

7
8 Based on reassessment of tank waste loss events in C Farm, C-101 has a loss estimate of
9 20,000 gal. Tank C-105 has an estimated leak loss range from 40 to 2000 gal. The C-105 leak
10 was targeted in the Phase 1 characterization efforts because of the presence of high ¹³⁷Cs
11 (>10,000,000 pCi/g) in drywell 30-05-07. Tank C-110 waste loss appears to be the result of a
12 tank overflow through spare inlet nozzles and is less than 2000 gal. Waste loss from C-111
13 indicates that the liquid level decrease can be attributed to evaporation. Available information
14 on specific leak events is provided in RPP-ENV-33418.

15
16 Leaks from ancillary equipment were observed and recorded when sufficient fluid reached the
17 surface from the buried, but near-surface, sources. The primary parts of the ancillary equipment
18 system responsible for the surface spills appear to be the collection points for fluids being
19 transferred around the tank farm (e.g., diversion boxes, valve pits, and catch tanks).
20 Numerous pipes feed into these collection points. The pipes were frequently attached, detached,
21 and reattached as part of normal operations because the permanent pipelines would become
22 clogged or unusable. Plugging of underground pipelines resulted in waste escaping containment,
23 especially transfer and cascade lines. RPP-ENV-33418 provides information that 11 pipelines in
24 WMA C are known or are suspected to have failed (Table 2-8). In addition, C-101, C-103,
25 C-104, C-105, C-106, C-109, C-201, C-202, and C-204 have potential waste losses from spare
26 inlets (Table 2-7). An effort to investigate these tanks related to spare inlet losses are being
27 conducted under the near-term field sampling activities (RPP-PLAN-35341 Appendix D).

28
29 Other support facilities and other operations within and adjacent to the tank farm may have been
30 sources for contamination. Some of these facilities are listed in the following:

- 31
32 a. A pit for steam cleaning heavy equipment was dug during 1954 northeast of C-103
33 (241-CR Steam Cleaning Pit). The pit has been covered but is not delimited above
34 ground in any way other than being within the C Farm fence (HW-60807, *Unconfined*
35 *Underground Radioactive Waste and Contamination in the 200 Areas, 1959*). Thus, its
36 exact location is unknown.
- 37 b. A 300-ft x 800-ft burial ground, known as dry waste garden #12, went into service in
38 1956, located 500 ft north of the north corner of the C Farm. It received boxed waste
39 from the PUREX Plant containing both plutonium and mixed fission products. One
40 trench was filled, while two are open as of 1959 (HW-60807).
- 41 c. A construction burial ground was completed in 1958. It is a plot 150 ft x 500 ft located
42 2000 ft north of 241-C at the northwest edge of the burning pit. It was used to handle
43 equipment from 293-A construction and the temporary PUREX canyon ventilation
44 barricade used for the new crane addition (HW-60807).

d. The cask loading area within the C-801 building has a drain line connecting to the valve pit. The valve pit and cask loading area have separate drain lines connecting to a drywell located outside of the tank farm fence (drawings H-2-4573 and H-2-4554). This drywell is located approximately 23 m (75 ft) north of the C-801 building, outside the tank farm fence (DOE/RL-88-30, rev. 16, page 659). No record was located providing information on the volume and types of wastes potentially discharged to this drywell. An unknown amount of PUREX P1 and P2 waste types along with decontamination solutions may have been discharged to this drywell as a result of operations conducted at the C-801 building.

3.1.2 Releases to Soils

Fourteen UPRs have occurred in WMA C that were recorded (see Section 2.4.4). Of these releases, only UPR-200-E-82 was investigated as part of the Phase 1 characterization effort. UPR-200-E-82 is a pipeline leak of 2600 gal containing 4.34 Ci/gal of ^{137}Cs . It was chosen for Phase 1 characterization due to the presence of soil samples containing 550,000,000 pCi/g of ^{137}Cs (ARH-1945, *B Plant Ion Exchange Feed Line Leak*).

Section 2.4.4 discusses these UPR sites that have impacted the soils.

Twelve UPRs are known or thought to have occurred within or adjacent to WMA C within the designated DQO boundary. These UPR sites are of the highest priority for characterization as expressed by Ecology. There is uncertainty in the nature and extent of UPRs from components within WMA C. Estimates of contaminant release volumes, inventories, and locations for some UPRs are included in the WIDS. There are several sites mentioned in the source documents and WIDS that do not provide direct indication of some of their locations, making confirmation sampling of the waste sites more difficult.

Consolidated UPRs (i.e., within the WMA C DQO boundary and collectively documented in Appendix B of HFFACO (Ecology et al. 1989) under the operable unit for WMA C (200-PO-3) include the following:

UPR-200-E-16	UPR-200-E-72	UPR-200-E-86	UPR-200-E-118
UPR-200-E-27	UPR-200-E-81	UPR-200-E-91	UPR-200-E-136
UPR-200-E-68	UPR-200-E-82	UPR-200-E-107	UPR-200-E-137

Section 2.4.4 provides a complete discussion of these 12 consolidated UPR sites. Section 2.4.4 has additional UPRs associated in the vicinity of WMA C that are outside the designated DQO boundary. Two of the UPRs are associated with tank leaks [i.e., UPR-200-E-136 (tank C-101) and UPR-200-E-137 (tank C-203)]. An additional two UPRs are outside the designated DQO boundary (UPR-200-E-200-99 and UPR-200-E-100) but are addressed in Section 2.4.4.

In addition, various operations in the tank farm may have contributed to releases to the soils. Floor and process drains in the 271-CR and 271-CR annex buildings connected to an underground vitrified clay pipeline that discharged to the 216-C-8 crib. Letter 7G420-MEJ-06-007 summarizes the analyses of the TFPC waste stream from reference documents as well as the various tests conducted in the 271-CR and 271-CR annex buildings. Although process records are incomplete, a minimum of 31,780 gal of treated TFPC was

1 discharged to the crib 216-C-8 from January 1960 through March 1965. Potential leaks from
 2 pipelines within C Farm may have also impacted the soils as described in Section 2.4.4.
 3 Approximately 10 miles of pipelines exist inside the WMA C fence line boundary. One of these
 4 lines is a candidate for additional investigation under 200-IS-1 (DOE/RL-2002-14,
 5 *Tanks/Lines/Pits/Boxes, Septic Tank and Drain Fields Waste Group Operable Unit RI/FS Work*
 6 *Plan and RCRA TSD Unit Sampling Plan; Includes: 200-IS-1 and 200-ST-1 Operable Units*).

7
 8 As discussed in Section 2.4.3.6, the C-801 cask loading building had process piping going to it as
 9 well as a return line. An additional return line was also completed, providing an alternative
 10 effluent return route from the C-801 cesium load-out building to tank C-103 in November 1964.
 11 See drawing H-2-4574 for details of this piping. A three-way ball valve was inserted in the
 12 C-801 effluent return line to C-102 to enable routing waste to C-103 or C-102. The process
 13 waste stream being treated was a cesium-depleted PUREX HLW supernate (P1). After the ¹³⁷Cs
 14 was removed, 60% of the ⁹⁹Tc was then removed before returning the waste stream to the tanks.
 15 No records were found to explain the need for a second return line, but its construction may
 16 indicate concerns about the integrity of the initial return line and possible waste losses. Section
 17 2.4.3.6 provides more detail, and the line replacement is discussed in Table 2-8.

18
 19 For C-101 and its 20,000-gal leak volume as discussed in Section 3.1.1, soil contamination was
 20 also present. In 1970, several new drywells (30-01-01, 30-01-06, 30-01-09, and 30-01-12) were
 21 installed around C-101. Drywells 30-01-01 and 30-01-12 were installed in March 1970.
 22 Drywell 30-01-06 was installed in January 1970. Drywell 30-01-09 was installed in April 1970.

23
 24 During the drilling of the fourth drywell on March 17, 1970, 5000-10,000 c/m contamination
 25 was encountered at the 38-ft level and drilling was terminated (ARH-1526-1, *Chemical*
 26 *Processing Division Daily Production Reports, January 1970 through March 1970*, page 130).
 27 Drilling of the fourth drywell was resumed on March 18, 1970, and 5000 to 10,000 c/m
 28 contamination was encountered between the 42- and 48-ft level, but after 48 ft, no contamination
 29 was seen (ARH-1526-1, page 132). Drilling of the fourth drywell around C-101 was reported as
 30 being completed on March 24, 1970 (ARH-1526-1, page 138). Contamination was not reported
 31 as being encountered during the drilling of other wells around C-101. It is not clear which
 32 drywell is referred to as the "fourth" in ARH-1526-1. Since this is the last drywell installed
 33 around C-101 in 1970, it is thought that the "fourth" drywell is in reference to drywell 30-01-09.
 34 According to RHO-CD-896, *Review of Classification of the Nine Hanford Single-Shell*
 35 *"Questionable Integrity" Tanks*, page 46, drywell number 30-01-09 was found to have
 36 contamination between the 29- and 36-ft levels when first monitored, which is consistent with
 37 the "fourth" drywell being 30-01-09.

38 **3.2 NATURE AND EXTENT OF CONTAMINATION DETERMINED FROM** 39 **PHASE 1 INVESTIGATIONS**

40 An understanding of the nature and extent of subsurface contamination in the vadose zone in
 41 WMA C is needed to determine where additional characterization efforts are required beyond
 42 Phase 1 and the characterization activities addressed in RPP-35169. For the Phase 1
 43 characterization effort, before the field investigation was conducted, preliminary conceptual
 44 models of the subsurface contamination were developed (RPP-14430) that were based on
 45 historical tank farm operations records (RPP-7494, *Historical Vadose Zone Contamination from*

1 *the A, AX, and C Tank Farm Operations*), geology and hydrology (RPP-14430), and gross
2 gamma and spectral gamma logging data (e.g., RPP-8321, *Analysis and Summary Report of*
3 *Historical Dry Well Gamma Logs for the 241-C Tank Farm-200 East Area*; GJO-HAN-92,
4 *Vadose Zone Characterization Project at the Hanford Tank Farms: Tank Summary Data Report*
5 *for Tank C-110*; GJO-98-39-TAR, *Hanford Tank Farms Vadose Zone: C Tank Farm Report*;
6 GJO-98-39-TARA, *Hanford Tank Farms Vadose Zone: Addendum to the C Tank Farm Report*).
7 For a review of subsurface contamination in the groundwater, see PNNL-13024; PNNL-16439,
8 *Hanford Site Groundwater Monitoring for Fiscal Year 2006*; and DOE/RL-2008-01 with updates
9 in the annual Hanford Site Groundwater Monitoring reports through FY 2007.

10
11 The following discussions concerning the nature of contamination at specific areas within
12 WMA C are organized to first address those sites for which characterization activities were
13 conducted as part of the Phase 1 field investigation. These sites include the potential leak from
14 C-105 and the pipeline leak to the west of C Farm near diversion box 241-C-152
15 (UPR-200-E-82). Additional sites that are known to have contamination are discussed to provide
16 as comprehensive a description of contamination within WMA C as possible. The discussions
17 for other sites are largely based on historical information and are, therefore, less detailed.

18
19 At borehole C4297 near C-105, soil samples were taken at different depths and analyzed for
20 radionuclide and chemical content, and hydrogeologic characteristics. The data from these sites
21 are summarized in this section, with additional soils characterization data provided in
22 RPP-35484; PNNL-15503, *Characterization of Vadose Zone Sediments Below the C Tank Farm:*
23 *Borehole C4297 and RCRA Borehole 299-E27-22*; and DOE/ORP-2008-01.

24
25 At UPR-200-E-82, soil samples were taken from different direct pushes at different depths, and
26 similar analyses were conducted. These data are summarized below with more detailed
27 discussions of these data provided in PNNL-15617, *Characterization of Vadose Zone Sediments*
28 *from C Waste Management Area: Investigation of the C-152 Transfer Line Leak*.
29 Characterization of the UPR-200-E-82 site was selected preferentially over two other UPRs,
30 UPR-200-E-86 and UPR-200-E-81, for the initial characterization effort because of higher
31 reported ¹³⁷Cs contamination (ARH-1945) and more easily interpreted characterization data.
32 From this perspective, additional characterization was considered more likely to significantly
33 improve the understanding of waste distribution in the vadose zone. The other two UPRs
34 (UPR-200-E-86 and UPR-200-E-81) were also pipeline leaks associated with waste transfer
35 facilities west of C Farm. Under the near-term DQO (RPP-35169), the releases from
36 UPR-200-E-81 and the UPR-200-E-86 are presently being investigated.

37
38 After completion of initial plans for WMA C and initiation of field activities, a preliminary
39 surface geophysical exploration (SGE) using a high-resolution resistivity (HRR) technique was
40 implemented at WMA C (RPP-RPT-31558, *Surface Geophysical Exploration of C Tank Farm at*
41 *the Hanford Site*). Although not part of the original characterization plan, this technique has
42 been used at other waste sites in the 200 Areas (PNNL-14948, *Plume Delineation in the BC*
43 *Cribs and Trenches Area*, RPP-RPT-28955, *Surface Geophysical Exploration of T Tank Farm at*
44 *the Hanford Site*; RPP-RPT-30976, *Surface Geophysical Exploration of S Tank Farm at the*
45 *Hanford Site*; RPP-RPT-31557, *Surface Geophysical Exploration of U Tank Farm at the*
46 *Hanford Site*; and showed enough promise to be used at other locations such as WMA C.
47 The objective of the preliminary investigation was to collect and analyze an initial set of

1 resistivity data to identify low-resistivity regions that could be correlated to soil inventory
2 records. The resistivity data was used to aid in selection of locations for conventional sampling
3 and analysis for this work plan. Section 3.2.1.2 provides more information on the SGE
4 deployment and results. Results from these field activities, coupled with evaluation of historical
5 processing records and previous characterization data, have led to a better understanding of the
6 nature and extent of subsurface contamination in WMA C , as described in Section 3.2.1.

7 **3.2.1 Vadose Zone**

8 The major investigation finds from the Phase 1 characterization activities are summarized as
9 follows:

- 10 a. Chemical analyses of sediments retrieved from borehole C4297 near C-105 showed
11 several features characteristic of tank waste vadose zone contamination. These included
12 high ^{99}Tc and nitrate concentrations between 135 and 160 ft bgs and an altered zone just
13 below the tank bottom between 45 and 60 ft bgs with elevated pH values and high
14 sodium content.
- 15 b. A shallower contaminated zone, within borehole C4297 sediments, contained elevated
16 ^{137}Cs and ^{154}Eu concentrations at approximately 13 ft bgs, and a ^{60}Co contamination zone
17 between 40 and 60 ft bgs. This contamination is attributed to loss of waste from one or
18 more transfer lines.
- 19 c. Direct-push sediment sample data around UPR-200-E-82 showed maximum ^{99}Tc and
20 nitrate concentrations at the deepest sampling location, approximately 80 ft bgs, and
21 underneath the estimated leak location. These data suggest that the leak fluids and
22 mobile contaminants have penetrated at least 80 ft bgs and are likely present at greater
23 depths. Recent high ^{99}Tc activity at nearby monitoring wells may indicate that some
24 fraction of this waste has entered the unconfined aquifer.
- 25 d. Surface geophysical exploration in WMA C showed one large anomalous resistivity zone
26 centered around C-104 and a smaller zone between C-108 and C-109. The sources of
27 these anomalies are not well understood nor are the depth intervals at which they occur.

28 **3.2.1.1 Sampling Results**

29 Borehole C4297 was drilled near the source of the C-105 leak near the southwest portion of
30 C-105 and close to drywell 30-05-07 where high ^{137}Cs ($>10^7$ pCi/g) concentrations were
31 measured at and below tank bottom depth. The C4297 borehole laboratory data indicates the
32 following:

- 33 a. An elevated pH zone, 8 to 9.3, between 40 and 52 ft bgs.
- 34 b. Elevated water leachable anion concentrations of nitrate, carbonate, sulfate, chloride, and
35 fluoride occur at discrete depth intervals. Elevated fluoride (1 to 2 $\mu\text{g/g}$) and carbonate
36 (44 to 158 $\mu\text{g/g}$) occur just below the backfill from 40 to 52 ft bgs for fluoride and from
37 40 to 60 ft bgs for carbonate, generally coincident with the high pH zone. Conversely,
38 the highest concentrations of nitrate, sulfate, and chloride are deeper in the vadose zone.
39 Chloride concentrations (3 to 21 $\mu\text{g/g}$) are highest between 135 and 196 ft bgs, nitrate
40
41

1 concentrations (11 and 20 $\mu\text{g/g}$) are highest between 133 and 195 ft bgs, and sulfate
2 concentrations (52 to 133 $\mu\text{g/g}$) are highest between 133 and 161 ft bgs.

- 3
- 4 c. Variable water leachable concentrations of cations (sodium, calcium, magnesium, and
5 strontium) occur at discrete depth intervals. Sodium concentrations are elevated (32 to
6 131 $\mu\text{g/g}$) between 40 and 60 ft bgs, coincident with the high pH zone. A secondary zone
7 of slightly elevated sodium concentrations (20 to 24 $\mu\text{g/g}$) occurs in the backfill between
8 12 and 40 ft bgs. Calcium, magnesium, and strontium are clearly concentrated (25 to 30,
9 8 to 11, and 0.12 to 0.14 $\mu\text{g/g}$, respectively) between 133 and 137 ft bgs. Conversely,
10 these cations are depleted (< 2 , < 0.5 , and < 0.004 $\mu\text{g/g}$, respectively) in the high sodium
11 concentration zone between 40 and 60 ft bgs (see Figure 3-1).
- 12
- 13 d. Water leachable concentrations of trace constituents (^{99}Tc , uranium, and molybdenum)
14 are present at distinguishable concentrations with depth (see Figure 3-2). Technetium-99
15 is present between 40 and 159 ft bgs, and concentrations are bimodal with depth. Highest
16 concentrations (0.4 to 8.4 pCi/g) occur from 133 to 154 ft bgs, with less elevated
17 concentrations (0.14 to 2.6 pCi/g between 40 and 66 ft bgs). Elevated uranium
18 concentrations (0.007 to 0.01 $\mu\text{g/g}$) occur between 40 and 60 ft bgs, coincident with the
19 high pH zone. Molybdenum is elevated (0.01 to 0.1 $\mu\text{g/g}$) between 55 and 65 ft bgs.
- 20
- 21 e. Gamma energy analysis for gamma-emitting radionuclides indicated ^{137}Cs activity
22 (between 3 and 32 pCi/g) near the surface (2 to 12 ft bgs) and ^{60}Co (between 0.1 and
23 0.5 pCi/g) at greater depth (41 to 66 ft bgs).
- 24

25 Characterization data pertinent to the tank waste release from pipeline V122 (UPR-200-E-82)
26 west of the C Farm in 1969 are summarized in this section. The types of available data include
27 sediment sample analyses from 20 vertical direct-push probeholes surrounding the
28 UPR-200-E-82 site, a gunite cap covering the pipe leak, and six slanted direct-push probeholes
29 that were directed underneath the cap from peripheral locations. Integration of this information
30 leads to the following key observations.

31

32 Water extracts from recovered vadose zone sediment samples are routinely high in nitrate and
33 sodium with respect to water extracts from ambient sediments collected at a site not contacted by
34 tank waste (water extract data from the H2 Hanford formation sediments collected at
35 borehole 299-E33-338 south of the B Farm are used for comparison). In numerous instances,
36 pH values are also more alkaline. These observations indicate that essentially the entire area
37 investigated by these direct-push probes has been contacted by alkaline and enriched nitrate and
38 sodium fluids.

39

40 Water extracts of sediments from vertical probehole data show two distinct near-surface areas
41 (10 to 20 ft bgs) contaminated by ^{99}Tc (up to 3.3 pCi/g dry sediment) and Hanford-processed
42

Figure 3-1. Distribution of pH and Major Anions and Cations in Borehole C4297 Sediments

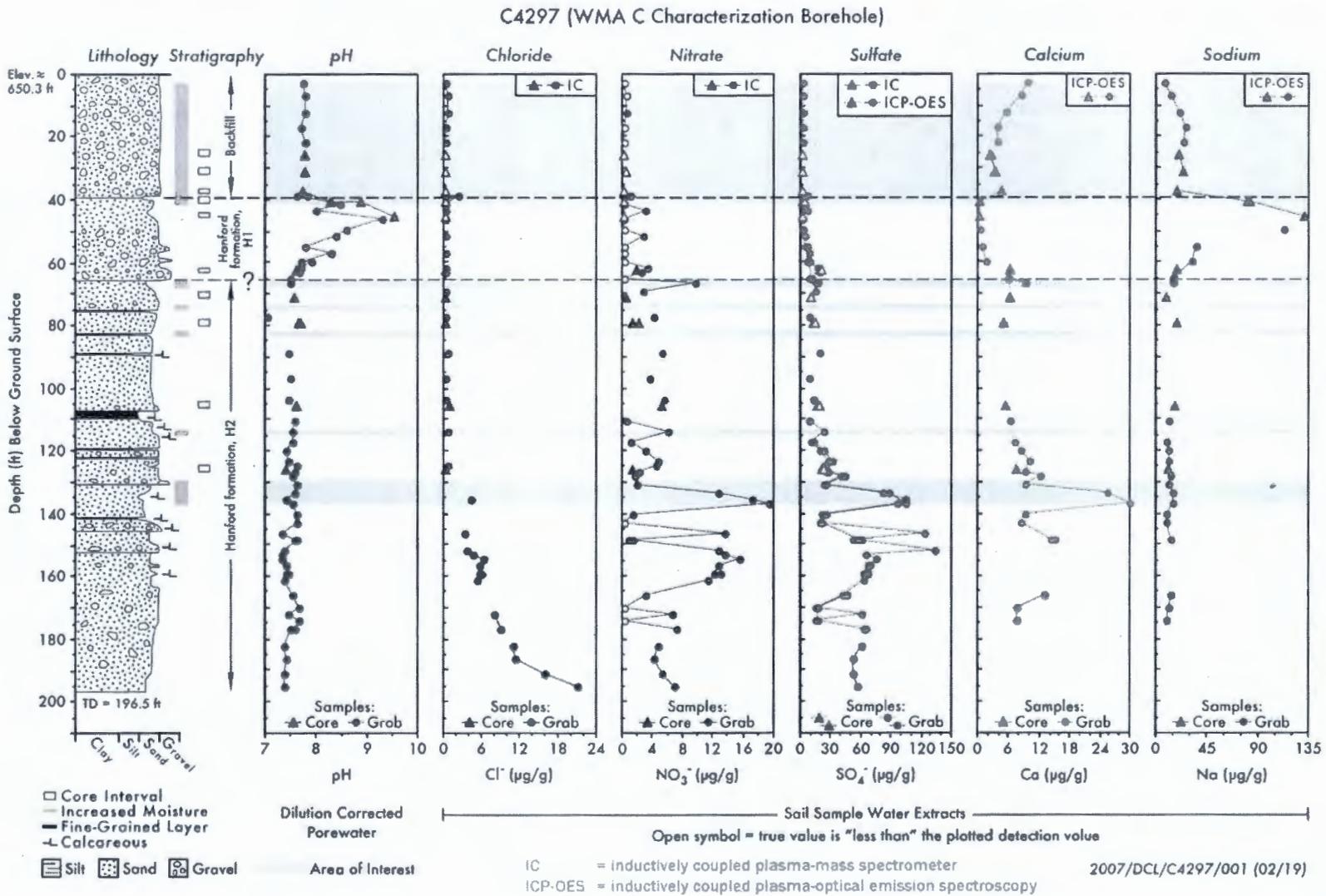
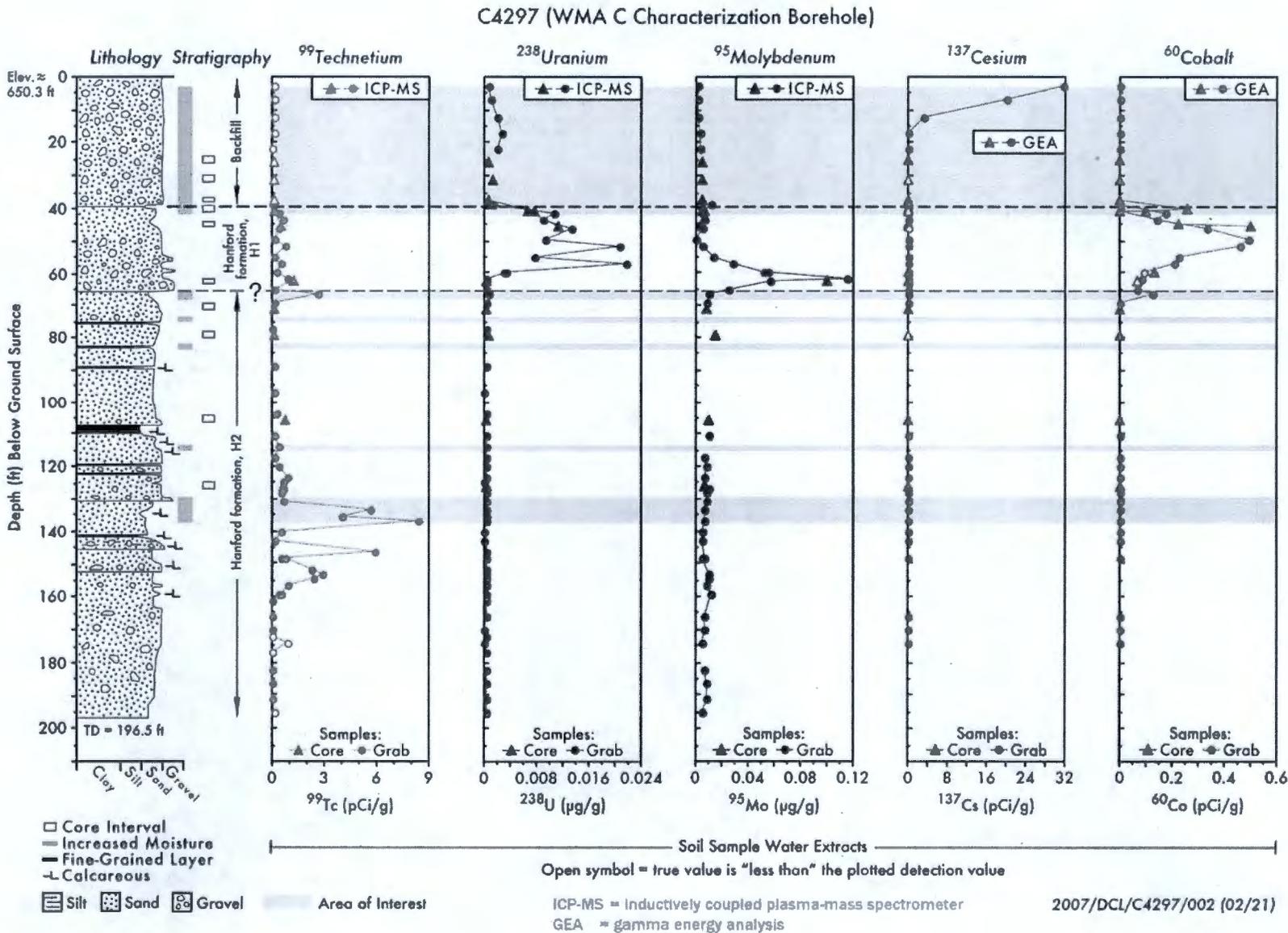


Figure 3-2. Distribution of Trace Mobile Constituents in Borehole C4297 Sediments



1
2
3

4
5

1 uranium (up to 0.77 $\mu\text{g/g}$ dry sediment). These areas are just to the southwest and northeast of
2 the UPR-200-E-82 site leak location and may indicate the lateral extent of the leak. Water
3 extract data show varying degrees of alkalinity and enrichment in sodium and nitrate.
4 Slant probehole data closest to the UPR-200-E-82 site leak location and sampled at the greatest
5 depth (approximately 80 ft bgs) show maximum and coincident water extractable ^{99}Tc (10 to
6 30 pCi/g dry sediment) and nitrate (10 to 20 $\mu\text{g/g}$ dry sediment).

7
8 From the information presented in RPP-35484, it is concluded that the UPR-200-E-82 site tank
9 waste fluids have migrated to at least 80 ft bgs since the leak event in 1969. Conversely,
10 estimates of the lateral extent of the leaked fluid are less certain. The more contaminated zones
11 to the southwest and northeast of the breached pipeline location are consistent with lateral
12 spreading of that leak but may also be an indication of separate leak events. Both of these
13 locations are close to diversion boxes and associated extensive pipeline infrastructure typical of
14 diversion boxes. Given the ubiquitous sodium and nitrate enrichment in water extracts from
15 sediments throughout the sampled area, multiple losses of waste fluids are plausible.

16
17 At the C-108/C109 anomaly, neither of the drywells within the anomaly footprint contain
18 significant levels of gamma-emitting contamination. The closest indication of a source term is at
19 drywell 30-08-02, where ^{137}Cs and ^{154}Eu peak at approximately 20 ft bgs, suggesting another
20 transfer line leak. Examination of more recent geophysical logging shows at least four episodes
21 of contamination in this drywell: one prior to 1976, between 1989 and 1997, between 1997 and
22 2002, and between 2002 and 2006. In each episode, ^{60}Co appears to have started at
23 approximately 40 ft bgs and moved downward to approximately 80 ft bgs. Whether this leak is
24 related to the apparent anomaly just to the west is unclear. Soil chemistry data from borehole
25 C4297 can be used to estimate major aqueous species.

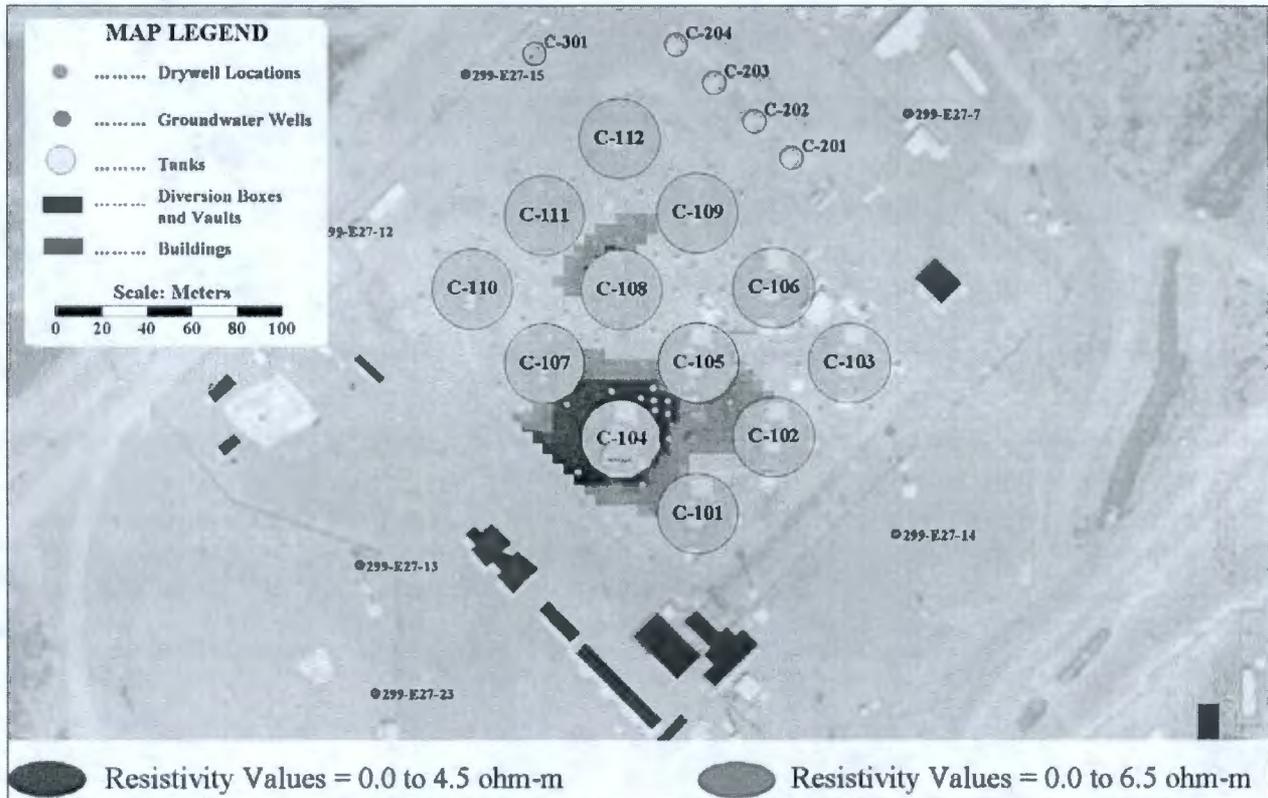
26 3.2.1.2 Preliminary Surface Geophysical Exploration Results

27 In August 2005, a reconnaissance-level geophysical survey of C Farm was made using electrical
28 resistivity techniques (RPP-RPT-31558). The usefulness of this technique was predicated on the
29 concept that the intrinsic ability of vadose zone soils to conduct electric current can be changed
30 with the addition of high salt waste fluids. If so, measurable contrasts in conductivity (or the
31 inverse property resistivity) between contaminated versus uncontaminated soils can occur. In
32 particular, increases in nitrate and sodium content in contaminated soil are hypothesized to
33 facilitate soil conductivity properties, thereby lowering measured resistivity values. By passing
34 electric current through large volumes of soil using numerous transmission pathways, a
35 qualitative, three-dimensional picture of waste distribution may be derived. The additional
36 advantage of this method is that large volumes of soil can be tested fairly easily in this manner.

37
38 The preliminary geophysical investigation was performed by collecting resistivity data using
39 69 drywells within the tank farm and with a set of eight monitoring boreholes (e.g., groundwater
40 wells), one buried electrode installed in the west end of the tank farm, and four surface electrode
41 arrays outside of the farm. The four surface electrode arrays were run parallel to the tank farm
42 fenceline. Only the well-to-well electrode readings provided resistivity data having the capability
43 to identify and delineate contaminant plume features within and around tank farms.

1 Areas of low resistivity are shown in Figure 3-3 for the C Farm. Areas with low resistivity are
 2 most likely associated with increased soil and/or inorganic salt concentration provided by waste
 3 solutions contacting vadose zone soil. Specific areas of low-resistivity values within the C Farm
 4 are a region near tanks C-101, C-102, C-104, C-105, and C-107, along with a smaller low-
 5 resistivity zone near C-108.
 6

7 **Figure 3-3. Well-to-Well Surface Geophysical Exploration Results for Drywells Only**

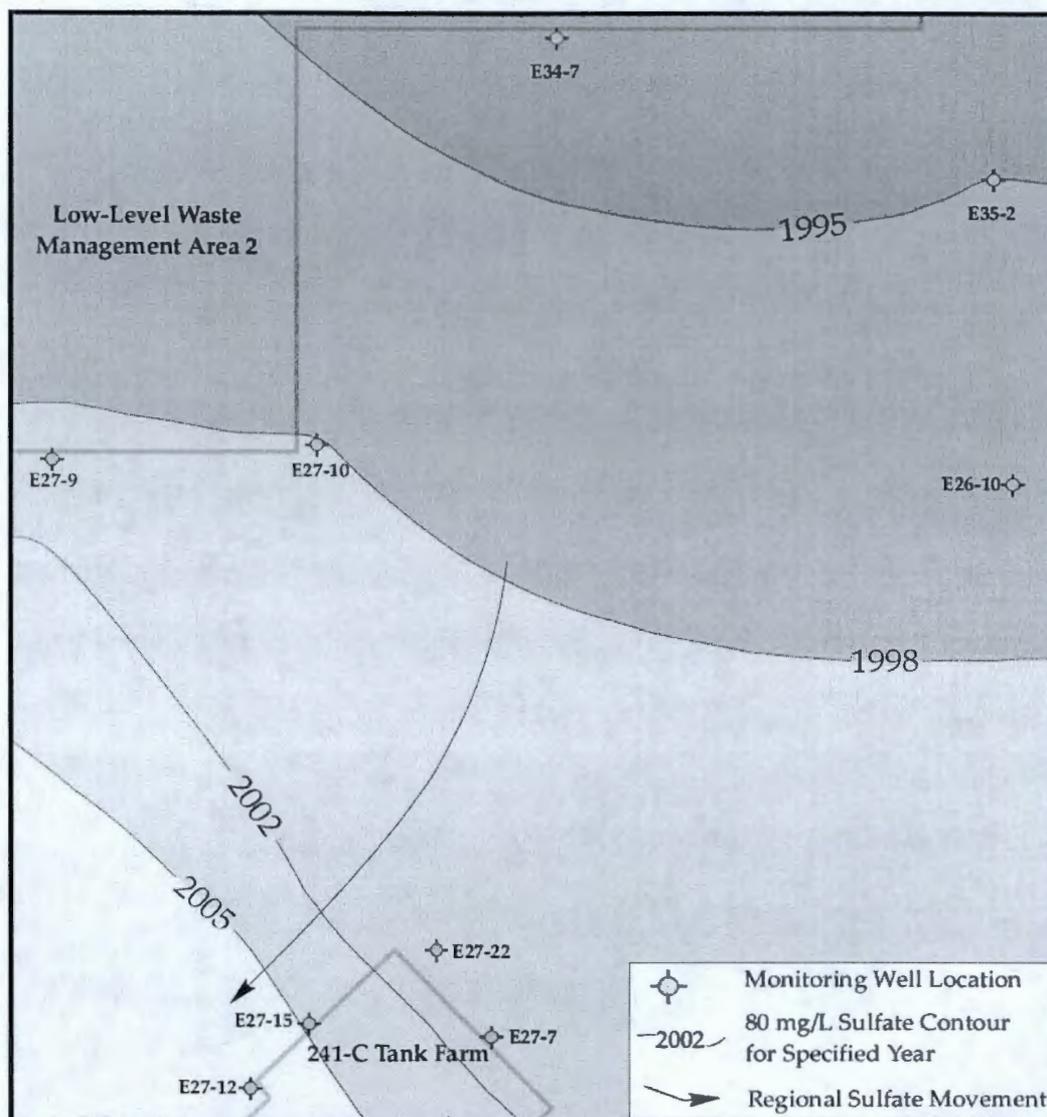


8

9 **3.2.2 Groundwater**

10 The primary contaminants observed at this site are sulfate, ⁹⁹Tc, and nitrate. Also, there are
 11 elevated chloride concentrations and low levels of cyanide at some wells. Sulfate concentrations
 12 are influenced by high levels of regional sulfate contamination migrating into the area from the
 13 northeast as the aquifer recedes towards a pre-Hanford water table (Figure 3-4). A time series of
 14 the 80 mg/L contour illustrates the movement of sulfate into and across WMA C to the
 15 southwest. The source of the sulfate associated with the draining aquifer is being investigated
 16 under the BP5 RI/FS under CERCLA. This mapping also confirms the southwest flow direction
 17 across the site.

1 **Figure 3-4. Time Series Contours Illustrating the Regional Control of Sulfate from High**
 2 **Values Associated with the Receding Aquifer Along the Basalt Subcrop.**

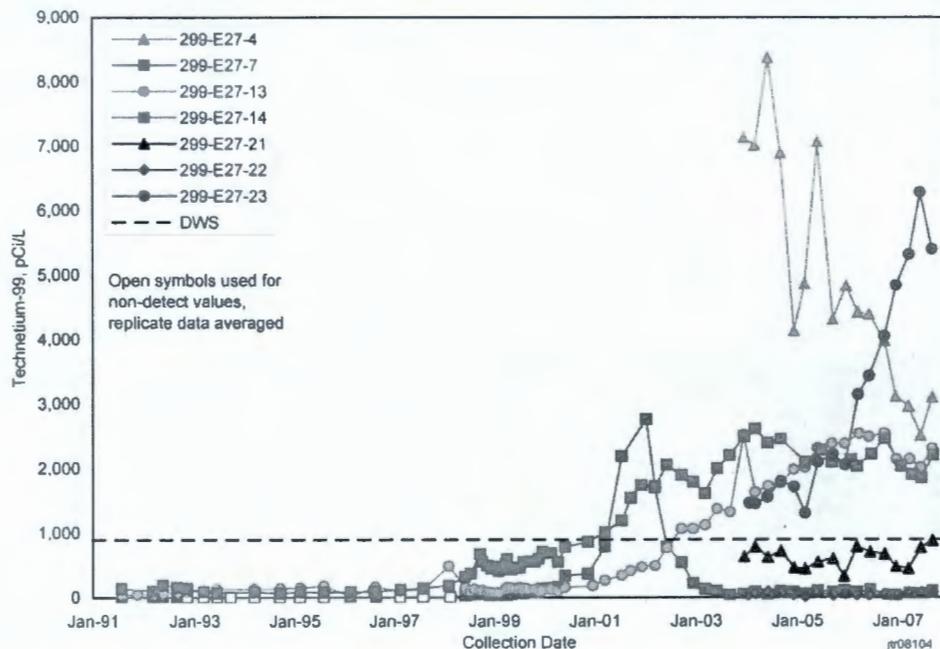


3 Note: Movement of sulfate contours over time confirms southwest flow at WMA C.
 4
 5

6 At WMA C, nitrate, ^{99}Tc , and sulfate have been the most significant contaminants found in
 7 underlying groundwater. In addition, low levels of cyanide have been observed in the
 8 groundwater in some wells. Nitrate concentrations have generally increased in all monitoring
 9 wells. Maximum ^{99}Tc concentrations (approximately 8400 pCi/L) occurred in June 2004 in
 10 monitoring well 299-E27-4 near the southwest corner of WMA C. Technetium-99 concentration
 11 levels have declined since then to 2510 pCi/L in 2007. In several monitoring wells to the east
 12 and southeast of groundwater monitoring well 299-E27-4 (299-E27-13, 299-E-27-14, and
 13 299-E27-23), ^{99}Tc concentrations have generally increased since the late 1990s, and all of these
 14 monitoring wells currently have concentrations near or in excess of 2000 pCi/L (Figure 3-5).
 15 This suggests a tank waste source near monitoring well 299-E27-4 and the ongoing development
 16 of a plume toward the east beneath WMA C. Transfer line losses of PUREX waste
 17 (UPR-200-E-82 in 1969 and UPR-200-E-86 in 1971) occurred very near to monitoring well

1 299-E27-4 (southwest of well E27-12 shown in Figure 3-4 and Figure 2-5) and because of their
 2 proximity, either are plausible sources of the contamination seen in that well. If one or both of
 3 these releases are sources of current groundwater contamination, additional high volume
 4 discharges seem necessary to have caused the current contamination. That is, the estimated
 5 volumes lost during the leak events (2600 and about 17,400 gal from UPR-200-E-82 and
 6 UPR-200-E-86, respectively) and the subsequent natural recharge do not appear sufficient to
 7 have contaminated groundwater in the 36 to 38 years since the release events. DOE/RL-2008-01
 8 suggests that the trends of nitrate to ^{99}Tc concentration ratios for each well (299-E27-13,
 9 299-E27-4, and 299-E27-23) may be three different sources for groundwater contamination on
 10 the southwest side of WMA C.
 11

12 **Figure 3-5. Recent Technetium-99 Concentrations in Samples**
 13 **from Groundwater Monitoring Wells in WMA C**



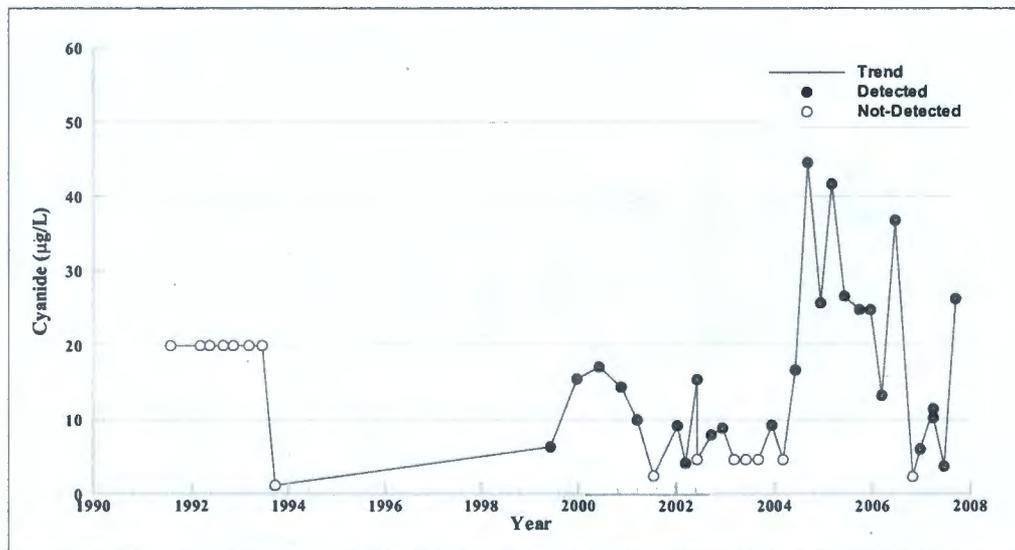
14
 15 The other occurrence of high ^{99}Tc at WMA C occurred in upgradient monitoring well 299-E27-7
 16 in January 2002, when a relatively sharp peak value of 2760 pCi/L was measured. This high
 17 ^{99}Tc spike dropped rapidly within several months. At this time period, regional sulfate
 18 contamination began migrating into the area from the northwest. It is not known if these
 19 observations are related. However, DOE/RL-2008-01 suggests ^{99}Tc contamination observed in
 20 FY 2002 at groundwater monitoring well 299-E27-7 is currently affecting the groundwater
 21 quality in well 299-E27-23 based on overlapping trends of nitrate to ^{99}Tc concentration ratios for
 22 each well.
 23

24 The last contaminant of interest is cyanide. Cyanide-contaminated waste was a byproduct of the
 25 uranium recovery process completed in the early 1950s to separate uranium from metal waste
 26 generated by the bismuth phosphate process. This process was TBP-based and was known as
 27 TBP waste. Because the TBP waste volume exceeded tank storage capacity, intentional
 28 discharges to the subsurface were needed. The main impediment to subsurface discharge was

1 extremely high concentrations of fission products, particularly ^{137}Cs , in TBP waste. To scavenge
 2 ^{137}Cs from TBP waste, a ferrocyanide-based separation process was used. Numerous facilities at
 3 C Farm were used for this process. These included tanks that stored TBP and scavenged TBP
 4 waste, the 244-CR vault where scavenging took place, and various diversion boxes and pipes
 5 through which waste was transferred. Thus, tank farm operations occurred that could have lost
 6 cyanide-contaminated waste to the subsurface. Although WMA C facilities were used in the
 7 ^{137}Cs separations processes, the intentional discharges to the subsurface ^{137}Cs did not take place
 8 at or nearby to WMA C.

9
 10 The largest and most consistent cyanide concentrations in monitoring wells around WMA C
 11 occur at upgradient monitoring well 299-E27-7 on the northeast side of WMA C. Unequivocal
 12 cyanide concentrations were first measured in October 1999 and reached a maximum value of
 13 about 45 $\mu\text{g/L}$ in September 2004. The latest measurement in June 2007 was 3.8 $\mu\text{g/L}$
 14 (Figure 3-6). Cyanide has also been measured sporadically at all other WMA C monitoring
 15 wells to the north, west, and south of monitoring well 299-E27-7. In these locations cyanide
 16 concentrations have ranged from non-detected to 18 $\mu\text{g/L}$.

17
 18 **Figure 3-6. Cyanide Concentrations at Groundwater Monitoring Well 299-E27-7**



19
 20
 21
 22 Currently, a particular leak event from this operation period is not known that could have been
 23 the precursor to the current groundwater contamination. One point of entry into the unconfined
 24 aquifer appears to be near the 299-E27-7 location.

25 26 3.2.3 Three-Dimensional Physical Representation of WMA C

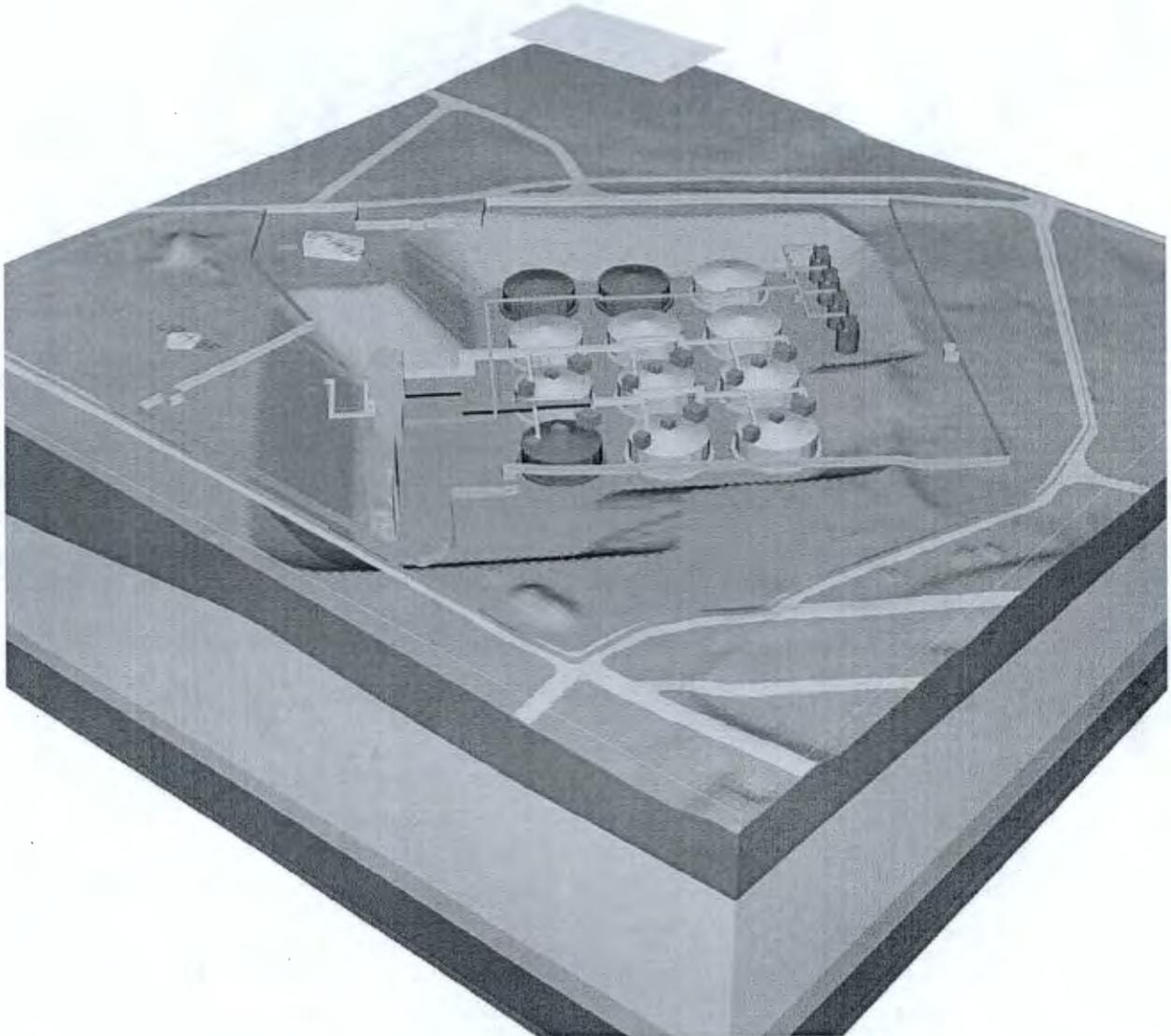
27 For this work plan, a three-dimensional computer representation of WMA C using the data
 28 collected to date was prepared. Figure 3-7 is one view from a three-dimensional representation
 29 of WMA C. The complete three-dimensional model was imported into an Adobe[®] Portable

1 Document Format⁸ (PDF) that allows any user with Adobe Reader to use Adobe's three-
2 dimensional tool to manipulate the model (e.g., rotate, zoom, pan, add layers, etc.)

3

4

Figure 3-7. Three-Dimensional Computer Representation of WMA C



5

6 The model includes the following:

7

a. WMA C fenceline, nearby roads, and the DQO boundary.

8

b. Topographic information major contour lines are every 2.5 m (shown in blue) and minor contour lines (light green).

9

⁸ Adobe® Portable Document Format is a registered trademark of Adobe Systems Incorporated, San Jose, California.

- 1 c. Major geologic units; click on the colors in the stratigraphic legend to add and remove
2 layers; contour lines are also provided for the top of each stratigraphic unit.
- 3 d. Infrastructure: SSTs (100-series, 200-series), CR vaults, most but not all diversion boxes,
4 and major pipelines.
- 5 e. Contaminant concentrations for ^{137}Cs , ^{60}Co , nitrate, and ^{99}Tc . Cesium-137 and ^{60}Co
6 measurements were collected as part of the spectral gamma logging efforts of the late
7 1990s (GJO-HAN-92, GJO-98-39-TAR, GJO-98-39-TARA), while the nitrate and ^{99}Tc
8 were measured from samples taken as part of the Phase 1 characterization activities.
- 9 f. A set of predetermined views.

10
11 The model along with instructions for manipulating the model is included in Appendix C.
12
13

14 **3.3 CONCEPTUAL MODELS**

15 The National Research Council in "Conceptual Models of Flow and Transport in the Fractured
16 Vadose Zone," (NRC 2001) defines a conceptual model as "... an evolving hypothesis
17 identifying the important features, processes, and events controlling fluid flow and contaminant
18 transport of consequence at a specific field site in the context of a recognized problem."
19 Furthermore, Dr. Eileen Poerter (Colorado School of Mines), while giving the 2006 Darcy
20 Lecture for the National Groundwater Association, recommended using "multiple working
21 hypotheses" (alternative conceptual models) when studying complex geohydrologic systems.
22 This section provides an overview of the alternative conceptual models supporting the DQO
23 process for the Phase 2 characterization data needed for the WMA C CMS. As more data are
24 collected during the Phase 2 characterization activities, these conceptual models will be updated
25 and revised as necessary.
26

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

38 **3.3.1 Alternative 1: Phase 1 Conceptual Model**

39 This model is documented in Chapter 16 and Appendix A of DOE/ORP-2008-01 and was
40 derived from process records, gross gamma logging information collected from the 1960s

1 through the 1990s,⁹ spectral gamma data collected in the late 1990s to early 2000s,¹⁰ and the data
 2 collected during the Phase 1 characterization efforts conducted from 2000 to 2007.¹¹ One of the
 3 primary goals of the Phase 1 characterization effort was to understand the relationship of the
 4 inventory of contaminants (that adversely impact groundwater) observed in the vadose zone to
 5 the concentrations of those contaminants in the groundwater. To accomplish this, the Phase 1
 6 characterization effort collected soil samples at major leaks within a WMA with known high
 7 ¹³⁷Cs concentrations (10,000,000 pCi/g) in the nearby soils to find depth of the mobile
 8 contaminants (i.e., ⁹⁹Tc, nitrate, etc.) based on the relationship between ¹³⁷Cs and ⁹⁹Tc in the
 9 fission process (i.e., if high ¹³⁷Cs is present, then ⁹⁹Tc should also be present, but deeper because
 10 ⁹⁹Tc does not adsorb onto the soil).

11
 12 The complete Phase 1 conceptual model is described in DOE/ORP-2008-01 (Appendix A).
 13 Rather than evaluating individual leaks sequentially, the summary discussion in Appendix A is
 14 oriented toward comparisons of similar information related to several leak events where possible,
 15 particularly the larger leaks that are more completely characterized. The purpose of these
 16 comparisons is to emphasize and describe those key characteristics and processes that are
 17 common to all leak events and therefore are indicative of systematic behavior. At the same time,
 18 it is important to keep in mind that each tank waste release site is unique in some way and that
 19 site-specific factors not emphasized in this general discussion may provide significant impacts to
 20 contaminant behavior in the subsurface. These factors, which must be determined from site-
 21 specific evaluation, may result in more refined or alternative conceptual models that are most
 22 appropriate for a given site.

23
 24 At a summary level, the following key characteristics and processes in Sections 3.3.1.1 through
 25 3.3.1.4 are concluded to be the primary components of the conceptual model and common to all
 26 major tank leak events.

27 **3.3.1.1 Initial Leak Period**

- 28 a. Unintentional discharges of tank waste were events that occurred because waste transfer
 29 pipelines and storage tanks were compromised and allowed waste releases to the
 30 subsurface. The primary degrading waste storage conditions of tanks were overheating
 31 and overfilling.
- 32 b. Following release into the vadose zone, waste fluids increased ambient moisture content
 33 and perturbed the local geochemical conditions at the point of entry and beyond. Natural

⁹ 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, RPP-8821).

¹⁰ See DOE's Grand Junction Office reports and Associated Addendum: 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, GJO-99-113-TARA.

¹¹ See Field Investigation Reports (RPP-7884, RPP-10098, RPP-23752, DOE/ORP-2008-01 Appendixes L and M, RPP-35484 and RPP-35485).

1 physical and chemical processes sometime after the leak event began to eliminate these
2 perturbations.

- 3 c. Waste fluids were distributed rapidly over limited areas of the vadose zone until ambient
4 moisture contents were essentially restored. Key characteristics and processes were
5 unsaturated flow and lateral migration that resulted from hydrogeologic controls.
6 Consequently, waste contacted an expanded vadose zone volume compared to the initial
7 volume of the released waste.
- 8 d. Chemical reactions between tank waste fluid and the vadose zone soil-water system
9 occurred as waste fluids were distributed in the vadose zone. Key characteristics and
10 processes were moderation of the high local elevated pH conditions typical of tank waste
11 fluids and sorption/precipitation of reactive contaminants onto soil surfaces. In some
12 cases, tank waste chemistry altered the reactivity of specific contaminants relative to their
13 behavior under ambient conditions [notably, for waste with high sodium content
14 (SX-108), ^{137}Cs mobility was temporarily enhanced]. By the time ambient moisture
15 content was essentially reestablished, contaminants were variably distributed in the
16 vadose zone volume contacted by tank waste, depending on their reactivity. Maximum
17 distribution occurred for nonreactive constituents (e.g., ^{106}Ru , ^{99}Tc , and nitrate).

18 3.3.1.2 Current Conditions

- 19 a. Following the initial waste fluid release and distribution into the vadose zone, lateral and
20 vertical waste migration continued, but controlling physical and chemical processes
21 changed in some respects. Migration was driven by local recharge conditions that were
22 dictated by the permeability of the gravel/sand fill that covers the SST system in the tank
23 farm. Chemical reactions continued that were primarily controlled by the ambient
24 environment.
- 25 b. To date, observable migration has occurred only for nonreactive to slightly reactive
26 contaminants (mostly nitrate and ^{99}Tc and to a lesser extent ^{60}Co , chromium, and
27 uranium, where present). The exception to this observation is at the SX-108 leak where
28 enhanced ^{137}Cs mobility occurred due to the presence of high sodium concentrations in
29 the tank waste (RPP-10098, *Field Investigation Report for Waste Management*
30 *Area B-BX-BY*). Under these conditions, sodium sorbs preferential on soil phase sorption
31 sites.
- 32 c. Under natural recharge conditions through a gravel cover, vertical migration rates of
33 1 to 3 ft/year in the Hanford formation of the vadose zone for ^{60}Co have been observed at
34 a few dry wells in WMAs C and B-BX-BY, most notably at dry wells 22-03-09,
35 22-06-05 (HNF-3532, *Analysis of Historical Gross Gamma Logging Data from BY Tank*
36 *Farm*) and 30-08-02 (RPP-8321).
- 37 d. A number of characterization boreholes were installed during the Phase 1
38 characterization activities. Technetium-99 was found approximately between 85 ft bgs
39 and 150 bgs for the 200 West WMAs and 130 to 170 ft bgs for the 200 East WMAs
40 (DOE/ORP-2008-01). Drilling depths were sufficient to reach and in some cases pass
41 through a maximum concentration zone where ^{99}Tc concentrations at the deepest location

1 were one or more orders of magnitude below the highest recorded values in the borehole.
2 Based on these analyses, the bulk of the inventory for ^{99}Tc is inferred to still reside in the
3 vadose zone, approximately 70 to 150 ft above the unconfined aquifer.

- 4 e. The lower CCU is present in the 200 West Area but not in the 200 East Area.

5 3.3.1.3 Future Conditions

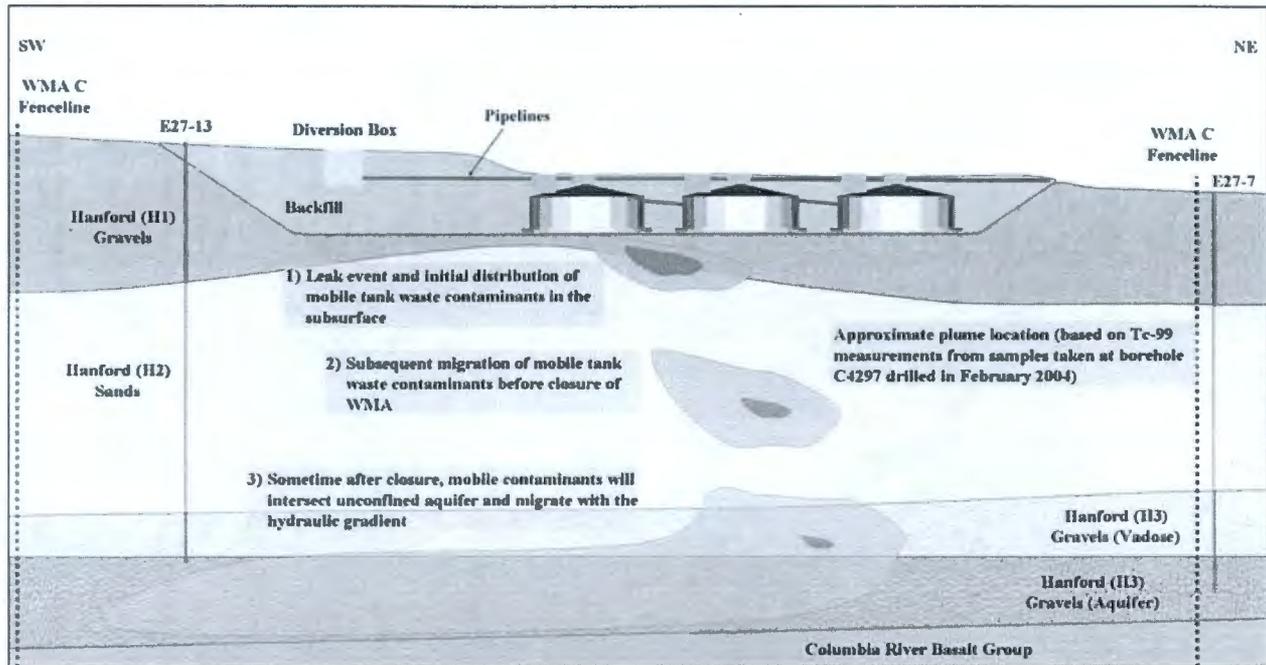
- 6 a. Future migration rates are expected to diminish if an engineered barrier is installed. If
7 installed, an engineered barrier will reduce recharge rates from approximately 100 mm/y
8 to much less than 1.0 mm/yr for some time (DOE/ORP-2005-01). This rate may
9 experience an eventual small increase with barrier degradation. Ambient chemical
10 conditions will be maintained and only highly mobile or slightly retarded contaminants
11 ($K_d < 0.6 \text{ mL/g}$) will reach the unconfined aquifer in a period of several thousand years.
12 For those mobile contaminants currently in the shallow vadose zone, significant increases
13 in travel time and reductions in peak groundwater concentrations relative to current
14 conditions are projected.
- 15 b. For those contaminants deeper in the vadose zone, the engineered barrier is less effective,
16 and if no remedial actions take place, the inventory of nonreactive contaminants in the
17 vadose zone will continue to migrate to the unconfined aquifer causing the ground
18 concentrations to rise and to peak over the maximum contaminant level (MCL) sometime
19 in the future (RPP-7884, *Field Investigation Report for Waste Management Area S-SX*;
20 RPP-10098; RPP-23752, *Field Investigation Report for Waste Management Areas T and*
21 *TX-TY*; DOE/ORP-2005-01).

22 These general periods are shown as different plume locations in Figure 3-8. The depicted
23 plumes can be considered as the distribution of highly mobile contaminants that always migrate
24 with the waste fluid. The data and analytical results collected during Phase 1 characterization
25 indicates the bulk of the contaminant inventory remains in the vadose zone.
26

27 3.3.1.4 Importance of Water as a Driving Force

28 Despite the measurement of the highest levels of nonreactive to slightly reactive contaminants
29 (^{99}Tc , chromium, nitrate, and cyanide) in the vadose zone approximately 70 to 120 ft above the
30 water table, groundwater monitoring data from wells near waste management area fencelines
31 indicate that some tank waste has reached the aquifer in discrete locations, notably on the
32 southern side of the SX Farm, the east side of S Farm, the northeastern corner of the T Farm and,
33 east of BX Farm and south of C Farm. These sites are noted for high ^{99}Tc concentrations (above
34 the MCL of 900 pCi/L) in nearby groundwater monitoring wells and high uranium
35 concentrations (above the MCL of 30 $\mu\text{g/L}$) at BX Farm as well. If these contaminants were
36 initially present in leaked tank waste, the conceptual model described above must be expanded to
37 include these observations.
38

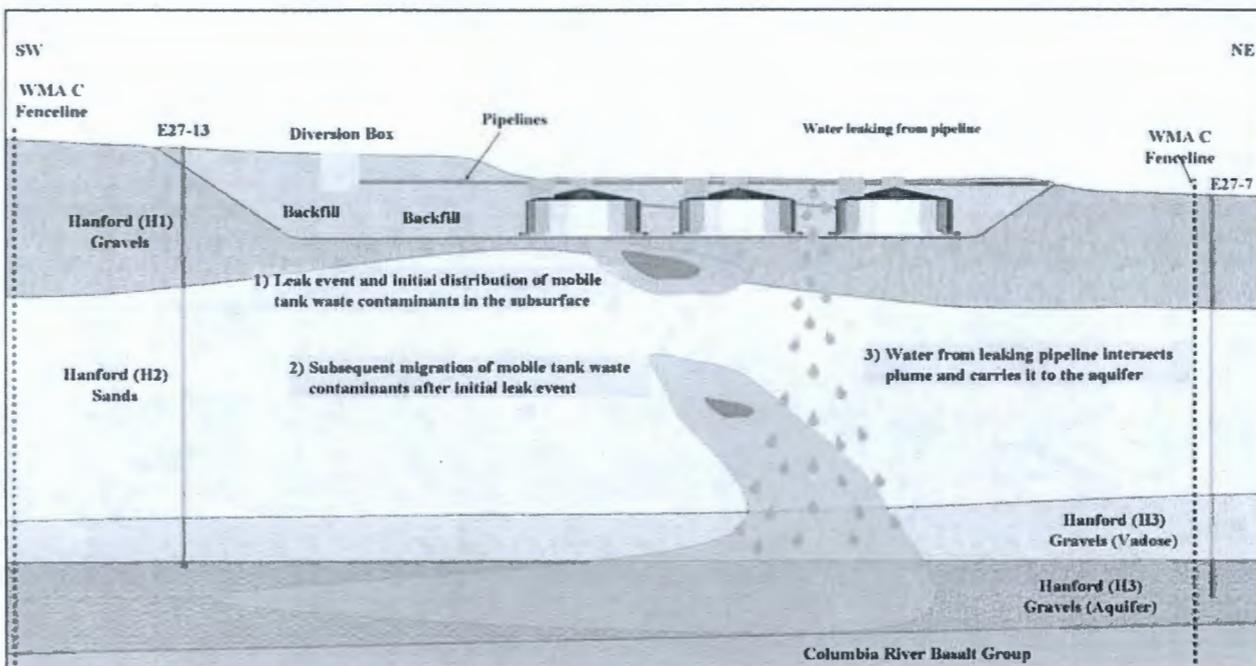
Figure 3-8. Alternative 1: Phase 1 Conceptual Model



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

- a. At the southeast corner of SX Farm, a several year period of steady water loss from an operating raw water pipeline (pipes are not routinely monitored at all 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 additions of water to the vadose zone locally (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 3-9).
- b. 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 average recharge rates from precipitation of about 100 mm (4 in.) per year. For example, if a pipe joint leak occurs at the rate of 0.5 gpm, the yearly volume output is 262,800 gal. If this fluid volume migrates through a flux plane of 100 m², the equivalent annual volume discharge from ambient recharge of 100 mm/yr would be 2642 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.

1 **Figure 3-9. Expanded Phase 1 Conceptual Model Accounting for Artificial Recharge due**
 2 **to Pipeline Leak**



3
4
5 c. At T Farm, there was a large snow melt event in February 1979, which created temporary
6 ponding over the farm followed by rapid infiltration into the subsurface. At that time, the
7 drywells were not grouted to 90 ft and could have provided preferential pathways for
8 vertical migration to that depth (RPP-23752).

9 d. Large intentional discharges of raw water or waste water occurred in cribs, trenches, and
10 ditches close to WMAs B-BX-BY and U. WMA B-BX-BY is bounded on the west and
11 north by cribs that have received approximately 30,000,000 gal of liquid effluent. At this
12 location, a perched water table is observed approximately 220 to 240 ft bgs. If tank waste
13 as it travels through the vadose zone encounters a perched water table, the perched water
14 table will impact when and where contaminants from the vadose zone will enter the
15 unconfined aquifer. At WMA U, the 216-U-14 trench is located to the east, while
16 216-Z-20 trench is located west to the West. Large volumes of water (~346,000,000 gal)
17 were discharged to these trenches of water during their operational lifetime. Perching
18 occurred on top of the CCU and elevated moisture content was observed in the vadose
19 zone at WMA U (DOE/ORP-2008-01, Appendix M; RPP-35485, *Field Investigation*
20 *Report for Waste Management Area U*). Intentional discharges to cribs, ditches, and
21 trenches ceased in the mid-1990s.

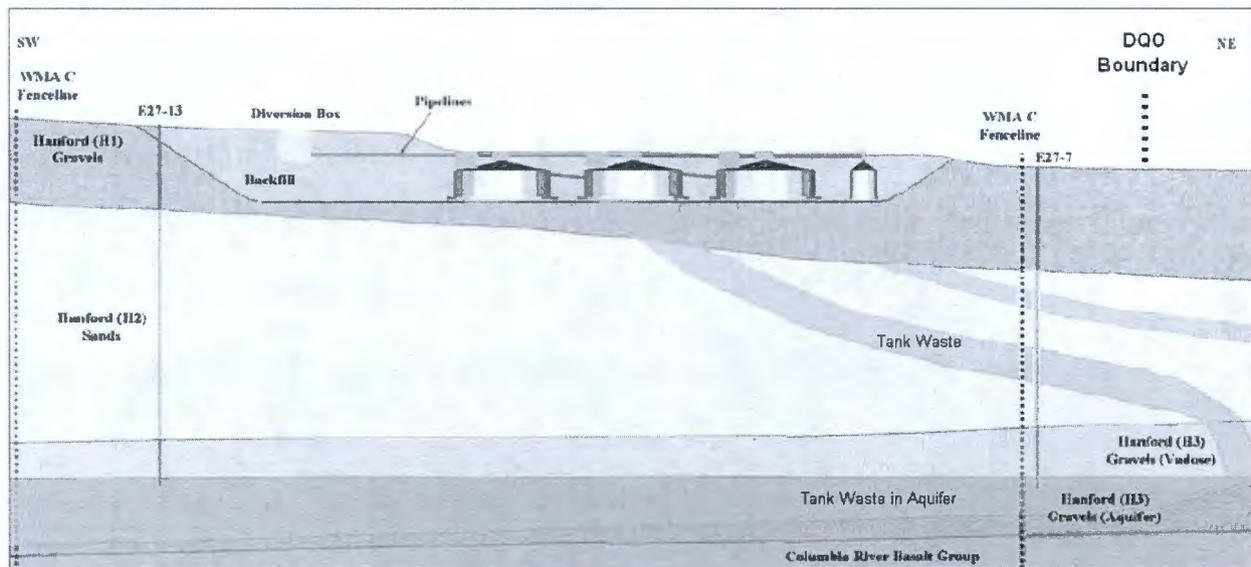
22 It is inferred from these observations that when enhanced recharge encounters preexisting tank
23 waste in the vadose zone, this preexisting tank waste can be transported to the unconfined
24 aquifer. Because of the detrimental impact of enhanced recharge in the tank farms, a series of
25 interim corrective actions (Section 3.5) have been implemented to prevent enhanced recharge.
26

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

Dr. Stan Sobczyk has provided an updated depiction of the 2007 conceptual model (see Figure 3-10). Dr. Sobczyk bases this conceptual model on the following:

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

Figure 3-10. Alternative 2: Movement of Contaminants down Stratigraphic Dip Conceptual Model



Dr. Sobczyk has suggested a similar conceptual model for the release from BX-102 for the movement of uranium from the BX-102 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 as discussed in Section 4.4.2.

3.3.3 Alternative 3: Preferential Pathways Conceptual Model

Preferential pathways have been hypothesized as a method of moving contaminants through the vadose zone. These are typically small-scale features with physical properties that can enhance the movement of contaminants vertically downward through the vadose zone. The ones cited most frequently at Hanford are poorly constructed wells and/or clastic dikes. Of these two

1 features, the poorly constructed well would likely be associated with larger void spaces and
2 therefore allow a greater migration rate.

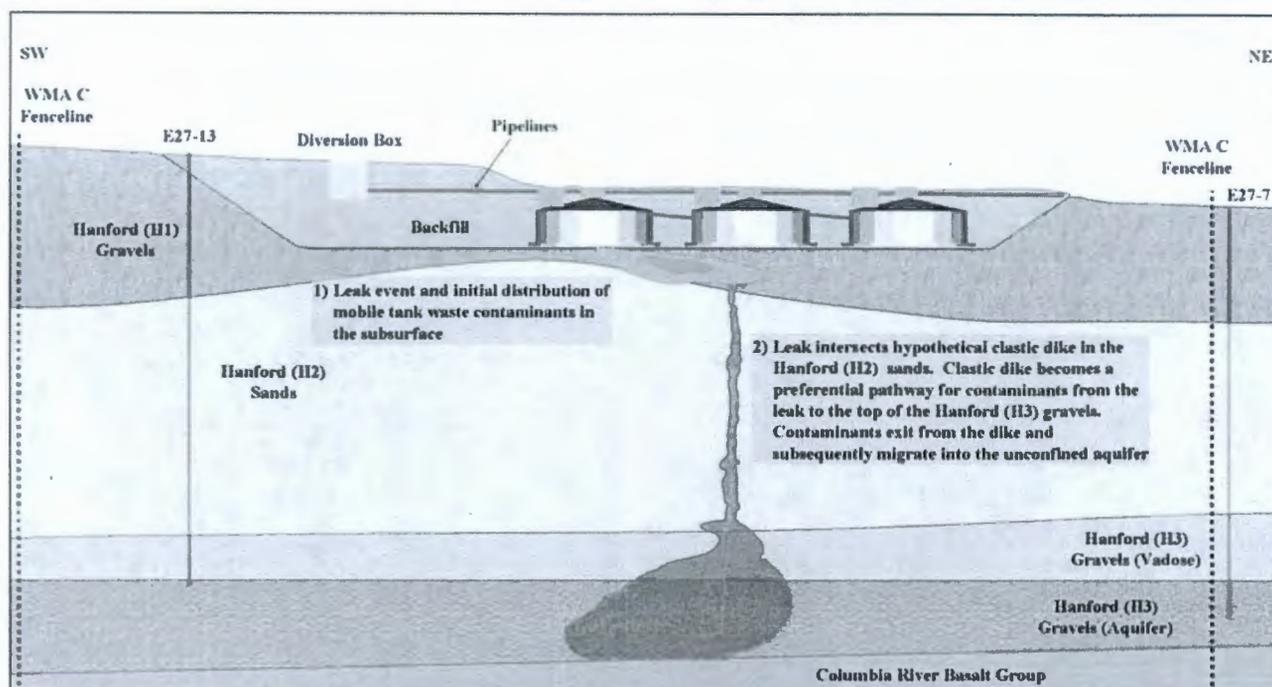
3
4 Poorly constructed wells might allow the contaminant to move vertically downward between the
5 casing and the surrounding media. However, at tank farms, the depth of almost all drywells
6 within the tank farms is 100 ft bgs, while groundwater is 230 to 300 ft bgs. Therefore, it is
7 unlikely that a poorly constructed drywell within a tank farm is providing a preferential pathway
8 all the way to groundwater. On the other hand, in some locations nearby groundwater
9 monitoring wells extend to the aquifer and could have provided a sufficient pathway for aquifer
10 contamination. This may have occurred in WMA B-BX-BY where some ⁹⁹Tc and uranium from
11 the BX-102 leak may have reached the unconfined aquifer.

12
13 Clastic dikes are common structures that occur in many geologic units in the Pasco Basin and
14 vicinity (BHI-01103, *Clastic Injection Dikes of the Pasco Basin and Vicinity – Geologic Atlas*
15 *Series*). Clastic dikes are tubular and tapered intrusive bodies that are composed of continental
16 clastic sediments. BHI-01103 contains a photograph (Figure 9-44 on p. 9-55) of irrigation on top
17 of a clastic dike. In this photograph, water can be seen moving down the clastic dike until it
18 reached the bottom of the dike, at which point, water began spreading laterally and vertically.
19 This photograph illustrates the potential for clastic dikes to become preferential pathways.
20 However, it should be noted that BHI-01103 in describing this clastic dike noted the following:

- 21
22 • *The highest observed hydraulic infiltration within an infilling unit was in a*
23 *random occurrence dike network located in Lind Coulee east of Warden,*
24 *Washington (32 km north of the Pasco Basin).*
- 25 • *The rate of moisture movement was not measured, but water could be*
26 *observed moving down the dike at rates estimated at least 10 times the rates*
27 *observed in other dikes in this study. The clastic dike acted as a conduit to*
28 *transmit soil moisture downward through a preferential pathway to the base*
29 *of the dike before spreading out into the host sediments.*
- 30 • *The very high moisture velocity in the infilling unit that was observed is due to*
31 *the unconsolidated, well-sorted nature of the sediments. **The characteristics***
32 *of this infilling unit are unique compared to infilling units observed in the*
33 *Pasco Basin and vicinity.*

34 Clastic dikes have been noted in the vicinity of all tank farms. However, due to the small-scale
35 nature of these features, it is not possible to address this conceptual model in the DQO process
36 for Phase 2 characterization, but movement down a hypothetical clastic dike can be captured in
37 the CMS assessment of groundwater impacts. The likelihood of effectively locating, retrieving,
38 and analyzing clastic dike materials is too small to successfully execute a dedicated
39 characterization effort. Instead, modeling analyses must be relied on to evaluate the significance
40 of this conceptual model as a mechanism for enhancing contaminant migration through the
41 vadose zone. Figure 9-44, p. 9-55 of BHI-01103, was used to develop a conceptualization of
42 contaminant movement down a clastic dike (Figure 3-11).

1 **Figure 3-11. Alternative 3: Preferential Pathways (Clastic Dikes) Conceptual Model**



2
3
4 **3.3.4 Alternative 4: Unknown Leak Event Conceptual Model**

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

8
9 Each WMA contains miles of pipeline; it is plausible that one or more of these pipelines leaked
10 without any knowledge of such a leak. These leaks, if they occurred, could lead to large volumes
11 (i.e., >30,000 gal) of waste discharged over a period of years resulting in localized volumes of
12 soil with elevated levels of tank waste contaminants. Figure 3-12 shows this conceptualization.

13
14 If it can be demonstrated that SGE can discriminate subsurface anomalies in the tank farm
15 environment, it may be possible to target specific areas that may be representative of this model.
16 A final determination of the application of SGE to help locate unknown leaks will be made
17 following the confirmation testing around UPR-81, UPR-82, and UPR-86.

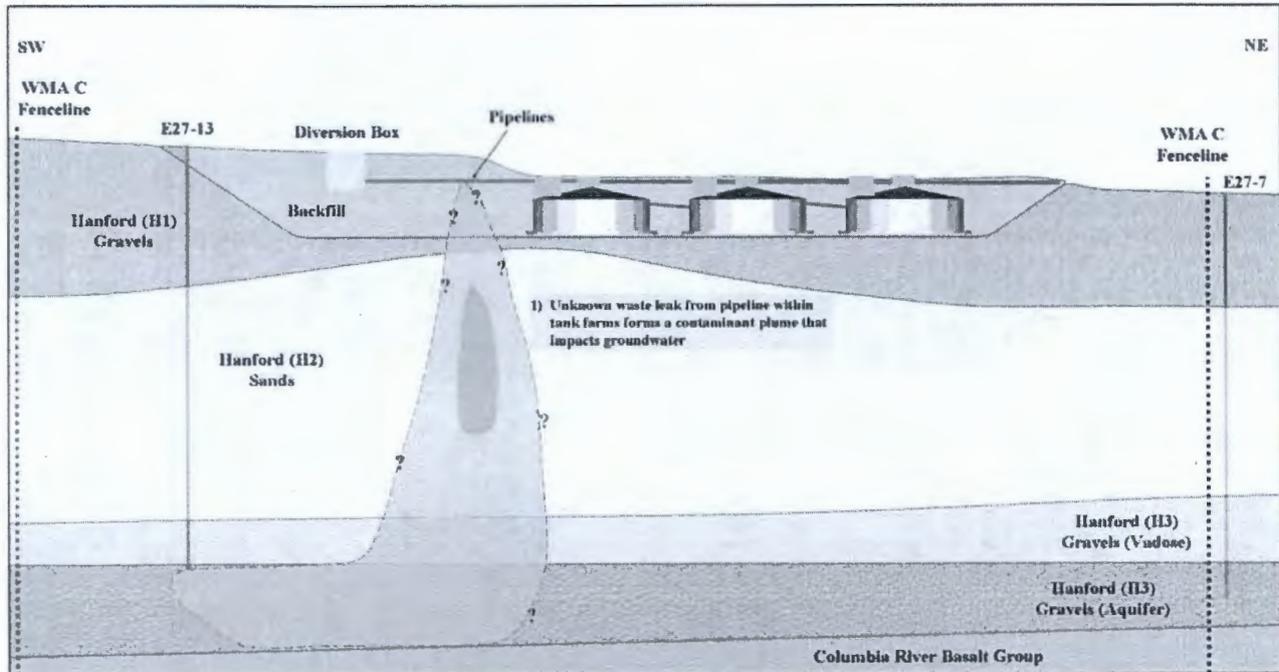
18 **3.3.5 Application of Conceptual Models to WMA C**

19 The generalized conceptual models for tank farm releases and migration through the vadose zone
20 can be further refined for WMA C based on known and suspected releases. These models can be
21 organized into five source term/location configurations:

- 22
23 a. Interior portions of the tank farm including the C-100-series tanks and associated
24 infrastructure.
25 b. C-200-series tanks and associated infrastructure.

- c. Pipelines and diversion boxes in the western portion of the tank farm.
- d. Pipelines and drains located outside of the tank farm.
- e. Airborne contaminated surface sites outside of the tank farm.

Figure 3-12. Alternative 4: Unknown Leak Event Conceptual Model



3.3.5.1 Conceptual Model for Interior Portions of the C Farm

The conceptual model for UPRs within the interior portion of C Farm includes consideration of the generalized conceptualization for alternative conceptual models 1, 2, and 4 and is based on information from characterization borehole C4297 located between C-104 and C-105. This borehole was drilled to a depth of 196 ft bgs with ^{99}Tc being reported to a depth of 160 ft bgs. At this location, the bulk of the ^{99}Tc inventory has not yet reached groundwater, because ^{99}Tc was not detected below 160 ft. These data do not indicate that the C-105 leak caused this contamination as a likely source of high ^{99}Tc concentration levels in the nearby unconfined aquifer. However, since no other sources of the high ^{99}Tc levels outside of WMA C are readily inferred, at least one groundwater contamination source within or adjacent to WMA C must be considered, necessitating further characterization near the tanks. Other events at WMA C are potential sources for contamination of the groundwater. These events (e.g., tank leaks, overfilling tanks, and pipeline leaks) can be either known (tank C-101 overfill) events or unknown events.

The Phase 1 conceptual model and alternative conceptual models 1 and 3 capture the concept that the migration of contaminants may have had a stronger lateral migration and has reached groundwater. In addition, the possibility exists that within the interior of the tank farm of the 100-series tanks there is one or more unknown releases (model 4) that have occurred and migrated to at least 175 ft bgs and possibly to groundwater.

3.3.5.2 Conceptual Model for C-200-Series Tanks

This conceptual model is based on alternative conceptual models 1 and 2. This model is also based on the information associated with UPR-200-E-137 for C-203, which indicates that over a period of 2 to 3 years, precipitation apparently entered this tank and then leaked out in 1984. The volume of the leak has been estimated at 400 gal (HNF-EP-0182, *Waste Tank Summary Report for Month Ending June 30, 2008*) containing PUREX waste with the uranium and plutonium still present (RPP-15408). In addition, documents indicate that the C-200-series tanks may have been overfilled leading to a release through the spare inlet ports. This conceptual model assumes the potential that all four C-200 tanks may have released waste but in relatively small volumes; waste migration is attenuated by the small volume released, and it is expected that evidence of a leak would be detected below the tanks and that the waste has not yet migrated to groundwater.

3.3.5.3 Conceptual Model for 244-CR Vault, Pipelines, and Diversion Boxes in the Western Portions of the C Farm

This conceptual model for releases at these locations includes consideration of alternative conceptual models 1, 2, and 4; and is also based on information associated with UPR-82, UPR-86, UPR-81, and documented flooding of the 244-CR vault. This western portion of the C Farm conceptual model represents contaminant releases occurring in the upper regions of the vadose zone from pipeline leaks and documented flooding. In addition, the conceptual model for UPR-82 and UPR-86 includes consideration of contaminant migration being attenuated by the placement of gunite piles over these sites. As part of the Phase 1 characterization effort, a number of vertical and slant probeholes were drilled at UPR-82. The vertical probeholes were drilled to a depth of 30 ft bgs around the outer edges of the gunite pile over this pipeline leak, while the deepest slant probehole was drilled to a depth of 80 ft bgs directly under this location. Technetium-99 was found at this depth. Since the probehole did not penetrate through the ⁹⁹Tc contamination, further characterization at this location is warranted with the goal of penetrating through the ⁹⁹Tc contamination. Furthermore, a number of probeholes will be used to collect samples at UPR-81, near the CR vaults.

3.3.5.4 Conceptual Model for Near Surface, Shallow Releases outside of the C Farm

The conceptual model for these includes consideration alternative models 1, 2, and 4. This model is also based on information associated with the 216-C-8 French drain, 241-C-801 valve drain, UPR-72, and associated pipelines and drains.

Although process records are incomplete, a minimum of 31,780 gal of treated 241-A TFPC was discharged to the 216-C-8 French drain from January 1960 through March 1965 (Letter 7G420-MEJ-06-007). At the cesium loadout facility (241-C-801 building) located in the northeastern corner of the WMA C, cesium and technetium were loaded onto casks containing ion exchange resin. The origin of the waste was from C-104 and consisted of PUREX P1 and P2 tank waste. The valve pit connected to the loadout facility had a drain line connected to a drywell drain outside of the tank farm fence. While no records have been located that provide information on volumes or types of waste that were potentially discharged to the drain from the valve pit, the potential for discharges to have occurred exists. UPR-72 is assumed to be buried radioactive material.

1
2 This conceptual model represents planned release sites that are known or suspected to have
3 contributed to vadose zone contamination. Migration of contaminants could vary from little or
4 no migration or to a depth of 160 ft or more. The potential for these releases to have reached
5 groundwater is unknown because of the uncertainty in the volumes released and other
6 influencing factors.

7 **3.3.5.5 Conceptual Model of Contaminated Surface Sites outside the C Farm**

8 The conceptual model for these sites describes surface contamination. This model is based on
9 information associated with UPR-91, UPR-107, UPR-115, and UPR-118. All represent surface
10 contamination from airborne releases of small volumes, and the contamination is expected to be
11 at or near the ground surface (<15 ft).

- 12
- 13 a. UPR-91 is located approximately 100 ft from the northeast side of the tank farm and
14 resulted from surface contamination that migrated from WMA C. The contaminated area
15 was scraped and contaminated material removed (DOE/RL-92-04).
 - 16 b. UPR-107 is a surface spill located north of the 244-CR vault, inside WMA C.
17 DOE/RL-92-04 states that a spill occurred on November 26, 1952, when a pump
18 discharged an estimated 5 gal of liquid to the ground surface during a pump installation.
 - 19 c. UPR-115 is located east of C Farm, south of 8th Street, across an unnamed gravel road.
20 Routine radiological surveys confirm radiological contamination in this area. No surveys
21 can be found to provide information about the radiological conditions inside the posted
22 area. Very little is known about this posted area. In 1980, a larger area of posted
23 contamination was located in the same vicinity. The contaminated soil from
24 UPR-200-E-91 was removed in 1981. It is difficult to determine if the two sites are
25 related. In June 2004, 200-E-115 was stabilized with gravel and posted as an
26 Underground Radioactive Material Area.
 - 27 d. UPR-200-E-118 is located in the northeast portion of the tank farm and extends north up
28 to about 300 m (1000 ft) beyond the fenceline. It was the result of an airborne release
29 from C-107 that occurred in April 1957.

30 These releases and the conceptual model are not believed to represent a risk to groundwater but
31 potentially are a risk through direct contact and to ecological receptors.

32 **3.4 PERFORMANCE ASSESSMENT**

33 The master work plan provides the process for performance assessments in the RCRA corrective
34 action process. This process is governed by HFFACO, Appendix I, Section 2.5 (Ecology et al.
35 1989) which states that the performance assessment must address the requirements in RCRA,
36 *Hazardous Waste Management Act (HWMA)*, *Clean Water Act of 1972 (CWA)*, *Safe Drinking*
37 *Water Act of 1974 (SDWA)*, and *CERCLA*, as well as the *Atomic Energy Act of 1954 (AEA)*.

38
39 To meet RCRA, HWMA, CWA, SDWA, and CERCLA requirements, the performance
40 assessment evaluates the impacts associated with contaminants in the soils based on reasonable

1 maximum exposure¹² from possible future land use options (e.g., residential, industrial) for
 2 groundwater and direct contact exposure pathways, as well as ecological risk receptors.
 3 Furthermore, it provides estimates of media cleanup standards (OSWER Directive 9902.3-2A)
 4 for scenarios where risks exceed performance objectives will be used for evaluating CMAs.

5
 6 *Atomic Energy Act of 1954* requirements are met through DOE O 435.1, *Radioactive Waste*
 7 *Management*, which requires the dose to representative members of the public for (1) all
 8 exposure pathways and (2) air pathway be evaluated along with release of radon from the facility
 9 (DOE M 435.1-1, *Radioactive Waste Management Manual*, Chap IV, Sections P 1A – 1C).

10
 11 It is expected that the WMA C performance assessment will be divided into two major sections:
 12 impacts to human health and impacts to the ecological environment. A summary of the approach
 13 for calculating impacts to human health is provided in Section 3.4.1. This is a summary because
 14 the methods and assumptions that will be used in WMA C PA will be determined through
 15 agreements with Ecology (RPP-PLAN-37243). These agreements will take into account, as
 16 appropriate, the assumptions and methodologies used by Tank Closure and Waste Management
 17 Environmental Impact Statement. The methodology and approach for calculating ecological risk
 18 is provided in Section 3.4.2.

19
 20 The ecological risk approach follows guidance given in *Washington Administrative Code* (WAC)
 21 “Terrestrial Ecological Evaluation Procedures” (WAC 173-340-7490) and
 22 DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and*
 23 *Terrestrial Biota*. This approach is provided in Section 3.4.2.

24 **3.4.1 Estimated Impacts to Human Health**

25 This section presents the conceptual exposure model developed to identify potential impacts to
 26 human health and the environment from waste sites in WMA C. Information pertaining to
 27 contaminant sources, release mechanisms, transport media, exposure routes, and receptors is
 28 discussed to develop a conceptual understanding of potential risks and exposure pathways.
 29 Assumptions concerning potential receptors are based on current and anticipated future use of
 30 land and groundwater. This information will be used to support an evaluation of potential human
 31 health and environmental risk in the RFI/CMS to be prepared following the investigation.

32 **3.4.1.1 Land and Groundwater Use**

33 Land and groundwater use information is applied as appropriate in conjunction with the
 34 identification of potential exposure routes and receptors.

35
 36 Current land use activities associated with the 200 Areas and the Central Plateau are industrial in
 37 nature [64 FR 61615, “Record of Decision: Hanford Comprehensive Land-Use Plan
 38 Environmental Impact Statement (HCP EIS)”; 73 FR 55824, “Amended Record of Decision for
 39 the Hanford Comprehensive Land-Use Plan (CLUP) Environmental Impact Statement”]. Under
 40 the amended Record of Decision (73 FR 55824), the land use activities will remain in effect as
 41 long as DOE retains legal control of some portion of the Hanford Site, which is expected to be

¹² In WAC-173-340-708(3)(b): The reasonable maximum exposure is defined as the highest exposure that is reasonably expected to occur at a site under current and potential future site use.

1 longer than 50 years and will use the regulatory processes in addition to the implementing
2 procedures of the HCP EIS to ensure consistency with CLUP land-use designations. The
3 facilities located in the Central Plateau were built to process irradiated fuel from the plutonium
4 production reactors in the 100 Areas. Most of the facilities directly associated with fuel
5 reprocessing are inactive now and awaiting final disposition. Several waste management
6 facilities operate in the 200 Areas, including permanent waste-disposal facilities such as the
7 Environmental Restoration Disposal Facility, low-level waste (LLW) burial grounds, and a
8 RCRA-permitted, mixed-waste trench, and the SSTs and DSTs. Construction of tank waste
9 treatment facilities in the 200 East Area began in 2002, and the 200 East Area is the planned
10 disposal location for the vitrified low-activity tank wastes. Other Federal agencies, such as the
11 U.S. Department of the Navy, use the Hanford Site 200 East Area for disposal of TSD units. In
12 addition, a commercial LLW disposal facility currently is operated by US Ecology, Inc., on a
13 100-acre tract of land at the southeast corner of the 200 East Area, which is leased to the State of
14 Washington.

15
16 The reasonably anticipated future land use for the 200 Areas is continued industrial activities for
17 the foreseeable future. This land-use assumption is applied to the pathway and receptor
18 considerations in risk calculations for the waste sites.

19
20 Groundwater in the 200 Areas currently is contaminated and is not withdrawn for beneficial
21 uses. The Columbia River is the second largest river in the contiguous United States in terms of
22 total flow and is the dominant surface-water body on the Hanford Site. The Columbia River is
23 the principal source of drinking water for the Tri-Cities and the Hanford Site. Regionally, it also
24 is used extensively for irrigation and for recreation, which includes fishing, hunting, boating,
25 water skiing, diving, and swimming.

26
27 Washington State cleanup regulations define groundwater as a "potential future source of
28 drinking water" based on yield, natural quality, and pumpability [WAC 173-340-720(2),
29 "Ground Water Cleanup Standards," "Potable Ground Water Defined"]. Based on these
30 technical standards, groundwater underlying the 200 Areas may be considered a potential future
31 drinking-water source. In addition, groundwater underlying the 200 Areas is hydraulically
32 connected to groundwater systems that currently are used for drinking water and irrigation, and it
33 ultimately discharges to the Columbia River. In accordance with 40 CFR 300, "National Oil and
34 Hazardous Substances Pollution Contingency Plan," the goal is to restore the groundwater at the
35 Hanford Site to maximum beneficial uses, if practicable. The groundwater-protection corrective
36 measures action objective for WMA C will be based on WAC 173-303-645, "Releases from
37 Regulated Units," WAC 173-340-720, "Ground Water Cleanup Standards," and 40 CFR 141,
38 "National Primary Drinking Water Regulations." Given the local hydrogeology at WMA C,
39 protection of the groundwater from the contaminants, by design, also will result in protection of
40 the Columbia River. It is anticipated that current uses of the Columbia River will continue in the
41 future.

42 **3.4.1.2 Contaminant Sources and Release Mechanisms**

43 Since there are no nearby liquid disposal facilities at WMA C, the primary sources of
44 contamination for SST WMA C are unplanned air and liquid waste releases (e.g., leaks) to
45 surrounding soils from tanks, lines, pits, diversion boxes, and associated structures. Releases to

1 the environment from the primary contaminant sources have produced contaminated surface
2 soils and subsurface soils beneath waste sites. Once released into the soils, contaminants can
3 spread through the environment by infiltration, resuspension of contaminated soil, volatilization,
4 biotic uptake, leaching, and external radiation. During the periods when UPRs to the
5 environment occurred, the dominant mechanism of contaminant transport was initially the leak
6 event itself, followed by infiltration both natural and man-made. After a liquid release from a
7 structure ceased, the liquids continued to move through the soil column for an undetermined
8 period. Currently, the dominant mechanism of contaminant transport through the vadose zone is
9 from residual effluent moisture and natural recharge.

10 **3.4.1.3 Potential Receptors**

11 Potential receptors (i.e., human and ecological) can be exposed to the affected media through
12 several exposure pathways, including the following:

- 13 a. Ingestion of contaminated soils (including dust inhalation), sediments, or biota.
- 14 b. Inhalation of contaminant dusts, vapors, or gases.
- 15 c. Dermal contact with contaminated soils or sediments.
- 16 d. Direct exposure to external gamma radiation in site soils and sediments.

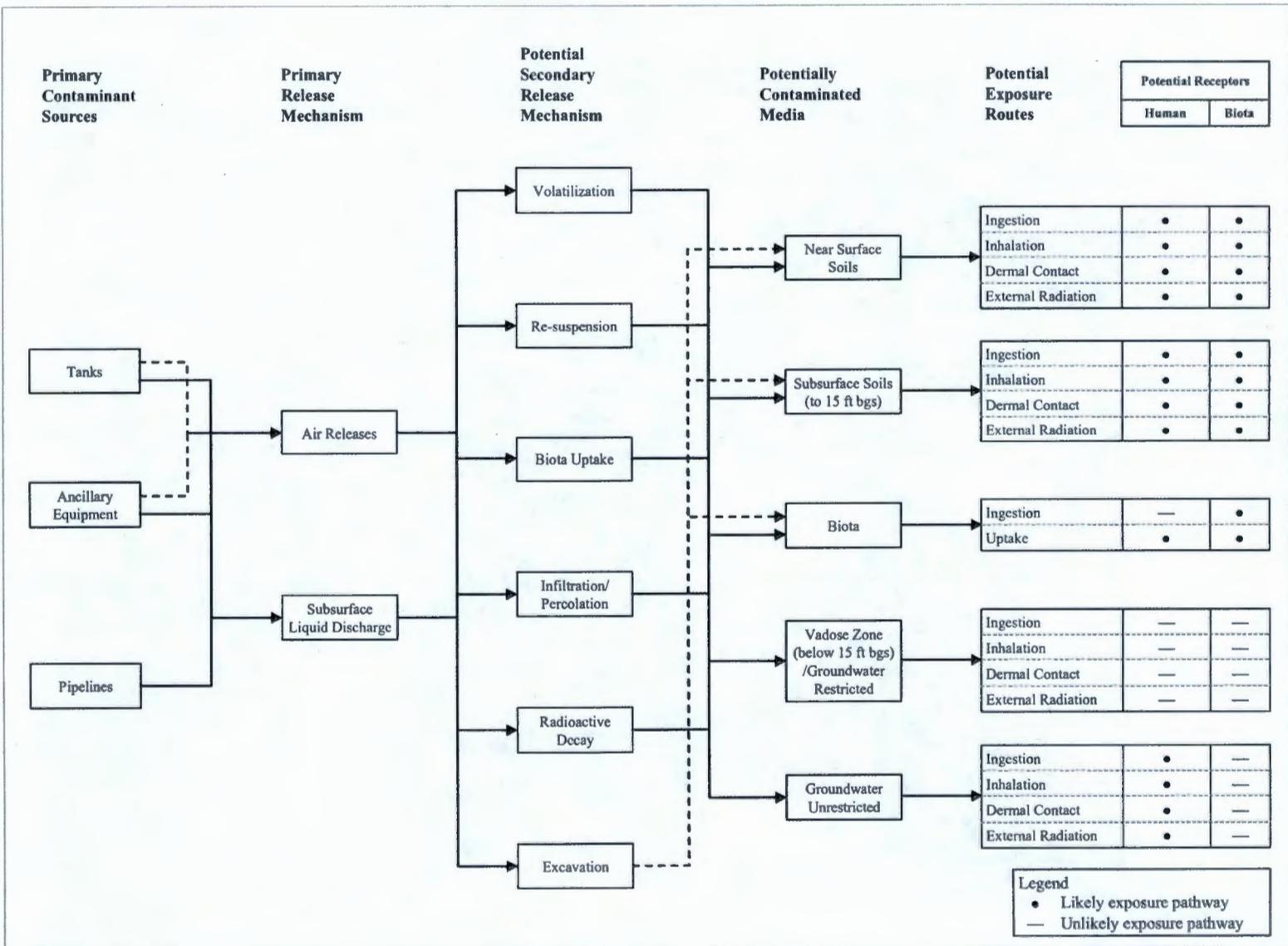
17
18 Potential human receptors include current and future Hanford Site workers and site visitors
19 (i.e., occasional users). Under a restricted future-land-use scenario, site worker and visitor
20 exposure pathways primarily would involve incidental soil and sediment ingestion, inhalation of
21 contaminants, dermal contact with contaminated soils and sediments, and external gamma
22 radiation (Figure 3-13).

23 **3.4.1.4 Estimated Impacts**

24 Potential contaminant exposures and health impacts to humans depend largely on allowable land
25 uses. The land use inside the core zone selected by the DOE is industrial (exclusive). Outside
26 the core zone, the selected land use is conservation (mining). The DOE determined these
27 land-use designations through the *National Environmental Policy Act of 1969* process; the
28 designations are identified in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan
29 Environmental Impact Statement*, and documented in 64 FR 61615 (HCP EIS).” WMA C is
30 located in the core zone. Therefore, based on the land-use decision for the 200 Areas, potential
31 impacts from the waste-site contaminants in the core zone would be to current and future site
32 workers. Potential impacts from waste-site contaminants located outside the core zone would be
33 assessed based on unrestricted land use.

34
35 Existing characterization data and the proposed sampling and analysis activities (Phases 1 and 2)
36 are expected to be sufficient to address potential impacts to human health and the environment.
37 Results of the risk assessment will be presented in the Phase 2 RFI/CMS report.
38

Figure 3-13. Conceptual Exposure Pathway Model



1 3.4.2 Ecological Risk Assessment Approach

2 Sections 3.4.2.1 through 3.4.2.5 describe the general approach for conducting the ecological risk
 3 assessment (ERA) for WMA C. The ERA is an element of the CMS alternatives evaluation
 4 process for all of the waste management areas associated with the SST farms. WMA C is the
 5 first WMA to undergo implementation of corrective actions under the CMS. Information
 6 developed under the ERA process will be used in the development and analysis of CMAs,
 7 including the no-action alternative. To maintain consistency across the Hanford Site, the ERA
 8 for WMA C will adopt relevant methodology and data that were used in the Central Plateau
 9 ecological risk assessment (CPERA).

10 3.4.2.1 Ecological Risk Assessment Requirements and Guidance

11 The SST system at WMA C will require cleanup under both the RCRA TSD closure and RCRA
 12 corrective action requirements. As part of RCRA corrective action, certain applicable
 13 requirements of *Model Toxics Control Act* (MTCA) cleanup regulations (WAC 173-340) that are
 14 incorporated into the WAC 173-303, "Dangerous Waste Regulations," including
 15 WAC 173-340-357, "Quantitative Risk Assessment of Clean-Up Action Alternatives," must be
 16 followed. WAC 173-340-357 requires assessment of ecological risk as part of the determination
 17 of cleanup levels and remedial action alternatives. The MTCA addresses hazardous chemicals
 18 but does not address the radionuclide contaminants which are known to have been released into
 19 the environment at WMA C. To address chemical and radiological ecological risks, the WMA
 20 ERAs will be performed in accordance with two guidance documents:

- 21 a. WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures."
- 22 b. DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic*
 23 *and Terrestrial Biota.*

24 3.4.2.1.1 Washington Administrative Code Terrestrial Ecological Evaluation Procedures.

25 WAC 173-340-7490 prescribes a protocol for evaluating risks to terrestrial receptors from
 26 chemical (nonradionuclide) constituents in soil. WAC 173-340-7490 establishes a tiered
 27 approach for assessing risk and determining cleanup levels that are protective of terrestrial soil
 28 biota, plants, and animals. Tiers are based on exclusions for certain types of sites, simplified
 29 ecological evaluations, and site-specific evaluations. Site-specific terrestrial ecological
 30 evaluation methodology (WAC 173-340-7493, "Site-specific terrestrial ecological evaluation
 31 procedures") identifies a variety of methods that may be used to evaluate risks and determine
 32 protective cleanup levels for terrestrial organisms. The process also has provisions for allowing
 33 certain sites to "exit" from further consideration if specified criteria are met.

34
 35 **3.4.2.1.2 DOE Graded Approach for Evaluating Radionuclides.** The International Atomic
 36 Energy Agency (IAEA) has concluded that chronic radiation doses below 0.1 rad/day will not
 37 harm terrestrial animal populations, and that chronic dose rates below 1 rad/day are unlikely to
 38 have an adverse effect on terrestrial plants or aquatic biota (IAEA, *Effects of Ionizing Radiation*
 39 *on Plants and Animals at Levels Implied by Current Radiation Protection Standards*).
 40 DOE-STD-1153-2002 was developed to address risks of radiation doses to aquatic and terrestrial
 41 biota based on the IAEA dose standards. DOE-STD-1153-2002 provides a graded approach to
 42 ecological risk evaluation and contains Level 1 biota concentration guides (BCG) for
 43 radionuclides in soil, sediment, and water that equal the 0.1 and 1 rad/day threshold dose levels.

1 For exposure to multiple radionuclides, the technical standard uses the sum of the fractions (i.e.,
2 sum of the fractional dose contributions from each radionuclide) to calculate the total dose. The
3 Level 1 screening methodology is used primarily to prioritize actions for sites with the greatest
4 potential for generating adverse effects. If the calculated dose is greater than the BCG for a
5 given radionuclide, the initial screening level has been exceeded, indicating that the second step,
6 a site-specific evaluation, should be performed.

7
8 The software program RESRAD-BIOTA (Version 1.21, ANL 2006) was developed as the
9 calculation tool that is currently approved, updated, and supported for implementing
10 DOE-STD-1153-2002. The code serves as the DOE's "next generation" biota dose evaluation
11 tool and duplicates the Level 1 screening (i.e., BCGs) and analysis methods contained in
12 DOE-STD-1153-2002. RESRAD-BIOTA is the most current and extensive source of BCGs.

13
14 The BCGs, calculation tools, and general methodology for evaluating the risk from radionuclide
15 exposures to ecological receptors will be used for radionuclide evaluation in the WMA C ERA.

16 **3.4.2.2 Summary of Ecological Risk Assessment Approach**

17 The geographical scope of the WMA C ERA will generally be defined as the WMA C proper
18 plus a buffer area with a 100-m width outside of the fenceline (Figure 3-14). This is also known
19 as the "CMS Boundary." The areas inside the WMA C fenceline are currently managed such
20 that there is no viable habitat by using herbicides and pesticides on a regular basis and fences are
21 placed around the perimeter to keep larger animals out of the WMAs, including WMA C (see
22 Section 2.2). However, adjacent areas outside of the fence offer potential habitat that could
23 support receptor species. Current conditions outside the fenceline may be indicators of future
24 colonizing species and receptors.

25
26 The purpose of the WMA C ERA is to

- 27 a. Evaluate potential threats to the terrestrial environment from releases of hazardous
28 substances (chemicals and radionuclides) associated specifically with WMA C.
- 29 b. Determine whether a release of hazardous substances to soil may pose a threat to the
30 terrestrial environment.
- 31 c. Characterize existing or potential threats to plants or animals exposed to hazardous
32 substances in soil.
- 33 d. Establish site-specific cleanup standards, as applicable.
- 34 e. Facilitate selection of a corrective action by developing information necessary to conduct
35 evaluations of CMAs.

36 Documentation resulting from the ERA for WMA C will ultimately guide development and
37 implementation of corrective measures at WMA C and other SST WMAs.
38

1
2
3

Figure 3-14. Aerial Photograph of WMA C Facility Boundary (Black).
(Geographical extent of the ERA will include habitat within 100 m outside of the facility boundary)



4
5
6

1 **3.4.2.3 Implementation of Ecological Risk Assessment Approach**

2 The ERA approach for WMA C (as well as the other SST WMAs) is guided by
3 WAC 173-340-7490. Specifically, WAC 173-340-7493 will be used.

4
5 There are two elements in planning a site-specific terrestrial ecological evaluation. Both
6 elements are performed in consultation with and approval by Ecology. The two elements are the
7 following:

- 8 a. Completing the problem formulation step.
9 b. Selecting one or more methods under WAC 173-340-7493(3) for addressing risks
10 identified in the problem formulation step.

11 **3.4.2.3.1 Problem Formulation.** Ecological risk assessment problem formulation identifies
12 the chemicals of ecological concern, the exposure pathways, terrestrial receptors of concern, and
13 includes a toxicological assessment in accordance with WAC 173-340-7493(2)(i) through (iv).
14 Each of these elements of the problem formulation are briefly described in the following.

15
16 **Identification of Chemicals of Ecological Concern.** WAC 173-340-7493 identifies hazardous
17 substances of concern that should be considered in a site-specific terrestrial ecological
18 evaluation. Metals, pesticides, chlorinated organics, nonchlorinated organics, and petroleum are
19 identified as priority constituents in Table 749-3 of WAC 173-340-900, "Tables" "Model toxics
20 control act—cleanup." Priority constituents identified in Table 749-3 (WAC 173-340-900) that
21 are expected to be present as a result of a release of tank waste to soil within the 0 to 4.6 m (0 to
22 15 ft) depth will be evaluated in the ERA.

23
24 Based on process knowledge and existing radiological survey or soil characterization data,
25 radionuclides are known to be present within WMA C. DOE-STD-1153-2002 will be used to
26 evaluate compliance with specified limits on radiation dose to populations of terrestrial biota.
27 Specifically, DOE-STD-1153-2002 provides dose evaluation methods that can be used to meet
28 the requirements for protection of biota in DOE O 540.1A, *Environmental Protection Program*,
29 and DOE Order 5400.5 *Radiation Protection of the Public and the Environment*, and the dose
30 limits for protection of biota developed or discussed by the National Council on Radiation
31 Protection and Measurements (NCRP 1991) and IAEA (1992).

32
33 RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, presents a
34 comprehensive list of volatile organic, semivolatile organic, general organic, inorganic, and
35 radionuclide constituents expected in tank waste. RPP-23403 bins tank waste constituents for
36 analysis as either "primary" or "secondary" constituents. Primary constituents are those likely to
37 be present in SSTs that may be analyzed by reliable methods and within the constraints of the
38 DQOs. Secondary constituents are those that are reported using the methods for primary
39 contaminants but not identified specifically as primary constituents. Secondary constituents that
40 require evaluation in the risk assessment may be moved to the primary constituent list. WAC
41 Table 749-3 (WAC 173-340-900) contains soil indicator concentrations for several of the
42 primary and secondary tank waste constituents identified during the SST DQO process
43 (RPP-23403). Nearly all primary and secondary radionuclide constituents identified in
44 RPP-23403 have paired BCGs for the protection of terrestrial and aquatic receptors
45 (DOE-STD-1153-2002, ANL 2006).

1
2 Available data on contaminants in the soil will be used to determine which substances in WAC
3 Table 749-3 (WAC 173-340-900) and RESRAD-Biota Level 1 BCGs (ANL 2006) are present in
4 WMA C. The identification process for contaminants of potential ecological concern (COPEC)
5 will consider the likelihood that primary and secondary constituents are sufficiently persistent
6 and accessible within WMA C to cause exposure to terrestrial receptors.

7
8 **Exposure Pathway Identification.** An exposure pathway is the pathway that a hazardous or
9 radioactive substance takes or could take from its source to the exposed organism. The exposure
10 pathway describes the mechanism by which an individual or population is exposed or has the
11 potential to be exposed to hazardous substances. Each exposure pathway includes an actual or
12 potential source or release from a source, an exposure point, and an exposure route. If the
13 exposure point differs from the source of the hazardous substance, the exposure pathway also
14 includes a transport/exposure medium. Examples of exposure pathways include but are not
15 limited to dermal contact with or ingestion of contaminated soil, uptake of soil contaminants by
16 biota resulting in exposure to a receptor, or secondary transport and exposure via consumption of
17 contaminated prey items.

18
19 Understanding the exposure pathways and mechanisms are important for evaluating CMAs. The
20 ERA will identify and document potential pathways from contaminant sources to terrestrial biota
21 within WMA C and adjacent areas.

22
23 **Terrestrial Receptors of Concern.** Terrestrial receptors of concern to be evaluated in the ERA
24 will be representative of the taxonomic groupings identified in WAC 173-340-7493(2)(a)(iii).
25 Receptor groups include soil biota (invertebrates), vascular plants, ground-feeding birds, ground-
26 feeding small mammal predators, and herbivorous small mammals. To strengthen the pathway
27 evaluation, two higher trophic predatory species, the badger and the red-tailed hawk, will be
28 considered in the WMA C ERA.

29
30 **Toxicological Assessment.** The purpose of the toxicological assessment is to identify
31 significant adverse effects to the receptors of concern that may result from exposure to the
32 chemicals of ecological concern [WAC 173-340-7493(2)(iv)]. The toxicological assessment
33 consists of an ecological effects evaluation using the hazardous substance soil indicator
34 concentrations for primary and secondary SST contaminants established in WAC 173-340-900,
35 Table 749-3, for the protection of plants, soil biota, and wildlife. The ecological effects
36 evaluation for radionuclides in soil will be performed using RESRAD Biota Level 1 BCG values
37 for primary and secondary contaminants provided for the protection of terrestrial plants and
38 wildlife (DOE-STD-1153-2002, ANL 2006).

39
40 Soil contamination data for soil depths ranging from 0 to 4.6 m (0 to 15 ft) will be assembled
41 from existing sources such as borehole and vadose zone characterization reports, results from
42 Phase 2 characterization activities, monitoring reports, radiological field survey results, and other
43 available sources for WMA C. Maximum concentrations for each primary and secondary
44 nonradionuclide listed in Table 749-3 (WAC 173-340-900) will be evaluated against its
45 respective published screening values for terrestrial plants, soil biota, and wildlife. Maximum
46 radionuclide concentrations in existing soil data or radiological field survey data will be

1 compared to applicable Level 1 soil BCGs that are provided for protection of radiological effects
2 on terrestrial plants and animals (as reported from RESRAD-BIOTA, Version 1.2.1, ANL 2006).

3
4 Soil data collected to support the human health risk investigation for WMA C will also be
5 included in the toxicological assessment for terrestrial ecological receptors of concern.

6
7 Table 3-1 provides soil indicator concentrations for nonradionuclides published in
8 WAC 173-340-900 (Table 749-3) for the contaminants that have been identified as primary or
9 secondary contaminants in SST DQO (RPP-23403), plus pesticides and petroleum products.
10 Table 3-2 provides BCGs for terrestrial plants and wildlife for radionuclides in soil, as published
11 in DOE-STD-1153-2002 and the current version of its companion software, RESRAD-BIOTA
12 (currently Version 1.21, ANL 2006) for the contaminants identified as primary or secondary
13 contaminants in RPP-23403.

14 **3.4.2.3.2 Risk Evaluation.** Following the problem formulation is the risk evaluation step. The
15 purpose of the risk evaluation is to assemble the information necessary to develop cleanup levels
16 and adequately support the selection and evaluation of corrective action alternatives in the CMS.
17 Ecological risk evaluation methods will follow guidance published in WAC 173-340-7493(3).

18
19 During the toxicological assessment performed under the problem formulation step, analytical
20 results for soil will be compared to the available soil indicator concentrations presented in
21 Table 749-3 of WAC 173-340-900 and BCGs established in RESRAD-BIOTA (ANL 2006) and
22 DOE-STD-1153-2002. Any analyte that exceeds the published soil indicator concentration for a
23 terrestrial receptor will be identified as a COPEC and the need for corrective action will be
24 established. However, if analytical data do not signify an exceedance of a soil indicator
25 concentration for a given receptor, a combination of additional measures may be taken to further
26 evaluate potential risk.

27
28 **Soil Indicator Concentrations.** For hazardous substances published in Table 749-3
29 (WAC 173-340-900) where a soil indicator concentration for a given receptor is not assigned, an
30 indicator concentration can be developed in accordance with WAC 173-340-7493(4). Two
31 approaches would be applied: further literature survey and development of a wildlife exposure
32 model.

- 33 a. **Literature Survey.** Indicator concentrations for soil biota and plants may be developed
34 by consulting the scientific literature using methods provided by the Oak Ridge National
35 Laboratory (ORNL/TM-13391, *Methods and Tools for Estimation of the Exposure of*
36 *Terrestrial Wildlife to Contaminants*).
- 37 b. **Wildlife Exposure Model.** Indicator concentrations for wildlife would be developed as
38 prescribed in WAC 173-340-7493(3)(c) using wildlife exposure model parameters
39 published in WAC 173-340-900 Tables 749-4 and 749-5.

40 **Tissue Analysis and Dietary Exposure Modeling.** Small mammal tissue sampling and analysis
41 is proposed as a supplemental method for evaluating contaminant pathways and risks to wildlife
42 receptors (Appendix B). Small mammals would be collected in available habitat adjacent to the
43 WMA C fenceline where potential overlap may occur between small mammal home range and
44 the occurrence of soil contamination within WMA C.

Table 3-1. Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Biota (2 sheets)

(Benchmarks adapted from WAC 173-340-900 Table 749-3)

Hazardous Substance	Plants ^a	Soil Biota ^a	Wildlife ^a	SST Priority ^b
Metals				
Aluminum (soluble salts)	50			Primary
Antimony	5			Primary
Arsenic III ^c			7	Primary
Arsenic V ^c	10	60	132	Primary
Barium	500		102	Primary
Beryllium	10			Primary
Boron	0.5			Secondary
Bromine ^d	10			
Cadmium	4	20	14	Primary
Chromium (total)	42	42	67	Primary
Cobalt	20			Primary
Copper	100	50	217	Primary
Fluorine ^e	200			
Iodine ^f	4			
Lead	50	500	118	Primary
Lithium	35			Secondary
Manganese	1,100		1,500	Primary
Mercury, inorganic	0.3	0.1	5.5	Primary
Molybdenum	2		7	Secondary
Nickel	30	200	980	Primary
Selenium	1	70	0.3	Primary
Silver	2			Primary
Technetium ^f	0.2			
Thallium	1			Primary
Tin	50			Secondary
Uranium	5			Primary
Vanadium	2			Primary
Zinc	86	200	360	Primary
Pesticides^g				
Aldrin			0.1	Secondary
Benzene hexachloride (including lindane)			6	Secondary
Chlordane		1	2.7	
DDT/DDD/DDE (total)			0.75	
Dieldrin			0.07	Secondary
Endrin			0.2	Secondary
Hexachlorobenzene			17	
Heptachlor/heptachlor epoxide (total)			0.4	
Pentachlorophenol	3	6	4.5	Secondary
Other Chlorinated Organics				
1,2,4-Trichlorobenzene		20		Primary
1,2-Dichloropropane		700		Secondary
1,4-Dichlorobenzene		20		Secondary
2,4,5-Trichlorophenol	4	9		Primary

Table 3-1. Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Biota (2 sheets)

(Benchmarks adapted from WAC 173-340-900 Table 749-3)

Hazardous Substance	Plants ^a	Soil Biota ^a	Wildlife ^a	SST Priority ^b
2,4,6-Trichlorophenol		10		Primary
Chlorobenzene		40		Primary
PCB mixtures (total) ^h	40		0.65	Primary
Other Nonchlorinated Organics				
Acenaphthene	20			Primary
Benzo(a)pyrene			12	Secondary
Di-n-butyl phthalate	200			Primary
Nitrobenzene		40		Primary
Phenol	70	30		Secondary
Styrene	300			Secondary
Toluene	200			Primary
Petroleum				
Gasoline range organics		100	5,000 except that the concentration shall not exceed residual saturation at the soil surface	
Diesel range organics		200	6,000 except that the concentration shall not exceed residual saturation at the soil surface	

^a Blank cells indicate that no value is available for analyte-receptor combination.

^b Only Primary and Secondary contaminants from the SST DQO (RPP-23403) are included in this table except for pesticides and petroleum where all pesticides listed in WAC 173-340-900 Table 749-3 are included. Pesticides and petroleum are considered primary analytes for ecological risk. For primary analytes, if detected a numerical value is reported, if not detected, analytes are reported with a less than minimum detection limit (MDL). For secondary organic analytes, if detected a numerical value is reported as an estimate, if not detected, the analytes are not reported. This is the same process used in SST DQO RPP-23403.

^c Total arsenic is reported [same as SST DQO (RPP-23403)].

^d Bromine is reported as bromide [same as SST DQO (RPP-23403) where it was classed as secondary].

^e Fluorine is reported as fluoride [same as SST DQO (RPP-23403) where it was classed as primary]

^f Included in the radionuclide analysis, radionuclide will be converted from radioactivity to mass using specific activity. ¹²⁹I- and ⁹⁹Tc were both classed as primary in SST DQO (RPP-23403).

^g In addition to the semivolatile organic analysis, EPA Method 8080 for pesticides will also be run to meet the reporting requirements for ecological indicator soil concentrations.

^h Polychlorinated biphenyls (PCB) reported as both arochlor and total PCBs.

Table 3-2. Soil Biota Concentration Guides for Terrestrial Animals and Plants.
(Adapted from RESRAD-BIOTA Level 1 Terrestrial Evaluation, ANL 2006)

Nuclide	Terrestrial Animal BCG (pCi/g)	Terrestrial Plant BCG (pCi/g)	SST Priority
Americium-241	3.9E+03	2.2E+04	Primary
Carbon-14	4.8E+03	6.1E+04	Primary
Curium-242	2.1E+03	7.9E+04	Primary
Curium-244	4.1E+03	1.5E+05	Primary
Cobalt-60	6.9E+02	6.1E+03	Primary
Cesium-137	2.1E+01	2.2E+03	Primary
Europium-152	1.5E+03	1.5E+04	Primary
Europium-154	1.3E+03	1.3E+04	Primary
Europium-155	1.6E+04	1.5E+05	Primary
Tritium (H-3)	1.7E+05	1.7E+06	Primary
Iodine-129	5.7E+03	1.7E+05	Primary
Neptunium-237	3.9E+03	8.2E+03	Primary
Plutonium-238	5.3E+03	1.8E+04	Primary
Plutonium-239	6.1E+03	1.3E+04	Primary
Antimony-125	3.5E+03	3.5E+04	Primary
Strontium-90	2.3E+01	3.6E+03	Primary
Technetium-99	4.5E+03	2.2E+04	Primary
Thorium-228	5.3E+02	6.4E+03	Primary
Thorium-230	1.0E+04	1.8E+05	Primary
Thorium-232	1.5E+03	2.4E+04	Primary
Uranium-233	4.8E+03	5.2E+04	Primary
Uranium-234	5.1E+03	5.2E+04	Primary
Uranium-235	2.8E+03	2.7E+04	Primary
Uranium-238	1.6E+03	1.6E+04	Primary

Results of tissue analyses would be used to verify contaminant exposure of small mammals via direct contact or ingestion of soil, as well as serve as inputs to dietary exposure models for upper trophic level receptors (i.e., badger and red-tailed hawk).

While tissue analysis and dietary exposure modeling are not specifically identified as a means of evaluation in WAC 173-340-7493, the information obtained from such data is valuable for documenting potential for contaminant transport and biotic uptake to higher trophic, predatory species of wildlife.

3.4.2.3.3 Uncertainty Analysis. The WMA ERA will include a qualitative uncertainty analysis to identify specific causes of uncertainties and evaluate their potential impact on the risk estimates. Other considerations of uncertainties, including natural variability, range and uncertainty of potential risks, and methods to reduce uncertainty will also be documented in accordance with WAC 173-340-7493(5).

1 3.4.2.4 Hanford Site Ecological Risk Assessments and Related Activities

2 The WMA C ERA is a component of the broadly scoped SST ERA that will be conducted as part
3 of the CMS for the SST farm. The ERAs for tank farms will support closure decisions for the
4 Hanford Site. This section briefly summarizes the other assessment and monitoring projects
5 relevant to characterizing ecological risks at the Hanford Site.

6 **3.4.2.4.1 Central Plateau Ecological Risk Assessment.** The CPERA evaluates risks to
7 ecological receptors from waste sites in the 200 Area under current conditions. The purpose of
8 the CPERA is to characterize the potential for ecological risk to support waste-site remedy
9 decision making and to fulfill the CERCLA requirements for evaluating baseline ecological risk
10 to the surface and near-surface environment of the Central Plateau. Work conducted for the
11 CPERA was conducted using CERCLA guidance for ecological risk assessment
12 (EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for*
13 *Designing and Conducting Ecological Risk Assessments (Interim Final)*) and included regulator
14 and stakeholder interviews and workshops; identification of contaminants of potential ecological
15 concern and potential ecological risk receptors (DOE/RL-2001-54, *Central Plateau Ecological*
16 *Evaluation*); and identification of DQOs (WMP-20570, *Central Plateau Terrestrial Ecological*
17 *Risk Assessment Data Quality Objectives Summary Report – Phase I*; WMP-25493, *Central*
18 *Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report –*
19 *Phase II*; and WMP-29253, *Central Plateau Terrestrial Ecological Risk Assessment Data*
20 *Quality Objectives Summary Report – Phase III*); SAPs (DOE/RL-2004-42, *Central Plateau*
21 *Terrestrial Ecological Sampling and Analysis Plan – Phase I*; DOE/RL-2005-30, *Central*
22 *Plateau Terrestrial Ecological Sampling and Analysis Plan – Phase II*; and DOE/RL-2006-27,
23 *Central Plateau Terrestrial Ecological Sampling and Analysis Plan – Phase III*) and field
24 characterization activities ((D&D-28419, DTS-RPT-077, *Central Plateau Terrestrial Ecological*
25 *Sampling Report – Phase I*; and DTS-RPT-078, *Central Plateau Terrestrial Ecological Sampling*
26 *Report – Phase II*).

27
28 Specific investigations conducted for the CPERA included collection and analysis of soil, biota,
29 soil gas, and media associated with West Lake. Soils were analyzed for metals, polychlorinated
30 biphenyls (PCB) (including PCB congener analyses), organochlorine pesticides, and
31 radionuclides. Supporting soil measurements (e.g., soil nutrients, pH, total organic carbon, and
32 particle size) also were collected to aid in risk interpretation. Vegetation surveys were
33 performed to evaluate relative abundance, diversity, and measures of habitat quality. Biota
34 collected included ground-dwelling invertebrates, lizards, and small mammals. Each biotic
35 receptor was analyzed for tissue concentrations of contaminants. Lizards and small mammals
36 also were examined in the field for gross abnormalities. Relative abundance was estimated for
37 invertebrates, lizards, and small mammals. These activities have culminated in extensive
38 information to identify and calculate the potential for risks to the environment from
39 concentrations of Hanford Site contaminants on the Central Plateau (DOE/RL-2007-50, *Central*
40 *Plateau Ecological Risk Assessment Report*).

41
42 Operable unit decisions for Central Plateau waste sites and groundwater are supported by
43 remedial investigations and feasibility studies. These decisions are supported by the CPERA.
44 The CPERA report (DOE/RL-2007-50) presents the results of the ERA for the Central Plateau
45 waste sites. The groundwater operable unit decisions address remedies for existing groundwater

1 plumes and are intended to ensure that contaminant plumes are contained within the Central
2 Plateau and do not pose a future threat to the River Corridor or Columbia River.

3 **3.4.2.4.2 River Corridor Baseline Risk Assessment.** The River Corridor Baseline Risk
4 Assessment (RCBRA) evaluated risks from CERCLA waste sites to human health and the
5 environment (DOE/RL-2007-21, *Risk Assessment Report for the 100 Area and 300 Area*
6 *Component of the River Corridor Baseline Risk Assessment*). The RCBRA waste are located in
7 the 100 Area, 300 Area, and portions of the 600 Area. The RCBRA also evaluated adjacent
8 riparian and near-shore environs of the Columbia River. Results of the RCBRA will be used to
9 support development of final Records of Decision in the Hanford Site River Corridor. Remedial
10 actions are currently being performed in contaminated areas of the River Corridor under Interim
11 Action Records of Decision. The ERA component of RCBRA was conducted using
12 EPA/540/R-97/006 and included numerous regulator and public workshops and meetings. The
13 RCBRA involved development of a work plan (DOE/RL-2004-37, *Risk Assessment Work Plan*
14 *for the 100 Area and 300 Area Component of the RCBRA*), a DQO process report (BHI-01757,
15 *DQO Summary Report for the 100 Area and 300 Area Component of the River Corridor*
16 *Baseline Risk Assessment*), and a SAP (DOE/RL-2005-42, *100 Area and 300 Area Component of*
17 *the RCBRA Sampling and Analysis Plan*). The RCBRA project employed similar sampling
18 strategies and methods to characterize risk in the terrestrial portion of the assessment as the
19 CPERA. Given the similarity of terrestrial site sampling between RCBRA and Central Plateau
20 projects, data from both projects were shared for performing risk analyses.

21 **3.4.2.5 Ecological Risk Assessment Schedule**

22 The schedule showing the following activities for the ecological risk assessment is provided in
23 Chapter 6.

- 24 • Compilation of Existing Data
 - 25 - Ecological/field Descriptive Information
 - 26 - Analytical Data
- 27 • Problem Formulation
 - 28 - Identification of Chemicals of Ecological Concern
 - 29 - Exposure Pathway Identification
 - 30 - Terrestrial Receptors of Concern
 - 31 - Toxicological Assessment (including benchmark evaluation)
- 32 • Risk Evaluation -
 - 33 - Tissue Analysis and Dietary Exposure Modeling
- 34 • Uncertainty Analysis

35
36 If no relevant existing data are available for analysis, collection of supplemental samples (soils
37 for human health risk assessment, small mammal tissues for exposure model) would be
38 coordinated with the problem formulation phase of the ERA. If existing data are available to
39 perform initial steps of the ERA through the toxicological assessment, supplemental soil and
40 tissue data may be collected as necessary following problem formulation prior to risk evaluation.

3.5 IDENTIFICATION OF CONTAMINANTS OF CONCERN

The DQO for this work plan (RPP-RPT-38152) used the same approach as RPP-23403 for developing analytical parameters. In this approach, "primary" constituents were identified from the Hanford Facility Dangerous Waste Part A Permit Application, Form 3, Revision 8, for the SST system [Letter 03-ED-009, "Hanford Facility Dangerous Waste Part A Permit Application Form 3, Revision 8, for the Single-Shell Tank (SST) System"] (Part A), underlying hazardous constituents, 10 CFR 61.55, "Licensing Requirements for Land Disposal of Radioactive Waste," and identified potential risk contributors. Analytical methods were identified for the primary constituents. In addition to the identified constituents, a number of these methods can also detect many other chemicals or radionuclides. These other or "secondary" analytes will be evaluated and reported using strategies described in RPP-23403.

This approach was adopted in D&D-30262, *Data Quality Objectives Summary Report for the 200-IS-1 Operable Unit Pipelines and Appurtenances*, for tank farm pipelines and associated appurtenances and associated UPRs. In addition, WMP-28945, *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process*, identifies constituents that will be analyzed as part of the groundwater characterization. The analytes from these documents were considered in formulating the analytical parameters for the DQO supporting this work plan.

Extensive lists of sample analysis methods and analytes (chemicals and radionuclides, see section 4.5 of RPP-RPT-38152) were identified during the DQO. However, not all methods will be performed on every sample. Analysis methods that will be performed or analytes that will be available on specific samples are identified in Section 3.5.1.

3.5.1 Stepped Approach for Evaluating Tank Waste Contaminants of Concern

To optimize the cost-effectiveness of this characterization effort, the analysis of vadose zone samples will use a two-tiered step approach. This is consistent with previous tank farm characterization efforts conducted in support of the Phase 1 RFI process. There are two key variables in this approach: the concentration of any hazardous substance or radionuclide and the risk created by these constituents. Step 1 is to assess if there are chemicals present that are of concern in the context of human health and biotic risk. If the answer is yes, we proceed to step 2, which will provide the data to determine the extent of the risk created by the presence of contaminants in the Phase 2 RFI/CMS. If the answer to step 1 is no, then no further sampling at that location would be conducted. The two-step approach was developed in the DQO process and is described in the WMA C DQO (RPP-RPT-38152). Step 1 will employ a method-based screening process to determine if the soil has been contaminated with tank waste. A select set of threshold indicator constituents will be used to indicate the presence of tank waste. If any one of the tank waste indicator threshold is met, then the full suite of step 2 analytes will be analyzed (see Section 4.0 of RPP-RPT-38152). The Step 1 analytes and their threshold values¹³ are as follows.

¹³ DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Volume I. DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*.

1	²³⁸ U	Detected at or above 1.39 pCi/g.
2	²³⁹ Pu	Detected at or above 0.0233 pCi/g.
3	¹³⁷ Cs	Detected at or above 1.37 pCi/g.
4	⁹⁰ Sr	Detected at or above 0.262 pCi/g.
5	NO ₃	Detected at or above 232 µg/g.
6	Cr (for Cr-6)	Detected at or above 26.8 µg/g.
7	⁹⁹ Tc	Detected.
8	¹²⁹ I	Detected.
9	CN	Detected.

10
11
12 Uranium-238, ²³⁹Pu, ¹³⁷Cs, ⁹⁰Sr, NO₃, and Cr are present at low levels in Hanford background
13 soil. The stated thresholds are met only if the contaminants are detected and the detected
14 concentrations are at or above the stated values.

15
16 The following methods would be performed on samples to acquire the above analytes:
17 inductively coupled plasma/mass spectroscopy, alpha energy analysis, inductively coupled
18 plasma spectroscopy, ion chromatography, gamma energy analysis (GEA), separation/beta
19 counting for ⁹⁰Sr, separation/GEA for ¹²⁹I, spectrophotometric for cyanide, and semivolatile
20 organic analysis by gas chromatography/mass spectroscopy (GC/MS) for tributyl phosphate.
21 Cobalt-60 concentration will be obtained by GEA along with ¹³⁷Cs. Cobalt-60 and ⁹⁹Tc sample
22 results will be used to assess the relationship of these radionuclides in the soil.

23 3.5.2 Optimizing for Organics and PCBs, Pesticides, and Gasoline and Diesel Range 24 Organics

25 Five direct-push locations have been identified as candidate sites that have the highest potential
26 for providing data on organic waste releases associated with tank wastes. The five candidate
27 direct-push sites are associated with UPR-81 (three locations) and on the northwest and northeast
28 side of SST C-103 (two locations). At these five locations, following the spectral gamma and
29 neutron logging, the entire suite of analytes will be analyzed in the sample zones. Tributyl
30 phosphate will be used as the indicator organic for the occurrence of any organic contamination
31 associated with tank waste. Tributyl phosphate is a known tank waste contaminant because it
32 was used extensively as a solvent in the reprocessing of spent nuclear fuel. The DQO team
33 agreed to use this compound as an indicator for tank waste organics. If TBP is not detected in
34 any of the samples, then organics will be eliminated from the list of contaminants of potential
35 concern (COPC) and not analyzed for at other locations in WMA C. If TBP is detected in any of
36 the samples, then organics will remain on the list of COPCs and organic compounds will be
37 analyzed for as part of the step 2 suite of analytes following a detection of the step 1 tank waste
38 trigger constituents. Other volatile and semivolatile compounds were rejected as either not being
39 indicators of tank waste or more importantly are common laboratory contaminants. For
40 example, the following compounds are recognized as common laboratory contaminants detected in
41 the analysis for volatile and semivolatile organics.

- 1 • Volatiles
- 2 - Methylene chloride.
- 3 - Acetone.
- 4 - 2-Butanone.
- 5 - bis-2 Ethylhexyl Phthalate.
- 6 - Diethyl Phthalate.
- 7 - Benzyl Phthalate.
- 8 - Chloroform (volatile organic compound).
- 9 • Semivolatiles
- 10 - Common Phthalate contaminants.
- 11 - n-Butyl Phthalate.
- 12 - n-Octyl Phthalate.

13
14 This list of contaminants is not all inclusive. However, the list serves to illustrate the potential
15 for false positive results being reported due to laboratory contamination. Identifying common
16 laboratory contaminants and accounting for their influence on how data are interpreted will
17 improve the decision error by reducing the potential for false positives to be interpreted as
18 contaminants being present and the risk that a decision is made to remediate a site that is not
19 contaminated.

20
21 Polychlorinated biphenyls are of specific concern to direct contact and ecological risk and will be
22 sampled in the near-surface vadose zone only. Three vadose zone samples will be collected in
23 the region of 0 to 15 ft bgs at the five direct-push locations (15 samples) and analyzed for
24 Aroclors and congeners. If polychlorinated biphenyls are not detected in any of the samples,
25 then they will be eliminated from the list of COPCs and not analyzed for at other locations in
26 WMA C. If PCBs are detected in any of the samples, then they will remain on the list of s and
27 be analyzed for as part of the step 2 suite of analytes following a detection of the step 1 tank
28 waste trigger constituents. The results from the initial five samples will be used to attempt to
29 establish a correlation between PCB Aroclors and congeners that would support future analysis
30 for only PCB Aroclors.

31
32 Pesticide application is widespread throughout the tank farms as part of operation and
33 maintenance activities to prevent vegetation from becoming established. Petroleum products
34 were also used, principally as fuels. At these five sites, samples collected from 0 to 14 ft will be
35 evaluated for pesticides and petroleum. If a pesticide or petroleum product is detected at or
36 above its threshold value in any of the five samples, then they will remain on the list of COPCs
37 and will be analyzed for as part of the step 1 suite of screening analytes at subsequent sample
38 locations. If no pesticides or petroleum products are detected at the five sites, they will be
39 dropped from further analysis. The pesticides and petroleum products that will be analyzed are
40 the following:

41	Aldrin	Detected
42	Benzene hexachloride (including lindane)	Detected
43	Chlordane	Detected
44	DDT/DDD/DDE (total)	Detected
45	Dieldrin	Detected
46	Endrin	Detected

1	Hexachlorobenzene	Detected
2	Heptachlor/heptachlor epoxide (total)	Detected
3	Pentachlorophenol	Detected
4	Tributyl phosphate	Detected
5	Gasoline range organics	Detected
6	Diesel range organics	Detected

7

8 Gas chromatography/mass spectroscopy will be used to screen for pesticides to determine if a
9 method-based analysis for pesticides is required. If the GC/MS analysis does not detect any of
10 the pesticides, no further analysis will be conducted.

11 3.6 INTERIM MEASURES

12 This section describes the interim measures that have been evaluated and/or implemented as they
13 relate to WMA C. Interim measures are initial response actions that can be taken while
14 characterization activities are under way and while long-term strategies are being developed to
15 reduce the impacts of past releases on groundwater under RCRA. Interim measures do not
16 require comprehensive evaluation in a CMS. Interim measures identified to date for WMA C
17 focus on actions to minimize infiltration and contaminant migration to groundwater. Interim
18 measures have been implemented at WMA C during the past several years.

19

20 Corrective measures are response actions that are intended to reduce contaminant migration to
21 groundwater to acceptable regulatory levels. Corrective measures require the balancing of risk,
22 benefits, and costs. In general, corrective measures involve a substantial commitment of
23 resources, require a more thorough evaluation prior to implementation, and are intended to
24 provide a more permanent solution to the long-term threats posed by a contaminant release.
25 Detailed evaluation of the proposed WMA C corrective measures will be undertaken in the
26 Phase 2 RFI/CMS report based on the results of this Phase 2 field investigation for WMA C and
27 the field investigation report for WMAs C and A-AX (RPP-35484). An accelerated CMS would
28 be required if an imminent threat or danger to the public or environment arises.

29

30 Current interim measures that have been implemented include the following (DOE/ORP-2008-01
31 Appendix K):

32

a. All waterlines within WMA C have been cut and capped or pressure tested.

33

b. All groundwater wells and drywells have watertight caps.

34

c. Several run-on control structures were constructed adjacent to WMA C.

35

Some waterlines were not needed, thus they were abandoned, effectively removing them as
36 sources of inadvertent recharge.

37

38 RPP-5002, *Engineering Report, Single-Shell Tank Farms Interim Measures to Limit Infiltration*
39 *Through the Vadose Zone*, identified wells and drywells as "unfit for use." These wells are
40 potential preferential pathways for downward contaminant migration. The majority of wells
41 identified in RPP-5002 are the drywells used to monitor movement of contaminants through the
42 vadose zone. The Tank Summary Data Reports associated with GJO-98-39-TAR discuss
43 drywells (i.e., boreholes) that should be sealed and abandoned or decommissioned in accordance

1 with WAC 173-160, "Minimum Standards for the Construction and Maintenance of Wells."
2 These include boreholes 30-00-10, 30-00-06, 30-00-03, 30-00-09, and 30-00-12. Borehole
3 30-00-10 is blocked at a depth of about 52 ft, and the perforated casing in this borehole might
4 provide a migration path for shallow contaminants to reach greater depths. The other boreholes
5 all are perforated and provide a potential avenue for enhanced migration downward into the
6 vadose zone. Borehole 30-08-03 should be plugged and abandoned (GJO-98-39-TAR and
7 RPP-35484).

8
9 Upgradient surface water run-on control measures consist of some combination of regarded
10 ground surfaces, soil/gravel berms, asphalt pavement, concrete curbs, gutters and valley drains,
11 and culverts. All of these were constructed outside the SST farms to prevent surface water from
12 pressurized waterline leaks outside of the tank farm boundary and unusual meteorological events
13 from flowing onto the tank farm areas.

14
15 During FY 2002, several run-on control structures were designed and constructed adjacent to
16 WMA C. Berms were placed to redirect surface water away from the tank farm surfaces, and
17 curbs and gutters were placed along the roadways to redirect runoff.

18
19 In addition, historical pipeline leak events (e.g., UPR-200-E-82 and UPR-200-E-86) have gunite
20 caps placed on the surface. These gunite caps provide an interim solution to the long-term threats
21 posed by contaminant releases by minimizing infiltration, contaminant migration to groundwater,
22 and contaminant exposure to present-day workers.
23

4. WORK PLAN RATIONALE AND APPROACH

The Phase 2 RCRA corrective action process is the RCRA-specified method by which UPRs to the environment are characterized and corrective action alternatives are evaluated and implemented if required to minimize potential risks to human health and the environment. Furthermore, this RCRA-specified method is consistent with the CERCLA method for characterization and remediation. HFFACO (Section 7.1) lists and compares the major steps involved with cleanup of RCRA and CERCLA "past practices" and concludes they are functionally equivalent (see also Section 3.1.2 of RPP-PLAN-37243). Objectives and data needs must be identified before designing a data collection program to support the Phase 2 RFI/CMS process. The data collected are used as a basis for making an informed risk management decision regarding the most appropriate corrective action(s) to implement. The data needs for field characterization efforts at WMA C were identified through a DQO process (RPP-RPT-38152) that was executed based on the requirements established in the HFFACO commitments (Ecology and DOE 2007). The data identified in the DQO process will be collected in accordance with HFFACO Milestone M-45-60 (i.e., this work plan), HFFACO Milestone M-45-00, and HFFACO Appendix I.

4.1 RATIONALE

Further understanding of subsurface conditions and contaminant migration processes is required to support decision-making on interim measures and corrective measures (Section 3.2.3). A comprehensive list of data needed to support these decisions was developed based on the current level of understanding in a DQO process (RPP-RPT-38152). However, it is generally recognized on both a technical and regulatory basis that present knowledge of existing contaminant concentrations, contaminant inventory, distribution of contaminants in the vadose zone from past releases, and uncertainties associated with contaminant migration processes is insufficient to support future decision-making for corrective actions. Therefore, there is a need to collect additional information through Phase 2 field and laboratory investigations, which will be supplemented by ongoing groundwater and vadose zone monitoring data, to support decisions on corrective actions and WMA closure. Groundwater monitoring data are collected on a regular basis as part of the RCRA groundwater monitoring program, while vadose monitoring (HRR leak detection monitoring and leak detection mitigation and monitoring) takes place during waste retrieval operations

Characterization objectives and data needs for WMA C were developed during the DQO process (RPP-RPT-38152) carried out under the Phase 2 RFI/CMS master work plan (RPP-PLAN-37243) and this work plan. The development of this document and characterization activities for Phase 2 were supported by the DQO process.

The DQO process (EPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process*) is a planning approach, based on the scientific method,¹⁴ for defining the decisions that any data collected should satisfy. The EPA seven-step DQO process and several

¹⁴ The scientific method involves the principles and processes regarded as characteristic of or needed for scientific investigation, including rules for concept formation, conduct of observations and experiments, and validation of hypotheses by observations or experiments.

1 associated activities and workshops were implemented to support preparation of this work plan.
2 These workshops included participants from the TOC, Ecology, DOE, and other key Hanford
3 Site programs (see also Section 1.2). As appropriate, the DQO process included project
4 managers from Ecology and DOE, with technical support by the TOC staff, and input from other
5 key Hanford Site programs and agencies.

6
7 The DQO process provides assurance that the type, quantity, and quality of environmental data
8 used to support remediation decisions are suitable for the intended application. The process
9 establishes a consistent, cooperative, and streamlined approach that encourages optimum use of
10 available data, information, and technical resources.

11
12 Before initiating meetings to discuss characterization activities to be conducted during Phase 2,
13 the Tank Farm Vadose Zone Program technical team conducted a review of existing information
14 that included published and unpublished reports, interpretations of historical and recent
15 geophysical survey data, and information from previous DQO meetings. To prioritize data needs
16 for inclusion in the Phase 2 characterization effort, a review of the available information on the
17 current state of knowledge of WMA C subsurface contamination was conducted by the Tank
18 Farm Vadose Zone Program technical team. The review results are summarized in Chapters 2, 3,
19 and 5 of this work plan.

20
21 A series of DQO meetings were held from February 6, 2008, to June 18, 2008, that focused
22 specifically on the data needs for the field characterization efforts to be conducted at WMA C.
23 These meetings served to identify the following:

- 24
25 a. Existing data and what is currently known about WMA C.
26 b. Data needs that will likely be satisfied by Phase 2 characterization activities.
27 c. Options for data collection from the additional characterization activities.

28 These meetings included representatives from Ecology, DOE, and Hanford Site contractors.
29 Meetings held as a part of the DQO process involved varying levels of involvement by all
30 participants. The DQO meetings provided a foundation of existing information and identified
31 characterization options for consideration by the decision makers.

32
33 Through the DQO process, the primary goal of the WMA C field investigation was determined
34 to be implementation of vadose zone characterization activities that will support the iterative
35 process of improving the understanding of inventory (i.e., nature and extent of past releases) and
36 contaminant migration processes (fate and transport) necessary to support risk assessments. This
37 work plan focuses on additional characterization data needed to support near-term CMA
38 decisions as they relate to soils within and immediately surrounding WMA C. The
39 characterization effort is designed to provide data that, when combined with historical data,
40 including data collected under the Phase 1 RCAP and near-term field investigations, will allow
41 informed corrective measures decisions to be made. Additional engineering data associated with
42 corrective measure technologies provided in RPP-ENV-34028, *Central Plateau Vadose Zone*
43 *Remediation Technology Screening Evaluation* and cost and implementability studies will
44 provide the additional information needed to make CMA decisions. This work plan only

1 implements the additional soil characterization data needed to fulfill the WMA C DQO
2 (RPP-RPT-38152).

3
4 The rationale for this Phase 2 RFI/CMS work plan is based on the various conceptual site models
5 presented in Section 3.3 and regulator input through the DQO process. Ecology expressed the
6 desire to achieve the following goals during this Phase 2 characterization effort: (1) evaluating
7 UPR sites associated with WMA C, (2) addressing stakeholder concerns related to contaminant
8 migration, (3) near-surface (less than 15 ft bgs) soil sampling to support direct contact and
9 ecological risk assessment, and (4) other potential areas of unintentional releases associated with
10 the ⁹⁹Tc groundwater contamination and ability to close WMA C after retrieval completion. The
11 sampling strategy is focused on addressing these data needs. The rationale for site selection is
12 given in Section 4.4.

13 4.2 DATA NEEDS

14 Current understanding of the nature and extent of contamination at WMA C is based largely on
15 order-of-magnitude estimates of past leak volumes and inventories and on historical information
16 on the distribution of gamma-emitting radionuclides measured to a depth of 100 to 150 ft bgs
17 using drywells located around the tanks and groundwater monitoring from groundwater
18 monitoring wells. Historical drywell gross gamma data were collected from the early 1960s
19 through 1994; however, detailed analysis of the gross gamma data has only recently been
20 conducted. For the C Farm, RPP-8321 was issued on this subject.

21
22 Comprehensive spectral gamma logging of all drywells in WMA C was completed in the 1996
23 through 1999 period as a baseline, then revisited in 2000, and after 2000 as necessary to support
24 waste retrieval leak loss determinations as specified in tank waste retrieval work plans and
25 additional vadose zone characterization investigation needs. In 2000, a new analysis technique, a
26 high rate logging system, was deployed to measure ¹³⁷Cs concentration levels in high gamma
27 flux zones where the spectral gamma logging system was unable to collect usable data because
28 of high dead times and detector saturation from the baseline period. Spectral gamma logging
29 reports were issued for C Farm (GJO-98-39-TAR and GJO-98-39-TARA). Spectral gamma
30 logging data provide insight into the distribution and movement of specific gamma-emitting
31 contaminants (e.g., ¹³⁷Cs, ⁶⁰Co). More recently, soil characterization data have been collected
32 that partially indicate the distribution of non-gamma-emitting mobile tank waste contaminants
33 including ⁹⁹Tc, hexavalent chromium, and nitrate (see Section 3.2). While there are emerging
34 data on the distribution and movement of tank waste contamination in the groundwater, the data
35 are not sufficient to support more than qualitative hypotheses on the specific sources of
36 contaminants responsible for the observed groundwater contamination. Specific sources were
37 identified through field investigations conducted at C-105 (borehole C4297), direct pushes at
38 UPR-200-E-82, UPR-200-E-86, and UPR-200-E-81. At UPR-200-E-82, ⁹⁹Tc and nitrate were
39 found at a depth of approximately 80 ft bgs with maximum and coincident concentration of
40 water-extractable ⁹⁹Tc (10 to 30 pCi/g dry sediment) and nitrate (10 to 20 µg/g dry sediment)
41 (RPP-35484).

42
43 In borehole C4297, elevated concentrations of several constituents in the sediments are attributed
44 to fluids from C-105. An elevated pH zone (8.0 to 9.3) occurs between 40 and 52 ft bgs. The
45 primary set of tank waste constituents includes ⁹⁹Tc, sulfate, nitrate, and sodium. Elevated

1 concentrations of water-extractable ⁹⁹Tc (approximately 0.14 to 8.4 pCi/g dry sediment) extend
 2 between 40 and 159 ft bgs, and show a bimodal distribution with depth. Peak concentrations of
 3 water-extractable ⁹⁹Tc and nitrate were measured at depths between 133 and 154 ft bgs.
 4 Elevated water-extractable sodium concentrations (20 to 131 µg/g) range from 20 to 60 ft bgs,
 5 with a well defined peak concentration zone between 40 and 60 ft bgs (RPP-35484).

6
 7 During the DQO process, the participants determined that the primary focus of the Phase 2 data
 8 collection effort at WMA C should be directed toward further characterizing the contamination
 9 sources in association with CMAs for the soils. This effort should improve the understanding of
 10 leak inventory and distribution to support testing and refining a site-specific conceptual model
 11 for past operational leaks and contaminant migration processes. A number of characterization
 12 technologies, including screening techniques, were considered. Because the current
 13 understanding of the distribution of radionuclides in the contaminated vadose zone is still limited
 14 and is based primarily on indirect evidence, the focus of the Phase 2 data collection program at
 15 WMA C will be on sampling the vadose zone soils in areas of known releases that includes
 16 spills, tank leaks, and overflow events within the tank farms and analyzing the samples for a range
 17 of contaminants of interest and in areas where it is suspected there has been a release that has not
 18 been documented in WIDS. These sites have been identified in a review of process records.

19
 20 Isotopic analysis of vadose zone porewater and groundwater to identify sources was not
 21 considered in the DQO process (RPP-RPT-38152) for the following reasons:

- 22
 23 1. No other liquid waste disposal facilities (i.e., cribs, trenches, ditches, etc.) nearby
 24 WMA C; releases from WMA C are considered the source of contamination to the
 25 groundwater (RPP-35484).
- 26
 27 2. The difficulty in identifying a particular tank as a source because of the timing and
 28 nature of the waste streams to each individual tank (see Table 2-5).

29
 30 RCRA guidance (EPA 530/SW-89-031, *Interim Final RCRA Facility Investigation Guidance –*
 31 *Development of an RFI Work Plan and General Considerations for RCRA Facility*
 32 *Investigations*) and CERCLA guidance (EPA 540/G-89-004, *Guidance for Conducting Remedial*
 33 *Investigations and Feasibility Studies Under CERCLA – Interim Final*) states that if suspected
 34 releases are confirmed during initial investigations, further characterization of such releases will
 35 be necessary. This characterization includes identification of the type and concentration of
 36 hazardous waste or hazardous constituents released, the rate and direction at which the releases
 37 are migrating, and the distance over which releases have migrated. Therefore, UPRs will be
 38 addressed as potentially contributing sources to the vadose zone in WMA C and the
 39 characterization efforts will support the risk assessment and subsequent alternatives evaluation to
 40 select a corrective action. In addition to the UPRs that exist within the WMA boundary, there
 41 are UPRs that are either adjacent to the boundary but outside the fenceline or are in close enough
 42 proximity to the WMA and therefore warrant integration in RCRA corrective action process
 43 planning.

4.3 CHARACTERIZATION OPTIONS

Known or suspected release sites are described in Sections 2.4.3 and 2.4.4. They are the sources for the potentially contaminated soils still remaining to be characterized and are briefly discussed in Sections 3.1.1 and 3.1.2. These known or suspected release sites present characterization options for further investigation.

RPP-ENV-38838, *Tank Farm Vadose Zone Program Characterization Processes*, identifies and describes the possible characterization technologies that could be deployed for this effort, including a description of the advantages and disadvantages of each characterization technology. Through the DQO process (RPP-RPT-38152), characterization options include direct push technology, targeted and WMA C SGE, as well as drywell and groundwater monitoring well spectral gamma logging to investigate possible contamination in the soils at WMA C. The selection of characterization technologies is described in Section 4.6.

The direct push technology has been capable of obtaining a sample as deep as 240 ft bgs. It has the capability of obtaining more than one sample per probehole and does not bring up cuttings that need to be disposed of. This provides the same objective as drilling a deep borehole given the data collection objectives. The SGE technology provides a nonintrusive method of delineating potential release sites across an area. This method is being tested to determine if deep electrodes will provide valuable vertical dissemination of potential releases high in salt content. Drywell and groundwater monitoring well spectral gamma logging has been used in the tank farms and is a proven technology. Based on review of this data, it was determined some of the groundwater monitoring wells have not been logged and 8 years have passed since the last drywells were logged. Thus, this effort is to resolve data gaps that could support migration of contaminants, in particular ^{60}Co migration.

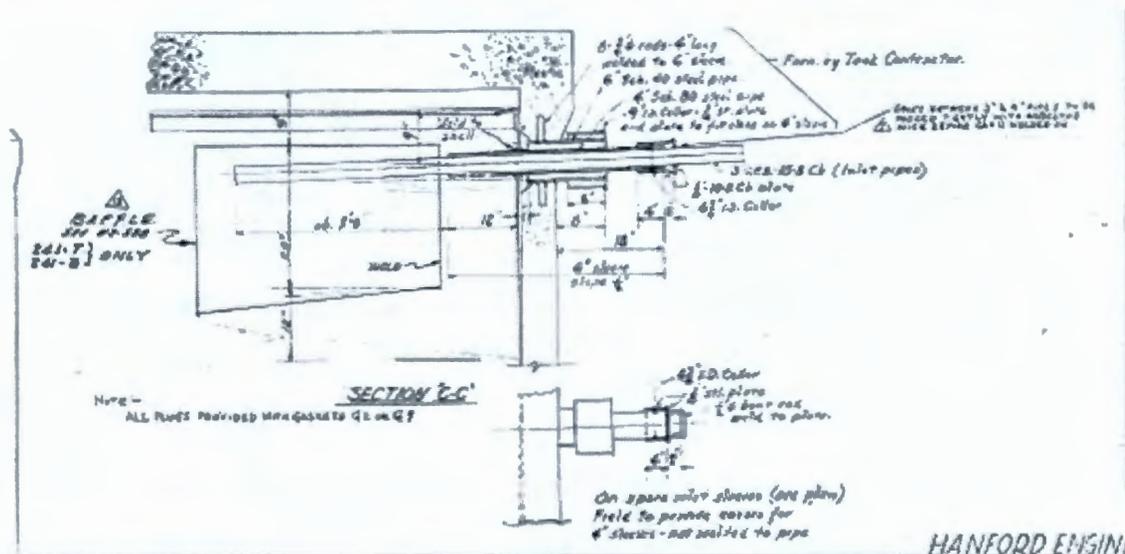
Some of the characterization options will have to address the spare inlet ports that may have been breached as discussed in Section 2.4.4. Additional information is provided in Section 4.3.1 to understand why these spare inlet ports were specifically selected. Additional probable contamination areas that exist in other supporting facilities associated in and around WMA C are discussed in Section 4.3.2.

4.3.1 Potential Waste Losses from Spare Inlet Nozzles

The SSTs in the C Farm are each equipped with four horizontal inlet nozzles, as shown in Figure 4-1 (W-72742, *Hanford Engineering Works Bldg. 241, 75' Diameter Storage Tanks T-U-B & C Arrangement drawing*, and W-72743, *Hanford Engineering Works 20'-0" Diameter Storage Tanks Arrangement Bldg # 241-T, 241-U, 241-B, 241-C*). While Figure 4-1 depicts a typical inlet nozzle for the 200-series SSTs, the inlet nozzles were constructed the same way in the 100-series SSTs. An inlet nozzle consists of an inner 4-in.-diameter schedule 80 steel pipe with an outer 6-in.-diameter schedule 40 steel pipe. The outer 6-in.-diameter steel pipe is imbedded in the concrete sidewall of the SST, attached to the exterior of the carbon steel sidewall using mastic, and protrudes ~8 in. from the exterior of the tank wall. The 4-in.-diameter steel pipe is inserted through the 6-in.-diameter steel pipe, protrudes ~12-in. inside the SST and ~18-in. beyond the exterior of the concrete sidewall of the SST. The 4-in.-diameter steel pipe is welded to the sidewall of the carbon steel tank. An 8-in.-diameter steel collar is tightly fitted

1 around the 6-in.-diameter steel pipe where the 4-in.-diameter steel pipe exits this outer pipe.
 2 Process waste lines, which are 3-in. inner diameter, 11 gauge 18-8Cb (i.e., an early form of
 3 stainless steel) tubing, are inserted through the 4-in.-diameter steel pipe and extend ~4 ft inside
 4 the SST.

5
 6 **Figure 4-1. 20-Foot Diameter SST Detail Showing Inlet Nozzles (Best Image Available)**



7
 8
 9 The elevation of the four inlet nozzles for the 100-series SSTs is 17 ft 4 in. from the center of the
 10 tank bottom (H-2-1744, *Tank Farm Riser & Nozzle Elev*). The elevation of the four inlet nozzles
 11 for the 200-series SSTs is 24 ft 7 in. from the center of the tank bottom (H-2-1744). All inlet
 12 nozzles on the 100-series SSTs in C Farm are located at approximately the 8 o'clock position
 13 relative to north being 12 o'clock. For the 200-series SSTs, two spare inlets are located
 14 approximately at the 12:30 o'clock position, and two spare inlets are located approximately at
 15 the 9:30 o'clock position relative to north being 12 o'clock.

16
 17 The process waste lines connecting to the inlet nozzles on SSTs C-101, C-104, C-107, C-108,
 18 C-110, and C-111 are supported by concrete troughs (W-74108 and H-2-2929, *Waste Fill Lines*
 19 *& Clean Outs 1st Cycle Waste 241-C Tank Farm*). The concrete supports are 30 in. tall and
 20 32 in. wide, except for C-101, which are 30 in. tall but only 26 in. wide. The concrete support
 21 beams have a 4-in.-tall shoulder, resulting in a 24-in. (only 18 in. for C-101) wide trough running
 22 down the center of the beam.

23
 24 Process waste lines from diversion box 241-C-252 connect to two inlet nozzles on each of the
 25 C-200 series SSTs and are supported by concrete troughs (W-74317, *Hanford Engineering*
 26 *Works Building No. 241 T-U-B & -C Concrete Details of Pipe Supports (20' Dia. Tanks)*. The
 27 other two inlet nozzles are spares on the C-200 series SSTs and are not supported. For the
 28 200-series SSTs, the concrete-support troughs are 37-in. tall and 20-in. wide with a 4-in.-tall
 29 shoulder. The interior width of the trough supporting the pipelines is 12-in.

1 Some of the inlet nozzles on the SSTs are spares and do not have installed process waste lines.
2 The design for the SSTs identified a 4.5-in.-diameter cover was to be placed over the
3 4-in.-diameter spare inlet nozzles (see Figure 4-1). It is known that some of the spare inlet
4 nozzles are poorly sealed. SST BX-102 was overfilled in February 1951 and waste was lost to
5 the ground through the spare inlet nozzles (HW-20742, *Loss of Depleted Metal Waste Supernate*
6 *to Soil*). As part of the investigation into the waste loss from SST BX-102, spare inlet nozzles on
7 several SSTs were examined (specific tanks were not identified). This investigation revealed
8 "...that some [inlet nozzles] have blanks which are welded tight, some have wooden plugs
9 driven into the spare nozzle covered by a cap and sealed with waterproofing, and some have caps
10 covered with waterproofing membrane and then sealed in cement" (HW-20742, page 5).

11
12 Based on the SST BX-102 waste loss investigation, the potential exists that some waste may
13 have been similarly released in the C Farm if any of the SSTs were filled above the height of the
14 spare inlet nozzles. If waste losses occurred through the spare inlets for SSTs C-101, C-104,
15 C-107, C-108, C-110, and C-111, the waste may have been contained and channeled along the
16 concrete troughs.

17
18 The waste volumes in all WMA C SSTs were reported monthly from January 1945 through
19 December 1960 (except no data for August 1951 through March 1952), semiannually from
20 January 1961 through June 1965, quarterly from September 1965 through September 1976, and
21 monthly thereafter. SSTs were removed from service in January 1981 and no waste additions
22 were allowed after this date.

23
24 Based on a review of waste volume data for the WMA C tanks, SSTs C-101, C-103, C-104,
25 C-106, C-109, C-111, C-201, C-202, and C-204 were filled with waste above the elevation of the
26 spare inlet nozzles on several occasions. This overfilling could have potentially resulted in waste
27 leaking from these SSTs into the surrounding soil. The date and waste type present in each SST
28 when the tank was filled with waste above the elevation of the spare inlet nozzles are
29 summarized in Table 2-7.

30 **4.3.2 Planned Release Facilities Such As Cribs, Drains and Discovery Sites**

31 There are several facilities in and around WMA C which were designed to discharge into the
32 vadose zone. No documentation that discharges occurred has been located. These facilities
33 include the following:

- 34
35 a. **Cesium Loadout Facility Drain** – The cask loading area within the 241-C-801 building
36 has a drain line connecting to the valve pit. The valve pit and cask loading area have
37 separate drain lines connecting to a drywell located outside of the tank farm fence
38 (drawings H-2-4573 and H-2-4554). This drywell is located approximately 23 m (75 ft)
39 north of the C-801 building, outside the tank farm fence (DOE/RL-88-30, page 659). No
40 record was located that provides information on the volume and types of wastes
41 potentially discharged to this drywell. An unknown amount of PUREX P1 and P2 waste
42 types along with decontamination solutions may have been discharged to this drywell as
43 a result of operations conducted at the C-801 building.

- 1 b. **271-CR French Drains, Drywell Drain, and Tile Fields** – The 271-CR Building had
 2 several drains associated with it that were located both inside and outside of the WMA C
 3 fenceline. Drains included a French drain, drywell drains, and two tile fields. The two
 4 tile fields were associated with the septic tank system. An original tile field was replaced
 5 with a second expanded system along with a new septic tank. One of the drains appears
 6 to have been associated with a condensate line. Waste releases to the remainder of the
 7 drain systems, if any, is unknown and does not have associated documentation.
- 8 c. **200-E-115** – Located east of C Farm, south of 8th Street, across an unnamed gravel road.
 9 As a result of routine surveys confirming radiological contamination in this area, the
 10 Dyncorp Integrated Soil, Vegetation, and Animal Control group submitted a Waste Site
 11 Information Form to WIDS in 2000. The site was classified as Discovery until
 12 programmatic responsibility and ownership were determined in March 2001. No surveys
 13 can be found to provide information about the radiological conditions inside the posted
 14 area. Very little is known about this posted area. During an interview with the Dyncorp
 15 Radiological Group in October 2000, an assumption was made that the area was posted
 16 by the CH2M HILL Hanford Group, Inc. East Tank Farm Radiological Control Group.
 17 A review of underground pipeline locations did not indicate a pipeline at this location. In
 18 1980, a larger area of posted contamination (see UPR-200-E-91) was located in the same
 19 vicinity. The contaminated soil from UPR-200-E-91 was removed in 1981. Because so
 20 much time has passed, it is difficult to determine if the two sites are related. In June
 21 2004, 200-E-115 was stabilized with gravel and posted as an Underground Radioactive
 22 Material Area.

24 **4.4 SITE SELECTION**

25 During the DQO process, it was determined that 23 areas of interest, referred to as sites, would
 26 be characterized using a variety of characterization techniques. Sections 4.4.1 through 4.4.7
 27 provide the rationale for choosing these 23 sites.

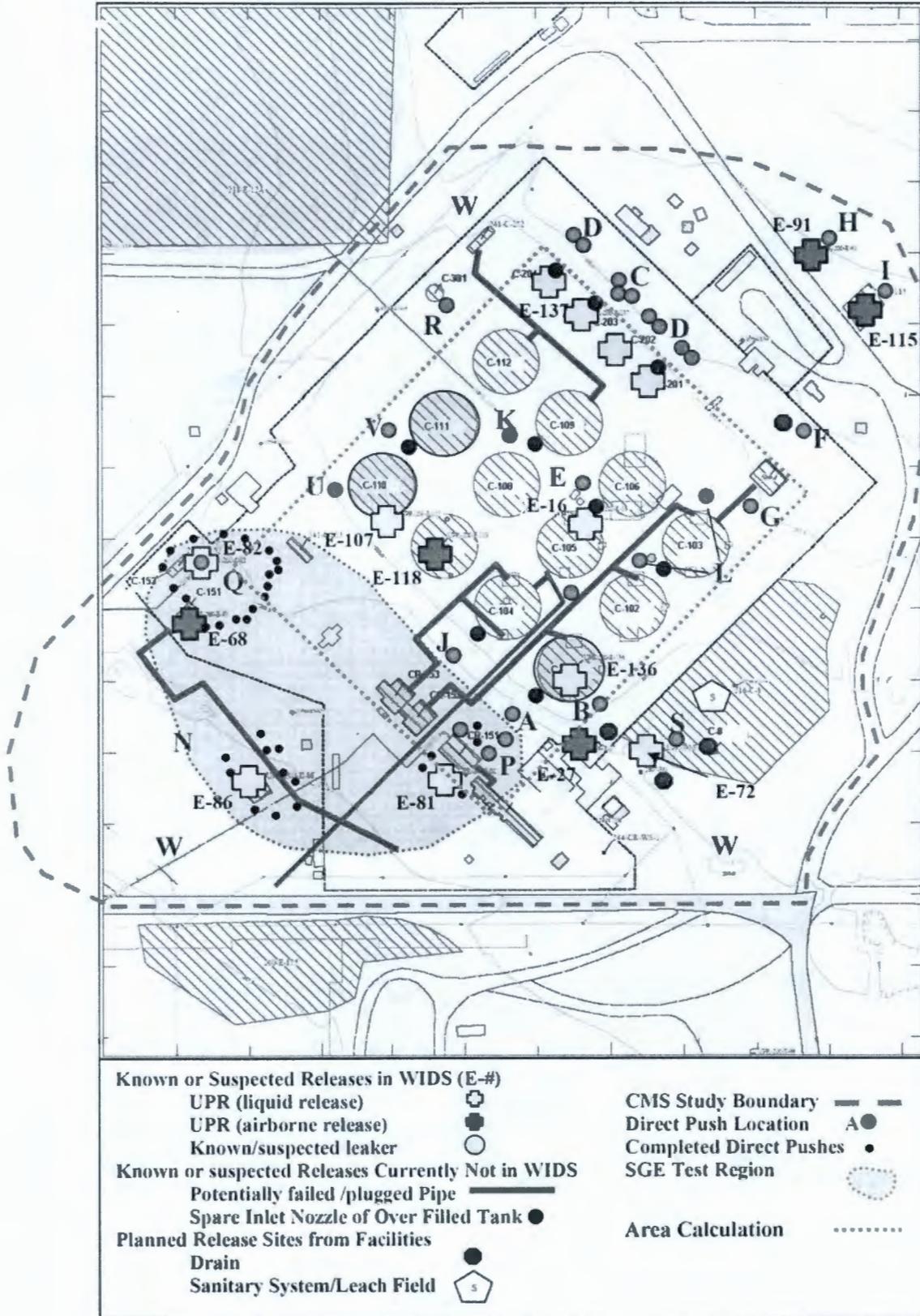
28 **4.4.1 Site Selection using Alternative 1: Phase 1 Conceptual Model**

29 The Phase 1 conceptual model was used to select a number of sites to investigate. These sites
 30 consist of known or potential release sites that may have impacted the soils (Figure 4-2). To
 31 support tanks that may have been overfilled and potentially lost waste out the spare inlet ports,
 32 sites A (C-101) and J (C-104) were chosen.

33
 34 Sites B, C, D, R, U, and V were chosen to support possible tank leaks and/or overflow events that
 35 lack existing drywell monitoring coverage. This includes southeast side of C-101 (Site B), the
 36 C-200-series tanks (Sites C and D, and C-801 (Site R). If contamination is found at Site C, the
 37 other C-200-series tanks (C-201, C-202, and C-204) will be investigated (Site D). Sites B, C, D,
 38 U, and V are also being investigated to evaluate alternative conceptual model 2.

39
 40 Although UPR-200-E-82 (Site Q) was investigated during Phase 1, it will be further investigated
 41 as part of this work plan. At UPR-200-E-82, the highest concentration of ⁹⁹Tc and nitrate was
 42 found at 80 ft bgs (RPP-34584). This limiting depth (80 ft bgs) was a result of the
 43

Figure 4-2. Sample Locations for Phase 2 Characterization



2
3

1 characterization limitations of the direct push technology deployed at that time using a slant
 2 probehole to collect the sample. This slant probehole at the time of deployment eliminated the
 3 possibility of going deeper in light of the gunite cap on top of this UPR. Therefore, the proposed
 4 vertical push through the center of mass will allow the ability to find out how deep the ^{99}Tc and
 5 nitrate has migrated, thus defining the depth of ^{99}Tc and nitrate at this location. Since the time of
 6 the leak in December 1969 to sometime after 1991, UPR-82 was covered in sand and gravel.
 7 Sometime after 1991, the gunite cap was placed over it. This provided for over 20 years of
 8 recharge over this UPR at 100 mm/yr, providing an opportunity to evaluate the Phase 1
 9 conceptual model or evaluate alternative conceptual models 2 and 4.

10
 11 Sites P and S are also being investigated under this conceptual model. Site P (UPR-200-E-81)
 12 was chosen because a 36,000-gal pipeline leak occurred in 1969. At Site S (216-C-8 French
 13 drain) approximately 32,000 gal of treated tank farm processing condensate was discharged to
 14 the French drain 216-C-8 from January 1960 through March 1965. Site S is also being
 15 investigated to evaluate alternative conceptual model 2.

16 **4.4.2 Site Selection using Alternative 2: Movement of Contaminants Down Stratigraphic** 17 **Dip**

18 Data to support the alternative conceptual model 2 of movement of contaminants down
 19 stratigraphic dip, are sites K (C-108), E (between C-109 and C-106), L (C-103 and C-106), and F
 20 (Building C-801 chemical drain). One of the problems is that waste loss from locations L and F
 21 could be commingled with other waste loss sources. As documented in RPP-34584, migration of
 22 ^{60}Co both laterally and vertically has occurred in the vadose zone from the C-108 transfer line
 23 leak and migrated to the northeast (downdip) toward C-106. Investigation at these sites will
 24 provide data to support this conceptual model.

25
 26 Movement of ^{60}Co has been detected from the vicinity of C-108 laterally to the east and
 27 downward to greater than 120 ft bgs near drywell 30-06-10. It is possible this contamination
 28 originated from a transfer line leak (GJO-98-39-TARA).

29
 30 Between C-108 and C-109, a transfer line leak source is indicated by contamination in drywell
 31 30-08-02 (RPP-14430). High ^{137}Cs concentrations occur between 20 and 22 ft bgs and peak at
 32 1100 pCi/g in this zone. A ^{154}Eu peak (24 pCi/g) is coincident with ^{137}Cs and the more mobile
 33 ^{60}Co is present between 50 and 80 ft bgs at concentrations up to 10 pCi/g. These contaminants
 34 were present when the drywell was installed in 1974. This contaminant plume appears to extend
 35 at least to drywell 30-06-10 where a similar ^{60}Co plume occurs between 86 and 115 ft bgs at
 36 lesser concentrations (up to 1 pCi/g). Cobalt-60 also occurs to a lesser degree in
 37 drywell 30-09-01 at 90 to 95 ft bgs. This location may represent the eastern extent of this
 38 contaminant plume. Other nearby drywells may also contain contamination that has migrated
 39 from this source.

40
 41 These drywells (30-09-06, 30-09-07, and 30-09-02) along with drywells 30-08-02 and 30-06-10
 42 contain mobile ^{60}Co that migrated in the 1980s between 40 and 115 ft bgs, according to the gross
 43 gamma record. The apparent lag time between initial discharge to the vadose zone before 1974
 44 and the observed ^{60}Co migration in the 1980s may indicate additional leakage or enhanced
 45 migration instigated by artificial recharge (RPP-14430).

1
2 At the tank C-108/C-109 anomaly, neither of the drywells within the anomaly footprint contains
3 significant levels of gamma-emitting contamination. The closest indication of a source term is at
4 drywell 30-08-02, where ^{137}Cs and ^{154}Eu peak at approximately 20 ft bgs, suggesting another
5 transfer line leak. Examination of more recent geophysical logging shows at least four episodes
6 of contamination in this drywell: one prior to 1976, between 1989 and 1997, between 1997 and
7 2002, and between 2002 and 2006. From 1976 to 2006, ^{60}Co appears to have migrated from
8 approximately 40 ft bgs to approximately 80 ft bgs. Whether this anomaly is related to the
9 apparent anomaly just to the west is unclear.

10
11 Site B (southeast side of C-101) and S (216-C-8) are also being investigated under this
12 conceptual model because low levels (0.6 pCi/g) of ^{60}Co were measured in the vadose zone
13 between 130 and 250 ft bgs at groundwater well 299-E27-14. It has been speculated that the
14 ^{60}Co has migrated to this well from either a C-101 tank leak or is the result of disposal to
15 216-C-8 French drain.

16 4.4.3 Site Selection using Alternative 3: Preferential Pathways Conceptual Model

17 Alternative conceptual model 3, preferential pathways, is a possible transport mechanism, but as
18 noted in Section 3.3.3, it could not be addressed in the DQO and no characterization sites were
19 selected using this conceptual model. In addition, Section 3.6 identifies drywells and
20 groundwater monitoring wells that may provide a conduit for preferential pathways for
21 contaminant migration to the groundwater.

22 4.4.4 Site Selection using Alternative 4: Unknown Leak Event Conceptual Model

23 Another possible conceptual model is the unknown leak event or events (alternative conceptual
24 model 4). Each WMA contains miles of pipelines and infrastructure, like catch tanks and valve
25 boxes. It is plausible that leaks could occur along these pipelines. With the numerous waterline
26 leaks that have been documented in the past within tank farms as the hydraulic driving force,
27 contaminants could have migrated downward faster than under normal recharge. This
28 conceptual model could also be applied to small releases from tanks, like catch tank C-301.
29 These are known as "hot spots." However, the ability to locate "hot spots" at WMA C is
30 problematic. For locating hot spots, the EPA recommends using a systematic grid sampling
31 design (EPA QA/G-5S, *Guidance on Choosing a Sampling Design for Environmental Data for*
32 *Use in Developing a Quality Assurance Project Plan*). This methodology places a sampling grid
33 over an area and sampling within the grid to find a hot spot. The size of individual grid elements
34 is dependent on the size of the hot spot. Applying this technique at WMA C is impracticable for
35 two reasons:

- 36 a. Because the size of the area to be sampled (WMA C) is large (~700,000 ft² or 16 acres)
37 and the hot spots are expected to be relatively small (<625 ft² or 25 ft x 25 ft), a very
38 large number of samples would have to be taken to locate a hot spot.
- 39 b. A portion of the WMA C is inaccessible to a drill rig/direct push rig due to the
40 underground infrastructure (tanks, pipelines, and diversion boxes), aboveground retrieval
41 equipment, and topography. For example, the most likely area for finding hot spots
42 would be near and around the SSTs. This area is shown by the green dotted rectangle in

1 Figure 4-2. The area of this rectangle is approximately 210,000 ft²; however, the area
2 within this rectangle that cannot be sampled due to underground infrastructure is
3 approximately 90,000 ft². Thus, 45% of the sampling grid in the area of the SSTs could
4 not be sampled.
5

6 To address site selection of unknown leak events, the following two methods will be employed:
7 judgmental sampling and SGE. Judgmental sampling (EPA QA/G-5S) uses historical
8 information to best select a site. In this case, information presented in Section 2.4.3.6 infers that
9 certain pipelines may have leaked. One of these pipelines existed between building C-801 and
10 C-103 (Site G). According to historical records, a pipeline was installed to complete an
11 alternative effluent return route from the building C-801 tank C-103. Since one already existed,
12 this installation could imply a problem existed in the old line, including a leaking pipeline.
13

14 The other method is SGE, in which the resistivity of the underlying strata is measured, thereby
15 providing an indirect indication of where pipelines, tanks, and other infrastructure may have
16 leaked into the environment. Since waste fluids at tank farms contain nitrate that can reduce the
17 electrical resistivity of the underlying strata, the resistivity measurements will be made at site N
18 (UPR-81, UPR-82, and UPR-86) and compared against samples taken at these sites.

19 Furthermore, samples collected at site P (UPR-81) will be used to compare analytical data
20 against resistivity data. Using the results from the testing of SGE at site N, a plan would be
21 developed to interrogate WMA C and surrounding environment using SGE. This is designated
22 as Site O.

23 4.4.5 Site Selection for Surface Contamination

24 UPR-200-E-91 (Site H) was a large area of contaminated soil, located north and east of the
25 C Farm. In 1981 contaminated soil was removed from this area and taken to another location
26 (UPR-200-E-56). The radiological posting was removed in 1981. This release site is no longer
27 marked or posted. This site was selected to verify the soils were removed. Waste site 200-E-115
28 (Site I) is selected as a site with surficial contamination that was discovered in October 2001.

29 4.4.6 Site Selection for Geophysical Logging

30 In addition to the list of sites that will be investigated, updated drywell spectral gamma
31 monitoring of tanks C-103, C-104, C-106, C-108, C-109, C-110 C-111, and C-112 (Site M) will
32 be conducted to investigate changes that may have occurred since 2000 as it relates to ⁶⁰Co
33 migration. In addition to the drywells inside the WMA fenceline, the following groundwater
34 wells would also be logged: 299-E27-12, 299-E27-13, 299-E27-14, and 299-E27-15 (Site W).
35 These wells were selected because they are the only groundwater wells near WMA C that have
36 not been logged, except 299-E27-14 that was last logged in the 1990s.

37 4.4.7 Groundwater Sampling Activities

38 Groundwater sampling activities at the WMA C RCRA wells are conducted under the Hanford
39 Site Groundwater Monitoring Project. Groundwater samples are collected and analyzed in
40 accordance with PNNL-13024. The results from these groundwater sampling activities will be
41 available to the preparers of the RFI/CMS. No sampling of groundwater will be conducted as

1 part of these characterization efforts. If any new RCRA groundwater monitoring wells are
 2 installed, the monitoring results from the new well would be used to further assess the
 3 conceptual models as they relate to groundwater flow.

4 4.5 SITE CHARACTERIZATION

5 For this work plan, site characterization will be performed at the 23 sites identified in Figure 4-2.
 6 The site characterization activities include the following:

- 7 a. Soil collection and analysis through direct push technology (Section 4.5.1).
- 8 b. Tissue sampling for ERA (Section 4.5.2).
- 9 c. Drywell and groundwater monitoring well geophysical logging (Section 4.5.3).
- 10 d. SGE (Section 4.5.4).

11
 12 The characterization options selected for implementation at WMA C for this work plan are
 13 provided in Table 4-1. Table 4-1 includes the sampling method, implementation design, and
 14 objective.

15
 16 Soil samples for chemical analysis will be collected using direct push technology at 18 of the
 17 23 selected sites. The number of sampling direct pushes ranges from one to three at each site for
 18 a total of up to 29 direct pushes. Furthermore, a demonstration of SGE with deep electrodes is
 19 also planned at Site N. Following the demonstration, if SGE is successful at Site N for resolving
 20 depth of contaminants with deep electrodes, a plan would be developed to deploy SGE to
 21 encompass the WMA C DQO boundary. Additionally, new spectral gamma and moisture
 22 logging would be performed at tanks C-103, C-104, C-106, and C-108 through C-112. This
 23 work is contingent on available funding and on whether the direct push installation schedule is
 24 consistent with other schedule priorities. Additional characterization technology development
 25 (see Section 4.5.5) also is contingent on available funding.

26
 27 The initial (Phase 1) site-specific investigation conducted between FY 2004 through FY 2007
 28 entailed the installation of one vertical borehole near C-105 along with the application of direct
 29 push technology at UPR-82 (vertical and slant probeholes). To complement these data, direct
 30 pushes were conducted around UPR-86 and UPR-81 in FY 2008 (RPP-35169) that will provide
 31 additional information about contamination in the south portion of C Farm. The sampling plan
 32 consists of vertical and slant probeholes using direct push technology near selected waste
 33 releases along with SGEs around UPR-81, UPR-82, and UPR-86 and potentially WMA C.
 34 Spectral gamma and moisture logging around certain tanks with drywells that have detected ^{60}Co
 35 will be logged as will the groundwater monitoring wells that have not been spectral gamma
 36 logged in the past.

37
 38 Table 4-1 shows the current understanding of access availability (i.e., October 2008) for each of
 39 the 23 sites. Specific sample locations will be selected based on defined site limitations (slope of
 40 the ground surface), and infrastructure constraints (see Figures 4-3 and 4-4). The actual sample
 41 locations will be established following the field survey with ground-penetrating radar (GPR) and
 42 other site preparation activities. The GPR survey will define where subsurface conflicts exist,
 43 which will help define acceptable sample locations. During the survey, aboveground conflicts
 44 will also be defined.

Table 4-1. Sample Plan WMA C Phase 2 Characterization for RFI/CMS (3 sheets)

Map Design	Group ^a	Location	Deployment	Number of Holes	Average Number of Samples	Known or Suspected Event	Objective	Accessibility	Ecology/ Stakeholder Interest
A	G3	Spare inlet 241-C-101	Direct push, slant	1-2	8	Tank overflow. Loss through spare inlet	Characterize C-101 release and refine conceptual models 1, 2, and 4	Fair	High
B	G2	241-C-101, south side	Direct push, vertical or slant	1	8	Tank release	Characterize C-101 release and refine conceptual models 1 and 2	Good	High
C	G4	241-C-203	Direct push, slant	3	3: 0-15 ft 15: >15 ft	Tank leak and/or tank overflow. Loss through spare inlet	Determine if C-200 actually leaked and refine conceptual models 1, 2, and 4	Fair	Moderate to high
D	G4	241-C-201 ^b 241-C-202 241-C-204	Direct push, slant	1-2/tank	8	200 series tank leaks	Determine if C-200 actually leaked and refine conceptual models 1, 2, and 4	Fair	Moderate, depending on C-203 results
E	G2	Between 241-C-106 and 200-C-109	Direct push, vertical	1	8	Suspected release	Assess ⁶⁰ Co and refine conceptual models 1, 2, and 4	Fair	High
F	G2	Bldg C-801 chemical drain	Direct push, vertical	1	8	Suspected release site	Assess release of PUREX waste, ¹³⁷ Cs and ⁹⁹ Tc, and ⁶⁰ Co and refine conceptual models 1, 2, and 4	Good	Moderate to high
G	G2	Between Bldg C-801 and 241-C-103	Direct push, vertical	1	8	Suspected transfer line release site	Assess release and ⁶⁰ Co and refine conceptual models 1, 2, and 4	Good	High
H	G5	Northeast side of E-91	Direct push, vertical	1	8	Surface release	Surface exposures and assess ⁶⁰ Co and surface release conceptual Model	Good	High
I	G5	Northeast side of E-115	Direct push, vertical or slant	1	8	Surface release	Surface exposures and assess ⁶⁰ Co and surface release conceptual model, refine conceptual models 1, 2, and 4	Good	High
J	G3	241-C-104	Direct push, slant	1	8	Tank release	Assess suspected release and refine conceptual models 1, 2, and 4	Fair	High
K	G2	241-C-108	Direct push, vertical or slant	1	8	Transfer line leak, hot dry well (09-02)	Assess suspected release and refine conceptual models 1, 2, and 4	Poor	High
L	G2	241-C-103 and 241-C-106	Drywell logging and direct push, vertical	2 / log drywells	8	Potential transfer line leak and tank overflow	Update logging data for ⁶⁰ Co, ¹³⁷ Cs, uranium, and moisture and assess potential release and refine conceptual models 1, 2, and 4	Fair	Moderate

Table 4-1. Sample Plan WMA C Phase 2 Characterization for RFI/CMS (3 sheets)

Map Design	Group*	Location	Deployment	Number of Holes	Average Number of Samples	Known or Suspected Event	Objective	Accessibility	Ecology/ Stakeholder Interest
M	G7	241-C-104, 108, 109, 110, 111, and 112	Drywell logging	N/A	N/A		Update logging data for ⁶⁰ Co, ¹³⁷ Cs, uranium, and moisture	Fair to good	Moderate
N	G8	UPR-86, UPR-82 and UPR-81	SGE	N/A	N/A		Test SGE: resolve depth with deep electrodes; define plume at UPRs-81, -82 and -86; refine conceptual models 1, 2, and 4	Good	High
O	G9	WMA C	SGE	N/A	N/A		3-D vision of suspected releases – may lead to supplemental sample locations	Good	High
P	G1	UPR-81	Balance of direct pushes to complete characterization for soil sampling	3	8	Known release site	Characterize release and refine conceptual models 1, 2, and 4	Good	High
Q	G6	UPR-82	Direct push through center of UPR-82	1	8	Known release site	Penetrate center of mass, and refine conceptual models 1, 2, and 4	Good	High
R	G2	241-C-301 Catch Tank	Direct push vertical	1	8	Unlined concrete catch tank	Assess potential catch tank release and refine conceptual models 1, 2, and 4	Good	Moderate to high
S	G5	UPR-72 and C-8 Drain	Direct push vertical	1	8	Buried radioactive material and French drain from 241 CR Building are in this area	Assess presence of buried material and potential releases to C-8 drain and refine conceptual models 1, 2, and 4	Good	Moderate to high
T	TBD	TBD, based on SGE data for entire WMA	TBD, direct push vertical and/or slant	TBD	TBD	Previously unknown release sites	TBD	TBD	Moderate to high
U	G3	C-110	Direct push, slant	1	8	Tank leak and/or tank overflow. Loss through spare inlet	Characterize C-110 release and conceptual conceptual models 1, 2, and 4	Fair	High

Table 4-1. Sample Plan WMA C Phase 2 Characterization for RFI/CMS (3 sheets)

Map Design	Group ^a	Location	Deployment	Number of Holes	Average Number of Samples	Known or Suspected Event	Objective	Accessibility	Ecology/ Stakeholder Interest
V	G2	C-111	Direct push vertical	1	8	Tank leak and/or tank overfill. Loss through spare inlet	Characterize C-111 release and conceptual conceptual models 1, 2, and 4	Good	High
W	G9	299-E27-4, 299-E27-12, 299-E27-13, 299-E27-14, 299-E27-15	Log groundwater monitoring wells outside of WMA C				Log wells to collect data on U, ⁶⁰ Co, ¹³⁷ Cs, and moisture	Good	High

^a Group refers to the expected work package associated with the characterization effort broadly defined as follows:

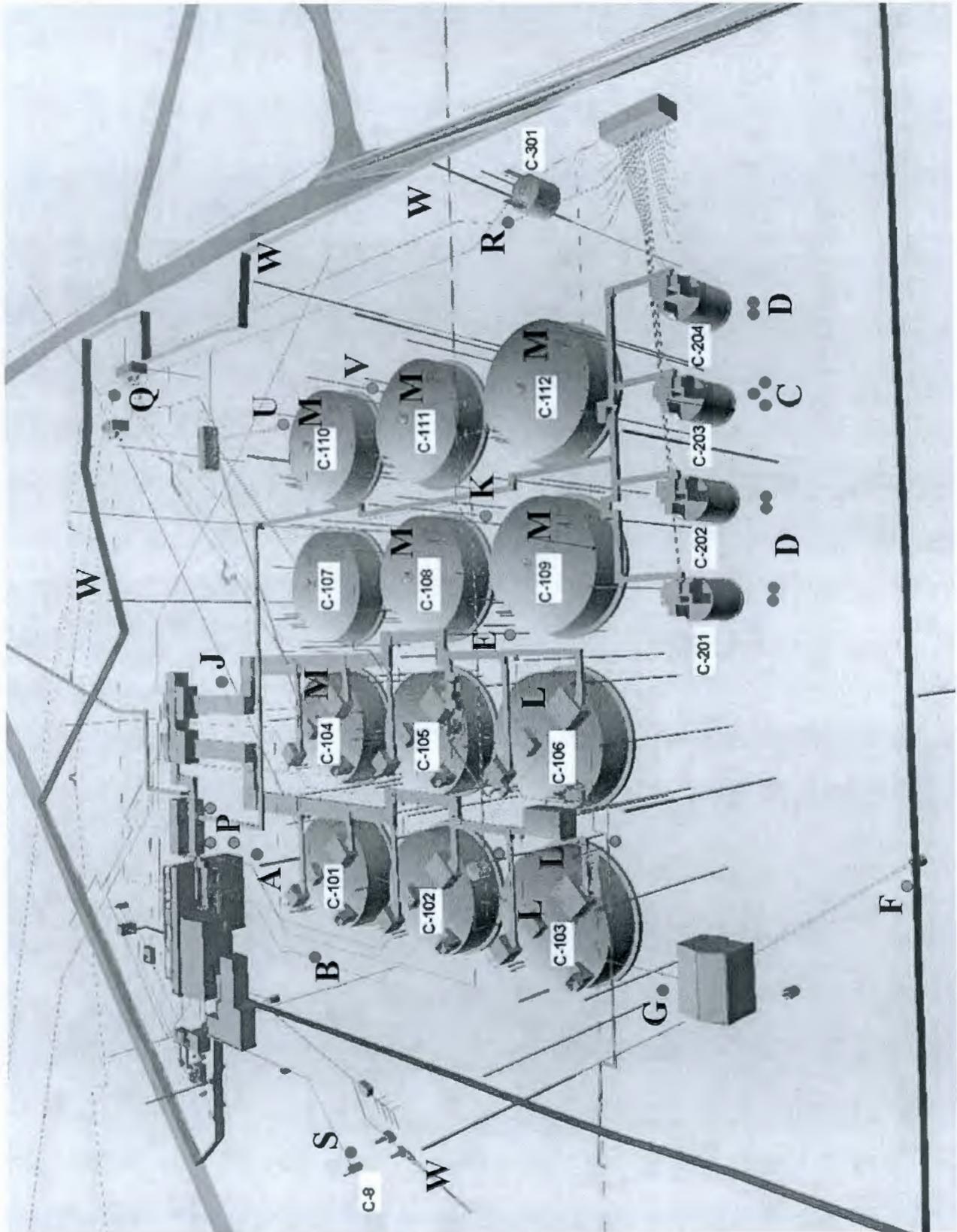
- G1 = Direct push at UPR-81 (covered by existing work package).
- G2 = Vertical direct pushes at nine investigative sites around the 100-series SSTs.
- G3 = Slant direct pushes at three investigative sites around the 100-series SSTs.
- G4 = Slant direct push at the C-200 Series tanks.
- G5 = Outside the WMA, vertical direct push at the investigative sites.
- G6 = Vertical direct push through gunite at UPR-82.
- G7 = Drywell logging at select dry wells.
- G8 = Three separate SGE areas at the following locations: UPR-81, UPR-82, and UPR-86.
- G9 = Deploy SGE at WMA C taking into account the results from testing at site N.

^b Sampling the vadose zone around these three tanks will be dependent on the result of C-203. If there is no indication of a release from C-203, samples will not be collected at these three tanks.

1 **Figure 4-3. Surface Facilities, Candidate Sample Locations, and Surface Geophysical**
2 **Exploration Interrogation Areas**



Figure 4-4. Candidate Sample Locations and Infrastructure Constraints



2
3

1 Deployment of direct-push technology at the proposed locations in WMA C would be expected
 2 to continue to address a number of questions related to the concentration and distribution of
 3 contaminants, including the following:

- 4 a. What contaminants are present that are routinely identified as contaminants of concern
 5 (COC) from a groundwater impact standpoint (e.g., ⁹⁹Tc, nitrate)?
- 6 b. What are the contaminant concentrations of ¹³⁷Cs and other COC in the upper 15 ft of the
 7 soils to provide soil data to support direct exposure and ecological risk assessment?
- 8 c. What is the vertical extent of the COC in the backfill material?
- 9 d. What is the horizontal extent of the COC across the areas of interest?
- 10 e. What are the potential drivers (e.g., sediment moisture profile) in the upper portion of the
 11 vadose zone that could control the migration of contaminants?

12 This option was selected because a probehole at these locations would provide source
 13 characterization data over the majority of WMA C along with distribution of contaminants at the
 14 locations of interest from WMA C. Source characterization would

- 15 a. Provide a basis for verifying estimating current location of COC inventories in the vadose
 16 zone.
- 17 b. Support evaluation of the spatial correlations between concentrations of COC and
 18 existing gamma data
- 19 c. Support assessment of contaminant mobility, potential drivers (e.g., moisture content),
 20 and the effects of releases on soil properties to support predictive numerical modeling
 21 efforts necessary to evaluate potential future groundwater impacts, the associated risks,
 22 CMs, and further characterization as warranted.

23
 24 Source characterization efforts also would involve identifying what contaminants are present
 25 and, subsequently, identifying the potential COCs for corrective action and closure decisions as
 26 they relate to soil and groundwater contamination.

27 **4.5.1 Installation of Vertical/Slant Probeholes**

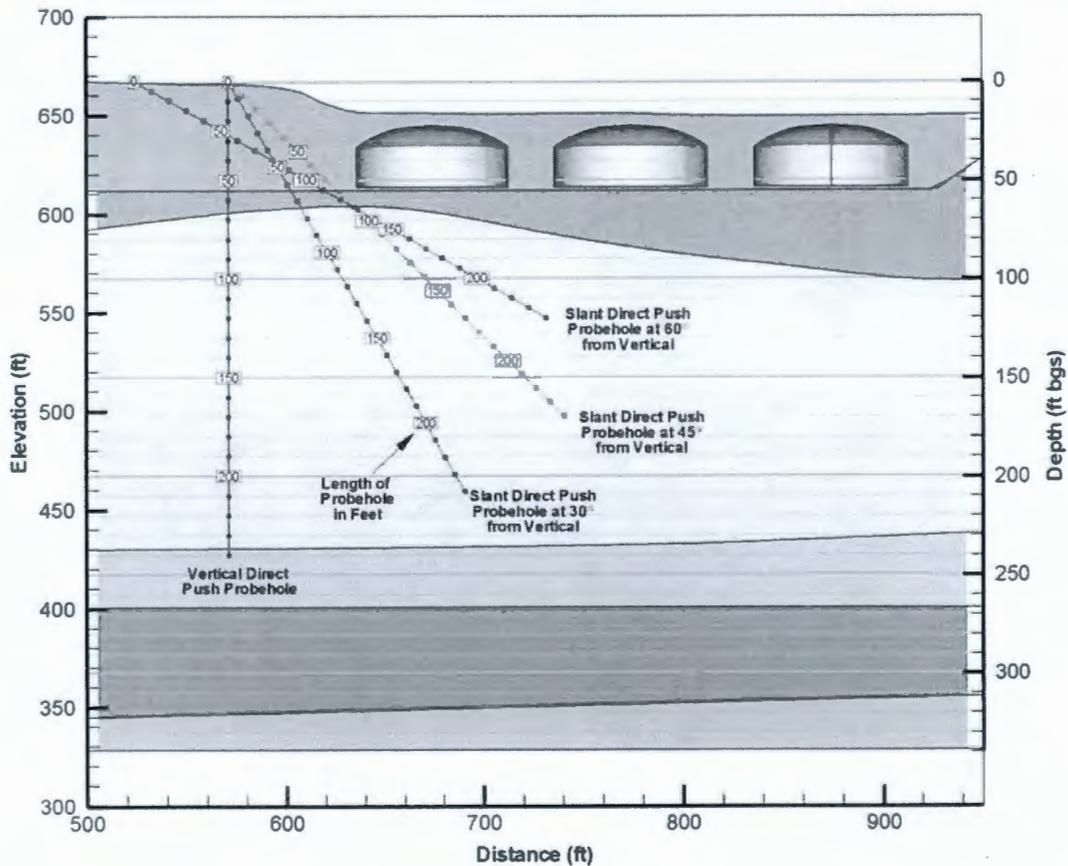
28 Several options were considered for collection of vadose zone data. The preferred option is
 29 installation of direct push probehole(s). The direct push technology has been capable of
 30 obtaining a sample as deep as 240 ft bgs. It has the capability of obtaining more than one sample
 31 per probehole and does not bring up cuttings that need to be disposed. Furthermore, it does not
 32 take up as much space as a conventional drilling rig, which allows it to be deployed at more
 33 locations within the WMA C. The direct push technology provides the same objective as drilling
 34 a deep borehole given the data collection objectives. Up to 27 direct push probeholes are
 35 planned for 16 sampling locations. While the approximate locations for each probehole are
 36 shown on Figures 4-2 through 4-4, the exact locations for each probehole are dependent on the
 37 accessibility and subsurface interferences to the site, which will be determined after the results of
 38 a GPR survey become available. Vadose zone samples will be collected after the initial push is
 39 conducted and evaluated with soil moisture and gamma data. The precise sampling depths will
 40 be based on review of the geophysical logging data collected from the exploratory probehole. It

1 is expected that the modified bismuth-germinate oxide logging tool (Section 4.6) will reduce the
 2 risk of selecting the wrong horizon to sample because of the lower detection limits associated
 3 with this tool.

4
 5 For planning purposes, it is assumed that all direct push probeholes will be vertical, except for
 6 the probeholes at Sites A, C, D, J, and U. At those sites, the probeholes would be slanted
 7 because the slope of the hill on the southwestern side of tanks C-101, C-104, C-110 (Sites A, J,
 8 and U) and the northeastern side of the C-200-series tanks (Figure 2-2, cross-sections A and B)
 9 prohibit placing the direct push rig close to the outlet ports at these tanks.

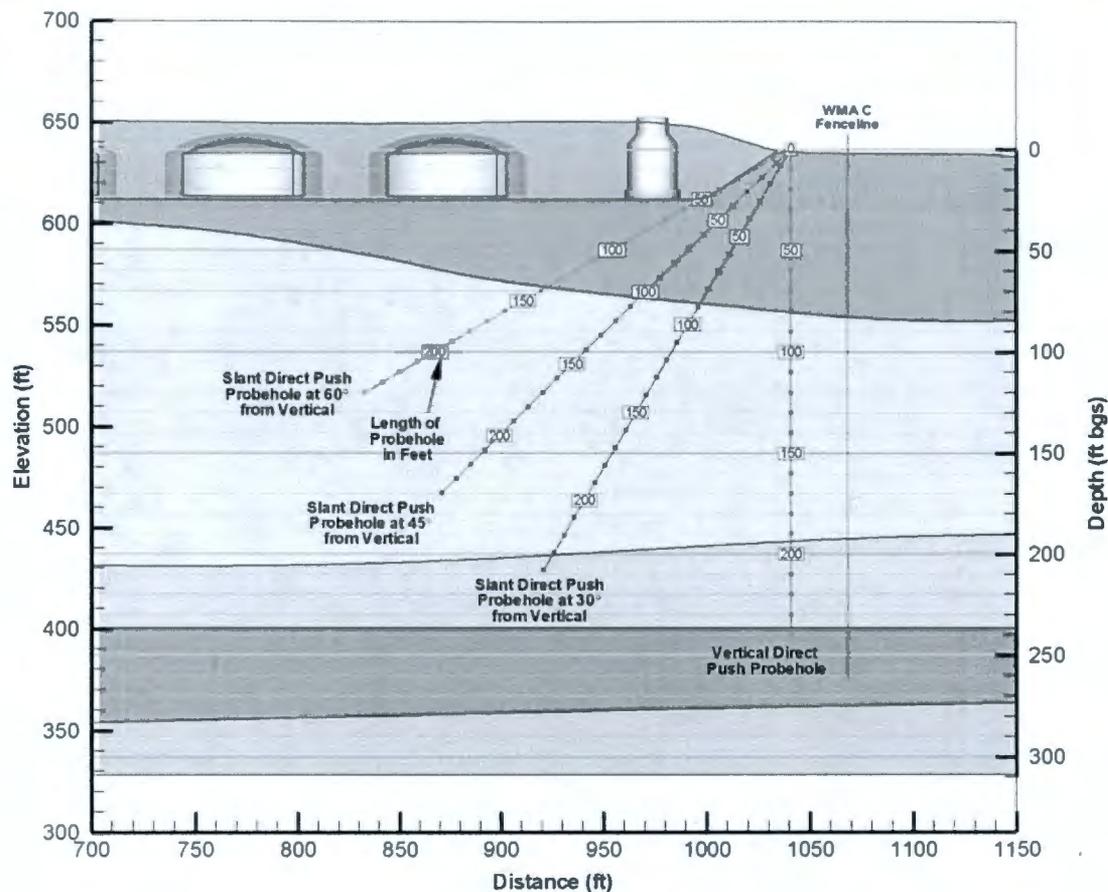
10
 11 The goal of slanted direct push probeholes is to find evidence of tank fluids that have leaked into
 12 the vadose zone. Therefore, at these sites, the target region for samples is within 10 ft of the tank
 13 bottom. The exact angle, 30, 45, or 60 degrees, of the probehole to intersect the target region
 14 will be determined by field conditions (e.g., where can the direct push rig set up to avoid existing
 15 infrastructure). Figures 4-5 and 4-6 delineate possible angles for the slant holes at the 100-series
 16 tank and 200-series tanks, respectively. In these figures, the lines represent the probehole
 17 divided into 50-ft lengths with every 10-ft length marked. The slant boreholes at the
 18 C-200-series would also be extended to the southwest beyond the tanks to collect soil samples
 19 directly below pipelines running between the C-200-series and C-100-series tanks.
 20
 21

Figure 4-5. Possible Configurations for a Slant Probehole at the 100-Series Tanks



22

Figure 4-6. Possible Configurations for a Slant Probehole at the 200-Series Tanks



4.5.1.1 Direct Push Sampling Technique

The direct push technology uses a dual-wall percussion system to obtain multiple samples in a single probehole location. Driving will be conducted with outer push tubing that is currently planned to be 6.67 cm (2.625 in.) OD x 4.76 cm (1.875 in.) ID and inner tubing that is 3.17 cm (1.25 in.) OD x 2.7 cm (1.08 in.) ID. The dual-wall system with a “dummy” tip will be advanced to the predetermined sample depth. The tubing will be back-pulled 0.06 m (approximately 2 in.) to 0.12 m (approximately 5 in.) to relieve pressure and materials from the drive shoe and tip. When sampling depth is achieved and the rods back-pulled for sampling, the removable tip will be removed by extracting the inner rods. On removal of the inner string of tubing, a sampler will be attached to the inner string and returned to the bottom of the outer casing/push tubing and positioned against the inner receiver face of the drive shoe. The inner and outer tubing strings are “locked” together by use of a proprietary method, and the entire assembly is advanced through the targeted sample interval.

The sampler body holds three stainless steel liners that are currently planned to be 3.17 cm (1.25 in.) OD x 2.7 cm (1.08 in.) ID. After the sampler is advanced approximately 0.6 m (2 ft), the inner string is released and retrieved to the surface. The liners are removed from the sampler body and surveyed. Trained sample-handling technicians document recovery, sample condition,

1 and volume recovery percent, and then package and transport the sample to the selected
2 laboratory for analysis. The “dummy” tip is reattached to the inner string and returned to the
3 bottom and placed in the casing shoe. The entire assembly is advanced to the next designated
4 sample depth, and the process is repeated until all sample depths are achieved or the tubing
5 meets refusal (i.e., the inability of the direct push method to advance further into the vadose
6 zone). On completion of the final sample extraction or on meeting refusal, the dummy tip or
7 sampler is removed and the probehole is decommissioned in accordance with WAC 173-160
8 requirements.

9 **4.5.1.2 Sequencing Direct Push Sampling**

10 Technically, to collect the data to meet the goals of the DQO, sampling should be sequenced
11 correctly. Sites to be used for the evaluation of organic data (Section 3.8.2) should be the first
12 sites investigated. For WMA C, these sites are Sites P and L (Table 4-1). Before soil sampling
13 at other sites as listed in Table 4-1, the results of the organic analyses at Sites P and L should be
14 reported to determine if further organic analyses at other sites associated with this work plan is
15 warranted. However, while preparing this work plan, the waste retrieval schedule was modified
16 to include 244-CR vault which may prohibit accessibility at the identified organic sampling
17 site P. Furthermore, above ground infrastructure near C-103 may prevent early sampling at
18 site L. Therefore, discussions with DOE and Ecology will be initiated during the review of this
19 work plan by Ecology for determining how to proceed with identifying new organic sites within
20 the DQO boundary of WMA C or analogous organic sites at new locations other than WMA C
21 for the purpose of evaluating organic chemical data.

22
23 Additionally, Sites F and G should be investigated before Sites H and I. If contamination is not
24 found at depth at Sites F and G, the depth of the direct push at Sites H and I will stop at 15 bgs.
25 Sites H and I were located to address surficial contamination at UPR-200-E-91 and 200-E-115,
26 but depths of the direct pushes can be extended if it appears contaminants are moving down dip
27 northeasterly. If contamination is found at depth at Sites F and G, then the depth of the direct
28 pushes at Sites H and I will be extended based on the information from Sites F and G. The
29 purpose of extending the depth of these direct pushes is to provide information related to
30 contaminant movement down dip (alternative conceptual model 2).

31 **4.5.1.3 Ground-Scanning**

32 Prior to implementing direct push sampling and SGE activities, ground scans are conducted to
33 verify drawings that show areas containing buried equipment, underground structures, and
34 pipelines. Ground scans typically use GPR, which uses a transducer to transmit frequency
35 module electromagnetic energy into the ground. Interfaces in the ground, defined by contrasts in
36 dielectric constants, magnetic susceptibility, and, to some extent, electrical conductivity, reflect
37 the transmitted energy. The GPR system measures the travel time between transmitted pulses
38 and the arrival of reflected energy. The reflected energy provides the means for mapping
39 subsurface features of interest. The display and interpretation of GPR data are similar to those
40 used for seismic reflection data. When numerous adjacent profiles are collected, often in two
41 orthogonal directions, a plan view map showing the location and depth of underground features
42 can be generated.

1 4.5.1.4 Direct Push Sampling Strategy

2 For planning purposes, the following summarizes the sampling strategy (RPP-ENV-38838) at
3 each vertical direct push site:

- 4 a. At each site, a minimum of two direct push probeholes pushes will be completed. The
5 initial probehole is logged for both gross gamma using the modified bismuth-germinate
6 oxide tool (Section 4.6) and neutron moisture. Following logging, deep electrodes are
7 installed for SGE. The second push is for soil sampling based on the data observed from
8 the first push.
- 9 b. The depth of the first push would be to no greater than 200 ft bgs or refusal at all sites
10 except H, I, and S. This target depth is based on the observation of ⁹⁹Tc and nitrate at
11 160 ft bgs at borehole C4297 and ⁶⁰Co concentrations above 0.1 pCi/g between 150 and
12 160 ft bgs at well 299-E27-4. The depth at Site S would be to 260 ft bgs or refusal based
13 on ⁶⁰Co above 0.1 pCi/g at nearby well 299-E27-14. At Sites H and I, the depth of the
14 direct push would be 15 ft unless data from Sites F and G indicate that the direct pushes
15 at Sites H and I should be deeper.
- 16 c. Deep electrodes are placed near the base of the initial probehole and at a depth of
17 approximately 50 ft bgs.
- 18 d. For the second probehole at depths less than 15 ft bgs, three samples are targeted to be
19 taken at 5-, 10-, and 14-ft bgs in the vadose zone. The purpose of collecting samples in
20 the first 15 ft is to provide data for the direct exposure pathway and to provide initial data
21 for ecological risk by comparing soil concentrations against WAC Table 749-3 (WAC
22 173-340-900) and RESRAD-Biota Level 1 BCGs (ANL 2006).
- 23 e. For depths greater than 15 ft bgs, the depth location for sampling individual horizons
24 would be done by reviewing the gamma and moisture logs of the first direct push, along
25 with the following information: any leak loss inventory information pertinent to the site,
26 geologic summary of the area, operational history, and historical characterization data at
27 that site. The selection of sampling horizons will be done in an open meeting in which
28 TOC staff, DOE, Ecology, EPA, and other site contractors are invited.

29
30 The sampling strategy for the sites with slant probeholes is the same as for vertical probeholes
31 with the following exceptions:

- 32 a. The angle of the slant probehole would be determined after the GPR survey is completed.
- 33 b. The length of slant direct pushes at the C-100-series tanks would be no greater than 200 ft
34 or refusal, while for the 200-series tanks, the length would be no greater than 160 ft or
35 refusal. The exact length depends on the setup location and the angle of the direct push.
36 The goal of the probeholes is to find evidence of tank fluids that have leaked into the
37 environment. The target zone for sampling is between 5 and 10 ft for sampling of the
38 tank bottom. Additionally, the direct push probeholes placed at the C-200-series tanks
39 would be extended to sample soils beneath the pipelines running between the C-200
40 series and the C-100-series tanks.
- 41 c. For slant probeholes, three soil samples (direct exposure and ecological risk) would be
42 taken in the upper 15-ft of the vadose zone. The location along the length of these

1 probeholes will be determined by the angle of the probehole, but samples would be
2 collected at 5-, 10-, and 14- ft bgs. See item d for the vertical probeholes; deeper samples
3 will be taken using the same methodology as outlined in item e of the vertical probeholes.

4 d. One deep electrode would be installed at the base of the initial slant probehole.

5
6 Should contamination be found in any of the soil sampling probeholes at their total depth,
7 additional or other characterization technologies may be deployed to define the maximum depth
8 of contamination at an unspecified date in the future. This data would be shared with Ecology to
9 determine a path forward and implemented before corrective measures in the deep vadose zone
10 area of interest. If the decision is to collect additional samples at deeper depths, then either this
11 work plan will be amended or a separate work plan will be prepared which states the
12 characterization technique to be used (direct push, borehole, etc.), the number of samples to be
13 taken at depth, the total depth of the new characterization hole, and how to complete the new
14 hole in accordance to WAC 173-160.

15 **4.5.1.5 Surficial Sampling at Direct Push Locations**

16 In addition to taking samples within each probehole, a soil sample would also be taken from
17 0 to 1 ft bgs at each direct push site. The purpose of these surficial samples is to collect data to
18 be used in calculating direct exposure pathway, as well as the ecological risk. The sample would
19 be analyzed for the chemicals and radionuclides listed in Tables 3-1 and 3-2, respectively, using
20 the approach given in Section 3.5.

21 **4.5.2 Tissue Sampling**

22 Presently, WMA C is managed in a way to eliminate, to the extent possible, the intrusion of
23 plants and animals into the facilities. However, WMA C may have an impact on animals located
24 outside WMA C. Therefore, in addition to the soil samples taken to evaluate ecological risk
25 (Section 4.5.1.4), small mammal tissue sampling and analysis would be completed as a
26 supplemental method for evaluating contaminant pathways and risks to wildlife receptors.
27 Animals would be collected from around the perimeter of WMA C for tissue sampling.
28 Appendix B provides the sampling and analysis instruction for collecting these samples.

29 **4.5.3 Geophysical Logging**

30 Based on concerns raised by stakeholders and Tribal Nations related to the presence and mobility
31 of ⁶⁰Co, spectral gamma as well as moisture logging would be done for the drywells associated
32 with tanks C-103 and C-106 with potential direct pushes to refine the ⁶⁰Co movement in this
33 area. In addition, past releases from transfer lines in this vicinity may have impacted the soil as
34 well as tank overfill events. The purpose of the spectral gamma logging would be to update the
35 data collected during the baseline spectral gamma analysis conducted in 1998 (GJO-98-39-TAR)
36 and 2000 (GJO-98-39-TARA). In addition, spectral gamma analysis in drywells around tanks
37 C-104 and C-108 through C-112 would be performed to update the spectral gamma and moisture
38 logging data to provide insight into changes that may have occurred since 2000. Figure 4-7
39 shows the locations of the drywells in WMA C.
40

4.5.4 Surface Geophysical Exploration

One of the characterization options considered and selected during the DQO process was SGE. This method of indirect investigation is proposed around UPR-200-E-81, UPR-200-E-82, and UPR-200-E-86. The SGE methodology and its results could be interpreted with the insight of the direct push results from around these waste sites. In addition, electrodes at depth have been installed at these sites and would provide a first-of-its-kind opportunity to determine a three-dimensional version of SGE. If successful, the three-dimensional “vision” into the soils would aid in locating investigative direct pushes or boreholes to find waste with ionic strength, potentially ^{99}Tc and other mobile contaminants. Part of this work is to evaluate the relationship between electrical resistivity and waste fluid concentrations taken from probehole samples.

The task involves a three-dimensional resistivity survey surrounding UPRs -81, -82, and -86. Buried electrodes have been placed at each of these sites (UPR-82 = one, UPR-81 = six (four locations with two dual electrodes), and UPR-86 = four). In addition 300 surface electrodes would be placed at each UPR. The preliminary plan is to treat each of these UPRs individually. The region is rich with underground piping. Each of the sites was reported as the location of significant loss of waste to the environment. Direct push investigation in each UPR region as part of the near-term work plan (RPP-PLAN-35341) would be used to verify the sites identified waste signatures commensurate with the leak loss estimate for the individual site and contrasted to the SGE results for each individual site. The results would be reported in the RFI/CMS report that fulfills HFFACO Milestone M-45-61.

A survey that entails approximately 300 surface survey electrodes, arranged for a fully three-dimensional interrogation is to be performed. Conceptually, this single string of electrodes would be placed so that each of the UPR locations is centered in the grid. Depth of interrogation is dependent on the size of the source and the resistivity contrast. The buried electrodes for each site would be included in the grid. At UPR-81, the preliminary results from the direct push at this location show the highest concentration of nitrate (199 mg/g) was found at 42-43 ft bgs. Therefore, the target depth for SGE at this location would be approximately 50 ft. The results from the deployment at the UPRs would be used to determine how SGE will be deployed over the entire WMA C. Using the results and lessons learned from the deployment of SGE at UPRs -81, -82, and -86, this work plan will be updated or a supplemental work plan will be generated to describe the field activities to support the deployment of SGE over the WMA C DQO boundary.

During collection of the resistivity data, it will be necessary to deactivate cathodic protection systems in the region. Because of increased tripping hazards associated with the cables and perceived electrical hazards, access to the farm will be severely restricted during this activity.

4.5.5 Develop New Characterization Technology

At the present time, the only way to measure levels of ^{99}Tc contamination in the soil is to take samples to send to the laboratory for analysis. This methodology is labor intensive and provides samples only at chosen intervals (see Section 4.5.1.3). The development of a ^{99}Tc sensor that can be deployed during the placement or decommissioning of direct push probeholes could quickly indicate where sampling intervals should be located and avoid costs associated with null

1 sample results. Such a sensor would be based on robust, existing technology of silicon beta
2 detectors, noting that very few long-lived beta-emitting radionuclides exist in the Hanford
3 sediments. The development of this sensor would be in two stages, a laboratory testing stage
4 followed by deployment in the field. The prototype ^{99}Tc sensor would first be built and tested in
5 the laboratory. If testing of the laboratory prototype proved successful, then a ^{99}Tc sensor that
6 could log small-diameter probeholes would be built and field tested.

7
8 This work is contingent on available funding. Development of this ^{99}Tc sensor would provide
9 cost-effective soil sampling related to the mobile contaminants of ^{99}Tc and nitrate that impact
10 groundwater by only sampling in direct push probeholes that the ^{99}Tc sensor identified as having
11 ^{99}Tc . The interest in this new technology was recognized through data needs workshops
12 conducted for Phase 2 RFI/CMS processes and was shared with Ecology, who expressed an
13 interest in deployment in WMA C. This new characterization technology, ^{99}Tc sensor, will aid
14 in the selection of soil samples in addition to the standard use of gross gamma and neutron
15 moisture logging data that is conducted before soil sampling decision-making (see
16 Section 4.51.4).

18 4.6 OPTIMIZING SAMPLING

19 Based on data needs identified in the DQO meetings, a number of options were considered for
20 the Phase 2 characterization effort at WMA C. These characterization options included using
21 direct-push technology and nonintrusive geophysical techniques (e.g., SGE) and updating
22 spectral gamma logging around tanks C-103 and C-106 and C-104, C-108, C-109, C-110, C-111,
23 and C-112 as well as groundwater monitoring wells 299-E27-12, 299-E27-13, 299-E27-14, and
24 299-E27-15. These options are based on characterization techniques and innovative technologies
25 identified in RPP-PLAN-37243 and RPP-ENV-38838 for methods that have been successfully
26 used on the Hanford Site. These options and potential deployment locations were evaluated in
27 terms of the type of information that could be provided, as well as the technical risk associated
28 with deployment during Phase 2. Although all of the options considered could provide valuable
29 data that would serve to improve the understanding of subsurface contamination, a number of the
30 options were considered to be of lesser value or not feasible due to technical risk for the
31 characterization effort to be implemented beginning in FY 2009. The accessibility of some of
32 these sites is limited by waste retrieval operation equipment located on the surface and
33 subsurface infrastructure interferences for WMA C. The list of characterization options
34 considered during the DQO process, along with the rationale for including or omitting each
35 option from Phase 2 effort, is provided.

36
37 RPP-16608, *Site Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMAs A-AX, C,*
38 *and U*, evaluated sampling and analysis options and alternative field sampling technologies.
39 That evaluation and the experience gained during implementation of the Phase 1 RFI field
40 investigation has resulted in identifying the following sampling technologies for the initial Phase
41 2 characterization efforts: direct push, SGE, and borehole logging. These technologies allow for
42 investigations for the presence of contaminants in the vadose zone to be conducted using both
43 indirect and direct evaluation techniques. Subsurface investigations will include geophysical
44 logging using spectral gamma and moisture, SGE, and soil sampling using direct push
45 technology.

1
2 Direct push technology is planned for use during the initial Phase 2 characterization of the
3 vadose zone in WMA C. The advantage of this technology is ease in deployment, better option
4 of evaluating lateral extent of contamination, no contaminated soil cutting being brought to the
5 surface, and lower costs. The direct push technology plans to use the dual string approach where
6 multiple samples can be collected. The dual string (2.625 in. OD) approach can collect a 1.08 in.
7 x 24 in. sample at multiple depths. In the 200 East Area, the direct push technology has
8 demonstrated the ability to go to great depths (~200 ft) thus providing the opportunity to use its
9 advantages, especially no contaminated soil cuttings being brought to the surface. This is an
10 advantage over traditional drilling of a borehole that is more expensive, provides no ability to
11 easily evaluate lateral extent of contamination, and brings contaminated soil cuttings to the
12 surface.

13
14 The disadvantages of this technology are (1) the quantity of sample material available for
15 analysis, and (2) the small diameter of the probeholes prevents use of high resolution logging
16 tools. The depth limitations mean that the lateral extent of contamination may be determined but
17 not necessarily the full vertical extent. The ability to collect multiple samples in a given
18 probehole results in a 51% decrease in the volume of sample that can be collected. In the past,
19 gamma geophysical logging in small diameter probeholes was limited to sodium iodide crystal.
20 The vadose zone program used this tool for a rapid scan (4 ft/minute) for identifying zones of
21 elevated gamma counts. At times, zones of elevated gamma counts were re-logged with longer
22 count times to acquire a limited spectral speciation. The lower limit of detection with the sodium
23 iodide crystal is about 10 pCi/g. Lower detection limits, such as 0.1 pCi/g, and better spectral
24 speciation requires a 4-in. cased well. However, recently at TY Farm, a modified bismuth
25 germinate oxide (BGO) logging tool was successfully deployed by Pacific Northwest
26 Geophysics (PNG) that contains a small diameter (approximately 2.54 cm crystal), which allows
27 detecting gamma radiation at lower levels than the sodium-iodide crystal. This tool and its
28 modifications are briefly described.

29
30 The BGO crystal has a high density matrix which allows for capture of high energy gamma rays,
31 especially in comparison to a sodium iodide detector, which has a lower density crystalline
32 structure. The ability to capture high energy gamma rays allows the tool to be utilized for
33 spectral interpretation of high-energy gamma-emitting nuclides such as thorium (2775 KeV) and
34 more precise quantification of mid-level energetic gamma rays such as the 1173 and 1332 KeV
35 energy spectra from cobalt.

36
37 The BGO tool was previously deployed in C Farm for characterization of direct push exploration
38 probes surrounding the C-152 Diversion Box in 2005. At that time the BGO instrumentation
39 was operating in an analog mode. That is, all detector signals were transmitted up-hole for
40 processing at surface. PNG identified two problems with the original BGO tool that caused
41 degradation of the signal clarity and resolution. These were (1) using complete analog mode
42 created a baseline drift issue caused by heat buildup in the down-hole electronics and surface
43 processors, and (2) magnetic fields generated by the impacts on the direct-push tubing created
44 electromagnetic interference, which led to signal degradation. The first problem was corrected
45 by converting the system to a digital mode where all energy changes detected by the BGO crystal
46 are processed by a downhole processor (multi-channel analyzer) and transmitted to a surface

1 recorder in a digital mode. The second problem was addressed by containing the detector within
2 three layers of mumetal (a nickel alloy), which shields the electronics from the magnetic field
3 effects instead of one layer. These changes have resulted in reduced signal noise and removal of
4 baseline drift due to heat buildup due to signal density in the surface multi-channel analyzer.

5
6 In this modified configuration, recent calibration efforts and field deployment data have
7 demonstrated the detector is capable of detecting cesium concentrations as low as 0.5 pCi/g and
8 cobalt as low as 0.6 pCi/g. In addition to the low man-made radionuclide detection levels the
9 KUT (potassium, uranium, thorium) ratios provided by the BGO have allowed for improved
10 lithologic interpretations from geophysical log data. The major drawback to this logging tool is
11 the longer count times (3.3 minutes/ft). The calibration of the BGO logging tool will be
12 described in the logging report for the TY direct push due out in the second quarter of 2009.

13
14 In the event that sampling via direct-push technology does not provide the necessary
15 information, subsequent revisions of the DQO would be used to address supplemental sampling
16 approaches. The data gathered through application of direct-push technology will be available to
17 target those regions requiring deeper investigation through other established techniques (drill and
18 sample, drive and sample, etc.).

19
20 The Tank Farm Vadose Zone Program technical team plans to use existing information and the
21 characterization data collected during the Phase 1 and near-term (FY 2008) characterization to
22 develop a best basis or best estimate of the concentration and distribution of COC in WMA C.
23 This will involve the integration and synthesis of historical data, process knowledge, in-tank
24 inventory models, and the characterization data collected during Phase 1. The integration and
25 synthesis of these data will require interpolation and extrapolation due to the limitations of
26 collecting samples within the tank farms. This effort will result in a conceptualization of COC
27 concentrations and distributions that would be used to evaluate human health and environmental
28 risks.

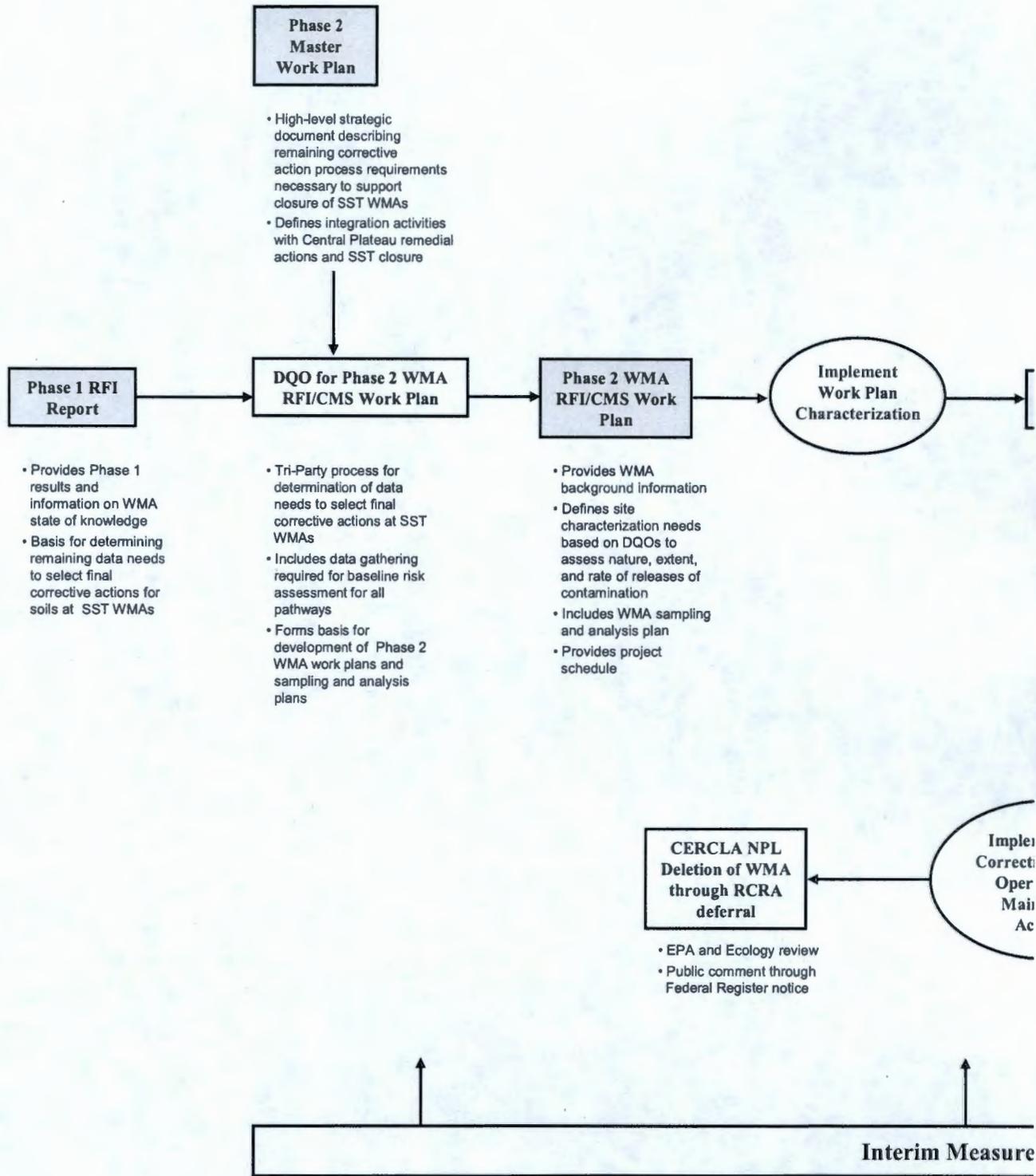
29 **4.7 INVESTIGATIVE SAMPLING AND ANALYSIS AND DATA VALIDATION**

30 Samples and data will be collected during the vertical/slant probehole installation while driving
31 the casing and by conducting geophysical surveying as described in the SAP presented in
32 Appendix A. Periodic sediment samples will be collected. Sample lengths will be reduced if
33 necessary when penetrating known hot zones to reduce worker exposure. All samples will be
34 field screened for radiation, sealed, refrigerated, and shipped for analysis. Laboratory analyses
35 will be performed on the sediment samples for radiological and geochemical constituents, as
36 described in Appendix A. Limited analysis for physical parameters (e.g., moisture retention and
37 hydraulic conductivity) may also be performed on sediments that show visible evidence of being
38 altered by the leak chemistry (e.g., cementation, discoloration).

39
40 Data from the vertical probeholes determined by project management to be relevant for the
41 purpose of validation will be made available by the primary laboratory on request. Validation
42 will be performed in accordance with the quality assurance program description in Attachment 1.
43

1

1



 Ecology Review and Approval as a Primary Document

5.1 INTEGRATION WITH OTHER PROGRAMS AND AGENCIES

Several ongoing Hanford Site characterization, remediation, and other activities may impact or be impacted by the Phase 2 RCAP activities. Integration of these activities is important to optimize the use of resources and provide an understanding of cumulative impacts. Currently, the Soil and Groundwater Remediation Project has lead contractor responsibility for integrating all groundwater and vadose zone activities. The Soil and Groundwater Remediation Project is managed by the Plateau Remediation Contractor. The RCAP is committed to integrating planning, field activities, and analyses with principal interfaces in support of these integration projects. The Phase 2 master work plan (RPP-PLAN-37243) discusses project scope, points of contact, and integration needs associated with the following principal interfaces:

- a. Soil and Groundwater Remediation Project.
- b. Hanford Groundwater Performance Assessment Project.
- c. 200 Areas Remedial Action Assessment.
- d. Other River Protection Project projects, such as waste retrieval.
- e. Other organizations.

Integration will primarily occur through monthly project reporting as well as coordination and involvement during DQO activities. Additional benefit can be gained through communication on innovative technology lessons learned and by coordinating resources through multi-project teams. The overall integration management plan discusses these interfaces (DOE/RL-2007-20, *Hanford Integrated Groundwater and Vadose Zone Management Plan*). The overall integration strategy is also provided in Chapter 5 of the Phase 2 master work plan (RPP-PLAN-37243).

Project management occurs throughout the RCRA corrective action process. Project management is used to direct and document project activities so that the objectives of the work plan are met and the project remains within budget and on schedule. Other project management activities include day-to-day supervision of and communication with project staff and support personnel; meetings; control of cost, schedule, and work; records management; progress and final reports; quality assurance; health and safety; and community relations.

The project management objectives throughout the course of the Phase 2 WMA C process as identified in HFFACO Milestone M-45-60, -61 and -62 (Ecology et al. 1989) are to direct and document project activities so the data and evaluations generated meet the goals and objectives of the work plan and to ensure that the project is kept within budget and on schedule. General project management objectives are to (1) ensure the safety of the work force and the affected environment, (2) direct and document project activities, (3) ensure that project goals and objectives are met, and (4) administer the project within budget and schedule. The Phase 2 WMA C DQO workshop defined the specific scope and schedule elements. These elements resulted in the development of a DQO report (RPP-RPT-38152) that provided the data needs and characterization locations identified in the DQO process.

5.2 FIELD INVESTIGATION ACTIVITIES

The following sections summarize the planned tasks that will be performed during the Phase 2 RFI/CMS work plan for WMA C for the soils within and immediately surrounding the WMA C that were impacted by tank farm activities. Planned tasks include the following:

- a. Planning.
- b. Field investigation.
- c. Management of waste.
- d. Laboratory analysis and data validation.

These tasks and subtasks reflect the work structure that will be used to manage the work and develop the project schedule provided in Chapter 6.

5.2.1 Planning

The planning subtask includes tracking and coordinating activities to be completed and documentation that must be completed before the Phase 2 RFI/CMS field activities can begin. This includes interfacing with other organizations and/or project managers who will be providing information for presentation in the Phase 2 RFI/CMS report due to Ecology on December 31, 2010, to fulfill HFFACO Milestone M-45-61. It also included conducting a DQO process with Ecology, ORP, TOC, and integration with Plateau Remediation Contractor and RL personnel for coordination of activities associated with the groundwater operable unit 200-BP-5 that is under WMA C (RPP-RPT-38152).

In addition to this work plan, which fulfills HFFACO Milestone M-45-60, radiological work permits, excavation permits, supporting surveys (e.g., cultural, radiological, wildlife, utilities), work instructions, personnel training, and the procurement of materials and services (e.g., drilling and geophysical logging services) also will be required. In addition, characterization locations identified in the SAP (Appendix A) will be located using GPR and staked using a global positioning satellite system.

Attachment 2 provides a health and safety plan that outlines health and safety requirements for field investigation activities. This health and safety plan in coordination with TFC-PLN-43, *Tank Operations Contractor Health and Safety Plan*, ensures protection of onsite investigators. Initial surface radiological surveys will be performed to document any radiological surface contamination and background levels in and around the sampling locations. This information will be used to document initial site conditions.

5.2.2 Field Investigation

The field investigation task involves performing data-gathering activities in the field that are required to satisfy the DQOs. The field characterization approach is summarized in Section 4.2 and detailed in the SAP and sampling and analysis instructions provided in Appendixes A and B. The scope includes soil sampling and analysis to characterize the vadose zone soil at selected locations and geophysical logging. Major subtasks associated with the field investigation include the following.

- 1 a. Conduct direct-push installations for geophysical logging, soil sample collection, and
2 deep electrode placement.
- 3 b. Conduct probehole geophysical surveying and analysis (e.g., neutron, gross gamma).
- 4 c. Obtain sediment samples to analyze for the presence and concentration of contaminants
5 and to evaluate alterations of the sediments from waste chemistry effects.
- 6 d. Obtain tissue samples from surrounding environment for ERA.
- 7 e. Geophysical logging of drywells within WMA C and groundwater wells within the DQO
8 boundary.
- 9 f. Conduct testing SGE at UPR-81, UPR-82, and UPR-86. Based on lessons learned from
10 the UPRs, deploy SGE across WMA C.

11 The vadose zone investigation for Phase 2 WMA C will comprise compiling pertinent existing
12 data and collecting data from field investigation activities in the vadose zone. The types of data
13 needed from the surface and vadose zone include the following:

- 14 a. Thickness and areal extent of geologic units.
- 15 b. Lithology, bedding types, facies geometry, particle size, and sorting.
- 16 c. Presence, concentration, and nature of contaminants in sediments of the vadose zone.
- 17 d. The vadose zone information will be evaluated to determine the following:
 - 18 1. Refinement of WMA C conceptual vadose zone model.
 - 19 2. Release and movement of contaminants.
 - 20 3. Development and evaluation of CMS alternatives.

21
22 Chapter 4 provides the rationale and approach for the field investigation. The requirements for
23 geologic and geophysical surveying and sediment sampling for physical and laboratory
24 analytical parameters in the vadose zone are provided in Appendix A.

25
26 Based on Chapter 4 and the DQO (RPP-RPT-38152), shallow soil investigation (i.e., 200 ft bgs)
27 will be conducted within the area of the DQO boundary. The shallow investigation will
28 comprise collecting sediment samples between the ground surface and refusal using direct-push
29 technology at 18 locations. The samples will be transported to the laboratory and analyzed for
30 the constituents identified in Appendix A. The physical and operational constraints will require
31 evaluation prior to identifying the specific target locations.

32
33 Shallow soil characterization will be carried out principally using a hydraulic hammer direct-
34 push-technology-based system. Specific sites cleared for access (i.e., underground piping and
35 electrical services identified) and with an approved excavation permit will be interrogated with a
36 gross-gamma probe. The depth of investigation will be determined at least partly by the depth to
37 which the direct-push boring can be advanced using standard deployment. Each direct push
38 location requires a nonsampling direct push for gamma and neutron logging to target a location
39 to sample (i.e., high moisture and/or high gamma) followed by a direct push to collect the soil.
40

1 The graphical log developed using the gross gamma measurements and moisture measurements
2 will be used to select intervals to be sampled. The sampling push is to be made in a location that
3 is no more than 0.7 m (2 ft) from the site of the gamma push. A single point sampler will be
4 used to collect the required samples.

5
6 Subsurface conditions are variable and the process of the field investigation must be flexible.
7 Some or all of the work described in Appendix A may require modification. This work plan is
8 intended to serve as a guideline and is designed to allow for changes depending on conditions
9 encountered in the field. Any change will be recorded on the appropriate field documentation,
10 memoranda, or letters. A complete documented record of activities will be maintained for
11 preparation of a final summary report.

12 **5.2.3 Management of Waste**

13 Waste generated during the RFI/CMS will be managed in accordance with a waste-control plan
14 for the sampling activity. Attachment 4 provides general waste management processes and
15 requirements for the waste. Since this field investigation will principally use direct push
16 technology, no waste to minimal waste will be generated.

17
18 All waste will be handled in accordance with the requirements of WAC 173-303, "Dangerous
19 Waste Regulations," and as reflected in the site-specific waste control plan. These techniques
20 are based on the practice of minimizing the exposure of field personnel to both radiation and
21 chemical pollutants to as low as reasonably achievable (ALARA) and are in compliance with
22 regulatory requirements.

23
24 Appropriate permits and compliance with the notice of construction permit (DOE/ORP-2000-05,
25 *Notice of Construction for Tank Waste Remediation System Vadose Zone Characterization*) will
26 be maintained during the field operations inside the tank farm. The selected field interrogation
27 methods comply with the requirements of the Washington State Department of Health for the
28 notice of construction permit and other pertinent requirements and appropriate engineering
29 systems to prevent contaminated air from being released to the environment.

30 **5.2.3.1 Laboratory Analysis and Data Validation**

31 Soil samples will be analyzed for a suite of radionuclides and nonradionuclide constituents
32 identified during the Phase 2 WMA C DQO process. The list of analytes, methods, and
33 associated target-detection limits is provided in the SAP (Appendix A). The SAP also specifies
34 quality assurance, quality control, and data-reporting requirements for the laboratory analysis.
35 Validation of a representative number of laboratory data packages will be performed. Data
36 review and validation will be completed in accordance with best-basis inventory procedures.

37 **5.3 PHASE 1 DATA EVALUATION**

38 All Phase 1 characterization data is compiled and reviewed in DOE/ORP-2008-01, *RCRA*
39 *Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*, since the
40 completion of field operations and receipt of laboratory results for Phase 1. Field screening
41 results, geophysical logging data, and laboratory analyses were included and summarized in the

1 report. Results were tabulated and maps and plots prepared to show the contaminant
2 distribution. Based on the results of Phase 1, an assessment was completed concerning the need
3 for additional data collection for each of the SST WMAs. It was determined that additional
4 characterization data was needed to support risk assessment evaluations and corrective measures
5 decision-making, and planning for Phase 2 was initiated. The results were modification of the
6 HFFACO to add an additional three interim milestones (M-45-60 through M-45-62) (Ecology
7 et al. 1989), modify an existing interim milestone (M-45-58) and amend Appendix I, Section 2.3,
8 to elaborate on the Phase 2 activities and modified specific Phase 1 master work plan
9 deliverables for the RFI. The modification no longer required a comprehensive and ecological
10 risk assessment as a summary of impacts from the initial SST performance assessment was
11 required in the HFFACO Milestone M-45-55 and included the field investigation reports for
12 WMAs C, A-AX, and U. Phase 1 results were used to determine Phase 2 data needs in WMA C.
13

14 **5.4 PHASE 2 RCRA FACILITY INVESTIGATION/CORRECTIVE MEASURES** 15 **STUDY**

16 Phase 2 will entail gathering additional data to support corrective action decisions, including no
17 action. Results of both near-term and Phase 2 of the characterization data will be presented in the
18 Phase 2 RFI/CMS report for WMA C fulfilling HFFACO Milestone M-45-61 (Ecology et al.
19 1989). Data generated during the field investigation will be integrated and evaluated with
20 previous field investigations, coordinated with Central Plateau RI/FS activities, and presented in
21 an ongoing manner to allow decisions regarding any necessary rescoping to be made during the
22 course of the project. The assessment of data against the planning process, use of the data by
23 others, and potential use to support future activities will be conducted and documented in a
24 Phase 2 RFI/CMS report for WMA C. The results of these evaluations will be made available to
25 project management personnel to keep project staff informed of progress made. The
26 interpretations developed under this task will be used to refine the conceptual model and refine
27 the CMAs to support future closure requirements and risk assessments.

28 **5.4.1 Data-Quality Assessment**

29 A data quality assessment in accordance with HASQARD will be performed on the analytical
30 data to determine if they are the right type, quality, and quantity for their intended use. The data
31 quality assessment completes the data life cycle of planning, implementation, and assessment
32 that began with the DQO process. In this task, the data will be examined to see if they meet the
33 analytical quality criteria outlined in the DQO and are adequate to evaluate the decision rules in
34 the DQO.
35

36 **5.4.2 Data Evaluation and Conceptual-Model Refinement**

37 This task will consist of evaluating the information that has been collected. The nonradiological
38 and radiological data associated with the soil samples will be compiled, tabulated, and evaluated
39 to satisfy data needs as defined in the DQO (RPP-RPT-38152). Data evaluation tasks may
40 include the following.

- 1 a. Perform initial screening for contamination by evaluating the data with respect to
2 background, using simple comparisons of maximum values to background
3 concentrations.
- 4 b. Compare the data to potential cleanup levels.
- 5 c. Describe the distribution of contamination within the vadose zone based on field
6 screening and laboratory analytical results.
- 7 d. Describe the vertical and lateral distribution of contamination in soil based on
8 geophysical logging results and analytical data for soil samples.
- 9 e. Construct data diagrams and plots to evaluate spatial correlations within and between
10 samples. This evaluation will be used to assess whether contamination is concentrated in
11 a particular area, in relationships between contaminant levels and locations in
12 surrounding soil.
- 13 f. If sufficient data are available, perform statistical analyses. This step has many facets,
14 including determining the distribution of the data and selecting the appropriate statistical
15 tests.

16 If available data are not sufficient for statistical analysis, maximum concentrations will be used
17 in the data evaluation process. The combined chemical and geophysical data will be used for
18 refining the initial conceptual contaminant-distribution models and as inputs to the risk
19 assessment.

20 **5.4.3 WMA C Performance Assessment**

21 As part of the WMA C performance assessment and to meet the requirements of the Phase 2
22 RFI/CMS report for WMA C, a risk assessment with a “no action” alternative to address
23 CERCLA requirements will be prepared as part of the report for all potential pathways: human-
24 health direct contact, ecological, and protection of groundwater.

25
26 The risk assessment with a “no action” alternative will evaluate risk to human and ecological
27 receptors from potential exposure to contaminants in surface sediments and accessible shallow
28 subsurface soils. The risk assessment also will evaluate the potential for contaminants that are
29 currently in the vadose zone soil to impact groundwater in the future. Risks from current
30 groundwater contamination will not be evaluated; this evaluation will be conducted as part of the
31 RI/FS process for the Central Plateau respective groundwater OUs through the CERCLA process
32 and HFFACO Milestone M-15-00.

33
34 A risk assessment with a “no action” alternative analysis for those COC detected within the soils
35 will be completed. Initial screening will consider the constituents to be directly accessible to
36 potential receptors as applicable for their exposure pathways. These modeling results will be
37 considered in the risk evaluations associated with various potential leave-in-place CMAs
38 (e.g., no action, decontamination flushes, grouting).

5.4.3.1 Standards, Guidance Documents, and Computer Codes

The human-health risk assessment will be conducted in accordance with appropriate subsections of WAC 173-340, with agreements with Ecology on the WMA C performance assessment as described in RPP-PLAN-37243, and with the following DOE and EPA guidance documents:

- a. DOE/RL-91-45, *Hanford Site Baseline Risk Assessment Methodology*.
- b. EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGs)*, Volume I – Human Health Evaluation Manual, (Part A) Interim Final, OSWER 9285.7-01A.
- c. OSWER Directive 9285.6-03, *Risk Assessment Guidance for Superfund*, Vol. I, Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, (Interim Final).
- d. EPA/600/P-95/002Fa, *Exposure Factors Handbook Volume 1: General Factors*.
- e. EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* (Part E, Supplemental Guidance for Dermal Risk Assessment) Final.
- f. EPA/600/P-92/003C, *Proposed Guidelines for Carcinogen Risk Assessment*.
- g. OSWER Publication 9285.6-10, *Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*.
- h. OSWER Publication 9285.7-081, *Supplemental Guidance to RAGS: Calculating the Concentration Term*.

The RESidual RADioactivity (RESRAD) computer program (ANL 2002) will be used to obtain risk and dose estimates from direct-contact exposure (i.e., top 15 ft) to radiological constituents present in the shallow zone of the waste sites. Additional analysis may be performed using other appropriate fate and transport models (e.g., PNNL-12028, *STOMP Subsurface Transport Over Multiple Phases, Version 2.0, Application Guide*) to assess impact to the groundwater from chemicals and radionuclides in the vadose zone (in accordance with WAC 173-340-747(8), “Deriving Soil Concentrations for Ground Water Protection,” “Alternative Fate and Transport Models”).

5.4.3.2 Additional Risk Assessment Information

For WMA C, risk assessment will be performed for an industrial-exposure scenario to establish the “no action” alternative. As part of the Phase 2 RFI/CMS, additional risk assessment for informational purposes may be performed to evaluate other scenarios (such as Native American, residential, or an intruder scenario to evaluate post-remediation residual risks).

Contaminant concentrations, distribution, and pathway availability will be evaluated. Analytical data and hydrogeologic information used in risk calculations include the following:

- a. Laboratory analytical results from sampled media (soils only).
- b. Waste-site configuration and construction.
- c. Depth of burial [above or below the 4.6 m (15-ft) direct human-exposure point of compliance] [in accordance with WAC 173-340-740(6)(d), “Unrestricted Land Use Soil

1 Cleanup Standards,” WAC 173-340-740(3)(b), “Unrestricted Land Use Soil Cleanup
2 Standards,” “Method B Soil Cleanup Levels for Unrestricted Land Use,” “Standard
3 Method B Soil Cleanup Levels,” as appropriate].

- 4 d. Known or estimated volume of a waste stream released in relation to the available pore
5 volume of soil.
- 6 e. Comparison of concentrations of contaminants relative to concentrations considered
7 protective of groundwater (e.g., compared with WAC 173-340-747 derived concentration
8 values).
- 9 f. Contaminant inventory (types and location).
- 10 g. Release mechanism.
- 11 h. Expected distribution of contamination based on configuration of the release.
- 12 i. Geological setting.
- 13 j. Neighboring waste sites, structures, or utilities.
- 14 k. Potential for hydrologic and contaminant impacts to groundwater.

15 Information and assessments completed for each release into the environment that is known will
16 be a part of the Phase 2 RFI/CMS work plan for WMA C and will be incorporated into the
17 Phase 2 RFI/CMS report for WMA C. Results of the risk assessment will be used to support the
18 evaluation and selection of the appropriate corrective action. The characterization data that was
19 compiled during Phase 1 and additional characterization data provided from the near-term
20 characterization effort and this Phase 2 effort should provide sufficient information to select
21 CMAs for each soil release site within the study boundary. Following CMS, additional data
22 collection will be performed as needed to optimize alternative design and verify achievement of
23 cleanup goals under the corrective measures implementation (CMI) (HFFACO M-45-62). For
24 sites that are candidates for a removal action, final verification sampling results will provide
25 sufficient data to document that cleanup levels specified in the RCRA Permit have been
26 achieved.

27 **5.4.4 Ecological Evaluation and Risk Assessment**

28 As part of RCRA corrective action, WAC 173-340-357 requires assessment of ecological risk as
29 part of the determination of cleanup levels and CMAs. The MTCA addresses hazardous
30 chemicals but does not address the radionuclide contaminants that are known to have been
31 released into the environment at WMA C. To address chemical and radiological ecological risks,
32 the SST WMA ERAs will be performed in accordance with the following:

- 33 a. WAC 173-340-7490, “Terrestrial Ecological Evaluation Procedures.”
- 34 b. DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic*
35 *and Terrestrial Biota.*

36 Information developed under the WMA ERA process will be used in the development and
37 analysis of CMAs, including the no-action alternative. To maintain consistency across the
38 Hanford Site, the ERA for the WMAs will integrate some of the methodology and data that were

1 used in the CPERA. A detailed discussion on the approach to SST WMA ERA is provided in
2 Section 3.4.

3 **5.4.5 Treatability Studies Needs**

4 In conjunction with the Phase 1 RFI data compilation and assessment for WMA C
5 (DOE/ORP-2008-01), the Phase 2 RFI/CMS activities will be initiated and will include the
6 identification of applicable CMAs. Treatability studies may be required to verify the feasibility
7 of a technology, cost of a remedy, or applicability of a technology or action. Phase 1 RFI/CMS
8 characterization activities have provided additional information that may contribute or be used in
9 lieu of treatability studies needed to complete the Phase 2 RFI/CMS. Information obtained
10 during Phase 1 and 2 characterization activities would provide support in addressing the existing
11 condition of selected soil contamination levels, level of effort and costs to acquire data, and
12 worker-exposure conditions associated with certain corrective measure remedies. Additionally,
13 the results from Phase 2 characterization activities, would be used to identify the need for
14 engineering studies. Treatability studies for the deep vadose zone are presently being evaluated
15 as part of the remedial investigation process under CERCLA that is being conducted by DOE-RL
16 and the Plateau Remediation Contractor (DOE/RL-2007-56, *Deep Vadose Zone Treatability Test
17 Plan for the Hanford Central Plateau*). Should deep vadose zone treatability be warranted in
18 WMA C, DOE-RL and its contractor would implement these treatabilities. .

19 **5.4.6 Corrective Measures Study Outline**

20 As required by the guidance for the RCAP (OSWER 9902.3-2A), a proposed outline (that may
21 be modified as appropriate following Phase 2 characterization activities) for the RFI/CMS report
22 including a description of how the information will be presented is provided in the following:

- 23 a. **Introduction/Purpose:** The purpose of the document and a summary description of the
24 project will be provided.
- 25
- 26 b. **Summary of Phase 2 RFI Results:** A brief summary/discussion of new characterization
27 performed during the Phase 2 RFI since the Phase 1 RFI report (Appendix L of
28 DOE/ORP-2008-01) was finalized will be provided. The Phase 2 RFI information will
29 form the basis for the evaluation of risks from a no-action alternative and the CMA(s)
30 developed in the CMS.
- 31
- 32 c. **Media Cleanup Standards:** Proposals of media cleanup standards may be provided.
33 The standards must be based on promulgated federal and state standards, risk derived
34 standards, all data and information gathered during the corrective action process (e.g.,
35 from interim measures, RCRA Facility Investigation, etc.), and/or applicable guidance
36 documents. Final media cleanup standards are determined by Ecology when the remedy
37 is selected and are documented in the Statement of Basis/Response to Comments or
38 permit modification.
- 39
- 40 d. **Identification, Screening, and Development of Corrective Measures Alternatives:**
- 41
- 42 1. **Identification:** The CMS will define potentially applicable corrective measure
43 technologies that may be used to achieve the corrective action objectives.

1
2 2. **Screening:** When evaluating a number of corrective measures technologies, an
3 evaluation of the technology limitations will show why certain corrective measures
4 technologies may prove not feasible to implement given existing waste and site-
5 specific conditions (see RPP-ENV-34028).

6
7 3. **Corrective Measures Development:** Section 5.4.7 provides a description of the
8 development of CMAs.

9
10 e. **Evaluation of CMA(s):** For each alternative a detailed analysis of how the potential
11 alternatives will comply with each of the standards provided in Section 5.4.8 will be
12 developed. After this detailed analysis, a comparative analysis of the alternatives will be
13 developed. In evaluating the selected alternative or alternatives, information shall be
14 presented that documents that the specific remedy will meet the standards listed in
15 Section 5.4.8.

16 **5.4.7 Development of Corrective Measures Alternatives**

17 After completion of the field work, CMAs identified in this section will be more fully developed
18 and will be evaluated against WAC closure performance standards [WAC 173-303-610(2)] and
19 evaluation criteria developed in accordance with WAC 173-303-64610 through
20 WAC 173-303-64620 and Section 7.4 of the HFFACO and discussed in (OSWER
21 Directive 9902.3-2A).

22
23 The EPA recommends that all CMAs be developed to address all of the contamination issues at a
24 site. This requires tailoring the evaluation of alternatives based on site-specific circumstances.
25 The CMS would only evaluate implementable approaches, consistent with expected future land
26 uses, and will limit the number of alternatives evaluated to those necessary to demonstrate that
27 the preferred remedy is capable of achieving the following: (1) protection of human health and
28 environment, (2) achieving media cleanup objectives and standards, (3) controlling/remediating
29 sources of release, and (4) acceptable with respect to the balancing/evaluation criteria (e.g., cost,
30 effectiveness, acceptance, etc. (see Section 5.4.8).

31
32 The EPA provides an overview of the approach to selecting corrective measures processes
33 consistent with the following (OSWER Directive 9902.3-2A):

- 34 a. Define corrective action objectives and RCRA corrective action performance standards
35 and ensure consistency with RCRA closure performance standards.
- 36 b. Evaluate only the most likely alternatives that can reasonably be expected to meet
37 corrective action goals and agreed to by the facility and regulators.
- 38 c. The level of documentation required is only that necessary to adequately document the
39 decision rationale.
- 40 d. Simple, straightforward contamination scenarios may require evaluation of a more
41 limited number of alternatives and less detailed evaluation and documentation.
- 42 e. More complex contamination scenarios may require evaluation of a greater number of
43 alternatives and more detailed evaluation and documentation.

- 1 f. Identify potential technologies and process options associated with each general response
2 action. See RPP-ENV-34028 for vadose zone soil remediation technologies potentially
3 applicable on the Central Plateau.
- 4 g. Screen the process options to select a representative process for each type of technology
5 based on its effectiveness, implementability, and cost. See RPP-ENV-34028 for vadose
6 zone soil remediation technologies potentially applicable on the Central Plateau.
- 7 h. Assemble viable technologies or process options into alternatives representing a range of
8 treatment and containment, plus a no-action alternative. Identify technologies to address
9 each COC and medium of concern.
- 10 i. Combine technologies into alternatives that address all contamination issues at the site
11 including contaminants of concern, media of concern, and risk and exposures.
- 12 j. Evaluate alternatives and present information needed to support corrective measure
13 selection and comply with RCRA closure of the unit, pursuant to Hanford Facility RCRA
14 Permit, Condition II.K (WA 7890008967, *Hanford Facility Resource Conservation and
15 Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage,
16 and Disposal of Dangerous Waste*).

17
18 Potential CMAs identified for this effort, which does not include the deep vadose zone soils and
19 groundwater include the following:

- 20 a. Take no action [required for consistency with the *Comprehensive Environmental
21 Response, Compensation, and Liability Act of 1980 (CERCLA)*].
- 22 b. Removal (excavation), treat as appropriate, and disposal of waste.
- 23 c. Treat contaminants to reduce toxicity, mobility, or volume.
- 24 d. Treat vadose zone to reduce mobility of released contaminants.
- 25 e. Install surface barrier.
- 26 f. Combination of any of the above, except for no action.

27 Sections of contaminated soils are located in areas where the use of surface cap/barrier may be
28 proposed for corrective actions that will impact other operable units or projects, such as
29 200-BP-5. Evaluation of CMAs for WMA C will consider the benefits of these proposed
30 barriers and how remedial strategies and decisions can be integrated.

31
32 A summary of each of these potential alternatives as it would apply to WMA C will be provided.
33 Two principal categories of CMAs are currently identified: those actions that require removal
34 and those that entail in-place remedies. In-place remedies would include in-situ treatment
35 (stabilization), or maintaining an existing soil cover, if already present, with institutional
36 controls.

37 **5.4.7.1 No Action**

38 To maintain consistency with CERCLA requirements, 40 CFR 300 requires that a no-action
39 alternative be evaluated as a baseline for comparison with other remedial/CMAs. The no-action
40 alternative represents a situation where no legal restrictions, access controls, or active remedial

1 measures are applied to the site. No action implies allowing the wastes to remain in the current
 2 configuration, thus being affected only by natural processes. No maintenance or other activities
 3 will be instituted or continued. Selecting the no-action alternative would require that a waste site
 4 pose no unacceptable threat to human health or the environment. Typically, this alternative is
 5 used as a comparison to the other CMAs.

6 **5.4.7.2 Removal, Treatment, and Disposal**

7 Contaminated soil is physically removed from the vadose zone and disposed to an engineered
 8 landfill designed to prevent release of materials. Key factors to be considered in the selection of
 9 removal and disposal include the following:

- 10 a. **Volume of material to be excavated**—Involves estimating excavation volume based on
 11 preliminary cleanup levels. Costs for excavation and disposal are directly related to the
 12 volume of soil to be managed.
- 13 b. **Excavation design and strip ratio**—Standard excavation equipment is limited to a depth
 14 of approximately 35 feet without having to bench the side slope. Standard mining
 15 techniques can be used to design excavations of considerable depths. With increased
 16 depth and the need for benching and laybacks, the effective strip ratio of noncontaminated
 17 to contaminated materials increases significantly, adding to the material handling costs.
- 18 c. **Underground equipment**—There is a dense array of ancillary equipment (piping, catch
 19 tanks, diversion boxes, vaults) that will be routinely encountered from the surface to
 20 ~5–20 ft bgs while removing soil within tank farms. Residuals within this equipment
 21 will add significantly to the cost of removal, treatment, and disposal and may result in
 22 potentially higher dose rates than for soil removal alone.
- 23 d. **Disposal capacity**—Excavating large-diameter, deep waste sites will generate a large
 24 amount of waste requiring disposal. Capacity of an approved engineered landfill is
 25 typically at a premium.
- 26 e. **Worker exposure**—Excavation of highly contaminated sediments can pose significant
 27 worker exposure and contamination control issues, both of which increase with depth and
 28 size of excavation.
- 29 f. **Hot spot removal**—A subalternative would include the removal and disposal to
 30 selectively remove near-surface localized areas of high contamination or hot spots. This
 31 subalternative could remove the greatest mass of contaminants, while minimizing the
 32 volume of material to be handled and disposed. Removing hot spots to shrink the size of
 33 surface barriers is another potential use of this subalternative.
- 34 g. **Backfilling**—After contaminated materials are removed, the excavation will require
 35 backfilling with clean material to bring it back to grade. Backfill will require compacting
 36 to achieve conditions as close to undisturbed as possible.

37 **5.4.7.3 Treat Contaminants to Reduce Toxicity, Mobility, or Volume**

38 Some soil locations may have attributes where application of an in-situ treatment technology
 39 would be an appropriate remedy to reduce the toxicity, mobility, or volume of contaminated
 40 material. The candidate technologies for this alternative include the following: desiccation,

1 in-situ gaseous reduction, multistep geochemical manipulation, nanoparticles, and in-situ
2 phosphate/calcite immobilization.

3 **5.4.7.4 Treat Vadose Zone to Reduce Mobility of Released Contaminants**

4 Other soil locations may have attributes where application of an in-situ treatment technology
5 would be an appropriate remedy that would allow isolation of the contaminants in the vadose
6 zone. The candidate technologies for this alternative include subsurface barriers and permeation
7 grout.

8 **5.4.7.5 Install Surface Barrier**

9 Surface barriers are placed over contaminated sites to control the amount of water that infiltrates
10 into contaminated media to reduce or eliminate leaching of contamination to groundwater. In
11 addition to their hydrological performance, barriers also can function as physical barriers to
12 prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate
13 radiation. Surface barriers are effective for all contaminants, are readily implementable, and
14 have been extensively used. A range of surface barriers has been identified for Hanford Site
15 application (e.g., Hanford Barrier, Modified RCRA Subtitle C and D, and evapotranspiration
16 barriers) that are viable process options depending on the site-specific level of protection
17 required (RPP-ENV-34028, DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study*
18 *Implementation Plan – Environmental Restoration Program*) and predominantly rely on
19 evapotranspiration processes to control the movement of water.

20
21 Surface barriers are applicable for groundwater, human health, and ecological protection. Site-
22 specific conditions establish the level of hydraulic or physical barrier performance required. If
23 groundwater protection is required, the barrier will need to limit the infiltration of precipitation.
24 If the prevention of ecological and human intrusion is a performance requirement, then the
25 physical barrier components become more important. For sites with deep vadose contamination
26 (e.g., greater than 150 ft), surface barriers may not sufficiently contain the contamination, and
27 supplemental technologies (e.g., in-situ remediation) may be needed. Site-specific modeling
28 should be performed to evaluate the size and depth over which surface barriers are effective in
29 protecting groundwater. Provisions for groundwater monitoring should be included as part of the
30 alternative for sites with deep vadose zone contamination.

31
32 Surface barriers have been designed with a life expectancy up to 1000 years for the Hanford Site
33 (DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management*
34 *Units in the 200 Areas*). For barriers that use naturally stable geologic materials, the primary
35 factor establishing life expectancy is projected erosion rates, which can be minimized by
36 maintaining the vegetation cover and adding armoring appropriately.

37 **5.4.8 Corrective Measures Alternatives, Performance Standards, and Selection Criteria**

38 Section 7.4.3 of the HFFACO requires that the information obtained through the CMS must be
39 functionally equivalent to the information obtained in the CERCLA feasibility study process. In
40 addition, OSWER Directive 9902.3-2A provides the nine RCRA Corrective Action

1 balancing/evaluation criteria. As such, during the detailed analysis, each alternative will be
2 evaluated against the following:

- 3 a. Overall protection of human health and the environment.
- 4 b. Compliance with applicable or relevant and appropriate requirements (ARAR).
- 5 c. Long-term reliability and effectiveness.
- 6 d. Reduction of toxicity, mobility, or volume of wastes.
- 7 e. Short-term effectiveness.
- 8 f. Implementability.
- 9 g. Cost.
- 10 h. State acceptance.
- 11 i. Community acceptance.

12 The first two criteria are considered threshold criteria, which the CMAs being evaluated must
13 meet. The next five criteria are considered balancing or evaluating criteria, which are used to
14 assist in selecting the most appropriate CMA. The last two criteria are considered modifying
15 criteria, which are used to assist in finalizing the selection of a CMA. The modifying criterion of
16 Ecology acceptance will be documented in the draft RCRA permit modification. The final
17 modifying criterion, community acceptance, will be applied following the CMS during the draft
18 RCRA permit modification public review phase.

19
20 Overall protection of human health and the environment is a general mandate from the RCRA
21 statute and is the primary goal of corrective action. This criterion should be evaluated based on
22 reasonably anticipated current and future land use(s). Protection of human health and the
23 environment can be achieved by removing contamination, treating contamination, preventing
24 exposure to contamination, or a combination of these actions.

25
26 Compliance with applicable or relevant and appropriate requirements can occur by achieving the
27 media cleanup objectives/standards and/or control/remediate release sources. Sources include
28 both the location of the original release as well as locations where any significant mass or
29 concentration of contaminants may have migrated.

30
31 Long-term reliability and effectiveness criteria should evaluate the degree of certainty that an
32 alternative will remain protective of human health and the environment. The long-term
33 reliability and effectiveness of the criteria should take into consideration the magnitude of risk
34 that will remain and the reliability of any containment systems or institutional controls.

35
36 Reduction of toxicity, mobility, or volume of wastes criterion should take into account the degree
37 to which treatment reduces toxicity, mobility, and volume of hazardous waste. Under this
38 criterion, consideration of the amount treated, degree to which treatment is irreversible and the
39 potential toxicity, mobility, and volume of treatment residues should be evaluated.

40
41 Short-term effectiveness criterion should take into consideration implementation timeframes and
42 short-term risks posed by the corrective action. This criterion should take into account the
43 potential short-term increases in exposure caused by the corrective action from exposure to
44 contaminated subsurface soil and airborne dust during excavation as well as mobilization of

1 groundwater contamination caused by increased gradients or injected material. Finally, the
2 amount of time required for design, construction, and implementation should be assessed.

3
4 The criterion of implementability should take into consideration the ease or difficulty of
5 implementation and should consider the technical feasibility of constructing, operating, and
6 monitoring the implemented corrective measure, its administrative feasibility, and the
7 availability of services and materials required (e.g., disposal services, construction material).

8
9 Cost criterion should take into account capital costs, operation and maintenance costs, and net
10 present value of costs. Operation and maintenance costs should reflect realistic timeframe
11 estimates and not be based on an arbitrary time period, such as 30 years. Net present value of
12 costs will provide an equal basis for comparison of alternatives with different durations and
13 assumes current year funds will be invested for payment of future year costs.

14
15 Community acceptance should consider the degree to which a CMA will be acceptable to
16 interested community. This community acceptance should consider public participation and
17 community involvement and public comments.

18
19 State acceptance should consider the degree to which the CMA is acceptable to the regulating
20 state. This aspect is particularly important when EPA selects the corrective measure rather than
21 the state.

22
23 In addition, an analysis of any RCRA or applicable MTCA evaluation criteria not covered by the
24 above will be included in accordance with WAC 173-303-64620(4). MTCA evaluation criteria
25 are contained in WAC 173-340-360. These criteria are consistent with CERCLA and RCRA
26 corrective action evaluation criteria; however they are arranged in a slightly different manner.
27 To ensure that MTCA alternatives are met for SST WMA corrective actions, a separate
28 evaluation of MTCA criteria will likely be accomplished. The criteria include threshold
29 requirements which must be met for an alternative to be selected as a final remedy and "other
30 requirements" and "action specific requirements" that modify the threshold requirements:

31 a. Threshold requirements.

- 32 1. Protect human health and the environment.
33 2. Comply with cleanup standards.
34 3. Comply with applicable state and federal laws.
35 4. Provide compliance monitoring.

36 b. Other requirements.

- 37 1. Use permanent solutions to the maximum extent practicable.
38 2. Provide a reasonable restoration time frame.
39 3. Consider public concerns.

40 c. Action-specific requirements.

- 41 1. Non-permanent groundwater cleanup actions.
42 2. Institutional controls.
43 3. Releases and migration/dilution and dispersion.
44 4. Remediation levels.

1
2 The RCRA closure performance standards (WAC 173-303-610(2), "Closure and Post-Closure,"
3 "Closure Performance Standard") will be used to evaluate whether the alternatives comply with
4 RCRA closure requirements. These standards require the closure of TSD units in a manner that
5 achieves the following:

- 6 a. Minimizes the need for further maintenance.
- 7 b. Controls, minimizes, or eliminates to the extent necessary to protect human health and
8 the environment, post-closure escape of dangerous waste, dangerous waste constituents,
9 leachate, contaminated run-off, or dangerous waste decomposition products to the
10 ground, surface water, groundwater, or the atmosphere.
- 11 c. Returns the land to the appearance and use of surrounding land areas to the degree
12 possible, given the nature of the previous dangerous waste activity.

13 In addition, RCRA corrective-action performance standards (WAC 173-303-64620) will be used
14 to evaluate how well the alternatives comply with RCRA corrective-action requirements. These
15 standards state that corrective action must achieve the following:

- 16 a. Protect human health and the environment for all releases of dangerous waste and
17 dangerous constituents, including releases from all solid-waste management units at the
18 facility.
- 19 b. Occur regardless of the time at which waste was managed at the facility or placed in such
20 units and regardless of whether such facilities or units were intended for the management
21 of solid or dangerous waste.
- 22 c. Be implemented by the owner/operator beyond the facility boundary where necessary to
23 protect human health and the environment.

24 The Phase 2 RFI/CMS report for WMA C also will include supporting information needed to
25 complete the detailed analysis and meet regulatory integration needs, including the following:

- 26 a. Summarize the field investigation findings including the nature and extent of
27 contamination, the contaminant distribution models, and an assessment of the risks to
28 help establish the need for corrective measures and estimate the volume of contaminated
29 media.
- 30 b. Refine the conceptual exposure pathway model to identify pathways that may need to be
31 addressed by corrective action.
- 32 c. Provide a detailed evaluation of potential ARARs, beginning with potential ARARs
33 identified in the Phase 2 master work plan (RPP-PLAN-37243, Section 3.4).
- 34 d. Refine potential corrective action objectives and preliminary remediation goals identified
35 in the DQO report (RPP-RPT-38152), based on the results of the Phase 1 RCRA Facility
36 Investigation report (DOE/ORP-2008-01), ARAR evaluations, and current land-use
37 considerations, and input from the regulators.
- 38 e. Refine the list of CMAs identified in the DQO report (RPP-RPT-38152) and in this
39 section.

- 1 f. Provide a preferred CMA for the soils within WMA C to fulfill the requirements for
2 a RFI/CMS report.
- 3 g. Include as appendixes or separate documents, closure plans to address RCRA TSD units
4 in the operable unit. The closure plans may incorporate, by reference, specific sections of
5 the work plan or RFI report containing specific closure-plan information. The closure
6 plans will include closure performance standards, a closure strategy, general closure
7 activities including verification sampling, and a general post-closure plan for closing soils
8 within WMA C.

9 **5.5 CORRECTIVE MEASURES STUDY/CLOSURE PLAN/FEASIBILITY STUDY**
10 **COORDINATION**

11 Remedial actions in the Central Plateau are being investigated and evaluated on an operable unit-
12 by-operable unit basis, as defined in 40 CFR 300, "National Oil and Hazardous Substances
13 Pollution Contingency Plan"; 40 CFR 300.430, "Remedial Investigation/Feasibility Study and
14 Selection of Remedy," and the HFFACO Action Plan (Ecology et al. 1989). To provide
15 flexibility for implementing remedial actions, alternative methods for remediation of Central
16 Plateau waste-site groupings will be considered. Several alternatives are currently under
17 consideration. Three major alternatives (e.g., no action, leave-in-place and remove, treat, and
18 dispose) have been identified to provide flexibility in the decision-making process, facilitate
19 early action, and remediate and close specific areas or zones. These remedial actions under
20 CERCLA will have to be coordinated with the corrective measures being implemented under
21 RCRA and HWMA. Integration and coordination will be an overarching criterion for success of
22 both programs.
23

24 In addition, the CMS will need to incorporate the goals of closure through future closure plans.
25 This provides another avenue for coordination with the decision makers, Ecology and DOE,
26 along with the EPA. This aspect is discussed in greater detail in the RPP-PLAN-37243.
27

28 **5.6 REMEDY SELECTION, RCRA PERMIT MODIFICATION, AND CORRECTIVE**
29 **MEASURE IMPLEMENTATION ACTIVITIES**

30 Once the Phase 2 RFI/CMS report process for CMA evaluation for WMA C has been completed,
31 the lead regulatory agency, in this case Ecology, will evaluate the adequacy and accuracy of
32 information, including the risk assessment and the detailed and comparative analysis of
33 corrective measures. On approval of the CMS with comments incorporated, the lead regulatory
34 agency will prepare a draft statement of basis or draft permit modification language
35 incorporating the proposed preferred CMA(s). A draft RCRA permit modification will be
36 developed that contains a summary of the key elements of the CMS and presents the
37 recommended selected remedies for the soils within and surrounding WMA C. The draft RCRA
38 permit modification will indicate the draft permit conditions for the RCRA soil corrective action
39 proposed to be incorporated into the Hanford Facility RCRA Permit (WA7890008967). The
40 draft RCRA permit modification will go through a public involvement process as specified in
41 WAC 173-303-830, "Permit Changes,"

1 The public participation activities would require the lead regulatory agency to issue public
2 notices including dates of the public comment period; dates, times, and locations of public
3 meetings, and locations of repositories containing the Administrative Record.

4
5 After the public comment period is completed, the lead regulatory agency prepares a
6 responsiveness summary and modifies the permit, if necessary, and begins the process of CMI.
7 The modified permit documents the corrective measures action decisions for WMA C for soils
8 and the responses to the public comments.

9
10 **Post-Permit Modification Activities**

11
12 After the Hanford Facility RCRA Permit (WA 7890008967) modification is issued, a CMI work
13 plan and design report will be prepared to detail the scope of the corrective actions. As part of
14 this activity, DQOs will be established and SAPs will be prepared to direct verification sampling
15 and analysis. Before remediation begins, data necessary for the remedial design and to support
16 future risk assessments will be obtained. Verification sampling will be performed after the
17 corrective measures action is complete to determine if the permit conditions and requirements
18 have been met and if the corrective measures were effective. Remediation activities will be
19 designed to ensure integration of RCRA corrective actions and closure and CERCLA cleanup
20 activities, especially in regard to groundwater.

21
22 The CMI work plan may include the following components:

- 23 a. Introduction.
24 b. Purpose.
25 c. Program Management Plan.
26 d. Community Relations Plan (HFFACO Community Relations Plan may suffice).
27 e. Design Plans and Specifications.
28 f. Design Phases (i.e., preliminary, intermediate, and final).
29 g. Operations and Maintenance Plan.
30 h. Cost Estimate.
31 i. Project Schedule.
32 j. Construction Quality Assurance Objectives.
33 k. Health and Safety Plan.

34
35 All CMI schedule and activities will need to meet the requirements of the Hanford Facility
36 RCRA Permit modification for WMA C: Certification of closure in accordance with
37 WAC 173-303-610(6), "Closure and Post-Closure," "Certification of Closure," will be
38 performed after all corrective action and closure actions are complete. The site will be restored
39 as appropriate for future land use. If clean closure is not attained at a TSD unit, post-closure care
40 requirements will be met. These requirements will include final status groundwater monitoring,
41 maintenance and monitoring of institutional controls and/or surface barriers, and certification of
42 post-closure at the completion of the post-closure.

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In addition, CERCLA requirements for past releases will also need to be satisfied. It is expected that EPA and Ecology will choose to delete SST WMA from the 200 Area National Priorities List through their determination that actions implemented as part of RCRA closure and corrective action are consistent with CERCLA requirements for National Priorities List site closeout and through EPA's "Deletion Policy for RCRA Facilities" (60 FR 14641, "The National Priorities List for Uncontrolled Hazardous Waste Sites; Deletion Policy for Resource Conservation and Recovery Act Facilities"). The corrective action for soils is complete when the remedy has been selected and implemented properly, i.e., the cleanup goals are achieved consistent with anticipated future land use.

6. SCHEDULE

The approach and work described in Chapters 4 and 5 of this work plan are detailed in the schedule for developing plans and conducting field activities. Figure 6-1 shows the schedule that will be used to measure progress. The soil characterization activities described in this work plan were identified during the DQO process (RPP-RPT-38152) to support Phase 2 RCRA corrective action activities in WMA C. Future planned waste retrieval activities may conflict with the schedule.

An RFI/CMS report for soils will be generated for WMA C. The report will meet the site-specific RFI/CMS objectives. In general, the RFI/CMS will assess data that have been collected at the time of report preparation (generally, it is anticipated that available information will include Phase 1 and available Phase 2 soil characterization information). The assessment will be used to

- a. Define source areas of contamination.
- b. Assess the potential pathways of migration and the potential receptors and associated exposure pathways to the extent necessary to determine whether, or to what extent, a threat to human health or the environment exists.
- c. Develop and evaluate CMAs (including the no-action alternative).

The RFI/CMS will present alternatives that will provide decision makers with a range of options and information to compare alternatives against one another. A general description of ranges for source-control response actions will be developed based on the site-specific information available. A detailed and comparative analysis of CMAs will be assessed against available site-specific information. This information will be used to evaluate various conceptual models (i.e., pre-defined conditions, such as concentrations, depth, and treatability of contaminants for various contaminated soil groups) that will be applied to the CMAs. Through the comparative analysis of alternatives, it is expected that these conceptual models may result in selection of different corrective measures for different soil groupings (e.g., removal, treatment, and leave in place, or leave in place). The RFI/CMS also may define how the determination of the selected CMA will be made at each site.

Figure 6-1 shows the schedule for the planned Phase 2 RCRA FI/CMS report for WMA C that will fulfill HFFACO Milestone M-45-61 and address interim measures and CMAs for soils to the point of submittal to Ecology.

As indicated in Figure 6-1, the field work to collect the soils for analyses, the laboratory analyses of these soils, and the additional planned work will exceed the current HFFACO interim Milestone M-45-61. This schedule is an "early finish" schedule showing required logic and durations. The schedule is also based on continuous resources applied to this effort. Actual dates will vary depending on schedule priority and resources. To fulfill this logic and duration schedule, durations assume \$4 million/year for 3 years for WMA C soil characterization based on FY 2008 dollars. If more or less money is available, duration will be compressed or extended accordingly. The sequencing assumes no interferences from field activities, such as waste retrieval efforts, which are currently ongoing.

7. PROJECT MANAGEMENT AND PROGRAM INTEGRATION

This section describes the RCAP management and integration activities necessary to ensure that program objectives are achieved. The objectives of project management during the Phase 2 WMA C RFI/CMS implementation are to (1) ensure the safety of the work force and the affected environment, (2) direct and document project activities, (3) ensure that project goals and objectives are met, and (4) administer the project within budget and schedule. The WMA C DQO workshops defined the specific scope and schedule elements. These elements, as well as others defined during the DQO workshop, will result in the development of the Phase 2 WMA C work plan.

Sections 7.1 and 7.2 present a general discussion of the areas of project management that will be common to all aspects of the program. Section 7.3 provides a general discussion of the schedules for the Phase 2 RCAP activities, including HFFACO milestones for Phase 2. Processes for Tribal Nation and public involvement, an important and necessary part of DOE activities on the Hanford Site, are discussed in Sections 7.4 and 7.5. The overall approach to integration with other Hanford Site programs such as the Soil and Groundwater Remediation Project administered by the Plateau Remediation Contractor are discussed in Chapter 5 and the Phase 2 master work plan (RPP-PLAN-37243).

7.1 WORK BREAKDOWN STRUCTURE

The internal work breakdown structure is developed in a manner consistent with other Hanford Site projects. Based on DOE guidance for establishing a baseline scope, schedule, and budget for the various TOC projects, internal planning, management, and budget documents (e.g., River Protection Project system plan, baseline control, and related work authorizations and directives) were adopted. These documents incorporate milestones defined in the HFFACO (Ecology et al. 1989) and reflect the schedule and commitments made therein. It is anticipated that these documents will define the scope, schedule, and budget to a level of detail that will be adequate for the planning and management of the Phase 2 RFI/CMS activities. Inherent with the approach is that the DQO workshop defined the specific scope associated with this Phase 2 WMA C RFI/CMS work plan.

Detailed information in the form of work control instructions (formerly known as work packages) defining the site-specific activities and instructions needed to carry out the investigative tasks discussed in this section will be developed before initiating field work. Where appropriate, the work control instructions will reference the appropriate procedure or standards rather than listing the entire procedure for a task and will be in accordance with the HASQARD (DOE/RL-96-68). Any reference to the *Quality Assurance Program Description* (TFC-PLN-02) provided in Attachment 1 as a source of additional information will be referenced.

The work control instructions shall be prepared in accordance with TOC work control procedures. The work control instructions must satisfy the following requirements:

- a. Include a scope-of-work introductory section.

- 1 b. Identify any field screening activities not described in the work plan or in the relevant
2 procedures. Identify any field screening equipment to be used that is not described in the
3 relevant procedures.
- 4 c. Include the frequency of measurement.
- 5 d. Identify the applicable procedures needed to conduct the work. If a procedure includes
6 several different ways to accomplish the work, the work control instruction should
7 specify the method of choice or reference the specific procedure.

8 The integrated site baseline provides an integrated technical, cost, and schedule life-cycle
9 baseline for the various projects. It is a tool that is used to forecast activities into the future so
10 appropriate staffing, funding, and schedule needs can be assessed. The major activities for the
11 Phase 2 RFI/CMS as captured in HFFACO milestones are the following:

- 12 a. Phase 2 master work plan (HFFACO Milestone M-45-58).
- 13 b. Phase 2 WMA C work plan (HFFACO Milestone M-45-60).
- 14 c. Field characterization.
- 15 d. Phase 2 RFI/CMS report (HFFACO Milestone M-45-61).
- 16 e. Phase 2 CMI (HFFACO Milestone M-45-62).

17 **7.2 PROJECT MANAGEMENT**

18 This section addresses the basic concepts of project management that occur throughout the
19 project's life cycle. Specific tasks that will occur throughout the Phase 2 RCAP are described.
20 Individuals associated with the project who interface with other organizations are also described.

21
22 Further guidance on schedule control, cost control, meetings, and reporting can be found in the
23 HFFACO Action Plan (Ecology et al. 1989).

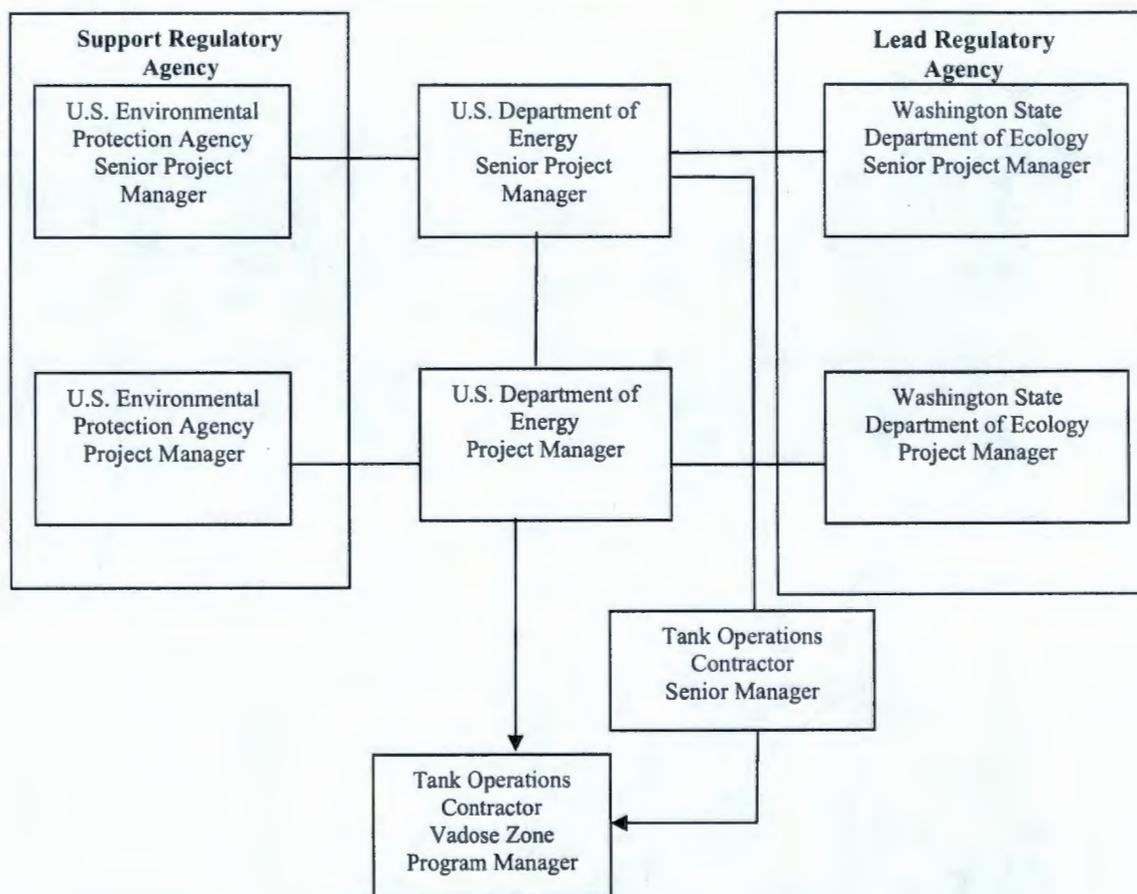
24 **7.2.1 Project Organization and Responsibilities**

25 The project organization for implementing activities outlined in this work plan is shown in
26 Figure 7-1. Sections 7.2.1.1 through 7.2.8 describe the functional responsibilities of the project
27 organization for the RCRA corrective action process shown in Figure 7-1. The positions
28 described here have overall functional management authority for the project and are not based on
29 an entities organization. Additional functional support roles are described in further detail in the
30 project management section of Attachment 1.

31 **7.2.1.1 Regulatory Agencies and the U.S. Department of Energy**

32 **Senior Project Managers.** Ecology, EPA, and DOE have each designated senior project
33 managers with responsibilities for the RCAP activities. These senior project managers will serve
34 as their agency's primary point of contact for the program under the HFFACO. The
35 responsibilities of the senior project managers and project managers are defined in Section 4.1 of
36 the HFFACO (Ecology et al. 1989).

1 **Figure 7-1. Project Organization for the RCRA Corrective Action Process**



2
3 **Project Managers.** Ecology, EPA, and DOE will each designate project managers for each
4 WMA. Ecology is designated as the lead regulatory agency for all WMAs, as indicated in the
5 HFFACO (Ecology et al. 1989). The project manager from DOE will be responsible for
6 maintaining and controlling the schedule and budget and keeping the Ecology and EPA project
7 managers informed of the status of the activities, particularly the status of agreements and
8 commitments.

9 **7.2.1.2 Tank Operations Contractor Vadose Zone Program Manager**

10 A vadose zone program manager has been assigned by the TOC program manager and is
11 responsible for day-to-day management of the program. The responsibilities of the TOC Vadose
12 Zone Program Manager will be to plan, authorize, and control work so it can be completed on
13 schedule and within budget, and to ensure that all planning and work performance activities are
14 technically sound. The TOC Vadose Zone Program Manager works closely with project
15 controls, quality assurance, health and safety, and the field engineer to ensure that the work
16 scope is being performed in accordance with each of these areas of responsibility. Interfaces
17 with tank farm operations are part of the work control, schedule control, and roles and
18 responsibilities assigned to the TOC Vadose Zone Program Manager. Other duties include
19 coordinating communications with DOE, EPA, and Ecology. The TOC Vadose Zone Program
20 Manager reports to the TOC Senior Manager and the DOE project manager (Figure 7-1).

1 **7.2.2 Work Control**

2 The primary goals of work control are to provide methods for planning, authorizing, integrating,
3 and controlling work so tasks can be completed on schedule and within budget. The TOC
4 ensures that all planning and work performance activities are technically sound and conform to
5 management and quality requirements. The TOC Vadose Zone Program Manager will have the
6 overall responsibility for planning and controlling investigation activities and for providing
7 effective technical, cost, and schedule baseline management. If a subcontractor is used, the TOC
8 Vadose Zone Program Manager will maintain overall project management responsibilities. The
9 management control system used for this project must meet the requirements of DOE O 430.1B,
10 *Real Property Asset Management*, or other applicable requirements and guidance (e.g., life-cycle
11 asset management).

12 **7.2.2.1 Cost Control**

13 Project costs including labor, other direct costs, and subcontractor expenses (e.g., drilling and
14 laboratory analyses) will be assessed monthly. The budget tracking activity is computerized and
15 provides the basis for invoice preparation and review, and for preparation of cost performance
16 reports. These reports assess the status of each project task against projected budgets, determine
17 performance, and describe any recovery plans that may be required. Any adjustments to budgets
18 are controlled through a formal management process, which includes the use of baseline change
19 proposals to modify baseline budgets. The DOE Project Manager will update the EPA and
20 Ecology Project Managers about their respective project costs to date (i.e., WMA) at the monthly
21 unit managers' meetings.

22 **7.2.2.2 Schedule Control**

23 The status of scheduled milestones will be updated, at a minimum, on a monthly basis for each
24 task on a given project. This will be performed in conjunction with cost performance reporting
25 associated with cost tracking. The status of milestones will also be updated monthly at unit
26 managers' meetings.
27

28 **7.2.3 Meetings**

29 Project managers from DOE, EPA, and Ecology meet monthly at unit managers' meetings to
30 discuss progress, address issues, and review near-term plans pertaining to their respective WMA.
31 The meetings are technical in nature with emphasis on technical issues and work progress. The
32 assigned DOE Project Manager for the WMA will be responsible for preparing revisions to the
33 schedule prior to the meeting. The schedule will address all ongoing activities associated with
34 active WMAs. This schedule will be provided to all parties and reviewed at the meeting. Any
35 agreements and commitments (within the project managers' level of authority) resulting from the
36 meeting will be prepared and signed by all parties as soon as possible after the meeting. Unit
37 managers' meeting minutes will be issued by the DOE Project Manager and will summarize the
38 discussion at the meeting, with information copies provided to the project managers.
39

1 As indicated by HFFACO Milestone M-45-56 (Ecology et al. 1989), Ecology and DOE will, at a
2 minimum, meet yearly (i.e., by July or as needed) to discuss interim measures. These
3 discussions will focus on defining and determining the need for implementing interim measures.
4 As appropriate, interim milestones will be established in coordination with these activities.

5
6 Other meetings will be held, as necessary, with subcontractors and other appropriate entities
7 (e.g., integrating projects identified in Section 7.3) to communicate information, assess project
8 status, and resolve issues. The DOE, Ecology, and EPA project managers will be requested to
9 participate in these meetings as part of the integration effort (e.g., WMA C DQO activities will
10 include an invitation to the Groundwater Remediation Project, DOE, Ecology, and EPA project
11 managers).

12 **7.2.4 Records Management**

13 HFFACO specifies documentation and records management requirements for remediation
14 activities at the Hanford Site. HFFACO categorizes applicable supporting documents based on
15 the importance of documenting final data or use in decision-making to support remediation.
16 Under HFFACO, these applicable documents are categorized as either primary or secondary
17 documents. Tables 9-1 and 9-2 of HFFACO provide a general list of primary and secondary
18 documents, respectively. Specific to the Phase 2 RCAP, primary documents include the Phase 2
19 master work plan, the WMA C work plan, and the Phase 2 RFI/CMS report. The process for
20 document review, comment, and revision will be as described in Section 9.2 of HFFACO Action
21 Plan (Ecology et al. 1989).

22
23 The information management overview (Attachment 4 of this work plan) details the applicable
24 programs for records management. As noted in Section 7.2.1, project managers are responsible
25 for implementing HFFACO requirements for the RCAP. Revisions, should they become
26 necessary after finalization of any document, will be in accordance with Section 9.3 of the
27 HFFACO. Changes in the work schedule, as well as minor field changes, can be made without
28 having to process a formal revision. The process for making these changes will be as stated in
29 Section 12.0 of the HFFACO. The Administrative Record will be maintained to support
30 activities in accordance with Section 9.4 of the HFFACO.

31
32 The project file will be maintained in an organized and secure manner and will be accessible to
33 the appropriate project personnel. The project file may also be maintained electronically. All
34 field reports, field logbooks, health and safety documents, quality assurance and quality control
35 documents, laboratory data, memoranda, correspondence, and reports will be logged into the
36 project file on receipt or transmittal.

37 **7.2.5 Progress and Final Reports**

38 Monthly progress will be documented at unit managers' meetings. Meeting minutes will be
39 prepared, distributed to the appropriate personnel and entities (e.g., project managers,
40 coordinators, contractors, and subcontractors), and entered into the project file. The process for
41 document review and comment and maintenance of the Administrative Record is covered by the
42 HFFACO action plan (Ecology et al. 1989).

1 7.2.6 Quality Assurance

2 The specific planning documents required to support the RCAP will be developed within the
3 overall quality assurance program structure mandated by the DOE for all activities at the
4 Hanford Site. Within that structure, the documents are designed to meet current EPA guidelines
5 for format and content and are supported and implemented through the use of standard operating
6 procedures drawn from the existing program or procedures developed specifically for tank farm
7 quality requirements to environmental investigations.

8
9 To ensure that the objectives of the RCAP are met in a manner consistent with applicable DOE
10 guidelines, all work conducted will be performed in compliance with TFC-PLN-02, which
11 specifically describes the application of requirements to environmental investigations.

12 7.2.7 Health and Safety

13 The health and safety plan (see Attachment 2) will be used to implement standard health and
14 safety procedures for employees and contractors engaged in RCAP activities. More specific
15 details on the management aspects of the health and safety plan are in Attachment 2. Minor
16 activities that do not require the level of detail found in the health and safety plan will be covered
17 by an activity hazard analysis.

18 7.2.8 Community Relations

19 Community relations activities will be conducted in accordance with the *Hanford Site Tri-Party*
20 *Agreement Public Involvement Community Relations Plan* (Ecology et al. 2002). All community
21 relations activities associated with the RCAP will be conducted under this overall Hanford Site
22 community relations plan.

23
24 In addition, a number of organizations participate in providing recommendations that can affect
25 the path of the RCAP. These organizations include the Hanford Advisory Board, the Interagency
26 Management Integration Team, the Washington State Department of Health, Tribal Nations, the
27 State of Oregon, and other interested stakeholders. This participation in project activities is
28 defined in Sections 7.5 and 7.6.

29 7.3 SCHEDULE

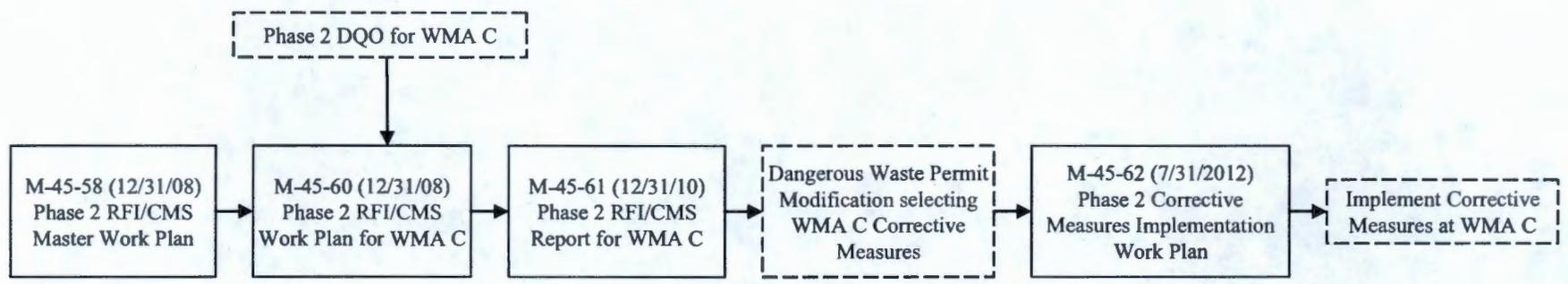
30 Figure 7-2 provides the current schedule that identifies the HFFACO milestone dates associated
31 with Phase 2. During the fiscal year planning effort, this milestone schedule will be updated.
32 The detailed project schedule will implement the work breakdown structure (see Section 7.1) and
33 will be updated during monthly unit managers' meetings.

34 7.4 TRIBAL NATION ROLE AND INVOLVEMENT

35 The Hanford Site is located on land ceded to the Federal government by treaties in the year 1855
36 with the Yakama Nation and the Confederated Tribes of the Umatilla Indian Reservation (i.e.,
37 the Umatilla, Cayuse, and Walla Walla Tribes). The Nez Perce Tribe has treaty rights on the
38 Columbia River. The Yakama Nation and Confederate Tribes of the Umatilla Indian
39 Reservation retain rights and privileges in the ceded areas, including the right to take fish at

1
2
3

Figure 7-2. RCRA Corrective Action Process



7-7

1 usual and accustomed places, to erect temporary buildings, to hunt, to gather roots and berries,
2 and to pasture horses and cattle on open and unclaimed land.
3

4 In addition to the treaties of 1855, the following laws apply to Native American rights and
5 culture at the Hanford Site: the *American Indian Religious Freedom Act of 1978*, the
6 *Archaeological Resources Protection Act of 1974*, the *National Historic Preservation Act of*
7 *1966*, the *Native American Graves Protection and Repatriation Act*, and the *American*
8 *Antiquities Preservation Act of 1906*.
9

10 The DOE provides grants to the Yakama Nation, the Confederated Tribes of the Umatilla Indian
11 Reservation, and the Nez Perce Tribe to ensure their involvement in the environmental
12 restoration and waste management activities for cleanup of the Hanford Site. The tribes will
13 advise the RCAP activities through direct consultation and project involvement (e.g., DQO
14 meetings). The tribes also participate in formal groups such as the State and Tribal Government
15 Working Group, the Hanford Advisory Board, the Hanford Summit Steering Committee, and the
16 Hanford Environmental Dose Reconstruction Project's Native American Working Group.

17 **7.5 PUBLIC INVOLVEMENT**

18 Public involvement is an integral and necessary part of DOE activities on the Hanford Site to
19 ensure that decisions are made with the benefit and consideration of important public
20 perspectives. Public involvement is a mechanism that brings a broad range of diverse viewpoints
21 and values into the DOE decision-making process and enables DOE to make more informed
22 decisions, improve quality through collaborative efforts, and build mutual understanding and
23 trust between DOE and the public. Within the RCAP, opportunities for public involvement will
24 occur throughout the process.
25

26 The community relations plan (Ecology et al. 2002) specifies how the public can be involved in
27 the processes that are followed on the Hanford Site. This is discussed further in Section 10.0 of
28 the HFFACO (Ecology et al. 1989).
29

30 In addition to other projects operating at the Hanford Site, a number of organizations participate
31 in providing recommendations that can affect the path of the RCAP. These organizations
32 include the Hanford Advisory Board, the Interagency Management Integration Team, the
33 Washington State Department of Health, Tribal Nations, the State of Oregon, and other
34 interested stakeholders.

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27 Applicability," *Washington Administrative Code*, as amended.
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- 32 WAC 173-340-357, "Model Toxics Control Act -- Cleanup," "Quantitative Risk Assessment of
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11 Washington.

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APPENDIX A

**SAMPLING AND ANALYSIS PLAN FOR THE
COLLECTION OF SOIL SAMPLES**

1
2 This appendix references the most recent sampling and analysis plan or its equivalent,
3 RPP-PLAN-38777, *Sampling and Analysis Plan for Phase 2 Characterization of Vadose Zone*
4 *Soil in Waste Management Area C*.

5
6 **Reference**

7 RPP-PLAN-38777, 2008, *Sampling and Analysis Plan for Phase 2 Characterization of Vadose*
8 *Zone Soil in Waste Management Area C*, Rev. 0, Washington River Protection Solutions
9 LLC, Richland, Washington.

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APPENDIX B

**SAMPLING AND ANALYSIS INSTRUCTIONS FOR SMALL
MAMMAL SAMPLING IN WMA C**

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ACRONYMS

1		
2		
3	AVMA	American Veterinary Medical Association
4	CFR	Code of Federal Regulations
5	COPEC	contaminant of potential ecological concern
6	DOE	U.S. Department of Energy
7	ERA	ecological risk assessment
8	HASQARD	<i>Hanford Analytical Services Quality Assurance Requirements Document</i>
9	HEPA	high-efficiency particulate air
10	HFFACO	<i>Hanford Federal Facility Agreement and Consent Order</i>
11	PCB	polychlorinated biphenyl
12	QA	quality assurance
13	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
14	RCBRA	River Corridor Baseline Risk Assessment
15	SAF	sample authorization form
16	SAI	sampling and analysis instruction
17	SAP	sampling and analysis plan
18	SST	single-shell tank
19	STR	subcontract technical representative
20	WMA	waste management area
21	WRPS	Washington River Protection Solutions, LLC
22		

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>	<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>
Length			Length		
Inches	25.4	millimeters	millimeters	0.039	inches
Inches	2.54	centimeters	centimeters	0.394	inches
Feet	0.305	meters	meters	3.281	feet
Yards	0.914	meters	meters	1.094	yards
Miles	1.609	kilometers	kilometers	0.621	miles
Area			Area		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			Mass (weight)		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			Volume		
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
gallons	3.8	liters			
Temperature			Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			Radioactivity		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

B1.0 INTRODUCTION

This sampling and analysis instruction (SAI) guide was prepared to provide the requirements for the sampling and analysis activities to be performed in support of the Corrective Measures Study for Waste Management Area C (WMA C). This SAI defines data collection methods for small mammals to augment the screening-level ecological risk assessment.

WMA C is one of several single-shell tank (SST) farm waste management areas located in the 200 East Area of the Hanford Site (see Figure B-1). Past releases to soil have resulted in contamination that will require evaluation and cleanup under the *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action program in accordance with the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989), also known as the Tri-Party Agreement. Elements of the corrective action process include soil characterization, assessment of risk from past releases to soil, evaluation and selection of corrective measures alternatives, and implementation of the selected corrective measures.

In support of the evaluation and selection of corrective measures alternatives, contaminant concentrations in abiotic and biotic media will be compared to endpoint criteria specified by Washington State regulations, U.S. Environmental Protection Agency technical guidance, U.S. Department of Energy (DOE) technical guidance, or as supported by the scientific literature. The approach for ecological risk assessment for WMA C is documented in Section 3.4.2 of this document.

Sampling and analysis of soil at WMA C will follow the specifications documented in the Sampling and Analysis Plan provided as Appendix A of the main document. The sampling and analysis tasks presented in this SAI guide are specific to small mammal collection and analysis to obtain data for use in dietary exposure modeling in the ecological risk assessment for WMA C.

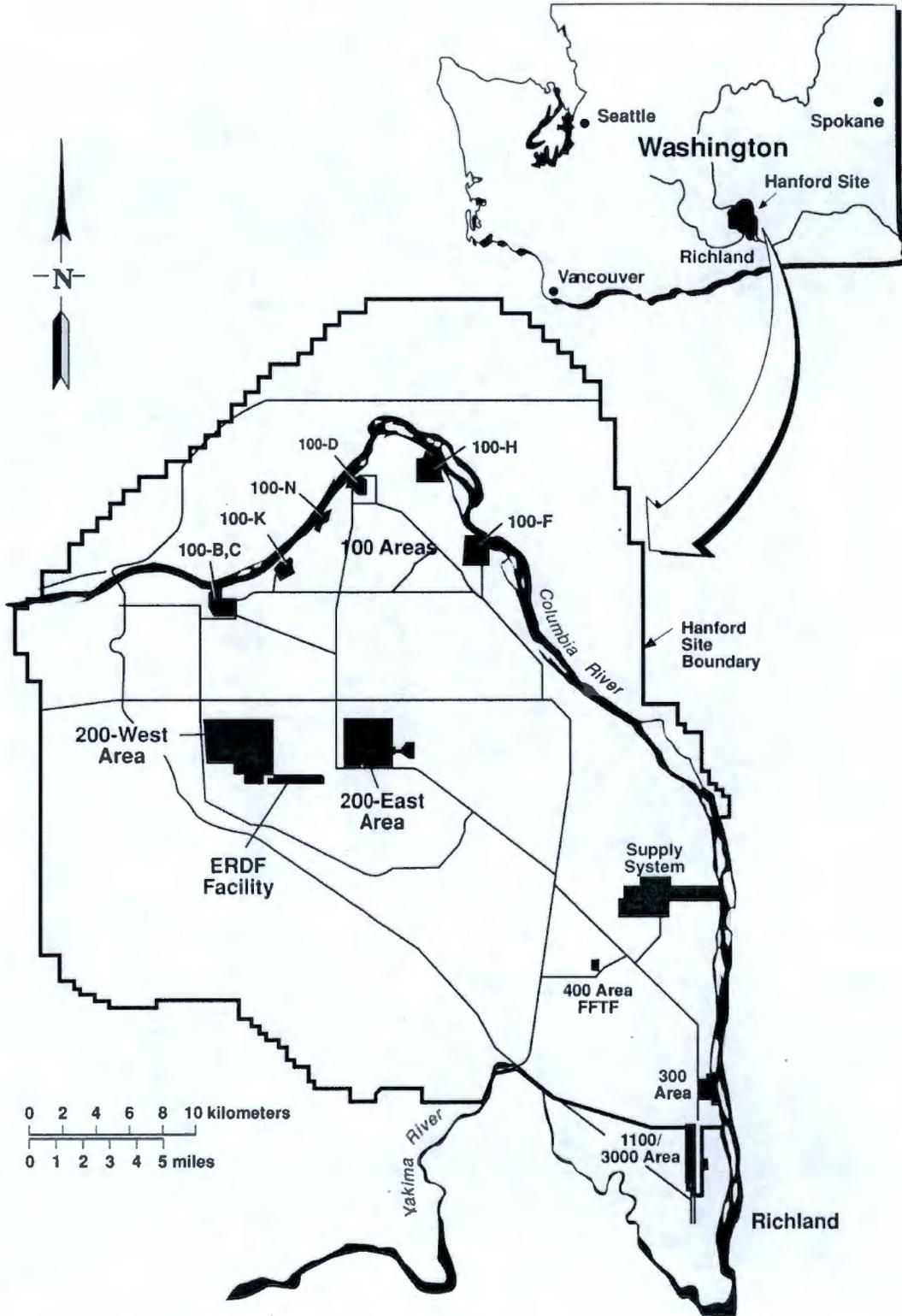
B1.1 BACKGROUND

The Hanford Site became a federal facility in 1943 when the U.S. Government took possession of the land to produce weapons-grade plutonium during World War II. The Hanford Site's production mission continued until the late 1980s when the mission changed from producing nuclear materials to cleaning up the radioactive and hazardous wastes that had been generated during the previous decades. The Central Plateau, which encompasses the tank farms, consists of approximately 75 mi² (195 km²) near the middle of the Hanford Site (see Figure B-1). The Central Plateau contains approximately 900 excess facilities formerly used in the plutonium production process.

WMA C is an SST farm located on the eastern portion of the 200 East Area. WMA C is currently undergoing Phase 2 investigation to support development and implementation of corrective measures. This SAI documents the methods for the collection of biological data (small mammal tissue) to support ecological risk assessment in the SST farms.

1

Figure B-1. Hanford Site Map.



2
3

E9803101.1

1 B1.2 PREVIOUS INVESTIGATIONS

2 Phase 1 characterization for soils of WMA C was documented in RPP-35484, *Field Investigation*
3 *Report for Waste Management Areas C and A-AX*.

4
5 Previous investigations of ecological risk at the Hanford Site date back to the early 1990s
6 (WHC-SD-EN-TI-122, *Biological Uptake of 300-FF-5 Operable Unit Contaminants*). Work is
7 being performed concurrently with this project as part of the Central Plateau Ecological Risk
8 Assessment Project (WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data*
9 *Quality Objectives Summary Report – Phase I*), the River Corridor Baseline Risk Assessment
10 (RCBRA), and WMP-23141, *100-NR-2 Groundwater Operable Unit Ecological Risk Assessment*
11 *Data Quality Objectives Summary Report*, and DOE/RL-2005-22, *100-NR-2 Study Area*
12 *Ecological Risk Assessment Sampling and Analysis Plan*. Monitoring activities and data
13 collection efforts to support ecological risk assessment (ERA), performed on an ongoing basis by
14 the Pacific Northwest National Laboratory as part of U.S. Department of Energy's (DOE) Public
15 Safety and Resource Protection Program, are available on request from the DOE Richland
16 Operations Office.

18 B1.3 INDICATOR CONTAMINANTS

19 Indicator contaminants for small mammal tissue analysis consist of the nonradionuclide
20 constituents listed in *Washington Administrative Code* (WAC) 173-340-7493, "Site-Specific
21 Terrestrial Ecological Evaluation Procedures" (Table 749-3), for which a wildlife benchmark is
22 provided. While analytical suites are not limited to these contaminants specifically, performance
23 of suite analyses ensures that these indicator contaminants are captured for evaluation as
24 contaminants of potential ecological concern (COPEC). Radionuclides are not addressed by the
25 WAC but potentially pose risk to wildlife at WMA C via the dietary exposure pathway from
26 small mammals. Radionuclide analyses will be performed on small mammal tissues to
27 determine the type and quantity of radionuclides in the ecosystem, and their subsequent risks to
28 predator species. Contaminant suite analyses to be performed for upland soil and tissues are
29 listed in Table B-1.

30
31 Environmental conditions often limit the ability to collect a sufficient amount of sample material
32 for the analyses of all indicator contaminants; therefore, the full list of indicator contaminants
33 must be prioritized for samples with limited sample mass. In general, the priorities for these
34 samples (in order from highest to lowest) are gamma spectroscopy, metals (SW-846, *Test*
35 *Methods for Evaluating Solid Waste, Physical/Chemical Methods*, Methods 6010/6020 and
36 7471), radiogenic strontium, polychlorinated biphenyls (PCB) and pesticides (SW-846
37 Methods 8082 and 8081A, respectively), isotopic uranium, isotopic thorium, and semivolatile
38 organic compounds (SW-846 Method 8270A) or most current approved SW-846 methodology.
39 Gamma spectroscopy is listed as the highest analytical priority because it is a nondestructive
40 analysis, requires significantly more mass than other analyses, but may not be feasible for some
41 samples.

1 B1.4 PROBLEM DEFINITION

2 The purpose of the ERA for WMA C is to ascertain risk to receptors from contaminants of
 3 potential ecological concern (COPEC) originating from SST farm operations. The presence of
 4 contaminants in biological tissue (i.e., small mammals) is indicative of exposure and may serve
 5 as a exposure pathway to higher trophic predators, such as raptors and carnivorous mammals.
 6 Information gathered from small mammal tissue analyses will substantiate current exposure and
 7 aid in the development and implementation of corrective measures to ensure long-term
 8 protection of human health and the environment.
 9

Table B-1. Analytical Suites and Methods for Small Mammal Tissues

Analyte Group	Analytical Methods ^a	Analyzed in Tissues ^b	Indicator Contaminants ^c
Inorganic chemicals	6010/6020	Yes	Arsenic, cadmium, chromium, copper, barium, lead, molybdenum, nickel, manganese, selenium, zinc
	7471	Yes	Mercury (inorganic), mercury (organic),
PCBs and pesticides	8082 (PCBs)	Yes	PCB mixtures (total)
	8081A (pesticides)	Yes	Aldrin, benzene, chlordane, dieldrin, endrin, DDT/DDD/DDE (total), heptachlor/heptachlor epoxide (total), hexachloride (including lindane)
Semivolatile organic chemicals	8310	Yes	Benzo(a)pyrene
	8270A	Yes	Hexachlorobenzene chlorinated dibenzofurans (total), dioxins, pentachlorophenol
Radionuclides	Gamma energy analysis	Yes	¹³⁷ Cs, ⁶⁰ Co, ¹⁵² Eu, ¹⁵⁴ Eu, ²²⁶ Ra
	Alpha energy analysis	Yes	²⁴¹ Am
	Isotopic plutonium	Yes	²³⁸ Pu
	Isotopic thorium	Yes	²²⁸ Th, ²³² Th
	Isotopic uranium	Yes	^{233/234} U, ²³⁵ U, ²³⁸ U
	Total radioactive strontium	Yes	⁹⁰ Sr

^a All analyses obtained by these methods.

^b Analyses are subject to obtaining a sufficient amount of small mammal whole organism tissue.

^c Indicator contaminants for small mammal tissues are those that identified as WAC soil indicator contaminants for wildlife.

11 B1.5 DIETARY EXPOSURE

12 Dietary exposure to COPECs will be evaluated using methodology published in
 13 EPA/600/R-93/187, *Wildlife Exposure Factors Handbook*. The principal aspect of vertebrate
 14 exposure is the measurement of COPEC concentrations in food and abiotic media. The exposure
 15 evaluation for higher trophic level receptors (i.e., badger and red-tailed hawk) is based on the

1 food intake rates and diet preference of representative small mammal species. The general
2 equation for dietary exposure to badger and red-tailed hawk is as follows:

$$3 \quad E_{oral} = C_{soil} \cdot I_{soil} \cdot AUF_{soil} + C_{water} \cdot I_{water} \cdot AUF_{water} \cdot (1/d_{water}) + C_{food} \cdot I_{food} \cdot AUF_{food}$$

5 where

7 E_{oral} = the estimated oral daily dose for a COPEC (mg/kg/day)

9 C_{soil} = the concentration of chemical constituent x in soil (mg/kg dry weight)

11 I_{soil} = the normalized daily soil ingestion rate (kg of soil / [kg of body weight • day],
12 simplified to kg/kg/day in subsequent equations)

14 AUF_{soil} = the area use factor that represents the fraction of soil ingested from a
15 contaminated area (this fraction is set to one)

17 C_{food} = the concentration of COPEC in food (mg/kg dry weight)

19 I_{food} = the normalized daily dietary ingestion rate (kg of food [dry weight] / [kg of
20 body weight • day], simplified to kg/kg/day in subsequent equations)

22 AUF_{food} = the fraction of the diet derived from a contaminated area (this fraction is set to
23 one).

25 **B1.6 DECISIONS TO BE MADE**

27 The sampling of small mammal tissue in WMA C will help establish ecological exposure and
28 transport pathways to chemicals and radionuclides present in the SST farms. The quantity of
29 samples collected and the duration of the evaluation will be appropriate to inform the corrective
30 measures study which is being performed concurrently for WMA C. Samples will be collected
31 from three distinct transects: the WMA C perimeter fenceline transect, and two habitat transects
32 located in proximity to but outside of the WMA C perimeter. A composite of kidney and liver
33 tissues from a minimum of six captured organisms per transect group will serve as indicators of
34 bioconcentration of inorganic contaminants in these target organs. The remaining small mammal
35 carcasses (whole organism, minus the liver and kidney) will be composited separately for
36 analysis. In the dietary exposure model, a weighted average of the COPEC concentrations in
37 carcass (90%) and liver and kidney (10%) is used as the exposure point concentration. Under
38 this study design, six samples will be submitted for analysis: three composite samples of liver
39 and kidney tissue from collected organisms, and the three composite samples of small mammal
40 carcass, representing each of the three transect groups.

42 **B1.7 CONTINGENCIES**

43 It is necessary to prepare for contingency sampling in the event that planned sample numbers are
44 compromised. For example, it may be that insufficient sample mass exists for a particular group

1 targeted for tissue analyses. In the event of low capture frequency, additional sampling may be
2 performed until adequate sample mass requirements are met. For all samples the analytes shall
3 be measured in the following general priority order: gamma spectroscopy (first because it is a
4 nondestructive analysis; it is assumed that samples measured for gamma radiation will be
5 available for other analyses, but it requires a significant mass so it may not always be
6 appropriate), metals, PCBs, total radioactive strontium, isotopic uranium, isotopic plutonium,
7 and isotopic thorium.

8

1
2 **B2.0 PROJECT MANAGEMENT**

3 This section addresses the roles and responsibilities of the project management team to ensure
4 that project participants understand the sampling goals and approaches to be used and that the
5 planned outputs are appropriately documented.
6

7 **B2.1 PROJECT TASK ORGANIZATION**

8 This project will be managed by Washington River Protection Solutions, LLC (WRPS). The
9 WRPS will assign a project manager, a risk assessment manager, and a subcontract technical
10 representative (STR). The risk assessment manager has overall responsibility for this project
11 including oversight of the project schedule and budget. The manager makes final project
12 decisions with the authority to commit the necessary resources to perform activities.
13

14 The WRPS STR is responsible for coordination and oversight of all environmental data
15 collection activities, including sampling, field analytical measurements, and field ecological
16 observations. The STR is responsible for tracking and reporting the progress of field work and
17 laboratory analysis and interfacing with quality assurance (QA), health and safety, and cultural
18 resources representatives to ensure work is performed in accordance with all project objectives
19 and requirements, such as those specified in this SAI.
20

21 Sample collection will be performed by qualified subcontractors in accordance with this SAI and
22 applicable procedures documented in the Sampling and Analysis Plan (Appendix A of the main
23 document). Subcontractor and WRPS field personnel will provide daily status during fieldwork
24 and report problems in the field and to the STR.
25

26 The project QA representative oversees quality control and laboratories and is independent of the
27 personnel performing data generation. The QA representative is responsible for ensuring field
28 and laboratory activities are performed in accordance with WRPS project quality management
29 plans, WRPS-approved field and laboratory subcontractor QA plans, and applicable procedures.
30 The QA representative is also responsible for coordinating and performing audits and
31 assessments of field and laboratory work.
32

33 **B2.2 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA**

34 The detection limits and precision and accuracy requirements for each of the analyses performed
35 are summarized for biotic tissue in Table B-2. The process for determining these requirements is
36 documented in existing ERA planning documentation, including data quality objective reports
37 and SAPs for the Central Plateau Terrestrial ERA and the RCBRA. The matrix-specific target
38 COPEC quantitation limits used in this SAI were derived for the RCBRA and Central Plateau
39 Terrestrial ERA by calculating the COPEC concentrations in prey that would result in a predator
40 dose approaching the threshold toxicity reference values. For additional detail on derivation of
41 these numbers, see planning documentation for those reports.
42

Table B-2. Analytical Performance Requirements for Tissue Analyses (2 sheets)

Indicator Contaminant	Chemical Abstracts Service Number	Analytical Instrument and/or Method	Laboratory Target Detection Limit ^b (pCi/g or mg/kg)	Precision	Accuracy
Radionuclides					
Americium-241	14596-10-2	AEA	0.1	±30%	70-130
Cesium-134	13967-70-9	GEA	0.1	±30%	70-130
Cesium-137	10045-97-3	GEA	0.1	±30%	70-130
Cobalt-60	10198-40-0	GEA	0.05	±30%	70-130
Europium-152	14683-23-9	GEA	0.1	±30%	70-130
Europium-154	15585-10-1	GEA	0.1	±30%	70-130
Europium-155	14391-16-3	GEA	0.1	±30%	70-130
Plutonium-238	13981-16-3	Isotopic Pu - AEA	1.0	±30%	70-130
Radium-226	13982-63-3	GEA	0.1	±30%	70-130
Strontium-90	10098-97-2	Total rad Sr – GPC	1	±30%	70-130
Thorium-228	14274-82-9	Isotopic Th – AEA	1.0	±30%	70-130
Thorium-232	14274-82-9	Isotopic Th - AEA	1	±30%	70-130
Uranium-234	13966-29-5	Isotopic U - AEA	1	±30%	70-130
Uranium-235	15117-96-1	Isotopic U - AEA	1	±30%	70-130
Uranium-238	7440-61-1	Isotopic U - AEA	1	±30%	70-130
Organics					
Pesticides	Chemical-specific	8081A	0.017	±30%	50-150
PCBs	Chemical-specific	PCBs – EPA Method 8082	0.017	±30%	50-150
Semivolatile organic chemicals	Chemical-specific	SVOA-8270A	Chemical-specific	±30%	50-150
Metals					
Arsenic	7440-38-2	Metals	10/1	±30%	70-130
Barium	7440-39-3	Metals	2/0.5	±30%	70-130
Cadmium	7440-43-9	Metals	0.5/0.2	±30%	70-130
Chromium (III)	7440-47-3	Metals	1/0.2	±30%	70-130
Copper	7440-50-8	Metals	1	±30%	70-130
Iron	7439-89-6	Metals	5	±30%	70-130
Manganese	7439-96-5	Metals	5	±30%	70-130
Mercury	7439-97-6	Method 7471	0.2	±30%	70-130
Molybdenum	7439-98-7	Metals	2	±30%	70-130
Nickel	7440-02-0	Metals	40	±30%	70-130
Selenium	7782-49-2	Metals	0.1	±30%	70-130
Zinc	7440-66-6	Metals	1	±30%	70-130

^a Derivation of these values based on Tables 4-19 through 4-22 and 5-15 through 5-18 of *Data Quality Objectives Summary Report for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment (BHI-01757, DQO Summary Report for the 100 Area and 300 Area Component of the RCBRA)*.

^b Achievable detection limits may be affected if insufficient material is available for analysis. Where two values are presented, second value refers to inductively coupled plasma trace detection limit.

AEA = alpha energy analysis

GEA = gamma energy analysis

SVOA = semivolatile organic analysis

1 **B2.3 SPECIAL TRAINING REQUIREMENTS**

2 The following training is typically required for subcontractors deployed to the site in support of
3 sampling activities:

- 4
- 5 • Site-specific Waste Management Instruction.
 - 6 • Integrated Work Control Program.
 - 7 • Hanford General Employee Training.
 - 8 • First aid and cardio-pulmonary resuscitation training.
 - 9 • Cultural Resource Awareness Training (at least one person on each crew).
 - 10 • Ecological resource and biological hazard training.

11

12 The following training may be required for certain areas:

- 13
- 14 • Site-specific Waste Management Instruction.
 - 15 • Integrated Work Control Program.
 - 16 • Rad Worker II (for entry into posted radiological control zones)
 - 17 • 24-hour Hazardous Waste Worker Training (for entry into waste sites with ongoing
18 remedial activities).

19

20 The qualifications of field personnel must be forwarded to the WRPS STR and must be approved
21 by the STR prior to beginning work.

22

B3.0 MEASUREMENT/DATA ACQUISITION

This chapter presents the sampling design and requirements for sampling methods, sample handling and custody, and analytical methods. The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

B3.1 SAMPLING PROCESS DESIGN

The sample design reflects the project work scope developed in Section 3.4.2 of this document. This SAI contains sample design details, summary tables, and figures that address sampling procedures, sampling locations, sampling frequencies, and field and laboratory requirements.

B3.2 SAMPLING METHOD REQUIREMENTS

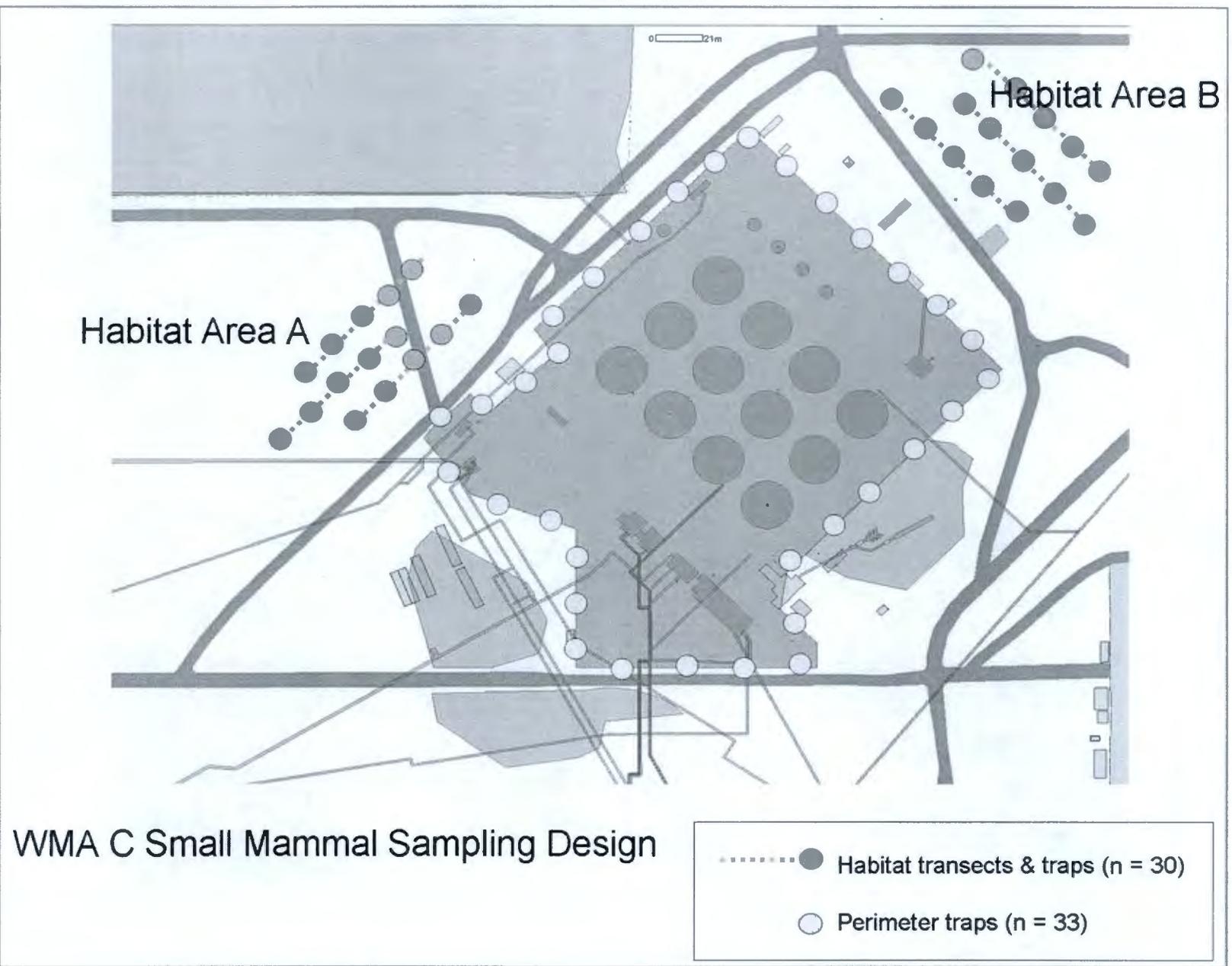
Sampling will be performed in accordance with this SAI guide. The "study area" refers to the perimeter fenceline of the WMA C property and two habitat areas outside of the fenceline in proximity to the industrial area (Figure B-1). The dimension of the study area is based on a deer mouse home range (0.077 hectares), which equates to a median dispersal distance of approximately 150 m. Dominant small mammal species anticipated for collection in the study include deer mice (*Peromyscus maniculatus*) or pocket mice (*Perognathus parvus*). A minimum of six animals per transect group (total of 18 mice) will be collected and prepared for analysis.

B3.2.1 SMALL MAMMAL SAMPLING

Three transect groups (one perimeter and two habitat transect groups) of Sherman live traps [8 cm (3 in.) wide by 9 cm (3.5 in.) high by 23 cm (9 in.) long] will be placed to accommodate the shape of the investigation area. Due to the scarcity of habitat within the WMA C property fenceline, it is expected that the capture rate will be less than in vegetated areas. For the perimeter fenceline transect, traps will be spaced systematically at 25-m (82-ft) intervals along the perimeter fenceline of WMA C (Figure B-2). Two habitat transect groups will be established in vegetation communities adjacent to and outside of the WMA C property boundary. Habitat transect groups A and B (Figure B-2) will each consist of three staggered trap lines, approximately 100 m (330 ft) long. Five traps will be placed along each 100-m transect, with the distance between traps approximately 25 m (82 ft). The location for the trap where an animal is captured will be noted in the field logbook.

The animals will be trapped over a sufficient number of nights to obtain at least six mice for each transect group, for a total of 18 mice. The number of trap-days required to collect at least six animals per transect group will be recorded. This will provide a relative measure of animal density. A minimum of six mice per transect group will be dissected and combined into two composite samples (one liver/kidney composite and one carcass composite) for analysis. The composite sample represents the average concentration of COPECs at the site that are available for uptake to higher trophic species through the dietary pathway.

Figure B-2. WMA C Small Mammal Sampling Design.



1 Information on species, approximate age, sex, reproductive status (subadults/adults and
2 nonscrotal males/scrotal males, and nonlactating/lactating females), body weights [± 2.0 g
3 (0.1 oz)], and general external condition (any gross deformities, hair loss, infections, lesions,
4 etc.) will be recorded in the field logbook for all captured animals. Animals captured and
5 released (nontarget animals, such as juvenile mice) should be marked so that the total number of
6 new captures per trap-night can be used to represent relative abundance estimates measured and
7 documented for each study site.

8
9 At the laboratory, the mammals will be weighed on a calibrated balance (± 0.01 g) and then
10 rinsed with deionized water to remove most exterior soil per HASQARD (DOE/RL-96-68).
11 Small mammals are to be analyzed exclusive of external concentrations so that these data will be
12 better suited to developing bioaccumulation models. The exposure models incorporate incidental
13 soil ingestion; therefore, rinsing the mammals prevents double counting soil ingestion in
14 exposure model calculations. Further sample preparation includes dissecting organs
15 (liver/kidney) from the carcass (including the gastrointestinal tract) for weighing and separate
16 homogenization.

17 18 **B3.2.1.1 Trapping Instructions**

19 Sherman live-traps should be used to collect small mammals. The number of small mammal
20 traps installed and the number of nights the traps are left open may vary according to the size and
21 configuration of the study grid and the trapping effort required to satisfy minimum sample size
22 requirements. NOTE: The collector must have a valid Washington State scientific collection
23 permit to conduct small mammal trapping in Washington State. A flag should be placed at the
24 beginning of each trap line that identifies the Washington State scientific collection permit
25 number (specific contact information is provided on the investigation area sign), contact name,
26 and phone number.

27 28 Field Trapping Equipment List:

- 29 1. Plastic bags.
- 30 2. High-efficiency particulate air (HEPA) mask.
- 31 3. Lysol[®] solution and spray bottle.
- 32 4. Spring scales [with at least 2-g (0.1-oz) intervals].
- 33 5. Rubber gloves (gardening or thicker) or leather gloves.
- 34 6. Field trapping record form.
- 35 7. Nontoxic permanent marker.
- 36 8. Ice and cooler (preferably two coolers).
- 37 9. Scientific collection permit.
- 38 10. Sherman live traps (small mammal sizes).
- 39

[®] Lysol is a registered trademark of Rickitt Benckiser, Inc., Richmond, Virginia.

1 11. Trap shades (one for each trap where vegetation or cover/shade is limited).

2 Small Mammal Trapping Instructions:

- 3
- 4 1. Set traps in accordance with specification in Section B3.2.1.1.
- 5 2. Traps should be spaced systematically 25 m (~82 ft) apart along each transect.
- 6 3. Place traps nearby or underneath vegetation/rocks to reduce likelihood of heat-stress/
7 cold-stress. If natural cover is insufficient to prevent heat/cold stress to animals, then a
8 trap shade should be placed over the top of the trap and secured to the ground with stakes
9 or heavy objects.
- 10 4. Set trap trigger sensitivity to ensure consistent trapping success efforts between areas.
- 11 5. Bait traps with an oatmeal-peanut butter mixture [approximately 30 mL (2 tbsp) of
12 peanut butter and 2.7 L (0.7 gal) of oatmeal in a 4-L (1-gal) zippered plastic bag].
- 13 6. Check traps daily, preferably before ambient temperatures exceed approximately 90°F.
- 14 7. If samples are abundant, sacrifice only reproductively active specimens for contaminant
15 analysis.
- 16 8. When traps have been tripped and a small mammal is captured, don a HEPA mask
17 (optional) and gloves, and position yourself in a generally upwind direction from the
18 trapped animal.
- 19 9. Empty trap contents (small mammal, bait, and feces) into a new plastic bag. If animal is
20 not sacrificed, mark the ventral portion of its tail with a black, blue, or red nontoxic
21 permanent marker to ensure all marked animals can be identified later if recaptured.
- 22 10. Record species, age, sex, reproductive status, and weight, and note any abnormalities of
23 condition on the field record form. (Do not record this information if the animal has been
24 previously captured and recorded.)
- 25 11. If animal is selected for collection, euthanize selected small mammals by American
26 Veterinary Medical Association ("AVMA Panel on Euthanasia," AVMA 1986) approved
27 cervical dislocation technique.
- 28 12. Place each sacrificed specimen in a new plastic bag, labeled with the date, trap grid, trap
29 number, sample number (1 of 6, etc.), collection permit number, and collector's initials,
30 and store in an iced cooler until samples can be transferred to the laboratory for sample
31 preparation process.
- 32 13. Reset the trap, checking the sensitivity, and re-bait the trap.
- 33 14. Spray hands (with gloves donned) with Lysol solution, doff the HEPA mask, and then
34 gloves.
- 35 15. Record all trapping efforts on small mammal field record forms.
- 36

1 **B3.2.1.2 Small Mammal Condition Inspections and Tissue Sample Preparations at the**
 2 **Laboratory**

3 Small Mammal Laboratory Equipment List:
 4

- 5 1. Appropriate sample containers (see Table B-3).
 6 2. Autoclave.
 7 3. Stainless steel forceps.
 8 4. Blunt scissors.
 9 5. Surgical (nitrile) gloves.
 10 6. Liqui-nox^{®1} solution.
 11 7. Deionized water (Teflon^{®2} squeeze bottle).
 12 8. Teflon weighing and wash tray.
 13 9. Calibrated balance (± 0.01 g).
 14 10. Laboratory-grade blender.
 15 11. Absorbent paper and aluminum weigh boats.
 16 12. Lysol solution (5% Lysol) and spray bottle.
 17 13. Animal necropsy/gross external observations form.
 18 14. Chain-of-custody seals.
 19 15. Chain-of-custody form.
 20 16. Dry ice.
 21 17. Laboratory grade blend and stainless steel 500-mL cup.
 22

23 **Table B-3. Sample Collection and Packaging Requirements (per sample basis)**

Sample Type	Sample Container Requirements	Analyte Group	Target Sample Volume
Mammal carcass	Plastic bag, transferred to amber glass bottle with polyethylene cap prior to laboratory shipment	PCBs, PEST	250 g
		Inorganic chemicals	50 g
		Radionuclides	500 g
Mammal liver/kidney	Amber glass bottle with polyethylene cap	Inorganic chemicals only	75 g

24 ¹ Liqui-nox[®] is a registered trademark of Alconox, Inc., White Plains, New York.

² Teflon[®] is a registered trademark of I. E. du Pont de Nemours and Company, Wilmington, Delaware.

1 Small Mammal Sample Inspection Instructions:

- 2
- 3 1. Remove samples to be processed from refrigerated locked storage. Keep organism sealed
- 4 in plastic bag until transported to the biological hood in the laboratory.
- 5 2. Weigh animal on digital scale while sealed in bag (0.01 g) and record weight on animal
- 6 sample processing form.
- 7 3. Open the bag under the biological hood.
- 8 4. Don latex/rubber gloves.
- 9 5. Remove specimen from the bag, observe animal's general external condition, and then
- 10 thoroughly rinse specimen in the Teflon wash tray containing deionized water for
- 11 approximately 30 seconds. (Clean container with Liqui-nox solution and rinse with
- 12 deionized water between each small mammal sample rinsing event.)
- 13 6. Place specimen on new absorbent towel (still in biological hood).
- 14 7. Wash gloves and dissection instruments with Liqui-nox solution and rinse with deionized
- 15 water.
- 16 8. Conduct final condition inspection (gross external necropsy) and record species, age, sex,
- 17 weight, and reproductive status on the animal sample processing form or in the laboratory
- 18 record book.
- 19 9. Dissect organism with pre-cleaned stainless steel scissors and forceps to remove kidneys
- 20 and liver for composite analysis. Note any unusual coloration or appearance of organs in
- 21 the laboratory record book or on the sample processing form.
- 22 10. Briefly rinse the organs with deionized water and place organs on pre-cleaned aluminum
- 23 or Teflon tared weighing tray (or tared sample bottle) and record organ weights on
- 24 calibrated scale (± 0.01 g).
- 25 11. Place carcass (whole organism minus kidney and liver tissues) in appropriate sample
- 26 container(s) according to analytes and sample mass requirements prescribed in sample
- 27 authorization form.
- 28 12. Tissue subsamples for carcass and organs will be prepared separately by blending tissues
- 29 in a laboratory-grade blender with dry ice for approximately 30 sec to 1 minute to allow
- 30 homogenization. (NOTE: The tissue should be partly frozen before attempting to
- 31 homogenize with blender.)
- 32 13. Small mammal samples require autoclaving at 121°C for at least 90 minutes to eliminate
- 33 hantavirus concerns. (NOTE: See special container, sample preservation, and
- 34 preparation requirements for small mammals.) Sterilization should be verified with
- 35 sterile indicator test device.
- 36 14. Label sample containers consistent with the sample analysis report.

- 1 15. After all small mammal samples are prepared, thoroughly clean fume hood and all
2 sample processing tools using a disinfectant solution (1% bleach or 5% Lysol). Let
3 solution stand on all surfaces for at least 1 minute before wiping clean.
- 4 16. Record pertinent sample preparation activities (deionized water, purity, etc.) in the
5 laboratory record book.

6

7 **B3.2.2 SAMPLE HANDLING, SHIPPING, AND CUSTODY REQUIREMENTS**

8 All sample handling, shipping, and custody requirements will be consistent with established
9 WRPS procedures and HASQARD (DOE/RL-96-68). Sample transportation shall be in
10 compliance with the applicable regulations for packaging, marking, labeling, and shipping
11 hazardous materials, hazardous substances, and hazardous waste that are mandated by the U.S.
12 Department of Transportation [Title 49 *Code of Federal Regulations* (CFR) 171-177, Chapter 1,
13 "Research and Special Programs Administration, Department of Transportation"; Part 171,
14 "General Information, Regulations, and Definitions," through Part 177, "Carriage by Public
15 Highway"] in association with the International Air Transportation Authority, DOE
16 requirements, and applicable program-specific implementing procedures.

17

18 **B3.2.3 QUALITY CONTROL REQUIREMENTS**

19 The quality control procedures must be followed in the field and laboratory to ensure that
20 reliable data are obtained. When performing this field sampling effort, care shall be taken to
21 prevent the cross-contamination of sampling equipment, sample bottles, and other equipment
22 that could compromise sample integrity. The WRPS or subcontractor QA plan will be reviewed
23 for consistency with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance*
24 *Requirements* (HASQARD).

25

26 **B3.2.4 INSTRUMENT CALIBRATION AND MAINTENANCE**

27 All field screening and analytical instruments shall be calibrated and maintained in accordance
28 with HASQARD. The results from all instrument calibration and maintenance activities shall be
29 recorded in a bound logbook in accordance with procedures outlined in the most recent WRPS
30 procedure for maintenance of field logbooks.

31

32 **B3.2.5 FIELD DOCUMENTATION**

33 Project documentation and records include field logbooks, field measurement records,
34 chain-of-custody records, analytical data packages, and validation reports. At the direction of the
35 task lead, all data packages and/or validation reports shall be subject to technical review before
36 submittal to regulatory agencies or inclusion in reports/technical memoranda. When appropriate,
37 electronic access shall be through computerized databases (e.g., Hanford Environmental
38 Information System). Where electronic data are not available, hard copies will be provided in
39 accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order*
40 (Ecology et al. 1989).

1 Field documentation shall be kept in accordance with the most recent WRPS procedures for

- 2 1. Field logbooks.
- 3 2. Environmental site identification and information reporting.
- 4 3. Chain of custody.

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B4.0 ASSESSMENTS AND RESPONSE ACTIONS

Random surveillance and assessments may be conducted in accordance with the most recent QA plan or its equivalent, TFC-PLN-02, *Quality Assurance Program Description*, for the RCRA corrective action process. Deficiencies identified by one of these assessments shall be reported in accordance with TFC-ESHQ-Q_PP-P-02, "Quality Assurance Surveillances." When appropriate, corrective actions will be taken by the project engineer in accordance with HASQARD Volume 1, Section 4.0, to minimize recurrence.

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B5.0 DATA VERIFICATION AND VALIDATION REQUIREMENTS

Data verification and validation are performed on analytical data sets primarily to confirm that sampling and chain-of-custody documentation is complete, sample numbers can be tied to the specific sampling location, samples were analyzed within the required holding times, and analyses met the data quality requirements specified in this SAI. All data verification and validation shall be performed in accordance with Attachment 3 of the main document and the current TFC-PLN-17, *Document Control and Records Management Program*.

1
2 **B6.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE**

3
4 Waste generated by sampling activities will be managed consistent with the most recent waste
5 management plan or its equivalent, TFC-PLN-33, *Waste Management Basis*, for the RCRA
6 corrective action process.

7
8 Unused samples and associated laboratory waste for analysis will be dispositioned in accordance
9 with the laboratory contract and agreements. In accordance with 40 CFR 300.440, "National Oil
10 and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and
11 Implementing Off-Site Response Actions," Remedial Project Manager approval is required
12 before unused samples or waste is returned from offsite laboratories.
13
14

B7.0 HEALTH AND SAFETY

1
2 All field operations will be performed in accordance with the most recent TFC-PLN-43, *Tank*
3 *Farm Contractor Health and Safety Plan*, and TFC-PLN-47, *Worker Safety and Health Program*,
4 or their equivalent, for the RCRA Corrective Action Program.
5
6

B8.0 REFERENCES

- 1
2 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of*
3 *Federal Regulations*, as amended.
4
5 49 CFR 171-177, "Transportation," *Code of Federal Regulations*, as amended.
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22 Protection Agency, and U.S. Department of Energy, Olympia, Washington.
23
24 EPA/600/R-93/187, 1993, *Wildlife Exposure Factors Handbook*, Office of Health and
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26 Available on the Internet at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2799>
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28 *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.
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31 CH2M HILL Hanford Group, Inc., Richland, Washington.
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33 SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, Third Edition,
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38
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40 Protection Solutions LLC, Richland, Washington.
41
42 TFC-PLN-02, as revised, *Quality Assurance Program Description*, Washington River Protection
43 Solutions LLC, Richland, Washington.
44
45 TFC-PLN-17, as revised, *Document Control and Records Management Program Description*,
46 Washington River Protection Solutions LLC, Richland, Washington.

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TFC-PLN-33, as revised, *Waste Management Basis*, Washington River Protection Solutions LLC, Richland, Washington.

TFC-PLN-43, as revised, *Tank Farm Contractor Health and Safety Plan*, Washington River Protection Solutions LLC, Richland, Washington.

TFC-PLN-47, as revised, *Worker Safety and Health Program*, Washington River Protection Solutions LLC, Richland, Washington.

WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures," *Washington Administrative Code*, as amended.

WHC-SD-EN-TI-122, 1993, *Biological Uptake of 300-FF-5 Operable Unit Contaminants*, Westinghouse Hanford Company, Richland, Washington.

WMP-23141, 2004, *100-NR-2 Groundwater Operable Unit Ecological Risk Assessment Data Quality Objectives Summary Report*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

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APPENDIX C

THREE DIMENSIONAL REPRESENTATION OF WMA C

C1.0 WMA C 3-D MODEL VISUAL AID

This appendix contains a three-dimensional model of WMA C on the following page. Adobe has provided a 3-D tool within Adobe Reader that allows the user to rotate, pan, zoom, cut cross-sections through the model, and turn on and off different 3-D objects that are included in the model. A brief tutorial is provided.

C2.0 BRIEF TUTORIAL

- Step 1)** Set the correct Adobe preferences, this is done by choosing by going to the Adobe Reader's Edit menu and selecting preferences. Choose 3-D under categories. On that menu, toggle on "Enable Double-Sided Rendering". See page G-4 for additional information on setting preferences
- Step 2)** Return to 3-D model
- Step 3)** Click on the gray color box in the stratigraphy legend that says Basalt, then blue box for the unconfined aquifer, etc.
- Step 4)** Until the model has all the layers except the Backfill at that point, click on the Retrieved/Unretrieved buttons, and then on any of the side buttons (i.e. uprs, pipelines, etc.)
- Step 5)** Click on the Backfill color in the legend (orange) to fill in the backfill
- Step 6)** Click on all the buttons you used to turn on the additional features and turn them off (undo step 4)
- Step 7)** Click on the word Stratigraphy (that should remove the geology)
- Step 8)** Select C-105 View from Adobes 3-D Toolbar Dropdown box
- Step 9)** Now click on the color boxes in the contaminant legends, starting with the highest value, and working your way down the legend, you should see the boreholes get populated with boxes showing the contaminant levels. The boxes are based on the measured value at that location
- Step 10)** Click on the title of the contaminant legend (that should remove the boxes contaminant samples)
- Step 11)** On the view list click on the WIDS:Tank view when that view comes up click on the paperclip icons located on the tanks and pdf file will open giving the WIDS report for that tank
- Step 12)** On the view list click on the Water Table view when that view comes up click on the graph icons located by the wells and pdf file will open giving a time-history of Tc-99, Nitrate, Cyanide, and water levels at that well

If you wish to use Adobe's 3-D tool to manipulate the model, see page G-3 for the user guide.

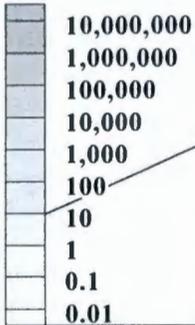
Known Bugs: Sometimes the model does not perform as expected, if you click on an item and nothing happens, click on the Animation Tool on the Adobe's 3-D menu (blue triangle pointed to the right).

Stratigraphy

-  Back Fill
-  Hanford Gravels (H1)
-  Hanford Sands (H2)
-  Hanford Gravels (H3) (Vadose)
-  Hanford Gravels (H3) (Sat.)
-  Basalt

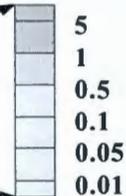
**Cs-137
(pCi/g)**

(Max = 25,070,920)



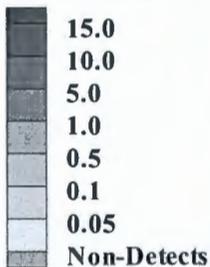
**Co-60
(pCi/g)**

(Max = 9.89)



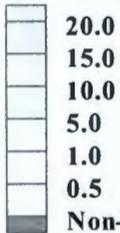
**Tc-99
(pCi/g)**

(Max = 28.6)



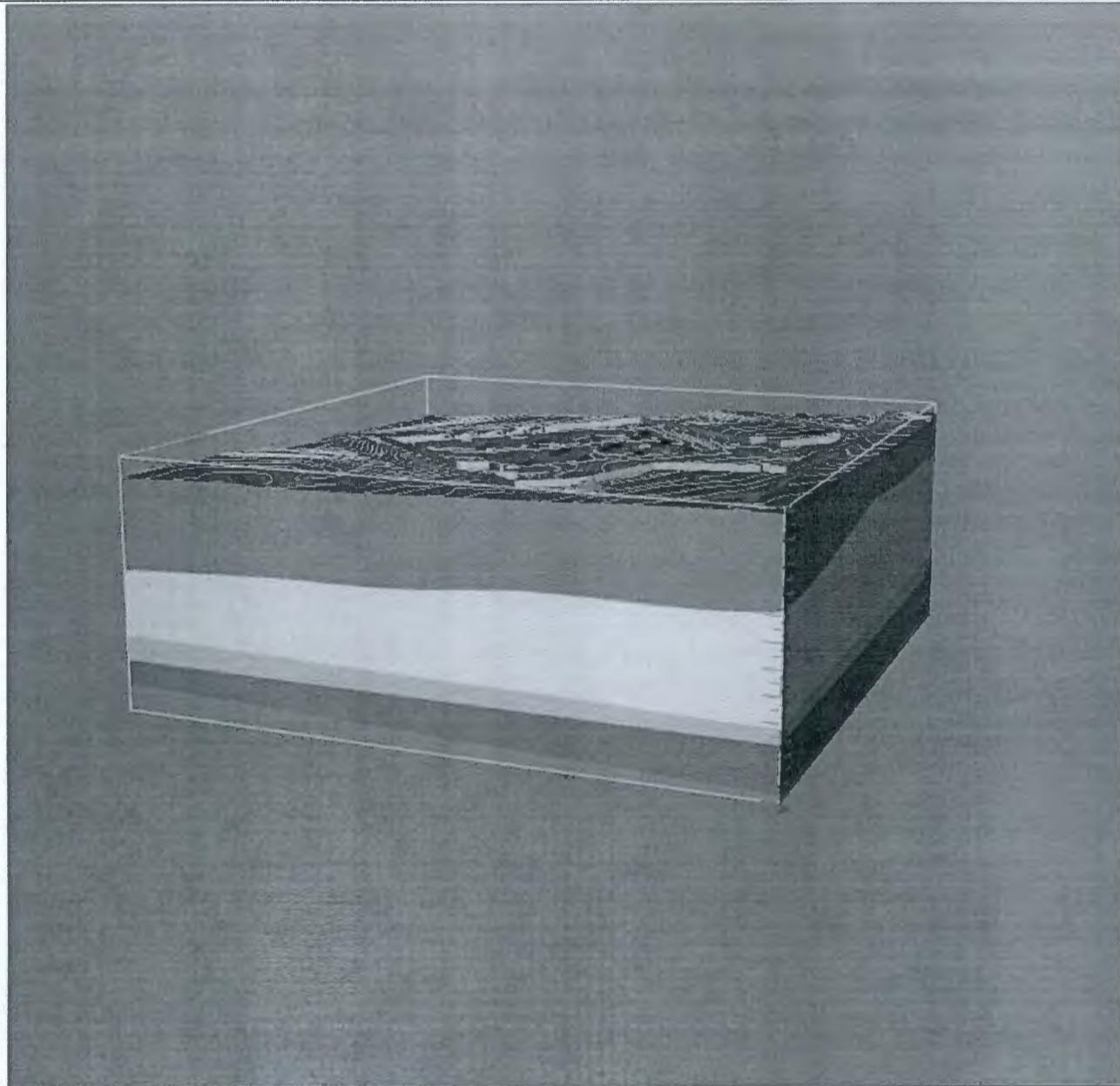
**Nitrate
(µg/g)**

(Max = 29.3)



Note Blue Tanks are Assumed Leakers

UPRs	Wells
Topography	Roads and Boundaries
Tank Labels	Pipe Lines and D/Bs



Defined Views

- Default
- Geology
- Looking**
- West
- South
- East
- North
- Down
- C-105
- Cross-Section
- Reset
- WIDS: Tanks
- WIDS: Anc. Eq
- WIDS: UPR
- Water Table

Retrieved Tanks	<input type="checkbox"/> Hide Leakers	Unretrieved Tanks	<input type="checkbox"/> Hide Leakers					
C-103	C-201	C-202	C-102	C-104	C-105	C-107	C-108	
C-106	C-203	C-204	C-109	C-112	C-101	C-110	C-111	Reset

[Click Here for Instructions](#)

3-D Preferences Instructions (click here if model is not solid)

Instructions for using Acrobat's 3-D tool and WMA C Geologic Model (return to model →)

- Click on the 3-D Graphic to activate Acrobat's 3-D tool
- Use Acrobat's 3-D Tool Bar and Model Tree to manipulate the WMA C Geologic Model (3-D Tool Bar Description is given below)
- Use Model Tree on the left to: 1) expand layers, 2) turn on/off layers, 3) turn layers transparent (right click on the layer) and 4) go to set views

Item	Image	Tool	Description
1		Roller Ball	Use mouse* to roll the model around a pivot point
2		Spin	Use mouse* to spins the model around a pivot point (I prefer this tool for rotating model)
3		Translate	Use mouse* to move model from it's present location
4		Magnify	Use mouse* to magnify model (this can also be accomplished by holding the right mouse button)
5		Measure	Use the mouse to measure distance between objects
6		View	Click on the picture of the house to return to the default view or select a view by clicking the down arrow
7		Model Tree	This opens and closes Acrobat's "Model Tree" which controls the display of each individual item (click on the plus signs in the model tree to see all of the items under the different model groups (i.e. topography, boundaries, tanks and UPRs, etc.). These individual items can be turned on/off by clicking in the check box, furthermore right clicking with the mouse on individual item brings up more controls such as transparency, so an individual part can be made transparent
8		Animate	If an animation is present use this arrow to play the animation or to bring up the animation's controls
9		Orthographic/ Perspective	Toggle between orthographic and perspective views of the model
10		Model	Click on the down triangle and select the type of model (i.e. solid, wireframe, illustration, etc.) being displayed (default is solid). Those of you with a poor graphics card will see bounding box displayed when model is moved.
11		Lights	Click on the down triangle and select the type of lights model uses (default is CAD Optimized Lights)
12		Background Color	Click on the down triangle and select background color (black is better when displaying on light box, while white is better for printing.
13		Cross-Section	Use this tool to turn on and manipulate the clipping plane (this allows you to make cross-sections through the model

* note mouse moves are done by holding down the left mouse button while moving the mouse

Return to model →

If the model being displayed is not solid (i.e. you can see through the layers and the geology is not properly displayed), you will need to set Adobe's 3-D preferences. To do this follow these instructions

- 1) Go to the Edit Menu and Select Preferences or hit Ctrl-K on the key board that will bring up the following menu

Preferences

Categories:

- Commenting
- Documents
- Full Screen
- General
- Page Display
- 3D**
- 3D Capture
- Accessibility
- Batch Processing
- Catalog
- Color Management
- Convert From PDF
- Convert To PDF
- Forms
- Identity
- International
- Internet
- JavaScript
- Measuring (2D)
- Measuring (3D)
- Meeting
- Multimedia
- Multimedia Trust
- New Document
- Online Services
- Reading
- Reviewing
- Search

3D Options

Renderer Options

Preferred Renderer: DirectX 9

Enable hardware rendering for legacy video cards

Enable double-sided rendering

Preferred 3D PMI Rendering Mode: Always render 3D PMI using Z-buffer

3D Tool Options

Open Model Tree on 3D Activation: Use Annotation's Setting

Default Toolbar State: Use Annotation's Setting

Enable toggle for 3D Toolbar control

Enable 3D selection for the Hand tool

Consolidate tools on the 3D Toolbar

Enable view transitions

Auto-Degrade Options

Optimization scheme for low framerate: None

Framerate threshold: 15 FPS

OK Cancel

Preferences to Set	
a)	Select 3D Category
b)	Enable double-sided rendering
c)	Select "Always render 3D PMI using Z-Buffer"
d)	If you do not have a good graphics card (i.e. moving model is sluggish), play around with these settings, until you get something you can live with.

C-4

RPP-PLAN-39114, Rev. 0

Return to model →

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ATTACHMENT 1

**TANK FARM CONTRACTOR
QUALITY ASSURANCE PROGRAM DESCRIPTION**

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1 This attachment references the most recent quality assurance plan or its equivalent,
2 TFC-PLN-02, *Quality Assurance Program Description*, for the RCRA corrective action
3 program.

4

5 **Reference**

6

7 TFC-PLN-02, as revised, *Quality Assurance Program Description*, Washington River Protection
8 Solutions LLC, Richland, Washington.

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ATTACHMENT 2

GENERAL HEALTH AND SAFETY PLAN

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1 This attachment references the most recent health and safety plans, TFC-PLN-43, *Tank*
2 *Operations Contractor Health and Safety Plan*, and TFC-PLN-47, *Worker Safety and Health*
3 *Program*, or their equivalent, for the RCRA corrective action program.

4

5 **References**

6

7 TFC-PLN-43, as revised, *Quality Tank Operations Contractor Health and Safety Plan*,
8 Washington River Protection Solutions LLC, Richland, Washington.

9 TFC-PLN-47, as revised, *Worker Safety and Health Program*, Washington River Protection
10 Solutions LLC, Richland, Washington.

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ATTACHMENT 3
INFORMATION MANAGEMENT OVERVIEW

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1 This information management overview attachment references the most recent plan or its
2 equivalent that addresses information management, TFC-PLN-17, *Document Control and*
3 *Records Management Program Description*, for the RCRA corrective action program.
4

5 **Reference**
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7 TFC-PLN-17, as revised, *Document Control and Records Management Program Description*,
8 Washington River Protection Solutions LLC, Richland, Washington.
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ATTACHMENT 4

**WASTE MANAGEMENT FOR THE RCRA
CORRECTIVE ACTION PROGRAM**

1 Waste generated by sampling activities will be managed consistent with the most recent waste
2 management plan or its equivalent, TFC-PLN-33, *Waste Management Basis*, for the RCRA
3 corrective action process.

4
5 Unused samples and associated laboratory waste for analysis will be dispositioned in accordance
6 with the laboratory contract and agreements. In accordance with 40 CFR 300.440, "National Oil
7 and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and
8 Implementing Off-Site Response Actions," Remedial Project Manager approval is required
9 before unused samples or waste is returned from offsite laboratories.

10
11 **Reference**

12
13 TFC-PLN-33, as revised, *Waste Management Basis*, Washington River Protection Solutions
14 LLC, Richland, Washington.

