



Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

10-AMCP-0055

DEC 22 2009

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

Dear Ms. Hedges:

INTEGRATED 100 AREA REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN, ADDENDUM 5: 100-N DECISION UNIT, DOE/RL-2008-46-ADD5, DRAFT A, AND SAMPLING AND ANALYSIS PLAN FOR THE 100-N DECISION UNIT REMEDIAL INVESTIGATION/FEASIBILITY STUDY, DOE/RL-2009-42, DRAFT A

This letter transmits the Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-N Decision Unit, DOERL-2008-46-ADD5, Draft A, and Sampling and Analysis Plan for the 100-N Decision Unit Remedial Investigation/Feasibility Study, DOE/RL-2009-42, Draft A, and for your review and comment.

This Work Plan is submitted in accordance with Tri-Party Agreement Milestone M-016-61, "Submit Remedial Investigation/Feasibility Study Work Plan for the 100-NR-1 and 100-NR-2 Operable Units," by December 31, 2009.

The Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, DOE/RL-2008-46, Draft A, previously submitted on May 28, 2009, (09-AMCP-0134) contains the planning elements common to the Hanford Site 100 Area source and groundwater Operable Units and a summary of the Remedial Investigation/Feasibility Study tasks.

The Work Plan describes the 100-N Decision Unit and planned efforts to conduct a Remedial Investigation/Feasibility Study in support of a final Record of Decision. The 100-N Decision Unit includes the 100-NR-1 Source Operable Unit and the 100-NR-2 Groundwater Operable Unit. The scope described in this document and the supporting sampling and analysis plan are designed to meet the Tri-Party Agreement Target (M-015-62-T01) "Submit a Feasibility Study Report and Proposed Plan for the 100-NR-1 and 100-NR-2 Operable Units including Groundwater and Soil," by December 31, 2011.

Ms. J. A. Hedges
10-AMCP-0055

-2-

DEC 22 2009

Please provide comments to the U.S. Department of Energy Richland Operations Office within 60 days of receipt of this letter, as described in Section 9.2, of the Tri-Party Agreement Action Plan.

If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137, or Joe Franco, Assistant Manager for the River Corridor, on (509) 376-6628.

Sincerely,



Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:KMT

Attachments

cc w/attachs:

G. Bohnie, NPT
A. Boyd, Ecology
L. Buck, Wanapum
L. Buelow, EPA
D. A. Faulk, EPA
S. Harris, CTUIR
R. Jim, YN
S. L. Leckband, HAB
K. Niles, ODOE
J. B. Price, Ecology
Administrative Record
Environmental Portal

cc w/o attachs:

D. G. Black, CHPRC
J. V. Borghese, CHPRC
J. G. Vance, FFS

Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan, Addendum 5: 100-N Decision Unit

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

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



P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-N Decision Unit

Document Type: WP

Date Published
December 2009

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

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



P.O. Box 1600
Richland, Washington

J. D. Cardel 12/20/2009
Release Approval Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

Approval Page

Title: *Integrated 100 Area Remedial Investigation/Feasibility Study
Work Plan, Addendum 5: 100-N Decision Unit*

Concurrence:

U.S. Department of Energy, Richland Operations Office

Signature

Date

U.S. Environmental Protection Agency

Signature

Date

This page intentionally left blank.

Executive Summary

1
3 This document is Addendum 5 of the *Integrated 100 Area Remedial Investigation/
4 Feasibility Study Work Plan*¹. The purpose of a work plan is to explain the Remedial
5 Investigation/ Feasibility Study (RI/FS) project background and rationale, and to present
6 detailed plans for investigation of a contaminated site under *Comprehensive
7 Environmental Response, Compensation, and Liability Act of 1980*² (CERCLA). It should
8 be noted that the CERCLA/RI/FS results are intended to address Resource Conservation
9 and Recovery Act (RCRA) corrective action requirements for areas of RCRA concern.
10 This document supports final remedy selection under the CERCLA for the
11 100-N Decision Unit at the Hanford Site. Five 100 Area Decision Units (Figure ES-1)
12 have been defined for the River Corridor:³ 100-B/C Area, 100-K Area, 100-D and
13 100-H Areas, 100-N Area, and 100-F Area combined with 100-IU-2/6 Areas. An additional
14 decision unit is defined for the 300 Area. Planning for the 300 Area Decision Unit will be
15 addressed separately. These Decision Units combine groundwater contamination, soil
16 contamination sites, and facilities in geographic areas that encompass the 100 Area
17 National Priorities List⁴ sites.

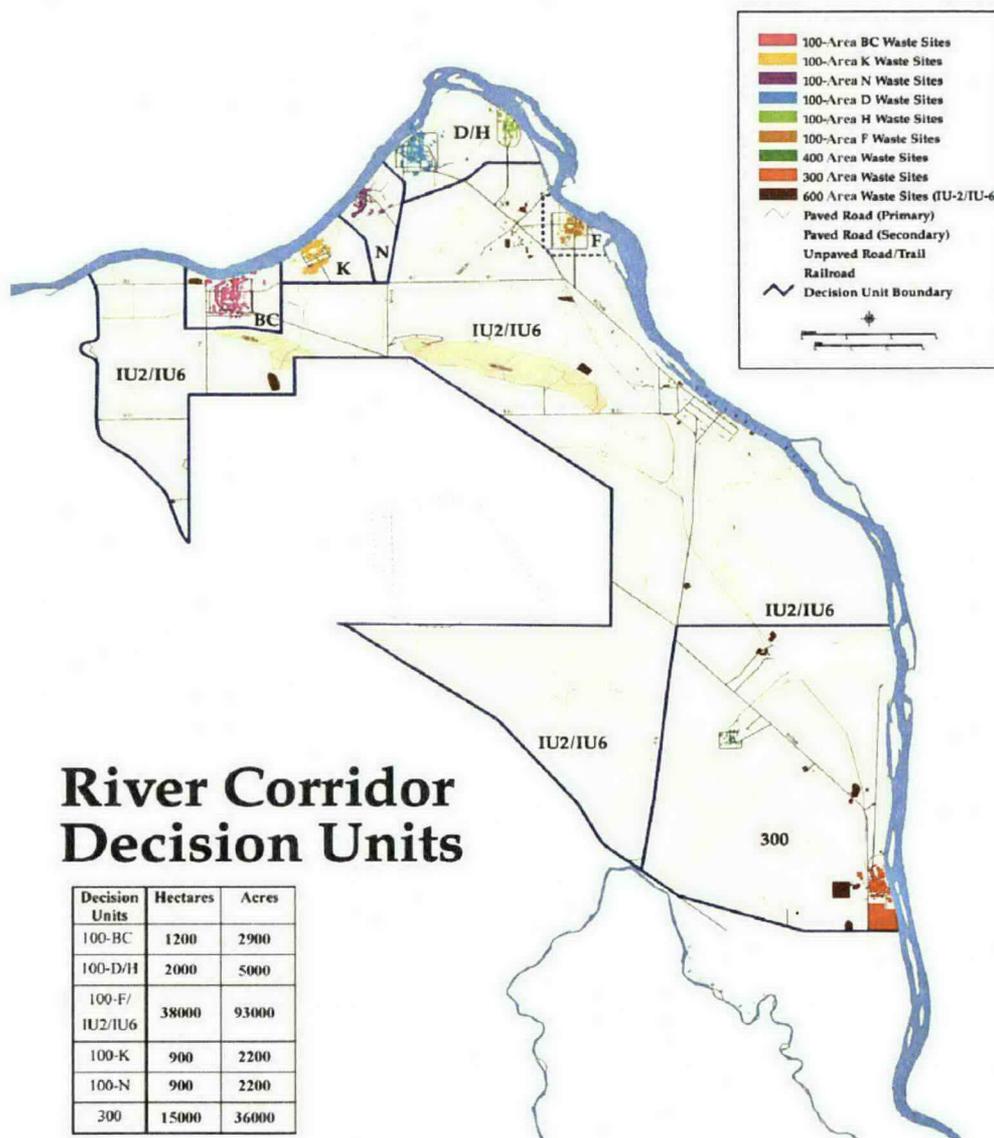
18 The work plan implements an approach designed to reach final remediation decisions,
19 describes key features of the planning process to support implementation of this
20 approach, and provides important key regulatory and risk assessment assumptions
21 common to the 100 Area Decision Units. This document, Addendum 5 to the work plan,
22 provides information for the 100-N Decision Unit. The 100-N Decision Unit includes the
23 100-NR-1 Source Operable Unit (OU), and the 100-NR-2 Groundwater OU. The location
24 of the 100-N Decision Unit and proximity to other Decision Units is provided in
25 Figure ES-1.

1 DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

2 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
http://www4.law.cornell.edu/uscode/42/usc_sec_42_00009601----000-.html.

3 Decision unit" is a term developed as part of this cleanup strategy to enable coordinated decisions for contiguous source and groundwater operable units.

4 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Title 40, *Code of Federal Regulations*, Part 300.
http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr300_08.html.



River Corridor Decision Units

Decision Units	Hectares	Acres
100-BC	1200	2900
100-D/H	2000	5000
100-F/ IU2/IU6	38000	93000
100-K	900	2200
100-N	900	2200
300	15000	36000

Figure ES-1. River Corridor Decision Unit Boundaries

A planning process was conducted to identify data collection and analysis needs to support final remediation decisions at the 100-N Decision Unit. The following key elements were identified during this planning process:

- **Information was identified and collected on the existing site conditions.**

Information includes the facilities operational history (with an emphasis on disposal operations), the nature and extent of groundwater and soil contamination,

1 geohydrologic information, source and groundwater remedial actions and their
2 effectiveness, and the results of treatability and characterization studies.

3 Strontium-90 (Sr-90) contamination is the primary risk driver at the 100-N Decision
4 Unit; however, other groundwater plumes exist. Appendix B presents maps of the
5 facilities source sites, and the Sr-90 groundwater plume. To date, 20 source sites have
6 been remediated, including the major Sr-90 disposal sites (116-N-1 and 116-N-30
7 Cribs and Trenches). Ninety-three source sites remain for remedial action.

8 • **A conceptual site model was developed.**

9 The conceptual site model (CSM) examined the known contamination levels and
10 location(s), and information needed to support remediation decisions. A CSM is a
11 description of a site representation that organizes the information available and
12 provides a summary of the site conditions. The CSM was used to identify data and
13 information gaps, establish data needs, and design a field program to address the data
14 needs.

15 An important feature of the CSM was identifying potential sources of Sr-90, and
16 providing explanations regarding Sr-90 plume persistence and mass distribution in
17 soil. Based on reactor operations process knowledge, reactor process water
18 discharges contained levels of Sr-90 in excess of 600 pCi/L (Table 4-1). The effluent
19 infiltration and migration to groundwater in the 100 N Area produced Sr-90
20 concentrations about 6,000 pCi/L in a monitoring well during the mid-1980s
21 (WHC-SR-0377, 1988). As of 2008, Sr-90 concentrations above the maximum
22 contaminant level (MCL) extend inland from the river approximately 1.2 km
23 (4,000 ft) in the 100 N Area with an overall plume area estimated as 0.58 km²
24 (0.22 mi²) (N-Area Map, Appendix B).

25 • **Data gaps, or uncertainties, were identified as part of the conceptual site model
26 development process.**

27 A list of data gaps, or statements of uncertainty, was identified as part of the planning
28 process. These data gaps included recognition of the need for additional information to
29 better define the following:

- 30 – Assess risk for direct exposure, protection of groundwater, and protection of the
31 Columbia River at unremediated waste sites

- 1 – Potential effects of residual soil contamination following remedial action on human health,
2 groundwater, and the environment
- 3 – Extent of contamination in the unconfined aquifer
- 4 – Extent of contamination in the Ringold Upper Mud (RUM) Unit
- 5 – Continued persistence of strontium-90 contamination in the groundwater in areas of the
6 Decision Unit
- 7 – Hydraulic properties of the RUM Unit
- 8 – Potential adverse effects from remaining undiscovered sites

9 Chapter 4 presents the data gaps defined during the planning process.

10 • **Data needs were defined to address each of the data gaps or uncertainties.**

11 Each of the gaps are defined by a data need that, when filled, provides information to
12 reduce or eliminate the associated uncertainty. Table 4-4 and DOE/RL-2009-42,
13 *Sampling and Analysis Plan for the 100-N Decision Unit*, present the data needs and
14 describe how they will be filled for the 100-N Decision Unit. An important
15 consideration in Table 4-4 is that several ongoing programs (e.g., facility demolition,
16 waste site remediation, and treatability testing) will provide data and may resolve many
17 of the uncertainties identified for the 100-N Decision Unit. The sampling and analysis
18 plan (DOE/RL-2009-42) identifies only those data collection activities the ongoing
19 programs will not address. The RI/FS study report prepared for the 100-N Decision
20 Unit will use data and information obtained from ongoing remediation programs that
21 become available during development of the report. The results of ongoing
22 deactivation, decontamination, decommissioning, and demolition, and from waste site
23 and groundwater interim remediation actions plus the proposed investigations will be
24 used in the selection of final remedies and be incorporated into a proposed plan leading
25 to a final record of decision. Table ES-1 summarizes the characterization field program
26 proposed under this addendum. Table ES-2 presents the number of field samples and
27 analytes that would be collected.

Table ES-1. Proposed 100-N Decision Unit Characterization

Type	100-N Area
Source sites scheduled for evaluation, characterization and or remediation*	93
New boreholes (vadose zone)	0
New wells (unconfined aquifer)	2
New wells into Ringold Upper Mud Unit	2
Sampling of monitoring wells (to support groundwater spatial/temporal uncertainty)	18

* This task is not within the scope of the SAP. Source sites are being addressed according to DOE/RL-96-17 Remedial Design Report/Remedial Action Work Plan.

1

Table ES-2. Number of Field Samples and Analytes proposed for the 100-N Decision Unit

Source	Soil Samples*	Groundwater Samples	Analytes
New boreholes (vadose zone)	NA	NA	NA
New wells (unconfined aquifer)	30	11	1404
New wells into Ringold B unit	20	16	1204
Sampling of monitoring wells (to support groundwater spatial/temporal uncertainty)	0	54	2268

NOTE: Table does not include field quality control or archive samples.

* Includes both chemical and physical property analyses.

2

- **A sampling and analysis plan was developed as the implementing document for the field program.**

3

4

5

6

7

8

9

10

The sampling and analysis plan contains a list of target analytes for use with soil samples and a list of contaminants of potential concern for use with groundwater samples. The current methodology defines analyses for soil characterization and for groundwater samples to address River Corridor Baseline Risk Assessment groundwater risk uncertainty. This addendum is based on the premise and observation that after 13 years of active remediation and study, a limited number of uncertainties remain that should be addressed to support final remediation decisions.

11

12

In the 100-N Decision Unit, substantive work remediating groundwater contamination, removing facilities and contaminated soils has been completed over

1 the past decade or is planned over the next few years. Results of these activities
2 provide the basis for identifying the remaining uncertainties needed to make final
3 remediation decisions. The completed and planned work for the 100-N Decision Unit
4 is provided in Section 1.2.

Contents

1			
2	1	Introduction	1-1
3		1.1 Scope	1-2
4		1.2 100-N Remediation Accomplishments.....	1-2
5		1.2.1 100-N Decision Unit Deactivation, Decommissioning, Decontamination, and	
6		Demolition Actions.....	1-4
7		1.2.2 100-N Decision Unit Waste Site Remediation	1-7
8		1.2.3 100-N Decision Unit Orphan Site Evaluation.....	1-9
9		1.2.4 100-N Decision Unit Pump-and-Treat System	1-10
10		1.2.5 Hanford N-Springs Sheet Pile Program Summary	1-13
11		1.2.6 In Situ Treatability Test Planning Workshop Report.....	1-14
12		1.2.7 Innovative Treatment and Remediation Demonstration Program.....	1-15
13	1.3	Current Groundwater Remediation Approach.....	1-19
14		1.3.1 Apatite Barrier Installation	1-19
15		1.3.2 Phytoremediation.....	1-21
16		1.3.3 Petroleum Removal.....	1-23
17		1.3.4 Aquatic and Riparian Impact Assessment	1-26
18	2	Site Background and Environmental Setting.....	2-1
19		2.1 100-N Decision Unit Overview.....	2-1
20		2.1.1 Process History Description.....	2-4
21		2.1.2 Secondary Mission: Isotope Production and Electrical Power Generation at the	
22		Hanford Generating Plant	2-8
23		2.1.3 Waste Sites Description and History	2-9
24		2.1.4 Orphan Sites Process and Remaining Sites.....	2-10
25		2.1.5 Decommissioning Activities.....	2-11
26	2.2	Environmental Setting.....	2-13
27		2.2.1 Topography.....	2-13
28		2.2.2 Geology	2-13
29		2.2.3 Hydrogeology	2-33
30	2.3	Known and Potential Contamination.....	2-37
31		2.3.1 Nature and Extent of Vadose Zone Contamination	2-37
32		2.3.2 Results Summary	2-43
33		2.3.3 Nature and Extent of Contamination in the Groundwater	2-60
34	3	Identification of Investigation Requirements	3-1
35	4	Conceptual Site Model.....	4-1
36		4.1 Contaminant Inventory and Release Characteristics.....	4-1
37		4.1.1 Strontium-90 Releases	4-3

1	4.1.2	Petroleum Releases	4-7
2	4.1.3	Sodium Dichromate Releases	4-8
3	4.1.4	Tritium and Nitrate Release	4-9
4	4.2	Contaminant Migration and Distribution in the Vadose Zone	4-10
5	4.2.1	Strontium-90 Migration and Distribution in the Vadose Zone	4-10
6	4.2.2	Petroleum Product Migration and Distribution in the Vadose Zone.....	4-18
7	4.2.3	Chromium Migration and Distribution in the Vadose Zone	4-18
8	4.2.4	Tritium and Nitrate Migration and Distribution in the Vadose Zone	4-25
9	4.3	Contaminant Migration and Distribution in the Unconfined Aquifer	4-25
10	4.3.1	Summary of Groundwater Flow History	4-26
11	4.3.2	Strontium-90 Migration and Distribution in the Unconfined Aquifer	4-32
12	4.3.3	Petroleum Product Migration and Distribution in the Unconfined Aquifer.....	4-38
13	4.3.4	Chromium Migration and Distribution in the Unconfined Aquifer	4-40
14	4.3.5	Tritium and Nitrate Migration and Distribution in the Unconfined Aquifer	4-42
15	4.4	Identification and Resolution of Data Needs.....	4-47
16	4.4.1	100-N Decision Unit Data Needs – Source Areas	4-47
17	4.4.2	100-N Area Data Needs – Groundwater	4-55
18	5	Project Schedule	5-1
19	6	References	6-1

Appendices

21	A	100-N Decision Unit Conceptual Site Model Component Plates.....	A-i
22	B	100-N Area Maps	B-i
23	C	100-N Decision Unit Waste Sites Description and History	C-i
24	D	Summary of 100-N Decision Unit Facilities	D-i

25

Figures

1		
2	Figure 1-1.	Relationship between the Work Plan and Addenda..... 1-1
3	Figure 1-2.	River Corridor Decision Unit Boundaries 1-3
4	Figure 1-3.	100-N Area D4 Progress Demolition as of July 2009 1-5
5	Figure 1-4.	Aerial Photos of 100-N in 1962..... 1-7
6	Figure 1-5.	Aerial Photos of 100-N in 2008 Displaying D4 Progress..... 1-7
7	Figure 1-6.	Excavation to Remove Contaminated Soil at 116-N-1 Crib and Trench..... 1-8
8	Figure 1-7.	Excavation of Contaminated Soil at 116-N-3 Crib and Trench..... 1-9
9	Figure 1-8.	Area Addressed by 100-N Area Orphan Sites Evaluation Process..... 1-10
10	Figure 1-9.	Location of the 100-NR-2 Pump-and-Treat System Wells (2008)..... 1-12
11	Figure 1-10.	Apatite Barrier Technology Test Site Adjacent to the Columbia River at the 100-N Area 1-13
12	Figure 1-11.	Theoretical Formation of an Apatite Chemical Barrier for SR90 Removal 1-21
13	Figure 1-12.	Coyote Willows Growing in the Test Plot in the 100-K Area..... 1-22
14	Figure 1-13.	116-N Tank Farm Facility (Early 1960s) 1-24
15	Figure 1-14.	100-N Tank Farm Facility (1990s)..... 1-25
16	Figure 1-15.	Sampling Regions Located Along the Shoreline at the 100-NR-2 Groundwater Operable
17		Unit Study Area 1-28
18	Figure 2-1.	Map of Hanford Site Showing Location of the 100 Area and Decision Units 2-2
19	Figure 2-2.	Aerial View of 100-N Area (1968; Source: DOE) 2-3
20	Figure 2-3.	Aerial View of 100-N Area and the Hanford Generating Plant, 1983..... 2-4
21	Figure 2-4.	Construction of 1908-N Outfall and 100-N-79 Emergency Spillway (1961)..... 2-6
22	Figure 2-5.	Contemporary Condition of 1908-N (2005) 2-7
23	Figure 2-6.	100-N Area (2002)..... 2-12
24	Figure 2-7.	Generalized Geologic Stratigraphic Section of 100-N Decision Unit..... 2-15
25	Figure 2-8.	Locations of Cross-Sections within the 100-N Area 2-16
26	Figure 2-9.	Detailed View of Cross-Section E to E' 2-17
27	Figure 2-10.	Geologic Cross-Section A to A' 2-20
28	Figure 2-11.	Geologic Cross-Section B to B'..... 2-22
29	Figure 2-12.	Geologic Cross-Section C to C'..... 2-24
30	Figure 2-13.	Geologic Cross-Section D to D' 2-26
31	Figure 2-14.	Geologic Cross-Section E to E' 2-28
32	Figure 2-15.	Ringold Unit E Elevations in the 100-N Decision Unit..... 2-31
33	Figure 2-16.	RUM Elevations in the 100-N Decision Unit..... 2-32
34	Figure 2-17.	100-N Area Water Table Map, March 2008..... 2-35
35	Figure 2-18.	Water Levels in 100-N Decision Unit Wells, 1962 through 2009..... 2-37
36	Figure 2-19.	Vadose Zone Boreholes Sampled for Strontium-90 within the 100-N Decision Unit..... 2-51
37	Figure 2-20.	1301-N (116-N-1) Vadose Zone Strontium-90 Sampling Results 2-52
38	Figure 2-21.	1325-N (116-N-3) Vadose Zone Strontium-90 Sampling Results 2-53

1 Figure 2-22. Strontium-90 Concentrations, by Depth, At Five Boreholes along the Long Axis of 1301-N
 2 (116-N-1).....2-54

3 Figure 2-23. Strontium-90 and Chromium Profile for Borehole 199-N-109AF2-56

4 Figure 2-24. Strontium-90 Concentrations, by Depth, At Five Boreholes Downgradient of 1301-N
 5 (116-N-1).....2-58

6 Figure 2-25. 100-N Decision Unit Average Strontium-90 Concentrations in the 100-N Area,
 7 Unconfined Aquifer2-61

8 Figure 2-26. 100-N Decision Unit Strontium-90 in Groundwater at the Shoreline Study Area,
 9 September 2008, Upper Part of Unconfined Aquifer (DOE/RL-2008-66).....2-62

10 Figure 2-27. Average FY2008 Nitrate in Groundwater within the 100-N Decision Unit, Unconfined
 11 Aquifer.....2-63

12 Figure 2-28. Tritium Concentrations in Groundwater near the 116-N-1 and 116-N-3 Waste Sites.....2-65

13 Figure 2-29. Hexavalent Chromium on the Western Portion of the 100-N Decision Unit, Unconfined
 14 Aquifer.....2-66

15 Figure 4-1. Primary Reactor Fluid Discharge Pathways in the 100 N Area.....4-2

16 Figure 4-2. Comparison of Annual Fluid Discharges versus Annual Strontium-90 Releases Into
 17 1301-N and 1325-N4-6

18 Figure 4-3. Location of the 166N Tank Farm and 184-N Day Tank Facility4-8

19 Figure 4-4. Subsurface Sampling Locations for Sediments Contaminated with Strontium-90 at
 20 100 N Area.....4-11

21 Figure 4-5. Strontium-90 Concentrations with Depth at Five Boreholes along the Long Axis of
 22 1301-N4-13

23 Figure 4-6. Strontium-90 Concentrations with Depth at Five Boreholes Downgradient of 1301-N
 24 Liquid Waste Disposal Facility.....4-15

25 Figure 4-7. Subsurface Sampling Locations for Sediments Contaminated with Chromium at
 26 100-N Area4-19

27 Figure 4-8. Total Chromium Concentrations with Depth at Five Boreholes along the Long Axis of
 28 1301-N Liquid Waste Disposal Facility4-21

29 Figure 4-9. Total Chromium Concentrations with Depth at Three Boreholes through the
 30 1301-N and 1325-N Cribs and Perpendicular to the Long Axis of 1301-N and
 31 1325-N Liquid Waste Disposal Facilities.....4-23

32 Figure 4-10. Water Table Elevations at Wells near 1301-N and 1325-N Liquid Waste Disposal
 33 Facilities.....4-27

34 Figure 4-11. Water Table Mound Associated with 1301-N Crib and Trench – July 1965; Reproduced
 35 from DOE/RL-90-22 Draft B4-28

36 Figure 4-12. Comparison of Water Table Elevations over Time at Groundwater Monitoring Wells
 37 near 1325-N Liquid Waste Disposal Facility (Wells 199-N-32 and 199-N-52).....4-29

38 Figure 4-13. Current Water Table Elevations – 100-N Decision Unit – 20094-30

39 Figure 4-14. 100-N Area Water Table Map for June and October 1995 (Hydrogeologic, 1999)4-31

40 Figure 4-15. Measured Annual Average Strontium-90 Concentrations at N-Springs (pCi/L)
 41 and Estimate Inventory Flux into the Columbia River4-33

42 Figure 4-16. Gross Beta Concentrations versus Head Levels at Wells 199-N-67 and 199-N-144-34

43 Figure 4-17. Current Strontium-90- Distribution in the Unconfined Aquifer under the 100-N Area4-35

1 Figure 4-18. Comparison of Aquifer Tube Gross Beta Measurements with River Stage
2 Elevations (PNNL-16346).....4-37
3 Figure 4-19. Sediment and Groundwater Sampling Locations where Total Petroleum
4 Hydrocarbons-Diesel Range have been Measured4-39
5 Figure 4-20. Total Petroleum Hydrocarbons-Diesel Range Measurements at Well 199-N-18.....4-40
6 Figure 4-21. Comparison of Water Table Elevations and Chromium Concentrations over Time
7 at Well 199-N-67.4-42
8 Figure 4-22. Tritium Contamination Levels (pCi/L) at Groundwater Monitoring Well 199-N-4.....4-43
9 Figure 4-23. Annual Average Tritium Concentrations (pCi/L) at N Springs (100 Area Liquid
10 Effluent Reports)4-44
11 Figure 4-24. Nitrate and Head Measurements at Groundwater Monitoring Well 199-N-3
12 Between 1970 and the Present.....4-45
13 Figure 4-25. Current Regional Distribution of Nitrate in the 100-N Area4-46
14 Figure 4-26. Well Drilling Location Map4-56
15 Figure 4-27. 100-N Decision Unit Groundwater RI/FS Sampling Locations4-58
16 Figure 5-1. Addendum 5 Project Schedule.....5-2
17

1

2

3

This page intentionally left blank.

Tables

1		
2	Table 1-1.	Summary of Facility Status in the 100-N Decision Unit (April 2009).....1-4
3	Table 1-3.	Summary of Preliminary Findings for the 100-NR-2 Ecological Impact Assessment.....1-27
4	Table 2-1.	100-N Decision Unit Site Location Information2-1
5	Table 2-2.	Significant Dates for 100-N Area Operation (from DOE/RL-90-22).....2-4
6	Table 2-3.	Summary of Waste Sites in the 100-N Decision Unit (April 2009)2-10
7	Table 2-4.	Summary Information on the Status of the 100-N Decision Unit Facilities.....2-12
8	Table 2-5.	Elevation and Thickness of Major Geologic Units Beneath the 100-N Area2-14
9	Table 2-6.	Summary of 100-N Area Limited Field Investigation (Vadose)2-38
10	Table 2-7.	Closed Out and Interim Closed Out Waste Sites in the 100-N Decision Unit.....2-41
11	Table 2-8.	Summary of the Limited Field Investigations for the 100-N Area.....2-44
12	Table 4-1.	Radionuclide Concentrations and Estimated Annual Discharges in 1969 to 1970 from
13		N Reactor Effluents (DUN-7372)4-3
14	Table 4-2.	Annual Volume and Radioactive Contaminant Releases to 1301-N and 1325-N
15		Liquid Waste Disposal Facilities4-4
16	Table 4-3.	Annual Wastewater Volume and Sodium Dichromate Releases to 1301-N and 1325-N
17		Liquid Waste Disposal Facilities4-9
18	Table 4-4.	Identified Data Gaps and Needs for the 100-N Decision Unit4-49
19	Table 4-5.	Proposed 100-N Decision Unit Characterization.....4-53
20	Table 4-6.	Number of Field Samples and Analytes Proposed for the 100-N Decision Unit.....4-53
21		
22		

1

2

3

This page intentionally left blank.

Terms

1		
2	AA	atomic absorption
3	ABT	Apatite Barrier Technology
4	AEA	<i>Atomic Energy Act of 1954</i>
5	AEC	Atomic Energy Commission
6	aka	also known as
7	amsl	above mean sea level
8	ARAR	applicable or relevant and appropriate requirement
9	AWQC	Ambient Water Quality Criteria
10	bgs	below ground surface
11	CD	compact disk
12	CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of</i>
13		<i>1980</i>
14	COC	contaminant of concern
15	COPC	contaminant of potential concern
16	CrVI	hexavalent chromium
17	COPEC	contaminant of potential ecological concern
18	CSM	conceptual site model
19	CVP	cleanup verification package
20	D&D	decontamination and decommissioning
21	D4	deactivation, decommissioning, decontamination, and demolition
22	DOE	U.S. Department of Energy
23	DOW	description of work
24	DQO	data quality objectives
25	DWS	drinking water standard
26	Ecology	Washington State Department of Ecology
27	EMA	elevated metals area
28	ENU	Elementary Neutralization Unit
29	EPA	U.S. Environmental Protection Agency
30	ERA	Expedited Response Action

1	ERDF	Environmental Restoration Disposal Facility
2	EWS	Export Water System
3	FFS	focused feasibility study
4	FS	feasibility study
5	GPR	ground-penetrating radar
6	GPS	Global Positioning System
7	GW	groundwater
8	H ₂ SO ₄	sulfuric acid
9	HGP	Hanford Generating Project
10	IC	ion chromatography
11	ICP	inductively coupled plasma
12	ICR	incremental cancer risk
13	ISS	interim safe storage
14	ISV	in situ vitrification
15	ITRD	Innovative Treatment and Remediation Demonstration
16	K _d	soil distribution coefficient
17	LFI	limited field investigation
18	LTS	Long-Term Stewardship
19	LWDF	Liquid Waste Disposal Facilities
20	MCL	maximum contamination limit
21	MNA	monitored natural attenuation
22	msl	mean sea level
23	NaOH	sodium hydroxide
24	NAPL	non-aqueous phase liquid
25	NPDES	National Pollutant Discharge Elimination System
26	OSE	orphan site evaluation
27	OU	operable unit
28	PCB	polychlorinated biphenyl
29	PECA	preliminary engineering cost analysis
30	PNNL	Pacific Northwest National Laboratory

1	PRB	permeable-reactive barrier
2	PRG	preliminary remedial goal
3	QA	quality assurance
4	QAPjP	quality assurance project plan
5	QC	quality control
6	QRA	qualitative risk assessment
7	RAG	Remedial Action Goal
8	RAO	remedial action objective
9	RCBRA	River Corridor Baseline Risk Assessment
10	RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
11	RD/RAWP	Remedial Design/Remedial Action Work Plan
12	RI	remedial investigation
13	RL	U.S. Department of Energy, Richland Operations Office
14	ROD	record of decision
15	RTD	removal, treatment, and disposal
16	RUM	Ringold Upper Mud
17	SAP	sampling and analysis plan
18	SDA	suspected diesel contaminated area
19	SIS	Stewardship Information System
20	SME	subject matter expert
21	SPA	strontium plume area
22	Sr-90	Strontium-90
23	SVOC	semivolatile organic compound
24	SWMU	solid waste management unit
25	TAG	Technical Advisory Group
26	TBD	to be determined
27	TCE	trichloroethylene
28	TCLP	Toxicity Characteristic Leaching Procedure
29	TPH	total petroleum hydrocarbons
30	TPH-DR	total petroleum hydrocarbons – diesel range

1	Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i> (Ecology et al., 1989a)
2	TSD	treatment, storage, and disposal
3	UCL	upper confidence limit
4	UPR	unplanned release
5	VOA	volatile organic analyte
6	VOC	volatile organic compound
7	WAC	<i>Washington Administrative Code</i>
8	WIDS	Waste Information Data System
9	ZOI	zone of interaction

1 Introduction

This document is Addendum 5 to DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan*. This addendum describes the 100-N Decision Unit and planned efforts to conduct a remedial investigation (RI) in support of a final record of decision (ROD). The 100-N Decision Unit includes the 100-NR-1 Source Operable Unit (OU) and the 100-NR-2 Groundwater OU. The integrated work plan contains the planning elements common to the Hanford Site 100 Area source and groundwater OUs and a summary of the RI/feasibility study (FS) tasks. Figure 1-1 shows the relationship between the RI/FS work plan and this addendum.

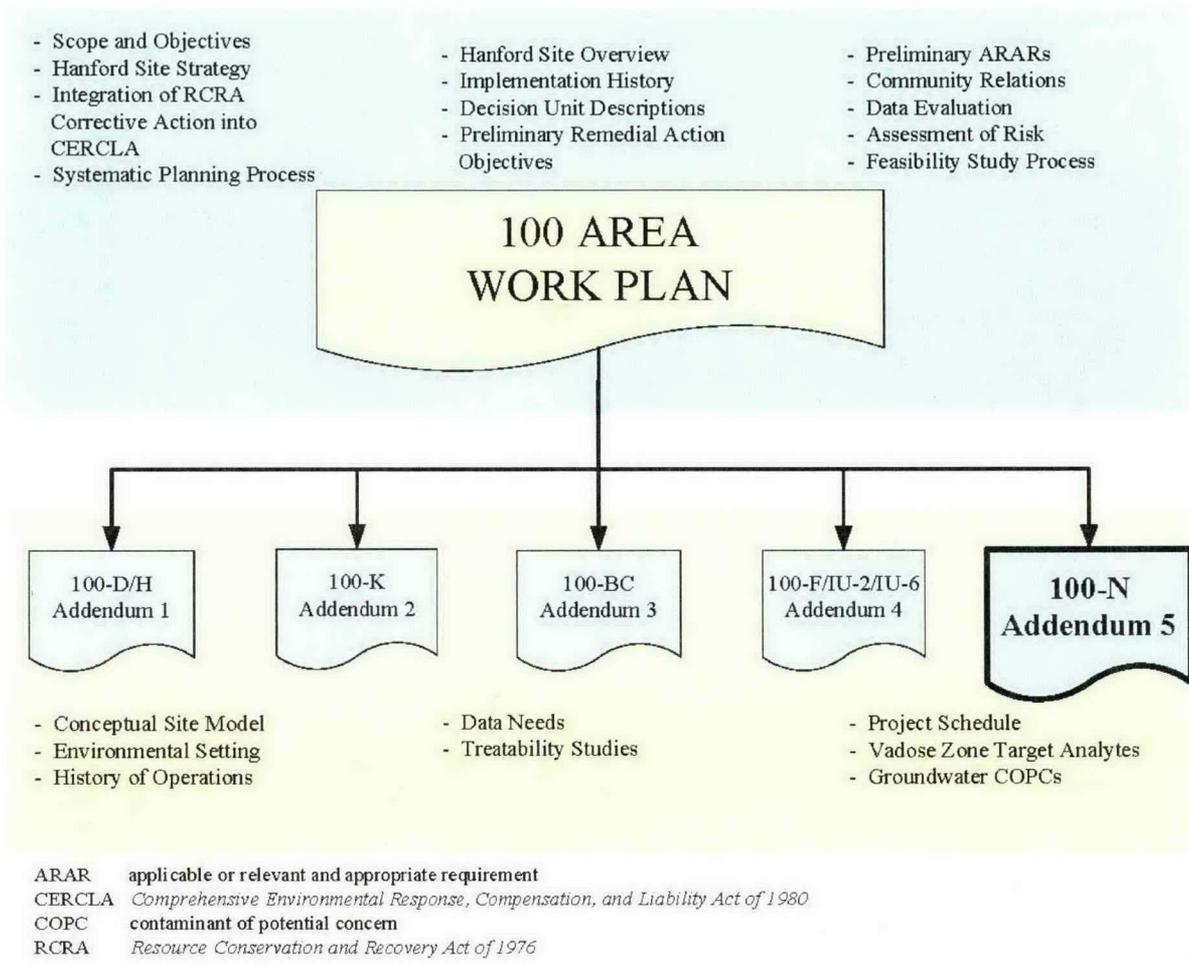


Figure 1-1. Relationship between the Work Plan and Addenda

This addendum describes key data collection and analysis elements that will support final remediation decisions for the 100-N Decision Unit. The planning process followed to develop this addendum included evaluating the results of past and ongoing remediation activities; describing the remaining uncertainties in the context of a conceptual site model (CSM)⁵ to support remedial decisions; and justifying the type,

⁵ A conceptual site model is a set of hypotheses and assumptions about the physical characteristics (e.g., media properties) and phenomena (e.g., model of fluid flow) that describe and postulate the behavior of contamination. The conceptual site model describes contaminant sources and receptors, and the interactions linking them; and is used to identify uncertainties and provide a framework to identify data and information needed to resolve each uncertainty. Conceptual site models evolve as new data and information are developed.

1 location, and quantity of data needed to reduce or eliminate the identified uncertainties. A key component
2 of the planning process involved developing “plates” (see Appendix A) that present the CSM components
3 needed to help identify principal study questions, supporting information, and resulting data gaps that
4 may require further evaluation. These plates were provided to DOE/RL and Ecology for review and
5 comment. A working session was held to discuss and resolve comments, and initiate CSM plate updates.
6 Upon completion of the CSM plates, the contractors developed the data needs and proposed sampling
7 approaches outlined in this addendum.

8 **1.1 Scope**

9 This addendum addresses the data and information needed to support groundwater and waste site
10 remediation investigations associated with the 100-N Decision Unit. Geographically, the 100-N Decision
11 Unit consists of the 100-N Reactor Area, portions of the adjacent 600 Areas, and associated waste sites.
12 Figure 1-2 shows the location of the 100-N Decision Unit and its proximity to other decision units.

13 This addendum identifies data gaps and a process to address the gaps whose resolution is significant to
14 making informed remediation decisions. The CSM is a useful tool to guide characterization and identify
15 effective remediation gaps. A CSM is a representation of the site that organizes the information available
16 and provides a summary of the site conditions. More importantly, a CSM can identify data gaps and
17 establish programmatic priorities for sampling and testing hypotheses.

18 Additional data collection and other investigations address data gaps significant to making remediation
19 decisions. The CSM addresses contaminant sources, nature and extent of contamination, fate and
20 transport, and exposure assessment (River Corridor Baseline Risk Assessment, [RCBRA]); it supports
21 risk characterization, remedial action selection, performance monitoring, and site closure. Chapter 2
22 provides the background and environmental setting information necessary to support the development of
23 the 100-N Decision Unit CSM.

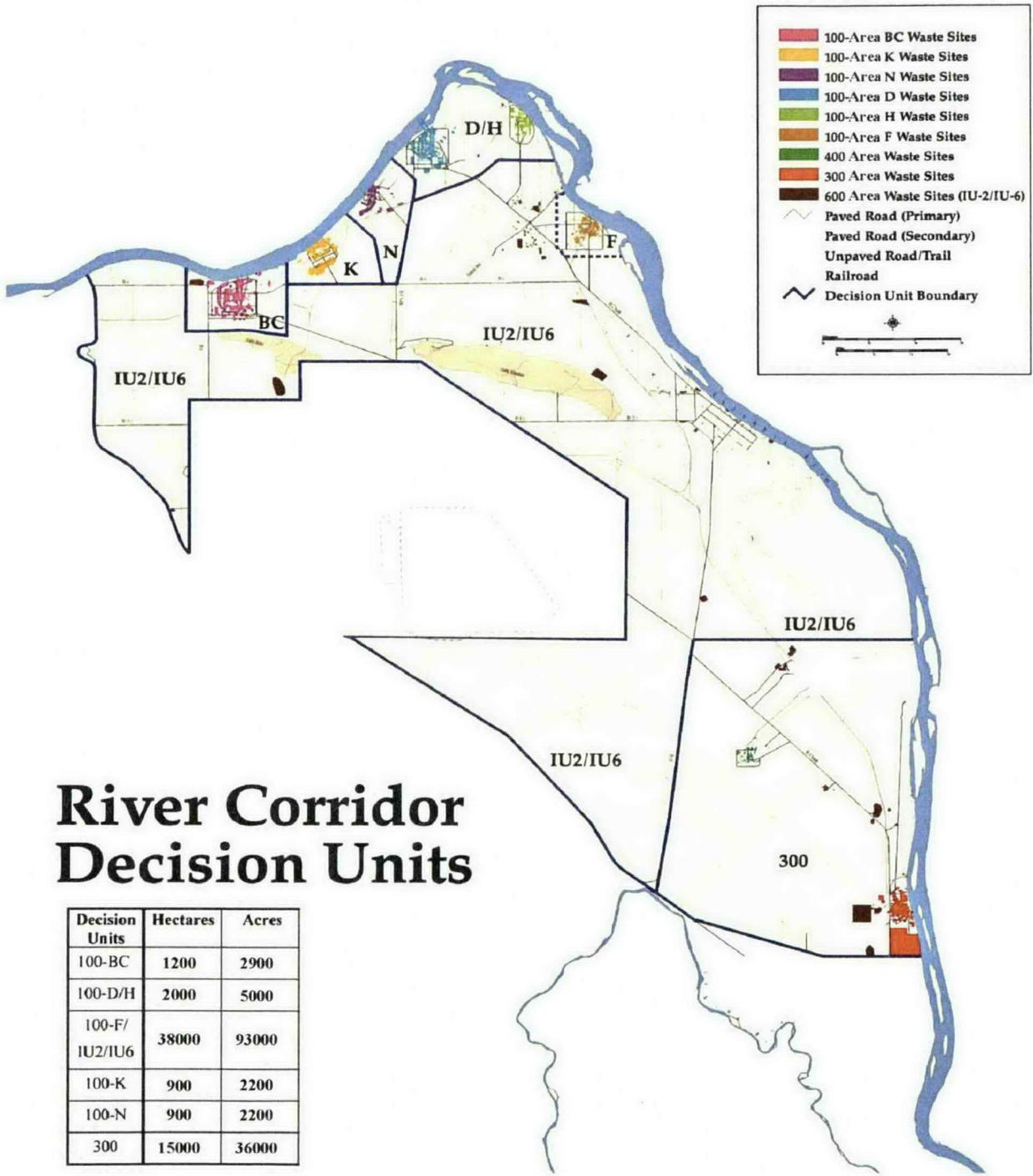
24 During multiple workshops, presentations, and meetings, the use of CSM component summaries
25 identified and fostered discussion of issues of concern to the participants. This information was used to
26 solicit input from regulators, agencies, and subject matter experts (SMEs) (provided in Appendix A).
27 Chapter 4 presents the CSM and data gaps/needs table for the 100-N Decision Unit.

28 Most importantly, data needs identification led to development of a sampling and analysis plan (SAP) that
29 establishes characterization activities specific to the 100-N Decision Unit. The SAP (DOE/RL-2009-42,
30 *Sampling and Analysis Plan for the 100-N Decision Unit Remedial Investigation/Feasibility Study*)
31 includes a field sampling plan with the sampling strategy and techniques to obtain the data required for
32 the RI/FS. The SAP provides a quality assurance project plan (QAPjP) to ensure data collected meet the
33 appropriate quality assurance (QA) and quality control (QC) requirements.

34 **1.2 100-N Remediation Accomplishments**

35 A considerable amount of environmental remediation and restoration is already completed or planned at
36 the Hanford Site. These remediation activities, many of which are ongoing, have achieved significant
37 cleanup progress across the site. These activities include characterizing groundwater plumes and their
38 potential sources, cleaning up the groundwater and soil, and testing new and alternative treatment
39 methods specific to the issues and contaminants on the Hanford Site.

40 The following subsections provide information on the cleanup progress already undertaken in the
41 100-N Decision Unit.



River Corridor Decision Units

Decision Units	Hectares	Acres
100-BC	1200	2900
100-D/H	2000	5000
100-F/ IU2/IU6	38000	93000
100-K	900	2200
100-N	900	2200
300	15000	36000

Figure 1-2. River Corridor Decision Unit Boundaries

1
 2

1 **1.2.1 100-N Decision Unit Deactivation, Decommissioning, Decontamination,**
 2 **and Demolition Actions**

3 The 100-N Decision Unit includes 234 former and remaining facilities, including the reactor, water
 4 treatment plants, a generating plant, storage buildings, offices, maintenance shops, process plants, an
 5 electric substation, storage tanks, pump stations, and outfall structures. The definition of facility
 6 (as applied to the Facility Decommissioning Process) is “a freestanding building, plant, laboratory, or
 7 other enclosure and associate buildings that fulfills, or fulfilled, a specific purpose, and is owned by or
 8 otherwise under the responsibility of the DOE.” (Note: this usage differs substantially from that in the
 9 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* [CERCLA] and
 10 *Resource Conservation and Recovery Act of 1976* [RCRA]). Until the structures that are located over
 11 a source site are removed, soil remediation cannot be completed. The facilities are—and have been—
 12 undergoing removal to clear the way for remedial work focusing on underlying soil contamination.
 13 Table 1-1 shows the status of the 234 100-N Decision Unit facilities.

Table 1-1. Summary of Facility Status in the 100-N Decision Unit (April 2009)

Area	Total Number of Facilities	Demolished	Removed	Active	Inactive
100-N Decision Unit Total	234	96	82	27	29

Active: Facility is occupied and in use (supports Hanford Site missions).

Removed: Facility foundation has been removed along with any substructure 0.3 to 0.9 m (1 to 3 ft) below grade.

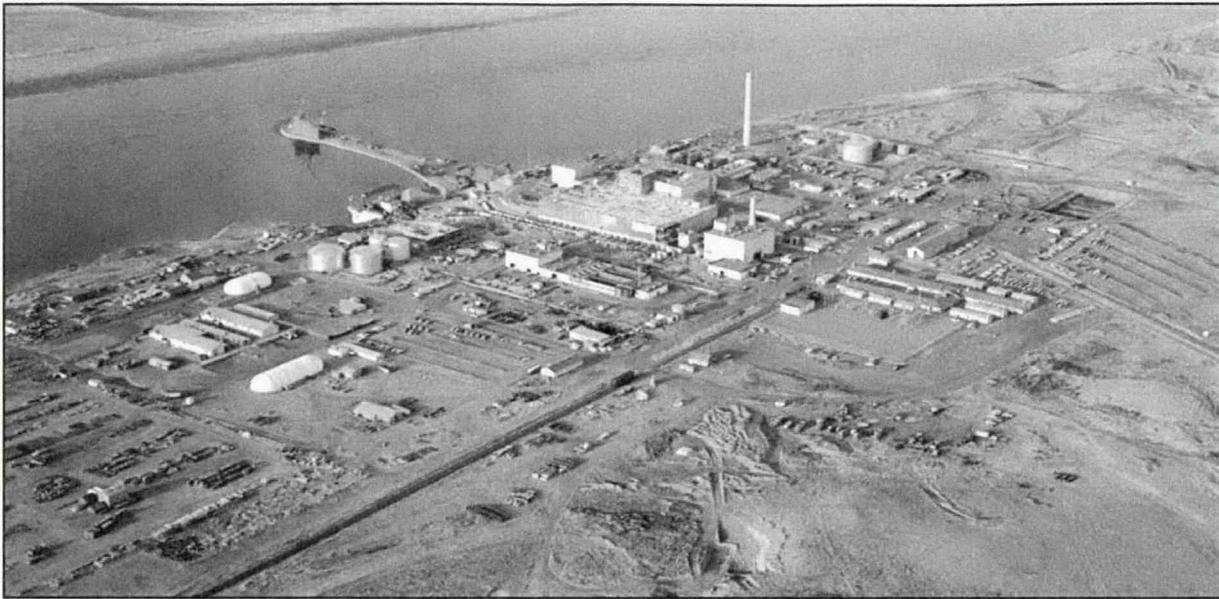
Inactive: Facility is no longer in use and is waiting decommissioning and demolition.

Demolished: Facility has been removed to grade (slab or foundation remains).

14 Since April 2009, the N Reactor began undergoing the final stage of stabilizing and enclosing the highly
 15 radioactive reactor core in an upgraded, weather-resistant shell for potentially 75 years. This stabilization,
 16 interim safe storage (ISS), will prevent environmental degradation of the structure and prevent the spread
 17 of contamination. The ISS shell also will serve to minimize the spread of any potential contamination
 18 from and beneath the reactor. ISS completion is scheduled for September 2011. These actions minimize
 19 the facility footprint by removing peripheral reactor buildings and equipment and disposing of the debris.
 20 The principal structures remaining are the Reactor (105-N) and the Heat Exchanger Building (109-N).

21 Along with ISS activities, the 100-N Area is undergoing continued deactivation, decommissioning,
 22 decontamination, and demolition (D4). Figures 1-3, 1-4 and 1-5 provide illustrations of the 100-N Area
 23 D4 actions and progress. A complete status of facilities in the 100-N Decision Unit is provided in
 24 Appendix D.

This page intentionally left blank.



1
2
3
Figure 1-4. Aerial Photos of 100-N in 1962



4
5
Figure 1-5. Aerial Photos of 100-N in 2008 Displaying D4 Progress

6 **1.2.2 100-N Decision Unit Waste Site Remediation**

7 In 1996, the overall pace of the Hanford Site cleanup along the river accelerated. An expedited response
8 action to address Strontium-90 (Sr-90) groundwater contamination was implemented at N-Springs
9 (*Action Memorandum: N-Springs Expedited Response Action Cleanup Plan, U. S. Department of Energy
10 Hanford Site, Richland, WA; Ecology and EPA, 1994*) and several interim action RODs were adopted for
11 source and groundwater OUs in the various reactor areas. The primary focus for source OUs was former
12 liquid effluent sites for which removal, treatment (as necessary), and disposal (RTD) is the standard

1 remedy. The RTD was designed to achieve the remedial action objectives (RAOs) and goals specified in
2 interim action RODs for direct exposure 0-4.6 m (0-15 ft) below groundwater surface and protection of
3 groundwater and the Columbia River. However, the interim action RODs for the OUs located at the
4 100-N Area were not adopted until 1999 and after (EPA/ROD/R10-99/112, *Interim Remedial Action*
5 *Record of Decision for the 100-NR-1 and -NR-2 Operable Units of the Hanford 100-N Area, Washington*
6 *State Department of Ecology, Olympia, Washington*; EPA/ROD/R10-00/120, *Interim Remedial Action*
7 *Record of Decision for the 100-NR-1 Operable Unit of the Hanford 100-N Area, Hanford Site, Benton*
8 *County, Washington, U.S. Environmental Protection Agency, Washington State Department of Ecology*;
9 EPA/ESD/R10-03/605, *Explanation of Significant Difference for the 100-NR-1 Operable Unit Treatment,*
10 *Storage, and Disposal Interim Action Record of Decision and 100-NR-1/NR-2 Operable Unit Interim*
11 *Action Record of Decision, May 2003, Washington State Department of Ecology, and U.S. Department*
12 *of Energy*).

13 Each excavation is soil sampled and modeled (if needed) to assess the potential impact to human health,
14 groundwater, and the Columbia River from residual contamination. Every remediated waste site is
15 sampled and analyzed as part of cleanup verification to demonstrate that remedial actions achieved the
16 RAOs. Where remedial action goals and objectives are achieved, the waste site is considered
17 interim closed.

18 Through 2009, roughly 97,775 metric tons (107,777 tons) of contaminated soil and debris have been
19 removed from 100-N Area waste sites and more than 650 soil samples have been collected to verify
20 cleanup and document interim closure status. Figures 1-6 and 1-7 show the excavations for two sites—the
21 116-N-1 (1301-N) and 116-N-3 (1325-N) Cribs and Trenches. These two liquid disposal facilities were
22 the major sources of contamination to the groundwater.



23
24

Figure 1-6. Excavation to Remove Contaminated Soil at 116-N-1 Crib and Trench



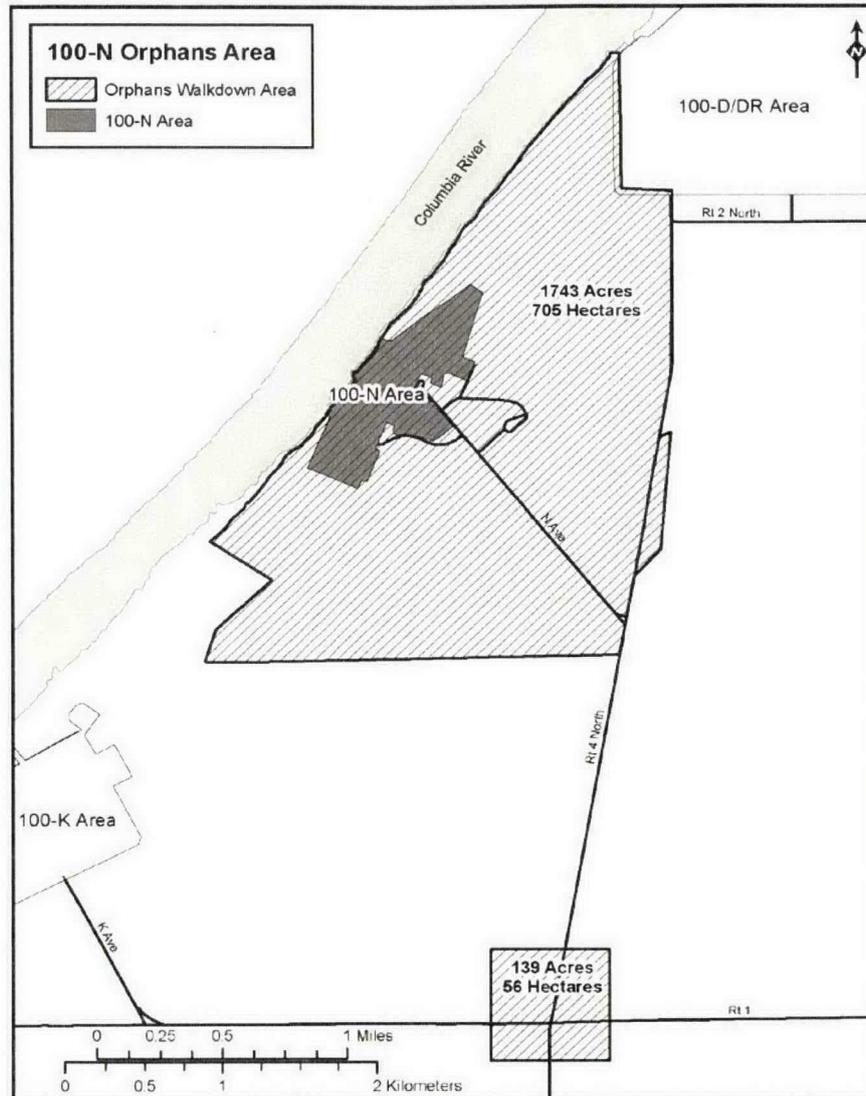
1
2 **Figure 1-7. Excavation of Contaminated Soil at 116-N-3 Crib and Trench**

3 Of the 175 waste sites identified in the 100-N Decision Unit through April 2009, 18 have been closed or
4 interim closed, and 38 have been assigned a no action or not accepted status (Chapter 2, Table 2-3). These
5 status categories generally indicate whether a site meets the cleanup goals and objectives of the interim
6 action RODs. At present, 92 accepted waste sites remain to be cleaned up in the 100-N Decision Unit, and
7 27 discovery sites remain to be dispositioned. Interim remedial actions are scheduled for completion by
8 the end of 2011.

9 **1.2.3 100-N Decision Unit Orphan Site Evaluation**

10 An orphan site evaluation (OSE) was conducted on the highest potential impact areas of the
11 100-N Decision Unit to identify unknown waste sites potentially requiring additional characterization
12 and possibly remediation (OSR-2009-0001, *100-NR-1 Area Orphan Sites Evaluation Report, Draft A*).
13 The orphan site evaluation in the 100-NR-1 OU was conducted between August 2006 and March 2007.
14 A detailed description of the orphan site evaluation process is provided in Chapter 2. The scope, shown
15 in Figure 1-8, covered a total area of approximately 7.62 km² (2.94 mi²) (761 ha [1,882 ac]). A total of
16 23 orphan sites were identified during the evaluation process. These discovery sites will be incorporated
17 into the Decision Unit according to the TPA-MP-14 process (RL-TPA-90-0001, *Tri-Party Agreement*
18 *Handbook Management Procedures, Guideline Number TPA-MP-14, "Maintenance of the Waste*
19 *Information Data System (WIDS),"* U.S. Department of Energy, Richland Operations Office, Richland,

1 *Washington, 2007*) and addressed according to interim action RODs or ROD amendments. The 23 orphan
2 waste sites are included in the decision unit waste site count of 175.



3
4 **Figure 1-8. Area Addressed by 100-N Area Orphan Sites Evaluation Process**

5 **1.2.4 100-N Decision Unit Pump-and-Treat System**

6 The widespread Sr-90 plume was derived from two liquid waste disposal facilities (1301-N and 1325 N).
7 The discharges to these two facilities resulted in establishing riverbank seeps almost immediately after
8 N Reactor operations began; the seeps were called N-Springs. The effect of releases at N-Springs to the
9 Columbia River was initially monitored using 13 short, perforated, carbon steel casings located at the
10 edge of the riverbank below the seepage face. Sr-90 levels as high as 9,100 pCi/L were recorded at
11 N-Springs-3 in 1988, with the majority of the releases found between locations N-Springs-1 and
12 N-Springs-6. BHI-00185 presents the groundwater conditions at N-Springs (circa 1994) that required the
13 Expedited Response Action (ERA) described below.

1 In January 1994, RL submitted to EPA and Ecology an engineering evaluation/cost analysis entitled the
2 N-Springs ERA Proposal, DOE\RL-93-23. The ERA Proposal evaluated multiple alternatives (reviewed
3 and screened 5 technologies and 20 process options) to reduce the Sr-90 flux to the Columbia River. The
4 ERA proposal recommended a vertical barrier composed of a slurry wall 853.4 m (2,800 ft long)
5 constructed by a deep soil mixing method, to cut off Sr-90 contamination flux to the river. The ERA
6 Proposal established a primary objective of eliminating, or significantly reducing, the flux of Sr-90 to the
7 Columbia River through the N-Springs.

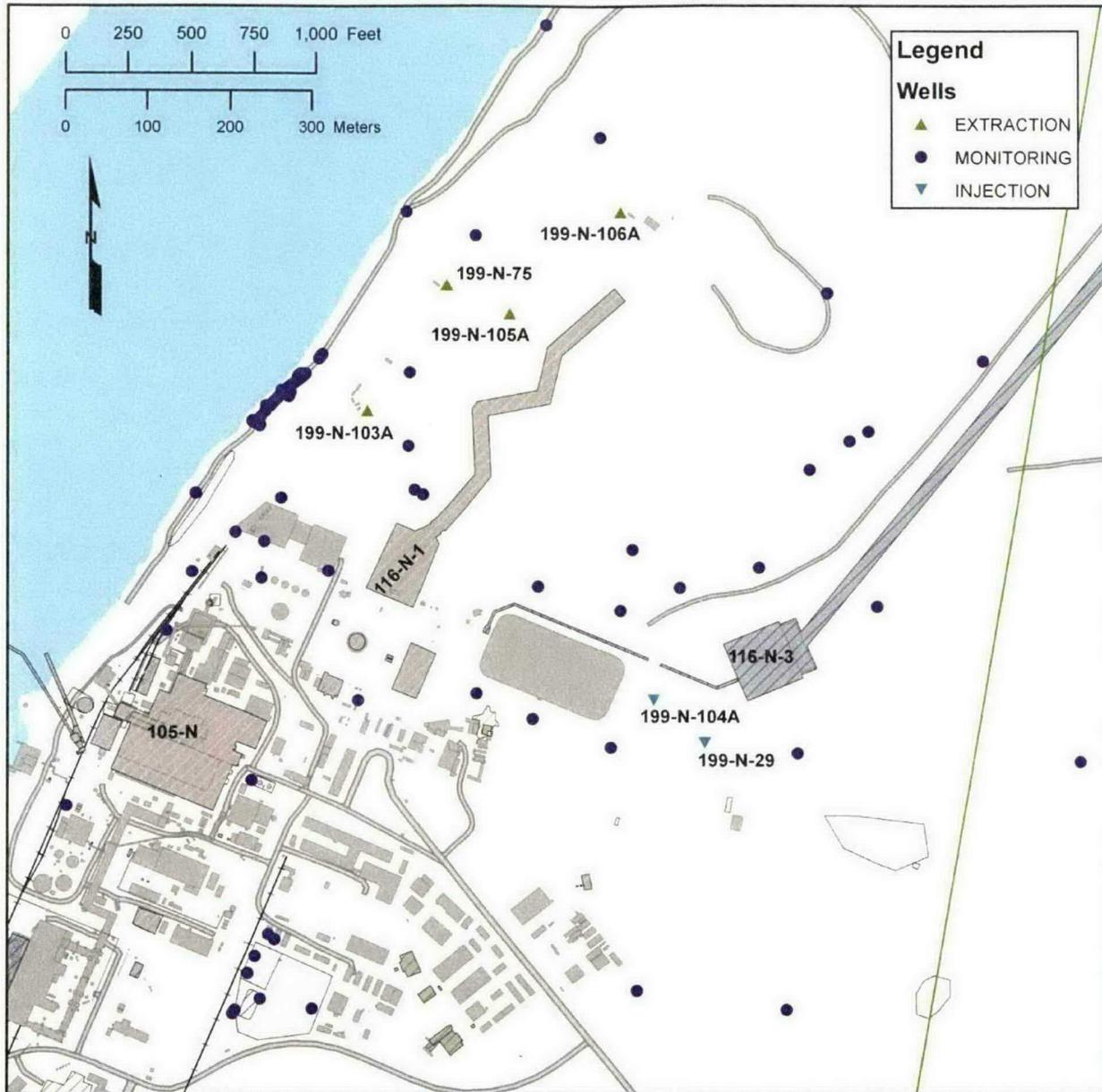
8 On February 22, 1994, an Independent Technical Review Report was made available for review and
9 comment as part of the ongoing public comment period on the ERA Proposal (AS1, 1994). This report
10 presented the conclusions of the panel of independent third-party technical experts regarding the technical
11 adequacy and conclusions of the N-Springs ERA Proposal. The independent review board expressed
12 concern with many of the findings and conclusions in ERA Proposal, including the assumed effectiveness
13 of the pump-and-treat remedy, and noted uncertainties in the ability of the methods to achieve the
14 estimated Sr-90 removal levels. A recommendation was made to reassess the potential constructability of
15 a grouted, interlocked sheet pile wall, and the feasibility of constructing a barrier within 15.24 m (50 ft) of
16 the Columbia River. These discussions were followed by an Action Memorandum.

17 The Action Memorandum, (*Action Memorandum: N-Springs Expedited Response Action Cleanup Plan*,
18 Ecology and EPA, 1994) dated September 23, 1994, required installing and operating a 189 L/min
19 (50 gpm) pump-and-treat system by September 1995 and a grouted-hinge sheet pile wall at the
20 river's edge.

21 The Action Memorandum presented a new alternative that was adopted based on the combination of
22 public comments, the conclusions reached in the Independent Technical Review, and the information in
23 the historical documents. In correspondence dated March 23, 1995, Ecology and EPA concurred with RL
24 that installing the sheet pile wall could not be achieved in the manner specified. Ecology and EPA
25 subsequently directed RL to proceed with installing a pump-and-treat system as an ERA. The N-Springs
26 pump-and-treat system was completed by August 1995 and in full operation by September 1995, meeting
27 the Tri-Party Agreement Milestone M-16-12D. Based on recommendations in the N-Springs Expedited
28 Response Action Performance Evaluation Report (DOE/RL-95-110) and the N-Springs Pump-and-treat
29 Optimization Study (DOE-RL-1997), the system was upgraded to operate at 227 L/min (60 gpm)
30 beginning on December 17, 1996. Under this configuration, the network consisted of four extraction wells
31 (199-N-75, 199-N-103A, 199-N-105A, 199-N-106A) and two injection wells (199-N-29 and
32 199-N-104A), as depicted in Figure 1-9. The optimized extraction wells were located to reduce the flux of
33 Sr-90 to the Columbia River along this seepage face. The Sr-90 was removed from groundwater by
34 passage through vertical tanks containing clinoptilolite, which was later disposed in ERDF.

35 The pump-and-treat system captured water along the entire length of the 1301 N trench and performed as
36 designed during the optimization study. However, the system demonstrated a limited capability to remove
37 Sr-90 from the aquifer and was terminated in March 2006.

38 From September 1996 through March 2006, the pump-and-treat system in the 100-N Decision Unit
39 treated more than 1.1 billion L (305 million gal) of groundwater and removed approximately 1.8 Ci of
40 Sr-90 from the aquifer in the 100-NR-2 OU (DOE/RL-2008-66, *Hanford Site Groundwater Monitoring*
41 *Report for Fiscal Year 2008*, Rev. 0). In the 100-N Area, between 72 and 85 Ci of Sr-90 remain in the
42 saturated sediment and 0.8 Ci in groundwater (PNNL-17429; EPA/ROD/R10-99/112).



1
2 **Figure 1-9. Location of the 100-NR-2 Pump-and-Treat System Wells (2008)**

3 Despite the hydraulic containment provided by the pump-and-treat system, elevated Sr-90 concentrations
4 near the shoreline have persisted since the beginning of pump-and-treat operations. Figure 1-10 illustrates
5 the impact of the pump-and-treat system on Sr-90 concentrations in the groundwater at the riverbank. The
6 green line shows that discharge to the cribs discontinued in 1991. The red line shows annual average
7 concentrations of Sr-90 in porewater at Well N-46, which is located at the road along the riverbank within
8 the Sr-90 plume. Concentrations steadily increased from 1980 until about 1989. Since that time,
9 concentrations have fluctuated widely, presumably in response to river stage and sampling date relative to
10 water level. Nevertheless, near-shore pore fluid Sr-90 concentrations have remained elevated. This
11 observation confirms modeling results indicating that Sr-90 in the near-shore aquifer or stream bank
12 storage zone will decline primarily by radioactive decay. In marked contrast, tritium (a non-adsorbing,
13 100-NR-2 co-contaminant) declined rapidly after the beginning of pump and treat operations and is

1 currently at or below the detection limit (~200 pCi/L) in near-shore groundwater samples, but remains
2 elevated (average of about 20,000 pCi/L) in the pump-and-treat capture zone (DOE-RL 2006-08,
3 *Calendar Year 2005 Summary of 100-Area Pump and Treat Operations*). This observation provides
4 evidence that the predicted hydraulic containment functioned as designed. Although the pump-and-treat
5 system may have met the objective of reducing the flow of groundwater (and non-adsorbing
6 co-contaminants) in the sSr-90 plume area to the river, it has not met the objective of reducing Sr-90
7 concentrations in aquifer pore fluid at the shoreline or in the stream bank storage zone. Minimizing
8 exposure of eco-receptors in the near-shore aquatic and riparian zone to Sr-90, the primary 100-NR-2
9 contaminant of potential ecological concern (DOE-RL 2005-96, Rev. 0, Reissue, *Strontium-90*
10 *Treatability Test Plan for 100-NR-2 Groundwater Operable Unit*), requires a different approach.



11
12 **Figure 1-10. Apatite Barrier Technology Test Site Adjacent to the**
13 **Columbia River at the 100-N Area**

14 **1.2.5 Hanford N-Springs Sheet Pile Program Summary**

15 Between December 2 and December 30, 1994, DOE-RL conducted a sheet pile installation test program.
16 The objective was to evaluate the ability to drive sheet pile to a depth of 15 m (50 ft) along the proposed
17 914.4 m (3,000 ft) barrier wall alignment. Initial subcontractor attempts used vibratory hammers to install
18 piling. After several failed efforts, a diesel impact hammer was attempted without success. It became
19 obvious that larger hammers would be required if the dense soil was to be penetrated. Test pits confirmed
20 that dense soil and medium-sized obstructions prevented penetration. A more powerful, variable energy
21 hydraulic hammer was obtained and tested. Early indications appeared successful; however, after
22 extraction, it was determined that the pile had reached only ~9 m (~30 ft) below ground surface. The
23 high-energy impact hammer resulted in destroying the bottoms of the test piles. Three drive tests were
24 completed with similar results: sheet pile destruction after penetrating ~9 m (~30 ft), yet 3 to 6 m

1 (10 to 20 ft) short of the target depth objective clay unit. Adequate testing was performed to demonstrate
2 that interlocking piling could not be driven to the clay layer and severe damage occurred at lesser depths.
3 It was concluded that the Ringold Formation was not penetrable with standard sheet piling installation
4 methods and a sheet pile barrier could only be installed after the in situ material was broken up and
5 loosened prior to pile driving.

6 **1.2.6 In Situ Treatability Test Planning Workshop Report**

7 The following text is paraphrased from the "In Situ Treatability Test Planning Workshop
8 Report." (BHI-00787).

9 "On May 1 and May 2, 1996, the U.S. Department of Energy (DOE), Richland Operations Office
10 (RL) conducted a planning workshop for the In Situ Treatment Zone (ISTZ) treatability test. The
11 proposed ISTZ was a 9m 30 (ft) deep by 1m (3ft) wide by 30m (100ft) long trench filled with
12 clinoptilolite, a naturally occurring zeolite mineral. The proposed location of the treatability test was
13 along an access road, approximately parallel to the Columbia River at the shoreline. The ISTZ
14 would be constructed by either conventional trench excavation with shoring systems, or by auger
15 drilling with steel casings to provide the excavation and earth-support systems. The purpose of the
16 ISTZ test was to provide an innovative, long-term remedial treatment for groundwater
17 contaminated with Sr-90.

18 The objectives of the treatability test were to demonstrate the feasibility of using ISTZ to
19 accomplish the following:

- 20 • Cause the Sr-90 to be adsorbed from the groundwater that passes through the zone
- 21 • Delay Sr-90 from reaching the Columbia River.

22 The objective of the groundwater remediation alternative was to reduce the flux of Sr-90 to the
23 Columbia River. In the short term, Sr-90 concentrations would be reduced as groundwater leaves
24 the ISTZ and enters the Columbia River. In the long term, the delay would be sufficient for natural
25 decay to occur so that the concentration levels would be below regulatory concern when the Sr-90
26 finally breaks through the ISTZ.

27 Secondary objectives of the treatability test were to demonstrate:

- 28 • Constructability
- 29 • That the ISTZ test can be accomplished while preserving Native American cultural and
30 religious values

31 The workshop was attended by regulators, stakeholders, and several Native American tribes.
32 Concerns centered on the following:

- 33 • Constructability of the ISTZ
- 34 • ISTZ performance in preventing migration of Sr-90 to the Columbia River
- 35 • Native American Tribal cultural and religious values
- 36 • Applicability of an ISTZ in the 100-N Area

1 Agreements reached and documented at the conclusion of the workshop included:

- 2 • All parties agreed that the ISTZ could be constructed.
- 3 • All parties agreed that improved shoring will not be needed for the short-term ISTZ test.
- 4 • No riprap will be left along the Columbia River bank after the test.
- 5 • All parties agreed that the treatability test plan would be updated to reflect the results of the
- 6 discussions associated with concerns noted during the workshop and in an earlier
- 7 questionnaire.
- 8 • All parties agreed that a proposed upcoming CMS will address specific issues related to
- 9 long-term implementation of the ISTZ, which are outlined in the concerns.
- 10 • All parties agreed that the ISTZ will be removed at the end of the test."

11 **1.2.7 Innovative Treatment and Remediation Demonstration Program**

12 The Innovative Treatment and Remediation Demonstration (ITRD) Program was initiated in 1993 by
 13 DOE in cooperation with EPA's Technology Innovation Office. The following text describing the results
 14 of that effort is paraphrased from the summary ITRD final report.

15 In January 1998, the DOE Hanford Field Office requested ITRD technical assistance to evaluate
 16 innovative technologies to address strontium-90 (90Sr) contamination in the vadose zone and in
 17 the groundwater at the 100-N site. The Hanford Environmental Restoration program asked that the
 18 ITRD project focus on identification of technologies for long-term implementation to enhance or
 19 improve the baseline design for groundwater remediation (pump-and-treat), and support the
 20 assessment of innovative approaches needing further evaluation for site-specific implementation.

21 The ITRD formed and coordinated a Technical Advisory Group (TAG) with technology experts and
 22 participants from site-specific government, industry, and regulatory groups. At the beginning of the
 23 ITRD, contaminated soil had been removed to 4.6 m (15 ft) below average grade in the 1301-N
 24 and 1325 N liquid waste disposal facilities and disposed at ERDF, the pump-and-treat system at
 25 N-Springs was operational, and groundwater monitoring was continuing.

26 The strength of the ITRD process rested in its review and evaluation of approximately 40
 27 technologies, as shown in Table 1.

Table 1. Technologies Considered for 100-N Area through the ITRD Process

Technology	Type or Source
Electrokinetic shoreline w/surfactant	In situ
Soil flushing – aquifer/shoreline w/amendments	In situ
Permeable treatment wall – funnel and gate	In situ
Permeable treatment wall – zeolite/CaSO ₄ /phosphate/apatite	In situ
Permeable treatment wall – Fe ⁰	In situ
Chemical Fixation – Apatite/Phosphate/Sulfite/Carbonate	In situ
Chemical Fixation - Modification of aquifer materials	In situ
Natural Attenuation	In situ

Table 1. Technologies Considered for 100-N Area through the ITRD Process

Technology	Type or Source
Pump-and-treat	In situ
Passive hydraulic – barrier/hydraulic control	In situ
Contaminated zone – freezing with excavation	In situ
Phytoremediation	In situ
In situ vitrification	In situ
Oxidation of Manganese	In situ
Injectable barrier – 300 year flowpath	In situ
Bioaccumulation (shellfish, oysters, etc)	In situ
Impermeable barrier (chromium, sulfite, nitrate)	In situ
Chemical Process	In situ
Recirculation wells	In situ
Jet Grouting	In situ
Gel technology to form impermeable barrier	In situ
Slurry walls/grout curtains/sheet pile	In situ
Cryogenic barrier	In situ
Biologic barrier	In situ
Cryosweep	In situ
Total Excavation	In situ
Mandrel	In situ
Jet grouting with reactive materials	In situ
Vibratory Membrane filtration	Ex situ
Chemic Process	Ex situ
Reverse Osmosis/electrodialysis	Ex situ
Electrically- switched ion exchange	Ex situ
3M Filters	Ex situ
Hydrofracturing/pneumatic fracturing	Enabling Technologies
Cassette emplacement for barrier material	Enabling Technologies
Horizontal Wells	Enabling Technologies
Cryogenic removal	Enabling Technologies
Monitored Natural Attenuation	Identified by TAG members
Phytoremediation	Identified by TAG members
Permeable Clinoptilolite Barrier	Identified by TAG members
Impermeable Sheet Pile/Cryogenic Barrier	Identified by TAG members

1 The TAG developed screening criteria and decision processes to evaluate technologies
2 appropriate for site characterization and remediation. Remediation technologies developed by
3 domestic and foreign industries, EPA, and DOE were evaluated for applicability to site-specific
4 needs for the Hanford 100-N Site. The TAG began by reviewing historical and operational
5 documents, contaminant inventory and sampling data, treatability studies, pump-and-treat efforts,
6 and regulatory clean-up goals. Technologies were accepted or rejected based upon the following
7 four major assessment criteria developed by the TAG:

- 8 1. Cost
- 9 2. Performance Attributes (such as)
 - 10 Treatment rate (relative to no-action or to current pump-and-treat)
 - 11 Required treatment period (depending on final remediation goals)
- 12 3. Attributes of Deployment Location, (such as)
 - 13 a. Environmental impacts (e.g., cultural sensitivity at the point of deployment)
 - 14 Geologic impacts: instability/erosion at the point of deployment
- 15 4. Other Attributes of New Technologies (such as)
 - 16 a. Cumulative health/worker risk
 - 17 Ability to reach clean-up standards/goals

18 Following the screening criteria assessment, the TAG identified areas requiring further
19 investigation before remediation scenarios or technology recommendations could be addressed.
20 The TAG identified the general areas where more information was needed: aquifer geochemistry,
21 desorption distribution coefficient (K_d), and fluctuating Columbia River stage impacts on
22 contaminant flux to the river. The results of these studies can be found in the following reports:

- 23 • Bank Stability Evaluation (BHI—01324)
- 24 • Groundwater-River Interaction in the Near River Environment at the 100-N Area
25 (HydroGeoLogic, Inc., 1999)
- 26 • Use of Phosphatic Materials for Sr-90 Stabilization (Moody, 1999)
- 27 • Strontium Mobilization using Chemical Lixivants (MSE-49, 1999)

28 The treatment technologies evaluations led to the development of five remediation scenarios.
29 Scenarios involving combinations of the candidate technologies for remediation of the 100-N
30 Area were formulated. Preliminary engineering cost analyses (PECA) of the remedial
31 scenarios were conducted (Studer, 2001). All but one of the remediation scenarios relies on a
32 combination of two or more technologies to create a complete system. In general, the TAG
33 concluded that the near-river environment is an area in which remediation will be difficult due
34 to the presence of cultural resources and the effect on groundwater movement of the highly
35 fluctuating near-river flow dynamics. The five possible remediation scenarios developed
36 included the following:

- 37 1. Monitored Natural Attenuation.

- 1 2. Permeable Clinoptilolite Barrier.
- 2 3. Monitored natural attenuation on the river side of the barrier.
- 3 a. Monitored natural attenuation and phytoremediation on the river side of the barrier.
- 4 4. Apatite Seeds/Liquid Phosphate Stabilization with impermeable barrier. Apatite on the
- 5 river side of barrier, phosphate on inland side of barrier.
- 6 5. Soil Flushing with impermeable barrier, phytoremediation on the river side of barrier,
- 7 phosphate stabilization, and soil flushing on inland side of barrier.
- 8 a. Soil Flushing with impermeable barrier, natural attenuation on the river side of barrier,
- 9 liquid phosphate stabilization, and soil flushing on inland side of barrier.

10 The evaluation process narrowed the field to five potentially useful technologies: a Clinoptilolite
11 Permeable Barrier, a Sheet Pile/Cryogenic Impermeable Barrier, Monitored Natural Attenuation,
12 Phytoremediation, and Soil Flushing. The suggested technologies are generally lower in cost,
13 generate less waste, or possess a greater maturity than competing technologies for site-specific
14 contaminants.

15 The two barrier technologies would be constructed along the riverbank and used in conjunction
16 with the other three technologies. The historical stability and the information obtained from the river
17 model indicate that river velocity erosion potential resulting in impact to the performance of
18 subsurface barrier elements is considered negligible. Similarly, erosion potential associated with
19 proposed barriers construction is considered negligible under construction industry standard of
20 care practices and mitigation measures. Limiting access to the roadway and minimizing vibrations
21 during barrier installation activities would significantly reduce potential damage to the environment
22 that could be caused during construction.

23 The TAG evaluated the other three technologies in detail and made the following conclusions
24 and recommendations:

25 Monitored Natural Attenuation - the short half-life and strong sorption of Sr-90 make this an
26 attractive option. Hydrogeologic modeling provides the basis for predicting that movement of Sr-90
27 is slow and flushing by interaction with fluctuating river stages will not remove substantial amounts
28 of Sr-90 from the riverbank. This remediation method may be appropriate for the portion of the
29 plume far from the river but will do little to limit the current discharges of Sr-90 at the N-Springs that
30 are currently in excess of the regulatory limit. Long-term monitoring strategies are needed; these
31 may emerge as part of DOE efforts to establish protocols for Long-Term Stewardship (LTS). The
32 site meets the criteria established by DOE for monitored natural attenuation (MNA). We
33 recommend that, when LTS protocols are established, this option should be examined in more
34 detail.

35 Soil Flushing - this remediation option is likely to be effective in removing both radioactive and
36 non-radioactive Sr-90 from the site in the least amount of time. Modeling calculations indicate it is
37 possible to build a wellfield, then detect and control potential excursions. Long-term monitoring
38 may still be required after the flushing is nominally completed; it is recommended that this issue be
39 examined in more detail in consultation with regulators.

1 Phytoremediation - the technology did not receive a detailed analysis in this study. However, it may
2 be the best option for controlling current releases of Sr-90 at the river. Leaf litter control may be an
3 issue: however, it may be suitable for a 30-year period to control the riparian zone while MNA or
4 stabilization is used to control those portions of the plume further from the river.

5 Stabilization of Sr-90 by phosphate injection was examined in this study but removed from further
6 consideration by a subcommittee of the TAG. The work done at the time (under contract to ITRD)
7 to design a stabilization system was insufficient to support recommendation of this option.
8 Phosphate solid injection and co-precipitation were found to remove Sr-90; however, the vendor
9 did not provide sufficient design information or explain inconsistent results for contrasting behavior
10 of radiogenic and stable strontium.

11 The Technical Advisory Group (TAG) did not conclude the method should be abandoned. It was
12 recognized that it might be possible to create a long-term barrier in areas of the plume using phosphate
13 stabilization. Current work in the DOE Tanks Focus Area provided new data that encouraged
14 re-examination of this option, which occurred and is described below.

15 **1.3 Current Groundwater Remediation Approach**

16 Since the completion of the ITRD Report, several important developments have occurred (*Evaluation of*
17 *Strontium-90 Treatment Technologies for the 100-NR-2 Groundwater Operable Unit*, CH2M HILL,
18 2004). The TAG determined that soil flushing was not a feasible option, primarily because of the massive
19 volumes of lixiviant required for injection and removal, and the problems inherent in treating and
20 disposing large volumes of radioactive wastewater.

21 Interest was renewed in strontium stabilization by phosphate injection (chemical injection) based on
22 reports of successful bench testing at Sandia National Laboratory. The merits of apatite sequestration and
23 phytoremediation were presented at a workshop in August 2003 by Pacific Northwest National
24 Laboratory (PNNL) and Sandia National Laboratory scientists. Because of the potential for these
25 technologies to remove or sequester Sr-90 from the riverbank sediments, DOE funded two laboratory
26 studies at PNNL in fiscal year (FY) 2004 to determine their appropriateness for the 100-NR-2 OU:

- 27 • Phytoremediation of Sr-90 at the Hanford 100N Area
- 28 • Sr-90 Sequestration by Apatite at the Hanford 100N Area

29 Currently, a chemical barrier composed of apatite is being tested as a primary treatment technology and
30 phytoremediation as a secondary treatment or "polishing" step.

31 **1.3.1 Apatite Barrier Installation**

32 At the 100-N Decision Unit, innovative technology is being tested to fix mobile Sr-90 in a chemical
33 barrier injected into the aquifer. The description of the apatite barrier provided is from PNNL-16891,
34 Hanford 100-N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO₄ Solution Injection and
35 Sr-90 Immobilization in 100-N Sediments). This technology reduces disruption to areas that would be
36 caused by installing slurry or clinoptilolite barriers. The method creates a chemical filter allowing
37 groundwater to pass unimpeded while providing dissolved Sr-90 access to the mineral apatite. Apatite
38 (a stable mineral found in rocks, teeth, and bone) contains calcium and phosphate and has a strong affinity
39 for substituting strontium into its mineral structure. Scientists proposed injecting apatite-forming elements
40 directly in groundwater (DOE/RL-2005-96, *Strontium-90 Treatability Test Plan for 100-NR-2*
41 *Groundwater OU*, Rev. 0). The apatite incorporates the Sr-90 in the mineral matrix, thereby preventing
42 further migration. Figure 1-10 shows the 100-N Decision Unit test site where the Apatite Barrier

1 Technology is being developed. If the technology proves successful, the test site will expand into
2 a full-sized barrier to protect the Columbia River along the length of the Sr-90 groundwater plume.

3 The method of constructing an apatite barrier in subsurface sediments at the 100-N Area is injecting an
4 aqueous solution containing a Ca-citrate complex and Na-phosphate into the groundwater. Citrate is
5 needed to keep Ca in solution long enough (days) to allow the injected solution to spread through the
6 Sr-90 contaminated aquifer. The relatively slow biodegradation of the Ca-citrate complex (days) allows
7 sufficient time to disperse the reagents through the aquifer where treatment is required. As Ca-citrate
8 degrades, the free Ca and phosphate ions combine to form amorphous apatite, as shown in Figure 1-11.
9 Amorphous apatite formation occurs within one week and crystalline apatite within a few weeks. Apatite
10 minerals are very stable and practically insoluble in water. The Sr-90 rapidly adsorbs onto the mineral
11 surfaces and then slowly substitutes for Ca in the mineral matrix over a period of months.

12 The timing of injections is very important to achieving the residence times needed for apatite formation in
13 the aquifer. The rate of water movement in the Hanford formation can be up to 10 times faster than
14 observed in the Ringold Formation, and flow in both formations respond to water elevations related to
15 Columbia River stage. To address this problem, the current plan is to inject the Ca-citrate-phosphate
16 solution separately into the Hanford formation and Ringold Formation, Unit E sediments. Simulations of
17 injections into the lower (less transmissive) Ringold Formation at sustained low and high river stage
18 reveal the river stage does not move the Ca-citrate-phosphate injection plume a significant distance before
19 apatite is precipitated. Therefore, injections into the Ringold Formation, Unit E, is best at lower river
20 stages (late fall) to get apatite movement toward the river, but the effort is not time dependent.

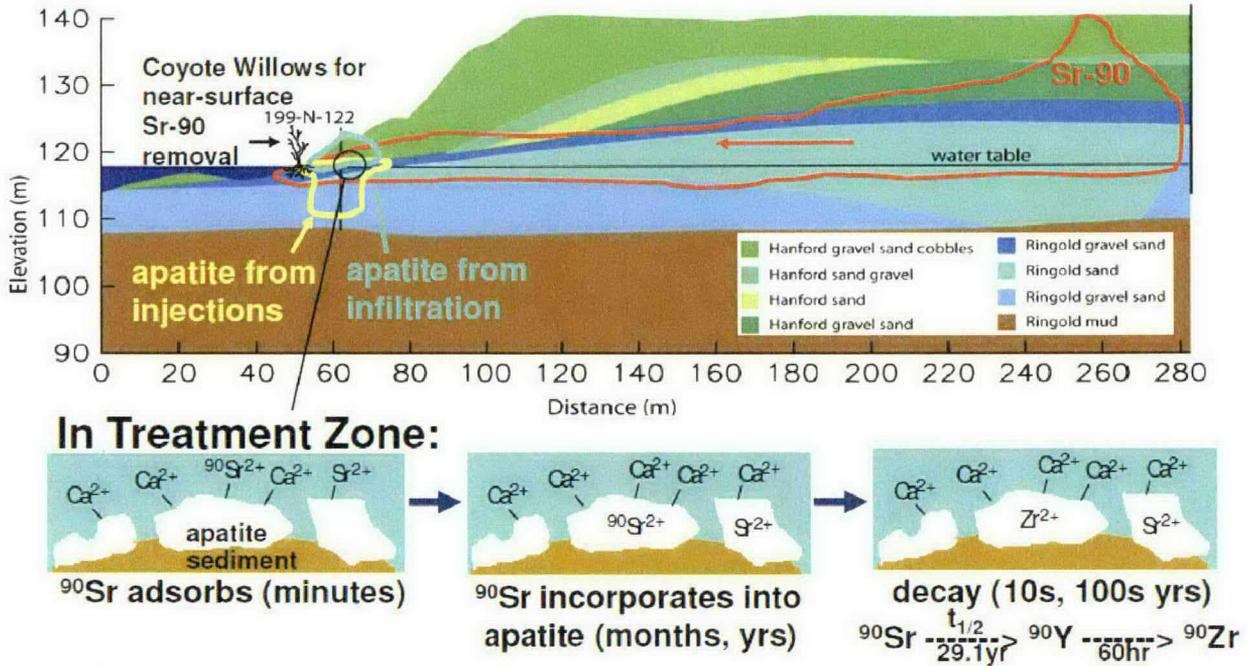
21 In contrast, apatite-forming solution injection into the Hanford formation rewetted zone needs to be done
22 during high river stage so the formation is water saturated (late spring). In addition, because solution
23 movement toward the river is desired, it would be advantageous for the injection at a high river stage
24 (saturating the formation) followed by a moderate river stage, to get slow flow toward the river.

25 In July 2005, the plan to inject apatite-forming chemicals into the soils beneath selected closed waste sites
26 was completed. The plan focused on soil and groundwater along approximately 91 m (300 ft) of the
27 Columbia River bank where Sr-90 concentrations are highest; testing was launched in 2006.

28 Throughout 2006 and 2007, a low-concentration, apatite-forming solution was injected through 10 wells
29 into the test area shallow groundwater. The objective of the low-concentration, calcium-citrate-phosphate
30 injections was to stabilize Sr-90 in the aquifer at the test site. The results and experience from the
31 low-concentration injections led to the design for higher concentration injections. During summer 2008,
32 16 wells were injected using adjusted techniques and chemical mixes. Apatite is slow to incorporate Sr-90
33 under field conditions, and it may take 1 year before results are collated and defined. The high chemical
34 mixture concentration has been decreasing slowly in some areas.

35 Despite these challenges, the monitoring data are encouraging and reveal apatite is forming, and Sr-90 is
36 being adsorbed as designed. Sr-90 concentrations, based on gross beta, fell below baseline levels in 19 of
37 20 wells. Data indicate Sr-90 in the remaining well, while exhibiting levels above baseline minimum
38 values, is on a downward trend.

- 1 The average reduction in Sr-90 concentrations at four compliance monitoring wells was 95 percent
 2 relative to the high end baseline range, and 84 percent relative to the low end, indicating the performance
 3 objective specified in the treatability test plan (90 percent reduction in Sr-90 concentration) after one year
 4 of treatment (PNNL, 2009, *100-NR-2 Apatite Treatability Test FY09 Status: High concentrations*
 5 *Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*, Draft
 6 Letter Report).
- 7 Apatite technology is showing great promise as a remediation option. If the results remain positive, a plan
 8 to expand the method to a full-scale treatment option will move forward.



9
 10 **Figure 1-11. Theoretical Formation of an Apatite Chemical Barrier for SR90 Removal**

11 **1.3.2 Phytoremediation**

12 Phytoremediation (or more specifically phytoextraction) is a managed remediation technology in which
 13 plants are used to extract or fix soil contaminants. The coyote willow (a common plant growing along the
 14 banks of the Columbia River) was tested to become part of a treatment to stop Sr-90 from entering the
 15 water. Early testing confirmed its effectiveness; these shrubs (Figure 1-12) will help restore the
 16 environment by removing Sr-90 from groundwater and the vadose zone along the riparian zone. The
 17 riparian zone or riparian area is the interface between land and a stream.



1
2 **Figure 1-12. Coyote Willows Growing in the Test Plot in the 100-K Area**

3 Phytoremediation technology uses plants to extract and/or fix soil contaminants (DOE/RL-2008-66). The
4 coyote willow is considered the most suitable plant for use along the Columbia River shore. Known for
5 its rapid and robust regrowth abilities, coyote willow is already used extensively along the Columbia and
6 Yakima Rivers for bank stabilization and revegetation purposes. As part of a chain of remedial
7 technologies aimed at treating Sr-90, phytoremediation using coyote willow is a polishing step in multiple
8 processes protecting the river.

9 In the proposed configuration, the treatment system would first incorporate an apatite barrier
10 (previously described) designed to extract Sr-90 either present near the river now or expected to move
11 toward the river over the next 300 years. The phytoremediation treatment, designed as an extraction
12 system along the riparian zone of the Columbia River, would be constructed to address Sr-90 in the
13 vadose and saturated zones associated with the Columbia River riparian zone. Once the apatite barrier
14 was fully functional and the coyote willow had extracted the Sr-90 from the riparian zone, the
15 phytoremediation component will be discontinued.

1 The key to using phytoremediation as part of the treatment, besides the volume of sediment to be treated,
2 is biomass production, the focus was to determine whether the technology is usable. The study involved
3 two major objectives:

- 4 1. Determine the most efficient fertilization method for coyote willow to generate the greatest biomass
5 possible while protecting the Columbia River from excess nutrient runoff.
- 6 2. Demonstrate the efficacy of using coyote willow as a phytoremediation tool along the riparian zone
7 associated with the 100-N Decision Unit.

8 The study began in late spring 2007, with 50 coyote willow starts planted in a fenced area at the
9 100-K Area. This part of the study targeted plant growth rather than phytoremediation capabilities, so the
10 100-K Area, which was not contaminated with Sr-90, was well suited as a host location. Often flooded by
11 the annual high Columbia River stage well into June, this site is a severe test for the ability of the willow
12 shrubs to survive realistic field conditions.

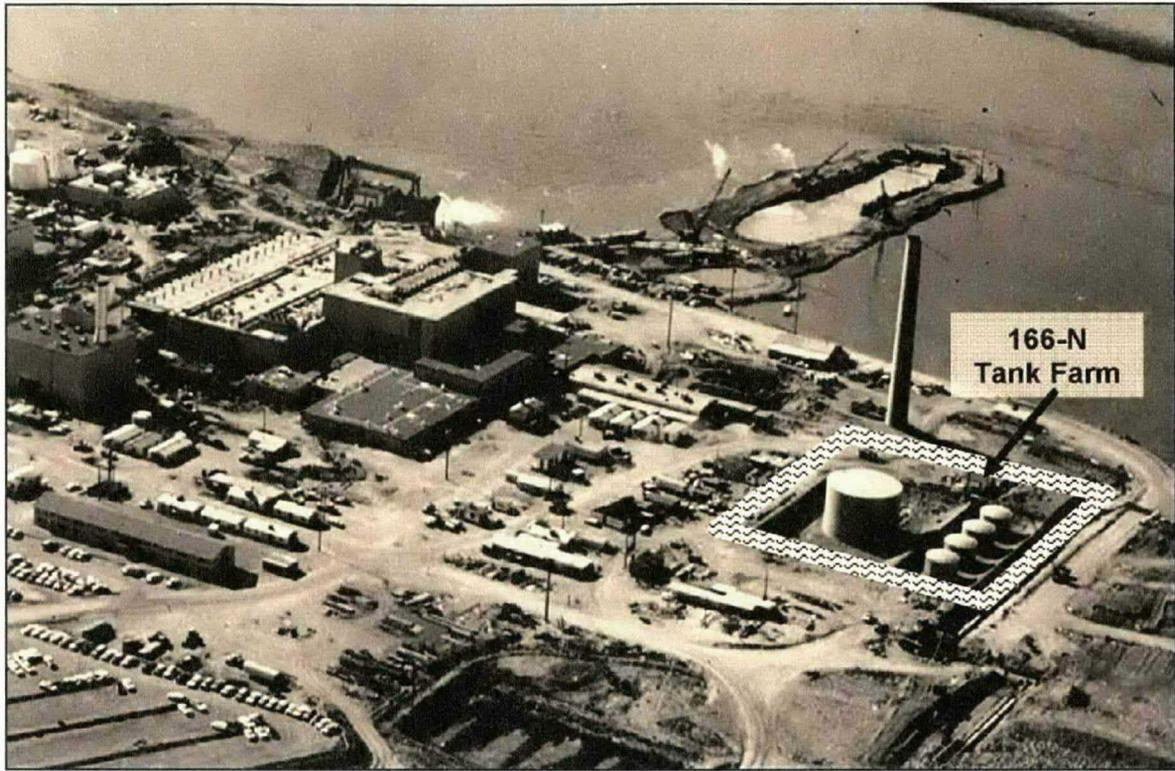
13 During the first year of the test, relatively little growth occurred while the plants became established and
14 developed root systems. In October 2007, the plants were pruned down to the trunk plus primary
15 branches. Forty-nine of the 50 plants survived the winter. In May and June 2008, the site was once again
16 flooded and serious growth began in July. The second year harvest was completed in October 2008. The
17 average biomass was 369 percent greater than the first year at about 340 kg (750 lb) per acre, which was
18 in line with predictions.

19 The stem and foliage of coyote willows accumulating Sr-90 will present not only a mechanism to remove
20 the contaminant but also will be viewed as a source of nutrition for natural herbivores and, therefore,
21 a potential pathway for the isotope to enter the riparian food chain. Management of the willows will
22 include a series of engineered barriers: large and small animal fencing will control intrusion of herbivores
23 such as deer and rodents, bird intrusion would be minimized by placing netting over the top of the
24 enclosure, and detritus (leaves and twigs) would be retained by fencing and removed on a regular basis.
25 A recent study concluded the risk for detectable transfer of Sr-90 from willow trees growing in the
26 contaminated soil along the 100-N shoreline through the food chain of herbivorous insects is slight to
27 nonexistent (PNNL-18294, 100-N Area Stontium-90 Treatability Demonstration Project: Food Chain
28 Transfer Studies for Phytoremediation along the 100-N Columbia River Riparian Zone).

29 If the coyote willow continues to perform over the coming year, the next step will be testing at the
30 100-N Decision Unit in actual Sr-90 contaminated soil. Methods for safely planting, tending, and
31 harvesting the willows along the rip-rap covering the 100-N Decision Unit shoreline will need to be
32 developed; however, the 100-N Decision Unit tests proved successful and phytoextraction will be
33 incorporated as part of the treatment protecting the Columbia River from Sr-90 contamination.

34 **1.3.3 Petroleum Removal**

35 Soil and groundwater petroleum contaminant removal in the 100-N Decision Unit is being performed to
36 protect the Columbia River, currently within a limited scope, with the majority of petroleum removal
37 slated to start next year. Petroleum in the vadose zone and groundwater is primarily from a 1966 diesel
38 fuel leak of more than 302,833 L (80,000 gal) (DOE/RL-95-111) associated with the 166-N Tank Farm
39 (Figures 1-13 and 1-14). Other petroleum releases consisting of significantly smaller volumes occurred
40 over time. Because of these leaks, petroleum is present in soil and groundwater as free-product. Free
41 product petroleum contamination consists of a fraction that floats on groundwater in addition to
42 a dissolved fraction.



1
2

Figure 1-13. 116-N Tank Farm Facility (Early 1960s)

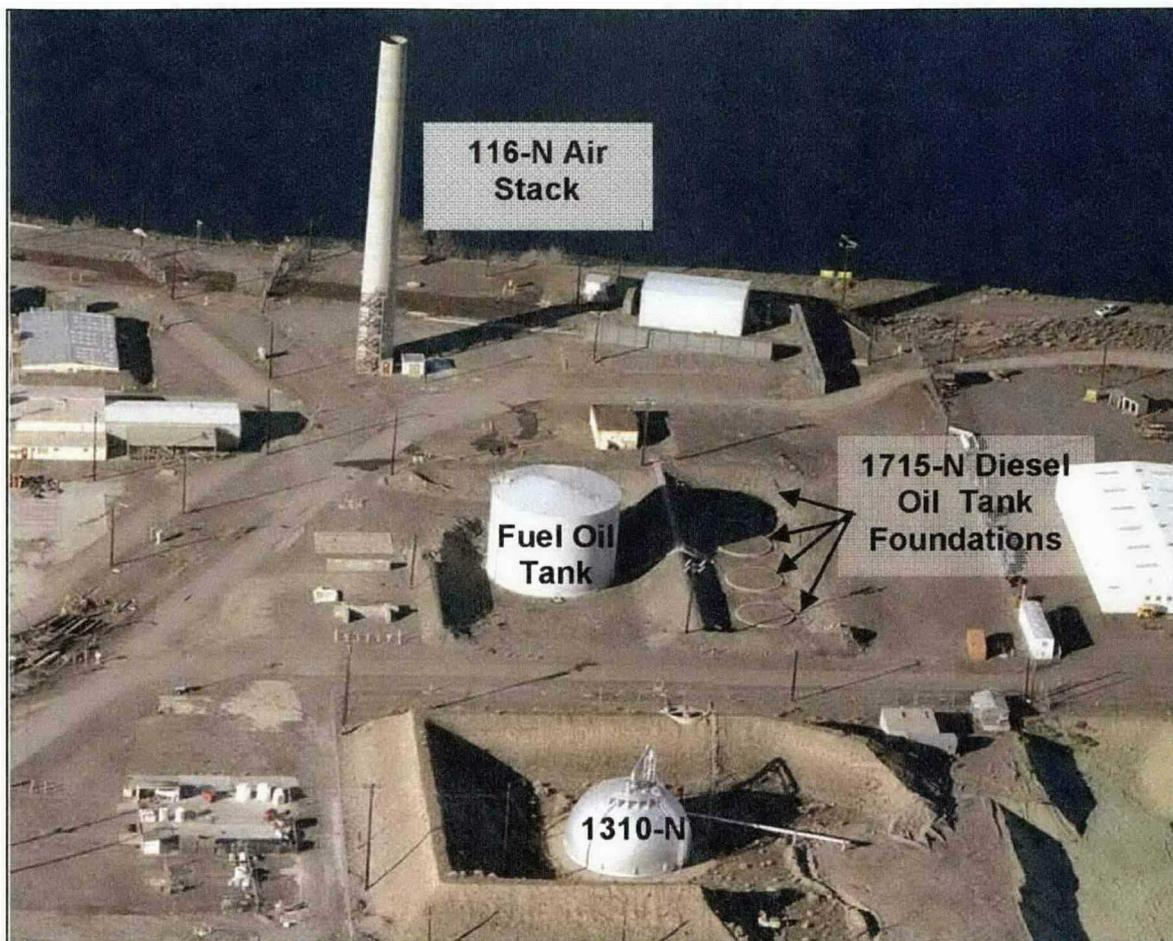


Figure 1-14. 100-N Tank Farm Facility (1990s)

1
2
3 A Phase I Bioremediation pilot system, which was installed in FY 2009 to address petroleum in the soil,
4 is operational in the 100-N Decision Unit. Bioremediation is the breakdown of petroleum to innocuous
5 byproducts by naturally occurring bacteria in the environment, a well-established remedial method for
6 petroleum. The form of bioremediation elected for this pilot testing is bioventing, injecting air into the
7 vadose zone to facilitate bioremediation by native biota. Bioventing increases oxygen in the subsurface,
8 which stimulates the growth of bacteria that survive in an oxygen-rich environment. These bacteria are
9 highly effective in breaking down the petroleum compounds into innocuous byproducts.

10 The pilot study includes seven bioremediation vadose wells conducting bioventing tests. Data collected
11 from this study will be used to evaluate the potential applicability of bioremediation to meet cleanup goals
12 for the petroleum waste sites at the 100-N Area and support design of a possible large-scale bioventing
13 system to address vadose zone petroleum.

14 Free-phase petroleum (diesel) was detected on the water table in Well 199-N-18, the well closest to the
15 1960s leak area (DOE/RL-95-111). A passive treatment method has been used in the well since
16 October 2003 to remove residual amounts of the free-phase diesel because it was too thin (less than 2 cm
17 [0.8 in.]) for removal by active remediation methods. The passive method uses a polymer with a
18 molecular structure that selectively absorbs petroleum from the surface of the water (that is, acting as
19 a sponge) while the device floats at the air/hydrocarbon/water interface (PNNL-14548, *Hanford Site*
20 *Groundwater Monitoring for Fiscal Year 2003*). A bundle of four cylinders are lowered into the well.

1 The cylinders are changed every two months, after which the cylinders are removed, weighed, and
2 replaced with a new pre-weighed bundle. Experience indicates that two months are generally sufficient
3 for the cylinders to become saturated with oil.

4 Additional characterization of petroleum in the 100 Area is ongoing, including a well installation between
5 the tank farm and the river in March 2009. The results of the additional characterization will support
6 ecological risk assessments and provide data to support assessment of other remedial technologies.

7 **1.3.4 Aquatic and Riparian Impact Assessment**

8 An initial assessment of the current impacts of contaminated groundwater plumes on aquatic and riparian
9 zones within the 10-NR-2 Operable Unit was conducted in 2005. This summary is based on information
10 described in DOE/RL-2006-26, *Aquatic and Riparian Receptor Impact Information for the*
11 *100-NR-2 Groundwater Operable Unit*).

12 This assessment was one component of the selected remedy described in the Interim Remedial Action
13 ROD for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington
14 (EPA/541/R-99/112, *Interim Remedial Action Record of Decision for the 100-NR-1 and*
15 *100-NR-2 Operable Units, Hanford Site, Benton County, Washington*). Historical data and new data
16 obtained during 2005 were used for this impact assessment. For the evaluation, water, sediment, soil, and
17 aquatic and terrestrial biota were collected during calendar year 2005 and analyzed for contaminants of
18 potential ecological concern (COPECs), including Sr-90, uranium, technetium-99 (Tc-99), heavy metals,
19 polychlorinated biphenyls (PCBs), and petroleum hydrocarbons.

20 The impact assessment parameters and data used during the assessment consisted of the following:

- 21 • Whole-body and tissue dose calculations for radionuclides (primarily Sr-90).
- 22 • Chemical effects modeling (Ecological Contaminant Exposure Model) for tissue and
23 environmental media.
- 24 • Visual and microscopic examination of whole animal and tissue samples for abnormalities.
- 25 • Presence (or absence) and abundance of key species.
- 26 • Habitat evaluations.
- 27 • Comparisons with upstream reference area (Vernita), background concentrations of COPECs, and
28 state and federal criteria for the protection of aquatic and terrestrial organisms.

29 Table 1-3 presents a summary of findings for the assessment.

Table 1-3. Summary of Preliminary Findings for the 100-NR-2 Ecological Impact Assessment

Plume Area	Guild Species Present?	Contaminant Exposure Pathway?	Evidence of Contamination in Biota?	Dose or Media Concentration Exceeded? ^a	Health Status Indicators		
					Body Condition	Histology	Population/Community
SPA	Yes	Yes	Yes	Yes	Normal	Abnormal ^b	Normal ^c
SDA	Yes	Yes	No	Yes	Normal	Not Available	Normal ^d
EMA	Yes	Yes	Yes	Yes	Normal	Normal	Normal ^d

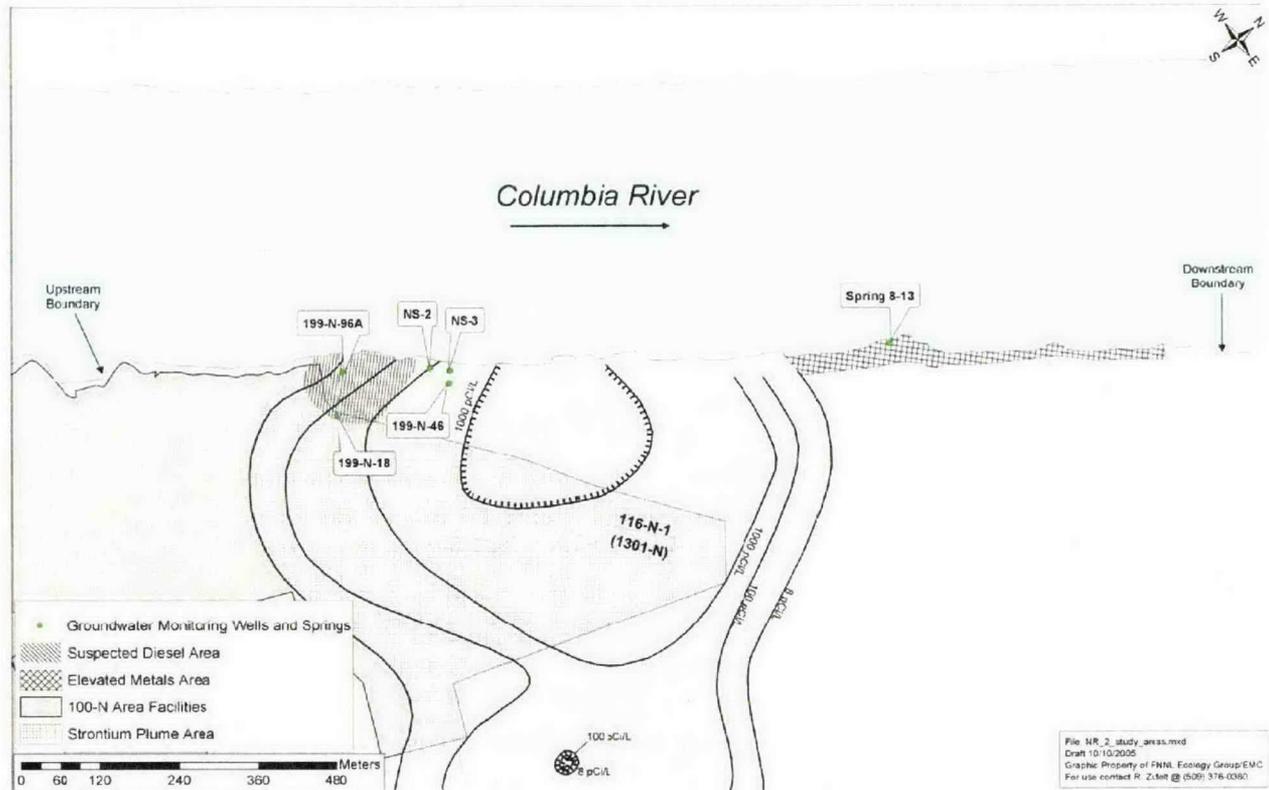
Source: DOE/RL-2006-26 Revision 1

- a. Refers to dose calculations based on soil, sediment, or water and related exposure pathways and tissue concentrations or threshold concentrations for soil, sediment, or water protective of aquatic and riparian biota.
- b. A greater percentage of abnormal oocytes and cell shapes was reported for clam tissue than at the reference area. However, the sample size may be too small to make a definitive conclusion.
- c. Higher river stage during the survey and presence of riprap prevented access to the central portion of the SPA; overlap from the EMA and SDA covered the sides of the SPA.
- d. Population/community indicators primarily based on mollusk survey indicating a normal age class structure of *Corbicula* in the study areas and presence of snail species indicative of north temperature streams with high water quality.

- EMA = elevated-metals areas
- SDA = suspected diesel-contaminated area
- SPA = strontium plume area

1 **Strontium Plume Area.** Levels of Sr-90 were elevated in Asiatic clams compared with Vernita;
 2 however, estimated radiological doses for all biota evaluated were well below U.S. and international
 3 thresholds. Minimal indication of adverse effects of Sr-90 contamination was found in health-status
 4 indicators surveyed in these sampling efforts. The exception was a slightly higher frequency of abnormal
 5 oocytes and an apparent increase in the frequency of digestive tract cellular abnormalities and digestive
 6 gland hemocytosis in clam tissue samples from the strontium plume area compared to the reference area.
 7 The zone with the highest clam tissue concentrations (N-Springs-3, near well 199-N-46 [Figure 1-15])
 8 should be the target of alternative treatment methods to reduce Sr-90 exposures in the near-shore aquatic
 9 zone (DOE/RL-2006-26). In addition, barium, cadmium, nickel, vanadium, and zinc were detected at
 10 levels above ecological benchmarks in the strontium plume area.

11 **Suspected Diesel-Contaminated Area.** Indications of potential adverse effects were identified for the
 12 section of shoreline (approximately 150 m [492 ft]) in the vicinity of the suspected diesel contaminated
 13 area (SDA) from a spill that occurred in the 1960s. Data for shallow aquifer tubes (10 cm [3.9 in.] beneath
 14 the riverbed) indicate the impacted area is anoxic with elevated dissolved iron and manganese
 15 concentrations that exceed water quality benchmarks for the protection of aquatic life. The occurrence of
 16 elevated iron and manganese concentrations is consistent with anaerobic microbial decomposition of
 17 petroleum hydrocarbons, suggesting that this diesel-related contaminant plume will decline by natural
 18 biodegradation processes. Additional follow-up sampling is warranted to better delineate the extent of the
 19 impacted area.



1
 2 Source: DOE/RL-2006-26 Revision 1

3 **Figure 1-15. Sampling Regions Located Along the Shoreline at the**
 4 **100-NR-2 Groundwater Operable Unit Study Area**

5 **Elevated-Metals Area.** Barium, manganese, lead, and zinc in water; arsenic, barium, cadmium, lead, and
 6 nickel in soil; and cadmium and zinc in biota exceed benchmarks for wildlife in the elevated metals area
 7 (EMA), SDA, and the strontium plume area (SPA). Threshold exceedances of some of these metals may
 8 not be attributable to 100-N Area operations. For example, metals from upstream sources (lead/zinc
 9 mining and refinery operations in Canada and Idaho, and uranium mining near Spokane, Washington)
 10 may account for above-background concentrations of lead, cadmium, and zinc (and possibly barium and
 11 other metals) in environmental media and selected biota. Chromium was detected in clam tissue in the
 12 EMA and SPA, but pore fluid concentrations of hexavalent chromium (CrVI) for springs and aquifer
 13 tubes did not exceed the aquatic standard for chromium, a ubiquitous contaminant in the plutonium
 14 production reactor areas. Lead was detected at elevated levels in two of the deer mice sampled in this
 15 area, and maximum lead concentrations in soil in the EMA were above the most relevant screening
 16 criteria for birds and mammals. Further sampling would be needed to better identify the exposure
 17 pathway for lead and the extent of elevated lead in the riparian zone. Maximum concentrations of arsenic,
 18 chromium, and uranium are also slightly greater in the EMA than the soil-screening criteria. The highest
 19 concentrations of soil uranium were found at Vernita. The assessments are based on maximum observed
 20 values compared against the most sensitive benchmarks. Modeling using the Ecological Contaminant
 21 Exposure Model (based on median soil, water, and sediment concentrations of metals) did not indicate
 22 unacceptable risk for these metals.

23 **Polychlorinated Biphenyls.** Some congeners of PCBS were detected in samples at the 100-NR-2 study
 24 area, but concentrations were well below current ecological benchmarks and were comparable to
 25 concentrations observed at Vernita.

1 **Weight-of-Evidence Information.** In addition to contaminant concentrations and histological data,
2 general habitat conditions were evaluated. This information is intended for use by key decision makers in
3 a weight-of-evidence approach in evaluating the acceptability of apparent risks. A principal finding of the
4 present study was a normal distribution of aquatic mollusk species indicative of high water quality
5 conditions in the 100-NR-2 OU contaminant plume study areas. In addition, a normal age distribution of
6 Asiatic clams was noted throughout the study area, indicating favorable habitat conditions. A survey of
7 aquatic invertebrates conducted in September and October 2005 indicated a normal distribution of aquatic
8 insects and other invertebrates in the study area. Evaluations of terrestrial or riparian habitat indicators
9 were less clear. This was primarily a result of prior large physical disturbances in the study area and the
10 use of herbicides to prevent the growth of mulberry and other nuisance vegetation in the SPA. However,
11 the small mammal population was found to be reproductively active in the study area.

12

1

2

This page intentionally left blank.

1 **2 Site Background and Environmental Setting**

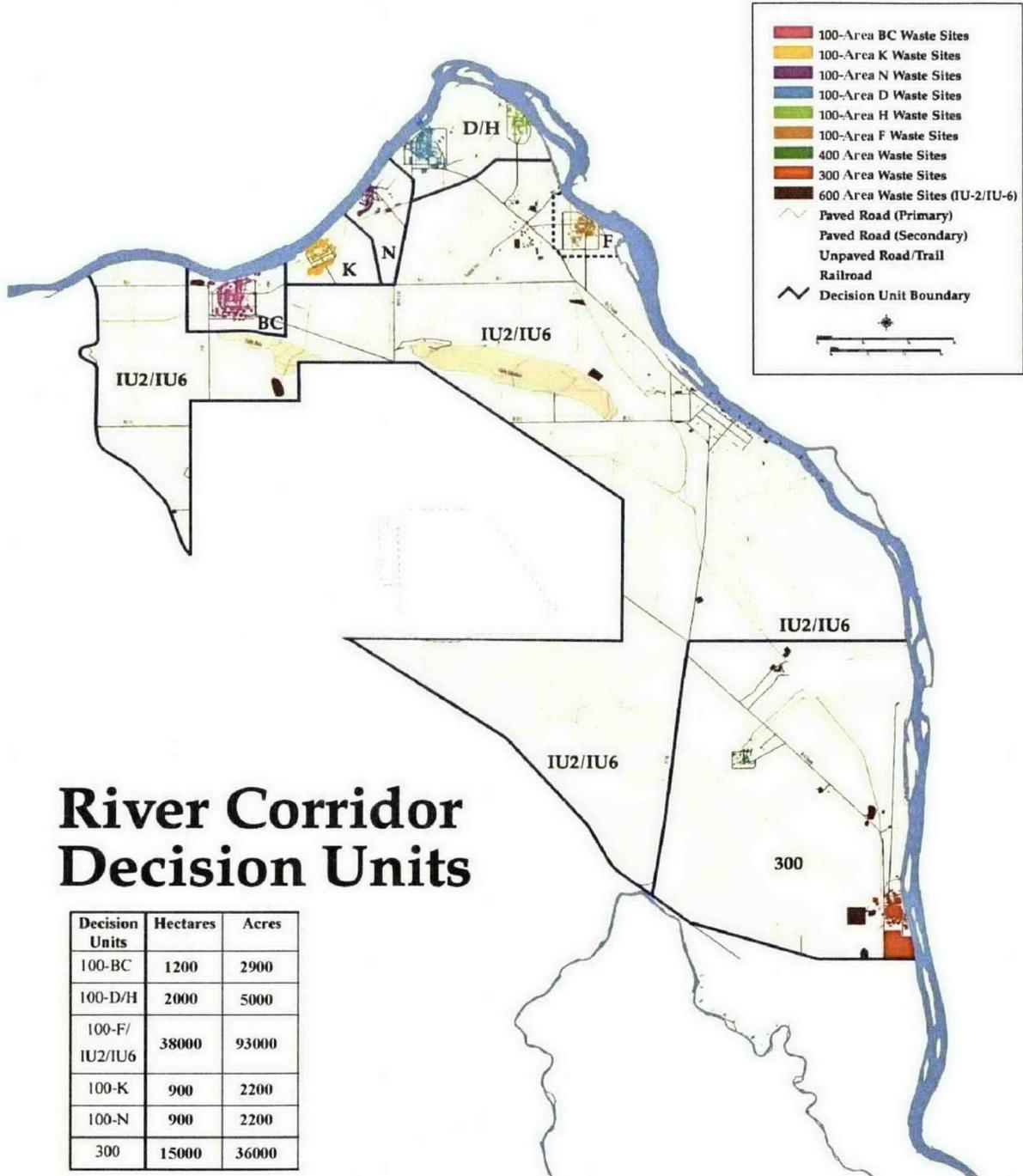
2 Between 1943 and 1963, nine nuclear reactors were built along the Columbia River with the core function
3 of producing special nuclear materials for national defense. The 100-N Decision Unit includes the
4 N Reactor and its ancillary production and waste disposal facilities. This section describes the
5 background, history, and environmental setting of the 100-N Decision Unit and includes information on
6 the waste generated and known soil and groundwater contamination.

7 **2.1 100-N Decision Unit Overview**

8 The 100 Area(s) are located in the northern part of the Hanford Site along the south shore of the
9 Columbia River (Figure 2-1). The five decision units identified within the 100 Area(s) are composed of
10 source OUs and groundwater OUs (Chapter 1 and Figure 2-1). Source OUs address liquid, solid, and
11 radioactive waste disposal sites; groundwater OU's address groundwater conditions found within the
12 decision unit. The 100-N Area source OU is 100-NR-1; the groundwater OU is 100-NR-2. The
13 100-N Decision Unit site information summary is in Table 2-1.

Table 2-1. 100-N Decision Unit Site Location Information

Decision Unit Sub-Area	Site Information
100-N	100-N Area is located upstream of the northwest bend of the Columbia River, between the 100-D/H and 100-K Decision Units. There is one production reactor, 105-N and its associated infrastructure. The source area OU is 100-NR-1.
Groundwater	The 100-NR-2 OU encompasses the groundwater beneath the 100-N Decision Unit.
OU = operable unit	



River Corridor Decision Units

Figure 2-1. Map of Hanford Site Showing Location of the 100 Area and Decision Units

1
 2
 3

1 D4 activities are ongoing at the 100-N Decision Unit, and ISS activities are in progress for the
2 105-N Reactor Building. The ISS of the N Reactor is scheduled for completion by 2012. Figures 2-2
3 and 2-3 provide aerial views of the 100-N Area before the start of ISS activities.



4
5 **Figure 2-2. Aerial View of 100-N Area (1968; Source: DOE)**
6

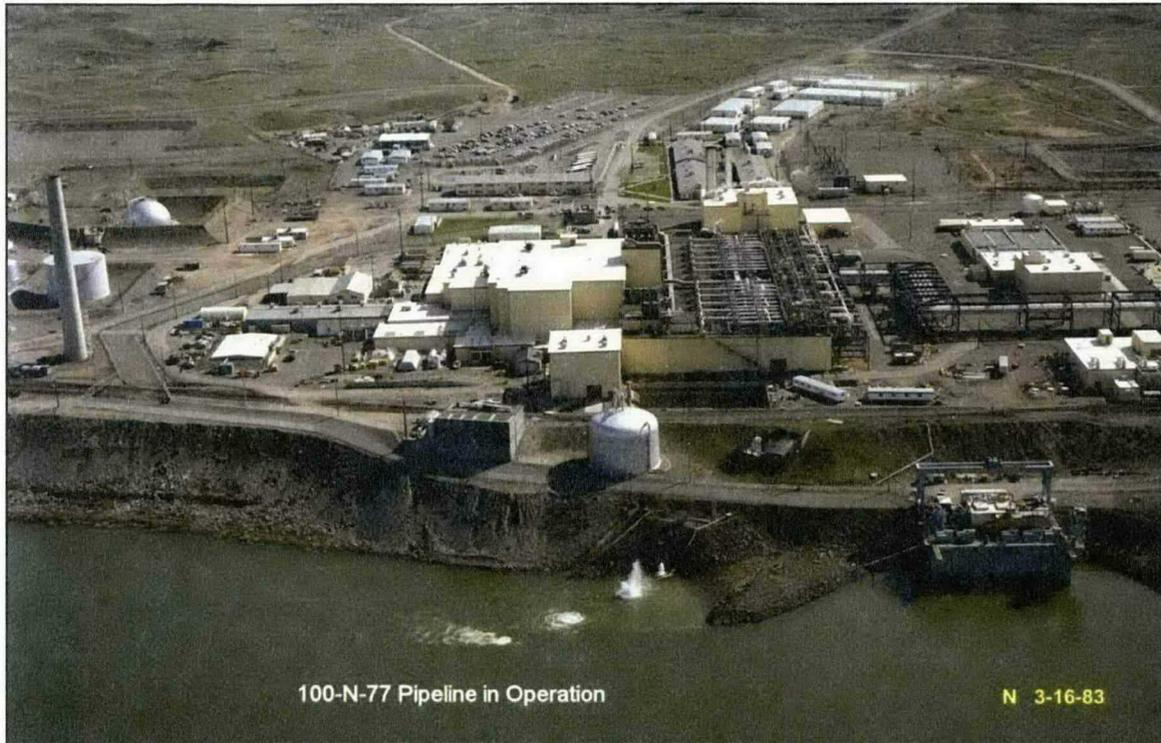


Figure 2-3. Aerial View of 100-N Area and the Hanford Generating Plant, 1983

2.1.1 Process History Description

The Hanford site's ninth defense materials production reactor, N Reactor, operated from 1964 to 1986. Although there were many differences between this last reactor and the previous eight, the primary difference was N Reactor had two separate cooling loops: the primary loop providing cooling to the fuel elements, and the secondary loop providing water to remove heat from the primary system and release heated water to the Columbia River. This two loop cooling system released significantly less radioactive effluent (waste water) on a daily basis as compared to the 8 previous reactors. N Reactor's primary coolant system used from 378.54 to 5 678.12 liters (100 to 1,500 gals) per minute of fresh, treated water, a vast decrease from the 132 489.42 to 397 468.25 liters (35,000 to 105,000 gals) per minute consumed by Hanford's single pass reactors (WHC-MR-0521). Table 2-2 summarizes significant milestones in N Reactor Operations

Table 2-2. Significant Dates for 100-N Area Operation (from DOE/RL-90-22)

Date	Milestones
May 13, 1959	Construction of N Reactor Began
September 1963	Construction of the Hanford Generating Plant began
December 1963	N Reactor went into production
March 1964	Construction of N Reactor was completed
November 1964	N Reactor reached 4,000 MW (thermal)
April 1966	HGP construction was completed

Table 2-2. Significant Dates for 100-N Area Operation (from DOE/RL-90-22)

Date	Milestones
December 1966	N Reactor reached 800 MW (electrical) (combined with HGP output)
1975	N Reactor irradiated fuel storage began in KE Reactor fuel storage basin
1981	N Reactor irradiated fuel storage began in KW Reactor fuel storage basin
December 12, 1986	N Reactor placed in stand-down status
February 1988	N Reactor placed in cold standby
1989	Shipment of N Reactor irradiated fuel to 100-K Area was completed
1990	N Reactor dewatered
October 1991	N Reactor ordered shut-down

Source: DOE/RL-90-22

HGP = Hanford Generating Project

MW = mixed waste

1 Materials that passed through the reactor for the manufacturing of special nuclear materials or contacted
 2 items passing through the reactor were considered radiologically contaminated and represented the
 3 majority of the wastes produced. Contaminant categories from the manufacturing process include
 4 the following:

5 • Process inputs

- 6 – Raw materials to be processed through the reactor, such as uranium fuel and cooling water
- 7 – Process chemicals for water conditioning and inhibiting corrosion (hydrazine, and sodium
 8 dichromate in the first years of operations) because water management was crucial to reactor
 9 operations and represented a major input subsystem
- 10 – Materials used for reactor maintenance (acids, solvents, and heavy metals)

11 • Process outputs

- 12 – Isotopes and byproducts, such as Plutonium-239 (Pu-239), Sr-90
- 13 – Radioactive and chemically contaminated materials (solid and liquid wastes)
- 14 – Radioactive and chemically contaminated cooling water
- 15 – Uncontaminated waste materials

16 The irradiated fuel elements were shipped to the 200 Area for chemical processing. Unlike the single-pass
 17 reactors, N Reactor decontamination solutions were often piped to storage facilities before being
 18 transported to the 200 Area for disposal. During production, fuel element failures and infrastructure
 19 failures (e.g., pipe leaks) resulted in contaminated materials released to the environment.

1 Burial grounds at the 100-B/C, 100-K, and 100-D Areas were used to dispose contaminated solid wastes
2 generated at 100-N (DOE/RL-95-111; WHC-SD-EN-TI-239, *100-K Area Technical Baseline Report*;
3 DUN-3063, *Underground Radioactive materials at 100-D Plant*); K Basins were used for long-term
4 N Reactor spent fuel storage (WHC-MR-0521). Wastes resulting from supporting reactor operations were
5 similarly disposed in each area according to phase, quantity, radioactivity, and composition (liquids,
6 solids; high/low mass or volume; high-level, low-level; strictly chemical; septic, and so forth).

7 **2.1.1.1 Liquid Discharges**

8 The 100-NR-1 OU includes liquid and solid waste disposal sites and unplanned release sites related to
9 operations associated with the 100-N Reactor.

10 Liquid wastes were disposed to the 100-N Area soil column and to the Columbia River through a variety
11 of disposal facilities including outfalls, spillways, cribs, ponds, pits, French drains, and septic systems.
12 Two Columbia River outfall structures were constructed in the 100-N Area: the 1908-N and
13 1908-NE Outfall Structures. The 1908-N Outfall (Figure 2-4 and Figure 2-5) was designed primarily for
14 the return of raw river water used to remove heat from the secondary cooling system. It also provided an
15 emergency disposal method for primary cooling water and fuel storage basin water should it be needed.
16 The outfall structure includes a reinforced-concrete weir box that discharged to the bottom of the
17 Columbia River through a 2.6 m (102 in.) diameter steel pipeline.



18
19 **Figure 2-4. Construction of 1908-N Outfall and 100-N-79 Emergency Spillway (1961)**



1
2 **Figure 2-5. Contemporary Condition of 1908-N (2005)**

3 The 1908-NE Outfall served the same purpose as the 1908-N Outfall, but serviced only the Hanford
4 Generating Project (HGP) facilities. Because the HGP was physically isolated from the reactor facilities,
5 this outfall did not provide for emergency disposal of water. The 1908-N and 1908-NE Outfalls were
6 permitted under the Hanford Site National Pollutant Discharge Elimination System (NPDES) permit and
7 are still identified in the permit. However, all discharges via these outfalls have been discontinued.

8 Wastewater collected from sumps and from drains designed to manage radioactive wastes within the
9 facility was discharged to the crib and trench facilities. These drains contained effluent from water quality
10 testing laboratories, personnel decontamination stations, waste transfer stations, and from floor drains
11 located in controlled contaminated areas of the reactor building. Settling and percolation ponds were used
12 in the 100-N Area to settle out solids from filter backwash, treat corrosive regeneration effluent, and
13 dispose of backwash effluents. The ponds were generally unlined trenches and relied on infiltration of the
14 liquid into the soil.

15 The 163-N Demineralization Plant provided demineralized water for N Reactor primary coolant systems.
16 Large ion-exchange columns were located in the plant to remove minerals from the filtered water. The
17 plant demineralized, filtered, and treated water from the 183-N Water Treatment Facility; degassed it; and
18 pumped it to a water storage tank. This water was used in the primary, secondary, and fuel storage basin
19 cooling water systems. Sodium hydroxide (NaOH) and sulfuric acid (H₂SO₄) were used to regenerate the
20 ion-exchange columns. Following regeneration, the NaOH and H₂SO₄ were discharged to the
21 163-N Neutralization Pit and a French drain.

1 In November 1988, the 120-N-2 Surface Impoundment was discontinued when the newly constructed
2 Elementary Neutralization Unit (ENU) was put online inside the 163-N Demineralization System facility.
3 The ENU neutralized the spent regenerant before discharge to the 120-N-1 Percolation Pond, and did so
4 with greater efficiency and operator control than was possible in the 120-N-2 Surface Impoundment
5 facility (WHC-SD-EN-TI-251; DOE/RL-90-22, *Resource Conservation and Recovery Act of 1976*
6 *[RCRA] Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit*).

7 Primarily, radioactive effluents and wastes were generated within the 105-N Reactor Building and the
8 109-N Heat Transfer Building. The radioactive process effluent and waste streams ultimately were sent to
9 the 116-N-1 Crib and Trench (1301-N Facility), the 116-N-3 Crib and Trench (1325-N Facility), or the
10 1314-N Liquid Waste Loadout Station. In order to maintain low dose rates and an efficient cooling
11 system associated with the reactor core, the steam generator, and the fuel storage basin work areas, fresh
12 demineralized waters were added to these independent systems, and the wastewater (bleed off) was
13 discharged to the 116-N-1 (1301-N) and 116-N-3 (1325-N) cribs and trenches

14 Water released to the 116-N-1 and 116-N-3 Cribs eventually reached the Columbia River through the
15 groundwater system. The 100-N Reactor contains additional alloys and materials not present in the older
16 reactors. These materials were protected from corrosion and the heat transfer surfaces protected against
17 fouling by suitable water treatment, resulting in a reduced need for the addition of chemical corrosion
18 inhibitors such as sodium dichromate. Although not substantially used in the reactor cooling water
19 system, the historical record indicates 7 to 9 tons of sodium dichromate per year at the 100-N Area for
20 several years after start up for the rod cooling water system that discharged to the crib
21 (e.g., 1301-N/116-N-1 [DUN-4668, DUN-6205, and DUN-7162]). Thus, approximately 25 tons of
22 sodium dichromate was documented as discharged.

23 The sodium dichromate usage in the documented interval 1968 to 1970 was probably typical; therefore,
24 the usage period is likely 1963-1970 and potentially twice the documented inventory (e.g., about
25 45.4 m tons (50 tons) was discharged. No other historical documents mention sodium dichromate use, and
26 the early 1970s timeframe is coincident with process changes implemented at the 100-N Area for
27 environmental reasons (WHC-MR-0521). The "rod cooling system" in the cited documents is most likely
28 the reactor control rod cooling system; one of the periphery cooling systems discussed in
29 WHC-SD-EN-TI-251. Sodium dichromate was a corrosion control agent in that system and the spent
30 effluent was discharged to the 1301-N Crib.

31 A major oil release (302,833 L [80,000 gal]) of No 6 fuel oil occurred in 1966 when a 4 in. line lost
32 integrity through external corrosion in the 166-N Tank farm. The diesel oil drained through the soil to the
33 Columbia River. A trench was excavated along the riverbank to intercept the oil before it could reach the
34 river. Oil exposed at the trench was burned periodically through 1967 (DOE/RL-90-22). Remediation of
35 this spill continues (later in this Chapter).

36 **2.1.2 Secondary Mission: Isotope Production and Electrical Power Generation at the** 37 **Hanford Generating Plant**

38 Secondary missions beside the production of special nuclear material at N Reactor included tritium
39 production and electrical power generation (WHC-MR-0521; WHC-SD-EN-TI-251).

40 These secondary missions contributed specific waste management challenges for each reactor area and
41 introduced variations from the initial common design and requirements. The secondary missions
42 increased the complexity of waste management operations for each site in how they interfaced with the
43 main production mission and when they occurred.

1 From 1965 to 1967, a “co-product” demonstration campaign took place, in which tritium was produced in
2 the reactor from special lithium aluminate fuel elements. Beginning in 1966, N Reactor steam for
3 electrical production was harnessed at the HGP, which was constructed west of the N Reactor facilities by
4 the Washington Public Power Supply System.

5 The Atomic Energy Commission (AEC) order issued in 1971 to close the KE Reactor included closure of
6 N Reactor. An agreement reached later in 1971 allowed the N Reactor to continue operations to produce
7 steam for the HGP and to pre-produce fuel-grade (not weapons-grade) plutonium for the breeder reactor
8 program. The spent fuel produced at the N Reactor was never used by the breeder reactor program and
9 was stored at the 100-K Basins (DOE/RL-97-1047). The continued operation of N Reactor resulted in
10 modifications and upgrades to waste management/treatment systems at these facilities (WHC-MR-0521).

11 **2.1.3 Waste Sites Description and History**

12 The two primary liquid waste disposal sites in the 100-N Area include the 116-N-1 and 116-N-3 Crib and
13 Trenches, also known as the 1301-N and 1325-N Liquid Waste Disposal Facilities (LWDF), respectively.
14 The oldest is the 116-N-1 Crib, used from the time the reactor went online in 1963 until September 1985.
15 The trench was extended in 1965 because the wastewater volume exceeded the capacity of the crib. The
16 116-N-3 Crib, built in 1983, was to augment the original 116-N-1 Crib (1301-N LWDF). In 1985,
17 a covered extension trench was added to the 116-N-3 Crib (1325-N LWDF) to increase the capacity of
18 that facility. To enhance percolation, the 116-N-3 Crib and Trench were sited where borehole geophysical
19 logs indicated relatively high permeability. The newer facility was located approximately twice the
20 distance from the river as the old facility, and was completely covered (WHC-SP-0377). Remedial action
21 goals were achieved during remediation of the 116-N-1 and 116-N-3 Cribs and Trenches
22 (CVP-2002-00002; CVP-2006-00004). Both waste sites were classified as “interim closed out” in
23 accordance with the waste site reclassification guideline TPA-MP-14 (RL-TPA-90-0001).

24 As of April 29, 2009, 151 waste sites (including four discovery sites) are located within the
25 100-N Decision Unit (Table 2-3). These waste sites are inactive, past-practice disposal sites described as
26 trenches, ditches, cribs, ponds, aquifers, and unplanned releases.

27 As of 2009, approximately 473,798 m tons (522,231 U.S. tons) of contaminated soil and debris have been
28 removed from the 100-N Area to mitigate and reduce impacts to human health and the environment.
29 Of this, 97,775 m tons (107,777 tons) are from waste site remediation. A total of 90 accepted waste sites
30 and four discovery sites remain in the 100-N Decision Unit to be cleaned up/evaluated and are tentatively
31 on the path for interim remedial action as of April 29, 2009. Table 2-3 summarizes the individual waste
32 site classifications in the 100-N Area. These WIDS classifications are defined in the work plan.
33 Appendix C provides a description and history for each waste site, and lists the contaminants of concern
34 (COCs) for each waste site. Appendix B provides the locations of the 100-N Decision Unit waste sites,
35 including key waste sites, and distinguishes those that received Sr-90.

36 The use and evolution of onsite facilities and their roles in waste management operations is described in
37 other technical documents (WHC-SD-EN-TI-251, DOE/RL-95-111). The uses and/or evolution of
38 facilities and waste sites impacted their D4 actions (e.g., implementation of the ENU, rather than use of
39 120-N-1 and 120-N-2 for waste management or the segregation of the HGP outfall (1908-NE) from the
40 other N Reactor discharge facilities). Facility remnants (e.g., foundations, pads, and subgrade piping) may
41 become classified as waste sites as D4 activities progress. If residual waste remains at a facility location
42 after the completion of D4, that location is reclassified as a waste site. However, in some cases, facilities
43 are completely removed and no residual waste remains, thus no corresponding waste site remains at the
44 end of D4. Specific site information obtained from contemporary characterization and remediation
45 activities are available from WIDS.

Table 2-3. Summary of Waste Sites in the 100-N Decision Unit (April 2009)

Area	Total Number of Waste Sites ^a	Closed Out ^b	Interim Closed ^c	No Action ^d	Not Accepted ^e	Accepted ^f	Discovery ^g
100-N Decision Unit Total	175	1	17	1	37	92	27

- a. Total number of sites includes discovery sites.
- b. Closed Out: A waste site meets applicable cleanup standards or closure requirements (as a request of failing cleanup actions).
- c. Interim Closed: A waste site meets the cleanup standards specified in an interim record of decision (as a request of failing cleanup actions).
- d. No Action: A waste site does not require remedial action based on quantitative data collected from the site.
- e. Not Accepted: Based on an assessment, a Waste Information Data System (WIDS) site is determined not to be a waste site and is therefore not within the scope of the *Hanford Federal Facility Agreement and Consent Order Action Plan*, as amended (Ecology, EPA, and DOE, 1998b) <http://www.hanford.gov/?page=117&parent=92>). This classification requires lead regulatory agency approval.
- f. Accepted: Based on an assessment, a WIDS site is determined to be a waste site as defined Ecology et al. (1989b).
- g. Discovery: A newly discovered WIDS site, with evidence of a potential waste site but the assessment is not yet complete.

1 Four waste sites within the 100-NR-1 OU are treatment or disposal units under RCRA authority: 116-N-1
 2 and 116-N-3 (1301-N and 1325-N LWDF), 120-N-1 (1324-NA percolation pond), and 120-N-2
 3 (1324-N surface impoundment). RCRA Part A, Permit Application forms for these units were initially
 4 submitted in 1986 and 1987.

5 In order to ensure all CERCLA hazardous substances (including radionuclides) were addressed during
 6 closure and to make disposal of closure wastes in the Environmental Restoration Disposal Facility
 7 (ERDF) (a CERCLA facility), the Tri-Parties subsequently developed an integrated CERCLA remedial
 8 action and RCRA closure approach for these units. Under this approach, a corrective measures
 9 study/closure plan document was developed, followed by a 1998 CERCLA Proposed Plan that included
 10 draft RCRA Permit conditions. Following public comment, a CERCLA ROD was issued in 2000
 11 containing remedial action requirements for the 116-N-1 and 116-N-3 treatment, storage, and disposal
 12 (TSD) units (EPA/ROD/R10-00/120). Sampling of the 120-N-1 and 120-N-2 showed that no hazardous
 13 substances were present. As a consequence, these units were excluded from the CERCLA ROD.
 14 Concurrent with the ROD issuance process, the Hanford Facility RCRA Permit was modified to
 15 incorporate closure requirements for the RCRA TSDs. Thus, joint RCRA and CERCLA authorities are
 16 applicable to closure and remediation of the 116-N-1 and 116-N-3 Facilities. The 120-N-1 and
 17 120-N-2 Facilities were closed pursuant to RCRA authority.

18 **2.1.4 Orphan Sites Process and Remaining Sites**

19 DOE has implemented a number of processes to identify new waste sites (work plan, Chapter 3). The
 20 process of identifying new waste sites increases confidence that waste disposal and releases requiring
 21 characterization and clean up within a given land parcel on the Hanford Site are addressed.

1 In addition to the previously described waste sites, other locations are categorized as “remaining sites”
2 and “orphan sites.” Remaining sites include various locations that generally were believed to have
3 received small discharge volumes and/or low levels of contaminated materials. Radioactive liquid effluent
4 waste sites are the primary source of contamination in groundwater. Past stack emissions are not
5 identified as sources of groundwater contamination (DOE/RL-2005-49).

6 Orphan sites are considered human-made features, items, or activity areas within the river corridor that:

- 7 • Meet the TPA-MP-14 criteria for waste site identification.
- 8 • Are not identified for characterization or cleanup within the regulatory decision documents
9 (e.g., Interim Action ROD).
- 10 • Have been presented to and accepted by the WCH Field Remediation Closure Project,
11 U.S. Department of Energy, Richland Operations Office and the regulators (WCH-218, *Orphan Sites*
12 *Evaluation Project Execution Plan*).

13 The OSE process is a systematic approach to review land parcels and identify potential waste sites in the
14 river corridor that are not currently listed in existing CERCLA decision documents. The orphan site
15 evaluation of the 100-NR-1 OU was conducted between August 2006 and March 2007. Documentation of
16 this investigation of the 100-N-1 Area is currently being completed (*100-NR-1 Area Orphan Sites*
17 *Evaluation Report*, OSR-2009-0001 Draft A) and anticipated issued in late FY 2009. The scope covered
18 an area of approximately 761.62 he (1,882 ac). Twenty-three orphan sites were identified during the
19 evaluation process. These discovery sites will be incorporated into the decision unit according to the
20 TPA-MP-14 process and addressed according to Interim Action RODs or ROD amendments.

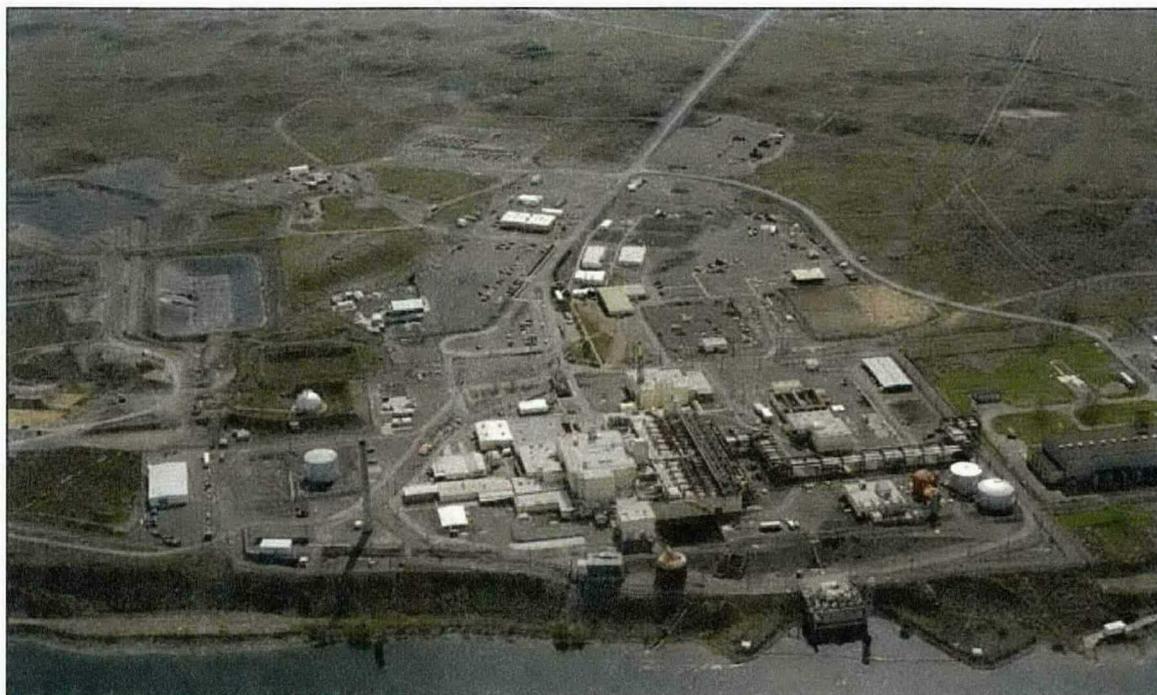
21 The “remaining sites” category includes a diversity of sites such as septic systems from contaminated
22 facilities, burn pits, French drains, pre-Hanford and Hanford-era waste dumps, small oil spills, landfills,
23 outfalls, ponds, process facilities, retention basins, storage tanks, sumps, unplanned releases, and
24 non-reactor effluent pipelines, and sub-sites of the two reactors. Remediation of these waste sites began in
25 the 100-N Decision Unit in 2005 (DOE/RL-2005-40).

26 Some remaining sites have been investigated and designated for removal action (i.e., RTD). However, the
27 presence of contamination in many of these sites is uncertain, so the remedial alternative chosen in the
28 interim action ROD is confirmatory sampling, with removal of discovered waste that exceeds the
29 100 Area cleanup criteria. Because of the lower contaminant levels expected, vegetation is not cleared
30 from many of these sites.

31 Remaining sites and orphan sites are considered known or suspected sources of contamination. These
32 sites are newly discovered potential waste sites that will be evaluated to determine their impact (if any) to
33 the environment, with potential changes to work planning and execution administered through established
34 project management channels.

35 **2.1.5 Decommissioning Activities**

36 In April 1986, an accident at the Chernobyl nuclear plant in Soviet Russia initiated a stand down for
37 safety evaluations at the N Reactor. After the stand down, DOE ordered the N Reactor to cold standby in
38 February 1988, and a large decontamination and decommissioning (D&D) project that led to its final
39 disposition began in 1994 (WHC-SP-0615, *N Reactor Deactivation Program Plan*). Figure 2-6 shows the
40 D-4 success through 2002.



1
 2
 3
 4

Figure 2-6. 100-N Area (2002)

Table 2-4 shows the status of facilities within the Decision Unit. The description and history of each decision unit facility is summarized in Appendix B.

Table 2-4. Summary Information on the Status of the 100-N Decision Unit Facilities

Area	Total Number of Facilities	Status			
		Demolished*	Removed*	Active*	Inactive*
100-NR-1	234	96	82	27	29

Reference: SIS, January 6, 2009.

* Status:

Active: Facility is occupied and in use supporting Hanford Site missions.

Demolished: Facility has been removed to grade (slab or foundation remains).

Inactive: Facility is no longer in use and is awaiting decommissioning and demolition.

Removed: Facility foundation is removed and any substructure is 30.5 to 91 cm (1 to 3 ft) below grade.

5 In 1995, CERCLA action memorandum directing the N Reactor be placed in ISS condition was issued
 6 (CCN-119850, *105-N Reactor Building and 109-N Heat Exchanger Building Action Memorandum*).
 7 ISS represents a series of actions taken to protect the reactor from environmental degradation and prevent
 8 the spread of contamination by “cocooning,” or providing an upgraded, weather-resistant shell to isolate
 9 the reactor core until final remedial activities are conducted. The action minimizes the facility footprint by
 10 removing peripheral reactor buildings and equipment, and disposing of that debris properly. Completion
 11 of ISS activities at the N Reactor is projected for 2012.

2.2 Environmental Setting

The 100 Area environmental setting is provided in detail in the work plan (DOE/RL-2008-46, Section 2.3), with specific 100-N Decision Unit information included here.

2.2.1 Topography

The 100-N Decision Unit topography is relatively flat inland from the Columbia River (Figure 2-3). The area has been graded extensively since reactor construction began in the 1960s through present-day waste site remedial activities. The elevation of the 100-N Area ranges from approximately 120 m (390 ft) above mean sea level (msl) at the Columbia River to approximately 140 m (459 ft) above msl on the east side of the decision unit (DOE/RL-93-81, *Limited Field Investigation Report for the 100-NR-2 Operable Unit*). The slope along the riverbank has gradients of at least 15 percent. Bluff heights above the river surface range to approximately 21 m (70 ft) at the 100-N Area. The surrounding terrain is the result of catastrophic flooding associated with Pleistocene glaciation (DOE/RL-93-81), and is characterized by low hills and mounds. Several geologic terraces and levees are located along both sides of the river channel in the 100-N Area. Geological carbon-14 dating of organic material contained in soil samples taken from an older terrace near the N-Springs area and several other locations along this section of the river indicate that this section of the river has been in its present position for several thousand years (BHI-01324). In addition, an archeological study excavated into the second terrace/levee above the river immediately north of the HGP and mussel shells found in the sands near the base of the terrace were collected for radiocarbon analysis. The radiocarbon date calculated for the shells was 7,880 +/- 110 years. This terrace is present under the fill at the HGP based on aerial photographs taken prior to construction at the 100-N Area. Based on the system of terraces and levees correlative to the second terrace (discussed above), the Columbia River has occupied the same channel from 100-B/C Area to 100-D Area for at least the past ~8,000 years (BHI-016428 and WCH-46). Therefore, despite the tremendous volumes of water flowing past the 100-N Shoreline, the shoreline itself is stable and has been so for several thousand years.

The landscape is a semiarid (steppe) environment with a sparse covering of cold desert shrubs and drought-resistant grasses. This landscape supports occasional small, wetland-like features affected by infrastructure drainage, facilities, and past development. Numerous infrastructure features are present and include pipelines, reactor buildings, former waste sites, and groundwater remediation systems and equipment.

2.2.2 Geology

An overview of the regional geology of the 100 Area is provided in the integrated work plan. Additional information specific to the 100-N Decision Unit is provided in this section.

The 100-N Decision Unit is underlain by the Miocene-age (approximately 17 to 8.5 million years) Columbia River Basalt Group and late Miocene to Pleistocene-age sediments (approximately 10.5 million to 12,000 years) that overlie the basalts.

The sediments are divided into two main units: the Ringold Formation of late-Miocene to middle-Pliocene age (approximately 10.5 to 3 million years) and the Hanford formation of Pleistocene age (approximately 1 million to 12,000 years). Holocene deposits of silt, sand, and gravel form a relatively thin veneer at the surface. The water table is in the Ringold Formation Unit E, as is the unconfined aquifer within the Decision Unit. Based on limited borehole information, the Ringold Upper Mud (RUM) underlies the entire decision unit, is a relatively low-permeability unit, and forms the base of the unconfined aquifer. Table 2-5 shows the elevations and thicknesses of the Ringold Formation and Hanford formation in the 100-N Area.

Table 2-5. Elevation and Thickness of Major Geologic Units Beneath the 100-N Area

Geologic Unit	Top elevation (m)	Thickness range (m)	Description
Hanford Formation	122 - 145	6-23	Uncemented pebble-cobble gravel
Ringold Unit E	118 - 128	5 - 20	Pebble-cobble gravel; variably cemented
Ringold Upper Mud	106 - 109	17 - 29	Silt and clay with minor sandy layers
Ringold Unit C	80	3 - 5	Sand
Ringold Paleosol-Overbank Interval	75	38 - 43	Silt and sand
Ringold Unit B	40	20 - 22	Sand
Ringold Lower Mud	10	30	Clay and silt
Ringold Unit A	-20	4 - 8	Gravel
Elephant Mountain	-30	40 - 50	Basalt

Sources: WHC-SD-EN-EV-027 and Hanford Well Information System geologic logs.

1 The properties of these formations influence the distribution and behavior of contamination in the
 2 subsurface. Within the 100-N Decision Unit, the vadose zone is composed mainly of the Hanford
 3 formation with portions of the Ringold Unit E locally. Figure 2-7 provides a generalized geologic
 4 stratigraphic section of the 100-N Decision Unit. Five new cross-sections were constructed to show the
 5 geology throughout the 100-N Area. Data from several previous geologic reports, existing and
 6 decommissioned wells, and data from new well installations were used to present the best depiction of the
 7 100-N Area geology. Figure 2-8 (Locations of Cross-Sections within the 100-N Area) shows the locations
 8 of the cross-sections within the 100-N Area. Figure 2-9 (Detailed View of Cross-Section E to E') shows
 9 the location of cross-section E to E' in detail. The cross-sections show strontium-90 data collected for the
 10 well or borehole (where available) during drilling activities. The data are shown for the intervals where
 11 they were collected and represent the amount of Sr-90 present at that respective depth and decayed
 12 through December 31, 2009. Two interesting points are shown by this data, where it is available: (1) the
 13 bulk of the Sr-90 sampled is retained in the Hanford formation/vadose zone above current water table and
 14 (2) the amount of Sr-90 present decreases with depth into the top of the Ringold Unit E and below current
 15 water table. This is in direct correlation to the conceptual model information presented in Chapter 4.
 16 Cross-section A to A' (Figure 2-10) shows the general drop in elevation along the river shore as you
 17 proceed down river. There is variation in the Hanford-Ringold Unit E contact along the length of the
 18 section. There is also a "channel" cut into the Ringold Unit E near the upper portion of the section, which
 19 will influence groundwater flow at the contact. Cross-section B to B' (Figure 2-11) shows a
 20 south-westerly dip in the contacts between the Hanford-Ringold Unit E and the Ringold Unit E-RUM on
 21 the upriver end of the section. The "channel" in the Ringold formation is also evident in the middle of this
 22 section. Cross-section C to C' (Figure 2-12) also shows the "channel" in the top of the Ringold Unit E in
 23 the middle of the section. Cross-section D to D' (Figure 2-13) shows the elevation differences between
 24 the upland and river shore portions of the 100-N Area. The section cuts across the existing apatite PRB
 25 and through the head-ends of both the 1301-N and 1325-N Cribs. There is some variation in the contact
 26 between the Hanford formation and the Ringold Unit E along the section; the contact is highest in
 27 elevation near the 1301-N Crib and dips to the northwest towards the river shore. There is a dip in the
 28 contact near the 1325-N Crib, but it rises in elevation again to the southeast of the crib. Cross-section E

1 to E' (Figure 2-14) runs SW to NE along the existing apatite PRB, and represents a more detailed look at
 2 wells within the larger A to A' cross-section. There are two lower areas in the contact between the
 3 Hanford and Ringold Unit E, one in the middle of the upper half of the barrier and one in the middle of
 4 the lower half of the barrier. The contact dips to the NE at the end of the barrier. The contact between the
 5 Ringold Unit E and RUM is consistent in elevation along the length of the barrier.

Generalized Hydrogeology of the 100N Area

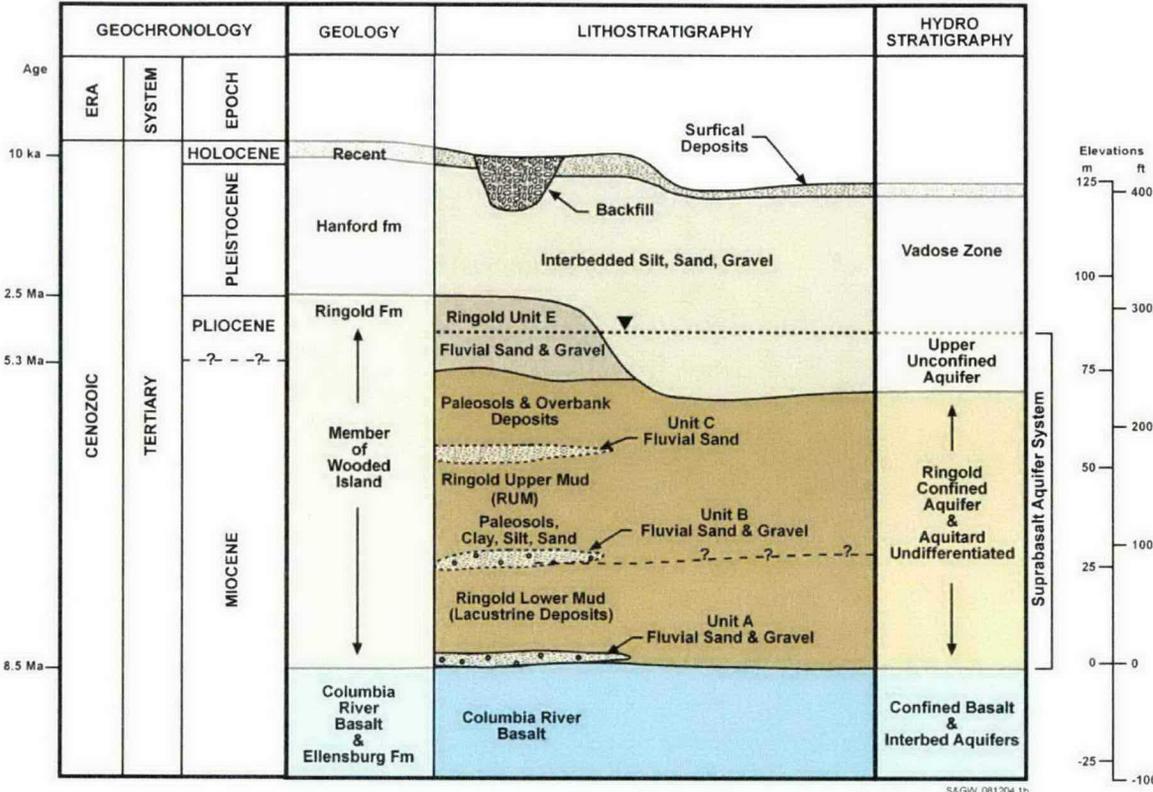


Figure 2-7. Generalized Geologic Stratigraphic Section of 100-N Decision Unit

7
8

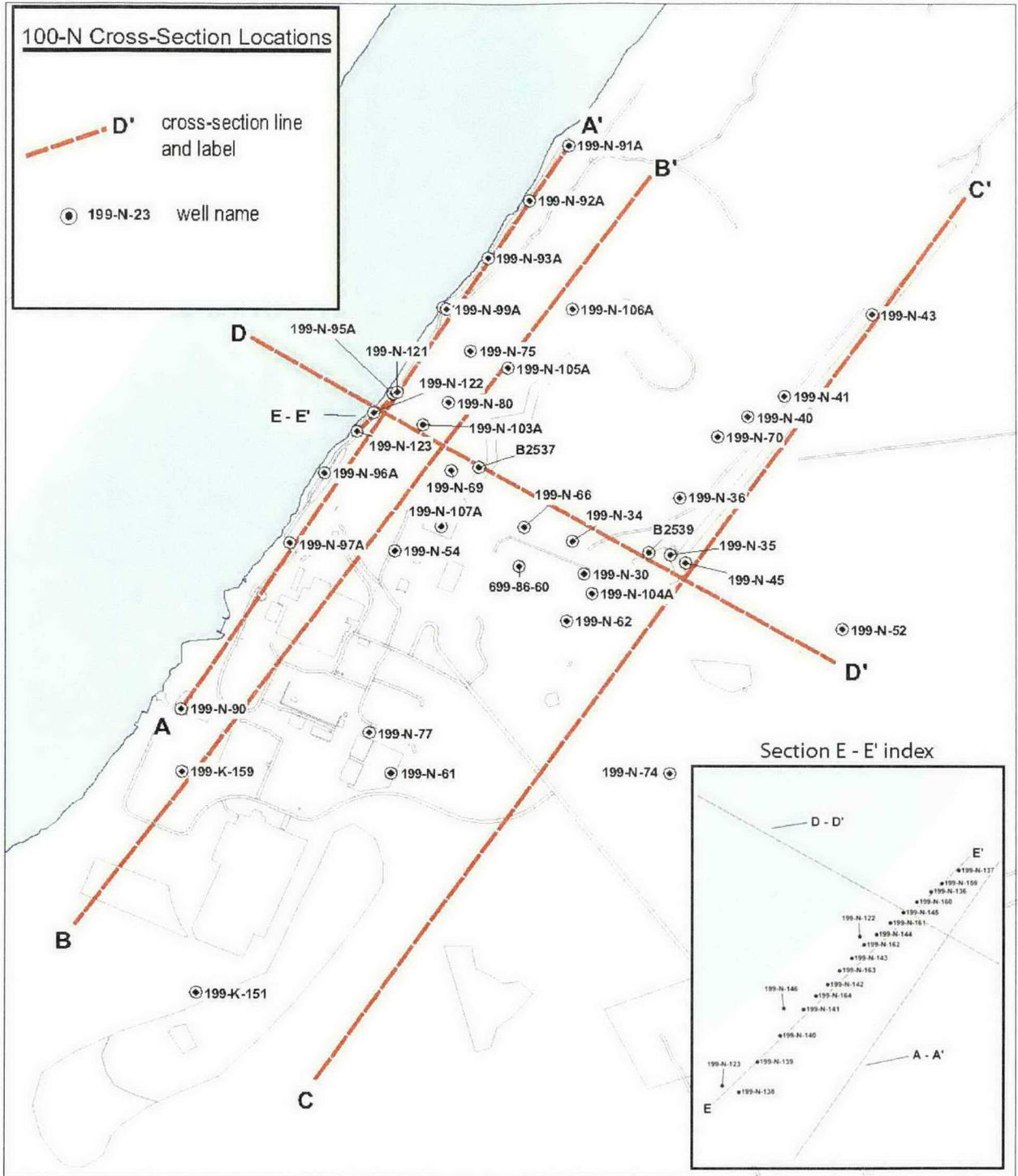


Figure 2-8. Locations of Cross-Sections within the 100-N Area

1
 2
 3

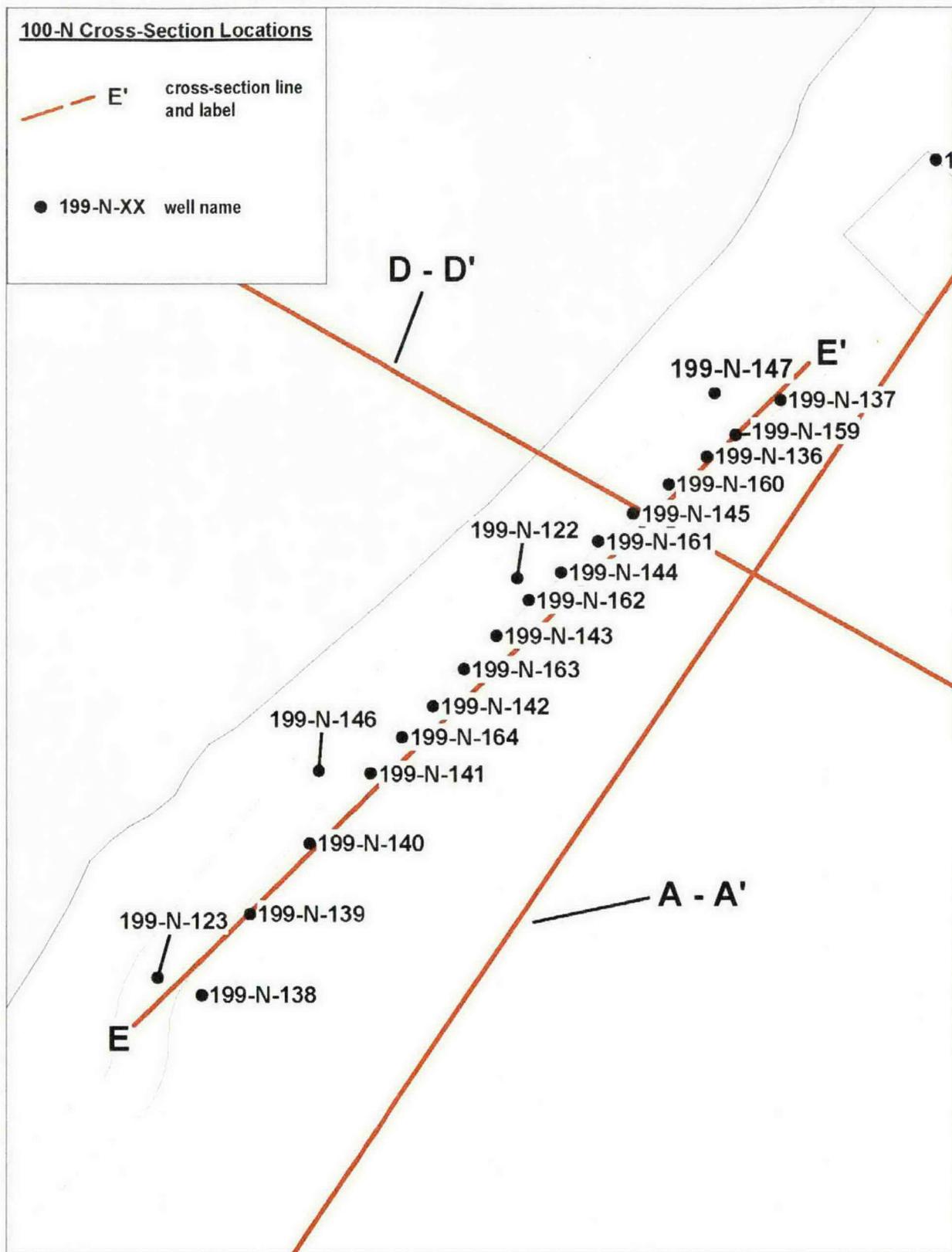


Figure 2-9. Detailed View of Cross-Section E to E'

1
2

1

2

3

This page intentionally left blank.

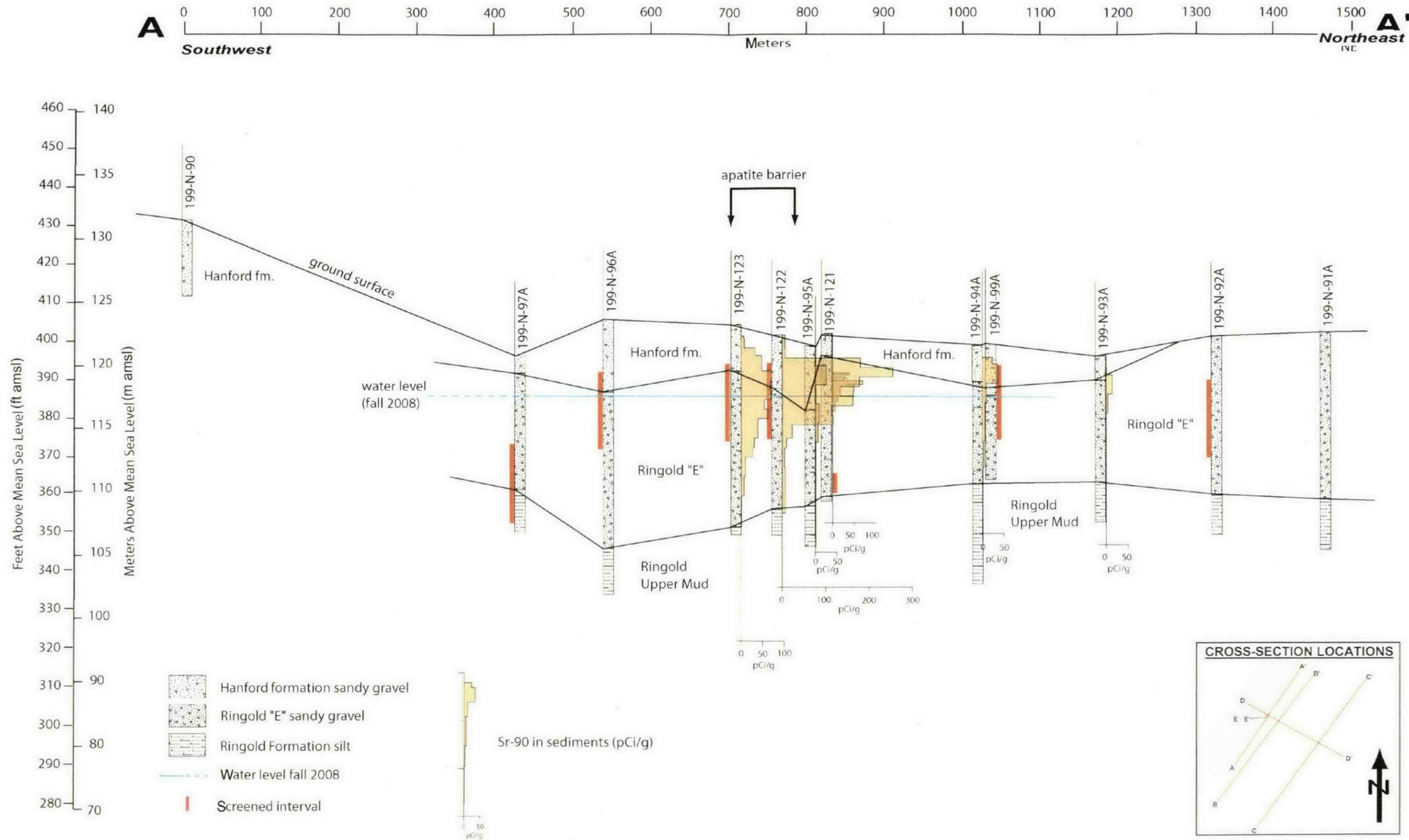


Figure 2-10. Geologic Cross-Section A to A'

1

2 This page intentionally left blank.

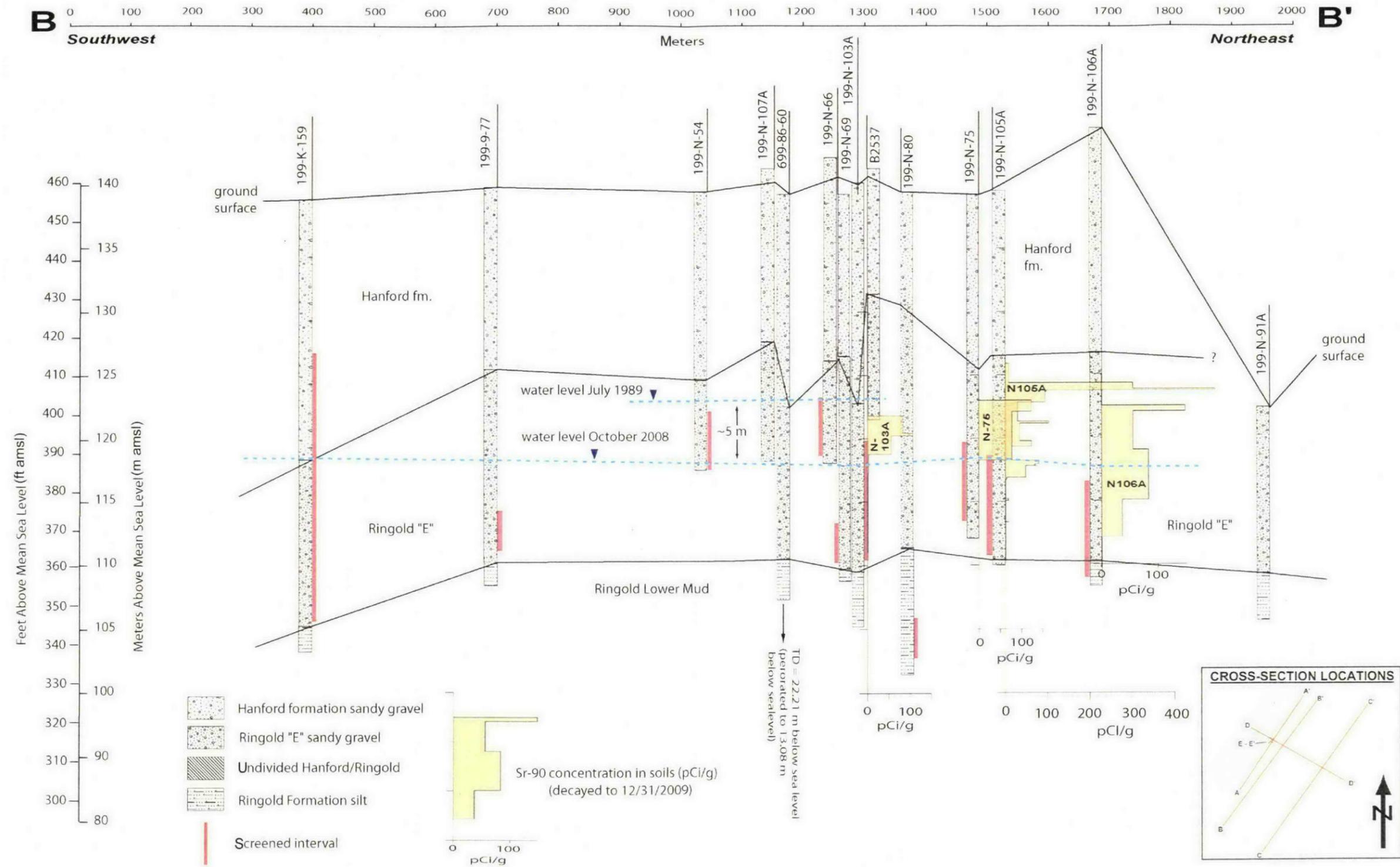


Figure 2-11. Geologic Cross-Section B to B'

1
 2
 3

1

2 This page intentionally left blank.

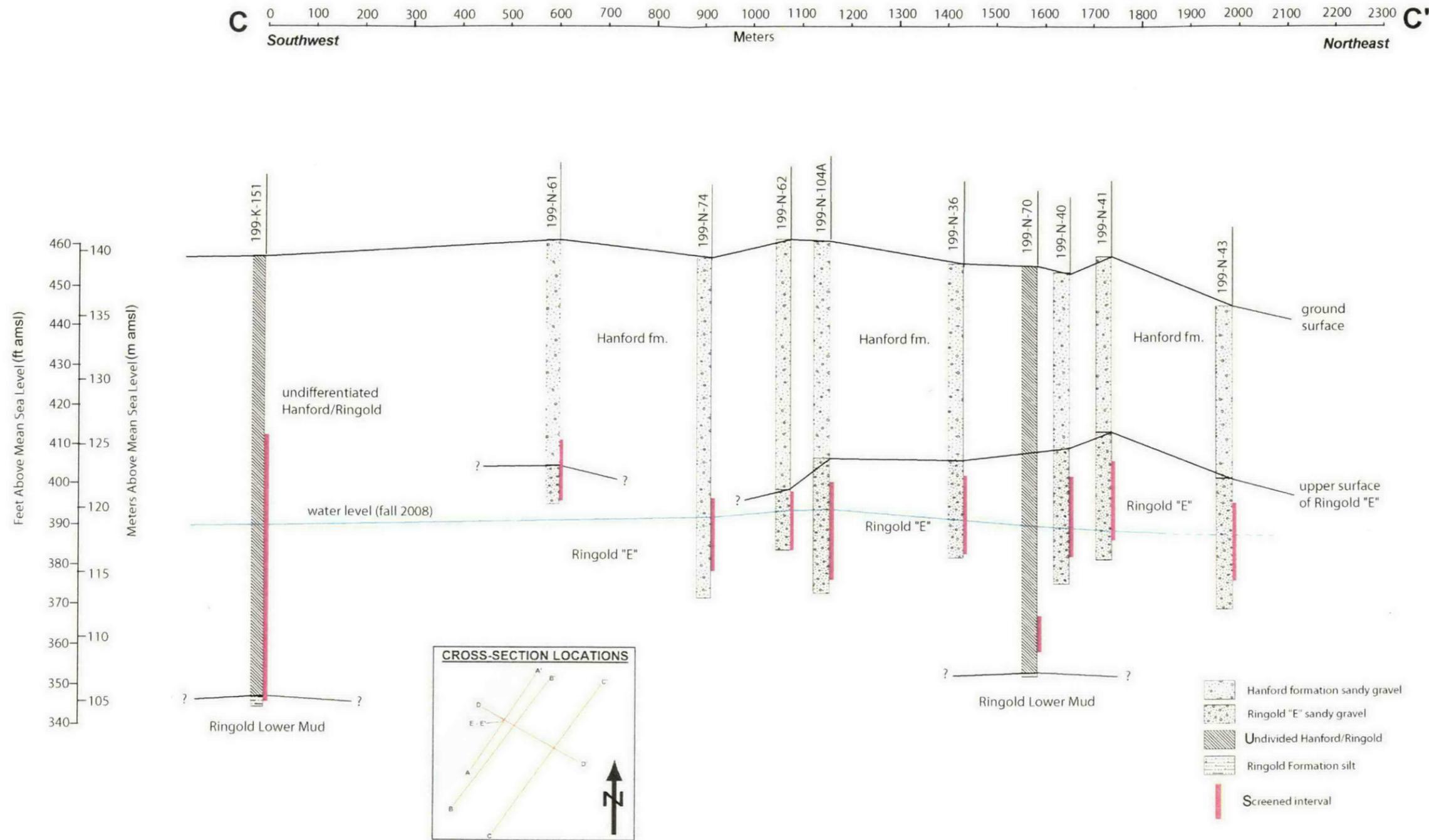


Figure 2-12. Geologic Cross-Section C to C'

1
 2
 3
 4

1

2 This page intentionally left blank.

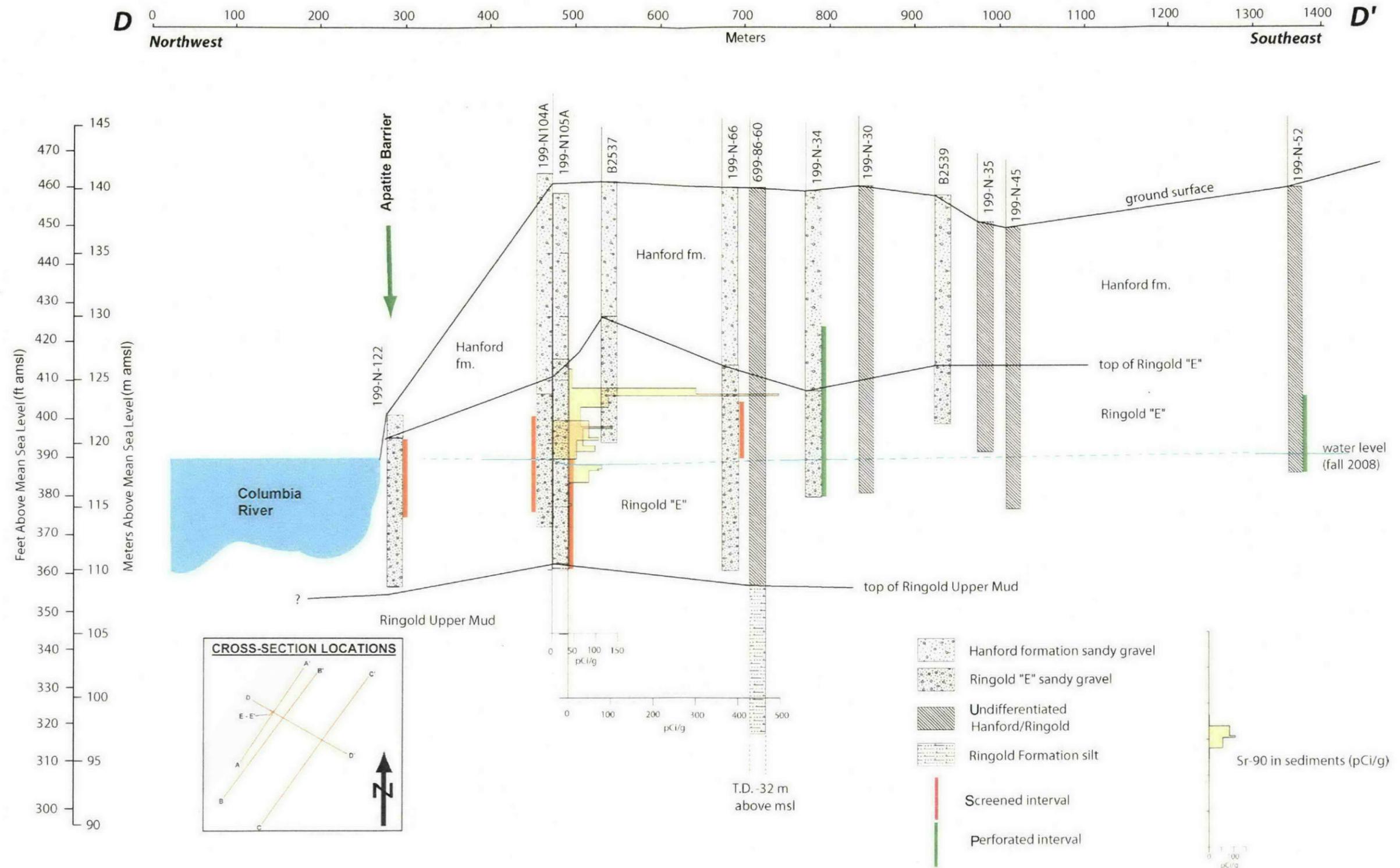


Figure 2-13. Geologic Cross-Section D to D'

1
 2
 3

1

2 This page intentionally left blank.

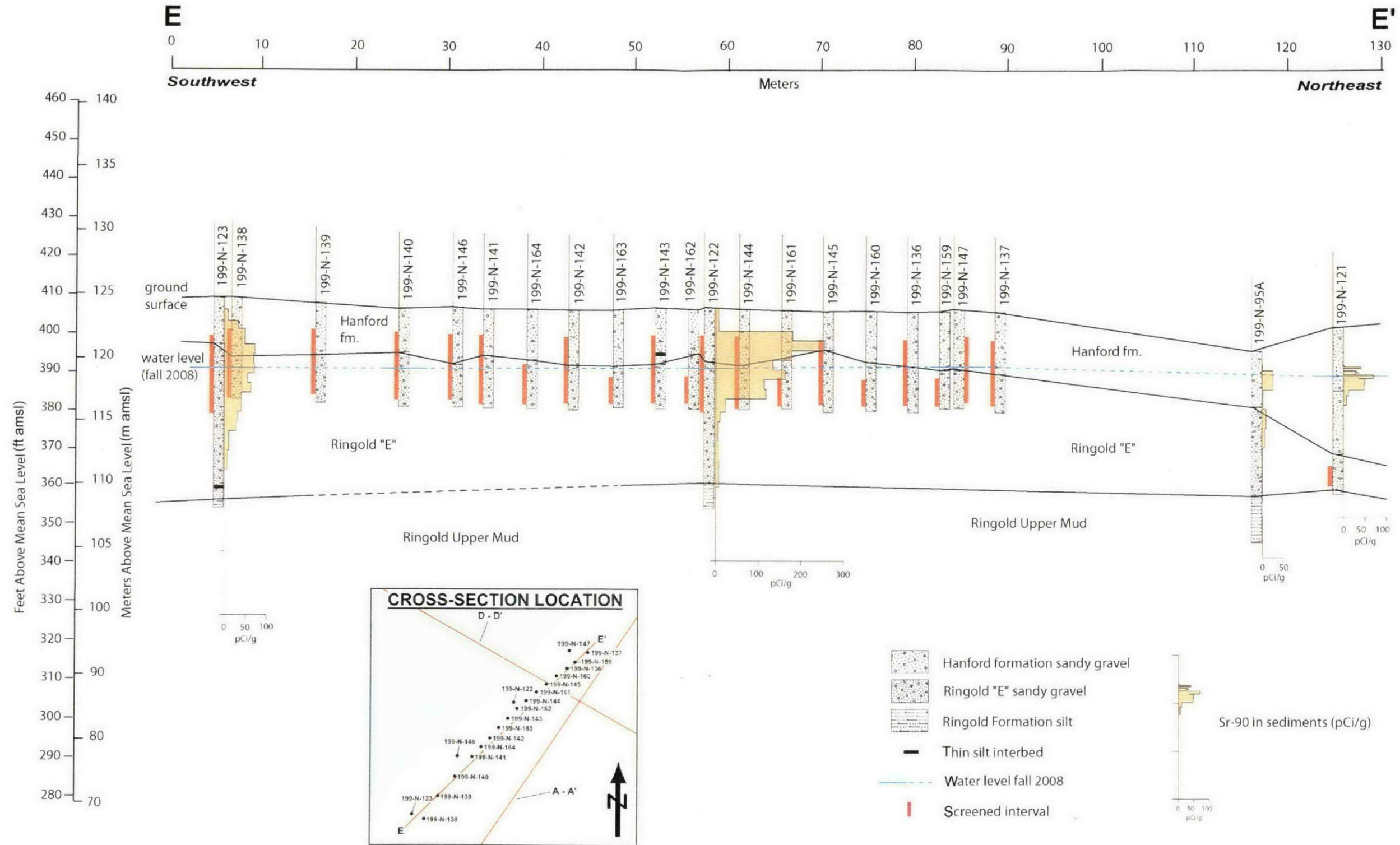


Figure 2-14. Geologic Cross-Section E to E'

1
 2
 3

1

2 This page intentionally left blank.

1 **2.2.2.1 Ringold Formation**

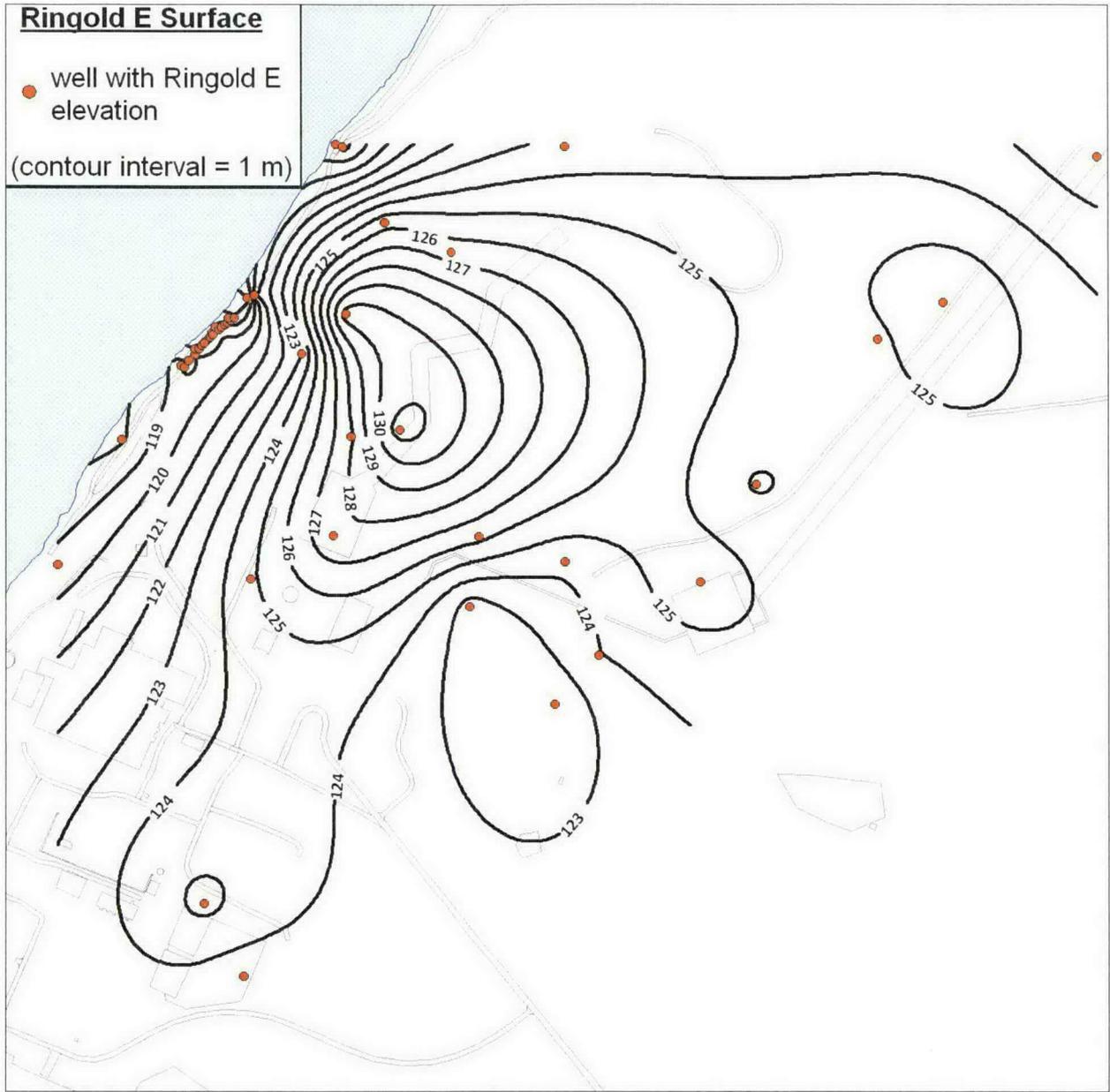
2 The Ringold Formation unconformably overlies the Columbia River Basalt Group. The Ringold Units
3 identified from oldest to youngest in the 100-N Decision Unit include Unit A, Ringold lower Mud,
4 Unit B, paleosol-overbank interval, Unit C, RUM, and Unit E. Within the 100-N Decision Unit, the top of
5 the Ringold Formation ranges from 6 m (19 ft) to approximately 23 m (77 ft) below ground surface (bgs).
6 It was deposited by fluvial-lacustrine (stream-lake) processes, and is composed of a mix of fluvial
7 gravels, fluvial sands, overbank deposits, paleosols, and lake deposits (WHC-SD-EN-EE-004,
8 WHC-SD-EN-TI-011). The Ringold Formation ranges from 137.2 to 150.5 m (450 to 494 ft) in thickness
9 in the 100-N Area, based on two wells drilled to the top of basalt (WHC-SD-EN-EV-027).

10 The Ringold Unit A consists of fluvial gravel-dominated deposits. The lower mud consists of a lower
11 paleosol-dominated interval and an upper lake deposit-dominated interval. Units B and C are
12 characterized by fluvial sands with lesser, but still common overbank deposits and minor fluvial gravels.
13 The paleosol-overbank interval between Units B and C is a silt-rich deposit that locally contains abundant
14 pedogenic carbonate development and minor sand interbeds (generally less than 3 m [10 ft]) thick). The
15 Upper Mud consists of fine-grained deposits of typical overbank and paleosol facies, Unit E is comprised
16 of pebble to cobble fluvial gravels, in a fine to coarse grained sand matrix, with localized, discontinuous
17 cementation. Figure 2-15 shows the top of the Ringold Unit E. The base of the unconfined aquifer is
18 defined by the top of the RUM, which is considered an aquitard rather than a completely impermeable
19 unit. The hydraulic conductivity of the RUM within the 100-N Decision Unit is not known. Channels
20 were eroded into the top of the RUM, which established an undulating surface throughout the 100 Area.
21 Figure 2-16 shows RUM elevations within the 100-N Decision Unit. The Ringold Unit E overlies the
22 RUM and typically consists of fluvial gravels with lesser amounts of sand, silt, and clay, with variable
23 and locally discontinuous cementation. The unconfined aquifer in the 100-N Decision Unit is primarily
24 within the Ringold Unit E except during high-river stage when the water table is within the Hanford
25 formation near the river. The Ringold Unit E ranges in thickness from 5 m (17 ft) to 20 m (65 ft) in the
26 100-N Decision Unit (WHC-SD-EN-EV-027, BHI-00135), and is overlain by the Hanford formation.

27 **2.2.2.2 Hanford Formation**

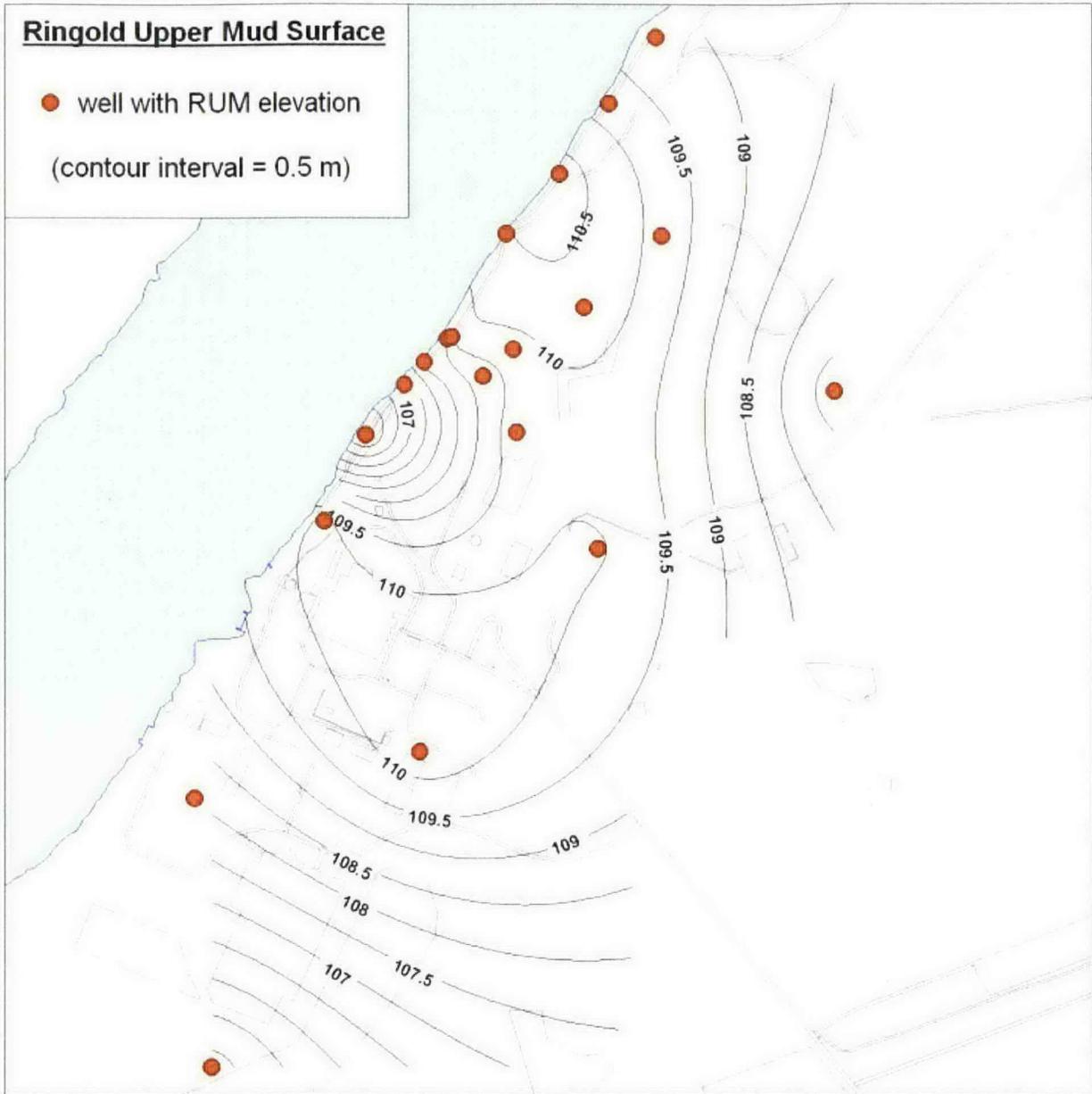
28 In the 100-N Decision Unit, the Hanford formation is present to depths of approximately 23 m (77 ft) bgs.
29 It is an open framework boulder-cobble gravel, sand, and silt deposited by cataclysmic flood waters from
30 glacial Lake Missoula during the Pleistocene epoch (DOE/RW-0017, *Draft Environmental Assessment:
31 Reference Repository Location, Hanford Site*). The Hanford formation is divided into three facies:
32 (1) gravel-dominated, (2) sand-dominated, and (3) silt-dominated (DOE/RL-2002-39, *Standardized
33 Stratigraphic Nomenclature for the Post-Ringold-Formation Sediments within the Central Pasco Basin*).
34 The grains typically are sub-round to round gravel and sub-angular to round in the sand grain fraction.
35 The gravel-dominated facie typically is well stratified and contains little to no cementation
36 (WHC-SD-EN-EV-027; WHC-SD-EN-TI-132, *Geologic Setting of 100-HR-3*), but may contain discreet
37 sand lenses.

38



1
2
3

Figure 2-15. Ringold Unit E Elevations in the 100-N Decision Unit



1
2

Figure 2-16. RUM Elevations in the 100-N Decision Unit

2.2.2.3 Hanford/Ringold Contact

The Hanford formation is more transmissive and permeable than the Ringold Formation and the contact between the two potentially affects vadose zone and groundwater contaminant transport. Several criteria differentiate the two units. The sand fraction in Hanford gravels generally contains 40 to 70 percent basalt as compared to Ringold deposits that generally contain less than 25 percent basalt (WHC-SD-EN-TI-132; WHC-SD-EN-EV-027; BHI-00135). Hanford gravels may display salt-and-pepper and gray coloring, while Ringold gravels are generally oxidized and reddish-brown to yellow-red in color. Hanford gravels tend to be less consolidated or cemented than Ringold gravels. Drilling rates are slower in the Ringold Formation, which exhibits decreased hydraulic conductivity. Consequently, this contact may support contaminant spreading because of hydrologic differences. Studies done at the Apatite permeable-reactive barrier (PRB), installed along approximately 91.44 m (300 ft) of the Columbia River shoreline at 100-N, have shown there are significant hydrologic differences between the Hanford and Ringold Formations. The Hanford formation is much more transmissive than the underlying Ringold Unit E; however due to hydrologic heterogeneity, the hydraulic conductivity in both units is highly variable. Typical values of 15.2 and 182 m/day (50 and 597 ft/day) have been used for modeling purposes for the Ringold and Hanford units, respectively (Connelly, MP, 2001, *Strontium-90 Transport in the Near-river Environment at the 100-N Area*, Innovative Treatment and Remediation Demonstration Program, HydroGeoLogic, Reston, Virginia). A further example of the differences that can occur between the Hanford fm and Ringold Unit E was demonstrated when development data from apatite PRB injection wells was used to determine the specific capacity for each well. Specific capacity is the quantity of water a well can produce per unit drawdown and provides a method for comparing the relative transmissivity of the aquifer. While specific capacity is not directly proportional to hydraulic conductivity, it is an indicator of both hydraulic conductivity and well efficiency. The specific capacity on the downstream half of the PRB is 10 to 30 times higher than the upstream portion of the barrier (PNNL-17429).

The Hanford/Ringold contact is irregular in the 100-N Decision Unit and was affected by post-Ringold erosion (e.g., Pleistocene flooding). The elevation of the Hanford/Ringold contact within the 100-N Decision Unit is shown in Figure 2-15 (WHC-SD-EN-TI-011, *Geology of Northern Part of Hanford Site Outline of Data Sources and Geologic Setting of 100 Areas*).

2.2.2.4 Surface Deposits

The Holocene deposits consist of silt, sand, and gravel that form a relatively thin (up to 5 m [16ft]) veneer across the 100-N Decision Unit. The sediments were deposited by a mix of windblown and alluvial processes during the past 10,000 years and consist of very fine- to medium-grained angular to subangular sand with minor silt and gravel. In some portions of the 100-N Decision Unit, the surficial sediments consist of reworked backfill material from the Hanford formation (WHC-SD-EN-TI-011).

2.2.3 Hydrogeology

Liquid waste, including radionuclides and hazardous chemicals, has been discharged to the surface in the 100-N Decision Unit. Some of the contaminants reached groundwater. Understanding groundwater flow and aquifer properties is necessary to properly monitor groundwater and track the spread of contaminants.

2.2.3.1 Aquifer Properties

The uppermost aquifer in the 100-N Decision Unit is unconfined, and comprises the sands and gravels of Ringold Formation Unit E. During high river stage, the water table rises temporarily into the lower portion of the Hanford formation near the river. The unconfined aquifer is approximately 9 to 12 m (30 to 40 ft) thick beneath the decision unit. Fine-grained units of the Ringold upper mud unit form the base of the unconfined aquifer.

1 Most of the monitoring wells in the 100-N Area are screened in the top 6 m (20 ft) of the unconfined
2 aquifer. A few wells (e.g., 199-N-69, 199-N-70, 199-N-77, 199-N-121) are screened at the bottom of the
3 aquifer, immediately above the RUM unit. Former extraction wells (199-N-103A, 199-N-105A, and
4 199-N-106A) are screened across the entire thickness of the aquifer.

5 Transmissivity of the unconfined aquifer ranges from 93 to 560 m²/d (1,000 to 6,000ft²/day) throughout
6 most of the 100-N Area (WHC-SD-EN-EV-027). Wells in the northwest seem to show a higher
7 transmissivity (up to 1,900 m²/d [20,000ft²/day]). These values correspond to horizontal hydraulic
8 conductivity of 15 to 91 m/d (50 to 300ft/day), and 300 m/d (1000ft/d) in the northwest. Vertical
9 hydraulic conductivity is 0.03 to 21 m/d (0.1 to 70ft/d).

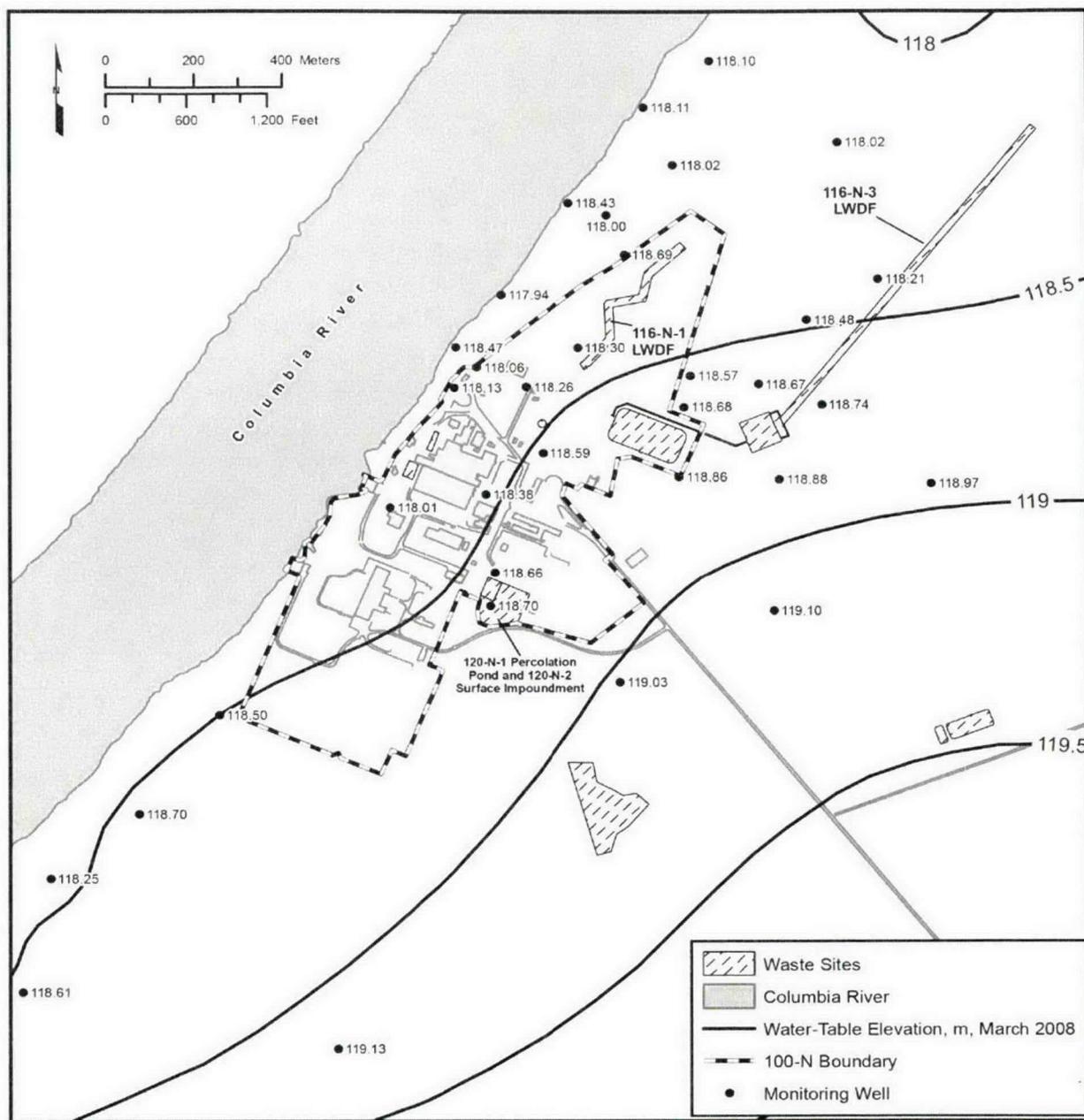
10 In 2006, as part the permeable reactive barrier siting investigations, DOE conducted a tracer injection test
11 and two pilot injection tests in wells on the 100-N Area shoreline (PNNL-17429, *100-NR-2 Apatite*
12 *Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ*
13 *Strontium-90 Immobilization*). Hydraulic and transport response data were evaluated at two pilot test
14 sites. Researchers determined that there was a greater contrast in permeability between the Hanford and
15 Ringold formations at the downstream site (near Well 199-N-137) than at the upstream site
16 (near Well 199-N-138). Permeability of the Hanford formation was more variable than that of the
17 Ringold Formation.

18 Deeper, confined aquifers occur within the Ringold Formation and in the basalt/interbed system
19 (Figure 2-7). Wells 199-N-80 and 199-N-8P are screened in sandy layers within the RUM unit. No wells
20 in the 100-N Decision Unit are screened in the basalt-confined aquifers. The confined aquifers are
21 isolated from the overlying aquifers by low-permeability strata.

22 **2.2.3.2 Groundwater Flow and Groundwater River Interaction**

23 Both natural and artificial hydrologic processes have influenced subsurface contaminant distribution.
24 Ongoing natural processes include natural recharge and river stage changes. Artificial recharge from
25 liquid waste discharged to cribs and ponds in the 1960s through 1980s influenced groundwater flow and
26 contaminant distribution.

27 Beneath the 100-N Area, groundwater flows primarily toward the northwest, toward the Columbia River
28 (Figure 2-17 [DOE/RL-2008-66]). Groundwater discharges to the river primarily below the low water
29 line. There are currently two riverbank springs discharging above the low water line.



1
 2

Figure 2-17. 100-N Area Water Table Map, March 2008

3 Daily and seasonal changes in the Columbia River stage are controlled by the Priest Rapids Dam, located
 4 upstream of the Hanford Site. During spring, the river level rises because snowmelt runoff is allowed to
 5 flow through the dam. During these periods of high river stage, river water flows into the aquifer along
 6 the Hanford Reach, causing the water table to rise throughout the 100 Areas. High-river stages can be
 7 more than 3 m (10 ft) higher than low-river stages. River stage may fluctuate several feet over short time
 8 intervals (i.e., hours to days) based on Priest Rapids Dam operations (DOE/RL-96-84). Changing river
 9 stage influences groundwater elevations over 1 km (3,000 ft) inland from the river.

1 In 2007 a series of three-point problems were solved to calculate gradient in various well triangles in the
2 100-N Area (DOE/RL-2008-05). For selected wells equipped with transducers, net annual gradient and
3 flow were calculated. The following are general observations:

- 4 • Net groundwater flow during the year was northwest beneath the overall 100-N Area. Net flow was
5 north-northwest beneath 116-N-1 and toward the northwest farther inland.
- 6 • Net flow velocity during calendar year (CY) 2007 was approximately 0.04 m/day (0.13 ft/day) or
7 approximately 15 m/year [49 ft/year].
- 8 • When the river stage was low, groundwater flow direction was toward the river (northwest), which
9 was also the net flow direction.
- 10 • When the river stage was high, groundwater flow direction was away from the river (southeast)
11 overall, and east-northeast in inland areas.
- 12 • The water table gradient and velocity are as much as an order of magnitude larger during low river
13 stage than during high river stage.

14 During the 1960s through 1980s, effluent discharged to liquid waste disposal facilities created
15 groundwater mounds that influenced groundwater flow and the distribution of contaminants. The 116-N-1
16 site (former 1301-N liquid waste disposal facility) operated 1963 through 1985. The 116-N-3 site
17 (former 1325-N liquid waste disposal facility) operated from 1983 through 1991. The 120-N-1 site
18 (former 1324-NA percolation pond) operated from 1977 to 1991. The long-term discharges created
19 groundwater mounds under the discharge facilities. These mounds had substantial impacts on
20 contaminant migration patterns in the unconfined aquifer, which are discussed further in Chapter 4.
21 Similar mounds in the each of the 100 Areas raised the water table regionally through the entire northern
22 portion of the Hanford Site (WCH-SD-EN-TI-023). While the groundwater mounds existed, the water
23 table was in the Hanford formation in some parts of the 100-N Decision Unit. At that time, groundwater
24 discharged to the Columbia River through a series of riverbank springs above the water line, known as
25 "N Springs."

26 Figure 2-18 shows the trends in water levels in four wells in the 100-N Decision Unit. The elevated water
27 table was evident 1.7 km (1.1 mi) inland at upgradient well 699-81-58. The groundwater mounds in the
28 100-N Area dissipated rapidly in the early 1990s after liquid effluent disposal ceased. The regional water
29 table (699-81-58) appears to be still declining in 2009. The "bump" in water levels in the mid-1990s was
30 caused by higher-than-average river stage.

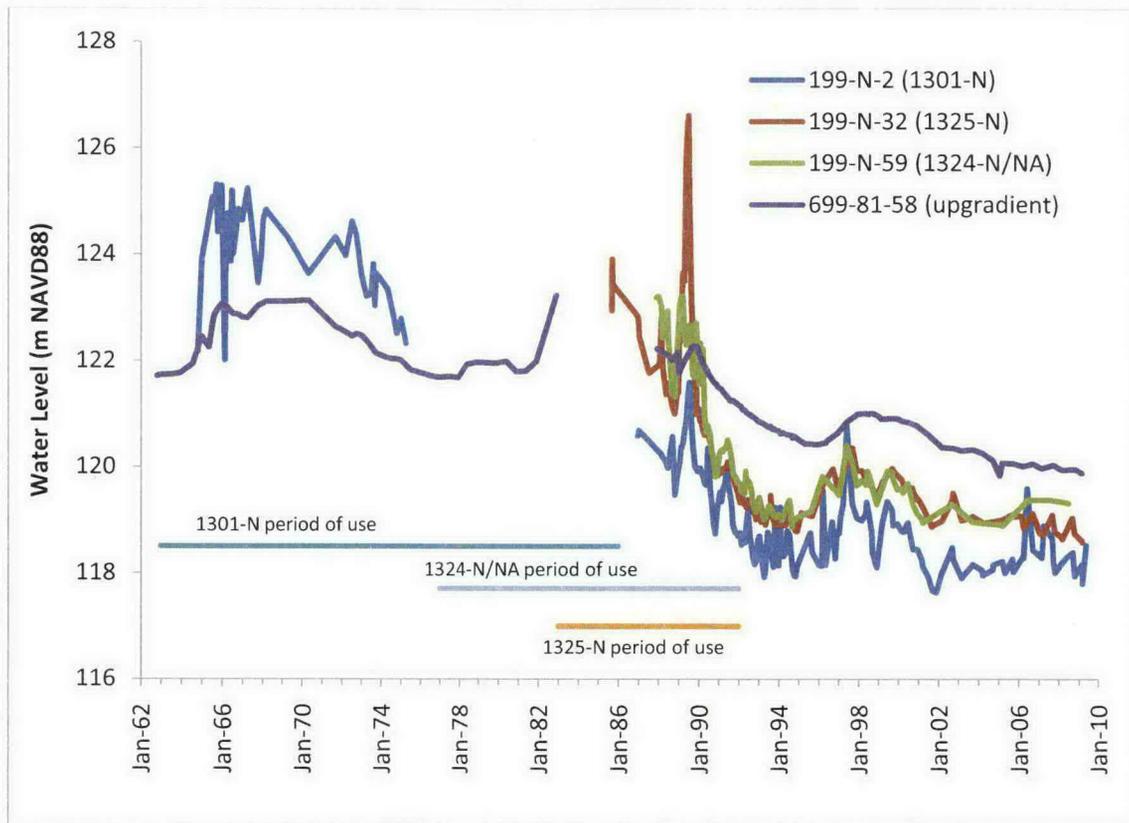


Figure 2-18. Water Levels in 100-N Decision Unit Wells, 1962 through 2009

2.3 Known and Potential Contamination

This section summarizes previous investigations and the current understanding of the nature and extent of vadose zone and groundwater contamination. Investigation results for the 100-N Decision Unit are discussed in this section and were considered in the development of the CSM (Chapter 4).

A compact disk (CD) located in Appendix C-1 contains investigation data from the 100-N Decision Unit in Excel format from samples taken within the 100-N Decision Unit. The CD contains data for soil, groundwater, and aquifer tubes. Also included in Appendix C-1 is text containing explanations of these datasets. For comparison with cleanup levels, soil background, and groundwater background see WAC 173-340, DOE/RL-92-24, and DOE/RL-96-61, respectively.

2.3.1 Nature and Extent of Vadose Zone Contamination

Initial characterization of the vadose zone consisted of Limited Field Investigations (LFIs) performed in the early 1990s. Additional information and data from the vadose zone has been gathered through wells drilled for the groundwater monitoring program, remediation and characterization of waste sites that began in 1996 under the authority provided by interim action RODs, and through implementation of interim groundwater remediation technologies. The results from these investigations and activities provide information about where contamination was detected in the 100-N Decision Unit. However, vadose zone characterization beneath remediated waste sites is addressed in Chapter 4 of this addendum.

2.3.1.1 100-N Area Source Operable Unit Field Investigations

To assess impacts associated with discharging effluent to the soil column at various waste sites, LFIs were conducted for the 100-NR-1 OU in 1992 and 1995. The results (documented in DOE/RL-93-80 and DOE/RL-96-11) indicate radiological contamination is the primary concern and assumed to be the main contributor to overall risk within vadose zone soils. Cross-sections shown in Figures 2-10, 2-11, and 2-13 show Sr-90 concentration depth interval information associated with wells drilled along the river and near the 1301-N Crib as part of the LFIs. In addition, metals are present at several sites, with some concentrations exceeding Hanford site background values (DOE/RL-92-24, Rev. 4). Other contaminants (e.g., volatile organic compounds [VOCs], semivolatile organic compounds [SVOCs], and PCBs) were detected in relatively few samples at low concentrations.

As part of the LFIs, soils sampling and analyses of were performed at nine high priority waste sites. Seven of the waste sites were intrusively investigated during the 1992 LFI (see Table 2-6) including the 116-N-2 Treatment and Storage Facility, 119-N Cooling Water Drain Line, 120-N-2 Surface Impoundment, 1322-N Sampling Building, South Settling Pond, and 166-N Tank Farm (UN-100-N-17). A test pit was excavated at the 120-N-1 Percolation Pond. Data collection and analyses were conducted in accordance with DOE/RL-90-22. Contaminant of potential concerns (COPCs) and sampling requirements were identified in BHI-00368, *Data Quality Objectives Workshop Results for 1301-N and 1325-N Characterization*. Two waste sites were intrusively investigated in 1995, the 1301-N (116-N-1) and 1325-N (116-N-3) Liquid Waste Disposal Facilities (DOE/RL-96-11).

Other investigation methods conducted as part of the LFI's include surface sediments sampling, field screening for VOCs, metals, and radionuclides; sampling for geological and physical properties; radiological and chemical constituents sampling; and borehole geophysical logging.

Samples were collected as part of the 1992 LFI (DOE/RL-93-80) to a maximum depth of 30.2 m (99 ft) and were analyzed for various chemicals, radionuclides, and soil properties (including bulk density, particle size distribution, moisture content, saturated hydraulic conductivity, and unsaturated hydraulic conductivity). Summary information describing the LFI investigations is presented in Table 2-6. The maximum extent of remedial action (i.e., remove, treat, and dispose) is in the table to provide an indication of contamination removed (see this Chapter).

Table 2-6. Summary of 100-N Area Limited Field Investigation (Vadose)

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation m (ft)	Maximum Extent of Contamination m (ft)	Maximum Extent of Remediation m (ft)	LFI
116-N-1	5 ^a	Soil	22.9 (75) ^f	21.0 (69) ^f	6.5 (21.3)	DOE/RL-93-80, DOE/RL-96-11
116-N-2	1	Soil	7.2 (23.5)	6.4 (21)	N/A Accepted Waste Site	DOE/RL-93-80
116-N-3	1	Soil	19.7 (64.5)	18.7 (61.5)	5.2 (17)	DOE/RL-96-11
119-N		Soil	7.6 (25)	7.3 (24)	N/A Accepted Waste Site ^b	
120-N-1	1 test pit	Soil	21.3 (70)	21.3 (70)	0*	DOE/RL-93-80
120-N-2	1	Soil	23.5 (77)	23.2 (76)	0 ^c	DOE/RL-93-80

Table 2-6. Summary of 100-N Area Limited Field Investigation (Vadose)

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation m (ft)	Maximum Extent of Contamination m (ft)	Maximum Extent of Remediation m (ft)	LFI
100-N-58 (South Settling Pond)	1	Soil	23.8 (78)	23.8 (78)	0 ^c	DOE/RL-93-80
1322-N	1	Soil	7.5 (24.5)	6.9 (22.5)	N/A Accepted Waste Site ^d	DOE/RL-93-80
166-N	1	Soil	22.9 (75)	22.6 (74)	N/A Accepted Waste Site ^e	DOE/RL-93-80

- a. 3 boreholes drilled as part of DOE/RL-93-80 (199-N-75, N-76, and N-80) not completed within waste site footprint.
- b. Two unplanned releases have been accepted for the 1322-NA site: UPR-100-N-9 and UPR-100-N-14.
- c. Remedial/corrective action field activities at the 120-N-1, 120-N-2, and 100-N-58 sites were conducted in September 2000, and included the removal and disposal of miscellaneous structural debris-type items (CVP-2001-00021).
- d. Two unplanned releases have been accepted for the 1322-NA site: UPR-100-N-4 and UPR-100-N-8.
- e. Five unplanned releases have been accepted for the 1322-NA site: UPR-100-N-17, UPR-100-18, UPR-100-N-20, UPR-N-24, and UPR-100-N-43.
- f. Maximum value for boreholes drilled through waste site footprint.

2 The 1995 LFI was performed at the 1301-N (116-N-1) and 1325-N (116-N-3) Liquid Waste Disposal
 3 Facilities (DOE/RL-96-11). The purpose, as established by the Tri-Parties, was to supplement previous
 4 field investigations, verify historical information, and provide necessary information so the Tri-Parties
 5 could address the following:

- 6 1. Determine if immediate action is required on soil at 116-N-1 (1301-N) and 116-N-3 (1325-N) to
 7 protect groundwater.
- 8 2. Determine if, for the long-term, soil remediation is required to protect groundwater from a future
 9 potential impact and, if so, when remediation should be performed.

10 The LFI field activities included borehole drilling, sampling, and geophysical logging to investigate both
 11 contaminant and moisture distribution in soil(s) beneath the 1301-N and 1325-N facilities. The 1993 LFI
 12 (DOE/RL-93-80) provided considerable information on near-surface contamination and subsurface
 13 conditions at some distance from the facilities, but not within the facility footprints. Three new boreholes
 14 (199-N-107A, 199-N-108A, and 199-N-109A) were drilled as part of the 1995 LFI. Borehole
 15 199-N-107A was drilled within the 1301-N Crib, while boreholes 199-N-108A and 199-N-109A were
 16 drilled immediately adjacent to the 1301-N Trench and 1325-N Crib, respectively. Soils from the
 17 boreholes were surveyed in the field for radioactivity. Vadose zone soils were sampled and submitted for
 18 physical, chemical, and radiological laboratory analyses. Downhole geophysical techniques were used to
 19 measure gamma-ray emitting contaminants, soil density, and moisture distribution. In addition to the new
 20 boreholes, four existing wells were geophysically logged.

3 **2.3.1.2 Interim Remedial Action and Existing Waste Site Contamination**

4 Characterization of the 100-N Area waste sites began under the authority provided by DOE/RL-90-22,
5 *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit* and
6 continued under DOE/RL-96-39, *100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures*
7 *Study/Closure Plan*. 100-N Area waste sites remediation commenced under authority of the Interim
8 Action ROD (EPA/ROD/R10-99-112) in 1999.

9 The highest cobalt-60 (Co-60), cesium-137 (Cs-137), and Pu-239/240 concentrations detected in
10 100 Area soils were from the 100-N Area. The highest Co-60 concentration (18 ± 1.80 pCi/g) was
11 detected west of the head end of the 116-N-1 Crib (1301-N). Additionally, soil at the head end but
12 southwest of the 116-N-1 Crib and Trench, contained the highest Cs-137 concentration
13 (2.2 ± 0.223 pCi/g). The highest Pu-239/240 concentration (0.06 ± 0.008 pCi/g) detected was at the same
14 location as the highest Co-60 concentration (WHC-SD-ER-TI-251). RTD is the standard remedy selected
15 for source waste sites in the 100 Area. Remedial actions are designed to achieve RAO and goals specified in
16 interim action RODs for direct 0 to 4.6 m (0 to 15 ft) bgs and protection of groundwater and the
17 Columbia River. In practice, this has involved excavating wastes and soil exceeding cleanup criteria, and
18 disposing waste to the ERDF. Residual contamination (after the selected remedy) is sampled and modeled to
19 assess impacts to groundwater and the Columbia River. Where RAOs are achieved, the waste site is
20 considered interim closed. Remedial actions for contaminated sites in the 100-NR-1 OU are organized into
21 three categories.

22 One category is the 100-N RCRA TSD, which includes the 116-N-1 (1301-N) and 116-N-3 (1325-N)
23 LWDF, the 120-N-1 Percolation Pond, the 120-N-2 Surface Impoundment and associated pipelines, and
24 the South Settling Pond. Another category is represented by the river shoreline site, which is closely tied
25 to the remediation of the 100-NR-2 Groundwater OU and N-Springs. The final category is represented by
26 all other waste sites in the 100-NR-1 OU, which will be handled through the CERCLA process. These
27 waste sites consist primarily of liquid waste sites, spills and unplanned releases (including
28 petroleum-contaminated soils), and burn-pit/dumping areas. The remedial action remedy for the CERCLA
29 waste sites is under the authority of the Interim Action ROD, *Interim Remedial Action Record of Decision*
30 *for the 100-NR-1 and 100-NR-2 Operable Units Hanford Site, Benton County, Washington*
31 (EPA/ROD/R10-99/112) and the *Explanation of Significant Differences for the 100 Area Remaining Sites*
32 *Interim Remedial Action Record of Decision* and *100-NR- 1/100-NR-2 Operable Unit Interim Remedial*
33 *Action Record of Decision* (EPA/ESD/R10-03/605).

34 The RD and implementation of the remedial action process for the CERCLA waste sites in the
35 100-NR-1 OU is described in the remedial design/remedial action work plan (RD/RAWP)
36 (DOE/RL-2005-93). The selected remedy for the CERCLA waste sites is remove/dispose for the majority
37 of the sites, and in situ and ex situ bioremediation of the petroleum-contaminated waste sites. Verification
38 of remedial actions for the RCRA TSD sites was addressed under *Sampling and Analysis Plan for the*
39 *100-NR-1 Treatment, Storage, and Disposal Units during Remediation and Closeout* (DOE/RL-2000-07).
40 The remedial action remedy for the river shoreline is institutional controls as defined in the interim
41 action ROD.

42 Determining clean closure or interim closed waste sites is based on data assembled in the cleanup
43 verification packages (CVPs) and summarized in Appendix C. These data support the premise that the
44 residual contamination at interim closed waste sites is less than the regulatory action level, meets, or
45 exceeds the remedial action goal. The primary statistical calculation to evaluate compliance with cleanup
46 standards is the 95 percent upper confidence limit (UCL) on the arithmetic mean of the data
47 (DOE/RL-2000-16, Rev. 2; DOE/RL-2000-07, Rev. 1; and WAC 173-340-740(7)(g)). The data in
48 Appendix C generally include the maximum concentrations and/or concentrations representing the

1 95 percent UCL of waste site COCs for both the shallow and deep zones (0 to 4.5 m [0 to 15ft] and
2 greater than 4.5 m [15ft] bgs, respectively). The CVP (A list of the 100-N Decision Unit CVPs is
3 provided in Table 2-6) data and background information on the waste sites do not support the need for
4 additional characterization based on residual concentrations. The “clean closure” determination shows the
5 remedial actions were successful. In combination with the pre-excavation/removal drilling and sampling
6 efforts having characterized the vadose zone, therefore no further characterization is recommended A list
7 of sites remediated in the 100-N Area (as of October 31, 2009) in accordance with the interim action
8 ROD (EPA/ROD/R10-99-112) is provided in Table 2-7.

Table 2-7. Closed Out and Interim Closed Out Waste Sites in the 100-N Decision Unit

Site Code	Site Type	Operable Unit	Site Names	Reclassification Status	Closure Document
100-N-1	Pond	100-NR-1	100-N-1, HGP SWMU #6, Settling Pond	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0. WSRF 2004-060
100-N-3	French Drain	100-NR-1	100-N-3, Maintenance Garage French Drain, HGP-SWMU #9, Maintenance Garage Waste Water Treatment Unit	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-4	Drain/ Tile Field	100-NR-1	100-N-4, HGP SWMU #5 Tile Field	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-41	Septic Tank	100-NR-1	100-N-41, 1701-NE Gate House Septic Tank, HGP-SWMU #9	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-45	Septic Tank	100-NR-1	100-N-45, 1703-N Septic Tank, HGP-SWMU #9	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-46	Storage Tank	100-NR-1	100-N-46, HGP Diesel Oil Storage Tank	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-5	Storage	100-NR-1	100-N-5, HGP Disposal and Storage Area, HGP Bone Yard, HGP-SWMU #10	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-50	Single-Shell Tank	100-NR-1	100-N-50, HGP SWMU 4, Turbine Oil filter Unit, Turbine oil cleaning system	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.
100-N-51	Storage	100-NR-1	100-N-51, HGP Building Oil Storage Area, 100-N-51A, HGP SWMU #2	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.

Table 2-7. Closed Out and Interim Closed Out Waste Sites in the 100-N Decision Unit

Site Code	Site Type	Operable Unit	Site Names	Reclassification Status	Closure Document
100-N-51B	Sump	100-NR-1	100-N-51B, HGP Building Floor Drains and Sumps, HGP SWMU #3	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.
100-N-52	Storage Tank	100-NR-1	100-N-52, HGP Gasoline Storage Tank	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
100-N-58	Pond	100-NR-1	100-N-58, South Pond, 120-N South Settling Pond, 1324-N South Settling Pond	Closed Out	CVP-2001-00021
100-N-63:1	Radioactive Process Sewer	100-NR-1	100-N-63:1, Pipeline Section From 116-N-1 to 116-N-3 Crib Including Concrete Encased Pipe Bypass Structure	Interim Closed Out	CVP-2002-00002
100-N-78	Maintenance Shop	100-NR-1	100-N-78, 1716-NE Maintenance Garage, HGP SWMU #8	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
116-N-1	Crib	100-NR-1	116-N-1, 1301-N Liquid Waste Disposal Facility, 1301-N Crib and Trench	Interim Closed Out	CVP-2006-00004
116-N-3	Crib	100-NR-1	116-N-3, 1325-N Liquid Waste Disposal Facility, 1325-N Crib and Trench	Interim Closed Out	CVP-2002-00002
1908-NE	Outfall	100-NR-1	1908-NE, HGP Outfall, 1908-NE Building, HGP-SWMU #7	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.
UPR-100-N-37	Unplanned Release	100-NR-1	UPR-100-N-37, HGP Transformer Yard Oil Stained Gravel (SWMU #1)	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.

CVP = cleanup verification package

HGP = Hanford Generating Project

SWMU = solid waste management unit

2 **2.3.1.3 Additional Vadose Zone Sampling Actions**

3 In addition to the LFI and waste site remediation activities described above, additional vadose zone data
4 has been collected during well drilling for the groundwater monitoring program, other focused
5 investigation activities (BHI-00135), and implementation of groundwater remedial actions including the
6 installation of a groundwater pump-and-treat system (DOE/RL-95-111) and apatite barrier testing
7 (PNNL-16891, PNNL-16894, PNNL-17429).

8 **2.3.2 Results Summary**

9 The following section summarizes vadose zone sampling results from LFI, waste site remediation, and
10 other 100-N Decision Unit investigative activities.

11
12 **2.3.2.1 Radionuclides**

13 Based on the field investigation results, radiological contamination is the primary concern and assumed to
14 be the main contributor to overall risk within vadose zone soils. LFI sampling results are summarized in
15 Table 2-8.

16 Radionuclides detected above background included Co-60, Sr-90, Cs-137, radium-226 (Ra-226),
17 thorium-228 (Th-228), thorium-232 (Th-232), and uranium-238 (U-238). The highest radionuclide
18 concentrations were generally found in soils near the bottom of the 116-N-1 and 116-N-3 waste sites.
19 In general, radiological contamination is highest immediately beneath the former waste site engineered
20 structure, and decreases with depth within the vadose zone to the water table maxima established during
21 facility operations. Radionuclides were transported to the depth of the former water table, and those
22 contaminant concentrations increase from that point to the current water table.

23

24

Table 2-8. Summary of the Limited Field Investigations for the 100-N Area

Waste Site	Radiological	Metal (exceeded HSB)	Organic	Relevant Information
116-N-1 Crib and Trench (1301-N) Depth: 3.66 m (12 ft) Number of boreholes: 2 Crib borehole 199-N 107A: 22.8 m (75 ft) depth Trench borehole 199-N-108A: 22 m (72 ft) depth	Am-241 Cs-134 Cs-137 Co-58 Co-60 Eu-154 Eu-155 manganese-54 Pu-238 Pu-239/240 K-40 Ra-226 Ra-228 Sr-90 Th-228 Th-232 U-234 U-238	cadmium chromium lead	acetone carbon disulfide methylene chloride toluene 4-methyl 2- pentanone 2-butanone bis(2-ethylhexyl) phthalate di-n butylphthalate n-nitrosodiphenylamine fluoride sulfate nitrate	<p>Radiological and metal contaminants were obtained from two boreholes within the waste site in 1995 (1301-N and 1325-N LFI). Organic analyses were not performed on these samples. Reported organic contaminants were from the three boreholes (199-N-75, 199-N-76, and 199-N-80) located more than 91.5 m (300 ft) away from the 1301-N, toward the Columbia River. The boreholes support the 100-NR-2 LFI. Chemical analyses from these three wells were part of the 100-NR-1 LFI scope.</p> <p>No pesticides or PCBs were detected.</p> <p>VOAs were found with the highest concentration at depths greater than 15 m (50 ft).</p> <p>The highest levels of phthalate compounds were detected at depths greater than 4.6 m (15 ft).</p> <p>The highest concentrations of radionuclide contaminations occur at the crib base to a few feet below the crib base. This interval is referred to as the concentrated layer. Sr-90 has been detected throughout the soil column from the crib base to the water table.</p> <p>The concentrated layer also contains chromium and lead at above background concentration.</p>

Table 2-8. Summary of the Limited Field Investigations for the 100-N Area

Waste Site	Radiological	Metal (exceeded HSB)	Organic	Relevant Information
116-N-3 Crib and Trench (1325-N) Crib Depth: 3.6 m (12 ft) Trench depth : 2.1 m (7 ft) Number of borehole: 1 Crib borehole 199-N 109A: 19.5 m (64 ft) depth	actinum-228 Am-241 bismuth -214 Cs-137 Co-60 Eu-152 Eu-154 Eu-155 lead-214 manganese-54 Pu-238 Pu-239/240 K-40 Ra-224 Ra-226 Ra-228 Sr-90 Th-228 Th-232 U-234 U-235 U-238		No organic analyses were performed.	Cadmium was not detected. Chromium, lead, and nickel results were less than background. The highest concentrations of radionuclide contaminations were near the depth of the crib base.
120-N-1 Percolation Pond Depth: 4.6 m (15 ft) Number of test pits: 1	NA	copper zinc	acetone benzene chloroform methylene chloride toluene bis(2-ethylhexyl) phthalate di-n butylphthalate fluoride sulfate	Radionuclide contamination was not expected at this waste site, and none was detected via field screening. Laboratory analyses for radionuclides were not performed. No pesticides or PCBs were detected.

Table 2-8. Summary of the Limited Field Investigations for the 100-N Area

Waste Site	Radiological	Metal (exceeded HSB)	Organic	Relevant Information
120-N-2 Surface Impoundment (1324-N) Depth: 4.6 m (15 ft) Borehole depth: 23.5 m (77 ft)	NA	copper	2-butanone (MEK) 2-hexanone acetone chloroform methylene chloride toluene xylene bis(2-ethylhexyl) phthalate di-n butylphthalate diethylphthalate fluoride sulfate	Radionuclide contamination was not expected at this waste site, nor was it found, except for one elevated beta-gamma detection from the 12.2 m to 14 m (40ft to 46 ft) interval. Laboratory analyses for radionuclides were not performed. No pesticides or PCBs were detected.
South Settling Pond Depth: 4.6 m (15 ft) Number of borehole: 1 Borehole depth: 24 m (78 ft)	NA	manganese	acetone methylene chloride toluene bis(2-ethylhexyl) phthalate di-n butylphthalate diethylphthalate fluoride sulfate	Radionuclide contamination was not expected at this waste site. Field screening showed radioactivity levels to be either non-detected or below background. Laboratory analyses for radionuclides were not performed. No pesticides or PCBs were detected.
1322-N and 1322-NA Sampling Buildings Number of boreholes: 1 Borehole depth: 7.5 m (24.5 ft)	Am-241 Cs-137 Co-60 Pu-239/240 K-40 Ra-226 Sr-90 Th-228/232 U-233/234 U-238	copper lead zinc	methylene chloride toluene aroclor-1260 benzo(a)anthracene benzo(b)fluoranthene bis(2-ethylhexyl) phthalate chrysene dimethylphthalate di-n butylphthalate fluoranthene phenanthrene pyrene fluoride sulfate	No pesticides were detected. SVOCs were detected in one surface sample, and may be associated with creosote, a wood preservative.

2-45

Table 2-8. Summary of the Limited Field Investigations for the 100-N Area

Waste Site	Radiological	Metal (exceeded HSB)	Organic	Relevant Information
116-N-2 Treatment and Storage Facility Number of borehole: 1 Investigation depth: 7.2 m (23.5 ft)	Am-241 Cs-137 Co-60 Pu-239/240 K-40 Ra-226 Tc-99 Th-228 Th-232 U-233/234 U-238	lead	1,1,1 trichloroethane 2-butanone methylene chloride toluene 1,4-dichlorobenzene anthracene aroclor-1254 aroclor-1260 benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene chrysene diethylphthalate di-n butylphthalate fluoranthene phenanthrene pyrene fluoride nitrate sulfate	Sr-90 was not detected in any samples. No pesticides were detected. SVOCs were detected from two surface samples, and may be associated with creosote, a wood preservative.
119-N Cooling Water Drain Line Number of borehole: 1 Borehole depth: 7.6 m (25 ft)	NA	NA	acetone methylene chloride fluoride sulfate nitrate	Radionuclide contamination was not expected at this waste site. No radionuclide analyses were performed. No inorganic compounds were detected above background. No SVOCs, pesticides, or PCBs were detected.

Table 2-8. Summary of the Limited Field Investigations for the 100-N Area

Waste Site	Radiological	Metal (exceeded HSB)	Organic	Relevant Information
166-N Tank Farm Number of borehole: 1 Borehole depth: 22.8 m (75 ft)	Co-60 K-40 Ra-226 Sr-90 Th-228 Th-232 U-228 U-233/234		2-butanone acetone benzene ethylbenzene toluene xylene 2-methylnaphthalene anthracene di-n-butylphthalate fluorene naphthalene phenanthrene pyrene fluoride sulfate nitrate	The highest VOA concentration(s) were found at depths from 16.5 m to 21.6 m (54ft to 71 ft). The source of these potential contaminants is likely related to the UN-100-N-17 unplanned release. No pesticides or PCBs were detected. No inorganic compounds were detected above background. All radionuclides were detected at greater than 4.6 m (15-ft) depth.

Table 2-8. Summary of the Limited Field Investigations for the 100-N Area

Waste Site	Radiological	Metal (exceeded HSB)	Organic	Relevant Information
Am-241	=	americium-241		
Cs-134	=	cesium-134		
Cs-137	=	cesium-137		
Co-58	=	cobalt-58		
Co-60	=	Cobalt-60		
Eu-152	=	europium-152		
Eu-154	=	europium-154		
Eu-155	=	europium-155		
K-40	=	potassium-40		
LFI	=	limited field investigation		
NA	=	not available		
PCBs	=	polychlorinated biphenyls		
Pu-238	=	Plutonium-238		
Pu-239/240	=	Plutonium-239/240		
Ra-224	=	radium-224		
Ra-226	=	radium-226		
Ra-228	=	radium-228		
Sr-90	=	strontium-90		
SVOCs	=	semivolatile organic compound		
Tc-99	=	Technetium-99		
Th-228	=	thorium-228		
Th-232	=	thorium-232		
U-233	=	uranium-233		
U-234	=	uranium-234		
U-238	=	uranium-238		
VOAs	=	volatile organic analyte		

2-48

1 Post remediation sample results are shown in the following figures. Strontium-90 was sampled from
2 23 boreholes in the 100-N Decision Unit (Figure 2-19) and soil samples collected during waste site
3 interim action remedial activities (Figures 2-20 and 2-21). The following are key observations about the
4 nature and extent of Sr-90 in the vadose zone.

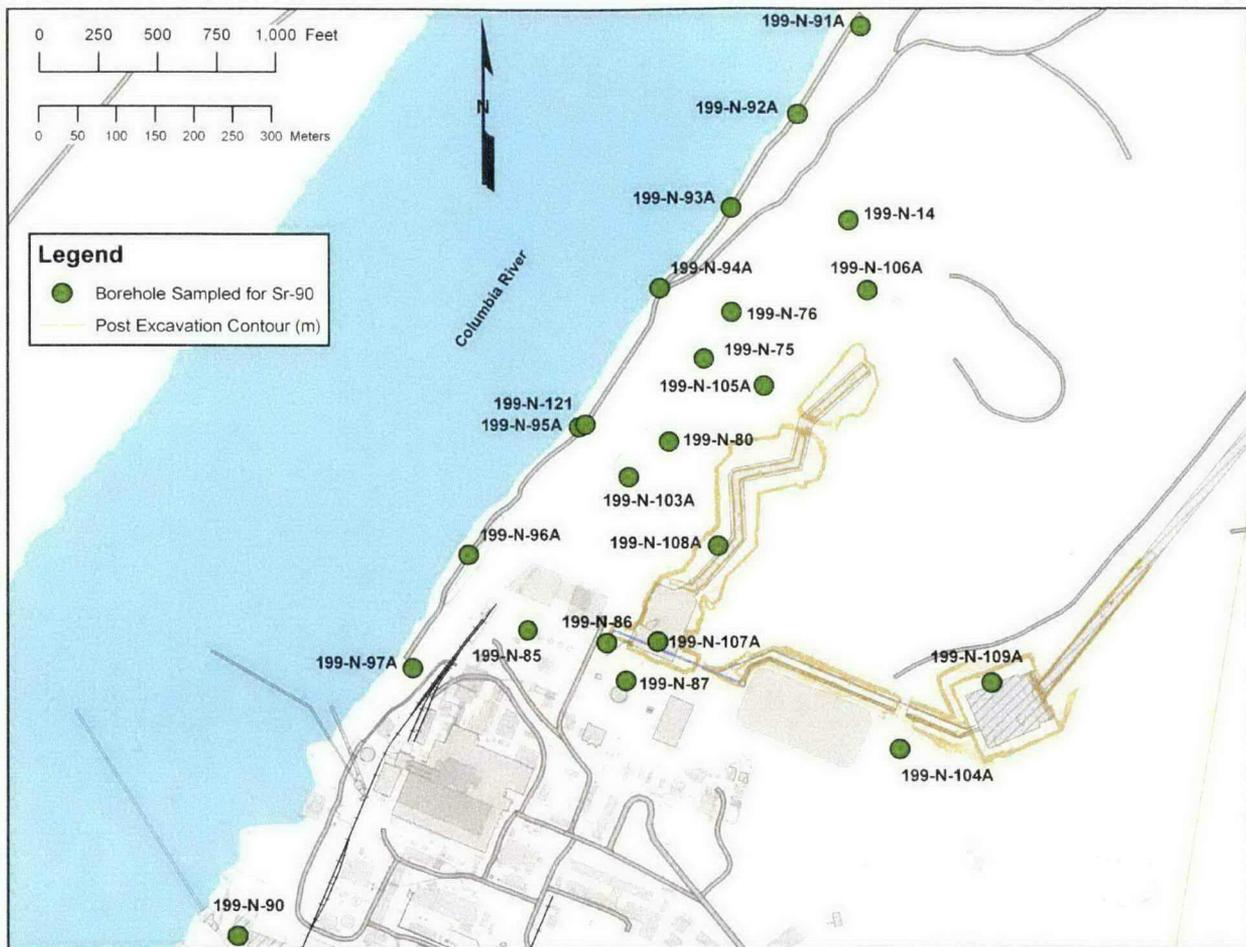
- 5 • First, the highest Sr-90 concentrations occur closest to the point of entry into the waste site that
6 received the Sr-90 waste (primarily liquids to 1301-N and 1325-N), at pipe outlets and along the
7 trenches. In the LFI boreholes drilled directly into the 1301-N Crib (199-N-107A), and the
8 1301-N Trench (199-N-108A) Sr-90 concentrations in soils were highest immediately below the
9 bottom of the waste site or within a few feet of the bottom (Figure 2-20). In the LFI borehole
10 (199-N-109A) drilled through 1325-N, Sr-90 concentrations were highest just below the bottom of
11 the waste site (Figure 2-23).
- 12 • Second, Sr-90 concentration levels drop at least one order of magnitude within 6.1 m (20 ft) of the
13 points of entry in all directions. This characteristic is best observed in sediment analyses near 1301-N
14 where the most data has been collected. An evaluation of the Sr-90 soil analytical data shows
15 relatively high Sr-90 concentrations present only in soils near the bottom or next to the waste site
16 structure are less than 2,000 pCi/g at any depth more than a few feet below the crib bottom
17 (Figure 2-20).
- 18 • Third, with distance from the 1301-N Crib, concentrations decrease within the vadose zone, and there
19 is a secondary zone of relatively elevated Sr-90 concentrations near the bottom of the current vadose
20 zone (Figures 2-22 and 2-24). This zone is coincident with the range of water table depth fluctuations
21 (the mound) underneath 1301-N because of startup, maintenance, and cessation of discharge to
22 the facility.

23 **2.3.2.2 Other Contaminants**

24 Metals were detected in soil samples associated with the 100-N-1, 100-N-58 (South Settling Pond),
25 116-N-1, 116-N-2, 116-N-3, 120-N-1, and 120-N-2 waste sites, and the 1322-N Facility. Metals detected
26 above the Hanford site background value (95 percent UCL, DOE/RL-92-24, Rev. 4) were barium
27 (2 samples), chromium (7 samples), copper (10 samples), iron (3 samples), manganese (1 sample), lead
28 (13 samples), nickel (8 samples), silicon (2 samples), silver (4 samples), sodium (6 samples), and zinc
29 (8 samples). In addition, the following metals were detected in select soil samples for which no Hanford
30 background value has been published: antimony, boron, cadmium, selenium, and thallium. Additional
31 discussion of metals contamination in the vadose zone is provided in Chapter 4.

32 Petroleum contamination was primarily investigated by collecting soil samples from one well, 199-N-85,
33 drilled to evaluate the subsurface contamination caused by the diesel fuel line leak 302,833 L (80,000 gal)
34 on the west side of the 166-N tank farm in 1966. Characterization Well 199-N-85 is located a proximal to
35 the leak location. Ten samples were collected over the vadose zone between 4.6 and 22.5 m (15 and
36 74 ft) bgs. A suite of volatile and semi-volatile compounds were analyzed (DOE/RL-93-80) that are
37 considered species present in diesel fuel or degradation products (e.g., xylene, anthracene,
38 2-methylnaphthalene). These contaminants identified between 18 and 22.5 m (59 and 74 ft) bgs.
39 A passive bioremediation technology is being installed to remediate petroleum hydrocarbons in the
40 vadose zone (WCH-323). Details of petroleum contamination in the 100-N Decision Unit are discussed
41 in Chapter 4.

42 VOCs, SVOCs, and PCBs (arochlor-1254 and arochlor-1260) were detected in subsurface samples but
43 generally at low concentrations, often below quantitation limits, and in a relatively few samples.



1
2

Figure 2-19. Vadoso Zone Boreholes Sampled for Strontium-90 within the 100-N Decision Unit

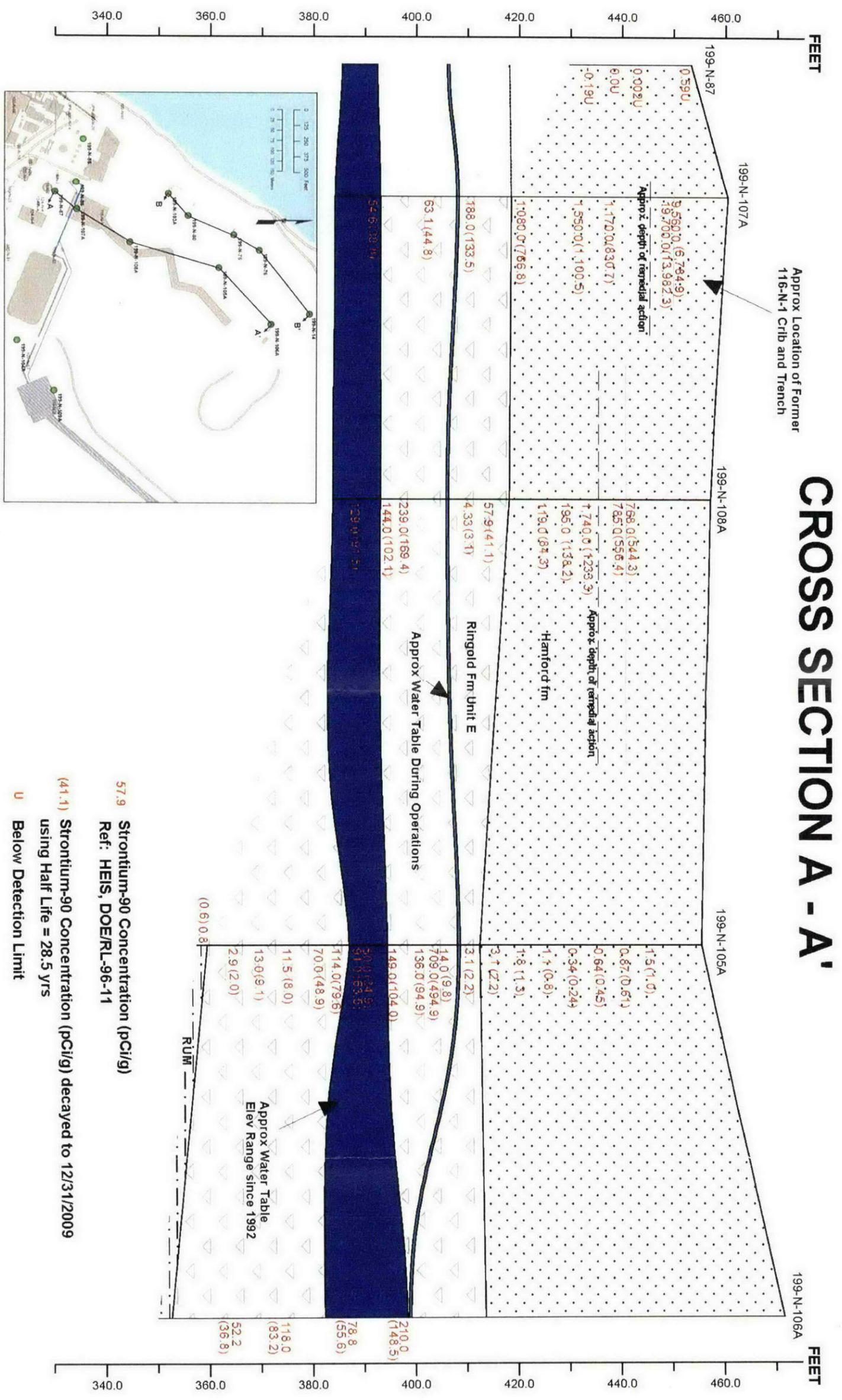


Figure 2-22. Strontium-90 Concentrations, by Depth, At Five Boreholes along the Long Axis of 1301-N (116-N-1)

1

2 This page intentionally left blank.

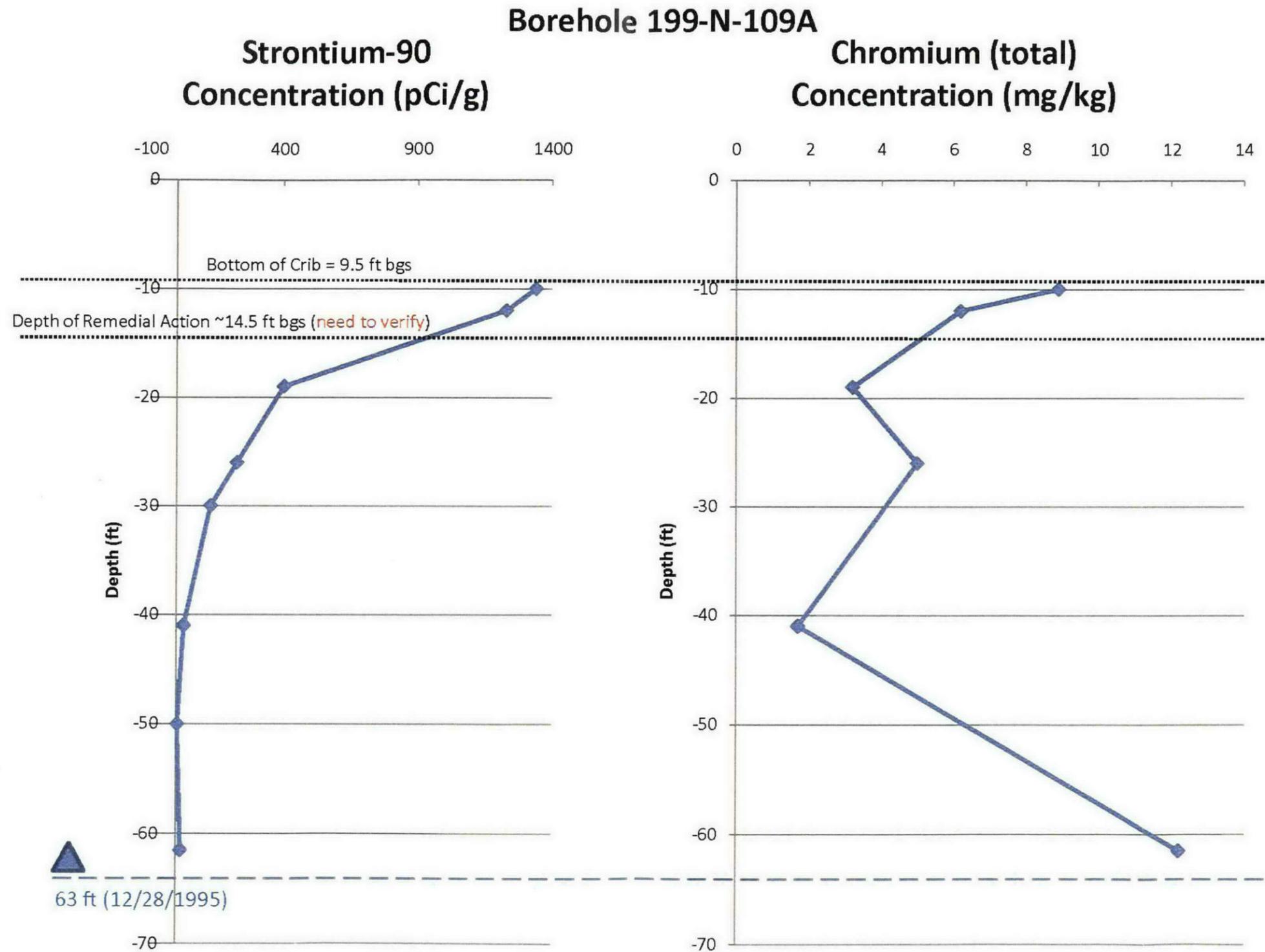


Figure 2-23. Strontium-90 and Chromium Profile for Borehole 199-N-109AF

1
2
3

1

2 This page intentionally left blank.

CROSS SECTION B - B'

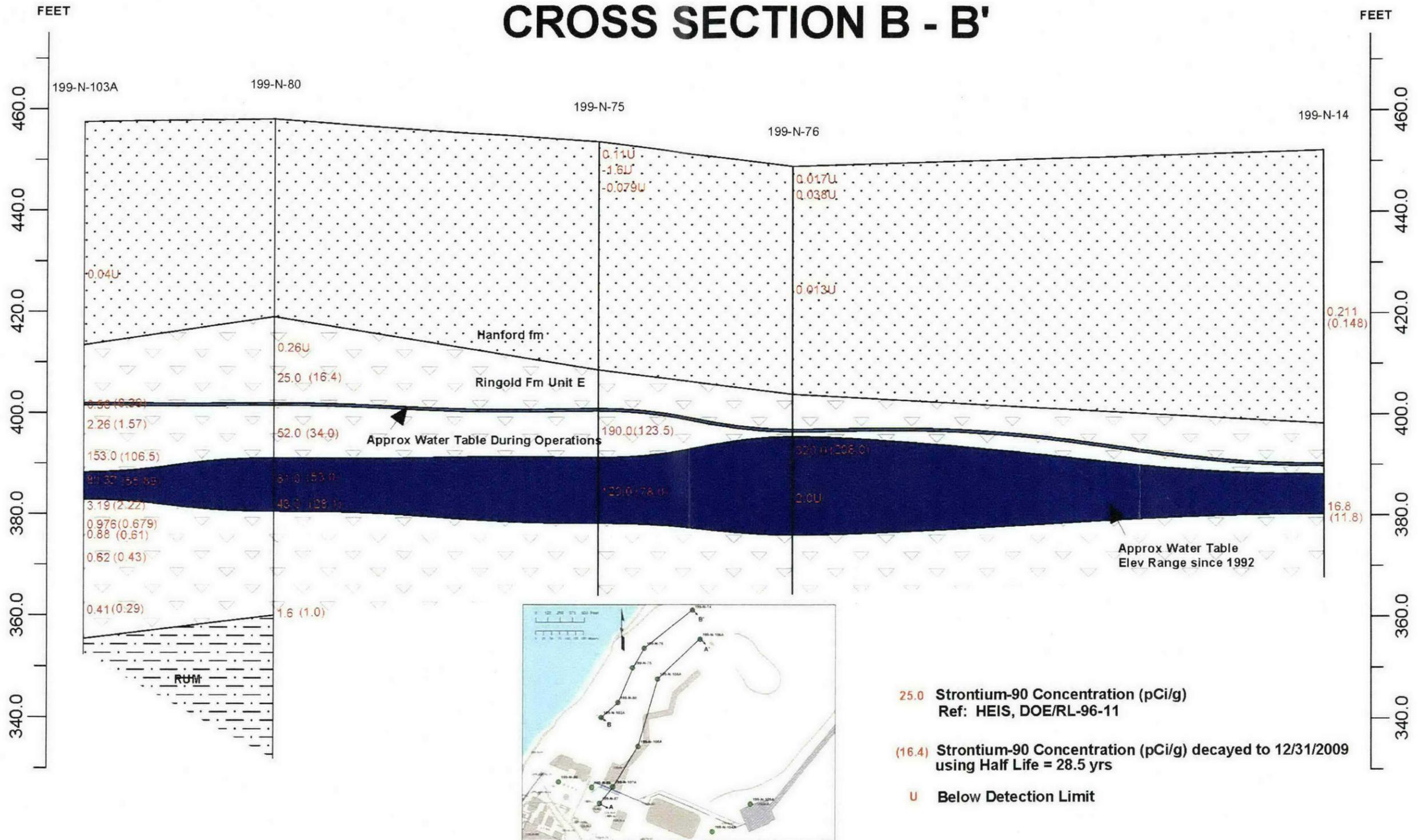


Figure 2-24. Strontium-90 Concentrations, by Depth, At Five Boreholes Downgradient of 1301-N (116-N-1)

1

2 This page intentionally left blank.

2.3.3 Nature and Extent of Contamination in the Groundwater

This section describes the nature and extent of groundwater contamination (100-NR-2 Groundwater OU) within the 100-N Decision Units. The detailed groundwater information within the 100-N Decision Unit is included in found in the Annual Hanford Site Groundwater Monitoring Reports (e.g., DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*) and the annual groundwater pump-and-treat reports (e.g., DOE/RL-2008-05, *Calendar Year [CY] 2007 Annual Summary Report for 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit [OU] Pump and Treat Operation*). 100-N Decision Unit groundwater-monitoring wells locations are included in Appendix B.

2.3.3.1 Strontium-90

The primary groundwater contaminant is Sr-90. The area where the highest concentrations of Sr-90 reach the Columbia River is of special concern for remediation and monitoring. As of 2008, an estimated 72 Ci of Sr-90 are contained in the saturated sediments, and approximately 0.8 Ci are retained in the groundwater; this equates to a Sr-90 retardation factor of approximately 100 (PNNL-17429). Because Sr-90 has a much greater affinity for sediment than for water (high K_d), its rate of transport in groundwater to the river is considerably slower than the actual groundwater flow rate. The relative velocity of Sr-90 transport to groundwater flow is approximately 1:100 (PNNL Draft High-Conc. Report). In FY 2008, Sr-90 concentrations above the 8 pCi/L maximum contamination limit (MCL) extend inland from the river approximately 1.2 km (4,000 ft) in the 100-N Area (DOE/RL-2008-66). The overall plume area is estimated at 0.58 km² (0.22mi²) (Figure 2-25).

Strontium-90 is found primarily adsorbed to sediments by ion exchange (99 percent adsorbed, less than 1 percent in groundwater) in the upper portion of the unconfined aquifer and lower vadose zone (CHPRC-00067-FP, *An Innovative Approach for Construction an In-Situ Barrier for Strontium-90 at the Hanford Site, Washington*). Strontium-90 is limited to the upper portion of the unconfined aquifer. Strontium-90 is not detected in Wells 199-N-69 and 199-N-70, which are screened at the bottom of the unconfined aquifer, while relatively high concentrations are noted for adjacent, shallow Wells 199-N-67 and 199-N-81.

In FY 2008, maximum Sr-90 concentrations were measured between 115.7 m and 116.3 m (379.6ft and 381.5 ft) elevation in the Ringold Formation within aquifer tubes, while lower concentrations were reported for the deeper tubes. Concentrations were much lower in the shallowest aquifer tubes, which monitor the Hanford formation (DOE/RL-2008-66).

The extent and magnitude of the Sr-90 plume at the 8 pCi/L (maximum contamination limit [MCL]) has not changed in many years.

The only flowing 100-N Area seep is located downgradient of the Sr-90 plume (DOE/RL-2008-66). Strontium-90 has been detected in seeps and aquifer tubes at concentrations greater than the MCL along the length of the approximately 670 m (2,200 ft) 100-N shoreline. The highest Sr-90 concentration at the shoreline was 75,000 pCi/L in aquifer tube NVP2-116.0 (calculated from gross beta measurement). This represented a spike in concentration caused by injections into the apatite barrier (DOE/RL-2008-66). Baseline concentrations (pre-treatment) at the injection well locations ranged from approximately 400 to 2,800 pCi/L (PNNL-17429).

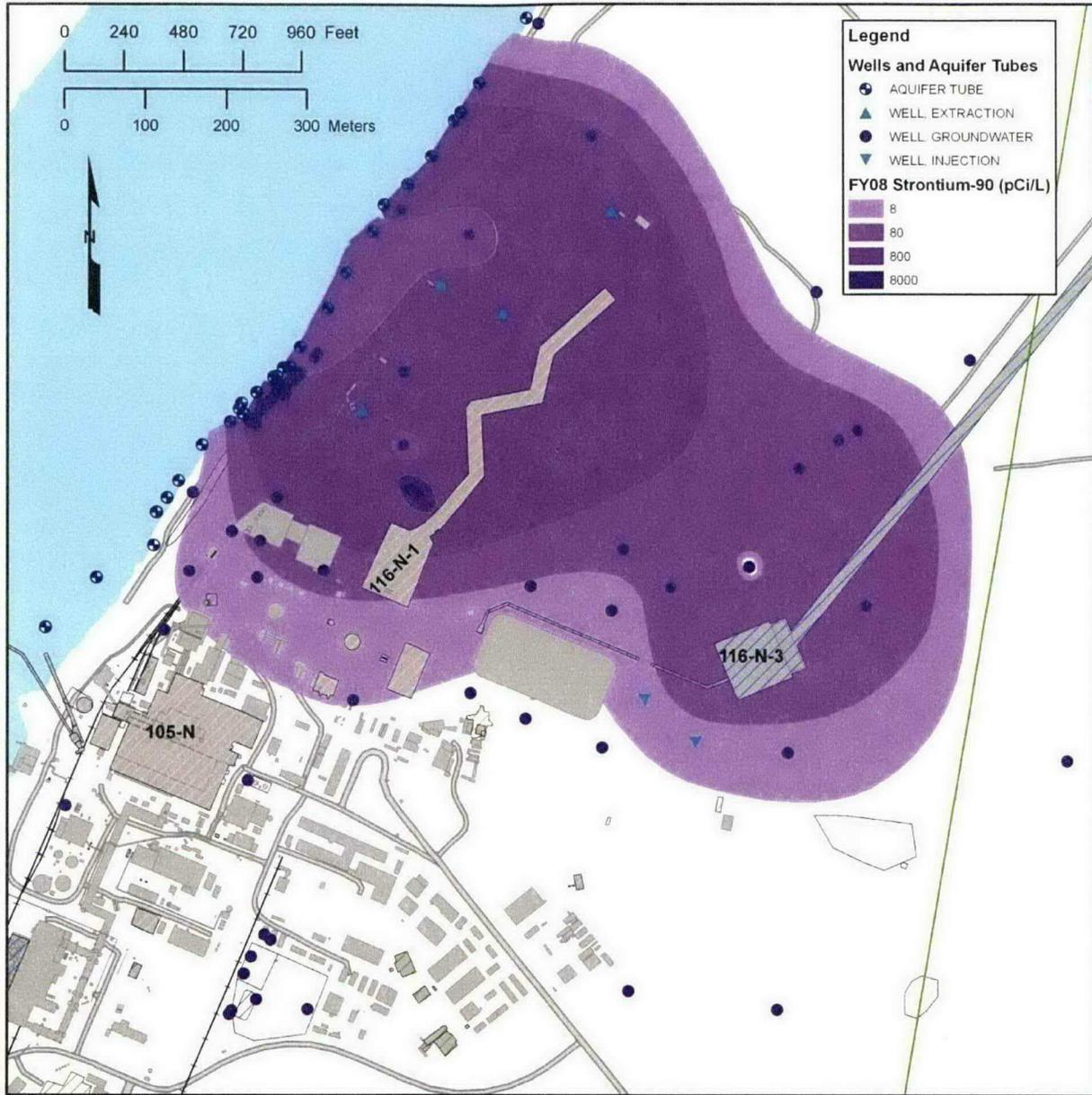
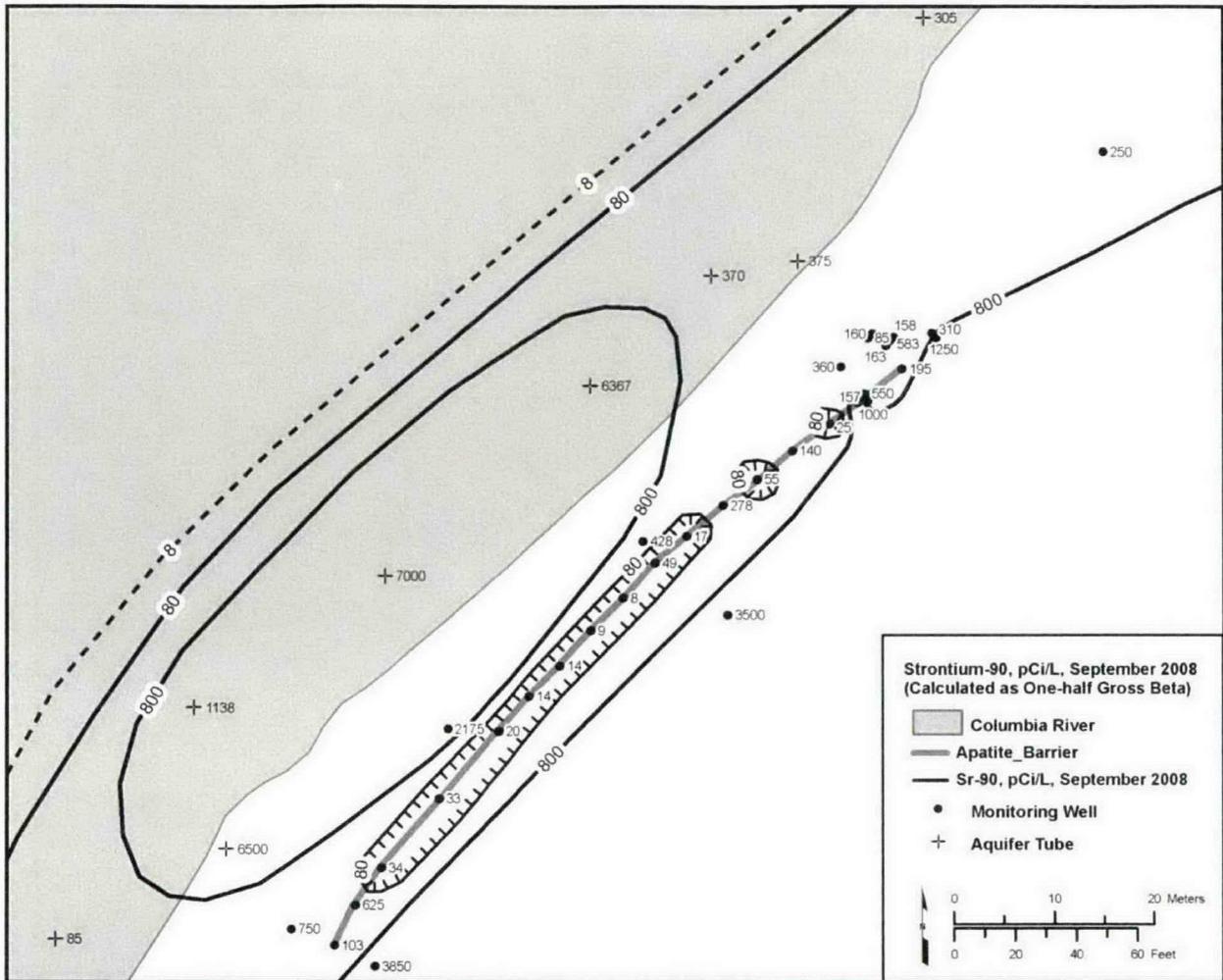


Figure 2-25. 100-N Decision Unit Average Strontium-90 Concentrations in the 100-N Area, Unconfined Aquifer

1
2
3
4

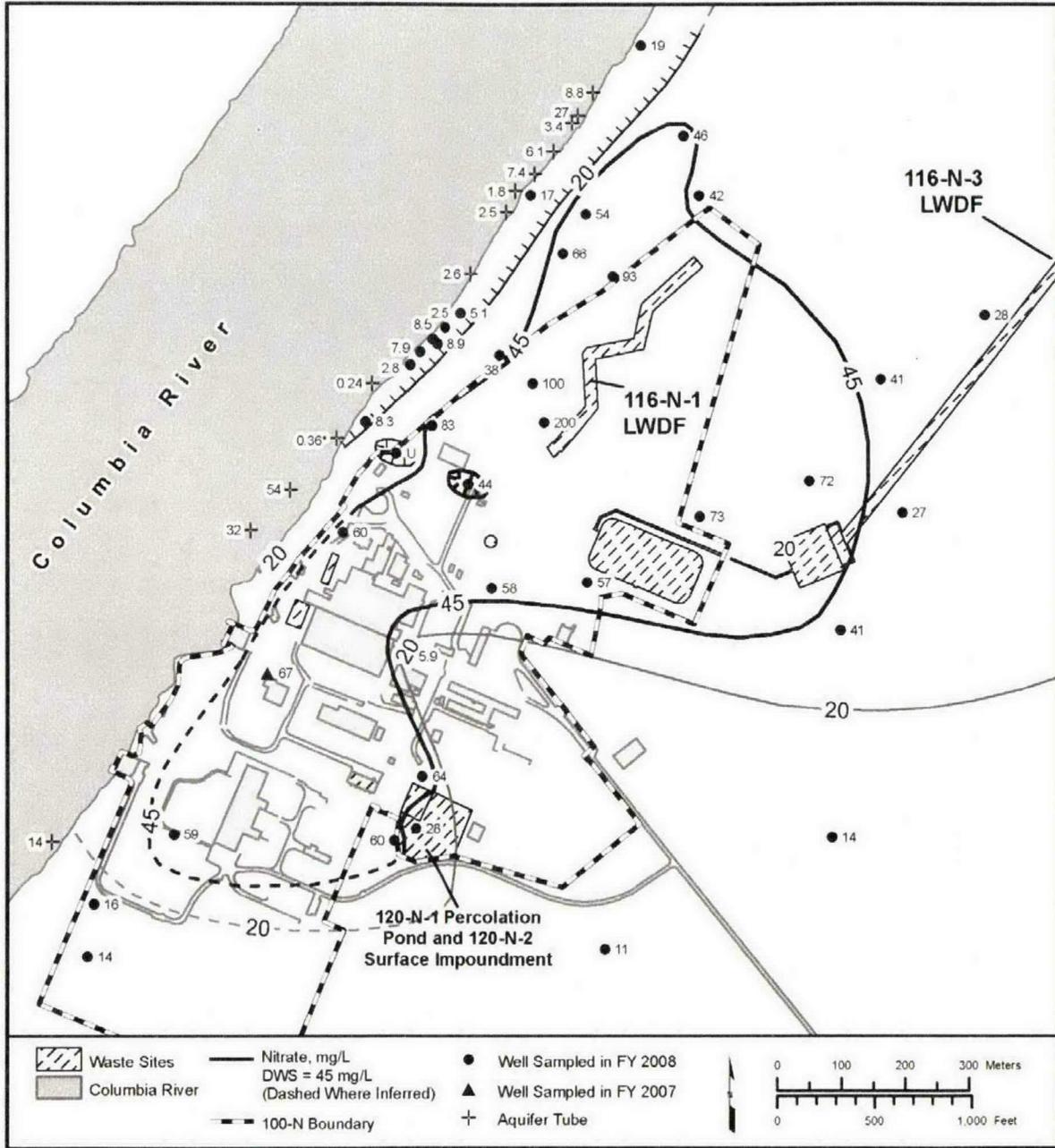
1 Since shoreline monitoring began in 1985, the highest Sr-90 concentration detected has been
2 15,700 pCi/L from Well 199-N-46 (1988) (Figure 2-26).



3
4
5
6
Figure 2-26. 100-N Decision Unit Strontium-90 in Groundwater at the Shoreline Study Area, September 2008, Upper Part of Unconfined Aquifer (DOE/RL-2008-66)

1 **2.3.3.2 Nitrate**

2 Nitrate concentrations exceed the drinking water standards (DWS) (45 mg/L)
3 100-N Area (Figure 2-27). Sources for nitrate groundwater contamination include both pre-Hanford
4 (e.g., agriculture) and Hanford activities.



5
6
7

Figure 2-27. Average FY2008 Nitrate in Groundwater within the 100-N Decision Unit, Unconfined Aquifer

1 In FY 2008, the maximum concentration detected within the 100-N Decision Unit was 6,680 mg/L from
2 Well 199-N-143. This high-nitrate concentration is an artifact of Apatite Barrier Technology (ABT)
3 performed in this area, as evidenced by this high concentration observed in only one sampling round
4 shortly after injection of apatite solution, and the concentration is more than an order of magnitude higher
5 than upgradient wells. Nitrate concentrations exceeding the DWS were detected in 31 wells in the
6 100-N Decision Unit in FY 2008. The nitrate plume above the DWS covers an area of approximately
7 0.54 km² (0.21 mi²).

8 **2.3.3.3 Petroleum**

9 Petroleum hydrocarbons from a 1960s diesel fuel leak (DOE/RL-95-111) associated with the 166-N Tank
10 Farm reached groundwater. Petroleum has been detected in groundwater since 1987, when
11 petroleum-related constituent sampling in monitoring wells was initiated. Petroleum compounds have
12 been detected in wells near and downgradient from the former tank farm. The water table has petroleum
13 free product in Well 199-N-18, which is closest to the former leak site (Figure 4-3) and previously
14 exhibited the highest levels of groundwater contamination. In April 2008, this well had 150 mg/L total
15 petroleum hydrocarbons (TPH) in the diesel range. Relatively low levels of TPH have been detected in
16 wells and aquifer tubes downgradient of the former tank farm.

17 **2.3.3.4 Tritium**

18 In FY 2008, only one well, 199-N-32, had an average tritium concentration exceeding the DWS
19 (20,000 pCi/L). The maximum concentration in this well, located near the 116-N-3 Facility, was
20 22,000 pCi/L. Historically, the highest tritium concentration detected in 100-N Decision Unit wells was
21 400,000 pCi/L from well 199-N-3 in 1972.

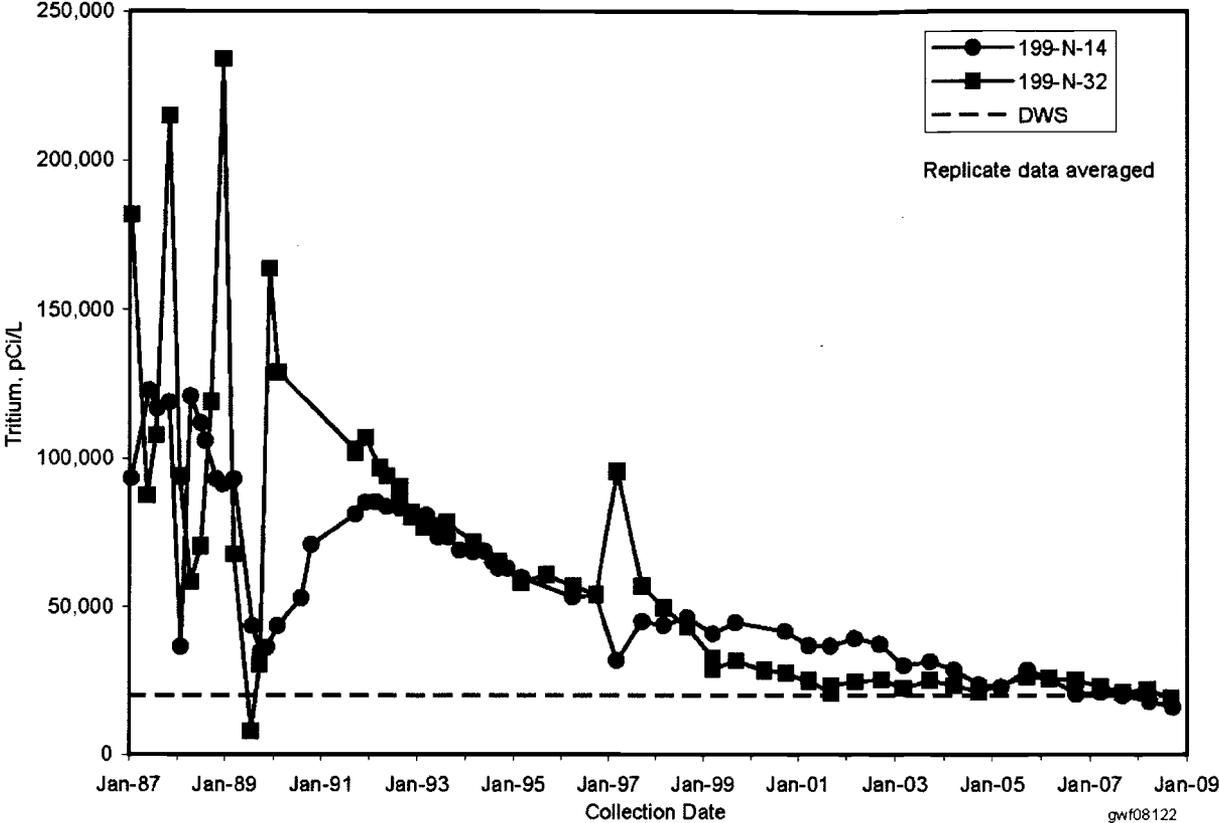
22 Tritium concentrations in the groundwater beneath the 100-N Decision Unit have decreased more than
23 one order of magnitude since effluent discharges to the 116-N-3 Facility ceased in 1991 (Figure 2-28).

24 Tritium is generally evenly distributed throughout the unconfined aquifer. Concentrations in Wells
25 199-N-69 and 199-N-70, completed at the base of the unconfined aquifer, are approximately equal to
26 those detected in nearby shallow wells. Tritium concentration in Well 199-N-80, which monitors a sandy
27 interval in the RUM, was 15,000 pCi/L in FY 2008, and has not been above the MCL since 2005.

28 **2.3.3.5 Total and Hexavalent Chromium**

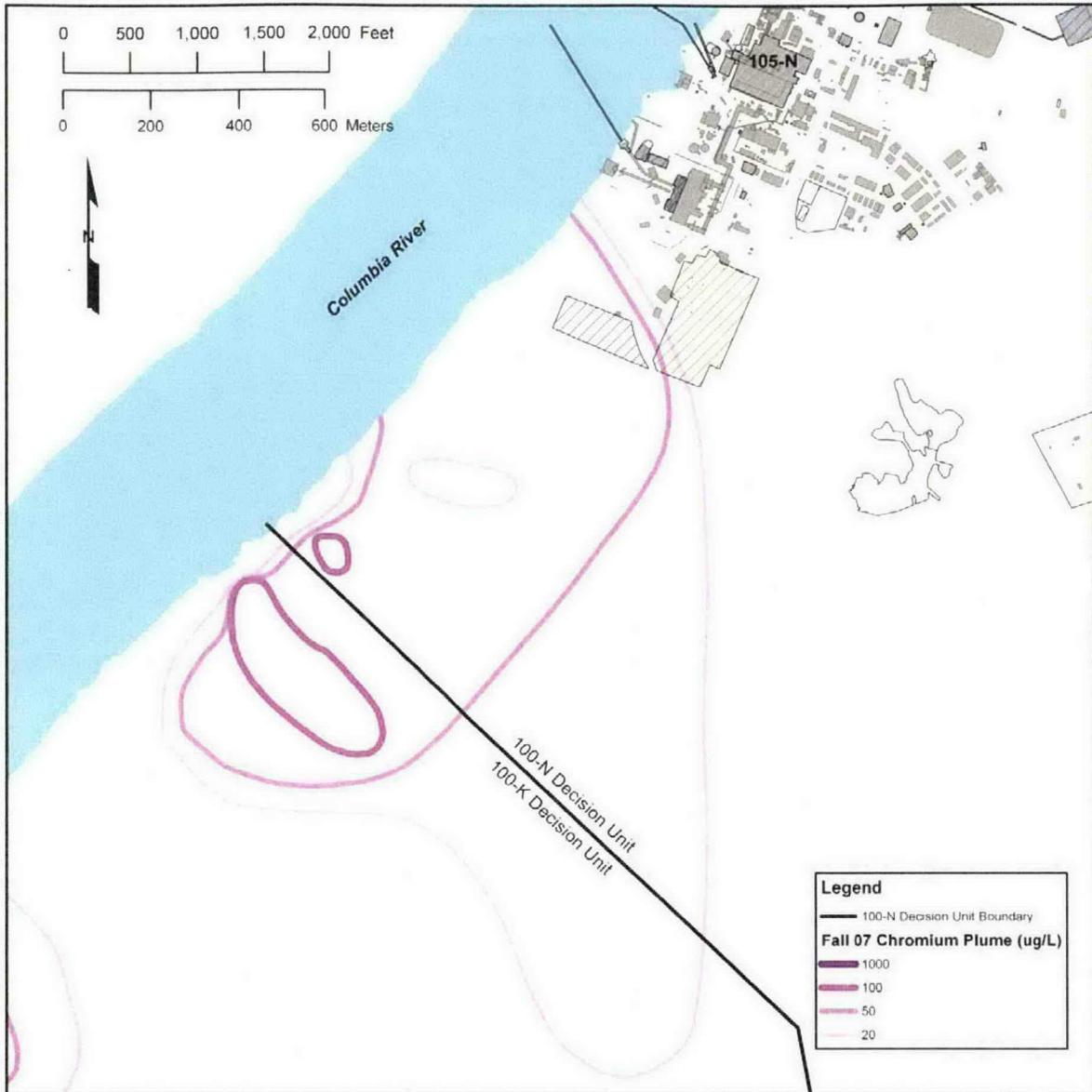
29 Hexavalent chromium is present within the 100-N Decision Unit. Groundwater monitoring for CrVI is
30 inconsistent and discontinuous in frequency and well location. Therefore, only one CrVI plume is
31 mappable using available data. This plume is located in the western portion of the decision unit where
32 a contaminant plume has migrated northeastward from the 100-K Decision Unit (Figure 2-29). Because
33 this plume originates in the 100-K Decision Unit, it will not be addressed by the 100-N Decision Unit
34 remedial actions.

35



1
2

Figure 2-28. Tritium Concentrations in Groundwater near the 116-N-1 and 116-N-3 Waste Sites



1
2 **Figure 2-29. Hexavalent Chromium on the Western Portion of the 100-N Decision Unit, Unconfined Aquifer**

3 Near the N Reactor, CrVI has been analyzed from 23 groundwater samples; 11 monitoring wells in the
4 unconfined aquifer and 22 samples from 12 aquifer tubes. The analytical results from these non-filtered
5 samples revealed maximum CrVI concentrations up to 300 $\mu\text{g/L}$ in monitoring wells (199-N-3 in 1969)
6 and 24 $\mu\text{g/L}$ in aquifer tubes (C6318 in 2008). The last CrVI detection above 20 $\mu\text{g/L}$ (the concentration
7 protective of aquatic receptors) was 60.3 $\mu\text{g/L}$ from Well 199-N-64 in 2005, which was the only CrVI
8 sample collected from this well. CrVI is not a typical analyte in 100-N Area wells.

9 An insufficient number of CrVI samples were collected during any sampling event to provide the basis
10 for a plume map. As discussed in Chapter 4, additional sampling of existing monitoring wells for CrVI
11 is proposed.

1 Total chromium samples have been collected from wells in the unconfined aquifer in the 100-N Area
2 since 1985. The state and federal DWSs (100 µg/L) were exceeded in several wells. Some wells that
3 revealed exceedances in the mid-1990s have not been sampled for since that time (e.g., Well 199-N-17).
4 In 2008, total chromium in filtered samples (assumed representative of CrVI) exceeded the 20 µg/L in
5 seven wells. Six wells are part of the apatite barrier, and the elevated concentrations observed were an
6 artifact of ABT performed in this area. The chemicals used to foster the creation of the apatite matrix
7 temporarily change the geochemical environment and allow previously sorbed species to move through
8 groundwater. This effect is short-lived; the liberated species are re-sorbed and the apatite barrier
9 traps Sr-90.

10 DWS for total chromium were exceeded in samples from six wells during FY 2008, four are part of the
11 apatite barrier and considered artifacts related to the barrier performance. In addition, total chromium
12 exceeded the DWS in several wells in the early 1990s, but has not been an analyte since that time.

13 In one well completed beneath the unconfined aquifer (Well 199-N-80, completed in an approximately
14 1.5 m (5 ft) thick sandy interval within the RUM), the federal DWS has been exceeded for total chromium
15 since 1992, with concentrations ranging from 130 to 234 µg/L.

16 **2.3.3.6 Other Contaminants**

17 Additional contaminants were detected in groundwater in the unconfined aquifer above the DWSs within
18 the 100-N Decision Unit, generally within the area of the Sr-90 plume. Contaminants such as iron,
19 manganese, and sulfate exceed the secondary DWS. The secondary DWS were established as guidelines
20 by EPA to assist in managing drinking water for aesthetic considerations, such as taste, color, and odor.
21 These contaminants are not considered to present a risk to human health.

22 These other contaminants did not necessarily originate from the same primary sources as the Sr-90.
23 Radiological contaminants (other than Sr-90) have been detected in groundwater near former reactor
24 buildings and associated structures, but at concentrations less than DWSs (except tritium, as discussed
25 in Chapter 2).

26 Manganese concentrations continued to exceed the secondary DWS (50 µg/L) in filtered samples from
27 two wells affected by petroleum contamination: 199-N-16 (371 µg/L) and 199-N-18 (4,570 µg/L). Iron
28 concentrations also exceeded the secondary DWS (300 µg/L) in well 199-N-18 (20,500 µg/L).

29 The former 120-N-1 Percolation Pond introduced sulfate and sodium to 100-N Area groundwater. The
30 highest sulfate concentration in FY 2008 was 251 mg/L in well 199-N-59, adjacent to the 120-N-1
31 Percolation Pond. This was the only well with a concentration above the 250 mg/L secondary DWS.

1 Total chromium samples have been collected from wells in the unconfined aquifer in the 100-N Area
2 since 1985. The state and federal DWSs (100 µg/L) were exceeded in several wells. Some wells that
3 revealed exceedances in the mid-1990s have not been sampled for since that time (e.g., Well 199-N-17).
4 In 2008, total chromium in filtered samples (assumed representative of CrVI) exceeded the 20 µg/L in
5 seven wells. Six wells are part of the apatite barrier, and the elevated concentrations observed were an
6 artifact of ABT performed in this area. The chemicals used to foster the creation of the apatite matrix
7 temporarily change the geochemical environment and allow previously sorbed species to move through
8 groundwater. This effect is short-lived; the liberated species are re-sorbed and the apatite barrier
9 traps Sr-90.

10 DWS for total chromium were exceeded in samples from six wells during FY 2008, four are part of the
11 apatite barrier and considered artifacts related to the barrier performance. In addition, total chromium
12 exceeded the DWS in several wells in the early 1990s, but has not been an analyte since that time.

13 In one well completed beneath the unconfined aquifer (Well 199-N-80, completed in an approximately
14 1.5 m (5 ft) thick sandy interval within the RUM), the federal DWS has been exceeded for total chromium
15 since 1992, with concentrations ranging from 130 to 234 µg/L.

16 **2.3.3.6 Other Contaminants**

17 Additional contaminants were detected in groundwater in the unconfined aquifer above the DWSs within
18 the 100-N Decision Unit, generally within the area of the Sr-90 plume. Contaminants such as iron,
19 manganese, and sulfate exceed the secondary DWS. The secondary DWS were established as guidelines
20 by EPA to assist in managing drinking water for aesthetic considerations, such as taste, color, and odor.
21 These contaminants are not considered to present a risk to human health.

22 These other contaminants did not necessarily originate from the same primary sources as the Sr-90.
23 Radiological contaminants (other than Sr-90) have been detected in groundwater near former reactor
24 buildings and associated structures, but at concentrations less than DWSs (except tritium, as discussed
25 in Chapter 2).

26 Manganese concentrations continued to exceed the secondary DWS (50 µg/L) in filtered samples from
27 two wells affected by petroleum contamination: 199-N-16 (371 µg/L) and 199-N-18 (4,570 µg/L). Iron
28 concentrations also exceeded the secondary DWS (300 µg/L) in well 199-N-18 (20,500 µg/L).

29 The former 120-N-1 Percolation Pond introduced sulfate and sodium to 100-N Area groundwater. The
30 highest sulfate concentration in FY 2008 was 251 mg/L in well 199-N-59, adjacent to the 120-N-1
31 Percolation Pond. This was the only well with a concentration above the 250 mg/L secondary DWS.

3 Identification of Investigation Requirements

1
2 This chapter is included in the addendum to indentify and discuss 100-N Decision Unit I to the following
3 sections of the work plan (DOE/RL-2008-046):

- 4 • Preliminary Remedial Action Objectives (Section 3.6)
- 5 • Preliminary Remediation Goals (Section 4.1)
- 6 • Potential Applicable or Relevant and Appropriate Requirements (Section 4.2)
- 7 • Assessment of Baseline and Residential Risk in the 100 Area (Section 4.3)
- 8 • Preliminary Remedial Actions (Section 4.5)

9 Because there are no exceptions to the work plan information, all the bulleted items refer to text provided
10 in Chapter 4 of the work plan.

11

1

2

This page intentionally left blank.

4 Conceptual Site Model

This chapter describes the CSM for the 100-N Decision Unit. The CSM expresses the current understanding of site conditions in the decision unit and makes possible the identification of data gaps and data needs in conjunction with the planning process described in Section 4.5 of this Work Plan. The CSM identifies waste site key features, distills the information that is already known, and captures decision to be made. It describes sources and receptors, interactions linking them, and identifies uncertainties and provides a framework for data and information needed to resolve each uncertainty. The CSM will evolve as new data and information are developed. The goal of the CSM is the synthesis of decision unit knowledge in a manner that supports project needs, and addresses decision-making requirements (including the design of remedial actions). The CSM is presented here as a discussion of known and potential contaminant sources (including release mechanisms), contaminant migration and distribution in the vadose zone, contaminant migration and distribution in the unconfined aquifer, and exposure pathways and receptors.

This discussion focuses primarily on Sr-90, the contaminant for which the bulk of remediation efforts have been directed at the 100-N Decision Unit. Some specific discussion is provided for petroleum species, tritium, and nitrate, which have been observed in the unconfined aquifer. In addition, some discussion is provided for sodium dichromate which is a prominent contaminant of concern at other 100 Area reactor sites (particularly 100 D and K Areas), but is not widely distributed in the 100-N Area. In this evaluation, the CSM model is used primarily to indicate why chromium is not a significant environmental contaminant in the 100-N Decision Unit.

4.1 Contaminant Inventory and Release Characteristics

At the 100-N Decision Unit, the N Reactor (105-N) operated for the better part of 23 years from late 1963 through late 1986. In support of its operation to produce special nuclear materials through irradiation of uranium-enriched fuels and to generate commercial power, large quantities of contaminated fluids and solids were generated routinely and discharged to the surrounding environment. The majority of contaminant mass released to the environment was dissolved or suspended as particulates in various fluids discharged to LWDFs near the reactor, primarily 1301-N LWDF and 1325-N⁶ LWDF. Throughout the reactor operations period and for some time afterward, these facilities received liquid waste. The majority of the discharge volume went to 1301-N LWDF from 1964 to late 1985 and the remainder went to 1325-N LWDF from 1983 into 1993. The major types of fluids included:

- Reactor coolant and periphery cooling systems bleed off
- Reactor primary coolant loop decontamination rinse solution
- Spent fuel storage basin cooling water overflow
- Building drains where radioactive solutions were generated

⁶ 1301-N is also known as 116-N-1; 1325-N is also known as 116-N-3.

1 With the exception of the primary coolant loop decontamination rinse solution, which was generated
 2 every two to four years (WHC-EP-0675), all solutions were generated and discharged continuously. The
 3 coolant fluids and basin fluids were the primary sources of LWDF discharge (see Figure 4-1, adapted
 4 from WCH-0675). These fluids became contaminated by contact with ruptured fuel elements and
 5 subsequent dissolution of readily dissolvable isotopes. The fluids were piped from the N Reactor or the
 6 fuel storage basin to the 1322-N Facility, then to the 1310-N Storage Facility or the cribs, depending on
 7 the contamination levels. Fluids with unacceptably high contamination levels went to 1310-N and were
 8 transport by rail to the 200 Area for disposal. Criteria defining the need to transport waste to the
 9 200 Area, nor the destination were located in supporting documents.

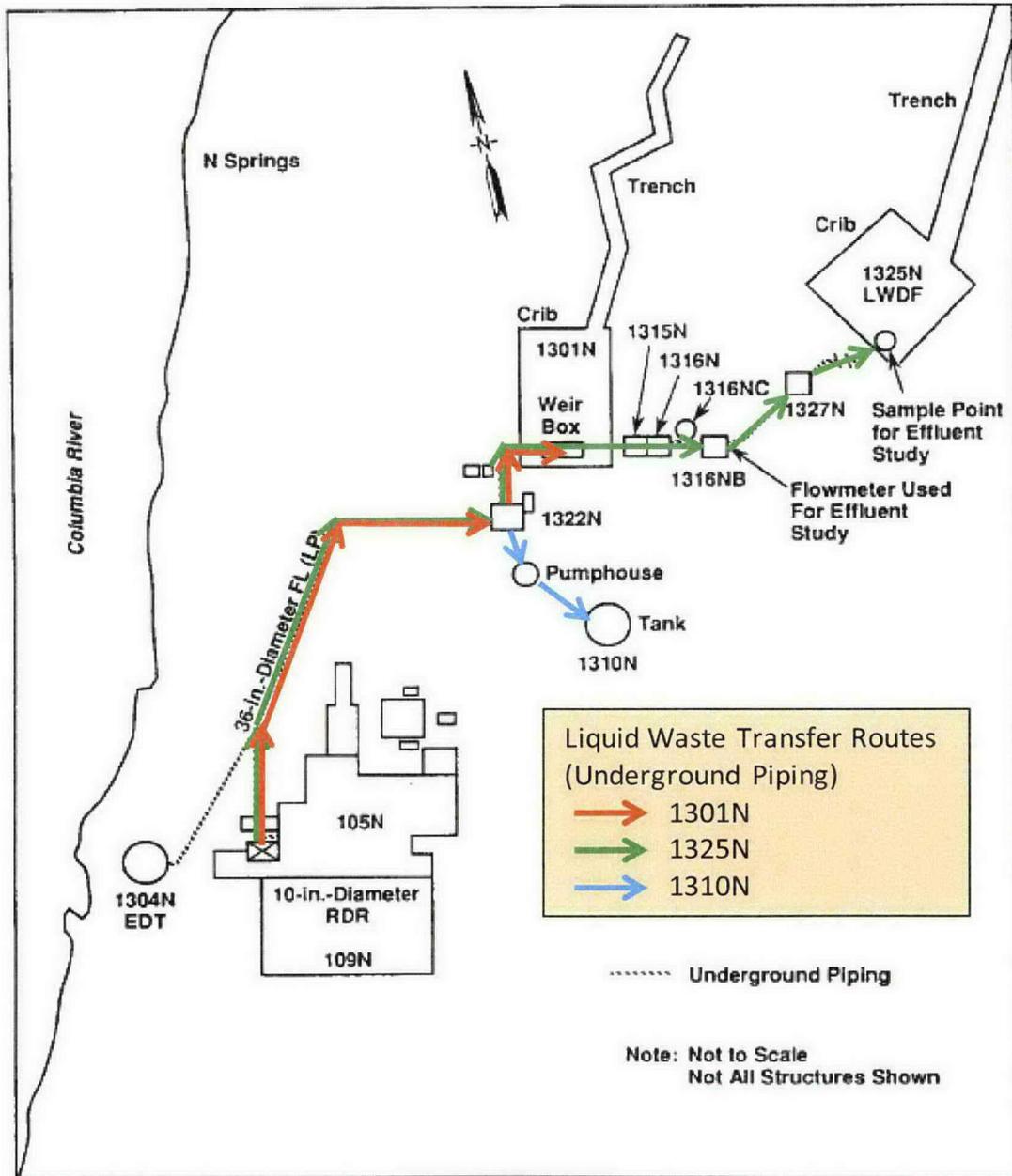


Figure 4-1. Primary Reactor Fluid Discharge Pathways in the 100 N Area

10
 11

1 **4.1.1 Strontium-90 Releases**

2 Readily available documentation provides summary level quantitative information about Sr-90 and other
 3 radioactive contaminants and their concentration levels present in the various discharged fluids. The most
 4 explicit discussion of early contamination levels was provided in DUN-7372, where measured
 5 concentrations in reactor effluents were reported for about 25 radionuclides. The fluids were collected in
 6 the winter of 1969 to 1970. Concentrations of notable contaminants that have been measured
 7 subsequently in soils underneath the cribs and in groundwater are listed in Table 4-1. Measurements were
 8 also provided in DUN-7372 for a suite of radionuclides with half lives less than 1 year. The estimated
 9 annual discharge volume for this inventory was 4.2E+09 L (1.11E+09 gal), of which 3.8E+09 L
 10 (1.003E+09 gal) came from the reactor coolant systems and 4.0E+08 L (1.06E+08 gal) from the basins
 11 overflow. From these data, it can be seen that the basin waters provided the majority of contaminant mass
 12 to the 1301-N Crib in about 10 percent of the total discharge volume. The higher concentrations in the
 13 basin fluids are apparently the result of more prolonged exposure to ruptured fuel rods in the fuel storage
 14 basin compared to that in the reactor cooling systems and the discharge of particulates in fluids
 15 accompanying fuel transfer to the storage basin (WHC-SD-RNTI-251).

16

**Table 4-1. Radionuclide Concentrations and Estimated Annual Discharges
 in 1969 to 1970 from N Reactor Effluents (DUN-7372)**

Isotope	Reactor Coolant Fluids						Annual Total Ci
	Primary Loop		Rod Coolant		Basin Fluids		
	pCi/L	Ci/Yr	pCi/L	Ci/Yr	pCi/L	Ci/Yr	
Co-60	6.4E+04	1.0E+02	1.5E+02	3.3E-01	1.0E+05	4.0E+01	1.4E+02
Sr-90	2.0E+01	3.2E-02	1.8E+02	3.9E-01	1.7E+04	6.8E+00	7.2E+00
Cs-137	1.2E+03	1.9E+00	1.3E+02	2.8E-01	6.6E+04	2.6E+01	2.8E+01
H-3					3.0E+05	1.20E+02	1.2E+02

Co-60 = cobalt-60
 Cs-137 = cesium-137
 H-3 = tritium
 Sr-90 = strontium-90

17 Historical records of radioactive contaminant discharges indicate annual discharge volumes and average
 18 radioactive contaminant concentrations were generally similar to those measured in 1969 and 1970.
 19 Annual reports of crib discharges were prepared for most of the operations periods beginning in 1973.
 20 These reports provided measured total volume releases to the cribs and contaminant contents
 21 (both average concentrations and total quantities). A partial summary of these data is provided in
 22 Table 4-2.

Table 4-2. Annual Volume and Radioactive Contaminant Releases to 1301-N and 1325-N Liquid Waste Disposal Facilities

Source Document	Year	Annual Crib Discharges (L)			Discharged Inventory (Ci)			Average Concentrations (pCi/L)		
		1301-N	1325-N	Total	Sr-90	Cs-137	Co-60	Sr-90	Cs-137	Co-60
UNI-3533 and DOE/RL-96-11	1964 ^a	3.45E+09		3.45E+09	195	60	180	5.65E+04	1.74E+04	5.21E+04
	1965 ^a	3.45E+09		3.45E+09	195	60	180	5.65E+04	1.74E+04	5.21E+04
	1966 ^a	3.45E+09		3.45E+09	195	60	180	5.65E+04	1.74E+04	5.21E+04
	1967 ^a	3.45E+09		3.45E+09	270	88	200	7.82E+04	2.55E+04	5.79E+04
	1968 ^a	3.45E+09		3.45E+09	270	41	82	7.82E+04	1.19E+04	2.37E+04
DUN-7372 and UNI-3533	1969	4.18E+09		4.18E+09	7.4	28	84	1.77E+03	6.70E+03	2.01E+04
	1970	4.18E+09		4.18E+09	7.3	51	230	1.75E+03	1.22E+04	5.50E+04
UNI-3533	1971 ^a	3.45E+09		3.45E+09	17	92	330	4.92E+03	2.66E+04	9.55E+04
UNI-3533 and DOE/RL-96-11	1972 ^a	3.45E+09		3.45E+09	21	18	220	6.08E+03	5.21E+03	6.37E+04
DOE/RL-96-11	1973	3.18E+09		3.18E+09	16	48	320	5.04E+03	1.51E+04	1.01E+05
DOE/RL-96-11	1974	3.47E+09		3.47E+09	63	170	320	1.82E+04	4.90E+04	9.23E+04
DOE/RL-96-11	1975	3.47E+09		3.47E+09	93	240	370	2.68E+04	6.92E+04	1.07E+05
DOE/RL-96-11	1976	3.61E+09		3.61E+09	110	320	640	3.04E+04	8.86E+04	1.77E+05
DOE/RL-96-11	1977	5.29E+09		5.29E+09	120	380	870	2.27E+04	7.18E+04	1.64E+05
DOE/RL-96-11	1978	4.56E+09		4.56E+09	120	340	940	2.63E+04	7.45E+04	2.06E+05
DOE/RL-96-11	1979	4.93E+09		4.93E+09	130	290	770	2.64E+04	5.89E+04	1.56E+05
DOE/RL-96-11	1980	4.56E+09		4.56E+09	160	36	1200	3.51E+04	7.89E+03	2.63E+05
DOE/RL-96-11	1981	3.83E+09		3.83E+09	84	240	370	2.19E+04	6.26E+04	9.65E+04
DOE/RL-96-11	1982	3.83E+09		3.83E+09	140	270	500	3.65E+04	7.05E+04	1.30E+05

4-4

Table 4-2. Annual Volume and Radioactive Contaminant Releases to 1301-N and 1325-N Liquid Waste Disposal Facilities

Source Document	Year	Annual Crib Discharges (L)			Discharged Inventory (Ci)			Average Concentrations (pCi/L)		
		1301-N	1325-N	Total	Sr-90	Cs-137	Co-60	Sr-90	Cs-137	Co-60
DOE/RL-96-11	1983 ^b	2.53E+09	7.15E+08	3.25E+09	110	200	770	3.39E+04	6.16E+04	2.37E+05
DOE/RL-96-11	1984 ^b	2.96E+09	6.94E+08	3.65E+09	310	210	1500	8.49E+04	5.75E+04	4.11E+05
UNI-3533 and DOE/RL-96-11	1985 ^b	2.63E+09	1.02E+09	3.65E+09	240	88	590	6.58E+04	2.41E+04	1.62E+05
UNI-4370	1986		2.65E+09	2.65E+09	36.0	210	390	1.36E+04	7.94E+04	1.47E+05
DOE/RL-96-11	1987		7.67E+08	7.67E+08	15.0	48	200	1.96E+04	6.26E+04	2.61E+05
DOE/RL-96-11	1988		6.06E+08	6.06E+08	15.0	8	11	2.47E+04	1.32E+04	1.82E+04
DOE/RL-96-11	1989		6.06E+08	6.06E+08	28	23	33	4.62E+04	3.80E+04	5.45E+04
BHI-00368	1990		2.00E+08	2.00E+08	14	7.1	7.8	7.00E+04	3.55E+04	3.90E+04
BHI-00368	1991		NA	NA	0.85	0.13	0.0048			
BHI-00368	1992		NA	NA	14	7.1	7.8			
BHI-00368	1993		NA	NA	0.85	0.13	0.0048			
Totals		8.14E+10	7.26E+09	8.86E+10	2997	3633	11496			

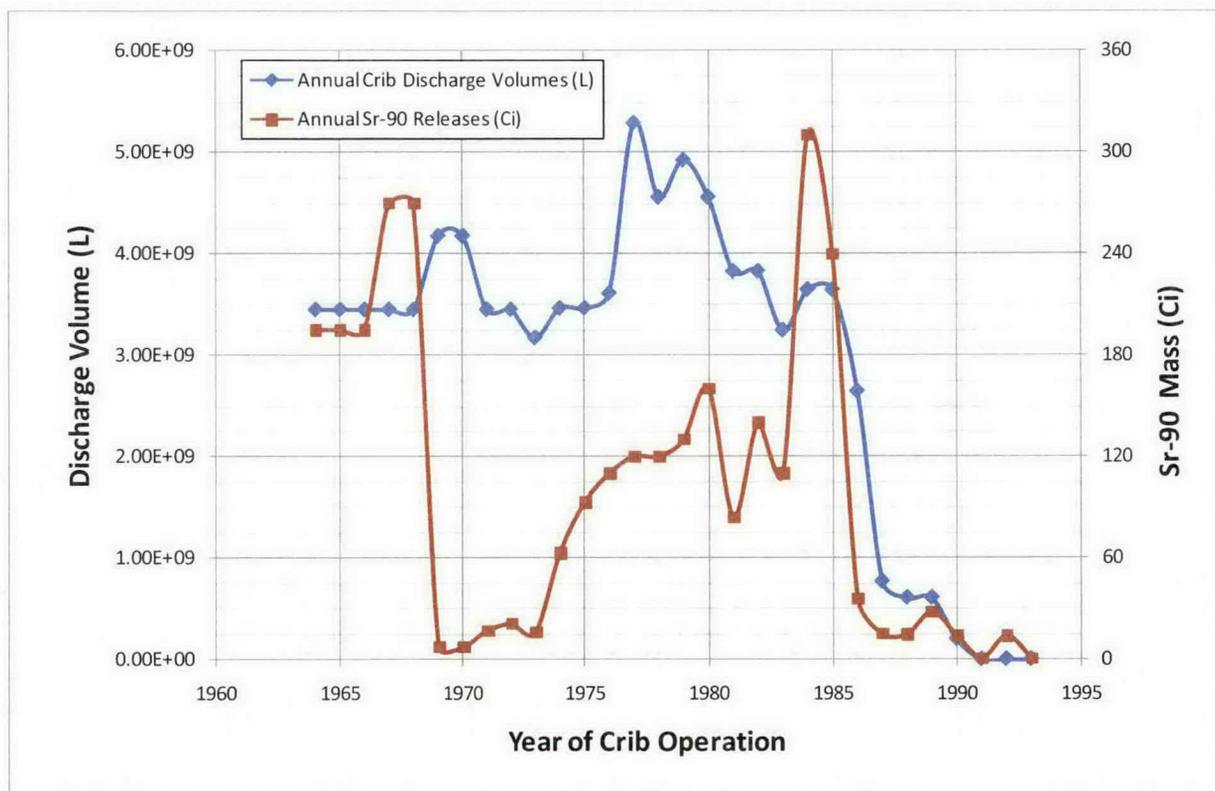
Source: UNI-3533, DOE/RL-96-11, DUN-7372, UNI-4370, BHI-00368

a. Because annual discharge volumes were unreported in these years, the values shown were extrapolated from early 1970s reported volumes. From 1964-1966, contaminant releases were also not reported and values shown are similarly extrapolated.

b. Fluids were discharged to both facilities in 1983, 1984, and 1985. The annual contaminant releases to each crib are assumed proportional to the discharge volume ratios. For example in 1983, estimated annual Sr-90 releases to 1301-N and 1325-N are 24 and 85 Ci, respectively, in 1984, 59 and 251 Ci, and in 1985, 97 and 173 Ci.

Cs-137 = cesium-137
 Co-60 = cobalt-60
 Sr-90 = strontium-90

1 The Table 4-2 data shows that annual fluid discharges were relatively constant during the reactor
 2 operations period but the annual contaminant releases were not. As an example, a comparison of annual
 3 discharge volumes versus Sr-90 discharges is shown in Figure 4-2, where there is a general but
 4 inconsistent correlation between the two data sets. During reactor operations between 1964 and 1987,
 5 annual discharges fluctuated over a relatively small range between 3 and 5.5 E+9 L. During that time,
 6 a substantial drop in the annual Sr-90 release occurred in 1969 versus 1968 (7.4 and 270 Ci, respectively).
 7 Then for the remainder of the reactor operations periods, annual Sr-90 releases steadily increased. This
 8 particular divergence in behavior has not been explained in the historical documentation but is attributed
 9 to changes in basin overflow contamination levels, which responded to differences in ruptured fuel
 10 storage practices and whatever administrative controls might have been placed on acceptable Sr-90 limits.
 11 It is significant that almost a third of the total Sr-90 releases (about 1,125 Ci) are estimated to have been
 12 discharged by 1969. This inventory is considered the primary source of Sr-90 that first reached N Springs
 13 in the mid 1980s (see Section 4.4).



14 **Figure 4-2. Comparison of Annual Fluid Discharges versus Annual**
 15 **Strontium-90 Releases Into 1301-N and 1325-N**
 16

17 The end of reactor operations, which started between 1985 and 1986, is clearly indicated by the rapid
 18 drop in both curves. Reactor operations began slowing in 1985 and the facility was put into cold standby
 19 in early 1987, at which point the bulk of fluid discharges were associated with draining facility fluids as
 20 part of the facility shutdown. The reductions in Sr-90 discharges were influenced by the startup of a basin
 21 wastewater filtration program in late 1984 and the spent fuel transfers to the 100 K Area
 22 basins (UNI-3880).

23 In addition to intentional releases of Sr-90-bearing liquid wastes, several unplanned releases (UPRs)
 24 through cracked pipelines discharged Sr-90 and other radioactive contaminants to the subsurface.
 25 Of these, the two most notable events were leaks at the 111-N spacer silos (UPR-100-N-3/118N and

1 UPR-100-N-12/118-N-1, see Table 4-2) which released an estimated 80 and 120 μCi respectively.
2 Clearly, these releases are relatively insignificant compared to the intentional discharges to 1301-N
3 and 1325-N LWDFs.

4 **4.1.1.1 100-N Area Skyshine Dose Evaluation**

5 100-N Area facilities and waste sites with inventories of gamma emitting radionuclides can create a
6 phenomenon known as "skyshine." Skyshine is produced by the interaction of gamma rays with the
7 atmosphere and the subsequent downward scatter of the gamma rays. Skyshine was first observed in 1980
8 by 100-N Area operators who were able to correlate elevated radiation readings with the amount of
9 shielding (i.e., depth of water) over the 116-N-1 and 116-N-3 Cribs. Skyshine is known to increase
10 radiation exposure to users of the Columbia River and its shoreline adjacent to the 100-N Area.

11 Decommissioning, deactivation, and interim remedial action (e.g., removal of shielding, excavation)
12 temporarily contributes to skyshine.

13 BHI-01204, 1998, *N Area Skyshine Dose Evaluation*, Bechtel Hanford Inc, Richland Washington, showed
14 that skyshine results in an increase in ambient radiation over background conditions in the 100-N Area.
15 As a result of cleanup efforts at 105-N Basin, the report indicates the average dose rate calculated for
16 13 skyshine exposure points is 1.2 mrem over an 888-hour period. Although the average dose rate was
17 twice the original calculated value prior to cleanup, it was still less than 2 mrem over an 888-hour period
18 (BHI-1998). Ecology and DOE have established a deactivation cleanup criteria along the shoreline of an
19 average dose rate of no more than 2 mrem increase over 888 hours (CCN-055080, 1998, *N Basin Cleanup*
20 *Criteria*, letter from T.E. Logan/BHI to P.M. Pak/DOE/RL, Bechtel Hanford, Inc., Richland,
21 Washington). The maximum dose rate for the 13 skyshine exposure points after cleanup of 100-N Area
22 deactivation buildings was 11.2 mrem over 888-hours. The minimum skyshine dose rate was 5.5 mrem
23 over 888 hours. The total skyshine dose rate from the 100-N Area deactivation of buildings was well
24 below the total 100-N Reactor allowable contribution of 25 mrem over an 888-hour period (BHI-01204).

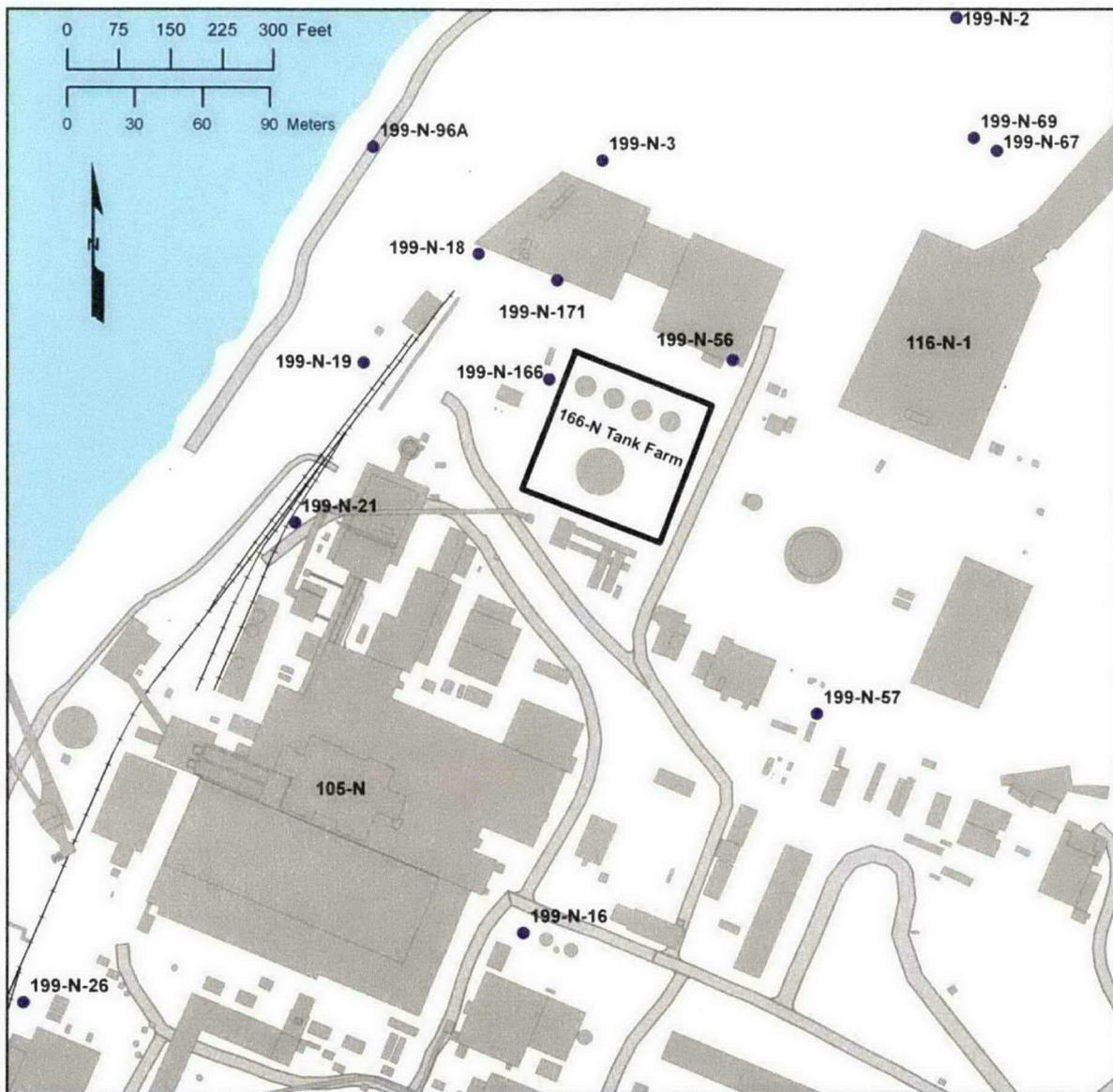
25 Since 1980, measures were taken to minimize impact from skyshine, including placing concrete panels
26 over the 116-N-1 and 116-N-3 Cribs and cleanup of waste sites and facilities. Skyshine has been
27 minimized or eliminated after cleanup (i.e., interim remedial actions) as contaminants are effectively
28 removed and waste sites are backfilled. At the 116-N-1 and 116-N-3 Cribs, which were known historical
29 contributors of skyshine, contaminated soils were removed to a maximum depth of 6.5 m (21.3 ft). The
30 skyshine effect was further minimized or eliminated by placing backfill over remaining
31 residual contamination.

32 **4.1.2 Petroleum Releases**

33 Petroleum product releases occurred at fuel storage facilities (notably the 166-N Tank Farm and the
34 184-N Day Tanks) and connecting underground transfer lines on several occasions (see Appendix C). The
35 166-N Tank Farm (Figure 4-3) consisted of one large fuel oil storage tank (5,204,941 L [1,375,000 gal])
36 and four smaller diesel oil storage tanks (397,468 L [105,000 gal]). From the 166-N Tank Farm,
37 underground pipelines transferred fuel to the 184-N Day Tanks, which then supplied fuel to the N Reactor
38 (105-N).

39 Beginning in 1966, a number of mechanical and operational failures (pipe systems failures of transport
40 diesel and fuel oils, storage facilities overflowing, and spills during fuel transfers [WCH-323]) at these
41 facilities resulted in releasing petroleum hydrocarbon contamination into the subsurface. The first and
42 largest known leak occurred in August 1966 when a 4 in. diameter diesel fuel line leaked, because of
43 corrosion, releasing an estimated 301,832 L (80,000 gal) of fuel. The leak (UPR-100-N-17) was detected
44 through an observed discrepancy in the fuel inventory. The line was excavated and repaired.

1 Subsequently, numerous smaller leaks and some tank overflows released estimated fuel volumes of more
2 than 16600 L (4400 gal). Generally, these lines were also repaired.



3
4 **Figure 4-3. Location of the 166N Tank Farm and 184-N Day Tank Facility**

5 **4.1.3 Sodium Dichromate Releases**

6 The primary function of sodium dichromate used in the N Reactor was to provide corrosion protection for
7 aluminum parts. These included ancillary equipment supporting the primary loop cooling system
8 (HW-69000), rod cooling system and aluminum-bearing fuel used during the tritium production runs
9 between 1965 and 1967 (WHC-MR-0521). Because of the reactor design, less sodium dichromate
10 (approximately 100 times less) was needed for corrosion control compared to that required at eight
11 constructed and operated single pass reactors in the 100 Area. Generally, using a recirculating cooling
12 water system reduced water usage at 105-N, and using more corrosion resistant metals in the fuel and
13 facility (e.g., Zircaloy) reduced the need for sodium dichromate as a corrosion reductant. Other chemicals,

1 primarily hydrazine for oxygen control and morpholine for pH control, were used from the beginning of
2 reactor operations to minimize corrosion rates. Consequently, less sodium dichromate was used annually
3 and anecdotal historical information (BHI-00368) suggests sodium dichromate use at 105-N ended in the
4 early 1970s. Sodium dichromate use was last reported in 1973 (UNI-158) and the relatively small amount
5 suggests that the practice was essentially abandoned in 1972. Given this chronology, all sodium
6 dichromate used during operations was discharged to 1301-N LWDF from the N Reactor (105-N)
7 (Figure 4-1).

8 Sodium dichromate was stored in solid form at 105-N and mixed into cooling water as needed.
9 Documentation of sodium dichromate quantities use is available for 4 years, 1965 and 1968 through 1970
10 (Table 4-3). For purposes of this discussion, an average mass of 6,804 kg (15,000 lb) of sodium
11 dichromate are assumed in the years for which no documentation is readily available. Given the total
12 discharges, average concentrations in the discharge wastewater are estimated to be between 0.5 and 0.9
13 mg/L. These concentrations are consistent with those reported at the single pass reactors.
14

**Table 4-3. Annual Wastewater Volume and Sodium Dichromate Releases
to 1301-N and 1325-N Liquid Waste Disposal Facilities**

Document Source	Year	1301-N Discharges (L/yr)	Sodium Dichromate Used (lb)	Cr Fraction (kg)	Average Concentration (mg/L)
	1964	3.45E+09	15,000	2,727	7.90E-01
RL-NRD-828 ^a	1965	3.45E+09	11,280	2,051	5.94E-01
	1966	3.45E+09	15,000	2,727	7.90E-01
	1967	3.45E+09	15,000	2,727	7.90E-01
DUN-4668	1968	3.45E+09	15,700	2,855	8.26E-01
DUN-6205	1969	4.18E+09	18,400	3,345	8.00E-01
DUN-7162	1970	4.18E+09	15,300	2,782	6.66E-01
	1971	3.45E+09	15,000	2,727	7.90E-01
	1972	3.45E+09	15,000	2,727	7.90E-01
UNI-158	1973	3.18+09	200	36	1.1E-02
Totals		3.25E+10	135,680	24,704	

Source: RL-NRD-828, DUN-4668, DUN-6205, DUN-7162, UNI-158

a An additional 9600 lb of sodium dichromate was reported to be in storage as of January 1966.

15 4.1.4 Tritium and Nitrate Release

16 Tritium, like Sr-90, Cs-137, and Co-60, was a primary radioactive contaminant in the wastewater
17 discharged to 1301-N and 1325-N. Typical concentrations were 1E+05 pCi/L and approximately 6500 Ci
18 were released through 1301-N and 1325-N LWDFs. This total is the sum of annual estimates that were
19 documented in annual liquid effluent reports (1973 through 1989). For other years, the discharge
20 inventory was estimated by taking the product of the approximate average concentration (1E+05 pCi/L)
21 and the annual volume discharge estimates (Table 4-2). Given the short half-life of tritium (12.5 yr),
22 about 75 percent of this inventory has decayed.

1 The source of nitrate has never been clearly determined. The common source of nitrate in wastewater is
2 nitric acid, which was used in many facilities. However, neither nitric acid nor nitrate was a reported
3 component of wastewater discharged into the 1301-N LWDF or 1325-N LWDF. The shape of the current
4 groundwater plume suggests that fluid losses from facilities around the N Reactor (105-N) were at least
5 partial sources. Given the lack of historical records about such losses, no inventory estimate can
6 be determined.

7 **4.2 Contaminant Migration and Distribution in the Vadose Zone**

8 Following discharge of contaminants into the subsurface (as described in this Chapter), migration through
9 the vadose zone began. The rate of migration and subsequent distribution within the vadose zone was
10 dependent on several dominant factors including the recharge history, contaminant-specific reactivity
11 with vadose zone soils, and the physical properties of the discharge facility floor and vadose zone
12 stratigraphy (e.g., thickness and permeability). At the 100 N Area, critical characteristics were the
13 creation of high recharge rate zones under 1301-N and 1325-N LWDFs during reactor operations,
14 a vadose zone stratigraphy consisting primarily of highly permeable Hanford formation sands and gravels
15 of moderate thickness, and contaminant reactivity ranging from essentially inert to highly reactive. In the
16 following sections the vadose zone characterization data for Sr-90, sodium dichromate, and petroleum are
17 described and interpreted in the context of the dominant environmental characteristics described above.

18 **4.2.1 Strontium-90 Migration and Distribution in the Vadose Zone**

19 Migration of Sr-90 through and its current distribution within the vadose zone has been strongly
20 influenced by the recharge history through 1301-N and 1325-N LWDFs and its reactivity with crib, trench
21 floor, and vadose zone sediments. The primary data set indicating the nature of Sr-90 migration in the
22 vadose zone is the suite of soil characterization data collected prior to, and during remediation. Given the
23 operations history, soil sampling locations, shown on Figure 4-4, have been concentrated near 1301-N
24 and 1325-N LWDFs, along the river shore downgradient of LWDFs, and in the intermediate zone
25 between 1301-N and the shore. At 1301-N, boreholes were drilled through and near the crib and samples
26 collected as a function of depth from the near surface into the unconfined aquifer. In addition, during the
27 later stages of operations (1981 to 1985), sediments were collected along the trench floor (TS-1 through
28 TS-9). Sampling was not as extensive at 1325-N LWDF and consisted of two boreholes in the crib area,
29 and operational period crib bottom samples (C-1 through C-12) taken in the latter stages of facility
30 operation (1985 to 1987). Finally, as both facilities were excavated during remediation (concrete
31 materials and underlying soils), cleanup verification soils were collected down to about 6.1 m (20 ft) bgs
32 throughout the length of the facility.

33

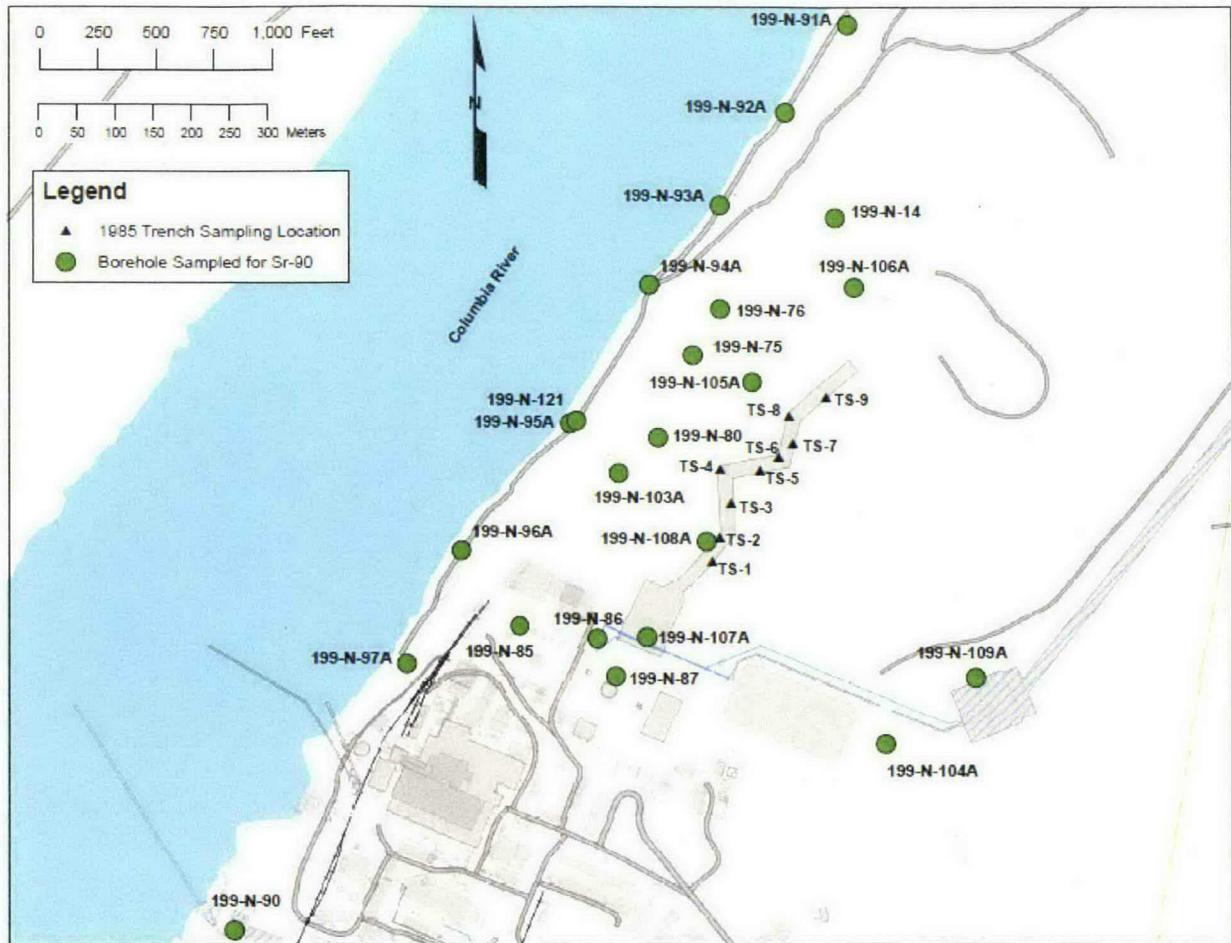


Figure 4-4. Subsurface Sampling Locations for Sediments Contaminated with Strontium-90 at 100 N Area

1
2
3

4 From these data, three characteristics are notable and are illustrated in Figure 4-5 and 4-6. In Figure 4-5,
 5 Sr-90 concentrations are shown with depth in the vadose zone at four boreholes roughly parallel to the
 6 long axis of 1301-N along with vadose zone stratigraphy. Also shown are water table levels at various
 7 times. The head end of 1301-N is at the left of Figure 4-5. In Figure 4-6, similar information is shown for
 8 downgradient wells, between 1301-N and the river shore.

9 First, the highest Sr-90 concentrations occur nearest the point of entry into the LWDFs, at pipe outlets,
 10 and along the trenches. During operations at 1301-N LWDF, Sr-90 concentrations at the TS-1 through
 11 TS-12 locations were between 10^4 and 10^5 pCi/g and tended to decrease slightly with distance from the
 12 crib. In the only borehole drilled directly into the 1301-N Crib (199-N-107A), Sr-90 concentration levels
 13 in soils within 2 to 3 ft of the crib bottom ranged between 12,600 to 19,700 pCi/g. At 1325-N LWDF,
 14 operations period measurements of soils near the crib bottom showed Sr-90 concentrations between
 15 10^3 and 10^5 pCi/g. At borehole 199-N-109A (drilled at the edge of the 1325-N Crib), contamination levels
 16 within 2 ft of the trench bottom ranged from 1080 to 1340 pCi/g.

1

2

This page intentionally left blank.

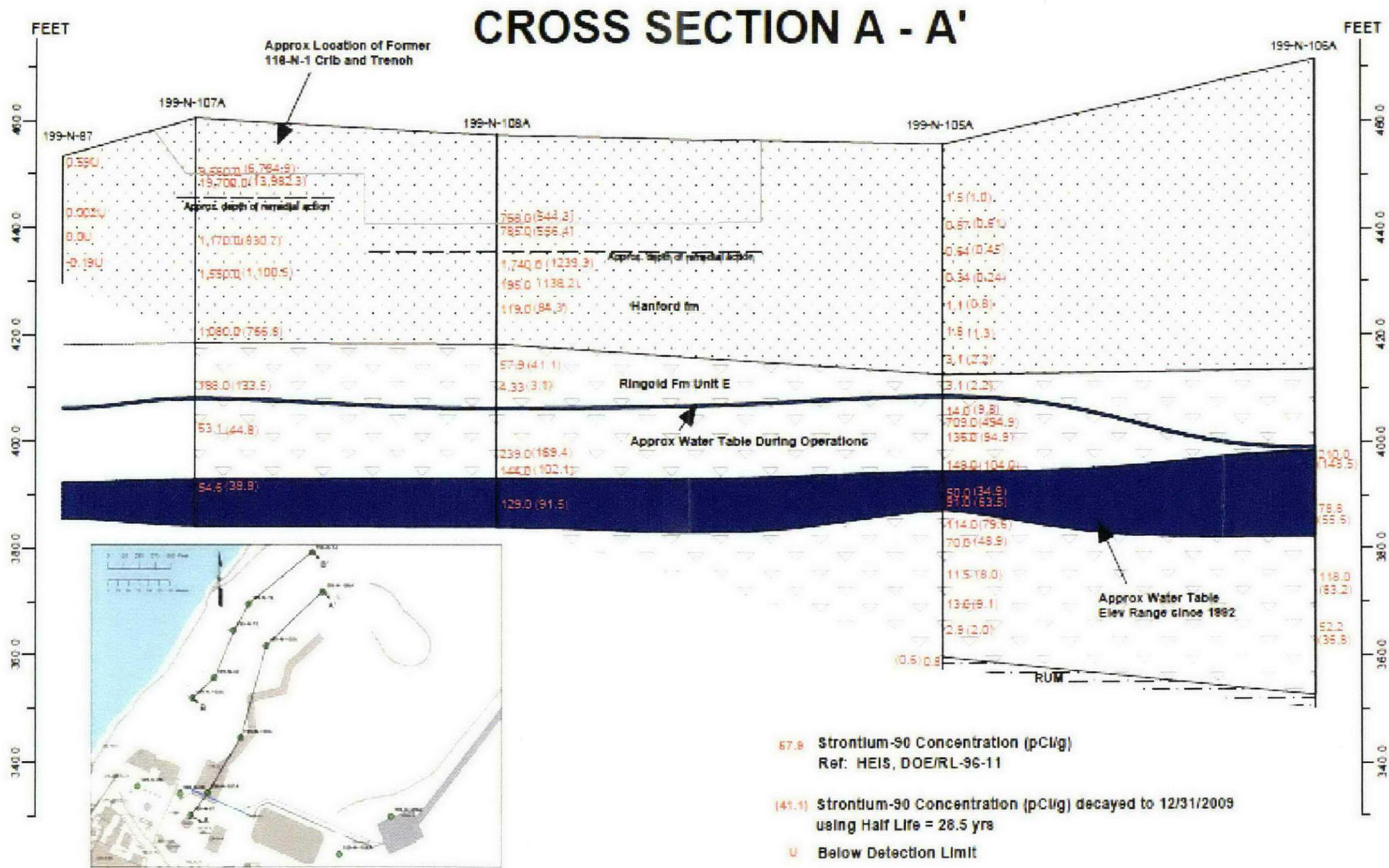


Figure 4-5. Strontium-90 Concentrations with Depth at Five Boreholes along the Long Axis of 1301-N

1
2
3
4

1 This page intentionally left blank.

CROSS SECTION B - B'

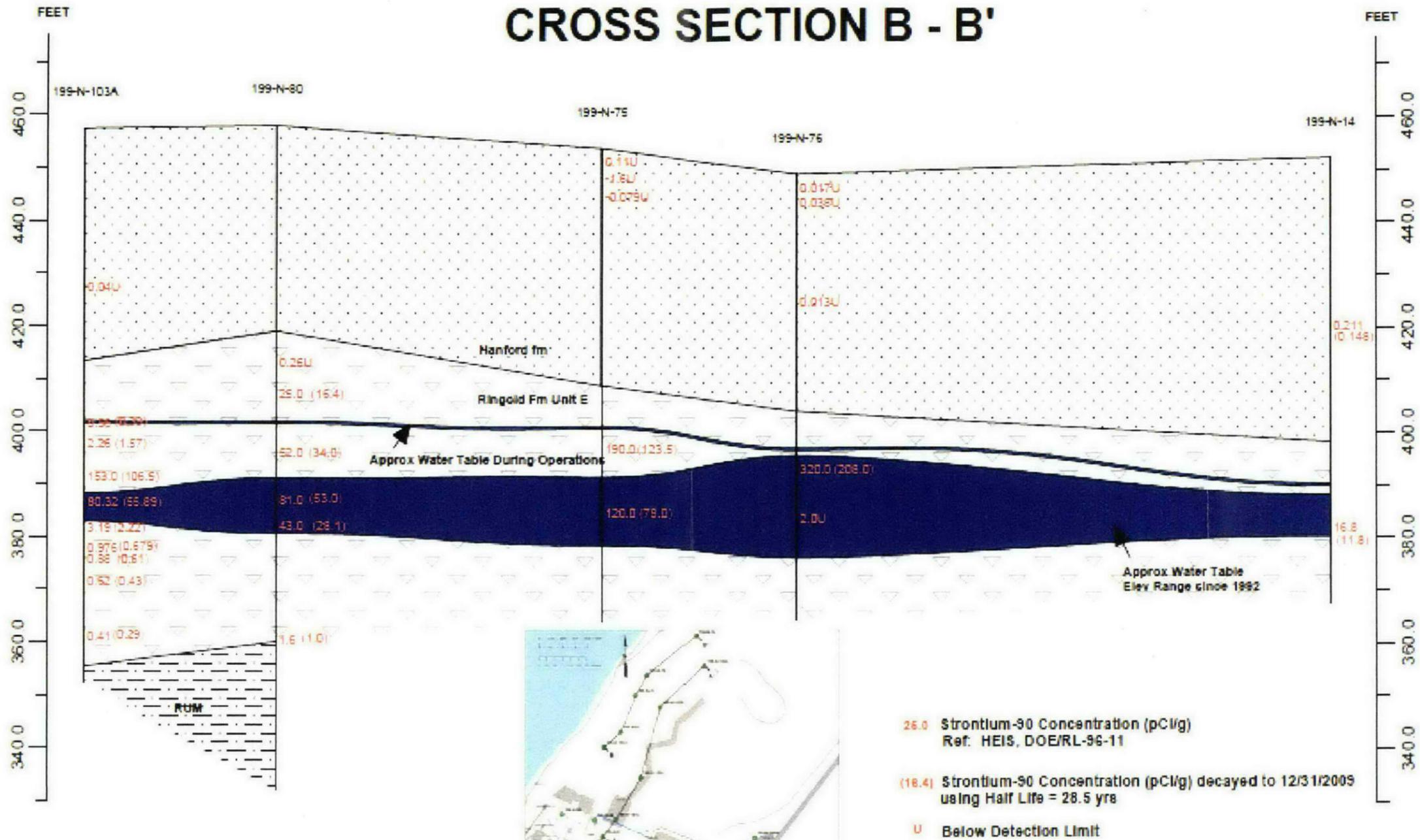


Figure 4-6. Strontium-90 Concentrations with Depth at Five Boreholes Downgradient of 1301-N Liquid Waste Disposal Facility

2
 3
 4

1

2 This page intentionally left blank.

3

1 Second, Sr-90 concentration levels drop at least one order of magnitude within 6.1 m (20 ft) of the points
2 of entry in all directions. This characteristic is best observed in sediment analyses near 1301-N LWDF
3 where more data has been collected. Examination of the data shows that Sr-90 concentrations are
4 consistently present only at borehole 199-N-107A and borehole 199-N-108A in or adjacent to the crib and
5 are less than 2,000 pCi/g at any depth more than 0.6 m (2 ft) below the crib bottom.

6 Third, with distance from the 1301-N Crib, a secondary zone of relatively elevated Sr-90 concentrations
7 occurs near the bottom of the current vadose zone around 122 m (400 ft) above mean sea level (amsl).
8 This zone is coincident with the range of water table depths that have fluctuated underneath 1301-N
9 LWDF because of startup, maintenance, and cessation of discharge to the facility. Wells shown in
10 Figures 4-5 and 4-6 demonstrate this characteristic.

11 The key observations summarized above suggest the following conceptual model for Sr-90 migration
12 through the subsurface, a model that is essentially the same as the one described in previous documents
13 (BHI-00368 and DOE/RL-96-11). Once discharged into the cribs and trenches, Sr-90 migration was
14 retarded at the crib and trench floors to the extent that the majority of released Sr-90 did not migrate
15 farther than a few feet below this depth. For example, in a previous calculation assuming average Sr-90
16 concentration estimates (BHI-00368), a 1 m (3.3 ft) thickness of soil underneath the 1301-N Crib
17 footprint was estimated to contain over 500 Ci of Sr-90, about 25 percent of the total mass released into
18 crib. This estimate could easily be low if bulk density and average Sr-90 were unrealistically low. Recent
19 remediation efforts to remove contaminated soils at 1301-N and 1325-N have removed essentially all of
20 this source term (Section 2.3.1).

21 The high level of Sr-90 capture near the crib and trench floors is assumed due to a combination of
22 chemical and physical processes. Sr-90 is known to be moderately sorptive (e.g., a K_d of 15 ml/g) and
23 sorption reactions no doubt occurred. However, given the extremely high wastewater discharge rates
24 during the reactor operations period, a modest sorption reaction is insufficient to retain the majority of
25 Sr-90 inventory near the crib and trench floor. In two early modeling studies whose purpose was to
26 simulate the Sr-90 migration to N Springs seepage water (WHC-EP-0369 and WHC-SD-ER-TA-001), the
27 authors found it necessary to assign K_d values greater than 1,500 ml/g in the crib/trench floor layer to get
28 relevant retardation estimates and good correlation with N Springs Sr-90 concentration time profiles. The
29 authors concluded that these K_d values were not true indications of chemical behavior but evidence of
30 some type of physical capture such as filtration of Sr-90-bearing particulates. The most obvious
31 mechanism was concluded to be filtration of Sr-90-bearing particulates. The K_d application was therefore
32 a crude and non-realistic, but successful approach for simulating the observed Sr-90 migration rate.
33 Regardless of the real capture mechanisms, no significant lateral movement of Sr-90 movement occurred,
34 although there are indications of substantial wastewater lateral movement (see chromium discussion in
35 the next section).

36 The fraction of Sr-90 that did penetrate below this capture zone proceeded to migrate at a more rapid rate
37 because only the modest normal chemical sorption processes would have retarded Sr-90 transport in this
38 region. Historical sorption experiments on Hanford Site soils (e.g., EPA 520/6-78-007) report K_d values
39 between 10 and 20 ml/g for normal vadose zone conditions (moderate pH values about 8 and moderate
40 levels of dissolved species) with naturally present calcium being the primary competitor for sorption sites.
41 Significant perturbation of natural vadose zone groundwater conditions from interactions with wastewater
42 seems unlikely given the lack of high salt concentrations and extreme pH characteristics in the discharged
43 wastewater. The early modeling transport studies (WHC-EP-0369 and WHC-SD-ER-TA-001) suggest
44 that a moderate K_d value is correct. In these analyses, assumed K_d values of 10 and 15 ml/g resulted in a
45 good match between measured and modeled concentration versus time profiles at N Springs.

1 Given the very high discharge rates during operations and moderate sorption, minimal Sr-90 that
2 penetrated more than a few feet below the crib/trench floor was retained in the portion of the vadose zone
3 present during operations. The lack of measured Sr-90 concentrations in this part of the current vadose
4 zone supports this hypothesis. The only small deviation from this general observation occurs at well
5 locations drilled very close to the initial point of wastewater discharge (e.g., wells 199-N-107A and
6 199-N-109A) where the most concentrated Sr-90 releases would have occurred. Even at these locations,
7 the drop off in Sr-90 concentration is rapid (see Sr-90 information in well 199-N-107A in Figure 4-5) and
8 the total inventory is therefore small. The presence of relatively elevated Sr-90 concentrations at the
9 bottom of the current vadose zone, but within the range of historical water table elevations, is indicative
10 of Sr-90 that reached the unconfined aquifer during operations. It remained in the current vadose zone
11 because the combination of retarded migration, due to sorption, and the rapid drop in the water table
12 underneath 1301-N and 1325-N following the end of operations slowed the migration rate.

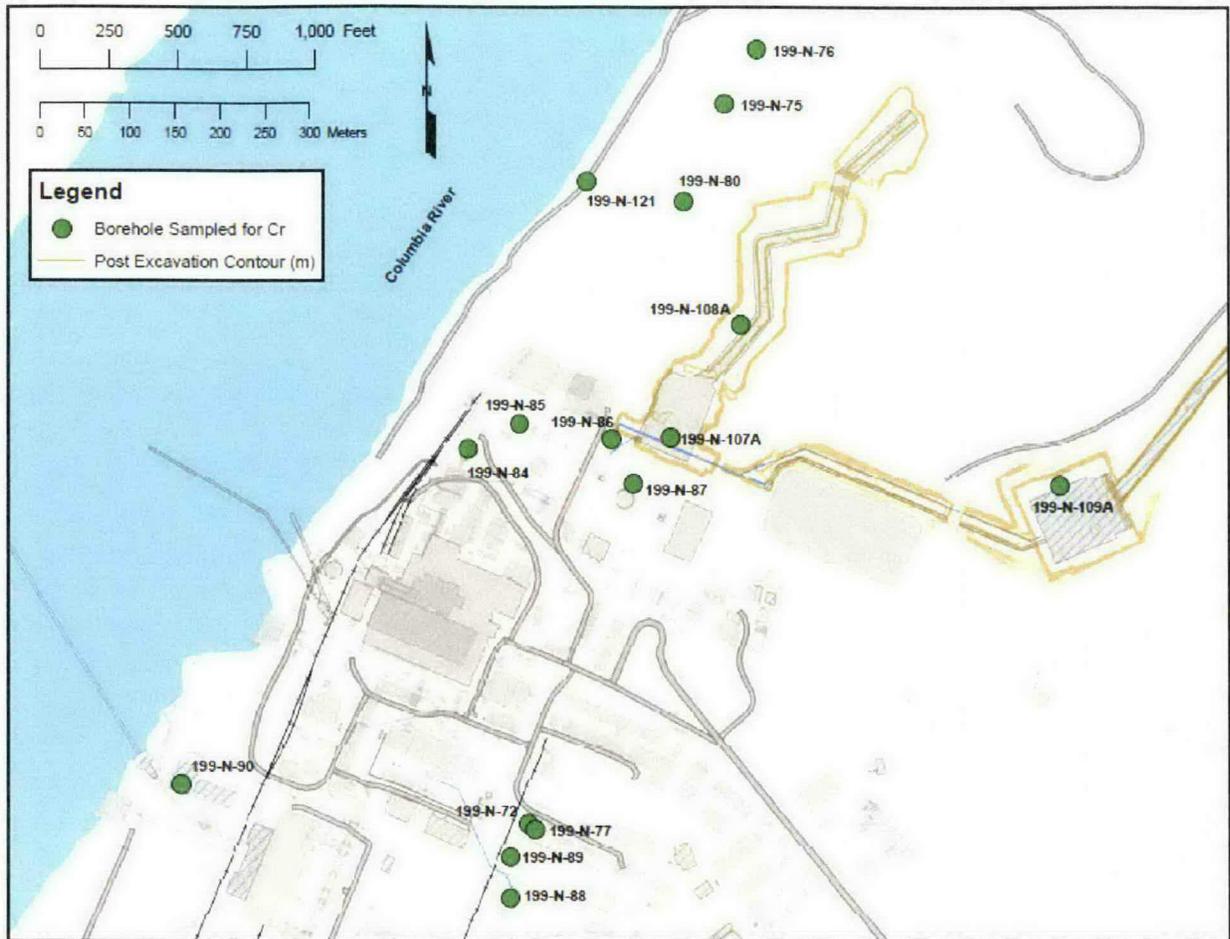
13 **4.2.2 Petroleum Product Migration and Distribution in the Vadose Zone**

14 Migration of petroleum products through the vadose zone is inferred from vadose zone data collected at
15 one well, 199-N-85, drilled to evaluate the subsurface contamination caused by the diesel fuel line leak
16 302,833 L (80,000 gal) on the west side of the 166-N Tank Farm in 1966. Characterization well 199-N-85
17 is located a few feet from the leak location. Ten samples were taken that covered the vadose zone
18 between 4.6 and 22.5 m (15 and 74 ft) bgs. A suite of VOCs and SVOCs was measured (DOE/RL-93-80)
19 that are considered species present in diesel fuel or degradation products (e.g., xylene, anthracene,
20 2-Methylnaphthalene). These contaminants were found between 18 and 22.5 m (59 and 74 ft) bgs.

21 Despite the limited nature of this database, several observations suggest minimal leaked petroleum
22 product remains in the vadose zone. First, while these samples were in the vadose zone at the time of
23 sampling in the early 1990s, they would have been at the top of the unconfined aquifer shortly after the
24 leak event because of the groundwater mounds established by wastewater discharges from
25 1301-N LWDF. Extrapolation of estimated water table elevation contours (see Section 4.4.1) suggests an
26 elevation of 16.8 to 17 m (55 to 56 ft) bgs in the mid 1960s. Second, the well's proximity to the leak
27 location would make it the most likely to show vadose zone contamination if present. Third, petroleum
28 products likely migrated through the vadose zone as a non-aqueous phase liquid (NAPL) that did not react
29 chemically with vadose zone sediments, as indicated by current groundwater sample data showing at least
30 some of the petroleum product is still a NAPL (see Section 4.3.3). The highly permeable (primarily sandy
31 gravel) and thin vadose zone would have facilitated rapid migration and little dissolution.

32 **4.2.3 Chromium Migration and Distribution in the Vadose Zone**

33 Migration of chromium through, and its current distribution within, the vadose zone has been strongly
34 influenced by the recharge history through 1309-N and 1325-N LWDFs, and slightly influenced by its
35 interaction with vadose zone sediments. The primary data set indicates the nature of chromium migration
36 in the vadose zone is the suite of soil characterization data collected prior to and during remediation.
37 As with Sr-90, soil sampling locations (Figure 4-7) have been concentrated near 1301-N and
38 1325-N LWDFs, along the river shore downgradient of the LWDFs, and in the intermediate zone between
39 1301-N LWDF and the shore.



1
2
3
**Figure 4-7. Subsurface Sampling Locations for Sediments Contaminated
with Chromium at 100-N Area**

4 From these data, two key characteristics are notable and illustrated in Figures 4-8 and 4-9. These figures
5 are similar to Figures 4-5 and 4-6, showing chromium contamination as a function of depth at various
6 well locations. As before, sampling locations are shown in the context of subsurface stratigraphy and
7 water table history. First, the highest chromium concentrations (46 and 58 mg/kg) occur at well
8 199-N-107A at the interface between the 1301-N Crib floor and the vadose zone. Sediment total
9 chromium concentrations decrease away from this location and the reductions at distant locations are
10 generally within factors of two to ten. However, concentration reductions show no consistent decrease
11 with distance either vertically or horizontally. Second, the collected data samples provide no indication of
12 a well-defined volume of vadose zone chromium contamination in the sense that chromium is present at
13 elevated levels at all available sample locations and is found throughout the vadose zone.

14 Higher chromium levels were also measured in vadose sediments collected underneath and around the
15 1324-NA Percolation Pond and 1324-N Surface Impoundment at Wells 199-N-72, 199-N-77, 199-N-88
16 and 199-N-89 (Figure 4-7). Elevated chromium concentrations ranged between 10 and 15 mg/kg, and
17 higher concentrations were found near the surface and near the bottom of the vadose zone in some of the
18 boreholes. The occurrence of these higher concentrations appears related to facility use, primarily
19 neutralization of acidic and caustic fluids from the 163-N Demineralization Plant. Given that the
20 1324-NA Percolation Pond was unlined, some of the relatively extreme pH solutions could have entered
21 the vadose zone before complete neutralization, and dissolved natural chromium. If so, transport deeper

1 into the vadose zone and entry into the unconfined aquifer is plausible. Another possibility is that
2 chromium contamination could have been present in the effluents as trace contamination. Given the high
3 discharge rates of about 605,600 L/day (160,000 gal/day) (DOE/RL-80-63) at the 1324-N/1324-NA
4 Area, total inventory loss could have been environmentally significant, although unlikely to approach the
5 sodium dichromate inventory used deliberately for corrosion control.

6 The key observations summarized above suggest the following conceptual model for chromium migration
7 through the vadose zone. Historical record indicates chromium was discharged to the 1301-N LWDF, but
8 not 1325-N LWDF. Once discharged into the 1301-N Crib and 1301-N Trench, chromium migration was
9 slightly retarded at the crib and trench floors. Consequently, a small fraction of the total chromium mass
10 received by 1301-N was retained at the near surface. A rough calculation of the chromium content at the
11 1301-N Crib, assuming the 199-N-107A concentrations of about 50 mg/kg distributed over a 1-m (3.3-ft)
12 thick layer underneath the 1301-N Crib, produces a total chromium mass of no more than a few thousand
13 kilograms of chromium. This mass represents a few percent of the estimated total mass discharge of over
14 100,000 kg (220,462 lb) (Table 4-1).

15 The lack of chromium retardation is consistent with observations of rapid chromium migration rates at
16 other 100 Area locations where widespread chromium contamination in the unconfined aquifer is present,
17 particularly in the 100-D and 100-K Areas. The extensive chromium aquifer contamination at 100-D and
18 100-K Areas is attributed to large-scale wastewater discharges similar to those at 1301-N and 1325-N
19 LWDFs (e.g., the 116-K-2 trench received approximately 300 billion liters of wastewater containing
20 chromium over a 16-year period).

21 The small fraction of initial chromium inventory near the 1301-N floor/vadose zone interface has
22 probably remained because of a combination of physical entrapment processes (e.g., particulate filtration)
23 and various chemical reactions. Studies of chromium interactions with subsurface soils at other 100 Area
24 sites are applicable to this site and provide insight into the mechanisms that control chromium migration.
25 For example, sediments were collected from underneath the 116-D-7 and 116-H-7 Retention Basins as
26 part of remediation field studies and leached (CVP-99-00007 and CVP-2000-00027). These sediments had
27 been thoroughly leached by chronic leaks from the basins for more than 10 years, and laboratory leaching
28 studies were able to remove less than 1 percent of the remaining chromium present in the collected
29 sediments. This observation leads to the conclusion that the remaining chromium in the soil was leach
30 resistant because of chemically binding reactions.

31 A more detailed leaching and characterization study was completed using near surface soils (less than
32 3 m) (less than 10 ft) bgs collected near sodium dichromate storage tanks and railroad tracks in the
33 100 BC Area (PNNL-17674). In this study, two types of leaching behavior were observed. First, large
34 fractions of the CrVI in the contaminated soil were eluted in the first pore volume (about 65 percent) and
35 about 4 percent of the initial mass was released in the next five pore volumes. The remaining CrVI
36 leached much more slowly and at the end of the experiment (after exposure to 25 pore volumes) between
37 10 and 30 percent of the CrVI remained in the contaminated soils. Microscale characterization of the
38 sediments suggested that leach resistant CrVI may be precipitated in a barium chromate phase and/or
39 incorporated in alumino-silicates and/or iron-rich alumino-silicates. Association of chromium with iron
40 bearing minerals also suggests localized reduction of chromium (VI) to chromium (III) by iron (II).

41

42

1

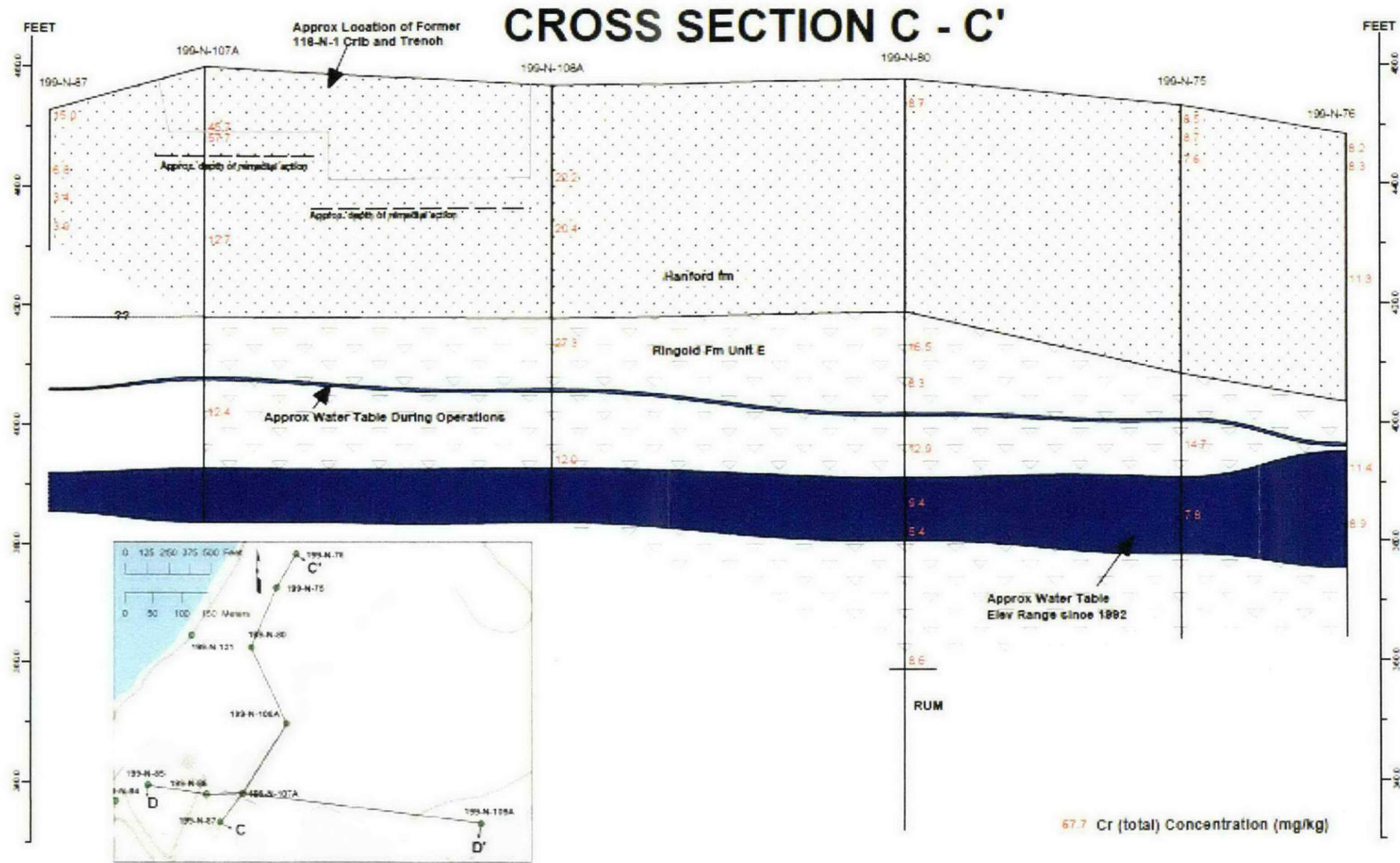


Figure 4-8. Total Chromium Concentrations with Depth at Five Boreholes along the Long Axis of 1301-N Liquid Waste Disposal Facility

2

3

4

5

1 . This page intentionally left blank.

2

CROSS SECTION D - D'

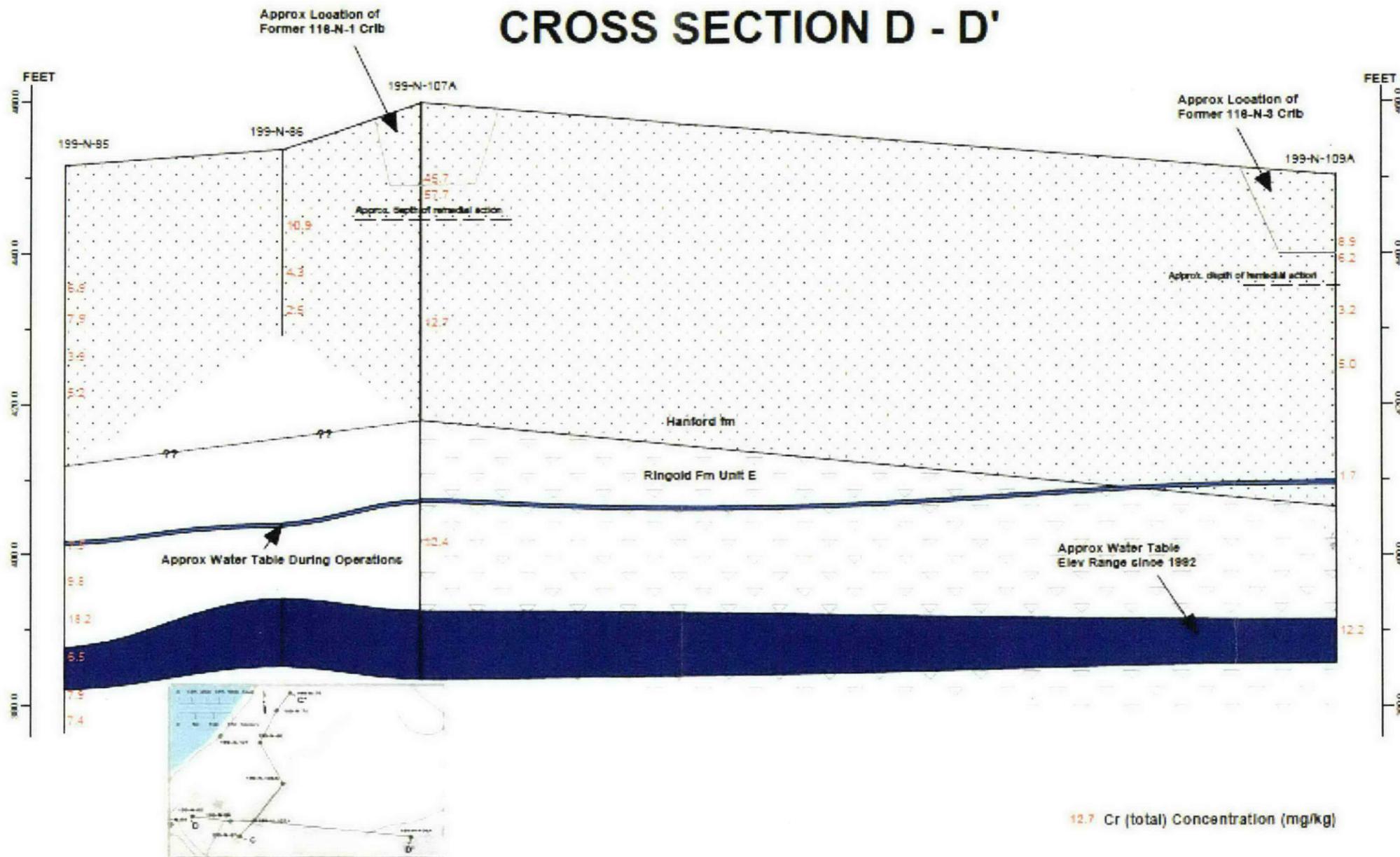


Figure 4-9. Total Chromium Concentrations with Depth at Three Boreholes through the 1301-N and 1325-N Cribs and Perpendicular to the Long Axis of 1301-N and 1325-N Liquid Waste Disposal Facilities

3
 4
 5

1

2 This page intentionally left blank.

3

1 Considered collectively, these experimental results suggest that after CrVI is discharged to the soil
2 column, two primary phases of chromium reactivity occur that influence its transport characteristics. First,
3 the majority of CrVI remains mobile and transports readily through the vadose zone. Second, the
4 remaining CrVI is fixed by a variety of mechanisms that retard further migration rates and reduce
5 groundwater concentrations. The effectiveness of these processes increase over time. In the retention
6 basin soils (CVP-99-00007 and CVP-2000-00027), it appears the initial highly mobile component of
7 discharged CrVI had already been flushed from the sampled soils because of repeated leaching from
8 chronic leakage. This situation is analogous to 1301-N LWDF conditions where even more extensive
9 exposure to wastewater throughout occurred. The effectiveness of chromium leaching would have been
10 enhanced by the more than 10 years of leaching by chromium-free wastewater discharged into
11 1301-N LWDF after sodium dichromate used was discontinued at the N Reactor (105-N) in the
12 early 1970s.

13 Once chromium penetrated deeper into the vadose zone, physical entrapment processes would have been
14 insignificant, but the same chemical reactions would continue, allowing the majority of chromium to
15 move with wastewater and a small fraction to be sequestered by the chemical reactions discussed above.
16 Given the high solubility of most chromium and its limited point of entry into the vadose zone under the
17 1301-N LWDF footprint, its apparent widespread but sporadic presence in the vadose zone (Figures 4-8
18 and 4-9) suggests some lateral migration of wastewater in the vadose zone. This lateral spreading is
19 attributed to the inability of the soil column to process the high volume discharge efficiently. The
20 potential for surface overflow was a matter of concern during the operations period, requiring
21 construction and use of discharge facilities with expanded capacity, beginning in 1964 with the
22 construction and use of the 1301-N Crib followed by the 1301-N Trench (1965), the 1325-N Crib (1983)
23 and the 1325-N Trench (1985). The lateral movement of discharge water apparently began near the
24 crib/trench floor depth given the existence of chromium contamination at depths of about 3 m (10 ft) bgs
25 at various well locations (e.g., at Well 199-N-109A at the side of the 1325-N Crib). Assuming this
26 chromium emanated from 1301-N, lateral migration extended at least 500 m (1,640 ft) inland.

27 Currently, total chromium appears widespread in the vadose zone at low concentrations. Near surface
28 chromium (e.g., underneath 1301-N and 1325-N LWDFs) has been removed while deeper contamination
29 remains. Because of the extensive wastewater discharge history, ample soil washing has occurred, leaving
30 behind only the chromium strongly bound to the soil by various reactions. This characteristic, along with
31 reduced recharge rates, apparently limits the chromium migration within the vadose zone and provides a
32 source term to the unconfined aquifer insufficient to generate or sustain chromium concentrations above
33 acceptable levels.

34 **4.2.4 Tritium and Nitrate Migration and Distribution in the Vadose Zone**

35 Both tritium and nitrate are essentially nonreactive with subsurface sediments. Therefore, the tritium in
36 the 1301-N and 1325-N LWDFs wastewater migrated quickly through the vadose zone with no residuals
37 in the vadose zone. Because the source of nitrate is unknown, its migration rate and remaining vadose
38 zone contamination cannot be determined. However, the generally high recharge rates in the 100-N Area
39 imposed by the 1301-N and 1325-N LWDFs, combined with a highly permeable and relatively thin
40 vadose zone, suggests nitrate has been essentially flushed from the vadose zone.

41 **4.3 Contaminant Migration and Distribution in the Unconfined Aquifer**

42 Following contaminant migration through the vadose zone, discharge into the unconfined aquifer
43 commenced. The rate of migration and subsequent distribution within the unconfined aquifer was
44 dependent on several dominant factors including the recharge history, the contaminant-specific reactivity
45 with unconfined aquifer soils, and the physical properties of unconfined aquifer stratigraphy

1 (e.g., thickness and permeability). At the 100-N Area, critical characteristics were the perturbation to the
2 nature hydrologic system imposed by the long-term high volume discharges through the 1301-N and
3 1325-N LWDFs, an unconfined aquifer stratigraphy composed largely of the Ringold E Formation and
4 bounded by the RUM unit, and contaminant reactivity ranging from essentially inert to highly reactive.

5 Given the importance of the evolution of groundwater flow in the unconfined aquifer at the
6 100-N Decision Unit for all contaminants, This Chapter addresses this topic. In subsequent sections, the
7 unconfined aquifer data for Sr-90, sodium dichromate, and petroleum are described and interpreted in the
8 context of the dominant environmental characteristics described above.

9 **4.3.1 Summary of Groundwater Flow History**

10 Prior to the startup of 100-N Area operations, the unconfined aquifer properties are presumed to have
11 been essentially the same as pre Hanford Site conditions. Although very little data are available to
12 quantify those conditions, a well accepted hypothesis is that pre Hanford Site conditions are generally
13 similar to those being observed currently, and that groundwater flow is generally to the north-northwest
14 under a low hydraulic gradient, primarily in the Ringold E Formation unit. In addition, daily, weekly, and
15 seasonal changes in river elevations caused water table fluctuations throughout the 100-N Area. At peak
16 river stage levels in midsummer, hydraulic gradients were reversed and river water flowed inland.

17 The startup of reactor operations and simultaneous initiation of high volume discharges to the
18 1301-N Crib in 1963 quickly created a groundwater mound underneath the crib. In Well 699-86-60,
19 located approximately 200 m (656 ft) southeast of the 1301-N Crib, the water table rose about 4 m (13 ft)
20 between early 1964 and late 1966 (Figure 4-10). The majority of the water table rise occurred in the first 6
21 months of operation and reflects the rapid vertical migration rates imposed by high volume discharges.
22 The rapidity of mound formation was also facilitated by highly permeable vadose zone sediments (sandy
23 gravels primarily) and a moderate vadose zone thickness of about 21.3 m (70 ft). A map view of the
24 groundwater mound underneath 1301 is shown in Figure 4-11 as it existed in 1965; during this time water
25 flowed in all directions away from the mound center.

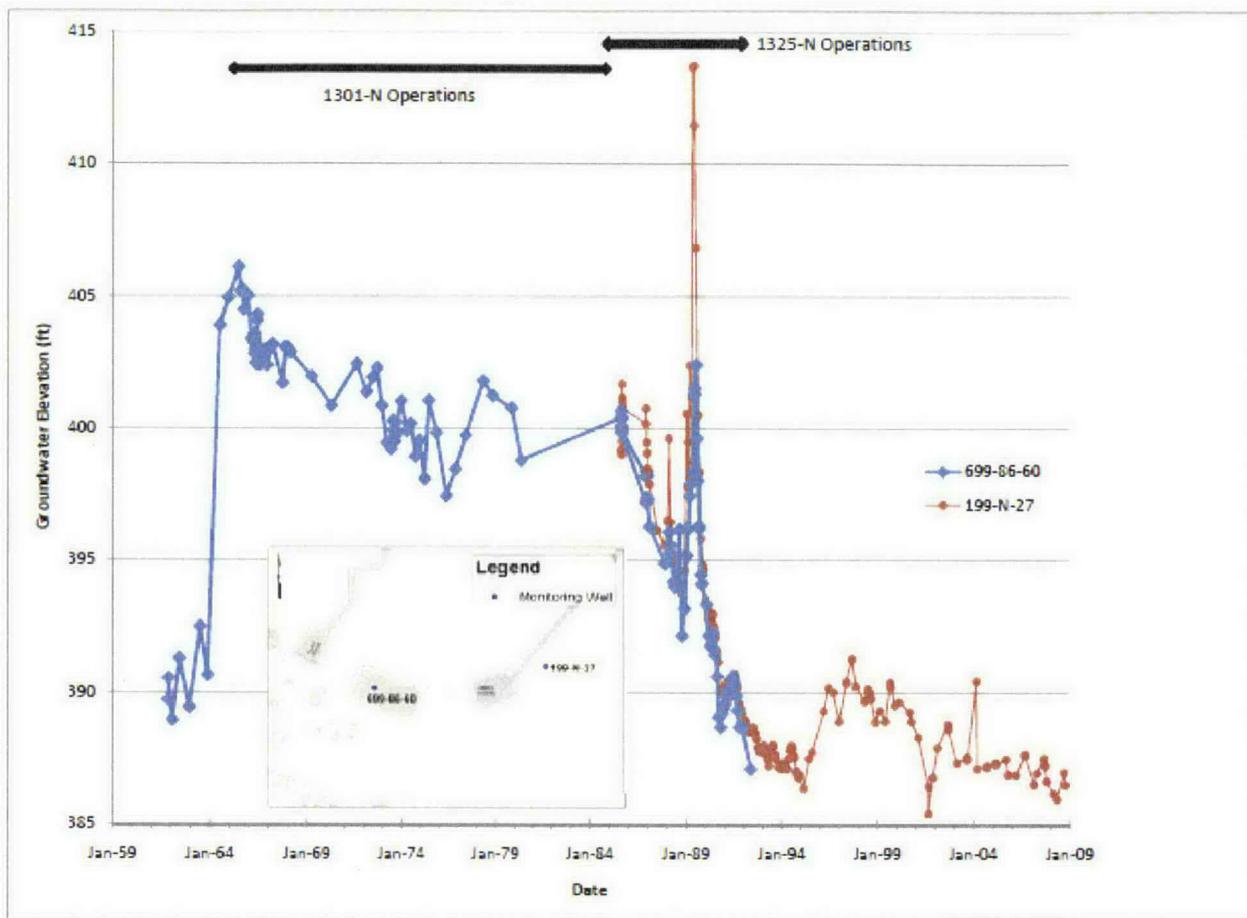
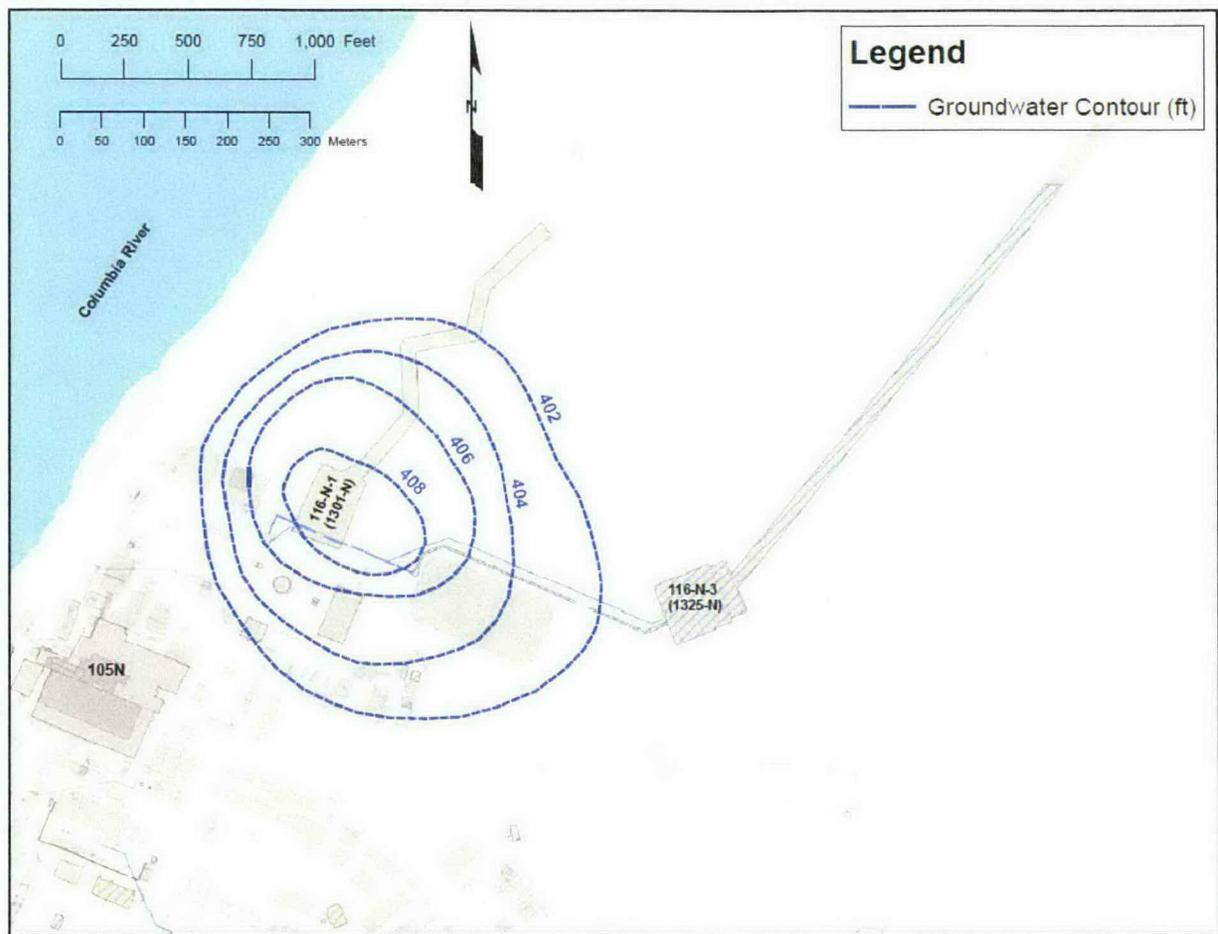


Figure 4-10. Water Table Elevations at Wells near 1301-N and 1325-N Liquid Waste Disposal Facilities

1
2
3
4



1
 2 **Figure 4-11. Water Table Mound Associated with 1301-N Crib and Trench – July 1965;**
 3 **Reproduced from DOE/RL-90-22 Draft B**

4 This groundwater mound was maintained into the mid 1980s when wastewater discharges transitioned
 5 from the 1301-N LWDF to the 1325-N LWDF between 1983 and 1985. Over this time period, the
 6 groundwater mound under the 1301-N LWDF dissipated and the water table began to rise under the
 7 1325-N LWDF. The extent of the groundwater mound that formed under 1325-N is not well bounded, but
 8 the available data suggest it was most pronounced in 1985 and lasted into 1989. The mounding effects are
 9 inferred from the comparison of head data at Well 199-N-32 west of 1325-N versus Well 199-N-52 east
 10 of 1325-N LWDF (Figure 4-12). During the period of high volume discharges, water table elevations
 11 were higher at well 199-N-32 because it was nearer to the discharge point. About 1990, when high
 12 volume discharges ceased, relative water table elevations reversed and were higher at Well 199-N-52
 13 because it is upgradient of Well 199-N-32 in the natural unperturbed flow regime.

14 Despite the continued discharges into the 1325-N LWDF, a general decline in water table elevation began
 15 at the end of 1985 and continued thereafter with the exception of a response to some undocumented
 16 discharge event that occurred in 1989 causing the spike shown in Figures 4-10 and 4-12. This gradual
 17 decline was due to a combination of two factors, discharge at a greater distance from the river and
 18 decreasing annual discharge volumes after 1985. By 1991, the natural flow condition was essentially
 19 restored (Figure 4-13).

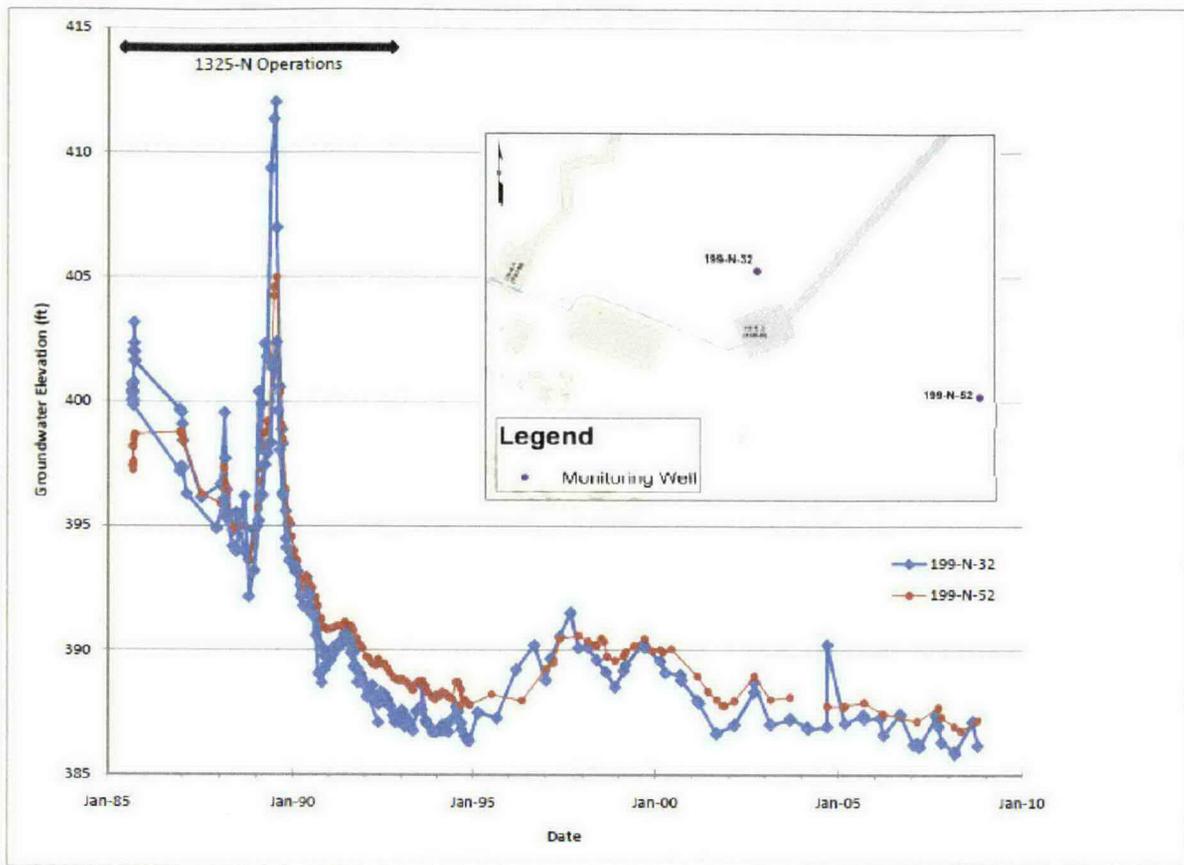


Figure 4-12. Comparison of Water Table Elevations over Time at Groundwater Monitoring Wells near 1325-N Liquid Waste Disposal Facility (Wells 199-N-32 and 199-N-52)

1
2
3
4
5

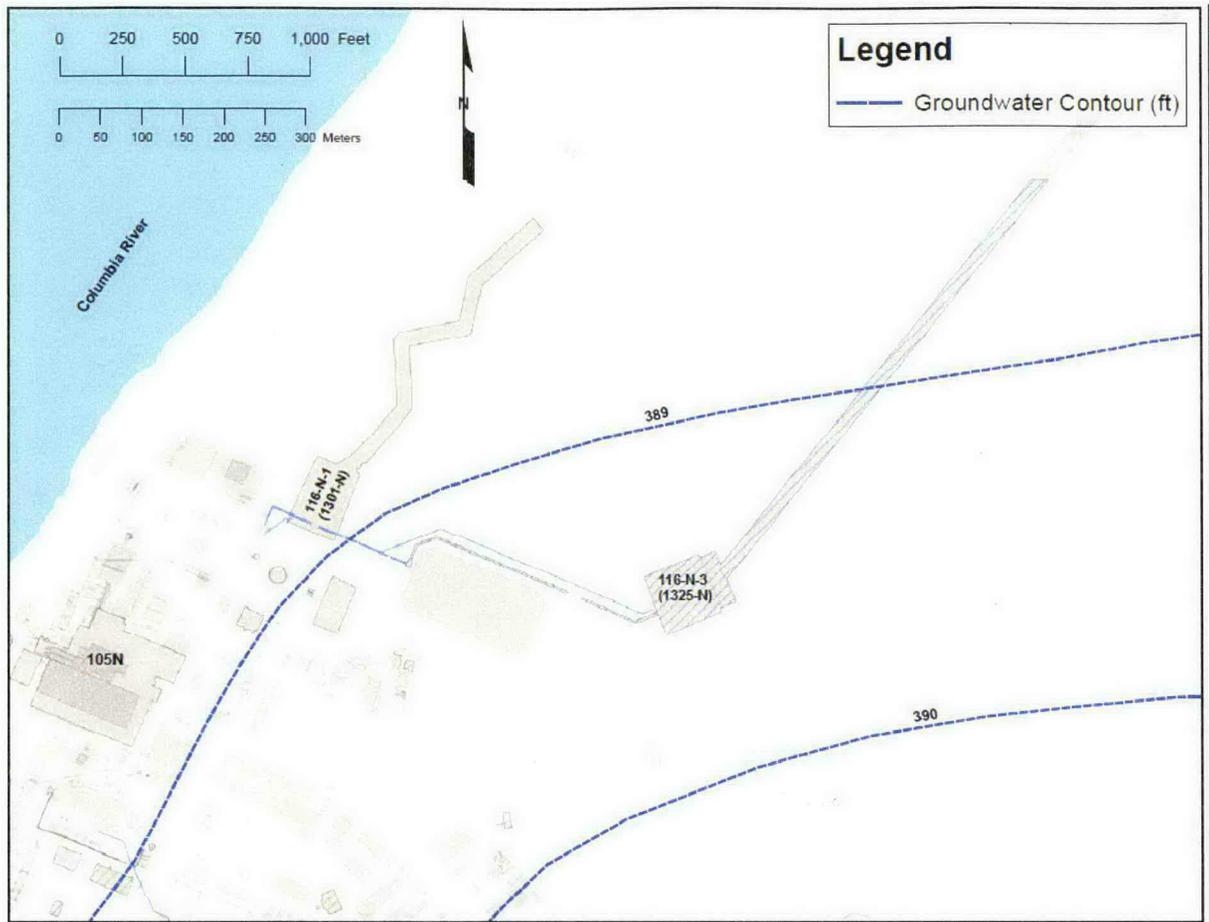


Figure 4-13. Current Water Table Elevations – 100-N Decision Unit – 2009

1
2

3 River stage fluctuations and associated changes in groundwater fluxes at the shoreline occur continuously
 4 and have occurred throughout the period pertinent to this discussion. The jagged profiles in water table
 5 elevations shown in 100-N Decision Unit monitoring wells (e.g., 699-86-60 and 199-N-27 in Figure 4-10)
 6 after cessation of operations illustrate this phenomenon. Water table changes on a larger scale are shown
 7 in Figure 4-13 where water table conditions are shown at high and low river stage in 1995. These changes
 8 occur because the weight of the water column in the river provides an opposing hydraulic pressure to that
 9 provided by recharge into the unconfined aquifer. While aquifer recharge provides a relative constant
 10 hydraulic pressure, river stage changes apply variable degrees of opposing pressure, thereby changing the
 11 net flux almost continuously.

12 At maximum river stage in midsummer, the water table elevates over the entire 100-N Area and net water
 13 flux is inland (Figure 4-14a). Conversely, at minimum river stage, the water table drops and net flux is
 14 into the Columbia River (Figure 4-14b). A comparison of water table contours in Figure 4-13 shows that
 15 inland flow is not uniform because of variable permeability in the rewetted vadose zone, which is
 16 composed of different lenses, with different particle size distributions. Examination of these differing
 17 water table contours shows an oscillation of primary groundwater flow direction occurs annually because
 18 of seasonal changes in river elevations. Flow direction downgradient of 1301-N ranges from
 19 northerly to almost northerly.

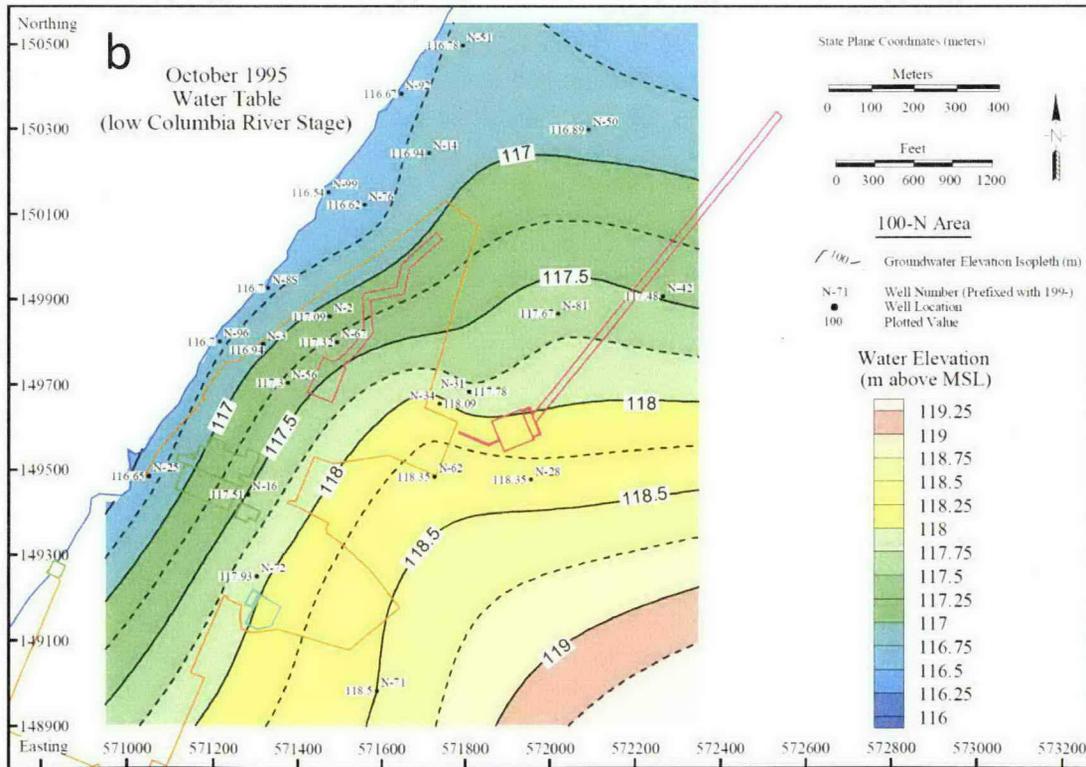
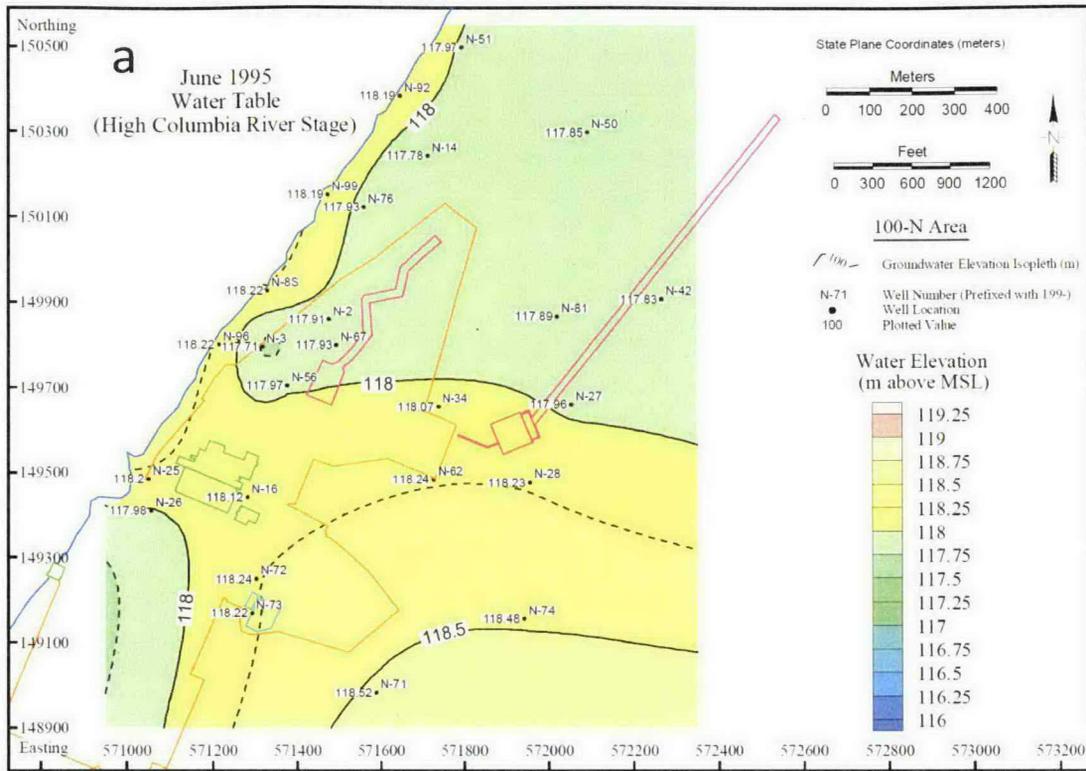


Figure 4-14. 100-N Area Water Table Map for June and October 1995 (Hydrogeologic, 1999)

1
 2
 3

1 Regional changes in water table elevations occurred seasonally during the reactor operations period as
2 indicated by measured water table fluctuations in monitoring during that time. However, well data are too
3 sparse to indicate the specific changes in these contours to allow comparison with post operations
4 characteristics shown in Figure 4-13. However, the additional hydraulic head (energy) imposed by the
5 1301-N and 1325-N LWDFs discharges greatly increased the aquifer gradient and would have caused
6 increased flux into the river. It is reasonable to assume the general direction of preferential flow during
7 inland flux was maintained to some degree. A geophysical investigation (*Investigation of Preferential*
8 *Groundwater Flow Pathways in the 100-NR-2 Area Hanford Site*) was conducted by the Confederated
9 Tribes of the Umatilla Indian Reservation for the U.S. DOE during June 2006, yielded results that
10 compare favorably with the June water table map (Figure 4-14a). The preferential groundwater pathway
11 was identified in the same general area.

12 **4.3.2 Strontium-90 Migration and Distribution in the Unconfined Aquifer**

13 The majority of Sr-90 that entered the unconfined aquifer originated in the 1301-N LWDF and probably
14 from the early releases, particularly prior to 1970 when approximately one-third the total inventory
15 (about 1,100 Ci) was discharged. This hypothesis is supported by the combination of discharge rate
16 history and Sr-90 concentration levels measurements over time in monitoring wells.

17 The time at which initial fluxes of Sr-90 from the 1301-N LWDF into the unconfined aquifer began is not
18 known because of insufficient monitoring data. A rough approximation can be derived from monitoring
19 data around 1325-N LWDF where more data were collected and discharge rates were similar although
20 smaller and shorter in duration. At 1325-N LWDF, about two-thirds of the Sr-90 in wastewater was
21 discharged between 1983 and 1985 (Table 4-1). Strontium-90 measurements at monitoring
22 Well 199-N-36, at the edge of the 1325-N Crib, shows a steady rise in Sr-90 concentrations beginning in
23 early 1987 and peaking in late 1988 and perhaps beyond. These data suggest a travel time of about 5 years
24 in the vadose zone for the majority of mobile Sr-90. The comparison with 1301-N LWDF migration
25 characteristics is only approximate because the retarding processes at the crib/vadose zone interface were
26 not necessarily the same and lower discharge rates occurred at the 1325-N LWDF. Nevertheless, an
27 estimate of a few years for significant entry into the unconfined aquifer is reasonable.

28 Assuming the beginning of major releases into the unconfined aquifer around 1970, transport through the
29 unconfined aquifer was largely controlled by the groundwater mound under the 1301-N LWDF that was
30 fully established by then. This condition accelerated migration rates compared to unperturbed conditions,
31 and spread contamination in all directions although preferential distribution is clearly indicated by soil
32 and groundwater sampling data.

33 Because of these discharges, Sr-90 appeared at the N springs (seepage locations that developed along the
34 riverbank because of crib discharges) and routine monitoring practices tracked changes in concentration
35 levels, which were documented in annual effluent release reports. The first reported Sr-90 contamination
36 measurements were reported in 1973 (UNI-158) as an annual average value of periodic measurements
37 taken at several shoreline locations. The average concentration rose steadily through 1988 (Figure 4-15)
38 and are interpreted as indicators of the leading edge of the Sr-90 plume migrating through the unconfined
39 aquifer during the operations period. The annual inventory flux into the Columbia River during this time
40 was simply estimated as the product of half the annual discharge volume to the cribs and the average
41 concentration. Using these assumptions a cumulative loss of 45 Ci, between 1973 and 1990, was
42 estimated. This estimate may be substantially in error because it did not take into account the influence of
43 river stage fluctuations on contaminant migration and the Sr-90 releases further inland beginning in 1983.

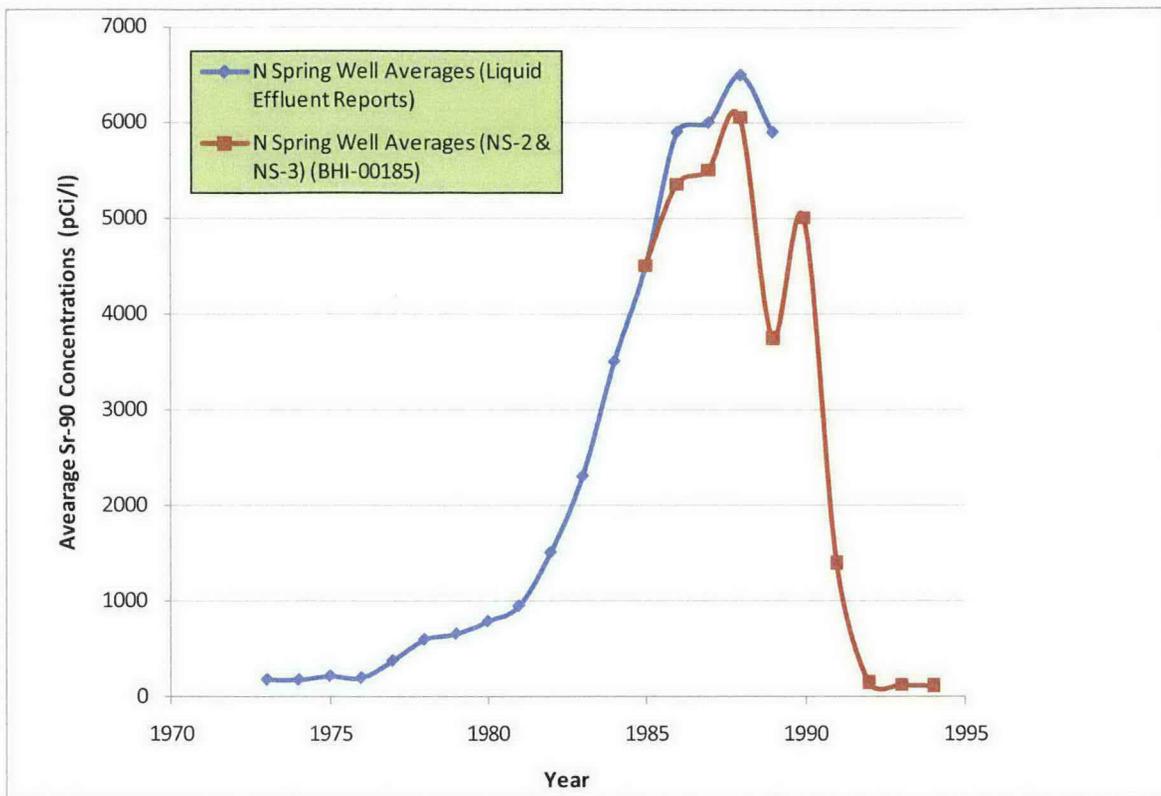


Figure 4-15. Measured Annual Average Strontium-90 Concentrations at N-Springs (pCi/L) and Estimate Inventory Flux into the Columbia River

1
 2
 3
 4 When high volume discharges to the 1325-N LWDF were terminated in 1990, Sr-90 migration through
 5 the unconfined aquifer slowed substantially. For example, Figure 4-15 shows a nearly five-fold decrease
 6 in the average Sr-90 concentration at the river shore between 1990 and 1991, illustrating transport rates
 7 from upgradient sources were no longer sufficient to increase or maintain shoreline concentration levels.
 8 This hypothesis is supported by groundwater data collected since then in the 100- N Area. Generally, the
 9 data downgradient of the 1301-N LWDF show very little change in plume concentration contours,
 10 suggesting minimal Sr-90 migration since the early 1990s. For example, Figure 4-16 shows Sr-90
 11 concentrations and head data at two wells that bound the extent of high Sr-90 distribution in the
 12 subsurface (i.e., well 199-N-67 30 m north of 1301-N Crib and well 199-N-14 north of 1301-N Trench
 13 [Figure 4-1]). In both wells Sr-90 concentrations vary over a small range, particularly after 1992, and the
 14 average value changes very little. The current regional Sr-90 distribution in the unconfined aquifer is
 15 shown in Figure 4-17.

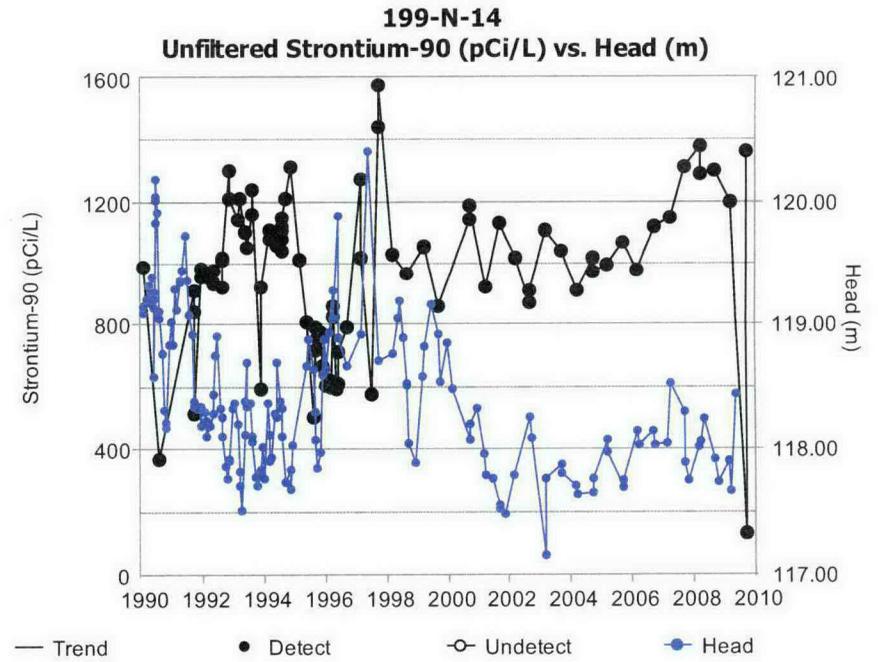
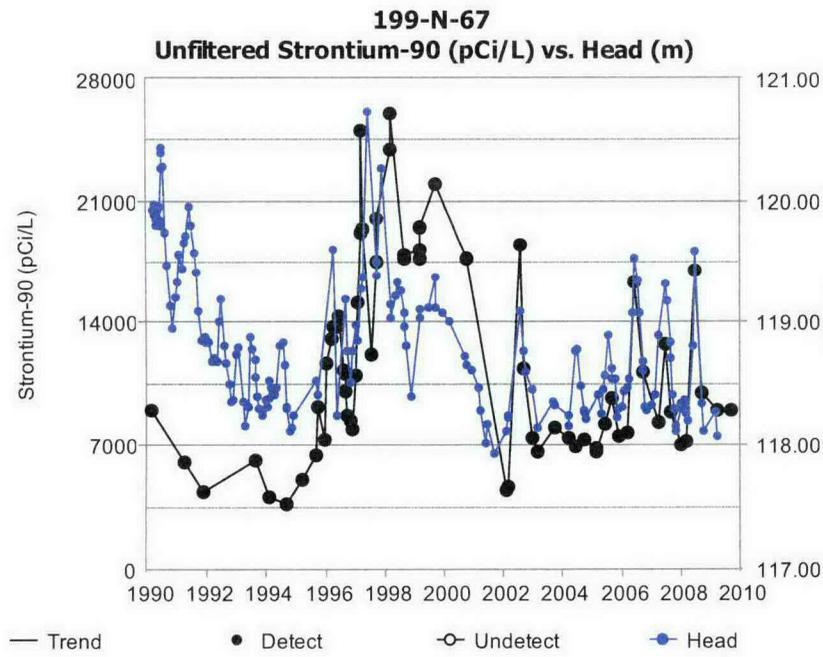
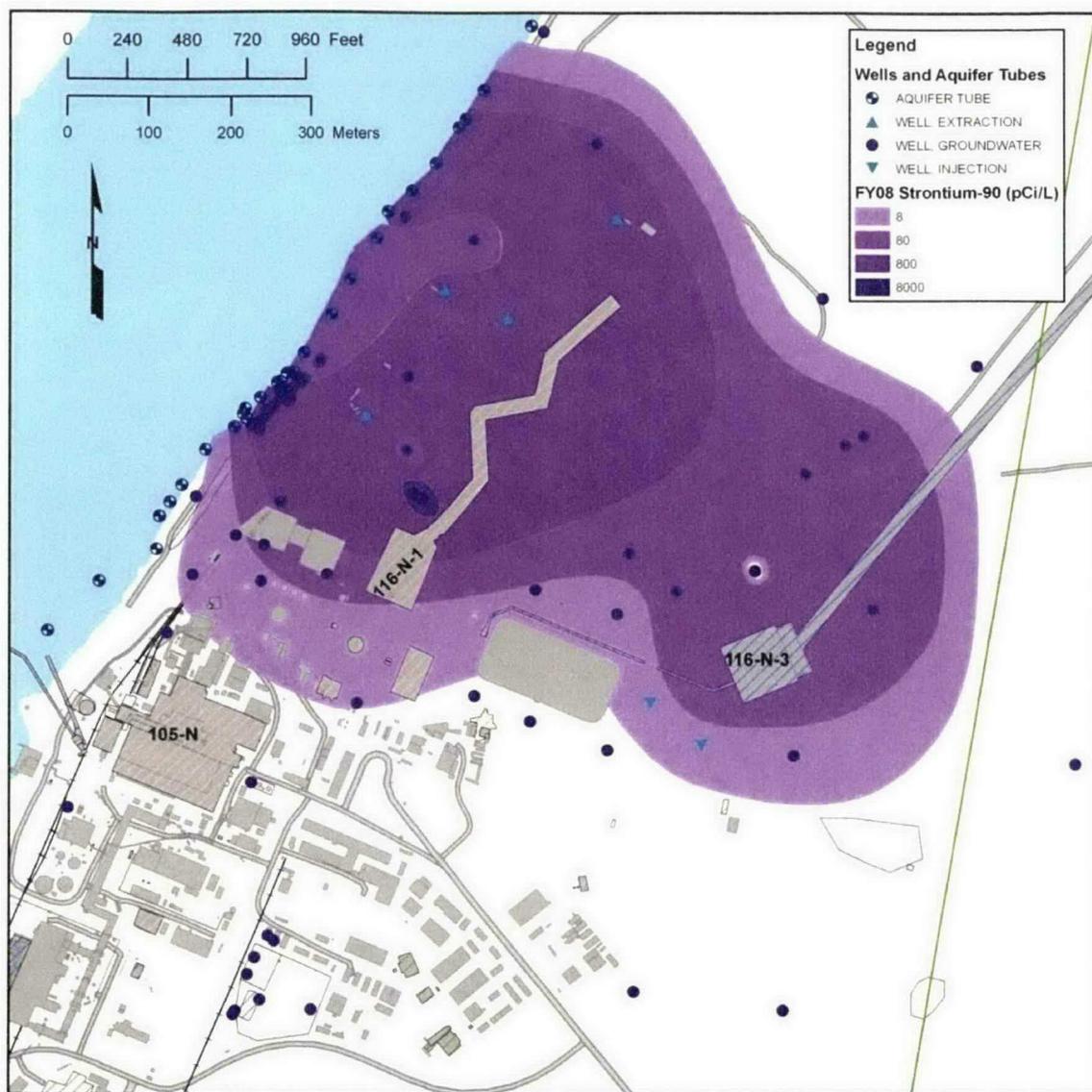


Figure 4-16. Gross Beta Concentrations versus Head Levels at Wells 199-N-67 and 199-N-14

1



2
 3
 4

Figure 4-17. Current Strontium-90- Distribution in the Unconfined Aquifer under the 100-N Area

5 Given the relative spatial stability of fluid Sr-90 concentration contours in the unconfined aquifer, the
 6 sorbed portion of Sr-90 in the aquifer must have been essentially fixed since the early 1990s. The
 7 subsurface soils characterization and aquifer data collected as a function of depth in the aquifer show the
 8 following notable characteristics:

- 9 • Strontium-90 is generally distributed in a thin layer (approximately 3 m (10 ft) thick) around the
 10 current water table, mostly in the upper part of the Ringold E Unit. The contaminated layer is found
 11 along the entire crib/trench length and north of the trench (see Figures 4-5 and 4-6). Less than 100 Ci
 12 of Sr-90 have been estimated as present in this layer with about 99 percent sorbed and 1 percent in
 13 solution (PNNL, 10899).

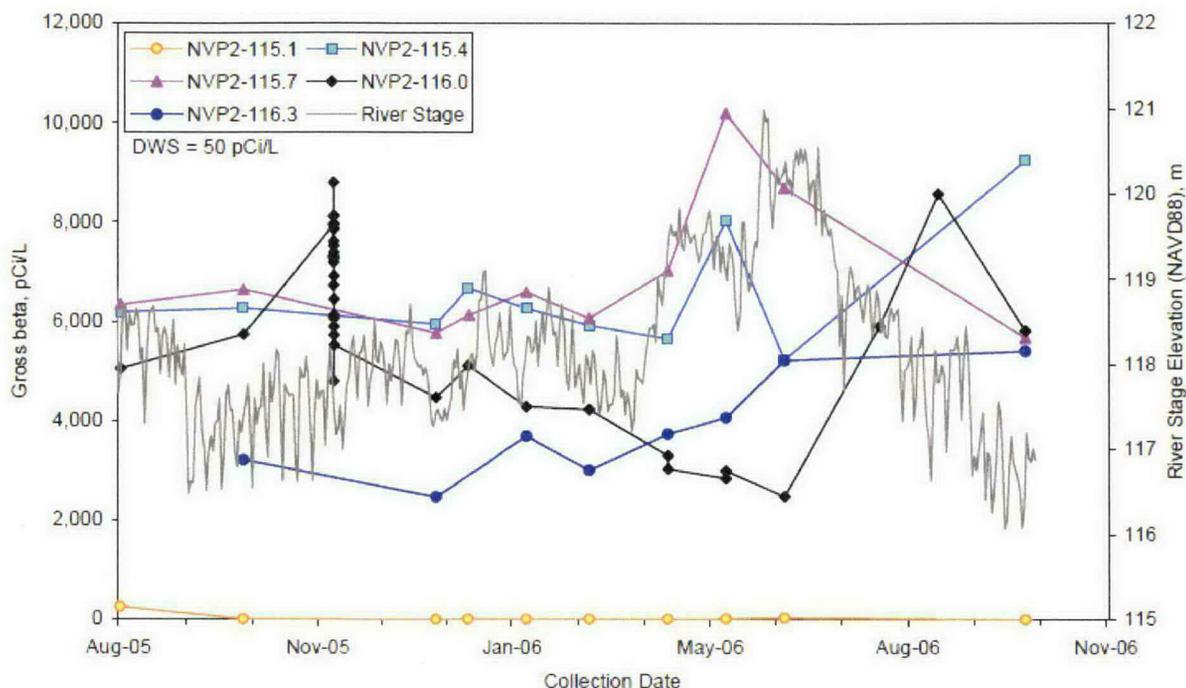
- 1 • Strontium-90 mass inventory for a given soil volume within the contamination levels tends to
2 diminish gradually and, for the most part, evenly away from the 1301-N LWDF with soil sample
3 measurements frequently above 100 pCi/g within 150 m of 1301-N LWDF (see Figures 4-5 and 4-6)
4 and dropping below 100 pCi/g near the shoreline.
- 5 • Some spatial anomalies in contamination levels are apparent. First, a groundwater hot spot persists
6 next to the crib at Well 199-N-67 (about 15,000 pCi/L), indicating a remnant maximum concentration
7 zone. Second, a less contaminated zone appears downgradient of the middle of the trench around
8 Well 199-N-80, where the maximum soil concentration was 52 pCi/g, about three times less
9 concentrated than soil measured at adjacent wells. This contrast extends to well 199-N-121 straight
10 downgradient of Well 199-N-80 and within 15 m (50 ft) of the Columbia River. Third, soil and
11 groundwater contamination hot spots exist. A more contaminated zone is present at the northern end
12 of the trench (near Wells 199-N-105A, 199-N-106A and 199-N-14). Another hot zone exists at the
13 shoreline around Wells 199-N-46 and 199-N-122 located in the middle of the apatite barrier. This hot
14 spot extends underneath the river to a cluster of aquifer tubes, including NVP1-5, NVP2 and NS-3A.

15 These observations suggest a logical and relatively uncomplicated evolution of Sr-90 spatial distribution
16 in the unconfined aquifer developed during the reactor operations period. Sr-90 discharged into the
17 unconfined aquifer as a line source underneath the 1301-N LWDF footprint. At the 1301-N LWDF,
18 a somewhat larger release of Sr-90 occurred at the crib because it was the initial point of entry into the
19 subsurface. Thus, the apparent remnant hot spot nearby is reasonable. The dominant directions of flow
20 ranged from north-northwesterly to northerly, flow directions common as imposed by both the
21 groundwater mound and the regional gradient. This commonality may explain why there appears to have
22 been less migration to the west, south, and east. Strontium-90 did not migrate deeply into the unconfined
23 aquifer because of its chemical reactivity, and more transport in the more permeable Hanford formation.
24 Finally, within the downgradient subsurface soils, there may be preferential flow paths, particularly one
25 leading from the 1301-N Crib toward Wells 199-N-46 and 199-N-122 at the river shore and the nearby
26 aquifer tubes. This particular flow path has been described at least since 1969 by N Springs monitoring
27 activities (BNWL-CC-2326).

28 An elevated zone of Sr-90 mass is present under the 1325-N LWDF, but soil and groundwater data
29 indicate it is less widely distributed and contains less Sr-90 mass. For example, Sr-90 soil concentrations
30 in Well 199-N-109A (near the point of wastewater entry in the crib) are about 15 pCi/g in the deep vadose
31 zone, approximately 10 times less than soil concentrations around 1301-N. Groundwater concentrations
32 around 1325-N have generally been less than a few hundred pCi/L with occasional brief spikes
33 approaching 2000 pCi/L. Overall, these concentrations are several times lower than those measured in
34 wells downgradient of the 1301-N LWDF. These measurements are consistent with the historical
35 evidence that significantly less wastewater and Sr-90 were discharged at the 1325-N LWDF.

36 While regional Sr-90 immobility in the 100-N Decision Unit or Area subsurface has been demonstrated
37 over the last 20 years, local periodic oscillations in Sr-90 groundwater concentrations are ubiquitous at
38 inland monitoring wells which correlate with seasonal river stage changes (Figure 4-16). From this
39 correlation, a cause and effect hypothesis is indicated. During high river stage, uncontaminated river
40 water moves inland and raises the water table, thereby periodically rewetting the lower few feet of the
41 vadose zone. This water then desorbs contamination in the rewetted zone and, because the sorbed
42 contamination tends to be more concentrated in the rewetted zone, the dissolved concentrations are
43 higher. Conversely, when the river stage is low, aquifer water equilibrates with less contaminated
44 sediments and measured Sr-90 concentrations decrease.

1 In contrast to monitoring well groundwater data inland, fluctuations in Sr-90 concentrations in concert
 2 with river stages are not clearly indicated in samples taken from aquifer tubes located in the
 3 Columbia River since 2005. These tubes allow collection of groundwater below the riverbed at various
 4 depths. A comparison of gross beta measurements (a proxy for Sr-90) with river stage elevations is shown
 5 in Figure 4-18 for some of the aquifer tube locations.



6 **Figure 4-18. Comparison of Aquifer Tube Gross Beta Measurements with**
 7 **River Stage Elevations (PNNL-16346)**
 8

9 Fluctuations in Sr-90 concentrations in the aquifer tubes have occurred as a result of tests being conducted
 10 to develop an apatite barrier being designed to immobilize Sr-90 near the Columbia River. On several
 11 occasions (2006, 2007, and 2008) solutions have been injected into the subsurface through a row of
 12 injection wells about 50 ft inland from and parallel to the river shore (PNNL-17429, DOE/RL-2008-66).
 13 The hot spot wells 199-N-122 and 199-N-46 are located in the middle of this row. Both calcium-rich and
 14 phosphate-rich solutions have been injected to precipitate in situ apatite, which both sorbs and
 15 incorporates Sr-90 into its mineral structure. The apatite formation process has not been entirely efficient,
 16 leaving excess calcium and phosphate in solution, which has migrated toward the Columbia River under
 17 the influence of the injected solution volumes. During these transient events, the added calcium replaced
 18 preexisting Sr-90 sorbed onto sediments, thereby liberating a fraction of the Sr-90 along the flow path.
 19 The mobilized Sr-90 and calcium traveled as far as some of the aquifer tubes in the riverbed and caused
 20 observable concentration spikes in groundwater sampled just below the riverbed. This supports the
 21 reasonable supposition that Sr-90 discharge to the Columbia River occurs through upwelling of
 22 groundwater through the riverbed.

23 Given the discussion presented above, current and future discharges into the Columbia River are and will
 24 be strongly influenced by the lack of Sr-90 mobility. Most importantly, Sr-90 immobility implies that the
 25 source of Sr-90 currently discharging into the Columbia River must be limited and most likely close to
 26 the shoreline, underneath the riverbed, and a short distance inland. By extension, the inland mass and
 27 larger fraction of Sr-90 in the subsurface cannot reach the region near the Columbia River and will not be

1 a source of future Sr-90 discharge into the river. Critical factors preventing significant migration are
2 chemical retardation, low hydraulic gradient, and radioactive decay. The slow movement of Sr-90 toward
3 the river allows radioactive decay of the contaminant to occur before it is discharged into the river in all
4 but the narrow area near and under the river.

5 To better understand the dynamics of Sr-90 plume behavior and improve confidence in this hypothesis,
6 a complex modeling analysis was completed in 2004 (Connelly, 2004). In this analysis, a two half-life
7 projection was completed from 1995 forward on regional Sr-90 contamination levels along a cross section
8 perpendicular to the Columbia River and parallel to the general direction of hydrologic flow. The model
9 considered hydraulic processes including river stage effects, the existing Sr-90 distribution in the
10 subsurface, chemical retardation effects, radioactive decay, and recharge conditions similar to
11 current levels.

12 Two significant results were derived from this analysis. First, no significant movement of the center of
13 mass of the Sr-90 plume toward the Columbia River occurred during the 57-yr simulation. The contour
14 lines changed because of radioactive decay. This result was entirely consistent with the past decade of
15 observations and was expected because none of the major plume controlling factors was modeled
16 differently from existing conditions. Another implication of this result is that the available source term for
17 Columbia River discharge must not extend very far inland from the river shore.

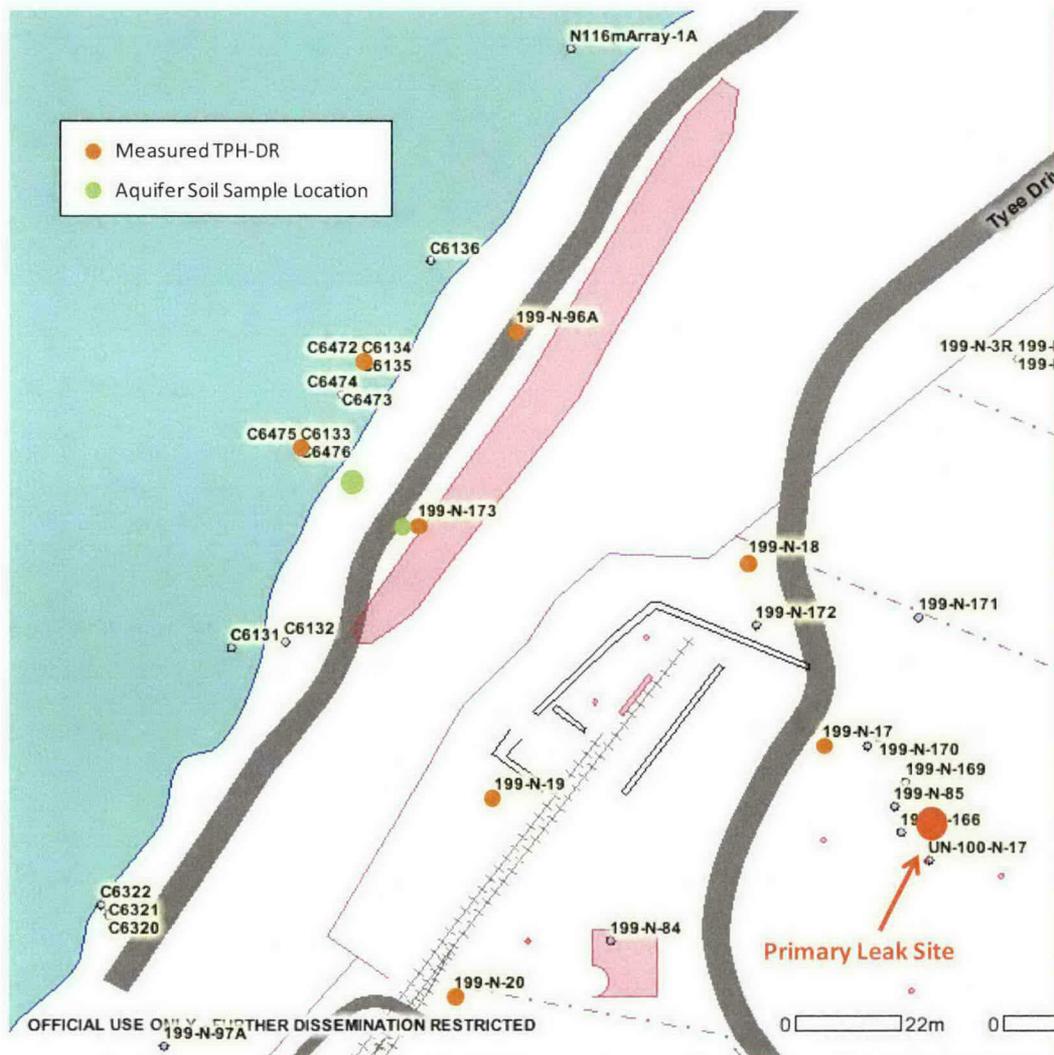
18 The analysis provided several informative results. First, no significant movement of the center of mass of
19 the Sr-90 plume toward the Columbia River occurred during the 57-yr simulation. This result, entirely
20 consistent with the past decade of observations, was expected because none of the major plume
21 controlling factors was modeled differently from existing conditions. The implication is that the available
22 source term for Columbia River discharge is unlikely to increase significantly and must not extend very
23 far inland from the river shore. A quantitative determination of the size of the source term area has not
24 been estimated. Second, despite the large fluxes of water across the river shore boundary, the net annual
25 flux into the river is quite small, about 0.35 m^3 per meter (12.36 ft^3 per foot) of flux plane width parallel
26 to the river shore. Third, the flux into the Columbia River occurs primarily through the lower part of the
27 unconfined aquifer, and Sr-90 concentrations in these fluids are largely unaffected by river stage effects
28 such as those noted at inland wells. Results imply aquifer concentrations in discharged groundwater
29 should be relatively constant. Over the 57-year projection, annual fluxes did remain constant (estimated to
30 be 0.14 to 0.19 Ci/yr) but decreased gradually because of source term decay. The aquifer tube data to
31 date, being relatively constant except when affected by injection tests, support this result. Continued
32 monitoring will provide additional information.

33 Efforts to hasten the reduction of the Sr-90 source term with the development of the apatite barrier and
34 potential use of phytoremediation treatments are ongoing for purposes of accelerating the removal of the
35 Sr-90 source. If successful, Sr-90 flux into the Columbia River could be reduced more quickly.

36 **4.3.3 Petroleum Product Migration and Distribution in the Unconfined Aquifer**

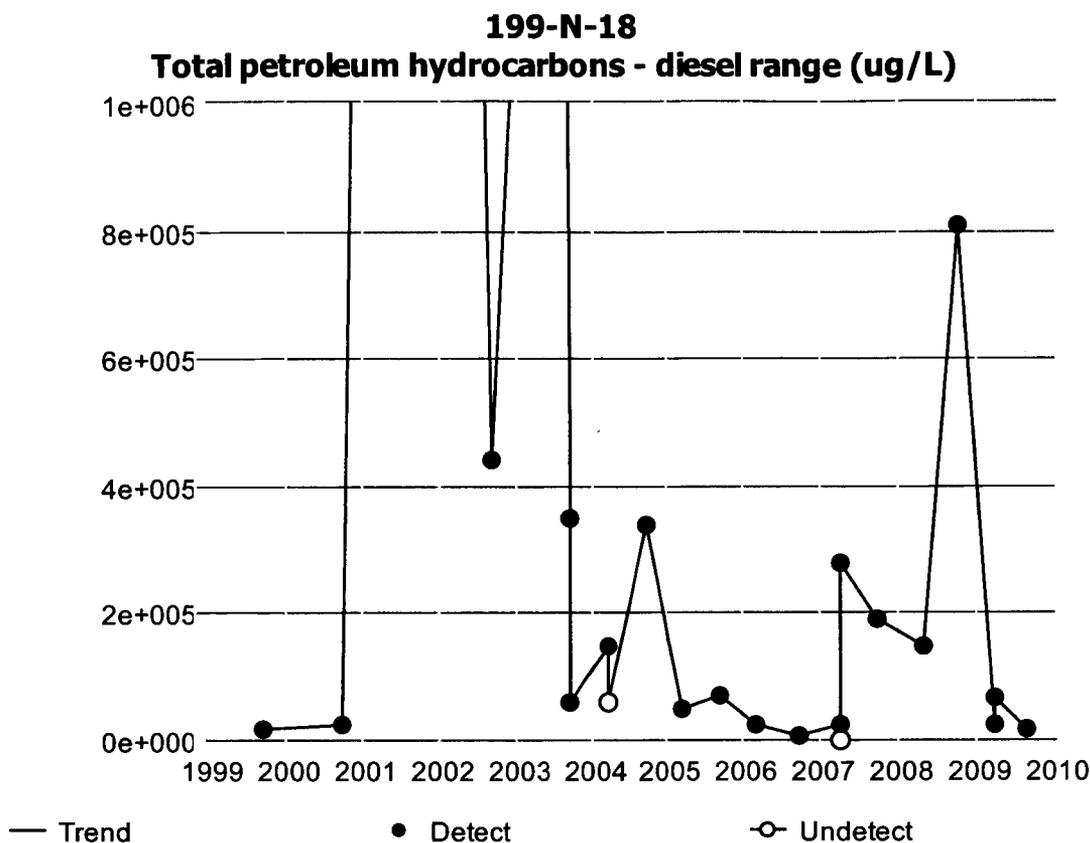
37 The discharge of leaked diesel fuel into the unconfined aquifer occurred over a small area underneath the
38 166-N Tank Farm. Assuming little interaction with vadose zone soils, and migration as a NAPL,
39 complete discharge into the unconfined aquifer occurred well before the end of the reactor operations
40 period. Given the generally low solubility of petroleum products and their tendency to persist as an
41 immiscible fluid, migration rates and dispersion through the unconfined aquifer are difficult to understand
42 and predict. Petroleum products were found as fluids floating at the water table in well 199-N-18 in the
43 1980s, then disappeared until 2003 (PNNL-14548, *Hanford Site Groundwater Monitoring for Fiscal*
44 *Year 2003*). An existing trench along the Columbia River was used to burn petroleum products as they

1 migrated toward the Columbia River from the 1966 spill, and burning continued until about 1969. The
2 trench was backfilled in 1994.
3 Currently, some portion of the discharged inventory remains in the subsurface by the Columbia River.
4 Recent monitoring and characterization efforts indicate a relatively narrow area downgradient of the leak
5 location that is currently contaminated with petroleum products (Figure 4-19). The largest concentrations
6 of total hydrocarbons-diesel range (TPH-DR) are found in Well 199-N-18 where concentrations in excess
7 of $1E+05$ $\mu\text{g/l}$ have been measured (Figure 4-20). Other characterization data suggest the heart of the
8 plume trends along a northwest line from well 199-H-18, between Wells 199-N-73 and 199-N-96A and
9 into the aquifer tube cluster N-116m ARRAY-0A (shown on Figure 4-19 as the group C6475, C6133, and
10 C6476). This trend is consistent with the regional gradient. In this zone, source term inventory is clearly
11 still present. Recent soil characterization data collected at Well 199-N-173 and near the shoreline
12 (Figure 4-19) show TPH-DR concentrations ranging from 30 to 1,200 mg/kg (PNNL-18645).
13 Contamination at these sites is present throughout the lower vadose zone sediments periodically wetted at
14 high river stage and concentration levels increase with depth.



15
16
17
Figure 4-19. Sediment and Groundwater Sampling Locations where Total Petroleum Hydrocarbons-Diesel Range have been Measured

1



2

3

Figure 4-20. Total Petroleum Hydrocarbons-Diesel Range Measurements at Well 199-N-18

4

5

6

These data suggest a reasonable and expected migration direction for this plume in the future, but migration rates and the length of time for plume dissipation is uncertain because of poorly quantified residual inventory and the uncertain nature of immiscible fluid migration characteristics.

7

4.3.4 Chromium Migration and Distribution in the Unconfined Aquifer

8

9

10

11

12

13

14

15

16

17

18

19

The majority of chromium that entered the unconfined aquifer originated from discharges through the 1301-N LWDF. Given its high solubility and lack of sorption to subsurface sediments, chromium is assumed to have entered the unconfined aquifer over a fairly large flux plane, and very shortly after discharges began at the 1301-N LWDF. The size of the flux plane was determined by the amount of lateral migration of 1301-N discharge volumes in the vadose zone before vertical movement became the dominant flow direction. As discussed in Section 4.3.3, the measurement of slightly elevated chromium near the bottom of the 1325-N Trench is attributed to lateral spreading of 1301-N wastewater containing dissolved chromium. This observation corresponds to a lateral spreading distance of about 500 m (approximately 1,640 ft). If so, lateral spreading in the vadose zone could have reached the river shore. Similar types of releases may also have occurred under 1325-N and 1324-NA, which operated from 1977 until the end of reactor operations. The facility received an average of 605,600 L/day (160,000 gal/day) (DOE/RL-93-80), enough discharge volume to drive some lateral spreading.

1 During the reactor operations period, the large hydraulic gradients imposed and maintained by crib
2 discharges forced very rapid migration of non-sorbing contaminants to the river shore. In 1969,
3 I-131 migration was tracked from the 1301-N LWDF to the N Springs by noting the timing between the
4 discharge of more concentrated solutions into the 1301-N LWDF, and then the occurrence of an I-131
5 concentration peak at N Springs sampling locations. This study showed that transport to N Springs took
6 about two weeks. Given the high discharge rates that occurred continuously while chromium was
7 delivered to 1301-N and then continued for another ten years after sodium dichromate ceased, the mobile
8 portion of discharged chromium was thoroughly flushed into the Columbia River by the end of the reactor
9 operations period.

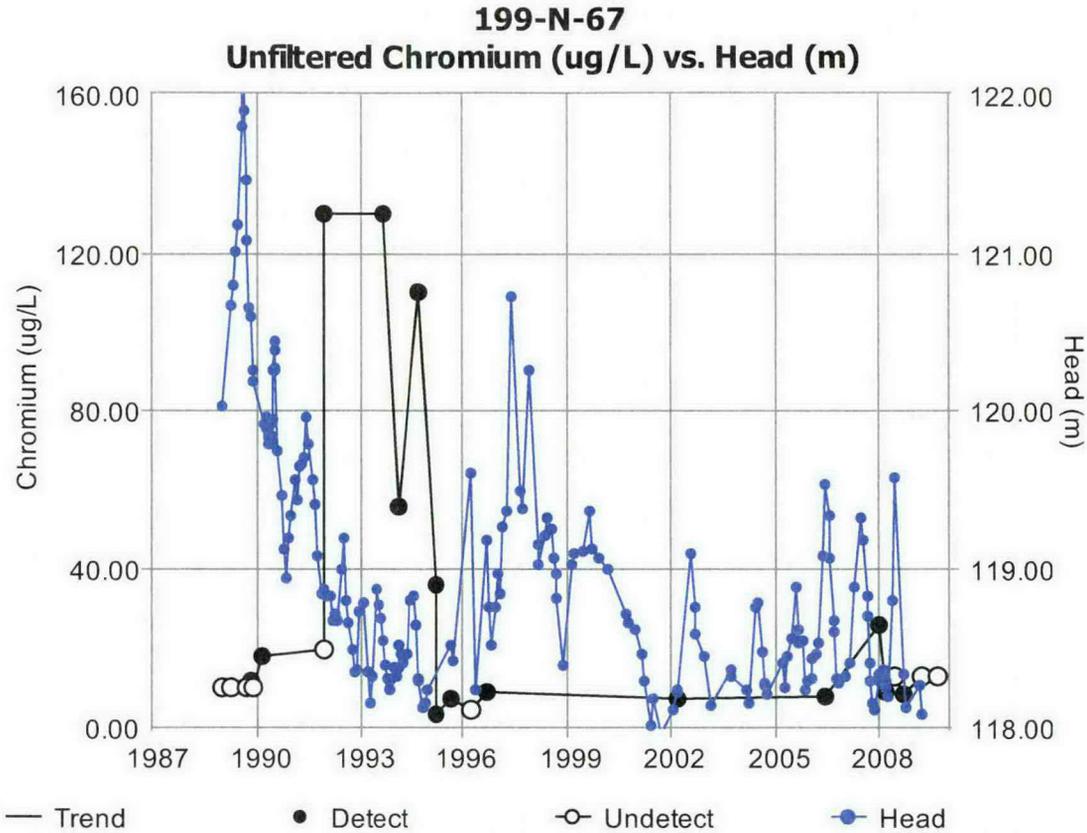
10 Since the early 1990s, total chromium has been measured, for the most part, at low levels (less than
11 20 µg/l) in numerous groundwater monitoring wells. The well data do not indicate a plume, but rather
12 somewhat random occurrences in the unconfined aquifer under the 100-N Area. The continuing presence
13 of chromium in the unconfined aquifer is attributed to leaching the sorbed or precipitated chromium in
14 soils in the lower vadose zone and more resistant to leaching.

15 One exception to these observations was the occurrence of higher concentration levels in the early 1990s
16 at numerous wells. These data show a repeated pattern with respect to water table elevations. Following
17 the water table spike in 1989 that occurred in wells around the 1301-N and 1325-N LWDFs, a spike in
18 chromium concentration appeared about three years later in those wells. An example of this pattern is
19 shown in Figure 4-21 at Well 199-N-67 near the 1301-N Crib. This relationship suggests that the rising
20 water table caused a temporary resumption of chromium-contaminated sediment leaching in the rewetted
21 zone that had stopped with the cessation of crib discharges several years previously. Because chromium
22 was present in a more leach resistant condition, leach rates were slow and vertical migration rates of the
23 leached chromium were retarded relative to the subsequent drop in the water table elevation. Therefore,
24 appearance of the spike occurred afterwards. The higher chromium concentrations are attributed to
25 leaching of more contaminated sediments in the rewetted zone where less leaching had occurred since
26 cessation of high volume crib discharge.

27 If this hypothesis is correct, future spikes in contamination levels may occur if significant water table
28 elevations occur again. Given that reactor operations will not resume, this event seems unlikely.
29 Otherwise, no plausible mechanism would permit future increases in chromium contamination in the
30 unconfined aquifer. Currently, only Well 199-N-80, downgradient of the 1301-N LWDF, shows elevated
31 chromium concentrations above the drinking water standard (about 175 µg/l). This anomalous behavior is
32 thought to be the result of well screen corrosion and will continue to be monitored.

33
34

1



2

3

4

Figure 4-21. Comparison of Water Table Elevations and Chromium Concentrations over Time at Well 199-N-67.

5

4.3.5 Tritium and Nitrate Migration and Distribution in the Unconfined Aquifer

6

7

8

9

10

11

Essentially complete solubility of tritium and nitrate causes these contaminants to move as water does in the subsurface. Given the strong influence of crib discharges on groundwater movement during reactor operations and a good understanding of the tritium source term, the major characteristics of tritium migration and contaminant level changes over time at 100-N Area are easily explained. Unfortunately, ambiguity about nitrate source terms makes interpretation of its migration patterns in the unconfined aquifer equally ambiguous. Each is described below.

12

13

14

15

16

17

18

19

20

21

22

At groundwater monitoring wells near 1301-N and 1325-N, two periods of peak activity were observed, the first occurring in the early 1970s and the second in the late 1980s. Tritium contamination level peaks are shown in Figure 4-22 for groundwater monitoring Well 199-N-4, located between 1301-N and 1325-N. The early peak occurs in the early 1970s and is attributed to tritium contaminated discharge through 1301-N, a period when a substantial inventory (approximately 1200 Ci) was reported in the wastewater. The second peak occurs in the late 1980s when 1325-N was the only operating crib. The end of this peak period is coincident the cessation of high volume discharges in 1991. Annual Effluent release reports documented tritium concentrations at N Springs between 1973 and 1989. The annual average concentrations (Figure 4-23) show essentially the same tritium level occurring in essentially the same time interval again showing how rapidly discharged wastewater moved downgradient during reactor operations and how little dispersion occurred prior to arrival at the river shore.

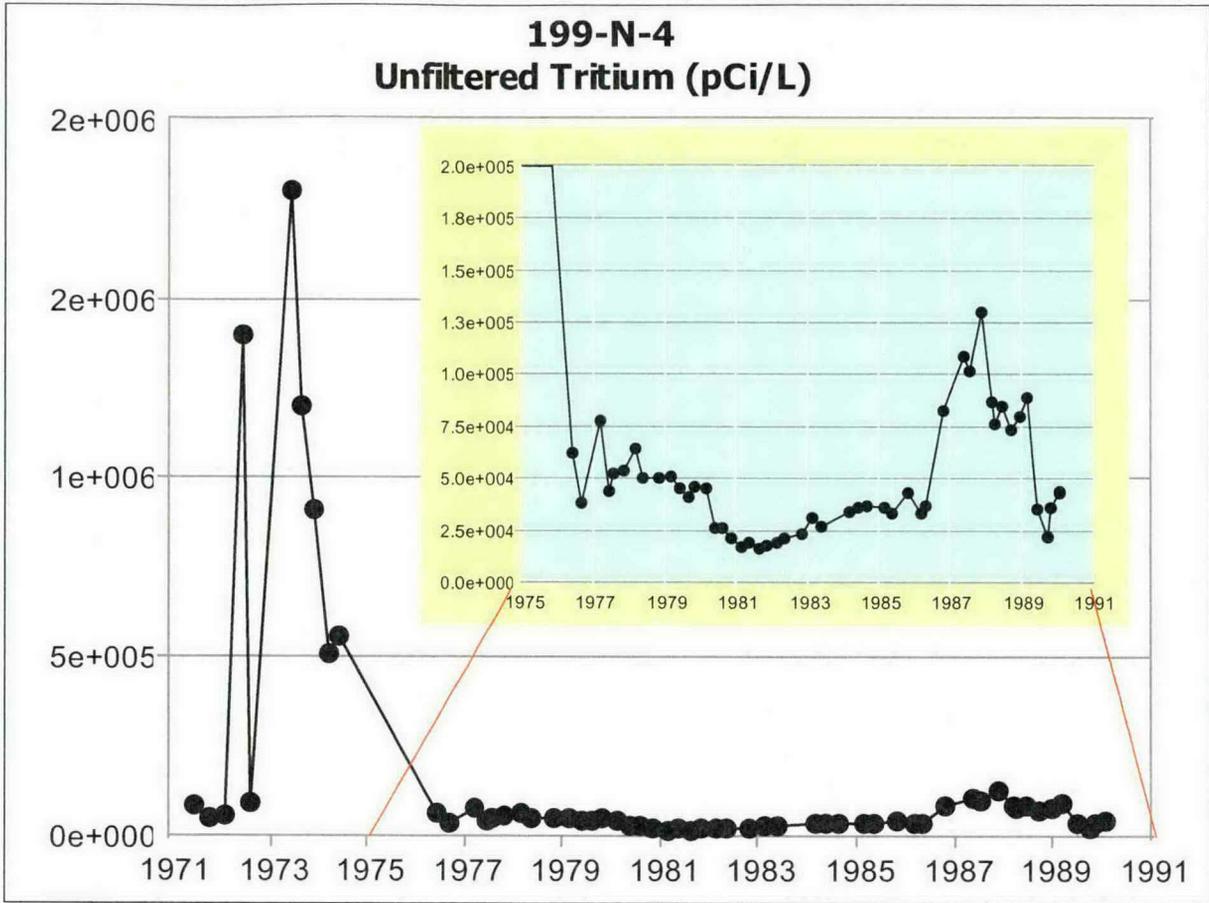


Figure 4-22. Tritium Contamination Levels (pCi/L) at Groundwater Monitoring Well 199-N-4

1
2
3

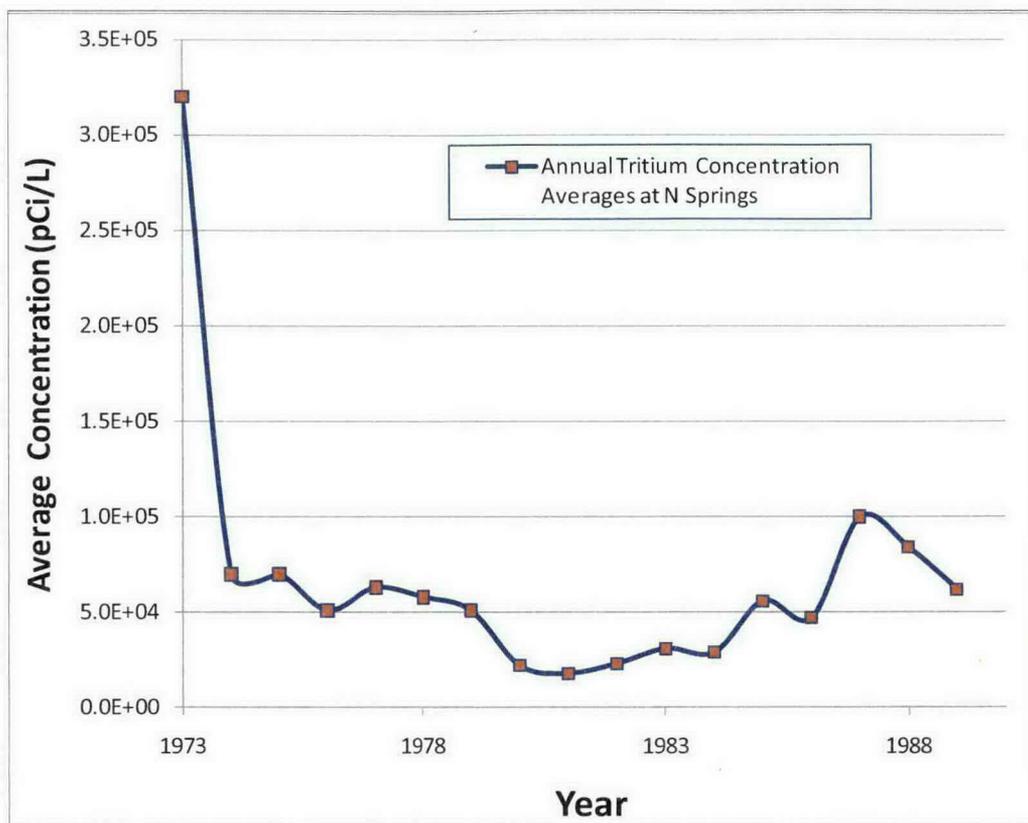


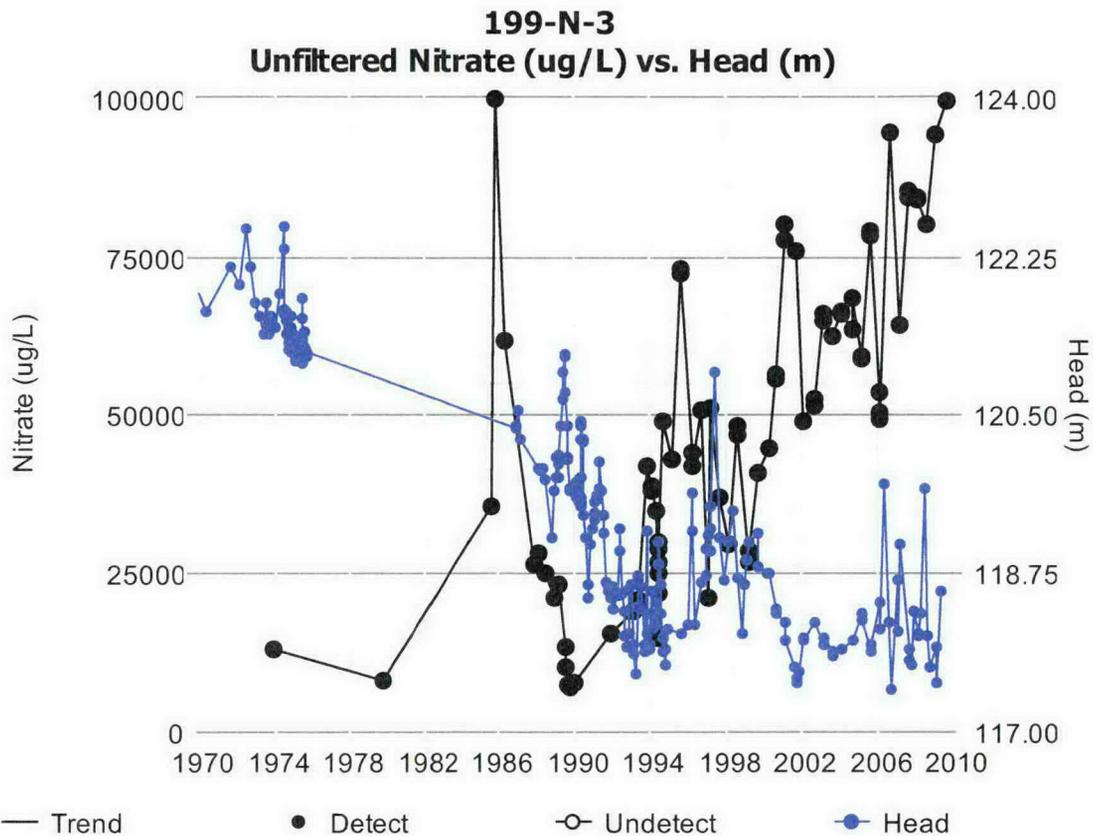
Figure 4-23. Annual Average Tritium Concentrations (pCi/L) at N Springs
 (100 Area Liquid Effluent Reports)

Following the cessation of reactor discharges, most of the tritium was present in the unconfined aquifer. Tritium migration rates slowed with the reduction in hydraulic gradient, and contamination levels have been diminishing since then because of the decay. Currently, average tritium measurements in all wells are below the maximum concentration limit of 20,000 pCi/L and will continue to decrease because of decay.

The nitrate migration patterns indicated by groundwater monitoring data available since the early 1970s are difficult to interpret because of uncertainty about the source term or source terms and incomplete chronological and spatial coverage for nitrate contamination levels. Only three monitoring wells around 1301-N were used to measure nitrate concentrations in the 1970s and few wells cover the period from 1965 to present. One of the more complete records is available at well 199-N-3 downgradient of 1301-N (Figure 4-24). Several characteristics are notable.

- In the mid 1970s, concentrations ranged from 5,000-10,000 µg/L. Similar nitrate contamination levels were measured in this period at wells 199-N-4 and 199-N-5 near the 1301-N crib and 199-N-14 north of the 1301-N trench.
- By the early 1980s, nitrate concentrations began to rise, and in late 1985, a sharp nitrate peak occurred at followed by a rapid drop in concentration until about 1990. This peak was measured about the same time at wells to the west, around 105-N and slightly earlier at some wells to the east around 1325-N in May of 1985. High concentrations were generally between 100,000 and 150,000 µg/L around 1301-N and between 105-N and the river shore.

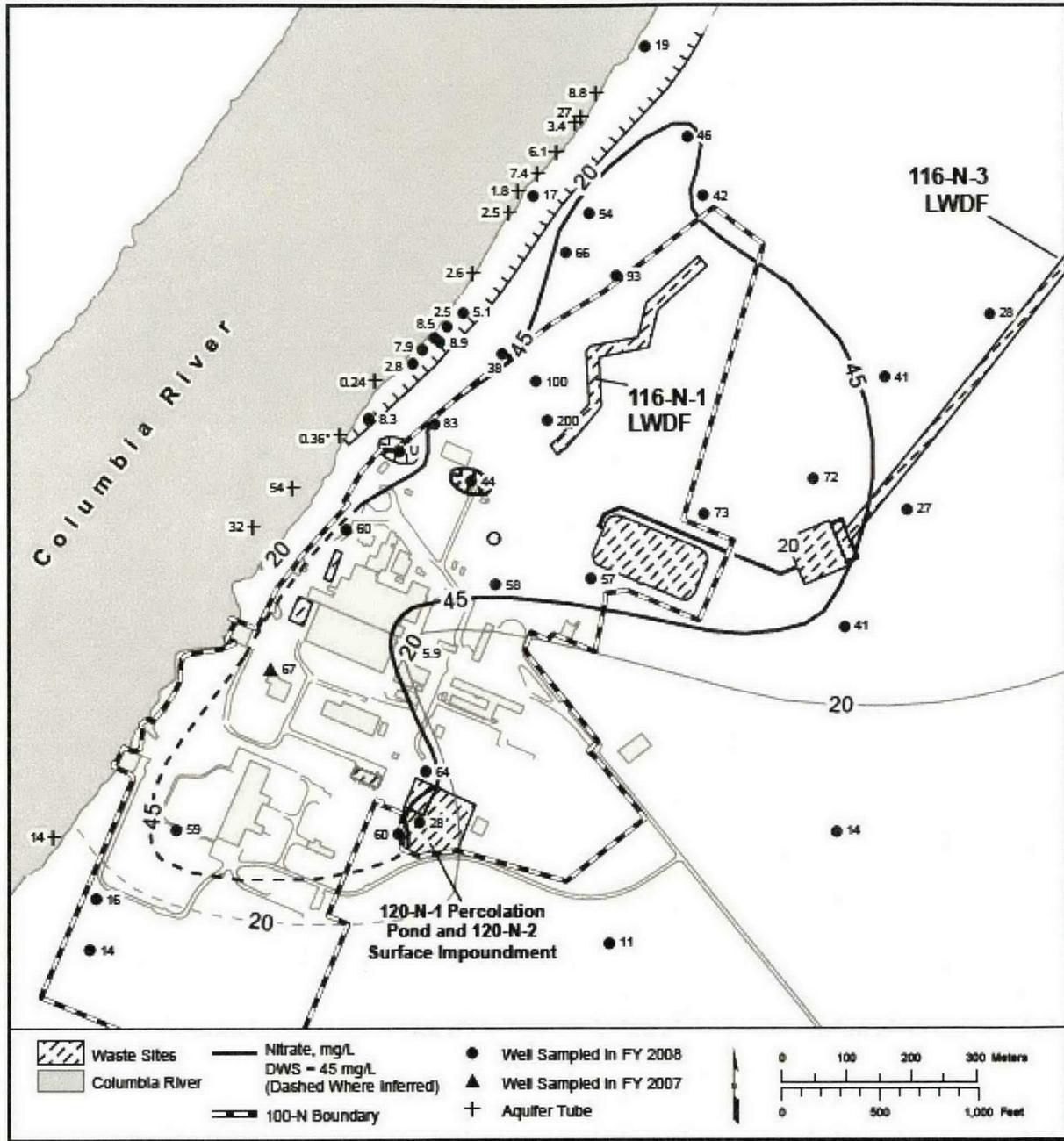
- 1 • Since about 1990, a general increase in nitrate concentration began and has continued in contrast to
 2 water table elevations, which have decreased. This pattern occurs in numerous wells throughout the
 3 area. Highest concentrations are again generally between 100,000 and 200,000 $\mu\text{g/L}$ around 1301-N
 4 and between 105-N and the river shore. One exception is a hot spot at 199-N-67, next to 1301-N,
 5 where concentrations have frequently exceeded 3,000,000 $\mu\text{g/L}$. Concentrations in other parts of the
 6 100 Area are lower. Farther north along the river shore concentrations are generally less than
 7 50,000 $\mu\text{g/L}$. Underneath the Columbia River, just off shore, aquifer tube data show concentration
 8 levels less than 10,000 $\mu\text{g/L}$.



9
 10 **Figure 4-24. Nitrate and Head Measurements at Groundwater Monitoring Well 199-N-3**
 11 **Between 1970 and the Present**

12 These data strongly indicate the primary sources of nitrate have been, and continue to be upgradient of
 13 100-N Area. If the primary sources of nitrate were in the 100-N Area, then nitrate migration patterns
 14 should have mimicked the tritium pattern (see Figure 4-21). If so, nitrate should have been effectively
 15 flushed into the Columbia River during the operations period leaving behind a dwindling plume. Instead,
 16 nitrate contamination levels began to increase after the high discharge period ended. Given that nitrate is
 17 highly mobile, its migration trend in the 1990s has reflected the prevailing hydraulic gradient imposed by
 18 regional hydrologic flow to the northwest and north. The fact that the pattern shown in Figure 4-23 is
 19 repeated almost simultaneously in multiple areas suggests a broad contaminant plume over much of the
 20 100-N Area at the same time. If so, perhaps two plumes have entered the area, one in the early 1980s and

1 another in the early 1990s, which is ongoing. The reason for the dip in the contour curve between 1301-N
2 and 105-N (Figure 4-25) is not clearly understood. It is interesting to note that this area readily increases
3 in water table elevation during high river stages (see Figure 4-14a). This commonality may indicate
4 a zone where river stage effects are more effective removing nitrate.



5
6

Figure 4-25. Current Regional Distribution of Nitrate in the 100-N Area

1 If the nitrate source is upgradient as proposed, the source term inventory and current distribution is
2 ambiguous. One possibility is that nitrate releases in the 200 Areas migrated through Gable Gap and are
3 reaching the 100 Areas. Given these uncertainties, future nitrate contamination levels are difficult to
4 predict. Recent data suggest the center of the plume is generally between 1301-N and the river shore. It is
5 likely the condition will persist for some time if the estimates of net flux (HydroGeoLogic 2004) are
6 generally correct.

7 **4.4 Identification and Resolution of Data Needs**

8 During planning workshops for the 100-N Decision Unit, discussions were held to identify the extent of
9 new information needed to support the reduction of existing uncertainties needed for refinement of the
10 CSM and final decision making in a final ROD. Appendix A, attached to this report, presents the results
11 of those discussions. The data gaps and needs discussed herein resulted from the planning process, and
12 were further refined during preparation of this addendum.

13 The evaluation of site-specific conditions at the 100-N Decision Unit indicates that not all data gaps are
14 applicable but all have been kept in the discussion to maintain consistency with the other addendum and
15 to indicate a level of comprehensiveness not achievable if left out. The justification used to indicate a data
16 gap was “not applicable” is provided and considered an important part of the overall planning process.

17 Table 4-4 lists the data gaps and associated data needs, and summarizes the required scope of work
18 planned to address each. Data gaps are general statements indicating insufficient information to support
19 decision making is available. Data needs are analytical (e.g., laboratory sample results), quantitative
20 (e.g., sample geographical coordinates), and process-related (e.g., fate and transport calculations) that
21 would fill the data gap. Data gaps are presented in the Executive Summary. Data needs are
22 discussed below.

23 Implementation details are found in the sampling and analysis plan in DOE/RL-2009-42. Tables 4-5 and
24 4-6 summarize the field program necessary to fill the data gaps.

25 **4.4.1 100-N Decision Unit Data Needs – Source Areas**

26 Data needs specific to sources (soils) are identified and described in this section.

27 *Data Need #1: Characterize unremediated waste sites to assess nature and extent of contamination in the*
28 *vadose zone.*

29 **Data Need Description:** Soil sampling associated with interim remedial actions efficiently obtains
30 necessary data defining levels of residual contamination.

31 Remediation in the 100-N Areas began in 1999 under remedial authority of an interim action ROD and
32 continues to the present day. Ongoing soil remedial action efforts include remedial action planning,
33 implementation, site verification and interim closeout, backfill, and revegetation. Remedial action
34 schedules are driven by enforceable milestones established as part of the Tri-Party Agreement (Ecology et
35 al., 1989a) and a CERCLA statutory requirement(s).

36 Ninety-three unremediated waste sites (89 accepted and 4 discoveries) remain in the decision unit that
37 will be addressed according to the interim action ROD (EPA/541/R-99/112) and associated with this data
38 need. Data needs associated with soil remedial actions in the 100-N Decision Unit will be met by
39 planning and scheduling the remedial actions, collecting data to verify waste sites cleanup, and obtaining
40 regulators' concurrence on the achievement of remedial action goals for direct exposure, protection of
41 groundwater and surface waters.

1 The implementation of interim remedial actions for the 93 unremediated sites is described and directed by
2 DOE/RL-2000-16, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment,*
3 *Storage, and Disposal Units,* and DOE/RL-2005-93, *Remedial Design Report/Remedial Action Work*
4 *Plan for the 100-N Area.* This addendum recognizes these data are an important source of information for
5 assessing contaminant distribution, direct exposure, and protection of groundwater and the Columbia
6 River. After the unremediated sites are addressed according to the interim action ROD, additional
7 characterization will be considered. Additional characterization may be phased through interim action
8 RODs in a Phase 2 RI work plan, sampling and analysis plan, or as directed by the final ROD. As these
9 sites are interim closed, additional discussion with the agencies may be needed to address potential
10 characterization needs at these waste sites. Remedial actions and site evaluations are being planned and
11 scheduled at the remaining 93 unremediated sites.

12 Accepted and discovery waste sites within this data need are identified in Section 2.1.3 of this document.
13 Appendix C provides the description and history for each waste site. Locations of the 100-N Area waste
14 sites are shown in Appendix B.
15

Table 4-4. Identified Data Gaps and Needs for the 100-N Decision Unit

Data Gap	Data Need Number	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath unremediated waste sites.	1	Characterize unremediated waste sites to assess nature and extent of contamination in the vadose zone.	Soil sampling associated with interim remedial actions efficiently obtains necessary data defining levels of residual contamination.	Yes	Complete contaminated soil remediation and necessary sampling at 93 waste sites in the 100-N Decision Unit. The location of unremediated waste sites is shown in Appendix B.	Soil remediation is necessary protect human health and the environment. Data collected to support remediation are needed to assess risk for direct exposure, protection of groundwater, and protection of the Columbia River.
Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.	2	Determine if the Sr-90 hot spot or petroleum is migrating, and the nature of the RUM.	See data needs 5 and 7.	Yes	None	Characterization will be performed to validate the effectiveness of the interim remedial action, address uncertainty regarding nature and extent of residual contamination in soils, and refine the conceptual site model (if necessary).
Vadose zone contaminant nature and extent needed to assess protection of groundwater around reactor structures.	3	Characterize waste sites around the reactor structure to assess nature and extent of contamination in the vadose zone near the reactor.	Data are needed to determine the nature and vertical extent of contamination in the vadose zone around reactor structures (105-N and 109-N Reactor/Heat Exchange Building).	Yes	Continue contaminated soil removal and sampling at waste sites around and associated with the 105-N/109-N sites. The locations of these waste sites are shown in Appendix B.	The ongoing soil remediation program provides an efficient mechanism to identify waste sites around the reactor and provides data after remediation to assess the potential for residual contamination to have a negative impact in the area of the reactor.
Unidentified waste sites (orphan/discovery sites) may exist in the decision unit.	4	Identify new waste sites and potential sources of contamination.	Complete orphan site evaluation process in the 100-N Decision Unit.	Yes	Complete orphan site evaluation process in 100-N Decision Unit.	The orphan site evaluation and waste site discovery process provides and effective mechanism to identify new waste sites and sources that are not in CERCLA decision documents.
The nature and extent of contamination in the unconfined aquifer above cleanup standards has not been defined in select areas.	5	Define additional groundwater needs to support groundwater remediation decisions.	Evaluate(drill one well) the potential for Sr-90 "hot spot" to impact remedial actions, define the scope of the petroleum contamination (drill one well) sufficiently to support potential remediation, and sample 18 wells to better define existing levels of contamination (See Gap #13).	Yes	Install two new wells (Figure 4-26). One well (sampling points #1, is proposed to define the extent of the Sr-90 "hot spot" adjacent to and down gradient of 116-N-1 and serve as an indicator of movement. Samples will be collected in N Area wells at the Hanford/Ringold contact. Well #2 is proposed to further define the nature and extent of contamination relating to diesel fuel spills. Sample existing wells for chromium and CrVI to spatially and temporally represent these contaminants in groundwater within the decision unit.	A new well is proposed to better define the extent of Sr-90 "hot-spot" and address the impact of any potential movement on proposed remedies. A second new well is defined near the petroleum spill to support remedy selection and potentially to support remediation. Sampling 18 groundwater wells is proposed because wells within the unit have not been sampled consistently for chromium and CrVI as well as to define the extent of groundwater contaminants not sampled in recent sampling events.

Table 4-4. Identified Data Gaps and Needs for the 100-N Decision Unit

Data Gap	Data Need Number	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The level of contamination entering the Columbia River is not well known.	6	Estimate the level of groundwater contamination entering the river.	Groundwater contamination at N Springs and the N Area has been studied and modeled (Connelly et al) since shortly after the start of N Reactor Operations. More recently aquifer tubes have been added to support estimates of groundwater discharge to the river. Sampling should be continued and moved to a monthly interval. Direct measurement of groundwater upwelling will be completed in early 2010.	Yes	Monitor aquifer tubes on monthly basis as conditions warrant for petroleum, tritium, and nitrate in addition to the existing suite of analytes. Collect groundwater upwelling samples in the Columbia River. Groundwater upwelling sampling and analysis in the Columbia River channel are planned for the spring of 2010 as part of an ongoing effort.	Aquifer tube data and "upwelling data" provide a valid basis to estimate the impacts of N Area contamination on the river's human risk assessment. To support re-evaluation of remedial activities, additional data relative to changing river stage are needed from the near-shore environment. More frequent sampling of the aquifer tubes will provide better temporal data to assess potential impacts to aquatic receptors.
The fate and transport of contaminants beneath the unconfined aquifer has not been evaluated.	7	Confirm the RUM in the area of N Decision Unit is an aquitard and that flow and contaminant transport is minimal.	Limited data indicate there is contamination in the upper few feet of the RUM over DWS (total chromium in well 199-N-80) The nearly 21.6 m (70 ft) silt unit is generally considered to possess low transmissivity. However, sandy pockets are known to exist that can be highly transmissive. Very limited information on the lithology, soil properties, and the depth to which contamination may exist is available. Complete two wells into the RUM to assess potential sand lenses, and confirm the aquitard nature of the RUM.	Yes	Drill and sample soil and groundwater from two new wells drilled approximately 15.24 m (50 ft) into the RUM. The locations are shown as boreholes R1, and R2 in Figure 4-26. Additional Soil Samples: Split spoon soil samples at total depth (1.5 m [5 ft]) into the RUM will be collected from the well installed to evaluate the Sr-90 "hot spot" as described in Data Need #4. This well is labeled as R2 on Figure 4-26.	Only two Wells (199-N-80 and 199-N-8P) have been installed in the RUM in the 100-N Decision Unit, Total chromium has been detected in the one of the wells above water quality standards. Groundwater contaminant concentrations in the 100-N Decision Unit remain above the aquatic and DWS in wells completed beneath the unconfined aquifer. These data recognize the importance of validating the assumption of a relatively low transmissive and uncontaminated unit on estimates of groundwater impacts due to upwelling within the river.
It is unknown if contamination within the RUM will adversely impact aquatic receptors in the Columbia River.	8	See data need #7.	N/A	N/A	N/A	N/A
The rate of exchange of groundwater between the groundwater and the river is unknown.	9	Not applicable to the N Decision Unit.	The study of N-Springs historical information, past modeling, and the recent addition of the apatite barrier have provided reasonable estimates of groundwater/river interactions.	N/A		
The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.	10	Vadose information is needed to better evaluate the extent of the residual contamination remaining from past petroleum leaks.	The understanding of the vadose sources of contamination is sufficient for the major COPCs with the exception of petroleum products to conduct an alternatives analysis. See data need number 5.	Yes	Petroleum: drill and sample soil and groundwater from one new well (Well 2, Figure 4-26) drilled into the aquifer. Details are found in the SAP.	Additional data are needed to address remediation decisions at this past leak.
Potential alternative remedial technologies for groundwater have not been sufficiently investigated.	11	Not applicable to the N Decision Unit.	Remedial alternatives have been discussed and evaluated since the initial Action Memo was issued in 1996.	No		

Table 4-4. Identified Data Gaps and Needs for the 100-N Decision Unit

Data Gap	Data Need Number	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
Insufficient data are available to support a fate and transport evaluations.	12	Not applicable to the N Decision Unit.	Multiple modeling studies have been conducted during the evaluation of remedial alternatives. These analyses would be considered sufficient to support any additional RI/FS modeling, if necessary.	No	N/A	No additional fate and transport modeling is expected, beyond what will be supported by ongoing remedial activities.
Data are needed to better define the spatial and temporal distribution of groundwater contamination.	13	Collect and analyze groundwater samples from select monitoring wells.	Additional groundwater data are needed that are spatially representative of the decision unit, reflect river stage influence, and include groundwater COPCs.	Yes	Collect groundwater data that chemically, spatially, and temporally represents the groundwater decision unit. Eighteen existing wells (Figure 4-27) will be sampled and analyzed for this purpose.	This spatial/temporal groundwater data is needed to address uncertainties associated with the initial groundwater risk results.

- CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
- COPC = contaminant of potential concern
- CrVI = hexavalent chromium
- DWS = drinking water standard
- FS = feasibility study
- N/A = not applicable
- RI = remedial investigation
- RUM = Ringold Upper Mud
- SAP = sampling and analysis plan
- Sr-90 = strontium-90

1

2 This page intentionally left blank.

1 Available information indicates 151 waste sites are in this decision unit, with 58 sites remediated or
2 dispositioned in accordance with an interim action ROD or other regulatory guidance. In an effort to
3 determine those sites that may require further characterization to address CSM uncertainties, a decision
4 tree (i.e., work plan) was used to sort these sites into the following three general categories:

- 5 • No further characterization required
- 6 • Further characterization needed under other programs (CVP or remaining site verification package;
7 not the RI/FS)
- 8 • Further characterization indicated under the 100-N Decision Unit RI/FS

9 To establish which sites to consider for further soil characterization under the 100-N Decision Unit RI/FS,
10 waste sites or facilities previously remediated and interim closed and possessing the following
11 characteristics, were identified:

- 12 • Historically affected groundwater quality
- 13 • Evidence of deep soil contamination
- 14 • In or near high concentration groundwater plumes
- 15 • Low volumes of high concentration liquids were disposed
- 16 • Possible data needs were identified in the systematic planning workshop

17 The data and information available for sites with the above characteristics were reviewed and evaluated
18 by subject matter experts in contaminant fate and transport, site remediation, risk assessment, and
19 environmental modeling. Based on the evaluation, no sites were identified for further soil characterization
20 to address CSM uncertainties regarding contaminant distribution in the vadose zone and groundwater
21 protection. Excavation and removal of the waste sites, followed by cleanup verification package sampling
22 and analyses along with previous borehole characterization data eliminate the need for additional drilling.

23 *Data Need #3: Characterize waste sites around the reactor structure to assess nature and extent of*
24 *contamination in the vadose zone.*

25 **Data Need Description:** Data are needed to determine the nature and vertical extent of contamination in
26 the vadose zone around reactor structures (105-N Reactor and 109-N Heat Exchange Building).

27 This data need will be filled by obtaining verification data collected during remediation of waste sites
28 around and associated with the 105-N Reactor and the 109-N Heat Exchange Building. After cleanup
29 verification data are available to characterize these waste sites, evaluation will be performed to assess the
30 need for additional characterization. The need to determine the extent of contamination in the soils around
31 the 105-N Reactor and the 109 Heat Exchange Building will generally be guided by remedial action goals
32 for protection of groundwater and protection of the Columbia River.

33 *Data Need #4: Identify new waste sites and potential sources of contamination.*

34 **Data Need Description:** Complete orphan site evaluation process.

35 The orphan site evaluation process identifies new waste sites (i.e., discovery sites) and sources not in
36 CERCLA decision documents. The orphan site process has been performed for the 100-NR-1 OU and the
37 report is currently under regulatory review.

Table 4-5. Proposed 100-N Decision Unit Characterization

Type	100-N Area
Source sites scheduled for evaluation, characterization and or remediation*	93
New boreholes (vadose zone)	0
New wells (unconfined aquifer)	2
New wells into Ringold Upper Mud Unit	2
Sampling of monitoring wells (to support groundwater spatial/temporal uncertainty) 18	

*This task is not within the scope of the SAP. Source sites are being addressed according to DOE/RL-96-17 Remedial Design Report/Remedial Action Work Plan.

1

Table 4-6. Number of Field Samples and Analytes Proposed for the 100-N Decision Unit

Source	Soil Samples*	Groundwater Samples	Analytes
New boreholes (vadose zone)	NA	NA	NA
New wells (unconfined aquifer)	30	11	1404
New wells into Ringold B unit	20	16	1204
Sampling of monitoring wells (to support groundwater spatial/temporal uncertainty)	0	54	2268

NOTE: Table does not include field quality control or archive samples.

* Includes both chemical and physical property analyses.

2 *Data Need #2: Determine if the Sr-90 hot spot or petroleum is migrating, and the nature of the RUM.*

3 **Data Need Description:** See data needs 5 and 7.

4 The 100-N Areas characterization was performed as part of the LFI DOE/RL-93-80, 1995, *Limited Field*
 5 *Investigation Report for the 100-NR-1 Operable Unit Abatement Assessment*)and Corrective Measures
 6 Study (DOE/RL-95-111, 1997, *Corrective Measures Study for 100-NR-1 and 100-NR-2 Operable Units*).
 7 Several boreholes have been sampled and the soil analyzed to assess subsurface conditions in the vadose
 8 zone. Contaminant data are available from interim remedial actions. Most contaminant data from the
 9 vadose zone were collected from depths no greater than 11 m (35 ft) bgs, with few exceptions.

1 **4.4.2 100-N Area Data Needs – Groundwater**

2 Data needs specific to groundwater are identified and described in this section.

3 *Data Need #5: Define additional groundwater needs to support groundwater remediation decisions.*

4 **Data Need Description:** Drill and sample two new groundwater monitoring wells to determine the nature
5 and extent of contamination and rate of movement at the Sr-90 hot spot and characterize petroleum
6 contamination near the 166-N Facility. Eighteen existing groundwater monitoring wells shall also be
7 sampled to assess the nature and extent of groundwater contamination. (See Gap #13).

8 Groundwater monitoring Well 1 (Figure 4-26) will be installed and used to define the extent of the Sr-90
9 “hot spot” (concentration of Sr-90 in groundwater greater than 1000 times the MCL) adjacent to and
10 downgradient of 116-N-1. This well would also provide information on the rate of movement of this hot
11 spot that may provide information important to potential remediation decisions.

12 Groundwater monitoring Well 2 (Figure 4-26) is planned to define the nature and extent of contamination
13 relating to diesel fuel spills.

14 Eighteen existing wells will be sampled for three rounds and analyzed to assess COCs not sufficiently
15 sampled during past sampling events.

16 **Justification:** Well 1 is needed to define the extent of Sr-90 “hot spot” in the direction of the groundwater
17 flow and verify the assumption the plume is not moving. Its planned location is adjacent to and
18 downgradient of the existing 116-N-1 Wells (199-N-67 and 199-N-69). These existing wells currently
19 exhibit elevated Sr-90 concentrations (greater than 8,000 pCi/L or more than 1,000 times the MCL).

20 Well 2 will be downgradient of the petroleum leak site (166-N Tank Farm) and will define the scope and
21 support potential remediation for the petroleum plume. Existing wells in the decision unit have not been
22 consistently sampled for hexavalent chrome, petroleum, and tritium. Additional data are needed from
23 existing and planned wells to define the extent of these contaminants in groundwater.

24 *Data Need #6: Estimate the level of groundwater contamination entering the river.*

25 **Data Need Description:** Groundwater contamination at N Springs and the N Area has been studied and
26 modeled (Connelly et al) since the beginning of N Reactor Operations. More recently, aquifer tubes have
27 been added to support estimates of the level of groundwater contamination entering the river. Sampling
28 should be continued and performed monthly to address changes over time and the effect of changes in
29 river stage. Direct measurement of groundwater upwelling is recommended and planned under programs
30 outside this addendum. Upwelling studies are currently scheduled to be completed in FY 2010. The scope
31 of these activities are documented in the upwelling study report (DOE/RL-2008-11, 2008, Draft A,
32 *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River*).

33 *Data Need #7: Confirm the RUM is an aquitard and that flow and contaminant transport is minimal as*
34 *expected by the CSM.*

35 **Data Need Description:** Data from one existing well indicates there is contamination in a sand layer of
36 the RUM above DWS (total chromium in Well 199-N-80). The nearly 70 ft thick silt unit is generally
37 considered to possess low transmissivity. However, sand lenses/pockets are known to exist and can be
38 highly transmissive. Very limited information is available to assess the lithology, soil properties, and
39 vertical extent of contamination in this unit.

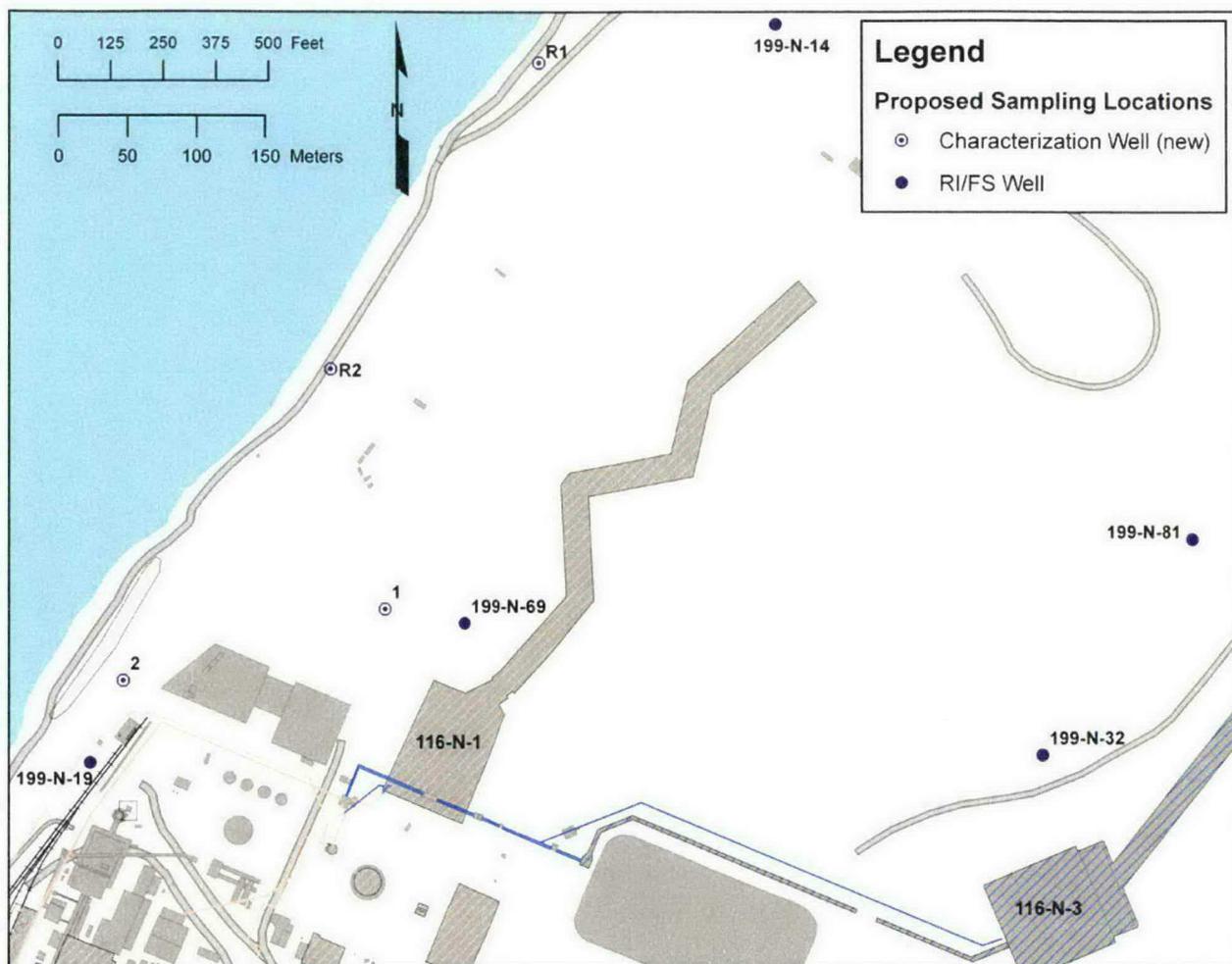


Figure 4-26. Well Drilling Location Map

1
2
3 The RUM unit is considered an aquitard where the integrity and potential transport mechanisms have not
4 been evaluated in the 100-N Area. The RUM groundwater may potentially discharge to aquatic receptors,
5 or portions may be technically considered an aquifer capable of a drinking water resource. Data collection
6 is planned to further define the extent of potential contamination in the RUM, better define its lithology,
7 and support fate and transport evaluations.

- 8 • Two wells are proposed (R1, and R2, Figure 4-26) and will be drilled approximately 15.24 m (50 ft)
9 into the RUM, then completed as groundwater monitoring wells. The monitoring wells will be
10 completed in the first water-producing unit within the RUM. Water samples will be collected from
11 within RUM water producing units. Soil collection (split-spoons) will begin at the base of the
12 unconfined aquifer, immediately on drilling into the RUM, and at two additional locations within the
13 RUM outside any producing zone. Details of the data collection and sampling can be found in the
14 SAP in DOE/RL-2009-42.

15 Water samples will be analyzed for all groundwater COPCs. Soil samples will be analyzed as follows:

- 16 • Soil property information (e.g., density, porosity, and sieve fraction, permeability) will be collected.
17 • Analytes, including CrVI, total chromium, metals, and radionuclides, will be collected from
18 a distilled water leach and from the soil fraction.

- 1 One split-spoon samples will be collected from each of the monitoring wells proposed in Data Need #4,
2 from the upper 1.5 m (5 ft) of the RUM, to address spatial variability of hydraulic properties of the RUM.
- 3 *Data Need #8: The information needed to address data gap # 8 is addressed in data need #7.*
- 4 *Data Need #9: This was determined as not applicable for the 100-N Decision Unit.*
- 5 *Data Need #10: The distribution of petroleum contamination in the vadose and groundwater is*
6 *insufficiently known to support final remedial decisions at the N Tank.*
- 7 **Data Need Description:** A single new groundwater well is planned to be drilled with samples collected
8 during drilling (Well 2, Figure 4-26). Details of the data collection and sampling are presented in the
9 SAP, DOE/RL-2009-42.
- 10 *Data Needs #11 and #12: These were determined as not applicable for the 100-N Decision Unit.*
- 11 *Data Need #13: Collect and analyze groundwater samples from 4 planned and 18 existing groundwater*
12 *monitoring wells.*
- 13 **Data Need Description:** Additional groundwater data are needed as spatially representative of the
14 decision unit, reflects river stage influence, and includes groundwater COPCs.
- 15 Collect and analyze groundwater samples from 18 monitoring wells to characterize the spatial, temporal,
16 and chemical extent of groundwater contamination. Wells are shown in Figure 4-27. Sampling details are
17 found in the SAP (DOE/RL-2009-42).

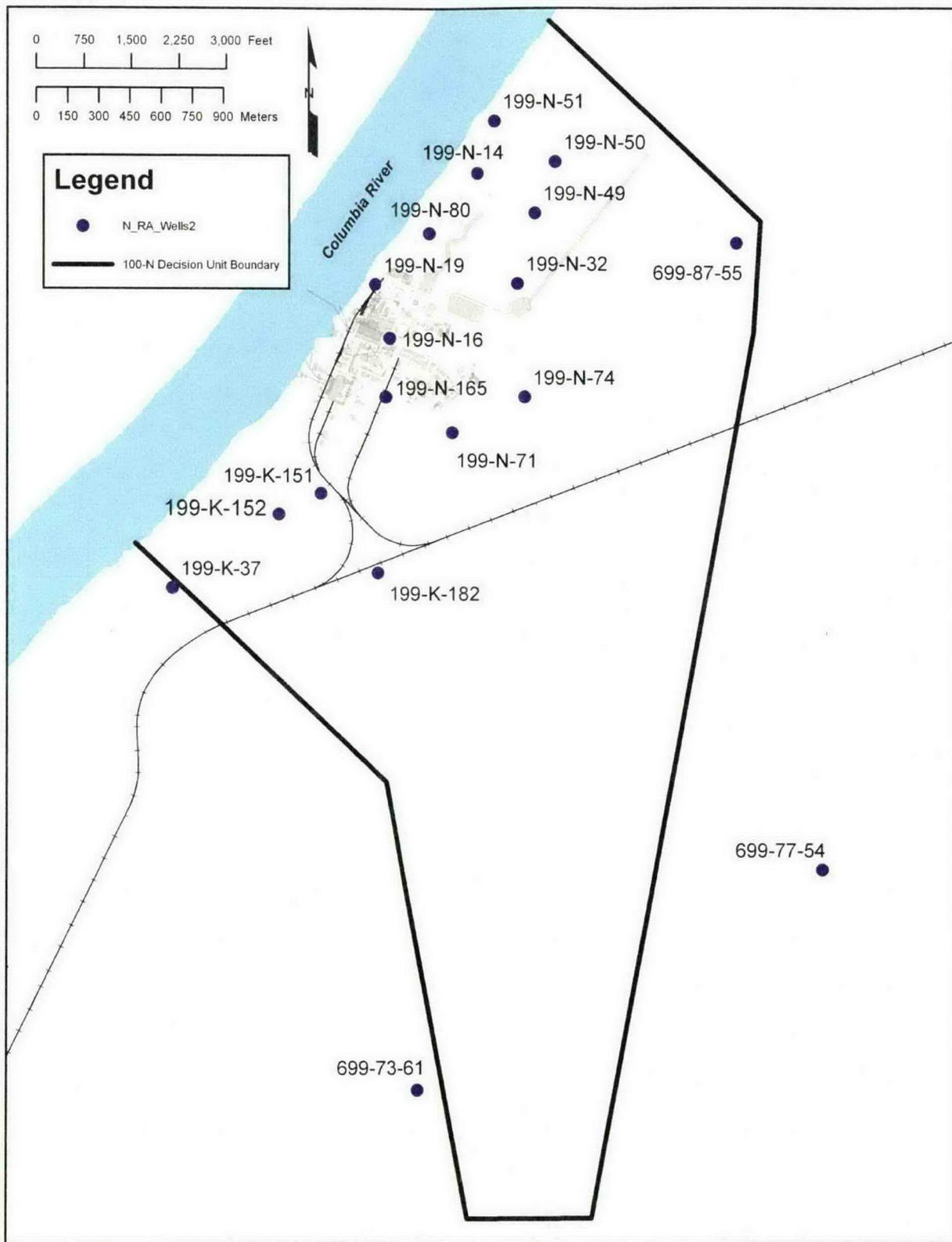


Figure 4-27. 100-N Decision Unit Groundwater RI/FS Sampling Locations

1
2
3

5 Project Schedule

1
2 The project schedule for activities discussed in this addendum is shown in Figure 5-1. This schedule will
3 serve as the baseline for the work planning process and used to measure the implementation progress.
4 Milestones associated with the activities described in this addendum are provided in the work plan
5 (DOE/RL-2008-46). Updates to the project schedule will be reflected in the annual work planning process
6 and are not anticipated to require a revision to this addendum.

6 References

- 1
2 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B,
3 "National Priorities List," Code of Federal Regulations. Available at:
4 http://edocket.access.gpo.gov/cfr_2008/julqtr/pdf/40cfr300AppB.pdf.
- 5 Advanced Sciences, Inc. (ASI), 1994. GIS Electronic Map Files. Prepared for U.S. Department of Energy.
6 San Diego, California. July.
- 7 *Atomic Energy Act of 1954 (AEA)*, 42 USC 2011 et seq. Available at:
8 <http://www.law.cornell.edu/uscode/42/2011.html>.
- 9 Atomic Energy Commission (AEC), 1968, Drawing H-1-37675: Piping Plan & Sections, U.S. Atomic
10 Energy Commission, Richland Operation Office, Hanford Engineering Services,
11 Richland, Washington.
- 12 BHI-00054, 1994, *Qualitative Risk Assessment for the 100-NR-1 Source Operable Unit*, Rev. 00, Bechtel
13 Hanford Inc., Richland, Washington. Available at:
14 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196064153>.
- 15 BHI-00055, 1994, *Qualitative Risk Assessment for the 100-NR-2 Source Operable Unit*, Rev. 00, Bechtel
16 Hanford Inc., Richland, Washington. Available at:
17 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196064152>.
- 18 BHI-00127, 1995, *100-H Area Technical Baseline Report*, Rev. 0, Bechtel Hanford Inc., Richland,
19 Washington. Available at:
20 <http://www2.hanford.gov/arpir/?content=findpage&AKey=D196035437>.
- 21 BHI-00185, 1995, *Technical Reevaluation of the N-Springs Barrier Wall*, Rev. 0-A, Bechtel Hanford
22 Inc., Richland, Washington. Available at:
23 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196004296>.
- 24 BHI-00221, 1994, *Pre-existing Conditions Survey of Hanford Site Facilities to be Managed by Bechtel*
25 *Hanford Inc.*, BHI-00221, Bechtel Hanford Inc., Richland, Washington.
- 26 BHI-00368, 1996, *Data Quality Objectives Workshop Results for 1301-N and 1325-N Characterization*,
27 Rev. 0, Bechtel Hanford Inc., Richland, Washington. Available at:
28 <http://www5.hanford.gov/arpir/?content=detail&AKey=D197189687>.
- 29 BHI-00540, 1995, *Sample Collection and Sample Analysis Plan for the Characterization of the*
30 *1300-N Emergency Dump Basin*, BHI-00540, Bechtel Hanford, Inc., Richland, Washington.
- 31 BHI-00606, 1996, *Final Report for the 1304-N Emergency Dump Tank Dose Reduction*, BHI-00606,
32 Bechtel Hanford Inc., Richland, Washington.
- 33 BHI-00627, 1996, *Hanford Site N Reactor Buildings Task Identification and Evaluation of Historic*
34 *Properties*, BHI-00627, Bechtel Hanford Inc., Richland, Washington.
- 35 BHI-00731, 1996, *Disposal of Sediments from the 1300-N Emergency Dump Basin*, Rev. 1, BHI-00731,
36 Bechtel Hanford Inc., Richland, Washington.
- 37 BHI-00785, 1996, *Engineering Evaluation/Cost Analysis for 100-N Area Waste*, BHI-00785, Bechtel
38 Hanford Inc., Richland, Washington.

- 1 BHI-00787, 1996, *In situ Treatability Test Planning Workshop Report*, Rev. 0, Bechtel Hanford Inc.,
2 Richland, Washington.
- 3 BHI-00981, 2002, *ERC Hazard Classification Matrices for Above-Ground Structures and Groundwater*
4 *and Soil Remediation Activities*, Rev. 4, BHI-00981, Bechtel Hanford Inc.,
5 Richland, Washington.
- 6 BHI-01092, 1999, *100-NR-1 Treatment, Storage, and Disposal Units Engineering Study*,
7 Rev. 1, BHI-01092.
- 8 BHI-01204, 1998, *N Area Skyshine Dose Evaluation*, Bechtel Hanford Inc, Richland Washington.
- 9 BHI-01271, 1999, *Data Summary Report for 116-N-1 and 116-N-3 Facility Soil Sampling to Support*
10 *Remedial Design*, Rev. 0, Bechtel Hanford Inc., Richland, Washington.
- 11 BHI-01324, 2000, *“Technical Memorandum for the 100-N Area ITRD Bank Stabilization Evaluation”*,
12 S. E. Parnell, PE and T. M. Routt, Bechtel Hanford Incorporated, Richland, Washington.
- 13 BHI-01324, 2000, *Technical Memorandum for the 100-N Area Innovative Treatment Remediation*
14 *Demonstration (ITRD) Bank Stability Evaluation*, Bechtel Hanford, Inc.,
15 Richland, Washington.
- 16 BHI-01648, 2004, *“Late Pleistocene and Holocene-Age Columbia river Sediments and Bedforms:*
17 *Hanford Reach Area, Washington Part 1 – Geologic Atlas Series”*, K.R. Fecht, B.N.
18 Bjornstad, D.G. Horton, G.V. Last, T.E. Marceau, R.E. Peterson, S.P. Reidel, and M.M.
19 Valenta, Bechtel Hanford Incorporated, Richland, Washington.
- 20 BHI-01725, 2004, *Final Hazard Categorization and Auditable Safety Analysis for the 107-N*
21 *Decontamination and Decommissioning Activities*, BHI-01725, Bechtel Hanford Inc.,
22 Richland, Washington.
- 23 BNWL-CC-208, 1965, *Adsorption, Migration and Dispersion of Strontium and Cesium in an*
24 *N-Area Soil*, BNWL-CC-208, Battelle Northwest Pacific Northwest Laboratories,
25 Richland, Washington.
- 26 BNWL-CC-2326, 1969, *Analysis of Travel Time of I-131 From the 1301-N Crib to the Columbia River*
27 *During July 1969*, BNWL-CC-2326, Battelle Northwest Pacific Northwest Laboratories,
28 Richland, Washington.
- 29 Bower, H. and R.C. Rice, 1976. “A slug test method for determining hydraulic conductivity of
30 unconfined aquifers with completely or partially penetrating wells,” *Water Resources*
31 *Research*, vol. 12, no. 3, pp. 423-428.
- 32 Bower, H., 1989, “The Bower and Rice slug test--an update,” *Ground Water*, vol. 27, no. 3,
33 pp. 304-309.
- 34 CCN 113663, 2005, “105-N Reactor Building and 109-N Heat Exchanger Building Action
35 Memorandum,” approved February 22, 2005, Washington State Department of Ecology and
36 U.S. Department of Energy, Richland, Washington.
- 37 CCN 119850, 2005, *105-N Reactor Building and 109-N Heat Exchanger Building Action Memorandum*,
38 approved February 22, 2005, Washington State Department of Ecology and U.S. Department
39 of Energy, Richland, Washington.

- 1 CCN 122923, 2005, Interoffice Memorandum, re: "Characterization Summary Report for the 151-N and
2 153-N Electrical Substations, 119-N Exhaust and 119-N Stack Air Monitoring Buildings,
3 1313-N Change Control Building, and 181-NC Sample Stack," Washington Closure Hanford,
4 Richland, Washington.
- 5 CCN 125295, 2005, Interoffice Memorandum, re: "Historical Site Assessment for 1303-N Spacer Silos,"
6 Washington Closure Hanford, Richland, Washington.
- 7 CCN 127193, 2006, Interoffice Memorandum re: "Historical Site Assessment for 117-NVH
8 (117-N Valve House)," Washington Closure Hanford, Richland, Washington.
- 9 CCN 128270, 2006, Interoffice Memorandum re: "Post Demolition Summary Report for the 119-N Air
10 Sampling Monitor and the 119-NA Air Sampling and Monitoring Facilities," Washington
11 Closure Hanford, Richland, Washington.
- 12 CCN 132235, 2007, Interoffice Memorandum re: "Post Demolition Summary Report for the 1313-N
13 Change Control Building," Washington Closure Hanford, Richland, Washington.
- 14 CCN 132236, 2007, Interoffice Memorandum re: "Post Demolition Summary Report for the 1314-N
15 Liquid Waste Loadout Station," Washington Closure Hanford, Richland, Washington.
- 16 CCN-055080, 1998, *N Basin Cleanup Criteria*, Letter dated February 24, 1998, from T.E. Logan/BHI to
17 P.M. Pak/DOE/RL, Bechtel Hanford, Inc., Richland, Washington.
- 18 CH2M HILL, 2004, *Evaluation of Strontium-90 Treatment Technologies for the 100-NR-2 Groundwater
19 Operable Unit*.
- 20 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
21 Available at: http://www4.law.cornell.edu/uscode/42/usc_sec_42_00009601----000-.html.
- 22 Confederated Tribes of the Umatilla Indian Reservation, 2006, *Investigation of Preferential Ground
23 Water Flow Pathways in the 100-NR-2 Area Hanford Site*, prepared by the Department of
24 Science and Engineering for the U.S. Department of Energy, Pendleton, Oregon.
- 25 Connelly, 2004, *Strontium-90 Transport in the Near River Environment at the 100-N Area*, prepared for
26 Sandia National Laboratory for the ITRD), Rev. 0, HydroGeoLogic, Inc.,
27 Herndon, Virginia.
- 28 CVP-2000-00027, 2001, *Cleanup Verification Package for the 116-H-7 Retention Basin*, Bechtel Hanford
29 Inc., Richland, Washington.
- 30 CVP-2001-00020, 2001, *Cleanup Verification Package for the Soil Column of the 120-N-1 and 120-N-2
31 Dangerous Waste Treatment and Disposal Sites and the 100-N-58 Site*, CVP-2001-00020,
32 Bechtel Hanford, Inc., Richland, Washington.
- 33 CVP-2002-00002, 2002, *Cleanup Verification Package/Clean Closure Report for the Soil Column of the
34 116-N-3 Trench and 100-N-63:1 Pipeline*, CVP-2002-00002, Bechtel Hanford, Inc.,
35 Richland, Washington.
- 36 CVP-2006-00004, 2006, *Cleanup Verification Package/Clean Closure Report for the Soil Column of the
37 116-N-1 Crib and Trench*, Rev. 1, Washington Closure Hanford, LLC, Richland, Washington.
- 38 CVP-99-00007, 2000, *Cleanup Verification Package for the 116-D-7 Retention Basin*, Bechtel Hanford
39 Inc., Richland, Washington.

- 1 DOE, 2001, *Hanford 100-N Area Remediation Options Evaluation Summary Report*, U.S. Department of
2 Energy, Washington, D.C. Available at:
3 <http://www5.hanford.gov/arpir/?content=detail&AKey=D9003794>.
- 4 DOE, 2008, www.em.doe.gov/pdfs/Groundwater_Booklet-2008.pdf, U.S. Department of Energy,
5 Washington, D.C.
- 6 DOE/RL, 2007, *Tri-Party Agreement Handbook Management Procedures, RL-TPA-90-0001, Guideline*
7 *Number TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," Rev. 1,*
8 U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- 9 DOE/RL-2000-07, 2002, *Sampling and Analysis Plan for the 100-NR-1 Treatment, Storage, and Disposal*
10 *Units During Remediation and Closeout*, Rev. 1, U.S. Department of Energy, Richland
11 Operations Office, Richland, Washington. Available at:
12 <http://www5.hanford.gov/arpir/?content=detail&AKey=D9002793>.
- 13 DOE/RL-2000-16, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment,*
14 *Storage, and Disposal Units*, U.S. Department of Energy, Richland Operations Office,
15 Richland, Washington. Available at:
16 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D8342118>.
- 17 DOE/RL-2001-04, 2001, *Annual Summary Report Calendar Year 2000 for the 100-HR-3, 100-KR-4, and*
18 *100-NR-2 Pump-and-Treat Operations*, DOE/RL-2001-04, Prepared by CH2M HILL
19 Hanford, Inc. for U.S. Department of Energy, Richland, Washington.
- 20 DOE/RL-2001-27, 2002, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2*
21 *Operable Unit*, DOE/RL-2001-27 Rev. 0, U.S. Department of Energy, Richland Operations
22 Office, Richland, Washington.
- 23 DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for the Post-Ringold-Formation*
24 *Sediments within the Central Pasco Basin*, DOE/RL-2002-39, Rev. 0, U.S. Department of
25 Energy, Richland Operations Office, Richland, Washington.
- 26 DOE/RL-2004-15, 2004, *Waste Characterization and Sampling and Analysis Plan for 107-N Basin*
27 *Recirculation/Cooling Facility, 1310-N Pump House and Liquid Storage Tank, and 1314-N*
28 *Liquid Waste Loadout Complex*, DOE/RL-2004-15, U.S. Department of Energy, Richland
29 Operations Office, Richland, Washington.
- 30 DOE/RL-2004-37, 2005, *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the*
31 *RCBRA*, DOE-RL-2004-37 Rev. 2, U.S. Department of Energy, Richland Operations Office,
32 Richland, Washington.
- 33 DOE/RL-2005-18, 2005, *Calendar Year 2004 Annual Summary Report for the 100-HR-3, 100-KR-4 and*
34 *100-NR-2 Operable Unit Pump-and-Treat Operations*, DOE/RL-2005-18 Rev. 0, U.S.
35 Department of Energy, Richland Operations Office, Richland, Washington.
- 36 DOE/RL-2005-40, 2006, *100-B/C Pilot Project Risk Assessment Report*, Draft B, U.S. Department of
37 Energy, Richland Operations Office, Richland, Washington. Available at:
38 <http://www5.hanford.gov/arpir/?content=detail&AKey=DA01944866>.
- 39 DOE/RL-2005-45, 2005, *Surplus Reactor Final Disposition Engineering Evaluation*, DOE-RL-2005-45,
40 U.S. Department of Energy, Richland Operations Office, Richland, Washington.

- 1 DOE/RL-2005-49, 2005, *RCBRA Stack Air Emissions Deposition Scoping Document*, Rev. 0,
2 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
3 <http://www5.hanford.gov/arpir/?content=detail&AKey=DA01649842>.
- 4 DOE/RL-2005-93, 2005, *Remedial Design Report/Remedial Action Work Plan for the 100-N Area*,
5 Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
6 Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=DA04193451>.
- 7 DOE/RL-2005-96, 2006, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater OU*, Rev. 0,
8 Reissue, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
9 Available at: <http://www5.hanford.gov/arpir/?content=detail&AKey=DA02781523>.
- 10 DOE/RL-2006-20, Rev. 1. *Comprehensive Environmental Response, Compensation, and Liability Act of*
11 *1980*, 42 USC 9601, et seq. Available at:
12 http://www4.law.cornell.edu/uscode/42/uscode_sec_42_00009601----000-.html.
- 13 DOE/RL-2006-26, Rev. 1, Reissue, *Aquatic and Riparian Receptor Impact Information for the 100-NR-2*
14 *Groundwater Operable Unit*, U.S. Department of Energy, Richland Operations Office,
15 Richland, Washington.
- 16 DOE/RL-2007-21, 2007, *Risk Assessment Report for the 100 Area and 300 Area, Draft A*,
17 DOE/RL-2007-21, Draft A, U.S. Department of Energy, Richland Operations Office,
18 Richland, Washington.
- 19 DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring Report for Fiscal Year 2007*, Rev. 0,
20 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
21 <http://www.hanford.gov/cp/gpp/library/gwrep07/html/start07.htm>.
- 22 DOE/RL-2008-05, 2008, *Calendar Year 2007 Annual Summary Report for the 100-HR-3, 100-KR-4, and*
23 *100-NR-2 Operable Unit Pump-and-Treat Operation*, Rev. 0, U.S. Department of Energy,
24 Richland Operations Office, Richland, Washington. Available at:
25 <http://www2.hanford.gov/arpir/?content=findpage&AKey=0807090160>.
- 26 DOE/RL-2008-05, Rev. 0. 2008. Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable
27 Unit Pump-and-Treat Operation. Piepho, M.G., J.L. Smoot, H.L. Anastos, R.S. Edrington,
28 M.J. Hartman, G.G. Kelty, and R.F. Raidl, U.S. Department of Energy, Richland, Washington.
- 29 DOE/RL-2008-11, 2008, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia*
30 *River*, Draft A, U.S. Department of Energy, Richland Operations Office,
31 Richland, Washington.
- 32 DOE/RL-2008-11, 2008, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia*
33 *River*, Draft A, Washington Closure Hanford, Richland, Washington.
- 34 DOE/RL-2008-46, 2009, pending, *Integrated 100 Area Remedial Investigation/Feasibility Study Work*
35 *Plan*, DOE/RL-2008-46, Draft A, U.S. Department of Energy, Richland Operations Office,
36 Richland, Washington.
- 37 DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring Report for Fiscal Year 2008*, Rev. 0,
38 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
39 <http://www.hanford.gov/cp/gpp/library/gwrep08/>.
- 40 DOE/RL-2008-66, 2009. Hanford Site Groundwater Monitoring for Fiscal Year 2008. Hartman, M.J.,
41 J.A. Rediker, and V.S. Richie, editors, U.S. Department of Energy, Richland, Washington.

- 1 DOE/RL-2009-42, 2009, pending, *Sampling and Analysis Plan for the 100-N Decision Unit Remedial*
2 *Investigation/Feasibility Study*, U.S. Department of Energy, Richland Operations Office,
3 Richland, Washington.
- 4 DOE/RL-2009-44, pending, *Sampling and Analysis Plan for the 100-BC Decision Unit Remedial*
5 *Investigation/Feasibility Study*, U.S. Department of Energy, Richland Operations Office,
6 Richland, Washington.
- 7 DOE/RL-80-63
- 8 DOE/RL-90-22, 1996, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the*
9 *100-NR-1 Operable Unit*, Rev. 0, U.S. Department of Energy-Richland Operations Office,
10 Hanford Site, Richland, Washington. Available at:
11 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196119051>.
- 12 DOE/RL-91-40, 1991, *Hanford Past Practice Strategy*, DOE-RL-91-40 Rev. 0, U.S. Department of
13 Energy, Richland Operations Office, Richland, Washington.
- 14 DOE/RL-92-11, 1994, *100 Area Feasibility Study, Phases 1 and 2*, DOE/RL-92-11, Rev. 0, U.S.
15 Department of Energy, Richland, Washington.
- 16 DOE/RL-92-23, 1992, *Hanford Site Groundwater Background*, DOE-RL-92-23, U.S. Department of
17 Energy, Richland Operations Office, Richland, Washington.
- 18 DOE/RL-93-80, 1995, *Limited Field Investigation Report for the 100-NR-1 Operable Unit Abatement*
19 *Assessment*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland,
20 Washington. Available at:
21 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196022762>.
- 22 DOE/RL-93-80, 1995, *Limited Field Investigation Report for the 100-NR-1 Operable Unit Abatement*
23 *Assessment*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland,
24 Washington.
- 25 DOE/RL-93-81, 1995, *Limited Field Investigation Report for the 100-NR-2 Operable Unit Hanford Site,*
26 *Richland, Washington*, Rev. 0, U.S. Department of Energy, Richland Operations Office,
27 Richland, Washington. Available at:
28 <http://www2.hanford.gov/arpir/?content=findpage&AKey=D196022787>.
- 29 DOE/RL-94-132, 1994, *Letter Report for Modeling Evaluation of N-Springs Barrier and Pump-and-Treat*
30 *Systems*, DOE/RL-94-132, Draft A, U.S. Department of Energy, Richland Operations Office,
31 Richland, Washington.
- 32 DOE/RL-94-61, 1994, *Remedy Selection Process for Remaining 100 Area Source Operable Unit Waste*
33 *Sites*, DOE/RL-94-61, Appendix N, Draft A, U.S. Department of Energy, Richland Operations
34 Office, Richland, Washington.
- 35 DOE/RL-95-110, 1996, *N-Springs Expedited Response Action Performance Evaluation Report*,
36 DOE/RL-95-110, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland,
37 Washington.
- 38 DOE/RL-95-111, 1997, *Corrective Measures Study for 100-NR-1 and 100-NR-2 Operable Units*, Rev. 0,
39 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
40 <http://www5.hanford.gov/arpir/?content=detail&AKey=D198056722>.

- 1 DOE/RL-96-11, 1996, *1301-N and 1325-N Liquid Waste Disposal Facilities Limited Field Investigation*
2 *Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland,
3 Washington. Available at:
4 <http://www5.hanford.gov/arpir/?content=detail&AKey=D197046154>.
- 5 DOE/RL-96-17, 2004, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5,
6 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
7 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D6542354>.
- 8 DOE/RL-96-22, 2005, *100 Area Remedial Action Sampling and Analysis Plan*, DOE-RL-96-22 Rev. 4,
9 U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- 10 DOE/RL-96-39, 2002, *100-NR-1 TSD Units Corrective Measures Study/Closure Plan*, Rev. 1,
11 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
12 <http://www5.hanford.gov/arpir/?content=detail&AKey=D9039847>.
- 13 DOE/RL-96-84, 2003, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4*
14 *Groundwater Operable Units Interim Action*, Rev. 0-A, U.S. Department of Energy, Richland
15 Operations Office, Richland, Washington. Available at:
16 <http://www2.hanford.gov/arpir/?content=findpage&AKey=D1348764>.
- 17 DOE/RL-96-84, Rev. 0A. 2003. Remedial Design and Remedial Action Work Plan for the 100-HR-3 and
18 100-KR-4 Groundwater Operable Units' Interim Action. Raidl, R.F., U.S. Department of
19 Energy, Richland, Washington.
- 20 DOE/RL-97-1047, 2002, *The Hanford Site Historic District - Manhattan Project 1943 - 1946, Cold War*
21 *Era 1947 - 1990*, DOE/RL-97-1047, Rev. 0, U.S. Department of Energy, Richland Operations
22 Office, Richland, Washington.
- 23 DOE/RL-97-22, 1997, *Engineering Evaluation/ Cost Analysis for the 100-N Area Ancillary Facilities and*
24 *Integration Plan*, DOE/RL-97-22 Rev. 1, U.S. Department of Energy, Richland Operations
25 Office, Richland, Washington.
- 26 DOE/RL-97-30, 1998, *Proposed Plan for Interim Remedial Action and Dangerous Waste Modified*
27 *Closure of the Treatment, Storage and Disposal Units and Associated Sites in the 100-NR-1*
28 *Operable Unit*, DOE/RL-97-30 Rev. 0, U.S. Department of Energy, Richland Operations
29 Office, Richland, Washington.
- 30 DOE/RW-0017, 1984, *Nuclear Waste Policy Act of 1984*, DOE/RW-0017, Environmental Assessment:
31 Reference Repository Location, Hanford Site, Washington, U.S. Department of Energy,
32 Washington, D.C. Available at:
33 http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=6033820.
- 34 DOE\RL-93-23. 1994. N-Springs Expedited Response Action (ERA) Proposal. January.
- 35 DOE-RL 2005-96, Rev. 0, Reissue, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater*
36 *Operable Unit*, U.S. Department of Energy, Richland Operations Office, Richland,
37 Washington.
- 38 DOE-RL-1997. N-Springs Pump and Treat Optimization Study.
- 39 DUN-3063, 1967, *Underground Radioactive Materials at 100-D Plant*, DUN-3063, Douglas United
40 Nuclear, Richland, Washington.

- 1 DUN-4668, 1968, *Chemicals Discharged to the Columbia River from DUN Facilities Fiscal Year 1968*,
2 DUN-4668, Douglas United Nuclear, Inc., Richland, Washington.
- 3 DUN-4847, 1968, *Quarterly Report Contamination Control—Columbia River April - June 1968*,
4 DUN-4847, Douglas United Nuclear, Inc., Richland, Washington.
- 5 DUN-6205
- 6 DUN-6463, 1968, *Dichromate Evaluation*, Douglas United Nuclear, Inc., Richland, Washington.
- 7 DUN-7162
- 8 DuPont, 1945, *Construction Hanford Engineer Works U. S. Contract No. W-7412-ENG-1, Dupont*
9 *Project 9536, History of the Project*, HW-10970, Vols. I and II, E. I. DuPont de Nemours &
10 Company, Richland, Washington.
- 11 Ecology and EPA, 1994, *Action Memorandum: N-Springs Expedited Response Action Cleanup Plan*,
12 U.S. Department of Energy Hanford Site, Richland, Washington.
- 13 Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order, 2 vols., as*
14 *amended*, Washington State Department of Ecology, U.S. Environmental Protection Agency,
15 and U.S. Department of Energy, Olympia, Washington.
- 16 Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*,
17 Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S.
18 Department of Energy, Olympia, Washington.
- 19 Energy Northwest, 2004, *Cleanup Verification Package for the Hanford Generating Plant UPR-100-N-37*
20 *Transformer Yard (SWMU #1), 100-N-51 Oil Storage Area (SWMU #2), 185-N Building*
21 *Drains and Sumps (SWMU #3), and 100-N-50 Turbine Oil Filter Unit (SWMU #4)*,
22 HGP-CVP-SWMUs 1, 2, 3, 4, Rev. 0, Energy Northwest Inc., Richland, Washington.
- 23 Energy Northwest, 2004, *Cleanup Verification Package for the Hanford Generating Plant 100-N-4 Tile*
24 *Field (SWMU #5), 100-N-1 Settling Pond (SWMU #6), 1908-NE Outfall (SWMU #7), 1716-NE*
25 *Maintenance Garage (SWMU #8) and 100-N-52 Underground Storage Tank; 100-N-3*
26 *Maintenance Garage French Drain, 100-N-41 Gate House Septic Tank, and 100-N-45 Office*
27 *Building Septic Tank (SWMU #9); 100-N-5 Bone Yard (SWMU #10); and 100-N-46*
28 *Underground Storage Tank*, HGP-CVP-SWMUs 5, 6, 7, 8, 9 & 10 Rev. 0, Energy Northwest
29 Inc., Richland, Washington.
- 30 EPA 520/6-78-007, 1978, *Radionuclide Interactions with Soil and Rock Media Volume 1: Processes*
31 *Influencing Radionuclide Mobility and Retention Element Chemistry and Geochemistry*
32 *Conclusions and Evaluation*, Pacific Northwest Laboratories, Richland, Washington.
- 33 EPA/540/1-89/001, 1989, *Risk Assessment Guidance for Superfund, Volume II*, Environmental
34 Management Manual, Office of Emergency and Remedial Response, U.S. Environmental
35 Protection Agency, Washington, D.C.
- 36 EPA/540/1-89/002, 1989, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation*
37 *Manual, Parts A, B, and C*, Office of Emergency and Remedial Response, U.S. Environmental
38 Protection Agency, Washington, D.C.

- 1 EPA/541/R-99/112, 1999, *Interim Remedial Action Record of Decision for the 100-NR-1 and*
2 *100-NR-2 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental
3 Protection Agency, Washington State Department of Ecology, and U.S. Department of
4 Energy, Olympia, Washington. Available at: <http://www.epa.gov/superfund/sites/rods/>.
- 5 EPA/AMD/R10-00/122, 1999, *Amended Record of Decision for the U.S. Department of Energy Hanford*
6 *100-HR-3*, U.S. Environmental Protection Agency, Region 10, Olympia, Washington.
- 7 EPA/ESD/R10-03/605, *Explanation of Significant Difference for the 100-NR-1 Operable Unit Treatment,*
8 *Storage, and Disposal Interim Action Record of Decision and 100-NR-1/NR-2 Operable Unit*
9 *Interim Action Record of Decision, May 2003, Washington State Department of Ecology, and*
10 *U.S. Department of Energy*). Available at:
11 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D1589099>.
- 12 EPA/ROD/R10-00/121, 2000, *Interim Action Record of Decision, 100 Area Burial Grounds,*
13 U.S. Environmental Protection Agency, Region 10, Seattle, Washington.
- 14 EPA/ROD/R10-00-120, 2000, *Interim Remedial Action Record of Decision for the 100-NR-1 Operable*
15 *Unit of the Hanford 100-N Area, Hanford Site, Benton County, Washington*, U.S.
16 Environmental Protection Agency, Washington State Department of Ecology, and
17 U.S. Department of Energy, Seattle, Washington. Available at:
18 <http://www.epa.gov/superfund/sites/rods/>.
- 19 EPA/ROD/R10-99/112, 1999, *Interim Remedial Action Record of Decision for the 100-NR-1 and -NR-2*
20 *Operable Units of the Hanford 100-N Area*, U.S. Environmental Protection Agency, and
21 Washington State Department of Ecology, Olympia, Washington.
- 22 GE, 1961, Drawing H-1-28400: Plot Plan Filter Building Stack and Loading Area, U.S. Atomic Energy
23 Commission Hanford Atomic Products Operation, General Electric, Richland, Washington.
- 24 Geist, D. R. and D. D. Dauble, 1998, "Redd Site Selection and Spawning Habitat Use by Fall Chinook
25 Salmon: The Importance of Geomorphic Features in Large Rivers," *Environmental*
26 *Management*, 22:655-669.
- 27 Geist, D. R., 2000, "The Interaction of Ground Water and Surface Water Within Fall Chinook Salmon
28 Spawning Areas in the Hanford Reach of the Columbia River," In *Proceedings of the*
29 *Ground-Water/Surface-Water Interactions Workshop*, vol. EPA/542/R-00/007, pp. 95-98,
30 U.S. Environmental Protection Agency, Washington, D.C.
- 31 Gerber, M. S., 2007, *On The Home Front: The Cold War Legacy Of The Hanford Nuclear Site, Third*
32 *Edition*, University of Nebraska Press, Lincoln and London, 2007.
- 33 HW-34499, 1955, *Adsorption and Retention of Strontium by Soils of the Hanford Project*, General
34 Electric Company, Richland, Washington.
- 35 HW-43066, 1966, *Metal Recovery Waste Scavenging Program History*, General Electric Company,
36 Richland, Washington. Available at:
37 <http://www5.hanford.gov/arpit/?content=findpage&AKey=D196029753>.
- 38 HW-56582, 1958, *Influence of Limestone Neutralization on the Soil Uptake of Sr-90 from a Radioactive*
39 *Waste*, General Electric Company, Richland, Washington.
- 40 HW-83918, 1964, *Construction Completion Report, CAI-816, 100-N Reactor Plant*, Hanford Atomic
41 Products Operation, Richland, Washington.

- 1 HydroGeoLogic, Inc., 1999, *Groundwater-River Interaction in the Near River Environment at the*
2 *100-N Area*, Prepared for Sandia National Laboratories by HydroGeoLogic, Inc.,
3 Herndon, Virginia.
- 4 HydroGeoLogic, Inc., 2004, *Strontium-90 Transport in the Near River Environment at the 100-N Area*,
5 Prepared for Sandia National Laboratories by HydroGeoLogic, Inc., Herndon, Virginia.
- 6 Moody, T.E., Ph.D., 1999, *The Use of Phosphatic Materials for Hanford N-Springs 90-Sr Stabilization*,
7 Final Report Phase I, M. Pulse Technology, Richland, Washington, Funded by Sandia
8 National Laboratories ITRD Division, December.
- 9 MSE-49, 2000, *Report on Strontium Mobilization using Potential Chemical Lixiviants at the Hanford*
10 *100-N Site*, MSE Technology Applications, Inc. 200 Technology Way, P.O. Box 4078, Butte,
11 MT 59702, Prepared for the Innovative Treatment Remediation Demonstration Project,
12 U.S. Department of Energy, Office of Environmental Restoration, Sandia National
13 Laboratories, Contract #5364, May.OSR-2009-0001, 2009, pending, *100-NR-1 Area Orphan*
14 *Sites Evaluation Report*, Draft A, Washington Closure Hanford LLC, Richland Washington.
- 15 PNL-10899, 1996, *Strontium-90 Adsorption-Desorption Properties and Sediment Characterization at the*
16 *100 N-Area*, Pacific Northwest Laboratory, Richland, Washington.
- 17 PNL-6456, 1988, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*, 3
18 vols., Pacific Northwest Laboratory, Richland, Washington. Available at:
19 www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0041/D196006954/D196006954_2395.pdf.
- 20 PNL-7008, 1980, *Resource Book – Decommissioning of Contaminated Facilities at Hanford*, Revision 3,
21 Battelle Pacific Northwest Laboratory, Richland, Washington.
- 22 PNL-8337, 1992, *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site*
23 *Unconfined Aquifer System*, Pacific Northwest Laboratory, Richland, Washington.
- 24 PNL-9437, 1994, *Monitoring Groundwater and River Interaction Along the Hanford Reach of the*
25 *Columbia River*, Pacific Northwest Laboratory, Richland, Washington.
- 26 PNL-9785, 1994, *Data Compendium for the Columbia River Impact Assessment*, Pacific Northwest
27 Laboratory, Richland, Washington.
- 28 PNNL, 2009, *100-NR-2 Apatite Treatability Test FY09 Status: High concentrations*
29 *Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*, Draft
30 Letter Report, Pacific Northwest Laboratory, Richland, Washington.
- 31 PNNL-10899, 1996, *Strontium-90 Adsorption-Desorption Properties and Sediment Characterization at*
32 *the 100-N Area*, Pacific Northwest Laboratory, Richland, Washington.
- 33 PNNL-11989, 2000, *Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project*,
34 Rev. 2, Pacific Northwest National Laboratory, Richland, Washington.
- 35 PNNL-13674, 2001, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia*
36 *River; Progress Report for the Groundwater/River Interface Task Science and Technology*
37 *Groundwater/Vadose Zone Integration Project*, Pacific Northwest National Laboratory,
38 Richland, Washington.
- 39 PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest
40 National Laboratory, Richland, Washington.

- 1 PNNL-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific
2 Northwest National Laboratory, Richland, Washington.
- 3 PNNL-16346, 2007, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, Pacific Northwest
4 National Laboratory, Richland, Washington. Available at:
5 <http://ifchanford.pnl.gov/pdfs/16346.pdf>.
- 6 PNNL-16891, 2007, *Hanford 100N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO4*
7 *Solution Injection and Sr-90 Immobilization in 100N Sediments*, Pacific Northwest National
8 Laboratory, Richland, Washington.
- 9 PNNL-17429, 2008, *100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate*
10 *Solution Injection for In Situ Strontium-90 Immobilization*, Pacific Northwest National
11 Laboratory, Richland, Washington. Available at:
12 <http://www.hanford.gov/docs/gpp/library/programdocs/PNNL17429.pdf>.
- 13 PNNL-17429, 2008. 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate
14 Solution Injection for In Situ Strontium-90 Immobilization. Williams, M.D., B.G. Fritz,
15 D.P. Mendoza, M.L. Rockhold, P.D. Thorne, Y. Xie, B.N. Bjornstad, R.D. Mackley,
16 D.R. Newcomer, J.E. Szecsody, and V.R. Vermeul, Pacific Northwest National Laboratory,
17 Richland, Washington.
- 18 PNNL-17603, 2008, *Hanford Site Environmental Report for Calendar Year 2007*, Pacific Northwest
19 National Laboratory, Richland, Washington.
- 20 PNNL-17674, 2008, *Geochemical Characterization of Chromate Contamination in the 100 Area Vadose*
21 *Zone at Hanford*, Pacific Northwest National Laboratory, Richland, Washington.
- 22 PNNL-18294, *100-N Area Strontium-90 Treatability Demonstration Project: Food Chain Transfer Studies*
23 *for Phytoremediation along the 100-N Columbia River Riparian Zone*. Pacific Northwest
24 National Laboratory, Richland, Washington.
- 25 PNNL-18645
- 26 PNNL-6415, 2007, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, Rev. 18,
27 Pacific Northwest National Laboratory, Richland, Washington.
- 28 PNNL-SA-53273, 2007, *Hanford Site Vadose Zone Studies: An Overview*, Pacific Northwest National
29 Laboratory, Richland, Washington.
- 30 PNWD-2222, 1994, *Radionuclide Release to the Atmosphere from Hanford Operations, 1944-1972*,
31 Battelle Pacific Northwest Laboratories, Richland, Washington.
- 32 Relander, C., 1956, *Drummers and Dreamers; The Story of Smowhala the Prophet and his Nephew Puck*
33 *Hyah Toot, the Last Prophet of the Nearly Extinct River People, the Last Wanapums*, Caxton
34 Printers, Caldwell, Idaho.
- 35 *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at:
36 <http://www4.law.cornell.edu/uscode/42/6901.html>.
- 37 Rice, D. G., 1968, *Archaeological Reconnaissance Hanford Atomic Works*, U.S. Atomic Energy
38 Commission, National Park Service, and Washington State University, Pullman, Washington.

- 1 Rickard, W. H., W. C. Hanson, R. E. Fitzner, 1982, "The Non-Fisheries Biological Resources of the
2 Hanford Reach of the Columbia River," *Northwest Science*, Vol. 56, No. 1.
- 3 RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures*, RL-TPA-90-0001,
4 Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System
5 (WIDS)," Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland,
6 Washington. Available at: <http://www.hanford.gov/hanford/files/TPA-MP14.pdf>.
- 7 RPP-26744, 2006, *Hanford Soil Inventory Model, Rev. 1*, Fluor Hanford, Inc., Richland, Washington.
- 8 SGW-35028, 2007, *Aquifer Sampling Tube Results for Fiscal Year 2007*, Rev. 0, Fluor Hanford, Inc.,
9 Richland, Washington.
- 10 SGW-39305, 2008, *Technical Evaluation of the Interaction of Groundwater with the Columbia River at
11 the Department of Energy Hanford Site, 100-D Area*, Rev. 0, , Fluor Hanford, Inc.,
12 Richland, Washington.
- 13 SIS, 2009, Stewardship Information System, Accessed January 6, 2009, Washington Closure Hanford,
14 Richland, Washington.
- 15 Studer, Jim, 2001, Technical Memorandum to Malcolm Siegel, Ph.D., *Preliminary Engineering Cost
16 Analysis of Hanford 100-N, Area Remediation Scenarios Developed by the ITRD Program*,
17 COMPANY, November 3.
- 18 UNI-158, 1974, *United Nuclear Industries, Inc. Reactor and Fuel Production Facilities 1973
19 Environmental Release Report*, United Nuclear Industries, Inc., Richland, Washington.
- 20 UNI-3533, 1987, *Closure/Post-Closure Plan for 1301-N and 1325-N Liquid Waste Disposal Facilities*,
21 UNI-3533, United Nuclear Industries, Inc., Richland, Washington.
- 22 UNI-3880, 1986, *United Nuclear Industries, Inc. Reactor and Fuel Production Facilities 1985
23 Environmental Release Report*, United Nuclear Industries, Inc., Richland, Washington.
- 24 UNI-74-25, 1974, *Leaking Check Valve-Emergency Dump Tank Bypass Line*, Occurrence Report
25 No. 74-25, United Nuclear Industries, Inc., Richland, Washington.
- 26 UNI-80-6, 1980, *Leak of Contaminated Liquid to Ground – 1-Inch FLV 858 Body Relief Line*, Occurrence
27 Report No. 80-6, United Nuclear Industries, Inc., Richland, Washington.
- 28 Vitro 1977, Drawing H-1-41123: Piping Plan & Sections, U.S. Energy Research and Development
29 Administration, Vitro Engineering Corporation, Richland, Washington.
- 30 WAC-173-340, *Model Toxics Control Act - Cleanup*, Washington Administrative Code, Olympia,
31 Washington. Available at: <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340>.
- 32 WCH-218, 2008, *Orphan Sites Evaluation Project Execution Plan*, Rev. 0, January, Washington Closure
33 Hanford LLC, Richland, Washington.
- 34 WCH-227, 2008, *Sampling and Analysis Instruction for Evaluation of the Distribution of Metals in the
35 Sediments at 128-F-2 Waste Site*, Washington Closure Hanford LLC, Richland Washington.
- 36 WCH-323, 2008, *Sampling and Analysis Instruction for Installation of UPR-100-N-17 Bioremediation
37 Wells and Performance of Bioventing Pilot Tests*, Rev. 0, Washington Closure Hanford LLC,
38 Richland Washington.

- 1 WCH-46, 2006, "*Late Pleistocene and Holocene-Age Columbia river Sediments and Bedforms: Hanford*
2 *Reach Area, Washington Part 2 – Geologic Atlas Series*", K.R. Fecht and T.E. Marceau,
3 Washington Closure Hanford, Richland, Washington.
- 4 WHC-EP-0369, 1991, Simulations of Strontium-90 Transport from the 100-N Area to the Columbia
5 River Using VAM2DH, Westinghouse Hanford Company, Richland, Washington.
- 6 WHC-EP-0477, 1991, *Facility Effluent Monitoring Plan for the N Reactor*, Westinghouse Hanford
7 Company, Richland, Washington.
- 8 WHC-EP-0478, 1991, *Summary of the Hanford Site Decontamination, Decommissioning, and Cleanup,*
9 *FY 1974 through FY 1990*, Westinghouse Hanford Company, Richland, Washington.
- 10 WHC-EP-0675, 1993, *Groundwater Impact Assessment Report for the 1325-N LWDF*, Rev. 0,
11 Westinghouse Hanford Company, Richland, Washington.
- 12 WHC-MR-0056, 1991, *WIDS Database Field Descriptions and Data*, Rev. 1, Westinghouse Hanford
13 Company, Richland, Washington.
- 14 WHC-MR-0521, 1996, *Plutonium Production Story at the Hanford Site: Processes and Facilities*
15 *History*, Westinghouse Hanford Company, Richland, Washington. Available at:
16 http://www.osti.gov/bridge/product.biblio.jsp?osti_id=664389.
- 17 WHC-SD-EN-EV-027 (used in first draft).
- 18 WHC-SD-EN-EV-027, 1993, *Hydrogeology of 100-N Area*, Rev. 0, Westinghouse Hanford Company,
19 Richland, Washington. Available at:
20 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196104589>.
- 21 WHC-SD-EN-TI-011, 1992, *Geology of Northern Part of Hanford Site Outline of Data Sources and*
22 *Geologic Setting of 100 Areas*, Rev. 0, Westinghouse Hanford Company, Richland,
23 Washington. Available at:
24 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196090817>.
- 25 WHC-SD-EN-TI-023 [erroneously written as "WCH-SD..." in my section!] 1992. Hydrologic
26 Information Summary for the Northern Hanford Site. Hartman, M.J. and R.E. Peterson,
27 Westinghouse Hanford Company, Richland, Washington.
- 28 WHC-SD-EN-TI-023, 1992, *Hydrologic Information Summary for the Northern Portion of the Hanford*
29 *Site*, Westinghouse Hanford Company, Richland, Washington.
- 30 WHC-SD-EN-TI-132, 1993, *Geologic Setting of 100-HR-3*, Rev. 0, , Westinghouse Hanford Company,
31 Richland, Washington. Available at:
32 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196126259>.
- 33 WHC-SD-EN-TI-239, 1994, *100-K Area Technical Baseline Report*, Rev. 0, Westinghouse Hanford
34 Company, Richland, Washington. Available at:
35 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196084907>.
- 36 WHC-SD-EN-TI-251, 1994, *100-N Area Technical Baseline Report*, Westinghouse Hanford Company,
37 Richland, Washington. Available at:
38 <http://www5.hanford.gov/arpir/?content=detail&AKey=D196229412>.

- 1 WHC-SD-ER-TA-001, 1991, *Numerical Simulation of Strontium-90 Transport from the 100-N Area*
2 *Liquid Waste Disposal Facilities*, Westinghouse Hanford Company, Richland, Washington.
3 Available at: <http://www5.hanford.gov/arpir/?content=detail&AKey=D196068231>.
- 4 WHC-SD-ER-TI-003, 1991, *Geology and Hydrology of the Hanford Site: A Standardized Text for use in*
5 *Westinghouse Hanford Company Documents and Reports*, Westinghouse Hanford Company,
6 Richland, Washington.
- 7 WHC-SD-NR-006, 1991, *N Reactor Layup Specification*, Rev. 2, Westinghouse Hanford Company,
8 Richland, Washington.
- 9 WHC-SD-RBTI-251
- 10 WHC-SP-0377, 1988, *Assessment of Westinghouse Hanford Company Methods for Estimating*
11 *Radionuclide Release from Ground Disposal of Waste Water at the N Reactor Sites*, Richland,
12 Washington.
- 13 WHC-SP-0615, 1993, *N Reactor Deactivation Program Plan*, Rev. 0, Westinghouse Hanford Company,
14 Richland, Washington.
- 15 WHC-SR-0377, 1988, *Assessment of Westinghouse Hanford Company Methods for Estimating*
16 *Radionuclide Release from Ground Disposal of Waste Water at the N Reactor Sites*,
17 Westinghouse Hanford Company, Richland, Washington.
- 18

1

Appendix A

2

100-N Decision Unit Conceptual Site Model Component Plates

3

4

1

This page intentionally left blank.

A1 Introduction

1
2 During workshops, presentations, and meetings, CSM component summaries were displayed as
3 wall-mounted plates used to identify and foster issues of concern discussions with the participants. Copies
4 of the plates for the 100-N Decision Unit, used to solicit input from regulators, agencies, and SME-s, are
5 provided here.

A2 References

- 6
7 *Atomic Energy Act of 1954*, 42 USC 2011, et seq. Available at:
8 [http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf#p](http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf#page=14)
9 [agemode=bookmarks&page=14](http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0980/ml022200075-vol1.pdf#page=14).
- 10 CCN 119850, 2005, *105-N Reactor Building and 109-N Heat Exchanger Building Action Memorandum*,
11 Washington State Department of Ecology and U.S. Department of Energy, Richland,
12 Washington. Available at: <http://www5.hanford.gov/arpir/?content=detail&AKey=D7590428>.
- 13 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
14 Available at: <http://www.epa.gov/oecaagct/lcla.html#Hazardous%20Substance%20Responses>.
- 15 DOE/RL-2001-68, 2002, *Removal Action Work Plan and Surveillance and Maintenance Plan for the*
16 *105-B Reactor Facility*, Draft A, U.S. Department of Energy, Richland, Washington.
17 Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D9003789>.
- 18 DOE/RL-2005-96, 2006, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater OU*, Rev. 0,
19 Reissue, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
20 Available at: <http://www5.hanford.gov/arpir/?content=detail&AKey=DA02781523>.
- 21 DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring Report for Fiscal Year 2008*, Rev. 0,
22 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
23 <http://www.hanford.gov/cp/gpp/library/gwrep08/>.
- 24 DOE/RL-96-39, 2002, *100-NR-1 TSD Units Corrective Measures Study/Closure Plan*, Rev. 1,
25 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
26 <http://www5.hanford.gov/arpir/?content=detail&AKey=D9039847>.
- 27 Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as
28 amended, Washington State Department of Ecology, U.S. Environmental Protection Agency,
29 and U.S. Department of Energy, Olympia, Washington. Available at:
30 <http://www.hanford.gov/?page=91&parent=0>.
- 31 RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures*, RL-TPA-90-0001,
32 Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System
33 (WIDS)," Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland,
34 Washington. Available at: <http://www.hanford.gov/hanford/files/TPA-MP14.pdf>.

35

1

This page intentionally left blank.

PROBLEM STATEMENT

- Large volumes of hazardous and radioactive wastes were disposed at the 100-N Decision Unit. Facility operations contaminated the vadose zone and groundwater.
- While Sr-90 is the main environmental threat, other contaminants are present, including petroleum hydrocarbons, tritium, nitrate, CrVI, and sulfate.
- Residual contamination remains after performing facility demolition and source removal activities.
- Soil and groundwater contaminant concentrations exceed applicable regulatory standards, posing a risk to human health and the environment.

DESCRIPTION

- The N Reactor was a 4,000-MWt, graphite-moderated, pressurized, light-water-cooled reactor.
- The HGP consisted of two 430-MWe turbines used for producing electrical power (Exhibit 1).
- Auxiliary facilities that supported plutonium production performed water treatment, liquid waste and spent-fuel storage, and waste disposal.
- Pressurized water was demineralized to minimize film deposition inside process channels.
- The most significant of the radioactive liquid waste disposal facilities were 116-N-1 and 116-N-3 crib and trench facilities.

OPERATIONAL HISTORY

- Dedicated by President John F. Kennedy (Exhibit 2), the N Reactor was constructed to produce plutonium for military (weapons-grade) and civilian (fuel-grade) uses, and to generate steam to produce electricity. The N Reactor achieved initial criticality in December 1963.
- In April 1966, the Washington Public Power Supply System (now Energy Northwest) piped steam from the N Reactor to HGP to produce electrical power.
- The N Reactor and the HGP (Exhibit 2) operated until January 1987, when the N Reactor was placed in stand-down status.

POST-OPERATIONAL HISTORY

- After stand-down, in 1988, the N Reactor was placed in cold standby, to remain capable of restarting within 3 years. However, it never restarted. Defueling was completed in 1989.
- The N Reactor deactivation was ordered in September 1991, with "final disposition" beginning in 1994.
- Tri-Party Agreement (Ecology et al., 1989a) waste site remediation activities began in 1989, and included solid waste removal, liquid waste site excavation, and support facility decommissioning and demolition. These activities continue under the Interim Action Records of Decision.
- Interim Safe Storage activities (Apr. 2009 to Sept. 2011) will protect the N Reactor from environmental degradation and minimize contamination spreading before the reactor is removed from the river corridor.

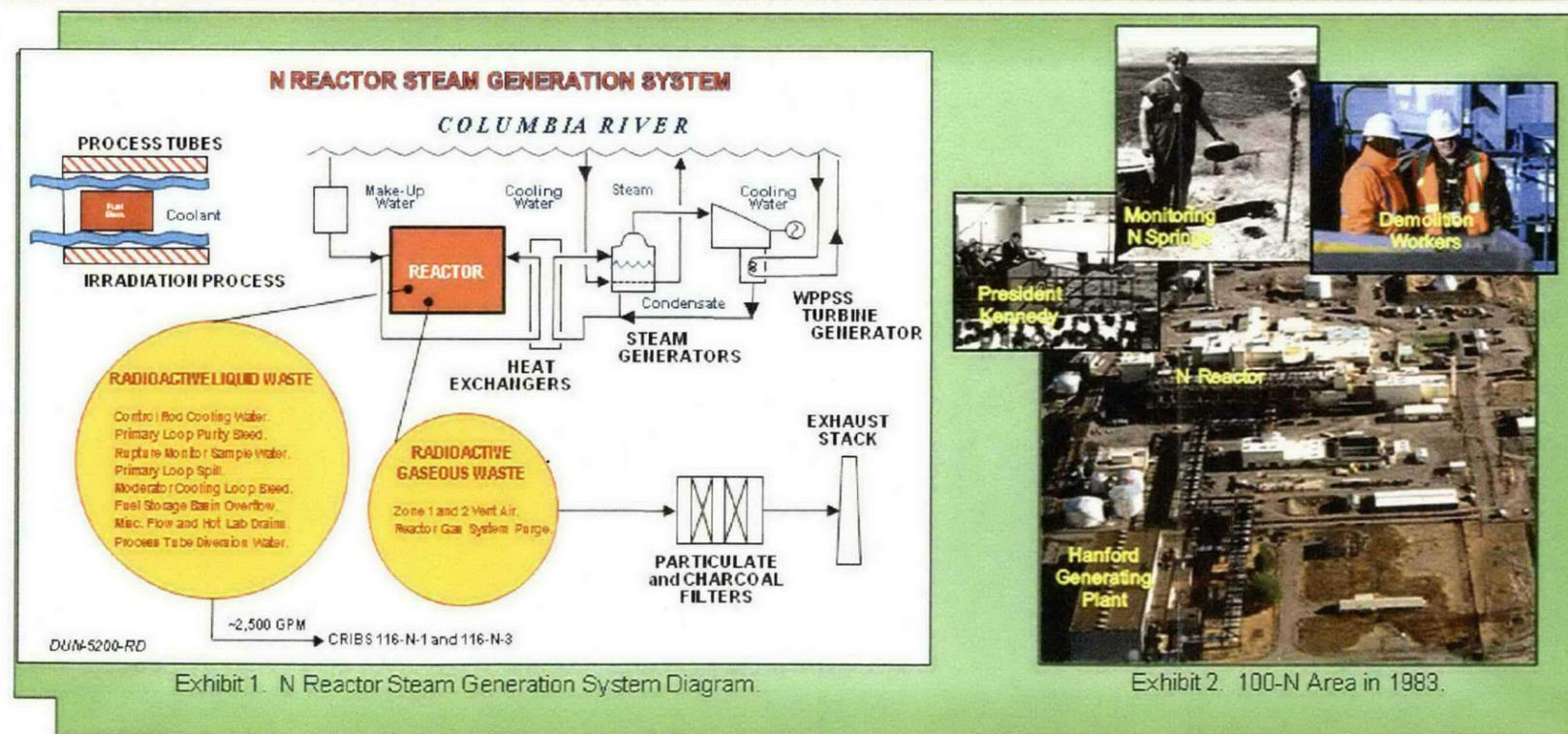
100-N SPECIFIC CONDITIONS AND PROCESSES

- The N Reactor's primary coolant system used up to 1,500 gpm of treated river water through a feed and bleed operation, far less than the ~35,000 to 105,000 gpm used by Hanford's single-pass reactors. This unique recirculating water system minimized direct discharge of contaminated cooling water to the Columbia River.
- Accumulated, long-lived fission product radionuclides in cooling water were discharged to 116-N-1 and 116-N-3 cribs, where radionuclides were retained in soil to extend their travel time and decay in the environment. These were located 304.8 m to 1005.84 m (1,000 ft and 3,300 ft), respectively, from the river.
- A 3.4 ml (900,000-gal), spherical, metal tank ("Golf Ball") in the 116-N-2 loadout facility temporarily stored contaminated liquid waste for transport to 200 Area storage tanks.
- Waste burial grounds at 100-BC, 100-D, and 100-K were used to dispose of most of the contaminated solid waste generated at 100-N.

100-N STATUS

- From 1996 to 2006, an Expedited Response Action pump-and-treat technology was used to address Sr-90 contamination in groundwater, before being placed in cold standby.
- In situ and phytoremediation technologies are being tested to address Sr-90 in groundwater.
- In accordance with the Tri-Party Agreement (Ecology et al., 1989a), drinking water standards are to be met at the river by 2016, with cleanup of site contamination by 2024.

MAJOR FEATURES OF THE 100-N DECISION UNIT



DATA GAPS

- #1: Vadose zone contaminant nature and extent are needed to assess protection of groundwater beneath unremediated waste sites.
- #2: Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.
- #3: Characterization of waste sites around the reactor structure is needed to assess nature and extent of contamination in the vadose zone.
- #4: Unidentified waste sites (orphan/discovery sites) may exist in the decision unit.
- #5: The nature and extent of contamination in the unconfined aquifer above cleanup standards has not been defined in select areas.
- #6: The level of contamination entering the Columbia River is not well known.
- #7: The fate and transport of contaminants beneath the unconfined aquifer has not been evaluated.
- #8: It is unknown if contamination within the RUM will adversely impact aquatic receptors in the Columbia River.
- #9: The rate of exchange between groundwater and the river is unknown.
- #10: The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.
- #11: Potential alternative remedial technologies for groundwater have not been sufficiently investigated.
- #12: Insufficient data are available to support fate and transport evaluations.
- #13: Data are needed to better define the spatial and temporal distribution of groundwater contamination.

Figure A-1. 100-N Decision Unit Process Description and History

This page intentionally left blank.

PROBLEM STATEMENTS

- 100-N Decision Unit facilities produced radioactive and hazardous liquid waste and solid waste during operations.
- Liquid waste was discharged to subsurface soils through RCRA TSD facilities as part of 100-N Reactor Operations. The resulting releases contributed to vadose zone and groundwater contamination.
- Contaminated facilities and resulting wastes may contribute to vadose zone and/or groundwater contamination, and require additional remedial activities and further evaluation.

DESCRIPTION

- Since 1999, many 100-N Facilities have been demolished or removed. In some cases, no waste sites were associated with these actions.
- As facilities undergo D4 activities, associated soils and subgrade structures are evaluated for evidence of contamination and potential classification as "waste sites". Not all facilities become classified as waste sites.
- Of the 100-N Decision Unit facilities, those considered to contain the bulk of the remaining contamination include the 105-N Reactor, the 109-N Heat Transfer Building, and the Hanford Generating Plant.

FACILITIES DESCRIPTION

- Each 100-N Facility was constructed for specific use. Specific vadose zone and groundwater contaminants may be traced to facility former uses and operations.
- Important disposal facilities were:
 - Two RCRA radioactive and hazardous waste liquid disposal facilities
 - One RCRA non-radiological waste surface impoundment
 - One RCRA non-radiological waste percolation pond.
- Other facilities where releases occurred were:
 - Former petroleum facilities at the 166-N Tank Farm, where over 302,744 L (80,000 gal) of diesel fuel was leaked to the environment
 - 105-N Spent Fuel Storage Basin, where two events resulted in the unplanned release of irradiated water.
- Some remaining facilities continue to pose a risk of hazardous substances release and exposure to humans and the environment. To address this, the D4 Program has directed ongoing activities for the D4 activities (Exhibit 1).

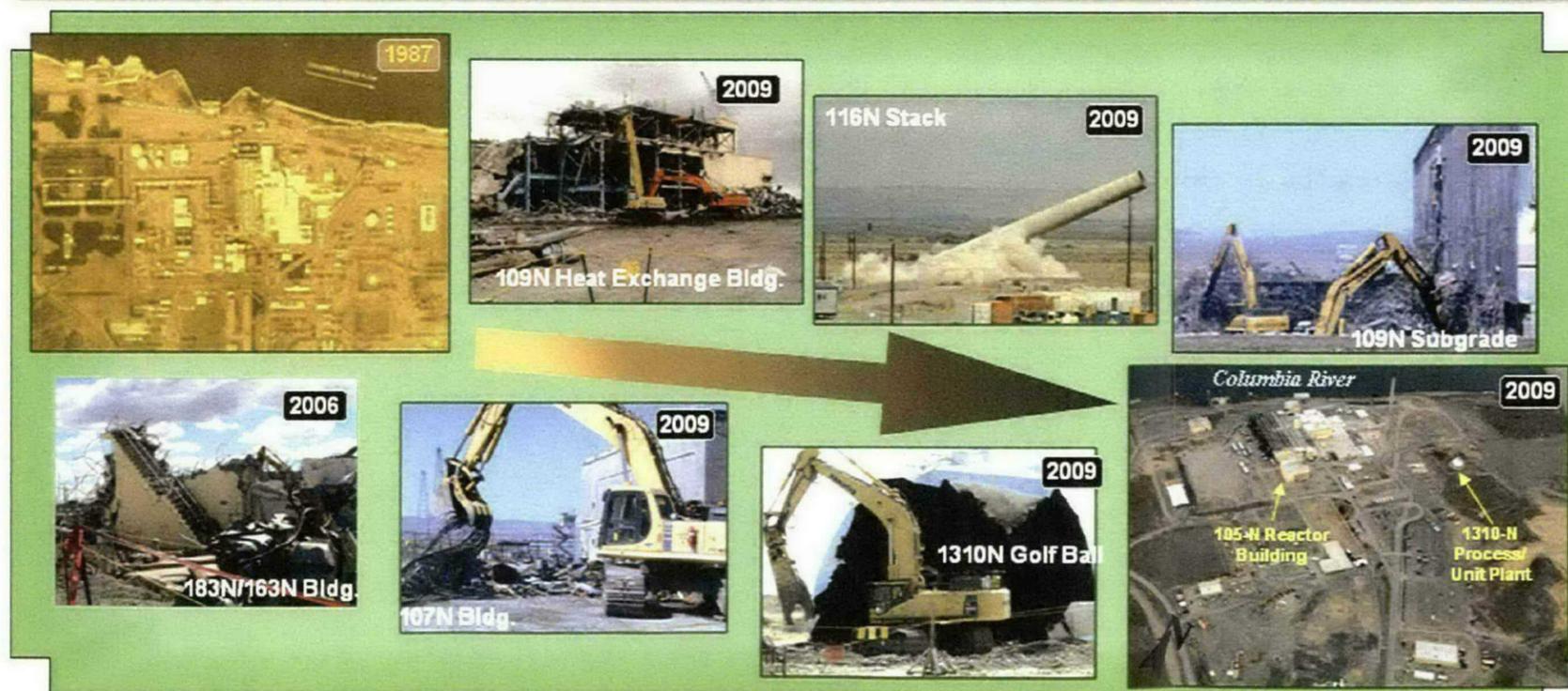
FACILITY CERCLA REMOVAL PLAN

- Several documents guiding cleanup at the 100-N have been issued including:
 - 100-NR-1 and 100-NR-2 Interim Action ROD (EPA/ROD/R10-99/112)
 - 100-NR-1 TSD Interim Action ROD (EPA/ROD/R10-00/120)
 - 105-N Reactor Building and 109-N Heat Exchanger Building Action Memorandum, (CCN-119850).
- Recommended alternatives for conducting 100-N Area facility removal actions include:
 - D4 ancillary facilities and portions of N Reactor facilities
 - Constructing a ISS enclosure over the reactors followed by long-term surveillance and maintenance.
- As part of ISS, the 109-Heat Exchange Building and the 105-N Building will be demolished to the 1.22 m (4 ft) thick shield walls surrounding the reactor core. Openings will be sealed with concrete or steel plates. A safe storage enclosure roof will be installed over the remaining structure.

FACILITY REMOVAL STATUS

- As of April 2009, fifty active and inactive facilities remain, while the status of other facilities is not determined. Recent D4 activities include removal and/or demolition of five, 30-ton storage tanks behind the N Reactor and the 107-N Building, the 116-N Stack, the 109-N Heat Exchange Building, the "Golf Ball", 183-N/163-N Facility, and the HGP (Exhibit 1).
- ISS of the 105-N Reactor Building is scheduled for completion in September 2011. To date, three Reactor ISS Closure Project Tri-Party Agreement (Ecology, et al., 1989a) milestones have been completed ahead of schedule.
- No FY 2009/2010 Tri-Party Agreement (Ecology, et al., 1989a) milestones are planned for the Reactor ISS Project. No performance milestones are anticipated for the Reactor ISS Project.

EXHIBIT 1. FACILITY DEMOLITION ACTIVITIES



<u>Facilities Status</u>	<u>No. of Facilities</u>
Active Facilities	25
Inactive Facilities	25
Demolished Facilities	61
Removed Facilities	70
To Be Determined	1
Total Facilities	182

SIS 04/29/2009

DATA GAPS

- #3: Characterization of waste sites around the reactor structures as needed to assess nature and extent of contamination in the vadose zone.

Figure A-2. 100-N Decision Unit Facilities

This page intentionally left blank.

PROBLEM STATEMENTS

- Waste management activities resulting from nuclear materials production and electric power generation in the 100-N Area have contaminated the vadose zone and unconfined aquifer.
- Continuing impacts to groundwater from the vadose zone are possible.
- The physical properties of soil that influence the fate and transport of contaminants in the vadose zone have not been sufficiently characterized.
- Minimal data have been collected around the reactor building and support structures to evaluate the nature and extent of contamination.

DESCRIPTION

- Operations generated large volumes of process effluents (spent reactor cooling water, fuel storage basin water, and decontamination solutions) that were contaminated with radionuclides, hazardous chemicals, or both.
- Liquid effluent was discharged to typically unlined surface impoundments, French drains, cribs, ditches, process sewers, and the Columbia River.
- Solid wastes generated were sludge, reactor components, and a variety of contaminated items used in reactor operations and maintenance.

CONTAMINATION SOURCES

- Primary 100-N Decision Unit contamination sources were the N Reactor and 109-N Heat Exchange building, their ancillary structures, and processes associated with reactor operations.
- Cooling water (the largest effluent by volume) contaminants were fission and irradiation byproducts, and water treatment chemicals.
- Waste was managed at several large effluent disposal sites. The LDWF generally released directly to the soil column through the 116-N-1 and 116-N-3 Cribs and Trenches.
- Other wastes were held at temporary holding facilities, such as 116-N-2, that staged waste before it was disposed elsewhere.
- Other releases also occurred at the 116-N-4 (1300-N Emergency Dump Basin), at places where water leaks occurred, through the radioactive process sewer lines, and numerous locations of unplanned releases to the ground.
- Most solid wastes from the 100-N were buried in 100-BC, 100-D, or 100-K.
- Not all of the 151 sites identified at the 100-N qualify for remedial action (e.g., 'no action' and 'not accepted' sites). These sites are dispositioned through a Tri-Party Agreement (Ecology, et al., 1989a) approval process (TPA-MP-14) and will require no further action.

CONTAMINANT DISTRIBUTION

- Interim remedial action activities have characterized waste sites to 6.093 m (~20 ft) below ground surface. Some contaminated soil concentrations exceed screening levels for groundwater and Columbia River protection in a few waste sites. Limited data have been collected at future remediation locations.
- Although 16 waste sites are classified as "interim closed out" (WDS), additional characterization may be necessary because soil contaminant concentrations exceeding protective standards may exist below the depth of remediation, or groundwater contamination may be associated with releases from the site.
- Additional discovery sites identified through the OSE process may increase the number of potential waste sites to be evaluated and cleaned up. The 100-N Area OSE is not yet completed, so additional sites may be identified.

SUMMARY OF WASTE SITES AND WASTE SITE STATUS

- Discovery sites identified through the OSE are dispositioned through the TPA-MP-14 process. Associated actions proceed through three phases:
 - Adding to an existing CERCLA decision document through an explanation of significant differences or interim ROD amendment
 - Characterizing to determine whether cleanup is required
 - Addressing in accordance with the selected remedy.
- Ninety accepted waste sites remain on the remedial action evaluation path. Four discovery sites are identified in the 100-N Decision Unit.

Reclassification Status	No. of Waste Sites
Interim Closed Out	16
Not Accepted	37
Accepted	90
Closed Out	3
No Action	1
Discovery	4
Total Waste Sites	151

SIS 04/23/2009

DATA GAPS

- #1: Vadose zone contaminant nature and extent are needed to assess protection of groundwater beneath unremediated waste sites.
- #2: Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.
- #4: Unidentified waste sites (orphan/discovery sites) may exist in the decision unit.
- #10: The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.
- #12: Insufficient data are available to support fate and transport evaluations.

EXHIBIT 1. INTERIM REMEDIAL ACTIONS AT 100-N AREA



Figure A-3. 100-N Decision Unit Waste Sites

This page intentionally left blank.

PROBLEM STATEMENT

- Final remedial decisions for the 100-N Decision Unit will consider how geology and hydrogeology control contaminant fate and transport in the vadose zone and groundwater.
- The technical basis for remedial decisions will require information on subsurface geologic and hydrogeologic characteristics that contribute to the CSM.

DESCRIPTION

- Describing and interpreting the geology and hydrogeology of the 100-N Decision Unit help to improve the CSM.
- Interpreting stratigraphic, hydrogeologic, and geochemical characteristics, together with modern Columbia River system dynamics, define liquid contaminant source retention and persistence in the vadose zone, and subsequent contaminant migration to groundwater.
- Understanding these behaviors are key to decision making in remedial investigation, feasibility study design, and remedy implementation in support of site cleanup.

GEOSTRATIGRAPHY

- Significant stratigraphic units at the 100-N Area include the Columbia River Basalt Group, Ringold Formation, and Hanford formation. The basalt underlies the fluvial-lacustrine deposits of the Ringold Formation and glaciofluvial deposits of the Hanford formation, respectively.
- The vadose zone is composed of fill material and native soils of the Hanford formation. The Hanford formation is composed of open framework, clast supported pebble-cobble-boulder gravel with minor sand and silt interbeds (Exhibit 1). The gravel is composed mostly of coarse-grained sand and an open-framework texture is common. For most of the 100-N Area, the Hanford formation extends to just above the water table, as much as ~23.5 m (77 ft) deep.
- The Hanford formation overlies the Ringold Formation, which consists of a mix of fluvial gravels, fluvial sands, overbank deposits, paleosols, and lake deposits. The uppermost Ringold stratum is Unit E, a fluvial gravel of variably cemented pebble to cobble gravel with a fine- to coarse-grained sand matrix. Ringold fluvial gravels range from well cemented to uncemented.

HYDROSTRATIGRAPHY

- Hydrogeologic units beneath the 100-N Decision Unit include the vadose zone (primarily Hanford formation), the unconfined aquifer (upper portion of the Middle Ringold Formation), a series of confined aquifers in the Ringold Formation, and a series of confined aquifers in the basalts and interbeds.
- The unconfined aquifer is a sand and gravel unit in the Ringold Formation. It is 12.192 m to 15.24 m (40 ft to 50 ft) thick. The base of the aquifer is a series of fine-grained units in the Ringold Formation.
- Primary constituents of interest include Sr-90 and H-3 associated with 116-N-1 and 116-N-3 (1301-N and 1325-N) sites; sulfate and sodium associated with the 1324-N/NA site; and petroleum products associated with leaks and spills between the N Reactor and the Columbia River.
- Radionuclides are detectable in water flowing into the Columbia River from N Springs.
- The most significant constituents in spring water are H-3 and Sr-90, and concentrations have declined since 1987. These constituents have also been detected in river water immediately adjacent to the 100-N Area but are rapidly diluted to less than laboratory detection limits.
- The contact between Ringold Unit E and the underlying RUM forms the base of the unconfined aquifer. The RUM is silty and much less transmissive than Unit E, and is ~60 m (197 ft) thick. Possible channels have been scoured into the RUM surface and vary in magnitude and width.

EXHIBIT 1. 100-N STRATIGRAPHY AND GEOLOGY

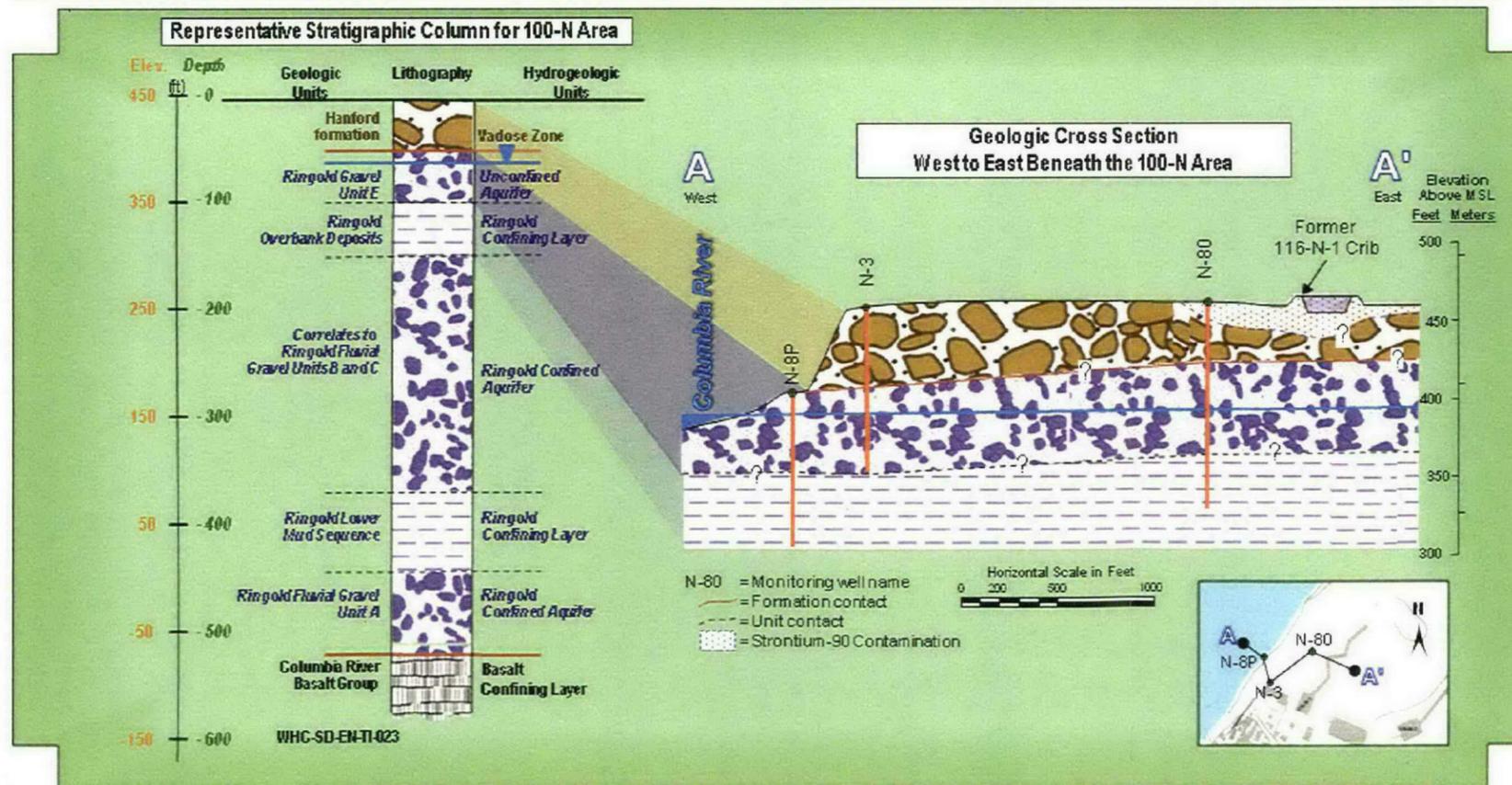


Figure A-4. 100-N Decision Unit Geology and Hydrogeology

GROUNDWATER FLOW AND CHARACTERISTICS

- Groundwater flows toward the Columbia River beneath most of the 100-N Area, except when river stage is high for extended periods of time. Also during high river stage, near-river groundwater rises into the Hanford formation.
- Daily river-level fluctuations may affect groundwater levels up to 230 m (750 ft) inland, while other, relative effects are observed up to 300 m (1,000 ft) inland.
- The groundwater gradient and aquifer flow velocities are up to an order of magnitude greater during low river stage than high river stage.
- While near-river vertical groundwater gradients are primarily upward, inland vertical gradients are not as well understood.
- During operations, liquid waste disposal generated water table mounds 6 m to 9 m (19.7 ft to 29.5 ft) above the nominal water table under liquid disposal facilities. This also affected the bottom portion of the Hanford formation in some locations. As a result, groundwater chemistry also has been affected by these discharges. This impact is important when identifying possible residual contamination that may reach, or has already reached groundwater.

DATA GAPS

- #9: The rate of exchange between groundwater and the river is unknown.
- #12: Insufficient data are available to support fate and transport evaluations.

This page intentionally left blank.

PROBLEM STATEMENT

- Groundwater at the 100-N Area has been contaminated with various radionuclides and nonionic and ionic constituents. Contaminants of concern in the 100-NR-2 OU include Sr-90, tritium, nitrate, sulfate, petroleum hydrocarbons, manganese, and chromium (Hartman et al. 2007).
- Of primary concern is Sr-90 in groundwater and its discharge to the Columbia River. Sr-90 is more mobile than many other 100-N Radiological contaminants (exceptions include tritium, Tc-99, and I-129) and because of its chemical similarity to calcium, it bioaccumulates in plants and animals. With a half-life of 28.6 years, it will take approximately 300 years for the Sr-90 concentrations in the 100-N Subsurface to decay to below current drinking water standards.
- The majority of vadose zone contaminant distribution has been estimated to be present in the upper 4.5 m (15 ft) bgs.
- Groundwater monitoring is conducted for contaminants (i.e., tritium, nitrate, and petroleum hydrocarbon) whose concentrations exceed primary drinking water standards, and for sulfate, manganese, iron, and chromium.

DESCRIPTION

- Vadose zone contamination sources are possible, because contaminants persist in the aquifer at the 100-N Area since reactor operations ceased.
- Areal extents of 100-N Aquifer contamination concentrations that meet or exceed drinking water standards (values are plume boundary contours) are:
 - Strontium-90: 8 pCi/L plume boundary = 0.58 km² (0.22 mi²)
 - Nitrate: 45 mg/L plume boundary = 0.54 km² (0.21 mi²)
 - Tritium: 20,000 pCi/L plume boundary = 0.06 km² (0.02 mi²)

STRONTIUM-90

- The zone of Sr-90-contaminated soils resulting from 30 years of wastewater discharge includes those portions of the vadose zone that were saturated during discharge operations, and the underlying aquifer, which extends to the Columbia River.
- In FY 2008, soil concentrations were highest near the spring high water table in well boring 199-N-122. Concentrations diminished with depth to near detection limits at ~30 m (100 ft).
- Groundwater Sr-90 concentrations exceeding 100 pCi/L are limited to approximately the upper half of the unconfined aquifer (Exhibit 1).
- The plume extent and magnitude has changed little since the mid 1990s. It extends from the 116-N-1 and 116-N-3 sites to the river, where plume concentrations exceed the drinking water standard (8 pCi/L) (Exhibits 2 and 3).
- In FY 2008, the highest aquifer tube Sr-90 concentration was 75,000 pCi/L, and the maximum aquifer tube concentrations were measured between the middle/upper portion of the Ringold Unit E.
- Aquifer tube concentrations were much lower in the shallowest aquifer tubes (Hanford formation).

TRITIUM

- Tritium has been detected at 100-N to the bottom of the unconfined aquifer. The plume size has been diminishing after effluent discharges to 116-N-3 ceased in 1991. Contaminant concentrations were similar in proximal deep and shallow wells.
- The maximum concentration was 22,000 pCi/L in Well 199-N-32, near 116-N-3. In September 2008, the observed tritium concentration in this well was less than the DWS.
- In deep Well 199-N-80, the tritium concentration was 15,000 pCi/L, (FY 2008) demonstrating a declining trend. This well is completed in a thin, confined Ringold Formation aquifer. Near-river Well 199-N-14 concentrations were also less than the drinking water standard in FY 2008.

NITRATE

- In FY 2008, nitrate concentrations exceeded the drinking water standard (45 mg/L) beneath a portion of the 100-N Area (Exhibit 2). Evidence of a source from the three nearby RCRA units has not been confirmed. The potential contribution from both Hanford operations and pre-Hanford agricultural uses is not quantified.
- Near the 120-N-1 Percolation Pond, nitrate concentrations increased in the 1990s. During pond use (1977 to 1990), only low nitrate levels (~1 mg/L) were detected in effluent to the facility (DOE/RL-96-39, 100-NR-1). Monitoring began in 1987, and nitrate concentrations in groundwater also were low (1 to 4 mg/L). Nitrate levels have exceeded the drinking water standard in Well 199-N-59 since 1998. Nitrate levels have increased in nearby Well 199-N-72, and have exceeded the standard since 2005.
- Anomalously low nitrate concentrations (undetected) continued in Well 199-N-18 as chemical reduction products of biodegradation of nearby petroleum. Low dissolved oxygen, low pH, detectable nitrite, and high metals concentrations may contribute to this process (DOE/RL-2008-66).

PETROLEUM HYDROCARBONS

- Petroleum hydrocarbons from a variety of tank leaks in the 1960s persist in 100-N Groundwater. These hydrocarbons are relatively insoluble in water and are unlikely to be found in biota; however, diesel may persist for long periods in soil.
- In April 2008, Well 199-N-18 had 150 mg/L total petroleum hydrocarbons in the presence of free-phase diesel. A passive remediation method currently used in Well 199-N-18 employs a polymer that selectively absorbs petroleum products from the water surface.
- Low hydrocarbon levels have been observed in other 100-N Wells in the past (2002) but not in FY 2008. Low TPH-diesel levels (<1 mg/L) were reported in several aquifer tubes around the 116m Array OA. Small oil sheens were observed during tube installation in January 2007. During monitoring well drilling in 2005, diesel was recovered from Wells 199-N-122 and 199-N-123.

HEXAVALENT CHROMIUM

- In FY 2008, filtered chromium was detected in deep Well 199-N-80 at a concentration greater than the WA state DWS (48 µg/L). This well is completed in a thin, confined aquifer of the RUM. A 2001, well video survey recorded well screen corrosion, which may account for the relatively steady CrVI concentrations in this well over the years. Therefore, the chromium detected in Well 199-N-80 is unlikely to have originated at the 116-N-1 waste site.
- Additionally, chromium contamination is observed encroaching into the southern portion of 100-N Area from sources in 100-K Area.

DATA GAPS

- #5: The nature and extent of contamination in the unconfined aquifer above cleanup standards has not been defined in select areas.
- #8: It is unknown if contamination within the RUM will adversely impact aquatic receptors in the Columbia River.
- #10: The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.
- #13: Data are needed to better define the spatial and temporal distribution of groundwater contamination.

STRONTIUM-90 AND NITRATE GROUNDWATER CONTAMINANT DISTRIBUTION IN THE 100-N DECISION UNIT

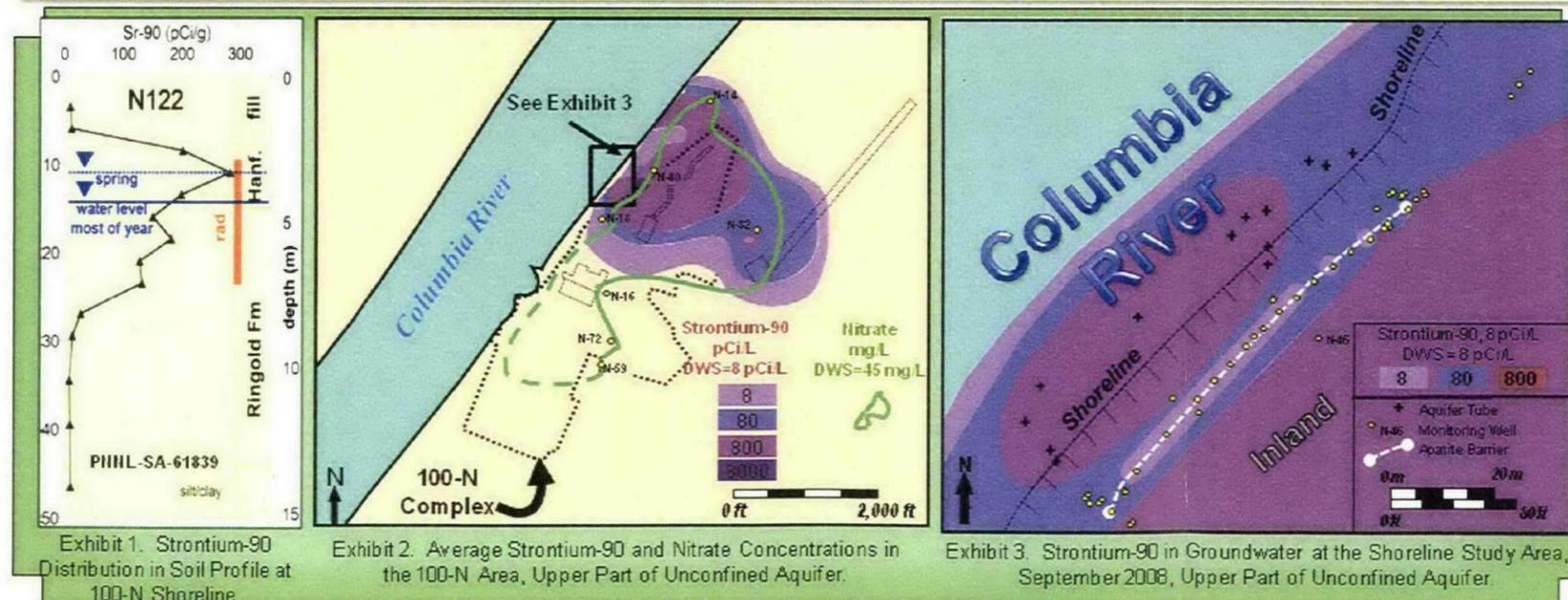


Figure A-5. 100-N Decision Unit Contamination Nature and Extent

This page intentionally left blank.

PROBLEM STATEMENT

- Relatively high Sr-90 levels remain in 100-N soil and groundwater. While source removal activities continue, contaminated soil and groundwater transport persists to pose potential risks to human health and ecological receptors.
- Previous fate and transport modeling used data from other 100 Area sites and were applied to conditions at 100-N. However, those results may not represent conditions at 100-N.
- Historical, lateral migration of contaminated groundwater beneath liquid discharge facilities may have augmented relative permeability and moisture in the vadose zone at these locations.

DESCRIPTION

- Several physical and chemical factors affect contaminant fate and transport. Further, the magnitudes of these factors contribute to the variability of soil and groundwater contaminant fate and transport.
- Groundwater discharge to the river is relatively low because of Hanford's semi-arid climate and the non-steady, corresponding aquifer recharge rate. Thus, contaminant transport through discharge is irregular and widely variable.

CONTAMINANT SOURCES

- Strontium-90, other radionuclides, and chemicals in liquid effluents were discharged to cribs and trenches. Contaminated soil removed from these facilities was replaced with clean soil fill (Exhibit 2). However, some Sr-90 remained beneath the excavated areas as an ongoing source to groundwater. Strontium-90 sorbs to Hanford soils, but its moderate mobility in groundwater has led to development of the large Sr-90 plume at 100-N.
- Other contaminant sources include various spills, leaks, and unplanned releases from facilities and infrastructure (e.g., diesel fuel releases and chemical spills at 116-N-2).

CONTAMINANT TRANSPORT MECHANISMS

- Historic contaminant transport mechanisms at 100-N included discharging, infiltrating, and percolating contaminated liquids to soil, and contaminated soil dispersion by wind or excavation activities.
- Current contaminant transport mechanisms at 100-N include the following:
 - Infiltration from precipitation and dust suppression activities during source removal excavation may temporarily enhance contaminant mobilization
 - Mobilization of contaminants in the periodically re-wetting zone. Higher water table elevations mobilize Sr-90 because higher-ionic-strength river water enters the aquifer
 - Contaminated groundwater migrating to the river and offsite.

GROUNDWATER FLOW

- Groundwater flows to the northwest near the 100-N Complex ("A", Exhibit 1) and discharges to the river through riverbank seeps and river-bottom sediments.
- During high river stage, the near-river gradient is flat to reversed ("B", Exhibit 1). In the decision unit's northeastern area ("C", Exhibit 1), groundwater flows to the north.
- Groundwater enters the decision unit primarily from the southeast ("D", Exhibit 1). However, a chromium plume has reached the 100-N Decision Unit from the northern end of the 116-K-2 Trench. This suggests some groundwater flow from the south/southwest.
- Impacts to groundwater flow and geochemistry that may persist from historical liquid waste discharges and their affect on contaminant transport behavior are not strongly quantified.
- Contaminant dispersion rates are controlled by the heterogeneity of vadose zone soil and fill material.

RIVER STAGE

- Upstream Priest Rapids Dam directly controls rapid (hourly to daily) river stage fluctuations of up to ~3 m (10 ft) throughout the year, which affects the near-river gradient by up to two orders of magnitude.
- Near the river, the hydraulic gradient of the unconfined aquifer is affected by seasonal river stage fluctuations, altering contaminant migration in groundwater.
- During higher river stage, the groundwater flow "net" velocity is slowed, and the rate of contaminant discharge to the river is reduced. As a result, plume migration toward the river is slowed.

GROUNDWATER FLOW IN THE 100-N DECISION UNIT

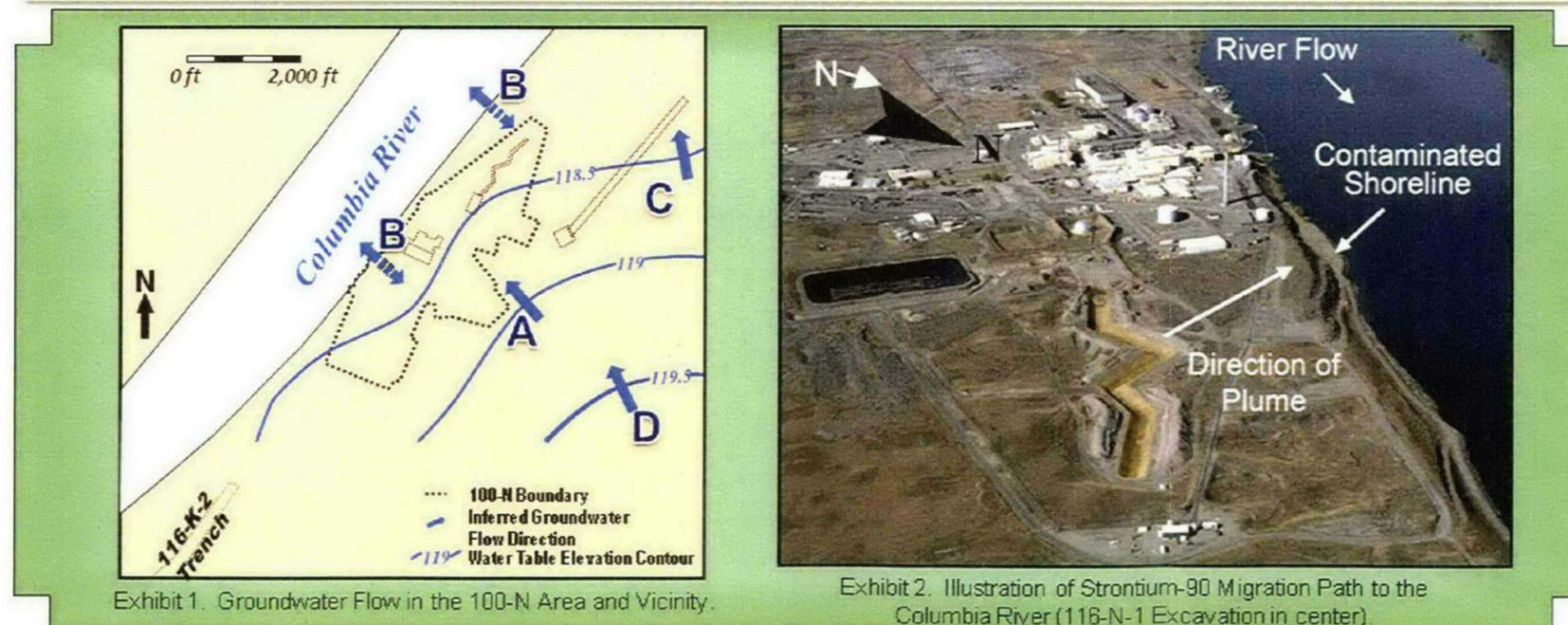


Exhibit 1. Groundwater Flow in the 100-N Area and Vicinity.

Exhibit 2. Illustration of Strontium-90 Migration Path to the Columbia River (116-N-1 Excavation in center).

Figure A-6. 100-N Decision Unit Contamination Fate and Transport

DATA GAPS

- #6: The level of contamination entering the Columbia River is not well known.
- #7: The fate and transport of contaminants beneath the unconfined aquifer has not been evaluated.
- #9: The rate of exchange between groundwater and the river is unknown.
- #10: The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.
- #12: Insufficient data are available to support fate and transport evaluations.

This page intentionally left blank.

PROBLEM STATEMENT

- The primary groundwater contaminant plume in the 100-N Decision Unit is Sr-90, which originated at two liquid waste disposal facilities (116-N-1 and 116-N-3). Other contaminants present in the groundwater include tritium, nitrate, sulfate, and petroleum hydrocarbons.
- Strontium-90 concentrations persist in groundwater at levels up to 1,000 times the drinking water standard (8 pCi/L).
- Vadose zone Sr-90 sources may continue to impact the aquifer beneath the 100-N Decision Unit.
- The persistence of diesel in the 100-N Decision Unit indicates that vadose zone contamination from leaks occurring in 1966 and later remain.

DESCRIPTION

- Strontium-90 is the main contaminant of concern for soil, groundwater and the Columbia River from the 100-N Decision Unit, although other contaminants remain in the subsurface.
- Remediation activities at 100-N aiding in the protection of groundwater include source removal at the liquid waste disposal sites and D4 of facilities.
- In 1995, DOE installed a pump-and-treat system to remove Sr-90 from groundwater. It used four extraction wells and two injection wells. The system operated at a treatment capacity of 189 L/min (50 gal/min) until shutdown in March 2006.
- Currently, passive diesel recovery system is used in one well. Total petroleum hydrocarbons as diesel are undergoing investigation in support of remedy selection.

DIESEL REMOVAL AND BIODEGRADATION

- Early attempts to reduce diesel migration to the river included an interceptor trench where diesel-impacted groundwater and free-phase diesel were collected and periodically removed.
- Since October 2003, DOE has continued to remediate free-phase diesel from Well 199-N-18 by suspending petroleum-absorbing materials at the water table, where the diesel free product is present, and replacing the sorbent material when saturated, about every two months.
- Subsequent activities include collecting groundwater samples to determine contamination levels and to evaluate existing cleanup technologies, create a treatability test plan, and deploy the selected technology.

STRONTIUM-90 GROUNDWATER REMEDIATION EFFORTS

- Pump and treat technology had been used in the past to treat contaminated groundwater at Hanford. It was considered appropriate for use in an ERA. A barrier wall was also included as part of the ERA, but was dropped because it was technically impractical to deploy at that time.
- The pump-and treat system removed little Sr-90 from groundwater over time; therefore, operation was suspended pending implementation of a more favorable treatment method.
- Although the pump and treat action was of limited effectiveness, its implementation and operation generated data useful in evaluating additional remedial technologies, such as the permeable reactive barrier (apatite sequestration) and phytoremediation.

IMPORTANT OBSERVATIONS FROM REMEDIAL ACTIVITIES

- Low dissolved oxygen (<1 percent saturation) is observed at several locations in the 100-N Decision Unit, indicating active bio-reduction of diesel in the aquifer.
- Natural hydrocarbon biodegradation creates reducing conditions, which could increase the solubility of metals such as manganese and iron from the well casing and/or aquifer sediment. Bio-reducing behavior is also used as part of the apatite sequestration process.
- The movement of contamination in response to river/groundwater dynamics relates to describing contaminant fate and transport in the conceptual site model of the 100-N Decision Unit.
- Floating contaminants, such as diesel, will tend to be retained in the top of the aquifer. Contaminants spread through the vadose zone and aquifer suggest more complicated processes working in concert to control the amount of contamination (Sr-90) released from soil to groundwater.
- The persistence and extent of Sr-90 contamination and the ineffectiveness of the pump and treat system in removing it from the groundwater indicate other technologies must be evaluated.

APATITE SEQUESTRATION TECHNOLOGY TESTING

- One technology being tested by DOE for treating Sr-90 in groundwater is injecting calcium-citrate-phosphate into the soil to form an apatite barrier (apatite sequestration).
- This is an in situ technology, creating a permeable reactive barrier. Apatite-forming chemicals are injected in a line of wells along the river in the 100-N Area. Groundwater then passes through the barrier.
- The chemical reaction in the permeable reactive barrier causes Sr-90 levels to diminish in groundwater by both ion-exchange and incorporation of Sr-90 into the apatite mineral matrix (See Figure 5A-10).

PHYTOREMEDIATION TECHNOLOGY TESTING

- Since March 2007, a phytoremediation test of native coyote willow biomass production has been monitored along the 100-K Area riverbank (Exhibit 4) for Sr-90 uptake. This type of testing also examines the control of off-site Sr-90 transport (i.e., animal intrusion, detritus loss, resistance to natural flooding).
- The second year harvest results indicated an average biomass at 369 percent greater than the first year at 857 kg/hectare (765 lb/ha).
- Phytoremediation tests are not concluded. Third-year harvest results (in 2010) will be used to better understand phytoremediation's usefulness to remediate Sr-90, in tandem with other remedial technologies, to achieve human health and aquatic receptor protection.

DATA GAPS

- #11: Potential alternative remedial technologies for groundwater have not been sufficiently investigated.
- #13: Data are needed to better define the spatial and temporal distribution of groundwater contamination.

STRONTIUM-90 PLUME TREATMENT HISTORY



Figure A-7. 100-N Decision Unit Groundwater Remediation

This page intentionally left blank.

PROBLEM STATEMENT

- The ZOI is directly affected by river stage, and by historical and recent disposal practices. Limited data are available to adequately understand groundwater flowpaths, contaminant migration, and mixing in the ZOI.
- Scenarios for plume discharge to the river vary widely because of seasonality and dynamic conditions in the ZOI. The greatest contaminant flux and highest concentrations at exposure locations occur during periods of low river stage, when the hydraulic gradient toward the river is steepest, and mixing between river water and groundwater is minimal.
- Plume characteristic changes may occur as groundwater contamination passes through the ZOI before discharging into the free-flowing stream. These changes may have implications regarding understanding contaminant dispersion, assessing the impacts of contaminants to receptors, and selecting, designing and implementing of a remediation technology.
- Contaminated discharges from groundwater to the river via riverbed pore water and riverbank springs.
- Contaminant mass within the 100-N Decision Unit is distributed within the vadose zone, periodically re-wetted zone, groundwater, and the aquifer matrix. For contaminants such as Sr-90, understanding the behavior of the periodically re-wetted zone is important for describing contaminant distribution.

DESCRIPTION

- As the water table rises and falls, the aquifer is exposed to contaminants within the periodically re-wetted zone that may continue to provide source contaminants to the unconfined aquifer and ultimately the river.
- Contaminants within the near shore area of the river undergo dilution and/or mixing in the ZOI, where river water mixes with groundwater. Groundwater gradients and geochemistry are dynamic in this ZOI and control the rate of discharge to the river.

RIVER STAGE AND FLOW

- River stage fluctuations change hydraulic and geochemical conditions in the ZOI between the river and groundwater systems (Exhibit 1). The highest river stages occur during spring runoff (May to late June). The lowest river stages occur during the late summer and early fall.
- River stage elevations at Hanford range from 120 m to 104 m (394 ft to 341 ft) above mean sea level, from the upstream to downstream shoreline. The upstream Priest Rapids Dam regulates river stage. The river stage fluctuates through daily and seasonal cycles that range from 0.5 m (1.6 ft) to several meters as observed through water levels in near-river wells, with lesser effects observed inland.
- Aquifer discharge is greatest when river discharge is lowest (late summer to early fall). During spring runoff, river water enters the aquifer and causes periods of reversed hydraulic gradient. Near the river, linear flow motion is forward and backward due to these gradient reversals.
- Ongoing monitoring data, and other newly collected data, will be used to improve the CSM. New data also can be used for risk assessments and for selecting appropriate and effective remedial actions.

PERIODICALLY REWETTED ZONE

- Two mechanisms introduce contaminants to the periodically rewetted zone: 1) the downward migration of recharge from the vadose zone and 2) the movement of groundwater upward into the vadose zone during high water table conditions.
- The ability of the periodically rewetted zone to retain and release contamination depends on multiple sediment and contaminant characteristics, such as adsorption onto sediment, precipitation as coatings on sediment grains, and entrapment in small pore spaces and mineral grain fractures.

INTERACTION BETWEEN GROUNDWATER AND RIVER WATER

- In the ZOI, mixing with river water dilutes contaminants that reach the hyporheic zone. Contaminated groundwater discharges from the unconfined aquifer to the river via the riverbed and riverbank springs (Exhibit 2).
- Groundwater movement primarily is perpendicular to the shoreline, with a semi-parallel flow component to river flow.
- Groundwater flow rates adjacent to the river in the unconfined aquifer are highest during low river stage.
- Aerial recharge (precipitation) varies greatly spatially and temporally, and depends on local climate, soil type, vegetation cover, and the frequency and intensity of storm events. Overall groundwater recharge is low due to the arid climate and the unsteady aquifer recharge rate.
- Precipitation and dust suppression liquid infiltration during excavation activities may enhance contaminant mobilization in some instances.
- Dissolved Sr-90 particles near the shore are anticipated to move inland during high river stage and reverse direction during low river stage, and are anticipated to discharge to near-shore shallows.
- Near the river, the hydraulic gradient of the unconfined aquifer is affected by seasonal river stage fluctuations, altering contaminant migration in groundwater. This is restricted to within tens of meters of the shoreline.
- As a result of these interactions, "net" plume migration velocity from source to river may be slowed.

EVOLVING CSM EFFORTS

- DOE manages extensive groundwater and river water monitoring programs to support RCRA and CERCLA programs, and also Public Safety and Resource Protection programs.
- Current knowledge of the ZOI has contributed to:
 - Assessing the impacts to receptors of contaminants at the river
 - Setting performance monitoring criteria for interim actions
 - Designing and implementing remedial technologies.
- Additional physical, chemical, and biological process data, and ongoing monitoring information may be needed to adequately understand the features and simulate the processes associated with the ZOI and support remediation decisions for the site-specific plume scale.
- Ongoing monitoring data, and other newly collected data, will be used to improve the CSM. New data also can be used for risk assessments and for selecting appropriate and effective remedial actions.

DATA GAPS

- #6: The level of contamination entering the Columbia River is not well known.
- #9: The rate of exchange between groundwater and the river is unknown.
- #10: The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.

100-N AREA GROUNDWATER AND RIVER INTERACTION FEATURES

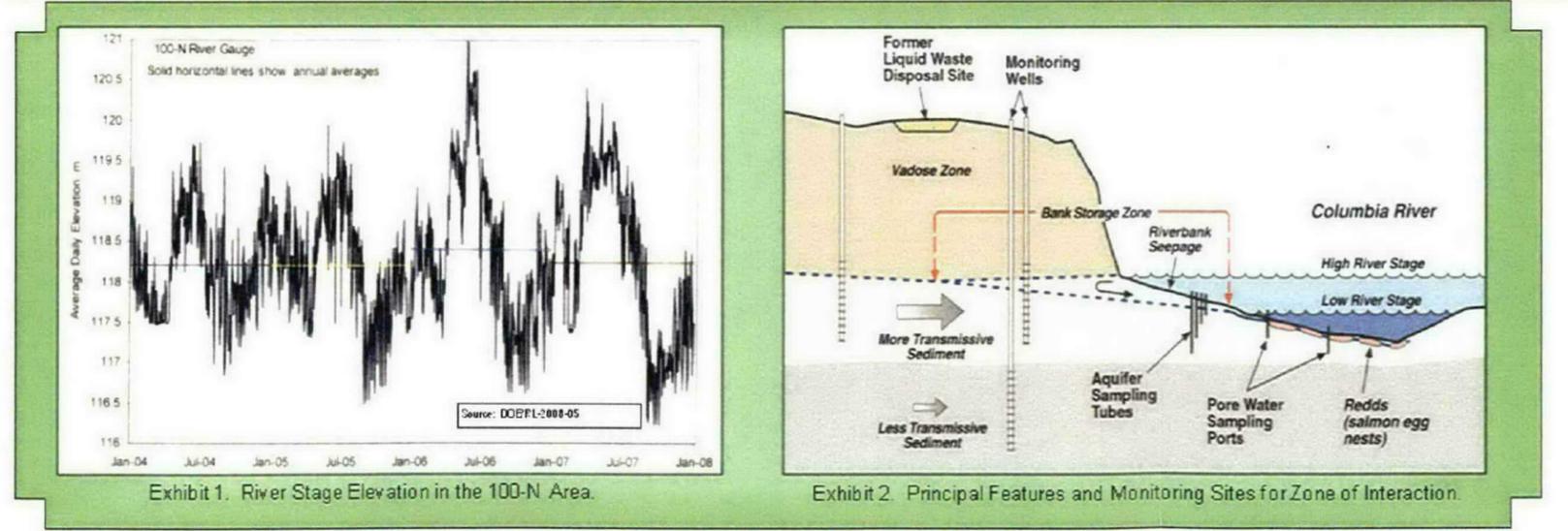


Figure A-8. 100-N Decision Unit Groundwater/River Interaction and the Periodically Re-Wetted Zone

This page intentionally left blank.

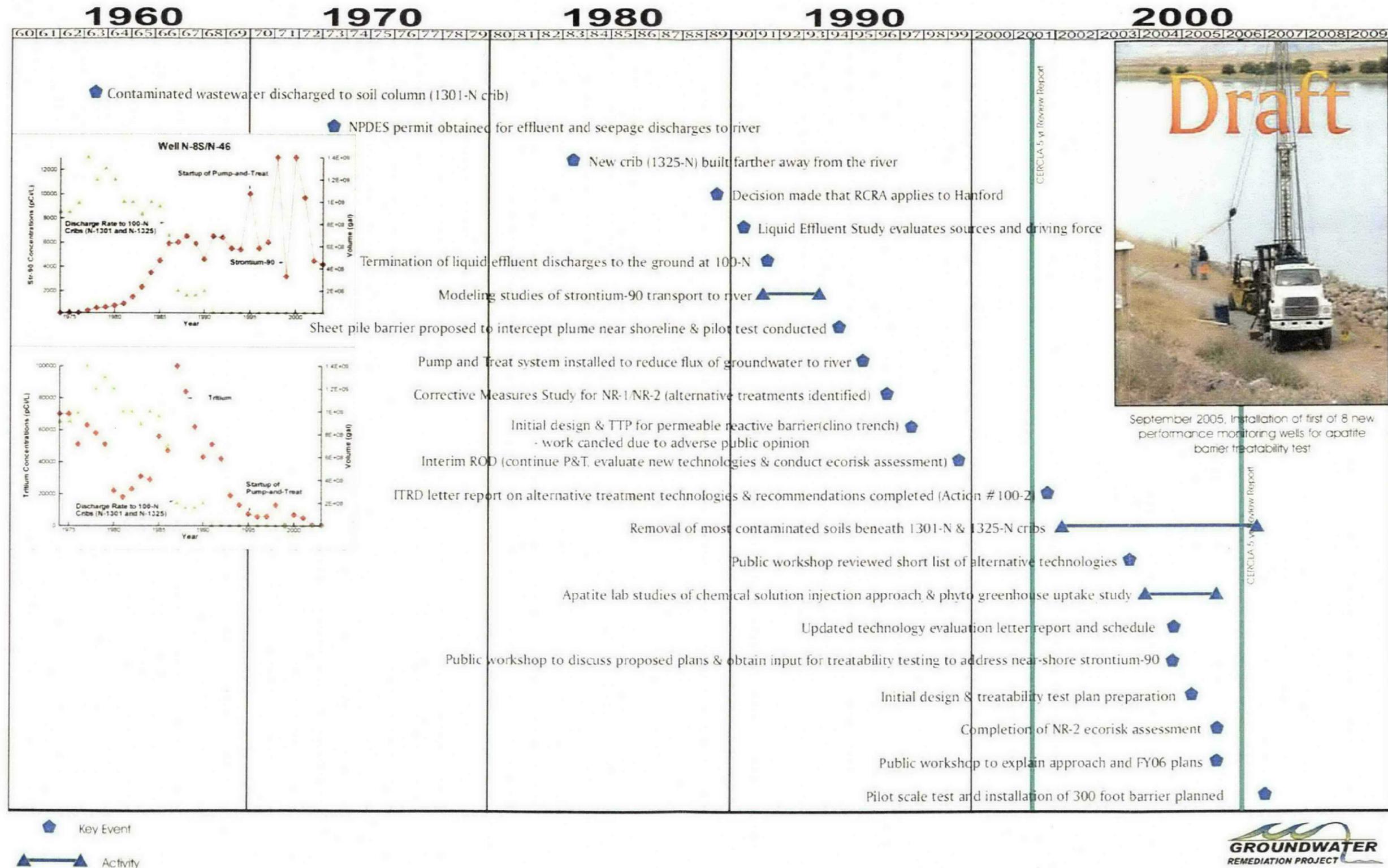


Figure A-9. History of Effluent Control and Groundwater Protection and Remedial Actions at 100-N

This page intentionally left blank.

PROBLEM STATEMENT

- In the 100-N Area, Sr-90 has impacted groundwater and the Columbia River. Strontium-90 presents a continued risk of exposure to receptors as it is mobilized by seasonal river stage increases.
- Strontium-90 persists in groundwater migrating toward the Columbia River at levels up to 1,000 times the drinking water standard (8 pCi/L).
- Safe and effective methods for mitigating Sr-90 in the deep vadose zone are limited.
- Before apatite barrier testing, limited data have been obtained regarding Sr-90 concentrations, geology, groundwater chemistry, river stage dynamics, and other variables that may affect the Sr-90 release.
- Comprehensive results of the pilot-scale permeable reactive barrier testing are not yet published.

DESCRIPTION

- Bench-scale and pilot-scale studies have indicated preliminary success for Sr-90 sequestration by injecting and infiltrating specific-strength solutions of calcium-citrate-phosphate into the vadose zone and groundwater along an impacted riverbank of the Columbia River.
- The success of Sr-90 sequestration depends on meeting multiple challenges during treatment, including river hydrodynamics, which have a potentially significant influence on the effectiveness of solution injection.
- Apatite injections treat Sr-90 in the aquifer and lower parts of the vadose zone; however, some of the contamination is in the upper portion of the vadose zone, where Sr-90 transport is affected by surface infiltration.

CALCIUM REPLACEMENT IN APATITE

- Apatite ($\text{Ca}_5(\text{PO}_4)_3\text{X}$) is a stable and very insoluble mineral. Strontium-90 replaces calcium in apatite. For this reason, apatite formation in the presence of Sr-90 in the vadose zone and groundwater was evaluated as a technological solution to support river protection.
- Apatite forms relatively quickly under conditions that are controlled by phosphate adsorption (hours); citrate biodegradation (tens of hours); and the groundwater infiltration rate.
- Rapid phosphate solution infiltration followed by slow groundwater infiltration can emplace apatite precipitation at depth and within low-permeability zones preventing further movement of Sr-90.

LABORATORY TESTING

- In 2004 and 2005, bench-scale testing was conducted to determine if this technology could precipitate sufficient apatite in the 100-N Area sediments and if the Sr-90 removal rate would be rapid enough to immobilize Sr-90 within the barrier and trap it for 300 years. The principal findings were:
 - Amorphous and crystalline apatite precipitation occurs.
 - Aerobic and anaerobic citrate biodegradation pathways and rates were quantified.
 - Strontium-90 uptake in apatite-laden 100-N sediment occurs.
 - Strontium-90 is initially held by ion exchange, but then over 6 to 20 weeks is more permanently held (presumed incorporated into apatite) (DOE/RL-2005-96).

FIELD PILOT TESTING

- Sixteen wells comprise the barrier in a 91.4 m (300 ft) line along the Columbia River and were used to inject a low-concentration, apatite-forming solution into the shallow aquifer to stabilize Sr-90 at the pilot test sites. Four monitoring wells are located between the barrier and the river.
- The pilot test site data, located at the west and east ends of the barrier, are useful to develop the injection design for the proposed expanded portions of the barrier.
- Calcium-citrate-phosphate solution is injected separately into the Hanford formation and Ringold Formation Unit E sediments. Different permeability between the Hanford formation and Ringold Formation throughout the barrier, in combination with challenges associated with low- and high-river-stage, led to higher-concentration injection testing.
- Ten wells are screened across both the Hanford and the Ringold formations. Six wells are screened across the Ringold Formation only.
- Apatite is slow to incorporate strontium under field conditions (up to a year), but this timescale is reasonable in the context of groundwater flow rates and the plume behavior.
- Bathymetric data collected perpendicular to the centerline of the Sr-90 plume reveal no significant elevation changes or structural differences that might impact contaminant discharge in this portion of the decision unit.
- Geologic cross sections and bathymetric data indicate that the river bottom rests on the underlying Ringold Formation Unit E, and perhaps in some locations, by the RUM unit. However, it does not appear that the river cuts through the entire thickness of the RUM.

ONGOING EVALUATIONS

- Pilot testing of the barrier is ongoing to evaluate an optimal infiltration strategy for calcium-citrate-phosphate solution injection at the barrier.
- Pending long-term pilot-testing success, the barrier system may be augmented with additional injection wells.
- Phytoremediation is anticipated to extract and sequester Sr-90 at the plume front and upper portion of the vadose zone until the barrier system is completely developed and operational.
- Although results are preliminary, the apatite barrier technology is showing promise as a remediation option. If the results continue to be positive, it is planned to expand the method to a full-scale treatment option.

DATA GAPS

- #6: The level of contamination entering the Columbia River is not well known.
- #10: The mass distribution in the subsurface within the vadose zone, periodically rewetted zone, aquifer, and aquitard for select contaminants is uncertain.
- #11: Potential alternative remedial technologies for groundwater have not been sufficiently investigated.

100-N AREA

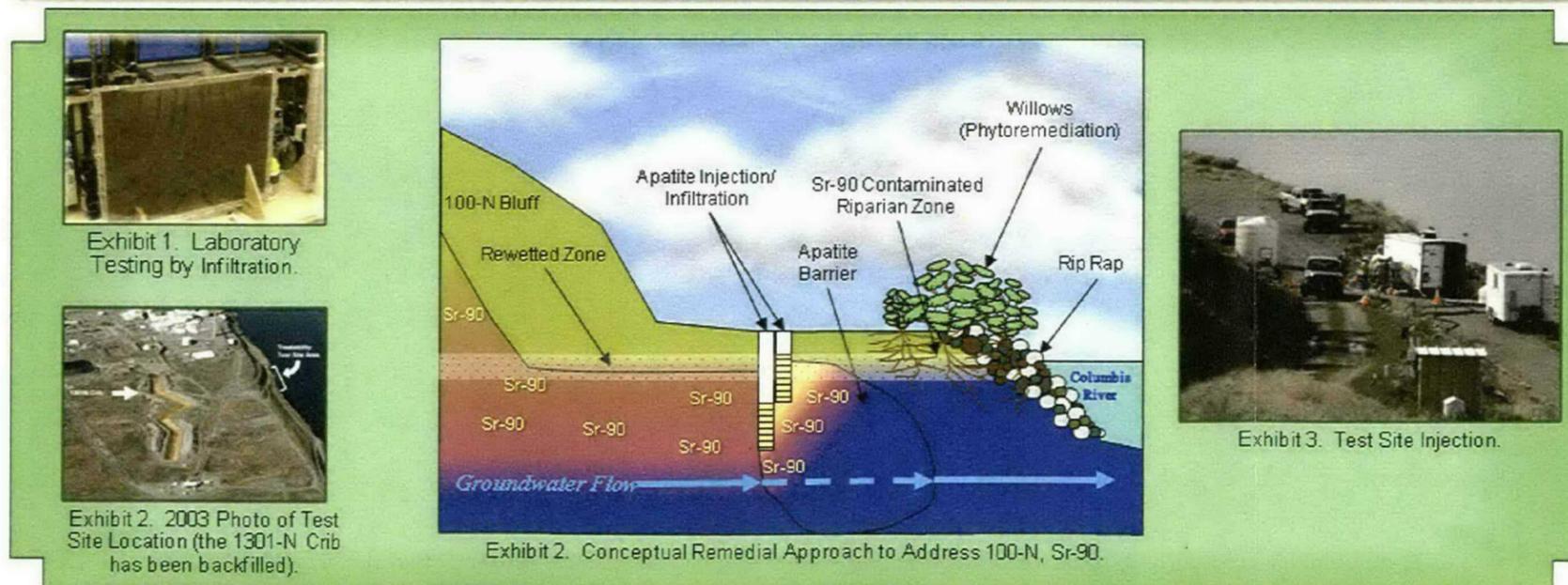


Figure A-10. 100-N Decision Unit Apatite Treatment

This page intentionally left blank.

Appendix B

100-N Area Maps (provided on CD)

This page intentionally left blank.

Introduction

Maps showing the facilities and waste sites located in the 100-N Area are provided on CD.

This page intentionally left blank.

1

Appendix C

2

100-N Decision Unit Waste Sites Description and History

3

1

This page intentionally left blank

C1 Introduction

Table C-1 provides a summary of the codes, types, and status of waste sites in the 100-N Decision Unit of the Hanford Site. Table C-1 also provides physical dimensions, dates of operation, a brief history for each site, and relevant decision/remedial action information, if available.

C2 References

40 CFR 144.82, "Underground Injection Control Program," "What Must I Do to Protect Underground Sources of Drinking Water?" *Code of Federal Regulations*. Available at:
http://edocket.access.gpo.gov/cfr_2008/julqtr/40cfr144.82.htm.

WHC-SD-EN-TI-251, 1994, 100-N Area Technical Baseline Report, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

CVP-2001-00021, 2002, *Cleanup Verification Package/Clean Closure Report for the Soil Column of the 120-N-1 and 120-N2 Dangerous Waste Treatment and Disposal Sites and the 100-N-58 Site*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D9066959>.

CVP-2002-00002, 2002, *Cleanup Verification Package/Clean Closure Report for the Soil Column of the 116-N-3 Trench, Crib, and 100-N-63:1 Pipeline*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D9215249>.

DOE/RL-88-30, 1991, *Hanford Site Waste Management Units Report: Waste Management Technology*, 2 vols., U.S. Department of Energy, Rev. 1, Richland Operations Office, Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196036020> and
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D196036029>.

Ecology, 1999. *100 N Area Ancillary Facilities Action Memorandum*, State of Washington, Department of Ecology, Kennewick, Washington. Available at:
http://www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0025/D199017700/D199017700_18545_1.pdf.

HGP-CVP-SWMUs 1, 2, 3, & 4, 2004, *Cleanup Verification Package for the Hanford Generating Plant UPR-100-N-37 Transformer Yard (SWMU #1), 100-N-51 Oil Storage Area (SWMU #2), 185-N Building Drains and Sumps (SWMU #3), and 100-N-50 Turbine Oil Filter Unit (SWMU #4)*, Rev. 0, Energy Northwest, Inc., Richland, Washington. Available at:
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D5457617> and
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D5457890>.

HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, 2004, *Cleanup Verification Package for the Hanford Generating Plant 100-N-4 Tile Field (SWMU #5); 100-N-1 Settling Pond (SWMU #6); 1908-NE Outfall (SWMU #7); 1716-NE Maintenance Garage (SWMU #8) and 100-N-52 Underground Storage Tank; 100-N-3 Maintenance Garage French Drain, 100-N-41 Gate House Septic Tank, and 100-N-45 Office Building Septic Tank (SWMU #9); 100-N-5 Bone Yard (SWMU #10); and 100-N-46 Underground Storage Tank*, Rev. 0, Energy Northwest, Inc., Richland, Washington. Available at: <http://www5.hanford.gov/arpir/?content=findpage&AKey=D5456103> and
<http://www5.hanford.gov/arpir/?content=findpage&AKey=D5456464>.

- 1 PNL-6456, 1988, Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford,
2 3 vols., Pacific Northwest Laboratory, Richland, Washington. Available at:
3 www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0041/D196006954/D196006954_2395.pdf.
- 4 RL-TPA-90-0001, 2007, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number
5 TPA-MP-14, "Maintenance of the Waste Information Data System (WIDS)," U.S. Department
6 of Energy, Richland Operations Office, Richland, Washington. Available at:
7 <http://www.hanford.gov/hanford/files/TPA-MP14.pdf>.
- 8 WAC 173-303-090, "Dangerous Waste Regulations," "Dangerous Waste Characteristics," *Washington*
9 *Administrative Code*, Olympia, Washington. Available at:
10 <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-090>.

11

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-1	100-N-1, HGP SWMU #6, Settling Pond	Pond	100-NR-1	30.48 x 12.19	This unit (100-N-1 Settling Pond SWMU #6) was constructed to control the Hanford Generating Plant (HGP) waste stream effluents. The effluent flowed into the pond, allowed solids to settle, and the remaining liquid was released to 1908-NE (HGP outfall). A valve was installed on the outlet pipe to prevent the discharge of oil to the outfall. The unit received waste from the HGP condenser pit, service water pumps demineralizer backwash and runoff from the roof and parking lot. An outlet pipe drained the pond directly to 1908-NE (HGP Outfall). The piping from the HGP Building floor drains and sumps to the settling pond was included with the settling pond. The settling pond was built in 1965 and became inactive in May 1993. Occasional releases of radiologically contaminated steam from N Reactor were assumed to be the source of the low level surface contamination. In September of 1993, a borehole was drilled into the Hanford Generating Plant settling pond to determine the extent of contamination beneath the waste site. Analytical results showed no evidence of chemical or radiological contamination at depth. The surface and three inch deep samples showed elevated levels of Co-60, chromium, lead, nickel, copper and zinc.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0. WSRF 2004-060	2001	2001	Not Documented	0.9	Co-60	1.53	N/A	0.653	N/A
												Cd	0.74 U	N/A	0.74 U	N/A
												Cr	18.5	N/A	14.7	N/A
												Pb	29.9	N/A	15.6	N/A
												Hg	0.2 U	N/A	0.2 U	N/A
												Diesel	10	N/A	10	N/A
												Heavy oil range hydrocarbons	28.7	N/A	28.7	N/A

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-10	100-N-10, 120-N-5 Facility Liquid Unplanned Release 2 (09/02/87)	Unplanned Release	100-NR-1	Not Documented	The release occurred at the 120-N-5 Acid/Caustic Transfer Trench. The transfer trench is a polymer lined concrete trench located between the 108-N Chemical Unloading Facility and the 163-N Demineralization Plant. On September 2, 1987 a leak was noted in the piping during a caustic transfer from the 108-N Storage Tank to the 163-N Caustic Day Tank. The caustic collected in the 120-N-5 Transfer Trench. When the leak was noticed, the transfer was stopped and the pipeline was repaired. There is no documentation to indicate the caustic reached the soil. There is no remaining evidence of the spill at the concrete-lined trench. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-052	N/A									
100-N-100	100-N Oil Filters #4	Dumping Area			This site consists of petroleum based material released to the ground surface and the underlying soils. The soil is crusted and no vegetation is growing in the affected area. There are four oil filters at this location.	Discovery	N/A										
100-N-101	100-N Stain Area #4	Dumping Area			The site consists of the underlying soil. The soil has no vegetation growing in the affected area.	Discovery											
100-N-102	100-N Potentially Contaminated French Drains	French Drain				Discovery											
100-N-103	100-N Steam Condensate French Drains	French Drain			This site consists of 13 discrete locations and underlying soil of steam condensate french drains and their associated below grade piping components.	Discovery											

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-11	100-N-11, 120-N-5 Transfer Trench Liquid Unplanned Release 3	Unplanned Release	100-NR-1	Not Documented	The site is the soil adjacent to 120-N-5, a concrete-lined neutralization pit and acid/caustic transfer trench. On November 9, 1987, a leak of approximately 760 L (200 gal) of sulfuric acid occurred during a transfer from the 108-N Storage Tank to the 163-N Facility. On December 4, 1987, it was noticed that the trench was open to the soil at the location where the leak occurred. This open area was found to be a dry well installed in 1986 during upgrading of the trench. The dry well was installed for steam trap drainage, not for containment of acid spills. An estimated 57 to 114 L (15 to 30 gal) of sulfuric acid was released to the ground. This release was cleaned up at the time. An unknown amount of soil was removed. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-053	N/A									
100-N-12	100-N-12, 166-N /184-N Pipelines Liquid Unplanned Release 1 (10/14/87 Cleaned Up)	Unplanned Release	100-NR-1	Not Documented	The site is a leak of fuel oil found contained in a drain trench, inside the 184-N Facility. The oil was absorbed and the trench cleaned up immediately. The spill was contained inside the building.	Not Accepted	Discovery Site Evaluation Checklist	N/A									
100-N-13	100-N-13, Contaminated Soil Solid Waste Site 1	Unplanned Release	100-NR-1	8.23 x 3.66	A May 1993 radiation survey identified the presence of cobalt-60 at the site. A photograph from about 1963 shows a dark circular area (possibly a burn pit) in the vicinity of this site. A 1988 photograph shows a crane (possibly regulated) parked in the vicinity of this site. The site is posted at four corners with "Underground Radioactive Material" signs. Approximately 0.3 to 0.6 m (1 to 2 ft) of soil has been placed on top of the site.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-14	100-N-14, Contaminated Soil Solid Waste Site 2	Dumping Area	100-NR-1	2.44 x 7.32	A May 1993 radiation survey identified the presence of cesium-137 at the site. The site is posted at four corners with "Underground Radioactive Material" signs. Approximately 0.3 to 0.6 m (1 to 2 ft) of soil has been placed on top of the site.	Accepted	Not Documented	N/A								
100-N-16	100-N-16, Burn Pit 1, 128N-FS-2	Burn Pit	100-NR-1	349.32 sq. m	The site (Burn Pit 1, 128N-FS-2) appears as a 18 m (20 yd) by 18 m (20 yd) semi-cleared circular area. Nonhazardous waste (paper, wood, trash) generated at 100-N were burned here. Ash is evident on the surface and the area is covered with glass, wire, coil, pipe, tin cans, metal, and other burned debris. Two other burn pits are physically located in the general area of this site and were used for similar purposes. In 1992 soil samples were collected and analyzed for the 100-NR-1 RI/CMS. Field screening samples were less than detectable for VOCs and TPH. Heavy metals and metal-complexed compounds did not differ from background. The site tested positive for PCBs.	Accepted	Not Documented	N/A								
100-N-17	100-N-17, Burn Pit 2, 128N-FS-1	Burn Pit	100-NR-1	92.90 sq. m	The site (Burn Pit 2, 128N-FS-1) is covered with gravel, cobbles, and dead tumbleweeds. Much of the site has been backfilled with fill material. Two other burn pits are located in the general area of this site and were used for similar purposes. Nonhazardous waste (paper, wood, trash) generated at 100-N were burned here. Other combustible materials such as vegetation, office wastes, tools, hardware, and possibly paints and solvents have been burned at this site. In 1992, soil samples were collected and analyzed for the 100-NR-1 RI/CMS. Field screening samples were less than detectable for VOCs, TPH, and PCBs. Heavy metals and metal-complexed compounds did not differ from background.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-18	100-N-18, Hanford Generating Plant Burn Pit, HGP Burn Pit	Burn Pit	100-NR-1	9.14 x 7.62	The site (HGP Burn Pit) shows evidence of burning including charred wood and burned metal. Vegetation at the site is sparse with a few rabbitbrush plants. Soil samples were collected from disturbed areas of the pit and analyzed using field screening methods. Samples tested contained less than detectable concentrations of VOCs, heavy metals, TPH, and PCBs.	Accepted	Not Documented	N/A								
100-N-19	100-N-19, HGP Construction Debris Dump Solid Waste Site, SWMU #11	Dumping Area	100-NR-1	1,000 x 150	The site (HGP Construction Debris Dump Solid Waste Site, SWMU #11) is a large area consisting of a series of pits and depressions containing soil, rock, concrete, metal, wood, and asphalt that have been dumped in the area over time. The site was used to dispose of non hazardous construction debris from 100-N and the HGP. The site is associated with 600-32 and 100-N-39 which are duplicate codes for the same site, a dumping area contained within the larger 100-N-19 Dumping Area. Various suspect waste site investigations and documents have identified waste dumps associated with the HGP and the BPA substation. The site descriptions in each document are similar but the location sketches are different, indicating various pits outside the HGP/BPA substation fence. These dumping areas have been entered into the WIDS database multiple times with various different names because the reference document authors were not aware of the other references.	Not Accepted	WSRF 2004-092	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-21	100-N-21, Blast Yard Solid Waste Site, 1143-N Blast Yard	Dumping Area	100-NR-1	20 (diameter)	The site (1143-N Blast Yard) has thin, scattered patches of red garnet sandblasting material. Paint chips reported in 1994 as being mixed in with the garnet are no longer visible. The site is in use as a parking lot. The garnet was used to sandblast noncontaminated equipment prior to painting. Samples of sandblast debris, presumably including the paint chips cleaned from the objects, were analyzed in 1989. The samples were taken from 12 sandblast sites in the 100 areas. All samples, including two from this site, were shown to be nonregulated for EP toxicity in accordance with WAC 173-303-090. No cleanup activities are recorded; the visual absence of the paint chips in 2000 may be due to wind action or crumbling from vehicle tires.	Not Accepted	WSRF 2000-032	N/A									
100-N-22	100-N-22, Sanitary Sewer System (Undocumented) 1705-N Septic Tank and Cesspool	Septic Tank	100-NR-1	Not Documented	This site (1705-N Septic Tank and Cesspool) most likely served the 105-N, 1705-N and 1706-N Buildings. A 1.1 m (3.5-ft) metal cover with a confined space posting is at ground level in the general area of the underground site.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-23	100-N-23, Resin Disposal Pit Liquid Waste Site 1	Process Pit	100-NR-1	22.86 x 16.76 x 2.49	According to site personnel, the pit was used to dispose of resin generated in the 163-N Demineralized Water Plant. The pit later served as the clearwell overflow up until about 1990. Although it is not used for that purpose anymore, it could be used on an emergency basis. On May 5, 1980 and January 1976, the overflow sump received neutralized waste that was pumped from cleanup actions for an acid spill that occurred on the 108-N/163-N Transfer Line. There are two drain pipes originating from the 163-N Clearwell that discharge into this site. It is reported that between 1990 and 1992, the resin was excavated out of the pit and it is unlikely that any remains today. Since the pit received water discharged from the clearwell overflow after it was used as a resin pit, any remaining resin would probably have worked down into the soil.	Accepted	Not Documented	N/A								
100-N-24	100-N-24, Hydrogen Dry Well Liquid Waste Site, Hydrogen Peroxide Drywell	French Drain	100-NR-1	4.42 x 3.35	The site (Hydrogen Peroxide Drywell) is identified by a buried vertical concrete pipe with a 0.83-meter dia. steel cover. The site received 50% hydrogen peroxide and water from the hydrogen peroxide sump under the hydrogen peroxide tank located in the 109-N Decontamination Facility. The solution used for washing down of the storage tank area. The hydrogen peroxide drywell was constructed to receive and disperse liquids from the Hydrogen Peroxide Sump Pump to the surrounding soil below ground level. The waste is the predominantly concrete and metal structure of the hydrogen peroxide drywell.	Accepted	Not Documented	N/A								
100-N-25	100-N-25, French Drain 1 Liquid Waste Site (100N TBR 4.86)	French Drain	100-NR-1	0.91 diameter	The site has a 0.9 m (3-ft) diameter metal cover at grade. The surrounding area is covered with gravel.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-26	100-N-26, French Drain 2 Liquid Waste Site (100N TBR 4.87)	French Drain	100-NR-1	0.91 diameter	The site receives yard steam condensate. The vertical concrete pipe extends 5 cm (2 in.) above grade and is closed by a vented metal cover. The surrounding area is covered with gravel. Waste sites 100-N-26 and 120-N-4 were impacted by a raw water pipeline break on 12/11/2008. In-process and post-event surface soil radiological field survey results did not find any contamination spread as a result of the water release.	Accepted	Not Documented	N/A								
100-N-27	100-N-27, 108-N Sump, 108-N Neutralization Pit	Sump	100-NR-1	1.52 x 1.1 x 1.83	The site (108-N Neutralization Pit) is constructed of concrete with a brick lining, and is covered with a steel lid. The pit was used to manually neutralize waste acid. This site received drainage from the 108-N floor drains and from the acid transfer tank. Sufficient quantities of 50% sodium hydroxide were used to neutralize the 93% sulfuric acid waste. The brick lining was replaced at least once. No known leaks occurred in the system.	Not Accepted	WSRF 2000-054	N/A								
100-N-28	100-N-28, Resin Disposal Pit Liquid Waste Site 2	Process Pit	100-NR-1	5.33 x 3.81 x 4.11	The site (Resin Disposal Pit Liquid Waste Site 2) was designed to receive the resin charge from the 109-N Ion Exchanger. The construction of the pit is such that all liquids entrained in the resin are filtered to the soil below the resin disposal pit. The effective volume of the resin disposal pit was 40.36 m ³ and the maximum resin charge in the ion exchanger was 3.12 m ³ . Site employees report that the pit was initially used for reactor decontamination waste and may have never actually been used as a resin disposal pit.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-29	100-N-29, Unplanned Release on 25 cm (10 in.) Blowdown Pipeline #1	Unplanned Release	100-NR-1	Not Documented	The 1300-N Emergency Dump Basin is an open basin that held radioactive water. The area surrounding it is level and graveled with no vegetation. Through process knowledge, it is known that several water leaks occurred around and adjacent to the dump basin in the early 1980s.	Accepted	Not Documented	N/A									
100-N-3	100-N-3, Maintenance Garage French Drain, HGP-SWMU #9, Maintenance Garage Waste Water Treatment Unit	French Drain	100-NR-1	3.05 x 3.05	The site (100-N-3 Maintenance Garage French Drain SWMU #9) received effluent from 100-N-78, the 1716-NE HGP Maintenance Garage. The unit received petroleum wastes. The WPPSS HGP RCRA Final Report described Solid SWMU #9 as three waste water treatment units (100-N-3, 100-N-45, 100-N-41) located east of the HGP building (185-N). Soil samples were collected from each site excavation in 2004 and analyzed for petroleum hydrocarbons. Petroleum hydrocarbons were not detected in any of the samples. Remediation was not necessary. The below grade structures were demolished in place and backfilled with soil in 2004.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.	April 2004 (confirmatory sampling)	April 2004 (confirmatory sampling)	N/A	N/A	Diesel range petroleum hydrocarbons	20 U	N/A	N/A	N/A	
							WSRF 2004-060						Heavy oil range petroleum hydrocarbons	50 U	N/A	N/A	N/A
100-N-30	100-N-30, Unplanned Release on 10 in. Blowdown Pipeline #2	Unplanned Release	100-NR-1	Not Documented	The site (Unplanned Release on 10 in. Blowdown Pipeline #2) is a level, graveled area with no vegetation. The area surrounding the dump basin is also graveled. The site is an open metal basin that held radioactive water. Through process knowledge it is known that several water leaks occurred around and adjacent to the dump basin in the early 1980s.	Accepted	Not Documented	N/A									
100-N-31	100-N-31, Unplanned Release on 30 in. Pipe Line	Unplanned Release	100-NR-1	Not Documented	The unit (unplanned release on 30 in. Pipe Line) is an open metal basin that held radioactive water. The surface area has no vegetation and is level and graveled. Through process knowledge, it is known that several water leaks occurred around and adjacent to the dump basin in the early 1980s.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-32	100-N-32, Unplanned Release on 25 cm (10 in.) Blowdown Pipeline #3	Unplanned Release	100-NR-1	Not Documented	The unit (Unplanned Release on 25 cm (10 in.) Blowdown Pipeline #3) is an open metal basin that held radioactive water. The surface area is level, graveled, and has no vegetation. Through process knowledge it is known that several water leaks have occurred around and adjacent to the dump basin in the early 1980s.	Accepted	Not Documented	N/A									
100-N-33	100-N-33, 100-N Military Installation Ash Pit	Coal Ash Pit	100-NR-1	Not Documented	The irregularly-shaped site (100-N Military Installation Ash Pit) is covered with a dark material that looks like uniform grain-size ash, perhaps the remnants of coal burning.	Accepted	Not Documented	N/A									
100-N-34	100-N-34, Debris Site	Dumping Area	100-NR-1	Not Documented	The debris site is an irregular shape with gravel/cobble (some in piles), weedy vegetation, and dead tumbleweeds (some in piles) present. Construction debris including asphalt, concrete, and metal pipe are also present.	Accepted	Not Documented	N/A									
100-N-35	100-N-35, BPA Hanford Substation, Hanford Generating Plant (HGP) Substation	Electrical Substation	100-NR-1	Not Documented	The substation consists of a control house, maintenance building, microwave tower, and a switchyard. The Hanford Generating Plant (185-N Building) produced electricity for the Bonneville Power Association (BPA) grid using steam from the N-Reactor operation. The Hanford Substation distributed the power into the grid. The Hanford Generating Plant operated continuously from April 1966 to December 1986. As of August 2000, the BPA Hanford Substation was still active. This site is on leased land which is excluded from the Tri-Party Agreement. Consequently it is not addressed as part of the 100-NR-1 Work Plan. The facility start date was July 12, 1971. The site is still active.	Not Accepted (proposed)	Proposed at this time	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-36	100-N-36, 107-N Oil Stained Pad	Unplanned Release	100-NR-1	Not Documented	The site consists of an air compressor pad adjacent to the 107-N Building. The concrete pad and adjacent asphalt are stained with lube oil from the air compressor that was previously installed on the concrete pad. It is evident that any leakage or release to the soil from the "seam" between the asphalt and concrete would be minimal if at all. When the area is decommissioned and the concrete and asphalt is removed, if any of the oil has reached the soil beneath, it would be removed and disposed of with the concrete and asphalt. The waste consists of non-hazardous petroleum product (oil) from air compressor leaks.	Accepted	Not Documented	N/A									
100-N-37	100-N-37, 109-N Asbestos Release	Unplanned Release	100-NR-1	Not Documented	Heavy rainfall caused a subsidence next to a caisson directly beneath the west elbow of the steam transfer line at the 109-N Building. The same rainfall saturated asbestos insulation lagging on the steam transfer piping causing a large chunk (estimated to weigh 180 to 320 kg) to fall off. It was apparent that some of the asbestos insulation washed down the subsidence next to the caisson. Surface asbestos material was cleaned up and disposed of. The subsidence was backfilled with clean fill material. No action was taken to remove asbestos contamination from the subsidence. Any excavation at the site could cause an airborne release of asbestos materials.	Accepted	Not Documented	N/A									
100-N-38	100-N-38, Unplanned Release at 1300-N	Unplanned Release	100-NR-1	Not Documented	This site (Unplanned Release at 1300-N) is an open basin with a steel liner that held radioactive water. The area surrounding the basin is level, graveled, and has no vegetation. Through process knowledge it is known that several water leaks have occurred around and adjacent to the dump basin in the early 1980s.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-39	100-N-39, Hanford Substation Construction Dump Area, SWMU #11	Dumping Area	100-NR-1	Not Documented	The site (HGP Construction Debris Dump Solid Waste Site, SWMU #11) is a large area consisting of a series of pits and depressions containing soil, rock, concrete, metal, wood, and asphalt that have been dumped in the area over time. The site was used to dispose of non hazardous construction debris from 100-N and the HGP. The site is associated with 600-32 and 100-N-39 which are duplicate codes for the same site, a dumping area contained within the larger 100-N-19 Dumping Area. Various suspect waste site investigations and documents have identified waste dumps associated with the HGP and the BPA substation. The site descriptions in each document are similar but the location sketches are different, indicating various pits outside the HGP/BPA substation fence. These dumping areas have been entered into the WIDS database multiple times with various different names because the reference document authors were not aware of the other references.	Not Accepted	WSRF 2000-114	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-4	100-N-4, HGP SWMU #5 Tile Field	Drain/Tile Field	100-NR-1	30.48 x 24.69	The site (100-N-4 Tile Field-SWMU #5) was an ancillary or support facility to the former HGP. The site received effluent from the 185-N Building drains of the HGP Sanitary Sewer and lab. Testing for corrosion inhibitors hydrazine and morpholine were performed in the lab. It is likely that reagents used for these tests were discharged to the unit. The unit was designed to release waste water by allowing it to percolate into the soil. Remediation was not necessary after evaluating confirmatory sampling data and protectiveness assessments.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0. WSRF 2004-060	2001 (confirmatory sampling)	2003 (confirmatory sampling)	N/A	N/A	Co-60	2.99	N/A	0.294	N/A	
													Cd	0.66 U	N/A	0.66 U	N/A
													Cr (total)	11.2	N/A	10.5	N/A
													Pb	15.3	N/A	10.7	N/A
													Hg	0.2 U	N/A	0.2 U	N/A
													Diesel range petroleum hydrocarbons	10 U	N/A	10 U	N/A
													Heavy oil range petroleum hydrocarbons	25.4	N/A	25.4	N/A
100-N-40	100-N-40, Unplanned Release at 108-N	Unplanned Release	100-NR-1	Not Documented	The site is a graveled field at the 108-N Chemical Unloading Facility. Approximately 38 L (10 gal) of sodium hydroxide was spilled to the ground on December 26, 1987. Difficulties during the transfer of sodium hydroxide from a rail car to the caustic storage tank prompted the operator to disconnect the transfer line and set it on the ground. The spill was cleaned up on December 31, 1987, but the extent of the remediation was not documented. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-055	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-41	100-N-41, 1701-NE Gate House Septic Tank, HGP-SWMU #9	Septic Tank	100-NR-1	3.05 x 3.05	The site (100-N-41 Gate House Septic Tank-SWMU #9) consisted of a septic system that received sanitary sewer effluent from the 1701-NE Gate House. The WPPSS HGP RCRA Final Report described Solid SWMU #9 as three waste water treatment units (100-N-3, 100-N-45, 100-N-41) located east of the HGP building (185-N). Remediation was not necessary. The below grade structures were demolished in place and backfilled with soil in 2004.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.	April 2004 (confirmatory sampling)	April 2004 (confirmatory sampling)	N/A	N/A	Diesel range petroleum hydrocarbons	20 U	N/A	N/A	N/A
							WSRF 2004-060						Heavy oil range petroleum hydrocarbons	50 U	N/A	N/A
100-N-45	100-N-45, 1703-N Septic Tank, HGP-SWMU #9	Septic Tank	100-NR-1	3.05 x 3.05	The site (SWMU #9) received sanitary sewer effluent from the 1703-N office building. The WPPSS HGP RCRA Final Report described Solid SWMU #9 as three waste water treatment units (100-N-3, 100-N-45, 100-N-41) located east of the HGP building (185-N). Remediation was not necessary. The below grade structures were demolished in place and backfilled with soil in 2004.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.	May 2004 (confirmatory sampling)	May 2004 (confirmatory sampling)	N/A	N/A	Diesel range petroleum hydrocarbons	20 U	N/A	N/A	N/A
							WSRF 2004-060						Heavy oil range petroleum hydrocarbons	50 U	N/A	N/A
100-N-46	100-N-46, HGP Diesel Oil Storage Tank	Storage Tank	100-NR-1	Not Documented	The site (HGP Diesel Oil Storage Tank) was a 75,700 L (20,000 gal) UST used for storing diesel fuel. The UST supplied diesel fuel to a backup generator and a backup heating boiler located in the former 185-N Building. The UST was located on the east side of the former 185-N Building. The UST was excavated and removed in 2001. Soil contaminated with diesel was also excavated from the UST excavation. Contaminated soil was spread over the former 1703-N Office Building concrete slab foundation for attenuation.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.	2001	2001	Not Available	6.7	Diesel range petroleum hydrocarbons	40 U	N/A	N/A	N/A
							WSRF 2004-060									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-47	100-N-47, Military Artillery Site Solid Waste Site	Military Compound	100-NR-1	609 x 213	The site (Military Artillery Site Solid Waste Site) includes ten separate intact concrete foundations and remnants of at least one other. A number of concrete walkways and remnants of walkways are associated with the foundations. There are remnants of asphalt roadways, parking areas, and piles of broken-up asphalt. There is a 0.6 m (2-ft) diameter sewer manhole and three associated down slope 1.2 by 1.2 m (4 by 4-ft) square concrete hatch covers (likely underground sanitary waste holding areas). Strewn through the military artillery site are wood poles, metal cables, wire, metal pipe, glass, paint cans, fire hose, metal cans, broken up concrete, concrete blocks, wood pallets, bricks, and transite siding. A number of 0.3 m (1-ft) diameter wooden poles are standing, and some have been cut off at ground level. On the 6.1 m (20-ft) by 15.2 m (50-ft) concrete foundation that is positioned between two 6.1 m (20 ft) high soil berms, are 31 (41 cm [16 in.] wide and 51 cm [20 in.] long) hive bodies and supers (bee boxes) left from a Pacific Northwest Laboratory (PNL) experiment conducted from 1981 to 1984. No strong evidence of hazardous or radioactive material has been found.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-5	100-N-5, HGP Disposal and Storage Area, HGP Bone Yard, HGP-SWMU #10	Storage	100-NR-1	5,181 sq. m	The site (HGP Disposal and Storage Area-SWMU #10) consisted of material and equipment which were stored inside the southwest corner of the Hanford Generating Plant facility fence. Some of the material included scrap metal, electrical equipment, pipes, and cables. The unit was located on a level area which had several spots of stressed or absent vegetation. Some of the soil was oil stained. Garnet sandblasting grit was also present. Remediation waste consisting of sand blast, ion exchange resin, and contaminated soil wastes were disposed of at the RABANCO landfill facility in Roosevelt, Washington.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0.	2001	2004	Waste was sent to RABANCO Landfill Facility	Not Documented	Pb	4.34	N/A	3.6	N/A	
													Diesel range petroleum hydrocarbons	20 U	N/A	20 U	N/A
													Heavy oil range petroleum hydrocarbons	940	N/A	N/A	N/A
													Cadmium, chromium, and mercury concentrations are also reported in the CVP; however these results are from pre-remediation sampling. Soil samples results in CVP are reported in units of mg/L instead of mg/kg.				
100-N-50	100-N-50, HGP SWMU 4, Turbine Oil filter Unit, Turbine oil cleaning system	Single-Shell Tank	100-NR-1	2.44 x 2.44	The 100-N-50 Turbine Oil Filter Unit (SWMU #4) was located in the 185-N Building basement along the northeast and southeast walls. The filter unit was used to clean turbine oil located in the basement of the Hanford Generating Plant (HGP) Building. It was surrounded by a concrete berm. The turbine oil filter unit was used to clean turbine oil during plant operation. The filters that contained waste are no longer in this inactive unit and their disposal location is unknown. The unit was on a concrete floor surrounded by a concrete curb that should have contained any small leaks. No releases are known to have occurred from this unit.	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.	2001	2004	Not Documented	Not Available (equipment removal and concrete scabbing)	Cd	Verification of cleanup of the concrete and metal building surfaces associated with the 185-N Building basement sites (100-N-51 Oil Storage Area [SWMU #2], 185-N Building Sumps and Drains [SWMU #3], and 100-N-50 Oil Filter Unit [SWMU #4]) is primarily based on photographic documentation and a qualitative and conservative bounding assessment rather than analytical laboratory data. For these cleaned but residually contaminated surfaces, verification is primarily in the form of documentation that the residual waste has been removed. The qualitative and conservative bounding protectiveness assessment for the 185-N Building basement sites is provided in Section 6.0 of the referenced decision document.				
																	Cr (total)
																	Pb
																	Hg

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)			
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b		
100-N-51	100-N-51, HGP Building Oil Storage Area, 100-N-51A, HGP SWMU #2	Storage	100-NR-1	7.62 x 2.44	The site (HGP Building Oil Storage Area, SMU #2) consisted of a cinder block room with a fire sprinkler system, steel grate floor, and shelving along the walls. The Hanford Generating Plant (HGP) Building Oil Storage Area was used to store both product and waste chemicals, some of which had hazardous constituents. The room was well designed for this purpose and no releases are known to have occurred. Stains on the grate and sump floor indicated that minor leaks from containers had been contained within the unit. A blind concrete sump (no outlet) was located below the grated floor.	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.	2001	2004	Not Documented	N/A (equipment removal and concrete scabbing)	Cd	Verification of cleanup of the concrete and metal building surfaces associated with the 185-N Building basement sites (100-N-51 Oil Storage Area [SWMU #2], 185-N Building Sumps and Drains [SWMU #3], and 100-N-50 Oil Filter Unit [SWMU #4]) is primarily based on photographic documentation and a qualitative and conservative bounding assessment rather than analytical laboratory data. For these cleaned but residually contaminated surfaces, verification is primarily in the form of documentation that the residual waste has been removed. The qualitative and conservative bounding protectiveness assessment for the 185-N Building basement sites is provided in Section 6.0 of the referenced decision document.					
							WSRF 2004-059											Cr (total)
																		Pb
																		Hg

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-51B	100-N-51B, HGP Building Floor Drains and Sumps, HGP SWMU #3	Sump	100-NR-1	Not Documented	HGP (185-N Building) Floor Drains and Sumps, HGP SWMU #3. The 185-N Building basement contained miscellaneous drains and sumps that are collectively included in SWMU #3. The drains and sumps collected spilled or leaked fluids. Some of the drains and all of the sumps were routed to a central sump.	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.	2001	2004	Not Documented	Not Available (equipment removal and concrete scabbing)	Cs-137	N/A	N/A	16.9	N/A
												Co-60	N/A	N/A	60.8	N/A
												Sr-90	N/A	N/A	0.25	N/A
												Statistical values for radionuclides were calculated using the waste characterization data and applied to the entire debris, cement grout controlled density fill, and borrow soil layer. This is extremely conservative, because the remaining residual waste would make up a fraction of a percent of the total fill layer volume. To ensure that this approach was conservative and to ensure that the radioactivity of the debris fill was adequately accounted for, the modeled radionuclide inventory was compared to a previously calculated inventory for the HGP facility. This comparison indicated that the approach is conservative. The inventory comparison is included in Appendix D of the referenced closure document.				
												Cd	Verification of cleanup of the concrete and metal building surfaces associated with the 185-N Building basement sites (100-N-51 Oil Storage Area [SWMU #2], 185-N Building Sumps and Drains [SWMU #3], and 100-N-50 Oil Filter Unit [SWMU #4]) is primarily based on photographic documentation and a qualitative and conservative bounding assessment rather than analytical laboratory data. For these cleaned but residually contaminated surfaces, verification is primarily in the form of documentation that the residual waste has been removed. The qualitative and conservative bounding protectiveness assessment for the 185-N Building basement sites is provided in Section 6.0 of the referenced closure document.			
Cr (total)																
Pb																
Hg																

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-52	100-N-52, HGP Gasoline Storage Tank	Storage Tank	100-NR-1	Not Documented	The site (HGP Gasoline Storage Tank) was located immediately north of the former 1716-NE Maintenance Garage and was used for the storage and dispensing of gasoline for maintenance vehicles. The tank had a capacity of 3,800 L (1,000 gal) and held unleaded gasoline. The UST was excavated and removed in 1992. The UST assessment report was included as Appendix D of the HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10. Because the 100-N-52 (UST) site was adjacent to the maintenance garage (100-N-78) it was included in the HGP-CVP for regulatory closure. Sample results were non-detectable for WTPH-HCID. (The 100-N-52 Gasoline UST site was not identified as a part of SWMU #8; however, because the UST was adjacent to the maintenance garage, SWMU #8 and the UST site were treated as a single unit.)	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0. WSRF 2004-060	1992	1992	N/A							
100-N-53		Storage Tank	100-NR-1	1.25 (deep) x 1.07 (diameter)	The site (181-N Building Waste Oil Tank) was an empty above-ground waste oil tank. The site received waste oil from diesel powered emergency pumps in the 181-N Building. The tank was in good condition and the potential for environmental release was low. A site visit in July 1999 found that the tank has been removed.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-54		French Drain	100-NR-1	1.65 (diameter)	The site (151-N Building Drywell) is a french drain, made of 1.2 m (4 ft) inner diameter and 1.65 m (5 ft 5 in.) outer diameter concrete pipe, with a steel cover. The site received waste water from the service sink located inside the 151-N Building. The 151-N Building controlled electrical power distribution to 100N facilities from the 151-N substation. The 151-N substation has been deactivated. Service water to the sink has been disconnected and sealed. The sink drain has also been sealed. The miscellaneous stream was eliminated July 11, 1997.	Accepted	Not Documented	N/A									
100-N-55		French Drain	100-NR-1	1.22 (diameter)	The site (153-N Building Drywell) is a french drain with a 1.2 m (4-ft) steel cover. The drywell receives steam condensate from a condensate pump and drainage from a service sink in the 153-N Building. The 153-N Building is the switchgear building, and contains a transformer/substation taking 13.8 kilovolts down to 4,160 volts. This miscellaneous stream was eliminated on July 7, 1997.	Accepted	Not Documented	N/A									
100-N-56		French Drain	100-NR-1	1.22 m (diameter)	The site (181-N Building Drywell) received waste water from the 181-N River Pumphouse Building. The drywell is not visible from ground surface and is apparently located underground. The ground surface is graveled. River water from inside the 181-N Pumphouse is the only source of waste water to this site.	Not Accepted	WSRF 2000-061	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-57	100-N-57, 1304-N Emergency Dump Tank	Catch Tank	100-NR-1	18.59 x 19.2	The site (1304-N Emergency Dump Tank) consists of a 500,000 gal above-ground storage tank used for emergency blowdown of thermally hot pressurized reactor primary coolant water. The tank maintained a constant volume of 2.6E+06 L (6.8E+05 gal) of unheated quench water. Because a small flow of primary coolant was maintained to the 1304-N Emergency Dump Tank to keep interconnecting piping in a thermally warm condition, the quench water normally contained a small inventory of radioactive materials. In 1974, four unplanned releases of primary reactor coolant were released from the 1304-N Emergency Dump Tank to the ground.	Accepted	Not Documented	N/A								
100-N-58	100-N-58, South Pond, 120-N South Settling Pond, 1324-N South Settling Pond	Pond	100-NR-1	33.53 x 15.24 x 4.57	The 100-N-58 site (120-N or 1324-N South Settling Pond) was initially constructed along with the 120-N-1, 120-N-2 sites (East Percolation Pond and North Settling Pond). These unlined ponds received 163-N anion/cation regeneration effluent as well as the 183-N Filtered Water Plant filter backwash effluent. In 1982, the 183-N filter backwash was rerouted and the 100-N-58 site was backfilled because of pond percolation problems. The 100-N-58 site was remediated with the 120-N-1 and 120-N-2 sites in September/October 2000.	Closed Out	CVP 2001-00021	Sep-00	Sep-00	None (material was disposed of in the inert demolition landfill in the 100-H Area)	Not Documented	Ba	93.7	N/A	86.9	N/A
							WSRF 2001-093					Cr (total)	14.6	N/A	10.5	N/A
							Cu					31.5	N/A	16.4	N/A	
							Pb					6.4	N/A	4.4	N/A	
							Hg					0.37	N/A	0.05	N/A	
							Ni					17.6	N/A	13.5	N/A	
							Zn					94.4	N/A	53.4	N/A	
							Sulfate					135	N/A	55.7	N/A	

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-59	100-N-59, Radioactively Contaminated Soil Northeast of 105-NB Building	Unplanned Release	100-NR-1	0.76 x 1.37	In September 1995, an underground liquid waste pipeline was found to be leaking. An area approximately 0.76 m (2.5 ft) by 1.4 m (4.5 ft) was excavated to repair the pipe. The soil below the pipe had a beta/gamma reading of 7,000 disintegrations per minute. A direct reading on the broken pipe found 35,000 disintegrations per minute. After repairing the pipe, the excavation was backfilled with clean dirt and posted with an Underground Radioactive Material sign. A site visit in August 2000 found that the single post with the Underground Radioactive Material sign was gone, but an Underground Radioactive Material sign was attached to the fence near the waste site.	Accepted	Not Documented	N/A								
100-N-6	100-N-6, 128-N-1, 128N-FS-3	Burn Pit	100-NR-1	1486 sq. m	The site (128-N-1 or 128N-FS-3) is a burn pit associated with two other burn pits, 100-N-16 and 128-N-1. In 1993, shallow soil samples were collected from several burn pits in the 100-NR-1 Operable Unit. The maximum depth of the samples was 0.3 m (1 ft). The samples were analyzed for volatile organic compounds (VOC), total petroleum hydrocarbons (TPH) and polychlorinated hydrocarbons (PCB). They were also examined with X-ray Fluorescence Spectroscopy (XRF). The samples were less than detectable for VOC and TPH. One sample taken at 128-FS-3 contained a slightly elevated amount of PCB. No heavy metals or metal compounds were identified. In 1992, soil samples were collected and analyzed for the 100-NR-1 Remedial Investigation/Corrective Measures Study (RI/CMS). Field screening were less than detectable for VOCs, TPH, and PCBs. Heavy metals and metal-complexed compounds did not differ from background.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-60	100-N-60, 1314-N Drywell	French Drain	100-NR-1	Not Documented	The site (1314-N Drywell) reportedly received spent decontamination solutions from a railroad waste tank car during an unplanned release. Occurrence Report 73-39 mentions a release of decontamination solutions that overflowed from a catch basin to an adjacent drywell. The drywell was not included in the WIDS database. A field investigation done in 1996 failed to visually locate the drywell as discussed in the referenced occurrence report. It is suspected that the area surrounding the catch tank may have been referred to as the drywell. Drawing H-1-37675, Detail D, shows a 5 cm (2 in.) underground drain pipe to a "drywell". It is possible the drywell exists, but cannot be visually verified. The site is suspected to be located underneath the 1314-N Building, in the southwest corner of the building in the vicinity of the catch tank.	Accepted	Not Documented	N/A								
100-N-61	100-N-61, 100-N Water Treatment and Storage Facilities Underground Pipelines	Process Sewer	100-NR-1	Not Documented	The site (100-N Water Treatment and Storage Facilities Underground Pipelines) encompasses all underground water pipelines used to transport reactor cooling water between water treatment facilities and the 105-N Reactor Building. These include all underground lines running between buildings and those that run to drainage facilities. Pipelines within buildings and all pipelines that are downstream from the reactor building, i.e., those lines that carry cooling water from the reactor to effluent disposal facilities such as the dump tank and cribs are excluded. Other underground pipelines running to the outfall structures are included in other waste sites and are therefore excluded from this site. Reactor cooling water was pumped from the Columbia River, settled and treated to remove minerals, then injected into the reactor primary coolant	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
					loop at a rate of about 760 L/minute (200 gal/minute).												
100-N-62	100-N-62, 100-N 105-N, 109-N, 163-N, 182-N, 183-N and 184-N Underground Pipelines	Radio-active Process Sewer	100-NR-1	Not Documented	This site includes those underground pipelines that transported reactor decontamination chemicals and/or radioactive liquid wastes from the 105-N/109-N Reactor facilities, and other pipelines that have the potential for radioactive contamination that are co-located on the east side of the 105-N/109-N Building complex. It does not include the pipelines that discharge to the 116-N-4 (1300-N), the 1304-N Emergency Dump Tank, pipelines to and from the 107-N and 105-N Buildings, or pipelines from the 105-N/109-N Buildings to the 1908-N Outfall that are addressed by a separate Waste Information Data System (WIDS) entry (100-N-65) for 100-N Reactor 105-N/109-N Cooling Water Effluent Underground Pipelines.	Accepted	Not Documented	N/A									
100-N-63	100-N-63, 100-N Reactor (1314-N, 116-N-1 and 116-N-3) TSD Underground Pipelines; 100-N-63:1 Pipeline and concrete encased pipe by-pass structure	Radio-active Process Sewer	100-NR-1	Not Documented	The site (100-N Reactor (1314-N, 116-N-1 and 116-N-3) TSD Underground Pipelines [See Subsites]) encompasses the Treatment, Storage, and Disposal (TSD) underground pipelines that transported reactor cooling water and radioactive liquid wastes from the 105-N Reactor facilities to the 116-N-1 (1301-N), 116-N-3 (1325-N) Crib, and 116-N-2 (1310-N Tank). It does not include the underground pipelines that discharge to the 116-N-4 (1300-N Emergency Dump Basin), 1304-N Emergency Dump Tank, pipelines to and from the 107-N and 105-N Buildings, or pipelines from the 105/109-N Buildings to the 1908-N Outfall that are addressed by a separate Waste Information Data System (WIDS) entry for the 100-N Reactor 105/109-N Cooling Water Effluent Underground Pipelines.	Accepted	CVP-2002-00002	21-Jul-00	1-Apr-02	140,270	>4.6	Am-241	0.387U	999	0.102	154	
							WSRF 2002-055						Co-60	0.796	62400	0.387	5580
													Cs-137	1.27	43100	0.406	4900
													Eu-154	0.18U	0.211	0.0603	8.7
													Eu-155	0.13U	130U	0.0422	6.45
													H-3	N/A	2.57U	N/A	-0.00726
													Ni-63	0.856U	6040	-0.0622	1030
													Pu-239/240	0.137U	1730	0.0282	258
													Sr-90	1.14	3710	0.17	1460
													Hg	0.02U	N/A	0.02	N/A
Nitrate	2.1	14.8	1.24	3													

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-63:1	100-N-63:1, Pipeline Section from 116-N-1 to 116-N-3 Crib including concrete encased pipe bypass structure	Radio-active Process Sewer	100-NR-1	Not Documented	This site is the pipeline section from 116-N-1 to 116-N-3 Crib including the concrete encased pipe bypass structure. The western portion of this pipeline was located between 116-N-1 and the 1312-N Diversion Box. The effluent flowed through a 448 m (1,468-ft) long by 0.9 m (Diameter Nominal [DN] 900) (36-in.) diameter pipeline. Two pipelines continued on from the 1312-N Diversion Box to the north then eastward to the southwest end of the crib. One of the pipelines was a pipe encased concrete by-pass structure that ran parallel to the original. The by-pass structure was built at the same time as the 1312-N Retention Basin (also known as the 1312-N LERF), however, neither was put into service. This portion of the pipeline 100-N-63:1, approximately 66 m (216.54 ft) west of 1213-N Diversion Box continuing to the southwest end of the 116-N-3 Crib, has been remediated and closed-out in CVP-2002-00002. For purposes of the CVP/closure report and consistent with the permitted TSD site designation, the 116-N-3 Crib and Trench, the 100-N-63:1 Pipeline, and the bypass structure are collectively referred to as the 116-N-3 site.	Interim Closed Out	CVP-2002-00002	21-Jul-00	1-Apr-02	140,270	>4.6	Am-241	0.387U	999	0.102	154	
							Co-60					0.796	62400	0.387	5580		
							Cs-137					1.27	43100	0.406	4900		
							Eu-154					0.18U	0.211	0.0603	8.7		
							Eu-155					0.13U	130U	0.0422	6.45		
							H-3					N/A	2.57U	N/A	-0.00726		
							Ni-63					0.856U	6040	-0.0622	1030		
							Pu-239/240					0.137U	1730	0.0282	258		
							Sr-90					1.14	3710	0.17	1460		
							Hg					0.02U	N/A	0.02	N/A		
Nitrate	2.1	14.8	1.24	3													
100-N-63:2	100-N-63:2, Pipelines Between 109N, 105N, 107N, 1310N, 1322N, 1926N And 36" Process Drain to Outfall	Radio-active Process Sewer	100-NR-1	Not Documented	Pipelines between 109N, 105N, 107N, 1210N, 1322N, 1926N, and 36 in. process drain to outfall.	Discovery	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-64	100-N-64, 100-N React or 105/109-N Cooling Water Effluent Underground Pipelines	Radio-active Process Sewer	100-NR-1	Not Documented	This site includes those underground pipelines that transported reactor cooling water from the 105-N Reactor facilities to the 116-N-4 (1300-N), the 1304-N Emergency Dump Basin and Tank respectively, the 107-N Filter Building and the pipelines from these facilities to the 1908-N Outfall Structure. It does not include the underground lines that discharge to the 1301-N (116-N-1) and/or 1325-N (116-N-3) Cribs that are addressed by a separate Waste Information Data System (WIDS) entry for the 105-N Reactor, 1314-N, 116-N-1, and 116-N-3 underground pipelines (site 100-N-63). The Emergency Dump Basin (116-N-4/1300-N) and the Emergency Dump Tank (1304-N) were designed to receive "single-pass" reactor cooling water in the case of an emergency. Both systems were used to periodically receive steam blowdown. The 1304-N Tank replaced the 1300-N Basin. This steam condensate normally contained low levels of radionuclide contamination and fission products. Overflow and drain lines to the 1908-N Outfall Structure are included in this waste site. However, the outfall structure is a separate waste site.	Accepted	Not Documented	N/A									
100-N-65	100-N-65, UPR-100-N-17 Interceptor Trench, Diesel Oil Interceptor Trench	Trench	100-NR-1	Not Documented	The site (UPR-100-N-17 Interceptor Trench, Diesel Oil Interceptor Trench) is a trench that was excavated along the Columbia River bank to intercept diesel oil before it could reach the river. In 1994, the trench was backfilled with material to the top of the adjacent berm. The trench was excavated as a result of an unplanned release of 303,000 L (80,000 gal) of diesel fuel that leaked from a pipeline within 166-N Tank Farm (See UPR-100-N-17). Several smaller unplanned releases also contributed to the need for the trench (See UPR-100-N-19 and UPR-100-N-20). Oil trapped in the trench was ignited and burned. A significant	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
					portion of the oil was thus removed before it could reach the river. No gross fuel oil contamination was found during placement of a characterization well on the berm in Fiscal Year 1994, but gross contamination was found in characterization wells to the south of the berm. The release dates for the Unplanned release UPR-100-N-17 occurred in 1966, UPR-100-N-20 occurred in 1985, and UPR-100-N-19 occurred in 1984.											
100-N-66	100-N-66, 105-N/109-N Reactor Building Complex	Reactor	100-NR-1	137.77 x 141.73 x 21.34 (105-N) 62.79 x 116.74 x 11.89 (109-N)	The site is the 105-N Reactor Building and the 109-N Heat Exchange Building. The 105-N Building is a reinforced concrete and structural steel building with channeled steel siding. The reactor is contained within a reinforced concrete enclosure which serves as a confinement zone capable of withstanding moderate overpressures. This enclosure also contains the control rod systems, inlet and outlet pipe galleries, exhaust fans, elevators for servicing the front and rear faces, a gallery beneath the reactor for various monitoring purposes, and receiving basin for spent fuel elements. Surrounding the reactor enclosure on three sides are rooms housing auxiliary facilities and supporting services. These include offices, common facilities, the main control room, electrical control rooms, shop area, ventilation supply rooms, gas dryer and cooler rooms, instrumentation rooms, metal preparation and storage facilities, spent fuel storage, examination facility, and transfer area. On the fourth side of the confinement enclosure, to the rear of the reactor, is the 109-N Heat Exchange Building which shares a common wall with the 105-N Building. The 109-N Building is a reinforced concrete, structural steel building with channeled steel siding. It is immediately adjacent to and shares a	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
					common wall (south wall of 109-N) with the 105-N Building. The 109-N Building contains a large pipe gallery on the north side which receives the primary reactor coolant system piping from the reactor for distribution into five separate cells each housing two large heat exchangers, a primary circulating pump and associated piping. A sixth cell contains a heat exchanger system for the moderator cooling system. The pipe gallery and steam generator cells are located in a reinforced concrete enclosure which, as in the case of the reactor, defines a confinement zone. Located outside of the confinement zone are the pump drive systems, dump condensers for disposal of export steam, condensate return pumps, other auxiliary equipment, a small chemical laboratory, and water sampling and monitoring facilities. A service bay has facilities for decontaminating the primary coolant system and contains the heating and ventilation equipment, shop areas, office and common space.											
100-N-67	100-N-67, HGP Dumping Area	Dumping Area	100-NR-1	Not Documented	The site (HGP Dumping Area) is a pile of metal banding material, barbed wire, wire rope, concrete, and pipe. Some of the materials are partially buried. The waste appears to have been generated from the construction of the Bonneville Power Administration (BPA) powerlines. A pipe extends down the bank and is buried near the top of the bank. This pipe may have once functioned as an effluent pipe, but no hazardous or radioactive facilities were in this area. The pipe was dry at the time of the inspection in 1997. It was also dry in August 2000. The soil below the end of the pipe shows no discoloration.	No Action	WSRF 2000-057	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-68	100-N-68, N Basin Low Level Radioactive Water Spill	Unplanned Release	100-NR-1	278.71 sq. m	The intake hose to the Final Transfer Filtration system had split sometime between 2:00-4:00 am, causing contaminated water from the basin to be released to the floor. The estimated amount of water released from the basin is approximately 1.36E+05 L (36,000 gal). The basin drains captured most of the water, however an estimated 7,600 L (2,000 gal) leaked under a set of roll-up doors and out of the building. This water spread onto the ground outside the 105-N Building, pooling on concrete and gravel surfaces (mostly in an area 6 by 9 m [20 by 30 ft]). On February 20, 1998, the areas contaminated by the January 7, 1998, unplanned release of basin water were capped. Both previously identified areas have asphalt covers on them. The site has been posted with contaminated area signs and the contamination has been temporarily stabilized with a fixative, tarps, and plywood.	Accepted	Not Documented	N/A									
100-N-69	100-N-69, 105-NB Stormwater Injection Well, Miscellaneous Stream #801	Injection/Reverse Well	100-NR-1	0.56 diameter x 2.56 deep	The site is covered with a 0.56 m (1.8 ft) diameter steel grate and is 2.56 m (8.4 ft) deep. The drywell is constructed of concrete. The drain was installed to prevent stormwater from collecting in low areas. Flow rates to the drain are estimated to be less than 19 L (5 gal) per minute. No contaminated areas were observed at the time of the inspection.	Not Accepted	Discovery Site Evaluation Checklist	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-7	100-N-7, 182-N Facility Liquid Unplanned Release (remediated)	Unplanned Release	100-NR-1	Not Documented	The site (182-N Facility Liquid Unplanned Release [Remediated]) consists of a concrete flume on the river bank that extends into the river. The release at this site was approximately 19 L (5 gal) of oil that was mixed with a continuous permitted water discharge. The oil was dispersed into the river with the rest of the permitted discharge from the flume. The flume is currently dry and there is no evidence of the release.	Not Accepted	Discovery Site Evaluation Checklist	N/A								
100-N-70	100-N-70, 1705-N Stormwater Injection Well, Miscellaneous Stream #802	Injection/ Reverse Well	100-NR-1	1.00 diameter x 1 deep	The site is covered with a 1 m (3.3 ft) diameter steel grate at grade level and is constructed of concrete. The site is filled with gravel and is located in a depression. The site appears to be a drain for stormwater that collects in a depression from the surrounding area and the roof of 1705-N. The flow rates to the site are estimated to be less than 19 L (5 gal) per minute. No contaminated areas were observed at the time of the inspection.	Not Accepted	Discovery Site Evaluation Checklist	N/A								
100-N-71	100-N-71, 100-N Sewer System, Project 4546.010	Septic Tank	100-NR-1	Not Documented	This site was added to WIDS before the septic system was built; subsequently the project has been cancelled because of lack of funds (per Nolan Draper).	Not Accepted	Not Documented	N/A								
100-N-72	100-N-72, 107-N Building East Area Stormwater Runoff, Miscellaneous Stream #396	Injection/ Reverse Well	100-NR-1	Not Documented	The site is a concrete french drain, about 0.5 m (1.5 ft) in diameter, with an open metal grate cover. The bottom is about 0.3 m (1 ft) deep and only sand and cobbles are visible. A concrete trench, about 18 m (60 ft) long, drains the paved and graveled area north of the 107-N Building, and empties into this french drain. The trench prevents stormwater from flowing to the west, and down a steep slope in the area fenced for security exclusion. The area is posted with underground radioactive materials (URM) signs, like most of the 100-N Area. This french drain receives stormwater only.	Not Accepted	Discovery Site Evaluation Checklist	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-73	100-N-73, 107-N Building West Area Stormwater Runoff, Miscellaneous Stream #395	Injection/Reverse Well	100-NR-1	Not Documented	The drain is a concrete structure with a steel lid, fed by a concrete trough running from north of the 107-N Building, along the base of the security fence. This miscellaneous stream drains stormwater from the area north and west of the 107-N Building and flows via a concrete trench to a drywell on the north side of the 181-N Pumphouse. It is designed to prevent erosion on the river bank that could otherwise be caused by stormwater.	Not Accepted	Discovery Site Evaluation Checklist	N/A								
100-N-74	100-N-74, 183-N Building Fire System Drain, Miscellaneous Stream #492	Injection/Reverse Well	100-NR-1	Not Documented	The site is in a graveled lot on the north side of the 183-N Building. A fire system relief valve (site 100-N-75) extends about 1 m (3 ft) above the ground, and is surrounded by six steel barrier poles to protect it from vehicles. Two metal 10 cm (4 in.) pipes with handles for turning valves are next to the relief valve, but no pit is visible. When fire system piping is opened at the valve pit for repair, untreated water from the Columbia River (via the Hanford Site export water system) drains from pipes into the pit.	Not Accepted	WSRF 2000-100	N/A								
100-N-75	100-N-75, 183-N Building Fire System Relief Valve, Miscellaneous Stream #493	French Drain	100-NR-1	Not Documented	This site is a relief valve that releases during upset conditions in the plant fire system. Released water flows into a container, and overflows onto the ground. The water is from the fire control test system which is clean, untreated river water from the Columbia River via the Hanford Site export water line.	Not Accepted	WSRF 2000-101	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-76	100-N-76, 181-N Pumphouse French Drains	French Drain	100-NR-1	0.46 diameter x 1.22 deep	The site is two french drains; the drains were plugged with grout on June 13, 2001. The french drains were connected to each other underground, and provided steam condensate and stormwater drainage just east of the 181-N Pumphouse. These drains are believed to have been built to receive steam condensate blowdown. However, when the steam line was removed the drains were left behind, and drained excess stormwater. The french drains were plugged, abandoned, and closed in accordance with 40 CFR 144.82.	Not Accepted	WSRF 2001-048	N/A									
100-N-77	100-N-77, 100N River Effluent Pipeline, River Line from 1908-N Outfall	Radio-active Process Sewer	100-NR-1	121.92	This site consists of a 260 cm (102 in.) pipeline that exits the northwest face of the outfall (1908-N) to the Columbia River. The river line is located in the Columbia River, adjacent to the 100N Area. The line extends into the main channel of the river from the 1908-N Outfall. The 100-N-77 river effluent pipeline originates from, and is perpendicular to, the face of the 1908-N outfall structure. The pipeline extends 118 m (386 ft) from the outfall face before turning 30 degrees upstream, and continuing for another 148 m (485 ft) to its discharge point in the Columbia River. The river effluent pipeline received more than 2 million cubic meters per day of single pass raw river water from the circulating raw water (CRW) system, and discharged it to the river. The CRW supplied once-through untreated river water to 16 dump condensers and 7 surface condensers. The water was used to cool the secondary cooling water for the N Reactor from the 1908-N Seal well (1908-N Outfall) and discharged it to the Columbia River. The outfall line is a NPDES discharge point, outfall number 009. During a site visit in 2005, the structure was found to be intact. Per the requirements of Tri-Party Commitment C-106-	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
					06B for DOE/RL to "Submit an engineering evaluation of the final disposition of the river pipelines and outfall structures to EPA and Ecology" by July 31, 2005, the 100-N-77 river effluent pipeline, along with other river effluent pipelines in the 100 Area, will be addressed through an Explanation of Significant Differences (a CERCLA decision document).												
100-N-77:1	100-N-77:1, 1908-N Outfall	Outfall	100-NR-1	111.86 x 3.66	The site consists of a spillway (also referred to as an emergency outfall) and is constructed of reinforced concrete. The flume was used when the river lines were blocked, damaged, or undergoing maintenance, or when the flow rate exceeded the capacity of the lines. The spillway was an emergency discharge point for the 1908-N Outfall structure. It was planned to be used only if the 100-N-77 river effluent pipelines were blocked, damaged, or undergoing maintenance. There is no corroborated physical or historical evidence that the spillway was ever used. Originally, the 1908-N Outfall, Spillway (Flume) and river pipelines were entered into WIDS as one site. Due to remediation project needs the outfall structure (1908-N), the River Effluent Discharge lines (100-N-77) and the spillway (flume) (100-N-79) have documented as separate waste sites. The 1908-N Outfall extends from the outfall under a service road, and discharges at the low water mark on the river shore 112 m (367 ft) from the outfall. During a site visit on February 7, 2005, the spillway and outfall were found intact.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-78	100-N-78, 1716-NE Maintenance Garage, HGP SWMU #8	Maintenance Shop	100-NR-1	Not Documented	The 1716-NE Maintenance Garage (SWMU #8) was located to the east of the former 185-N Building. The 1716-NE Maintenance Garage was used for vehicle maintenance. The garage had three vehicle bays with each containing a floor drain that led to the 100-N-3 Maintenance Garage French Drain (SWMU #9). Following removal of the building and concrete foundation no samples were collected from underlying soils. There were no visual indications (i.e., soil stains or discoloration of any releases from the building to the underlying soil.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0. WSRF 2004-060	2003	2004	N/A						
100-N-79	100-N-79, 1908-N Spillway, 1908 N Outfall Structure, 100-N-77:1 Flume	Outfall	100-NR-1	111.86 x 3.66	The site (1908-N Spillway, 1908 N Outfall Structure, 100-N-77:1 Flume) consists of a spillway (also referred to as an emergency outfall) and is constructed of reinforced concrete. The spillway was an emergency discharge point for the 1908-N Outfall structure. It was planned to be used only if the 100-N-77 river effluent pipelines were blocked, damaged, or undergoing maintenance. There is no corroborated physical or historical evidence that the spillway was ever used. There is anecdotal evidence that the spillway was never intended or expected to be used, as it was never permitted. An unknown level of radioactive contamination exists within the structure because the discharge lines were associated with the reactor's secondary steam system.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-8	100-N-8, 108-N Facility, 108-N CUF	Loading Dock	100-NR-1	Not Documented	The site (108-N Chemical Unloading Facility) was used for offloading, storage, and transfer of 93% sulfuric acid and 50% sodium hydroxide solutions received by railroad car or tank truck. Three UPRs are associated with this site. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-050	N/A								
100-N-80	100-N-80, River Line from 1908-NE Outfall	Process Sewer	100-NR-1	Not Documented	This site includes one, 335 cm (132 in.) (2 cm [0.75 in.] wall thickness) steel pipeline, extending from the face of the 1908-NE Outfall into the main channel of the Columbia River. The river effluent pipeline received single pass raw river water which had passed through the Hanford Generating Plant (HGP) condensers, as well as waste water from the 100-N-1 Settling Basin. The pipeline contains seven, 20 cm (8 in.) vents along its length, and discharges to the river via four, 3.4 m (11 ft) outlets. The pipeline is buried along its entire length to a depth of at least 1.2 m (4 ft) with soil, gravel, and riprap.	Accepted	Not Documented	N/A								
100-N-81	100-N-81, 100-N Kaiser Shops Garnet Sandblasting Material	Dumping Area	100-NR-1	Not Documented	Not Specified	Discovery	Not Documented	N/A								
100-N-82	100-N-82, 100-N Decontamination Pad	Unplanned Release	100-NR-1	Not Documented	Not Specified	Discovery	Not Documented	N/A								
100-N-83	100-N-83, Two Contamination Areas Found Near 116-N-1	Unplanned Release	100-NR-1	Not Documented	The site consists of two contamination areas found near 116-N-1.	Discovery	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-84	100-N 100-N Miscellaneous Pipelines	Product Piping	100-NR-1	Not Documented	This site consists of all miscellaneous pipelines in the 100-N Area that were identified during the Orphan Site Evaluation (OSE) process and not previously tied to an existing waste site. The site consists of two groups of piping and their underlying soil: (1) potentially contaminated product pipelines and (2) service water pipelines and associated features (manholes, storm drains, valve boxes, etc.).	Discovery	Not Documented									
100-N-85	1716-N Gas Station Fuel Tanks	Unplanned Release	100-NR-1	Not Documented	This site consists of soil contaminated with gasoline and diesel which remained after the removal of two underground fuel storage tanks located at the former 1716-NA Service Station. The soil is contaminated to a depth of at least 11 m (36 ft) below grade, although the actual depth is not known (WHC-SD-EN-TI-136). The lateral extent of the contamination is not documented.	Discovery	Not Documented									
100-N-86	151-N Substation Transformer and Oil Circuit Breakers	Electrical Substation	100-NR-1	Not Documented	This site is the 230-13.8 kv transformer concrete support pedestals and underlying soils, and the concrete pad and underlying soils for the three oil circuit breakers (OCBs) that were located 45 m (148 ft) to the east. It does not include the 151-N Electrical Substation Building or the 13.8-4.16kv transformer, pad, and underlying soils. These were demolished and removed by the D4 Project and documented with a D4 Project Soils and/or Below Grade Structures Completion form (D4-100N-0002).	Discovery	Not Documented									
100-N-87	116-N Ventilation Stack Piping and French Drain	French Drain	100-NR-1	Not Documented	The site consists of the 116-N ventilation stack drain piping and french drain. The site was part of the original 1962 construction, and was in use until the N-Reactor was ordered permanently shut down in 1991.	Discovery	Not Documented									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-88	1143-N French Drain	French Drain	100-NR-1	Not Documented	The site consists of a 0.61 m (24 in.) "catch basin" (french drain) and its associated 5.1 cm drain cold (DR) (2 in.) pipeline and underlying soil (drawing H-1-45007, Sht 6). Until about 1997, a sink within the facility discharged to this site. The potential existed for the site to have inadvertently received paint solvents and other hazardous liquids from the activities within the building. The sink was removed about 1997, and discharges to this site ceased.	Discovery	Not Documented										
100-N-89	117-NVH French Drain	French Drain	100-NR-1	Not Documented	The french drain is a 61 cm (24 in.) concrete pipe buried to 91 cm (36 in.). The top of the pipe is at grade and it is filled with gravel. An additional 46 cm (18 in.) of gravel is beneath the pipe. A metal plate covers the pipe (H-1-50093).	Discovery	Not Documented										
100-N-9	100-N-9, 120-N-5 Facility Liquid Unplanned Release 1 (08/07/87)	Unplanned Release	100-NR-1	Not Documented	The site (120-N-5 Facility Liquid Unplanned Release 1 [08/07/87]) is associated with 120-N-5 which is a concrete-lined neutralization pit and acid/caustic transfer trench. On August 7, 1987, sulfuric acid was found leaking outside of the 163-N Plant extending to an area of the 120-N-5 Transfer Trench that had not yet been treated with a polymer coating. The acid had corroded away the exposed concrete, and some of the liquid may have reached the soil. The extent of the release is unknown. There is no remaining evidence of the spill at the site. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-051	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
100-N-90	100-N Reactor Rod Caves	Storage	100-NR-1	Not Documented	The Rod Cave is two 30.5 cm (12 in) carbon steel pipes buried in the earth berm on the north side of the 117-N Air Filter Building. The west ends of the pipes have aluminum covers; the east ends are buried in the berm. Two vertical pipes for monitoring radiation levels extend through the berm.	Discovery	Not Documented										
100-N-91	100-N Battery Debris	Dumping Area	100-NR-2	Not Documented	The site consists of a 0.6 m (2 ft) diameter battery dump. The exterior of the batteries has degraded and the contents are mixed into the soil. There is no vegetation growing in the affected area.	Discovery	Not Documented										
100-N-92	100-N Stain Area #1	Dumping Area	100-NR-3	Not Documented	The site consists of a 3 m (10 ft) diameter area stained with a white substance resembling dried paint and two 4 L (1 gal) cans.	Discovery	Not Documented										
100-N-93	100-N Stain Area #2	Dumping Area	100-NR-4	Not Documented	The site consists of potentially contaminated soil. It includes concrete, metal, glass debris, stained soil, suspected friable asbestos, and garnet sand with areas lacking in vegetation.	Discovery	Not Documented										
100-N-94	100-N Oil Filters #1	Dumping Area	100-NR-5	Not Documented	The site consists of the underlying soil and approximately 50 oil filters.	Discovery	Not Documented										
100-N-95	Hanford Generating Plant (185-N) Septic Tank	Septic Tank	100-NR-6	Not Documented	This feature consists of a septic tank, associated piping, and underlying soil.	Discovery	Not Documented										
100-N-96	100-N Military Camp Disposal Pits	Dumping Area	100-NR-7	Not Documented	This site consists of three separate suspect disposal pits located southwest of the 100-N-47 military camp, identified from a 1957 aerial photograph. The suspect disposal pits were located outside the boundary of the military camp.	Discovery	Not Documented										
100-N-97	100-N Oil Filters #2	Dumping Area	100-NR-8	Not Documented	This site consists of underlying soil and three oil filters. There is no vegetation growing within the release area.	Discovery	Not Documented										

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
100-N-98	100-N Stain Area #3	Dumping Area	100-NR-9	Not Documented	The site consists of two locations where the surface is stained and no vegetation is growing in the affected area. One location (OSE - N-193) consists of multiple stained spots in a 30 m (98.4 ft) diameter area. The other location (OSE - N-194) is a single stained spot approximately 3 m (9.8 ft) in diameter.	Discovery	Not Documented									
100-N-99	100-N Oil Filters #3	Dumping Area	100-NR-10	Not Documented	The site consists of two locations where oil filters were discarded. The affected areas are devoid of vegetation and appear stained.	Discovery	Not Documented									
116-N-1	116-N-1, 1301-N Liquid Waste Disposal Facility, 1301-N Crib and Trench	Crib	100-NR-1	38.1 x 88.4 x 1.5 (crib) 15.3 x 488 x 3.7 (trench)	The site (1301-N Liquid Waste Disposal Facility, 1301-N Crib and Trench) includes a large crib and a "zig-zag" trench, which was added in 1965 to enhance percolation capacity. Both facilities operated in tandem after 1965. The crib and trench received radiologically contaminated water from the 105-N Reactor basin floor drains and the 109-N floor drains. The effluent contained activation and fission products as well as small quantities of corrosive liquids and laboratory chemicals. At times, the effluent consisted of water from the primary reactor coolant system, the periphery reactor cooling system and decontamination wastes from these systems. Operational records indicate cobalt-60, strontium-90 and cesium-137 were disposed of at this crib. In 1982, routine sampling of the riverbank springs indicated an increase in the radionuclide concentrations reaching the Columbia River. This condition indicated a decrease in the effectiveness of the 116-N-1 to retain radionuclides in the soil column. This led to the construction of the 116-N-3 Crib. The 1995 Limited Field Investigation concluded that the maximum levels of radionuclide contamination (based on field screening and geophysical logging) are expected to be found at depths between 18 and 20 m.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
116-N-2	116-N-2, 1310-N Chemical Waste Storage Tank, The Golf Ball, 1310-N Waste Storage Area	Storage Tank	100-NR-1	3.4E+06 L	The site (1310-N Chemical Waste Storage Tank [Golf Ball]) consists of piping, pumps, a transfer tank (commonly referred to as the silo), and a large, spherical storage tank. The site was used as a collection tank for N Reactor primary piping decontamination wastes. The tank was used to temporarily store and neutralize acidic decontamination waste from the internal decontamination of the N Reactor primary loop through an underground pipeline. An additional, small scale transfer line enters the tank from the N Reactor Building. The primary loop was decontaminated every 3 to 5 years, resulting in approximately 2.3E+06 L of contaminated solution per decontamination. The decontamination solutions contained approximately 80,000 L of 70% phosphoric acid and 180 kg (400 lb) of diethylthiourea. The solutions were neutralized with sodium hydroxide in the tank. From 1968 to 1972, the neutralized solutions were pumped into trucks parked on the east side of the containment area and transported to 200 Area for disposal. After 1972, the solution was sent to the 1314-N Liquid Waste Loadout Station. The solutions were also discharged to the 116-N-1 Crib, if necessary. Three unplanned releases (UN-100-N-5, UN-100-N-25, UPR-100-N-38) of decontamination solution occurred at this site which cumulatively totaled 3.43E+05 L.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
116-N-3	116-N-3, 1325-N Liquid Waste Disposal Facility, 1325-N Crib and Trench	Crib	100-NR-1	76.2 x 73.15 / 914.4 x 3.05 x 2.13	The 116-N-3 Crib (1325-N LWDF) was designed for the disposal of liquid waste percolation through the soil column. It was built to replace the 116-N-1 Crib and first received N Reactor effluent in 1983. The 116-N-3 Trench was put into service in September 1985 to provide additional disposal capacity. Effluent reportedly never overflowed the first earthen dam in the trench. The LWDF has not received waste since February 1987 and was closed under interim status. During the first few months of operation, the crib overflowed three times. Because of the low percolation rates, the 116-N-1 and 116-N-3 Crib were used alternately between 1983 and 1985. The trench associated with this unit was put into service in September 1985 to add additional percolation area. The 116-N-3 Crib then became the primary liquid disposal facility and the 116-N-1 Crib was used only as an emergency discharge crib. The average monthly flow to 116-N-3 Crib during normal N Reactor operations was 5,300 L (1,400 gal) per minute).	Interim Closed Out	CVP 2002-00002 WSRF 2002-055	21-Jul-00	1-Apr-02	140270	>4.6	Am-241	0.387U	999	0.102	154
												Co-60	0.796	62400	0.387	5580
												Cs-137	1.27	43100	0.406	4900
												Eu-154	0.18U	0.211	0.0603	8.7
												Eu-155	0.13U	130U	0.0422	6.45
												H-3	N/A	2.57U	N/A	-0.00726
												Ni-63	0.856U	6040	-0.0622	1030
												Pu-239/240	0.137U	1730	0.0282	258
												Sr-90	1.14	3710	0.17	1460
												Hg	0.02U	N/A	0.02	N/A
Nitrate	2.1	14.8	1.24	3												
116-N-4	116-N-4, 1300-N Emergency Dump Basin	Retention Basin	100-NR-1	39.62 x 24.38 x 809.37	The site consists of the 1300-N Emergency dump basin. The 116-N-4 Emergency Dump Basin is a rectangular shaped, outdoor, concrete storage basin with a 10.7 cm (0.188-in.) carbon steel liner. The 116-N-4 Emergency Dump Basin was originally designed to receive emergency single pass cooling water from N Reactor. In the late 1960s, the unit was determined to be insufficient for its original purpose because it did not have adequate capacity for the volume of coolant used during an emergency cooling operation. It was replaced with the 1304-N Emergency Dump Tank (EDT) in 1973. From 1973 to 1987, 116-N-4 received contaminated liquid generated during the	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
					periodic blowdown of the steam generators located in the 109-N Building. This condensate contained low levels of radioactive contaminants. It also received radioactive waste from the N Reactor Lift Station. Since the shutdown of N Reactor in 1987, approximately 2.0E+06 L (7.5E+05 gal) of water has been maintained in the basin to cover the layer of sludge in the bottom of the basin to prevent it from drying and causing airborne contamination. Nonfiltered river water has been added as needed to maintain an adequate water level. The basin leaked to the soil at the northeast and northwest corners of the basin during the early 1980s.												
116-N-8	116-N-8, 163-N Mixed Waste and Hazardous Waste Container Storage Pad, 1330-N, 116-N-8 Storage Pad	Storage Pad	100-NR-1	46.33 x 18.29	The pad is an active pad listed on the Environmental Restoration Contractor's 90 Day Pad Inventory List as the 1330N 90 Day Accumulation Areas. This method for managing active 90 Day Storage Pads is in agreement with Section 2.0, "Scope," of TPA-MP-14, and thus tracking these sites through WIDS is not necessary. However, once the site becomes inactive, the WIDS summary report will be updated. The 90 Day Storage Area and all dangerous waste are managed in compliance with WAC 173-303-200(b)(i) and will be closed in compliance with WAC 173-303-630(10). Containers are stored on a curbed and fenced concrete pad. The pad is covered by an open metal shed, divided into three storage areas each with its own locked gate. The entire unit is approximately 45 by 18 m (150 by 60 ft). A small cabinet in front holds personal protective equipment and spill response materials. The front of the unit is an asphalt parking/driving area; the sides and back are gravel. No spills have been recorded at this site. No stains are visible on the concrete.	Not Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
118-N-1	118-N-1, 100-N Area Silos, 100-N Area Spacer Silos, 118-N, 1303-N Spacer Silos, 1303-N Radioactive Dummy Burial Facility	Silo	100-NR-1	49.00 x 11.00	The site was a temporary storage facility for contaminated fuel spacers. The silos are partially underground with approximately 1.5 m (5 ft) of the structures above ground covered with soil. The soil mound had scant vegetation growing on it and a single vent stack protruded from the mound. A chain link fence surrounded the site on three sides and was posted with "Contamination Area, Underground Radioactivity and Soil Contamination Area" signs. The western side is barricaded with a 2.1 m (7-ft) concrete wall. Following surface stabilization in 1998, the site was posted with Underground Radioactive Material signs. The site contains three concrete silos, each 4.9 m (16 ft) in diameter. Periodically, the contents were shipped to the 200 Area Burial Grounds for permanent disposal. Two of the silos are open bottomed. The fence at the northwestern portion of the site was damaged and a soil contamination area was posted outside the damaged portion of the fence. When removing spacers in 1984, two fire hoses were used to spray water into the unit to prevent airborne contamination. This practice had the potential for washing radionuclides into the soil. No water has been released to this facility since 1984. In 1990, paint was used instead of water for contamination control. Groundwater monitoring wells in close proximity to the site are routinely sampled.	Accepted	Not Documented	N/A									
120-N-1	120-N-1, 1324-NA Percolation Pond	Pond	100-NR-1	2,694.19 sq. m	The 120-N-1 site was co-located with 100-N-58, 120-N-2 sites in the 100-N Area in the 100-NR-1 Operable Unit. In 1977 the 120-N-1, 120-N-2, and 100-N-58 sites were initially constructed as the East Percolation Pond and North and South Settling Ponds, respectively. These unlined ponds received 163-N	Accepted	CVP 2001-00021 WSRF 2001-093	N/A					Ba	93.7	N/A	86.9	N/A
													Cr (total)	14.6	N/A	10.5	N/A
													Cu	31.5	N/A	16.4	N/A
													Pb	6.4	N/A	4.4	N/A
													Hg	0.37	N/A	0.05	N/A

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
					anion/cation regeneration effluent as well as the 183-N Filtered Water Plant filter backwash effluent. In 1982, because of pond percolation problems, the 183-N filter backwash was rerouted to an effluent disposal pond (130-N-1). During this time period the 100-N-58 site was backfilled. The site was remediated in September/October 2000 and is awaiting regulatory closure documentation. Washington State Department of Ecology (Ecology) rejected the certification of closure from DOE. Ecology has revised the post-closure groundwater monitoring measures for the site as of 5/26/05. A post-closure groundwater plan must be submitted to ecology and approved prior to approval of the Certification of Closure documentation. Closure performance standards were established by Ecology, in concurrence with the U.S. Department of Energy, Richland Operations Office. These performance standards are documented in the 100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures Study/Closure Plan (CMS/CP) (DOE-RL-90-22) and the Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment, Storage, and Disposal Units (RDR/RAWP) (DOE-RL-2000-16). While sites 120-N-1, 120-N-2, and 100-N-58 are not included in a <i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i> (CERCLA) record of decision (ROD) corrective action activities have been documented in a CVP (CVP-2001-00021).								Ni	17.6	N/A	13.5	N/A
													Zn	94.4	N/A	53.4	N/A
													Sulfate	135	N/A	55.7	N/A

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
120-N-2	120-N-2, 1324-N Surface Impoundment	Surface Impoundment	100-NR-1	42.67 x 21.34 x 4.57	The 120-N-2 site (1324-N Surface Impoundment) was a double-lined basin was equipped with a leak detection and leachate collection system. Its design capacity was 1.605E+06 L (4.24E+05 gal) and was used to neutralize acid and caustic regeneration effluent from the 163-N Demineralization Plant which received 163-N anion/cation regeneration effluent as well as the 183-N Filtered Water Plant filter backwash effluent.	Accepted	CVP-2001-00021	N/A				Cr (total)	14.6	N/A	10.5	N/A	
							WSRF 2001-093						Cu	31.5	N/A	16.4	N/A
							Pb						6.4	N/A	4.4	N/A	
							Hg						0.37	N/A	0.05	N/A	
							Ni						17.6	N/A	13.5	N/A	
							Zn						94.4	N/A	53.4	N/A	
Sulfate	135	N/A	55.7	N/A													
120-N-3	120-N-3, 163-N Neutralization Pit and French Drain	French Drain	100-NR-1	10.2 x 2.8 x 2.4	The site (163-N Neutralization Pit and French Drain) measures 10.2 m (33.3 ft) by 2.8 m (9 ft) is covered with plywood covers and a portion of the 163-N Neutralization Pit is covered with a concrete slab and metal shed. Intermittent small releases of sulfuric acid and sodium hydroxide from the 163-N Demineralized Water Treatment Plant day-storage tanks were disposed to the soil at this location. The alkaline Hanford soils acted as a buffer to neutralize acidic wastes. In 1987, the unit was characterized to determine the presence or absence of hazardous materials. Acidic and caustic wastes were found. Ten to 15 cm (4 to 6 in.) of soil were removed and replaced with clean fill. In May 1988, the drain lines were rerouted to a sealed containment.	Accepted	Not Documented	N/A									
120-N-4	120-N-4, 1310-N Hazardous Waste Storage Area, 1310-N Waste Oil Storage Pad, 1310-N Non-Hazardous Waste Pad, 1524-N	Storage Pad	100-NR-1	30.48 x 22.86	The site (1310-N Hazardous Waste Storage Area) was a concrete surrounded with a concrete berm (curb) and locked chain-link fence. Outside the pad the ground surface is gravel. A small open shed is in the southwest corner of the pad. The site is posted as a Radioactive Materials Area, and is also posted "Contaminated Lead Storage Area (For Re-Use)." The area contain (April 12, 2000) several wrapped objects marked with radioactive warning signs.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
					<p>The unit stored waste held in drums and containers from 1985 to 1989. The waste oil drums have been removed. The pad is now used (as of April 12, 2000) to store lead lined burial casks and radioactive materials. It is no longer maintained on any <90 Day Storage Pad lists. Waste sites 100-N-26 and 120-N-4 were impacted by a raw water pipeline break on December 11, 2008. During the removal of the concrete pad at the 1524-N Hazardous waste storage facility on December 11, 2008 an unknown 1.5 in. tap into the export water line was inadvertently contacted. A rupture of the 12 in. export water line and a release of at least 50,000 gal of raw water onto the surrounding area resulted. A temporary berm was constructed around the area using excess clean 100 Area Borrow Pit material to contain the release and control potential spread of radiological contamination associated with the 1524-N pad. Once the water line was turned off the water in the area immediately percolated into the ground. In-process and post-event surface soil radiological field survey results did not find any contamination spread as a result of the water release. A follow-up review of nearby monitoring wells as well as the standard waste site confirmatory sampling will be used to ascertain potential impacts/conditions.</p>												

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
120-N-5	120-N-5, 108-N/163-N Transfer Line and Neutralization Pit	Product Piping	100-NR-1	220 (pipe)	<p>The site (108-N/163-N Transfer Line and Neutralization Pit) is a pipe trench that is located between the 108-N and the 163-N Buildings. The site transfers sulfuric acid and sodium hydroxide from the 108-N Chemical Unloading Facility to the 163-N Water Demineralization Plant for use in water treatment. The Transfer Line and Neutralization Pit is a trench (encasement) that contains two transfer lines that run between the 108-N and the 163-N Buildings. The concrete neutralization pit is designed to receive waste spills from within the encasement. When releases occurred within the trench, each spill was neutralized and pumped to the adjacent clearwell overflow sump. In 1976, the pit plugged and liquid waste backed up to the piping level, corroding the caustic and acid drain lines. In 1987, the Neutralization Pit was replaced and 167.3 metric tons (184 tons) of surrounding soil was removed for disposal offsite as hazardous waste (Cramer 1986). No sampling or other information is provided to know why the soil was disposed as hazardous waste. The neutralization pit was replaced after it was found to be leaking into the surrounding soil. The replacement pit was identical to the original one except that its inner surface was lined with polymer concrete, as was the pipe trench. Corroded piping was cut out and replaced, and new drain valves were installed. See UPR-100-N-34, UPR-100-N-15, 100-N-9, 100-N-10, and 100-N-11, which are all unplanned releases associated with this neutralization pit. Spilled sulfuric acid and sodium hydroxide have been neutralized or buffered by the soil and no longer exist in the soil as hazardous substances.</p>	Not Accepted	WSRF 2000-96	N/A									
				1.22 x 3.05 (pit)													

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
120-N-6	120-N-6, 108-N Acid Tank Vent French Drains	French Drain	100-NR-1	0.91 x 0.61	This site (108-N Acid Tank Vent French Drains) consisted of five french drains which were removed in 1988. Ten to 15 cm (4 to 6 in.) of surface soil were also removed and replaced with clean fill. Samples were taken in 1988 from each of the french drains and analyzed for metals. The results of the analyses showed no levels of concern (the full results are shown in the Field Work section). No evidence of the former french drains remains. Three french drains were designed to receive inadvertent overflows and condensate from the three sulfuric acid storage tanks located south of the 108-N Building. Two other french drains were designed to receive tank vent overflows and condensate from the transfer tank which was located in a concrete pit just west of the 108-N Building. Unknown quantities of sulfuric acid tank overflows and condensate were discharged to the drains. The drains were packed with limestone to neutralize the acid before entering the soil column. The sulfuric acid and sodium hydroxide spills at these sites were unused industrial-grade solutions that did not contain any process contaminants since the spills occurred on the supply side of the system. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils. An unplanned release of an unknown quantity of soda ash (soda ash is purified sodium carbonate) sufficient to cover a 6.1 by 9.2 m (20 by 30 ft) area occurred in 1981. Soda ash was used to neutralize acid spills. Any remaining amounts of this material would have been removed with the french drains and the surrounding soil in 1988.	Not Accepted	WSRF 2000-97	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
120-N-7	120-N-7, 108-N Acid Unloading Facility French Drain	French Drain	100-NR-1	1.22 x 0.91	The site (108-N Acid Unloading Facility French Drain) was used to collect small releases of sulfuric acid from the overhead transfer boom hose coupling which offloaded sulfuric acid from railroad tank cars or tank trucks. A lead funnel and pipe directed the small releases to the french drain. The unit received unknown amounts of sulfuric acid in intermittent discharges. Each discharge is estimated to have averaged less than 3.8 L (1 gal) of liquid. The sulfuric acid releases were unused industrial-grade products and did not contain any process contaminants since the releases occurred on the supply side of the reactor. The hazardous substances (acids) are no longer present due to natural neutralization processes. The concentrated acid may have etched lead from the funnel and pipe as it discharged to the french drain. This unit was characterized to determine the presence or absence of hazardous constituents in 1987. The Hanford Site Waste Management Units Report, Version 1 (DOE/RL-88-30, Ver. 1) reports that acid and lead waste were found at the site. A handwritten note dated 4/27/1987 reports the pH result for the sample as less than one. At the bottom of the note is the sentence "working on the metals." The metal results have not been located, and the only indication of a potential problem is a note in Cote' (1994) that lead wastes were found at the site. The corrective measures study report for the 100-N Area recommended no action for this site because of the natural attenuation of acid in the Hanford Soil. The alkaline Hanford soils act as a buffer to neutralize acidic wastes. The study does not address the potential for lead in the french drain.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
120-N-8	120-N-8, 163-N Sulfuric Acid Tank Vent French Drain	French Drain	100-NR-1	Not available	The site (163-N Sulfuric Acid Tank Vent French Drain) is a french drain used to receive overflow of sulfuric acid from the 163-N demineralization plant sulfuric acid day tank. The unit was constructed of clay pipe filled with limestone to neutralize the sulfuric acid releases. The sulfuric acid and sodium hydroxide spills at these sites were unused industrial-grade solutions that did not contain any process contaminants since the spills occurred on the supply side of the system. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils. The french drain was removed in 1988 and the site has been covered with gravel. The drain line was rerouted to sealed containment. There is currently no evidence of the former french drain at the site. The french drain was characterized in 1988 to determine the presence or absence of hazardous materials. No hazardous substances were found. There are no documented unplanned releases associated with the unit.	Not Accepted	WSRF 2000-102	N/A									
124-N-1	124-N-1, 124-N-1 Septic Tank, 100-N Sanitary Sewer System No. 1	Septic Tank	100-NR-1	Not Documented	This site (124-N-1 Septic Tank) supports the 163-N Water Treatment Building. This sanitary sewer system remains active. This unit receives approximately 5,300 L/day (1,400 gal/day) of sanitary sewage. Sanitary wastes entered the septic tank through a 10 cm (4 in.) vitrified clay pipe connecting the septic tank to the cesspool.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
124-N-10	124-N-10, 124-N-10 Sanitary Sewer System, 100-N Central Sewer System No. 10, Project H-677, 100-N Sewage Lagoon	Sewage Lagoon	100-NR-1	250.77 x 67.06	The site (124-N-10 Sanitary Sewer System) consists of a three pond sewage lagoon facility, a sewer trunk line and other pipelines, two lift stations, new manholes, and associated sewer system instrumentation and annunciation capability. The site has received domestic wastewater sewage from the 100-N Area and domestic sewage pumped from septic tanks throughout the Hanford Site. Incidental solids (rags, scum, and other debris) are removed from the system and disposed of as solid waste at an approved disposal site. The discharge from the infiltration pond percolates down to the groundwater.	Accepted	Not Documented	N/A								
124-N-2	124-N-2, 124-N-2 Septic Tank, 100-N Sanitary Sewer System No. 2	Septic Tank	100-NR-1	Not Documented	The unit (124-N-2 Septic Tank) includes a septic tank and seepage pit. The seepage pit provided approximately 18.4 m ² (200 ft ²) of infiltration surface area and 8,700 L (2,300 gal) of fluid storage. The site is located southeast of the 182-N Building. The unit was pumped and isolated after the 124-N-10 Septic Treatment Facility was placed in service in February 1987.	Accepted	Not Documented	N/A								
124-N-3	124-N-3, 124-N-3 Septic Tank, 100-N Sanitary Sewer System No. 3	Septic Tank	100-NR-1	Not Documented	A field visit in 1999 did not find any visual evidence of this site. The unit is a cesspool consisting of a 1,900 L (500 gal) precast concrete perforated pipe with a solid cover resting on a 0.61 m (2-ft) thick pad of crushed stone. There are no surface indications of the cesspool's location since there is no above-ground access port to the pit.	Accepted	Not Documented	N/A								
124-N-4	124-N-4, 100-N Sanitary Sewer System No. 4, 124-N-4 Septic Tank, 1903-N, 1903N	Septic Tank	100-NR-1	826.84 sq. m	The site (100-N Sanitary Sewer System No. 4, 124-N-4 Septic Tank) includes a large drain field and two septic tanks, each 63,644 L (14,000 gal). The total infiltration surface area of the drain field was 826.8 m ² (8,900 ft ²). The unit received approximately 136,400 L/day (30,000 gal/day) of sanitary sewage.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
124-N-5	124-N-5, 100-N Sanitary Sewer System No. 5, 124-N-5 Septic Tank	Septic Tank	100-NR-1	89.19 sq. m	The site (100-N Sanitary Sewer System No. 5, 124-N-5 Septic Tank) is in the middle of a large graveled lot, free of vegetation. The system serviced office buildings that did not generate hazardous or radioactive substances and is not located close to any other waste sites. The 124-N-5 Sanitary Sewer System was replaced by the new 124-N-10 Sanitary Sewer System in February 1987. The tank was isolated, pumped out, filled with sand, and abandoned in place. Fill dirt was placed over the drain field to a depth of 0.6 m (2 ft) or more. While Gydesen (1985) does not report why the fill dirt was placed on this drain field, he reports that the system was very overused, saturating the surface soils and supporting a thick growth of vegetation. The fill may have been an attempt to cut odors and provide a more solid surface to the ground surface.	Not Accepted	WSRF 2000-074	N/A									
124-N-6	124-N-6, 100-N Sanitary Sewer System No. 6, 124-N-6 Septic Tank	Septic Tank	100-NR-1	56.00 sq. m	The site (100-N Sanitary Sewer System No. 6, 124-N-6 Septic Tank) received sanitary sewage from office trailers 1113-N, 1114-N, and 1115-N. The system serviced office buildings that did not generate hazardous or radioactive substances. This septic system was directly hooked up to Sanitary Sewer System No.7, (124-N-7). The 124-N-6 Sanitary Sewer System was replaced by the new 124-N-10 Sanitary Sewer System in February 1987. The tank was isolated, pumped out, filled with sand, and abandoned in place.	Not Accepted	WSRF 2000-078	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
124-N-7	124-N-7, 100-N Sanitary Sewer System No. 7, 124-N-7 Septic Tank	Septic Tank	100-NR-1	510.97 sq. m	The system (100-N Sanitary Sewer System No. 7, 124-N-7 Septic Tank) received approximately 19,700 L/day (5,200 gal/day) of sanitary sewage from office trailers 1103-N, 1104-N, and 1145-N and after modifications received sanitary sewage from 124-N-6 Sanitary Sewer System and the 1145-N Building. The system serviced office buildings that did not generate hazardous or radioactive substances. The 124-N-7 Sanitary Sewer System was replaced by the new 124-N-10 Sanitary Sewer System in February 1987. The tank was isolated, pumped out, filled with sand, and abandoned in place. The tank was then covered with a layer of parking lot gravel and can no longer be located.	Not Accepted	WSRF 2000-081	N/A								
124-N-8	124-N-8, 100-N Sanitary Sewer System No. 8, 124-N-8 Septic Tank	Septic Tank	100-NR-1	153.29 sq. m	The system (100-N Sanitary Sewer System No. 8, 124-N-8 Septic Tank) received approximately 3,400 L/day (900 gal/day) of sanitary sewage from office trailers 1132-N, 1133-N, 1134-N and 1135-N. The system serviced office buildings that did not generate hazardous or radioactive substances. The 124-N-8 Sanitary Sewer System was replaced by the new 124-N-10 Sanitary Sewer and Lagoon System in February 1987. The tank was isolated, pumped out, filled with sand, and abandoned in place.	Not Accepted	WSRF 2000-092	N/A								
124-N-9	124-N-9, 124-N-9 Septic Tank, 100-N Sanitary Sewer System No. 9	Septic Tank	100-NR-1	11,355 L	The site (124-N-9 Septic Tank, 100-N Sanitary Sewer System No. 9) consists of two septic tanks and a drain field. Each tank has a volume of 11,360 L (3,000 gal), and the drain field has an infiltration surface area of 325 m ² (3,500 ft ²). This unit receives approximately 8,300 L/day (2,200 gal/day) of sanitary sewage.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
128-N-1	128-N-1, 100-N Burning Pit, 128-N-1 Burning Pit	Burn Pit	100-NR-1	Not Documented	The site (100-N Burning Pit) shows evidence of burning, in the form of burnt trash and cans. Most of the site has been backfilled. Combustible materials, such as nuisance vegetation and combustible wastes (office waste, tools and hardware, and potentially paints and solvents), have been burned at this site. The quantity of material burned at the site is unknown. Since the establishment of the Hanford Central Landfill (in the early 1970s), this unit has been used for burning nuisance vegetation only.	Accepted	Not Documented	N/A								
130-N-1	130-N-1, 183-N Backwash Discharge Pond, 126-N-1, 183-N Filter Backwash Pond and Pipeline	Pond	100-NR-1	Not Documented	The site (183-N Backwash Discharge Pond) consists of a natural marsh-like pond which receives filter backwash from the 183-N Water Filter Plant. The unit receives filter backwash containing polyacrylamide and aluminum sulfate.	Accepted	Not Documented	N/A								
1908-N	1908-N, 1908-N Outfall	Outfall	100-NR-1	21 x 10 x 7	This site consists of an open-topped, compartmentalized, reinforced concrete outfall structure used as a sump for several discharge lines and to drop the liquid discharge level for overflow to the river. The outfall also discharged to a flume which was used as an alternative to the river pipelines. The outfall received more than 2 million m ³ per day of single pass raw river water from the Circulating Raw Water (CRW) System, and discharged it to the river. During a site visit in 2005, the structure was found to be intact. Originally, the 1908-N Outfall, Spillway (Flume) and river pipelines were entered into WIDS as one site number (1908-N). Due to remediation project needs of the outfall structure, the River Effluent Discharge lines (100-N-77) and the spillways (flumes) (100-N-79) have been documented as separate waste	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
					sites. An unknown level of radioactive contamination exists within the structure because the discharge lines were associated with the reactor's secondary steam system. Therefore, while no specific COPCs have been identified, the outfall structure has potential radioactive contamination												
1908-NE	1908-NE, HGP Outfall, 1908-NE Building, HGP-SWMU #7	Outfall	100-NR-1	30.48 x 24.38	The site (HGP Outfall SWMU #7) consisted of an open-topped, compartmentalized, reinforced concrete outfall structure. The outfall received single pass raw river water which had passed through the Hanford Generating Plant (HGP) condensers, as well as waste water from the 100-N-1 Settling Basin. The site consisted of a seal well and a pipeline extending out into the Columbia River. The seal well was located on the river bank, where condenser cooling water and waste water from the 100-N-1 Settling Pond were discharged through the river pipeline extending a 1,000 ft into the river. Effluent from the nearby N Reactor did not enter into the HGP system or the 1908-NE Outfall. The preferred remedy from the ROD (EPA 1999, 100 N Area Ancillary Facilities Action Memorandum) is institutional control; therefore, no remedial or demolition activities were conducted for the outfall site.	Interim Closed Out	HGP-CVP-SWMUs 5, 6, 7, 8, 9, & 10, Rev. 0. WSRF 2004-060	2000 (confirmatory sampling)	2000 (confirmatory sampling)	N/A	N/A	Diesel range petroleum hydrocarbons	50 U	N/A	N/A	N/A	
													Heavy oil range petroleum hydrocarbons	100 U	N/A	N/A	N/A
													Sludge samples were not analyzed for total metals; however, metals analysis using the TCLP method indicated that the sludge would not be a Washington State characteristic dangerous waste. In addition these constituents were not detected in the water samples collected from the Outfall Seal Well.				
2607-FSM	2607-FSM, 609 Building Septic Tank, 2607-FSM, 100 Area Fire Station Septic Tank, 1607-FSM, 6607-FSM	Septic Tank	100-NR-1	3.35 x 1.37	The site (100 Area Fire Station Septic Tank) is a single-chamber, reinforced concrete tank. This unit includes a drainfield. It receives sanitary effluent from the 609 Building and disposes of it through a sub-surface soil absorption system. The septic system has also used 6607-FSM, 2607-FSM and 1607-FSM site name designations.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
600-32	600-32, N Area Landfill	Dumping Area	100-NR-1	426.72 x 304.8	The site (HGP Construction Debris Dump Solid Waste Site, SWMU #11) is a large area consisting of a series of pits and depressions containing soil, rock, concrete, metal, wood, and asphalt that have been dumped in the area over time. The site was used to dispose of non hazardous construction debris from 100-N and the HGP. The site is associated with 600-32 and 100-N-39 which are duplicate codes for the same site, a dumping area contained within the larger 100-N-19 Dumping Area. Various suspect waste site investigations and documents have identified waste dumps associated with the HGP and the BPA substation. The site descriptions in each document are similar but the location sketches are different, indicating various pits outside the HGP/BPA substation fence. These dumping areas have been entered into the WIDS database multiple times with various different names because the reference document authors were not aware of the other references.	Not Accepted	WSRF 2000-113	N/A								
600-339	100 Area Fire Station Dry Well	French Drain	100-NR-1			Discovery										
600-347	100 Area Fire Station Burn Pit	Burn Pit	100-NR-1			Discovery										
600-348	100 Area Fire Station Underground Storage Tanks	Storage Tank	100-NR-1			Discovery										

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
600-35	600-35, Rock Screening Area	Dumping Area	100-NR-1	91.44 x 91.44	This relatively flat site appears to be a former rock crushing/screening operation and borrow pit (on the northern edge). The ground is covered with fine gravel chips with little or no vegetation. Miscellaneous surface debris (ladder, pipe, wire rope, wood, aluminum pieces, lead acid battery, 55 gal drum) was the only waste identified at this site. Arrangements were made to remove/dispose of the drum and battery. The operation date for this site is unknown, but it is believed to have been pre-1980. The waste type has been designated as "potentially hazardous". The release potential is negligible.	Accepted	Not Documented	N/A								
628-2	628-2, 100 Area Fire Station Burn Pit	Burn Pit	100-NR-1	1011 sq. m	The site (100 Area Fire Station Burn Pit) is an unmarked pit composed of sand and dirt with sparse vegetation (cheatgrass, bunch grasses, some sagebrush) showing signs of stress. The site has ash, debris (charred wood, metal, electrical wiring and equipment, roofing material), and soil discoloration. The original information indicates that mainly motor oil and diesel fuel contaminated with water or deemed unusable was burned; however, there is no supporting written documentation. Other chemicals were potentially burned at the site. Information indicates the burn pit was approximately 0.9 to 1.2 m (3 to 4 ft) deep and 1.8 m (6 ft) in diameter. However physical evidence (e.g., ash, debris, soil discoloration, etc.) indicates the area affected by the burning activities is considerably larger (approximately 0.10 ha [0.25 ac]). Soil sampling is required.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
UPR-100-N-1	UPR-100-N-1, 100-N 1304-N Dump Tank, UN-100-N-1, Emergency Dump Tank Inlet Valve Box Leak	Unplanned Release	100-NR-1	1858 sq. m	The site is an unplanned release extending from the 1304-N Emergency Dump Tank to the front of the 181-N River Water Pump House, approximately 45 m (147 ft) from the Columbia River. On March 27, 1974, an estimated 113,550 L (30,000 gal) of radioactive water leaked onto the ground due to a line leak from the inlet valve box near the 1304-N Emergency Dump Tank. The water flowed down the bank from the Emergency Dump Tank, covered the roadway below the tank, and extended to the front of the 181-N Building. An estimated 139 m ² (1,500 ft ²) was contaminated outside the 100-N area security fence. The security fence is considered the site boundary. Contaminated soil reading greater than 1,000 counts per minute was removed. The remainder was covered with clean fill. Observations and radiation surveys indicate that none of the contaminated water reached the river.	Accepted	Not Available	N/A									
UPR-100-N-10	UPR-100-N-10, 100-N Area 105-N Check Valve, UN-100-N-10, Lift Station Gravity Drain Line Leak	Unplanned Release	100-NR-1	3.05 x 3.05	Approximately 379 L (100 gal) of contaminated water leaked to the ground during preparations for the removal of a check valve in the gravity drain line to the lift station on May 13, 1975. Pumps were shut down, and a small dirt dam was built to confine the water within the existing radiation zone boundary. The contaminated soil was secured with a plastic cover until it could be removed (note: there is no record of the contaminated soil being removed although UNI-75-18 states that "contaminated dirt will be removed and disposed of before August 1, 1975.").	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
UPR-100-N-11	UPR-100-N-11, Five Hundred Pound Valve Bonnet Contamination in Uncontrolled Area, 100-N Area Valve Bonnet, UN-100-N-11	Unplanned Release	100-NR-1	9.1 x 0.3	A contaminated 227 kg (500 lb) valve bonnet, wooden box, and plastic wrapping fell from a truck onto the road and into a field adjacent to the roadway. The wooden box broke open spreading spot contamination on the roadway and in the field. Contamination levels measured were: on roadway blacktop (impact/contact) - 1,000 mrad/hr; on roadway adjacent to where valve hit - 20,000 to 50,000 counts per minute; area where valve came to rest - 5 rads to 10 rads per hour; area adjacent to where valve came to rest - 25,000 to 50,000 counts per minute. The following day the remaining contamination was removed. Approximately 6.1 m ³ (8 yd ³) of dirt and 0.38 m ³ (0.5 yd ³) of blacktop were removed and transported to 200 West Area for burial. There is a high probability non-fixed (spot) radioactive contamination was blown into the surrounding area from winds that were at least 30.6 km (19 mi) per hour during the early morning hours prior to work resuming on cleanup.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-12	UPR-100-N-12, Spacer Transport Line Leak, UN-100-N-12	Unplanned Release	100-NR-1	0.61 x 0.91 x 18.29	The site began as sink hole resulting from a leak in the dummy fuel spacer transfer line. The maximum leak rate was estimated to be 284 L (75 gal) per minute. Potential for contamination remains as there is no record or reason to believe that the contaminated soil was excavated to the Hanford Unconfined Aquifer. There is also no record of the disposition of excavated radioactive contaminated soil. The transport line was repaired, and the sink hole was filled with clean soil. The release consisted of 946,000 L (250,000 gal) of storage basin water containing 0.19 curies of cobalt-60, 0.4 curies of cesium-137, and 0.00057 curies of plutonium-239/240. The water was originally from the fuel storage basin and had been used to help dislodge fuel spacers through the spacer transport line.	Accepted	Not Documented	N/A								
UPR-100-N-13	UPR-100-N-13, 1314-N Loading Station, 1314-N Drywell Overflow, UN-100-N-13	Unplanned Release	100-NR-1	6.1 x 6.1	The release was located inside the radiation zone at the 1314-N Liquid Waste Loadout Station. While filling a railroad waste tank car, solution began overflowing from the tank car fittings. The solution flowed up through the catch basin drain. The catch basin overflowed into the adjacent dry well, which also filled and overflowed. Approximately 380 L (100 gal) of spent decontamination solution flowed out of the dry well and was released to the ground. The contaminated soil was properly packaged and shipped to a 200 Area Burial Ground. Some of the contaminated soil remaining was covered with clean fill.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-14	UPR-100-N-14, 119-N Drain System Leak, UN-100-N-14	Unplanned Release	100-NR-1	74.32 sq. m	While maintenance personnel were working on the 119-N drain system, to correct loss of coolant flow in a condensate collection sampler, backflow from the drain occurred. Irradiated reactor cooling water was discharged to the ground near the 119-N building. Soil contaminated over 1,000 counts/minute was removed and shipped to the 200 Area for disposal. Soil under 1,000 counts/minute was covered with clean fill.	Accepted	Not Documented	N/A								
UPR-100-N-15	UPR-100-N-15, 108-N Neutralization Sump Spill, UN-116-N-15, UN-100-N-15, Acid Spill at 108-N	Unplanned Release	100-NR-1	Not Documented	The release site consists of concrete structures and a graveled field. The release is a result of a leak in the discharge line from the 108-N neutralizing sump that was being used during cleanup activities following a sulfuric acid release inside of the 108-N Building. The surface leakage was neutralized with soda ash. No further actions were deemed necessary at that time. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-058	N/A								
UPR-100-N-17	UPR-100-N-17, 166-N Diesel Oil Supply Line Leak, UN-100-N-17	Unplanned Release	100-NR-1	Not Documented	The site is an unplanned release that occurred at the 166-N Tank Farm. External corrosion of a 10.2 cm (4 in.) diesel oil supply line, between the oil storage tank and the west dike, caused the line to leak and release diesel oil to the soil in August 1966. The oil drained through the soil to groundwater where it migrated toward the Columbia River. The line was excavated and repaired in September 1966. Oil near the river was collected in an interceptor trench and periodically burned off during 1967 in an attempt to intercept it before it could reach the river. (See related site 100-N-65.) Currently, all underground diesel oil transfer piping is treated for corrosion protection to preclude a reoccurrence of leakage.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-18	UPR-100-N-18, 166-N Four-inch Diesel Oil Supply Line to 184-N Leak, UN-100-N-18	Unplanned Release	100-NR-1	Not Documented	The release consisted of diesel fuel and occurred between the 166-N Tank Farm and the 184-N Diesel Oil Day Tank when external corrosion caused leakage in the diesel oil supply line. The line was excavated and repaired.	Accepted	Not Documented	N/A								
UPR-100-N-19	UPR-100-N-19, 184-N Day Tank Fuel Oil Spill, UN-116-N-19, UN-100-N-19	Unplanned Release	100-NR-1	Not Documented	The release occurred at the 184-N Fuel Oil Day Tank when the day tank was overfilled, and No. 6 fuel oil spilled onto the ground. A site visit in July 1999 found that the Day Tanks have been removed. The tank foundations are located inside an area surrounded by light post and chain.	Accepted	Not Documented	N/A								
UPR-100-N-2	UPR-100-N-2, 100-N FLV-858 Valve Leak, UN-100-N-2	Unplanned Release	100-NR-1	28 sq. m	A cracked drain line leaked mildly contaminated reactor effluent from a point 3 m (10 ft) below grade. The line was excavated and repaired, and the groundwater was monitored. Contaminated soil that was accessible was removed and replaced with clean fill. Contaminated dirt was sent to a 200 Area Burial Ground. Most of the contaminated water from the leak area was transferred with a portable pump to a steel basin designed to retain low level contaminated water. A shoreline survey was conducted at ground level and no detectable contamination was observed.	Accepted	Not Documented	N/A								
UPR-100-N-20	UPR-100-N-20, 166-N Two-inch Diesel Oil Return Line Leak, UN-116-N-20, UN-100-N-20	Unplanned Release	100-NR-1	Not Documented	The release site was located near Tank 1 in the 166-N Tank Farm. A return line was excavated and repaired and the groundwater was monitored. Oil-contaminated soil was removed, and a valve was installed to isolate this portion of the return line which is no longer used. The release consisted of Number 2 diesel oil.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-21	UPR-100-N-21, 184-N Diesel Oil Day Tank Overflow, UN-116-N-21, UN-100-N-21	Unplanned Release	100-NR-1	Not Documented	Failure of the tank-level annunciator caused overflowing of the day tank during an oil transfer on April 25, 1986. The release consisted of Number 2 diesel oil. Groundwater monitoring wells were sampled, and no oil was detected. The Day Tanks have been removed. The tank foundations are located inside a chained area.	Accepted	Not Documented	N/A								
UPR-100-N-22	UPR-100-N-22, 184-N Diesel Oil Supply Line Leak No. 1, UN-100-N-22, UN-116-N-22	Unplanned Release	100-NR-1	Not Documented	External corrosion caused the diesel oil supply line to leak. The release consisted of Number 2 diesel oil. The line was excavated and rerouted. Oil-contaminated soil was removed. Groundwater wells were sampled, and oil was detected in an adjacent well (N-16) in July 1986. Subsequently, residual oil was pumped from the groundwater through this monitoring well.	Accepted	Not Documented	N/A								
UPR-100-N-23	UPR-100-N-23, 184-N Diesel Oil Supply Line Leak No. 2, UN-100-N-23, UN-116-N-23	Unplanned Release	100-NR-1	Not Documented	External corrosion caused the diesel oil supply line to leak. The release consisted of Number 2 diesel oil. The line was isolated and excavated. Oil-contaminated soil was removed. Groundwater wells were sampled and residual oil was pumped from the groundwater.	Accepted	Not Documented	N/A								
UPR-100-N-24	UPR-100-N-24, 166-N Fuel Oil Supply Line Leak, UN-116-N-24, UN-100-N-24	Unplanned Release	100-NR-1	Not Documented	The leak was caused by external corrosion brought on by a leaking heat trace line. Leakage occurred during routine oil transfer, and waste oil was periodically removed. The release consisted of Number 6 fuel oil.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
UPR-100-N-25	UPR-100-N-25, Uncontrolled Venting of 1310-N Tank, UN-100-N-25	Unplanned Release	100-NR-1	Not Documented	The release consisted of primary loop water and decontamination solution containing phosphoric acid and diethylthiourea adjacent to the 1310-N Chemical Waste Tank. An estimated 378 to 1,900 L (100 to 500 gal) of contaminated water was released to the ground inside the posted Radiation Zone. Radiological surveys found a maximum of 20,000 counts per minute after the release. The extent of contamination is unknown. However, a radiation survey showed no contamination outside of the posted zone. Localized contamination was covered with approximately 15 cm (6 in.) of clean fill.	Accepted	Not Documented	N/A									
UPR-100-N-26	UPR-100-N-26, Backflow of Radioactive Waste in 1314-N Facility, UN-100-N-26	Unplanned Release	100-NR-1	Not Documented	Reactor decontamination solution backflowed while being pumped into a tank car, contaminating the floor of the valve pit at the 1314-N Radioactive Liquid Waste Load-Out Facility. The release consisted of reactor decontamination solution containing phosphoric acid and diethylthiourea. Most of the solution was pumped back into a tank car. The remaining solution was absorbed and sent to a 200 Area Burial Ground.	Accepted	Not Documented	N/A									
UPR-100-N-29	UPR-100-N-29, 1304-N Dump Tank, Emergency Dump Tank Bypass Line Leak, UN-100-N-29	Unplanned Release	100-NR-1	9.14 x 1.22	A leaking check valve caused a release of primary coolant water on April 23, 1974. The leak consisted of primary coolant water containing radioactive fission and activation products, mostly manganese-56 and sodium-24. The release occurred on the east side of the 1304-N Emergency Dump Tank.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-3	UPR-100-N-3, Dummy Fuel Transfer Line, UN-100-N-3, Spacer Disposal System Transport Line Leak, UN-116-N-3	Unplanned Release	100-NR-1	18.29 x 3.05 x 1.22	The site began as a sink hole as a result of a leak in the dummy fuel spacer transfer line which extends from the 100-N Fuel Storage Basin to the dummy disposal pit. Currently, the spill site is within a radiation control zone. This is also the location for UPR-100-N-10 and UPR-100-N-12. The line was repaired and the excavated contaminated soil was removed and taken to the 200 Area Burial Ground for disposal. The sink hole was filled and the area was covered with clean soil. Potential for contamination remains as there is no record or reason to believe that the contaminated soil was excavated to the aquifer.	Accepted	Not Documented	N/A								
UPR-100-N-30	UPR-100-N-30, 1304-N Dump Tank, Emergency Dump Tank Overflow, UN-100-N-30	Unplanned Release	100-NR-1	15.24 x 15.24	The site includes the ground surrounding the 1304-N Emergency Dump Tank. During a drawdown test, the tank overflowed, spilling primary coolant water. No water reached the river. There is no visual evidence of this release. At the time of the release, the area was posted as a Radiation Zone. The contaminated soil was temporarily stabilized in place using sand and fines as a cover. The contaminated soil was later removed and disposed of in the 200 Area.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
UPR-100-N-31	UPR-100-N-31, Radioactive Effluent Water Spill Near 1301-N, UN-100-N-31	Unplanned Release	100-NR-1	188 sq m	The release occurred on the west side of the berm just west of the 1301-N Liquid Waste Disposal Facility. While sample lines were being installed in a 15 cm (6-in.) steel casing through the berm on the west side of the 1301-N Crib, the water level in the crib was raised 38 to 46 cm (15 to 18 in.) as a result of an Emergency Dump Tank drawdown test. Due to the increased water level, approximately 3,785 L (1,000 gal) of effluent was released, contaminating 186 m ² (2,025 ft ²) of soil. The contaminated soil was removed and transported to the 200 Area for disposal. Clean fill was used to restore the area. The release occurred on July 22, 1974. No known confirmatory sample information exists for the remediation done after the release. It is not known if the site meets current clean up standards.	Accepted	Not Documented	N/A									
UPR-100-N-32	UPR-100-N-32, 1304-N Dump Tank, Emergency Dump Tank Bypass Line Leak, UN-100-N-32	Unplanned Release	100-NR-1	Not Documented	The release occurred on the southeast side of the 1304-N Emergency Dump Tank when leaking check valve in the Emergency Dump Tank bypass line released radioactive effluent water to the ground. The contaminated soil was removed and disposed of in the 200 Area Burial Ground. Some of the contaminated soil was covered in place.	Accepted	Not Documented	N/A									
UPR-100-N-33	UPR-100-N-33, 108-N Acid Transfer Spill, UN-116-N-33, UN-100-N-33	Unplanned Release	100-NR-1	Not Documented	The location of this release is a graveled lot at the 108-N Chemical Unloading Facility (CUF) where approximately 3,800 L (1,000 gal) of 97% sulfuric acid was spilled during an acid transfer from a rail car to the sulfuric acid storage tank at 108-N. Acid and caustic spill sites have been neutralized or buffered by the soil and no longer exist in the soil as hazardous substances. There is no evidence of the spill at the site.	Not Accepted	WSRF 2000-059	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
UPR-100-N-34	UPR-100-N-34, 108-N Tank Transfer, Sulfuric Acid Line Break, UN-100-N-34	Unplanned Release	100-NR-1	Not Documented	The release occurred in a concrete trench in a graveled lot. Approximately 12,870 L (3,400 gal) of 94% sulfuric acid was released to the ground from a sulfuric acid and sodium hydroxide line encasement at the encasement sump. Contamination was limited to the region near the sulfuric acid transfer line in the vicinity of the sump. The acid in the encasement was neutralized with 50% sodium hydroxide and pumped to the clearwell overflow. The acid that overflowed to the surrounding ground was neutralized with soda ash and liquid sodium hydroxide. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils. There is no evidence of the spill at the site.	Not Accepted	WSRF 2000-060	N/A									
UPR-100-N-35	UPR-100-N-35, 100-N Fuel Basin Drainage System Leak, UN-116-N-35, 105-N Fuel Storage Basin Drainage System Leak, UN-100-N-35	Unplanned Release	100-NR-1	Not Documented	The release occurred at the 105-N Reactor Building. Routine sampling of the 100-N Area groundwater wells detected slightly elevated levels of iodine-131. Drawdown tests on the basin determined that the leak was not from the basin. Further tests and investigations determined the intermittent leak to be coming from a sub-basin drain line approximately 8.5 m (28 ft) below the ground. The leak, estimated to be less than 11 L (3 gal) per minute, occurred only during feed and bleed (addition of water) of the 100-N Fuel Basin. On December 5 and 8, 1986, the southwest basin weir and drain line were grouted and sealed off. Subsequent weekly sampling of adjacent groundwater wells showed no further elevated levels of radioactivity.	Accepted	Not Documented	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-36	UPR-100-N-36, 184N Annex, 184N, Diesel Generator Area	Unplanned Release	100-NR-1	39.62 x 18.29	The unit is in a graveled area located between buildings 153N and 184N. The site is previously disturbed from historic spills. Numerous spills of diesel fuel and motor oil used for normal operation and maintenance occurred over a 13-year period when the site was used as a diesel air compressor staging area. The most recent spills have been cleaned up.	Accepted	Not Documented	N/A								
UPR-100-N-37	UPR-100-N-37, HGP Transformer Yard Oil Stained Gravel (SWMU #1)	Unplanned Release	100-NR-1	Not Documented	The site (HGP Transformer Yard Oil Stained Gravel [SWMU #1]) was located on the northwest side of the former 185-N Building. The transformer yard consisted of nine large transformers. Minor leaks from transformer oil pumps and piping had stained the concrete transformer pads and contaminated adjacent soil. Oil stains were visible at the base of every transformer in the yard. Mineral oil containing polychlorinated biphenyls (PCB's) and solvents was used routinely during equipment maintenance. WPPSS personnel indicated that dielectric fluid was used in the transformer that did not contain PCB's.	Interim Closed Out	HGP-CVP-SWMUs 1, 2, 3, & 4, Rev. 0.	2001	2004	Not Documented	Not Documented	Aroclor-1262	0.176	N/A	0.176 (max)	N/A
							WSRF 2004-059					Heavy Range Hydrocarbon (mineral oil)	779	N/A	779 (max)	N/A
													COCs were detected in less than 50% of the samples, therefore the statistical value is the maximum detected value.			
UPR-100-N-38	UPR-100-N-38, 116-N-2 Facility Liquid Unplanned Release, 100-N Spring 1983 Caustic, Truck Spill 116-N-2	Unplanned Release	100-NR-1	Not Documented	In spring 1983, a tanker truck was offloading caustic sodium hydroxide to the silo (transfer tank) at 1310-N when a fitting came loose, spilling 380 L (100 gal) of sodium hydroxide to the soil. Acid and caustic spill sites are not contaminated based on natural buffering and dissociation processes in the soils.	Not Accepted	WSRF 2000-094	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-39	UPR-100-N-39, Corridor 22 Suspect Liquid Unplanned Release (Cleaned Up)	Unplanned Release	100-NR-1	Not Documented	In 1983 or 1984, several hundred liters of radioactively contaminated water was spilled outside Corridor 22. Scrub water from the Fission Product Filter Trap overflowed and discharged to the ground. The concrete was painted over and an indeterminate amount of soil was removed. The site consists of a concrete slab and hatch cover posted "Surface Contamination." The surrounding area is gravel.	Accepted	Not Documented	N/A								
UPR-100-N-4	UPR-100-N-4, 1322-A Sump Overflow, UN-100-N-4	Unplanned Release	100-NR-1	139.35 sq. m	The original site of contamination was the 1322-NA (Effluent Water Pilot Plant) floor and ground by the front and rear doors on outside. The site also includes the drainage tank in Building 1322-N (Waste Treatment Pilot Plant Facility). The 1322-N Drainage Tank top vent sprayed low-level radioactive water. The 1322-NA sink drain backed up and flowed over the 15 cm (6-in.) curb and onto the ground in the front and back of the building. Most or all of the contaminated soil was removed.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)		
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b	
UPR-100-N-40	UPR-100-N-40, Regeneration Waste Transport System Liquid UPR 1 (06/14/86, Cleaned Up) 6/14/86 163-N Cation/Anion Regeneration Waste Spill, UN-116-N-27	Unplanned Release	100-NR-1	Not Documented	A leak was detected in the waste transport pipe while wastes from the anion and cation regeneration process were being routed to 120-N-2 Surface Impoundment. A sample was collected at the point of leak and found to have a pH of 1.4. It was estimated that 25,000 L (6,500 gal) of acidic regeneration waste had leaked to the ground and formed a pond in an area south and east of the 163-N/183-N Buildings. Caustic regeneration waste was pumped through the line and allowed to leak into the acidic pond to neutralize the spilled material until the pH of the spilled material reached 6.9. The neutralized liquid was released to the Columbia River via the outfall. An unknown amount of soil around the leak was excavated and disposed of. Based on the CVP for the 120-N-1 and 120-N-2 disposal sites and similar wastestreams, this unplanned release should also meet the 100-N Area cleanup standards.	Not Accepted	Discovery Site Evaluation Checklist	N/A									
UPR-100-N-41	UPR-100-N-41, Regeneration Waste Transport System Liquid UPR 2, 163-N Regeneration, Waste Spill	Unplanned Release	100-NR-1	Not Documented	A spill of acidic wastewater (pH 1.1) from the 163-N Demineralized Water Treatment Plant occurred when a temporary hose became dislodged for approximately 4 minutes during a discharge cycle, spilling approximately 3,800 L (1,000 gal) of the liquid. The corrective action was to add 82 kg (180 lb) of soda ash to the spill to neutralize the acid. Subsequent pH of the spill was 10.1 standard units. No cleanup action is mentioned in the occurrence report. Based on the CVP for the 120-N-1 and 120-N-2 waste sites and similar waste streams, this unplanned release should also meet the 100-N Area cleanup standards.	Not Accepted	Discovery Site Evaluation Checklist	N/A									

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-42	UPR-100-N-42, 184-N Day Tank Area Liquid Unplanned Release, 10/9/87 184-N, Day Tank Diesel Oil Spill	Unplanned Release	100-NR-1		The 184-N Day Tank Area is surrounded by a 1.5 m (4.8-ft) concrete wall that is 25 m (85 ft) long by 12.8 m (42 ft) wide, has a sand floor, and contains two 130,000 L (35,000 gal) Number 6 fuel oil tanks and one 30,000 L (8,000 gal) diesel oil tank.	Accepted										
UPR-100-N-43	UPR-100-N-43, 166-N / 184-N Pipelines Liquid Unplanned Release 2 (4/26/89, Cleaned Up)	Unplanned Release	100-NR-1	Not Documented	The release site occurred at the oil supply piping from the 166-N to 184-N Buildings. A diesel oil leak occurred at three locations along the pipeline from 166-N to 184-N Buildings at three different flange joints. The exact location of these flange joints is not given in the referenced descriptions. A total of 46 drums and 8 dump trucks of contaminated soil were removed. Sampling was conducted in nearby Wells N-16 and N-17 and oil was detected.	Accepted	Not Documented	N/A								
UPR-100-N-5	UPR-100-N-5, 1310-N Chemical Waste Storage Tank Leak, UN-100-N-5, 116-N-2 Radioactive Chemical Waste Treatment Storage Facility	Unplanned Release	100-NR-1	18.29 (deep)	The release occurred in the 1310-N Radioactive Chemical Waste Handling Facility (116-N-2) on the recirculation pump discharge line radioactive waste was discharged to the ground. Contaminated soil reading greater than 1,000 counts per minute was removed and taken to the 200 Area for disposal, and the remainder was covered with clean fill. Potential for contamination remains as there is no record that contaminated soil less than 1,000 counts per minute was ever removed, or that soil was removed to a depth of 18.3 m (60 ft) which is the depth to the aquifer.	Accepted	Not Documented	N/A								
UPR-100-N-6	UPR-100-N-6, 1 1/2 in. Chemical Decontam. Waste Drain Line Leaks, UN-100-N-6, UN-116-N-6, Chemical Decontamination Waste	Unplanned Release	100-NR-1	Not Documented	This site is a chemical decontamination waste drain line waste line, buried 0.9 m (3 ft) below grade and runs between the 1714N (Radioactive Chemical Waste Handling Facility) and the 1310N (Chemical Waste Storage Tank). The leaking line was repaired and approximately 16.7 m ³ (590 ft ³) of contaminated soil reading 7,000 to 25,000 counts	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
	Drain Line Leak				per minute was removed from four locations along the line. The excavations were backfilled with clean soil. The line was repaired and is no longer active. The contaminated soil was removed, which effectively removed any potential for further release from these specific locations. A site visit in August 2000 found a roped area east of 1714-N. The area was posted Underground Radioactive Material and Controlled Area. A soil mound was inside the roped area.											
UPR-100-N-7	UPR-100-N-7, Ten-inch Radioactive Drain Return Line Leak, UN-116-N-7, UN-100-N-7	Unplanned Release	100-NR-1	Not Documented	A leak occurred in a buried 25.4 cm (10-in.) drain line between the 109-N Building and the 1909-N Valve Pit. This pipe is approximately 69.4 m (228 ft) from the bank of the Columbia River. Contamination related to this event was identified during a field radiation survey on November 5, 1996. Adjacent groundwater monitoring wells detected increased levels of iodine-131, indicating a nearby leak to the water table. Groundwater monitoring wells were sampled daily until concentrations of iodine-131 had returned to background levels. Approximately 1,907,842 L (504,000 gal) leaked. The release occurred on April 29, 1985. The leaking pipe was repaired. All radionuclides except manganese-54, cobalt-60, and cerium-144 have undergone more than ten half-lives and are no longer present. The three remaining radionuclides bind readily to soil particles and are not present in groundwater monitoring samples. Approximately 32 m ³ (1,130 ft ³) of contaminated soil were removed and the hole was backfilled with clean soil.	Accepted	Not Documented	N/A								

Table C.1 100-N Decision Unit Waste Sites Description and History

Site Code	Site Name	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow ^a	Deep ^b	Shallow ^a	Deep ^b
UPR-100-N-8	UPR-100-N-8, 1322-A Sump Overflow, UN-100-N-8	Unplanned Release	100-NR-1	2.32 sq. m	The original site of contamination was the 1322-NA (Effluent Water Pilot Plant) including the area surrounding the sump, floor, various pieces of equipment, and the ground just outside the rear door (south door). The release took place in the soil immediately outside the south door of 1322-NA Effluent Water Pilot Plant when a tygon sample tube came off the radioactive drain return line sampler sample line and up to 379 L (100 gal) of radioactive water was released to the soil. This is partly on the same location as UPR-100-N-4. Most of the contaminated soil was removed. The excavation was then backfilled with clean fill material.	Accepted	Not Documented	N/A								
UPR-100-N-9	UPR-100-N-9, 119-N Cooling Water Drain Line Leak, UN-100-N-9	Unplanned Release	100-NR-1	Not Documented	A backhoe accidentally ruptured a buried 5 cm (2-in.) diameter cooling water drain valve during exploratory digging. Contaminated water immediately flowed into the excavation hole around the valve at approximately 19 L (5 gal) per minute and maintained a water level 1.2 m (4 ft) below grade. A GM portable survey instrument held near the surface of the water read 20,000 counts per minute. Repair was completed on the 5 cm (2-in.) valve and drain line. An unknown amount of contaminated excavation spoils were removed to a 200 Area Burial Ground and the area was filled with clean soil.	Accepted	Not Documented	N/A								
UPR-600-17	UPR-600-17, 600 Area Patrol Boat Spill, UN-600-17	Unplanned Release	100-NR-1	Not Documented	The release occurred at the patrol boat refueling area just south of 100N Area on the Columbia River. Gasoline was spilled inside a patrol boat during refueling operations, and gasoline was discharged from the boat to the shoreline. Because the site is periodically flooded by the Columbia River, and since the spill occurred in 1986 and has dissipated over that time, no trace of the gasoline spill is expected to remain.	Not Accepted	WSRF 2000-095	N/A								



7 This page intentionally left blank

Appendix D

100-N Decision Unit Facilities

1

2

3

1

This page intentionally left blank.

D1 Introduction

Table D-1 provides a summary of the buildings/facilities that have existed in the 100-N Decision Unit of the Hanford Site. Many of these buildings/facilities have been demolished or are no longer used. Table D-1 also provides physical dimensions and a brief history for each building/facility.

D2 References

BHI-00221, 1994, "Pre-Existing" Conditions Survey of Hanford Site Facilities to be Managed by Bechtel Hanford, Inc., Bechtel Hanford, Inc., Richland, Washington.

BHI-00540, 1995, Sample Collection and Sample Analysis Plan for the Characterization of the 1300-N Emergency Dump Basin, Bechtel Hanford, Inc., Richland, Washington.

BHI-00606, 1996, Final Report for the 1304-N Emergency Dump Tank Dose Reduction, Bechtel Hanford, Inc., Richland, Washington.

BHI-00627, 1996, The Hanford Site N Reactor Buildings Task Identification and Evaluation of Historic Properties, Bechtel Hanford, Inc., Richland, Washington.

BHI-00731, 1996, Disposal of Sediments from the 1300-N Emergency Dump Basin, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI-00981, 2002, ERC Hazard Classification Matrices for Above-Ground Structures and Groundwater and Soil Remediation Activities, Rev. 4, Bechtel Hanford, Inc., Richland, Washington.

BHI-01725, 2004, Final Hazard Categorization and Auditable Safety Analysis for the 107-N Decontamination and Decommissioning Activities, Bechtel Hanford, Inc., Richland, Washington.

CAS 127-18-4, Chemical Abstracts Service (CAS) No. 127-18-4, tetrachloroethylene.

CCN 113663, 2004, Interoffice Memorandum re: 107-N Basin Recirculation Building Flowchart, ERC Team, Richland, Washington.

CCN 122923, 2005, Interoffice Memorandum re: Characterization Summary Report for the 151-N and 153-N Electrical Substations, 119-N Exhaust and 119-N Stack Air Monitoring Buildings, 1313-N Change Control Building, and 181-NC Sample Stack, Washington Closure Hanford, Richland, Washington.

CCN 125295, 2005, Interoffice Memorandum re: Historical Site Assessment for 1303-N Spacer Silos, Washington Closure Hanford, Richland, Washington.

CCN 127193, 2006, Interoffice Memorandum re: Historical Site Assessment for 117-NVH (117-N Valve House), Washington Closure Hanford, Richland, Washington.

CCN 128270, 2006, Interoffice Memorandum re: Post Demolition Summary Report for the 119-N Air Sampling Monitor and the 119-NA Air Sampling and Monitoring Facilities, Washington Closure Hanford, Richland, Washington.

CCN 132235, 2007, Interoffice Memorandum re: Post Demolition Summary Report for the 1313-N Change Control Building, Washington Closure Hanford, Richland, Washington.

- 1 DOE/RL-2004-15, 2004, Waste Characterization and Sampling and Analysis Plan for 107-N Basin
2 Recirculation/Cooling Facility, 1310-N Pump House and Liquid Storage Tank, and 1314-N
3 Liquid Waste Loadout Complex, U.S. Department of Energy, Richland Operations Office,
4 Richland, Washington.
- 5 H-1-28400, 1961, Drawing: Plot Plan Filter Building Stack and Loading Area, U.S. Atomic Energy
6 Commission Hanford Atomic Products Operation, General Electric, Richland, Washington.
- 7 H-1-37675, 1968, Drawing: Piping Plan & Sections, U.S. Atomic Energy Commission, Richland
8 Operation Office, Hanford Engineering Services, Richland, Washington.
- 9 WHC-SD-EN-TI-251, 1994, 100-N Area Technical Baseline Report, Rev. 0, Westinghouse Hanford
10 Company, Richland, Washington.
- 11 WHC-SD-NR-RD-006, 1991, N Reactor Layup Specification, Rev. 3, Westinghouse Hanford Company,
12 Richland, Washington.
- 13 **108440-34CN, (This is just a photograph)**
- 14

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
104-N	Storage	100	100-NR-1	6.1 x 7 (facility dimensions) 7.3 x 7.3 (concrete pad)	Demolished	1982	1996	The 104-N Facilities Auxiliary Shop was a rectangular, corrugated-metal storage building with wood framing on a concrete slab. There was also a fenced storage yard next to the facility. The 104-N Facility was used for a snubber repair shop during plant operations. After shutdown, it was used for storage.
105-N	Reactor	100	100-NR-1	164.9 x 79.9 (105-N) 2.4 x 7.3 (105-NA) 32.0 x 24.4 (105-NB) 12.2 x 11.6 (105-NC) 3.4 x 2.4 (105-ND) 5.2 x 5.8 x 9.1 (105-NE)	Inactive	1963	Not Recorded	<p>The 105-N Reactor (105-N) was a dual-purpose nuclear reactor and contained the reactor block, front and rear elevators, pipe galleries, exhaust fans, a receiving basin for spent fuels, offices, control rooms, electrical and instrument rooms, a shop area, ventilation supply, metal preparation and storage areas, fuel storage basin, and a transfer area. The 105-N Reactor Building was deactivated in 1998 and is in the process of being placed in ISS. Additional facilities include:</p> <p>The 105-NA Emergency Diesel Enclosure, which housed an emergency lift station diesel pump. The 105-NA Emergency Diesel Enclosure has been deactivated and the associated underground diesel oil storage tank was removed in December 1990.</p> <p>The 105-NB Mechanical Shop Addition was used as a maintenance shop. It was demolished in August 2007 and the concrete slab foundation was removed in May 2008.</p> <p>The 105-NC Emergency Diesel Generator Building was a reinforced-concrete building with a flat roof. The building was never used, due to the shutdown of the N Reactor. The two diesel oil tanks were installed, never used, and have been removed. No other equipment was installed in the facility. The building was demolished between March 1996 and July 1997.</p> <p>The 105-ND Remote Air Intake was constructed in 1987 during an upgrade of the N Reactor to provide emergency air, in the event of a nuclear accident, for the personnel in the 105-N Control Room and 182-N High Lift Pump House.</p> <p>The 105-NE Fission Products Trap (1305-N), was a reinforced-concrete structure approximately 9.1 m (29 ft) deep. The trap was used for clean out and removal of crud and fission product material from the risers.</p>
107-N	Process Unit/Plant	100	100-NR-1	14.3 x 21.0 x 14.6 (107-N building) 29.0 (Length of pipe trench connecting 105-N and 107-N)	Inactive	1985	Not Recorded	The facility was a reinforced-concrete structure with a steel-framed, metal-sided annex on the north end. During its operating years from 1984 through 1989, the facility recirculation system cooled and filtered water from the 105-N Irradiated Fuel Storage Basin in order to reduce or eliminate the need to discharge water to the crib areas associated with N Reactor operations. Facility components included: a pump well and two recirculation pumps, two heat exchangers, two sandbed filters, a sand filter backwash tank, three ion exchange vessels, one caustic tank, one acid tank, one regeneration waste collection tank, one resin loadout tank, three building sumps, and one hydrogen peroxide tank and pump. The 107-N Building is in the process of being demolished (as of February 27, 2008). It is estimated more than 100 curies of radioactive material remained in the facility at the start of D&D activities (BHI-01725). Major radionuclides were: Am-241, Co-60, Cs-137, Pu-239/240, Pu-241, and Sr-90. The primary source of liquid and sediment in the 107-N Building was water, dissolved solids, and suspended solids from the 105-N Fuel Storage Basin.
108-N	Storage	100	100-NR-1	8.2 x 9.1	Demolished	1963	2007	The 108-N Facility consisted of several parts: a pump house, three acid storage tanks, one caustic storage tank, a pneumatic transfer tank, an underground neutralization pit, and, tank car unloading station. It was used to receive, transfer, and store caustics and acids for use in the 163-N Demineralizer Building for regeneration of ion exchange beds (BHI-00221).

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/Removal/Cocooned Date	Facility Description
109-N	Process Unit/Plant	100	100-NR-1	NA	Inactive	1963	Not Recorded	<p>The 109-N Heat Exchanger Building contained a pipe gallery, auxiliary cell, six steam generator cells in parallel, each cell containing two steam generators, a drive turbine, a circulating water pump and associated piping, valves, and instrumentation. Primary coolant was circulated through the 105-N Reactor to steam generators located in the 109-N Heat Exchanger Building and then routed back to the reactor via primary coolant pumps. Secondary steam from the steam generators was either dumped into water-cooled dump condensers or piped to the 185-N HGP to generate electricity. Circulation of radioactive primary coolant through the 109-N Systems contaminated the equipment, piping, and steam generators to levels comparable with the 105-N Reactor primary cooling system piping and equipment. Tube leaks in the 109-N Steam Generators allowed small amounts of radiologically contaminated primary water to be carried to the 109-N Secondary Systems and to the HGP. 109-N Heat Exchanger Building has been deactivated. The steam generator cells, pipe gallery, auxiliary system cell, and pressurizer cell will become part of the SSE during the ISS of the 105-N Reactor. Two of three chemical storage tanks have been removed with their concrete pedestals remaining. The third tank, which stored ammonium hydroxide, remains as of February 2008. Two of four transformers were removed; the concrete pads have not been removed as of February 2008.</p> <p>109-NA housed instruments for monitoring steam flow to the HGP and condensate return to 109-N. 109-NB housed hydraulic power packs that were used to power the HPV 201 Valves in the 109-N Heat Exchanger Building. The 109-NA Steam & Flow Instrument Building and the 109-NB Hydro Power Unit have been demolished to concrete slab-on-grade. THE HPU Building was a 33.8 m² (364 ft²), pre-engineered, one-story, metal building with metal siding and roofing, on a concrete slab (BHI-00221).</p>
1100-N	Office	100	100-NR-1	70.1 x 12.2	Demolished	1961 (moved to 100N)	1994	The 1100-N Building facility contained three restrooms, two kitchens, and 53 offices. The photographic record logbook indicates the facility was to be a TC Office. No known processes that produced hazardous waste, other than routine building maintenance activities (light ballast and light bulb replacement), occurred within the facility.
1101-N	Office	100	100-NR-1	121.92 x 42.0624	Demolished	Not Recorded	1994	The 1101-N Office Building was originally used as an office building by the construction contractor during 100-N construction and then as administrative offices following completion of construction.
1102-N	Office	100	100-NR-1	12.2 x 6.1	Demolished	Not Recorded	1994	The 1102-N had three rooms and a bathroom with fluorescent lighting, and walls covered with sheetrock. The 1102-N originally was used for administrative purposes and personnel training. The offices were later converted into a lunchroom and kitchen facility.
1103-N	Office	100	100-NR-1	1866.0 square meters	Active	late 1970s-early 1980s	Not Recorded	1103-N consisted of 15 sheet metal and plywood trailers on I-beam trailer frames. It contained approximately 60 offices and 10 larger workstations, along with kitchens and restrooms. The facility was connected to the 124-N-7 Septic Tank.
1104-N	Office	100	100-NR-1	1002.4 square meters	Removed	late 1970s-early 1980s	Not Recorded	1104-N consisted of 12 sheet metal and plywood trailers on I-beam trailer frames. The 1104-N Building provided administrative office space for personnel in the 100-N Area. It contained approximately 60 offices and 10 larger workstations, along with kitchens and restrooms. The facility was connected to the 124-N-7 Septic Tank.
1105-N	Office	100	100-NR-1	122.6 square meters	Removed	late 1970s-early 1980s	Not Recorded	1105-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1105-N Building provided administrative office space for personnel in the 100-N Area.
1107-N	Office	100	100-NR-1	124.9 square meters	Removed	late 1970s-early 1980s	Not Recorded	1107-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1107-N Building provided administrative office space for personnel in the 100-N Area. It contained four offices and a restroom, and was used as a training facility.
1109-N	Office	100	100-NR-1	124.9 square meters	Removed	late 1970s-early 1980s	Not Recorded	1109-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1109-N Building provided administrative office space for personnel in the 100-N Area. It contained eight offices and restroom facilities.
1110-N	Office	100	100-NR-1	147.2 square meters	Active	1979	Not Recorded	1110-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1110-N Facility was used to provide office space in the 100-N Area. It contained 10 offices and was not equipped with restroom facilities.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1111-N	Office	100	100-NR-1	144.0 square meters	Removed	1980s	Not Recorded	1111-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1111-N Building was connected to the 124-N-5 Sewer System. It contained restrooms and six offices, and was used to house administrative personnel.
1112-N	Office	100	100-NR-1	28.0 x 7.6 (1112-N Guard Station) 3.7 x 3.7 (1112-NA Microwave Tower Annex building) 6.1 x 6.1 x 25.0 (1112-NA Tower (dimensions are for base)) 3.0 x 2.1 (1112-NB Badge House)	Demolished	1981	Not Recorded	The 1112-N Guard Station originally served as a security access control point to the 100-N Limited Access Area. Following 100-N Reactor shutdown, the facility served initially as document storage and later as office space. The 1112-NA Microwave Tower Annex and a portion of 1112-N, served as the central communications hub for the 100 Area. The 1112-NA Microwave Tower enabled telecommunications with the 100F, 100H, and 100D/DR Areas. As of April 2008, the 1112-N and 1112-NA Facilities are still active. The 1112-NB SEA Badge House was built in 1984 and used to house security personnel who issued SEA badges to personnel who required access to the 105-N Buildings, but did not regularly work there. A radiological survey taken in December 1995 showed the facility was not contaminated (N-1196). The building was removed in 1996. 1112-N has been demolished to slab-on-grade. The 1112-NA Microwave Tower is still standing.
1113-N	Office	100	100-NR-1	331.7 square meters	Removed	1980	Not Recorded	1113-N consisted of four sheet metal and plywood trailers on I-beam trailer frames. The trailer was connected to the 124-N-6 Sewer System. The 1113-N Facility was used to provide office space for Environmental & Radiation Control personnel in the 100-N Area. It contained 20 offices, restrooms, and a kitchen.
1114-N	Office	100	100-NR-1		Demolished	1980	2007	1114-N was one of several mobile offices that were installed in the 100-N Area in the 1980s. It consisted of four sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-6 Sewer System and was attached to the 1114-NA (MO-911) Mobile Office. Together with 1114-NA, the two facilities contained 20 offices, restrooms, and a kitchen.
1114-NA	Office	100	100-NR-1	223.1 square meters	Demolished	1980	2007	1114-NA consisted of two sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-6 Sewer System and was attached to the 1114-N (MO-055) Mobile Office. The 1114-NA Facility was used to provide office space for Field Support personnel in the 100-N Area. Together with 1114-N, the two facilities contained 20 offices, restrooms, and a kitchen.
1115-N	Office	100	100-NR-1	686.7 square meters	Demolished	1982	2007	1115-N consisted of eight sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-6 Sewer System. The 1115-N Facility was used to house support personnel offices in the 100-N Area. In addition to office space, 1115-N also contained a lunchroom/kitchen (1N-91-00423W), 32 offices, restrooms, and two classrooms (WHC-SD-NR-RD-006).
1116-N	Office	100	100-NR-1	686.7 square meters (1116-N) 589.0 square meters (1116-NB)	Demolished	1982	2007	1116-N consisted of 10 sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-5 Sewer System. The 1116-N Building was used as a training simulator for the 100-N Area, and housed a replica of the 100-N Reactor Control Room. In addition, it also contained seven offices, a kitchen, and restrooms. The 1116-NB Air Compressor Building housed an air compressor needed to operate the 1116-N Training Simulator.
1116-NA	Office	100	100-NR-1	135.3 square meters	Removed	1980s	Not Recorded	1116-NA consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1116-NA Mobile Office provided office space for maintenance and training personnel associated with the 1116-N Training Simulator. In addition, it also contained a kitchen and restrooms.
1117-N	Office	100	100-NR-1	1017.8 square meters	Removed	1980s	Not Recorded	1117-N consisted of 12 sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-6 Sewer System. 1117-N provided office space. The building contained 47 separate offices along with kitchen and restroom facilities.
1118-N	Office	100	100-NR-1	1017.8 square meters	Removed	1980s	Not Recorded	1118-N consisted of 12 sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-6 Sewer System. The 1118-N provided office space. The building contained 57 separate offices along with kitchen and restroom facilities.
1119-N	Change House	100	100-NR-1	257.5 square meters	Active	1977	Not Recorded	1119-N consisted of five sheet metal and plywood trailers on I-beam trailer frames. The 1119-N Facility was used as a change house in the 100-N Area. It was also equipped with restroom facilities.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1120-N	Office	100	100-NR-1	45.7 x 24.4 x 6.1	Active	1984	Not Recorded	1120-N was used as a warehouse, for offices, training, and potable water storage and preparation. The northeast corner of the facility is currently used to prepare potable water for personnel working in the field. Janitorial supplies and pest control supplies were located in rooms W2 and W3. Sign painters occupied room W1. For a brief period, room W5 was used for an RCT laboratory. Room 6 is currently a storage area for radioactive sources used to calibrate radiation detection instruments.
1123-N	Office	100	100-NR-1	122.6 square meters	Removed	1980s	Not Recorded	1123-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The trailer was connected to the 124-N-5 Sewer System. The 1123-N provided office space. The building contained seven offices, a kitchen, and restrooms.
1124-N	Office	100	100-NR-1	122.6 square meters	Demolished	1978	2007	1124-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The trailer was connected to the 124-N-5 Sewer System. The 1124-N provided office space. The building housed four offices, a kitchen, and restrooms. According to BHI-00627, the facility was later used for records storage.
1125-N	Office	100	100-NR-1	122.6 square meters	Removed	1980s	Not Recorded	1125-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1125-N Building was transferred to the 200 Area prior to 1990 (WHC-SD-NR-RD-006). The 1125-N Building housed administrative personnel in the 100-N Area. It contained a kitchen, restrooms, and eight offices.
1126-N	Office	100	100-NR-1	124.9 square meters	Removed	1979	Not Recorded	1126-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1126-NA Trailer was installed between 1107-N and 1126-N to connect the two mobile offices together into one unit. The 1126-N Facility was used to house administrative personnel in the 100-N Area. It contained six offices, a kitchen, and restroom facilities.
1127-N	Office	100	100-NR-1	124.9 square meters	Removed	1977	Not Recorded	1127-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1127-N provided office space. It contained 10 offices and was used to house administrative personnel.
1128-N	Change House	100	100-NR-1	124.9 square meters (Dimensions are for 1127-N, which appears to be identical to 1128-N)	Removed	1980s	Not Recorded	1128-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1128-N Facility appears to have originally been installed as part of a reactor outage project, and was removed shortly afterward.
1129-N	Storage	100	100-NR-1	124.9 square meters	Removed	1980s	Not Recorded	1129-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1129-N Facility was used to store spare parts for electrical instrumentation while it was in the 100-N Area.
1130-N	Storage	100	100-NR-1	122.6 square meters	Removed	1980s	Not Recorded	1130-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1130-N Trailer Building was used to store maintenance supplies. Minor repair tasks may also have been performed within the facility. After it was moved south and renumbered as 1143-NC, the trailer was still used for maintenance storage.
1131-N	Office	100	100-NR-1	122.6 square meters	Removed	1980s	Not Recorded	1131-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The trailer was connected to the 124-N-5 Sewer System. The 1131-N Building provided office space. The building housed a single office, a restroom, and a large open area for drafting.
1132-N	Office	100	100-NR-1	223.0 square meters	Removed	1980s	Not Recorded	1132-N consisted of four sheet metal and plywood trailers on I-beam trailer frames. The trailer was connected to the 124-N-8 Sewer System. The 1132-N Facility provided office space for personnel in the 100-N Area.
1133-N	Office	100	100-NR-1	223.0 square meters	Removed	1980s	Not Recorded	1133-N consisted of four sheet metal and plywood trailers on I-beam trailer frames. The trailer was connected to the 124-N-8 Sewer System. The 1133-N provided office space. The building housed 15 offices, a kitchen, and restrooms.
1134-N	Office	100	100-NR-1	253.6 square meters	Removed	1980s	Not Recorded	1134-N consisted of four sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-8 Sewer System. The 1134-NA Line Conditioner Building was a small metal shack located off the north end of the 1134-N Building that contained electrical equipment. The 1134-N provided office space. The building housed seven offices, a kitchen, and restrooms.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1135-N	Office	100	100-NR-1	223.0 square meters	Removed	1982	Not Recorded	1135-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-8 Sewer System and was attached to 1135-NA. The 1135-N provided office space. Along with 1135-NA, the building housed 11 offices, a kitchen, and restrooms. In the mid-1990s, the building was being used as a drug-testing facility.
1135-NA	Office	100	100-NR-1	214.5 square meters	Removed	1980s	Not Recorded	1135-NA was one of several mobile offices that were installed in the 100-N Area in the 1980s. It consisted of two sheet metal and plywood trailers on I-beam trailer frames. The building was connected to the 124-N-8 Sewer System and was attached to 1135-N. The Mobile Offices were located south of N Avenue, north of Turbine Lane, and about 425 m (1,394 ft) southeast of the 105-N Reactor. 1135-NA was centered at the coordinates (571588.859, 149146.797). The 1135-NA Building was excised in the late 1990s, and was eventually auctioned off to a private company and removed from the site (Cor11052007). As was the case with most of the mobile trailer buildings on the Hanford Site, the primary purpose of 1135-NA was to provide office space. Along with 1135-N, the building housed 11 offices, a kitchen, and restrooms. In the mid-1990s, the building was being used as a drug-testing facility.
1137-N	Office	100	100-NR-1	195.5 square meters	Removed	1980s	Not Recorded	1137-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1137-N Building provided office space for Hanford Patrol personnel.
1140-N	Change House	100	100-NR-1	13.9 square meters	Removed	Not Recorded	Not Recorded	The 1140-N Facility was a single-wide mobile office facility and was used as a restroom facility in the 100-N Area.
1141-N	Change House	100	100-NR-1	22.3 square meters	Removed	Not Recorded	Not Recorded	The 1141-N Facility was a single-wide mobile office facility in the 100-N Area and was used as a restroom facility in the 100-N Area.
1142-N	Office	100	100-NR-1	62.4 square meters	Removed	Not Recorded	Not Recorded	The 1142-N Building was a single-wide mobile office facility. This facility likely housed the equipment necessary to support the telephone system in the 100-N Area.
1143-N	Maintenance Shop	100	100-NR-1	29.3 x 27.4 (Overall site dimensions)	Active	1985	Not Recorded	The 1143-N Carpenter/Paint Shop is a one-story, pre-engineered, metal building. The north half of the building was used as a carpenter shop and the south half as a paint shop. The paint shop area was converted to a heavy equipment mechanics shop in the mid-1990s. A work site IH baseline survey of 1143-N conducted in April 2004 noted that the solvent (Safety-Kleen 105 Solvent Recycled) used in a parts cleaner was replaced with a "new" solvent, Safety-Kleen Premium Solvent, as it did not contain tetrachloroethylene (CAS 127-18-4). Other potential IH chemical hazards identified in the baseline included oils, lubricants, greases, petrols (gasoline, diesel), solvents, spray paints, adhesives, grinding wheels, and welding rods.
1143-NA	Storage	100	100-NR-1	111.5 square meters	Removed	1976	Not Recorded	The 1143-NA Facility was a modular office trailer facility in the 100-N Area. Originally, this facility was MO-312, which was a single-wide trailer and appears to have been present in the mid-1980s. By 1987, a double-wide trailer had replaced the original facility. This new facility was known as MO-389 (049562). The MO-389 building was excised circa 1999 (BHI-00981). The 1143-NA Building was used to store a variety of products for general maintenance and equipment repair.
1143-NB	Storage	100	100-NR-1	46.5 square meters	Removed	1980s	Not Recorded	1143-NB was a single-wide sheet metal and plywood trailer facility. The 1143-NB Facility was used for maintenance storage in the 100-N Area. It was used to store supplies associated with the 1143-N Shop Building.
1143-NC	Storage	100	100-NR-1	27.9 square meters	Removed	1980s	Not Recorded	1143-NC was a single-wide sheet metal and plywood trailer facility. The 1143-NC Facility was used for storage in the 100-N Area. It was used to store paint and other supplies associated with the 1143-N Shop Building.
1144-N	Maintenance Shop	100	100-NR-1	124.9 square meters	Removed	1977	Not Recorded	1144-N was a double-wide sheet metal and plywood trailer facility. The 1144-N Facility served as a maintenance building for SAS personnel in the 100-N Area. It contained space for four offices along with a larger work area; it later served as a print shop, and after that it may have been used to house personnel from the Sandia National Laboratory.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1145-N	Office	100	100-NR-1	124.9 square meters (Dimensions are for the second 1145-N)	Removed	Not Recorded	Not Recorded	The 1145-N Facility was first a single-wide change trailer, which was located southwest of the 1104-N Building. Two small restroom trailers were associated with this facility (1145-NA and 1145-NB). By 1987, this original facility had been removed and replaced by a double-wide facility, which contained restrooms and 11 offices. The first 1145-N Facility appears to have been used as a change house by maintenance personnel in the 100-N Area. The second 1145-N Facility provided office space. It was connected to the 124-N-7 Septic Tank.
1145-NA	Change House	100	100-NR-1	Not Specified	Removed	Not Recorded	Not Recorded	The 1145-NA Facility was a small, single-wide restroom trailer in the 100-N Area. 1145-NA provided restrooms for maintenance workers.
1145-NB	Restroom Trailer	100	100-NR-1	Not Specified	Removed	Not Recorded	Not Recorded	The 1145-NB Facility was a small, single-wide restroom trailer in the 100-N Area. 1145-NB provided restrooms for maintenance workers. The 1145-NB Facility, assuming it can be identified as the MO-397 structure present during the 1990s, was likely removed circa 1999 at the same time as many of the other trailers in the immediate vicinity.
1146-N	Office	100	100-NR-1	124.9 square meters	Removed	1982	Not Recorded	1146-N was a double-wide sheet metal and plywood trailer facility. The 1146-N Facility was used as a training facility, containing a large classroom, along with restrooms. According to BHI-00627, it was later used by as an HPT trailer.
1147-N	Office	100	100-NR-1	156.1 square meters	Removed	1980	Not Recorded	1147-N was a double-wide sheet metal and plywood trailer facility. The 1147-N Facility was used as a training facility, containing a large classroom along with restrooms.
1148-N	Change House	100	100-NR-1	171.7 square meters	Removed	Not Recorded	Not Recorded	1148-N was a double-wide sheet metal and plywood trailer facility and contained a restroom, kitchen, and three offices. The 1148-N Building was used as a change house by Facilities Maintenance personnel. It also had kitchen facilities and served as a lunchroom.
1149-N	Office	100	100-NR-1	124.9 square meters	Removed	1980s	Not Recorded	1149-N was a double-wide sheet metal and plywood trailer facility and contained space for 10 offices. The 1149-N Facility was used to house offices for administrative personnel in the 100-N Area.
1150-N	Office	100	100-NR-1	124.9 square meters	Removed	1980s	Not Recorded	1150-N was a double-wide sheet metal and plywood trailer facility and contained space for 10 offices. The 1150-N Facility was used to house offices for administrative personnel in the 100-N Area.
1151-N	Office	100	100-NR-1	147.2 square meters	Removed	1980s	Not Recorded	1151-N was a double-wide sheet metal and plywood trailer facility and contained space for 10 offices. The 1151-N Facility was used to house offices for administrative personnel in the 100-N Area.
1152-N	Office	100	100-NR-1	147.2 square meters	Removed	1980s	Not Recorded	1152-N was a double-wide sheet metal and plywood trailer facility and contained a kitchen, restrooms, and six offices. The 1152-N Facility was used to house offices for administrative personnel in the 100-N Area.
1153-N	Office	100	100-NR-1	147.2 square meters	Removed	1977	Not Recorded	1153-N was a double-wide sheet metal and plywood trailer facility and contained a kitchen, restrooms, and 10 offices. The 1153-N Facility was used to house offices for D&D personnel in the 100-N Area.
1154-N	Office	100	100-NR-1	124.9 square meters	Removed	1980s	Not Recorded	1154-N was a double-wide sheet metal and plywood trailer facility and contained 10 offices. The 1154-N Facility was used to house offices for administrative personnel in the 100-N Area.
1155-N	Office	100	100-NR-1	7.3 x 20.1	Removed	1980s	Not Recorded	1155-N consisted of two sheet metal and plywood trailers on I-beam trailer frames. The 1155-N Building was used to provide 10 offices for administrative personnel in the 100-N Area.
1156-N	Office	100	100-NR-1	145.7 square meters	Removed	1980s	Not Recorded	1156-N was a double-wide sheet metal and plywood trailer facility and contained 12 offices. The 1156-N Facility was used to house offices for administrative personnel in the 100-N Area.
1157-N	Maintenance Shop	100	100-NR-1	111.5 square meters	Removed	Not Recorded	Not Recorded	A physical description of this facility is not available. The location of this facility could not be determined. There is no evidence that this facility ever existed. If it did, it may have been quickly replaced and renumbered, probably within the 1984 through 1987 timeframe. The 1157-N Facility provided a shop area for facilities maintenance personnel. It also included a single office.
1157-NA	Storage	100	100-NR-1	3.0 x 7.3	Removed	Not Recorded	Not Recorded	The 1157-NA Facility was a single-wide trailer facility in the 100-N Area. The MO-375 Facility was used as a storage facility. It may have been associated with the 1143-N Shop Facilities, although the location of this facility could not be determined.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1158-N	Office	100	100-NR-1	147.2 square meters	Active	1978	Not Recorded	1158-N was a double-wide sheet metal and plywood trailer facility and contained 10 offices. The 1158-N Facility was used to provide office space for training personnel in the 100-N Area. It later provided office space in support of the nearby EAL facilities.
1158-NA	Laboratory	100	100-NR-1	85.8 square meters	Demolished	1993	2008	1158-NA was a single-wide sheet metal and plywood trailer facility and was connected to MO-426 through an enclosed wooden breezeway. On December 15, 1999, the diesel-powered air compressor associated with the facility was found to be leaking. An estimated 8 L to 11 L (2 gal to 3 gal) of diesel fuel was released into the soil. The contaminated soil was to be removed (0519796). The 1158-NA Facility was originally designed to be the EAL. EAL capabilities included VOAs by GC/MS, metals by ICP, anions by IC, CrVI, TOC/TIC, pH, conductivity, gross alpha/beta, gamma spectroscopy, and alpha energy analysis. The EAL was closed in 1996 and has since been used by the IH organization to calibrate and repair their instruments. MO-425 was used to house the analytical laboratory itself.
1158-NB	Storage	100	100-NR-1	85.8 square meters	Active	1993	Not Recorded	MO-426 was a single-wide sheet metal and plywood trailer facility and was connected to MO-425 through an enclosed wooden breezeway. Although it was a separate MO structure, it was often combined with MO-425 and referred to as part of 1158-NA. The 1158-NA Facility was originally designed to be the EAL. EAL capabilities included VOAs by GC/MS, metals by ICP, anions by IC, CrVI, TOC/TIC, pH, conductivity, gross alpha/beta, gamma spectroscopy, and alpha energy analysis. The EAL was closed in 1996 and has since been used by the industrial hygiene organization to calibrate and repair their instruments. MO-426 was used as a sample receiving and preparation facility.
1158-NC	Change House	100	100-NR-1	39.0 square meters	Active	1993	Not Recorded	1158-NC was a single-wide sheet metal and plywood trailer facility. The MO-427 Facility was used as a change room and break room in support of the EAL.
1159-N	Office	100	100-NR-1	46.5 square meters	Removed	1980s	Not Recorded	1159-N was a single-wide sheet metal and plywood trailer facility. A new RCL (MO-870, installed in 2007) now occupies the same spot. The 1159-N Facility was used to provide office space for construction services personnel in the 100-N Area.
1160-N	Office	100	100-NR-1	116.1 square meters	Removed	1980s	Not Recorded	1160-N was a double-wide sheet metal and plywood trailer facility. The 1160-N Facility was used to provide office space for construction services personnel in the 100-N Area.
1161-N	Office	100	100-NR-1	110.1 square meters	Removed	1980s	Not Recorded	1161-N was a double-wide sheet metal and plywood trailer facility. The 1161-N Facility was used to provide office space for construction services personnel in the 100-N Area.
1162-N	Office	100	100-NR-1	125.0 square meters	Removed	1980s	Not Recorded	1162-N was a double-wide sheet metal and plywood trailer facility. The 1162-N Facility was used to provide office space for construction services personnel in the 100-N Area.
1163-N	Office	100	100-NR-1	170.0 square meters	Removed	1980s	Not Recorded	1163-N was a double-wide sheet metal and plywood trailer facility. The 1163-N Facility was used to provide office space for construction services personnel in the 100-N Area.
116-N	Stack	100	100-NR-1	61.3 (h) x 7.2 (dia.) (Diameter listed is the diameter at the base; at the top it measures 4.6 m (15 ft) in diameter)	Inactive	1962	Not Recorded	The 116-N Reactor Stack is a circular ventilation stack set into a steel reinforced-concrete octagonal base. The 116-N Reactor Stack was constructed in 1962 and served an essential function in the 105-N Ventilation System, designed to prevent the spread of radioactive contamination. 105-N had five ventilation zones. Air exhausted from Zone 1 (primary radiation area), Zone 2 (secondary radiation area), and Zone 3 (normal access areas; metal preparation, storage basin, and transfer area) was routed through a HEPA filter system located in the 117-N Filter Building and discharged to the atmosphere from the 116-N Stack. In 1989, the year the N Reactor was permanently shutdown, the 116-N Stack operated at an average flow rate of 5,946 m ³ /min (210,000 ft ³ /min) and released 6.7 x 10 ⁻⁴ Ci. The isotopes released were Co-60, Sr-90, Cs-137, Pu-238, Pu-239, and Pu-240. There may be a drain in the bottom of the stack that drains to a French drain about 12 m (40 ft) east of the center of the stack (H-1-28400). A steel staircase that was located on the east side of the stack to allow access to stack monitoring equipment was removed during demolition of the 119-N and 119-NA Buildings in 2006 (CCN 128270). The stack was demolished with explosives in 2008. The below grade portion remains to be demolished.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
117-N	Process Unit/Plant	100	100-NR-1	36.6 x 22.9 (Overall site dimensions for both buildings)	Inactive	1963	Not Recorded	The 117-N Exhaust Air Filter House housed HEPA filters and activated charcoal filters. The building is below ground except for a removable steel roof. As of March 2008, the 117-N is in the process of being demolished. The 117-NVH Valve Control House is a small pre-engineered metal building. The 117-NVH Facility supported the 117-N Exhaust Air Filter facility, in that it housed instrumentation and controls for filter sprays in filter cells A, B, and D in case of heat indication (CCN 127193). The 117-NVH is deactivated awaiting demolition. The filters have been removed from the facility.
119-N	Laboratory	100	100-NR-1	1.8 x 2.1 (119-N) 3.6 x 3.7 (119-NA)	Demolished	1976	2006	The 119-N Exhaust Air Monitoring Building housed equipment used to sample/monitor the exhaust from the 116-N Stack (CCN 122923). The 119-NA Continuous Airborne Effluent Monitoring Building housed equipment used to sample/monitor the air exhausted from 116-N Stack (CCN 122923). The 116-N Stack was provided with a continuous sampling system. All the sampling equipment was located in the 119-N and 119-NA Buildings.
11-N	Storage	100	100-NR-1	9.1 x 5.5	Demolished	1963	2004	The facility was a portable, one-story, pre-engineered, wood-frame building with metal trusses and corrugated sheet metal siding and roof. It sat on wooden skids. It was originally used as a storage building and later used as a change facility for entry into the 1310-N and 1322-N Facilities (CCN 113663).
1300-N	Retention Basin	100	100-NR-1	24.4 x 39.6 x 4.6	Demolished	1963	2004	The 1300-N EDB was a concrete storage basin with a 0.48 cm (3/16 in) carbon steel liner. The EDB is also WIDS 116-N-4. The basin originally served as a quenching pool for reactor blowdown in the event of a primary coolant leak. In the late 1960s, the basin was determined to be of insufficient size for its original use and was replaced by the 1304-N EDT. From 1973 until 1987, the EDB received low levels of radioactive contaminated liquid effluent generated during periodic blow down of the steam generators and leaking isolation valves (primary and secondary coolant leaks). Water levels were maintained in the 1300-N to keep the bottom layer of contaminated sediment from being exposed (BHI-00540, BHI-00731). Water and sediment were removed from the 1304-N EDB in 1997 and a protective polypropylene liner installed to control spread of contamination. In 2004, the facility was demolished except for the north, east, and short portion of the south walls. Remaining structure and underlying soils were deferred to Remedial Action. The primary isotopes of interest during demolition of the basin were: Co-60, Cs-137, Eu-154, Eu-155, Sr-90/Y-90, Ni-63, Pu-241, Pu-239/240, and Am-241.
1301-N	Crib	100	100-NR-1	88.4 x 38 x 3.7	Inactive	1964	Not Recorded	This structure is also known as WIDS 116-N-1. 1301-N is the zig-zag crib/trench at 100-N. The crib and trench received radiologically contaminated water from the 105-N Reactor Basin Floor Drains and the 109-N Floor Drains. The effluent contained activation and fission products as well as small quantities of corrosive liquids and laboratory chemicals. At times, the effluent consisted of water from the primary reactor coolant system, the periphery reactor cooling system and decontamination wastes from these systems. The crib is a rectangular basin 88 m (290 ft) long by 38 m (125 ft) wide by 3 m (12 ft) deep. The walls of the crib are sloped soil and gravel embankment. Its bottom was filled with a 1 m (3 ft) layer of large stones. Early in 1981, a layer of additional rock was added to the area surrounding the weir box. The added rock was necessary for contamination control purposes. The added cover was 30 cm to 60 cm (12 in to 24 in) deep using cobbles sized from 30 cm to 60 cm (12 in to 24 in) (WHC-SD-EN-TI-251).

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1303-N	Silo	100	100-NR-1	49.1 x 11.0	Inactive	1963	Not Recorded	The 1303-N Spacer Silos are three buried spacer silos covered and surrounded with an earth berm, with a 30.5 m (100 ft) reinforced-concrete retaining wall along the west side (CCN 125295). When 100-N was operating, the silos received radioactive metal fuel spacers for temporary storage. The spacers were transferred from the fuel storage basin to the silos by placing a spacer in a 7.6 cm (3 in) spacer transfer line and then pushing it forward with the next spacer. N Basin water was used to dislodge spacers that became stuck in the transfer line. Non-contaminated water was sprayed into the silos in 1984 to prevent airborne contamination during the removal of spacers. However, it was decided the water spraying could potentially wash contamination into the soil and was discontinued. Paint was used instead of water spray to control contamination. When a silo was completely full, the spacers were removed and shipped to the 200 Area burial grounds for permanent disposal. The primary radionuclide associated with the 1303-N Spacer Silos is Co-60. Cs-137, iron-59, and Mn-54 were also associated with the spacers and may be present in the silos. Radionuclides associated with 100-N Basin water (primarily Cs-137, Sr-90, tritium, and potentially Pu-239/240) may also be present in the silos. All spacers were removed from the silos in 1995 and inspected with video cameras to confirm they were empty. The videos showed there could be an accumulation of several inches of paint in the bottom of silos 2 and 3 (CCN 125295). In 1996, contamination was found outside the chain-link fence surrounding the site. The site was interim stabilized by pushing the chain-link fence and posts into the contaminated area surrounding the silos and covering the entire contaminated area with 15.2 cm (6 in) of crushed rock. The site was down posted to a URM area.
1304-N	Storage Tank	100	100-NR-1	26.8 x 18.9 (Overall site dimensions) 19.2024 (1304-N EDT)	Demolished	1970	2004	The 1304-N EDT was an insulated, dome-topped, steel tank on a reinforced-concrete foundation and was designed to contain the entire volume of the N Reactor primary coolant system. The EDT was maintained One-half full of water so it could act as a quenching system for steam released during a reactor emergency. It was drained in 1989 and never refilled. In 1995, debris and pipe were removed from inside the tank to reduce "sky shine" (BHI-00606). The tank and foundation were demolished in 2004.
1310-N	Process Unit/Plant	100	100-NR-1	79.9 x 100.0 (Overall site dimensions) 18.9 (dia.) (1310-N spherical tank) 7.3 (dia.) (1310-N pump house silo)	Inactive	1963	Not Recorded	The 1310-N Radioactive Liquid Waste Treatment Facility consists of the 1310-N Spherical Tank (referred to as the "golf ball"), 1310-N Pump House Silo, and adjoining earth berm. The 1310-N Chemical Waste Storage Facility provided storage and treatment capability for contaminated liquid wastes generated at the N Reactor Facility. The lower portion of the golf ball tank is located underground. The entire tank is nearly surrounded by the earth berm that acted as a radiological shield. The pump house silo is a reinforced-concrete structure, partially buried below the ground surface (DOE/RL-2004-15). The 1310-N Facility was deactivated in 1997. Deactivation included removal of residual liquids in the spherical tank, liquid, and sediment in the silo were sampled and removed, and residual liquid in the piping was also removed. The radioactive material remaining is residual surface contamination in the facility. Substantial radioactive decay has occurred at the facility since it has been deactivated.
1312-N	Retention Basin	100	100-NR-1	156.4 x 80.5 x 8.0	Demolished	1987	2007	The 1312-N Facility was constructed as a part of the post-Chernobyl safety upgrades to N Reactor (N Reactor Accelerated Safety Enhancement Program). It was designed to retain reactor coolant and other contaminated water in the event of a loss of emergency coolant accident scenario. The 105-N Reactor never experienced an emergency coolant accident and therefore the 1312-N LERF was never used.
1313-N	Office	100	100-NR-1	3.6 x 3.7	Demolished	1978	2006	The 1313-N Change Control Building was a pre-engineered metal-frame building supported on a reinforced-concrete slab foundation (CCN 132235). The 1313-N Change Control Building was adjacent to 1314-N and was used to control the transfer of liquid waste, by remote valving, from the 107-N Recirculation Cooling Building to the 1310-N Chemical Waste Storage Facility or to rail tank cars for shipment. It also provided a change room for radiological-zone work in the nearby 1314-N Facility and was later used as a storage area for radioactive-contamination protection clothing.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1314-N	Office	100	100-NR-1	9.1 x 18.3	Demolished	1978	2007	The 1314-N Liquid Waste Loadout Station contained rail tank car loading equipment consisting of valving, pumps, underground and overhead piping, a 3,800 L (1,000 gal) transfer tank and a 757 L (200 gal) catch tank WHC-SD-EN-TI-251) and was designed to transfer liquid wastes into specially designed rail cars for transportation to the 200 Area for processing and disposal. The 1314-N Facility also received liquid waste from the 107-N Building. The facility contained a tank car washdown station with a sump to collect wash water. The wash water drained into a 3,800 L (1,004 gal) tank identified as the Overflow Tank. During the filling operation, excess liquid waste was designed to overflow through a closed piping system from the tank car to the Overflow Tank, which initiated delivery pump shutdown. A 757 L (200 gal) tank identified as the catch tank was installed to hold liquids that exceeded the capacity of the tank car wash sump (H-1-37675). The 1314-N Site was known to have extensive radiological soil contamination and suspected subsoil petroleum contamination from a nearby upgradient pipe leak near 1715-N.
1315-N	Process Unit/Plant	100	100-NR-1	2.7 x 4.6	Demolished	1977	2006	The 1315-N Reactor Effluent Diversion System Valve House was a 12.5 m ² (135 ft ²), pre-engineered metal building. 1315-N was used as a valving station that regulated discharge to the cribs or shallow disposal basin. Isotopes of concern from wastes generated during deactivation were: Co-60, Cs-137, U-235, U-238, and Sr-90.
1316-N	Process Unit/Plant	100	100-NR-1	11.1 m ² 13 m ² 10.5 m ² 2.3 m ²	Demolished	Not Recorded	2006	1316-N was used as a valving station for reactor effluent discharge to the shallow disposal basin. 1316-NA provided a housing for the valve station, which directed water discharge to either the 116-N-1 or 116-N-3 Cribs. 1316-NB housed a magnetic flow meter. 1316-NC housed a turbine meter.
1317-N	Process Unit/Plant	100	100-NR-1	1.52 x 1.52	Demolished	Not Recorded	1987	The structure appears to have been a wood and sheet metal weather enclosure over a valve pit for the export water line. The above grade structure was gone by 1987.
1322-N	Process Unit/Plant	100	100-NR-1	8.2 x 7.9 x 7.5 28 x 21 9 x 5 4.3 x 1.8	Inactive	1964	Not Recorded	1322-N was used to divert effluent waste from the reactor plant to the crib or the chemical waste tank. 1322-NA Building contained the liquid effluent waste treatment facility pilot plant. At one time it was used for pilot testing IX columns for the 107-N Facility. 1322-NB was used as a station for valving and sampling functions. 1322-NC was used for sampling and analysis of the effluent prior to entering the disposal crib.
1323-N	Process Unit/Plant	100	100-NR-1	1.8 m x 1.8 m	Inactive	Not Recorded	Not Recorded	The 1323-N Structure was the sampling station for the N8 Wells, a series of wells installed to monitor the N Springs. The wells were both groundwater monitoring and piezometers. 1323-N was a 1.8 m by 1.8 m (6 ft by 6 ft) metal shed with a corrugated metal roof that sat on the bank of the Columbia River about 15 m (50 ft) from the water.
1325-N	Process Unit/Plant	100	100-NR-1	28.04 x 21.03 76.2 x 73.1 915 x 16.7 x 2.1	Demolished	1983	2001	The 1325-N Crib (WIDS 116-N-3) was designed for the disposal of liquid waste percolation through the soil column. It was built to replace the 1302-N Crib (WIDS 116-N-1) and first received N Reactor effluent in 1983. The 116-N-3 Trench was put into service in September 1985 to provide additional disposal capacity. Effluent reportedly never overflowed the first earthen dam in the trench. The crib has not received waste since February 1987 and was closed under interim status. It has been demolished and remediated by FR. It is also known as WIDS 116-N-3.
1327-N	Process Unit/Plant	100	100-NR-1	9.14 x 7.32	Demolished	Not Recorded	2006	1327-N Diversion Valve House was a pre-engineered metal building and was designed to divert liquid effluent into 1312-N LERF in the event of an emergency.
1330-N	Storage	100	100-NR-1	45.72 x 18.29	Active	1983	2008	The 1330-N Waste Storage Facility was a curbed and fenced concrete pad. The facility was used to store and package waste for disposal. The pad was covered by an open metal shed made of structural steel and sheet metal installed over the pad in the late 1980s that was divided into three storage areas each with its own locked gate.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1331-N	Storage	100	100-NR-1	1.83 x 3.96	Demolished	1982	2006	The 1331-N Facility was a small metal framed and corrugated metal sheathed shelter. It consisted of a rack where drummed liquids could be held in a horizontal position with a metal pan to contain any spills.
1332-N	Storage	100	100-NR-1	12.19 x 2.44	Demolished	Not Recorded	2006	The 1332-N Gas Bottle Storage was a covered bottle storage area constructed of structural steel with a pan deck floor, corrugated steel roofing, concrete block, and steel-plate dividers. The facility was used to store bottles of compressed gas.
13-N	Storage	100	100-NR-1	6.1 x 12.2	Demolished	1963	2004	The 13-N was a portable, rectangular, one-story, wood-frame building with corrugated sheet metal exterior wall surfaces and gable roof. It sat on concrete blocks surrounded by a plywood skirting. The interior was a single room, the walls were wood and sheetrock. No underground lines associated with 13-N, Sheet 43. The 13-N Facility was a portable building brought to the site during construction of the N Area. It served as a storage area for pipe fitters working at 100-N and supported work activities related to reactor outages.
1510-N	Office	100	100-NR-1	18.29 x 7.32	Removed	1982	Not Recorded	The 1510-N (N-10) Crafts Lunchroom was a double-wide mobile office trailer building and used as a lunchroom for craft workers in the Kaiser Shop Area.
1512-N	Office	100	100-NR-1	18.29 x 7.32	Removed	1982	Not Recorded	The 1512-N (N-12) Facility was a mobile office trailer building and used to house offices/lunchroom for subcontractors.
1513-N	Storage	100	100-NR-1	18.29 x 7.32	Removed	1982	Not Recorded	The 1513-N Building was used for storing materials related to the 1519-N Pipefitters Shop. A 90-day hazardous waste storage pad was located on the north side of the building.
1514-N	Office	100	100-NR-1	18.3 x 7.3	Removed	1982	Not Recorded	The 1514-N (N-14) Facility was a mobile office trailer building. It was part of a cluster of subcontractor buildings, also known as the Kaiser Shop Area that consisted of a combination of office trailers and metal Butler style buildings. Most were placed at 100-N in 1982 in support of N Reactor upgrades. The 1514-N Building was used to house offices for subcontractors.
1515-N	Maintenance Shop	100	100-NR-1	24.38 x 14.63	Demolished	1982	2006	The 1515-N (N-15) Facility was used as a metal shop, where materials associated with fabricating small metal structures occurred. In addition to the shop floor, there were bathroom facilities and an ice house where containers of drinking water for site construction projects were prepared.
1516-N	Maintenance Shop	100	100-NR-1	6.1 x 11.28	Demolished	1982	2006	The 1516-N (N-16) Facility was a carpenters shop, where the normal activities and materials associated with fabricating small wooden structures occurred.
1517-N	Maintenance Shop	100	100-NR-1	10.97 x 12.5	Demolished	1982	2006	The 1517-N Facility was actually two buildings that shared a common wall. There was an attached storage structure constructed of scaffolding and plywood sheathing. An apparent drum pad was located to the south of this facility. To the north and west of this facility was an extensive area of discarded sand blasting grit. The facility was used for painting. At one time, one part of the facility was used to store respiratory protection equipment.
1518-N	Maintenance Shop	100	100-NR-1	6.4 x 12.5	Demolished	1982	2006	The 1518-N Building was apparently used in support of electricians and, at one time, the crushing of electric light bulbs.
1519-N	Maintenance Shop	100	100-NR-1	6.4 x 12.5	Demolished	1982	2006	This facility was apparently used in support of pipe fitters.
151-N	Electrical Substation	100	100-NR-1	17.07 x 13.11	Demolished	1963	2006	The 151-N was an electrical substation that converted 230-kV input, from the BPA power grid, to 13.8-kV output during initial startup and, as necessary, until the N Reactor could provide its own electrical power via the turbine-generator in the 184-N Powerhouse. The 13.8-kV supplied the "A" electrical bus for all 100-N Area facilities. Instruments and controls for operation and monitoring the substation and transformers were located within the 151-N Building.
1520-N	Storage	100	100-NR-1	18.29 x 3.66	Removed	1982	Not Recorded	The 1520-N Building was used as a storage area for electrical equipment used by the various subcontractors in the Kaiser Shop Area.
1521-N	Storage	100	100-NR-1	18.29 x 3.66	Removed	1982	Not Recorded	The 1521-N Building was a mobile office trailer, and was used as a storage building in the Kaiser Shop Area.
1522-N	Office	100	100-NR-1	18.29 x 3.66 x 0	Removed	1982	Not Recorded	The 1522-N Building was a mobile office trailer and was used as an office facility in the Kaiser Shop Area.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1523-N	Office	100	100-NR-1	18.29 x 3.66	Removed	1982	Not Recorded	The 1523-N Building was a mobile office trailer and was used to house offices and a lunchroom for workers in the Kaiser Shop Area.
1524-N	Storage	100	100-NR-1	24.38 x 24.38	Demolished	1985	2008	The 1524-N Facility was used to store drums and other containers of waste materials until 1989. During the 100-N Area deactivation period, it was used for the storage of radioactive materials including shipping casks and shielded containers.
1525-N	Storage	100	100-NR-1	18.29 x 12.19	Demolished	Not Recorded	2008	The 1525-N was a fenced laydown yard to prevent unauthorized removal of materials stored in the area. The facility was used for storing construction materials, and no contamination events are known to have occurred.
1526-N	Storage	100	100-NR-1	18.29 x 12.19	Removed	Not Recorded	Not Recorded	The 1526-N (N-26) Craft Shop was a single-wide mobile office (trailer) used by the crafts.
153-N	Electrical Substation	100	100-NR-1	24.08 x 17.07	Demolished	1963	2006	The 153-N Switch Gear Building was a rectangular, one-story, concrete-block structure with a basement and a flat concrete roof with gravel over four-ply built-up roofing. The 153-N Switch Gear Building was the location of the second source of plant power. The basement was primarily a cable spreading room.
155-N	Electrical Substation	100	100-NR-1	304.8 x 172.21	Active	1966	Not Recorded	The HGP produced electricity for the BPA grid using steam from the N Reactor operation. The 155-N Export Power Switchyard distributed the power to the grid. The 155-N Export Power Switchyard is a rectangular, fenced gravel area that contains a control house, a microwave tower, and a switchyard. The HGP operated from April 1966 to December 1986. As of August 2008, the Export Power Switchyard is still active.
1605-NE		100	100-NR-1	6 sq m	Inactive	1987	Not Recorded	The 1605-NE East Observation Post was an approximately 6 m ² (64 ft ²) pre-engineered, steel-framed structure with steel siding located on the roof of the 105-N Reactor Facility.
1614-N	Monitoring Station	100	100-NR-1	2.44 x 2.44	Demolished	Not Recorded	Not Recorded	The 1614-N Environmental Monitoring Station was a small concrete block building with a concrete floor and a flat wood roof with four-ply built-up roofing material. The footer for the building was 0.6 m (2 ft) below grade. No information could be found on type of monitoring equipment or processes in the facility.
163-N	Process Unit/Plant	100	100-NR-1	31.09 x 32.92	Demolished	1963	2007	The 163-N Demineralization Plant, completed in September 1963, was an L-shaped, one-story, highbay, metal frame building with a poured concrete foundation and corrugated metal exterior siding and flat roof. The 163-N Facility produced high-quality, demineralized makeup water for the 100-N Reactor. The 163-N Facility was deactivated in 1995 and demolished in 2007.
166-N	Storage	100	100-NR-1	66.3 sq m	Demolished	1964	2006	The 166-N Fuel Oil Storage Pump House was a reinforced-concrete support structure with a masonry fill-in on a poured concrete foundation. The building was one-story above ground and included a basement. A 5.3 million L (1.4 million gal) fuel oil storage tank and a rail tank car unloading/pumping station was part of the facility. The unloading station was a long, narrow concrete trench containing six tank car and two tank truck unloading stations. A waste oil collection system, designed to collect waste oil from diesel and fuel oil pumping operations plus waste from the diesel oil centrifuge, collected waste oil in a sump in the basement of 166-N Pump House. Waste oil was pumped to an at grade level, waste oil tank located to the south side of 166-N Pump House. A wastewater disposal system collected miscellaneous floor drains and steam condensate wastewater in a sump in 166-N Pump House basement. Wastewater was pumped to a drywell located approximately 2 m (6 ft) from the south wall of the building The drainage from hoses for railroad tank cars or truck unloading was to drywells located on the west side of the unloading stations. There were eight drywells, each composed of buried 76 cm (30 in) open-ended, concrete pipe designed to hold a 113 L (30 gal) drum. When filled, the drum could be removed and emptied.
1701-N	Office	100	100-NR-1	3.7 x 18.3	Demolished	1979	2006	The 1701-N (MO-992) 100-N Limited Access Area Badge House was a single-wide mobile trailer. The trailer was used by Hanford Patrol to control access to the 100-N Limited Access Area. More recently, it was used as a minor storage facility for fall protection equipment and poster board letters.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1701-NE	Office	100	100-NR-1	3.7x 6.1	Demolished	Not Recorded	Not Recorded	1701-NE was the gatehouse for entry into the Hanford Generating Plant, the area operated by the WPPSS.
1702-N	Office	100	100-NR-1	2.7 x 3.7	Removed	Not Recorded	Not Recorded	1702-N Vehicle Inspection Building controlled the vehicle gate into the 100-N Area Limited Access Area and was a weather shelter for guards inspecting vehicles entering the area.
1703-N	Office	100	100-NR-1	48.77 x 17.37	Demolished	Not Recorded	Not Recorded	The 1703-N was an irregular shaped, one-story, wood-framed building with a poured concrete foundation, plywood exterior wall surfaces, and a gable roof with an asphalt shingle surface. The 1703-N Building was moved to the 100-N Area to be used as storage and offices for 100-N security personnel (HPIF). The building was later used by WPPSS as an office building for engineering and other support personnel.
1705-N	Maintenance Shop	100	100-NR-1	39.93 x 6.1	Demolished	1963	2006	The 1705-N Facility was part of the original N Reactor complex to provide space for a variety of operations and support services including a module shop, communication shop, instrument shop, electrical shop, small appliance storage, document storage, conference room, and restrooms. The 1705-NA Facility was either part of the original N Reactor complex or was added about 1964, based on aerial photographs. It was originally used for maintenance work on motors and later as office space.
1706-N	Maintenance Shop	100	100-NR-1	1.52 x 2.74	Demolished	1984	2006	The 1706-N Building was constructed in 1984 to serve as a storage facility for the 100-N Area. Within a few years it was being used as an electrical motor repair shop. After deactivation and prior to demolition, the building was used for storage of a water truck and trailer for freeze protection. The 1706-NA included a cistern that was used to collect sewer wastes for pumping to a discharge basin. It was isolated in 2002.
1707-N	Storage	100	100-NR-1	12.19 x 5.49	Demolished	1984	2006	The 1707-N Patrol Boat House was used to house river patrol craft and associated marine equipment.
1712-N	Maintenance Shop	100	100-NR-1	6.1 x 12.19 x 6.1	Demolished	1962	2004	The 1712-N Insulation Shop was the primary work location for the 100-N Area insulators. The facility held equipment for shaping and cutting insulation for 100-N piping systems and equipment.
1714-N	Storage	100	100-NR-1	12.2 x 24.4	Demolished	1966	2004	The 1714-N Warehouse was initially used for warehousing small tools and parts used at 100-N. Later it was used to store radioactive materials.
1714-NA	Office	100	100-NR-1	24.4x 15.5	Demolished	1982	2004	The 1714-NA Receiving and Inspection Warehouse was constructed in 1982 to support the 100-N Area receiving and inspection activities. The building housed workstations for receiving and inspection functions.
1714-NB	Storage	100	100-NR-1	7.3 x 12.2	Demolished	1982	2004	The 1714-NB was constructed to provide space for small tools, parts, and equipment for daily use. It was later used for storage of radioactive materials.
1715-N	Storage Tank	100	100-NR-1	65.5x 22.56 x 2.44 9.1 dia. x 6.1 h	Demolished	1962	2006	The 1715-N DOS Tanks supplied diesel oil to the N Area DOS and IOS systems. The tanks were filled via the 166-N unloading station by transfer pumps located in the 166-N Pump House. The transfer pumps moved the oil to the storage tanks, 184-N Day Tank, or the 181-182-N Day Tank and transfer pumps.
1716-NA	Maintenance Shop	100	100-NR-1	1.83 x 1.83	Demolished	Not Recorded	1991	The 1716-NA Self-Service Gasoline Station provided 100-N Area vehicles with gasoline and diesel fuel. The two USTs associated with 1716-NA were 11,356 L (3,000 gal) and 7,571 L (2,000 gal) in size. Both tanks were removed in 1990 and 1991. One of the tanks leaked and soil beneath them was excavated to a depth of 11 m (36 ft) below grade, at which time approval to backfill the excavation was obtained.
1716-NE	Maintenance Shop	100	100-NR-1	10.67 x 17.68	Demolished	Not Recorded	2004	The 1716-NE Maintenance Garage was a one-story, pre-engineered, steel-framed structure with metal siding and flat metal roof, on poured concrete. The garage had four vehicle bays. The Maintenance Garage was used for vehicle maintenance. Floor drains in the facility led to a French drain, WIDS site 100-N-3 (SWMU #9). The garage was also a WIDS 100-N-78 (SWMU #8).

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1722-N	Maintenance Shop	100	100-NR-1	12.19 x 7.62	Inactive	1960s	Not Recorded	The 1722-N Decontamination - Hot Shop Building was a rectangular, pre-engineered, one-story, metal-framed structure with corrugated metal exterior wall and gable roof, on a reinforced-concrete slab. It was added to the 105-N Building in the late 1960s to expand the covered floor space for decontamination work near the fuel storage basin. Historic operations included decontamination of tools and equipment for reactor and fuel storage basin maintenance and as a type of airlock and loading dock between the reactor facility decontamination station and the outside areas west of the reactor building. The building was deactivated in 1998, is currently empty and will be demolished as part of the ISS work on the 105-N Reactor.
1723-N	Storage	100	100-NR-1	24.4 x 47	Demolished	1981	2006	The 1723-N Warehouse and 1723-NX Laydown Storage yard were used for material receiving, inspection, storage, and shipment in support of N Reactor operations. The warehouse was insulated, had HVAC and fire suppression systems. A 10 cm (4 in) drainline ran from 1723-N to the valve pit at the 1322-N Facility. Racks were used for storage of materials.
1723-NA	Change House	100	100-NR-1	3 x 14	Demolished	1980	2006	The 1723-NA (MO-913) Trailer was used as a change room (noncontaminated) and restroom for personnel working in the 100-N Area.
1723-NX	Storage	100	100-NR-1	10 x 46	Inactive	Not Recorded	Not Recorded	The 1723-NX Laydown Yard is a flat, gravel-covered, fenced area on the west and southwest sides of the 1723-N Warehouse. The 1723-NX was used as a laydown area. No stains or other signs of spills were observed.
1724-N	Process Unit/Plant	100	100-NR-1	11 x 12.8 17.7 x 12.8 3 x 4 x 2.4	Inactive	1988	Not Recorded	The DOE developed the N Reactor Safety Enhancement Program in response to the accident at Chernobyl in 1986. The hydrogen mitigation system utilized a combination of forced mixing, venting, and post-inerting with nitrogen. In addition to multiple fans and vents, nitrogen vapor would be pumped into the potentially dangerous areas, displacing the oxygen. Without sufficient levels of oxygen in a confined area, an explosion would not occur. 1724-N (Nitrogen Electrical Control) was intended to store and vaporize the nitrogen that would have been used in this system. The system was designed to lower the oxygen level in the confinement areas to less than 5 percent within 3 hours at the maximum flow rate (12,192 m ³ /min [40,000 ft ³ /min]). Construction began on the 1724-N Nitrogen Electrical Facility in 1988, but was halted when the N Reactor was shut down in 1989. The concrete for the nitrogen tanks, vaporizers, and the electrical vault had been poured. The two nitrogen tanks were delivered and set in place, but never filled, and were later excessed. Underground conduit and lines were laid. An underground vault for fuel oil tanks was never built. The facility was never energized.
1734-N	Storage	100	100-NR-1	18.29 x 6.4	Demolished	1963	1996	1734-N was completed on October 15, 1963, as part of the 100-N Area Construction Project. It was used as a storage area for compressed gas bottles, primarily nitrogen, oxygen, and helium (BHI-00221).
181-N	Pump Station	100	100-NR-1	18.3 x 3.7 x 3.7 2.1 x 3.6	Demolished	1963	2006	181-N River Water Pump House was designed to supply raw water for the 100-N Area. 181-NA provided housing and protection for security personnel to observe access to N-Area from the river side of the plant. 181-NB, #3 diesel was added to provide additional emergency pumping capacity. 181-NC was used to sample river water. It supported water treatment processes at the 100-N Area.
181-NE	Pump Station	100	100-NR-1	28.96 x 33.22 x 32.92	Inactive	Not Recorded	Not Recorded	The 181-NE HGP River Pumphouse provided water for the 185-N HGP. 181-NE included conventional trash racks, traveling screens, stop logs for individually isolating screen bays and pump bays, and high-pressure horizontal screen wash nozzles. Debris could be washed from the screens and returned to the river, along with wash water through a common trash trough. 181-NE also contained a diesel engine-powered pump and two backup electric-powered pumps that supplied the HGP fire protection system.
182-N	Pump Station	100	100-NR-1	32 x 31 9.1 x 6.1	Inactive	1963	Not Recorded	The 182-N Facility houses pumps for injecting demineralized water into primary and secondary cooling systems, as well as pumps for supplying makeup and cooling water to the moderator cooling systems located in the 105-N Reactor Building and 109-N Heat Exchanger Building. It also houses diesel emergency water pumps, potable water supply tank, fire supply system, and air compressors.
183-N	Process Unit/Plant	100	100-NR-1	20 x 10	Demolished	1963	2007	The 183-N Water Filter Plant housed equipment to provide filtered water to the 100-N Area. The process

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
				36.5 x 12.1 x 3.6 8.5 x 8.5				<p>consisted of pretreatment of the raw water with liquid alum in a chemical mix tank after which it flowed into a settling basin or coagulation basin. After passing through the coagulation basins, the water was filtered and collected in a clearwell, then distributed to the various systems and facilities. The building contained a service bay, a chemical treatment and pipe gallery bay, coagulators and filters, and a coagulator drive bay.</p> <p>The 183-NA is the Pumphouse.</p> <p>The 183-NB is the Clearwell. Several pumps and associated control equipment are mounted on top of the concrete surface.</p> <p>The 183-NC is the Filter Backwash Sump.</p>
184-N	Process Unit/Plant	100	100-NR-1	3.6 x 4.88	Inactive	1964	2008	<p>The 184-N Boiler and Auxiliaries provided process steam and electrical power for routine and emergency operations at the 100-N Area.</p> <p>The 184-NA contained two oil-fired burners that provided backup to the main boiler in 184-N.</p> <p>The 184-NB Air Handler Main Building conditioned air that supplied the boiler.</p> <p>The 184-NC Air Handler Annex conditioned air for the 184-NA Boilers.</p> <p>184-ND contained the fuel oil day tanks that supplied the oil burners in 184-N and 184-NA Buildings.</p> <p>The 184-NE and 184-NF were weather enclosures to protect equipment that supported the operation of 184-N.</p>
185-N	Process Unit/Plant	100	100-NR-1	33.53 x 9.14 x 10.97	Demolished	1962	2004	<p>Construction of the HGP was authorized by the Atomic Energy Commission in September of 1962 and it operated from 1966 until 1986. The facility housed two 430-MW, low-pressure turbine generators. Steam from the 100-N Reactor powered the HGP turbines before passing through the turbine condensers, where waste heat was transferred to the cooling water. The condensed steam was returned to 100-N Reactor for reuse. The condenser and auxiliary cooling systems were supplied with raw water from the Columbia River by the 181-NE HGP River Pumphouse. Cooling water was discharged to the Columbia River through the 1908-NE HGP Outfall Structure.</p> <p>Piping and equipment associated with the HGP steam and condensate systems became radioactively contaminated as a result of primary to secondary system leaks at the 100-N Reactor. Radionuclides of concern were Co-60, Cs137, and Sr-90.</p>
186-N	Process Unit/Plant	100	100-NR-1	4.88 x 12.19 x 5.18	Active	2000	Not Recorded	<p>The 186-N Potable Water Plant replaced the 163-N/183-N Facilities and was designed to supply the water for all domestic uses, such as tap water, field personnel drinking water, and sanitary use for bathrooms. After operations began, heavy concentration of particulates in the water caused disruptions in the process. A pre-filtration system, located in 1902-N, was added in 2002 to alleviate this problem.</p>
1900-N	Storage Tank	100	100-NR-1	15.2 dia. x 11 h 22.9 dia. x 9.8 h 19.8 dia. x 12.2 h 10.7 dia. x 10.7 h	Demolished	Not Recorded	2005	<p>The tanks were used to store, receive, and distribute water to the N Reactor and process systems.</p> <p>The AHR was designed as a reservoir of demineralized water for makeup to the secondary loop for normal operation and for flooding of the secondary loop in the water-to-water operation. It also served as storage for water spilled for level control of the secondary loop, water not needed in the secondary loop after the water-to-water operation, and condensate returns from various plant heaters.</p> <p>The DW Storage Tank was designed as a reservoir of effluent water from the demineralizer plant, and as the normal supply to the high- and low-pressure injection pumps. It also served as an emergency supply to the pumps of the afterheat removal fill system, the fog spray and fire protection pumping systems, the high lift emergency raw water pumping system, and the emergency raw water storage tank.</p> <p>The FW Storage Tank was designed for storage of filtered water pumped to it from the 183-N Building.</p> <p>The ERW Storage Tank was designed as a reservoir of tempered raw water for reactor emergency once-through cooling.</p> <p>The Silo was designed to supply raw water to the High Lift piping.</p>

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
1902-N	Process Unit/Plant	100	100-NR-1	4.88 deep	Active	Not Recorded	Not Recorded	The 1902-N Export Water Tie-In Building is a pre-engineered metal building sitting over the 1902-N81, a Fire Protection Valve House. Metal grating over the 1902-N81 Structure acts as the floor for 1902-N. Steel ladders accessed via trap doors in the floor grating of 1902-N provide access to the 1902-N81 Facility. 1902-N81 was constructed in the mid-1980s and ties into the main export water line that runs between the 100-B and 100-D Areas. The 1902-N Structure was added in the early 1990s. These buildings together supply the water for all domestic uses, such as tap water, field personnel drinking water, and sanitary use for bathrooms. After operations began, heavy concentration of particulates in the water caused disruptions in the process. A pre-filtration system, located in 1902-N, was added in 2002 to alleviate this problem.
1908-N BLDG	Outfall	100	100-NR-1	11.58 x 25.6 x 14.63	Inactive	Not Recorded	Not Recorded	The 1908-N Outfall Structure is a reinforced-concrete, box-shaped structure, extending several levels into the ground. Originally, cooling water from surface condensers, various heat exchangers, and other sources within 109-N and 105-N was discharged to a 168 cm (66 in) steel line, which discharged to seal well #1, also a part of the 1908-N Structure. Later, to comply with the Federal Water Pollution Control Act, the moderate temperature effluent was routed to seal well #2. Circulating raw water effluent from the 109-N Dump Condensers discharged into a 274 cm (108 in.) steel line, which discharged into the concrete seal well #2. The seal well maintained a natural siphon effect on the circulating water system, which enable the pumps at the 181-N River Pumphouse to deliver water at a lower head. From seal well #2, the effluent discharges to a 259 cm (102 in) outfall line to approximately the middle of the Columbia River.
1908-NE BLDG	Outfall	100	100-NR-1	23.47 x 32 x 14.33	Inactive	Not Recorded	Not Recorded	The 1908-NE HGP Outfall is a hexagonal-shaped, reinforced-concrete seal well with a pipeline extending out into the Columbia River. HGP condenser cooling water and wastewater from the 100-N-1 Settling Pond were fed into a 335 cm (132 in) diameter steel pipe that then discharged 304 m (1,000 ft) into the Columbia River. The 1908-NE does not have any structures on its operating deck except for a chain-link safety fence, some light stanchions, and an overhead bridge crane. The outfall operated from 1966 to 1988.
1909-N	Process Unit/Plant	100	100-NR-1	2.83 x 4.19 x 4.34	Inactive	Not Recorded	Not Recorded	The 1909-N Waste Disposal Valve Pit was a below grade, reinforced-concrete valve pit with a reinforced-concrete cover block for the radioactive drain system, which is included in WIDS site 100-N-63.
1926-N	Process Unit/Plant	100	100-NR-1	1.77 x 1.46 x 1.58	Inactive	Not Recorded	Not Recorded	The 1926-N Valve Pit was a below grade, reinforced-concrete structure. The 1926-N appears to have been a valve pit for directing chemical waste to the once planned, but never built Gable Mountain Crib. A 10.2 cm (4 in) chemical waste line from the 1310-N Silo ran to the valve pit where it was blanked off in the valve pit.
MO-374-N		100	100-NR-1		Removed	Not Recorded	Not Recorded	The MO-374 Facility was a single-wide mobile office facility. The MO-374 Facility had been removed from the 100-N Area by 1996 when it was in use in the 200 Area. It would later be used at the 100-D Area.
MO-383	Office	100	100-NR-1		Removed	1980s	Not Recorded	While in 100-N Area, MO-391 was used as a field support trailer at the 100 N Laydown Yard. The trailer had previously been located at the 100-F Area and was later located in the 300 Area.
MO-390-N		100	100-NR-1	3.1 x 9.8	Demolished	1987	2007	The MO-390 Trailer appears to have originally been located in the 200W Area near the 271-U Building during the mid-1990s, and was then relocated to the 100-B/C Area for the 105-C ISS project circa 1997. In 2000, the MO-390 trailer was brought to the 100-N Area (079928), where it remained until it was demolished in 2007. It was a single-wide trailer that measured 3.1 m by 9.8 m (10 ft by 32 ft).
MO-391-N	Office	100	100-NR-1	2.44 x 9.75	Removed	Not Recorded	Not Recorded	The MO-391 Facility was a single-wide mobile office facility. While in 100-N Area, MO-391 was used as a field support trailer at the 100-N Area Laydown Yard. The trailer had previously been located at the 100-F Area and was later located in the 300 Area.
MO-423-N	Laboratory	100	100-NR-1	2.44 x 9.75	Removed	Not Recorded	Not Recorded	The MO-423 Facility was a single-wide mobile office. It contained three rooms, one of which was equipped with a fume hood, work benches, air sample pump, grinder, and HEPA filtration system. The MO-423 served as a sample preparation and storage facility in support of the EAL. Two of the three rooms within the facility were designated as RMAs. In 1999, it was observed that significant quantities of project samples remained stored in MO-423.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
MO-544-N	Office	100	100-NR-1	2.44 x 9.75	Active	2005	Not Recorded	The MO-544 Facility was previously located in the 200-W Area in the mid-1990s, the 100-F Area in the late 1990s, and the 100-D Area in 2004 before it was relocated to the 100-N Area in 2005. It was a single-wide trailer building. The MO-544 Building was used as an RCT count room for the 107-N decommissioning project in the 100-N Area.
MO-545-N	Office	100	100-NR-1	2.44 x 9.75	Inactive	2005	Not Recorded	The MO-545 Building was a single-wide mobile office facility. It had previously been located in the 200-W Area and 100-F Area before being moved to the 100-N Area in 2005 and used as an office in support of D&D work.
MO-740	Office	100	100-NR-1	2.44 x 3.66	Removed	2004	Not Recorded	The MO-740 Facility was a small mobile office with no electrical power. The interior had gypsum board finish. The MO-740 Facility was used to control access to the 100-N Remediation site.
MO-765	Office	100	100-NR-1	2.44 x 3.66	Active	2004	Not Recorded	The MO-765 Facility was a single-wide trailer, used as office trailer in support of 100-NR-1 remediation activities. In 2006, the trailer was relocated to support D4 activities in the 100-N Area.
MO-767-N	Office	100	100-NR-1	3.66 x 17.07	Removed	2004	Not Recorded	The MO-767 Facility was a single-wide mobile office, installed in the 100-N Area in 2004. It functioned as a lunchroom trailer in support of the 116-N-1 Crib remediation project.
MO-768	Change House	100	100-NR-1	3.66 x 17.07	Unknown	Not Recorded	Not Recorded	MO-768 was a single-wide trailer, used as a change trailer in support of the 116-N Crib Remedial Action Project in the mid-2000s.
MO-801	Office	100	100-NR-1	3.66 x 17.07	Active	2007	Not Recorded	The MO-801 was a single-wide facility installed in 2007 to support the Asbestos Abatement and Hazardous Material Removal subcontract at the 100-N Area. It was used as a lunchroom trailer.
MO-802	Office	100	100-NR-1	3.66 x 17.07	Active	2007	Not Recorded	The MO-802 was a single-wide trailer, installed in 2007 to support the Asbestos Abatement and Hazardous Material Removal subcontract at the 100-N Area. It was used as an RCT trailer.
MO-803	Office	100	100-NR-1	3.66 x 17.07	Active	2007	Not Recorded	The MO-803 was a single-wide trailer, installed in 2007 to support the Asbestos Abatement and Hazardous Material Removal subcontract at the 100-N Area. It was used as a subcontractor trailer.
MO-804	Office	100	100-NR-1	3.66 x 17.07	Active	2007	Not Recorded	The MO-804 was a single-wide trailer, installed in 2007 to support the Asbestos Abatement and Hazardous Material Removal subcontract at the 100-N Area. It was used as an RCT trailer.
MO-805	Office	100	100-NR-1	3.66 x 17.07	Active	2007	Not Recorded	The MO-805 was a single-wide trailer, installed in 2007 to support the Asbestos Abatement and Hazardous Material Removal subcontract at the 100-N Area.
MO-806	Office	100	100-NR-1	312.2 sq m	Active	Not Recorded	Not Recorded	The MO-806 Facility was a four-wide trailer, installed in 2007 to house offices for WCH personnel in the 100-N Area.
MO-807	Office	100	100-NR-1	166.5 sq m	Active	2007	Not Recorded	The MO-807 Facility was installed in 2007 to house offices for WCH personnel in the 100-N Area.
MO-808	Office	100	100-NR-1		Active	2007	Not Recorded	The MO-808 Facility was installed in 2007 to house offices for WCH personnel in the 100-N Area. It was a four-wide trailer.
MO-827-N	Office	100	100-NR-1	7.32 x 18.29	Removed	Not Recorded	Not Recorded	The MO-827 was a double-wide mobile office trailer, installed in the 100-N Area in 2004 to serve as a conference room and office facility.
MO-846	Office	100	100-NR-1	7.32 x 18.29	Removed	1997	Not Recorded	The MO-846 Facility provided office space for personnel in the 100-N Area. Previously, it had been located in 300 Area. It was a double-wide modular office trailer.
MO-864	Change House	100	100-NR-1	3.66 x 17.07	Inactive	Not Recorded	Not Recorded	The MO-864 Facility served as a mask and change trailer for personnel working in the 100-N Area.
MO-865	Office	100	100-NR-1	3.66 x 17.07	Active	Not Recorded	Not Recorded	MO-865 Facility is a single-wide trailer and used as a mask trailer.
MO-866	Office	100	100-NR-1		Active	Not Recorded	Not Recorded	The MO-866 Facility is currently the laundry trailer. Earlier it served as a craft lunchroom trailer for personnel working in the 100-N Area.
MO-868	Change House	100	100-NR-1	3.66 x 17.07	Inactive	Not Recorded	Not Recorded	The MO-868 Facility served as a change trailer for personnel working in the 100-N Area.

Table D-1. Summary of 100-N Area Decision Unit Facilities

Facility Code	Facility Type	Area	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/ Cocooned Date	Facility Description
MO-870	Office	100	100-NR-1	3.66 x 17.07	Active	Not Recorded	Not Recorded	The MO-870 Building was a single-wide trailer, served as a RCF in the 100-N Area. It was used to count and identify radioactive samples from WCH projects.
MO-950	Office	100	100-NR-1	46.5 sq m	Demolished	Not Recorded	2007	The MO-950 was a single-wide mobile office trailer and used as office space at the 100-N Laydown Yard.
MO-957	Office	100	100-NR-1	3.66 x 17.07	Removed	Not Recorded	Not Recorded	MO-957 was a small mobile office and used to support construction activities at the 100-N Area.
MO-999-N	Office	100	100-NR-1	3.66 x 17.07	Inactive	Not Recorded	Not Recorded	The MO-999 Facility was a single-wide trailer. It had previously been located in the 100-D Area. It was moved to the 100-N and used as office space. One section of the facility was used as roman RCT and was posted as an RBA. Currently, MO-999 is identified as an RCT Office.

BPA = Bonneville Power Administration
 CFR = Code of Federal Regulations
 CMS = corrective measures study
 CMS/CP = corrective measures study Central Plateau
 COC = contaminant of concern
 CVP = closeout verification package
 DOE-RL U.S. = Department of Energy Richland Office
 EDT = emergency dump tank
 EP = electroplated
 CERCLA ROD = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* Record of Decision
 ERDF = Environmental Restoration Disposal Facility
 HGP = Hanford Generating Project
 LERF = Liquid Effluent Retention Facility

LWDF = Liquid Waste Disposal Facility
 N/A = not applicable
 OU = Operable Unit
 PCB = polychlorinated biphenyl
 PNL = Pacific Northwest Laboratory
 RI/CMS = remedial investigation/ corrective measures study
 SWMU = solid waste management unit
 TCLP = toxicity characteristic leaching procedure
 TPH = total petroleum hydrocarbon
 TSD = treatment, storage, and/or disposal
 UCL = upper confidence limit
 UPR = unplanned release
 UST = underground storage tank

Sampling and Analysis Plan for the 100-N Decision Unit Remedial Investigation/Feasibility Study

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



U.S. DEPARTMENT OF
ENERGY

Richland Operations
Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

Sampling and Analysis Plan for the 100-N Decision Unit Remedial Investigation/Feasibility Study

Date Published
November 2009

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



U.S. DEPARTMENT OF
ENERGY

Richland Operations
Office

P.O. Box 550
Richland, Washington 99352

J. D. Randal 12/10/2009
Release Approval Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

Contents

1			
2	1	Introduction	1-1
3		1.1 Vadose Zone Characterization	1-4
4		1.2 Groundwater Characterization	1-4
5		1.3 Target Analytes and Contaminants of Potential Concern	1-4
6		1.3.1 Soil/Aquifer Sediment	1-4
7		1.3.2 Groundwater	1-6
8		1.4 Data Needs	1-7
9		1.5 Sampling Design	1-7
10		1.6 Project Schedule	1-7
11	2	Quality Assurance Project Plan	2-1
12		2.1 Project Management	2-2
13		2.1.1 Project and Task Organization	2-2
14		2.1.2 Problem Definition and Background	2-4
15		2.1.3 Project and Task Description	2-4
16		2.1.4 Quality Objectives and Criteria	2-4
17		2.1.5 Special Training/Certification	2-26
18		2.1.6 Documents and Records	2-27
19		2.2 Data Generation and Acquisition	2-28
20		2.2.1 Sampling Process Design (Experimental Design)	2-28
21		2.2.2 Sampling Methods	2-29
22		2.2.3 Sample Handling and Custody	2-29
23		2.2.4 Analytical Methods	2-29
24		2.2.5 Quality Control	2-30
25		2.2.6 Instrument and Equipment Testing, Inspection, and Maintenance	2-33
26		2.2.7 Instrument and Equipment Calibration and Frequency	2-33
27		2.2.8 Inspection and Acceptance of Supplies and Consumables	2-34
28		2.2.9 Non-direct Measurements	2-34
29		2.2.10 Data Management	2-34
30		2.3 Assessment and Oversight	2-35
31		2.3.1 Assessments and Response Actions	2-35
32		2.3.2 Reports to Management	2-35
33		2.4 Data Validation and Usability	2-35
34		2.4.1 Data Review, Verification, and Validation	2-36
35		2.4.2 Verification and Validation Methods	2-36
36		2.4.3 Reconciliation with User Requirements	2-36
37		2.4.4 Corrective Actions	2-37

1	3	Field Sampling Plan	3-1
2		3.1 Site Background and Objectives	3-1
3		3.2 Documentation of Field Activities	3-1
4		3.3 Sampling Design	3-1
5		3.4 Calibration of Field Equipment	3-1
6		3.5 Sample Location and Frequency	3-2
7		3.5.1 Vadose Zone Characterization	3-2
8		3.5.2 Groundwater Characterization	3-9
9		3.6 Sampling Methods.....	3-13
10		3.6.1 Corrective Actions and Deviations for Sampling Activities.....	3-13
11		3.6.2 Decontamination of Sampling and Drilling Equipment.....	3-14
12		3.6.3 Radiological Field Data	3-14
13		3.7 Sample Handling	3-15
14		3.7.1 Sample Packaging	3-15
15		3.7.2 Container Labeling.....	3-17
16		3.7.3 Sample Custody Requirements	3-17
17		3.7.4 Sample Transportation.....	3-18
18		3.8 Management of Waste.....	3-18
19	4	Health and Safety	4-1
20	5	References	5-1

21

Figures

1
2 Figure 1-1. 100-N Decision Unit Planned and Existing Sampling Locations 1-2
3 Figure 1-2. 100-N Decision Unit Spatial and Temporal Uncertainty Monitoring Well Locations..... 1-3
4 Figure 2-1. Project Organization.....2-2
5

Tables

6
7 Table 1-1. Plan Activities and Data Needs 1-1
8 Table 1-2. Master 100-N Soil/Aquifer Sediment Target Analytes 1-4
9 Table 1-3. Groundwater Contaminants of Potential Concern..... 1-6
10 Table 2-1. Data Quality Indicators.....2-6
11 Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 12-9
12 Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 42-14
13 Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from
14 Wells R1 and R22-17
15 Table 2-5. Analytical Performance Requirements for Water Samples2-21
16 Table 2-6. Change Control for the 100-N Decision Unit Project2-27
17 Table 2-7. Project QC Checks2-30
18 Table 3-1. Sample/Measurement Locations and Depth3-4
19 Table 3-2. Spatial and Temporal Uncertainty Groundwater Monitoring Well Network3-9
20 Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples3-15
21 Table 3-4. Sample Preservation, Container, and Holding Time for Water Samples3-16

1

2

3

This page intentionally left blank.

Terms

ALARA	as low as reasonably achievable
ASTM	American Society for Testing and Materials
CFR	<i>Code of Federal Regulations</i>
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
DQA	data quality assessment
DQO	data quality objectives
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EQL	estimated quantitation limit
FS	feasibility study
HASQARD	<i>Hanford Analytical Services Quality Assurance Requirements Document</i>
HEIS	Hanford Environmental Information System database
ICP	inductively coupled plasma
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
SAP	sampling and analysis plan
TPH	total petroleum hydrocarbon
Tri-Party Agreement	Ecology et al., 1989a, <i>Hanford Federal Facility Agreement and Consent Order</i>
VOC	volatile organic compound
WAC	<i>Washington Administrative Code</i>

2

3

1

This page intentionally left blank.

1 Introduction

2 This sampling and analysis plan (SAP) supports the remedial investigation (RI)/feasibility study (FS)
 3 process for the 100-N Decision Unit. The 100-N Decision Unit is located on the Hanford Site in
 4 southeastern Washington State and is associated with one source operable unit, 100-NR-1. The 100-NR-2
 5 Groundwater operable unit underlies this source operable unit. This SAP describes the sampling and
 6 analysis to be performed associated with groundwater monitoring wells. Figure 1-1 shows the location of
 7 the planned groundwater monitoring wells within the scope of this SAP. Figure 1-2 shows the spatial and
 8 temporal uncertainty groundwater monitoring well network within the scope of this SAP. Chapter 2 of
 9 the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 5: 100-N*
 10 *Decision Unit* (DOE/RL-2008-46-ADD5) (Addendum 5) describes the site background and
 11 environmental setting of the 100-N Decision Unit. Table 1-1 presents the intersection of data needs
 12 discussed in Addendum 5 and sampling and analysis activities.

Table 1-1. Plan Activities and Data Needs

Planned Activity	100-N Area		
	Quantity	Location	Data Needs No.
New wells to characterize deep vadose zone and unconfined aquifer*	2	Well 1 Well 2	2, 5, 10
New wells to characterize deep vadose zone, unconfined aquifer, Ringold Upper Mud, and Ringold Unit B*	2	Well R1 Well R2	7, 9
Sample spatial and temporal uncertainty groundwater monitoring wells	18 existing locations		5, 13

NOTE: This sampling and analysis plan is in addition to other planned activities.

*Boreholes and groundwater monitoring wells will be logged with a neutron moisture tool and the high-resolution, spectral gamma ray logging system. Geologic samples also will be logged.

1-2

1

2

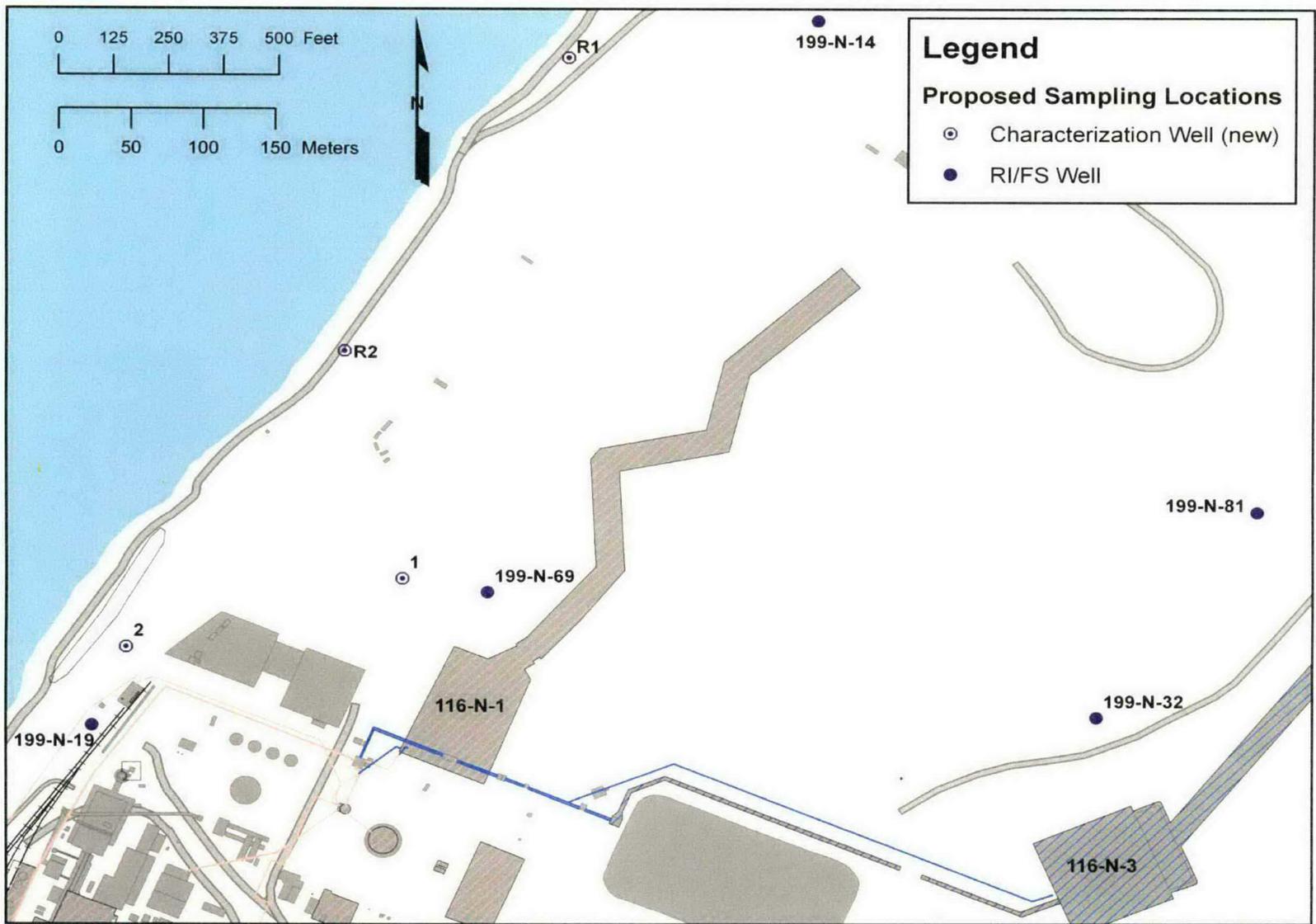
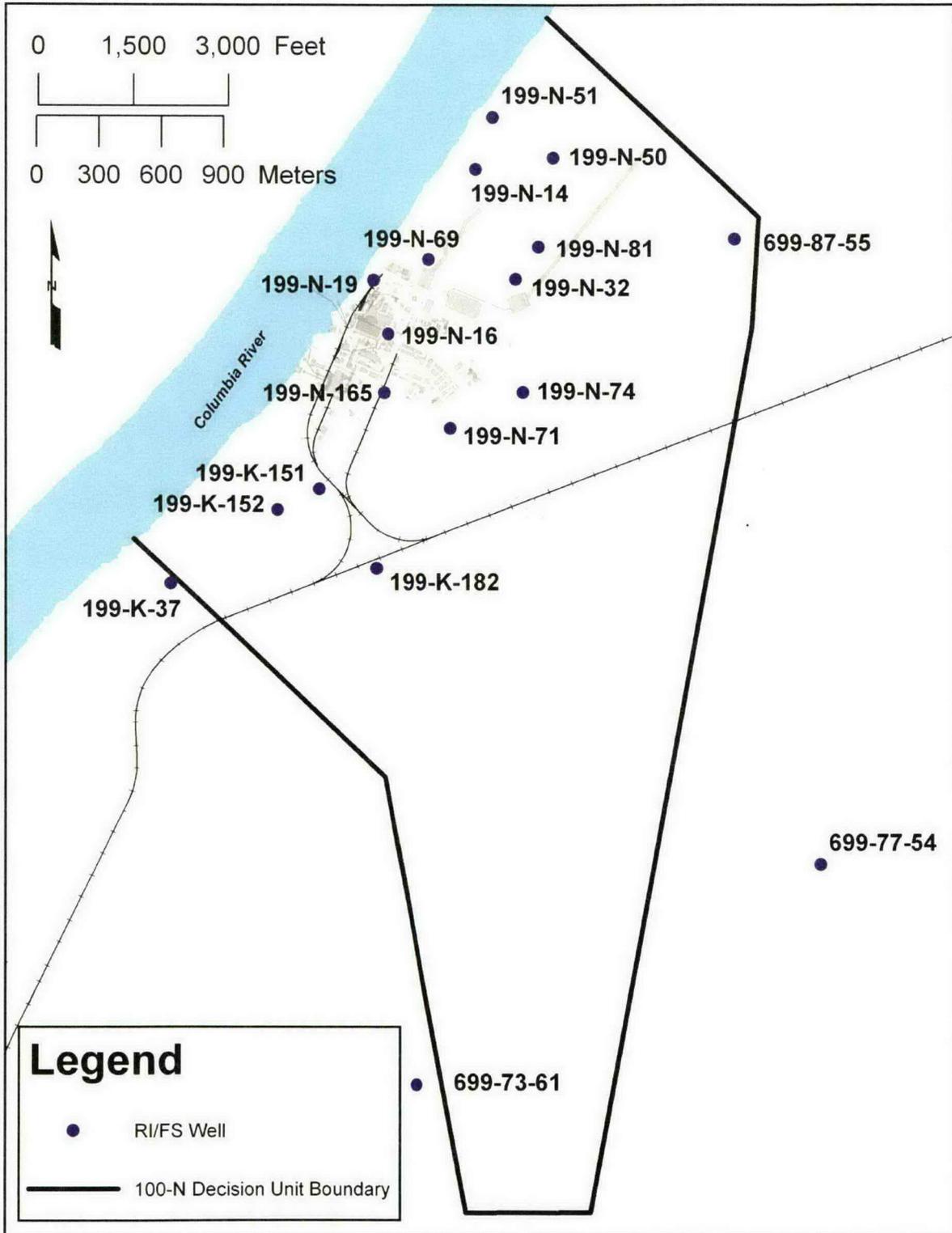


Figure 1-1. 100-N Decision Unit Planned and Existing Sampling Locations



1
2

Figure 1-2. 100-N Decision Unit Spatial and Temporal Uncertainty Monitoring Well Locations

1 **1.1 Vadose Zone Characterization**

2 This SAP describes activities planned to characterize the vadose zone and deep vadose zone at areas
3 within the decision unit. Vadose zone samples will be collected during installation of two monitoring
4 wells, one adjacent to and downgradient of 116-N-1 Crib and Trench and one adjacent to well 119-N-18.
5 Deep vadose zone soil samples will be collected during drilling of two additional groundwater wells
6 installed as part of the 100-N Decision Unit RI. Samples will be collected and analyzed to evaluate the
7 nature and extent of contamination.

8 **1.2 Groundwater Characterization**

9 Groundwater samples will be collected and analyzed from new and existing groundwater monitoring
10 wells to define the extent of contamination and to support evaluation of contaminant transport.
11 Groundwater sampling from completed groundwater wells will be performed in accordance with the field
12 sampling, sample handling, and documentation activities requirements in DOE/RL-96-98, *Hanford*
13 *Analytical Services Quality Assurance Requirements Document* (HASQARD). Where possible, new well
14 locations have been selected to satisfy multiple project data needs, such as delineating vadose zone and
15 groundwater contamination.

16 **1.3 Target Analytes and Contaminants of Potential Concern**

17 Method based analysis addresses the suites of analytical methods that will yield results for the target
18 analytes or contaminants of potential concern (COPCs). As shown in the Appendix A tables, multi-
19 constituent methods include related analytes in addition to the COPCs (Table 1-3) and target analytes
20 (Table 1-2).. Method based and, where applicable, single component analyses, will be performed in
21 accordance with Tables 2-2 through 2-5 for chemical soil/aquifer sediment and water samples analyzed
22 for this decision unit.

23 Results for all methods used will be reported in the Hanford Environmental Information System (HEIS)
24 database. The tables in the appendix have been provided to define the analytes which will be reported
25 when using a method based analysis approach. In addition, tentatively identified compounds will be
26 reported for Method SW-846 8260.

27 **1.3.1 Soil/Aquifer Sediment**

28 Table 1-2 presents the soil/aquifer sediment master list of target analytes. Process knowledge and
29 existing data were used for compilation of the target analyte list. The master list is a compilation of target
30 analytes for the entire 100-N Decision Unit as determined through review of historic and current
31 remediation and characterization documents and data. The list includes the target analytes identified for
32 sites proposed for characterization under this SAP. Analytical methods and references for determination
33 of the analytes are shown in Tables 2-2 through 2-4.

Table 1-2. Master 100-N Soil/Aquifer Sediment Target Analytes

Radionuclides	Nonradionuclides		
Americium-241	1,1,1-Trichloroethane	Aroclor-1248 (PCB)	Endrin Aldehyde
Carbon-14	1,2,4-Trichlorobenzene	Aroclor-1254 (PCB)	Fluoranthene
Cesium-137	1,2-Dichlorobenzene	Aroclor-1260 (PCB)	Fluorene
Cobalt-60	1,3-Dichlorobenzene	Arsenic	Fluoride
Curium-243	1,4-Dichlorobenzene	Asbestos	gamma- BHC (Lindane)

Table 1-2. Master 100-N Soil/Aquifer Sediment Target Analytes

Radionuclides	Nonradionuclides		
Europium-152	2,4,5-TP (Silvex)	Barium	Heptachlor
Europium-154	2,4,5-Trichlorophenol	Benzene	Heptachlor epoxide
Europium-155	2,4,5-Trichlorophenoxyacetic acid	Benzo(a)anthracene	Hexachlorobenzene
Iodine-129	2,4,6-Trichlorophenol	Benzo(a)pyrene	Hexachlorobutadiene
Neptunium-237	2,4-DB	Benzo(b)fluoranthene	Hexachlorocyclopentadiene
Nickel-63	2,4-Dichlorophenol	Benzo(ghi)perylene	Hexachloroethane
Niobium-94	2,4-Dichlorophenoxyacetic acid	Benzo(k)fluoranthene	Hexavalent Chromium
Plutonium-238	2,4-Dimethylphenol	Beryllium	Indeno(1,2,3-cd)pyrene
Plutonium-239/240	2,4-Dinitrophenol	beta- BHC	Isophorone
Silver-108m	2,4-Dinitrotoluene	Bis(2-chloro-1-methylethyl) ether	Lead
Strontium-90	2,6-Dinitrotoluene	Bis(2-chloroethoxy)methane	Lithium
Technetium-99	2-Butanone	Boron	Manganese
Tritium	2-Chloronaphthalene	Butylbenzylphthalate	Mercury
Uranium-233/234	2-Chlorophenol	Cadmium	Methoxychlor
Uranium-235	2-Methylnaphthalene	Carbazole	Molybdenum
Uranium-238	2-Methylphenol (o-cresol)	Carbon Disulfide	Naphthalene
	2-Nitroaniline	Carbon Tetrachloride	Nickel
	2-Nitrophenol	Chlordane	Nitrate (as N)
	3,3'-Dichlorobenzidene	Chloroform	Nitrite (as N)
	3-Nitroaniline	Chromium (total)	Nitrobenzene
	4,4'-DDD	Chrysene	N-Nitroso-di-n-propylamine
	4,4'-DDE	Cobalt	N-Nitrosodiphenylamine
	4,4'-DDT	Copper	Pentachlorophenol
	4,6-Di-nitro-2-methylphenol	Cyanide	Phenanthrene
	4-Bromophenylphenyl ether	Dalapon	Pyrene
	4-Chloro-3-methylpheno	delta- BHC	Selenium
	4-Chloroanilene	Dibenz[a,h]anthracene	Silver
	4-Chlorophenylphenyl ether	Dibenzofuran	Sulfate
	4-Methylphenol (p-cresol)	Dicamba	Tetrachloroethene
	4-Nitroaniline	Dichloroprop	Thallium

Table 1-2. Master 100-N Soil/Aquifer Sediment Target Analytes

Radionuclides	Nonradionuclides		
	4-Nitrophenol	Dieldrin	Toluene
	Acenaphthene	Diethylphthalate	Toxaphene
	Aldrin	Dimethylphthalate	Total petroleum hydrocarbons-diesel range
	alpha- BHC	Di-n-butylphthalate	
	Aluminum	Di-n-octylphthalate	Total petroleum hydrocarbons-gasoline range
	Anthracene	Dinoseb (DNBP)	
	Antimony	Endosulfan I	Tributyl Phosphate
	Aroclor-1016 (PCB)	Endosulfan II	Trichloroethene
	Aroclor-1221 (PCB)	Endosulfan Sulfate	Vanadium
	Aroclor-1232 (PCB)	Endrin	Vinyl chloride
	Aroclor-1242 (PCB)	Endrin Ketone	Zinc

1 **1.3.2 Groundwater**

2 Table 1-3 presents the 100-N Area groundwater COPCs. Chapter 4 of the work plan presents the
3 approach used for development of the COPCs.

Table 1-3. Groundwater Contaminants of Potential Concern

Radionuclides	Nonradionuclides	
Cobalt-60	1,4-Dichlorobenzene	Heptachlor epoxide
Strontium-90	4,4-DDD	Hexavalent Chromium
Tritium	4,4-DDT	Lead
	Aldrin	Manganese
	alpha-BHC	Mercury
	Antimony	Methoxychlor
	Arsenic	Nickel
	Benzene	Nitrate (as N)
	Cadmium	Nitrite (as N)
	Carbon Tetrachloride	Selenium
	Chlordane	Sulfate
	Chloroform	Tetrachloroethene
	Chromium	Thallium
	Cobalt	Total petroleum hydrocarbons-diesel range
	Copper	Total petroleum hydrocarbons-gasoline range

Table 1-3. Groundwater Contaminants of Potential Concern

Radionuclides	Nonradionuclides	
	Cyanide	Trichloroethene
	Dieldrin	Vanadium
	Endrin	Vinyl Chloride
	Fluoride	Zinc
	Heptachlor	

1 **1.4 Data Needs**

2 The *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2008-46) (work
 3 plan) and Addendum 5 cover the systematic planning process and its outcome. Chapter 1 of the work
 4 plan describes the systematic planning process used to identify 100-N Decision Unit problem statements
 5 and data gaps. Chapter 4 of Addendum 5 discusses the identified data needs resulting from the systematic
 6 planning process.

7 **1.5 Sampling Design**

8 The type of sampling design is judgmental sampling (e.g., based on prior knowledge and professional
 9 judgment and expertise). Locations for groundwater monitoring were defined to address the uncertainties
 10 and data needs identified during systematic planning. Figure 1-1 shows the location of the planned
 11 groundwater monitoring wells described in this SAP. Figure 1-2 shows the spatial and temporal
 12 uncertainty groundwater monitoring well network described in this SAP. Tables 2-2 through 2-5 present
 13 the analytical methods selected to meet the estimated quantitation limits (EQLs) and the analytical
 14 performance requirements.

15 **1.6 Project Schedule**

16 The 100-N Decision Unit RI field efforts are planned to occur between December 2009 and June 2010.
 17 The drilling lead will prepare the relative groundwater well schedule for new installations. Samples for a
 18 spatial and temporal uncertainty sample round, or event, will be collected from each seasonal "high,"
 19 low," and mid-point" water levels, for a total of three samples per well. Each round of monitoring in the
 20 network of wells for this decision unit will be completed within 30 consecutive calendar days to minimize
 21 statistical variability in water levels. The RI report will document the results provided by sampling and
 22 analysis in this plan.

23

1

2

3

This page intentionally left blank.

2 Quality Assurance Project Plan

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis. This QAPjP complies with the requirements of the following:

- DOE/RL-96-98, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD)
- DOE O 414.1C, *Quality Assurance*
- 10 CFR 830, Subpart A, "Quality Assurance Requirements"
- EPA/240/B-01/003, EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5.

Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b) require that quality assurance (QA)/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal units, as well as past-practice processes. Therefore, this QAPjP follows the QA elements of EPA/240/B-01/003. The QAPjP demonstrates conformance to Part B requirements of ANSI/ASQC E4-2004, *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use*.

In addition to the requirements cited above, the following reference also was used as a resource for identifying QAPjP elements:

- EPA-505-B-04-900A, *Intergovernmental Data Quality Task Force, Uniform Federal Policy for Quality Assurance Project Plans, Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs, Part 1: UFP-QAPP Manual*.

EPA-505-B-04-900A is not imposed through the Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). However, EPA-505-B-04-900A is a valuable resource and provides a comprehensive treatment of quality elements that should be addressed in any SAP. EPA-505-B-04-900A also was designed to be compatible with EPA/240/B-01/003, which forms the basis for this QAPjP.

The QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to this investigation.

Section 2.1 Project Management – This section addresses project management, including project history and objectives, roles, and responsibilities of the participants. These elements ensure the project has a defined goal, participants understand the goal and the approach to be used, and planning outputs are documented.

Section 2.2 Data Generation and Acquisition – This section addresses aspects of project design and implementation. Implementing these elements ensures appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and are properly documented.

Section 2.3 Assessment and Oversight – This section addresses the activities for assessing the effectiveness of implementing the project and associated QA and QC activities. The purpose of assessment is to ensure the QAPjP is implemented as prescribed.

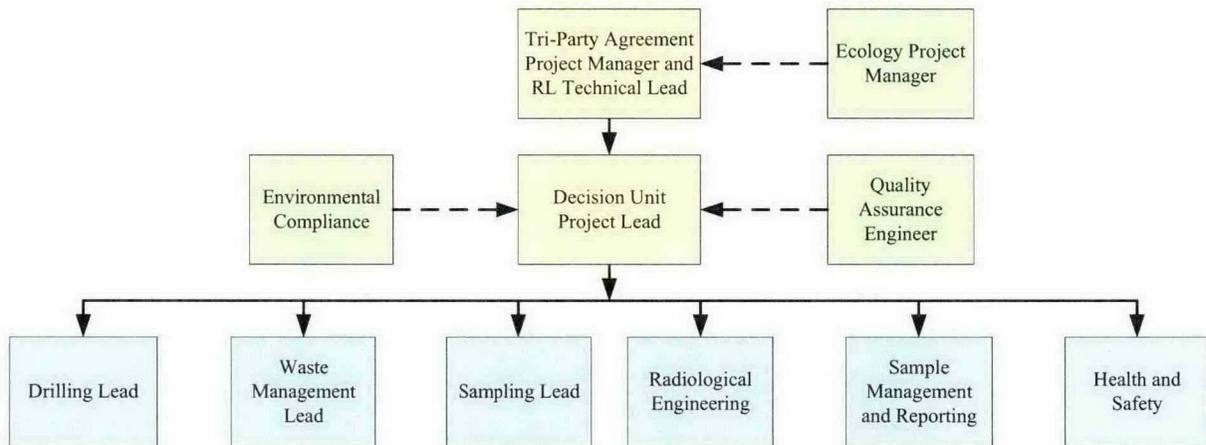
Section 2.4 Data Validation and Usability – This section addresses the QA activities occurring after the data collection or generation phase of the project is completed. Implementing these elements ensures data conform to the specified criteria, thus achieving the project objectives.

2.1 Project Management

The following sections address the basic aspects of project management, ensuring that the project has defined goals, the project team understands the goals and approaches used, and the planned outputs are appropriately documented. Project management roles and responsibilities discussed in this section apply to the major activities covered under the SAP.

2.1.1 Project and Task Organization

The Plateau Remediation Contractor and River Corridor Contractor, or its approved subcontractor, are responsible for planning, coordinating, sampling, preparing, packaging, and shipping samples to the laboratory. The following sections describe the project organization concerning sampling and characterization, also shown in Figure 2-1. The project lead maintains a list of individuals or organizations as points of contact for each functional element in the figure. For each functional primary contractor role, a corresponding oversight role exists within the U.S. Department of Energy (DOE).



Ecology = Washington State Department of Ecology
 RL = U.S. Department of Energy, Richland Operations Office
 Tri-Party Agreement = Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*

Figure 2-1. Project Organization

Ecology Project Manager. The Washington State Department of Ecology (Ecology) has assigned project managers responsible for overseeing the cleanup projects and activities. Ecology has approval authority as the lead regulatory agency for the work being performed under this SAP. Ecology will work with the U.S. Department of Energy, Richland Operations Office (RL) to resolve concerns over the work as described in this SAP in accordance with the Tri-Party Agreement (Ecology et al., 1989a).

Tri-Party Agreement Project Manager and RL Technical Lead. The Tri-Party Agreement Project Manager is responsible for authorizing RI/FS activities for the 100 Area decision units. The Tri-Party Agreement Project Manager also is responsible for obtaining lead regulatory approval of the work plan and SAP that authorize the RI/FS activities under the Tri-Party Agreement. The RL technical lead is responsible for overseeing the contractor in performing the work scope, working with the contractor and the regulatory agencies to identify and work through issues, and providing technical input to the Tri-Party Agreement Project Manager.

Environmental Compliance. The environmental compliance officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work and develops appropriate

1 mitigation measures with a goal of minimizing adverse environmental impacts. The environmental
2 compliance officer also reviews plans, procedures, and technical documents to ensure that environmental
3 requirements have been addressed; identifies environmental issues affecting operations and develops cost-
4 effective solutions; and responds to environmental/regulatory issues or concerns raised by RL and/or the
5 regulatory agencies. The environmental compliance officer also may oversee project implementation for
6 compliance with applicable internal and external environmental requirements.

7 **Decision Unit Project Lead.** The project lead is responsible for directly managing sampling documents
8 and requirements, field activities, subcontracted tasks, and for ensuring the project file is properly
9 maintained. The project lead ensures that the sampling design requirements are converted into field
10 instructions (e.g., work packages) providing specific direction for field activities. The project lead works
11 closely with QA, Health and Safety, the drilling lead, and the sampling lead to integrate these and other
12 lead disciplines in planning and implementing the work scope. The project lead maintains a list of
13 individuals or organizations filling each of the functional elements of the project organization
14 (Figure 2-1). In addition, the project lead is responsible for version control of the SAP to ensure that
15 personnel are working to the most current job requirements. The project lead also coordinates with RL
16 and the primary contractor management on sampling activities. The project lead supports RL in
17 coordinating sampling activities with the regulators.

18 **Quality Assurance Engineer.** The QA point of contact is matrixed to the project lead and is responsible
19 for QA issues on the project. Responsibilities include overseeing implementation of the project QA
20 requirements; reviewing project documents, including data needs summary reports, SAPs, and the
21 QAPjP; and participating in QA assessments of sample collection and analysis activities, as appropriate.
22 The QA point of contact must be independent of the unit generating the data.

23 **Drilling Lead.** The drilling lead has overall responsibility for planning, coordinating, and executing
24 drilling activities. Specific responsibilities include coordinating with the geological and drilling
25 contractors. The drilling lead also communicates with the decision unit project lead designee to identify
26 field constraints or emergent conditions affecting sampling design or execution, and directs the
27 procurement and installation of materials and equipment needed to support fieldwork.

28 **Waste Management Lead (Waste Coordinator).** The waste management lead communicates policies
29 and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in
30 a safe and cost-effective manner. In addition, Waste Management is responsible for identifying waste
31 management sampling and characterization requirements to ensure regulatory compliance, interpreting
32 the characterization data to generate waste designations and profiles, and preparing and maintaining other
33 documents that confirm compliance with waste acceptance criteria.

34 **Sampling Lead.** The sampling lead has overall responsibility for planning, coordinating, and executing
35 sampling activities. Specific responsibilities include converting the sampling design requirements into
36 field task instructions providing specific direction for field activities, as well as directing training,
37 mock-ups, and practice sessions with field personnel to ensure the sampling design is understood and can
38 be performed as specified. The sampling lead also communicates with the decision unit project lead
39 designee to identify field constraints or emergent conditions affecting sampling design or execution,
40 directs the procurement and installation of materials and equipment needed to support fieldwork, and
41 prepares data packages based on instructions from the project lead designee and information contained in
42 this SAP. The shipping lead reports to the sampling lead for shipment authorization. No sample material
43 will be transported on or off the Hanford Site without permission from an authorized shipper or designee.

44 **Radiological Engineering.** The Radiological Engineering lead is responsible for the radiological/health
45 physics support within the project. Specific responsibilities include conducting as low as reasonably

1 achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for
2 work planning. In addition, the Radiological Engineering lead identifies radiological hazards and
3 implements appropriate controls to maintain worker exposures ALARA (e.g., requiring personal
4 protective equipment). The Radiological Engineering lead also interfaces with the project Health and
5 Safety contact, and plans and directs radiological control technician support for activities.

6 **Sample Management and Reporting.** Sample Management and Reporting coordinates laboratory
7 analytical work, ensuring the laboratories conform to Hanford Site internal laboratory QA requirements,
8 or their equivalent, as approved by DOE, the U.S. Environmental Protection Agency (EPA), and Ecology.
9 Sample Management and Reporting receives analytical data from the laboratories, performs data entry
10 into HEIS, and arranges for data validation. Sample Management and Reporting is responsible for
11 informing the project lead of any issues reported by the analytical laboratory. Sample Management and
12 Reporting develops and oversees the implementation of the letter of instruction to the analytical
13 laboratories, oversees data validation, and works with the project lead to prepare a characterization report
14 on the sampling and analysis results.

15 The Sample Management and Reporting organization is also responsible for performing the data needs
16 process, or equivalent. Additional related responsibilities include developing the SAP, including
17 documenting the data needs and the sampling design, preparing associated presentations, resolving
18 technical issues, and preparing revisions to the SAP. Samples collected in the field and released to the
19 River Corridor Closure Contractor for shipping and analysis, as well as the resulting data, will be
20 managed in accordance with applicable procedures and work plans.

21 **Laboratories.** The laboratories analyze samples in accordance with established procedures, provide
22 necessary sample reports, and explain results in support of data validation. The laboratories must meet
23 site-specific QA requirements and must have an approved QA plan in place.

24 **Health and Safety.** Health and Safety is responsible for coordinating industrial safety and health support
25 within the project, as carried out through health and safety plans, job hazard analyses, and other pertinent
26 safety documents required by federal regulation or by internal primary contractor work requirements. In
27 addition, Health and Safety assists project personnel in complying with applicable health and safety
28 standards and requirements. Health and Safety coordinates with Radiological Engineering to determine
29 personal protective clothing requirements.

30 **2.1.2 Problem Definition and Background**

31 This SAP describes the sampling and analysis to be performed associated with installing and sampling
32 groundwater monitoring wells. The specific problems to be solved, background information, and general
33 information are provided in the work plan and Addendum 5. Media to be sampled include soil, aquifer
34 sediment, and water. Figure 1-1 shows the location of the planned groundwater-monitoring wells within
35 the scope of this SAP. Figure 1-2 shows the spatial and temporal uncertainty groundwater monitoring
36 well network within the scope of this SAP. The regulatory drivers and reference to agreement documents
37 for the activity are provided in the work plan.

38 **2.1.3 Project and Task Description**

39 Chapter 3 presents the field sampling plan. Tables 1-2 and 1-3 present the target analytes and COPCs.
40 Section 1.6 provides guidance on the implementation schedule.

41 **2.1.4 Quality Objectives and Criteria**

42 The QA objective of this plan is to develop implementation guidance providing data of known and
43 appropriate quality. Data quality indicators describe data quality, by evaluation against identified data

1 needs, and by evaluation against the work activities identified in this SAP. The applicable QC guidelines,
2 quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of
3 the data and the nature of the analytical method. The principal data quality indicators are precision, bias
4 or accuracy, representativeness, comparability, completeness, and sensitivity. These data quality
5 indicators are defined for the purpose of this document in Table 2-1. The data quality indicators will be
6 evaluated during the data quality assessment (DQA) process (Section 2.4.3).

7 Tables 2-2 through 2-4 present analytical performance requirements for soil/aquifer sediment by location,
8 based on the master target analyte list in Table 1-2. Table 2-5 presents analytical performance
9 requirements for water samples based on the COPCs in Table 1-3. Laboratory operations and analytical
10 services shall be in compliance with Volume 4 of HASQARD (DOE/RL-96-98) and specific criteria
11 identified in Tables 2-2 through 2-5, below. Criteria in Tables 2-2 through 2-5 take precedence over
12 similar criteria in HASQARD. In consultation with the laboratory, the project lead, and/or others as
13 appropriate, Sample Management and Reporting can approve changes to analytical methods as long as the
14 method is based upon a nationally recognized (e.g., EPA, American Society for Testing and Materials
15 [ASTM]) method, the new method achieves project data quality objectives (DQOs) as well or better than
16 the replaced method, and the new method is required due to the nature of the sample (e.g., highly
17 radioactive).

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project-Specific Information*	Corrective-Action Examples
Precision	<p>The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated either as the range or as the standard deviation.</p> <p>May also be expressed as a percentage of the mean of the measurements, such as relative range, relative percent difference, or relative standard deviation (coefficient of variation).</p>	<p>Use the same analytical instrument to make repeated analyses on the same sample.</p> <p>Use the same method to make repeated measurements of the same sample within a single laboratory or have two or more laboratories analyze identical samples with the same method.</p> <p>Split a sample in the field and submit both for sample handling, preservation and storage, and analytical measurements.</p> <p>Collect, process, and analyze co-located samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.</p>	<p>Field precision: At randomly selected locations, duplicate samples will be taken 1 per 20 samples per media.</p> <p>Laboratory precision: Analysis of laboratory duplicate or matrix spike duplicate results.</p>	<p>If duplicate data do not meet objective:</p> <ul style="list-style-type: none"> • Evaluate apparent cause (e.g., sample heterogeneity) • Request reanalysis or re-measurement • Qualify the data before use
Accuracy	<p>A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of sampling and analytical operations.</p>	<p>Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample), usually expressed either as percent recovery or as a percent bias.</p>	<p>Laboratory accuracy determination based on matrix spikes and matrix spike duplicate results.</p>	<p>If recovery does not meet objective:</p> <ul style="list-style-type: none"> • Qualify the data before use • Request reanalysis or re-measurement

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project-Specific Information*	Corrective-Action Examples
Representativeness	A qualitative term to express "the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition." (ANSI/ASQC S2-1995)	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	Samples will be collected as described in the sampling design. Judgment sampling ensures areas most likely to be contaminated, based on current information, will be evaluated.	If results are not representative of the system sampled: <ul style="list-style-type: none"> • Identify the reason result is not representative • Reject the data, or, if data are otherwise usable, qualify the data for limited use and define the portion of the system the data represent • Redefine sampling and measurement requirements and protocols • Resample and reanalyze
Comparability	A qualitative term expressing the measure of confidence with which one data set can be compared to another and can be combined for the decision(s) to be made.	Compare sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.	Sampling personnel will use the same sampling protocols. Samples will be submitted to the same laboratories when possible (based on laboratory contracts) for analysis by the same methods, thus data results will be comparable.	If data are not comparable to other data sets: <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze, if needed • Revise sampling/analysis protocols to ensure future comparability

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project-Specific Information*	Corrective-Action Examples
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's data needs.	The percent complete will be determined during data validation.	<p>If data set does not meet completeness objective:</p> <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze, if needed • Revise sampling/analysis protocols to ensure future comparability
Sensitivity	The capability of a method or instrument to discriminate among measurement responses representing different levels of the variable of interest.	Determine the minimum concentration or attribute to be measured by a method (method detection limit), by an instrument (instrument detection limit), or by a laboratory (quantitation limit). The practical quantitation limit is the lowest level that can be routinely quantified and reported by a laboratory.	Ensure that sensitivity, as measured by detection limits, is appropriate for the action levels.	<p>If sensitivity does not meet objective:</p> <ul style="list-style-type: none"> • Request reanalysis or re-measurement • Qualify/reject the data before use

*Field sampling requirements are noted. Laboratories will follow requirements for use and interpretation of laboratory control samples. ANSI/ASQC S2-1995, *Introduction to Attribute Sampling*.

2-8

1

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 1

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements^c								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	— ^d
12587-46-1	Gross alpha	100 dpm/100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^d
12587-47-2	Gross beta	5,000 dpm/100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^d
Performance Requirements for Laboratory Measurements (Radiological)								
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV ^e	NV ^e	GEA	±30 ^f	70-130 ^f
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV ^e	NV ^e			
10098-97-2	Strontium-90 ^g	1 pCi/g	4.5 pCi/g	NV ^e	NV ^e	Strontium-90	±30 ^f	70-130 ^f
15046-84-1	Iodine-129	2 pCi/g	2 pCi/g	2 pCi/g	2 pCi/g	Low Level GEA	±30 ^f	70-130 ^f
—	Plutonium-239/240	1 pCi/g	35.1 pCi/g	NV ^e	NV ^e	Isotopic Plutonium	±30 ^f	70-130 ^f
14762-75-5	Carbon-14	2 pCi/g	8.7 pCi/g	NV ^e	NV ^e	LSC – Carbon-14	±30 ^f	70-130 ^f
14133-76-7	Technetium-99	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.46 pCi/g	LSC – Technetium-99	±30 ^f	70-130 ^f
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g	LSC – Tritium	±30 ^f	70-130 ^f
10098-97-2	Strontium-90 ^g	1 pCi/L	N/A	N/A	N/A	Batch leach followed by Strontium-90	±30 ^f	70-130 ^f
Performance Requirements for Laboratory Measurements (Nonradiological)								
7429-90-5	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg	EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-36-0	Antimony	6 mg/kg ⁱ	32 mg/kg	5.4 mg/kg	25.3 mg/kg			

2.9

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 1

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-42-8	Boron	2 mg/kg	16,000 mg/kg	210 mg/kg	NV ^e			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV ^e			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-93-2	Lithium	2.5 mg/kg	160 mg/kg	192 mg/kg	NV ^e			
7439-96-5	Manganese ^j	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg ⁱ	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg ⁱ	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
7439-92-1	Mercury	0.2 mg/kg	24 mg/kg	0.33 mg/kg	0.33 mg/kg	EPA 7471 (Hg cold vapor)	±30 ^h	70-130 ^h
57-12-5	Cyanide	0.5 mg/kg	1,600 mg/kg	0.80 mg/kg	1.6 mg/kg	EPA 9010	±30 ^h	70-130 ^h
68334-30-5	TPH/diesel oil and motor oil	5 mg/kg	2,000 mg/kg	2,000 mg/kg	NV ^e	NWTPH-D+	±20 ^k	80-120 ^k

2-10

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 1

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg	EPA 8260 (VOCs)	±20 ^k	80-120 ^k
127-18-4	Tetrachloroethene	0.005 mg/kg	800 mg/kg	0.008 mg/kg	0.008 mg/kg			
16984-48-8	Fluoride	5 mg/kg	4,800 mg/kg	96 mg/kg	400 mg/kg	EPA 300.0 (Anions by IC)	±30 ^h	70-130 ^h
14797-55-8	Nitrate (as N) ^l	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg			
14797-65-0	Nitrite (as N) ^l	2.5 mg/kg	8,000 mg/kg	100 mg/kg	200 mg/kg			
14808-79-8	Sulfate	5 mg/kg	NV ^e	1,030 mg/kg	NV ^e			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^g	70-130 ^g
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ^h	70-130 ^h

2-11

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 1

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			
Performance Requirements for Physical Properties								
—	Grain-size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

- a. Unless otherwise noted, Preliminary Cleanup Goals were established in Revision 6 of *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17).
- b. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Well will be logged with a neutron moisture tool and the high resolution, spectral gamma ray logging system. Geologic samples will also be logged. Vadose zone soil samples will be field-screened for gross alpha, gross beta, and gross gamma activities. Aquifer sediment samples will be field-screened for gross gamma activity.
- d. Field measurements have no specific quality control requirement for accuracy except to perform checks to verify manufacturer's expected performance.
- e. Generic residual radioactivity modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years; however, site-specific modeling will be performed, as necessary, to determine whether Preliminary Cleanup Goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA methods, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 1

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			

- g. Strontium will be assessed as total radioactive strontium.
- h. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.
- i. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or IC/MS methods if estimated quantitation limits are met.
- j. The manganese preliminary cleanup goal groundwater and river protection values are not risk based. They are predicated on a secondary maximum contaminant level (taste and/or odor) and are based on Hanford Site background.
- k. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for Method SW-846 8260.
- l. Nitrate/Nitrite may also be reported as nitrogen in nitrate/nitrite by Method 353.1/353.2/353.3 with the reporting limits specified in Appendix A.

ASTM D422-63, *Standard Test Method for Particle-Size Analysis of Soils.*

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head).*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method.*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.*

CAS = Chemical Abstracts Service	LSC = liquid scintillation counter
dpm = disintegrations per minute	N/A = not applicable
EQL = estimated quantitation limit	NV = no value
GEA = gamma energy analysis	NWTPH-D = Northwest total petroleum hydrocarbon - diesel
IC = ion chromatography	TPH = total petroleum hydrocarbon
ICP = inductively coupled plasma	VOC = volatile organic compound

219

1
2

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 4

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements^c								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	— ^d
12587-46-1	Gross alpha	100 dpm/ 100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^d
12587-47-2	Gross beta	5,000 dpm/ 100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^d
Performance Requirements for Laboratory Measurements (Nonradiological)								
68334-30-5	TPH/diesel oil and motor oil	5 mg/kg	2,000 mg/kg	2,000 mg/kg	NV ^e	NWTPH-D+	±20 ^f	80-120 ^f
8006-61-9	TPH/ gasoline range ^g	5 mg/kg	N/A	N/A	N/A	WTPH-G	±20 ^f	80-120 ^f
83-32-9	Acenaphthene	0.1 mg/kg	4,800 mg/kg	97.9 mg/kg	131 mg/kg	EPA 8310 (PAH)	±20 ^f	80-120 ^f
208-96-8	Acenaphthylene ^g	0.1 mg/kg	N/A	N/A	N/A			
120-12-7	Anthracene	0.05 mg/kg	24,000 mg/kg	2,270 mg/kg	9,100 mg/kg			
56-55-3	Benzo(a)anthracene	0.015 mg/kg	1.37 mg/kg	0.856 mg/kg	0.04 mg/kg			
205-99-2	Benzo(b)fluoranthene	0.015 mg/kg	1.37 mg/kg	2.95 mg/kg	0.138 mg/kg			
207-08-9	Benzo(k)fluoranthene	0.015 mg/kg	1.37 mg/kg	21.5 mg/kg	0.138 mg/kg			
191-24-2	Benzo(ghi)perylene	0.03 mg/kg	2,400 mg/kg	5,700 mg/kg	7,070 mg/kg			
50-32-8	Benzo(a)pyrene	0.015 mg/kg	0.137 mg/kg	2.33 mg/kg	0.109 mg/kg			
218-01-9	Chrysene ^h	0.1 mg/kg	1.37 mg/kg	9.56 mg/kg	0.0446 mg/kg			

2-14

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 4

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			
53-70-3	Dibenz[a,h]anthracene ⁹	0.03 mg/kg	N/A	N/A	N/A			
206-44-0	Fluoranthene	0.05 mg/kg	3,200 mg/kg	631 mg/kg	178 mg/kg			
86-73-7	Fluorene	0.03 mg/kg	3,200 mg/kg	101 mg/kg	411 mg/kg			
193-39-5	Indeno(1,2,3-cd)pyrene	0.03 mg/kg	1.37 mg/kg	8.33 mg/kg	0.389 mg/kg			
91-20-3	Naphthalene	0.1 mg/kg	1,600 mg/kg	4.46 mg/kg	275 mg/kg			
85-01-8	Phenanthrene	0.05 mg/kg	24,000 mg/kg	1,140 mg/kg	9,100 mg/kg			
129-00-0	Pyrene	0.05 mg/kg	2,400 mg/kg	655 mg/kg	2,620 mg/kg			
Performance Requirements for Physical Properties								
—	Grain-size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D 2937	N/A	N/A

2-15

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Well 4

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure (Residential)	Groundwater Protection	River Protection			

- a. Unless otherwise noted, Preliminary Cleanup Goals were established in Revision 6 of *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17).
- b. Equivalent methods may be substituted. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Well will be logged with a neutron moisture tool and the high resolution, spectral gamma ray logging system. Geologic samples will also be logged. Vadose zone soil samples will be field-screened for gross alpha, gross beta, and gross gamma activities. Aquifer sediment samples will be field-screened for gross gamma activity.
- d. Field measurements have no specific quality control requirement for accuracy except to perform checks to verify manufacturer's expected performance.
- e. Generic residual radioactivity modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years; however, site-specific modeling will be performed, as necessary, to determine whether Preliminary Cleanup Goals have been met.
- f. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences.
- g. Constituents are not target analytes; therefore, established preliminary cleanup goals have not been stated.
- h. Calculated cleanup goals are below established analytical methodology capabilities. Analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

ASTM D422-63, *Standard Test Method for Particle-Size Analysis of Soils*.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*.

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*.

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*.

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*.

CAS = Chemical Abstracts Service
 dpm = disintegrations per minute
 EQL = estimated quantitation limit
 N/A = not applicable
 NV = no value

NWTPH-D = Northwest total petroleum hydrocarbon – diesel
 PAH = Polycyclic aromatic hydrocarbon
 TPH = total petroleum hydrocarbons
 WTPH-G = Washington total petroleum hydrocarbon - gasoline

2-16

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Wells R1 and R2

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements^c								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	— ^d
12587-46-1	Gross alpha	100 dpm/100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^d
12587-47-2	Gross beta	5,000 dpm/100 cm ²	N/A	N/A	N/A	Portable contamination detector	±50	— ^d
Performance Requirements for Laboratory Measurements (Radiological)								
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV ^e	NV ^e	GEA	±30 ^f	70-130 ^f
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV ^e	NV ^e			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV ^e	NV ^e			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV ^e	NV ^e			
10098-97-2	Strontium-90 ^g	1 pCi/g	4.5 pCi/g	NV ^e	NV ^e	Strontium-90	±30 ^f	70-130 ^f
10098-97-2	Strontium-90 ^g	1 pCi/L	N/A	N/A	N/A	Batch leach followed by Strontium-90	±30 ^f	70-130 ^f
Performance Requirements for Laboratory Measurements (Nonradiological)								
7440-36-0	Antimony	6 mg/kg ^h	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg ^h	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			

2-17

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Wells R1 and R2

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese ^j	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg ^h	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg ^h	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg ^h	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30 ⁱ	70-130 ⁱ
—	Distribution coefficient for metals	N/A	N/A	N/A	N/A	1:1 water extract followed by 6010, 6020, 7196, 7470 or 200.8	N/A	N/A

2-18

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Wells R1 and R2

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Physical Properties								
—	Grain-size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure or ASTM D422-63	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM 2937	N/A	N/A

- a. Unless otherwise noted, Preliminary Cleanup Goals were established in Revision 6 of *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17).
- b. Equivalent methods may be substituted. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.
- c. Well will be logged with a neutron moisture tool and the high resolution, spectral gamma ray logging system. Geologic samples will also be logged. Vadose zone soil samples will be field-screened for gross alpha, gross beta, and gross gamma activities. Aquifer sediment samples will be field-screened for gross gamma activity.
- d. Field measurements have no specific quality control requirement for accuracy except to perform checks to verify manufacturer's expected performance.
- e. Generic residual radioactive modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years; however, site-specific modeling will be performed, as necessary, to determine whether Preliminary Cleanup Goals have been met.
- f. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA methods, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.
- g. Strontium will be assessed as total radioactive strontium.
- h. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Wells R1 and R2

CAS	Analyte	EQL	Preliminary Cleanup Goals ^a			Analytical Method ^b	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			

furnace or ICP/mass spectrometry methods if estimated quantitation limits are met.

i. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples is also performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

ASTM D422-63, *Standard Test Method for Particle-Size Analysis of Soils.*

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma
dpm	=	disintegrations per minute	N/A	=	not applicable
EQL	=	estimated quantitation limit	NV	=	no value
GEA	=	gamma energy analysis			

2-20

1
2

Table 2-5. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL ^b	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
Performance Requirements for Field Measurements							
—	Oxidation reduction potential	REDOX PROBE	N/A	— ^c	— ^c	N/A	N/A
—	pH measurement	PROBE	0.5 pH unit	— ^c	— ^c	N/A	N/A
—	Specific conductance	PROBE	1 µS/cm	— ^c	— ^c	N/A	N/A
—	Temperature	PROBE	—	— ^c	— ^c	N/A	N/A
—	Dissolved oxygen	PROBE	—	— ^c	— ^c	N/A	N/A
—	Turbidity	PROBE	0.1 NTU	— ^c	— ^c	N/A	N/A
Performance Requirements for Laboratory Measurements (Radiological)							
10198-40-0	Cobalt-60	GEA	25 pCi/L	±30 ^d	70-130 ^d	100 pCi/L	Federal MCL
10098-97-2	Strontium-90 ^e	Strontium-90	2 pCi/L	±30 ^d	70-130 ^d	8 pCi/L	40 CFR 141.66
10028-17-8	Tritium	LSC - Tritium	400 pCi/L	±30 ^d	70-130 ^d	20,000 pCi/L	40 CFR 141.66
Performance Requirements for Laboratory Measurements (Nonradiological)							
7440-36-0	Antimony	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	5 µg/L	±20 ^f	80-120 ^f	5.6 µg/L	Human Health for the Consumption of Water + Organism
7440-38-2	Arsenic	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L ^{gh}	±20 ^f	80-120 ^f	0.018 µg/L	Human Health for the Consumption of Water + Organism
7440-43-9	Cadmium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L ^{gh}	±20 ^f	80-120 ^f	0.25 µg/L	Freshwater CCC
7440-47-3	Chromium	EPA 6010 (ICP metals)	10 µg/L	±20 ^f	80-120 ^f	74 µg/L	Freshwater CCC

Table 2-5. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL ^b	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
10198-40-0	Cobalt	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L	±20 ^f	80-120 ^f	4.8 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-50-8	Copper	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	8 µg/L	±20 ^f	80-120 ^f	9 µg/L	Freshwater CCC
18540-29-9	Hexavalent Chromium	EPA 7196 (Cr VI)	10 µg/L	±20 ^f	80-120 ^f	10 µg/L	WAC 173-201A
7439-92-1	Lead	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L	±20 ^f	80-120 ^f	2.1 µg/L	WAC 173-201A
7439-96-5	Manganese	EPA 6010 (ICP metals)	5 µg/L	±20 ^f	80-120 ^f	50 µg/L	40 CFR 143.3
7439 97 6	Mercury	ICP/MS 200.8	0.5 µg/L ^{gh}	±20 ^f	80-120 ^f	0.05 µg/L	WAC 173-201A
7440-02-0	Nickel	EPA 6010 (ICP metals)	40 µg/L	±20 ^f	80-120 ^f	52 µg/L	Freshwater CCC
7782-49-2	Selenium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L	±20 ^f	80-120 ^f	5 µg/L	Freshwater CCC
7440-28-0	Thallium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L ^{gh}	±20 ^f	80-120 ^f	0.24 µg/L	Human Health for the Consumption of Water + Organism
7440-62-2	Vanadium	EPA 6010 (ICP metals)	25 µg/L	±20 ^f	80-120+f	112 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
7440-66-6	Zinc	EPA 6010 (ICP metals)	10 µg/L	±20 ^f	80-120 ^f	91 µg/L	WAC 173-201A
72-54-8	4,4-DDD	EPA 8081 (Pesticides)	0.1 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.00031 µg/L	Human Health for the Consumption of Water + Organism

2-22

Table 2-5. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL ^b	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
50-29-3	4,4-DDT	EPA 8081 (Pesticides)	0.1 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.00022 µg/L	Human Health for the Consumption of Water + Organism
309-00-2	Aldrin	EPA 8081 (Pesticides)	0.05 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.000049 µg/L	Human Health for the Consumption of Water + Organism
319-84-6	alpha-BHC	EPA 8081 (Pesticides)	0.05 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.0026 µg/L	Human Health for the Consumption of Water + Organism
57-74-9	Chlordane	EPA 8081 (Pesticides)	0.5 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.0008 µg/L	Human Health for the Consumption of Water + Organism
60-57-1	Dieldrin	EPA 8081 (Pesticides)	0.05 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.000052 µg/L	Human Health for the Consumption of Water + Organism
72-20-8	Endrin	EPA 8081 (Pesticides)	0.1 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.0023 µg/L	WAC 173-201A
76-44-8	Heptachlor	EPA 8081 (Pesticides)	0.05 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.000079 µg/L	Human Health for the Consumption of Water + Organism
1024-57-3	Heptachlor epoxide	EPA 8081 (Pesticides)	0.05 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.000039 µg/L	Human Health for the Consumption of Water + Organism
72-73-5	Methoxychlor	EPA 8081 (Pesticides)	0.5 µg/L ^h	±20 ⁱ	80-120 ⁱ	0.03 µg/L	Freshwater CCC
68334-30-5	TPH-diesel range	WTPH-D	500 µg/L	±20 ⁱ	80-120 ⁱ	500 µg/L	WAC 173-340-720(3)
8006-61-9	TPH-gasoline range	WTPH-G	500 µg/L	±20 ⁱ	80-120 ⁱ	500 µg/L	WAC 173-340-720(3)
106-46-7	1,4-Dichlorobenzene	EPA 8260 (VOCs)	5 µg/L ^h	±20 ⁱ	80-120 ⁱ	1.82 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)

2-23

Table 2-5. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL ^b	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
71-43-2	Benzene	EPA 8260 (VOCs)	1.5 µg/L ^h	±20 ⁱ	80-120 ⁱ	1 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
67-66-3	Chloroform	EPA 8260 (VOCs)	5 µg/L	±20 ⁱ	80-120 ⁱ	5.7 µg/L	Human Health for the Consumption of Water + Organism
56-23-5	Carbon Tetrachloride	EPA 8260 (VOCs)	1 µg/L	±20 ⁱ	80-120 ⁱ	1 µg/L	Human Health for the Consumption of Water + Organism
127-18-4	Tetrachloroethene	EPA 8260 (VOCs)	5 µg/L ^h	±20 ⁱ	80-120 ⁱ	1 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
79-01-6	Trichloroethene	EPA 8260 (VOCs)	1 µg/L	±20 ⁱ	80-120 ⁱ	1 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
75-01-4	Vinyl Chloride	EPA 8260 (VOCs)	5 µg/L	±20 ⁱ	80-120 ⁱ	1 µg/L	Human Health for the Consumption of Water + Organism
57-12-5	Cyanide	EPA 9012	5 µg/L	±20 ⁱ	80-120 ⁱ	200 µg/L	Federal MCL
16984-48-8	Fluoride	EPA 300.0 (Anions by IC)	500 µg/L	±20 ^f	80-120 ^f	960 µg/L	WAC 173-340-720(4)(b)(iii)(A) and (B)
14797-55-8	Nitrate (as N)	EPA 300.0 (Anions by IC)	250 µg/L	±20 ^f	80-120 ^f	10,000 µg/L	40 CFR 141.62
14797-65-0	Nitrite (as N)	EPA 300.0 (Anions by IC)	250 µg/L	±20 ^f	80-120 ^f	1,000 µg/L	40 CFR 141.62
14808-79-8	Sulfate	EPA 300.0 (Anions by IC)	500 µg/L	±20 ^f	80-120 ^f	250,000 µg/L	40 CFR 143.3

Table 2-5. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method ^a	EQL ^b	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
<p>a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, <i>Methods for Chemical Analysis of Water and Wastes</i>. For EPA Method 200.8, see EPA/600/R-94/111, <i>Methods for the Determination of Metals in Environmental Samples, Supplement 1</i>. For the four-digit EPA methods, see SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i>. Tentatively identified compounds will be reported for Method SW-846 8260.</p> <p>b. Estimated quantitation limit (EQL) equal to 5 to 10 times the method detection limit (MDL) (SW-846). MDLs are listed in DOE/RL-2008-66, Table C-30. When the action limit is less than the MDL, the action limit defaults to the MDL.</p> <p>c. Field measurements have no specific quality control requirement except to perform checks to verify manufacturer's expected performance.</p> <p>d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA methods, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.</p> <p>e. Strontium will be assessed as total radioactive strontium.</p> <p>f. Accuracy criteria shown are for associated batch analytical matrix spike samples. Additional accuracy evaluation based on statistical control of laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike analyses or replicate sample relative percent differences.</p> <p>g. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/mass spectrometry methods if estimated quantitation limits are met.</p> <p>h. Calculated Action Levels are less than established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.</p> <p>i. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control, if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike and surrogate recoveries, as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences.</p>							
WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington"							
WAC 173-340-720(3), "Method A Cleanup Levels for Potable Ground Water"							
WAC 173-340-720(4), "Method B Cleanup Levels for Potable Ground Water"							
CAS	=	Chemical Abstracts Service		N/A	=	not applicable	
CCC	=	criterion continuous concentration		NTU	=	nephelometric turbidity unit	
EQL	=	estimated quantitation limit		TPH	=	total petroleum hydrocarbons	
IC	=	ion chromatography		VOC	=	volatile organic carbons	
ICP	=	inductively coupled plasma		WTPH-D	=	Washington total petroleum hydrocarbon - diesel	
ICP/MS	=	inductively coupled plasma/mass spectrometry		WTPH-G	=	Washington total petroleum hydrocarbon - gasoline	
MCL	=	maximum contaminant level					

2.1.5 Special Training/Certification

A graded approach is used to ensure workers receive a level of training that is commensurate with responsibilities and complies with applicable DOE orders and government regulations. The sampling lead and drilling lead, in coordination with line management, will ensure that field personnel meet special training requirements.

Typical training requirements or qualifications have been instituted by the primary contractor management team to meet training requirements imposed by the contract, regulations, DOE orders, DOE contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers standards and *Washington Administrative Code*. For example, the environmental, safety and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste-site experience
- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Hanford general employee training
- Radiological worker training.

Project-specific safety training, geared specifically to the project and the day's activity, will be provided. Project-specific training includes the following:

- Training requirements or qualifications needed by sampling personnel will be in accordance with QA requirements.
- Samplers are required to have training and/or experience in the type of sampling being performed in the field, soil/aquifer sediment sampling and water sampling.
- The Radiation Protection Program establishes qualification requirements for radiological control technicians. The radiological control technicians assigned to these activities will be qualified through the prescribed training program and will undergo ongoing training and qualification activities.

In addition, pre-job briefings will be performed to evaluate an activity and its hazards by considering many factors, including the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety procedures applicable to the job
- Training requirements for individuals assigned to perform the work

- 1 • Level of management control
- 2 • Proximity of emergency contacts.

3 Training records are maintained for each individual in an electronic training record database. The
4 contractor training organization maintains the training records system. Line management will be used to
5 confirm an individual employee’s training is appropriate and up-to-date before performing any fieldwork.

6 **2.1.6 Documents and Records**

7 The project lead is responsible for ensuring the current version of the SAP is being used and for providing
8 updates to field personnel. The administrative document control process maintains version control.
9 Before implementation, DOE and the lead regulatory agency will review and approve changes to the
10 sampling plan that affect the data needs. Information pertinent to sampling and analysis will be recorded
11 in field checklists and bound logbooks in accordance with existing sample collection protocols in
12 accordance with HASQARD (DOE/RL-96-98).

13 The sampling lead or drilling lead is responsible for ensuring the field instructions are maintained up-to-
14 date and aligned with revisions or other approved changes to the SAP. The sampling lead or drilling lead
15 will ensure that deviations from the SAP or problems encountered in the field are documented
16 appropriately (e.g., in the field logbook, on nonconformance report forms) in accordance with internal
17 corrective action procedures.

18 The project lead, drilling lead, sampling lead, or designee, will be responsible for communicating field
19 corrective action requirements and for ensuring immediate corrective actions are applied to field
20 activities. Table 2-6 presents the change control for this project.

Table 2-6. Change Control for the 100-N Decision Unit Project

Type of Change	Action	Documentation
By drilling lead or sampling lead: <ul style="list-style-type: none"> • Increasing sampling frequency based on field screening results or visual observations 	No SAP revision necessary	Field logbooks or operational records
By project management: <ul style="list-style-type: none"> • Change in target analytes or COPC • Adding/removing wells • Significant increases or decreases in sampling frequency 	Revise SAP (can be accomplished with Tri-Party Agreement Change Notice); obtain regulatory approval; distribute plan	Revised plan or approved Tri-Party Agreement Change Notice.

21 Logbooks are required for field activities. The logbook must be identified with a unique project name and
22 number. Individuals responsible for logbooks will be listed. Only authorized persons may make entries
23 in logbooks. Logbooks will be signed by the sampling lead, drilling lead, cognizant scientist/engineer, or
24 other responsible individual. Logbooks will be permanently bound, waterproof, and ruled with
25 sequentially numbered pages. Pages will not be removed from logbooks for any reason.

26 Logbook entries will be made in indelible ink. Corrections will be made by marking the erroneous data
27 through with a single line, entering the correct data, and initialing and dating the changes.

1 The project lead is responsible for ensuring a project file is properly maintained. The project file will
2 contain the records or references to their storage locations. The project file will include the following, as
3 appropriate:

- 4 • Field logbooks or operational records
- 5 • Data forms
- 6 • Global Positioning System data
- 7 • Chain-of-custody forms
- 8 • Sample receipt records
- 9 • Inspection or assessment reports and corrective action reports
- 10 • Interim progress reports
- 11 • Final reports
- 12 • Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of
13 Wells," and the master drilling contract
- 14 • Laboratory data packages
- 15 • RI report
- 16 • Verification and validation report(s).

17 The laboratory is responsible for maintaining, and having available upon request, the following:

- 18 • Analytical logbooks
- 19 • Raw data and QC sample records
- 20 • Standard reference material and/or proficiency test sample data
- 21 • Instrument calibration information.

22 Records may be stored in either electronic or hard copy format. Documentation and records, regardless of
23 medium or format, are controlled in accordance with internal work requirements and processes to ensure
24 accuracy and availability of stored records. Records required by the Tri-Party Agreement will be
25 managed in accordance with the requirements of the Agreement.

26 **2.2 Data Generation and Acquisition**

27 The following sections address data generation and acquisition to ensure the project methods for
28 sampling, measurement, and analysis; data collection or generation; data handling; and QC activities are
29 appropriate and documented.

30 **2.2.1 Sampling Process Design (Experimental Design)**

31 The sampling design is judgmental sampling. In judgmental sampling, sampling unit selection (e.g., the
32 number and location and/or timing of collecting samples) is based on knowledge of the feature or
33 condition under investigation and on professional judgment. Judgmental sampling is distinguished from
34 probability based sampling in that inferences are based on professional judgment, not statistical scientific
35 theory. Therefore, conclusions about the target population are limited and depend entirely on the validity
36 and accuracy of professional judgment. Probabilistic statements about parameters are not possible.
37 Section 3.5 provides types, number, and location of samples.

38

1 **2.2.2 Sampling Methods**

2 Section 3.6 describes the sampling methods. The specific information includes the following:

- 3 • Field sampling methods
4 • Corrective actions for sampling activities (the task lead will be responsible for corrective action)
5 • Decontamination of sampling equipment
6 • Radiological field data.

7 **2.2.3 Sample Handling and Custody**

8 A sampling and data tracking database is used to track the samples from the point of collection through
9 the laboratory analysis process. Samplers should note any anomalies (e.g., sample appears unusual,
10 sample is sludge) with the samples to prevent batching across similar matrices. If anomalies are found,
11 the samplers should write "DO NOT BATCH" on the chain-of-custody form and inform Sample
12 Management and Reporting.

13 Laboratory analytical results are entered and maintained in HEIS. HEIS sample numbers are issued to the
14 sampling organization for the project. Each chemical, radiological, and physical properties sample is
15 identified and labeled with a unique HEIS sample number.

16 Section 3.7 provides the following specific sample handling information:

- 17 • Container packaging
18 • Container labeling
19 • Sample custody requirements
20 • Sample transportation.

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

25 **2.2.4 Analytical Methods**

26 Tables 2-2 through 2-5 provide information on analytical methods. These analytical methods are
27 controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary
28 contractor, or vadose zone contractor as applicable, participates in overseeing the offsite analytical
29 laboratories to qualify the laboratories for performing Hanford Site analytical work.

30 If the laboratory uses a nonstandard or unapproved method, then the laboratory must provide method
31 validation data to confirm the method is adequate for the intended use of the data. This includes
32 information such as determination of detection limits, quantitation limits, typical recoveries, and
33 analytical precision and bias. In consultation with the laboratory, the project lead, and/or others as
34 appropriate, Sample Management and Reporting can approve changes to analytical methods as long as the
35 method is based upon a nationally recognized (e.g., EPA, ASTM) method, the new method achieves
36 project DQOs as well or better than the replaced method, and the new method is required due to the
37 nature of the sample (e.g., high radioactivity).

38 Laboratories providing analytical services in support of this SAP will have in place a corrective action
39 program addressing analytical system failures and documents on the effectiveness of corrective actions.
40 Issues affecting analytical results are to be resolved by Sample Management and Reporting in
41 coordination with the project lead.

1 Batch leach tests will be performed on soil and aquifer sediment samples. Standardized batch leach tests
 2 are done using a leach procedure based on ASTM D3987, *Standard Test Method for Shake Extraction of*
 3 *Solid Waste with Water*. The procedure recommends using soil screened through 9.5-mm (3/8-inch)
 4 mesh. Demineralized water, pH adjusted according to EPA's West Coast recommendation, will be used
 5 as the leaching liquid. Selected soil samples will be leached at soil to water weight ratios of 1 to 1, 1 to
 6 2.5, and 1 to 5 with one test in each series duplicated. Soil/water mixtures are placed in clean water-tight
 7 sample containers (extraction vessels) and rotated end-over-end through the vessel centerline at a rate of
 8 about 30 rotations per minute for 18 hours. Following 18 hours of mixing, the soil/water slurry is filtered
 9 using a 0.45- μ m filter. The leachate will be analyzed for pH, conductivity, and metals. Details of the test
 10 will be discussed with the laboratory personnel before analysis.

11 Distribution coefficient values will be established to support modeling needs. Distribution coefficient
 12 calculations will be based on a 1:1 reagent water leach of untreated soils analyzed for the same metals
 13 directly analyzed in the soils for other purposes. Metals analysis will be done using EPA Methods 6010,
 14 6020, or 200.8 for inductively coupled plasma (ICP) metals, as applicable. Details of the test will be
 15 discussed with the laboratory personnel before analysis.

16 Grain size (sieve) analysis may be performed as a field procedure or in the laboratory based on
 17 ASTM D422-63. Field grain size analysis may be used to select well screens for groundwater wells.

18 **2.2.5 Quality Control**

19 QC procedures must be followed in the field and laboratory to ensure reliable data are obtained. Field
 20 personnel will collect QC samples to evaluate the potential for cross-contamination and to provide
 21 information pertinent to field variability. Field QC for sampling will require the collection of field
 22 duplicates, trip or field transfer blanks, equipment blanks, and field splits. Laboratory QC samples
 23 estimate the precision and bias of the analytical data. Table 2-7 summarizes field and laboratory QC
 24 samples. Additional QC samples may be collected if conditions arise.

Table 2-7. Project QC Checks

QC Sample Type	Purpose	Frequency
Field Quality Control		
Full trip blank	Assess contamination from containers or transportation	One per 20 samples <i>per media sampled</i> .
Field transfer blank	Assess contamination from sampling site	One per day when volatile organic compounds are sampled <i>per media sampled</i> .
Equipment rinse blank	Verify adequacy of sampling equipment decontamination	As needed. ^a If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment rinse blank is not required. Otherwise, 1 per 20 samples <i>per media sampled</i> .
Field duplicates	Estimate precision, including sampling and analytical variability	One per batch, ^b 20 samples maximum, <i>per media sampled</i> .
Field split	Estimate precision, including sampling, analytical, and inter-laboratory variability	At a minimum, one per analytical method, per media for analyses performed where detection limit and precision and accuracy criteria have been defined in the Performance Requirements Tables.

Table 2-7. Project QC Checks

QC Sample Type	Purpose	Frequency
Laboratory Quality Control^b		
Method blank	Assess response of an entire laboratory analytical system	One per batch, ^b 20 samples maximum, or as identified by the method guidance, <i>per media sampled</i> .
Matrix spike	Identify analytical (preparation and analysis) bias; possible matrix affect on the analytical method used	When required by the method guidance, one per batch, ^b 20 samples maximum, or as identified by the method guidance, <i>per media sampled</i> .
Matrix duplicate or matrix spike duplicate	Estimate analytical bias and precision	When required by the method guidance, one per batch, ^b 20 samples maximum, or as identified by the method guidance, <i>per media sampled</i> .
Laboratory control samples	Assess method accuracy	One per batch, ^b 20 samples maximum, or as identified by the method guidance, <i>per media sampled</i> .
Surrogates	Estimate recovery/yield	When required by the method guidance, as identified by the method guidance.

a. Whenever a new type of non-dedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

1 **2.2.5.1 Field QC Samples**

2 The field QC sample types are discussed within this section.

3 **Full trip blanks** are samples prepared by the sampling team before traveling to the sampling site. The
 4 preserved bottle set is identical to the set collected in the field, but it is filled with reagent water or silica
 5 sand, as appropriate to the primary sample media. The bottles are sealed and transported, unopened, to
 6 the field in the same storage container used for samples collected the same day. Full trip blanks are
 7 typically analyzed for the same constituents as the samples from the associated sampling event.
 8 However, the analytical list for full trip blanks on soil may be limited to volatile organic analysis (VOA),
 9 semivolatile organic analysis, and TPH, depending on resolution/determination of the target analyte list.
 10 Full trip blanks are not required on aquifer sediments being analyzed for metals, mercury, hexavalent
 11 chromium, and strontium-90.

12 **Field transfer blanks** are preserved volatile organic analysis sample containers filled at the sample
 13 collection site with reagent water or silica sand, as appropriate to the primary sample media, transported
 14 to the field. The samples are prepared during sampling to evaluate potential contamination caused by
 15 field conditions. After collection, field transfer blank bottles are sealed and placed in the same storage
 16 container with the samples from the associated sampling event. The field transfer blank samples are
 17 analyzed for volatile organic compounds (VOCs) only.

18 A minimum of one field transfer blank will be collected at each well where the samples will undergo
 19 volatile organic analysis. The field transfer blank will consist of reagent water added to clean sample
 20 containers at the location where the VOC sample was collected. The field transfer blank will be batched
 21 with samples for which volatile organic analysis is being requested.

1 **Equipment rinsate blanks** are collected for reused sampling devices to assess the adequacy of the
2 decontamination process. Equipment blanks will consist of silica sand or reagent water poured over the
3 decontaminated sampling equipment and placed in containers, as identified on the project sampling
4 authorization form. If disposable (e.g., single-use) equipment is used, equipment blanks will not be
5 required.

6 For the field transfer blanks (e.g., full trip blank, field transfer blank, and equipment rinsate), results
7 greater than two times the method detection limit are identified as suspected contamination. However, for
8 common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate
9 esters, the limit is five times the method detection limit. For radiological data, blank results are flagged as
10 suspected contamination if the results are greater than two times the total minimum detectable activity.

11 **Field duplicate** samples are used to evaluate sample consistency and the precision of field sampling
12 methods. Field duplicates are independent samples collected as close as possible to the same point in
13 space and time. Field duplicates are two separate samples taken from the same source, stored in separate
14 containers, and analyzed independently.

15 A minimum of one soil and one aquifer sediment field duplicate will be collected for each day of
16 sampling. The duplicate should be collected generally from an area expected to have some
17 contamination, so valid comparisons between the samples can be made (e.g., at least some of the
18 constituents will be above the detection limit). When sampling is performed from a split spoon, VOC
19 samples and VOC duplicate samples are collected directly from the sampler. The remaining soil/aquifer
20 sediment is then composited in a stainless steel mixing bowl. The soil/aquifer sediment sample and
21 duplicate sample are collected from this composited material.

22 Evaluation of the results can provide an indication of intra-laboratory variability. Evaluation criteria for
23 field duplicate sample results is described in Section 2.2.5.3.

24 A **field split** is a representative sample from a sampling event sent to a third-party laboratory (i.e.,
25 reference laboratory). Evaluation of the results can provide an indication of inter-laboratory variability.
26 Field split sample result evaluation criteria are described in Section 2.2.5.3.

27 **2.2.5.2 Laboratory QC Samples**

28 The laboratory QC samples (e.g., method blanks, laboratory control sample/blank spike, matrix spike) are
29 defined for three-digit EPA methods (EPA/600/4-79/020, *Methods for Chemical Analysis of Water and*
30 *Wastes* and EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples,*
31 *Supplement 1*) and four-digit EPA methods (SW-846, *Test Methods for Evaluating Solid Waste:*
32 *Physical/Chemical Methods, Third Edition; Final Update IV-B*), and will be run at the frequency
33 specified in the respective reference. QC checks outside of control limits will be reflected in the data
34 validation process and during the DQA described in Section 2.4.

35 **2.2.5.3 QC Requirements**

36 If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment
37 rinsate blank is not required. If no VOC samples are collected, then a field transfer blank is not required.
38 Field transfer blanks are not required when simply transferring samples to the field gas chromatograph for
39 analysis.

40 Field duplicate results must agree within 20 percent, as measured by the relative percent difference, to be
41 acceptable. Only those field duplicate results with at least one result greater than five times the
42 appropriate detection limit or minimum detectable activity are evaluated. Large relative percent

1 differences can be an indication of laboratory performance problems and should be investigated.
2 Unacceptable field duplicate results are flagged with a "Q" qualifier in the HEIS database.

3 Field split results must agree within 20 percent, as measured by the relative percent difference, to be
4 acceptable. Only those field split results with at least one result greater than five times the appropriate
5 detection limit or minimum detectable activity are evaluated. Large relative percent differences can be an
6 indication of laboratory performance problems and should be investigated. Unacceptable field split
7 results are qualified and flagged in the HEIS database, as appropriate.

8 For chemical analyses, the acceptance criteria for laboratory duplicates, matrix spikes, matrix spike
9 duplicates, surrogates, and laboratory control samples are stated in Tables 2-2 through 2-5.

10 Holding time is the elapsed time period between sample collection and analysis. Exceeding required
11 holding times could result in changes in constituent concentrations due to volatilization, decomposition,
12 or other chemical alterations. Required holding times depend on the analytical method, as specified for
13 three- and four-digit EPA methods (EPA/600/4-79/020; EPA/600/R-94/111; SW-846). Holding times are
14 specified in laboratory contracts. Data associated with exceeded holding times are flagged.

15 Additional QC measures include laboratory audits and participation in nationally based performance
16 evaluation studies. The laboratories participate in national studies such as the EPA-sanctioned water
17 pollution and water supply performance evaluation studies. The Soil and Groundwater Remediation
18 Project periodically audits the analytical laboratories to identify and solve quality problems or to prevent
19 such problems. Audit results are used to improve performance. Summaries of audit results and
20 performance evaluation studies are presented in the annual groundwater monitoring report
21 (e.g., DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). Failure of QC
22 will be determined and evaluated during data validation and the DQA process. Data will be qualified as
23 appropriate.

24 **2.2.6 Instrument and Equipment Testing, Inspection, and Maintenance**

25 Equipment used for collection, measurement, and testing should meet the applicable standards
26 (e.g., ASTM) or have been evaluated as acceptable and valid in accordance with the procedures,
27 requirements, and specifications. The sampling lead or equivalent will ensure that the data generated
28 from instructions using a software system are backed up and/or downloaded regularly. Software
29 configuration will be acceptance tested before use in the field.

30 Measurement and testing equipment used in the field or in the laboratory that directly affects the quality
31 of analytical data will be subject to preventive maintenance measures to ensure minimization of
32 measurement system downtime. Laboratories and onsite measurement organizations must maintain and
33 calibrate their equipment. Maintenance requirements (such as documentation of routine maintenance)
34 will be included in the individual laboratory and the onsite organization QA plan or operating procedures,
35 as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with
36 three- and four-digit EPA methods (EPA/600/4-79/020; EPA/600/R-94/111; SW-846), or with auditable
37 Hanford Site and contractual requirements. Consumables, supplies, and reagents will be reviewed in
38 accordance with SW-846 requirements and will be appropriate for their use.

39 **2.2.7 Instrument and Equipment Calibration and Frequency**

40 Section 3.4 provides specific field equipment calibration information. Analytical laboratory instruments
41 and measuring equipment are calibrated in accordance with the laboratory's QA plan.

1 **2.2.8 Inspection and Acceptance of Supplies and Consumables**

2 Supplies and consumables used in support of sampling and analysis activities will be procured in
3 accordance with internal work requirements and processes described in the contractor acquisition system.
4 Responsibilities and interfaces necessary to ensure items are procured/acquired for the contractor to meet
5 the specific technical and quality requirements must be in place. The procurement system ensures
6 purchased items comply with applicable procurement specifications. Supplies and consumables are
7 checked and accepted by users before use. Supplies and consumables procured by the analytical
8 laboratories are procured, checked, and used in accordance with the laboratories' QA plans.

9 **2.2.9 Non-direct Measurements**

10 Non-direct measurements include data obtained from sources such as computer databases, programs,
11 literature files, and historical databases. Non-direct measurements will not be evaluated as part of this
12 activity.

13 **2.2.10 Data Management**

14 Sample Management and Reporting, in coordination with the project lead, is responsible for ensuring
15 analytical data are appropriately reviewed, managed, and stored in accordance with the applicable
16 programmatic requirements governing data management procedures. Electronic data access, when
17 appropriate, will be through a database (e.g., HEIS, a project-specific database). Where electronic data
18 are not available, hard copies will be provided in accordance with Section 9.6 of the *Hanford Federal*
19 *Facility Agreement and Consent Order Action Plan* (Ecology et al, 1989b).

20 Laboratory errors are reported to Sample Management and Reporting routinely. For reported laboratory
21 errors, a sample issue resolution form will be initiated in accordance with contractor procedures. This
22 process is used to document analytical errors and to establish resolution with the project lead. The sample
23 issue resolution forms become a permanent part of the analytical data package for future reference and for
24 records management.

25 Planning for sample collection and analysis will be in accordance with the programmatic requirements
26 governing fixed-laboratory sample collection activities, as discussed in sampling procedures. If specific
27 procedures do not exist for a particular work evolution, or it is determined additional guidance is needed
28 to complete certain tasks, a work package will be developed to adequately control the activities, as
29 appropriate. Examples of the sampling procedure requirements include activities associated with the
30 following:

- 31
- 32 • Chain-of-custody/sample analysis requests
 - 33 • Project and sample identification for sampling services
 - 34 • Control of certificates of analysis
 - 35 • Logbooks
 - 36 • Checklists
 - 37 • Sample packaging and shipping.

38 When this SAP is implemented, approved work control packages and procedures will be used to
39 document field activities, including radiological and nonradiological measurements. Field activities will
40 be recorded in the field logbook. Examples of the types of documentation for field radiological data
include the following:

- 41 • Instructions regarding the minimum requirements for documenting radiological controls information
42 in accordance with 10 CFR 835, "Occupational Radiation Protection"

- 1 • Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval
2 of primary contractor radiological records
- 3 • Minimum standards and practices necessary for preparing, performing, and retaining radiological
4 related records
- 5 • Indoctrination of personnel on the development and implementation of sample plans
- 6 • Requirements associated with preparing and transporting regulated material
- 7 • Daily reports of radiological surveys and measurements collected during conduct of field
8 investigation activities. Data will be cross-referenced between laboratory analytical data and
9 radiation measurements to facilitate interpreting the investigation results.

10 **2.3 Assessment and Oversight**

11 The elements included in assessment and oversight address the activities for assessing the effectiveness of
12 project implementation and associated QA and QC activities. The purpose of assessment is to ensure that
13 the QAPjP is implemented as prescribed.

14 **2.3.1 Assessments and Response Actions**

15 Contractor management, regulatory compliance, quality, and/or Health and Safety organizations may
16 conduct random surveillances and assessments to verify compliance with the requirements outlined in this
17 SAP, project work packages, the QAPjP, procedures, and regulatory requirements. Section 2.4 discusses
18 the only planned assessment, a DQA, for the activities identified in this SAP. The results of the DQA
19 will be provided to the project lead.

20 If circumstances arise in the field dictating the need for additional assessment activities, then additional
21 assessments will be performed. Deficiencies identified by these assessments will be reported in
22 accordance with existing programmatic requirements. The project's line management chain coordinates
23 the corrective actions in accordance with the contractor QA program, the corrective action management
24 program, and associated procedures that implement these programs.

25 Oversight activities in the analytical laboratories, including corrective action management, are conducted
26 in accordance with the laboratories' QA plans. The contractor conducts oversight of offsite analytical
27 laboratories and qualifies the laboratories for performing Hanford Site analytical work.

28 **2.3.2 Reports to Management**

29 Reports to management on data quality issues will be made if these issues are identified. Issues reported
30 by the laboratories are communicated to Sample Management and Reporting, which initiates a sample
31 issue resolution form in accordance with contractor procedures. This process is used to document
32 analytical or sample issues and to establish resolution with the project lead. At the end of the project, a
33 DQA report will be prepared to determine whether the type, quality, and quantity of collected data met
34 the quality objectives described in this SAP.

35 **2.4 Data Validation and Usability**

36 The elements under data validation and usability address the QA activities occurring after the data
37 collection phase of the project is completed. Implementation of these elements determines whether the
38 data conform to the specified criteria, thus satisfying the project objectives.

2.4.1 Data Review, Verification, and Validation

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

Data validation will be performed to ensure that the data quality goals established during the planning phase have been achieved. Data validation will be in accordance with internal procedures. The criteria for data validation are based on a graded approach. The primary contractor has defined five levels of validation, Level A through Level E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of data (e.g., calibration data; calculations of representative samples from the dataset). Validation will be performed to contractor Level C, which is a review of the QC data. Level C validation specifically requires verification of deliverables; requested versus reported analyses; qualification of the results based on analytical holding times, method blank results, matrix spike/matrix spike duplicate results, surrogate recoveries, duplicate sample results, and analytical method blank results. Level C validation will be performed on at least 5 percent of the data by matrix and analyte group. Analyte group refers to categories, such as radionuclides, VOCs, semivolatile organic compounds, polychlorinated biphenyls, metals, and anions. The goal is to cover the various analyte groups and matrices during the validation.

Relative to analytical data in sample media, physical data and/or field screening results are of lesser importance in making inferences of risk. Field QA/QC will be reviewed to ensure that physical property data and/or field screening results are usable.

2.4.2 Verification and Validation Methods

Validation activities will be based on EPA functional guidelines. Data validation may be performed by the analytical laboratory, by Sample Management and Reporting, and/or by a party independent of both the data collector and the data user. Data validation qualifiers must be compatible with the HEIS database.

When outliers or questionable results are identified, additional data validation will be performed. The additional validation will be performed for up to 5 percent of the statistical outliers and/or questionable data. The additional validation will begin with Level C and may increase to Levels D and E as needed to ensure that data are usable. Level C validation is a review of the QC data, while Levels D and E include review of calibration data and calculations of representative samples from the dataset. Data validation will be documented in data validation reports. An example of questionable data is if the positive detections are greater than the practical quantitation limit or reporting limit in soil/aquifer sediment from a site that should not have exhibited contamination. Similarly, results less than background would not be expected and could trigger a validation inquiry. The determination of data usability will be conducted and documented in a DQA report. Data validation will be documented in data validation reports, which will be included in the project file.

2.4.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. The results of the DQA will be used in interpreting the data and determining if the objectives of this activity have been met. The DQA will be in accordance with

1 EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide*, and EPA/240-B-06/003, *Data Quality*
2 *Assessment: Statistical Methods for Practitioners*.

3 **2.4.4 Corrective Actions**

4 The responses to data quality defects identified through the DQA process will vary and may be data- or
5 measurement-specific. Some pre-identified corrective actions are identified in Table 2-1.

6

1

2

3

This page intentionally left blank.

3 Field Sampling Plan

Additional details regarding field-specific collection requirements are provided in the following sections.

3.1 Site Background and Objectives

Site background information is presented in Addendum 5. The target analytes and COPCs are presented in Tables 1-2 and 1-3. Section 1.6 of this SAP provides a schedule for implementation. The objective of the field sampling plan is to clearly identify project sampling and analysis activities. The field sampling plan uses the sampling design identified during the systematic planning process and presents the design to identify sampling locations, the total number of samples to be collected, and analyses to be performed.

3.2 Documentation of Field Activities

Logbooks or data forms are required for field activities. Section 2.1.6 provides logbook requirements. Data forms may be used to collect field information. However, the data forms must follow the same requirements as those for logbooks presented below and the data forms must be referenced in the logbooks. The following is a summary of information to be recorded in logbooks:

- Purpose of activity
- Day, date, time, weather conditions
- Names, titles, organizations of personnel present
- Deviations from the QAPjP or procedures
- All site activities, including field tests
- Materials quality documentation (e.g., certifications)
- Details of samples collected (preparation, splits, duplicates, matrix spikes, blanks)
- Location and types of samples
- Chain-of-custody details and variances relating to chain-of-custody
- Field measurements
- Field calibrations and surveys and equipment identification numbers as applicable
- Equipment decontaminated, number of decontaminations, and variations to any decontamination procedures
- Equipment failures or breakdowns and descriptions of any corrective actions
- Telephone calls relating to field activities.

3.3 Sampling Design

As Section 2.2.1 presents, the sampling design is judgmental sampling.

3.4 Calibration of Field Equipment

The sampling lead is responsible for ensuring that field equipment is calibrated appropriately. On-site environmental instruments are calibrated in accordance with manufacturer operating instructions, internal work requirements and processes, and/or work packages that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from instrument calibration activities are recorded in logbooks and/or work packages. Hard copy or electronic versions are acceptable.

1 Calibrations must be performed as follows:

- 2 • Before initial use of a field analytical measurement system
- 3 • At the frequency recommended by the manufacturer or procedure, or as required by regulations
- 4 • Upon failure to meet specified QC criteria.

5 Field instrumentation, calibration, and QA checks will be performed in accordance with the following.

- 6 • As specified in its program documentation, Pacific Northwest National Laboratory calibrates
7 radiological field instruments on the Hanford Site.
- 8 • Daily calibration checks will be performed and documented for each instrument used to characterize
9 areas under investigation. These checks will be made on standard materials sufficiently like the
10 matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish
11 detection efficiency and resolution.

12 **3.5 Sample Location and Frequency**

13 The purpose of this section is to identify the sampling locations and frequencies and define the sampling
14 and analysis requirements for samples and measurements to be collected. Figure 1-1 shows the location
15 of the planned groundwater monitoring wells described in this SAP. Figure 1-2 shows the spatial and
16 temporal uncertainty groundwater monitoring well network described in this SAP. The actual locations
17 of new groundwater monitoring wells will be determined based on a field walkdown of current site
18 conditions to avoid Hanford Site National Historic restrictions, roads, and other obstructions.

19 **3.5.1 Vadose Zone Characterization**

20 Samples will be collected from boreholes and groundwater wells to support characterization of the vadose
21 zone and groundwater as outlined in Table 1-1. Vadose zone and deep vadose zone samples will be
22 collected for characterization during installation of each new groundwater well. These activities are
23 planned to characterize the nature and vertical extent of contamination in the vadose zone, characterize
24 the physical properties of soil/aquifer sediments and verify contaminant distribution coefficients to
25 support modeling and an assessment of risk. The data from the activities will be used to verify the
26 adequacy of interim remedial actions and refine the preliminary conceptual site model of the 100-N
27 Decision Unit.

28 The scope of vadose zone characterization efforts includes field screening, collecting and analyzing soil
29 samples from the vadose zone, collecting and analyzing aquifer sediment, performing groundwater
30 sampling and analysis, and performing geophysical logging. The sampling frequency will be continuous
31 within 3.1 m (10 ft) of the vadose zone-groundwater interface. Vadose zone samples will be collected
32 according to the sampling scheme shown in Table 3-1. The sampling scheme for deep vadose zone
33 samples at groundwater wells includes collecting soil/aquifer sediment samples above and at the water
34 table. Additional samples may be collected based on observations made in the field.

35 Physical property samples will be collected to provide site-specific values to support modeling efforts.
36 The physical property samples will be collected from lithologies representing major facies and
37 surrounding the Hanford Ringold contact. The physical property samples will be collected in conjunction
38 with split-spoon sample intervals, where possible.

39 **3.5.1.1 Field Screening**

40 Radiological field screening data, visual observation of lithologies, visual observation of contamination,
41 or site geologist professional judgment may be used to adjust sampling points presented in Table 3-1,

1 assist in determining sample shipping requirements, and support worker health and safety monitoring.
2 Section 3.6.3 describes radiological field screening methods.

3 **3.5.1.2 Geophysical Logging**

4 The planned boreholes and groundwater monitoring wells will be geophysically logged with the
5 high-resolution, spectral gamma-ray logging system to determine the vertical distribution and
6 concentration of gamma-emitting radionuclides. Soil moisture will be determined using a neutron
7 logging tool. The groundwater monitoring wells will be logged before the casing is telescoped. The
8 starting point for logging will be recorded; this is usually at the ground surface or the top of the casing.

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement ^a		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^b	Properties of Interest	Sample Interval Depth (ft bgs)	Analyte List
<p>Well 1</p> <p>Install borehole reaching a total depth approximately 5 ft into the RUM and screened in the unconfined aquifer in the 100-N Area.</p> <p>Justification. Proposed to further define a Sr-90 hot spot.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^d</p>	<p>Geologic archive samples^d</p>	<p>During drilling, samples to be collected at 5-ft intervals throughout approximately 30-ft-thick unconfined aquifer (<u>6 samples</u>)</p>	<p>Constituents and field screening parameters in accordance with Table 2-5</p>
	<p>20-22.5, 25-27.5, 30-32.5, 35-37.5, 40-42.5, 45-47.5, 50-52.5, 55-57.5, 60-62.5, 62.5-65, 65-67.5, 67.5-70, 70-72.5 (75-77.5 ft aquifer sediment sample^b) by split spoon (<u>14 samples</u>)</p>	<p>Target analytes, field screening parameters, and batch leach test in accordance with Table 2-2</p> <p>Sediment sample will only be analyzed for metals and Sr-90 in accordance with Table 2-2</p>	<p>During drilling, 75-77.5 ft or 5 ft below water table^b (<u>1 filtered groundwater sample</u>)</p>	<p>Metals and Sr-90 in accordance with Table 2-5</p>
	<p>During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon (<u>8 samples</u>)</p>	<p>Radiological methods, field screening parameters, and batch leach test in accordance with Table 2-2</p>		
	<p>Major formation and lithology changes 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (<u>4 samples</u>)</p>	<p>Physical properties in accordance with Table 2-2</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement ^a		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^b	Properties of Interest	Sample Interval Depth (ft bgs)	Analyte List
<p>Well 2</p> <p>Install borehole reaching a total depth approximately 5 ft into the RUM and screened in the unconfined aquifer in the 100-N Area.</p> <p>Justification. Proposed to define the extent of petroleum primarily in the re-wetted zone adjacent to well 199-N-18.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^d</p>	<p>Geologic archive samples</p>	<p>During drilling, samples to be collected at 5-ft intervals throughout approximately 25-ft-thick unconfined aquifer^c (5 samples)</p>	<p>Constituents and field screening parameters in accordance with Table 2-5</p>
	<p>During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon (8 samples)</p>	<p>Target analytes, field screening parameters, and batch leach test in accordance with Table 2-3</p>	<p>During drilling, 75-77.5 ft or 5 ft below water table^c (1 filtered groundwater sample)</p>	<p>Metals and Sr-90 in accordance with Table 2-5</p>
	<p>Major formation and lithology changes 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (4 samples)</p>	<p>Physical properties in accordance with Table 2-3</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement ^a		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^b	Properties of Interest	Sample Interval Depth (ft bgs)	Analyte List
<p>Well R1</p> <p>Install well reaching a total depth approximately 50 ft within the RUM and screened in the first water bearing unit of the RUM in the 100-N Area.</p> <p>Justification. Proposed to characterize the RUM.</p>	<p>During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings.^d</p>	<p>Geologic archive samples</p>	<p>During drilling, samples to be collected at 5-ft intervals throughout approximately 30-ft-thick unconfined aquifer and one sample to be collected during drilling from a water-bearing interval of the RUM unit if sufficient water is available (<u>7 samples</u>)</p>	<p>Constituents and field screening parameters in accordance with Table 2-5</p>
	<p>During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, at the bottom of the unconfined aquifer and from the top, middle, and bottom of the non-water-bearing units of the RUM unit by split spoon (<u>10 samples</u>)</p>	<ul style="list-style-type: none"> • Target analytes, field screening parameters, and batch leach test in accordance with Table 2-4 • Sediment samples will be analyzed for metals and Sr-90 in accordance with Table 2-4 	<p>During drilling, 75-77.5 ft or 5 ft below water table^c (<u>1 filtered groundwater sample</u>)</p>	<p>Metals and Sr-90 in accordance with Table 2-5</p>
	<p>Major formation and lithology changes 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (<u>4 samples</u>)</p>	<p>Physical properties in accordance with Table 2-4</p>		

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement ^a		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^b	Properties of Interest	Sample Interval Depth (ft bgs)	Analyte List
Well R2 Install well reaching a total depth approximately 50 ft within the RUM and screened in the first water bearing unit of the RUM in the 100-N Area Justification. Proposed to characterize the RUM.	During drilling, samples will be grab collected every 5 ft or where lithology changes occur in one pint jar and a chip tray from the drill cuttings. ^d	Geologic archive samples	During drilling, samples to be collected at 5-ft intervals throughout approximately 30-ft-thick unconfined aquifer and one sample to be collected during drilling from a water-bearing interval of the RUM unit if sufficient water is available (<u>7 samples</u>)	Constituents and field screening parameters in accordance with Table 2-5
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, at the bottom of the unconfined aquifer and from the top, middle, and bottom of the non-water-bearing units of the RUM unit by split spoon (<u>10 samples</u>)	<ul style="list-style-type: none"> • Target analytes, field screening parameters, and batch leach test in accordance with Table 2-4 • Sediment samples will be analyzed for metals and Sr-90 in accordance with Table 2-4 	During drilling, 75-77.5 ft or 5 ft below water table ^c (<u>1 filtered groundwater sample</u>)	Metals and Sr-90, and mercury in accordance with Table 2-5
	Major formation and lithology changes 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (<u>4 samples</u>)	Physical properties in accordance with Table 2-4		
Sample 18 spatial/temporal uncertainty monitoring wells (Table 3-2); multiple rounds Total number of samples	None	None	Three rounds of sampling will be occur that will represent low, high, and transition river stages (18 wells x 3 rounds = 54 samples).	Constituents and field screening parameters in accordance with Table 2-5

Table 3-1. Sample/Measurement Locations and Depth

Sampling Location	Soil/Aquifer Sediment Sample/Measurement ^a		Water Sample/Measurement	
	Sample Interval Depth (ft bgs) ^b	Properties of Interest	Sample Interval Depth (ft bgs)	Analyte List
Number of samples	<u>Soil/Aquifer sediment chemical</u> : 50 <u>Physical property</u> : 16 <u>Geologic archive samples</u> : variable		<u>Water samples collected during drilling</u> : 29 <u>Spatial/temporal uncertainty samples</u> : 54 (3 rounds total)	
Minimum number of field quality control samples	<u>Soil/Aquifer sediment chemical</u> : 10 (3 equipment blank, 3 field blank, 3 duplicate, 1 split) <u>Physical property</u> : 0 <u>Geologic archive samples</u> : 0		<u>Water samples collected during drilling</u> : 7 (2 equipment blank, 2 field blank, 2 duplicate, 1 split) <u>Spatial/temporal uncertainty samples</u> : 10 (3 equipment blank, 3 field blank, 3 duplicate, 1 split)	
Total number of samples	<u>Soil/aquifer sediment chemical</u> : 60 <u>Physical property</u> : 16 <u>Geologic archive samples</u> : variable		<u>Water samples collected during drilling</u> : 36 <u>Spatial/temporal uncertainty samples</u> : 64	

- a. Boreholes and groundwater monitoring wells will be logged with a neutron moisture tool and the high-resolution, spectral gamma ray logging system. Geologic samples will also be logged.
- b. Upon visual observation of contamination, a depth discrete sample will be collected for applicable analysis. For example, if hexavalent chromium contamination is observed at any interval other than those stated for sampling, a depth discrete sample would be collected for hexavalent chromium analysis.
- c. This sample is intended to be collected from 5 ft into the unconfined aquifer.
- d. Archive samples may be omitted at the discretion of the field geologist due to radiological field data.

bgs = below ground surface

Sr-90 = strontium-90

RUM = Ringold Upper Mud

1 **3.5.2 Groundwater Characterization**

2 Groundwater characterization, including well activities, identification of wells to be sampled, well depth
3 and screen placement, and well drilling and completion procedures, is discussed in this section.

4 **3.5.2.1 New Groundwater Wells**

5 Table 3-1 summarizes groundwater well activities. From each new well screened in the Ringold Upper
6 Mud unit, slug tests will be performed after development. Larger scale pumping tests will be planned for
7 groups of wells based on the results of the slug tests and proximity to key waste sites.

8 **Well Depth and Screen Placement**

9 For the two new groundwater wells in the unconfined aquifer in the 100-N Area, a 6.1 m (20-ft) screen
10 will be installed and centered so the middle of the screen is at the water table. For the two new deep
11 groundwater wells in the 100-N Area, up to a 6.1 m (20-ft) screen will be installed based on ability to
12 produce water in the water-bearing Ringold Upper Mud unit.

13 **Well Drilling and Completion Procedures**

14 Well drilling will be performed in accordance with WAC 173-160. The wells will be drilled using
15 25.4 cm (10-in.)-diameter (or larger) casing to total depth. The drilling method will be determined based
16 on discussions between the drilling lead and drilling contractor.

17 The wells will be constructed as 15 cm (6-in.) wells with Schedule 10, Type 304 or 316 stainless-steel,
18 V-slot continuous wire wrap screen, atop a 1.5 m (5-ft)-long, stainless steel sump with end cap.

19 A Schedule 10 stainless steel riser will be used to extend the permanent well into the vadose zone, with
20 Schedule 10 carbon steel casing through the vadose zone to ground surface. Colorado silica sand will be
21 used for the sand pack; sodium bentonite pellets and/or natural sodium bentonite chunks, crumbles, or
22 powdered bentonite will be used for bentonite sealing material; and Type I/II Portland cement will be
23 used for cement grout.

24 Surface construction consisting of protective casing, protective guard posts, and cement pad must be in
25 place before job completion. The protective casing shall be a minimum of 5 cm (2 in.) larger in diameter
26 than the permanent casing. Protective casing will rise approximately 0.9 m (3 ft) above the ground
27 surface. Permanent casing will rise to approximately 0.3 m (1 ft) below the top of the protective casing.
28 Protective casing will have a lockable well cap extending approximately 38 cm (15 in.) above the top of
29 the protective casing.

30 Final well design, including well screen placement and length, will be determined by concurrence of the
31 field geologist, drilling lead, and operable unit lead based upon field conditions. If the completion is
32 different from WAC 173-160 requirements, then variances will be obtained from Ecology.

33 **3.5.2.2 Spatial and Temporal Uncertainty Groundwater Network Development**

34 Table 3-1 summarizes spatial and temporal uncertainty groundwater well activities. Table 3-2 presents
35 spatial and temporal uncertainty monitoring wells to be sampled. Three spatial and temporal uncertainty
36 groundwater sample rounds, or events, will be performed to support the temporal uncertainty evaluation
37 at the 100-N Decision Unit for the RI.

Table 3-2. Spatial and Temporal Uncertainty Groundwater Monitoring Well Network

Well Numbers				
199-K-37	199-N-14	199-N-69	199-N-71	699-73-61
199-K-151	199-N-16	199-N-50	199-N-74	699-77-54

Table 3-2. Spatial and Temporal Uncertainty Groundwater Monitoring Well Network

Well Numbers				
199-K-152	199-N-19	199-N-51	199-N-81	699-87-55
199-K-182	199-N-32		199-N-165	

1 To determine spatial and temporal risk uncertainty for potential human and ecological receptors, the RI
 2 process requires that the groundwater be sampled, providing data representative of aquifer conditions. It is
 3 required that the groundwater be sampled throughout a decision unit without regard to the location of
 4 surface facilities or known groundwater plumes. If there are temporal changes in groundwater conditions,
 5 samples must be collected to capture these varying stages to properly delineate temporal risk uncertainties
 6 to potential receptors. The following discussion explains the method used to develop both the number and
 7 location of sampling points along with the sampling frequency for the 100-N Decision Unit to support the
 8 RI. The resulting well network data will be used to evaluate the groundwater risk information presented in
 9 DOE/RL-2007-21, *Risk Assessment report for the 100 Area and 300 Area Component of the River*
 10 *Corridor Baseline Risk Assessment*. Observations and conclusions regarding the data collected and the
 11 DOE/RL 2007 21 evaluation will be documented in the RI report (e.g., risk uncertainties associated with
 12 temporal and spatial representativeness, verifying groundwater risk conclusions, ensuring no
 13 contaminants were inadvertently overlooked, and establishing a "present condition" dataset that can be
 14 used to measure the progress of future cleanup actions).

15 **Sample Number and Location**

16 Sampling well locations within a groundwater decision unit must be identified to spatially represent all of
 17 the areas within a decision unit, regardless of facility or known contaminant plume locations. These
 18 sampling networks should represent locations where human or ecological receptors could potentially
 19 encounter groundwater. The primary pathway for human exposure is through direct contact with
 20 groundwater obtained from a residential or community water well. Identification of sampling locations to
 21 assess the direct exposure pathways is to assume development of the land for future human habitation.
 22 With this scenario as a guide to assessing a viable sampling grid of plausible groundwater pathways, land
 23 use regulations were used to develop a reasonable network of supply wells for each decision unit, based
 24 on state regulations and site-specific hydrologic properties. This approach resulted in a sampling grid and
 25 corresponding network of monitoring wells tailored for each decision unit. As part of this semi-
 26 quantitative approach, the locations of community water delivery systems were developed to meet not
 27 only the negotiated Tri-Party land use needs but also State of Washington requirements.

28 Rules and regulations of the Washington State Department of Health (DOH) regarding public water
 29 supplies, WAC 246-290, "Group A Public Water Supplies," are explained in the associated guidance
 30 document, DOH 331-123, *Water System Design Manual*. This manual is maintained by the DOH and
 31 provides the necessary information on specifications to develop groundwater resources for human use.
 32 By applying these specifications to the possible locations of water supply wells that might act as complete
 33 exposure pathways, the number and spacing of sampling locations is determined with credibility for each
 34 decision unit, providing justified and defensible monitoring networks.

35 Based on remedial action goals for *Interim Remedial Action Record of Decision for the 100-NR-1 and*
 36 *100-NR-2 Operable Units of the Hanford 100-N Area* (EPA/ROD/R-99/112), the assumption for future
 37 habitation is families will live on the land, grow a garden, and raise livestock to provide approximately 25
 38 percent of the family's food requirements. This land usage places specific state and daily water
 39 requirements for each residence. Because the remedial action goals are based on groundwater restored to
 40 highest beneficial use (i.e. drinking water), the *Washington Growth Management Act* requires each

1 residence occupy at least one acre of land. It is also assumed that at least a 5-acre plot per unit is
2 necessary to raise livestock. Thus, each residence in the following scheme assumes a family plot size of 5
3 acres.

4 Therefore, residential water usage must be sufficient to supply not only in-house needs but also to irrigate
5 a large garden and to water livestock. For a water well that supplies one residence, Ecology requires a
6 minimum of 1,514.2 liters per day (L/day) (400 gallons per day [gal/day]). Thus, an extreme lower limit
7 is established for in-house use. However, for a communal system, which the DOH regulates, guidance on
8 the daily water use is found in DOH 331-123. One of the key parameters for estimating potential water
9 use is the lot size of the individual residence.

10 Another important consideration is location of the well within the state because of climate differences east
11 and west of the Cascade Mountains. Based on utility records in eastern Washington, which has a
12 dominantly arid climate, a residence's maximum day demand is 5,675 L/day (1,500 gal/day) for lot sizes
13 in excess of 2.5 acres. Although values as high as 30, 283.3 L/day (8,000 gal/day) have been recorded,
14 the historical sizing guideline of 5,675 L/day (1,500 gal/day) has generally been adequate. With the
15 information on requirements for residential water supplies, the number of possible supply wells and thus
16 the number of sampling points is calculated based on how much water the local aquifer is expected to
17 produce.

18 To provide the number of sampling points for the well network, the average groundwater yields,
19 calculated from pump tests conducted at each decision unit, are used to determine the number of
20 residences supported on one supply well. Thus the grid size specific to each decision unit is determined.
21 Use of a random grid generator provides approximate locations for sampling points based on the final
22 number of sampling points and the total area of each decision unit. To the degree possible, one well
23 within each grid was chosen to represent the potential exposure pathway; thereby providing a network of
24 sampling points to provide a spatially representative sampling network of groundwater wells.

25 In addition to determining the maximum number and location of potential exposure pathways, additional
26 wells were added to networks to define potential exposures associated with known contaminant plumes.
27 Current monitoring wells were chosen to provide data on maximum contaminant levels and to define
28 plume extents. For decision units with active remedial activities, extraction/injection and chemical
29 treatment wells were not included in any of the well networks. The pump and treat wells are not
30 configured for routine sampling and the chemical treatment wells are not representative of ambient
31 groundwater conditions.

32 ***Sampling Frequency***

33 To capture baseline aquifer conditions fully, it is required that samples represent not only spatial
34 variations but also changes that occur over time. Near the river, these varying conditions are observed as
35 changes in groundwater flow, both direction and rate, causing temporary movement of contaminants
36 through different portions of the unconfined aquifer. For decision units bordering on the Columbia River,
37 the changing aquifer conditions are caused by fluctuating river elevations associated with flood control
38 and hydroelectric production. For representing baseline groundwater conditions, samples are required to
39 represent these varying aquifer conditions associated with high, low, and mid-point or transitional river
40 elevations. The date and frequency of sample collection is based on measurements of the river elevation
41 to optimize collection of samples representing these temporal changes in groundwater conditions.

42 ***Effect of River Elevation on Groundwater Conditions***

43 Along the Columbia River, rapid, periodic, or cyclic elevation fluctuations of the river occur in controlled
44 response to flood conditions, hydroelectric production, and salmon spawning programs at a series of dams
45 and reservoirs upriver of the Hanford Site. These rapid elevation changes in the river cause periodic

1 influences on flow conditions within the aquifer. For example, there are two times during a calendar year
2 when the river elevation peaks and two times the river elevation is low. The highest river elevation
3 occurs in early June when water is released from reservoirs that have reached capacity from the melting
4 snow pack in the Cascade Mountains. The lowest river elevation is engineered in late September to early
5 October to encourage salmon spawning in low pockets of the river bottom along the Hanford Reach.

6 When water is released upriver, the river elevation rises above the elevation of the local aquifer causing
7 movement of water from the river into the aquifer. At this time, the flow direction in the aquifer is
8 modified from the ambient condition and varies with local conditions along the river. This flow from the
9 river brings cleaner river water into the groundwater causing a temporary reduction in contaminant levels
10 in monitoring wells near the river.

11 When the river elevation is artificially lowered to a level below the aquifer by holding water back in the
12 upriver reservoirs, groundwater moves from the aquifer into the river. The river then recharges from the
13 aquifer, causing a change in the flow direction to roughly perpendicular to the river's edge, once again
14 varying with specific locations along the river. These changes in direction may bring contaminated
15 groundwater through observation wells at certain places and into the river. Thus, near the
16 river/groundwater interface, the flow direction and rate change with time. The effect on aquifer
17 conditions is greatest when the river peaks in June and, again, at its lowest level in late September to early
18 October. To capture these temporal effects on contaminant plumes within the aquifer from the low river
19 elevation, groundwater sampling should be conducted prior to late October.

20 Inland from the river, the rapid river elevation changes form a pressure pulse that appears to be
21 transmitted along the free surface of the unconfined aquifer. This effect causes groundwater elevation
22 changes in wells not affected by actual movement of aquifer water. For some places, the elevation
23 increase may allow the groundwater to interact with contaminated soils located just above the water table.
24 The timing of these periodic or cyclic river elevation changes determines the sampling frequency required
25 to represent the temporal variations in groundwater conditions.

26 **Groundwater Sampling Dates**

27 Because the goal of the temporal uncertainty groundwater sampling is to determine groundwater
28 conditions when the river has the maximum effect on flow rate and direction, sampling is scheduled for
29 late May to mid-June during the highest peak and from late September to late October during the time of
30 the lowest elevation. From the second week in June to mid-September, the river elevation is in transition,
31 decreasing from the maximum elevation to the lowest elevation. Also from March through April,
32 elevations change from low to the high that occur in the first week of June. Consequently, the best
33 opportunity to capture transitional conditions occurs during the months of March and April or July and
34 August.

35 Based on the previous discussion, three sampling events are recommended to represent the temporal
36 fluctuations in groundwater conditions at each of decision units located along the river corridor. One
37 sampling event captures the effect on the aquifer when the river stage is highest and the greatest increase
38 in aquifer elevation occurs (May to mid-June). The second sampling interval ranges from mid-September
39 to mid-October when the river is at the lowest elevation for the year. This period is when contamination
40 from the aquifer might be affecting the river. The third sampling point represents the mid-point or
41 transitional aquifer conditions occurring from either March through April or July through August. Thus,
42 the groundwater sampling schedules, which support the temporal uncertainty evaluation for the RI/FS at
43 each decision unit along the river, capture the maximum effects of changing river elevations on aquifer
44 conditions as well as the transitional time between the maximum and minimum changing conditions.

3.6 Sampling Methods

Soil/aquifer sediment sampling will be performed in accordance with approved procedures for soil and aquifer sediment sampling using a 10.2 cm (4 in.) split-spoon sampler. The split-spoon samplers will be equipped with separate stainless steel or polycarbonate liners. Site personnel will not override the sampling device. Samples for VOCs will be packaged first. Next, the remaining soil/aquifer sediment will be transferred to a pre-cleaned, stainless steel mixing bowl or other suitable pre-cleaned container, homogenized, then containerized in accordance with the sampling procedure. If sample volume requirements cannot be met, samples will be collected according to the following priority, except at Well 4, as applicable: strontium-90, metals (including mercury), batch leach test, tritium, technetium-99, other radionuclides, TPH, VOCs, semivolatile organic compounds, anions, and hydraulic properties. At Well 4, if sample volume requirements cannot be met, samples will be collected according to the following priority: TPH/diesel oil and motor oil, hydraulic properties, polycyclic aromatic hydrocarbons, batch leach test, and TPH/gasoline range.

Groundwater samples collected during drilling, before development, will be pumped from selected intervals. The pump will be operated for a period of time sufficient to provide stabilized field readings, but not necessarily three casing volumes.

For the spatial and temporal uncertainty groundwater monitoring well network, before sample capture, the pump will be operated for a period of time sufficient to provide stabilized field readings, and at least three casing volumes. Groundwater sampling from completed wells will be performed to support the spatial and temporal uncertainty investigation in accordance with field sampling, sample handling, and documentation activities per HASQARD (DOE/RL-96-98) requirements. Samplers fill out groundwater sample report forms during purging and sampling activities at each well. Field personnel measure water levels in each well before sampling and then purge stagnant water from the well. Water levels are typically measured with laminated-steel electrical sounding tapes with a precision of 2 mm. Procedures require sample collection after three casing volumes of water have been purged from the well and after field parameters (e.g., pH, temperature, specific conductance, and turbidity) have stabilized.

Measurement of field parameters is described in Table 2-5. Field parameters are typically measured in a flow-through container; however, when there is insufficient flow, samplers will measure field parameters in an open container. Both filtered and unfiltered samples are collected for metals analyses. Filtering is performed in the field to ensure that results represent dissolved metals and do not include particulates.

Sample preservation techniques will follow generally accepted practices (e.g., EPA-approved guidelines such as SW-846, or equivalent) and will be documented in sample authorization forms generated by the Sample Management and Reporting organization. Identification of preliminary sample preservatives is presented in Table 3-4.

3.6.1 Corrective Actions and Deviations for Sampling Activities

The project lead, sampling lead, drilling lead, or designee must document deviations from procedures or other problems pertaining to sample collection, chain-of-custody, target analytes, COPCs, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action procedures. The project lead, sampling lead, drilling lead, or designee will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

1 More significant changes in sample locations not affecting the data needs will require notification and
2 approval of the project lead. Changes to sample locations resulting in impacts to meeting the data needs
3 will require concurrence with DOE and regulator project leads. Changes to the SAP will be documented
4 as noted in Section 2.1.6.

5 **3.6.2 Decontamination of Sampling and Drilling Equipment**

6 Sampling equipment will be decontaminated in accordance with the sampling equipment decontamination
7 procedure. To prevent contamination of the samples, care should be taken to use clean equipment for
8 each sampling activity. Special care should be taken to avoid the following common ways in which
9 cross-contamination or background contamination may compromise the samples:

- 10 • Improperly storing or transporting sampling equipment and sample containers
- 11 • Contaminating the equipment or sample container by setting the equipment or sample container on or
12 near potential contamination sources (e.g., uncovered ground)
- 13 • Handling bottles or equipment with dirty hands or gloves
- 14 • Improperly decontaminating equipment before sampling or between sampling events. Field
15 decontamination (e.g., field washing and reuse) is not appropriate for sampling equipment.

16 The drill rig derrick, all downhole equipment, and temporary casing will be field decontaminated
17 (e.g., high pressure and temperature), at a minimum, before mobilization and demobilization.

18 **3.6.3 Radiological Field Data**

19 Alpha and beta/gamma data collection in the field will be used as needed to support sampling and
20 analysis efforts. Generally, cuttings from boreholes (excluding slough) will be field screened for evidence
21 of radiological contamination. Screening will be conducted visually and with field instruments.
22 Radiological screening will be performed by the radiological control technician or other qualified
23 personnel. The radiological control technician will record field measurements, noting the depth of the
24 sample and the instrument reading. Measurements will be relayed to the field geologist for inclusion into
25 the field logbook or operational records daily, as applicable.

26 The following information will be distributed to personnel performing work in support of this SAP.

- 27 • Instructions to radiological control technicians on the methods required to measure sample activity
28 and media for gamma, alpha, and/or beta emissions, as appropriate.
- 29 • Information regarding the Geiger-Müller, portable alpha meter, dual phosphors beta/gamma, and
30 sodium iodide portable instruments, will include a physical description of the instruments, radiation
31 and energy response characteristics, calibration/maintenance and performance testing descriptions,
32 and the application/operation of the instrument. These instruments are commonly used on the
33 Hanford Site for obtaining measurements of removable surface contamination measurements and
34 direct measurements of the total surface contamination.
- 35 • Information on the characteristics associated with the hand-held probes to be used in the performance
36 of direct radiological measurements will include a physical description of the probe, the radiation and
37 energy response characteristics, calibration/maintenance and performance testing descriptions, and
38 the application/operation of the instrument. The hand-held probe is an alpha detection instrument
39 commonly used on the Hanford Site for obtaining removable surface contamination measurements
40 and direct measurements of the total surface contamination.

3.7 Sample Handling

Sampling handling, including container packaging, container labeling, sample custody, and sample transportation, is discussed in this section.

3.7.1 Sample Packaging

Level I EPA pre-cleaned sample containers will be used for soil/aquifer sediment and water samples collected for chemical analysis. Container sizes may vary depending on laboratory specific volumes and requirements for meeting analytical detection limits. Radiological Engineering will measure the contamination levels and dose rates associated with the sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the sampling lead, in consultation with Sample Management and Reporting, can send smaller volumes to the laboratory. Preliminary container types and volumes are identified in Tables 3-3 and 3-4.

Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
Gamma energy analysis	None	6 months	G/P	750 g
Liquid scintillation counter	None	6 months	G	33 g
Strontium-90	None	6 months	G/P	5 g
Gas flow proportional counting	None	6 months	G/P	5 g
Isotopic Plutonium	None	6 month	G/P	5 g
EPA 6010	Cool ~4°C (~39°F)	6 months	G/P	15 g
EPA 7471	None	28 days	G/P	15 g
EPA 8310	Cool ~4°C (~39°F)	14/40 day	aG	120 g
EPA 300.0	Cool ~4°C (~39°F)	48 hours/28 days ^e	G/P	50 g
NWTPH-D+	Cool ~4°C (~39°F)	14 days	G	50 g
WTPH-G	Cool ~4°C (~39°F)	14 days	G	50 g
ASTM D2216-05	None	None	Moisture-proof container	200 g
ASTM D2937-04	None	None	G/P	1,000 g
ASTM D2434-68	None	None	P	1,000 g
ASTM D5084-03	None	None	P	1,000 g
Batch leach test	Cool ~4°C (~39°F)	28 days from field to extraction	G	100 g/120 mL
Distribution coefficient	Cool ~4°C (~39°F)		Moisture-proof container	250 g
ASTM D422-63	None	None	G/P	1,000 g

* Based on minimum quality control requirements.

For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*.

For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

ASTM D422-63, *Standard Test Method for Particle-Size Analysis of Soils*.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock*

Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
<i>by Mass.</i>				
ASTM D2434-68, <i>Standard Test Method for Permeability of Granular Soils (Constant Head)</i> .				
ASTM D2937-04, <i>Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method</i> .				
ASTM D5084-03, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i> .				
14/40 days	=	14 days to extraction, then 40 days to analysis		
48 hours/28 days	=	48 hours for nitrate, nitrite, and phosphate; 28 days for others		
aG	=	amber glass		
G	=	glass		
NWTPH-D	=	Northwest total petroleum hydrocarbon – diesel		
P	=	plastic		
WTPH-G	=	Washington total petroleum hydrocarbon – gasoline		

1

Table 3-4. Sample Preservation, Container, and Holding Time for Water Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
Gamma Spec	HNO ₃ to pH < 2	6 months	G/P	500 mL
Strontium-90	HNO ₃ to pH < 2	6 months	G/P	2,000 mL
Tritium (H-3)	None	6 months	G	60 mL
EPA 6020 or EPA 200.8	HNO ₃ to pH < 2	6 months	G/P	300 mL
EPA 6010	HNO ₃ to pH < 2	6 months	G/P	300 mL
EPA 7196	Cool ~4°C (~39°F)	24 hours	aG	500 mL
EPA 7470 or 200.8	HNO ₃ to pH < 2	28 days	G	500 mL
EPA 8260	Cool ~4°C (~39°F) HCl or H ₂ SO ₄ to pH < 2	14 days	aGs	40 mL
EPA 8081	Cool ~4°C (~39°F)	7/40 days	aG	3,000 mL
EPA 335.2 or EPA 9012	Cool ~4°C (~39°F) NaOH to pH >= 12	14 days	G/P	250 mL
WTPH-D	Cool ~4 C (~39°F) HCl to pH < 2	14/40 days	aG	3,000 mL
WTPH-G	Cool ~4 C (~39°F) HCl to pH < 2	14 days	aGs	160 mL
EPA 300.0	Cool ~4°C (~39°F)	48 hours/28 days	P	125 mL

* Based on minimum quality control requirements.

For EPA Method 200.8, see EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*.For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition: Final Update IV-B*.

7/40 days = 7 days to extraction, then 40 days to analysis

14/40 days = 14 days to extraction, then 40 days to analysis

Table 3-4. Sample Preservation, Container, and Holding Time for Water Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
48 hours/28 days	=	48 hours for nitrate, nitrite, and phosphate; others, 28 days		
aG	=	amber glass		
aGs	=	amber glass septum; no headspace		
G	=	glass		
NWTPH-D	=	Northwest total petroleum hydrocarbon – diesel		
P	=	plastic		
WTPH-G	=	Washington total petroleum hydrocarbon – gasoline		

1 **3.7.2 Container Labeling**

2 The sample location, depth, and corresponding HEIS numbers are documented in the sampler’s field
3 logbook. A custody seal (e.g., evidence tape) is affixed to each sample container and/or the sample
4 collection package in such a way as to indicate potential tampering. Each sample container will be
5 labeled with the following information on firmly affixed, water-resistant labels:

- 6 • HEIS number
- 7 • Sample collection date and time
- 8 • Analysis required
- 9 • Preservation method (if applicable)
- 10 • Sampling authorization form number.

11 In addition to the above information, sample records must include the following:

- 12 • Analysis required
- 13 • Source of sample
- 14 • Matrix
- 15 • Field data (pH, radiological readings).

16 Except for volatile organic analysis samples, a custody seal (i.e., evidence tape) will be affixed to the lid
17 of each sample container. The custody seal will be inscribed with the sampler’s initials and the date.
18 Custody seals are not applied directly to volatile organic analysis vials because of a potential for affecting
19 analytical results and/or fouling of laboratory equipment. Custody seals and any other required labels or
20 documentation can be fixed to the exterior of a plastic bag holding vials in such a manner to detect
21 potential tampering.

22 **3.7.3 Sample Custody Requirements**

23 Sample custody will be maintained in accordance with existing Hanford Site protocols to maintain sample
24 integrity throughout the analytical process. Chain-of-custody procedures will be followed throughout
25 sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-
26 of-custody record will be initiated in the field at the time of sampling and will accompany each set of
27 samples shipped to the laboratory. Shipping requirements will determine how sample shipping containers
28 are prepared for shipment. The analyses requested for each sample will be indicated on the
29 accompanying chain-of-custody form. Each time the responsibility changes for the custody of the
30 sample, the new and previous sample custodians will sign the record and note the date and time. The

1 sampler will make a copy of the signed record before sample shipment and will transmit the copy to
2 Sample Management and Reporting within 48 hours of shipping.

3 The following information is required on a completed chain-of-custody form:

- 4 • Project name
- 5 • Signature of sampler
- 6 • Unique sample number
- 7 • Date and time of collection
- 8 • Matrix
- 9 • Preservatives
- 10 • Signatures of individual involved in sample transfer
- 11 • Requested analyses or reference thereto.

12 **3.7.4 Sample Transportation**

13 Sample transportation will be in compliance with the applicable regulations for packaging, marking,
14 labeling, and shipping hazardous materials, hazardous substances, and hazardous waste mandated by the
15 U.S. Department of Transportation (49 CFR 171, "General Information, Regulations, and Definitions,"
16 through Part 177, "Carriage By Public Highway") in association with the International Air Transportation
17 Authority, DOE requirements, and applicable program-specific implementing procedures.

18 **3.8 Management of Waste**

19 All waste (including unexpected waste) generated by sampling activities will be managed in accordance
20 with DOE/RL-2004-30, *Waste Control Plan for the 100-BC-5 Operable Unit*. Pursuant to 40 CFR
21 300.440, "Procedures for Planning and Implementing Off-Site Response Actions," approval from the lead
22 regulatory agency Remedial Project Manager is required before returning unused samples or waste from
23 offsite laboratories.

4 Health and Safety

1
2 Field operations will be performed in accordance with health and safety requirements and appropriate Soil
3 and Groundwater Remediation Project requirements. Additionally, work control documents will be
4 prepared to further control site operations. Safety documentation will include an activity hazard analysis
5 and, as applicable, radiological work permits. The sampling procedures and associated activities will
6 implement ALARA practices to minimize the radiation exposure to the sampling team, consistent with
7 the requirements defined in 10 CFR 835.

8

1
2

This page intentionally left blank.

5 References

- 1
2 10 CFR 830, Subpart A, "Quality Assurance Requirements," *Code of Federal Regulation*. Available at:
3 http://edocket.access.gpo.gov/cfr_2008/janqtr/pdf/10cfr830.7.pdf.
- 4 10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at:
5 http://www.access.gpo.gov/nara/cfr/waisidx_08/10cfr835_08.html.
- 6 40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides," *Code of Federal Regulations*.
7 Available at: http://edocket.access.gpo.gov/cfr_2002/julqtr/40cfr141.66.htm.
- 8 40 CFR 143.3, "Secondary Maximum Contaminant Levels," *Code of Federal Regulations*. Available at:
9 http://www.access.gpo.gov/nara/cfr/waisidx_03/40cfr143_03.html.
- 10 40 CFR 300.440, "Procedures for Planning and Implementing Off-Site Response Actions," *Code of*
11 *Federal Regulations*. Available at:
12 http://edocket.access.gpo.gov/cfr_2008/julqtr/40cfr300.440.htm.
- 13 49 CFR 171-177, Part 171, "General Information, Regulations, and Definitions," through Part 177,
14 "Carriage By Public Highway," *Code of Federal Regulations*. Available at:
15 http://www.access.gpo.gov/nara/cfr/waisidx_08/49cfrv2_08.html.
- 16 ANSI/ASQC E4-2004, *Quality Systems for Environmental Data and Technology Programs:*
17 *Requirements with Guidance for Use*, American National Standards Institute/American
18 Society for Quality, New York, New York. Available at:
19 <http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2fASQ+E4-2004>.
- 20 ANSI/ASQC S2-1995, *Introduction to Attribute Sampling*, American National Standards
21 Institute/American Society for Quality, New York, New York. Available at:
22 <http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2FASQC+S2-1995>.
- 23 ASTM D422-63, 2007, *Standard Test Method for Particle-Size Analysis of Soils*, American Society for
24 Testing and Materials, West Conshohocken, Pennsylvania. Available at:
25 <http://www.astm.org/Standards/D422.htm>.
- 26 ASTM D2216-05, 2005, *Standard Test Methods for Laboratory Determination of Water (Moisture)*
27 *Content of Soil and Rock by Mass*, American Society for Testing and Materials, West
28 Conshohocken, Pennsylvania. Available at: <http://www.astm.org/Standards/D2216.htm>.
- 29 ASTM D2434-68, 2006, *Standard Test Method for Permeability of Granular Soils (Constant Head)*,
30 American Society for Testing and Materials, West Conshohocken, Pennsylvania. Available at:
31 <http://www.astm.org/Standards/D2434.htm>.
- 32 ASTM D2937-04, 2004, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder*
33 *Method*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.
34 Available at: <http://www.astm.org/Standards/D2937.htm>.
- 35 ASTM D3987-06, 2006, *Standard Test Method for Shake Extraction of Solid Waste with Water*,
36 American Society for Testing and Materials, West Conshohocken, Pennsylvania. Available at:
37 <http://www.astm.org/Standards/D3987.htm>.

- 1 ASTM D5084-03, 2003, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated*
2 *Porous Materials Using a Flexible Wall Permeameter*, American Society for Testing and
3 Materials, West Conshohocken, Pennsylvania. Available at:
4 <http://www.astm.org/Standards/D5084.htm>.
- 5 DOE O 414.1C, *Quality Assurance*, U.S. Department of Energy, Washington, D.C. Available at:
6 <http://www.directives.doe.gov/pdfs/doe/doetext/neword/414/o4141c.pdf>.
- 7 DOE/RL-96-17, 2004, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 6,
8 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
9 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D6542354>.
- 10 DOE/RL-96-98, 2007, *Hanford Analytical Services Quality Assurance Requirements Documents*
11 (HASQARD), Rev 3, Volumes 1, 2, 3, and 4, U.S. Department of Energy, Richland
12 Operations Office, Richland, Washington.
- 13 DOE/RL-2000-41, *Interim Action Waste Management Plan for the 200-NR-2 Operable Unit*,
14 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
15 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D8479569>.
- 16 DOE/RL-2007-21, 2008, *Risk Assessment Report for the 100 Area and 300 Area Component of the River*
17 *Corridor Baseline Risk Assessment*, Draft B, U.S. Department of Energy, Richland Operations
18 Office, Richland, Washington.
- 19 DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*, Rev. 0,
20 U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- 21 DOE/RL-2008-46-ADD5, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*
22 *Addendum 5: 100-N Decision Unit*, Draft A, U.S. Department of Energy, Richland
23 Operations Office, Richland, Washington.
- 24 DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Rev. 0,
25 U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
26 <http://www2.hanford.gov/arpir/?content=findpage&AKey=0905131281>.
- 27 DOH 331-123, *Water System Design Manual*, Washington State Department of Health, Olympia,
28 Washington. Available at: <http://www.doh.wa.gov/ehp/dw/publications/design.htm>.
- 29 Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as
30 amended, Washington State Department of Ecology, U.S. Environmental Protection Agency,
31 and U.S. Department of Energy, Olympia, Washington. Available at:
32 <http://www.hanford.gov/?page=91&parent=0>.
- 33 Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*,
34 Washington State Department of Ecology, U.S. Environmental Protection Agency, and
35 U.S. Department of Energy, Olympia, Washington. Available at:
36 <http://www.hanford.gov/?page=117&parent=92>.
- 37 EPA/240/B-01/003, 2001, *EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5*, Quality
38 Assurance Division, U.S. Environmental Protection Agency, Washington, D.C. Available at:
39 <http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf>.

- 1 EPA/240/B-06/002, 2006, *Data Quality Assessment: A Reviewer's Guide*, EPA QA/G-9R, Office of
2 Environmental Information, U.S. Environmental Protection Agency, Washington, D.C.
3 Available at: <http://www.epa.gov/quality/qs-docs/g9r-final.pdf>.
- 4 EPA/240/B-06/003, 2006, *Data Quality Assessment: Statistical Methods for Practitioners*, EPA QA/G-9S,
5 Office of Environmental Information, U.S. Environmental Protection Agency,
6 Washington, D.C. Available at: <http://www.epa.gov/QUALITY/qs-docs/g9s-final.pdf>.
- 7 EPA/600/4-79/020, 1983, *Methods for Chemical Analysis of Water and Office of Research and*
8 *Development*, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at:
9 <http://www5.hanford.gov/arpir/?content=findpage&AKey=D196019611>.
- 10 EPA/600/R-94/111, 1994, *Methods for the Determination of Metals in Environmental Samples,*
11 *Supplement 1*. U.S. Environmental Protection Agency, Washington, D.C.
- 12 EPA/ROD/R-99/112, 1999, *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2*
13 *Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection
14 Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia,
15 Washington. Available at: <http://www.epa.gov/superfund/sites/rods/>.
- 16 EPA-505-B-04-900A, 2005, *Intergovernmental Data Quality Task Force, Uniform Federal Policy for*
17 *Quality Assurance Project Plans, Evaluating, Assessing, and Documenting Environmental*
18 *Data Collection and Use Programs, Part 1: UFP-QAPP Manual*, U.S. Environmental
19 Protection Agency, Washington, D.C. Available at:
20 http://www.epa.gov/swerffir/pdf/ufp_qapp_v1_0305.pdf.
- 21 SW-846, 2007, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition;*
22 *Final Update IV-B*, as amended, Office of Solid Waste and Emergency Response,
23 U.S. Environmental Protection Agency, Washington, D.C. Available at:
24 www.epa.gov/SW-846/main.htm.
- 25 WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington*
26 *Administrative Code*, Olympia, Washington. Available at:
27 <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160>.
- 28 WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," *Washington*
29 *Administrative Code*, Olympia, Washington. Available at:
30 <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A>.
- 31 WAC 173-340-720(3), "Method A Cleanup Levels for Potable Ground Water," *Washington*
32 *Administrative Code*, Olympia, Washington. Available at:
33 <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720>.
- 34 WAC 173-340-720(4), "Method B Cleanup Levels for Potable Ground Water," *Washington*
35 *Administrative Code*, Olympia, Washington. Available at:
36 <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720>.
- 37 WAC 246-290, "Group A Public Water Supplies," *Washington Administrative Code*, Olympia,
38 Washington. Available at: <http://apps.leg.wa.gov/WAC/default.aspx?cite=246-290>.
- 39 *Washington Growth Management Act*, 1990, Chapter 36.70A, Revised Code of Washington. Available at:
40 <http://apps.leg.wa.gov/RCW/default.aspx?cite=36.70A>.

1 WCH-331, *100-N Decision Unit Target Analyte List Development for Soil*, Washington Closure
2 Hanford, LLC, Richland, Washington.

1

Appendix

2

3

4

Analyte Lists for Method Based Analyses

1

This page intentionally left blank.

A1 Analyte Lists for Methods-Based Analyses

Tables A-1 through A-7 provide lists of analytes which will be reported when using a methods-based approach. Therefore, strontium-90, tritium, hexavalent chromium, and mercury are not listed.

A2 References

EPA/600/4-79/020, 1983, *Methods for Chemical Analysis of Water and Wastes*, U.S. Environmental Protection Agency, Washington, D.C. Available at:
http://www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0047/D196019611/D196019611_58615572_76609_556.pdf

EPA/600/R-94/111, 1994, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*, U.S. Environmental Protection Agency, Washington, D.C.

SW-846, 2007, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at:
www.epa.gov/SW-846/main.htm

Table A-1. U.S. Environmental Protection Agency Method 300.0

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
24959-67-9	Bromide	250	2500	±20 / ±30	80-120 / 70-130
16887-00-6	Chloride	200	2000	±20 / ±30	80-120 / 70-130
16984-48-8	Fluoride	500	5000	±20 / ±30	80-120 / 70-130
14797-55-8	Nitrate*	250	2500	±20 / ±30	80-120 / 70-130
14797-65-0	Nitrite*	250	2500	±20 / ±30	80-120 / 70-130
NO3-N	Nitrogen in nitrate*	75	750	±20 / ±30	80-120 / 70-130
NO2-N	Nitrogen in nitrite*	75	750	±20 / ±30	80-120 / 70-130
14265-44-2	Phosphate*	500	5000	±20 / ±30	80-120 / 70-130
14808-79-8	Sulfate	500	5000	±20 / ±30	80-120 / 70-130

*Nitrate, nitrite and phosphate suite, or Nitrogen in nitrate, Nitrogen in nitrite and phosphorus in suite may either be reported.

EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*.

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

Table A-2. U.S. Environmental Protection Agency SW-846 Method 6010

CAS #	Constituent	Water EQL ($\mu\text{g/L}$)	Soil EQL ($\mu\text{g/kg}$)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
7439-92-1	Lead	50	5000	$\pm 20 / \pm 30$	80-120 / 70-130
7439-93-2	Lithium	25	2500	$\pm 20 / \pm 30$	80-120 / 70-130
7439-98-7	Molybdenum	20	2000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-28-0	Thallium	50	5000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-38-2	Arsenic	100	10000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-41-7	Beryllium	2	500	$\pm 20 / \pm 30$	80-120 / 70-130
7440-42-8	Boron	20	2000	$\pm 20 / \pm 30$	80-120 / 70-130
7782-49-2	Selenium	100	10000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-09-7	Potassium	4000	400000	$\pm 20 / \pm 30$	80-120 / 70-130
7429-90-5	Aluminum	50	5000	$\pm 20 / \pm 30$	80-120 / 70-130
7439-89-6	Iron	50	5000	$\pm 20 / \pm 30$	80-120 / 70-130
7439-95-4	Magnesium	750	75000	$\pm 20 / \pm 30$	80-120 / 70-130
7439-96-5	Manganese	5	5000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-02-0	Nickel	40	4000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-22-4	Silver	10	1000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-23-5	Sodium	500	50000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-36-0	Antimony	60	6000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-39-3	Barium	20	2000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-43-9	Cadmium	2	500	$\pm 20 / \pm 30$	80-120 / 70-130
7440-47-3	Chromium	10	1000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-48-4	Cobalt	4	2000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-50-8	Copper	8	1000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-62-2	Vanadium	25	2500	$\pm 20 / \pm 30$	80-120 / 70-130
7440-66-6	Zinc	10	1000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-70-2	Calcium	1000	100000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-31-5	Tin	100	10000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-69-9	Bismuth	100	10000	$\pm 20 / \pm 30$	80-120 / 70-130
7723-14-0	Phosphorus	100	50000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-21-3	Silicon	20	2000	$\pm 20 / \pm 30$	80-120 / 70-130
7440-24-6	Strontium (elemental)	10	1000	$\pm 20 / \pm 30$	80-120 / 70-130

Table A-2. U.S. Environmental Protection Agency SW-846 Method 6010

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i>					
CAS = Chemical Abstracts Service					
EQL = estimated quantitation limit					

1

Table A-3. U.S. Environmental Protection Agency Method 200.8 or SW-846 Method 6020

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
7439-92-1	Lead	2	500	±20 / ±30	80-120 / 70-130
7440-22-4	Silver	2	200	±20 / ±30	80-120 / 70-130
7440-28-0	Thallium	2	500	±20 / ±30	80-120 / 70-130
7440-36-0	Antimony	5	600	±20 / ±30	80-120 / 70-130
7440-38-2	Arsenic	4	1000	±20 / ±30	80-120 / 70-130
7440-39-3	Barium	5	500	±20 / ±30	80-120 / 70-130
7440-41-7	Beryllium	2	200	±20 / ±30	80-120 / 70-130
7440-43-9	Cadmium	2	200	±20 / ±30	80-120 / 70-130
7440-47-3	Chromium	2	200	±20 / ±30	80-120 / 70-130
7782-49-2	Selenium	4	1000	±20 / ±30	80-120 / 70-130
SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i>					
For EPA Method 200.8, see EPA/600/R-94/111, <i>Methods for the Determination of Metals in Environmental Samples, Supplement 1</i> .					
CAS = Chemical Abstracts Service					
EQL = estimated quantitation limit					

2

Table A-4. U.S. Environmental Protection Agency SW-846 Method 8081

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
72-54-8	4,4'-DDD	0.1	3.3	±20 / ±30	80-120 / 70-130
72-55-9	4,4'-DDE	0.1	3.3	±20 / ±30	80-120 / 70-130
50-29-3	4,4'-DDT	0.1	3.3	±20 / ±30	80-120 / 70-130
309-00-2	Aldrin	0.05	1.65	±20 / ±30	80-120 / 70-130
319-84-6	Alpha-BHC	0.05	1.65	±20 / ±30	80-120 / 70-130
5103-71-9	alpha-Chlordane	0.5	16.5	±20 / ±30	80-120 / 70-130
319-85-7	Beta-BHC	0.05	1.65	±20 / ±30	80-120 / 70-130
57-74-9	Chlordane	0.5	16.5	±20 / ±30	80-120 / 70-130
319-86-8	Delta-BHC	0.05	1.65	±20 / ±30	80-120 / 70-130
60-57-1	Dieldrin	0.05	3.3	±20 / ±30	80-120 / 70-130
959-98-8	Endosulfan I	0.05	1.65	±20 / ±30	80-120 / 70-130
33213-65-9	Endosulfan II	0.1	3.3	±20 / ±30	80-120 / 70-130
1031-07-8	Endosulfan sulfate	0.1	3.3	±20 / ±30	80-120 / 70-130
72-20-8	Endrin	0.1	3.3	±20 / ±30	80-120 / 70-130
7421-93-4	Endrin aldehyde	0.1	3.3	±20 / ±30	80-120 / 70-130
53494-70-5	Endrin ketone	0.1	3.3	±20 / ±30	80-120 / 70-130
58-89-9	Gamma-BHC (Lindane)	0.05	1.65	±20 / ±30	80-120 / 70-130
5103-74-2	gamma-Chlordane	0.5	16.5	±20 / ±30	80-120 / 70-130
76-44-8	Heptachlor	0.05	1.65	±20 / ±30	80-120 / 70-130
1024-57-3	Heptachlor epoxide	0.05	1.65	±20 / ±30	80-120 / 70-130
72-43-5	Methoxychlor	0.5	16.5	±20 / ±30	80-120 / 70-130
8001-35-2	Toxaphene	2	165	±20 / ±30	80-120 / 70-130

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8260

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
100-41-4	Ethylbenzene	5	5	±20 / ±30	80-120 / 70-130
100-42-5	Styrene	5	5	±20 / ±30	80-120 / 70-130
10061-01-5	cis-1,3-dichloropropene	5	5	±20 / ±30	80-120 / 70-130
10061-02-6	trans-1,3-dichloropropene	5	5	±20 / ±30	80-120 / 70-130
107-06-2	1,2-dichloroethane	5	5	±20 / ±30	80-120 / 70-130
108-10-1	4-methyl-2-pentanone	10	10	±20 / ±30	80-120 / 70-130
108-88-3	Toluene	5	5	±20 / ±30	80-120 / 70-130
108-90-7	Chlorobenzene	5	5	±20 / ±30	80-120 / 70-130
124-48-1	Dibromochloromethane	5	5	±20 / ±30	80-120 / 70-130
127-18-4	Tetrachloroethene	5	5	±20 / ±30	80-120 / 70-130
1330-20-7	Xylenes (total)	10	10	±20 / ±30	80-120 / 70-130
540-59-0	1,2-dichloroethene(total)	10	5	±20 / ±30	80-120 / 70-130
591-78-6	2-hexanone	20	20	±20 / ±30	80-120 / 70-130
67-64-1	Acetone	20	20	±20 / ±30	80-120 / 70-130
71-43-2	Benzene	1.5	5	±20 / ±30	80-120 / 70-130
71-55-6	1,1,1-trichloroethane	5	5	±20 / ±30	80-120 / 70-130
74-83-9	Bromomethane	10	10	±20 / ±30	80-120 / 70-130
74-87-3	Chloromethane	10	10	±20 / ±30	80-120 / 70-130
75-00-3	Chloroethane	10	10	±20 / ±30	80-120 / 70-130
75-01-4	Vinyl chloride	5	5	±20 / ±30	80-120 / 70-130
75-09-2	Methylene chloride	5	5	±20 / ±30	80-120 / 70-130
75-15-0	Carbon disulfide	5	5	±20 / ±30	80-120 / 70-130
75-25-2	Bromoform	5	5	±20 / ±30	80-120 / 70-130
75-27-4	Bromodichloromethane	5	5	±20 / ±30	80-120 / 70-130
75-34-3	1,1-dichloroethane	2	10	±20 / ±30	80-120 / 70-130
75-35-4	1,1-dichloroethene	10	10	±20 / ±30	80-120 / 70-130
78-87-5	1,2-dichloropropane	5	5	±20 / ±30	80-120 / 70-130
78-93-3	2-butanone	10	10	±20 / ±30	80-120 / 70-130
79-00-5	1,1,2-trichloroethane	2	5	±20 / ±30	80-120 / 70-130
79-34-5	1,1,2,2-tetrachloroethane	5	5	±20 / ±30	80-120 / 70-130

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8260

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
56-23-5	Carbon tetrachloride	2	5	±20 / ±30	80-120 / 70-130
79-01-6	Trichloroethene	2	5	±20 / ±30	80-120 / 70-130
67-66-3	Chloroform	5	5	±20 / ±30	80-120 / 70-130
106-46-7	1,4-Dichlorobenzene	5	5	±20 / ±30	80-120 / 70-130
156-59-2	cis-1,2-Dichloroethylene	5	5	±20 / ±30	80-120 / 70-130
156-60-5	trans-1,2-Dichloroethylene	5	5	±20 / ±30	80-120 / 70-130

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

1

Table A-6. U.S. Environmental Protection Agency SW-846 Method 8310

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
83-32-9	Acenaphthene	20	100	±20 / ±30	80-120 / 70-130
208-96-8	Acenaphthylene	25	100	±20 / ±30	80-120 / 70-130
120-12-7	Anthracene	10	50	±20 / ±30	80-120 / 70-130
56-55-3	Benzo(a)anthracene	0.3	15	±20 / ±30	80-120 / 70-130
50-32-8	Benzo(a)pyrene	0.5	15	±20 / ±30	80-120 / 70-130
205-99-2	Benzo(b)fluoranthene	0.5	15	±20 / ±30	80-120 / 70-130
191-24-2	Benzo(ghi)perylene	1	30	±20 / ±30	80-120 / 70-130
207-08-9	Benzo(k)fluoranthene	0.5	15	±20 / ±30	80-120 / 70-130
218-01-9	Chrysene	5	100	±20 / ±30	80-120 / 70-130
53-70-3	Dibenz[a,h]anthracene	1	30	±20 / ±30	80-120 / 70-130
206-44-0	Fluoranthene	5	50	±20 / ±30	80-120 / 70-130
86-73-7	Fluorene	3	30	±20 / ±30	80-120 / 70-130
193-39-5	Indeno(1,2,3-cd)pyrene	1	30	±20 / ±30	80-120 / 70-130
91-20-3	Naphthalene	20	100	±20 / ±30	80-120 / 70-130
85-01-8	Phenanthrene	10	50	±20 / ±30	80-120 / 70-130
129-00-0	Pyrene	5	50	±20 / ±30	80-120 / 70-130

Table A-6. U.S. Environmental Protection Agency SW-846 Method 8310

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
SW-846, <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B</i>					
CAS = Chemical Abstracts Service					
EQL = estimated quantitation limit					

1

Table A-7. Gamma Spectroscopy, Germanium High-Energy Detectors (Gamma Energy Analysis)

CAS #	Constituent	Water EQL (pCi/L)	Soil EQL (pCi/g)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
14331-83-0	Actinium-228			±30	70-130
14596-10-2	Americium-241	50	1	±30	70-130
13981-41-4	Barium-133		0.2	±30	70-130
13966-02-4	Beryllium-7	50	0.3	±30	70-130
14913-49-6	Bismuth-212			±30	70-130
14733-03-0	Bismuth-214			±30	70-130
CE/PR-144	Cerium/Praseodymium-144			±30	70-130
10045-97-3	Cesium-137	15	0.1	±30	70-130
10198-40-0	Cobalt-60	25	0.05	±30	70-130
14683-23-9	Europium-152	50	0.1	±30	70-130
15585-10-1	Europium-154	50	0.1	±30	70-130
14391-16-3	Europium-155	50	0.1	±30	70-130
15092-94-1	Lead-212			±30	70-130
15067-28-4	Lead-214			±30	70-130
14681-63-1	Niobium-94			±30	70-130
13966-00-2	Potassium-40			±30	70-130
13982-63-3	Radium-226		0.1	±30	70-130
15262-20-1	Radium-228		0.2	±30	70-130
14391-65-2	Silver-108m		0.2	±30	70-130
14274-82-9	Thorium-228			±30	70-130
TH-232	Thorium-232			±30	70-130

Table A-7. Gamma Spectroscopy, Germanium High-Energy Detectors (Gamma Energy Analysis)

CAS #	Constituent	Water EQL (pCi/L)	Soil EQL (pCi/g)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
15065-10-8	Thorium-234			±30	70-130
15832-50-5	Tin-126			±30	70-130
15117-96-1	Uranium-235	50	0.5	±30	70-130
U-238	Uranium-238	500	10	±30	70-130

Where EQL is not specified, current EQLs of laboratories contracted to the Hanford Site are applicable.

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

1

Table A-8. Gross Alpha/Beta by Gas Proportional Flow Counting Method 900.0

CAS #	Constituent	Water EQL (pCi/L)	Soil EQL (pCi/g)	Precision Requirement Water/Soil (%)	Accuracy Requirement Water/Soil (%)
12587-46-1	Gross Alpha Activity	3	NA	±30	70-130
12587-47-2	Gross Beta Activity	4	NA	±30	70-130

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

NA = not applicable

2