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Revision 0

Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Executive Summary

This document is Addendum 1 of the *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan*.[1] The purpose of a work plan is to explain the Remedial Investigation/Feasibility Study (RI/FS) project background and rationale, and to present detailed plans for investigation of a contaminated site under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[2] (CERCLA). This document supports final remedy selection under CERCLA for the 100-D/H Operable Units at the Hanford Site. The CERCLA RI/FS results are also intended to address *Resource Conservation and Recovery Act of 1976*[3] (RCRA) corrective action requirements. Five 100 Areas (Figure ES-1) have been defined for the River Corridor: 100-B/C, 100-K, 100-D and 100-H, 100-N, and 100-F combined with 100-IU-2/6. Planning for the 300 Area is being addressed separately. These operable units combine groundwater contamination, soil contamination sites, and facilities in geographic areas that encompass the 100 Area National Priorities List[4] sites.

The work plan implements an approach designed to reach final remediation decisions, describes key features of the planning process to support implementation of this approach, and provides important key regulatory considerations and risk assessment uncertainties common to the 100 Area. This document, Addendum 1 to the Work Plan, provides site-specific information for 100-D/H. The 100-D/H area consists of 100-D, 100-H, and the area between them, referred to as the "Horn." The 100-D/H area includes the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 Source Operable Units (OUs), and the 100-HR-3 Groundwater OU. The location of 100-D/H and proximity to other 100 Areas is provided in Figure ES-1.

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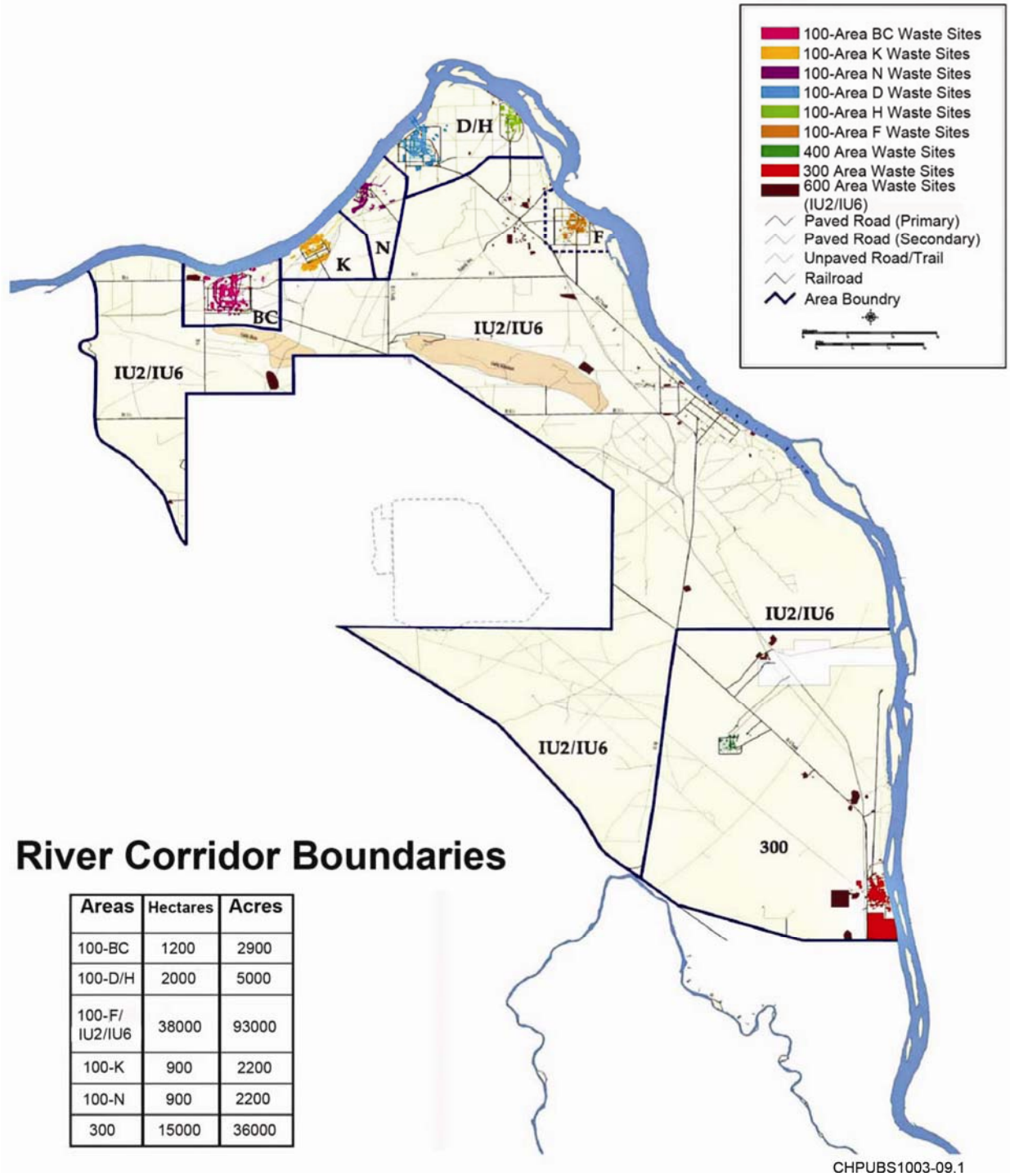
[1] DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[2] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq. Available at: http://uscode.house.gov/download/pls/42C103.txt.

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

[4] 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*. Available at: http://edocket.access.gpo.gov/cfr_2009/julqtr/40cfr300AppB.htm.



River Corridor Boundaries

Areas	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 Boundaries

A systematic planning process was used to develop a program for data collection and analysis to support final remediation decisions for the 100-D/H Operable Units. The following key elements were identified during this systematic planning process:

- **Information was identified and collected on the existing site conditions.**
  Collected information includes past operational history of the facilities (with an emphasis on disposal operations), the known nature and extent of groundwater and soil contamination, known geohydrologic information, source and groundwater remedial actions and their effectiveness, and the results of any treatability and characterization studies.

  Hexavalent chromium (Cr(VI)) contamination is the primary risk driver at 100-D/H; however, other groundwater plumes exist. Appendix B presents maps of the facilities source sites, and groundwater plumes. As of August 21, 2009, 108 sites have been dispositioned according to the Interim Action Record of Decision (IROD), including the major liquid effluent disposal sites: 6 units have been "closed out," 65 units have been "interim closed out," 6 units have "no action," 19 units have been "not accepted," and 12 units have been "rejected." While the interim closed out remedial actions satisfied the IRODs, they may not satisfy final CERCLA remediation and/or RCRA corrective action requirements due to vadose zone and/or groundwater contamination remaining after the IROD removal action. There are 127 sites remaining (122 accepted and 5 discovery) to be dispositioned.

- **A conceptual site model (CSM) was developed.**
  The CSM is a description of the site that organizes the available information and provides a summary of the site conditions. The CSM was developed to depict what was known about the site history (including process history), levels and location of contamination, and information needed to support decisions on remediation. The CSM was used to identify data and information gaps, establish data needs, and design a field program to address the gaps.

  An important feature of the CSM was identifying the potential sources of Cr(VI) and providing possible explanations regarding Cr(VI) plume persistence after many years of active groundwater remediation. Due to the complexities associated with the area, several concepts were identified that could singularly or collectively explain or affect components of the CSM. Concepts discussed in Section 4.5 that may explain the

persistence include (1) a source of Cr(VI) remains in the vadose zone and continues to impact groundwater; (2) a source of Cr(VI) remains in the variably wetted zone above the unconfined aquifer; (3) Cr(VI) is diffusing into the unconfined aquifer from the Ringold Upper Mud (RUM) Unit; (4) chromium product remains in pockets on low-permeable material within the unconfined aquifer or the RUM Unit; and (5) dissolved Cr(VI) simply covers a large area and the pump-and-treat systems have not removed sufficient water.

- **Data gaps, or uncertainties, were identified as part of the conceptual site model development process.**
  A list of data gaps, or statements of uncertainty, was identified as part of the systematic planning process. These data gaps included recognition of the need for additional information to better define the following possibilities:
  - Risk for direct exposure, protection of groundwater, and protection of the Columbia River at unremediated waste sites
  - Potential effects of residual soil contamination following remedial action on human health, groundwater, and the environment
  - Extent of contamination in the unconfined aquifer
  - Extent of contamination within the RUM Unit
  - Continued persistence of Cr(VI) contamination in the groundwater in some areas
  - Hydraulic properties of the RUM Unit
  - Potential adverse affects from remaining undiscovered sites

  Chapter 4 presents 14 data gaps that were defined during the systematic planning process.

- **Data needs were defined to address each of the data gaps or uncertainties.**
  Each of the 14 gaps is defined by a data need that, when filled, provides information to reduce or eliminate the uncertainty associated in the data gap. Table 4-6 and the Sampling and Analysis Plan (SAP) (DOE/RL-2009-40) present the data needs and describe how they will be filled for 100-D/H. An important consideration in Table 4-6 is that several ongoing programs (e.g., facility demolition, waste site remediation, and the pump-and-treat systems) are expected to provide data that will

resolve many of the uncertainties identified for 100-D/H. The Sampling and Analysis Plan identifies only those data collection activities that these ongoing programs will not address. The remedial investigation/feasibility study report prepared for 100-D/H will take full advantage of data and information obtained by ongoing remediation programs that are available during the development of the report. The results of ongoing deactivation, decontamination, decommissioning, and demolition, and waste site and groundwater interim remediation actions, in addition to proposed investigations, will be used in the selection of final remedies and will be incorporated into a proposed plan that will lead to a final record of decision (ROD). Table ES-1 summarizes the characterization field program proposed under this addendum. Table ES-2 presents the number of field samples and analytes that would be collected. While this work plan is intended to identify activities that will lead to a ROD for final actions, it is possible additional activities may be needed based on future site conditions encountered. These activities will be addressed through applicable processes (i.e., CERCLA and or RCRA).

Table ES-1. Proposed 100-D/H Characterization

Type	100-D Area	100-H Area	Total
Accepted and Discovery sites to be evaluated, characterized, and/or remediated (see Tables 2-3 through 2-5)*	81	46	127
New boreholes (vadose zone) (see Section 4.8.1.2)	5	5	10
Number of test pits (see Section 4.8.1.2)	3	2	5
New wells (unconfined aquifer) (see Section 4.8.2)	5	5	10
New wells into Ringold B Unit (confined aquifer) (see Section 4.8.2)	2	3	5
New aquifer tubes (see Section 4.8.2)	3	3	6
Sampling of monitoring wells (to support groundwater risk characterization)			53

Notes:

* This task is not within the scope of the sampling and analysis plan for this addendum (DOE/RL-2009-40). Accepted and Discovery sites are being evaluated, characterized, and/or remediated according to DOE/RL-96-17, Remedial Design Report/Remedial Action Work Plan.

Table ES-2. Number of Field Samples and Analyses Proposed for 100-D/H

Source	Soil Samples*	Groundwater Samples	Analyses
New boreholes (vadose zone)	141	10	2,055
Soil sampling of test pit (vadose zone)	54	0	502
New wells (unconfined aquifer)	112	62	1,592
New wells into Ringold B Unit (confined aquifer)	74	49	1,038
New aquifer tubes	0	18	180
Sampling of monitoring wells (to support groundwater risk characterization)	0	159	606

Notes:

Table does not include field quality control or archive samples.

* Includes both chemical and physical property analyses.

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

  The sampling and analysis plan also contains a list of target analytes for use with soil samples and a list of contaminants of potential concern (COPC) for use with groundwater samples. The approach used for development of the soil target analytes and groundwater COPCs is presented in Section 4.4 of the work plan. This addendum is based on the premise that there are data gaps and uncertainties that should be addressed to support final remediation decisions.

In 100-D/H, substantive work to remediate groundwater contamination, remove contaminated soils, and remove facilities has been completed over the past decade or is planned over the next few years. The results of these activities provide the basis for identifying the remaining uncertainties needed to be addressed to make final remediation decisions. The completed and planned work for 100-D/H is provided in Section 1.2.

Contents

1 Introduction 1-1

1.1 Scope 1-1

1.2 100-D/H Remediation Accomplishments 1-2

1.2.1 100-D/H Deactivation, Decommissioning, Decontamination, and Demolition Actions 1-2

1.2.2 100-D/H Waste Site Remediation 1-7

1.2.3 100-D/H Orphan Site Evaluation 1-11

1.2.4 Sources of Hexavalent Chromium Plumes in 100-D 1-14

1.2.5 Geochemical Characterization of Hexavalent Chromium Contamination in the Vadose Zone 1-19

1.2.6 100-D/H Pump-and-Treat Systems 1-20

1.2.7 100-D In Situ Redox Manipulation 1-28

1.2.8 Horn Study 1-29

1.2.9 Remedial Process Optimization 1-30

2 Site Background and Environmental Setting 2-1

2.1 100-D/H Overview 2-1

2.2 Environmental Setting 2-4

2.2.1 Topography 2-5

2.2.2 Geology 2-6

2.2.3 Hydrogeology 2-12

2.3 Process History 2-27

2.3.1 Facilities History and Description 2-27

2.3.2 Process History Description 2-31

2.3.3 Waste Sites Description and History 2-43

2.3.4 Decommissioning Activities 2-49

2.4 Known and Potential Contamination 2-49

2.4.1 Nature and Extent of Contamination in the Vadose Zone 2-50

2.4.2 Nature and Extent of Contamination in the Groundwater 2-79

3 Identification of Investigation Requirements 3-1

4 Conceptual Site Model 4-1

4.1 Introduction 4-1

4.2 Contaminant Sources and Release Mechanisms 4-1

4.2.1 Primary Sources of Contamination and Releases Mechanism 4-1

4.2.2 Secondary Sources of Contamination and Release Mechanisms 4-2

4.3 Contaminant Distribution 4-13

4.3.1 Vadose Zone Contamination 4-13

4.3.2 Hexavalent Chromium – Soil 4-15
4.3.3 Groundwater Contamination 4-18
4.4 Groundwater – Beneath the Unconfined Aquifer 4-21
4.4.1 100-D Area 4-21
4.4.2 100-H Area 4-22
4.5 Contaminant Fate and Transport 4-23
4.5.1 Hexavalent Chromium Source Term Release Characteristics 4-24
4.5.2 Hexavalent Chromium Transport in the Vadose Zone 4-28
4.5.3 Hexavalent Chromium Transport in the Unconfined Aquifer and the RUM Aquitard 4-30
4.5.4 Groundwater/River Interactions 4-40
4.5.5 Pump-and-Treat Operations 4-40
4.5.6 Potential Alternative Remedial Technologies 4-40
4.6 Human Receptors and Exposure Pathways 4-42
4.7 Ecological Receptors and Exposure Pathways 4-43
4.8 Identification and resolution of Data Needs 4-43
4.8.1 100-D/H Data Needs – Source Areas 4-51
4.8.2 100-D Area Data Needs – Groundwater 4-62
5 Project Schedule 5-1
6 References 6-1

Appendices

A 100-D/H Conceptual Site Model Component Plates ..... A-i
B 100-D Area and 100-H Area Maps ..... B-i
C 100-D/H Waste Sites Description and History ..... C-i
D Summary of 100-D/H Facilities ..... D-i
E 100-D/H Soil, Groundwater, and Aquifer Tube Data ..... E-i

Figures

Figure 1-1. Relationship Between the Work Plan and Addenda 1-1
Figure 1-2. River Corridor Boundaries 1-3
Figure 1-3. D and DR Reactors Before and After Interim Safe Storage 1-6
Figure 1-4. H Reactor After Interim Safe Storage 1-7
Figure 1-5. Extensive Excavation to Remove Effluent Pipelines near the 105-DR and 105-D Reactors 1-8
Figure 1-6. Thousands of Tons of Contaminated Soil Excavated near the Columbia River at 100-D 1-9
Figure 1-7. Thousands of Additional Tons of Contaminated Soil Excavated at 100-D 1-9
Figure 1-8. Disturbed Areas Representing Part of 100-H Extensive Waste Site Remediation 1-10
Figure 1-9. Area Addressed by 100-D Orphan Sites Evaluation Process 1-12
Figure 1-10. Area Addressed by 100-H Orphan Sites Evaluation Process 1-13
Figure 1-11. Map of Part of 100-D, Showing Wells Drilled for the Hexavalent Chromium Source Investigation in the Southwestern Plume 1-15
Figure 1-12. Contoured Concentrations of Hexavalent Chromium Concentrations in February 2009, Showing Hot Spot 1-17
Figure 1-13. 100-D SW Hexavalent Chromium Hot Spot Variation 2007 through 2009 1-18
Figure 1-14. Location Map for the Up to Fifteen Compact Sonic Drill Rig Vadose Zone Sampling Locations (marked as X) in 100-D 1-19
Figure 1-15. Chromium Contamination Visible as Yellow Stains 1-20
Figure 1-16. Location of the 100-HR-3 Pump-and-Treat System Wells in 100-D (2008) 1-22
Figure 1-17. Location of the 100-HR-3 Pump-and-Treat System Wells in 100-H (2008) 1-23
Figure 1-18. 100-HR-3, 100-D Hexavalent Chromium Plume 1999 and 2008 1-24
Figure 1-19. 100-HR-3, 100-H Hexavalent Chromium Plume 1996 and 2008 1-24
Figure 1-20. Proposed Location of Selected DX Expansion Pump-and-Treat Wells in 100-D 1-26
Figure 1-21. Proposed Location of Selected HX Expansion Pump-and-Treat Wells in 100-H 1-27
Figure 1-22. In Situ Redox Manipulation Technology 1-29
Figure 1-23. Well and Aquifer Tube Locations and Unfiltered Hexavalent Chromium Distribution (February 2008) 1-31
Figure 2-1. Location of the Hanford Site and the 100 Area 2-2
Figure 2-2. Aerial View of 100-D (Selected Facilities Identified, 1966) 2-4
Figure 2-3. Aerial View of 100-H 2-5
Figure 2-4. Generalized Geology of the 100 Area 2-6
Figure 2-5. Cross Section (Northwest to Southeast and Parallel to the Columbia River) of Subsurface Stratigraphy Underlying 100-H 2-8
Figure 2-6. Surface Contour Estimates of the Ringold Upper Mud Unit in 100-D/H 2-9
Figure 2-7. Isopach Map of the Unconfined Aquifer in the Horn 2-13
Figure 2-8. Regional Groundwater Elevations in 100-D and 100-H and the Horn 2-15

Figure 2-9. 100-D Area June and November 2008 Measured Water Table Comparison 2-17
Figure 2-10. 100-H May and November 2008 Measure Water Table Comparison 2-19
Figure 2-11. Facilities in 100-D that Produced, Stored, or Transferred Liquid Sodium Dichromate Solutions 2-22
Figure 2-12. 1967 Water Table Elevation Contours 2-25
Figure 2-13. Aerial View of 183-D Filter Plant (1945) 2-28
Figure 2-14. D and DR River Effluent Pipelines, Outfalls and Reservoir in Background (D Island; 1956) (Waste Site 100-D-60) 2-28
Figure 2-15. Export Water System Plan View 2-29
Figure 2-16. 108-D Chemical Pumphouse (1944) 2-34
Figure 2-17. French Drain at Sodium Dichromate Railcar Unloading Station (1997) (Waste Site 100-D-12) 2-35
Figure 2-18. 185-D between 189-D and 190-D, with Overhead Steam Lines and Rail Car in Foreground (1944) 2-36
Figure 2-19. Residual Sodium Silicate and Sodium Dichromate Solutions Found and Removed During Remediation of the 100-D-56:2 Pipelines (2006) 2-37
Figure 2-20. Hexavalent Chromium Contaminated Groundwater from Monitoring Well 199-D5-99 2-37
Figure 2-21. 190-D and 190-D Annex with 185-D and Steam Plant in Background (1954) 2-38
Figure 2-22. 185-D Sodium Dichromate Trench, During Demolition, Looking South (1994) (Waste Site 100-D-30) 2-39
Figure 2-23. Chromium Soil Staining (4.3-5.5 m [14-18 ft] bgs) at 185-D 2-40
Figure 2-24. Active Remediation of Chromium Contamination (4.3-5.5 m [14-18 ft] bgs) at 185-D 2-40
Figure 2-25. Facilities in 100-H that Produced, Stored, Handled, or Transferred Liquid Sodium Dichromate Solutions 2-43
Figure 2-26. Key Hexavalent Chromium Wastes Sites in 100-D 2-45
Figure 2-27. Key Hexavalent Chromium Waste Sites at 100-H 2-46
Figure 2-28. Post Remediation Vertical Profile of 116-DR-1&2 Trenches Contamination 2-57
Figure 2-29. Limited Field Investigation Vertical Profile of 116-DR-1&2 Trench Contamination 2-59
Figure 2-30. Limited Field Investigation Vertical Profile of 116-DR-1&2 Trench Contamination 2-61
Figure 2-31. Limited Field Investigation Vertical Profile of 116-D-1A Trench Contamination 2-63
Figure 2-32. Limited Field Investigation Vertical Profile of 116-DR-9 Retention Basin Contamination 2-65
Figure 2-33. 100-HR-1 Surface Radiological Survey Contamination Points 2-68
Figure 2-34. Limited Field Investigation Vertical Profile of 116-H-1 Trench Contamination 2-73
Figure 2-35. Limited Field Investigation Vertical Profile of 116-H-7 Retention Basin Contamination 2-75
Figure 2-36. 100-D/H – Monitoring Well Locations 2-84

Figure 2-37. 100-D Average Hexavalent Chromium Concentrations, Upper Portion of the Upper Unconfined Aquifer, Spring and Fall 2007 2-85
Figure 2-38. Horn Hexavalent Chromium Plume, 2007 2-88
Figure 2-39. 100-H Measured Water Table and Hexavalent Chromium Plumes, June and November 2007 2-89
Figure 2-40. Strontium Plume in 100 D/H, 2008 Data 2-93
Figure 2-41. Nitrate Plumes in 100 D/H, 2008 Data 2-97
Figure 4-1. Depth Discrete Vadose Zone and Groundwater Sampling Locations for Total Chromium Analysis 4-17
Figure 4-2. Concentration Profiles of Hexavalent Chromium for Wells Sampled in March 2008 near 100-D-12 4-19
Figure 4-3. Concentration Profiles of Hexavalent Chromium for Wells Sampled in June 2008 near 100-D-12 4-20
Figure 4-4. Hexavalent Chromium Migration at Groundwater Monitoring Wells near 100-D-12 4-20
Figure 4-5. Chronology of Head Measurements at Groundwater Monitoring Well 199-D5-12 in the Central 100-D Area 4-32
Figure 4-6. Seasonal Variability in Groundwater Flow Directions near the Columbia River in the Southern Portion of the 100-D Area 4-34
Figure 4-7. Water Table Map of the 100-H Area in 1987 4-38
Figure 4-8. Groundwater/Surface Water Flow Path 4-41
Figure 4-9. 100-D/H Hexavalent Chromium, Showing Salmon Redds 4-42
Figure 4-10. Remedial Investigation/Feasibility Study Sampling Locations 4-55
Figure 4-11. Total Chromium and Hexavalent Chromium Trends in Well 199-D8-54B 4-66
Figure 5-1. 100-D/H Project Schedule 5-3

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Tables

Table 1-1. Summary of Facility Status in 100-D/H 1-4
Table 1-2. Summary of Waste Sites in 100-D/H (November 2008) 1-11
Table 1-3. Current Pump-and-Treat Systems in the 100-HR-3 Operable Unit 1-21
Table 1-4. Ongoing and Planned Optimization and Expansion of the Pump-and-Treat Systems in 100-D/H 1-28
Table 2-1. 100-D/H Site Location Information 2-3
Table 2-2. Long-Term, High-Volume Discharge Sites in 100-D 2-21
Table 2-3. Summary Information on the Status of 100-D/H Waste Sites 2-44
Table 2-4. Reclassification of 100-DR-1 Operable Unit Waste Sites 2-47
Table 2-5. Reclassification of 100-DR-2 Operable Unit Waste Sites 2-47
Table 2-6. Reclassification of 100-HR-1 Operable Unit Waste Sites 2-48
Table 2-7. Reclassification of 100-HR-2 Operable Unit Waste Sites 2-49
Table 2-8. Summary of Borehole Locations Used in the Initial Radiological Characterization – 1975 2-50
Table 2-9. Summary of 100-D Limited Field Investigation (Vadose) 2-53
Table 2-10. Summary of Limited Field Investigation 2-69
Table 2-11. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in 100-D Groundwater 2-80
Table 2-12. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in 100-H Groundwater 2-82
Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area 4-3
Table 4-2. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-H Area 4-9
Table 4-3. Maximum Hexavalent Chromium Concentration Detected in Groundwater Wells Completed Beneath the Unconfined Aquifer in the 100-H Area 4-22
Table 4-4. Hexavalent Chromium Mass Discharge Estimates into the Subsurface Based on Reactor Coolant Throughput 4-25
Table 4-5. Estimates of Hexavalent Chromium in Reactor Coolant Discharges to the Subsurface 4-27
Table 4-6. Proposed Sampling Program for Remedial Investigation for 100-D/H 4-45
Table 4-7. Proposed 100-D/H Characterization 4-51
Table 4-8. Number of Field Samples and Analyses Proposed for 100-D/H 4-51
Table 4-9. Justification For Selecting Waste Sites for Characterization 4-57
Table 4-10. Spatial and Temporal Uncertainty Monitoring Well Network 4-69

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Terms

AA	atomic absorption
AEC	U.S. Atomic Energy Commission
aG	amber glass
aGs	amber glass septum
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ARCL	allowable residual contamination level
ARHCO	Atlantic Richfield Hanford Company
AT	aquifer tube
BG	background
bgs	below ground surface
BNW	Battelle Northwest
CAS	Chemical Abstracts Service
CCC	criterion continuous concentration
CD	compact disc
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
cpm	counts per minute
Cr(VI)	hexavalent chromium
CSDR	compact sonic drill rig
CSM	conceptual site model
CVP	cleanup verification package
CY	calendar year
D4	deactivation, decommissioning, decontamination, and demolition
D&D	decontamination and decommissioning
DE/GWP/RP	direct exposure/groundwater protection/river protection

DOE	U.S. Department of Energy
DQA	data quality assessment
Ecology	Washington State Department of Ecology
EDS	energy dispersive spectroscopy
EMSL	Environmental and Molecular Sciences Laboratory
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
EHW	extremely hazardous waste
EWS	Export Water System
FFTF	Fast Flux Test Facility
FS	feasibility study
FSB	Fuel Storage Basin
GC	gas chromatography
GEA	gamma energy analysis
GPERS	Global Positioning Environmental Radiological Surveyor
HEDL	Hanford Engineering Development Laboratory
HEIS	Hanford Environmental Information System
HEPA	high-efficiency particulate air (filter)
HHR	hydraulic hammer rig
IC	ion chromatography
ICP	inductively coupled plasma
ICP/MS	inductively coupled plasma/mass spectrometry
IROD	Interim Record of Decision
ISRM	in situ redox manipulation
ISS	interim safe storage
K_d	soil distribution coefficient
KV	kilovolt
LFI	limited field investigation
LSC	liquid scintillation counter
LSFF	Large Sodium Fire Facility

MCL	maximum contaminant level
mrep/hr	milli-roentgen equivalent physical per hour
MS	mass spectrometry
NPR	new production reactor
OSE	orphan site evaluation
OSWER	Office of Solid Waste Emergency Response (EPA)
OU	operable unit
PCB	polychlorinated biphenyl
PPE	personal protective equipment
P&T	pump-and-treat
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QRA	qualitative risk assessment
RA	risk assessment
RAG	remedial action goal
RAO	remedial action objective
RAWP	removal action work plan
RCBRA	River Corridor Baseline Risk Assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	radiological control technician
RDL	required detection limit
RESRAD	RESidual RADioactivity (computer code)
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RISS	reactor interim safe storage
RL	U.S. Department of Energy, Richland Operations Office
RLM	Ringold Lower Mud
ROD	record of decision
RPO	remedial process optimization

RS	remaining site
RS ROD	Remaining Site Record of Decision
RSVP	remaining sites verification process
RTD	removal, treatment, and disposal
RUM	Ringold Upper Mud
SAP	sampling and analysis plan
SEM	scanning electron microscopy
S&GRP	Soil & Groundwater Remediation Project
SSE	safe storage enclosure
SVOC	semivolatile organic compounds
TBD	to be determined
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
TSD	treatment, storage, and/or disposal (unit)
UCL	upper confidence limit
UKPA	total uranium by kenotic phosphorescence analysis
UNI	United Nuclear Industries
UST	underground storage tank
VOA	volatile organic analyte
VOC	volatile organic compound
VSR	vertical safety rod
WAC	*Washington Administrative Code*
WCH	Washington Closure Hanford, LLC
WIDS	Waste Information Data System
WMU	waste management unit
WSRF	waste site reclassification form
XANES	X-ray absorption near-edge structure
XMP	X-ray microprobe
XPS	X-ray photoelectron spectroscopy
XRF	X-ray fluorescence
ZOI	zone of interaction

1 Introduction

This document is Addendum 1 to DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan*, hereafter referred to as the Work Plan. This addendum describes 100-D/H and planned efforts to conduct a remedial investigation (RI) in support of a final record of decision (ROD) for the 100-D/H Operable Units (OUs). 100-D/H includes the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 Source OUs and the 100-HR-3 Groundwater OU. The work plan contains the planning elements that are common to all 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.

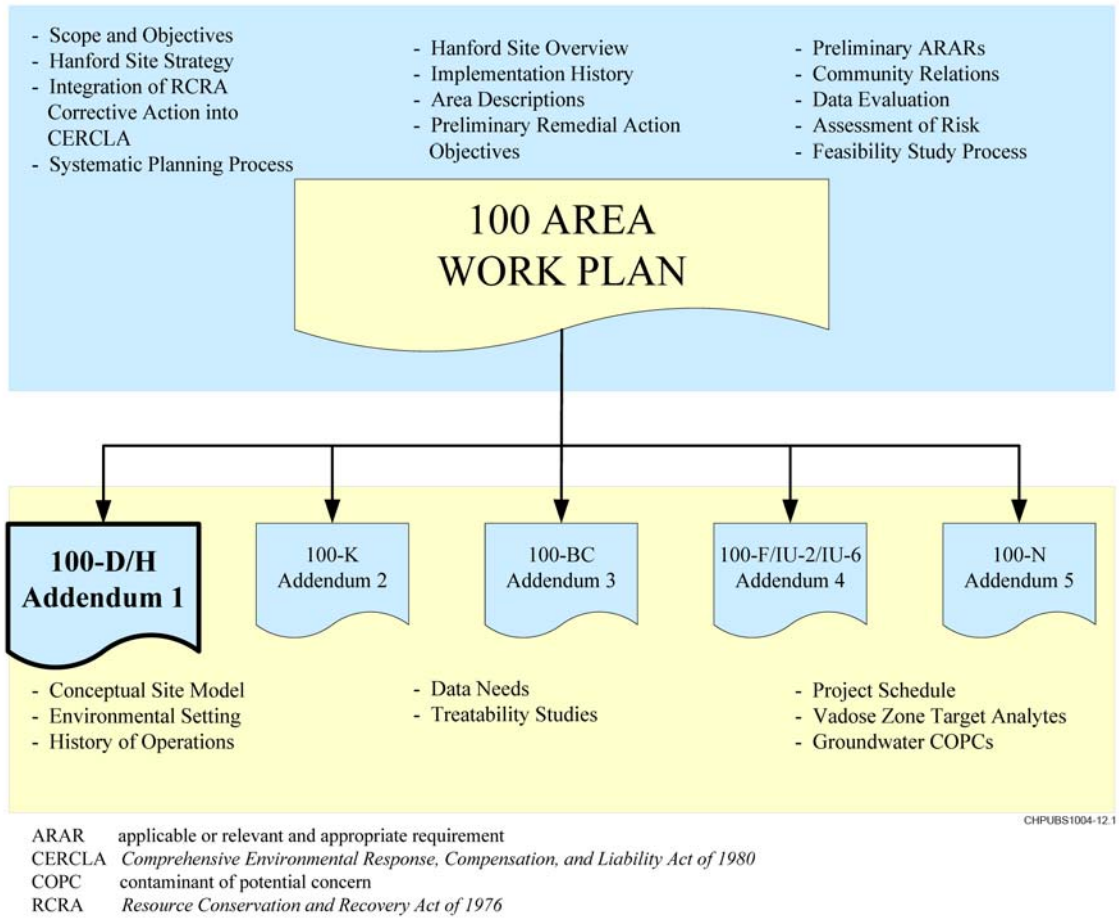


Figure 1-1. Relationship Between the Work Plan and Addenda

This addendum was developed through multiple interview sessions, workshops, and task teamwork organized through the Systematic Planning Process with the participation of subject matter experts. The planning process was guided by the needs of the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology).

1.1 Scope

This addendum addresses the data and information needed to support groundwater and waste site remediation investigations associated with 100-D/H. Geographically, 100-D/H consists of 100-D, 100-H,

and the area between them, referred to as the "Horn." The area also includes the 100-D-67 (D-Island) waste site, which is located in the Columbia River. Figure 1-2 provides the location of 100-D/H and its proximity to other area within the river corridor.

This addendum identifies data needs and a process to address the needs that are significant to remediation. A useful tool to guide characterization and identify effective remediation actions for 100-D/H is the conceptual site model (CSM). A CSM is a representation of the site, which organizes the information available and provides a summary of the site conditions. More importantly, a CSM can be used to identify data gaps and establish the programmatic priority for sampling and testing hypotheses.

Data gaps significant to making remediation decisions are addressed through additional data collection and other investigations. The CSM addresses contaminant sources (e.g., site history), contaminant flow and transport, and exposure assessment, and supports risk characterization, remedial action selection, performance monitoring, and site closure. Chapter 2 provides the background and environmental setting information necessary to support the development of the 100-D/H CSM.

During multiple workshops, presentations, and meetings, CSM component summaries (i.e., plates) were used to identify and foster discussion of issues of concern to the participants. Appendix A contains these plates, which were used to solicit input from regulators, agencies, and subject matter experts. Chapter 4 presents the CSM and includes a data gap /needs table for 100-D/H.

Most importantly, the identification of data needs led to development of a sampling and analysis plan (SAP) that establishes characterization activities specific to 100-D/H. The DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2 and 100-HR-3 Operable Units Remedial Investigation/ Feasibility Study* includes a field-sampling plan that provides the sampling strategy and techniques that will be used to obtain the supplemental data required for the RI/FS. The SAP also provides a quality assurance project plan (QAPP) to ensure that data collected meet the appropriate quality assurance and control requirements.

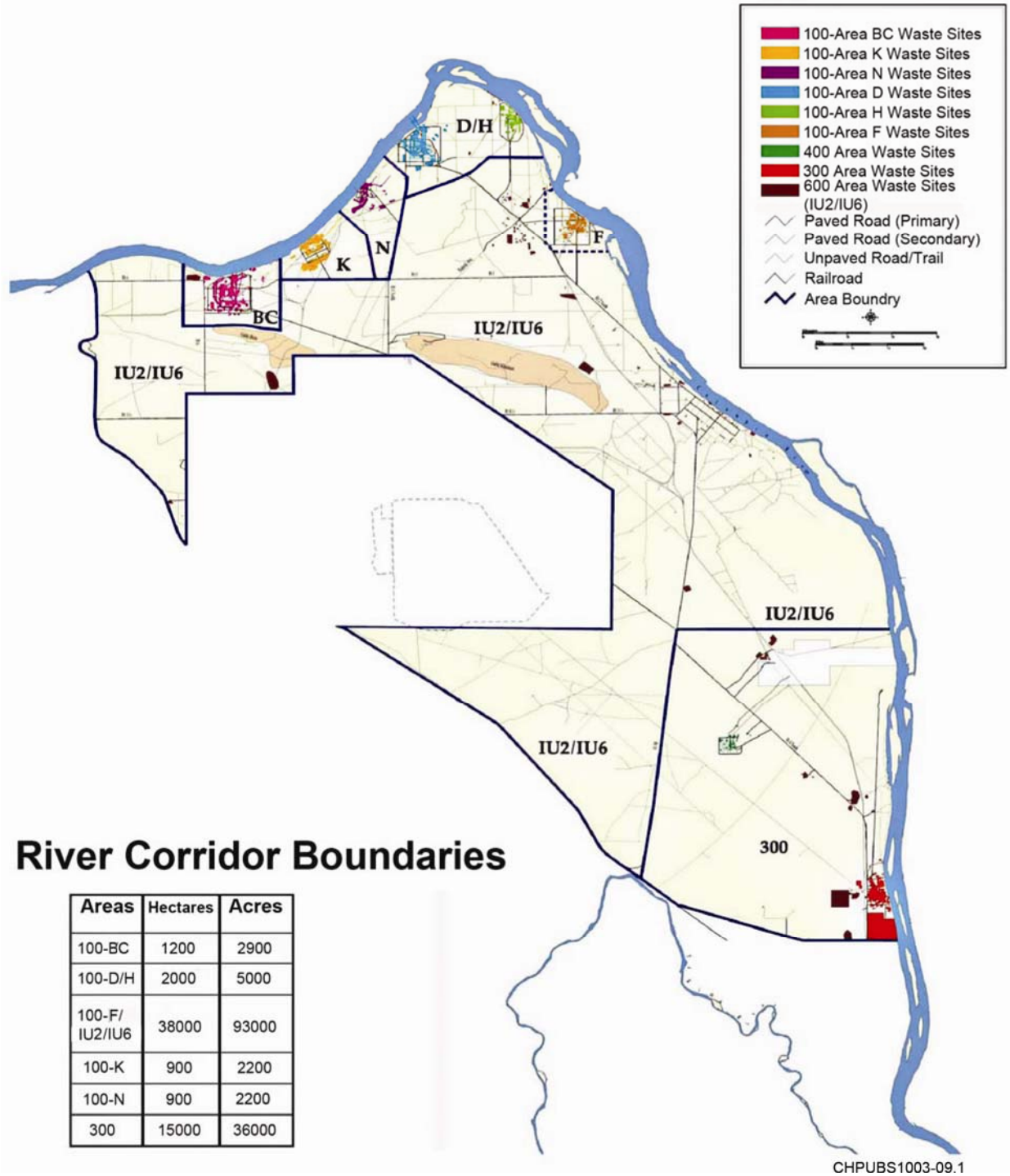
1.2 100-D/H Remediation Accomplishments

A considerable amount of environmental remediation and restoration has already been completed and more is planned at the Hanford Site. These remediation activities, many of which are ongoing, have achieved significant cleanup progress across the site. These activities include characterization of groundwater plumes and their potential sources, cleanup of the groundwater and soil, and testing of new and alternative treatment methods specific to the issues and contaminants on the Hanford Site.

The following subsections provide information on the cleanup progress that has already taken place in 100-D/H.

1.2.1 100-D/H Deactivation, Decommissioning, Decontamination, and Demolition Actions

Since original construction, 100-D/H has included 171 facilities, including three reactors, storage buildings, offices, retention basins, maintenance shops, process plants, an electric substation, storage tanks, pump stations, and outfall structures. Until the structures over a source site have been removed, no soil remediation can be completed. Therefore, the facilities (including contaminated pipelines associated with them) are and have been undergoing removal to clear the way for the remedial work that focuses on contamination in the soil.



River Corridor Boundaries

Areas	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 Boundaries

Facility (as applied to the Facility Decommissioning Process) is defined as a freestanding building, plant, laboratory, or other enclosure and associated buildings under its responsibility that fulfills, or fulfilled, a specific purpose, and is owned by or otherwise under the responsibility of DOE. (This usage differs substantially from that in *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* [CERCLA] and the *Resource Conservation and Recovery Act of 1976* [RCRA].)

Table 1-1 shows the status of 100-D/H facilities.

Table 1-1. Summary of Facility Status in 100-D/H

Area	Total Number of Facilities	Demolished[a]	Removed[a]	Active[a]	Inactive[a]	To Be Determined[a]
100-D	111	66	18	18[b]	7[c,d]	2
100-H	60	42	4	11[e]	2[f]	1
100-D/H Total	171	108	22	29	9	3

Notes:

This summary is current as of August 28, 2009.

a. Status:

Active: Facility is occupied and in use (supports Hanford Site missions).
Inactive: Facility is no longer in use and is awaiting decommissioning and demolition.
Demolished: Facility has been removed to grade (slab or foundation remains).
Removed: Facility foundation has been removed and any substructure is 0.3 to 0.9 m (1 to 3 ft) below grade.
To Be Determined: In the process of establishing facility status.

b. Active facilities in 100-D include office and storage buildings, the 151-D Primary Substation Switch House, the 181-D River Pump House, and 182-D Reservoir (which supply water to the 200 Area).

c. The D/DR Reactor buildings, the 183-D Filter Plant Power Operation Facility, the 1904-DR Outfall Structure, and a mobile office.

d. The 188-D Coal Ash Pit (126-D-1) is an inactive facility to be left in place. The soil beneath this site has been rejected as a waste site as guided by TPA-MP-14 (RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures,* Guideline Number TPA-MP-14, "Maintenance of the Waste Information Data System [WIDS]").

e. The H Area active facilities include mobile offices and the treatment center for the 100-HR-3 Groundwater OU Pump-and-Treat program.

f. The H Reactor and a storage building (1720-HA) that held munitions and explosives.

Actions have been taken to protect the reactors from environmental degradation and to prevent the spread of contamination by placing them into Interim Safe Storage (ISS) that is, providing an upgraded, weather resistant shell to isolate the reactor core until final remedial activities are conducted. These actions also minimize the facility footprint by removing all peripheral reactor buildings and equipment (including contaminated underground structures and pipelines) and disposing of the debris. The 105-DR ISS Project was completed in September 2002 and the 105-D ISS Project was completed in September 2004 (Figure 1-3). The ISS project for the 105-H Reactor (Figure 1-4) began in 2000 and was completed in 2005. The principal structures remaining in D/H are the three cocooned reactors and parts of the water treatment infrastructure.

In compliance with RCRA guidance, a number of 100-D/H treatment, storage, and/or disposal (TSD) units were addressed as part of the deactivation, decommissioning, decontamination, and demolition (D4)

work. The following text describes the history of the TSD units (183-H Solar Evaporation Basin, 100-D-Ponds, 105-DR Large Sodium Fire Facility).

1.2.1.1 183-H Solar Evaporation Basin

The 183-H Facility was constructed in 1949 and used for 100-H water treatment until mid-1960. This facility consisted of 16 concrete basins that were used in treating Columbia River water for subsequent use as reactor coolant. In 1973, four of these basins were converted for use in evaporation of other mixed wastes. Approximately 1.6 million kg (3.6 million lb) of waste per year were treated by solar evaporation. The facility received both routine and non-routine wastes, which consisted of spent acid etch solutions, metal constituents in the form of precipitates, and unused chemicals and spent solutions from miscellaneous processes. Most of the water treatment structures, including 12 additional adjoining basins, were demolished in 1974. The four remaining basins were inactive until July 1973 when radioactive and dangerous (mixed) waste from the 300 Area fuel fabrication facilities was shipped to the basins for storage and treatment. The last shipment of waste to the basins took place on November 8, 1985. By the fall of 1996, the basins had been completely demolished and demolition wastes were disposed in the adjacent 183-H Clearwells and at the Environmental Restoration Disposal Facility. The site was not clean closed under RCRA because fluoride and nitrate concentrations at depths below 4.6 m (15 ft) are above the Method B cleanup levels of WAC 173-340(3), *Model Toxics Control Act*, “Method B Soil Cleanup Levels for Unrestricted Land Use.” Therefore, the unit was closed in place under the modified closure provisions of the RCRA Hanford permit with post-closure care. The modified closure certification was accepted by the State of Washington Department of Ecology on May 13, 1997, (DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*). Because clean closure was not achieved, dangerous waste constituents remain in the vadose zone beneath the waste site. In addition, RCRA closures do not have authority to address the cleanup of radiological contamination. As such, accepted Waste Information Data System (WIDS) site 100-H-33 was created to address the radiological contamination that is within the same footprint as 116-H-6.

1.2.1.2 100-D Ponds (120-D-1)

The 100-D ponds were located approximately 500 m (1,640 ft) northeast of the 105-D reactor and were used from 1977 to 1994 for percolation of effluent. The ponds were constructed from the former 188-D coal ash disposal basin and consisted of two interconnected surface ponds. The original pond was constructed by excavating an area 9 m (30 ft) deep in the eastern half of the 188-D Basin. The site was modified in 1979 to form a two-compartment pond, one overflowing to the other. The modification resulted in a combined surface dimension of 50 by 67 m (160 by 220 ft).

After the construction of the ponds, all process sewer liquid effluents were diverted to the ponds instead of the Columbia River. The north pond was a percolation pond and the south pond was a settling pond. The ponds received corrosive waste from the regeneration of ion exchange columns located in the 185-D/189-D complex. The ponds also received nonhazardous waste from the 183-D sand-filter backwash, small quantities of filtered chlorinated water from hydraulic test loops, and fuel discharge trampoline tests.

The estimated flow rate was 170,000 liters/day (45,000 gal/day). In August 1996, contaminated sediment was removed from the 100-D Ponds as part of a DOE/RL voluntary cleanup action (DOE/RL-92-71, *100-D Ponds Closure Plan*). On August 27, 1999, Ecology accepted this TSD as clean closed.

1.2.1.3 105-DR Large Sodium Fire Facility (122-DR-1)

The Large Sodium Fire Facility (LSFF) was located in the former supply and exhaust fan wing of the 105-DR Reactor Building (DOE/RL-90-25, *105-DR Large Sodium Fire Facility Closure Plan*). The

LSFF operated from 1972 to 1986 and was used to study the fire and safety aspects associated with sodium and other alkali metal fires for application to liquid metal reactors. It is estimated that 20,000 kg (44,100 lb) of sodium and other alkali metals were used at the facility for the burn tests.

The facility closure plan divided the facility into seven areas for sampling and closure purposes. Four of the seven RCRA subunits of the LSFF (122-DR-1) were closed out under the DOE/RL-90-25. These subunits included the exhaust fan room, small fire room, large fire room, sodium handling room, and an office area (122-DR-1:1); the gravel scrubber (122-DR-1:3); the 117-DR Seal Pit Crib (122-DR-1:6); and the outdoor storage area (122-DR-1:7). Certification of closure of these LSFF TSD subunits is documented in the WHC-SD-EN-TI-307, *105-DR Large Sodium Fire Facility Soil Sampling Data Evaluation Report* and in a Washington State Department of Ecology letter regarding closure certification for the 122-DR-1 subsites 1, 3, 6, and 7 (Wilson, M., 1996, "Closure Certification for the 105-DR Large sodium Fire Facility)). The 122-DR-1:6 crib closure was based on process knowledge without further sampling and only applies to usage of this crib by LSFF operations. This crib and its associated influent piping are also separately identified as the 116-DR-8 and 100-D-50:8 waste sites, respectively, to address residual contamination associated with discharges to the crib.

The LSFF Closure Plan deferred the remaining three LSFF TSD subunits (122-DR-1:2, 122-DR-1:4, and 122-DR-1:5) to the CERCLA process (Ecology, et al., 1989a). These three subunits were excavated and remedial activities are presented in the cleanup verification package (CVP-2003-00018, *Cleanup Verification Package for the 105-DR Large Sodium Fire Facility*). A Washington State Department of Ecology letter regarding clean closure certification for the 122-DR-1 subsites 2, 4, 5 (Bond, 2004, Closure Certification for the 105-DR Large Sodium Fire Facility) acknowledged receipt and accepted DOE's closure certification and professional engineer's certification of closure for the *105-DR Large Sodium Fire Facility Closure Plan* (DOE/RL-90-25, Rev. 2), dated June 3, 2004.

Figures 1-3 shows 100-D before and after D4 actions; Figure 1-4 shows100-H after D4 actions.

Figure 1-3. D and DR Reactors Before and After Interim Safe Storage

Figure 1-4. H Reactor After Interim Safe Storage

1.2.2 100-D/H Waste Site Remediation

In 1996, when the pace of Hanford waste site cleanup accelerated, the primary focus was on former liquid effluent sites, for which removal, treatment (as necessary), and disposal (RTD) is the standard remedy. The RTD was designed to achieve the remedial action objectives (RAOs) and goals specified in interim action RODs for human exposure to contamination, protection of groundwater, and protection of the Columbia River. Soil from each excavation is sampled and modeled (if needed) to assess the potential impact to human health, groundwater, and the Columbia River from residual contamination. Every remediated waste site undergoes sampling and analysis as part of cleanup verification to demonstrate that the remedial action at a site achieved the RAOs. Where remedial action goals (RAGs) and objectives are achieved, the waste site is considered interim closed.

Roughly 1.15 billion kg (1.268 million tons) of contaminated soil and debris have been removed from 100-D/H waste sites (including contaminated pipelines) and over 600 soil samples have been collected to verify cleanup and document interim closure status (Figures 1-5 through 1-8) through Fiscal Year (FY) 2008.

Figure 1-5. Extensive Excavation to Remove Effluent Pipelines near the 105-DR and 105-D Reactors

Figure 1-6. Thousands of Tons of Contaminated Soil Excavated near the Columbia River at 100-D

Note: "cocooned" D and DR Reactors.

Figure 1-7. Thousands of Additional Tons of Contaminated Soil Excavated at 100-D

Figure 1-8. Disturbed Areas Representing Part of 100-H Extensive Waste Site Remediation

Of the 235 waste sites (which include contaminated pipelines) identified in 100-D/H through August 2009, 108 have been closed out, interim closed, rejected, or given no action or not accepted status, as shown in Table 1-2. These status categories generally indicate that a site meets the cleanup goals and objectives of the interim RODs. About 127 accepted waste sites remain to be cleaned up in 100-D/H, including discovery sites. Interim remedial actions are anticipated to be complete by the end of 2011.

Table 1-2. Summary of Waste Sites in 100-D/H (November 2008)

Area	Total Number of Waste Sites[a]	Closed Out[b]	Interim Closed Out[c]	No Action[d]	Not Accepted[e]	Rejected[f]	Accepted[g]	Discovery[h]
100-D	154	5	42	6	11	9	79	2
100-H	81	1	23	0	8	3	43	3
D/H Total	235	6	65	6	19	12	122	5

Notes:

a. Total number of sites includes discovery sites.

b. Closed Out: A reclassification status indicating that due to actions taken, a waste management unit meets applicable cleanup standards or closure requirements. (Note: Many remediation waste sites were identified as "Closed Out" based on a previous classification scheme. Since all the associated RODs are interim action RODs, these waste sites are considered "Interim Closed Out" based on current definitions.)

c. Interim Closed Out: A reclassification status indicating due to actions taken, a waste management unit meets cleanup standards specified in an interim action ROD or action memorandum but for which a final action ROD has not been issued.

d. No Action: A reclassification status indicating a waste site does not require any further remedial action under RCRA Corrective Action, CERCLA, or other cleanup standards based on an assessment or quantitative data collected for the waste site.

e. Not Accepted: A classification status indicating an assessment was made that a WIDS site is not a waste management unit and is not within the scope of the Tri-Party Agreement Action Plan, Section 3.1. (Ecology, et al., 1989) This classification requires lead regulatory agency approval.

f. Rejected: A reclassification status indicating a waste site does not require remediation under RCRA Corrective Action, CERCLA, or other cleanup standards based on qualitative information such as a review of historical records, photographs, drawings, walkdowns, ground penetrating radar scans, and shallow test pits. Such investigations do not include quantitative measurements.

g. Accepted: A classification status indicating as assessment has been made that a WIDS site is a waste management unit as defined in the Tri-Party Agreement Action Plan, Section 3.1.

h. Discovery: An initial classification status indicating evidence of a potential waste site; assessment not yet complete. This is the classification of a newly discovered WIDS site.

1.2.3 100-D/H Orphan Site Evaluation

An orphan site evaluation (OSE) was conducted on the highest potential impact areas of 100-D/H to identify potential waste sites that may require additional characterization and possibly remediation (OSR-2006-0001, *100-D Area Orphan Sites Evaluation Report*, and OSR-2008-0002, *100-H Area Orphan Sites Evaluation Report*). The remainder of 100-D/H will be surveyed over the next several years. The scope of the 100-D evaluation included the 100-D Source OUs shown in Figure 1-9. The total area covered was about 275 hectares (680 acres) and required about 185 km (115 miles) of walking surveys. The D-Area OSE resulted in the identification of 30 new waste sites.

The scope of the 100-H evaluation included the 100-H Source OU plus several hundred acres outside the operable unit, as shown in Figure 1-10. The total area covered was about 300 hectares (742 acres), requiring about 200 km (125 miles) of walking surveys. The H-Area OSE resulted in the identification of 15 new waste sites.

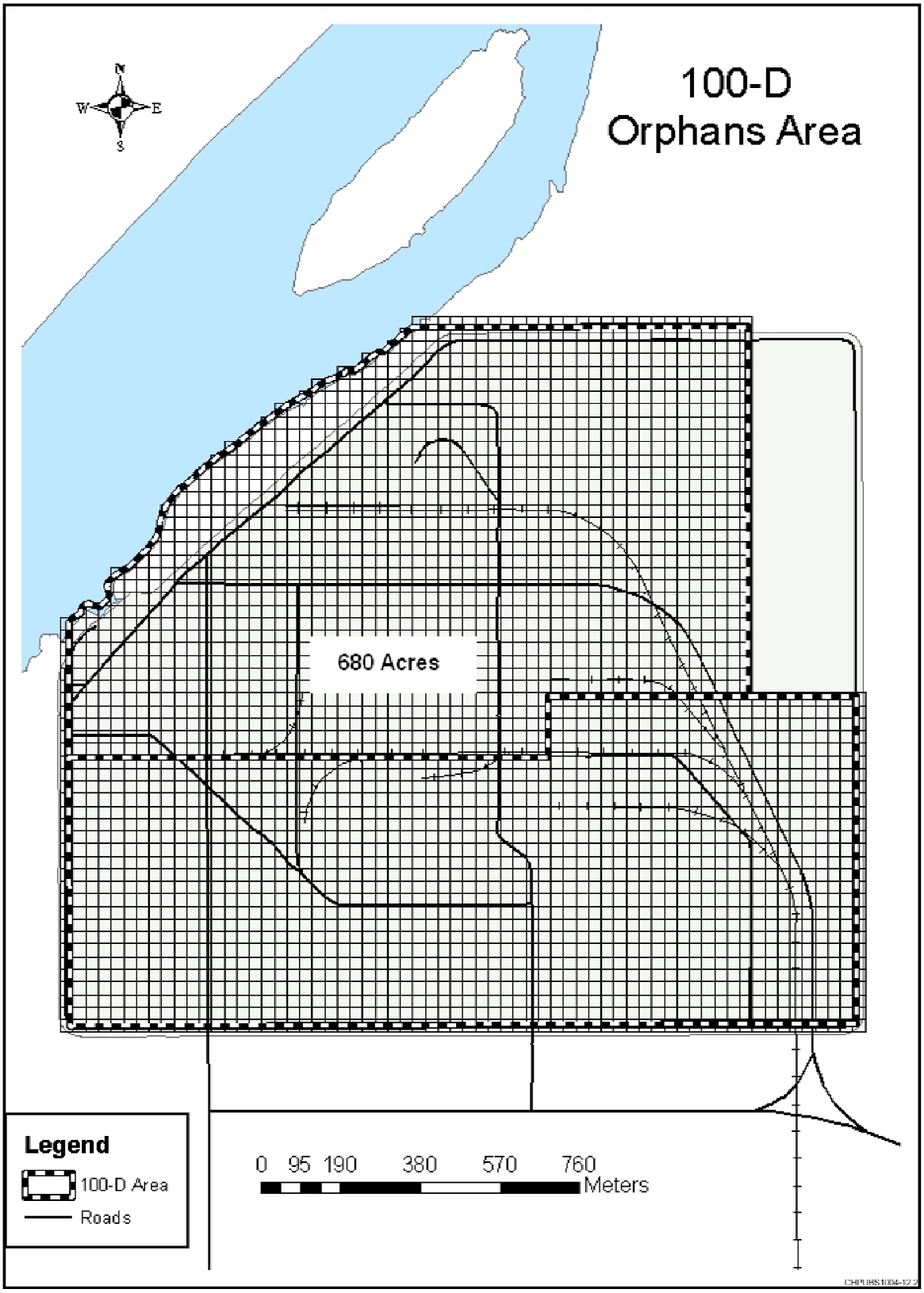


Figure 1-9. Area Addressed by 100-D Orphan Sites Evaluation Process

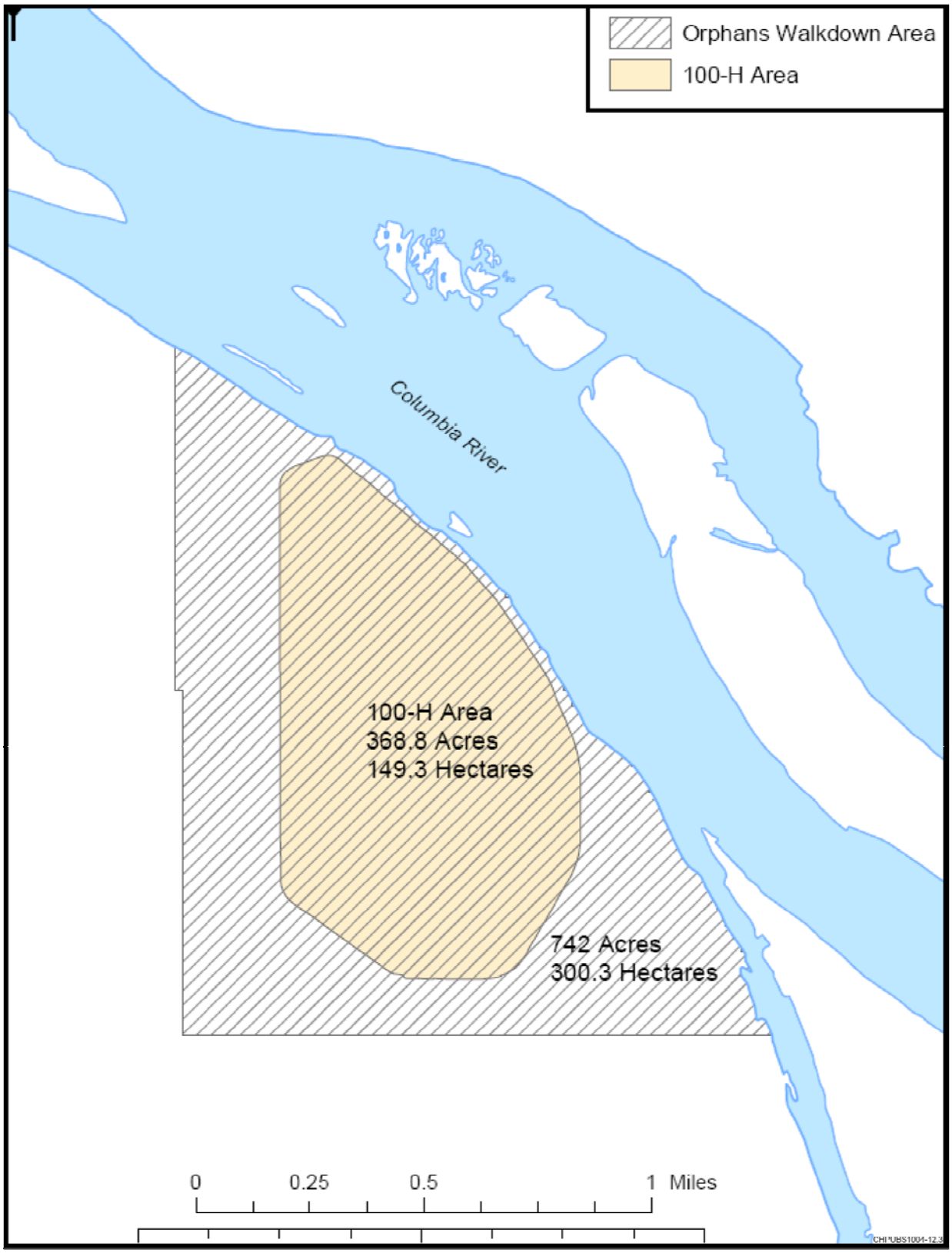


Figure 1-10. Area Addressed by 100-H Orphan Sites Evaluation Process

1.2.4 Sources of Hexavalent Chromium Plumes in 100-D

Despite removing over 200 kg (440 lb) of hexavalent chromium (Cr(VI)) through pump-and-treat operations, the plume of Cr(VI)-contaminated groundwater beneath 100-D has not markedly decreased over the past decade. This indicates that a source or sources continue to feed the plumes.

A recent project has refined the source location of the southwestern plume and work continues to do the same in the northern plume. These projects were designed to acknowledge the difficulty in pinpointing a source location, so the focus was placed on obtaining hydrogeologic and geochemical evidence from the aquifer in an attempt to backtrack the contamination to where it enters the aquifer from the vadose zone. Evidence from the saturated zone is supplemented by examination and chemical analysis of drill cuttings collected during the construction of new groundwater monitoring wells.

1.2.4.1 Evaluation of the Southwestern Plume

This project was composed of the following activities:

- Drilling 11 new groundwater monitoring wells in FY 2007 and FY 2008; all completed and fully penetrating the uppermost unconfined aquifer. These well locations are represented in Figure 1-11.
- Measuring Cr(VI) in vadose zone sediment samples collected during drilling.
- Measuring water level in the new wells hourly (with additional data from other wells in the Hanford Site automated water level measurement network).
- Collecting water samples from the new wells for determination of Cr(VI).
- Sampling depth-discrete groundwater and measuring Cr(VI) for selected wells to determine if the contaminant plume is stratified.

Groundwater samples collected from the investigation wells have revealed an area with very high Cr(VI) concentrations. Figures 1-12 and 1-13 are depictions of this hot spot, showing contoured Cr(VI) concentrations for groundwater in mid-May 2008 and in February 2009. The graph in Figure 1-13 illustrates the Cr(VI) concentration variation over a two and a half year period (February 2007 through August 2009).

It is reasonable to conclude that the location where Cr(VI) entered or continues to enter the aquifer at the water table is circumscribed by a 1 hectare (2.5-acre) circle. Wells upgradient of that area (e.g., Wells 199-D5-120 and 199-D5-121 upgradient of Well 199-D5-99) indicate Cr(VI) concentrations in groundwater several orders of magnitude lower than the suspected aquifer source area.

1.2.4.2 Evaluation of the Northern Plume

A program to drill boreholes in 100-D to locate the source of the northern Cr(VI) plume is being conducted (DOE/RL-2008-09, *Field Investigation Plan for the Source of the Northern Chromium Plume in the 100-D Area*). Additionally three groundwater wells were drilled to better define the plume. The compact sonic drill rig (CSDR) technology has allowed better definition of the distribution of Cr(VI) in the northern plume. Preliminary indications are that groundwater concentrations are more than an order of magnitude less in the northern plume than in the southern plume; however, chromium concentrations in the northern plume are significantly higher than state and federal water quality standards. Eleven CSDR vadose zone sampling locations were drilled within or adjacent to the plume (Figure 1-14). These locations were selected to provide vadose zone characterization points at suspected contamination areas based upon historical records and field observations of contamination identified during recent waste site remedial actions. A well and borehole planned in the vicinity of 132-D-3 were not drilled during the investigation; therefore, 132-D-3 remains a suspect location that will be further considered in the RI/FS report. The data collected from the investigation will be incorporated into the RI/FS report.

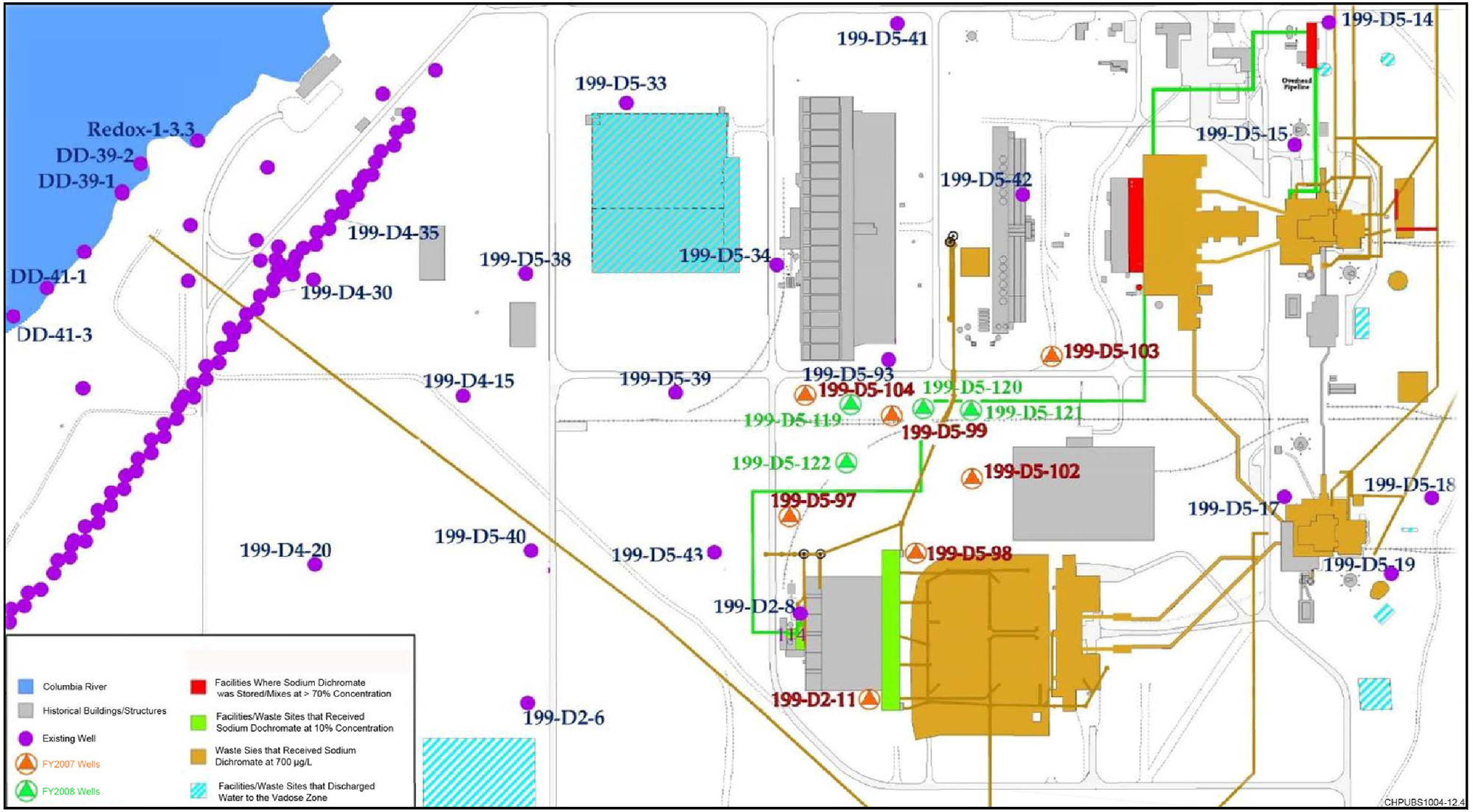


Figure 1-11. Map of Part of 100-D, Showing Wells Drilled for the Hexavalent Chromium Source Investigation in the Southwestern Plume

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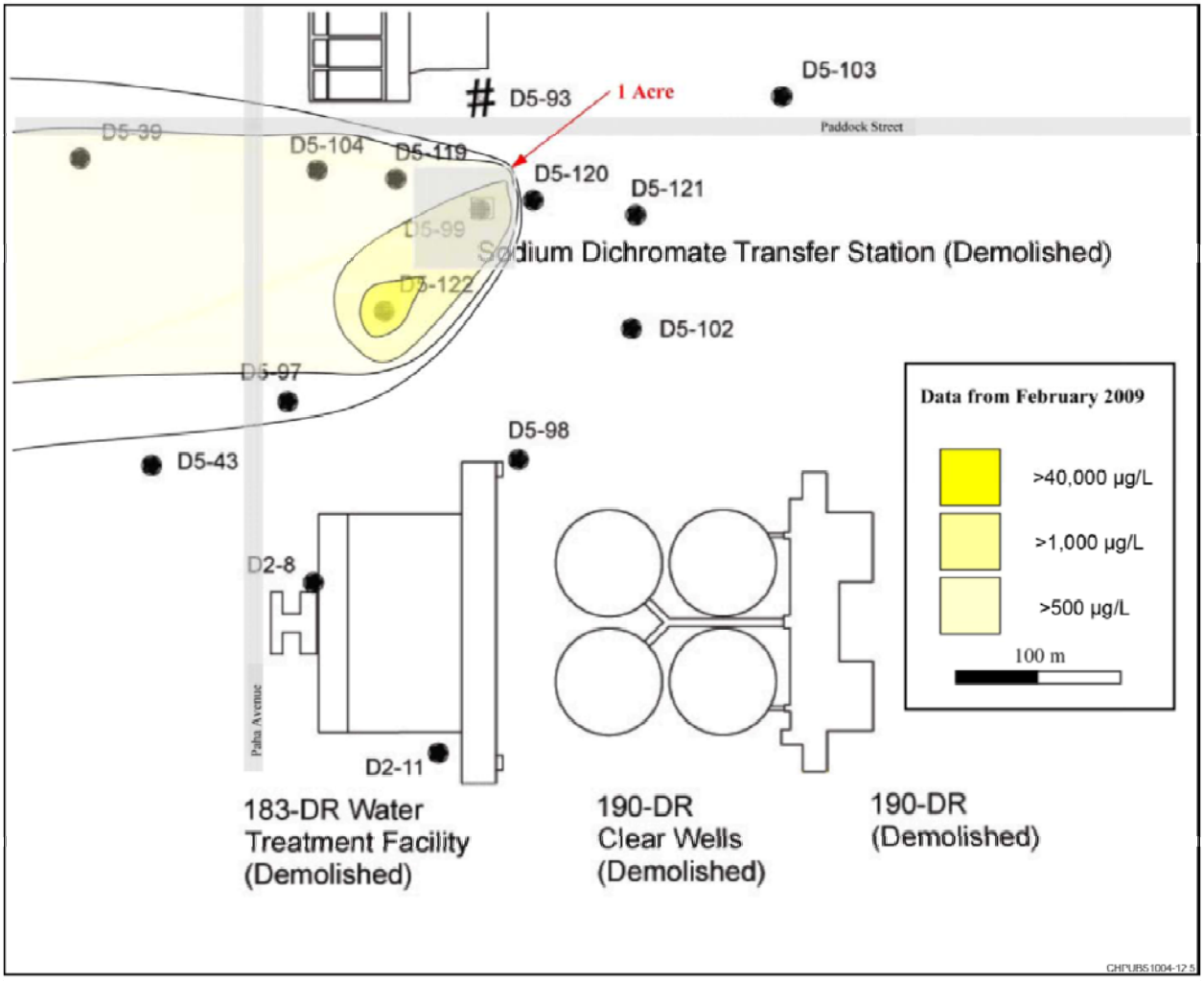

Figure 1-12. Contoured Concentrations of Hexavalent Chromium Concentrations in February 2009, Showing Hot Spot

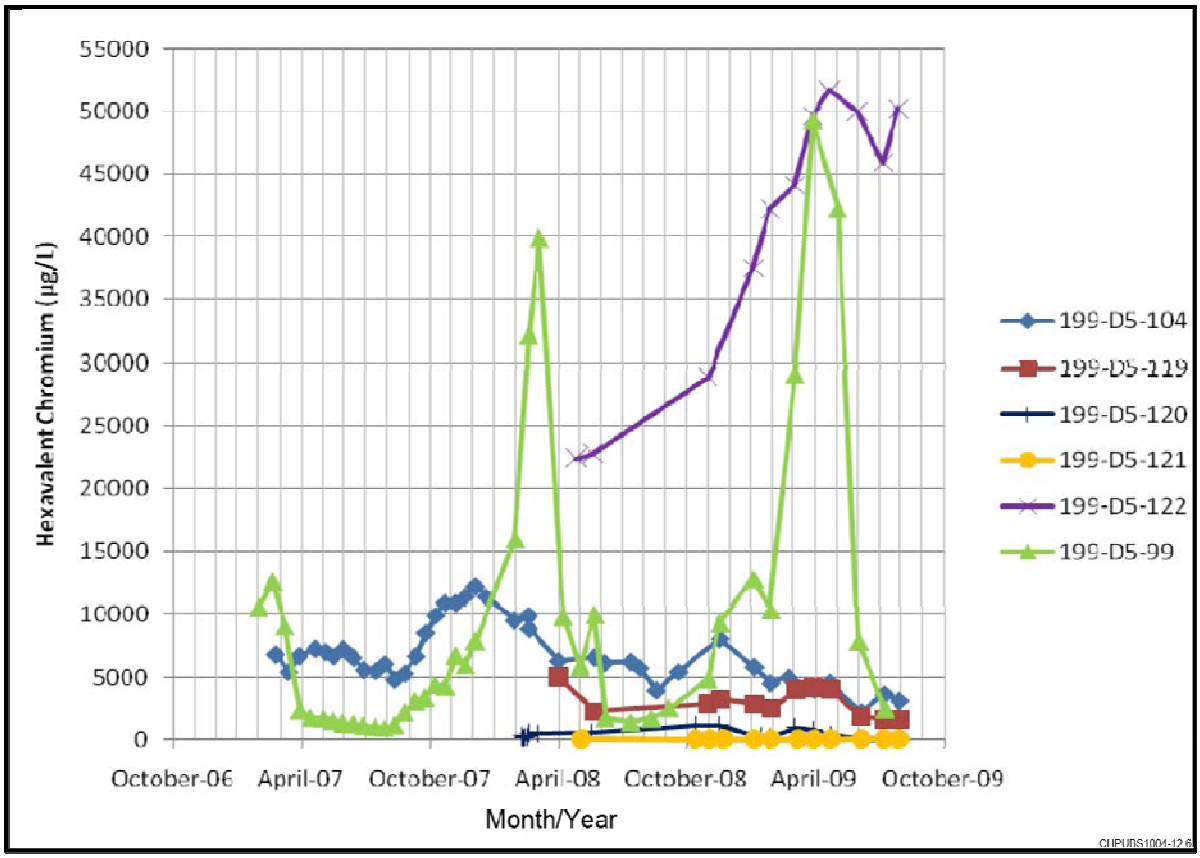

Figure 1-13. 100-D SW Hexavalent Chromium Hot Spot Variation 2007 Through 2009

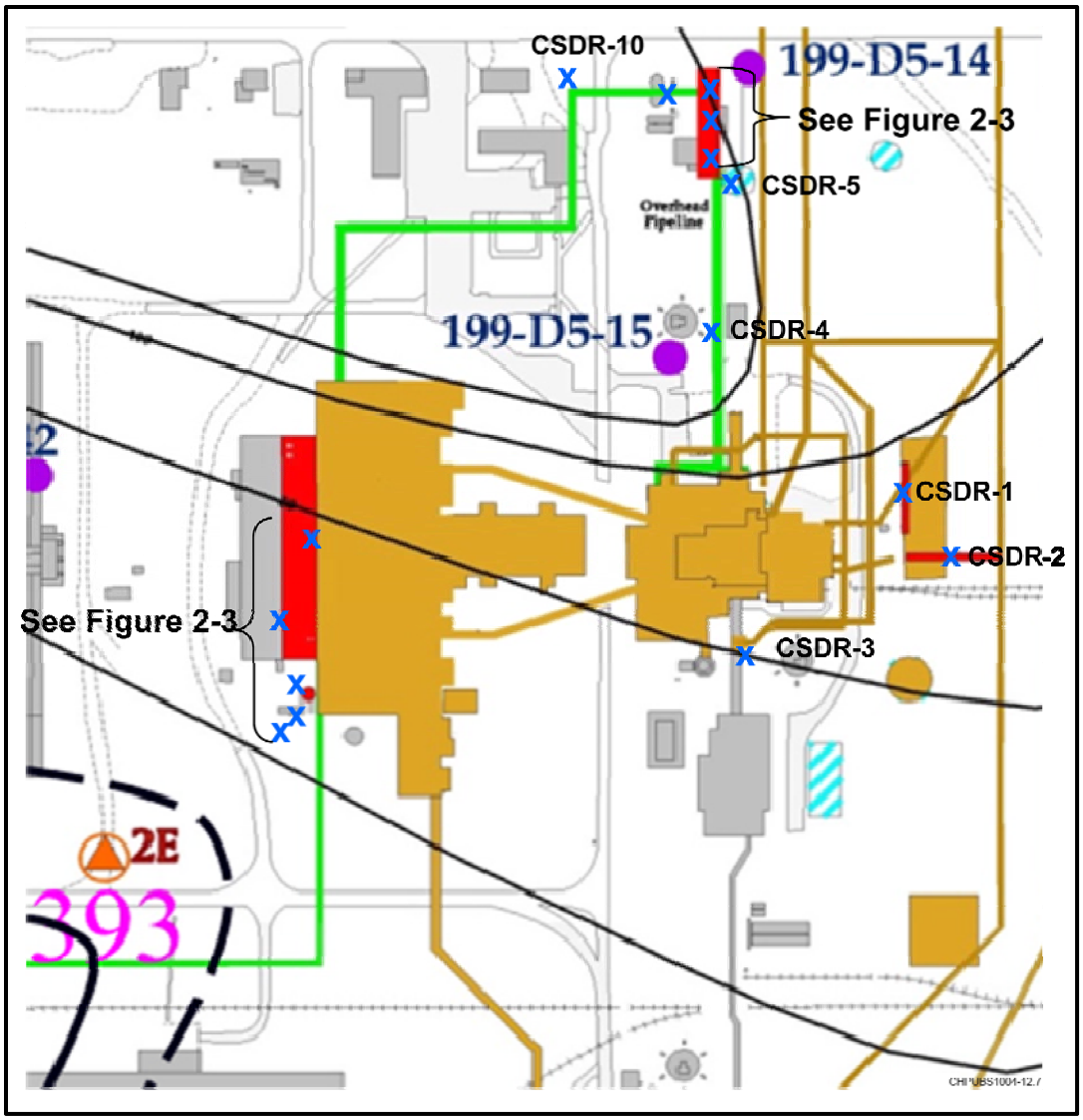

Figure 1-14. Location Map for the Up to Fifteen Compact Sonic Drill Rig Vadose Zone Sampling Locations (marked as X) in 100-D

1.2.5 Geochemical Characterization of Hexavalent Chromium Contamination in the Vadose Zone

At the Hanford Site, sodium dichromate was used throughout the 100 Area as a corrosion inhibitor in reactor cooling water. Sodium dichromate was delivered to various water treatment plants in railcars, tanker trucks, barrels, and local pipelines as sodium dichromate granular solid or stock solution. Sodium dichromate was inevitably discharged to surface or near-surface ground through spills during handling, pipeline leaks, or during disposal to cribs. Chromium contamination at the bottom of excavations (Figure 1-15) shows that spills carried Cr(VI) into the vadose zone.

Figure 1-15. Chromium Contamination Visible as Yellow Stains

A study has been completed for the following activities:

- Determining the leaching characteristics of Cr(VI) from contaminated sediments collected from 100 Area spill sites.
- Elucidating possible Cr(VI) mineral and/or chemical associations that may be responsible for Cr(VI) retention in the Hanford Site 100 Area using macroscopic leaching studies and microscale characterization of contaminated sediments (PNNL-17674, *Geochemical Characterization of Chromate Contamination in the 100 Area Vadose Zone at Hanford*).

In addressing these objectives, additional benefits accrued are as follows:

- A more complete understanding of Cr(VI) entrained in the vadose zone that can be used in modeling potential source terms.
- Accelerating the 100 Area Columbia River Corridor cleanup by providing valuable information to develop remedial action based on a fundamental understanding of Cr(VI) vadose zone geochemistry.

1.2.6 100-D/H Pump-and-Treat Systems

From January 1997 through December 2007, two pump-and-treat systems in 100-D and 100-H treated over 3 billion L (900 million gal) of groundwater and removed over 500 kg (1,100 lb) of Cr(VI) from the aquifer in the 100-HR-3 OU.

The pump-and-treat systems, one of the remedial actions implemented from the 1996 interim action ROD, were designed to remedy Cr(VI) in the groundwater along the Columbia River corridor of the Hanford Site. The systems' current network of 14 extraction wells and 4 injection wells draws the groundwater from the aquifer, processes it through an ion exchange system that removes toxic Cr(VI), and returns the treated groundwater to the aquifer. As shown in Table 1-3, the pump-and-treat systems have made progress in the last decade.

Table 1-3. Current Pump-and-Treat Systems in the 100-HR-3 Operable Unit

System	Startup	Groundwater Treated since Startup*	Cr(VI) Removed since Startup*	Design Capacity	Current Average Process Flow	Number of Extraction Wells	Number of Injection Wells
		million L (million gal)	kg (lb)	L/min (gpm)	L/min (gpm)		
HR-3	June 1997	3,200 (845)	325 (717)	1,100 (300)	630 (167)	10	3
DR-5	July 2004	230 (60)	178 (392)	200 (50)	140 (38)	4	1
Totals		3,430 (905)	503 (1,109)	1,300 (350)	770 (205)	14	4

Notes:

* Through December 2007

Cr(VI) = hexavalent chromium

The 100-HR-3 pump-and-treat system started operations in 1997 with seven extraction wells and three injection wells. This system focuses on remediation of the groundwater in the area of the 100-H Reactor and in the northern plume in 100-D. Figures 1-16 and 1-17 show the location of the extraction and injection wells of the HR-3 System. Figures 1-18 and 1-19 show the Cr(VI) plume in the late 1990s when the pump-and-treat system started and in 2008 after 11 years of operation. The 2008 results show that a significant portion of the plume has been cleaned to below the aquatic standard in 100-H that the pump-and-treat system covered. In FY 2009 and FY 2010, a rebound study is being conducted in 100-H to better understand the effectiveness of the pump and treat system since 1997 and the current water quality in the upper aquifer. Additionally, the rebound study will test the persistence of Cr(VI) contaminated groundwater in the Ringold Upper Mud (RUM) Unit through a long-term pumping test where several wells are being hooked up to the HR-3 pump and treat system.

The pump-and-treat system in the northern plume in 100-D has not been as effective because of continuing sources in the vadose zone or aquifer. Information on Cr(VI) in 100-H is presented in Chapter 4.

A task is underway to identify wells that can be connected to the HR-3 pump-and-treat system to increase the throughput of the system. The system is operating at 55 percent of the design capacity. Increasing the throughput will accelerate the remediation in the HR-3 OU. Wells are being placed north of the H Reactor to capture the low concentration, dispersed plume migrating across the Horn from D and DR Reactors. While Cr(VI) concentrations are generally less than 100 µg/L, the plume intercepts the river in an area of known salmon redds, and is thus an issue for protection of the aquatic receptors.

In July 2004, the 190 L/min (50 gpm) capacity DR-5 pump-and-treat system began operations to address a Cr(VI) “hot spot” identified in the 100-D southern plume. From July 2004 through December 2007, this system removed 178 kg (392 lb) of Cr(VI) and treated 230 million L (60 million gal) of groundwater. Figure 1-16 shows the location of the four extraction wells and one injection well included in this system. Because of its lower capacity, the DR-5 pump-and-treat is less cost effective than the larger plants, but has been kept in operation because of its Cr(VI) removal effectiveness.

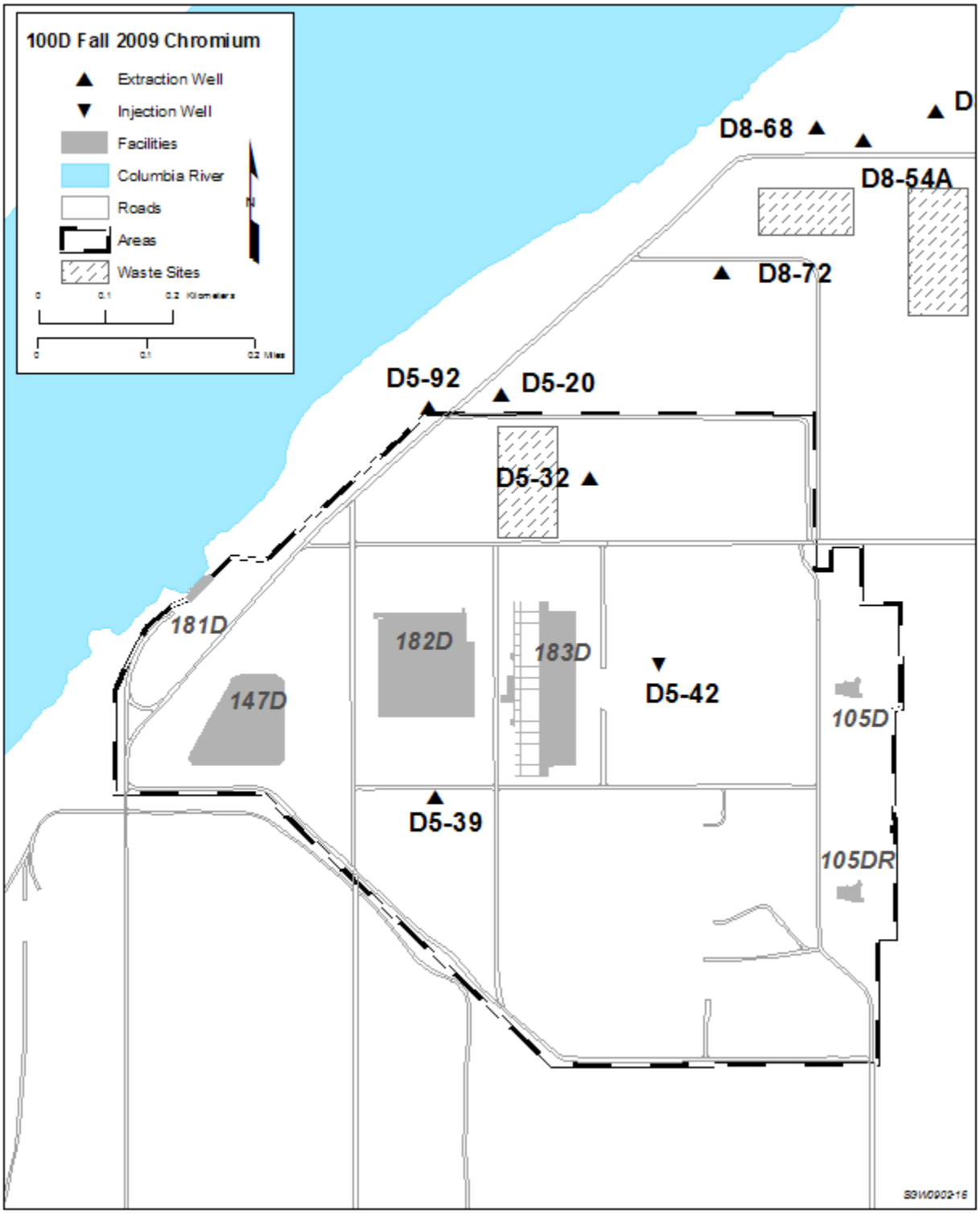

Figure 1-16. Location of the 100-HR-3 Pump-and-Treat System Wells in 100-D (2008)

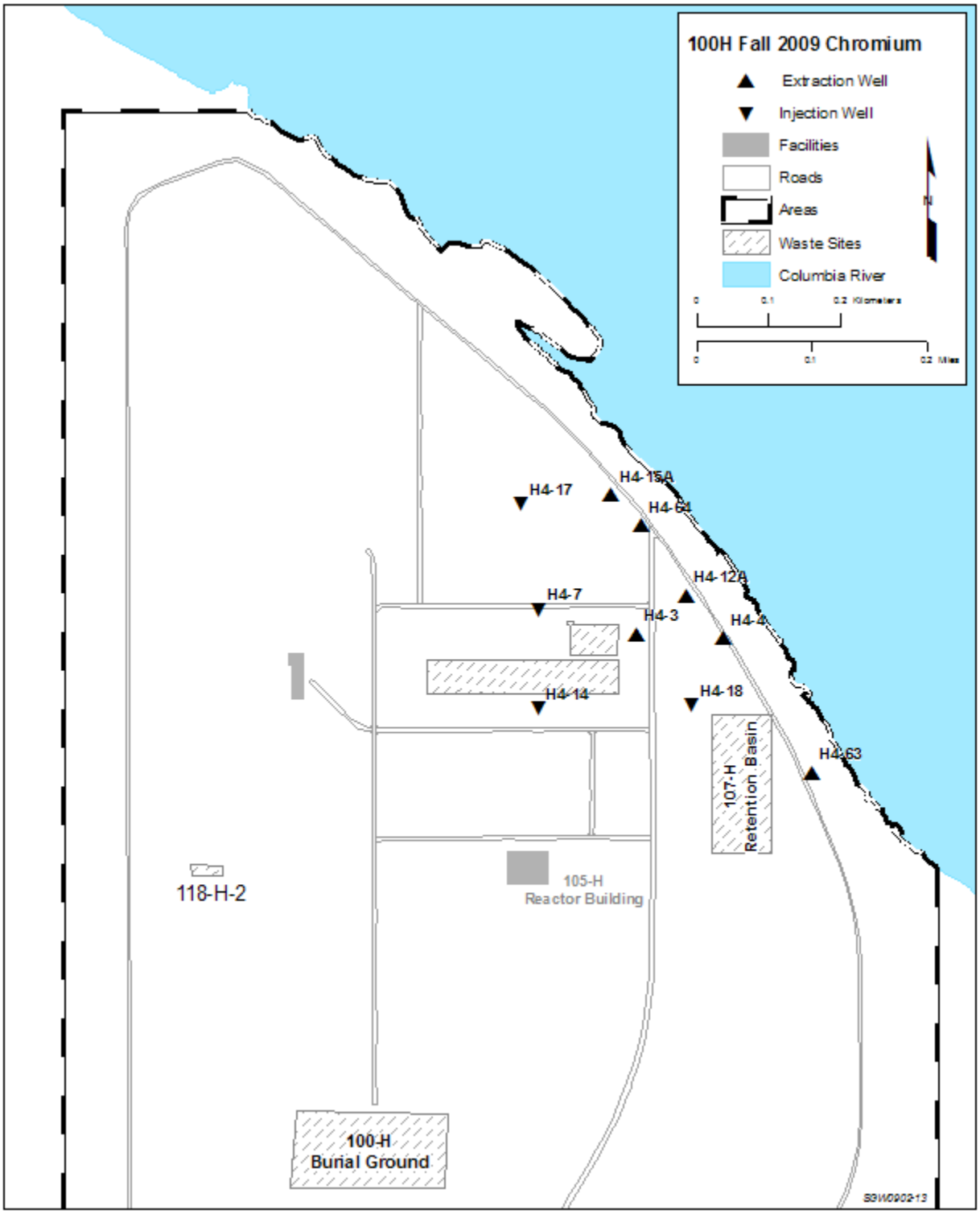

Figure 1-17. Location of the 100-HR-3 Pump-and-Treat System Wells in 100-H (2008)

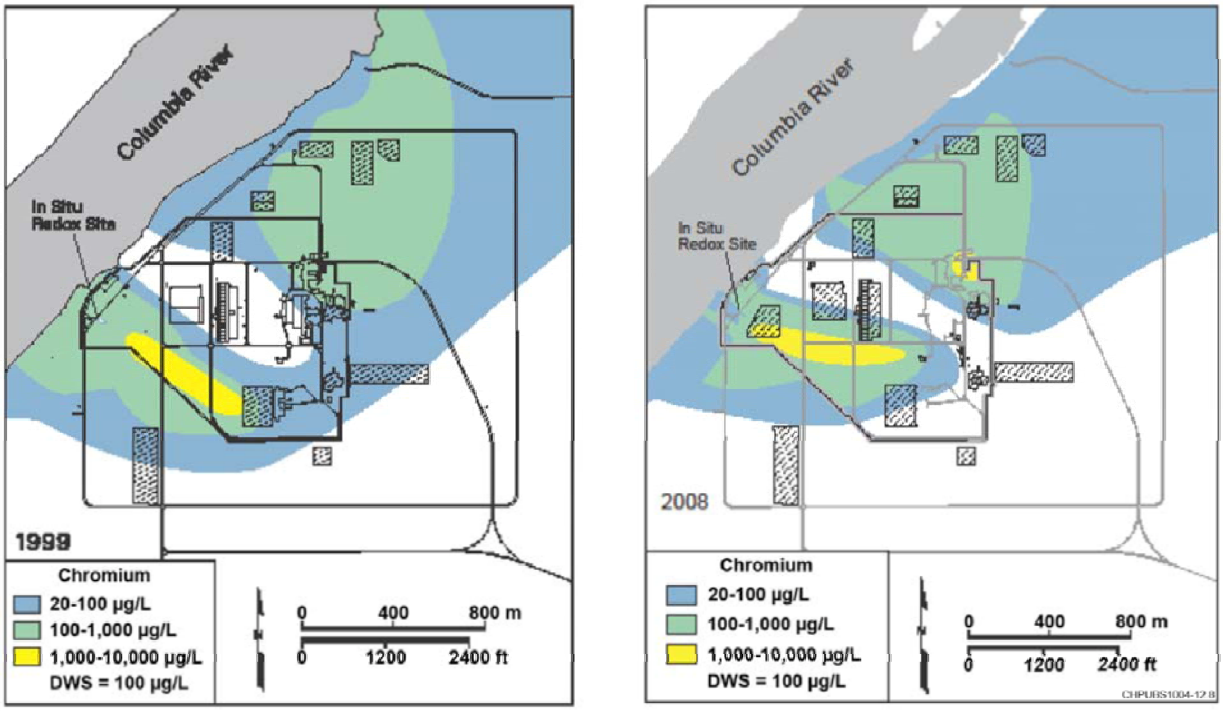

Figure 1-18. 100-HR-3, 100-D Hexavalent Chromium Plume 1999 and 2008

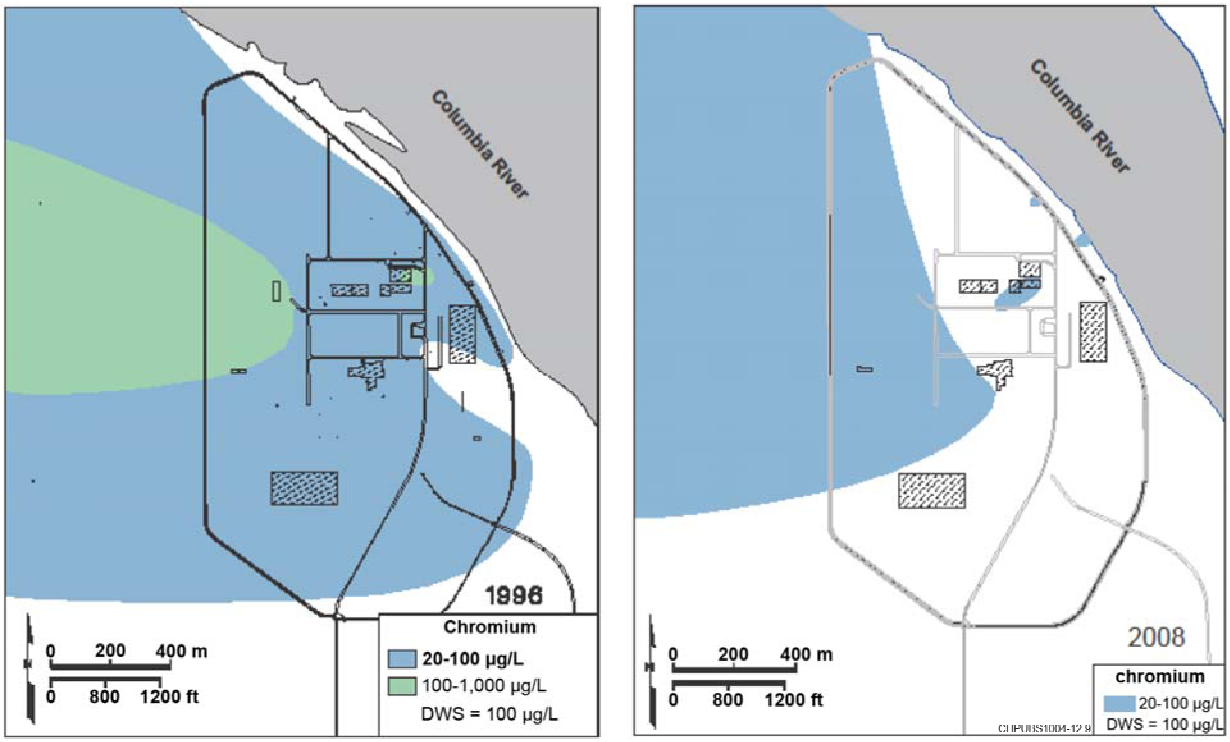

Figure 1-19. 100-HR-3, 100-H Hexavalent Chromium Plume 1996 and 2008

From the plume maps shown in Figures 1-18 and 1-19, it is clear that additional pumping capacity is needed to remediate the Cr(VI) plumes in the 100-HR-3 OU. Activities will be undertaken to significantly expand the pump-and-treat facilities associated with 100-D/H (Figures 1-20 and 1-21). The expanded pump-and-treat system (DX[1]) will focus on remediation of 100-D and adding hydraulic gradient control along the river shore to prevent groundwater flow into the river to achieve river protection. The criteria for operation of the expanded pump and treat system will be established in an upcoming revision of the DOE/RL-2009-56, *Remedial Design Report for 100-HR-3* (draft, not yet published), which will require regulatory approval. It is anticipated that the system will maintain separation of the 100-D north and south plumes, and be flexible downstream of the In Situ Redox Manipulation (ISRM) barrier to enable extraction (initially) or injection (eventually) to capture Cr(VI) that has migrated through the ISRM barrier. While the DX pump-and-treat system is primarily focused on 100-D, the current practice of transferring groundwater between 100-D and 100-H will continue as needed to establish hydraulic gradient control along the river shore in both areas to achieve protection of the river from Cr(VI) contamination.

[1] DX and HX refer to expanded pump-and-treat systems that will focus on remediation of 100-D and 100-H, respectively.

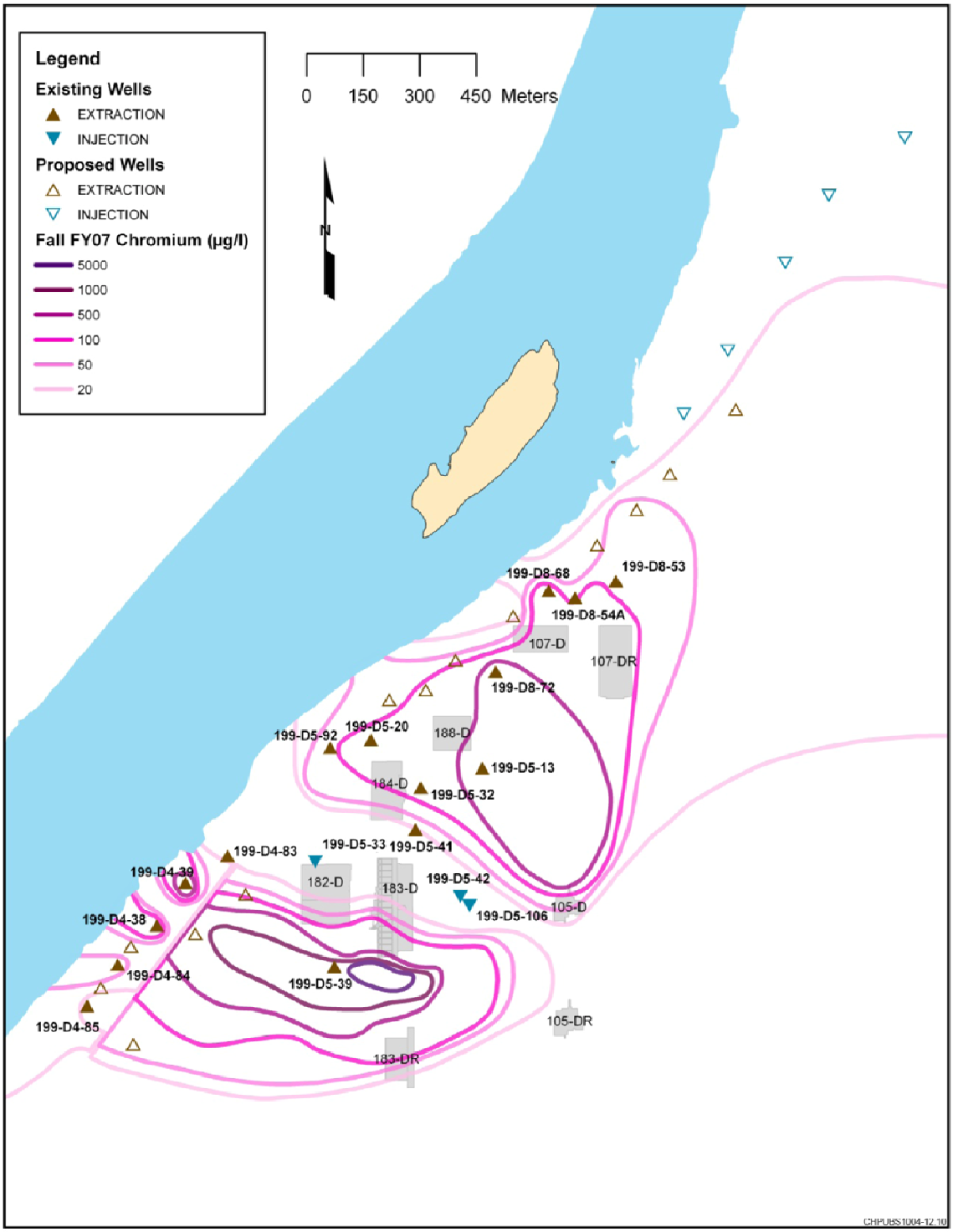

Figure 1-20. Proposed Location of Selected DX Expansion Pump-and-Treat Wells in 100-D

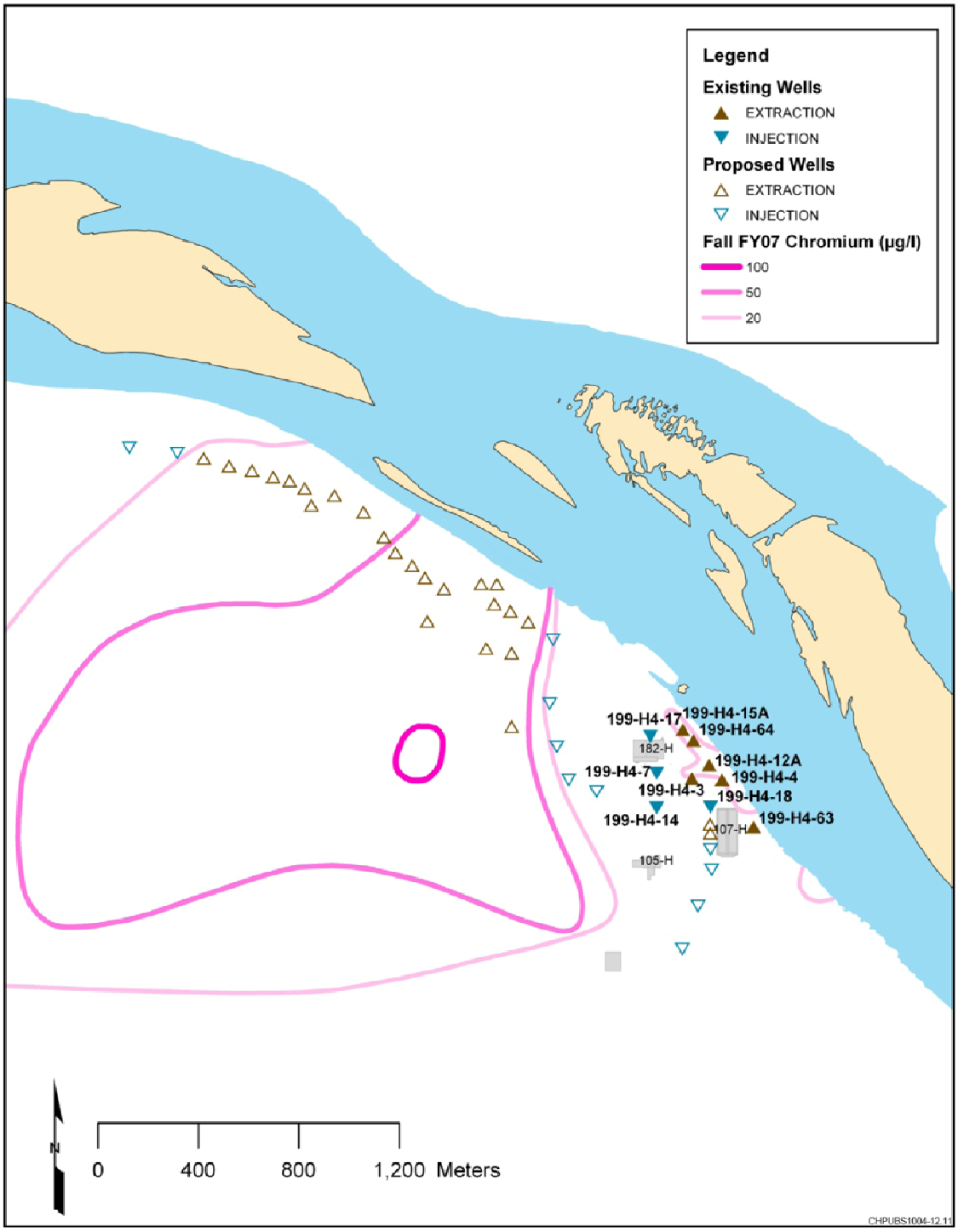

Figure 1-21. Proposed Location of Selected HX Expansion Pump-and-Treat Wells in 100-H

The present systems and planned improvements and expansions of the pump-and-treat network (listed in Table 1-4), in conjunction with other remedial actions, will accelerate achievement of the objective to protect the aquatic receptors.

Table 1-4. Ongoing and Planned Optimization and Expansion of the Pump-and-Treat Systems in 100-D/H

System	Actual/Scheduled Operation	Design Capacity L/min (gpm)	Number of Extraction Wells[a]	Number of Injection Wells[a]
HR-3	June 1997 - present	1,100 (300)	10	4
HX[c]	December 2011	2,700 (700)	31	13
DR-5[b]	July 2004 - present	190 (50)	4	1
DX[c]	December 2010	2,300 (600)	~35	~14
Totals by December 2011 (DX + HX)		~5,000 (~1,300)	~66	~27

Notes:

Values shown are approximate based on current information and may change as further design of the systems and system improvements occur.

a. New and existing wells are included in these numbers.

b. DR-5 is not included in the totals, as it will be shut down by December 2011.

c. DX and HX refer to expanded pump-and-treat systems that will focus on remediation of 100-D and 100-H, respectively.

gpm = gallons per minute

In addition to supporting system efficiencies, the evaluation of the pump-and-treat systems and their effectiveness will contribute to the feasibility study.

1.2.7 100-D In Situ Redox Manipulation

The ISRM barrier is a groundwater remediation technology that can successfully reduce Cr(VI) in place within an aquifer, resulting in a less toxic and immobile form of chromium. This fact led to the adoption of ISRM as the remedy of choice for the southern part of the Cr(VI) plume at 100-D. The ISRM technique involves the creation of a permeable treatment zone downstream of a contaminant plume. Injection of a chemical reducing agent alters the redox potential of aquifer fluids and sediments (Fruchter et al., 2000, “Creation of a Subsurface Permeable Treatment Zone for Aqueous Chromate Contamination Using In Situ Redox Manipulation”). Redox-sensitive contaminants migrating through this treatment zone are immobilized (metals) or destroyed (organic solvents) as the groundwater passes through. Injected reagents create the zone through reactions that reduce iron naturally present in aquifer sediments from ferric iron (Fe(III)) to ferrous iron (Fe(II)). Use of standard wells for treatment zone creation allows treatment of contaminants too deep for conventional trench-and-fill technologies.

Figure 1-22 illustrates how the ISRM technology works to protect the Columbia River from Cr(VI) contamination.

The ISRM barrier consists of 65 wells spaced across the width of the chromate plume. Based on maximum detected dissolved chromate levels, and the dissolved oxygen content in the groundwater, the barrier was originally estimated to be effective for 15 to 20 years, depending on the groundwater flow rate. However, a wide-spread groundwater plume of 60 mg/L nitrate may reduce the barrier longevity by 7 to 10 years.

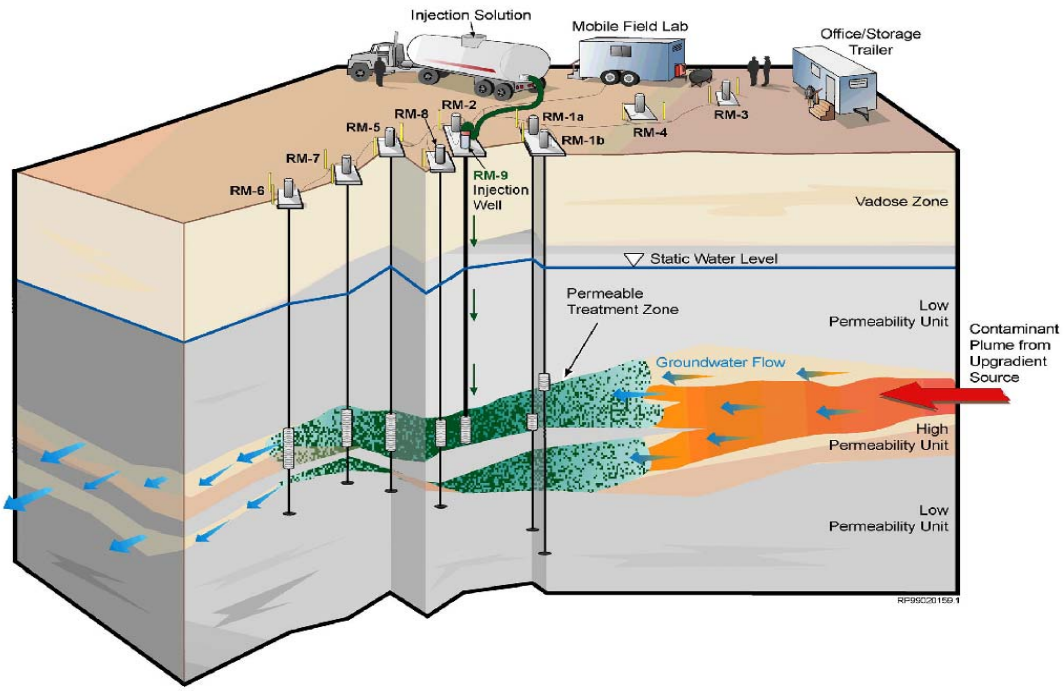

Figure 1-22. In Situ Redox Manipulation Technology

Currently, 17 wells show signs of performance deterioration. A particulate iron injection method and a biostimulation method are being tested as possible fixes for the wells that are not performing properly. In the meantime, the other 48 wells continue to function to reduce the Cr(VI) and protect the river.

1.2.8 Horn Study

It was known that a plume of Cr(VI) was present in the groundwater between 100-D and 100-H, the area known as the Horn, resulting from past operations at 100-D and 100-H. However, it was not known how widespread or how concentrated the plume was. Cr(VI), even in concentrations as low as 10 µg/L, may affect the development of young salmon in the Columbia River near the Horn. The investigation objectives were to better define the extent and concentrations of Cr(VI) in the Horn, disturb the land as little as reasonably possible, and minimize traces left after the investigation. Wells needed to be constructed to obtain groundwater samples throughout the Horn and the samples analyzed for Cr(VI). Additionally, special small-diameter screens (aquifer tubes) needed to be installed along the river shore during low river stage to determine how much Cr(VI) was present close to the salmon egg nests.

Field investigation of the Horn in the 100-HR-3 OU was performed in FY 2007 and FY 2008 (DOE/RL-2008-42, *Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*). This investigation is the initial response for the actions in Issues No. 9 and No. 12 of DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site*. Twenty-one groundwater monitoring wells and 18 aquifer tubes were installed in the Horn (Figure 1-23) to obtain underlying hydrogeological properties. The new monitoring wells also support the ongoing CERCLA groundwater monitoring and remedial actions at the 100-HR-3 Groundwater OU.

The investigation was successful in better defining the extent and concentration of Cr(VI) in the groundwater of the Horn (Figure 1-23). The Cr(VI) plume (above 20 µg/L) covers an area of approximately 6.3 km^2 (2.4 mi^2) with a maximum value of 103 µg/L. The federal drinking water standard for total chromium is 100 µg/L and the state of Washington, *Model Toxics Control Act* (MTCA),

(WAC 173-340-720) groundwater standard for Cr(VI) is 48 µg/L. Groundwater flow is generally west to east across the Horn, although groundwater flow is inland when the Columbia River stage is high. A significant silt and clay layer known as the RUM unit is continuous and mostly flat lying below the Horn, and is considered the bottom of the unconfined aquifer. The three monitoring wells completed within the RUM exhibit low levels of Cr(VI), which further implies that the silt and clay layer acts as the base of the unconfined aquifer. Details regarding the sources of chromium contamination in the RUM are provided in Chapter 4. The unconfined aquifer is generally from 1.5 to 7 m (5 to 24 ft) thick. Data from the new wells and aquifer tubes will be used to help determine cleanup strategies for the relatively diffuse portion of the plume across the Horn (DOE/RL-2008-42). Details regarding the sources of chromium contamination in the Horn are provided in Chapter 4.

1.2.9 Remedial Process Optimization

Remedial Process Optimization (RPO) is a process for the systematic evaluation and enhancement of site remediation processes to foster cost savings and improved technical effectiveness of a cleanup action. Some RPO data will be used to support this RI effort. An RPO effort was initiated for 100-D in FY 2008 and is continuing into FY 2009.

During FY 2008 and FY 2009, the RPO focused on the following activities:

- Identifying actions to reduce the cost and improve the performance of existing remedial systems including expansion of the pump-and-treat, resin testing, and hot spot treatment.
- Evaluating promising new technologies (e.g., bioremediation) for Cr(VI) remediation and developing potential applications of these technologies, along with the existing remedial actions, with the goal of achieving river protection by FY 2012 and groundwater cleanup by FY 2020.

These efforts culminated in the development of a two-step or phased approach for implementation of proposed remedial alternatives to 100-D and 100-H and the Horn. The following alternatives were developed:

- **Phase 1 – Continue Current Actions:** Existing institutional controls would remain in place and RTD and pump-and-treat operations would continue. The RTD and pump-and-treat operations will be expanded.
- **Phase 2 – Continue Current Actions with In Situ Chemical or Biological Remediation:** Current actions would continue with the addition of the option to conduct in situ bioremediation or chemical remediation to accelerate remediation of groundwater. Currently, chemical and biological remediation are not used on groundwater and soil contamination but will be evaluated in the future.

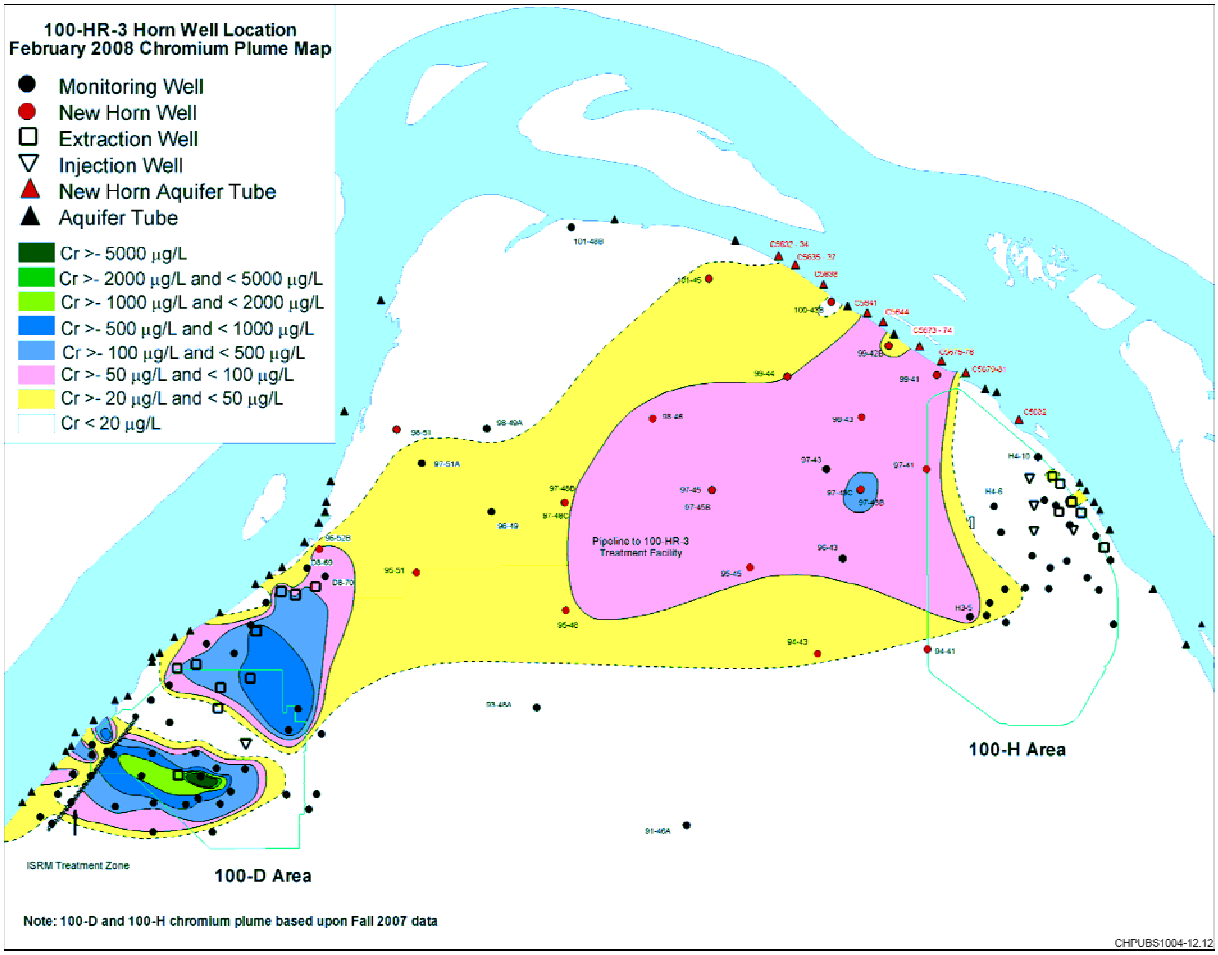

Figure 1-23. Well and Aquifer Tube Locations and Unfiltered Hexavalent Chromium Distribution (February 2008)

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2 Site Background and Environmental Setting

Between 1943 and 1963, nine plutonium production reactors were built along the Columbia River. Production of special nuclear materials for national defense was the core function of the 100 Area production reactors, with most of the associated infrastructure and capabilities in those areas centered on performing that task. The 100-D/H area includes three of these reactors. This section provides the background and environmental setting of 100-D/H and includes information on waste generated and contamination, both known and potential.

Information in this section primarily comes from WHC-SD-EN-TI-181, *100-D Area Technical Baseline Report*; BHI-00127, *100-H Area Technical Baseline Report*; UNI-946, *Radiological Characterization of the Retired 100 Areas*; DOE/RL-93-29, *Limited Field Investigation Report for the 100-DR-1 Source OU*; and DOE/RL-93-51, *Limited Field Investigation Report for the 100-HR-1 OU*.

2.1 100-D/H Overview

Portions of the Hanford Site are designated numerically, with the location of production reactors being the 100 Area. The 100 Area is located in the northern part of the Hanford Site along the south shore of the Columbia River (Figure 2-1). The 100 Area has been divided into five areas, each of which is composed of source and groundwater OUs (Figure 1-2).

Missions specific to the reactor areas include plutonium production and corrosion control process engineering at 100-D and plutonium production and equipment testing at 100-H (BHI-00127, *100-H Area Technical Baseline Report,* Rev. 0 and WHC-SD-EN-TI-181).

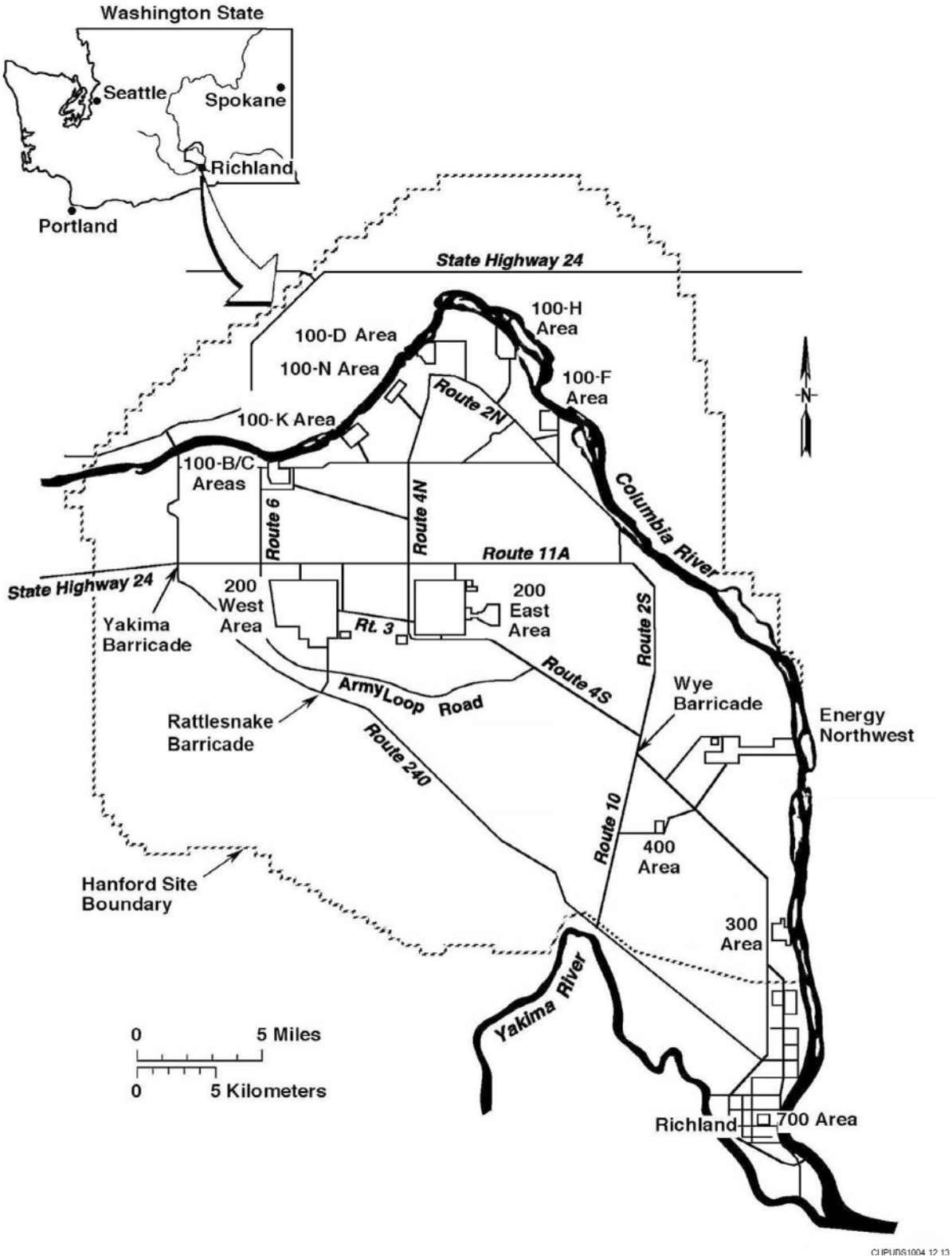


Figure 2-1. Location of the Hanford Site and the 100 Area

For cleanup and planning purposes, 100-D and 100-H were previously divided into source and groundwater OUs. Source OUs are concerned with liquid, solid, and radioactive waste disposal sites. The 100-D area includes the 100-DR-1 and 100-DR-2 Source OUs. The 100-H area includes the 100-HR-1 and 100-HR-2 Source OUs. The 100-HR-3 OU is a groundwater OU located beneath and between 100-D and 100-H and the Horn. All of these OUs are included in 100-D/H. The 100-D/H site information is summarized in Table 2-1.

Table 2-1. 100-D/H Site Location Information

Sub-Area	Site Information
100-D	The 100-D area is located west and upstream of the Horn where the Columbia River has a northeasterly flow (Figure 2-1). This location has two production reactors, D and DR, with their associated infrastructure. Source area OUs include 100-DR-1 and 100-DR-2.
100-H	The 100-H area is located east and downstream of the Horn where the Columbia River has a southeasterly flow (Figure 2-1). This location has one production reactor, H, with its associated infrastructure. Source area OUs include 100-HR-1 and 100-HR-2.
Horn (in the 600 Area)	The Horn is the region between 100-D and 100-H. It was used for agricultural purposes until 1943. A few isolated waste sites were located in the Horn (e.g., 600-151, 600-152, and the Sodium Dichromate Barrel Landfill), but this area is relatively undisturbed (Figure 2-1).
Groundwater	The 100-HR-3 Groundwater OU encompasses the groundwater beneath the entire region from 100-D to 100-H.

Notes:
OU = Operable Unit

The 105-D Reactor was constructed in 1944 in 100-D. It was the second of three original reactors built at the Hanford Site. In the late 1940s, the 105-D Reactor was believed to be nearing the end of its effective operational life because of growth and distortion of its core graphite, so a second reactor was planned as a replacement. The 105-DR Reactor construction was completed in 1949 and reactor operations began in October 1950. Operations at the 105-D Reactor continued after technical upgrades were implemented and a decision was made that the reactor was safe to operate. The 100-DR Reactor was deactivated in 1964 and the 105-D Reactor was deactivated in 1967 (WHC-SD-EN-TI-181). The 105-D and 105-DR Reactors have both been placed into ISS. The 105-D Reactor completed ISS in September 2004 and the 105-DR Reactor in September 2002. Figure 2-2 shows an aerial view of 100-D prior to ISS. Selected facilities show 100-D prior to decommissioning and demolition. Figure 1-3 shows 100-D after ISS.

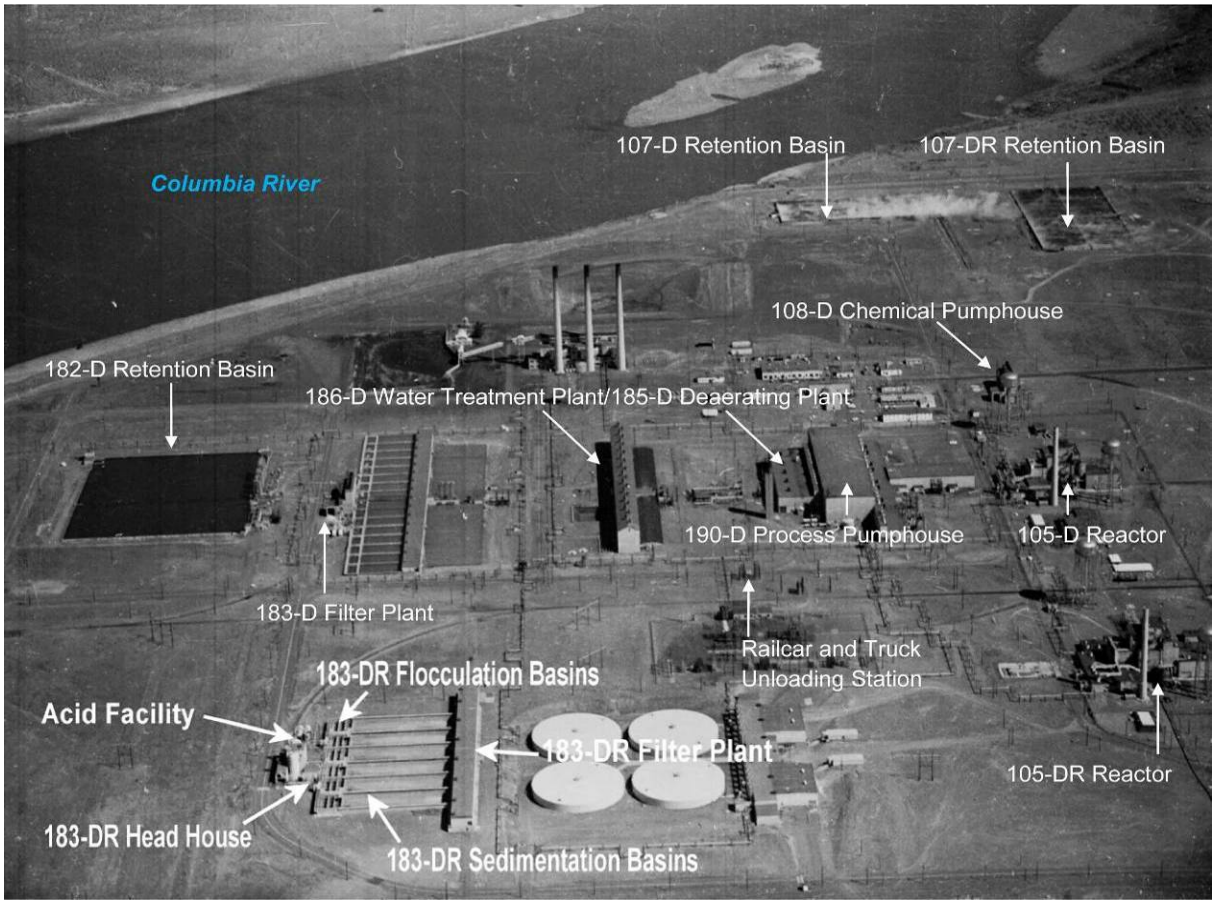


Figure 2-2. Aerial View of 100-D (Selected Facilities Identified, 1966)

The 105-H Reactor was constructed in 100-H in 1949 and was deactivated in 1965. The 105-H Reactor completed ISS in October 2005. Figure 2-3 shows an aerial view of 100-H prior to ISS. Selected facilities show 100-H prior to decommissioning and demolition. Figure 1-4 shows 100-H after ISS.

2.2 Environmental Setting

Environmental setting of the 100 Area is provided in detail in the Work Plan. Information specific to 100-D/H is included here. The environmental setting dictates much of the behavior of contamination within and through the vadose zone and groundwater.

The 100-D/H area is located in the northern portion of the Hanford Site adjacent to the Columbia River. The Columbia River has an average flow of approximately 3,400 cubic meters per second (m^3/s) (120,000 [ft^3/s]) (USGS, 2010, DART Streamflow for Columbia River Basin Graphics & Text Database). The 100-D and 100-H areas are geographically separated by the Horn where the southeasterly flow of the river is redirected to the northeast, rounds the tip of the Horn, and regains its southeasterly flow. The river stretch along the Horn defines the upper portion of the Hanford Reach, which is an important ecological, cultural, historical, and recreational feature.

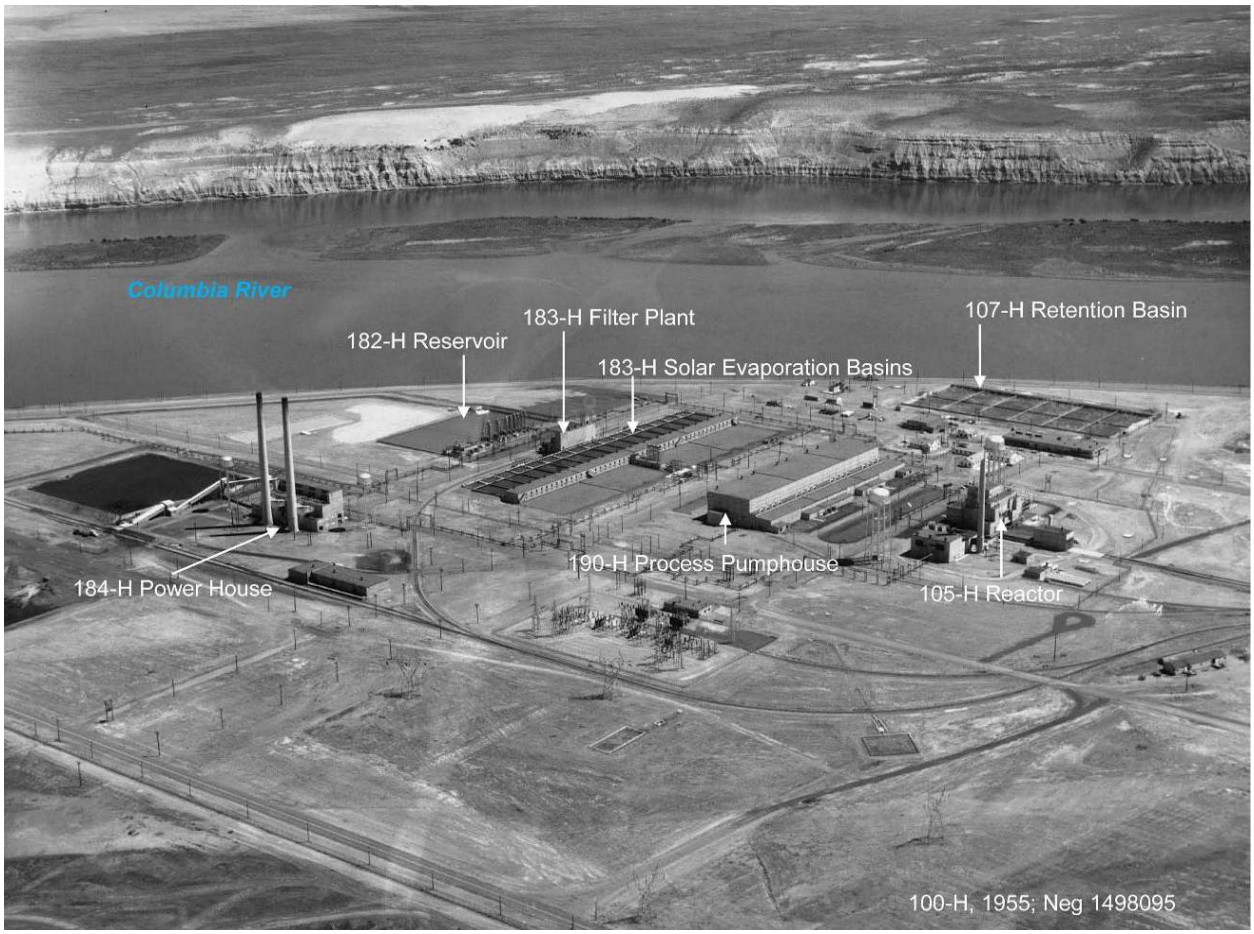


Figure 2-3. Aerial View of 100-H

2.2.1 Topography

The topography of 100-D/H is relatively flat inland from the Columbia River. The area has been disturbed and graded extensively by human activity since reactor construction began in the 1940s through present-day waste site remedial activities. The 100-D and 100-H areas lie on an essentially flat semi-arid bench south of the Columbia River. The elevations range from approximately 116 to 140 m (380 to 460 ft) above mean sea level (DOE/RL-93-43, *Limited Field Investigation Report for the 100-HR-3 Operable Unit*). The Columbia River falls approximately 3 m (10 ft) between 100-D and 100-H. The land surface slopes gradually toward the river, with a bank of up to 9 m (30 ft) at the edge of the river. In the Horn, swells and depressions mark the location of glacial flood bars and channels. Additional flood-related landforms are found to the south of the 100-HR-3 southern boundary.

The landscape is dominated by 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 drainage from infrastructure, facilities, and past development. Numerous infrastructure features are present including pipelines, reactor buildings, former waste sites, and groundwater remediation systems and equipment.[2]

[2] 100-D/H infrastructures and features are identified and described in Appendix D of this addendum.

2.2.2 Geology

An overview of the regional geology of the 100 Area is provided in the Work Plan. A depiction of generalized geology of the 100 Area is shown in Figure 2-4. Additional information specific to 100-D/H is provided in this section.

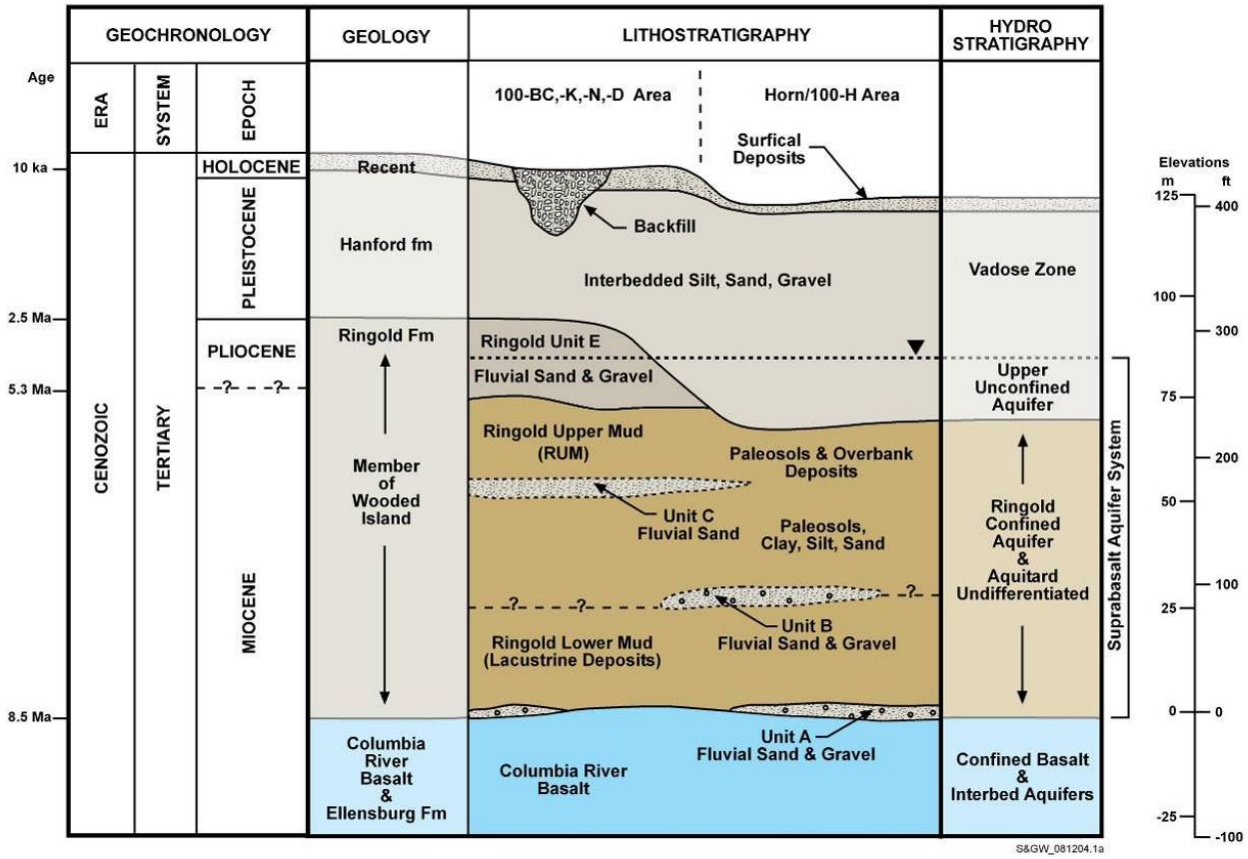


Figure 2-4. Generalized Geology of the 100 Area

The 100-D/H area is underlain by Miocene-aged (approximately 17 to 8.5 million years before present) basalt of the Columbia River Basalt Group and late Miocene to Pleistocene-aged sediments (approximately 10.5 million to 12,000 years before present) that overlie the basalts. The Columbia River Basalt Group locally may exceed 3,050 m (10,000 ft) in thickness and contains interbedded sediments of the Ellensburg Formation. The Ellensburg Formation consists of a series of sedimentary units (epiclastic and volcaniclastic) that are interbedded with and overlie many of the basalt flows of the Columbia River Basalt Group (USGS Bull. 1457-G," Revisions in Stratigraphic Nomenclature of the Columbia River Basalt Group"). The sediments that overlie the basalts are divided into two main units: the Ringold Formation of late Miocene to middle Pliocene age (approximately 10.5 million to 3 million years before present) (WHC-SA-0740-FP, *Sedimentology and Stratigraphy of the Miocene-Pliocene Ringold Formation, Hanford Site, South Central Washington*) and the Hanford formation[3] of Pleistocene age (approximately 1 million to 12,000 years before present) (USGS-PP-717, *Geology and Groundwater Characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington*). Holocene surficial deposits of silt, sand, and gravel form a relatively thin veneer at the surface

[3] The Hanford "formation" has not been accepted as a formal geologic unit in accordance with requirements of the North American Stratigraphic Code (AAPG 2005). Therefore, reference to the Hanford formation is lower case.

(WHC-SD-ER-TI-003, *Geology and Hydrology of the Hanford Site: A Standardized Text for Use in Westinghouse Hanford Company Documents and Reports* and Bjornstad et al., 2001, "Long History of Pre-Wisconsin, Ice Age Cataclysmic Floods: Evidence from Southeastern Washington State").

The properties of these formations influence the distribution of contamination in the subsurface. The Ringold Formation, which has been contacted by contaminated fluids, includes two or more formational units (e.g., the Ringold Formation Unit E and the RUM Unit). The Hanford formation, which comprises most of the vadose zone throughout the area, was affected by contaminated fluids in some areas. The Ringold Formation Unit E is present in 100-D and is the unconfined aquifer unit at 100-D. Elsewhere, the Hanford formation is the unconfined aquifer unit. The RUM is present everywhere across 100-D.

2.2.2.1 Ringold Formation

The Ringold Formation lies directly above the Columbia River Basalt Group. Within 100-D/H, the Ringold Formation ranges from as shallow as 17 m (56 ft) to more than 110 m (361 ft) below ground surface (bgs). Within 100-D/H, two wells have been drilled to basalt, as shown in Figure 2-5.

The Ringold Formation was formed by fluvial-lacustrine (stream-lake) processes. The Ringold Formation is composed of non-indurated and semi-indurated (loose to semi-hardened) clay, silt, fine to coarse-grained sand, or granule to cobble-size gravel (WHC-SD-EN-TI-011, *Geology of Northern Party of Hanford Site Outline of Data Sources and Geologic Setting of 100 Areas*). The Ringold Formation Units identified from deepest to shallowest depth in 100-D/H are Ringold Formation lower mud Unit (RLM), Unit B, RUM, and Unit E.

The RLM consists of fine-grained (silt and clay dominated) deposits typical of overbank-paleosol and lacustrine sediments (WHC-SD-EN-TI-132, *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington*). The RLM is approximately 5 m (15 ft) thick in 100-D/H.

Fine sand to silty sand deposits of the Ringold Formation Unit B overlie the RLM. These deposits are approximately 15 to 24 m (50 to 80 ft) thick. Fine-grained deposits of the RUM typical of overbank and paleosol facies overlie the Ringold Unit B. The RUM in 100-D/H is up to 61 m (200 ft) thick, based on borehole logs. The RUM is a low-permeability unit. It is encountered approximately 15 to 30 m (50 to 100 ft) bgs and is considered the base of the unconfined aquifer.

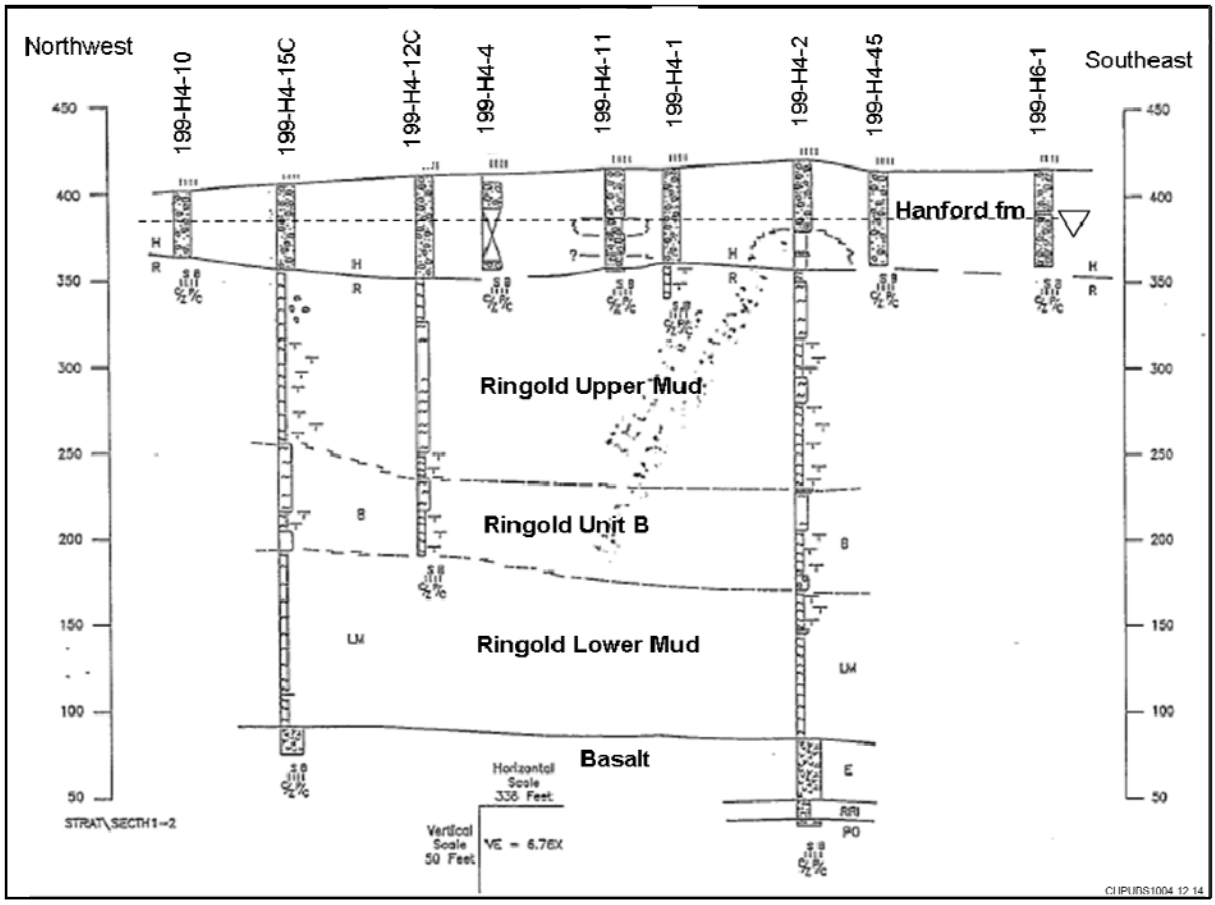
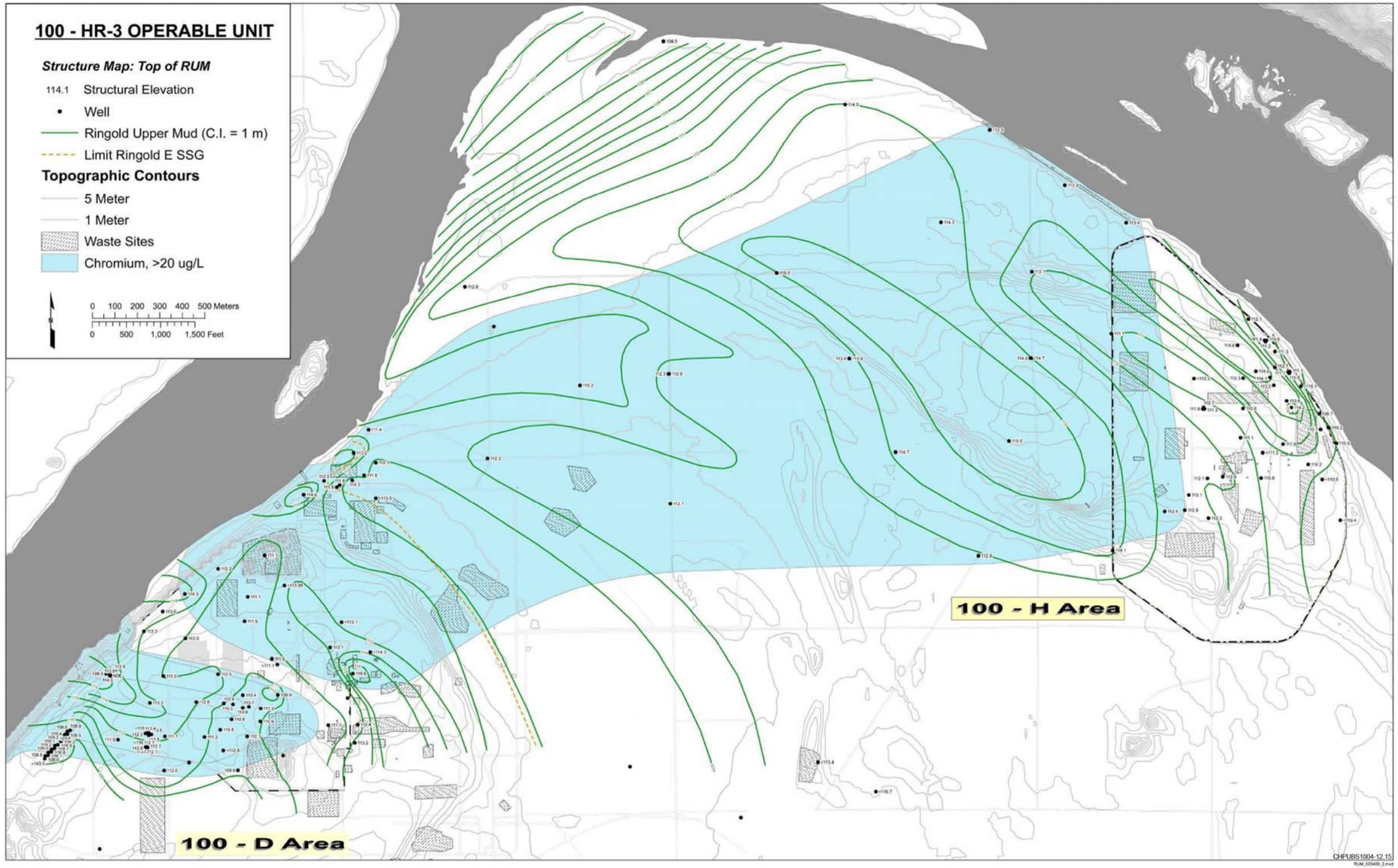


Figure 2-5. Cross Section (Northwest to Southeast and Parallel to the Columbia River) of Subsurface Stratigraphy Underlying 100-H

The base of the unconfined aquifer is defined by the top of the RUM. The RUM is a silt and clay-rich unit that is substantially less permeable than the overlying units are, but is considered an aquitard rather than an impermeable layer. However, the hydraulic conductivity of the RUM in this location is not known. A feature of the RUM that may be significant with respect to contaminant disposition is its surface topography. The RUM was scoured by river channel migration and erosion by the glacial floods that ultimately laid down the Hanford formation. Because of these erosional processes, the RUM is an undulating surface with periodic depressions. A structure contour map of the RUM is shown in Figure 2-6. Of particular interest in 100-D is the RUM depression just west of 105-D and 105-DR that is approximately 2 m (6 ft) deep, which may have provided a sink for discharged contaminant fluids (SGW-40781).

Overlying the RUM in 100-D/H is the Ringold Formation Unit E and the Hanford formation. The Ringold Formation Unit E typically consists of fluvial gravels with lesser amounts of sand, silt, and clay as well as areas of local cementation. The Ringold Formation Unit E pinches out between the northeast portion of 100-D and the Horn, and is not present in 100-H, presumably due to high-energy flows from Glacial Lake Missoula flood events that removed the Ringold Formation Unit E in this area. These scouring activities are also expressed by the abrupt drop in surface elevation at the eastern edge of 100-D above the Ringold Formation Unit E pinch out zone (WHC-SD-EN-TI-132).



Source: SGW-40781, *100-HR-3 Remedial Process Optimization Modeling Data Package,* Rev. 0, Figure 5-5, p. 5-14.

Figure 2-6. Surface Contour Estimates of the Ringold Upper Mud Unit in 100-D/H

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A loss of thickness is also present across central 100-D. Cementation of the Ringold Formation Unit E increases to the south and west in 100-D. Subsurface structure signatures suggest possible northward to northeastward trending channel scour in the RUM that is roughly parallel to the modern Columbia River. These features vary in magnitude and width.

2.2.2.2 Hanford Formation

In 100-D/H, the Hanford formation overlies the Ringold Formation. The Hanford formation is an unofficial designation that consists of gravel, sand, and silt deposited by cataclysmic flood waters that drained out of glacial Lake Missoula during the Pleistocene (DOE/RW 0017, *Nuclear Waste Policy Act, Environmental Assessment: Reference Repository Location, Hanford Site*). In 100-D, the Hanford formation is present to depths of approximately 17 m (55 ft) bgs. The Hanford formation is divided into three facies: gravel-dominated, sand-dominated, and silt-dominated (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for the Post-Ringold-Formation Sediments within the Central Pasco Basin*). Only the gravel and sand dominated facies are present in 100-D/H. Thicknesses range from 5 to 22 m (17 to 73 ft). The unit is thickest in the southwest-central part of 100-D/H and generally thins to the north and east (DOE/RL-2008-46). In 100-D, the Hanford formation overlies the Ringold Formation Unit E. The Ringold Formation Unit E pinches out in the eastern portion of the Horn and the Hanford formation overlies the RUM in the western portion of the Horn and in 100-H.

The Hanford formation is characterized by large to very large, cobble to boulder sized clasts in open-framework gravels that include discreet sand lenses, with minor to no silt and clay material. The grains typically are sub-round to round gravel and sub-angular to round in the sand grain fraction. The gravel dominated facies typically are well stratified and contain little to no cementation (WHC-SD-EN-TI-132).

2.2.2.3 Hanford/Ringold Contact

The Hanford formation is generally more transmissive and permeable than the Ringold Formation, and the contact between the two potentially affects contaminant transport in the vadose zone and groundwater. Hanford formation gravels overlie Ringold Formation Unit E gravels beneath the western portion of 100-D/H. Several criteria are used to differentiate the two units. The sand fraction in Hanford gravels generally contains greater than 40 percent basalt as compared to Ringold deposits, which generally contain less than 25 percent basalt (WHC-SD-EN-TI-132). Hanford gravels may display salt-and-pepper and gray coloring, while Ringold gravels are generally more oxidized and reddish-brown to yellow-red in color. Hanford gravels tend to be less consolidated or cemented than Ringold gravels. Drilling rates tend to be slower in the Ringold Formation and some decrease in hydraulic conductivity can occur in the Ringold Formation Unit E. Consequently, this contact may have provided some inclination for contaminant spreading because of hydrologic differences.

2.2.2.4 Surface Deposits

Recent localized surficial deposits and backfill overlie the Hanford formation. These Holocene deposits consist of silt, sand, and gravel that form a relatively thin (less than 1 m [3-ft]) veneer across 100-D/H. These sediments, which were deposited by a mix of eolian and alluvial processes during the past 10,000 years, consist of very fine- to medium-grained angular to subangular sand with small amounts of silt and gravel. In some portions of 100-D/H, the surficial sediments consist of re-worked backfill material consisting of Hanford formation materials.

It should be noted that indications of the presence of clastic dikes in 100-H have not been encountered during construction for remediation activity.

2.2.3 Hydrogeology

Liquid waste, including radionuclides and hazardous chemicals, have been discharged to the surface in 100-D and 100-H. A portion of these contaminants has reached groundwater. An understanding of groundwater flow is necessary to properly monitor groundwater at the Hanford Site and track the spread of these contaminants.

Within the Horn, the vadose zone and unconfined aquifer are composed almost entirely of the Hanford formation and occasional remnants of the Ringold Formation Unit E. The lack of the Ringold Formation Unit E is attributed to scouring during glacial flooding. The RUM was also scoured to some extent in addition to being eroded as the Columbia River channel migrated across the Horn prior to the glacial flooding events. Deeper erosion is particularly regular toward the north at the point of the Horn (Figure 2-6). The unconfined aquifer thickness varies from 2 to 9 m (6 to 30 ft) (Figure 2-7) and thickens toward the north and the point of the Horn, mimicking the changes in the structural contours of the RUM (DOE/RL-2008-42).

In 100-H, the Hanford formation and several units of the Ringold Formation are present (Figure 2-5) (SGW-40781). The unconfined aquifer is approximately 1 to 7 m (3 to 22 ft) thick. The surface topography of the RUM (Figure 2-6) suggests the former presence of a Columbia River paleochannel just east of the current channel before it migrated to its present location. If so, the ridge located approximately 0.8 km (0.5 mile) from the shoreline would be the remnant of the old river bank. Incision of the RUM by channel flow would then account for the decline in RUM surface elevation toward the shoreline, particularly within 150 m (500 ft) of the shore where the surface elevation drops by 3.7 to 4.6 m (12 to 15 ft). The thinnest part of the aquifer occurs at a ridge in the RUM surface and thickens slightly toward the river shore. Low levels of Cr(VI) have been found in both the RUM and the Ringold Formation Unit B. Explanatory hypotheses are provided in Chapter 4.

Hydrologic processes and anthropogenic activities have influenced contaminant distribution in the subsurface. The effects of natural processes on contaminant migration are ongoing, while the effects of anthropogenic activities have diminished over time with the cessation of reactor operations. However, some residual effects have not completely dissipated and other manmade processes continue to influence contaminant migration.

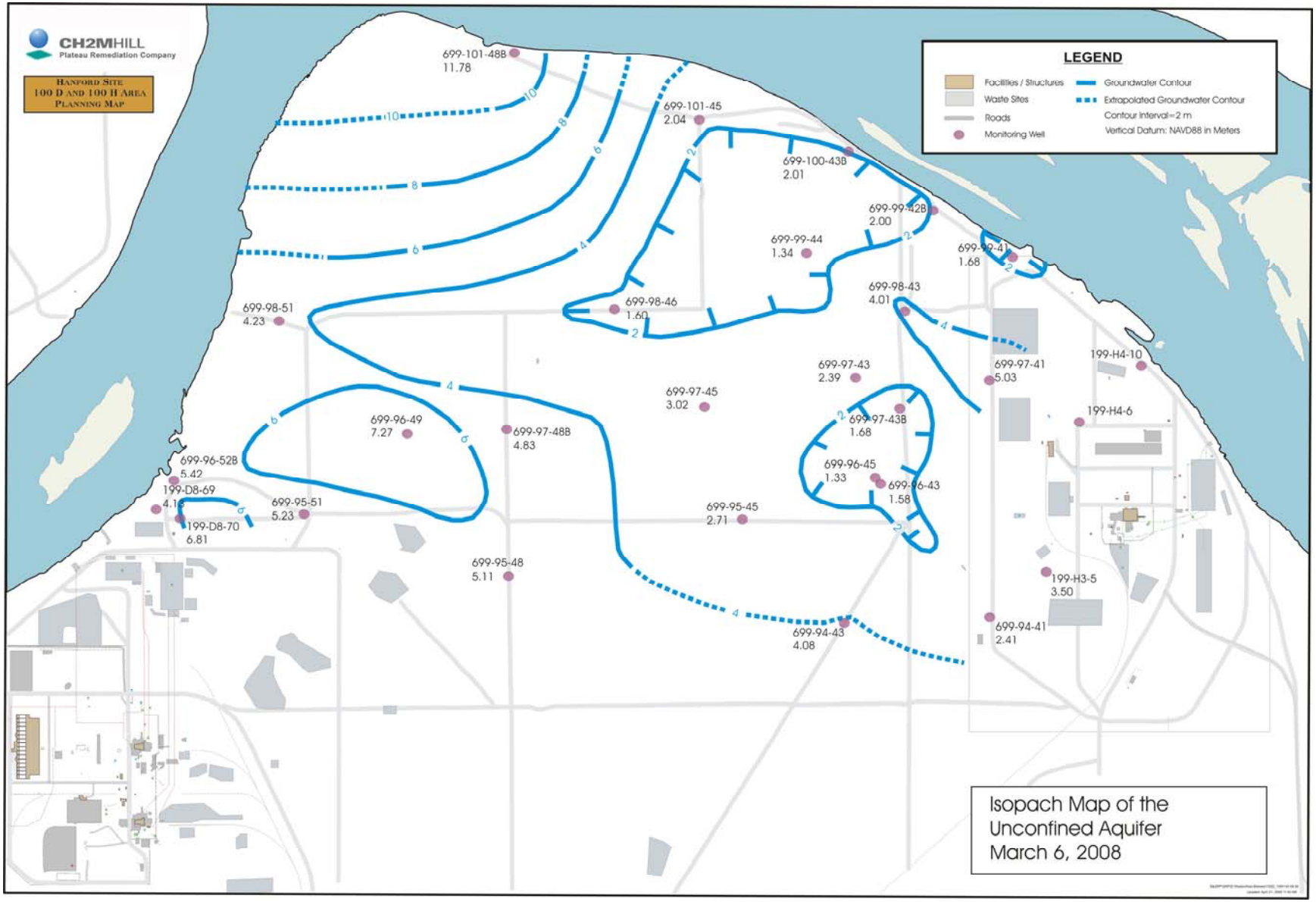


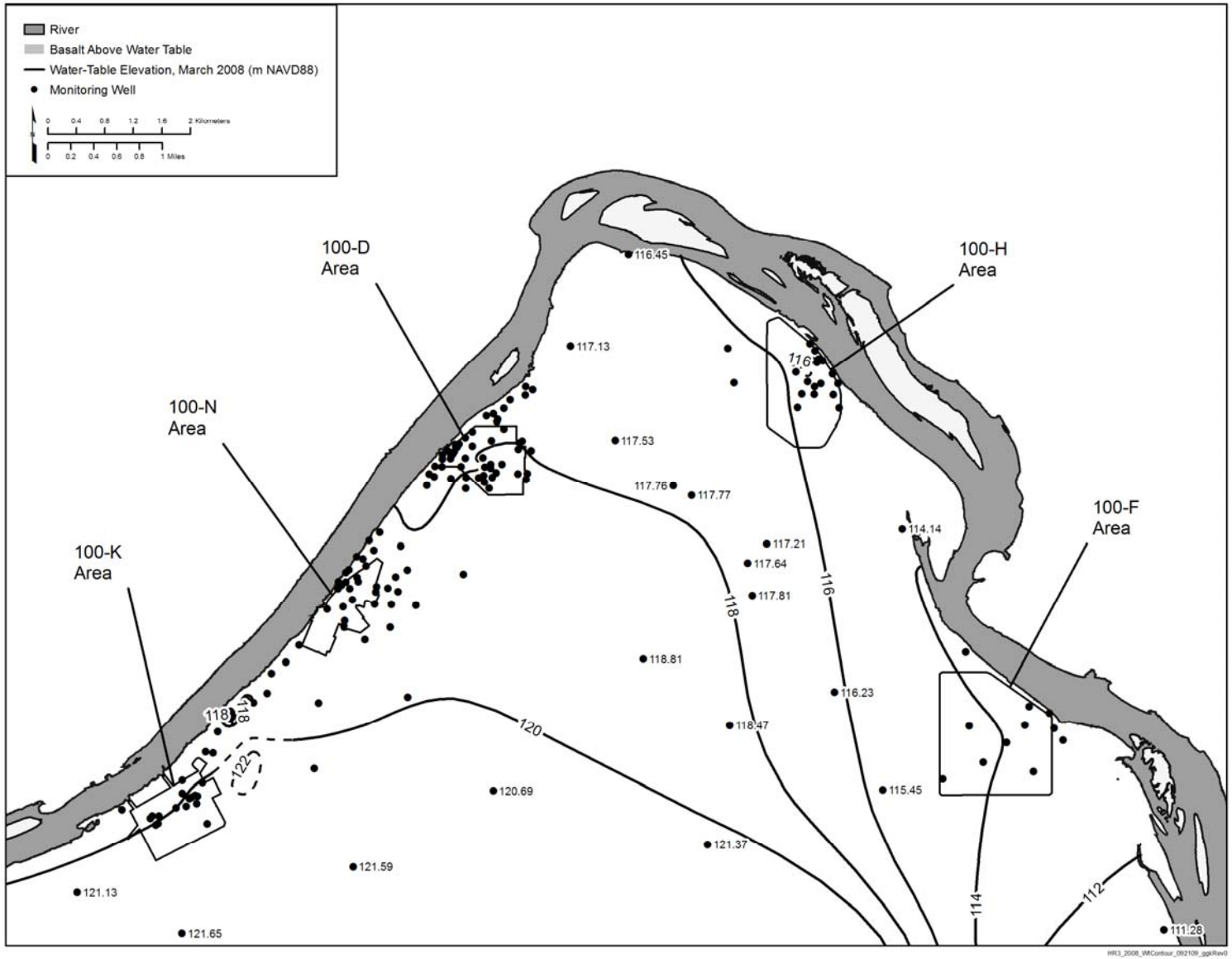
Figure 2-7. Isopach Map of the Unconfined Aquifer in the Horn

Regional groundwater elevations for the unconfined aquifer are shown in Figure 2-8. Generally, 100-D/H groundwater enters the area from the south and tends to fan out so flow near the Columbia River is essentially perpendicular to the shoreline (DOE/RL-2008-01; *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, DOE/RL-2008-05;*Calendar Year 2007 Annual Summary Report for 100-HR-3, 100-KR-4 and 100-NR-2 Operable Unit Pump and Treat Operation*, DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*; and DOE/RL-2009-15, *Calendar Year 2008 Annual Summary Report for the 100-HR-3, 100-KR-4 and 100-NR-2 Operable Unit Pump and Treat Operation*). Within 100-D, groundwater flow is generally toward the Columbia River. Inland from the Columbia River and in eastern portions of 100-D, flow direction changes to a northeasterly direction. Northeast of 100-D, groundwater flow becomes easterly across the Horn and toward 100-H. Groundwater from 100-D discharges to the Columbia River, within 100-H, and northeast of 100-H. A significant factor affecting flow pattern is the regional variability of unconfined aquifer properties.

Local flows in 100-D and 100-H are shown in Figures 2-9 and 2-10 (DOE/RL-2009-15). These figures provide a smaller scale look at the flow near the reactors. In Figure 2-9, components of flow are seen toward the ISRM barrier and again toward the river further north near the north plume. Flow is largely perpendicular to the river across 100-H.

In 100-D, the unconfined aquifer is in the Ringold Formation Unit E. Outside 100-D, the aquifer is in the higher permeability Hanford formation. These hydrologic property differences influence regional flow directions. West of the interface in the 100-D Ringold Formation Unit E, flow tends to deviate from the northeastward and curve around to a northward or northwestward direction; in the Hanford formation, flow tends to proceed in an eastward direction. In 100-H, flow is generally eastward toward the Columbia River.

In addition to regional flow that discharges into the Columbia River, the river water elevations change regularly in seasonal and shorter cycles (e.g., daily river stage changes) because of a combination of natural and anthropogenic influences. These changes are largely controlled by operation of the upgradient Priest Rapids Dam. During the spring, the river surface rises because snowmelt requires more flow through the dam. The surface water rise pushes water inland and causes water table upsurges throughout the 100 Area monitoring well locations. During this time, the hydraulic gradient is altered and less water flows into the river. Conversely, during the fall, the river surface declines and flow toward the river dominates once again. Depending on the location within 100-D, direction variability in flow occurs because of these competing influences. Other local influences on groundwater flow are ongoing leaks from the 182-D Reservoir and injection/extraction remedial actions. The zone of uncontaminated groundwater near the 182-D facility suggests a long-term contaminant dilution and diversion of contaminated groundwater from the mounding caused by the leaks. These leaks and their impact on groundwater flow have significantly diminished since the reduction of storage volume in the reservoir in 2004, to the point that influences on groundwater flow from reservoir leakage are indistinguishable from those created by nearby pump-and-treat activities (PNNL-SA-50369, *Project Work Plan Hanford 100-D Area Treatability Demonstration - In Situ Biostimulation for Reducing Barrier*). The local influences of current injection and extraction activities are shown in Figure 2-37, further in this chapter.



Source: DOE/RL-2008-66, Figure 2.1-2, page 2.1-9, Hanford Site Water Table Map, March 2008

Figure 2-8. Regional Groundwater Elevations in 100-D and 100-H and the Horn

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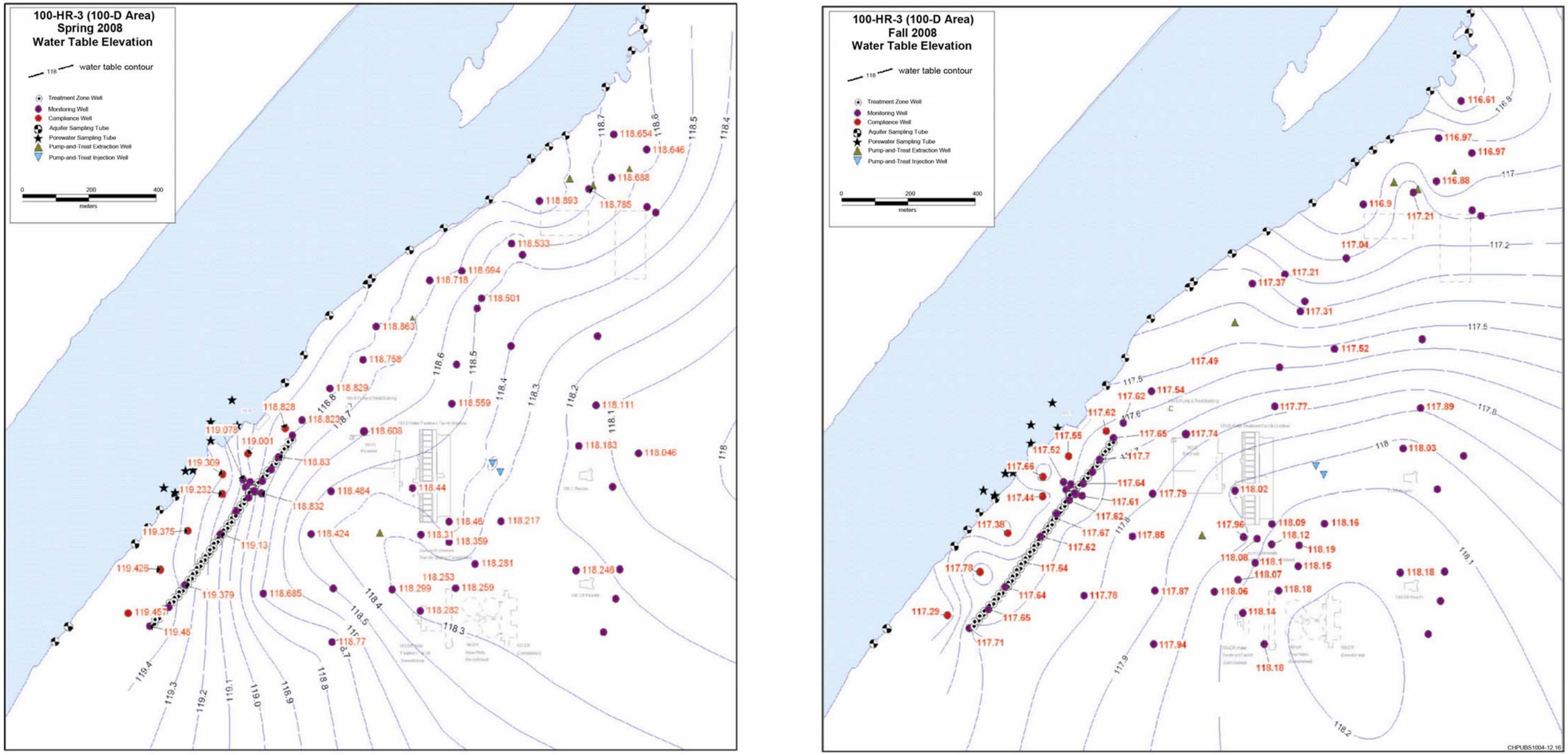

Figure 2-9. 100-D Area June and November 2008 Measured Water Table Comparison

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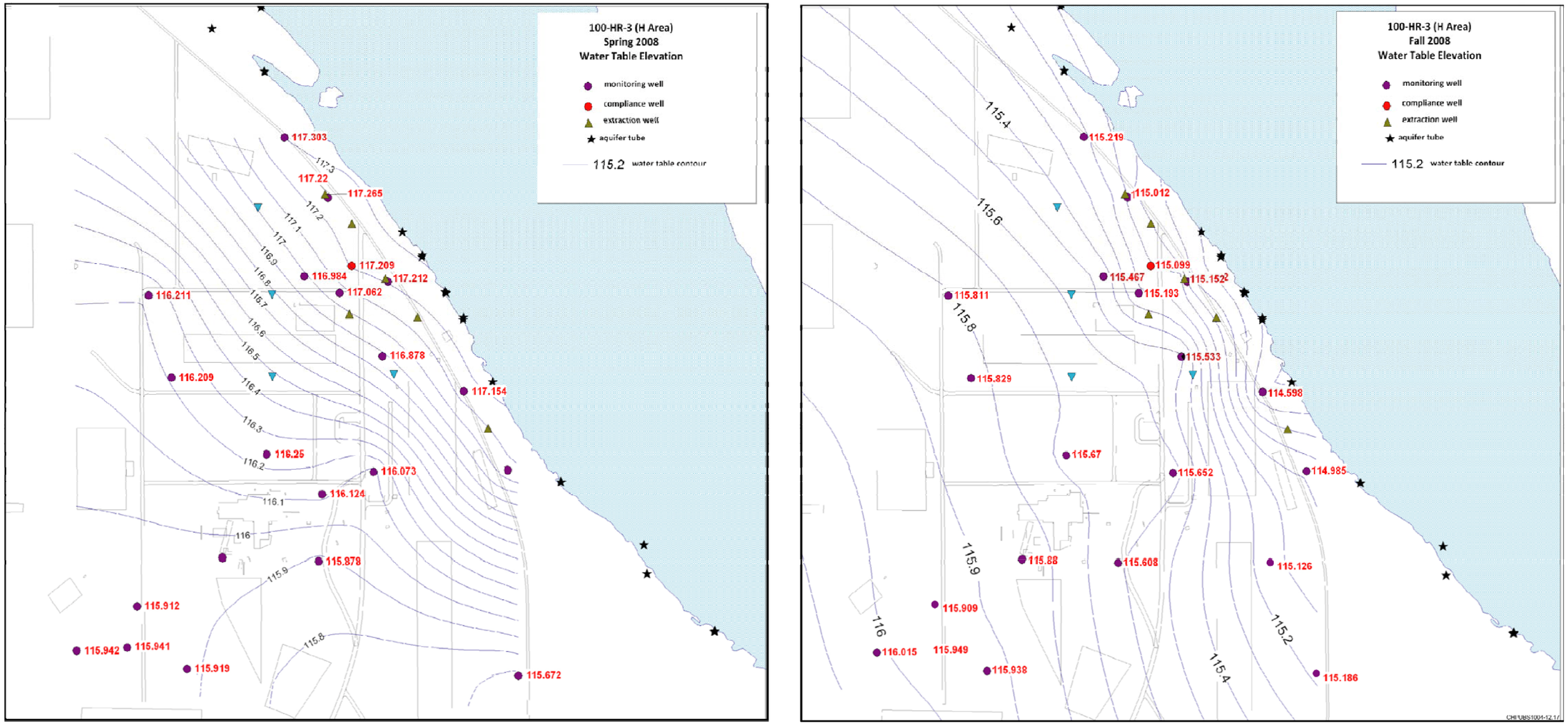

Figure 2-10. 100-H May and November 2008 Measure Water Table Comparison

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In 100-D and the Horn, the primary anthropogenic influences on groundwater flow patterns were chronic, unintentional losses of fluids from retention basins and intentional discharges in ponds and trenches. The facilities that released large quantities of fluid, generally over long periods, are summarized in Table 2-2, and their locations are shown in Figure 2-11 along with Cr(VI) discharge sites in 100-D. The effect of these long-term discharges was to create groundwater mounds under the discharge facility that overwhelmed the natural gradient some distance away from the discharge site. These discharges had substantial impacts on Cr(VI) migration patterns in the unconfined aquifer, which are discussed at length in Chapter 4.

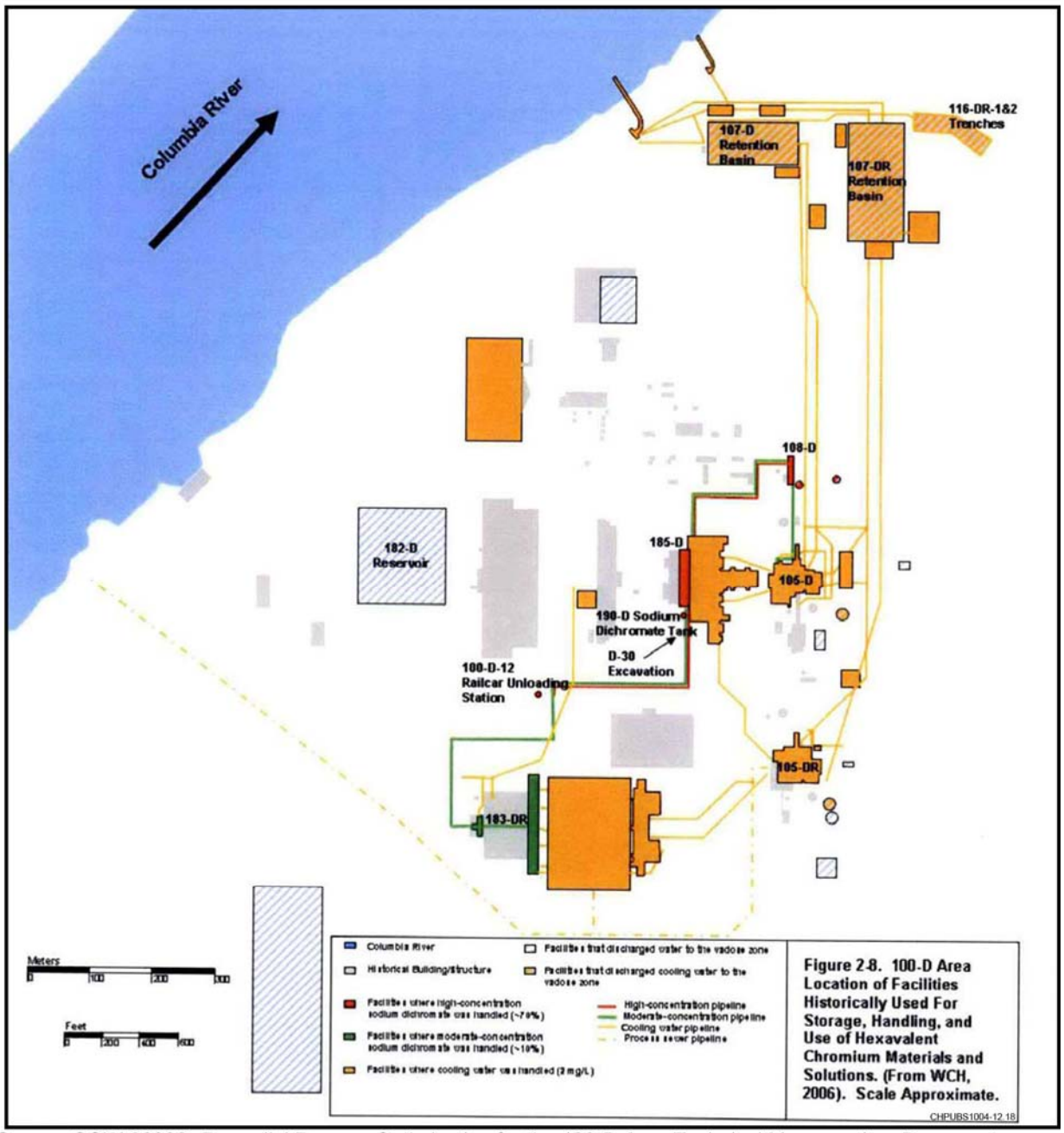
Table 2-2. Long-Term, High-Volume Discharge Sites in 100-D

Facility	Operations Period	Volume[a]L (gal)	Fluid Characteristics
107-D Retention Basin (116-D-7)	1944-1967	Millions	Reactor coolant
107-DR Retention Basin (116-DR-9)	1950-1967	Millions	Reactor coolant
116-DR-1 and 116-DR-2 Trenches	1945-1967	8×10^7 (2.1×10^7)	Radioactively contaminated reactor coolant
	March-June 1967	1.27×10^{10} (3.6×10^9)	Reactor coolant
120-D-1 Pond	1977-1992	2×10^9 (5.0×10^8)	Dilute wastewater from several facilities
182-D Reservoir[b]	1945-present	Millions	Columbia River water

Notes:

a. In this context, the volumes are inclusive of leaks and deliberate discharges from the facility and/or waste site. Discharge and leakage documents and records were obtained from the following sources: HW-46715, *Unconfined Underground Radioactive Waste and Contamination-100 Areas*; HW-77170, *Status of the Groundwater Beneath Hanford Reactor Areas*; BNWL-CC-1352, *Ground Disposal of Reactor Coolant Effluent*; UNI-946, WHC-EP-0666 Groundwater Impact Assessment Report for 100-D Ponds; WHC-SD-EN-TI-181; DOE/RL-92-71, and "Submission of 182-D Reservoir Needs Analysis" (Gallagher, 2004).

b. Since the implementation of administrative controls on the 182-D Reservoir operations beginning in 2004, measurements in the basin and at the water table find that the leakage rate has significantly reduced until no discernable leakage was measured in FY 2008 (DOE/RL-2009-01, *Fiscal Year 2008 Annual Summary Report for the In Situ Redox Manipulation Operations*).



Source: SGW-38338, *Remedial Process Optimization for the 100-D Area Technical Memorandum Document* Figure 2-8, p. 2-12

Figure 2-11. Facilities in 100-D that Produced, Stored, or Transferred Liquid Sodium Dichromate Solutions

In the northeast corner of 100-D, coolant water leaked chronically from a cluster of facilities during much of the operational period. These facilities include 107-D (116-D-7), 107-DR (116-DR-9), 116-DR-1, and 116-DR-2. These long-term releases had created a radial flow regime that was established early in the operations period and sustained until these facilities were drained (Figure 2-12 a and b). At the very end of the operation period, all reactor coolant produced between March and June 1967 was discharged directly into 116-DR-1 and 116-DR-2 instead of being released directly to the Columbia River through the outfall structures (Figure 2-12 c). This process greatly had enhanced the existing groundwater mound during that time. However, by September 1967, much of this effect had dissipated. Groundwater mounding dissipated quickly after cessation of releases from these sources.

After 1967, two 100-D facilities released gradient-altering volumes of water. In 1977, an intentional Discharge Pond 120-D-1 located just southeast of the reactor retention basins began receiving dilute waste. By the time the pond was closed in 1992, 2 billion L (500 million gal) had been discharged to this facility (Table 2-2). Its influence on groundwater mounding, elevation, and flow direction dissipated long ago.

The 182-D Reservoir was constructed and filled in 1945 to store raw river water that is still pumped to the Central Plateau for use as one of two sources of untreated, raw water (i.e., nonpotable water) to supply the Hanford Site. Up until the last few years, the 182-D Reservoir chronically leaked enough to sustain a local mound that creates the clean zone between the northern and southern plume in 100-D (Figure 1-23). This mound appears to have diverted groundwater flow to the north and south of the 182-D Reservoir location, with corresponding diversion and local dilution of the contaminants in groundwater. Recent efforts to reduce the leakage have included reducing the operating water level in the reservoir and attempting to seal concrete cracks and construction joints.

Localized groundwater depression and mounding are also associated with extraction and injection wells, respectively, at the operating 100-D pump-and-treat system. Enhanced natural recharge may also occur in areas subject to 100-D facility decommissioning activities. In some of these areas, structures and surface soil have been removed, leaving excavations in the coarse Hanford formation. These locations may be subject to run-on and accumulation of precipitation and enhanced infiltration. However, this effect has not been quantified.

In 100-H, the opportunities for groundwater mounding that could have formed from liquid effluent discharges were much less complex. Two large basins, the 182-H Reservoir and the 116-H-7 (107-H) Retention Basin held raw water and wastewater, respectively, throughout the operations period (Figure 2-3). In addition, effluent lines from the H Reactor to 116-H-7 transmitted about 2 trillion L (500 billion gal) of reactor coolant. The effluent lines and 116-H-7 both leaked routinely and are the only plausible sources for mounding. The mounding would have quickly dissipated after operations shutdown in 1965. Currently, pump-and-treat operations create small water table mounds in the middle of the site because injection wells introduce water into the subsurface. This information is summarized from HW-46715; HW-77170, *Status of the Groundwater Beneath Hanford Reactor Areas*; and UNI-946.

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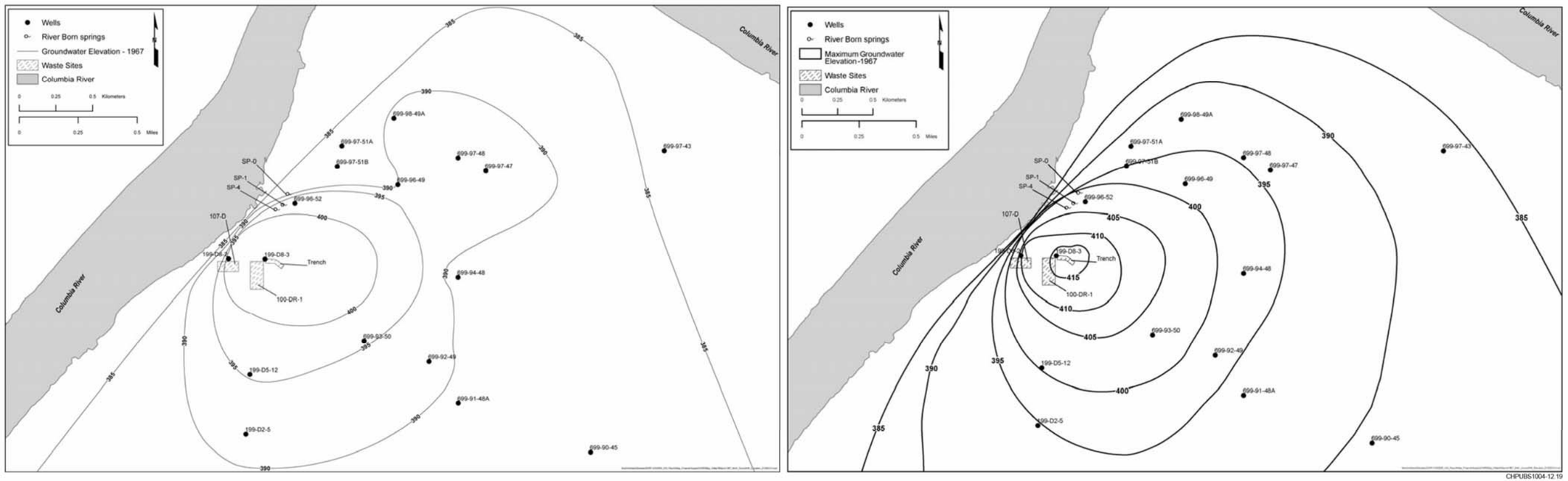

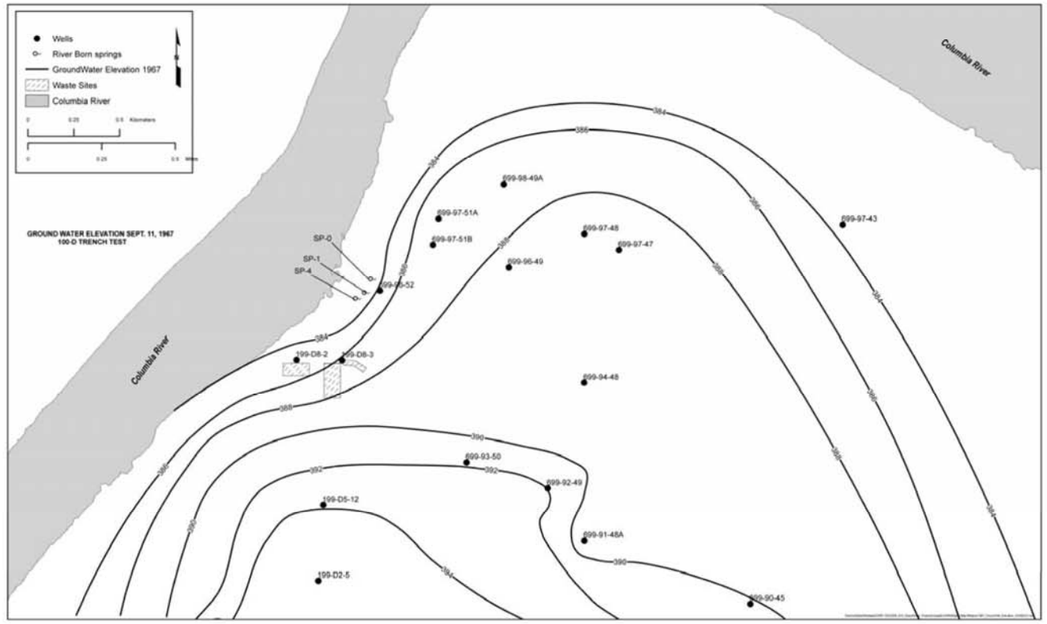

Notes:

Elevations recorded in feet above mean sea level.

Figure is modified after BNWL-CC-1352.

a. February established over 22 years from Liquid Discharges through 107-D, 107-DR, 116-DR-1, and 116-DR-2.

b. Soon after Completion of Direct Coolant Injection Test from March through June 1967 (BNWL-CC-1352).

c. September 1967.

Figure 2-12. 1967 Water Table Elevation Contours

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Groundwater flow of 100-D/H is influenced by river stages. During the year when river stage is relatively low (e.g., fall), natural groundwater flow is toward the river. When river stage is high (e.g., spring), groundwater can flow away from the river. High-river stages can be more than 3 m (10 ft) higher than low-river stages. River stage also can fluctuate several feet over short periods (i.e., hours to days), based on the upstream Priest Rapids Dam operations (DOE/RL-96-84, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action*). Changing river stage can influence groundwater elevations over 640 m (2,100 ft) inland from the river at 100-H (PNNL-13674, p B.4, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*) and over 700 m (2,300 ft) inland from the river at 100-D (SGW-38757, *Investigation of Hexavalent Chromium Source in the Southwest 100-D Area,* Draft A). In addition, because the hydraulic head is lower downgradient at 100-H, regional flow from the south tends to flow toward 100-H.

2.3 Process History

Liquid and solid wastes from reactor operations and associated facilities were released to the soil column and the Columbia River. Sources of contamination include liquid waste sites, burial grounds, unplanned release sites, facilities/structures, and pipelines/outfalls. These site types are defined in the Integrated Work Plan, Chapter 2. A complete listing of 100-D/H facilities and waste sites as of August 2009, including descriptions, histories, and classification statuses, is provided in Appendices C and D. Table C-2 in Appendix C shows a cross-walk of facilities and related waste sites within the facility footprint.

2.3.1 Facilities History and Description

This section provides the description and history of facilities used in 100-D/H and identifies the status of these structures. There were 171 facilities used or constructed in 100-D/H. Most of the facilities have a status of active, inactive, removed, or demolished (fully defined in the Integrated Work Plan, Chapter 2). Table 1-1 provides summary information on the status of facilities. A description and history of each facility is provided in Appendix D. Releases to the environment associated with waste sites are described mainly in Appendix C, Waste Site Description and History.

Facilities that were used during the operation of the reactors make up most of the demolished or removed facilities and consist of the retention basins, reactor stacks, office and storage buildings, maintenance shops, process plants, electric substation, storage tanks, and pump stations. Active facilities include office buildings, storage buildings, the 151-D Primary Substation Switch House, and the 181-D River Pumphouse and 182-D Reservoir, which serve as the 200/300 Area back-up water supply system. Inactive facilities remaining within 100-D/H include the reactor buildings, the 183-D Filter Plant Power Operation Facility (Figure 2-13), the 1904-DR Outfall Structure (Figure 2-14), a mobile office, and a storage building at 100-H.

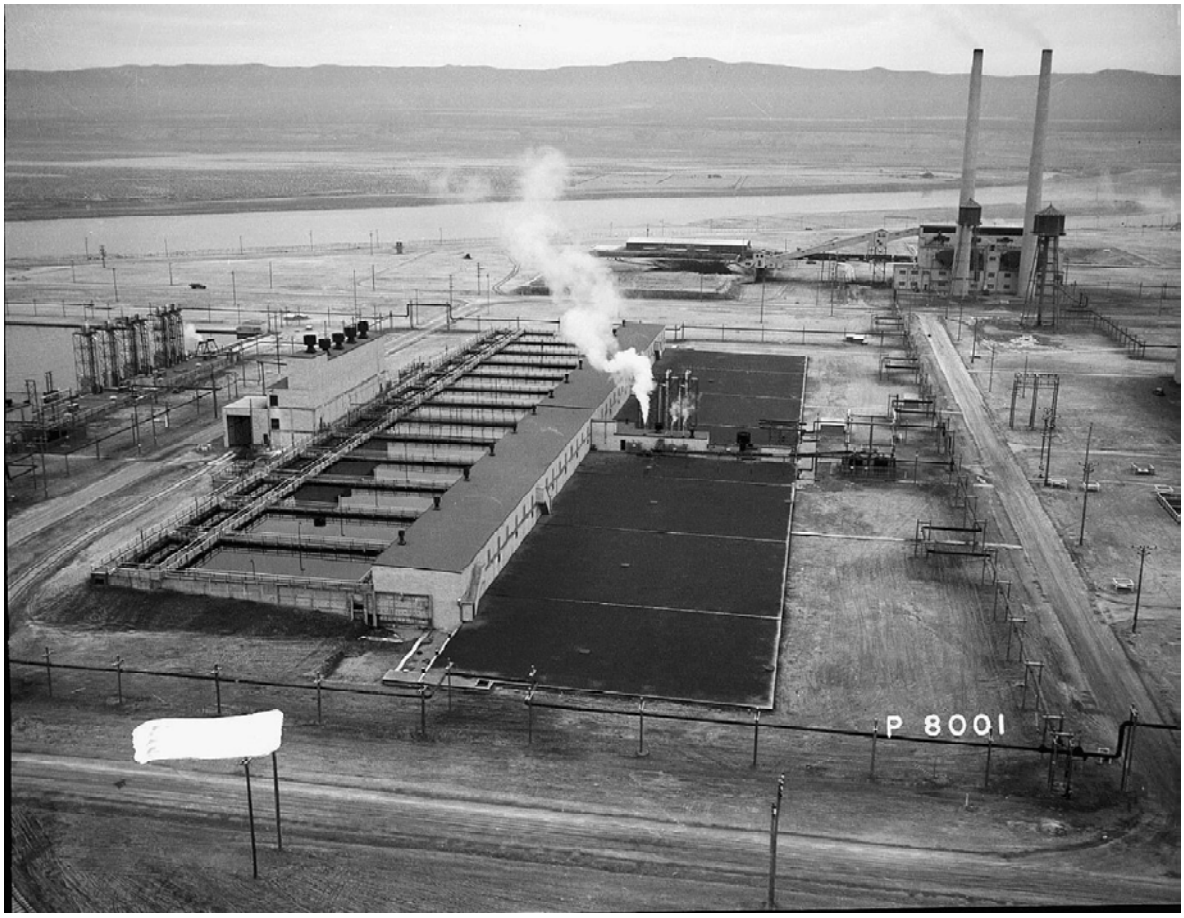

Figure 2-13. Aerial View of 183-D Filter Plant (1945)

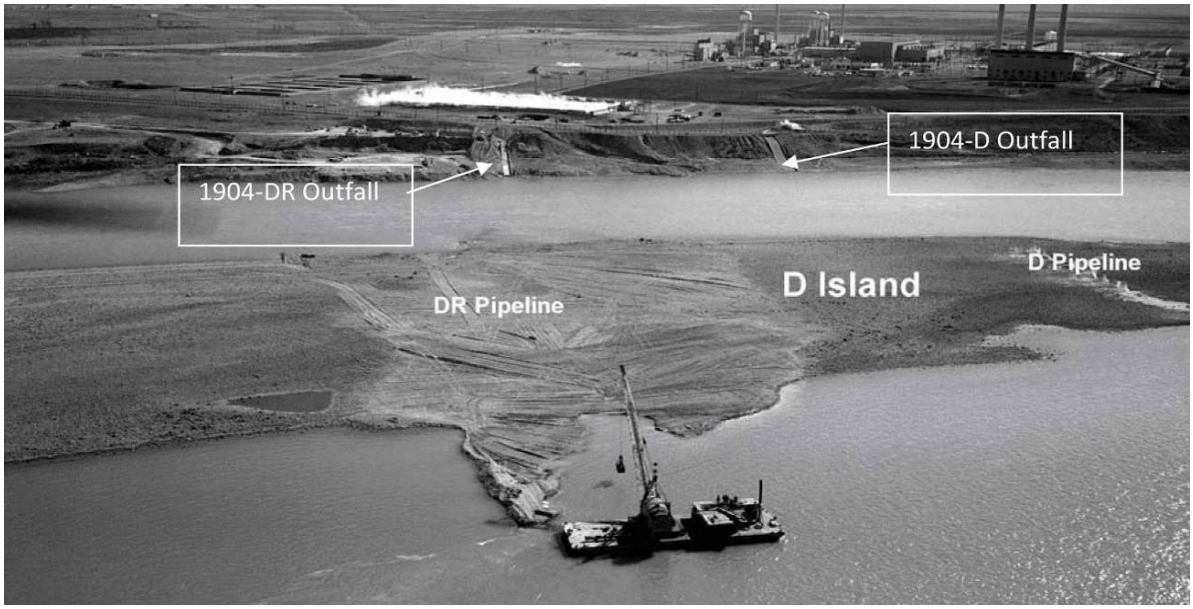

Figure 2-14. D and DR River Effluent Pipelines, Outfalls and Reservoir in Background (D Island; 1956) (Waste Site 100-D-60)

One facility of particular interest regarding its potential contribution to groundwater contaminant distribution is the Export Water System (EWS), shown in Figure 2-15. The EWS (including the 182-D Reservoir) is an operating system that has affected contaminant transport and groundwater flow. Leaks from the EWS basin (the 182-D Reservoir) occurred chronically since the beginning of reactor operations, creating and sustaining groundwater mounds in central 100-D. Leakage from the EWS basin and export water lines could affect groundwater flow, contaminant mobility, and the effectiveness and/or cost of groundwater cleanup (e.g., ISRM barrier and pump-and-treat remedies) in 100-D. There is clear historical evidence from groundwater monitoring wells near the reservoir (low specific conductance and elevated water levels) indicating that significant leakage had occurred and that it was an ongoing, chronic condition until recently. There is no evidence to indicate that existing operational export water lines leak.

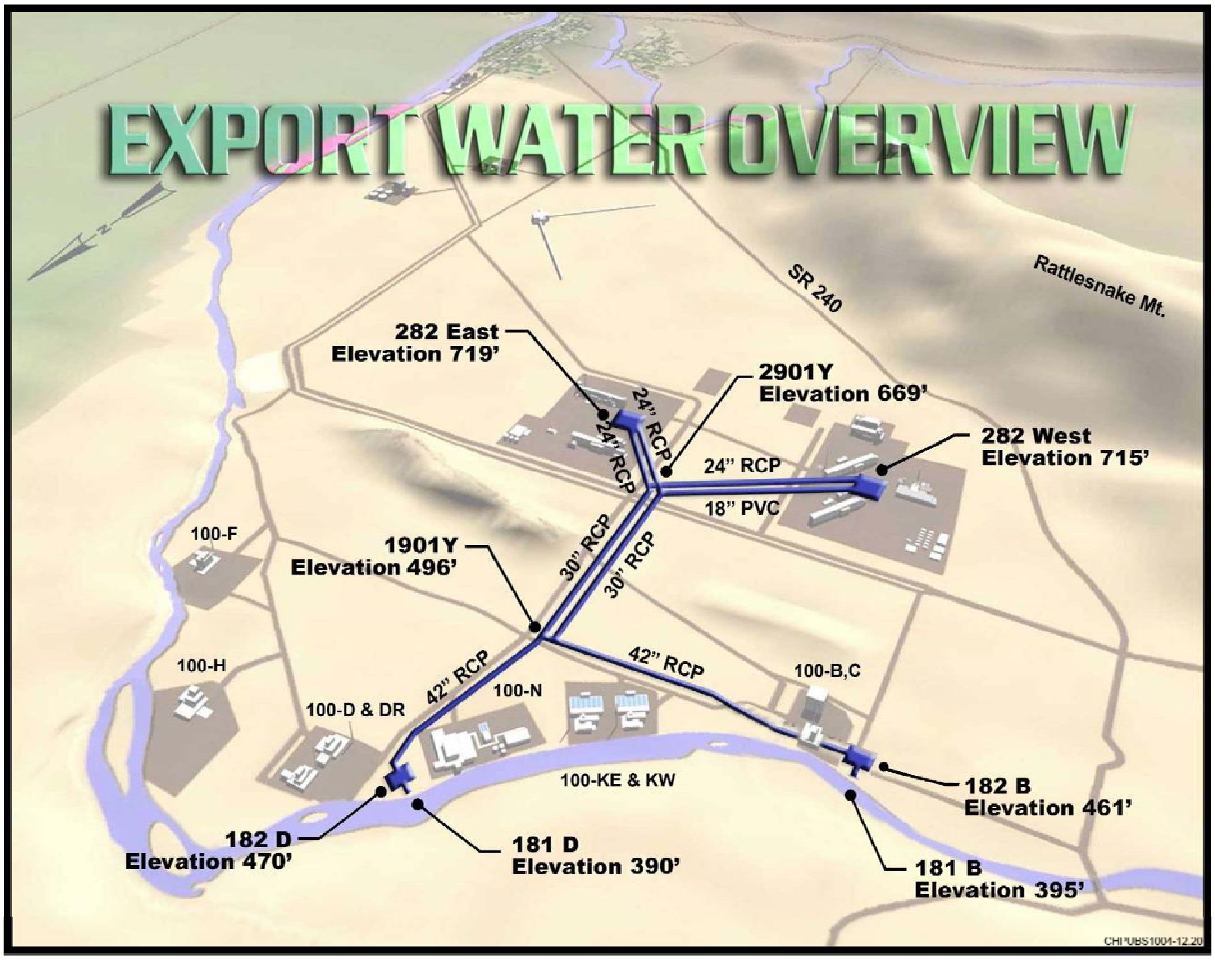

Figure 2-15. Export Water System Plan View

Raw water is used in large quantities (millions of liters/day [millions of gals/day]) at the Hanford Site for process water, fire control, dust suppression, and other non-potable uses. Water is pumped from the Columbia River to large-capacity reservoirs located in the 100 Area as part of the EWS. These reservoirs supply a network of large-diameter (1 m [3.5 ft]) pipelines to smaller pipelines traversing the 100 Area and connecting to moderately sized distribution reservoirs located on the Central Plateau. In 2004, the majority of the water lines in 100-D were removed from service. The only remaining active lines are the 1 m (3.5 ft) export water line and one 30.5 cm (12 in.) fire suppression water line. A key component of

this system is the 182-D Reservoir. It is one of two remaining structures at the Hanford Site that is used to store large quantities of untreated, raw water; however, 182-D is the back-up facility. The other reservoir used for this purpose is located in 100-BC and is the primary reservoir (FH, 2008, *November 6 & 7 Facilitated Session and the 182D Reservoir Repair and Modification report and Long Term Export Water Supply System alternatives Study*).

In response to the reservoir leakage information, a specific issue (Issue 10) was included in the Hanford Site Second CERCLA Five-Year Review (DOE/RL-2006-20) for DOE to provide direction to its operating contractor to conduct changes to the operation of the reservoir to minimize leakage. Those actions were completed and documented in the close out of the Five Year Review issue. The specific actions that have been implemented include the following:

- The 182-B Reservoir is designated as the primary export water source for the Hanford Site and 182-D Reservoir is used for emergency backup (maintained in a standby configuration).
- The original design water level for the 182-D Reservoir was a depth of 4.6 m (15 ft) with 0.3 m (1 ft) of freeboard; however, while in standby operations, the water levels within 182-D Reservoir have been reduced via operating controls over the past seven years using a graded approach and now are maintained at 0.3 to 0.9 m (1 to 3 ft).
- During emergency operations, the water levels within 182-D Reservoir are allowed to rise between 0.6 to 1.8 m (2 and 6 ft).
- Flow from the 182-D Reservoir is required infrequently for emergency operation, most recently to support operations at 242-A Evaporation during a pump maintenance shut down at 182-B Reservoir.
- The floor of the reservoir was cleaned and caulked.
- Monitoring of water levels in the reservoir and nearby monitoring wells (199-D5-33, 199-D5-38, and 199-D5-34) is conducted automatically via transducers.

In addition to the controls put in place for the reservoir, DOE instituted changes to the groundwater well monitoring program to provide information on the effects of the controls on the aquifer. Groundwater samples are and will continue to be collected at least quarterly from adjacent monitoring wells 199-D5-33, 199-D5-34, and 199-D5-38 as part of standard performance monitoring in the 100-HR-3 OU. Automated water level monitoring was installed as early as 2000 in Well 199-D5-38 and in 2004 in Wells 199-D5-33 and 199-D5-34.

Historically, it is believed that the reservoir may have leaked several hundred gallons per minute. There is uncertainty regarding past impacts of leakage on the northeast portion of the ISRM barrier. The most recent evaluations of the impacts on the aquifer have been reported in annual summary reports on the operation of the ISRM Barrier (DOE/RL-2008-10, *In Situ Redox Manipulation (ISRM) Annual Report Fiscal Year 2007*, DOE/RL-2009-01, and DOE/RL 2008-66). The evaluations conclude that the controls have been effective. With reductions of water levels within the reservoir, the leakage from the reservoir has been significantly reduced from approximately 378.5 L/m (100 gal/m) in FY 2006 to 25 gpm in FY 2007 and, most recently, no discernable leakage in FY 2008. DOE will continue to monitor and report on the impacts of leakage from the 182-D Reservoir and recommend modifications to their current monitoring approach and basin operations as warranted. It is acknowledged that as the EWS infrastructure continues to age, the risk of leakage from the reservoir and export water lines increases.

DOE is already in the process of expanding pump-and-treat operations in 100-D. Groundwater modeling that has been performed to support the expansion show that leakage from the reservoir (operated under standby conditions) will have no significant impact on the performance of the remediation system. Due to the expansion of the pump-and-treat system, DOE is evaluating the need for continued reliance on the ISRM barrier.

Remediation of waste sites needs to consider the proximity of the water lines as remediation of these sites may be difficult. An evaluation of all waste sites and their relationship to the export water lines was performed. The structures that are nearest to the export water line coming out of the 182-D Reservoir are small diameter pipelines. Some have been remediated and contamination removed (e.g., 100-D-56:2). Small portions of the 100-D-50:1 process sewer and 100-D-63 service water pipelines underlie or immediately overlie the export water line. These sites are accepted waste sites in WIDS and will be evaluated to determine whether remedial action is warranted. The export water line does not interfere with any other known waste sites.

DOE is evaluating whether the182-D Reservoir is necessary to support the continued Hanford cleanup mission. This evaluation is currently scheduled to be completed in 2010. The reservoir will be addressed under a Water Systems Master Plan, which will identify the preferred infrastructure solution of the reservoir. Monitoring requirements for the reservoir and export water lines will be reevaluated at that time.

2.3.2 Process History Description

Certain facilities and waste sites were used for discarding non-radiologically contaminated waste materials (e.g., solvents, chemicals), but were relatively small in magnitude.

Materials that had passed through the reactor for manufacture or materials contacting items that had passed through the reactor were considered radiologically contaminated. These materials represented the majority of the wastes produced. Active physical barriers and strong administrative measures were in place to minimize radiological hazards throughout the Hanford production areas. These measures affected the placement of disposal locations for various waste streams.

Contaminant categories from the manufacturing process include the following:

- Process inputs:
  - Raw materials processed through the reactor, such as uranium fuel and cooling water.
  - Process chemicals for water conditioning and inhibiting corrosion (e.g., sodium dichromate) because water management was crucial to the operation of the reactors and represents a major input subsystem.
  - Materials used for reactor maintenance, such as acids, solvents, and heavy metals.
- Process outputs:
  - Isotopes and byproducts, such as plutonium-239 (Pu-239), strontium-90 (Sr-90).
  - Radioactively and chemically contaminated materials (solid and liquid wastes).
  - Radioactively and chemically contaminated cooling water.
  - Uncontaminated waste materials.

Most of the irradiated fuel elements were shipped to the 200 Area for chemical processing, but some metallurgical studies on irradiated fuel were performed in the 100 Area in addition to plutonium production (WHC-SD-EN-TI-220, *100-B Area Technical Baseline Report,* and WHC-SD-EN-TI-251, *100-N Area Technical Baseline Report*). In addition, during production, fuel elements and infrastructure failures (e.g., pipe leaks) led to losses of contaminated materials to the environment (HW-27337, *Unconfined Underground Radioactive Waste and Contamination--100 Areas;* HW-33305, *Tabulation of Radioactive Liquid Waste Facilities*; HW-46715; and UNI-946).

The primary reactor operations activities causing environmental contamination were the production and use of treated Columbia River water to cool the reactors during operations. Over the lifetime of the D and DR Reactor operations from 1945 through 1967, approximately 4.5 trillion L (about 1.2 trillion gal) of coolant were produced and passed through these reactors. At the H Reactor, approximately 2 trillion L (about 500 billion gal) of coolant were used. As these fluids were produced and used, both intentional and unintentional discharges injected contaminants directly into the Columbia River and into the soil column underlying the operations infrastructure.

Other substantial infrastructure was installed at 100-D and 100-H to support reactor maintenance and operation. Wastes resulting from supporting production operations were similarly disposed in each area according to phase, quantity, radioactivity, and composition (e.g., liquids, solids, high/low mass or volume, high-level, low-level, strictly chemical, and septic). Thus, liquid and solid disposal locations were constructed and waste management practices were developed to manage these materials consistently.

Irradiated fuel elements were stored in the fuel storage basins associated with the 105-D, 105-DR, and 105-H reactors. Due to periodic fuel element ruptures at all three D/H reactors that likely occurred throughout their operation histories, the storage basin shielding water became highly contaminated by activation products such as Cs-137, Sr-90, and plutonium isotopes (WHC-SD-EN-TI-181 and BHI-00127). Fuel storage basin leaks were reported for the 105-D and 105-H fuel storage basins, causing vadose zone and possibly groundwater contamination. Upon closure of the reactors, the D and DR fuel storage basin shielding waters were lowered and the basins were cleaned-out in 1984. Miscellaneous basin equipment and sludge were packaged and disposed in the 200 Area burial grounds (UNI-3958, 1986, *Fuel Storage Basin Cleanup and Stabilization Project Report*). The remaining shielding water was processed and released to two ponds (116-D-10 and 116-D-11) that had been excavated specifically to receive the treated shielding water with an asphalt emulsion applied to the basin walls and floors to fix any remaining contamination. The H fuel storage basin was drained to within 1.2 m (4 ft) of the basin bottom and backfilled with soil, burying the sludge and miscellaneous equipment that remained in the basin (UNI-946).

The contaminants in the discharged water included chemicals in the treated water and radioactive isotopes dissolved in the cooling water from breached fuel cladding. A major element in this water, sodium dichromate, was added to minimize fuel cladding corrosion. More than 3,000 metric tons (6.6 million lb) of Cr(VI) were used in the coolant manufacture between 1945 and 1967 for 105 D and 105 DR and about 1,200 metric tons (2.6 million lb) for the 100-H Reactor (Table 4-4). The great majority of this mass was present in the reactor coolant. Cooling waters also picked up other contaminants during passage through the reactors. These contaminants included activated elements in the water (e.g., chromium-51), activation products from reactor components (e.g., tritium, carbon-14 [C-14], and cobalt-60 [Co-60]) and fission products released through breached fuel cladding (e.g., cesium-137 [Cs-137], Sr-90, and plutonium isotopes). However, the mass and environmental distributions of the radionuclides are minimal compared to Cr(VI) (WHC-SD-EN-TI-181and BHI-00127).

Known decontamination solutions included chromic, citric, oxalic, nitric, sulfamic, and sulfuric acids (neutralized with sodium carbonate before disposal), and sodium fluoride. Other chemicals, including organic solvents, were used in some decontamination processes at 100-D and 100-H at various times and locations (PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford, Volume 2*; WHC-SD-EN-TI-181; and BHI-00127).

These solutions were generally disposed in cribs, trenches, or french drains near the building in which they were used. Occasionally, decontamination solutions were combined with cooling water and discharged to the river via the retention basins. Tables 4-1 and 4-2, and Appendix C identify notable specific discharge locations (e.g., approximately 400,000 L (1,000 gal) of spent nitric acid and rinsate was discharged to 116-H-3). Nitrate is also suspected from pre-Hanford agricultural uses (BHI-01326, *Pre-Hanford Agricultural History: 1900-1943,* Bechtel Hanford, Inc., Richland, Washington). Nitrate is observed widely in Hanford groundwater (DOE/RL-2008-66). Nitric, oxalic, and chromic acids were documented as used in decontamination at 100-D and 100-H at various times and locations (PNL-6456 Vol. 2; WHC-SD-EN-TI-181; and BHI-00127).

2.3.2.1 Sodium Dichromate Life Cycle

In 100-D/H, the principal contaminant of concern (COC) is Cr(VI) (EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units*). Cr(VI) is present in the groundwater at 100-D at the highest concentrations observed at the Hanford Site, exceeding both aquatic and drinking water standards. Sodium dichromate, the source of the Cr(VI), was delivered and used in both dry chemical powder and concentrated liquid forms. The sodium dichromate process flow is presented schematically in Figure A-4 of Appendix A.

Because of the persistence of Cr(VI) in groundwater at 100-D and its complicated process history there, much of the following discussion focuses on facilities at 100-D. The 100-H area sodium dichromate life cycle, which is similar but much less complex, is discussed in Chapter 2. Figure 2-2 provides an aerial view of the facilities in 100-D as of 1966.

Liquid Discharges

To generate the cooling water solution for the reactors, concentrated sodium dichromate feed materials were processed through an infrastructure system that diluted the higher strength source materials in two steps. In this process, three types of fluids with distinct Cr(VI) concentration levels were produced and discharged to the subsurface, either intentionally or unintentionally. General characteristics of these types of fluids have been derived from historical records and described previously (WHC-SD-EN-TI-181; CCN 129547, "Sodium Dichromate Investigation for the 105-D-105-DR Reactor Area Report"). This information including fluid chemistry, discharge location, and frequency of discharge is summarized below primarily from the reference sources. The facilities that handled these fluids are shown in Figure 2-11. Table 4-1 summarizes the estimated quantities and types of Cr(VI)-bearing wastes.

Highly Concentrated Sodium Dichromate Materials

Highly concentrated sodium dichromate feed materials were provided in both solid and liquid form. From 1944 to 1950, solid sodium dichromate (about 90 percent by weight) was stored and mixed with water at the 108-D Building Chemical Pumphouse (Figure 2-16) to form a less concentrated solution. This solution was transferred to storage and injection systems at the 105-D Reactor (via overhead pipelines) or the 185-D De-aerating plant (via the underground 100-D-56:1 pipelines). In 1950, the mixing process was moved from the 108-D Chemical Pumphouse to the 185-D De-aerating Plant and continued there for about nine years. Contact between these solid materials and the ground surface are plausible, but unknown. Estimates of solid mass processing rates were not well documented, but a one-week record in 1945 showed mixing of 8,960 kg (19,800 lb) of material (HW-7-1388 Del, *Hanford Engineering Works Monthly*).

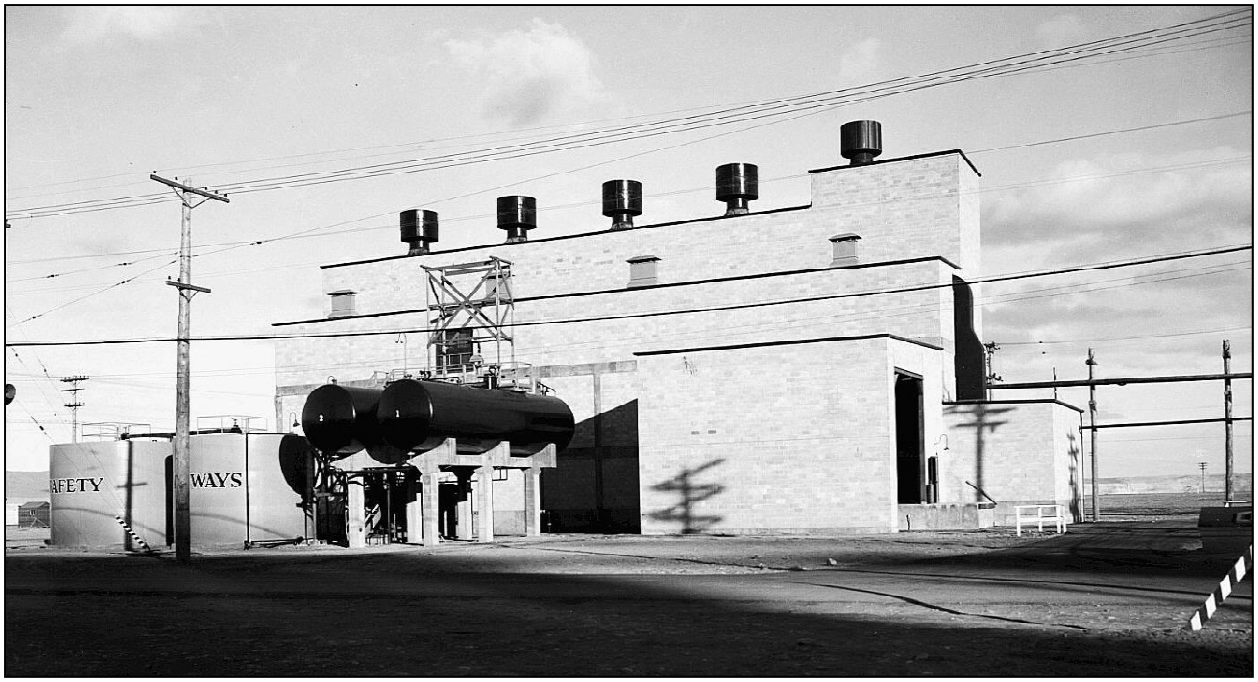

Figure 2-16. 108-D Chemical Pumphouse (1944)

Beginning in 1959, mixing solid sodium dichromate with water was abandoned in favor of delivering a highly concentrated acid salt solution by railcar or tanker to 100-D-12, the sodium dichromate pumping station located west of the 105-D Reactor. Figure 2-17 shows the transfer station in the background and the french drain (foreground) next to the transfer station. From the pumping station, the solution was transferred by the underground 100-D-56:2 pipelines to the nearby 185-D De-aerating Plant (Figure 2-18) or the 183-DR Headhouse, which then further diluted the solution to a 10 to 15 percent sodium dichromate weight solution (Interoffice Memorandum 129547). This process was used for the remainder of the 105-D and 105-DR Reactor operation period ending in 1967. The solution, frequently referred to as the greater than 70 percent solution, had a pH of about 1.5 to 2, Cr(VI) concentration of about 8.96 moles/L or 466 grams/L (PNNL-17674), and specific gravity of about 1.7. The 100-D-56:2 pipelines consisted of two 7.6 cm (3-in.) diameter pipelines; historical construction drawings indicate that both were installed for transferring sodium dichromate solution. However, field observations and sampling results during remediation of the pipelines show that the westerly pipe was converted to use for sodium silicate transfer at some point. Remediation of the pipelines found and removed a clear, green-tinged liquid in the western pipe with approximately 6.1 mg/L total chromium and a red liquid in the eastern pipe with approximately 40.8 mg/L total chromium (Figure 2-19). At 100-D-12, solutions were transferred by hose from the railroad cars or tankers into the pumping facility (WHC-SD-EN-TI-181). Complete transfer of these railcar or tanker fluids into the pumping facility did not occur. Residuals were drained from the transfer hoses between the pumping station and railcars and tankers. These residuals were discharged directly into a nearby french drain about 0.9 m (3 ft) in diameter.

This french drain (Figure 2-17) appears to be the primary discharge location for this waste type in 100-D/DR. The total volume and, therefore, mass of sodium dichromate discharged into the french drain are unknown. However, this process must have been routine and frequent to satisfy necessary production rates for reactor coolant. The deep yellow color of recently extracted groundwater (Figure 2-20) from a monitoring well located near the french drain (199-D-99) shows the presence of high levels of Cr(VI), up to about 40 mg/L. Other points of discharge may be pipe leaks between the transfer station and the 185-D

and 190-DR Storage Tanks (Figure 2-21) or by the tanks themselves. Near 185-D, an estimated 3,800 L (1,000 gal) leak at a failed weld in a sodium dichromate transfer line in 1964 was reported (HW-81001, *Irradiation Processing Dept Monthly Report*).

Figure 2-17. French Drain at Sodium Dichromate Railcar Unloading Station (1997) (Waste Site 100-D-12)

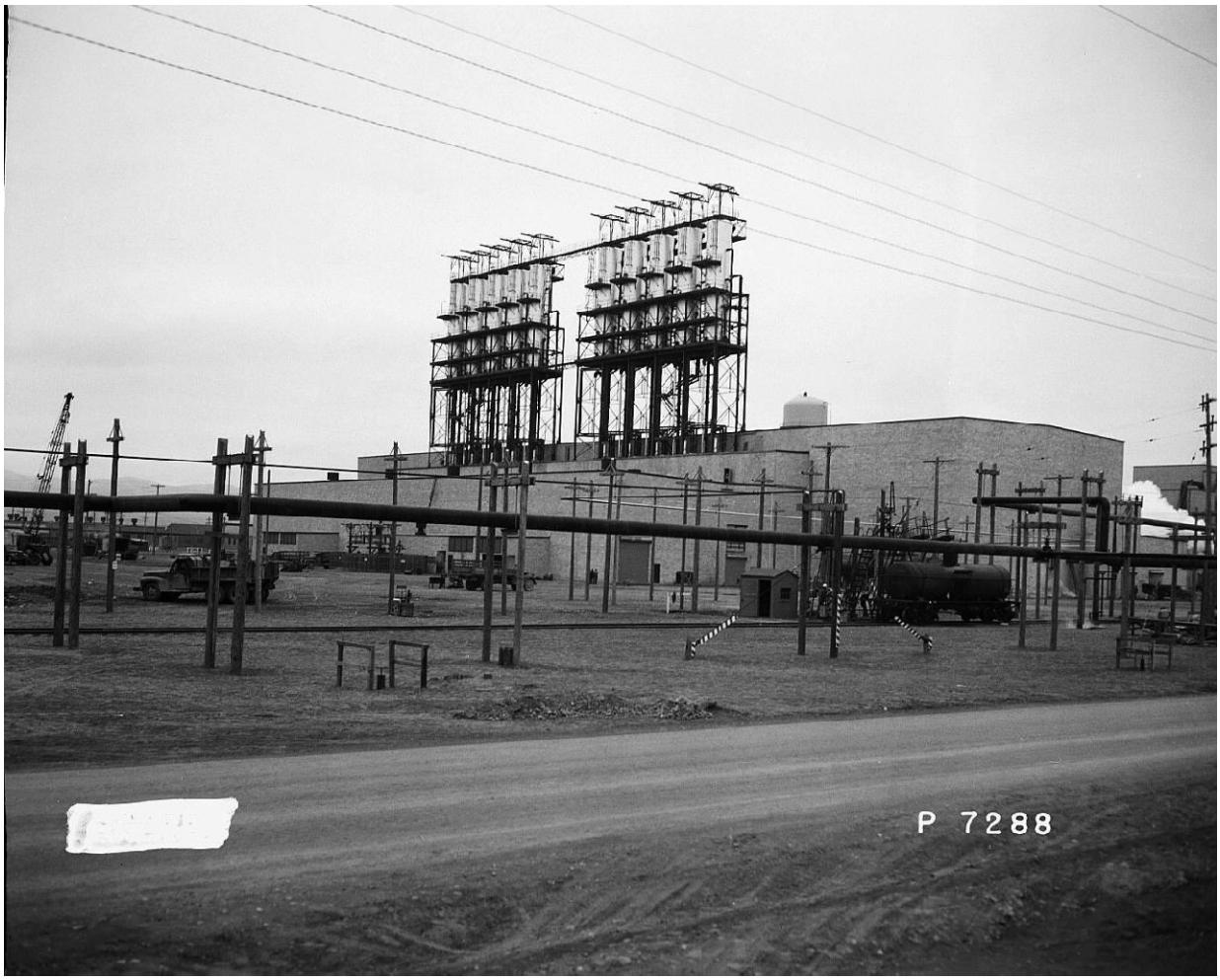

Figure 2-18. 185-D Between 189-D and 190-D, with Overhead Steam Lines and Rail Car in Foreground (1944)

Figure 2-19. Residual Sodium Silicate and Sodium Dichromate Solutions Found and Removed During Remediation of the 100-D-56:2 Pipelines (2006)

Figure 2-20. Hexavalent Chromium Contaminated Groundwater from Monitoring Well 199-D5-99

Figure 2-21. 190-D and 190-D Annex with 185-D and Steam Plant in Background (1954)

Moderately Concentrated Sodium Dichromate Solutions

The next step in the preparation of reactor coolant solution was to make an intermediate sodium dichromate solution. These solutions were 10 to 15 percent sodium dichromate by weight, had a pH of about 3, chromium concentrations of about 43 to 64 g/L (PNNL-17674), and a specific gravity between 1.08 and 1.12 (*Handbook of Chemistry and Physics* [Weast, R.C., ed., 1983]).

From 1944 to 1950, these solutions were made at the 108-D Building, then piped to storage tanks at the 105-D Reactor (overhead) and the 185-D Building (underground 100-D-56:1 pipeline) for further dilution (CCN 129547). Excess fluids were discharged to the process sewer. Demolition of the sodium dichromate trench between the 185-D and 190-D facilities is shown in Figure 2-22. During remediation, no residual sodium dichromate was found in the 100-D-56:1 pipeline, which was also observed to be heavily corroded, suggesting that any residual liquid had been flushed or leaked from the pipeline long before remediation.

Figure 2-22. 185-D Sodium Dichromate Trench, During Demolition, Looking South (1994) (Waste Site 100-D-30)

Beginning in 1950 and continuing to 1967, the 185-D Plant took over the function of preparing the 10 to 15 percent solution, first from solid sodium dichromate (1950 to 1959) and then from the 70 percent acid solution transferred from 100-D-12 into a storage tank west of the 190-D Building (1959 to 1967). When the mixing tanks were being cleaned, the sluicing fluids were discharged to the process sewer. These solutions were then pumped to storage tanks at the 183-DR Head House, the 183-DR Filter Building, and the 190-D Building where the final dilution step occurred (CCN 129547).

Likely points of entry into the subsurface for this waste type are near mixing tanks, sodium dichromate solution transfer lines between 185-D, and the process sewer that received mixing tank overflows and sluicing fluid generated between mixing campaigns. Losses of Cr(VI) to the subsurface were evident during remediation of the 185-D Facility (see Figure 2-4 in the Work Plan, and Figures 2-23 and 2-24) where frequent Cr(VI) contamination in the concrete trench underlying the facility (Figure 2-22) and surrounding soil was observed (from characteristic yellow staining) and measured. The process sewer fluids discharged into the Columbia River. Other than these discharges to the process sewer, no other locations are known where intentional discharges of these fluids occurred. Other discharges to the soil are feasible at the facilities described above that generated these solutions and the pipelines that carried them to other facilities. Volumes and sodium chromate masses lost to the subsurface in this waste stream are unknown and unquantifiable.

Figure 2-23. Chromium Soil Staining (4.3-5.5 m [14-18 ft] bgs) at 185-D

Figure 2-24. Active Remediation of Chromium Contamination
(4.3-5.5 m [14-18 ft] bgs) at 185-D

Dilute Sodium Dichromate Solutions

Final dilution occurred at three facilities. To make the final solution for the 105-D Reactor, the 10 to 15 percent solution was received and diluted with treated Columbia River water at the 190-D Facility and piped into reactor facilities from 1944 through 1967. The final solution was a near neutral pH value with a Cr(VI) concentration varying from 700 to 350 µg/L with a specific gravity of about 1.

Once through the 105-D Reactor, effluents were discharged via pipeline to the 107-D Retention Basin at the north end of 100-D and held there for a short time to allow further cooling with decay of very short-lived radionuclides. From there, coolant was piped into the Columbia River via the 116-D-5 Outfall Structure. Releases occurred in the middle of the river and along the shore. A similar process was used for the 105-DR Reactor Coolant. Fluids were routed to the 107-DR Retention Trench next to the 107-D Retention Trench and the Columbia River via the 116-DR-5 Outfall Structure. Approximately 4.5 trillion L (1.2 trillion gal) ran through this system over the 22-year operations period (Table 4-4).

Some fraction of the coolant water did not reach the Columbia River because numerous leaks developed in the retention basins and effluent lines. For example, a major leak was observed on the north side of the 107-D Retention Basin in 1950 and effluent pipes separated from the 107-DR Retention Basin in 1951. Nevertheless, the effluent line/retention basin/outfall structure system was used almost continuously through the reactor operations period. These leaks were never adequately repaired and coolant loss to the subsurface was sufficient to create long-standing groundwater mounds in that area (HW-27337, HW-33305; HW-46715; HW-77170; and UNI-946).

Outside the retention basins, other facilities also received coolant. Ancillary Trenches 116-DR-1 and 116-DR-2 near the retention basins began receiving radioactively contaminated coolant in 1950 and 1952. During reactor operations, an estimated 80 million L (20 million gal) were received in these two facilities. Also in 1967, about 13 billion L (3.4 billion gal) of coolant was injected into 116-DR-1 and 116-DR-2 over a four-month period (Table 4-5). Some other facilities received relatively small quantities of radioactively contaminated reactor coolant, including two trenches east of the 105-D Reactor. Also to the east of Reactor 105-D, two Pluto Cribs 116-D-2A (1950 to 1953) and 116-DR-4 (1950 to 1956) received contaminated reactor coolant in an attempt to sequester radioactive from non-radioactive coolant. This practice was abandoned in 1956.

Other Solutions Containing Hexavalent Chromium

The most significant source of Cr(VI)-contaminated waste not described above is contaminated water and sludge removed from the 105-D Fuel Storage Basin (FSB) and disposed in trenches 116-D-1A (1947 to 1952) and 116-D-1B (1953 to 1967). Trench 116-D-1A received 200,000 L (50,000 gal) containing 1,000 kg (2,200 lb) of sodium dichromate and 116-D-1B received 8 million L (2 million gal) containing 700 kg (1,500 lb) of sodium dichromate (PNL-6456).

Decontamination solutions were used routinely to clean facility equipment and surfaces. The Cr(VI) concentrations in these solutions and volumes discharged to cribs and drains is not known. Near the 108-D Building, decontamination solutions were discharged into two small cribs 116-D-3 (1951 to 1967) and 116-D-4 (1956 to 1967) (HW-22346, *Technical Activities Report Heat Water and Mechanical Studies*; HW-22886, *Technical Activities Report Heat Water and Mechanical Studies*; CCN 129547). Laboratory solutions derived from corrosion tests also included Cr(VI) and were disposed in 116-D-4.

Solid Waste Containing Hexavalent Chromium

The historical record suggests only a small mass of Cr(VI) was disposed as solid waste. References indicate that solid dichromate disposal occurred at the 184-D Coal Pit (126-D-2 waste site), the clearwell pit between the 183-DR and 190-DR facilities (126-DR-1 waste site), and the sodium dichromate barrel disposal landfill (600-105 waste site) located between 100-D and 100-H. Remediation has been performed at all these waste sites. No significant evidence of sodium dichromate disposal with other waste material was observed directly or by analytical sampling at the 126-DR-1 or 126-D-2 waste sites.

The Sodium Dichromate Barrel Landfill (600-105) was used in 1945 for disposal of crushed, empty barrels that formerly contained crystalline (solid) sodium dichromate. Liquid waste was not disposed at this site. The landfill is located in the 100-IU-4 Operable Unit, but is within the geographic boundary of 100-D/H. The site was described as a small depression approximately 30 m (100-ft) long and 15 m (50-ft) wide. A 1993 expedited response action at the 600-105 waste site removed approximately 5,000 crushed, empty 55-gal drums. Field screening and sampling of residual soil did not show significant residual chromium contamination at the site. This site has been closed out according to a 1996 Final Record of Decision for 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 (EPA/ROD/R10-96/151, 1996, *Declaration of the Record of Decision for the 100-IU-1, 100-IU-3, and 100-IU-4 Operable Units*).

Incidental concentrations of Cr(VI) may also be present in radioactive sludge that collected in the retention basins and various small solid waste disposal facilities. Descriptions of all 100-D/H waste sites are provided in Appendix C, with contaminant data used to interim close the waste sites.

2.3.2.2 100-H Area Operations

Approximately 2 trillion L (500 billion gal) of reactor coolant passed through the 105-H Reactor between 1949 and 1965. Radioactive contaminants released into the reactor coolant when fuel cladding ruptured periodically and equipment was frequently contaminated. As in 100-D, releases of these contaminants and cooling water chemicals have provided the source of environmental contamination. Currently, the most significant contaminant is Cr(VI), which has been found in the unconfined aquifer, the RUM, and the confined aquifer below the RUM. The amount of dissolved Cr(VI) in the total reactor coolant volume was approximately 1.2 million kg (2.2 million lb), assuming yearly concentrations between 700 and 350 µg/L (BHI-00127; RL-REA-2247, *Historical Events-Reactors and Fuels Fabrication*; DUN-4847, *Chemicals Discharged to the Columbia River from DUN Facilities Fiscal Year 1968*; DUN-4668, *Chemicals Discharged to the Columbia River from DUN Facilities*; and DUN-6888, *Historical Events Single Pass Reactors and Fuel Fabrication*).

Reactor coolant production for 100-H was far less complex than for the 105-D and 105-DR Reactors. The facilities involved in the reactor coolant process are shown in Figure 2-25. Instead of multiple mixing steps to progress from highly concentrated Cr(VI) solutions to dilute reactor coolant solutions, a one step process was used at 100-H. River water was treated for impurities and pumped to the 190-H Building where sodium dichromate was added to make the correct concentration. Historical records describing the transfer, storage, and mixing of concentrated sodium dichromate materials at the 100-H Reactor are not explicit. However, given the operations history of the 100-H Reactor (1949-1965), both solid sodium dichromate and the concentrated 70 percent solutions must have been used as starting materials. It is reasonable to assume that the transition from solid to liquids occurred around 1959 as it did at 100-D/DR and 100-F (HW-61789, *Irradiation Processing Dept Monthly Record Report*). Storage pads for solid sodium dichromate and one or more storage tanks were likely located at or near the 190-H Building.

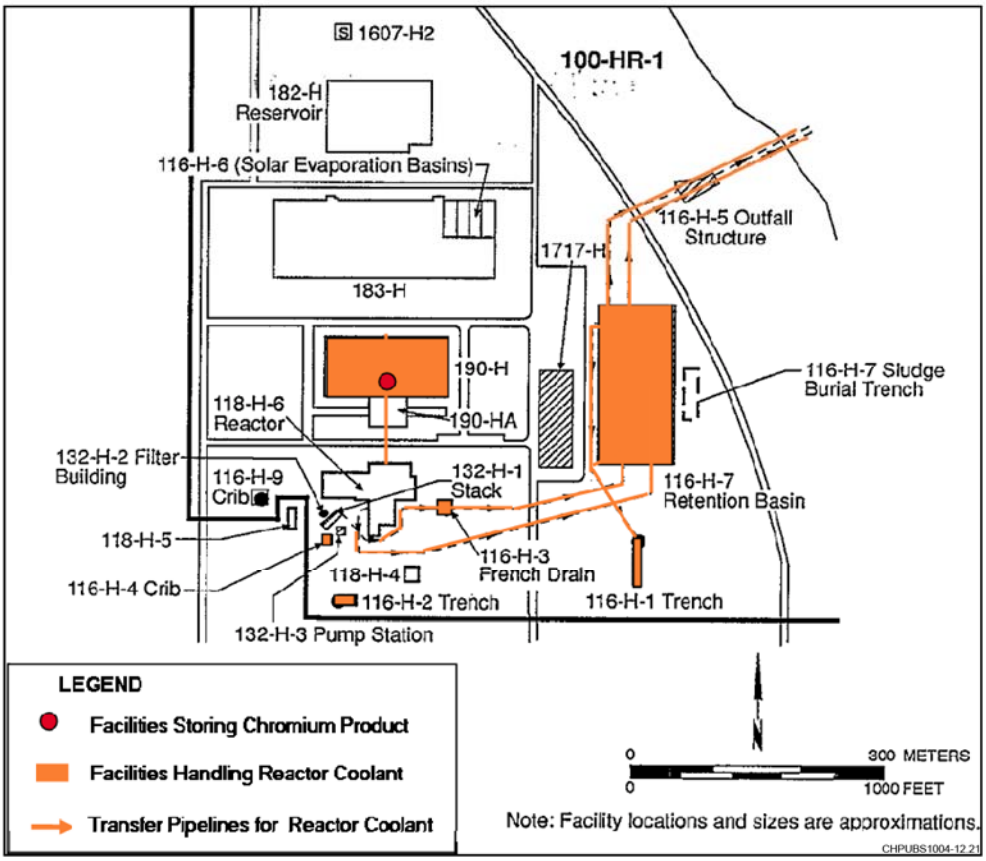

Figure 2-25. Facilities in 100-H that Produced, Stored, Handled, or Transferred Liquid Sodium Dichromate Solutions

From there, the coolant was pumped through the reactor and piped to the 116-H-7 Retention Basin for cooling. Two smaller facilities, the 116-H-1 Trench and the 116-H-4 Pluto Crib, also briefly received coolant in the early 1950s. After cooling, the fluid was pumped to the Columbia River and discharged through the 116-H-5 Outfall Structure. In addition to reactor coolant, Cr(VI) was present in equipment decontamination fluids, which were discharged to the 116-H-2 and 116-H-3 Trenches. Finally, numerous small solid waste burial grounds were used in 100-H and some amounts of Cr(VI) are likely present in these facilities as well.

Estimates for Cr(VI) contamination released to the subsurface are 31.5 kg (70 lb) at the 116-H-1 Trench, 210 kg (463 lb) at the 116-H-2 trench, 700 kg (1,540 lb) at the 116-H-3, and 350 kg (770 lb) at the 116-H-4 Pluto Crib. Because the 116-H-7 Retention Basin and effluent lines leaked periodically, some Cr(VI) was also lost to the soil from these sources (PNL-6456 and BHI-00127).

2.3.3 Waste Sites Description and History

As of August 2009, 235 waste sites exist within 100-D/H (Table 2-3). These waste sites consist mainly of inactive RCRA past practice sites described as trenches, ditches, cribs, ponds, burial grounds, and unplanned releases. There are 154 waste sites in the 100-DR-1 and 100-DR-2 OUs and 81 waste sites in the 100-HR-1 and 100-HR-2 OUs.

Table 2-3 summarizes the individual waste site classifications. These classifications are defined in the Work Plan. Appendix C provides a description and history for each waste site and lists the COCs for each

waste site. Locations of 100-D and 100-H waste sites are provided in Appendix B. Figures 2-26 and 2-27 show the locations of key waste sites and distinguish those that received chromium product or equivalent versus reactor coolant. Tables 2-4 through 2-7 provide the reclassification of the source OU waste sites and identify Cr(VI) waste sites and orphan sites.

Table 2-3. Summary Information on the Status of 100-D/H Waste Sites

Operable Unit	Number of Waste Sites[a]	Closed Out[b]	Interim Closed Out[c]	No Action[d]	Not Accepted[e]	Rejected[f]	Accepted[g,h]	Discovery[h,i]
100-DR-1	105	2[j]	30	4	6	7	54	2
100-DR-2	49	3	12	2	5	2	25	0
Total 100-D	154	5	42	6	11	9	79	2
100-HR-1	60	1	21	0	5	0	31	2
100-HR-2	21	0	2	0	3	3	12	1
Total 100-H	81	1	23	0	8	3	43	3
Total in 100- D/H	235	6	65	6	19	12	122	5

Notes:

This summary is current as of August 21, 2009. Additional information is provided in Appendix C.

a. Total number of sites includes discovery sites and not accepted sites.

b. Closed Out: A reclassification status indicating that due to actions taken, a waste management unit meets applicable cleanup standards or closure requirements. (Note: Many remediation waste sites were identified as "Closed Out" based on a previous classification scheme. Since all the associated RODs are interim action RODs, these waste sites are considered "Interim Closed Out" based on current definitions.)

c. Interim Closed Out: A reclassification status indicating due to actions taken, a waste management unit meets cleanup standards specified in an interim action ROD or action memorandum but for which a final action ROD has not been issued.

d. No Action: A reclassification status indicating a waste site does not require any further remedial action under RCRA Corrective Action, CERCLA, or other cleanup standards based on an assessment of quantitative data collected for the waste site.

e. Not Accepted: A classification status indicating an assessment was made that a WIDS site is not a waste management unit and is not within the scope of the Tri-Party Agreement Action Plan, Section 3.1. This classification requires lead regulatory agency approval.

f. Rejected: A reclassification status indicating a waste site does not require remediation under RCRA Corrective Action, CERCLA, or other cleanup standards based on qualitative information such as a review of historical records, photographs, drawings, walkdowns, ground penetrating radar scans, and shallow test pits. Such investigations do not include quantitative measurements.

g. Accepted: A classification status indicating an assessment has been made that a WIDS site is a waste management unit as defined in the Tri-Party Agreement Action Plan, Section 3.1.

h. This table lists 127 sites as unremediated (122 accepted sites and 5 discovery sites). Documentation to support the disposition or completion of interim remediation action of 40 of these 127 waste sites is in progress or has been submitted to the regulatory agencies for approval. The design and active remediation of another 40 of the 127 waste sites continues in the field. Remedial actions and site evaluation are being planned at the remaining 47 sites.

i. Discovery: An initial classification status indicating evidence of a potential waste site; assessment not yet complete. This is the classification of a newly discovered WIDS site.

j. 600-105 is in the 100-IU-4 operable unit and has been closed out according to a final ROD. 600-105 has been included in the D/H count above because it is physically within 100-D/H Boundary.

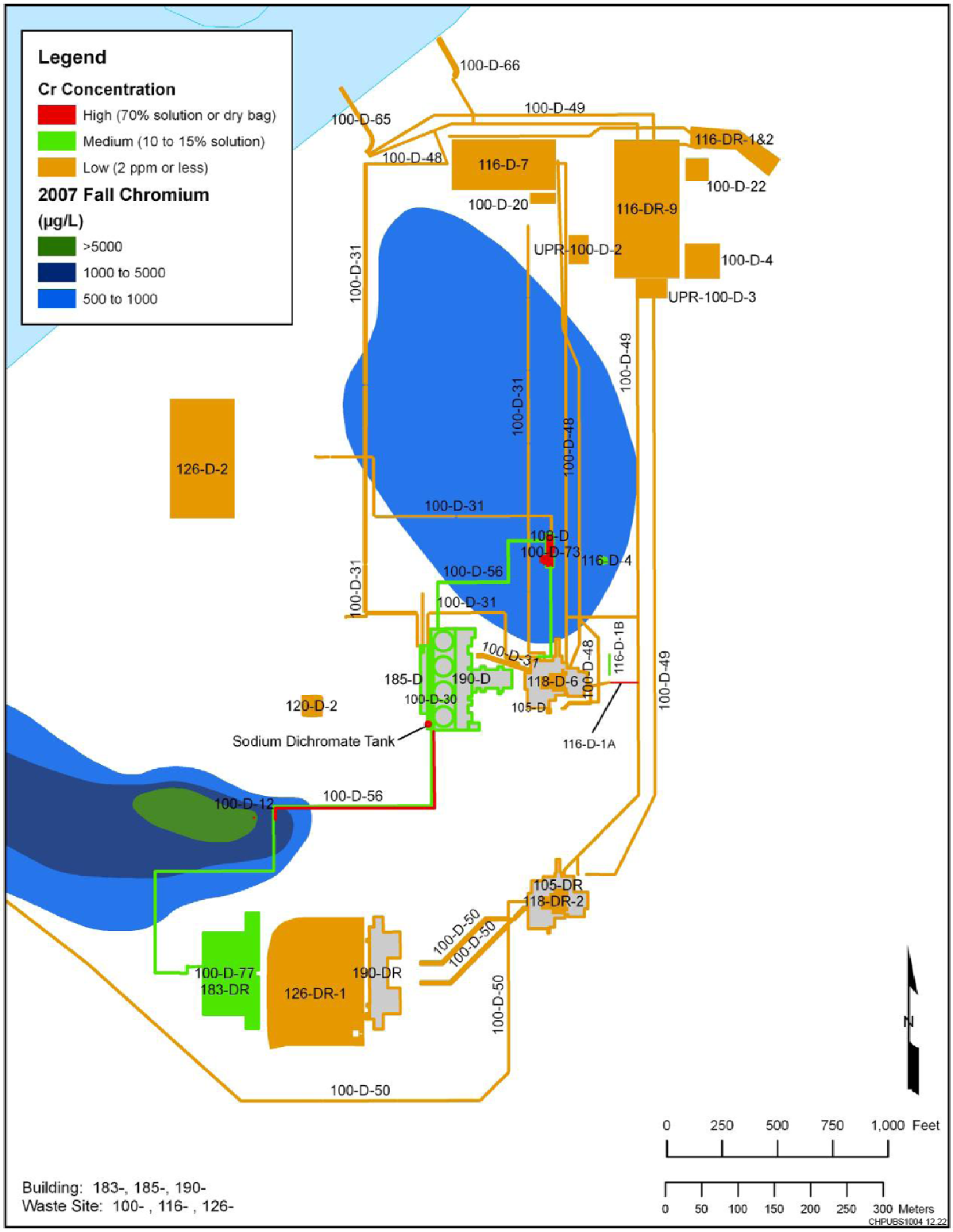

Figure 2-26. Key Hexavalent Chromium Wastes Sites in 100-D

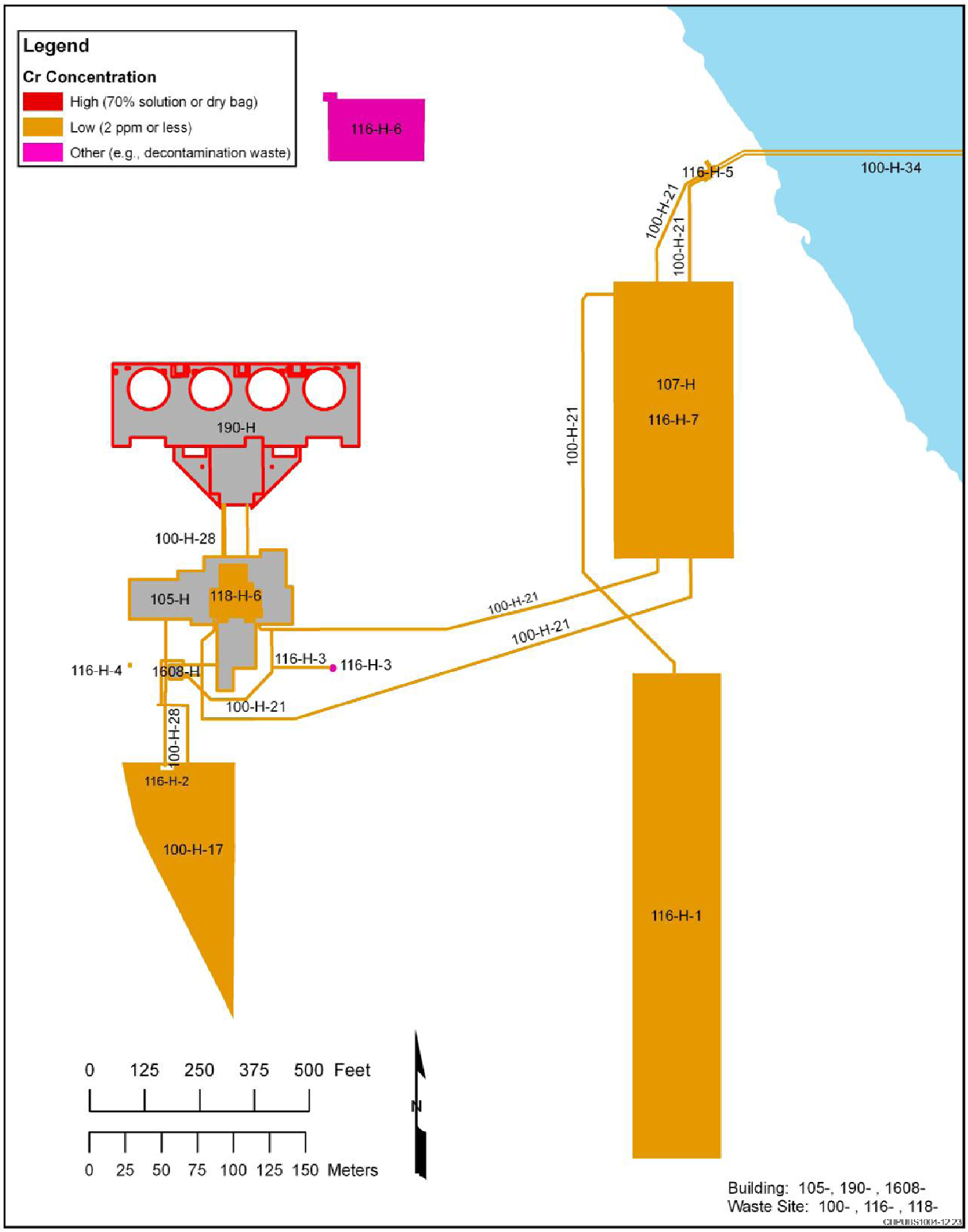

Figure 2-27. Key Hexavalent Chromium Waste Sites at 100-H

Table 2-4. Reclassification of 100-DR-1 Operable Unit Waste Sites

Reclassification Status	Waste Sites	Total (105)
Closed	120-D-1, 600-105[a]	2
Interim Closed	100-D-18**, 100-D-19**, 100-D-2, 100-D-20**, 100-D-21**, 100-D-22**, 100-D-25, 100-D-4**, 100-D-48**, 100-D-49**, 100-D-5, 100-D-52, 100-D-6, 100-D-9, 116-D-1A**, 116-D-1B**, 116-D-2**, 116-D-4**, 116-D-6**, 116-D-7**, 116-D-9**, 116-DR-1&2**, 116-DR-9**, 132-D-2, 132-D-3**, 132-D-4, 1607-D4, UPR-100-D-2**, UPR-100-D-3**, UPR-100-D-4**	30
No Action	100-D-3, 100-D-24, 116-D-3**, UPR-100-D-1	4
Not Accepted	100-D-10, 100-D-26, 100-D-34, 100-D-38, 100-D-57, 100-D-91	6
Rejected	100-D-32**, 100-D-33, 100-D-35, 100-D-41, 100-D-59, 126-D-1**, 126-D-3	7
Accepted	100-D-1, 100-D-7**, 100-D-8, 100-D-29, 100-D-30**, 100-D-31**, 100-D-42, 100-D-45, 100-D-50**, 100-D-56**, 100-D-60, 100-D-61, 100-D-63, 100-D-65**, 100-D-66**, 100-D-67, **100-D-70, 100-D-71, 100-D-72, 100-D-73**, 100-D-74, 100-D-75, 100-D-76, 100-D-79, 100-D-80, 100-D-81, 100-D-82, 100-D-83, 100-D-84, 100-D-85, 100-D-86, 100-D-87, 100-D-88, 100-D-90, 100-D-92, 100-D-93, 100-D-95, 100-D-96, 100-D-97, 100-D-98, 100-D-99, 116-D-5**, 116-D-10**, 116-DR-5**, 118-D-6**, 120-D-2**, 126-D-2,** 128-D-2, 130-D-1, UPR-100-D-5, 132-D-1, 1607-D-2, 1607-D-5, 628-3	54
Discovery	100-D-69, 100-D-101	2

Notes:

This summary is current as of August 21, 2009. Additional information provided in Appendix C, Tables C-1 and C-2.

** Sites received chromium waste stream in high (70% solution), medium (10-15% solution) and low (2 mg/kg or less) concentrations.

Bold text denotes an orphan site.

a. The sodium dichromate landfill (600-105) is in the 100-IU-4 operable unit and has been closed out according to a final ROD. 600-105 has been included in the D/H count above because it is physically within the 100-D/H Boundary.

Table 2-5. Reclassification of 100-DR-2 Operable Unit Waste Sites

Reclassification Status	Waste Sites	Total (49)
Closed	100-D-27, 122-DR-1, 1607-D3	3
Interim Closed	100-D-12**, 100-D-23, 100-D-46**, 100-D-53, 100-D-54, 100-D-64, 116-DR-4**, 116-DR-6**, 116-DR-7, 126-DR-1, 132-DR-1**, 132-DR-2	12
No Action	100-D-68**, 128-D-1	2
Not Accepted	100-D-11, 100-D-36, 100-D-37, 100-D-55, **100-D-89**	5
Rejected	100-D-17, 100-D-40	2

Table 2-5. Reclassification of 100-DR-2 Operable Unit Waste Sites

Reclassification Status	Waste Sites	Total (49)
Accepted	100-D-13, 100-D-14, 100-D-15, 100-D-28, 100-D-43, 100-D-47, 100-D-58, 100-D-62, 100-D-77**, **100-D-78, 100-D-94,** 116-D-8, 118-D-1, 118-D-2**, 118-D-3, , 118-D-4, 118-D-5, 116-DR-3**, 116-DR-8**, 116-DR-10**, 118-DR-1, 118-DR-2**, 1607-D1, 600-30, 100-D-100**	25
Discovery	None	0

Notes:

This summary is current as of August 21, 2009. Additional information provided in Appendix C, Tables C-1 and C-2.

** Sites received chromium waste stream in high (70% solution), medium (10-15% solution) and low (2 mg/kg or less) concentrations.

Bold text denotes an orphan site.

Table 2-6. Reclassification of 100-HR-1 Operable Unit Waste Sites

Reclassification Status	Waste Sites	Total (60)
Closed	116-H-6**	1
Interim Closed	100-H-1**, 100-H-5**, 100-H-9, 100-H-10, 100-H-11, 100-H-12, 100-H-13, 100-H-14**, 100-H-17**, 100-H-21**, 100-H-22**, 100-H-24, 100-H-30**, 100-H-31, 116-H-1**, 116-H-2**, 116-H-3**, 116-H-7**, 132-H-1, 1607-H2, 1607-H4	21
No Action	None	0
Not Accepted	100-H-6, 100-H-18, 100-H-19, 100-H-20, 100-H-26	5
Rejected	None	0
Accepted	100-H-3, 100-H-4, 100-H-7, 100-H-8, 100-H-28**, 100-H-33, 100-H-34**, 100-H-35, 100-H-36, 100-H-39, 100-H-40, **100-H-41, 100-H-42, 100-H-43, 100-H-44, 100-H-45, 100-H-46, 100-H-47, 100-H-48, 100-H-49, 100-H-50, 100-H-51, 100-H-52, 100-H-53,**116-H-4**, 116-H-5**, 116-H-9**, 118-H-6**, 126-H-2, 132-H-3, 1607-H3	31
Discovery	100-H-38, 100-H-54	2

Notes:

This summary is current as of August 21, 2009. Additional information provided in Appendix C, Tables C-1 and C-2.

** Sites received chromium waste stream in medium (10-15% solution) and low (2 mg/kg or less) concentrations.

Bold text denotes an orphan site.

Table 2-7. Reclassification of 100-HR-2 Operable Unit Waste Sites

Reclassification Status	Waste Sites	Total (21)
Closed	None	0
Interim Closed	132-H-2, 100-H-2**	2
No Action	None	0
Not Accepted	100-H-15, 100-H-27, 600-258	3
Rejected	100-H-16, 100-H-32, 126-H-1	3
Accepted	118-H-1, 118-H-2, 118-H-3, 118-H-4, 118-H-5, 128-H-1, 128-H-2, 128-H-3, 1607-H1, 600-151, 600-152, 100-H-55	12
Discovery	100-H-37	1

Notes:

This summary is current as of August 21, 2009. Additional information provided in Appendix C, Tables C-1 and C-2.

** Sites received chromium waste stream in low (2 mg/kg or less) concentrations.

Three active (operational) sites are located in 100-D/H (100-D-55-Gravel Pit number 21, 100-D-58 Septic System, and 1607-H1 Septic Tank). The 100-D-58 Septic System and the 1607-H1 Septic Tank are "accepted" waste sites. The 100-D-55 is classified as a "not accepted" site. "Not accepted" indicates all the Tri-Parties (DOE, EPA, and Ecology) agree that the site is not a waste management unit (WMU).

DOE has implemented a number of processes to identify new waste sites (Work Plan, Chapter 3). The process of identifying new waste sites increases confidence that waste disposal and releases requiring characterization and cleanup within a given land parcel on the Hanford Site are addressed. In 1996, 133 waste sites were identified in the WIDS. Between 1996 and 2009, an additional 102 waste sites were identified. This brings the number of waste sites up to 235, inclusive of about 45 new sites identified during the orphan site process (see Work Plan, Chapter 3), which was implemented in 2004. The orphan site evaluation process for 100-D and 100-H is complete. Evaluation of the Horn is scheduled for completion in 2011.

2.3.4 Decommissioning Activities

The facilities at 100-D and 100-H were the first to be declared excess after their reactors shut down starting in 1965. Follow-on housekeeping/decommissioning activities began in 100-D and 100-H as part of a Site-wide initiative in 1973, after deactivation of the remaining single-pass reactors. This activity progressed, as resources allowed, from 1974 through 1990 with buildings being demolished, surplus equipment salvaged or redeployed, and active operations maintained at a minimal level. Building and facility wastes remaining exist as contamination in demolished ductwork, concrete, paint, equipment, insulation, cracks, crevices, and remaining process piping and tanks.

2.4 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 100-D/H are discussed in this section and were considered in the development of the CSM (Chapter 4).

A compact disc (CD) located in Appendix E contains additional data in Excel format from samples taken within 100 D/H. The CD contains data for soil, groundwater, and aquifer tubes. Also included in Appendix E is text containing explanations of these datasets. For comparison with cleanup levels, soil background, and groundwater background see WAC 173-340, *Model Toxics Control Act—Cleanup*; DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*; and DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*; respectively.

2.4.1 Nature and Extent of Contamination in the Vadose Zone

Radiological characterization of the 100 Area initially was performed in 1975 and is documented in UNI-946. Limited Field Investigations (LFIs) conducted in the 1990s provided additional information on the vadose zone. The results from these investigations show where contamination was detected in 100-D/H. However, vadose zone characterization beneath remediated waste sites is limited and, therefore, the remaining vadose zone contaminant inventories beneath remediated waste sites is not known.

2.4.1.1 Initial Vadose Zone Radiological Characterization – 1975

The purpose of characterization was to establish radionuclide inventories, distribution, and concentrations at inactive solid and liquid wastes sites, reactors, and associated facilities. The focus of the sampling activities was 100-D and 100-H liquid waste receiving sites and retention basins. Shallow boreholes were drilled in and adjacent to waste site boundaries to a maximum depth of 10.5 m (35 ft). Based on process knowledge, samples were analyzed for the following constituents:

- Carbon-14
- Cesium-134
- Cesium-137
- Cobalt-60
- Europium-152
- Europium-154
- Europium-155
- Nickel-63
- Plutonium-238
- Plutonium-239/240
- Strontium-90
- Tritium
- Uranium

The investigation parameters are summarized in Table 2-8. Activity values reported are as presented in the source documentation and thus, are undecayed.

Table 2-8. Summary of Borehole Locations Used in the Initial Radiological Characterization – 1975

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation m (ft)
116-D-1A Trench	4	Soil	9.1 (30)
116-D-1B Trench	4	Soil	11 (35)
116-D-4 Crib	1	Soil	1.5 (5)
116-D-5 Outfall Structure	1	Soil	Not documented
116-D-7 Retention Basin	47*	Soil and sludge	10 (34)
116-D-9 Crib	1	Soil	Not documented
116-DR-1&2 Trench	*	Soil	9.1 (30)

Table 2-8. Summary of Borehole Locations Used in the Initial Radiological Characterization – 1975

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation m (ft)
116-DR-3 Trench	5	Soil	7.6 (25)
116-DR-4 Crib	3	Soil	7.0 (23)
116-DR-5 Outfall Structure	1	Soil	Not documented
116-DR-7 Crib	1	Soil	6.1 (20)
116-DR-8 Crib	1	Soil	3.0 (10)
116-DR-9 Retention Basin	*	Soil and sludge	9.1 (30)
100-D Area	2	Soil	Not documented
100-H-5 Trench	2	Soil	4.6 (15)
116-H-1 Trench	8	Soil	7.6 (25)
116-H-7 Retention Basin	15	Soil	9.1 (30)
116-H-2 Trench	6	Soil	4.6 (15)
116-H-3 French Drain	2	Soil	4.6 (15)

Notes:

* Forty-seven boreholes were drilled among 116-D-7, 116-DR-1 & 2, and 116-DR-9 waste sites.

In 100-D, results from this 1975 radiological characterization indicate contamination is present to the maximum depth investigated (10.5 m [35 ft]) and contaminants were detected beneath and adjacent to the waste sites. The depth noted (10.5 m [35 ft]) represents the maximum vertical extent of the investigation and the observed extent of contamination in the upper half of the vadose zone. Assessment of the lateral extent of contamination indicates lower concentrations of contamination were present immediately adjacent to waste sites. Contaminants detected in concentrations (greater than 1 pCi/g) during this investigation include Pu-239/240, Sr-90, tritium, europium isotopes, Co-60, Cesium-134 (Cs-134), Cs-137, nickel-63 (Ni-63), and C-14 (UNI-946, Table 2.7-44). Plutonium-238 (PU-238) and uranium in soil were not widely distributed and not detected in significant concentrations.

Maximum contaminant concentrations appear to be associated with areas where effluent enters the waste site near discharge pipes and are present beneath the engineered structure of waste sites. For contaminants detected, such as Cs-137 (high contaminant distribution coefficients), concentrations generally decrease with depth below points of effluent releases, although concentrations as high as 1,200 pCi/g are present at a depth of 7.6 m (25 ft) in the 116-DR-1&2 Trench. The maximum vertical extent of significant Cs-137 contamination (14 pCi/g) was detected at 10 m (34 ft) bgs adjacent to the 116-D-7 Retention Basin. Mobile contaminants, such as tritium (less than 30 pCi/g), also were detected near the vertical extent of the investigation. The distribution of europium isotopes and Co-60 in the subsurface varies and concentrations occasionally decrease with depth. However, elevated levels of contamination are present at or near the maximum extent of the investigation. Maximum concentrations were found at depth at boreholes.

Contaminants were detected in various boreholes during the investigation, but not all contaminants were detected in each borehole. The following is a list of maximum concentrations detected in the boreholes (UNI-946):

- Cesium-134 1.4 pCi/g
- Cesium-137 61 pCi/g)
- Cobalt-60 740 pCi/g
- Strontium-90 29 pCi/g
- Europiumm-152 280 pCi/g
- Europium-154 83 pCi/g
- Europium-155 22 pCi/g,
- Tritium 21 pCi/g
- Plutonium-238 < 1 pCi/g
- Plutonium-239/240 < 1 pCi/g
- Uranium-total < 1 pCi/g

In 100-H, results from this 1975 Radiological Characterization Area indicate contamination is present to the maximum depth investigated of 9 m (30 ft) with some lateral spread. The depth noted (9 m [30 ft]) represents the maximum vertical extent of the investigation and the observed extent of contamination in the upper half of the vadose zone. Contamination also was detected adjacent to the 116-H-7 Retention Basin. Contaminants detected at concentration greater than 1 pCi/g include Cs-134, Cs-137, Co-60, the europium isotopes, Ni-63, Pu-238, Pu-239/240, Sr-90, tritium, and Uranium. Soil was not tested for C-14 in, or adjacent to, the 116-H-7 Retention Basin (UNI-946, Table 2.7-74).

Sample holes drilled through the floor of the 116-H-7 Retention Basin indicate that most of the contamination is within a few meters of the basin floor. Immediately adjacent (less than 3 m [10 ft]) to the basin, elevated contamination was detected at depths of 3 to 4.5 m (10 to 15 ft). Concentrations generally decreased with depth in this zone, although Cs-137, europium isotopes, and Co-60 are present at the maximum extent of the investigation (9 m [30 ft]) at the following concentrations, respectively: 26 pCi/g, 1.6 pCi/g, and 23 pCi/g.

Contaminant data indicate that lateral spreading had occurred on the southeast side of the 116-H-7 Retention Basin extending at least 13 m (45 ft) from the basin. At a depth of 7.6 m (25 ft), Cs-137, Co-60, and europium isotopes in this zone were 14 pCi/g, 300 pCi/g, and 320 pCi/g, respectively (Sample No. 107-H-I-25, UNI-946, p. 2-146). At a distance of 35 m (115 ft) from the basin edge, contamination concentrations greater than 1 pCi/g are not noted. Contamination concentrations greater than 1 pCi/g were not observed at the inlet and outlet ends of the basin toward the north and south.

Samples collected near the bottom of the 116-H-1 Trench indicate higher levels of contamination are present on the inlet end (north end) of the waste site. Elevated levels of contamination are present at 4.5 to 7 m (15 to 23 ft) bgs. The maximum contaminant concentrations in this zone are Cs-137 (520 pCi/g), Co-60 (440 pCi/g), europium isotopes (2,500 pCi/g), and Sr-90 (82 pCi/g). At the bottom of the ditch on the south end, lower levels of contamination are present. The data indicate that contamination concentrations greater than 1 pCi/g were measured adjacent to the northeast end of this waste site at a depth of 0.6 m (2 ft). However, at an estimated distance of 6.7 m (22 ft) from the trench, contamination concentrations greater than 1 pCi/g were not detected.

Investigation of the 116-H-2 Trench and 116-H-3 French Drain indicates contamination was higher at the bottom of these waste sites and concentrations generally decrease with depth in the soil. Lateral spreading of contaminants appeared to be limited. Contaminant concentrations (greater than 1pCi/g) also were noted in near surface (less than 4.6 m [15 ft] bgs) soil adjacent to these two waste sites (UNI-946, p. 2-146 and 2-147). Samples were collected at a depth of 4.6 m (15 ft) (bottom of waste site) at the 100-H-5 Trench. Radionuclide concentrations observed were less than 1 pCi/g (sample number 107-H-I-25).

2.4.1.2 100-D Area Limited Field Investigations

To assess impacts associated with discharging effluent to the soil column at liquid waste sites, LFIs were performed in the 100-DR-1 and 100-DR-2 OUs in the early 1990s. The results (documented in DOE/RL-93-29 and DOE/RL-94-73, *Limited Field Investigation Report for the 100-DR-2 Source OU*) indicate radionuclide concentrations are elevated with higher concentrations in the 116-DR-9 Retention Basin and the trenches. In addition, metals are present at several sites. When the LFI was performed in early 1990s, none of the metal concentrations detected at these sites exceeded the 1991 WAC 173-340-740(3). Since then, regulations have been amended (1996, 2001, and 2007 WAC 173-340-740). In addition, higher levels of chromium were detected at the sodium dichromate loading facility (100-D-12), up to 516 mg/kg.

Sampling and analysis of soil was performed at waste sites during the 100-D LFI. Boreholes and test pits were excavated to assess subsurface conditions in 100-D. Boreholes were surveyed for radiological contamination using downhole geophysical techniques to delineate the locations and levels of contamination. Some of the boreholes deployed as part of the LFI went deeper than those in the initial radiological characterization. The sampling and analysis plan is described in detail in WHC-SD-EN-AP-061, *Description of Work for the 100-DR-1 Source OU* and WHC-SD-EN-AP-139, *Description of Work for 100-DR-2 OU Vadose Drilling Test Pits*.

Materials removed from boreholes and test pits were screened for volatile organic compounds (VOCs), total chromium, and evidence of radiological contamination. Volatile organic concentrations detected during screening range between 0.4 and 6.2 mg/kg. Higher concentrations were detected at 116-DR-6, 116-D-3, 130-D-1 10, and 4.9 m (16 ft) bgs. Cr(VI) was detected at a maximum concentration of 0.8 mg/kg. Beta-gamma radiological contamination above background ranged between 150 and 14,000 cpm with the maximum occurring at 116-DR-9 about 0 to 1.5 m (0 to 5 ft) bgs. Radiological contamination (80 cpm) at 130-D-1.was detected to a maximum depth of 10.7 m (35 ft).

Samples were collected to a maximum depth of 17.7 m (28 ft) bgs and analyzed for various chemicals, radionuclides, and soil physical properties. At the time of sampling, groundwater was encountered at 18 m (58 ft) bgs. However, none of the boreholes were sampled to the depth of the current water table, which is approximately 26 m (85 ft) bgs. The samples also were tested for bulk density, particle size distribution, moisture content, saturated hydraulic conductivity, and unsaturated hydraulic conductivity. Summary information describing the investigation is presented in Table 2-9. The maximum extent of remedial action (i.e., remove, treat, and dispose) is also inserted into the table to provide an indication of contamination removed.

Table 2-9. Summary of 100-D 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)	Analyte List
100-DR-1 OU						
116-D-1A Trench	1	Soil	16 (53)	16 (53)	4.6 (15.0)	ICP/AA Metals Mercury VOA SVOA PCBs Pesticides Gross alpha
116-D-1B Trench	1	Soil	11 (37)	11 (37)	4.6 (15.0)	
116-D-2 Crib	1	Soil	7.6 (25)	7.6 (25.0)	4.6 (15.0)	
116-D-3 French Drain	1	Soil	7.3 (24)	NAB	N/A No Action Waste Site	

Table 2-9. Summary of 100-D 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)	Analyte List
116-D-4 French Drain	1	Soil	7.0 (23)	3.8 (12.5)	2.8 (9.2)	Gross beta Gamma Spectroscopy Sr-90 Technetium C-14 Alpha Spectroscopy
116-D-5 Outfall Structure	1	Soil	8.2 (27)	NAB	N/A Accepted Waste Site	
116-D-6 French Drain	1	Soil	7.0 (23)	5.3 (17.5)	4.6 (15.0)	
116-D-7 Retention Basin	1	Soil	11 (37)	11.2 (36.6)	7.4 (24.3)	
116-D-9 Crib	1	Soil	8.5 (28)	6.3 (20.8)	5.5 (18.0)	
116-DR-1 &2 Trench	3[a]	Soil	19 (62.5)	14 (47.0)	5 (16.4)	
116-DR-5 Outfall Structure	1	Soil	8.5 (28)	8.4 (27.5)	N/A Accepted Waste Site	
116-DR-9 Retention Basin	3	Soil	11 (37)	11.4 (37.5)	4.75 (15.6)	
130-D-1 Underground Tank	1	Soil	11 (37)	8.2 (27.0)	N/A Accepted Waste Site	
132-D-3 Pumping Station	1	Soil	11.7 (38.6)	11.2 (36.8)	Facility demolished in place	
108-D/Sodium Dichromate Tanks[b]	5 test pits	Soil	1.5 (5.0)	1.5 (5.0)	N/A	
100-DR2 OU						
116-DR-3 Trench	2 test pits	Soil	3.0 (10)	3.0 (10)	N/A Accepted Waste Site	ICP/AA Metals Mercury Gross alpha Gross beta Gamma Spectroscopy Sr-90 Total activity Anions/IC Fluorides Sulfates Nitrates Nitrites
116-DR-7 Crib	1	Soil	9.8 (32)	9.0 (29.5)	4.8 (15.7)	
100-D-12 Sodium Dichromate Site	3 test pits	Soil	6.1 (20)	6.1 (20.0)	6 (20)	

Table 2-9. Summary of 100-D 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)	Analyte List

Notes:

a. Includes two LFI boreholes and one field remediation borehole. The field remediation borehole was drilled in 1999 to characterize the distribution of Cr(VI) to the water table.

b. 108-D and the Sodium Dichromate Tanks are characterized separately in the LFI report. The tanks are not listed as a WIDS waste site.

Total activity samples were also collected.

AA = atomic absorption
C-14 = carbon-14
IC = ion chromatography
ICP = inductively coupled plasma
N/A = Not Applicable
NAB = Not above background
PCB = polychlorinated biphenyl
Sr-90 = strontium-90
VOA = volatile organic analyte

According to the LFI, radiological contamination was the primary concern in 100-D in soil and was assumed the main contributor to overall risk. Radionuclides detected above background included Co-60, Sr-90, Cs-137, europium-152 (Eu-152), europium (Eu-154), Pu-239/240, and americium-241 (Am-241). The highest activities of radionuclides detected were in the 116-DR-9 Retention Basin (DOE/RL-93-29). The conclusion in DOE/RL-93-29 of higher radiological concentrations at 116-DR-9 is based on both UNI-946 and the LFI data. The summary of data in this section reflects LFI data and a remedial action borehole drilled in 1999. The maximum concentration of Cs-137 and Eu-152, and Co-60 activities detected were 322 pCi/g, 258 pCi/g, and 23.1 pCi/g, respectively, at 119-D-1a, 116-D-1B, and 116-DR-1&2. Metals contamination was present at several sites (116-D-1B Trench, 116-D-7 Retention Basin, 116-DR-9 Retention Basin, 116-DR-1 and 116-DR-2 Trenches, 116-D-3 French Drain, 130-D-1 Underground Tank, and the sodium dichromate site) with higher concentrations at 116-D-1A. The metals with the highest concentrations at 116-D-1A were cadmium (1.0 mg/kg), total chromium (108 mg/kg), and nickel (42 mg/kg). When the LFI was performed in early 1990s, none of the metal concentrations detected at these sites exceeded the 1991 WAC 173-340-740(3). Since then, regulations have been amended (1996, 2001, 2007, WAC 173-340-740).

Maximum activities of radionuclides in the 116-DR-7 Trench were detected near the bottom of the borehole from 7.6 m (25 ft) bgs through 9.0 m (29.5 ft) bgs. At these depths, the activities of the various radionuclides were tritium (5 pCi/g), Co-60 (1.9 pCi/g), Ni-63 (170 pCi/g), Cs-137 (3.6 pCi/g), and Eu-152 (7.9 pCi/g). Other radionuclides detected include potassium-40 (K-40), Plutonium (Pu-241), technetium-99 (Tc-99), radium-226 (Ra-226), Radium- (Ra-228), Sr-90, thorium-228 (Th-228), thorium-232 (Th-232), uranium-233/234 (U-233/234), and uranium-238 (U-238).

Samples collected at the 116-DR-3 Trench and 116-DR-7 Crib indicate inorganics and anions were not present above background concentrations. However, at the sodium dichromate loading facility (waste site 100-D-12), total chromium was detected at concentrations of 516 mg/kg at less than 3 m (10 ft) bgs and 260 mg/kg at 6 m (20 ft) bgs.

The VOCs and semivolatile organic compounds (SVOCs) were detected in the subsurface during the LFI. The concentrations of these organic constituents were generally low, often below quantitation limits. The vertical distribution profiles of contamination beneath the 116-DR-1&2 Trench, 116-D-1A Trench, and 116-DR-9 Retention Basin are shown in Figures 2-28, 2-29, 2-30, 2-31, and 2-32. These figures relate the contamination to local stratigraphy and the engineered structures. These sites are examples of waste sites that received high effluent discharge. The depth of remedial action is inserted into the profile as an indicator of soil removed during remedial actions conducted approximately eight years after completion of the LFI. Based on LFI data and process knowledge, these are the worst case waste sites based on available inventory, effluent volume discharged, and sample data. These sites received 200,000 to 40,000,000 L (50,000 to 10,000,000 gals) of effluent and 40 to 1,000 kg (90 to 2,000 lbs) of sodium dichromate. Burial grounds have not been included as worst case waste sites because limited liquids were received and potential impact on groundwater and the river is expected to be minimal. The greatest potential for impact on groundwater and river is from liquid waste sites.

Contaminant profiles of three boreholes drilled within the 116-DR-1&2 Trench is shown in Figures 2-28, 2-29, and 2-30. The profiles of 116-DR-1&2 generally show higher contaminant concentrations present within 1.5 m (5 ft), which is near the base of the engineered structure, but within the structure of the bottom of the trench and approximately 12 m (40 ft) above the water table. However, contaminant concentrations beyond the first 1.5 m (5 ft) of the profiles typically remain above detection with periodic increases (i.e., arsenic, Cr(VI), lead, Co-60, Eu-152, Pu-239, U-233/234, and U-238) and decreases (arsenic, chromium, mercury, Cs-137, Co-60, and Ni-63). All soil concentrations detected in this borehole are below interim remedial action goals. The distribution of contamination as shown in Figures 2-29 and 2-30 are similar to Figure 2-28 with the exception that Sr-90 concentrations generally trend up with depth, although concentrations are also below interim remedial action goals. The maximum Sr-90 concentration is 1.7 pCi/g in Figure 2-30. Although mercury concentrations in Figure 2-30 trend down with depth, one sample result collected approximately 5.2 m (17 ft) bgs is above the background concentration and the soil concentration (0.33 mg/kg) protective of the Columbia River [WAC 173-340(3)]. The maximum mercury concentration detected is 0.36 mg/kg, which is only slightly above. All other soil concentrations detected in this borehole are below interim remedial action goals.

The profile of 116-D-1A shows contaminant concentrations for the majority of samples generally decrease with depth below the depth of remedial action with exception of Am-241 and Sr-90. As an exception to the generalization, at approximately 10 m (33 ft) bgs, chromium, lead, nickel, Am-241, and Eu-154 increase (or spike) with the highest concentrations measured throughout the borehole. Similarly, the highest Cs-137 and Pu-239 concentrations were measured at ~8.2 and 10 m (27 and ~33 ft) bgs, respectively. Higher concentrations are generally present about 4.5 to 9 m (15 to 30 ft) bgs. Although Am-241 and Sr-90 concentrations increase below the depth of remedial action, these constituents do not exceed soil RAOs for groundwater protection. All constituents shown in Figure 2-31 are below cleanup levels for groundwater protection. The 116-D-1A Trench borehole did not extend to groundwater.

The profile of 116-DR-9 shows concentrations generally increasing with depth below the depth of remedial action (Figure 2-32). However, concentrations were less than the RAO for groundwater projection. The 116-DR-9 Trench borehole did not extend to groundwater.

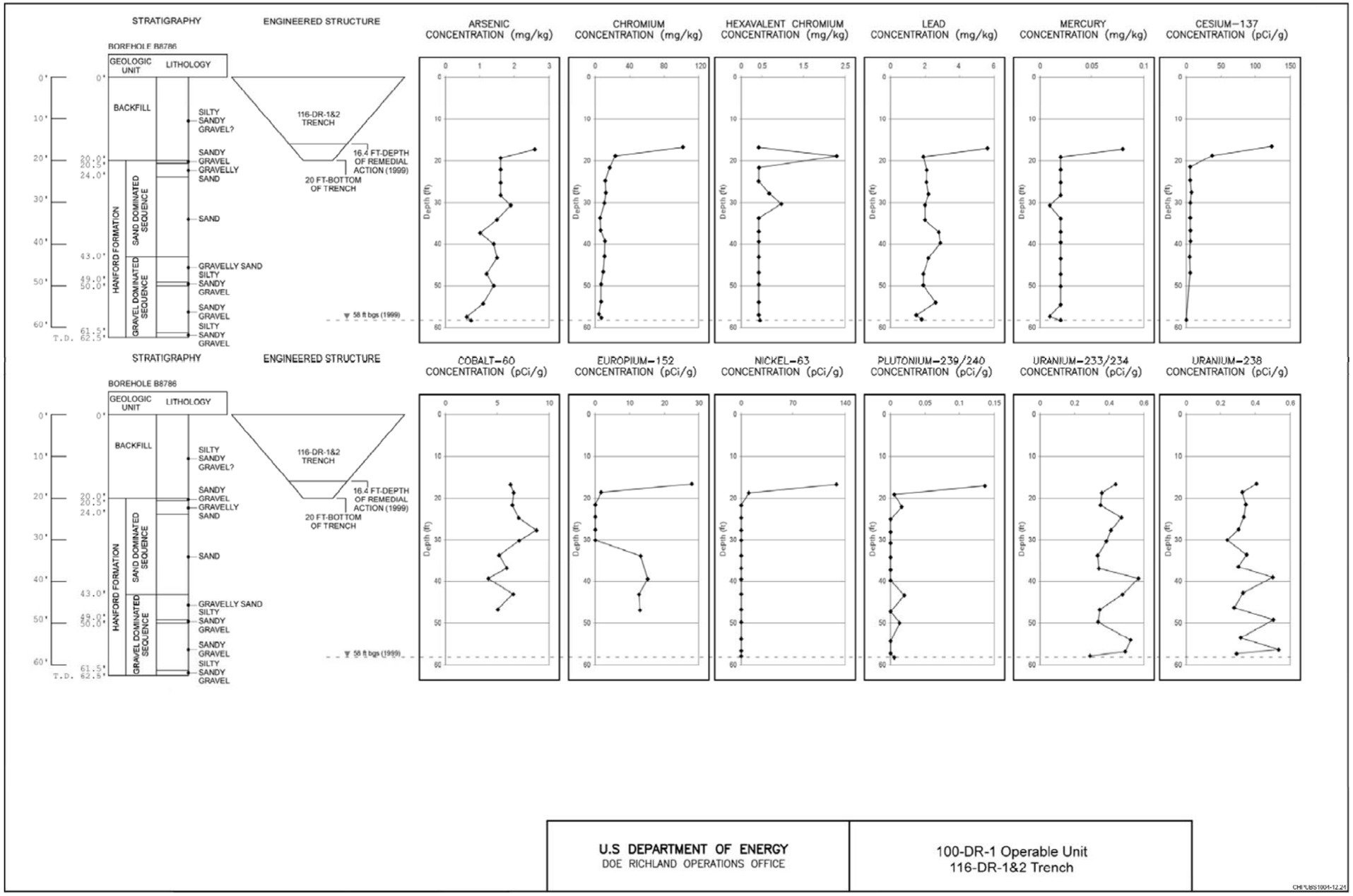

Figure 2-28. Post Remediation Vertical Profile of 116-DR-1&2 Trenches Contamination

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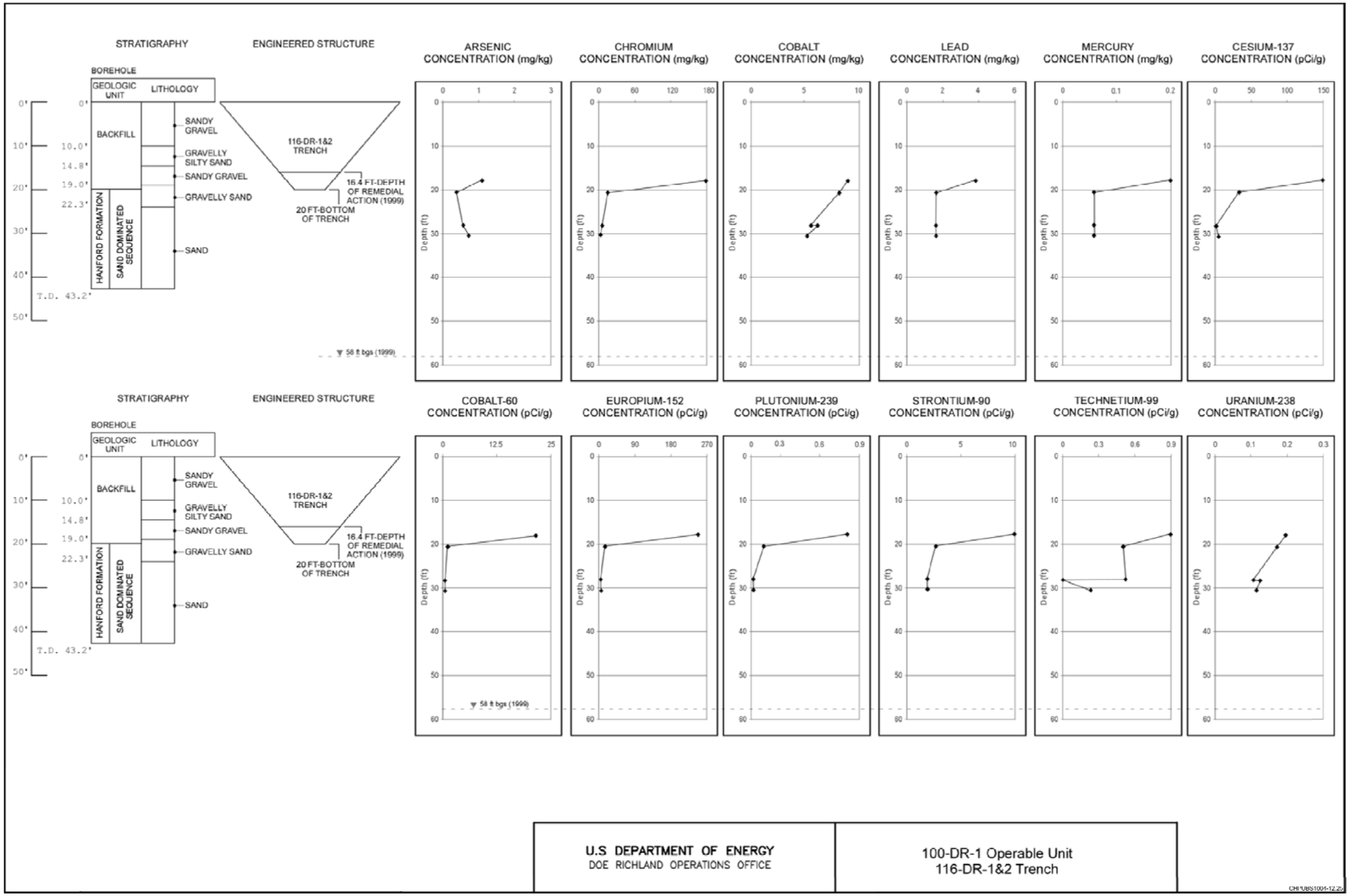

Figure 2-29. Limited Field Investigation Vertical Profile of 116-DR-1&2 Trench Contamination

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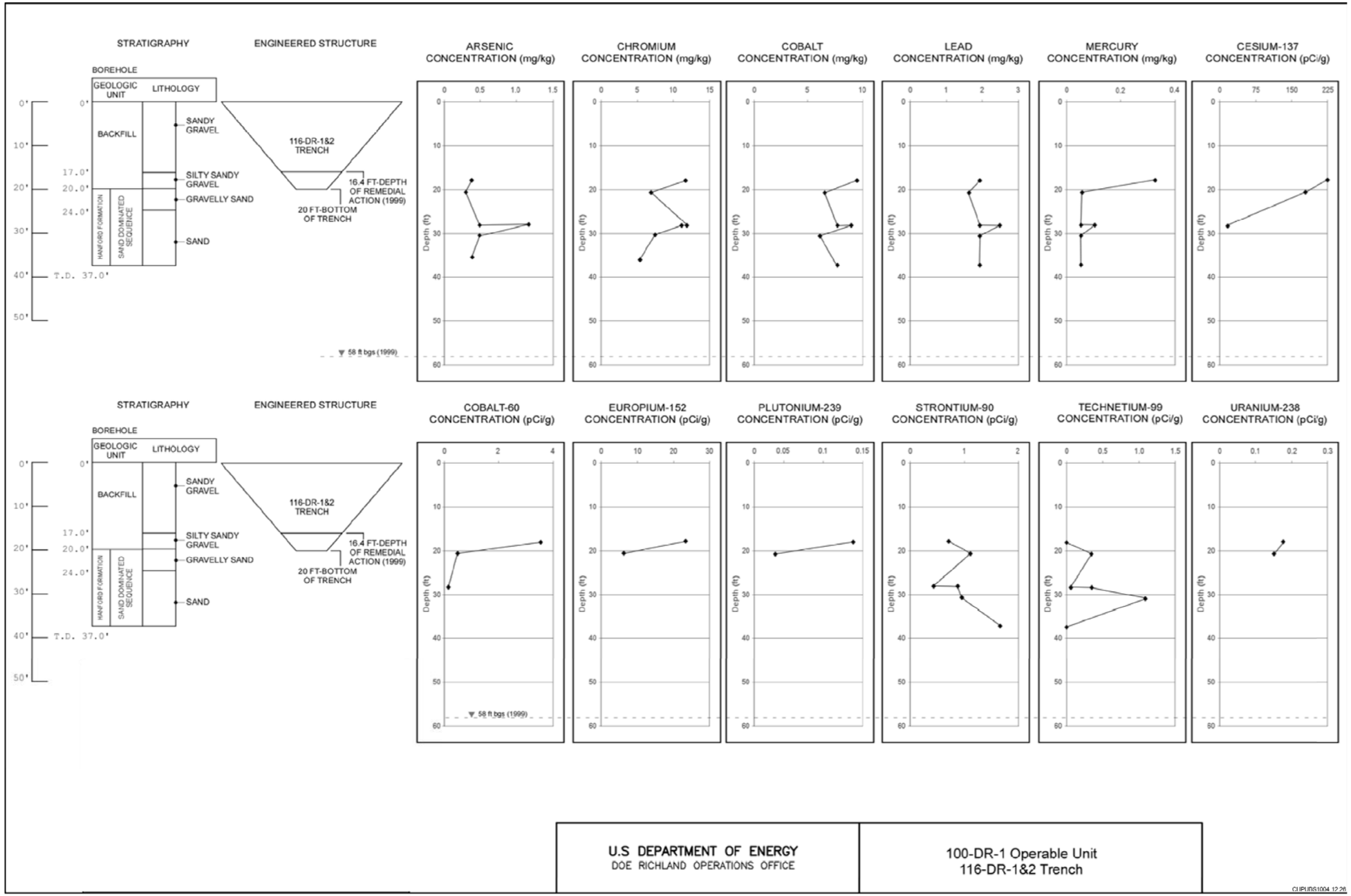

Figure 2-30. Limited Field Investigation Vertical Profile of 116-DR-1&2 Trench Contamination

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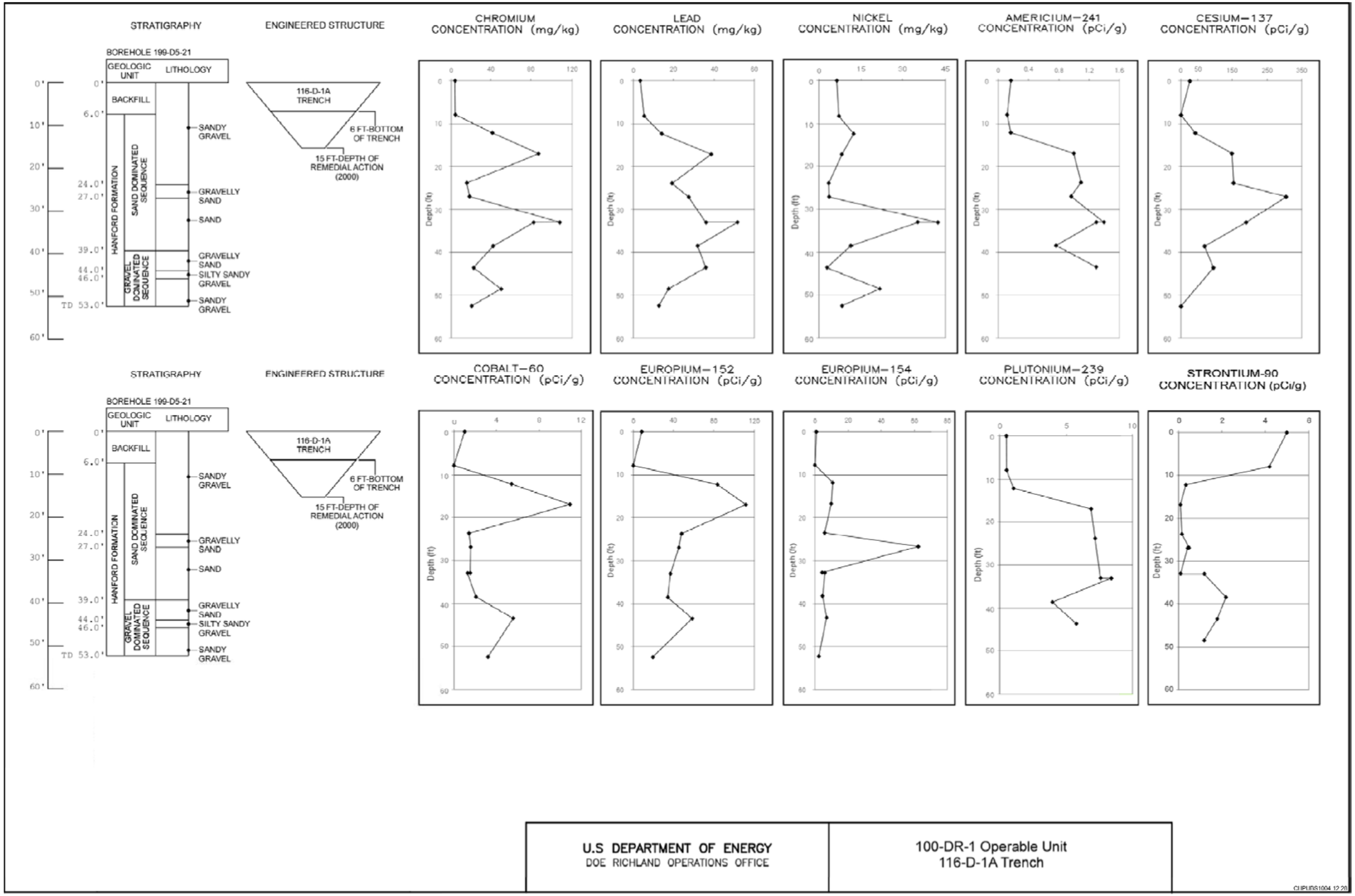

Figure 2-31. Limited Field Investigation Vertical Profile of 116-D-1A Trench Contamination

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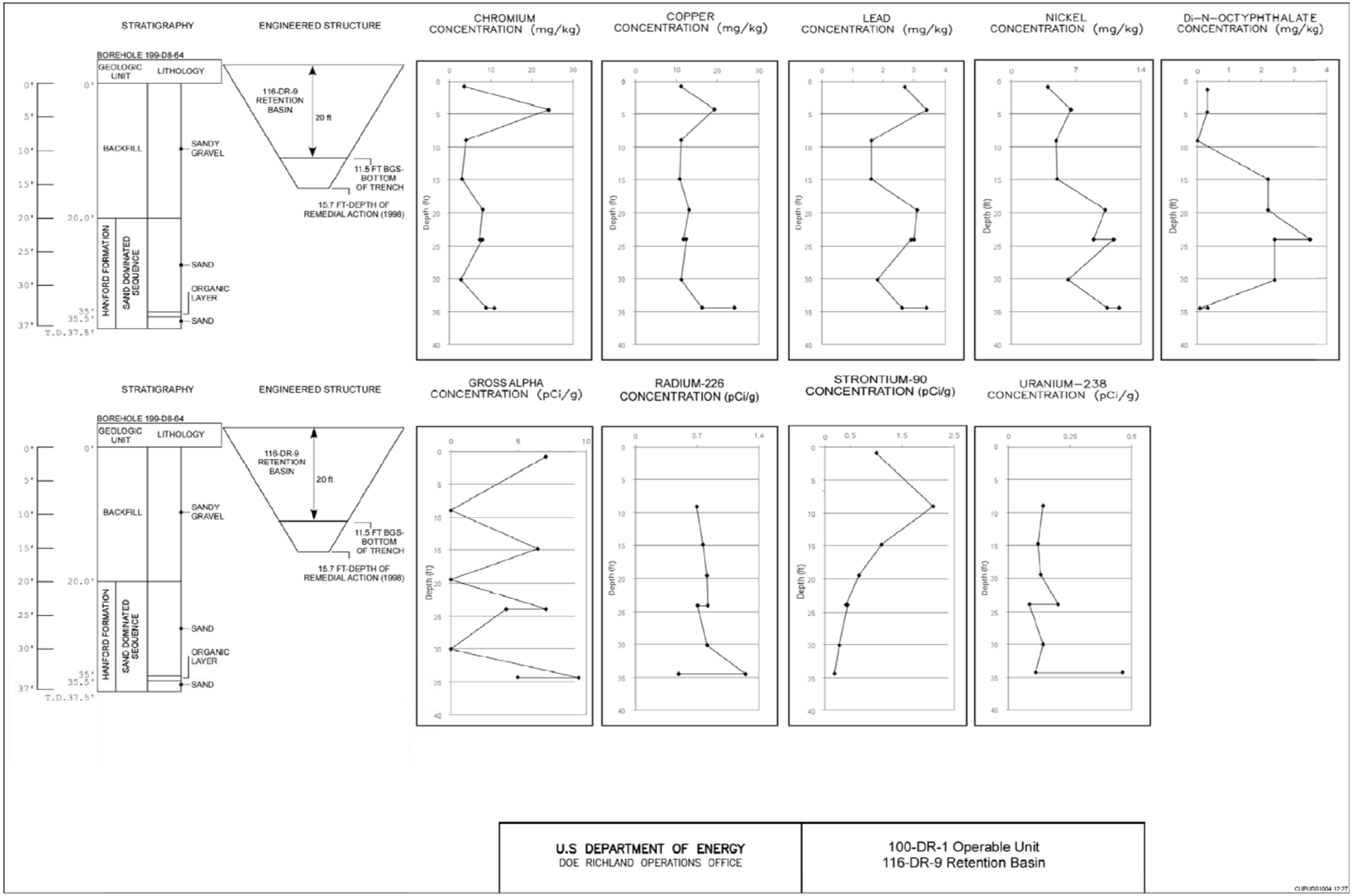

Figure 2-32. Limited Field Investigation Vertical Profile of 116-DR-9 Retention Basin Contamination

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2.4.1.3 100-H Area Limited Field Investigations

The LFIs were also performed in the 100-HR-1 and 100-HR-2 OUs in the early 1990s. Although boreholes did not typically extend beyond 6 and 7.6 m (20 and 25 ft), the results (documented in DOE/RL-93-51 and DOE/RL-94-53, *Limited Field Investigation Report for the 100-HR-2 OU*) indicate the majority of radionuclide contamination is found between 2.5 and 5.4 m (8.2 and 18 ft) and there are elevated levels of metals at the 116-H-1 Trench and the 116-H-7 Retention Basin.

Sampling and analysis of soil was performed at seven waste sites and of liquid and sludge at one waste site to characterize the nature and extent of contamination in 100-H. Data from boreholes, a test pit, and surface sampling were collected to assess surface and subsurface conditions. In addition, a radiological survey was conducted over the entire surface of the 100-HR-1 OU to assess gross gamma radiation levels of the surface soil (Figure 2-33). Planning for all the sampling activities is described in WHC-SD-EN-AP-066, *Description of Work for the 100-HR-1 Source OU*.

Little intrusive investigation was performed in the 100-HR-2 OU LFI. Investigations in the 100-HR-2 OU consisted mainly of a review of analogous site information, an evaluation of historical data, and surveys of soil gas and various surface geophysical properties. Data from 100-BC and 100-D source OUs were applied to the 100-HR-2 OU LFI evaluation using the analogous approach because the 100 Area Reactor and support facilities are similar in use and construction. Therefore, it was expected that some waste sites, across reactor area boundaries, would have similar process histories, waste streams, and expected suites of contaminants.

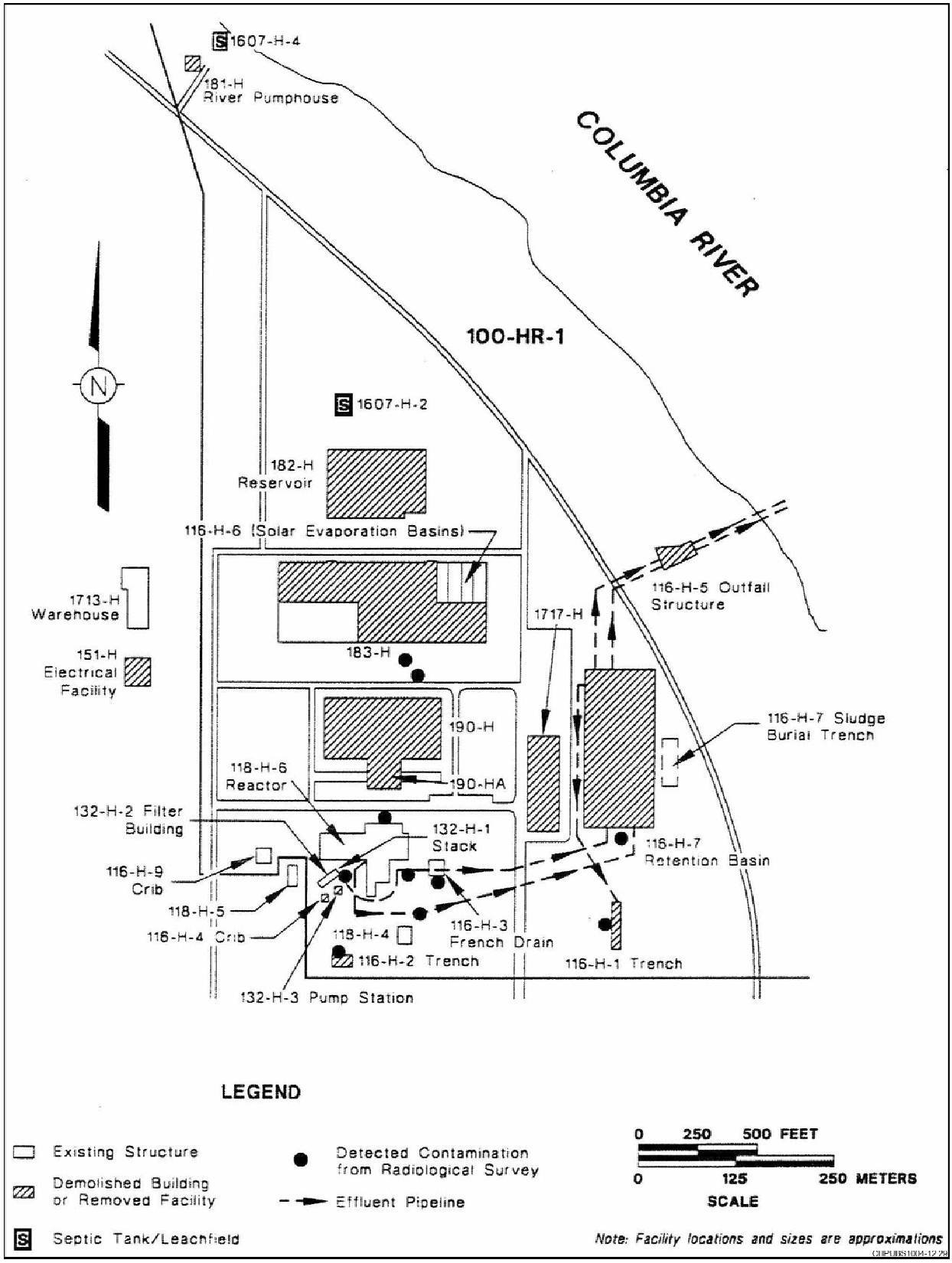

Figure 2-33. 100-HR-1 Surface Radiological Survey Contamination Points

The 100-BC, 100-D, and 100-H area analogous sites are identified in the LFI reports. The LFI reports include an evaluation of whether the sites were found to be analogous based on the borehole data collected. In addition, field screening was performed on a discolored soil site near the 1607-H-1 Septic System, and a surface radiation survey covering the 100-HR-2 OU was performed. Summary information describing the investigation is presented in Table 2-10.

Table 2-10. Summary of Limited Field Investigation

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation [m (ft)]	Maximum Extent of Contamination m (ft)	Maximum Extent of Remediation m (ft)	Analyte List
100-HR-1 OU						
116-H-1 Trench	1	Soil	7.83 (25.7)	6.3 (20.8)	4.6 (15.0)	ICP/AA metals Mercury Cyanide VOA Semi-VOA PCBs Pesticides Gross alpha Gross beta Gamma spectroscopy Sr-90 Tc-99 C-14 Alpha spectroscopy U-235 U-238
116-H-2 Trench	1	Soil	5.55 (18.2)	NAB	2.6 (8.5)	
116-H-3 French Drain	1	Soil	6.61 (21.7)	6.6 (21.7)	4.6 (15.0)	
116-H-7 Retention Basin	1	Soil	6.34 (20.8)	5.0 (16.4)	4.8 (15.7)	
116-H-9 Crib	1	Soil	7.38 (24.2)	6.1 (20.1)	N/A Accepted Waste Site	
116-H-5 Outfall Structure	Data used from analogous sites					
Process Effluent Pipelines	Nonintrusive data[b]					
116-H-5 Trench[a]	Nonintrusive data[b]					
132-H-3 Pumping Station	Data used from analogous sites					
132-H-2 Exhaust Air Filter Building	Nonintrusive data[b]					
132-H-1 Exhaust Stack	Nonintrusive data[b]					
116-H-4 Pluto Crib	Nonintrusive data[b]					
116-H-6 Retention Basin (183-H Solar Evaporation Basins)[c]	Not addressed in limited field investigation					
1607-H-2 Septic Tank	Liquid and sludge samples	Water and sludge	Surface	N/A	5.6 (18.4)	Pu-238 Pu-239
1607-H-4 Septic Tank	1 test pit	Soil	Subsurface	N/A	3.6 (11.8)	
151-H Electrical Facilities[d]	Surface sampling	Soil	Surface	N/A	N/A	

Table 2-10. Summary of Limited Field Investigation

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation [m (ft)]	Maximum Extent of Contamination m (ft)	Maximum Extent of Remediation m (ft)	Analyte List
100-HR-2 OU						
1607-H-1 Septic System	Field screening					Not applicable
118-H-1 Burial Ground	Nonintrusive data[b] and data from analogous sites					
118-H-2 Burial Ground	Nonintrusive data[b]					
118-H-3 Burial Ground	Nonintrusive data[b]					
118-H-4 Burial Ground	Nonintrusive data[b]					
118-H-5 Burial Ground	Nonintrusive data[b] and data from analogous sites					
105-H Rod Cave	Nonintrusive data[b]					
Burial Thimble	Nonintrusive data[b]					
128-H-1	Nonintrusive data[b]					
151-H Electric Facilities	Nonintrusive data[b]					

Notes:

a. This site previously was known as the 116-H-7 Trench (e.g., identified as such in DOE/RL-93-51).

b. Nonintrusive investigations relied on data compiled from a number of different sources, including historical data such as past sampling and analysis (UNI-946) and process knowledge.

c. The 116-H-6 Retention Basin (183-H Solar Evaporation Basins) is in post-closure status under the *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: http://www.epa.gov/lawsregs/laws/rcra.html.

d. This site is in the 100-HR-2 OU. However, samples were collected during the 100-HR-1 OU limited field investigation.

AA = atomic absorption
C-14 = carbon-14
ICP = inductively coupled plasma
N/A = not applicable
NAB = not above background
PCB = polychlorinated biphenyl
Pu-238 = plutonium-238
Pu-239 = plutonium-239
Sr-90 = strontium-90
Tc-99 = technetium-99
U-235 = uranium-235
U-238 = uranium-238
VOA = volatile organic analyte

According to the LFI, radiological contamination was the primary concern in 100-H in soil and was assumed the main contributor to overall risk. Although the borehole extended only from 3.3 to 7.3 m (10 to ~24 ft), the highest activities of radionuclide contamination found at the 116-H-1 Trench generally were found in samples taken from between 3.0 and 5.4 m (10 and 17.8 ft) bgs. Contaminants detected include Co-60, Sr-90, Tc-99, Cs-137, Eu-152, Eu-154, Pu-239, U-233/234, and U-238. Elevated levels of metals also were detected at the 116-H-1 Trench and the 116-H-7 Retention Basin. The maximum concentrations of metals in the 116-H-1 Trench samples were arsenic (37.9 mg/kg), total chromium (29.6 mg/kg), and lead (187 mg/kg).

Radionuclides detected at the 116-H-7 Retention Basin include Co-60, Sr-90, Cs-137, Eu-152, Eu-154, Ra-226, Th-228, Th-232, uranium (U-235), U-238, Pu-239/240, and Am-241. Although the borehole extended from only ~0.6 to 6.1 m (~2 to 20 ft), most of these radionuclides were detected within the 2.4 and 5.0 m (8.0-and 16.4-ft) interval. The maximum concentrations of metals in the 116-H-7 Retention Basin samples were arsenic (47 mg/kg) and lead (540 mg/kg). Metals also were detected in the 1607-H2 and 1607-H4 Septic Tanks. The contamination detected above background in 1607-H4 included several heavy metals (Ba, Cu, Pb, and Zn).metals detected at concentrations above background in the 1607-H2 waste site included Ag, Ba, Cd, Cr, Cu, Hg, Ni, Pb, and Zn.

The vertical distribution of contamination beneath the 116-H-1 Trench and 116-H-7 Retention Basin is shown in Figure 2-28 and Figure 2-31, respectively. The depth of remedial action is inserted into the profile as an indicator of soil removed during remedial actions conducted approximately 8-years after completion of the LFI. The profiles show the contaminant concentrations for most constituents generally decrease with depth where sampled below the depth of remedial action, with the exception of U-233/234, U-238 and mercury, (which is below background) at the 116-H-1 Trench.

Higher contaminant concentrations, with few exceptions, are generally present at these sites within 1.5 m (5 ft) of the bottom of the engineered structure. Uranium-233/234 and U-238 concentrations at 116-H-1 generally increase with depth, but were below the Hanford site background 1.1 pCi/g. Only Tc-99 (max 0.67 pCi/g) exceeds WAC 173-340-740(3) (2007 *Model Toxics Control Act*) cleanup levels (0.46 pCi/g) at 116-H-1. At waste site 116-H-7, no constituents exceeded the Method B cleanup levels.

2.4.1.4 Interim Remedial Actions and Existing Waste Site Contamination

Remediation and characterization of the waste sites in 100-D and 100-H began in 1996 under the authority provided by the interim action RODs and RCRA closure and monitoring plans, and continues to the present. Remediation consists mainly of removal, segregation, storage, transportation, and disposal of soil, debris, and waste material and then backfilling remediated waste sites. Remediation follows the observational approach including use of radiological field screening data, in process samples, and direct visual observation. Characterization of waste sites consists mainly of sample collection (i.e., confirmation and verification sampling) and analysis for purposes of assessing the nature and extent of contamination and verifying achievement of RAOs. Achievement of RAOs is based on attaining site remedial action goals (WAC 173-340) for direct exposure, protection of groundwater, and protection of surface waters. Interim RAOs and goals, as described in the Work Plan, were achieved at all interim closed and no action waste sites Cr(VI) (EPA/AMD/R10-00/122, *Amended Record of Decision for the U.S. Department of Energy Hanford 100-HR-3*).

After the implementation of remedial actions, contaminant inventories and impact to the environment are significantly reduced. This mitigation occurs because contaminants encountered to the depth of remedial action are effectively removed from the waste site; only residual contamination remains. Therefore, information from previous investigations presented in UNI-946 and the LFI reports for the OUs reflect contaminant concentrations measured in waste material that has since been removed during interim ROD

remedial action. For example, in Figures 2-28, 2-29, 2-30, 2-31, 2-32, 2-34, and 2-35, correlation is shown between the stratigraphy, the engineered structure, the depth of remedial action, and contamination at waste sites. The figures show that all material to the depth of remedial action has been removed. Thus, contaminant distribution in the remediated areas has been significantly modified and impact to the environment is reduced because of the remedial actions performed under interim action RODs.

Verification sampling typically consists of sample collection from residual soil from the exposed surface at the bottom and sidewalls of the excavation. Prior to 2005, soil was typically composited for verification samples as required by SAPs. Remediation footprints may be divided into shallow zone (0 to 4.6 m [15 ft] bgs) and deep zone (greater than 4.5 m [15 ft] bgs) based on direct exposure RAOs and the conditions encountered at a given waste site. Sample designs, which are approved by DOE-RL and the lead regulatory agency, may include focused and/or statistical elements based on site-specific conditions. The resulting data are compared to RAGs in interim waste site closure and documented in cleanup verification packages (CVPs) and summarized in Appendix C. These data also describe measured contamination levels at the extent of removed materials at interim closed waste sites. However, contaminants may exist in the vadose zone of liquid effluent disposal units beyond the extent of removed materials. The primary statistical calculation to evaluate compliance with cleanup standards is the 95 percent upper confidence limit (UCL) on the arithmetic mean of the data. The data in Appendix C generally include the maximum concentrations and/or concentrations representing the 95 percent UCL of waste site COCs for both the shallow and deep zones (0 to 4.5 m [15 ft] and greater than 4.5 m [15 ft] bgs, respectively). The close-out verification data and background information on the waste sites also will be used in this addendum to support selection of waste sites for additional characterization based on residual concentrations remaining at the site. Characterization efforts planned in this addendum will be used to verify the distribution of remaining contamination, provide information to support modeling input, and provide information to close data gaps to support final remediation decisions.

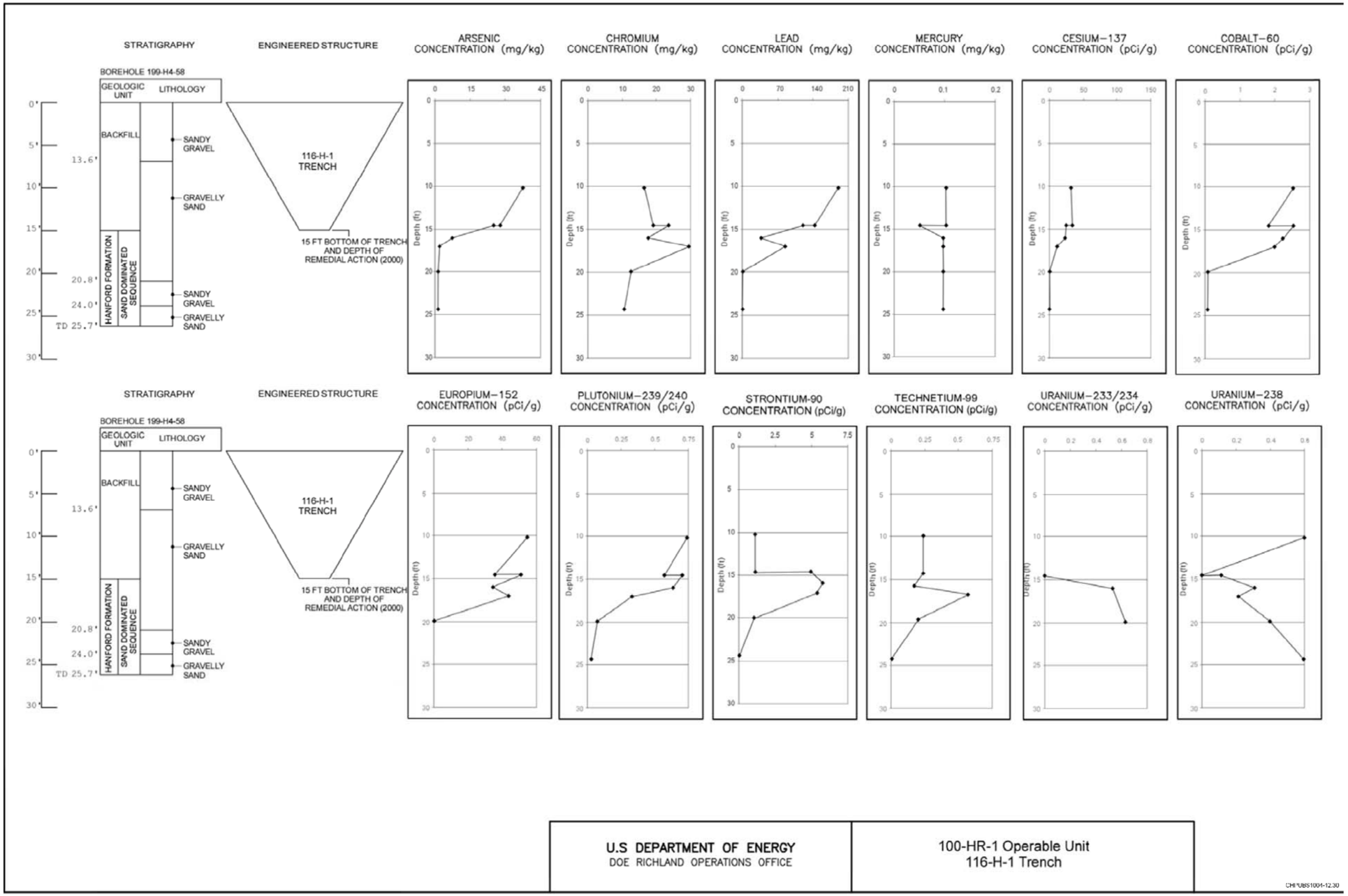

Figure 2-34. Limited Field Investigation Vertical Profile of 116-H-1 Trench Contamination

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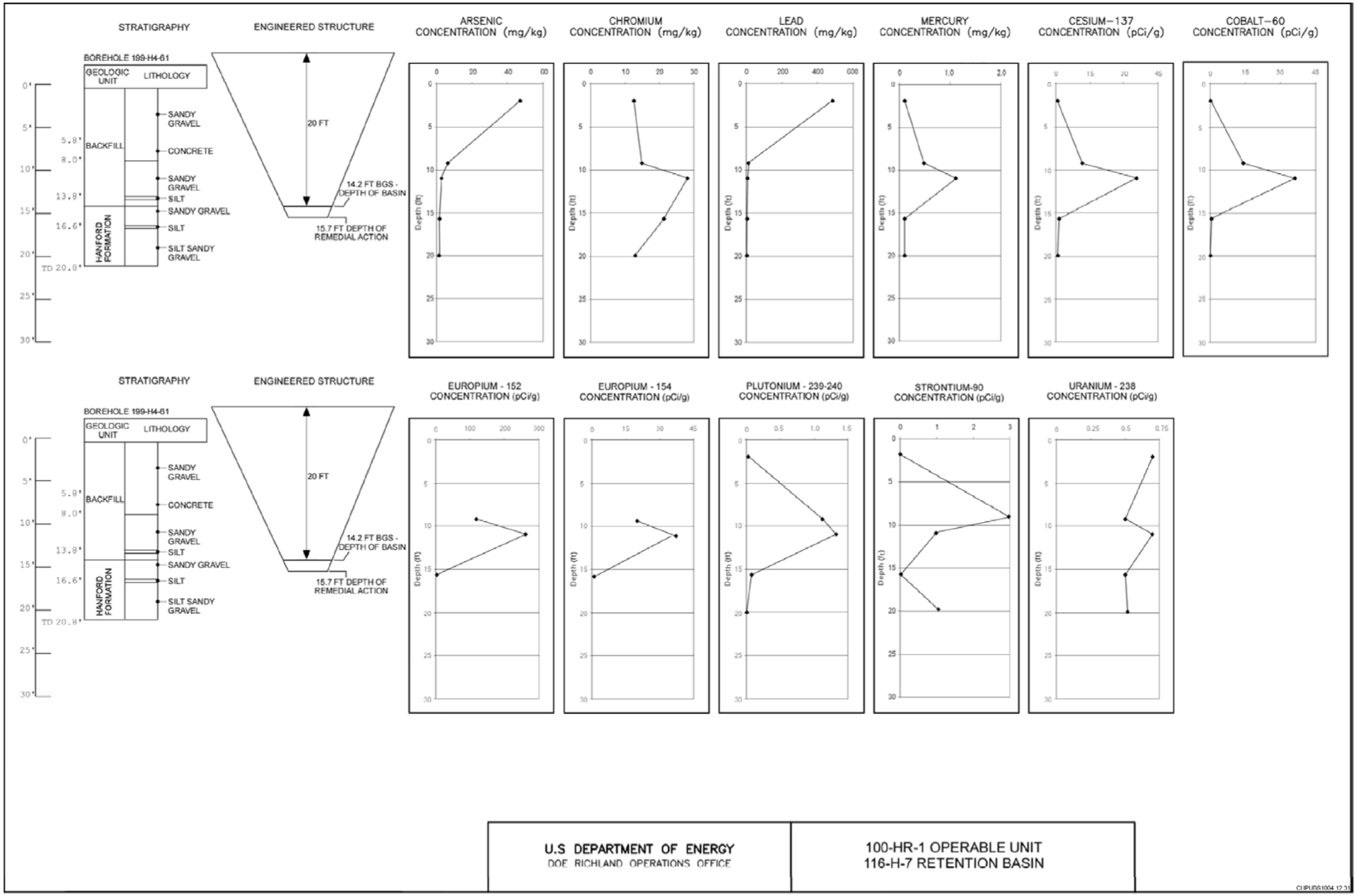

Figure 2-35. Limited Field Investigation Vertical Profile of 116-H-7 Retention Basin Contamination

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2.4.1.5 100-D/H Hexavalent Chromium Leach Test Studies

A series of leachability tests was conducted to assess the leaching potential of Cr(VI) in various contaminated soil at 100-D and 100-H. Shallow soil with relatively elevated levels of Cr(VI) were collected from the 116-H-7 and 116-D-7 Retention Basins and from various contaminated sites in reactor operations areas. The results of these studies are presented in CVP-99-00007, *Cleanup Verification Package for the 116-D-7 Retention Basin*, *Appendix D* and CVP-2000-00027, *Cleanup Verification Package for the 116-H-7 Retention Basin*, *Appendix D* showed that Cr(VI) remaining in the soil column was not readily mobilized. In one experiment, approximately 12 pore volumes of groundwater (shown to have a similar composition to vadose zone pore water) were forced through the column packed with 116-D-7 Retention Basin contaminated soil and the Cr(VI) concentrations in the effluent were measured periodically.

After the test was completed, less than 1 percent of the Cr(VI) present in the sediments was removed. The volume of water that was percolated through the sediment represented the total amount of water that would flush through the vadose zone in one year for a scenario that allowed 91 cm (36 in.) of water from rainfall (15 cm [6 in.]) and irrigation (76 cm [30 in.]). Separate leach tests were then performed with separate aliquots of these sediments using distilled water as the leachate (distilled water was used to minimize variables in this testing). Again, less than 1 percent of the Cr(VI) was leached from the soil. However, the authors observed that the chromium in this sediment may not be Cr(VI) and suggested one possibility that the methodology used may have converted CrIII to Cr(VI). Single and sequential leaching experiments with contaminated 116-H-7 soil using water with the same chemical composition as groundwater also showed little leaching of Cr(VI) (less than 2 percent). Generally, Cr(VI) concentrations in the leachate were less than detection (20 µg/L).

Additional chromium leachability experiments were conducted as part of the testing performed at 100-D and 100-BC (PNNL-17674). Contaminated soil were selected from various shallow (less than 3.0 m [less than 10 ft bgs]), yellow stained soil near sodium dichromate storage tanks and railroad tracks in the 100-B/C Reactor. Sediment samples were also collected for analysis from 100-D. Two column leach tests using synthetic groundwater were performed to evaluate the desorption of Cr(VI) in one soil contaminated recently and in another soil contaminated during reactor operations. Measurement of Cr(VI) concentrations from sequential effluent volumes in two column experiments showed essentially two types of behavior. First, large fractions of the Cr(VI) in the contaminated soil were eluted in the first pore volume (about 95 percent) and about 4 percent of the initial mass was released in the next five pore volumes. The remaining Cr(VI) leached much more slowly and at the end of the experiment after exposure to 25 pore volumes, 10 and 30 percent, respectively, of the Cr(VI) remained in the contaminated soil. The old spill soil retained the higher fraction of Cr(VI). Additional longer column tests with contaminated soil showed similar Cr(VI) leaching behavior.

Microscale characterization of the sediments suggests that leach resistant Cr(VI) may be precipitated in a barium chromate phase and/or incorporated in alumino-silicates and/or iron-rich alumino-silicates. Association of chromium with iron bearing minerals also suggests localized reduction of chromium (VI) to chromium (III) by iron (II).

Considered collectively, these experimental results suggest that after Cr(VI) is discharged to the soil column, two primary chemical stages of chromium reactivity occur, which influence its transport characteristics. First, the majority of Cr(VI) remains mobile, transports readily, and contributes groundwater concentrations commensurate with source term strength. Second, the remaining Cr(VI) is sequestered by a variety of mechanisms that retard further migration rates and reduce groundwater concentrations. The effectiveness of these sequestration processes increases over time. In the retention basin soil, it appears that

the initial highly mobile component of discharged Cr(VI) has already been flushed from the sampled soil. This is expected, given the high leakage volume from the retention basins during operations. Conversely, the reactor area soil have been contacted by much smaller volumes of water since the contaminating event. Therefore, extensive flushing of the soil has not been completed in the natural setting.

Thus, peak concentrations of Cr(VI) were observed in the first pore volume of leachate within the test. In contrast, the number of pore volumes of groundwater passed through contaminated soil in the 100 Area vadose zone is not well understood. Additionally, the experimental column soil conditions present a highly idealized environment for groundwater contact and transport with regard to the irregular subsurface features found in the local 100 Area geology. These features could harbor concentrated dichromate solutions or limit contact with groundwater and introduce more complex release mechanisms than those observed in the column tests. Therefore, studies and data collection focused on understanding the long-term hydrology, geological influences, and spatial distribution of Cr(VI) at work in various locations may be needed. Chapter 4 describes Cr(VI) CSM interpretations.

2.4.1.6 183-H Solar Evaporation Basin Site – Investigation

The 183-H Filter Plant was constructed in 1949 and used for 100-H water treatment until mid-1960. This facility included 16 concrete basins that were used in treating Columbia River water for subsequent use as reactor coolant. Subsequent to their use for water treatment, four of the 183-H facility basins (116-H-6 waste site) were converted for use for the evaporation of waste primarily from the 300 Area. Approximately 1.6 million kg (3.6 million lb) of waste per year were treated by solar evaporation. The facility received both routine and non-routine wastes. The routine wastes consisted of spent acid etch solutions (primarily nitric, sulfuric, hydrofluoric, and chromic acids) generated by the Nuclear Fuel Fabrication process. These acidic solutions were reacted with excess sodium hydroxide before being transported to the 183-H Basins. Metal constituents included copper, silicon, zirconium, nickel, aluminum, chromium, manganese, and uranium, which were in the form of precipitates. Non-routine wastes consisted of unused chemicals and spent solutions from miscellaneous processes. The waste had been designated an Extremely Hazardous Waste (EHW) because of toxicity.

In addition to the EHW stream, the following waste streams were permitted to be treated at the RCRA waste site: chromium, discarded chemical product formic acid, discarded chemical product containing cyanides, discarded chemical product containing vanadium pentoxide, discarded chemical product containing copper cyanide, discarded chemical product containing sodium cyanide, and discarded chemical product containing potassium cyanide.

Most of the water treatment structures, including the 12 additional adjoining basins, were demolished in 1974. The four remaining basins were inactive until July 1973 when radioactive and dangerous (mixed) waste from the 300 Area fuel fabrication facilities was shipped to the basins for storage and treatment. The last shipment of waste to the basins took place on November 8, 1985. By 1990, all the remaining sludge materials and liquid waste had been removed from each basin. Sampling of the concrete floors and soil underlying each basin was performed in 1989 and 1991 by completion of eight boreholes (BH-1 through BH-8). Four boreholes were drilled inside the basin and four boreholes were drilled adjacent to the basin. With the exception of BH-5 (located north of Basin 1, the eastern-most basin), the boreholes stopped 3 m (10 ft) above the water table; only BH-5 was drilled to the water table. Results supported redesignation of decontaminated structural concrete as nondangerous waste (DOE/RL-97-48) and showed contamination above background levels in the soil immediately beneath all four basins.

Demolition of the basins began in September 1995, and by the fall of 1996, the basins had been completely demolished and demolition wastes disposed in the adjacent 183-H Clearwells (126-H-2 waste site) and at the Environmental Restoration Disposal Facility (ERDF). After demolition of the basins, soil

removal and contaminant characterization began in February 1996 (described in BHI 1996, *1996 Phase II Soil Sampling at the 183-H Solar Evaporation Basin Site,* and DOE/RL-97-48). The results of the initial characterization effort indicated that arsenic and mobile constituents (Cr(VI), nitrate, and fluoride) remained at the depth of initial soil removal (i.e., 0.6 m [2 ft] beneath removed concrete base) beneath the eastern-most basin (Basin 1).

Additional characterization and soil removal to 4.6 m (15 ft) beneath Basin 1 were performed. A test pit to 7.6 m (25 ft) below the engineered structure was dug under Basin 1 to investigate contamination at depth because nitrate and fluoride contamination were found much deeper than earlier characterization information indicated. The site was backfilled and revegetated in the spring of 1997.

Waste site 116-H-6 is currently modified closed under RCRA as documented by *Tri-Party Agreement Handbook Management Procedures* (TPA-MP-14). The site was not clean closed under RCRA because fluoride and nitrate concentrations below 4.6 m (15 ft) are above the Method B cleanup levels of the *Model Toxics Control Act* (WAC 173-340). Therefore, the unit was modified closed under the closure provisions of the RCRA Hanford permit with postclosure care. The modified closure certification was accepted by the State of Washington Department of Ecology on May 13, 1997 (DOE/RL-97-48). Because clean closure was not achieved, dangerous waste constituents remain in the vadose zone beneath the waste site. In addition, the RCRA closure did not address the cleanup of radiological contamination. As such, accepted WIDS site 100-H-33 was created to address the radiological contamination that is within the same footprint as waste site 116-H-6. Thus, the radiological contamination will be addressed according to data gap No. 1 in Chapter 4. Data gap No. 1 addresses how the vadose zone beneath unremediated waste sites will be characterized and cleaned up according to the interim action ROD. In addition, the dangerous waste contamination will be addressed according to data gap No. 2 in Chapter 4. Data gap No. 2 addresses how the contaminated vadose zone beneath remediated waste sites will be characterized.

Historical groundwater monitoring results (PNNL-11470, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*) for the 183-H solar evaporation basins under an interim status system have indicated that dangerous waste constituents chromium and nitrate have been above groundwater protection standards for many years, as well as non-dangerous waste constituents uranium and Tc-99. Since removal of the source of contamination (the basin liquids) in the late 1980s, contaminant concentrations in the groundwater have generally declined. However, fluoride, nitrate, Cr(VI), Tc-99, and uranium, which remain constituents of interest, have been monitored under the revised plan for corrective action groundwater monitoring (PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*). Concurrent fluctuations in monitored groundwater concentrations of uranium, Tc-99, nitrate, and chromium (DOE/RL-2008-01) suggest contamination is being mobilized into groundwater beneath the 183-H Unit.

2.4.2 Nature and Extent of Contamination in the Groundwater

This section describes the nature and extent of groundwater contamination within 100-D/H as currently understood from soil sample analysis and groundwater monitoring. The groundwater OU, 100-HR-3, is contained within 100-D/H boundaries. More detailed information on the groundwater within 100-D/H can be found in DOE/RL-2008-01 (Sections 2.5 and 2.6), DOE/RL-2008-05, DOE/RL-2008-66 (Sections 2.5 and 2.6), and DOE/RL-2009-15. Locations of 100-D/H groundwater monitoring wells are shown in Figure 2-36. Groundwater and aquifer tube data are located in Appendix E. Maximum concentrations for contaminants and co-contaminants in Calendar Year (CY) 2007 and CY 2008 are shown in Tables 2-11 and 2-12 (reference DOE/RL-2009-15). These tables include the well names where each groundwater sample was collected. Figure 2-36 depicts monitoring well locations.

Table 2-11. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in 100-D Groundwater

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/Comment
			2008		
Hexavalent Chromium	39,900 (D)	UF	3/26/08	199-D5-99	Adjacent to former sodium dichromate transfer station
Chromium	1,870	UF	11/20/08	199-D5-39	Downgradient of former sodium dichromate transfer station
Chromium	1,880	F	11/20/08	199-D5-39	Downgradient of former sodium dichromate transfer station
Nitrate (as N)	116,000	UF	8/15/08	199-D2-6	Adjacent to solid waste burial ground
Strontium-90	59	UF	11/24/08	199-D8-68	100-HR-3 (D) extraction well
Tritium	25,000	UF	11/24/08	199-D4-78	Within ISRM treatment zone
Technetium-99	87	UF	2/6/08	199-D8-72	100-HR-3 (D) extraction well
Sulfate	549,000 (D)	UF	8/24/08	199-D4-84	Downgradient of ISRM treatment zone
Uranium	3.4	UF	11/19/08	199-D4-22	Upgradient of ISRM treatment zone
Gross beta	130	UF	11/14/08	199-D4-19	Within ISRM treatment zone
Gross alpha	2.83	UF	11/19/08	199-D4-22	Upgradient of ISRM treatment zone
			2007		
Hexavalent Chromium	12,560	UF	3/19/07	199-D5-99	Adjacent to former sodium dichromate transfer station
Chromium	9,970	UF	11/29/07	199-D5-104	Adjacent to former sodium dichromate transfer station
Chromium	10,500	F	11/29/07	199-D5-104	Adjacent to former sodium dichromate transfer station
Nitrate (as N)	85,900 (D)	UF	10/31/07	199-D2-6	Adjacent to solid waste burial ground
Nitrate (as N)	85,900 (D)	UF	12/6/07	199-D8-4	North of former D pond
Strontium-90	7.7	UF	11/27/07	199-D8-68	100-HR-3 (D) extraction well
Tritium	27,000	UF	11/7/07	199-D4-78	Within ISRM treatment zone
Technetium-99	2.2 (U)	UF	11/27/07	199-D8-53	100-HR-3 (D) extraction well
Sulfate	558,000 (D)	UF	11/7/07	199-D4-78	Within ISRM treatment zone

Table 2-11. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in 100-D Groundwater

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/Comment
Uranium	3.89	UF	10/30/07	199-D4-22	Upgradient of ISRM treatment zone
Gross beta	152	UF	10/30/07	199-D4-19	Within ISRM treatment zone
Gross alpha	6	UF	2/26/07	199-D5-16	East of former D Reactor

Notes:

Laboratory qualifiers: U = undetected; D = sample diluted

ISRM = In Situ Redox Manipulation

Table 2-12. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in 100-H Groundwater

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/Comment
			2008		
Hexavalent Chromium	157	UF	1/3/08	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM
Chromium	92.8	UF	1/3/08	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM
Chromium	100	F	1/3/08	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM
Nitrate (as N)	39,800 (D)	UF	11/10/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Total beta radio strontium	24	UF	2/6/08	199-H4-63	Currently used as extraction well; downgradient of former 107-H retention basin
Tritium	3,200	UF	2/6/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Technetium-99	45	UF	11/10/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Sulfate	72,300 (D)	UF	11/21/08	199-H4-46	Southeast and downgradient of former H Reactor
Uranium	7.98	UF	2/6/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Gross beta	74	UF	11/21/08	199-H4-13	East and downgradient of former 107-H retention basin
Gross alpha	3.7	UF	11/21/08	199-H4-46	Southeast and downgradient of former H Reactor
			2007		
Hexavalent Chromium	102	F	6/14/07	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM
Hexavalent Chromium	84.9	UF	11/30/07	199-H4-12C	Adjacent to extraction well H4-12A; well screened in upper RUM
Chromium	90.3	UF	11/30/07	199-H4-12C	Adjacent to extraction well H4-12A; well screened in upper RUM

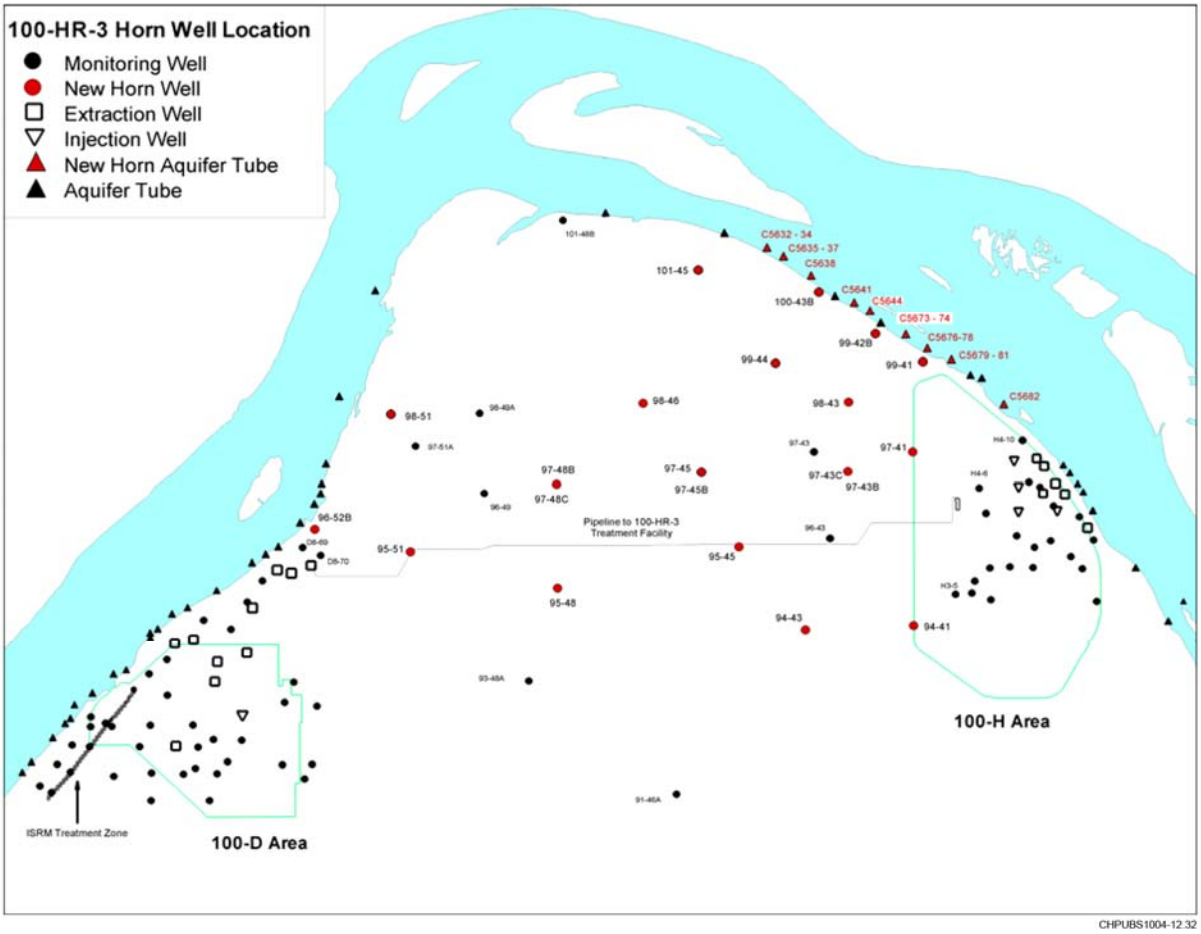
Table 2-12. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in 100-H Groundwater

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/Comment
Chromium	84.6	F	11/30/07	199-H4-12C	Adjacent to extraction well H4-12A; well screened in upper RUM
Nitrate (as N)	602,000 (D)	UF	2/6/07	AT-H-1-S	Aquifer tube downgradient of 199-H4-12A-C wells
Nitrate (as N)	66,400 (D)	UF	5/8/07	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Strontium-90	24.8	UF	11/30/07	199-H4-63	Currently used as extraction well; downgradient of former 107-H retention basin
Tritium	4,400	UF	12/27/07	199-H4-49	Southwest of former H Reactor
Technetium-99	99	UF	5/8/07	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Sulfate	80,000 (D)	UF	11/30/07	199-H4-46	Southeast and downgradient of former H Reactor
Uranium	22.1	UF	5/8/07	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins
Gross beta	57.2	UF	11/7/07	199-H4-13	East and downgradient of former 107-H retention basin
Gross alpha	4	UF	1/31/07	48-M	Aquifer tube downgradient of former 116-H-1 Trench
Gross alpha	2.72	UF	11/7/07	199-H4-13	East and downgradient of former 107-H retention basin

Notes:

DOE/RL-2009-15

RUM = Ringold Upper Mud

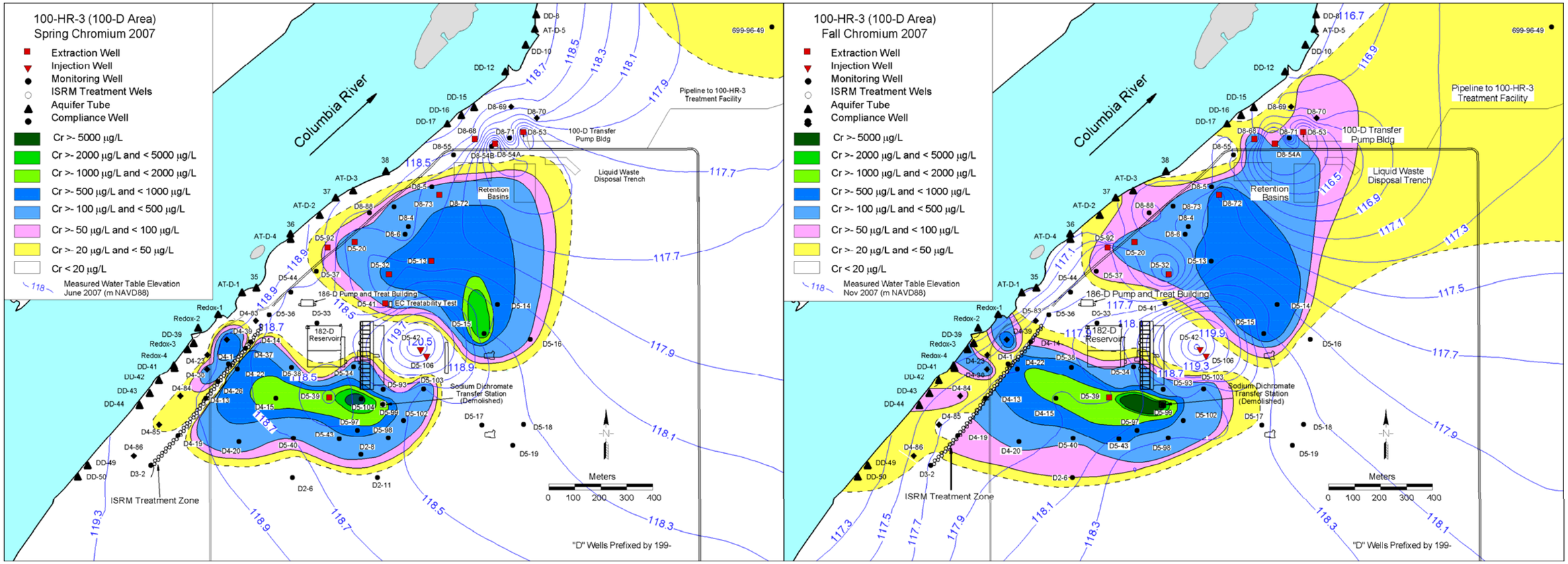


Source: Draft DOE/RL-2008-42

Figure 2-36. 100-D/H – Monitoring Well Locations

2.4.2.1 Hexavalent Chromium

Historical discharges of reactor cooling water at 100-D/H near the three former reactors created a relatively large, dispersed plume of Cr(VI) in groundwater beneath 100-D/H. Based on process knowledge of concentrations of Cr(VI) used in reactor operations, discharges of reactor process water contained Cr(VI) at approximately 2,000 µg/L. An interim action ROD completed in 1996 identified Cr(VI) as the principal threat to aquatic receptors and human health. As of 2007, Cr(VI) was detected in two areas at 100-D, commonly referred to as the north and south plumes (Figure 2-37). The south plume area is characterized by a relatively high Cr(VI) concentration (~40,000 µg/L) and small core possibly related to disposal of chromium product. The north plume is characterized by a relatively larger, lower concentration core [Cr(VI) approximately 1,000 µg/L]. Concentrations of Cr(VI) concentrations in the north and south plumes extend inland from the river approximately 1,200 m (4,000 ft) in 100-D. The extent of Cr(VI) above the aquatic cleanup standard inland from the river has not been completely defined.



Source: DOE/RL-2008-01

Figure 2-37. 100-D Average Hexavalent Chromium Concentrations, Upper Portion of the Upper Unconfined Aquifer, Spring and Fall 2007

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The point of concern for exposure or aquatic receptors is within the river substrate at depths down to 0.46 m (1.5 ft), where embryonic salmon could be present during part of the year. Because it is impractical to routinely monitor chromium concentrations at aquatic receptor exposure points, onshore groundwater monitoring near the river has been used to assess treatment effectiveness. Washington State initially established the chronic ambient water quality standard at 11 µg/L as protective of the Columbia River (WAC 173-201A-040, "Toxic Substances").

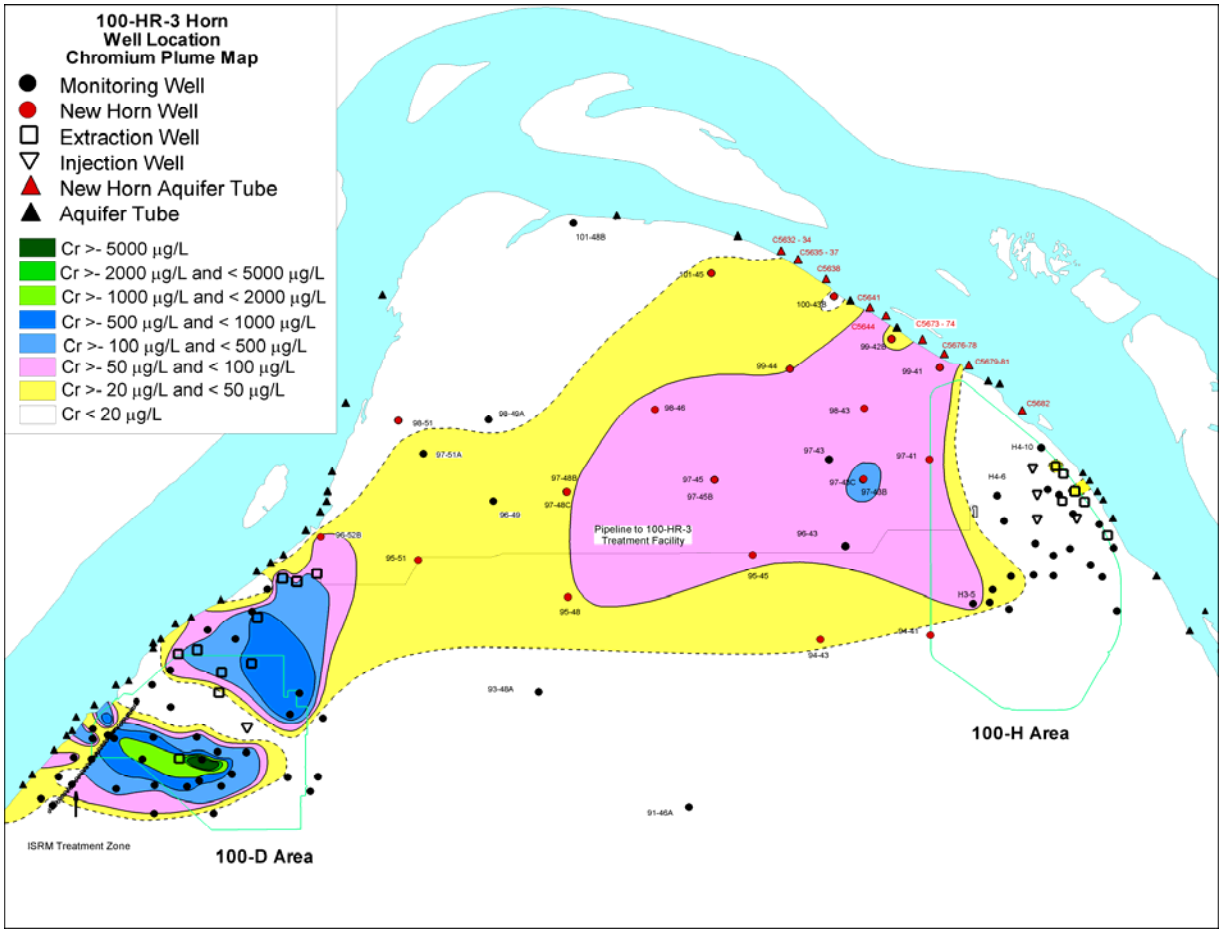
Based on a preliminary dilution factor of 1:1 between the compliance wells and the Columbia River, a remediation goal of 22 µg/L was established, as this Cr(VI) concentration in near river compliance monitoring wells is considered equivalent to 11 µg/L at the location of the aquatic receptors (EPA/AMD/R10-00/122).

In November 1997, the state lowered the chronic ambient water quality standard for Cr(VI) to 10 µg/L (EPA/AMD/R10-00/122). However, the interim action ROD (EPA/ROD/R10-96/134) for the 100-HR-3 Groundwater OU predates the state's 1997 decision. Therefore, the Cr(VI) RAO of 22 µg/L remains in effect for the 100-HR-3 Groundwater OU.

Cr(VI) from 100-D extends above the aquatic cleanup standard of 20 µg/L to the northeast across the Horn to 100-H, ultimately discharging to the Columbia River north of the H Reactor area (Figure 2-38). Cr(VI) groundwater contamination in the 100-H Reactor area in the upper aquifer is generally confined to two relatively small areas adjacent to the river, which are between 20 µg/L and 50 µg/L (Figure 2-39).

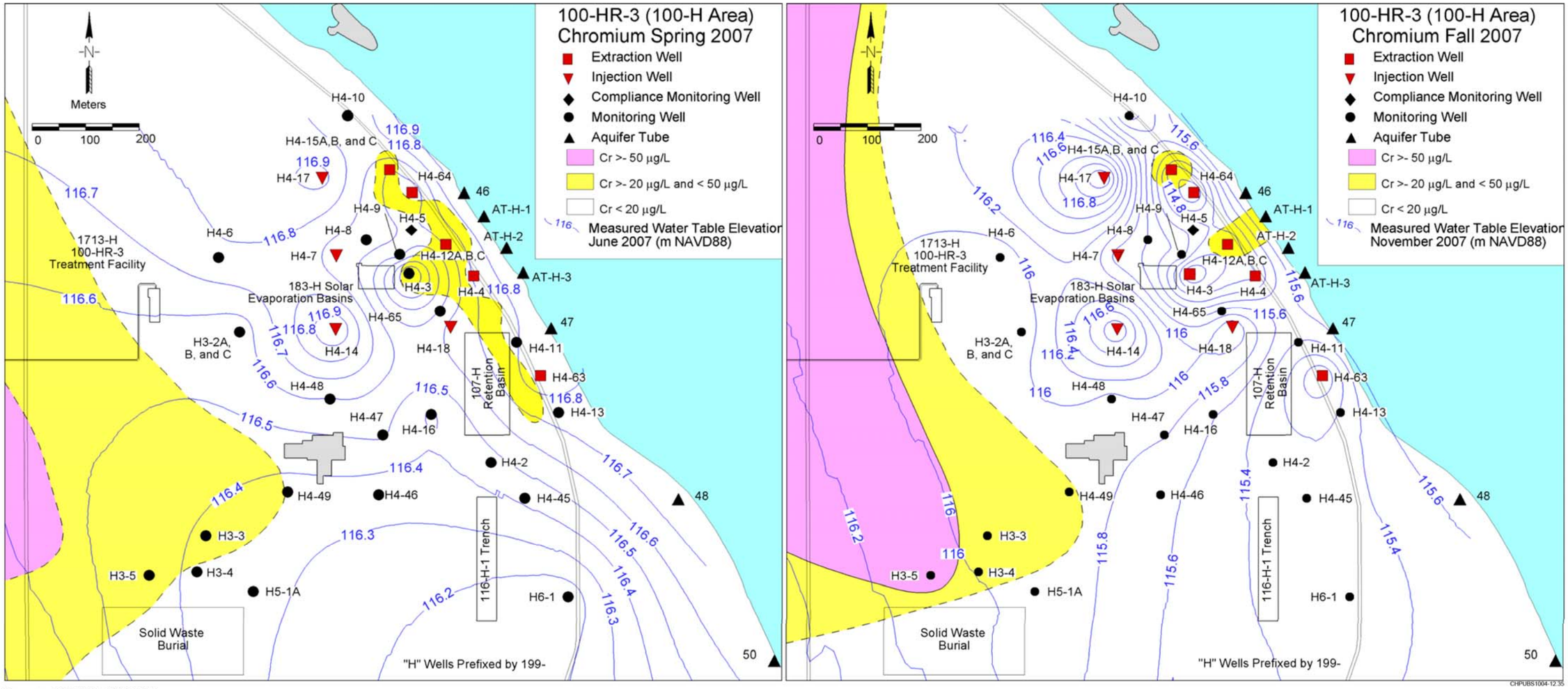
In the spring, during high river stage, concentrations of Cr(VI) above the aquatic cleanup standard are displaced inland and, based on samples collected from aquifer tubes, it is inferred that concentrations above aquatic cleanup standards are not discharging to the river. During low river stage, based on concentrations measured from aquifer tube samples, groundwater is inferred to be discharging to the river above aquatic cleanup standards. In FY 2008, chromium concentrations greater than ~100 µg/L are detected in tubes from 1 to 8 m (3 to 20 ft) bgs. The highest FY 2008 concentration was 60 µg/L in aquifer tube AT-36-M. This was a decrease from the FY 2007 concentration of more than 100 µg/L (Appendix E). Cr(VI) concentrations greater than 100 µg/L were detected in aquifer tubes from 1 to 8 m (3 to 26 ft) bgs near the shoreline. Concentrations found in the shallower aquifer tubes are generally less than concentrations found in the deeper aquifer tubes, most likely because of mixing with river water (DOE/RL-2008-66).

Cr(VI) has been detected periodically above the aquatic cleanup standard in samples collected beneath the unconfined aquifer within 100-D and 100-H, and less than the aquatic cleanup standard within the RUM in the Horn.



Source: DOE/RL-2008-42

Figure 2-38. Horn Hexavalent Chromium Plume, 2007



Source: DOE/RL-2008-05

Figure 2-39. 100-H Measured Water Table and Hexavalent Chromium Plumes, June and November 2007

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2.4.2.2 Strontium-90

The areas near the former retention basins in the north and near the 105-D Reactor in central 100-D have a history of Sr-90 detections in groundwater. Figure 2-40 shows plume based on 2008 data. Results from groundwater samples collected in FY 2007 indicated concentrations less than the 8 pCi/L drinking water standard (Tables 2-8 and 2-11, in DOE/RL-2009-15). However, the monitoring well with the highest concentrations of Sr-90 measured in 100-D (Well 199-D5-12, located east of the D Reactor) was sampled from 1987 to 1999, and was decommissioned in 2002 when the water level fell below the pump. At well decommissioning, measured Sr-90 concentrations exceeded the maximum contaminant level (MCL) of 8 pCi/L by approximately five times. Currently, no wells are available for sampling near the former location of well 199-D5-12.

Strontium-90 levels in extraction Well 199-D8-68 (located downgradient of 107-D and 107-DR retention basins) have historically been elevated but more recently have been below the drinking water standard (e.g., 4.7 pCi/L in 2008). In 100-H, the Sr-90 plume distribution has not changed appreciably in more than 10 years. Although few wells were monitored for Sr-90 in FY 2007, concentrations of Sr-90 continued to exceed the drinking water standard of 8 pCi/L beneath a portion of southeastern 100-H near the former retention basin and disposal trenches. The highest concentration was 30.7 pCi/L, a decline from recent years. The extent of the Sr-90 groundwater impacts near wells 199-H4-63 and 199-H4-45, near waste sites 116-H-1 and 116-H-7, and near the river is not defined in this area. Concentrations of Sr-90 in Well 199-H4-13, located downgradient of the 100-H-5 Retention Basin and the southern half of the 116-H-7 Retention Basin (see Appendix B for well and waste site location) have ranged from 17.3 pCi/L to 36.8 pCi/L from 1992 to 2005. The well has not been sampled since 2005. The groundwater samples in which 36.8 pCi/L was detected were collected in 2005.

Three aquifer tubes were monitored for Sr-90 from FY 2007 through FY 2009. With the exception of AT-47-M in FY 2008 (11.6 pCi/L), all results were below the drinking water standard. However, the data collected from aquifer tube samples are qualitative.

Within the Horn, Sr-90 has not been detected in groundwater samples above drinking water standards.

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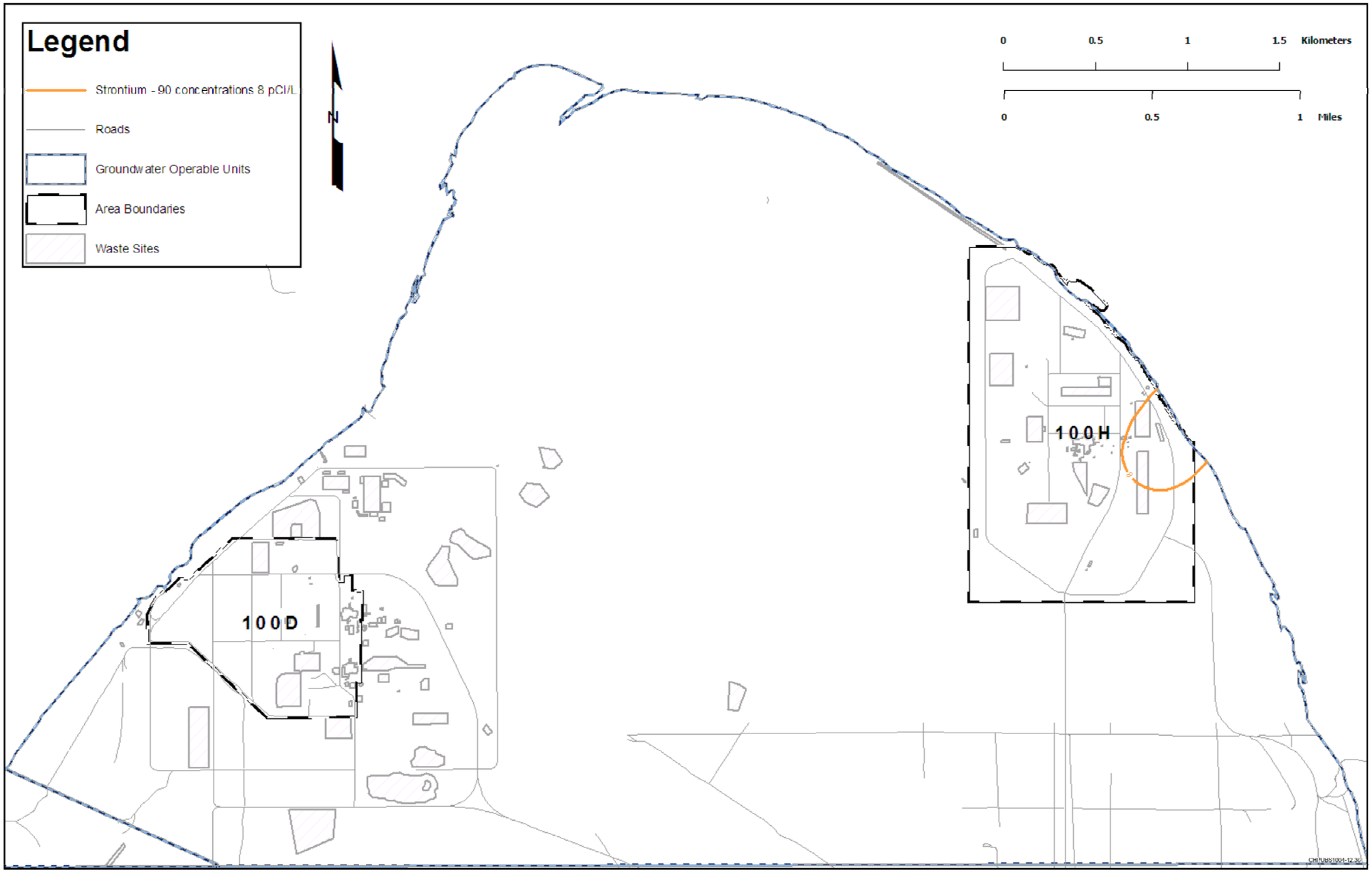

Figure 2-40. Strontium Plume in 100 D/H, 2008 Data

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2.4.2.3 Tritium

Tritium concentrations remained less than the 20,000 pCi/L drinking water standard in most wells in 100-D, but continued to exceed the standard in three wells and one aquifer tube near the southern part of the ISRM barrier (DOE/RL-2008-01; SGW-35028, *Aquifer Sampling Tube Results for Fiscal Year 2007*). The tritium contamination in south 100-D is believed to have originated as part of 100-N tritium plume to the south. A contamination peak moved past Well 199-D3-2 in the late 1990s and elevated levels have continued to be observed since 2004.

In FY 2007, the tritium concentration declined to less than the drinking water standard in one well located near waste sites associated with the former DR Reactor. Since 1996, concentrations have ranged from 12,000 to 26,400 pCi/L with no apparent increasing or decreasing trend in groundwater monitoring wells. Concentrations in nearby wells remained less than the standard.

In 100-H, tritium concentrations continued to decline in most wells. The highest concentration in 100-H was 2,800 pCi/L. A well located west (upgradient) of 100-H (in the Horn) continued to yield a higher tritium concentration (5,150 pCi/L) than wells within 100-H.

Within the Horn, tritium has not been detected in groundwater samples above the drinking water standard since 1984. Relatively low concentrations of tritium (less than 5,000 pCi/L) continue to be detected in groundwater samples.

2.4.2.4 Nitrate

In 100-D, with few exceptions, nitrate concentrations have remained in excess of the groundwater action threshold of 45 mg/L (SGW-35028). Figure 2-41 shows plumes based on 2008 data. Since 2003, concentrations have remained between approximately 60 and 70 mg/L in three regularly monitored groundwater monitoring wells. In FY 2007, the groundwater monitoring well maximum concentration was 89 mg/L southeast of the former 120-D-1 Pond. Both operational and agricultural sources for nitrate in groundwater are likely. The nitrate distribution is similar to that of Cr(VI); both constituents form two plumes. In the southern 100-D shoreline aquifer tubes, higher nitrate concentrations are noted than in other areas of 100-D (SGW-35028). High/maximum nitrate concentrations are reported for 2007 and 2008 and for Well 199-D2-6, adjacent to solid waste burial ground 118-D-2 (DOE/RL-2009-15).

In FY 2007, nitrate concentrations continued to exceed the drinking water standard of 45 mg/L in a few wells near the former 116-H-6 (183-H) Solar Evaporation Basin. The highest concentration was 66 mg/L in well 199-H4-3 in May 2007. A second nitrate plume in southeast 100-H is shrinking, and in FY 2007, the only results that exceeded the drinking water standard were in one groundwater monitoring well (46.9 mg/L) and one aquifer tube (45.2 mg/L). Nitrate concentrations have been stable at these sites in recent years (DOE/RL-2008-01). In FY 2007, nitrate concentrations continued to exceed the drinking water standard of 45 mg/L in a few wells near the former 116-H-6 Solar Evaporation Basins. The highest concentration was 66 mg/L in Well 199-H4-3 in May 2007. A second nitrate plume in southeast 100-H is shrinking. Although well coverage in this area is limited, in FY 2007, the only results that exceeded the drinking water standard were in one groundwater monitoring well, 199-H4-46 (46.9 mg/L). In FY 2009, aquifer tube 51-M located downstream exceeded the drinking water standard, (46 mg/L). Nitrate concentrations have also been near or above the drinking water standard in tube 50-M in recent years. Nitrate concentrations have been stable in 100-H in recent years (DOE/RL-2008-01).

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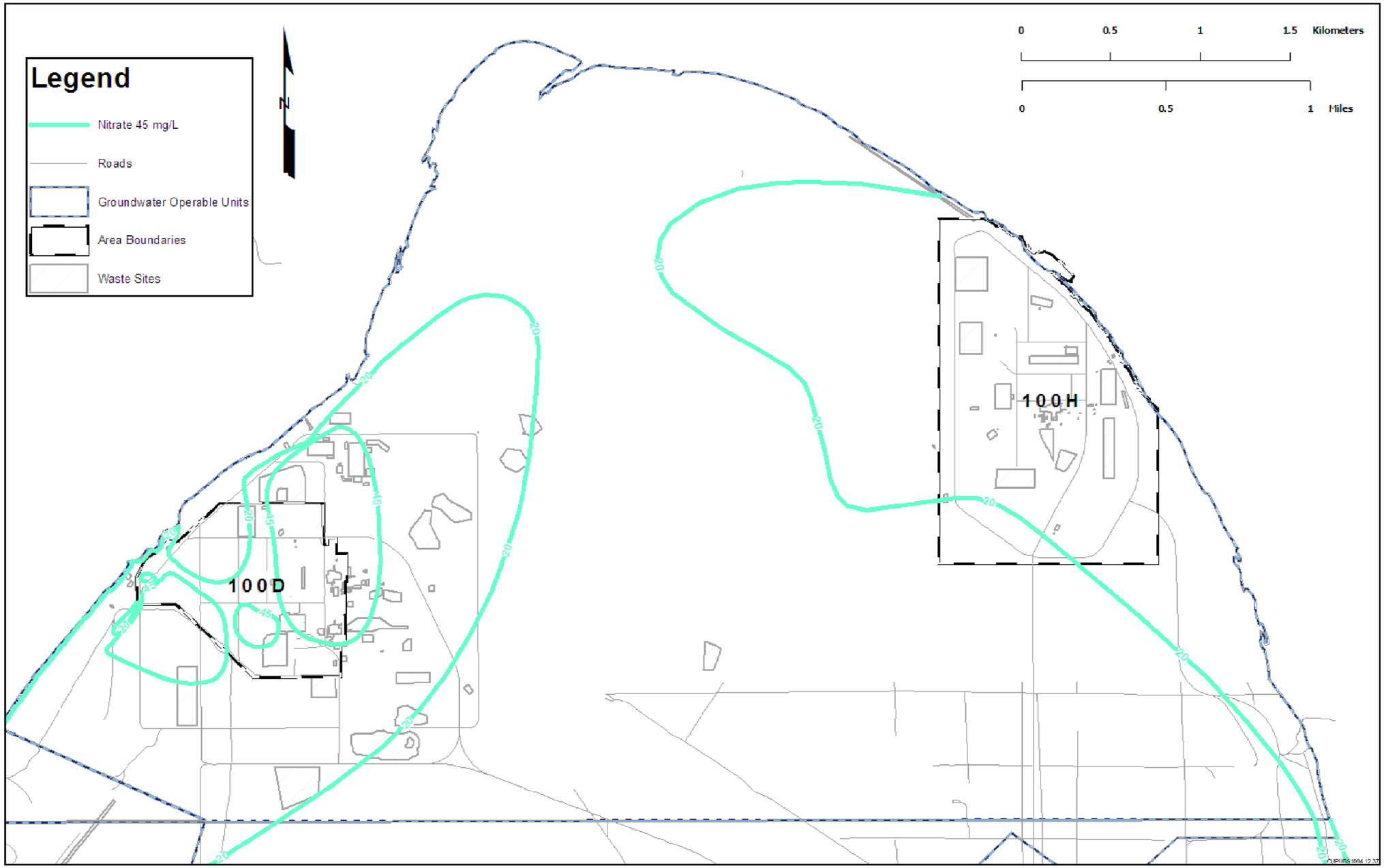

Figure 2-41. Nitrate Plumes in 100 D/H, 2008 Data

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Within the Horn, nitrate has not been detected in groundwater samples above the drinking water standard since 1985. Concentrations of nitrate (less than 33 mg/L, 2008) continue to be detected in groundwater samples.

There are several hypotheses that explain the source of nitrate in 100-D/H, but the nature and extent of the source term remains uncertain. Nitrate contamination in groundwater likely has both agricultural and operational origins. Nitrate derived from Hanford operations has been associated with the use of process chemicals and cleaning of equipment as well as septic systems; pre-Hanford agricultural activities still may be non-point source contributors. One use of nitric acid was for decontamination activities in the reactor areas. Nitric acid specifically was identified at 116-DR-6 and 116-H-3 (Plate 11, p. A-24). In addition, a nitrogen plume above the drinking water standard extends east from the southeast corner of 100-H, originating near the former guardhouse.

2.4.2.5 Other Contaminants

Arsenic is observed in Hanford soil in the 100 Areas. Arsenic has also been observed in groundwater wells associated with the ISRM barrier. Arsenic is present from pre-Hanford agricultural uses in the 100 Areas (BHI-01326), natural occurrence, and as a byproduct in some chemicals and products used during Hanford operations.

Iron, manganese, and sulfate exceed secondary drinking water standards in 100-D/H. However, federal secondary drinking water standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. The focus of the 100-D/H Addendum is on contaminants that pose a potential health risk to humans or ecological receptors.

In 100-D, in addition to Sr-90 and tritium discussed previously, the following radionuclides have been detected in groundwater samples, generally at very low concentrations and in a few samples: Sb-125, Cs-137, Co-60, gross alpha, gross beta, iodine-129 (I-29), iodine-131 (I-131), Ni-63, Pu-238, Pu-239/240, K-40, radium, ruthenium-106 (Ru-106), Tc-99, Th-228, U-233/234, U-235, and U-238.

In 100-H, in addition to Sr-90 and tritium discussed previously, the following radionuclides have been detected in groundwater samples, generally at very low concentrations and in a few samples: Am-241, Sb-125, C-14, Cs-134, Cs-137, Co-60, Eu-154, europium-155 (Eu-155), gross alpha, gross beta, I-129, I-131, Ni-63, Pu-238, Pu-239/240, K-40, radium, Ru-106, Tc-99, Th-232, U-233/234, U-238, and uranium-240 (U-240).

In the fall 2008, 11 wells and 3 aquifer tubes were sampled for Tc-99 and all results were less than the MCL of 900 pCi/L. The maximum activity was 45 pCi/L in well 199-H4-3. Well 199-H4-3 is located downgradient of the former 183-H Solar Evaporation Basins, which received liquid waste from 300 Area fuel fabrication processes (DOE/RL-2008-66).

Uranium concentrations for well 199-H4-3 have declined since the mid-1990s and have remained below drinking water standards since 2006. The maximum fall 2008 uranium concentration was 7.7 µg/L measured at Well 199-H4-3. The MCL for uranium is 30 µg/L. However, concentrations of uranium and other 183-H contaminants tend to be at a maximum in the spring with uranium concentrations generally exceeding the MCL. Spring sampling of Well 199-H4-3 has not been performed in the past few years.

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3 Identification of Investigation Requirements

This chapter is included for completeness to satisfy CERCLA requirements for this RI/FS work plan addendum. The following sections of the work plan (DOE/RL-2008-46) are included by reference:

- Assessment of Baseline and Residual Risks in the 100 Area (Section 3.6)
- Preliminary Remediation Action Objectives (Section 4.1)
- Preliminary Remediation Goals (Section 4.2)
- Potential Applicable or Relevant and Appropriate Requirements (Section 4.3)
- Preliminary Remedial Actions (Section 4.5)

For this work plan addendum, there are no exceptions to these sections of the work plan.

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4 Conceptual Site Model

4.1 Introduction

This chapter describes the CSM for 100-D/H. The CSM expresses the current understanding of site conditions and makes possible the identification of data gaps and data needs in conjunction with the systematic planning process described in Section 1.6 of the work plan. The CSM identifies waste site key features, distills the information that is already known, and captures decisions to be made. It describes sources, receptors, and the interactions linking them; identifies uncertainties; and provides a framework to identify data and information needed to resolve each uncertainty. The CSM evolves as new data and information are developed. The goal of the CSM is the synthesis of 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 distribution, contaminant fate and transport, and exposure pathways and receptors. The data and information requirements necessary to develop and implement the remedy are developed directly from the process of resolving the uncertainties through the evolution of the CSM.

4.2 Contaminant Sources and Release Mechanisms

Sources of contamination include spills, leaks, and past liquid and solid waste disposal sites. Contamination is found within remaining structure materials, pre-remedial action fill materials, vadose zone, and groundwater, and has migrated to the Columbia River.

4.2.1 Primary Sources of Contamination and Releases Mechanism

The primary sources of contamination in 100-D/H are three water-cooled nuclear reactors (105-D, 105-DR, and 105-H Reactors) and the structures (e.g., fuel storage basins) and processes (e.g., sodium dichromate additions to reactor coolant) associated with reactor operations. The reactors were built to irradiate uranium-enriched fuel rods from which plutonium and other special nuclear materials could be extracted. The extraction process was conducted in the 200 Area. The reactors and processes associated with operations generated large quantities of liquid and solid wastes. Effluent generated during operations consisted primarily of contaminated reactor cooling water, fuel storage basin water, and decontamination solutions.

Cooling water consisted of river water treated to remove dissolved solids and enhanced with chemicals to reduce corrosion. Cooling water contaminants consisted of fuel materials, fission and irradiation byproducts, and dilute concentrations of Cr(VI) (used as a corrosion inhibitor). Cr(VI) was also present at high concentrations in liquid and solid source materials that were an additive to reactor coolant prior to passage through the reactors. These highly concentrated materials are referred to in this chapter as chromium product. Because of the much greater Cr(VI) concentrations in these materials compared to reactor coolant fluids (by one to three orders of magnitude), their releases into the subsurface have generated the highest levels of contamination in the unconfined aquifer and present the most difficult challenges for attaining successful remediation.

Most of the chromium product points of entry into the subsurface are understood from reactor operation records. The bulk of proposed work activities focus on these locations. However, the lengthy and dynamic process history associated with Cr(VI) use at 100-D/H point to data gaps associated with inadvertent losses and loosely controlled disposal practices at these locations (data gaps No. 2 and No. 5). Additional sampling and analysis from existing and proposed locations as well as results from recent technical findings are anticipated to address the remaining data needs for these gaps.

Cr(VI) is recognized as the primary contaminant of concern in groundwater because of its mobility, widespread presence, and potential impact to human health and the environment. Solid wastes consisted of sludge, reactor components, and various other contaminated items. Waste generated from reactor operations was contaminated with radionuclides, hazardous chemicals, or both. A description of the chemical and radionuclides associated with area operations is provided in Appendices C and D.

Deliberate and unintended releases of waste resulting from operations are the primary contaminant release mechanisms. Contaminants were released to the environment by discharging effluent to the surface impoundments, french drains, cribs, ditches, process sewers, and directly to the Columbia River and through solid waste burial.

4.2.2 Secondary Sources of Contamination and Release Mechanisms

Liquid and solid wastes from reactor operations and associated facilities were released to the soil column and the Columbia River. Wastes released to the environment created secondary sources of contamination such as ponds, ditches, and cribs; burial grounds; and unplanned release sites. Soil, groundwater, and the Columbia River are also impacted by these secondary sources.

Secondary release mechanisms can occur from secondary contaminant sources. Releases from secondary sources also can impact the environment through the following processes:

- Resuspension of contaminated soils via wind or excavation activities
- Direct contact with contaminated soils
- Biotic uptake of contaminants via direct contact with soils or ingestion of soils, vegetation, or other animals
- Migration of contaminated liquids through the soil column via infiltration or percolation
- External radiation

Contaminant sources (i.e., facilities and waste sites) are listed in Appendix C and D. Higher inventory contaminant sources for Cr(VI) are provided in Tables 4-1 and 4-2.

Process knowledge and historical research including the orphan site process has identified primary and secondary sources. The orphan site evaluation process has not been completed in the Horn. The data gap associated with the source is listed.

Data Gap No. 4: *Unidentified waste sites (orphan/discovery sites) may exist in the 100 D/H Area. Unidentified sites may include chromium contamination in surface soils due to undocumented spills.*

Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area

Site ID	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
116-D-1A	105-D Storage Basin Trench No. 1	Interim Closed Out	1,000 (2,200)	$Na_2Cr_2O_7$	200,000 (53,000)	**Contaminated water and sludge from the 105-D fuel storage basin (CVP-2000-00010).**
116-D-1B	105-D Storage Basin Trench No. 2	Interim Closed Out	700 (1,500)	$Na_2Cr_2O_7$	8,000,000 (2,000,000)	Contaminated water and sludge from the 105-D fuel storage basin and contaminated liquid wastes from the decontamination of fuel spacers and reactor hardware (CVP-2000-00010).
116-D-2	105-D Pluto Crib	Interim Closed Out	0.004 (0.0088)	$Na_2Cr_2O_7$	4,000 (1,000)	Waste effluents from the 107-D (116-D-7) and 107-DR (116-DR-9) Retention Basins after outages due to ruptured fuel elements (CVP-2000-00013).
116-DR-1&2	107-DR Liquid Waste Disposal Trench No. 1 and No. 2	Interim Closed Out	40 (88)	$Na_2Cr_2O_7$	40,000,000 (10,000,000)	Trench No. 1: Received waste effluents from the 107-D (116-D-7) and 107-DR (116-DR-9) Retention Basins after outages due to ruptured fuel elements. Trench No. 2: Overflow effluents from the 116-DR-1 liquid waste disposal trench at times of high activity due to fuel element failures (CVP-2000-00002).
126-D-2	184-D Coal Pit	Accepted	Not Specified	Dry chemicals (suspect sodium dichromate crystals and others)	Not specified	Solid waste (OSR-2006-0001).
116-DR-3	105-DR Storage Basin Trench	Accepted	Not Specified	See Waste Description	4,000,000 (1,000,000)	Received contaminated sludge and water removed from the 105-DR fuel storage basin (OSR-2006-0001).
116-DR-4	105-DR Pluto Crib	Interim Closed Out	0.004 (0.0088)	$Na_2Cr_2O_7$	4,000 (1,000)	Liquid wastes isolated from tubes containing ruptured fuel elements in the 105-DR Reactor and may have been used for the disposal of excess liquid boron solution (INK) used in the 3X safety system (CVP-2000-00015).

Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area

Site ID	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
116-DR-6	1608-DR Liquid Disposal Trench	Interim Closed Out	2.0 (4.4)	$Na_2Cr_2O_7$	7,000,000 (1,800,000)	Coolant during the Ball 3X upgrade. Also received diverted water when maintenance was necessary on the effluent system. Site employees report that this trench also received decontamination effluents (dilute citric and nitric acid, water, and solvents) from the decontamination pad in the fuel storage area (CVP-2000-00014).
126-DR-1	190-DR Clearwell Tank Pit	Interim Closed	Not Specified	$Na_2Cr_2O_7$	Not Specified	Solid waste site that may contain Cr(VI) in both the soil and underground piping as a result of its association with water treatment (OSR-2006-0001).
118-DR-2:2 Zone 1	105-DR Fuel Storage Basin Leakage	Interim Closed Out	Not Specified	See Waste Description	Not Specified	This subsite includes the 105-DR Reactor below-grade structures and underlying soils. It was divided into five zones and the decon areas. Zone 1 consists of the 400 FSB, 410 storage and transfer area, 412 storage area, the 413 transfer bay, and the soils underlying the FSB (CVP-2003-00016).
100-D-12	Pumping Station Sodium Dichromate/Acid Railcar and Truck Unload Station and French Drain	Interim Closed	Not Specified	$Na_2Cr_2O_7$	Not Specified	**The sodium dichromate/acid pumping station is located just south of the 184-D building next to the railroad tracks. A 7.6 cm (3-in.) underground line provided the ability to pump solutions to storage tanks located outside 185-D and 190-DR. A 0.9 m (3-ft) -diameter French drain located at the site supported the flushing and draining of hoses and lines that connected to the tank cars. This is a significant waste site because undiluted volumes of sodium dichromate and acid solutions were dumped directly to the soil column at this location (CVP-2000-00016).**

Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area

Site ID	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
100-D-30	185-D Building (Associated Waste Site: 100-D-30)	Accepted	1,700 (3,700)	$Na_2Cr_2O_7$	4,000 (1,000)	**This facility was used to store highly concentrated sodium dichromate solution (> 70 percent by weight) and to produce/transfer moderately concentrated sodium dichromate solution (> 10-15 percent by weight). The largest reported loss occurred when a sodium dichromate transfer line failed in 1964, leaking about 4,000 L (1,000 gal) of waste into the subsurface. Other unintentional losses are presumed to have occurred (OSR-2006-0001).**
108-D (100-D-73)	108-D Building (Associated Waste Site: 100-D-73)	Accepted	Not Specified	$Na_2Cr_2O_7$	Not Specified	**This facility was used from 1944 to 1950 to store solid sodium dichromate, to produce moderately concentrated sodium dichromate solution (> 10-15 percent by weight) from the solid materials, and to transfer these solutions to 185-D Building and the 105-D Reactor. After 1950, the facility generated waste from decontamination activities and laboratory testing (OSR-2006-0001).**
100-D-7	Undocumented Solid Waste Site	Accepted	Unknown/ 163 ppm detected in soil	$Na_2Cr_2O_7$	0	The site contains debris, concrete, vitrified clay pipe, wood, rebar, tar, various types of metals, solvents, paint cans, empty oil cans, and an unknown white substance.
100-D-56	100-D Sodium Dichromate Underground Supply Line	Accepted	Unknown/ 70 percent solution	$Na_2Cr_2O_7$	Not documented	**Abandoned 7.6 cm (3-in.) pipeline contaminated with 70 percent dichromate solution (OSR-2006-0001).**
100-D-20	Trench	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.
100-D-22	Trench	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.

Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area

Site ID	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
100-D-31	Process Sewer	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Reinforced-concrete piping system from 100-D/DR Water Treatment Facility buildings 182-D, 183-D, 186-D, 185/189/ 190-D, 105-D, 108-D, 182-DR, and 183-DR. Carried process sewer waste and rain runoff to process effluent outfall (116-D-5) until 1977. The process sewer drainage was diverted to the 120-D-1 D Ponds from 1977 to 1994.
100-D-4	Trench	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.
100-D-48	Radioactive Process Sewers	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-D Reactor to the 107-D Retention Basin and the 116-D-5 Outfall.
100-D-49	Radioactive Process Sewers	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-DR Reactor and the 1608-DR Building to the 107-DR Retention Basin and the Outfalls.
100-D-50	Process Sewer	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Abandoned underground pipelines that carried treated and untreated wastewater from the 183-DR Building, the 183-DR Clearwells, and the 105-DR Reactor to the 100-D-8 Outfall.
100-D-65	Outfall	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	The site is the concrete spillway (also referred to as a flume) that led from the 116-D-5 Outfall Structure and terminated at the river shoreline.
100-D-66	Outfall	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	The site is the concrete spillway (also referred to as a flume) that led from the 116-DR-5 Outfall Structure and terminated at the river shoreline.

Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area

Site ID	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
100-D-77	183-DR Filter Plant	Accepted	Not Specified	$Na_2Cr_2O_7$	Not Specified	The area of the facility that was used for chemical storage, including sodium dichromate solutions and other water treatment chemicals, has the potential for contamination.
116-D-4	Crib/French Drain	Interim Closed	Unknown/ 10-15 percent solution	$Na_2Cr_2O_7$	30,000 L (7,925 gal)	Received contaminated liquid from the 108-D Maintenance and Technical Laboratory. Contaminated effluent also included decontamination solutions, solvents, and low-level fission products.
116-D-7	Retention Basin	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site was an open concrete basin that retained cooling water effluent from the 105-D Reactor for radioactive decay and thermal cooling before release to the Columbia River. Total radionuclide inventory in the vicinity ranged from 5 to 400 Ci.
116-DR-9	Retention Basin	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site was an open concrete basin that retained cooling water effluent from the 118-DR-2 (105-DR Reactor) for radioactive decay and thermal cooling before release to the Columbia River. Also received ruptured fuel element waste after 1954. Total radionuclide inventory in the vicinity ranged from 5 to 400 Ci.
118-D-6	105-D Fuel Storage Basin	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	The site includes the 105-D Reactor below-grade Fuel Storage Basin structure.
120-D-2	Surface Impoundment	Accepted	Not Specified	$Na_2Cr_2O_7$	Not Specified	The waste site consisted only of the 186-D waste acid reservoir and associated soils. An acid-proof brick-lined trench, running almost the entire length of the 186-D Building, was designed to gather waste acid from the demineralization process and deliver it to the 120-D-2 waste acid reservoir. Acid stored in the reservoir could be transferred to the 186-D acid mixing/ neutralization tanks, and subsequently discharged to the 100-D-50:7 segment of the process sewer. Structure demolished in place in 1979. Designated as a waste site because the lead flashing was not removed.

Table 4-1. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-D Area

Site ID	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
UPR-100-D-2	Unplanned Release	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.
UPR-100-D-3	Unplanned Release	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.

Notes:

Waste descriptions shown in **bold** font are those that received highly concentrated chromium waste, either chromium product or other waste.

CVP-2000-00010, *Cleanup Verification Package for the 116-D-1A/116-D-1B Storage Basin Trenches and 100-D 46 Burial Ground*.

CVP-2000-00013, *Cleanup Verification Package for the 116-D-2 Pluto Crib*.

CVP-2000-00002, *Cleanup Verification Package for the 116-DR-1&2 Process Effluent Trenches*.

CVP-2000-00014, *Cleanup Verification Package for the 116-DR-6 Liquid Disposal Trench*.

CVP-2000-00015, *Cleanup Verification Package for the 116-DR-4 Pluto Crib*.

CVP-2003-00016, *Cleanup Verification Package for the 118 DR 2:2, 105-DR Reactor Below-Grade Structures and Underlying Soils, and the 100-D-49:4 Reactor Cooling Water Effluent Underground Pipeline*.

CVP-2000-00016, *Cleanup Verification Package for the 100-D-12 Sodium Dichromate Pump Station*.

OSR-2006-0001, *100-D Area Orphan Sites Evaluation Report*.

Cr(VI) = hexavalent chromium

FSB = fuel storage basin

Table 4-2. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-H Area

Site Identification	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
100-H-17	Unplanned Release	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site was a triangular area that received overflow from the 1608-H Liquid Waste Disposal Trench.
100-H-21	Radioactive Process Sewer	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	This site includes two former 1.5 m (5-ft) diameter steel pipelines that carried 105-H Reactor cooling water effluent from the Reactor to the 116-H-7 Retention Basin and from the basin to the 116-H-5 Outfall. The site also includes a 0.5 m (1.6 ft) diameter steel pipeline that was used to divert reactor-cooling water from the retention basin to the 116-H-l Trench and a 0.5 m (1.6 ft) diameter steel pipeline along the west side of the retention basin and pipelines from the reactor to the 1608-H Pump House and the 116-H-2 Trench.
100-H-28	Process Sewer	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	Site includes upstream (pre-reactor) process sewers for the 100-H Reactor, including all underground water lines used to transport reactor-cooling water between water treatment facilities and the 105-H Reactor.
100-H-34	Radioactive Process Sewer	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	This site includes the river effluent pipelines (river lines) that extend from the outfall (116-H-5) into the main channel of the Columbia River. The river effluent pipelines discharged reactor coolant water to the river. Effluent was received from the 107-H Retention Basin and the area process sewer system to the outfall structure.
116-H-1	107-H Liquid Waste Disposal Trench	Interim Closed	90 (200)	$Na_2Cr_20_7$	90×10^6 (23×10^6)	Diversion effluent from the 107-H Retention Basin during reactor outages resulting from fuel element ruptures. The coolant effluent received by this trench reportedly contained fuel rupture debris. Additionally, the trench received water and sludge from the 107-H Retention Basin in April and May 1965, during basin deactivation.
116-H-2	1608-H Liquid Waste Disposal Trench	Interim Closed	600 (1,300)	$Na_2Cr_20_7$	600×10^6 (160×10^6)	Coolant water from the reactor building during the Ball 3X system upgrade and other upgrade programs.
116-H-3	105-H Dummy Decontamination French Drains	Interim Closed	2,000 (4,400)	$Na_2Cr_20_7$	400,000 (100,000)	Spent nitric acid and rinse water from the decontamination of fuel element spacers, reactor process tube caps, and other reactor hardware.

Table 4-2. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-H Area

Site Identification	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
116-H-4	Original 105-H Pluto Crib Site	Accepted	1,000 (2,200)	$Na_2Cr_20_7$	1000 (260)	Contaminated cooling water from reactor process tubes containing ruptured fuel elements. The pluto crib was uncovered and exhumed in 1960, during construction of the 105-H confinement system, so the 117-H Filter Building could be constructed at the same location. Wastes from the site were moved to the 105-H thimble pit (118-H-5), where they are now buried. The pluto crib wastes are thus included in the radionuclide inventory of 118-H-5 rather than that of 116-H-4 (OSR-2008-0002).
116-H-5	Outfall	Accepted	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	The outfall was a reinforced-concrete weir box that directed the 105-H Reactor coolant water either through the river discharge pipelines (100-H-34) or through the spillway (flume) (100-H-36). Received effluent from the 107-H Retention Basin.
116-H-6	183-H Solar Evaporation Basins	Closed	Not Specified	See Waste Description	Not Specified	Received routine and nonroutine chemical wastes. Routine wastes consisted of spent acid etch solutions, primarily nitric, sulfuric, hydrofluoric, and chromic acids. These acidic solutions were reacted with excess sodium hydroxide before being transported to the 183-H Basins. Metal constituents (including copper, silicon, zirconium, nickel, aluminum, chromium, manganese, and uranium) were in the form of precipitates. Nonroutine wastes consisted of unused chemicals and spent solutions from miscellaneous processes support of N Reactor (DOE/RL-97-48; PNNL-11573).

Table 4-2. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-H Area

Site Identification	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
116-H-7	107-H Retention Basin	Interim Closed	Not Specified	$Na_2Cr_20_7$	Not Specified (See Waste Description)	Several chemical additives were used to treat the cooling water (e.g., sodium dichromate, which was used to inhibit corrosion). The total volume of cooling water held at this basin over the years has not been estimated, but the flow rate ranged between 155,202 and 295,262 L/min (41,000 and 78,000 gpm). When operating, the retention basin had the capacity to hold 91,758,380 L (24,240,000 gal) of cooling water. Over the operating lifetime of H Reactor, the retention basins and effluent piping developed leaks, releasing cooling water to the area in and around the basins, lines, and river shore at a rate as high as several thousand (up to 10,000 L/min [2,600 gpm]) (UNI-946). Specific information on leak rates from the 116-H-7 Retention Basin is not available; however, contamination detected around the basin indicates that leakage did occur (CVP-2000-00027).
116-H-9	117-H Filter Building	Accepted	N/A	N/A	300,000 (80,000)	Drainage from the 117-H Filter Building confinement system seal pits (BHI-00127).
118-H-6	105-H Fuel Storage Basin	Interim Closed	Unknown/ 2 percent solution	$Na_2Cr_2O_7$	Not Specified	This site is the soil underlying the former fuel storage basin floor. Sample design during remediation was developed specifically to address potential contamination from the known leakage of the fuel storage basin (BHI-00127).
1608-H	Pump Station	Demolished	Unknown/ 2 percent solution	$Na_2Cr_20_7$	Not Specified	The facility served as a collection basin and lift station for the reactor floor drains system. Floor drain waste from the 105-H Reactor Building was gravity drained to the underground reservoir. From here it was pumped, as required, through underground lines to the 107-H Retention Basin, before being routed to the river. In 1986, the contaminated fixtures and radioactive sludge were removed. The structure was demolished and buried in place in 1987.
190-H (100-H-46)	190-H Building	Accepted	Not Specified	$Na_2Cr_20_7$	Not Specified	**This facility was used to store chromium product and to produce/transfer reactor coolant sodium dichromate solutions (2 mg/L or less).**

Table 4-2. Historically Estimated Inventories and Effluent Volumes at Known or Suspected Hexavalent Chromium Discharge Sites in 100-H Area

Site Identification	Site Name	Status	Sodium Dichromate Quantity kg (lb)	Chromium Species	Waste Volume L (gal)	Waste Description
600-105	Sodium Dichromate Barrel Disposal Landfill	Closed out in 100-IU-4 OU	28,100 kg (61,800 lbs)	$Na_2Cr_2O_7$	Liquids were not disposed at this site.	**5,000 empty crushed drums containing sodium dichromate residue. The estimated waste quantity of 28,100 kg (61,800 lbs) is based on the assumption that 1 percent of the original quantity of sodium dichromate remained in the drums (EPA-ROD-R10-96-151).**

Notes:

Waste descriptions shown in **bold** font are those that received highly concentrated chromium waste, either chromium product or other waste.

CVP-2000-00027), *Cleanup Verification Package for the 116-H-7 Retention Basin*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00031, *Cleanup Verification Package for the 100-H-17 Overflow, 116-H-2 Liquid Waste Disposal Trench, 100-H-2 Buried Thimble Site, and the 100-H-30 Sanitary Sewer Trench*.

CVP-2000-00032, *Cleanup Verification Package for the 116-H-3 French Drain*.

DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*.

OSR-2008-002, *100-H Area Orphan Sites Evaluation Summary*.

EPA/ROD/R10-96/151, *Declaration of the Record of Decision for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units, Hanford Site, Benton County, Washington*.

PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*.

NA = not applicable

OU = operable unit

4.3 Contaminant Distribution

This section summarizes the currently known and/or understood nature and extent of contaminant distribution in 100-D/H.

4.3.1 Vadose Zone Contamination

The distribution of contaminants in the vadose zone beneath waste sites is dependent on many factors. The volume of effluent discharged, contaminant inventory, vadose zone thickness, stratigraphy, soil distribution coefficient (K_d), and natural recharge are the primary physical and chemical properties that influence contaminant distribution in the vadose zone.

The generalized contaminant distribution model for 100-D/H is based on the observed distribution of contamination, and information on recharge histories and contaminant chemical reactivity with subsurface sediments that are to some degree waste site-specific. Effluent discharged to the soil column provides the primary driving force for contaminant migration during operations. Where saturated conditions were maintained during operation, the extent of contamination is more extensive. Since cessation of waste discharges, only natural recharge and, in some cases, artificial sources of recharge are available to facilitate continued contaminant transport. Artificial discharges include use of injection wells and addition of water for dust suppression (e.g., when demolishing the 185-D structure) in remediation activities, ongoing leaks from the 182-D Reservoir (see Chapter 2), and water export system line leaks and/or breaks.

Waste sites that received enough liquid effluent to impact groundwater have contamination at varying levels throughout most of the vadose zone. Contaminants with low contaminant distribution coefficients (near zero) such as Cr(VI) have migrated through the vadose zone and into the groundwater when the waste sites were operational. The available data indicate that residual concentrations of Cr(VI) remain in the vadose zone; however, a complete contaminant profile across the vadose zone is not available for contaminants that are considered mobile or relatively immobile in the environment. Concentrations of less mobile contaminants like Cs-137 are generally expected to decrease with depth below the waste site.

Field data (described in Figures 2-28, 2-29, and 2-30) indicate that contaminant distributions at high volume liquid waste sites like 116-DR-1&2 are highest near the bottom of the engineered structure and generally decrease with depth with occasional increases in contamination throughout the vadose zone. Soil samples collected at this site indicate that most of the contamination is high above the water table and does not exceed remedial action goals. However, soil data have not been collected throughout the vadose zone to make a complete assessment of contaminant distribution. For example, limited data are available to evaluate lateral contaminant distribution associated with liquid effluent disposal sites. However, during remediation, contaminant plumes that are encountered are remediated as necessary to their lateral and vertical extent.

Waste sites that received small amounts of dilute liquids are generally expected to have soil contamination extending limited distances into the vadose zone beneath waste sites (i.e., burial ground, reactor structures, and some unplanned releases). Comparison of soil column pore volume and the effluent volume provides reasonable assumption of impact. There is little reason to believe that groundwater was impacted at waste sites that received minimal discharges. The assumption will be verified by drilling boreholes in 116-D-1B and 116-H-4 and a monitoring well through 116-D-1A. These sites did not receive the effluent volume to impact groundwater. The working assumption in the CSM is that adverse impacts to groundwater from these sources are not expected where the vadose zone is substantially thick. Although objective evidence (i.e., sample data) is not available to verify contaminant distribution throughout the soil column beneath low volume waste sites, a source of contamination may remain in the vadose zone. Boreholes have not been drilled to groundwater at sites that received small quantities of liquids to date. The following text lists data gaps identified to assess the nature and extent of

contamination, protection of groundwater, and or protection of the Columbia River associated with vadose zone soils.

Data Gap No. 1*: Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath unremediated waste sites.*

Contaminated soils have been completely removed at waste sites to the depth of remedial action. At these sites, the inventory of contaminants within the remediation zone has been significantly reduced. The maximum depth of remedial action is 7.6 m (25 ft) while the typical depth of remedial action is generally 4.5 m (15 ft) or less. Some waste sites have not been remediated to the depth of the engineered structure. In addition, not all waste sites in 100-D/H have been remediated. Data collected from these remaining source sites will provide information to assess the potential for adverse impacts through direct exposure or transport to groundwater pathways from remaining residual contamination.

The principal environmental threat in 100-D/H is Cr(VI). Other contaminants that are potential risks to human health and ecological receptors (including arsenic, nitrate, tritium, U-233/234, U-235, and U-238, Tc-99, Sr-90, and other target analytes) are also present (see Chapter 2). The target analytes associated with the vadose zone are identified in the sampling and analysis plan (DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*). The list of target analytes was developed using the methodology described in Chapter 4 of the work plan.

The 108-D Chemical Pump House and the 183-DR Head House footprint have been identified as high priority sites for remediation due to use of chromium in their process history. The 100-D-73 waste site (108-D Chemical Pump House) and portions of the 100-D-77 waste site (specifically, the 183-DR Head House, the Sample Room, and, the Acid Facility area portions) have been identified as sites requiring design and remediation. The remaining portions of 100-D-77—flocculation basins, sedimentation basins, and filter building—will require confirmatory evaluation to make an RTD or No Action decision.

Field data from 116-DR-1&2 and 116-H-1 (shown in Figures 2-28 and 2-34) indicate that contaminant distributions at high-volume, retrieved liquid waste sites for contaminants (e.g., arsenic, total chromium, mercury, Cr(VI), lead, Cs-137, Co-60, Eu-152, Ni-63, Pu-239/240, U-238, and U-233/234) are highest at the bottom of the waste site and generally decrease with depth with observed sporadic increases throughout the vadose zone. Soil samples collected and analyzed during interim remedial actions (Borehole B8786 at 116-DR-1&2) indicate that residual contamination is located above the water table and the periodically re-wetted zone. A list of high-volume liquid waste sites is provided in Appendix C. Waste site locations are provided in Appendix B.

The working assumption in the CSM is that wastes sites that received small amounts of liquid are generally expected to have soil contamination extending limited distances into the vadose zone beneath waste sites (i.e., burial ground, some unplanned releases, and liquid sites). Adverse impacts to groundwater are not expected from these sites.

Contaminated soil at interim-closed and no action waste sites (Chapter 2) has been removed and/or confirmed to meet the remedial action goals identified in the Interim Record of Decision (IROD) remedial action goals. At these sites, contaminated soil down to 4.5 m (15 ft) bgs has been removed and/or confirmed to meet remedial action goals for 0 to 4.5 m (0 to 15 ft) bgs protection of groundwater, and protection of the Columbia River based on the requirements in EPA/ROD/R10-96/134. The inventory of contaminants initially in the soil column has been significantly reduced by interim remedial actions. Contaminated soil removal and disposal in ERDF for the remaining source sites will continue. Data collected from these

remaining source sites will provide information to assess the potential for adverse impacts through direct exposure or transport to groundwater pathways from remaining residual contamination.

Waste sites that received enough liquid effluent to impact groundwater have contamination at varying levels distributed sporadically throughout most of the vadose zone. Contaminants with low contaminant distribution coefficients (near 0) have migrated through the vadose zone and into the groundwater when the waste sites were operational. Analytical data are needed to assess the vertical extent of contamination beyond the depth of the interim remedial actions that were implemented at these waste sites. Specifically, there are insufficient nitrate, tritium, Cr(VI), or other target analyte contaminant data to assess the vertical extent of vadose zone contamination above levels that may adversely impact groundwater. Limited data are available to evaluate lateral contaminant distribution associated with liquid effluent disposal sites. However, during remediation, contaminant plumes that are encountered are remediated as necessary to their lateral and vertical extent.

Leach tests and/or verification sampling from soils collected at the bottom of the remediated waste sites combined with modeling, suggest that the residual contaminants are protective of groundwater and the Columbia River. However, since the leach tests and modeling were conducted under the IROD to meet WAC 173-340 (1996), these sites will be re-evaluated for the final ROD in compliance with WAC 173-340 (2007). In addition, a review of available contaminant data shows that the understanding of contaminant distribution is based mainly on data collected less than 11 m (35 ft) within a vadose zone that is up to 26 m (85 ft) thick. The lack of sufficient contaminant analytical data below depths of approximately 11 m (35 ft) results in considerable uncertainty regarding the projection of contaminant migration to groundwater. Additional work is being planned to characterize remediated sites to support final decision making.

Data Gap No. 2: *Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.*

Many facilities within 100-D/H have undergone deactivation, decommissioning, decontamination, and demolition (D4), and reactor buildings have been placed in interim safe storage (ISS). Waste sites that are identified as part of the facility removal process are remediated using remedial action under interim action RODs. This process has resulted in limited characterization of soils beneath reactor structures. Because contaminants passed through reactor structures or were produced in reactor structures as part of operations, contaminants may be present beneath the structures at concentrations that are a risk to human health or ecological receptors. Insufficient data are available to assess the environmental risk of the contamination beneath the reactor structures.

Data Gap No. 3: *Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath and around reactor structures.*

The continued search for additional waste sites is necessary to identify waste sites with a potential to adversely impact human health and the environment. Boreholes are planned for the fuel storage basins adjacent to the 105-D and 105-H Reactors. Control of runoff from the ISS reactor structures will be addressed in the feasibility study portion of the RI/FS.

Data Gap No. 4: *Unidentified waste sites (orphan/discovery sites) may exist in 100 D/H. Unidentified sites may include chromium contamination in surface soils due to undocumented spills.*

4.3.2 Hexavalent Chromium – Soil

Soil characterization efforts have been conducted at numerous facilities in 100-D to determine the nature and extent of radioactive and chemical contaminants. Characterization data are tabulated in several

sources, including initial studies by UNI-946, and in the LFI reports for 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 (DOE/RL-93-29, DOE/RL-94-73, DOE/RL-93-51, and DOE/RL-94-53). Subsequent characterization studies have focused on Cr(VI) in the vadose zone near 100-D Facilities that handled the more concentrated sodium dichromate solutions (PNNL-13486, *Characterization Activities Conducted at the 183-DR Site in Support of an In Situ Gaseous Reduction Demonstration*; PNNL-13107, *Identification of a Hanford Waste Site for Initial Deployment of the In Situ Gaseous Reduction Approach*; BHI-01185, *100-D Area Chromium Study Summary Report*; and BHI-01747, *Results of Hexavalent Chromium Sampling Near 100-D Area Sodium Dichromate Transfer Station Railroad Tracks*). Vadose zone Cr(VI) data within 100-D/H are listed in Appendix E.

In initial studies prior to remediation, (UNI-946, DOE/RL-93-29, DOE/RL-94-73, DOE/RL-93-51, and DOE/RL-94-53) the bulk of collected sediments were collected in the vadose zone in the top 9 to 12 m (30 to 40 ft), with emphasis on the first 4.5 to 6 m (15 to 20 ft) bgs. Generally, soil samples were collected at the large liquid discharge sites (107-D and 107-DR Retention Basins, 116-DR-1&2 Trenches), high-inventory sodium dichromate inventory sites (116-D1A and 1B), smaller cribs (116-D-3&4), and various buildings and burial ground sites. After remediation, relatively low concentrations of various radionuclides (e.g., Cs-137, Sr-90, europium, and plutonium isotopes) and various metals were routinely measured. The LFI found Cr(VI) contamination sporadically above detection levels (about 2 mg/kg) and then at levels generally less than 50 mg/kg, above background levels for total chromium of about 18.5 mg/kg. The most contaminated sediments were at 116-D1A, which reportedly received 1,000 kg (2,200 lb) of sodium dichromate present in water and sludge from the 105-D Fuel Storage Basin (PNL 6456). Total chromium concentration levels between 40 and 110 mg/kg were measured between 4 and 13 m (13 and 42 ft) bgs.

In more recent studies, sediments were collected at locations near the sodium dichromate pumping station in 100-D and sampled the entire vadose zone (see Figure 4-1 for sample locations). Peterson (2009 draft) provides total chromium data at the other borehole locations shown in Figure 4-1. In these locations, soils were sampled every 1.5 m (5 ft) for total chromium and/or Cr(VI). Of the wells shown in the figure, total chromium levels above background or detection limits occurred in sediments from just two Wells, 199-D5-120 and 195-D-122. In Well 199-5-120, Cr(VI) was measured at seven depths between 4.5 and 23 m (15 and 75 ft), at concentrations between 0.22 and 1.5 mg/kg. The maximum concentration occurred at 14 m (45 ft) bgs. At Well 195-D-122, Cr(VI) values of 0.25 to 0.32 mg/kg occurred between 21 and 24 m (70 and 80 ft) bgs near the water table.

Two boreholes were also drilled near the 183-DR Head House to a depth of 26.5 and 30.5 m (87 and 100 ft), respectively, (PNNL-13486), and soils were sampled from 6 to 26 m (20 to 85 ft) bgs. Only one measurement of 130 mg/kg was above background values for total chromium in one of the boreholes (199-D2-8), at 21 m (68 ft) bgs.

In 100-H, soil characterization efforts have been conducted at a few facilities to determine the nature and extent of radioactive and chemical contaminants. These investigations have been quite limited compared to those in 100-D. Characterization data are tabulated in two sources, including initial studies by UNI-946 and in a 1993 LFI report (DOE/RL-93-51) that analyzed soils for both radionuclides and chemicals. In the LFI report, vadose zone samples were taken at five facilities, four of which were reported to have received quantities of total chromium in the amounts of kilograms. The four Cr(VI)-related waste facilities included two facilities that received reactor coolant (116-H-1 Trench and 116-H-7 Retention Basin) and two facilities that received decontamination fluids (116-H-2 and 116-H-3). The fifth facility was the 116-H-9 Crib, which received waste from the 132-H-2 Reactor exhaust air filter building seal pits.

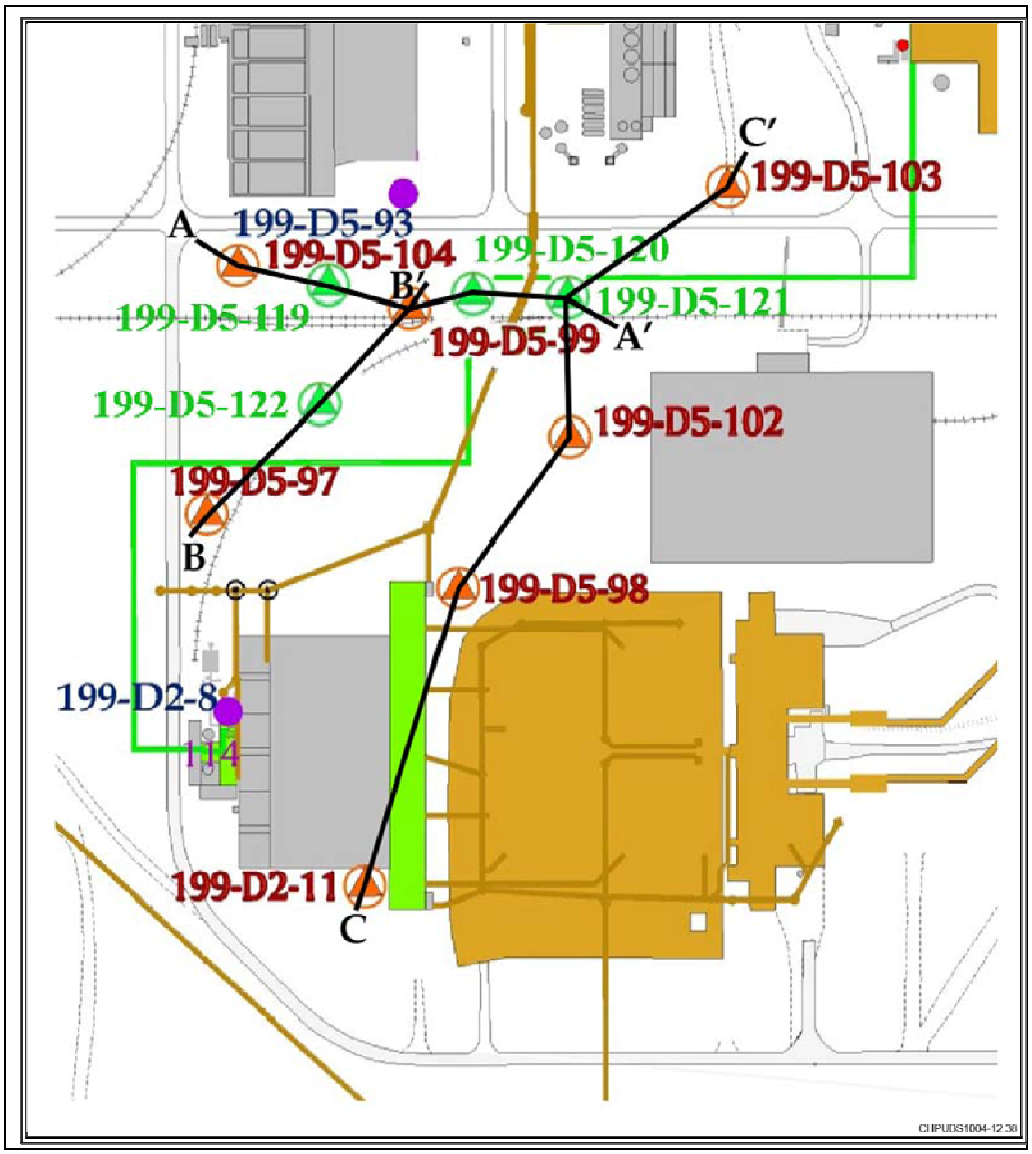

Figure 4-1. Depth Discrete Vadose Zone and Groundwater Sampling Locations for Total Chromium Analysis

At each of these facilities, one borehole was drilled and soil samples were collected for analysis. Two to seven samples were taken at a given facility, between 0.3 and 7.6 m (1 and 25 ft) bgs for a total of 20 samples. Of the five sites that handled chromium-bearing solutions as part of reactor operations, total chromium concentrations above background (27.9 mg/kg) occurred only at borehole 116-H-1 (at the north end of the 116-H-1 Trench) at about 5.2 m (17 ft) bgs. At this location, total chromium levels of 29.6 mg/kg were measured.

Fluid and sludge samples were also collected from two septic tanks (1607-H2 and 1607-H4). At 1607-H2, high concentrations of total chromium (1,020 and 2,510 mg/kg), along with high concentrations other heavy metals (e.g., cadmium, copper, mercury, and zinc), were measured in sludge samples. This system served facilities that played a role in reactor coolant production (183-H and 190-H) and are plausible sources of these heavy metals. A likely source is the intermittent discharge of chemical solutions into sanitation drains. Conversely, 1607-H-4 serviced the 181-H river pump house, a facility that supplied

water for reactor coolant production prior to the introduction of sodium dichromate into the system. In sludge samples collected from this facility, total chromium levels above background were not noted.

Surface stains of Cr(VI) have been identified during remedial activities, routine fieldwork, inspections, and/or site visits. Uncertainties exist as to whether the orphan and discovery site processes to date have identified all Cr(VI) surface stains. Cr(VI) from the soil has impacted the groundwater associated with 100-D/H (EPA/ROD/R10-96/134).

4.3.3 Groundwater Contamination

Data Gap No. 5: *The nature and extent of contamination in the unconfined aquifer above cleanup standards has not been defined in select areas.*

Historical discharges of reactor cooling water at 100-D created a relatively large, dispersed plume of Cr(VI) in groundwater beneath the area. Based on process knowledge of Cr(VI) concentrations used in reactor operations, discharges of reactor process water contained maximum levels of Cr(VI) (approximately 700 µg/L; DUN-4847) that infiltrated to groundwater in 100-D. As of 2007, Cr(VI) was detected in two areas at 100-D, commonly referred to as the north and south plumes (Chapter 2). The south plume area is characterized by a relatively high concentration and small core (Cr(VI) concentrations up to approximately 40,000 µg/L). The north plume is characterized by a relatively larger, lower concentration core (Cr(VI) approximately 1,000 µg/L). The extent of Cr(VI) above the aquatic cleanup standard (EPA/ROD/R10-96/134, Section 9.2) inland from the river has not been defined. The extent of the north and south plumes are depicted in Figure 2-37.

4.3.3.1 Hexavalent Chromium

Cr(VI) from 100-D extends above the RAO of 20 µg/L to the northeast across the Horn to 100-H, ultimately discharging to the Columbia River north of the H Reactor area. Cr(VI) groundwater contamination in the H Reactor area in the upper aquifer is generally confined to two relatively small areas adjacent to the river. Cr(VI) concentrations are between 20 µg/L and 50 µg/L (Chapter 2).

The highest concentrations of Cr(VI) concentrations within 100-D/H are found in 100-D.

Data Gap No. 6: *The level of groundwater contamination entering the Columbia River is not well known.*

Since 1992, increasing numbers of groundwater monitoring wells have been installed in 100-D to evaluate the nature and extent of Cr(VI) and other contaminants. The majority of measurements have been collected in the unconfined aquifer and near the water table. Cr(VI) in groundwater has migrated toward the northwest and the river, from vicinity of the D Reactor Building (north plume) and from the sodium dichromate pumping station and associated French drain (100-D-12). Raw water leakage from the 182-D Reservoir appears to have kept the north and south plumes separate due to a combination of dilution and water table mounding. Interpretations in the late 1990s of the southern plume near the ISRM barrier indicated that the plume appeared to travel parallel with the 1907-DR process sewer line. That orientation appears to have been caused primarily by the natural gradient and leakage from the 182-D Reservoir. The two 100-DR-5 Injection Wells are likely also contributing to groundwater mounding and dilution that is causing the north and south plume separation. The numbers have increased and locations have changed for injection and extraction wells since the start of remediation (DOE/RL-2008-05 and DOE/RL-2009-15).

Recent groundwater data collected near 100-D-12 provide a more detailed look at aquifer contamination within the south plume. Monitoring well locations are shown in Figure 4-1. Results of two depth-discrete sampling events from some of these wells are presented in Figure 4-2 and Figure 4-3. The trends in the data indicate relatively constant contamination concentration through depth (except for Well 199-D5-99

in June 2008, where concentration levels increase at the bottom of the aquifer). Data from vertical sampling in Wells 199-D5-123 and 199-D5-126 show that turbidity increased and Cr(VI) decreased with depth. The cause for this is uncertain, but could result from disturbance of the water column by repeated sampling with the Solinst® device. Due to the turbidity of the samples, the data may not be representative of actual chromium concentrations. More recent data also show the occurrence of a Cr(VI) spike at groundwater monitoring Well 199-D5-99 that is apparently beginning to reoccur at groundwater monitoring Well 199-D5-122 (DOE/RL-2009-15), suggesting southwesterly movement (Figure 4-4).

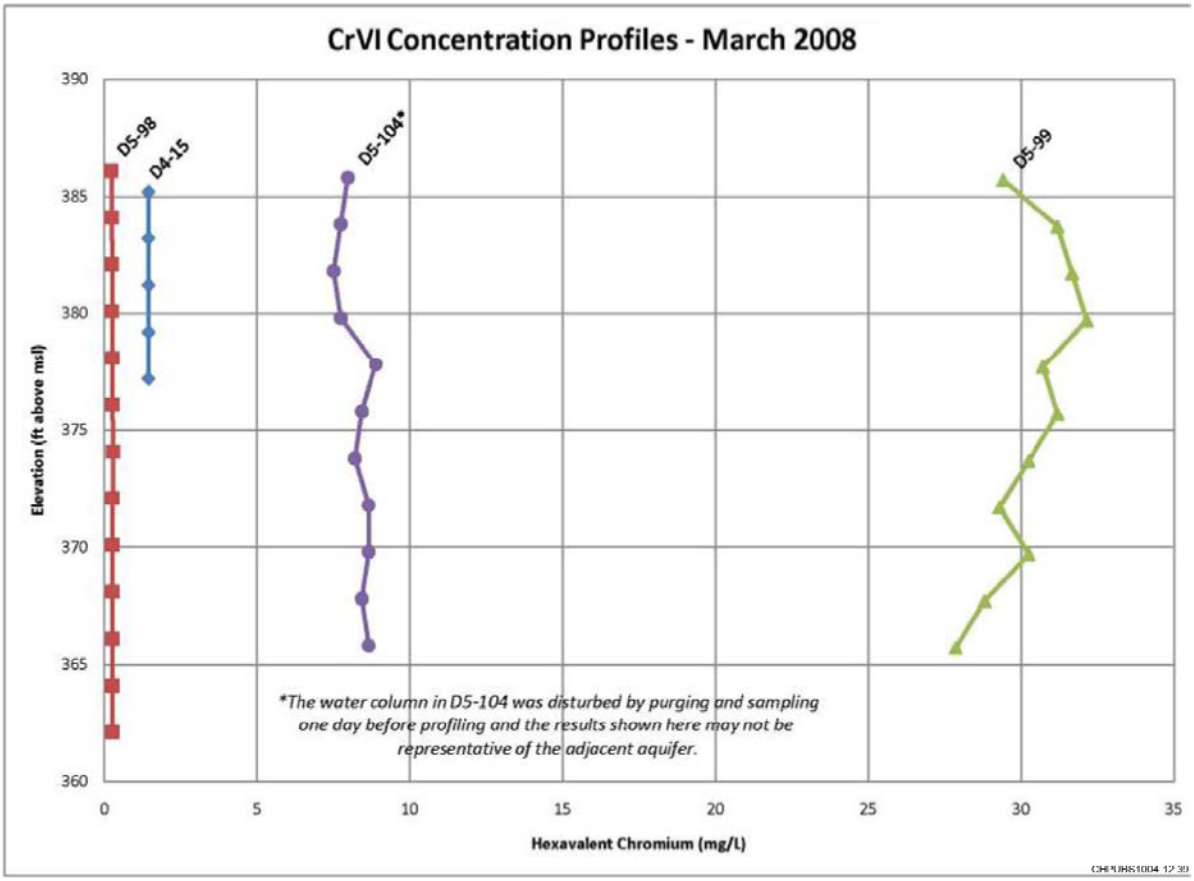

Figure 4-2. Concentration Profiles of Hexavalent Chromium for Wells Sampled in March 2008 near 100-D-12

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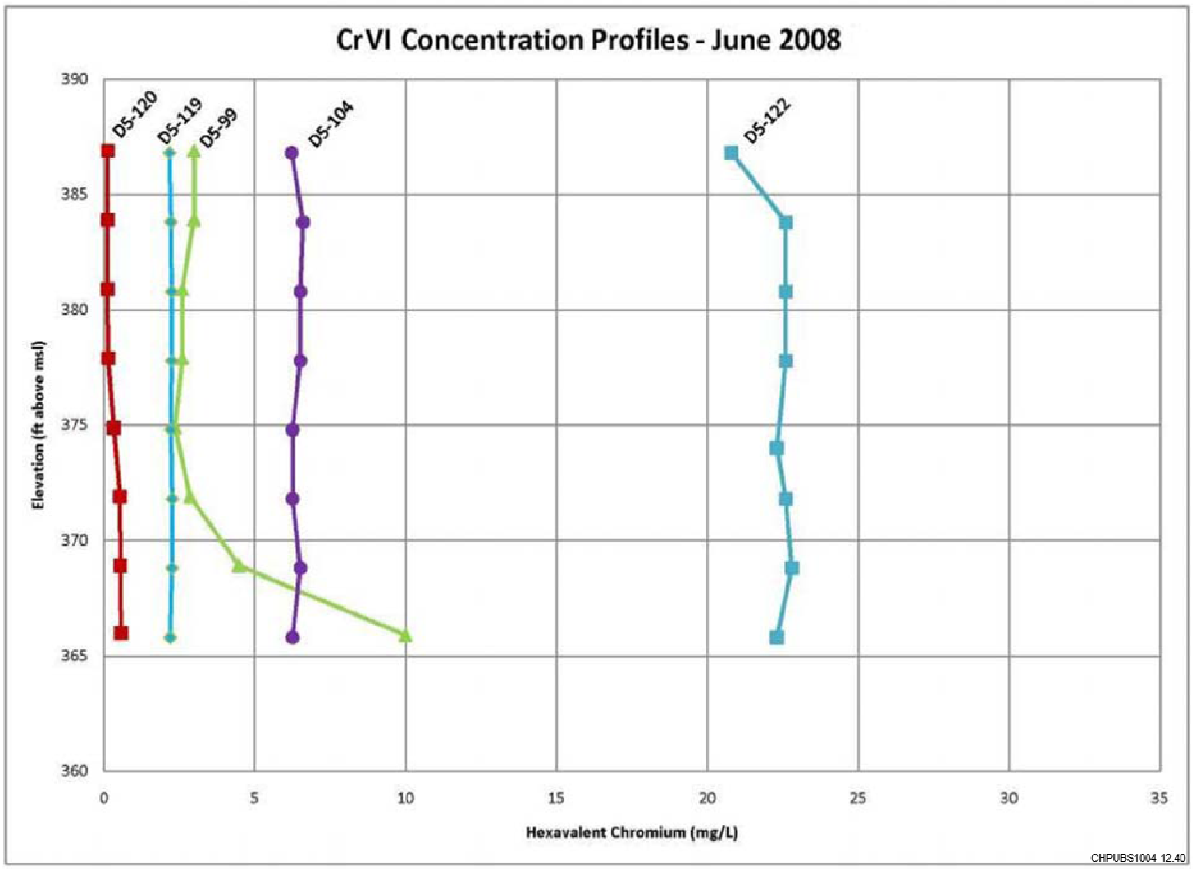


Figure 4-3. Concentration Profiles of Hexavalent Chromium for Wells Sampled in June 2008 near 100-D-12

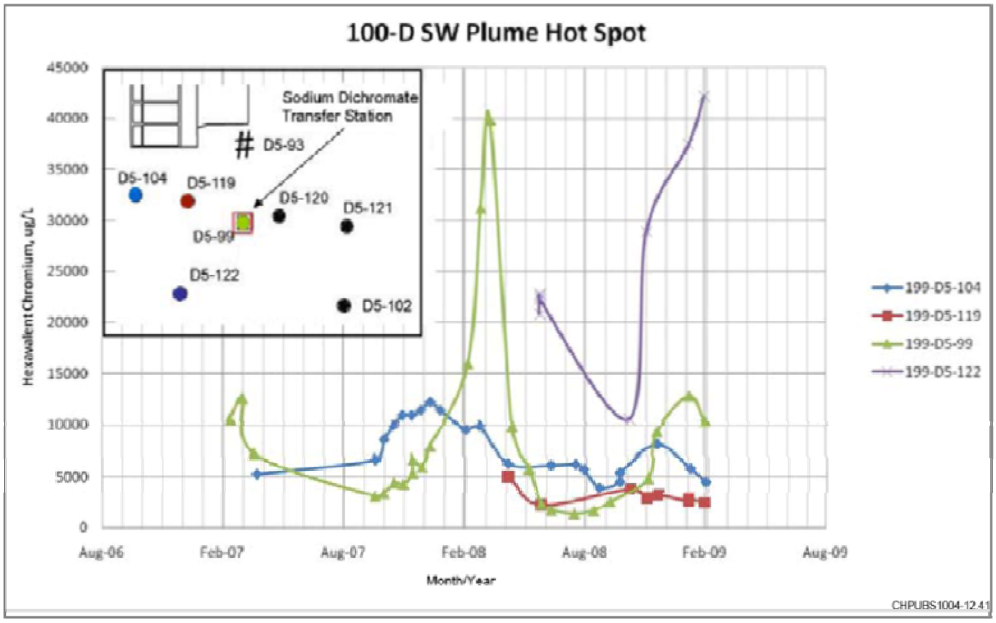


Figure 4-4. Hexavalent Chromium Migration at Groundwater Monitoring Wells near 100-D-12

4.3.3.2 Other Contaminants

Additional contaminants (e.g., arsenic, nitrate, tritium, and Sr-90) have been detected in groundwater in the upper aquifer above drinking water standards within 100-D/H. Radiological contaminants such as Sr-90 have been detected in the vicinity of former reactor buildings and associated structures (e.g., retention basins) in 100-D and 100-H. In 100-H, total uranium has been sampled in groundwater downgradient of the 183-H Solar Evaporation Basins (116-H-6) since 1980 in Well 199-H4-3. Total uranium exceeded the MCL of 30 µg/L in groundwater samples from Well 199-H4-3 from 1980 to 2006, with a maximum concentration of 2,090 µg/L in 1986. Technetium-99 has been sampled in groundwater in Well 199-H4-3 since 1987. Technetium-99 concentrations exceeded the groundwater MCL of 900 pCi/L from 1987 to 1999, with a maximum concentration of 5,141 pCi/L in 1996. These past observations have indicated the highest concentrations are measured in the spring/summer (DOE/RL-2008-01). To date, spring/summer samples have not been taken since 2006.

Inorganic contaminants (e.g., nitrate and arsenic) have also been detected in groundwater, generally within the area of the Cr(VI) plume in 100-D and 100-H. However, these other contaminants did not necessarily originate from the same primary sources as the Cr(VI). Tritium has been detected at concentrations exceeding the maximum contaminant level for drinking water in wells near the southwestern portion of the ISRM barrier. Historic groundwater data maps indicate that the source of the tritium is the 100-N Area (DOE/RL-2008-01).

Nitrate contamination in groundwater likely has both agricultural and operational origins. Nitrate derived from Hanford operations has been associated with the use of process chemicals (e.g., nitric acid) and septic systems. Nitric acid specifically was identified at 116-DR-6 and 116-H-3 (Appendix A, Plate 11). Operational sources of nitrate and other soil target analytes will be investigated primarily through Data Gaps No. 1 and No. 2 (Table 4-6). The nature and extent of nitrate and other groundwater COPCs will be evaluated through Data Gaps No. 5 and No. 13 (Table 4-6). The proposed and existing wells identified in Data Gaps No. 5 and No. 13 will be sampled for nitrate and other groundwater COPCs.

In addition, contaminants such as iron, manganese, and sulfate exceed secondary drinking water standards. However, the focus of this section and the CSM will be contaminants that pose a health risk to humans or ecological receptors.

4.4 Groundwater – Beneath the Unconfined Aquifer

The RUM Unit is generally recognized as the base of the unconfined aquifer in 100-D/H. In order to evaluate the vertical extent of contamination, groundwater samples have been collected within the RUM, the Ringold Unit B (the first confined aquifer encountered from the ground surface), the RLM Unit (the second confining unit encountered from the ground surface), and the basalt bedrock (the second confined aquifer encountered from the ground surface). A summary of the results for groundwater sampling beneath the unconfined aquifer within 100-D/H is provided in the following subsections.

4.4.1 100-D Area

One borehole in 100-D has been drilled and completed beneath the unconfined aquifer. Borehole 199-D8-54B was completed in the RUM as a monitoring well. Groundwater in the well has been analyzed for constituents including organics, inorganics, and radionuclides. Cr(VI) (which is the focus of EPA/ROD/R10-96/134) has not been detected at concentrations above the 20 µg/L groundwater interim remedial action objective for the protection of aquatic receptors (EPA/ROD/R10-96/134; EPA/AMD/R10-00/122) since 1997, in the RUM in 100-D.

Groundwater samples from the RUM have been analyzed for constituents including organics, inorganics, and radionuclides. Since 2000, metals (aluminum, arsenic, barium, beryllium, total chromium, copper, nickel, strontium, vanadium, and zinc), radionuclides (gross alpha and gross beta), and nitrate impacts have been detected in RUM groundwater samples at concentrations below aquatic or drinking water standards. The only constituent detected above its MCL since 2000 was iron (at 513 µg/L in Well 199-D8-54B), which exceeded the secondary drinking water standard (300 µg/L) in one sample in 2005.

The only well installed in the 100-D RUM (Well 199-D8-54B) is located in the northern portion of the north chromium plume. No wells have been completed in the RUM in the south chromium plume, where the highest concentrations of Cr(VI) have been detected in 100-D. Therefore, the vertical extent of Cr(VI) and other contaminants above cleanup thresholds beneath the upper aquifer's highest contaminant concentration area is unknown in 100-D.

4.4.2 100-H Area

The monitoring well data for the aquifers below the unconfined aquifer in 100-H have been collected from three wells: 199-H3-2C, 199-H4-12C, and 199-H4-15C.

Well 199-H3-2C is located approximately 500 m (1,640 ft) from the river. It is screened 30.5 to 33.5 m (100 to 110 ft) bgs in a relatively coarser grained layer within the RUM, described as clayey silty sand.

Well 199-H4-12C is located approximately 100 m (330 ft) from the river, between the river and the demolished 183-H Solar Evaporation Basins. The well is screened 22 to 24 m (72 to 78 ft) bgs in soil described as gravelly silt and gravelly clayey silt, which makes up the majority of the RUM matrix. The total drill depth of the well was 67 m (220 ft) bgs, so the well borehole may have served as a downward pathway for contamination in the unconfined aquifer during drilling and well completion activities.

Well 199-H4-15C contains four piezometers (P, Q, R, and S), which are screened in four different hydrogeologic units. The well is located approximately 100 m (328 ft) from the river, between the river and the demolished 182-H Reservoir and pump house. The four piezometers are screened within the basalt (99.1 to 99.7 m [325 to 327 ft] bgs), RLM (89.9 to 90.5 m [295 to 297 ft] bgs), Ringold Unit B (59.1 to 59.7 m [194 to 196 ft] bgs), and the RUM (23.8 to 24.4 m [78 to 80 ft] bgs), respectively. Piezometer 199-H4-15CS is screened in gravelly silt that makes up the majority of the RUM matrix. Table 4-3 summarizes Cr(VI) results from 100-H wells completed and sampled beneath the unconfined aquifer.

Table 4-3. Maximum Hexavalent Chromium Concentration Detected in Groundwater Wells Completed Beneath the Unconfined Aquifer in the 100-H Area

Well Identification	Maximum Level, µg/L (Date)	Current Level, µg/L (Date)
199-H3-2C	114a(09/02/1997)	45.4 (11/08/2007)
199-H4-12C	260 (10/22/1996)	84.3 (06/04/2009)
199-H4-15C S[a]	157 (01/03/2008)	95.2 (06/10/2009)
199-H4-15CR[b]	51.7 (01/03/2008)	5.0 (6/9/2009)
199-H4-15CQ[b]	37 (10/24/1996)	2.0 (6/9/2009)
199-H4-15CP[b]	8.7 (11/24/2008)	6.4 (6/9/2009)
199-H3-1[c]	93.4 (11/05/1997)	93.4 (11/05/1997)
199-H4-1[d]	No data	No data

Table 4-3. Maximum Hexavalent Chromium Concentration Detected in Groundwater Wells Completed Beneath the Unconfined Aquifer in the 100-H Area

Well Identification	Maximum Level, µg/L (Date)	Current Level, µg/L (Date)
199-H4-2[e]	Not detected	Not detected

Notes:

a. Results presented are for filtered total chromium. Well only sampled for Cr(VI) one time in 2005.
b. Well not sampled for Cr(VI) prior to November 2008. Samples results prior to November 2008 are for total chromium.
c. Well only sampled for Cr(VI) in 1986 and 1987. Maximum value of Cr(VI) detected was 58 mg/L on 10/24/1986. Results in table represent total chromium analyses.
d. Well never sampled for Cr(VI) or total chromium.
e. Well only sampled for total chromium from 1993 to 2007. Analyte never detected.

Data Gap No. 7: *The nature and extent of contaminants beneath the unconfined aquifer has not been evaluated.*

Three other wells—199-H3-1, 199-H4-1, and 199-H4-2—have been completed in 100-H with screened portions that intersect both the upper aquifer and the RUM.

4.5 Contaminant Fate and Transport

This section discusses contaminant fate and transport in the vadose zone and groundwater for those contaminants within 100-D/H whose distributions have been summarized in Chapter 2. In an effort to simplify the discussion, the focus is on Cr(VI), which is currently the most widespread and concentrated contaminant in the subsurface. This discussion follows the progression of chromium transport from source term releases into the subsurface and migration into the vadose zone, unconfined aquifer, the RUM aquitard, and the Columbia River. Emphasis is placed on proposed primary system characteristics and processes controlling its distribution. In addition, areas of greatest uncertainty with regard to the nature of the contaminant migration process are discussed.

Regarding past Cr(VI) use in 100-D/H, 95 percent is highly soluble and moves rapidly through the vadose zone with sufficient recharge/infiltration volumes (Chapter 2). High recharge/infiltration conditions were routine during 100-D/H Operations and this behavior could be inferred from historical information regarding effluent discharges.

Once saturated flow conditions ended, the rapid transport of Cr(VI) through the vadose zone to groundwater ceased. Some of the remaining Cr(VI) was retained and is being released over long periods through physical and/or chemical mechanisms present in the subsurface. The two reactor areas have different conditions with regard to Cr(VI) contamination. Around 100-D, there appears to be a plume with very high contaminant concentrations (greater than 1,000 µg/L) that is persistent and moving slowly toward the river. This condition is in contrast to the present case at 100-H, given the available groundwater measurements, where much lower contaminant concentrations are observed (Cr(VI) is detected above regulatory levels, but far below the concentration used during production, typically less than 50 µg/L vs. 700 µg/L).

A smaller fraction of the remaining Cr(VI) is reduced to insoluble trivalent chromium by other chemical processes in the soil. This fraction does not move to groundwater.

Data Gap No. 12: *Insufficient data are available to support a fate and transport modeling.*

On selected soil samples, estimate soil and hydraulic properties, determine level of contamination, confirm contaminant distribution coefficients, and perform batch leach test.

4.5.1 Hexavalent Chromium Source Term Release Characteristics

At the 100-D/H Area, the D, DR, and H Reactors operated for 23, 14, and 17 years, respectively. In support of their operation, contaminated fluids and solids were routinely generated and discharged to the surrounding environment. The majority of generated materials were byproducts of reactor coolant production that maintained the reactors at a safe operation temperature and provided corrosion protection to mitigate fuel pin ruptures with the addition of Cr(VI) to reactor coolant prior to transport through the reactors. Historical records/information indicates that Cr(VI) was released into the environment primarily as a dissolved species in two types of solutions: chromium product and reactor coolant. The differences in solution chemistry, associated production facilities, and discharge locations have had a substantial effect on current Cr(VI) distribution in the subsurface. Each type is considered separately.

The chromium products were highly concentrated sodium-dichromate stock solutions (70 percent, and 10 percent to 15 percent by weight) that were subsequently diluted to make reactor coolant solutions. The 10 percent to 15 percent were generated first by mixing solid sodium dichromate with water until about 1959 and subsequently by dilution of 70 percent liquid solutions that were shipped to the reactor sites by rail car and tankers (CCN-129547, *Sodium Dichromate Investigation for the 105-D/105-DR Reactor Area* and CCN-141284, *Historical Information for 100-D/DR Area Uses of Chromic Acid and Sodium Dichromate: Supplement to IOM 129547*). With regard to ultimate Cr(VI) distribution in the environment, the significant solution properties are concentration, pH, and specific density. The approximate Cr(VI) concentrations in the 70 percent, 15 percent, and 10 percent by weight solutions were 466, 64, and 43 g/L, respectively. These solutions were acidic (pH between 1.5 and 3) and significantly more dense than water (specific gravity of 1.7 to 1.1).

The reactor coolant was a dilute solution generated by mixing chromium product with treated Columbia River water to achieve hexavalent concentrations between 350 and 700 µg/L. The Cr(VI) coolant concentrations decreased over time as the understanding of adequate corrosion inhibition evolved. These solutions were passed through the reactors and then discharged downstream.

Because the chromium product materials were so much more highly concentrated in Cr(VI) than reactor coolant, subsurface contamination from the discharges has occurred at a much higher level and provides the greatest challenge to successful remediation of the unconfined aquifer. Facilities handling chromium product and from which chromium product was discharged into the subsurface are well known from reactor operations records and are a primary focus of current characterization and remediation efforts.

4.5.1.1 100-D and Horn Source Terms

Significant source term releases in the 100-D and Horn Areas were largely dominated by the byproducts of 100 D and DR Reactor processes. In 100-D, discharges of chromium product were responsible for the highest observed subsurface contamination levels. Substantial aquifer contamination by these sources is proposed at two locations in the central 100-D: (1) under the sodium dichromate transfer station (100-D-12), and (2) at facilities northeast of 100-D-12 (e.g., 185-D, 116-D-1a and 116-D-1b Cribs). Of these two locations, substantially more sodium dichromate was discharged at 100-D-12 (WCH 2008, “Historical Information for 100D/DR Area Uses of Chromic Acid and Sodium Dichromate: Supplement to IOM 129547” (memorandum to R.A. Carlson), Washington Closure Hanford, LLC, Richland, Washington). Conversely, reactor coolant discharges were the significant sources of Horn Area contamination. Reactor coolants were discharged at the northern corner of 100-D from retention facilities, ancillary liquid discharge facilities, and effluent lines.

The 70 percent solutions were used at 100-D between 1959 and 1967 as the initial stock solution and were shipped to a central pumping station (100-D-12) located just west of the reactors and about 0.8 km (0.5 mi) from the river shore. The exact startup date for this process is unknown, but a routine report on reactor operations in July 1959 (HW-61399, *Irradiation Processing Dept Monthly Record Report*) states that the liquid feed system was virtually complete. This solution was then transferred a short distance by underground pipeline to a storage tank near the 185-D, and then into 185-D for dilution and generation of the 10 to 15 percent solution. The mass of Cr(VI) that passed through this pumping station was not recorded but can be estimated from estimates of coolant water volumes that passed through the reactor (Table 4-4). On a yearly basis, from 1959 through 1967, about 100 - 140 billion L (26 to 37 billion gal) passed through each reactor, and then through D Reactor alone from 1965 through 1967, for a total of approximately 3.5 trillion L (930 million gal). During this time, Cr(VI) concentrations were reduced from 700 to about 350 µg/L in about 1961. From these volume and Cr(VI) concentration estimates, approximately 790,000 kg (1.7 million lb) of Cr(VI) passed through 100-D-12.

Table 4-4. Hexavalent Chromium Mass Discharge Estimates into the Subsurface Based on Reactor Coolant Throughput

	Yearly Throughput (L/yr [gal/yr])[a]				
Year	**105-D**	**105-DR**	**Total**	**Cr(VI) Inventory kg[b] (lb)**	**Equivalent 70% Solution Volume L/yr (gal/yr)**
1959[c]	3.5E+10 (9.2E+9)	3.5E+10 (9.2E+9)	7.0E+10 (1.8E+10)	4.9E+04 (1.1E+05)	1.1E+05 (2.9E+04)
1960	1.4E+11 (3.7E+10)	1.4E+11 (3.7E+10)	2.8E+11 (7.4E+10)	2.0E+05 (4.4E+05)	4.2E+05 (1.1E+05)
1961	1.4E+11 (3.7E+10)	1.4E+11 (3.7E+10)	2.8E+11 (7.4E+10)	9.9E+04 (2.2E+05)	2.1E+05 (5.6E+4)
1962	1.4E+11 (3.7E+10)	1.4E+11 (3.7E+10)	2.8E+11 (7.4E+10)	9.9E+04 (2.2E+05)	2.1E+05 (5.6E+4)
1963	1.4E+11 (3.7E+10)	1.4E+11 (3.7E+10)	2.8E+11 (7.4E+10)	9.9E+04 (2.2E+05)	2.1E+05 (5.6E+4)
1964	1.4E+11 (3.7E+10)	1.4E+11 (3.7E+10)	2.8E+11 (7.4E+10)	9.9E+04 (2.2E+05)	2.1E+05 (5.6E+4)
1965	1.4E+11 (3.7E+10)	--	1.4E+11 (3.7E+10)	4.9E+04 (1.1E+05)	1.1E+05 (2.9E+04)
1966	1.4E+11 (3.7E+10)	--	1.4E+11 (3.7E+10)	4.9E+04 (1.1E+05)	1.1E+05 (2.9E+04)
1967	1.4E+11 (3.7E+10)	--	1.4E+11 (3.7E+10)	4.9E+04 (1.1E+05)	1.1E+05 (2.9E+04)
Totals			**1.9E+12 (5.0E+11)**	**7.9E+05 (1.7E+06)**	**1.7E+06 (4.5E+05)**

Notes:

a. Yearly throughput taken from RL-REA-2247, 1965, *Historical Events—Reactors and Fuels Fabrication*, U.S. Atomic Energy Commission, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196083548.

b. Cr(VI) inventory estimate is based on a concentration range of 350 to 700 µg/L (3.5 - 7E-7 kg/L).

c. Volume estimates assume liquid feed only in the last quarter of 1959.

Delivery of the 70 percent solution into the pumping station was not completely efficient. The transfer of fluid from railcar or tanker to the pumping station was done using a hose. After each transfer was completed, residual fluid in the hose was discharged to a nearby french drain, thereby releasing Cr(VI) into the vadose zone. The fraction of fluid containing dissolved Cr(VI) discharged to the drain is not known, but possible masses of Cr(VI) lost through the french drain can be considered as fractions of total chromium brought in by railcar. For example, if 0.5 percent or 0.05 percent of the solution was sent to the french drain, a total chromium discharge of approximately 3,950 kg (8,700 lb) or 395 kg (870 lb), respectively, would have been discharged into the subsurface. In terms of volumes of 70 percent solution lost, these amounts on an average yearly basis correspond to about 950 L/yr (250 gal/yr) and 95 L/yr (25 gal/yr), respectively. These estimates are strongly dependent on the accuracy of the throughput estimates. Based on groundwater monitoring data, this facility is suspected to be the primary source of current contamination in the south plume.

The other locations for 70 percent solution losses were limited to the underground pipeline between 100-D-12 and the storage tank just outside of 185-D, the storage tank itself, and any other transfer lines within 185-D. A notable leak near the storage facility that occurred in 1964 was estimated to be about 3,800 L (1,000 gal) (HW-80011, *The Reduction of Uranium Bromide by Molten Aluminum from Fused KBR-ALBR3 Mixtures*). If this estimate were correct, about 1,700 kg (3,700 lb) of Cr(VI) would have been released and is a plausibly significant source term.

Discharge locations for the 10 percent to 15 percent solutions are less uncertain. These solutions were generated in tanks located inside facilities (108-D until 1950, and then 185-D thereafter, until the end of reactor operations in 1967) and were then transferred by pipelines to other facilities for the final dilution step to create reactor coolant. During the earlier period, the 10 percent to15 percent solutions were transferred from 108-D to the D Reactor, directly and to 190-D Building. During the later period, the solution was transferred from 185-D to 190-D and the 183-DR Head House, from which the final dilution step occurred to make reactor coolant for the D and DR Reactors, respectively. Given this infrastructure, opportunities for discharge to the subsurface were likely limited, although any of these sites may have contributed Cr(VI) to the subsurface (WCH 2006, CCN-129547; WCH 2008, CCN-141284).

On the other hand, residues (and apparently overflows) were routinely discharged to the process sewer from mixing tanks at 108-D and 185-D. Pipeline leaks likely developed, allowing fluids in the pipeline to discharge to the subsurface. Other possible locations for discharges of these fluids are two cribs just east of 108-D (116-D-3 and 116-D-4) and the 116-D-1A and 116-D-1B Trenches next to D Reactor that received waste in the late 1940s and early 1950s. The quantities and estimated concentrations of sodium dichromate disposed in 116-D-1A (1,000 kg [2,200 lb] and 1,750 mg/L of Cr(VI)) and 116-D-1B (700 kg [1,500 lb] and 31 mg/L) are clearly indicative of a concentrated sodium dichromate source rather than reactor coolant at the low concentration of 700 µg/L. These facilities appear to be the most likely source of current contamination in the northern aquifer plume. If so, this source term (primarily disposed over a short period in the early 1950s) appears to have created current aquifer contamination levels that are well above remediation thresholds. However, the quantity of Cr(VI) discharged to these sites is relatively small in comparison to the transfer station source term, which provided Cr(VI) to the subsurface between 1959 and 1967.

Reactor coolant solutions, once passed through the 105-D and 105-DR Reactors, were routed to the north into the 107-D and 107-DR Retention Basins and 116-DR-1&2 Trenches and then piped into the Columbia River through the outfalls. The larger fraction of the coolant volume discharged into the Columbia River through the outfalls but a smaller, although significant fraction was lost to the subsurface from the leaking infrastructure. These losses occurred between 1945 and 1967. The last and largest

discharge of reactor coolant was the intentional release of reactor coolant from March through June of 1967 into the 116-DR-1&2 Trenches.

A rough estimate of total chromium released from reactor coolant discharge at these various facilities is summarized in Table 4-5. Cr(VI) mass loss for 116-DR-1&2 from long-term operations is based on the compilation of waste discharges from historical record (PNL-6456 Vol. 2). At each trench, discharge of 40 million L (11 million gal) was estimated containing 40 kg (88 lb) of sodium dichromate or 28 kg (62 lb) of Cr(VI). The discharge volume in the 1967 test was approximately 13 billion L (3.4 billion gal). Assuming an average Cr(VI) concentration of 350 µg/L, a total chromium mass of 4,500 kg (10,000 lb) was released. For the retention basin system, losses can only be roughly approximated because the releases were unintentional. To make the rough approximation provided in Table 4-5, the annual discharge rate extrapolated from the injection test (40 billion L [11 billion gal]) was used as an upper bound for average retention basin leaks, knowing that the chronic discharge from retention basins created a smaller groundwater mound than that provided by the injection test (see Figure 2-12a versus Figure 2-12b). Assuming releases over a 22-year period at this annual rate, a total volume leakage of 900 billion L (240 billion gal) is estimated. If 10 percent of that total volume leaked, about 90 billion L (24 billion gal) containing about 60,000 kg (130,000 lb) of Cr(VI) leaked into the subsurface.

Table 4-5. Estimates of Hexavalent Chromium in Reactor Coolant Discharges to the Subsurface

Facility	Waste Type	Volume L (gal)	Cr kg (lb)	Estimate Source
116-DR-1&2 (1950-1967)	Reactor Coolant	8E+07 (2.1E+07)	28 (62)	PNL-6456[a]
	1967 Reactor Coolant Injection Test	1.3E+10 (3.4E+09)	4,500 (9,900)	BNWL-CC-1352[b]
107-D and 107-DR Retention Basins and Effluent Pipelines	Coolant	9E+10 (2E+10)	55,000 (120,000)	Fraction of Injection Test Rate (10 percent)
Total		**1E+11 (2E+10)**	**60,000 (130,000)**	

Notes:

a. PNL-6456, 1988, Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford (Volume 1 – Evaluation Methods and Results, Volume 2 – Engineered-Facility Sites {HISS Data Base} Volume 3 – Unplanned-Release Sites {HISS Data Base}), Pacific Northwest Laboratory, Richland, Washington.

b. BNWL-CC-1352, 1967, Ground Disposal of Reactor Coolant Effluent, Battelle Northwest Laboratory, Richland, Washington.

4.5.1.2 100-H Source Terms

Chromium product was used at 100-H to produce reactor coolant. The chromium product was stored within or near the 190-H Building where reactor coolant was generated. To date, no characterization data have been collected that indicate the loss of chromium product to the subsurface.

Cr(VI) was largely discharged into the subsurface as a dissolved species in reactor coolant and to a lesser degree in facility equipment decontamination fluids. Historical estimates of releases of Cr(VI) from specific sites (116-H-1, 116-H-2, 116-H-3, and 116-H-4) total 1,292 kg (2,848 lb). In addition, some unknown amount of Cr(VI) in reactor coolant was lost to the subsurface through leaks in the 116-H-7

Retention Basin and effluent pipelines. The Cr(VI) mass that passed through the reactor, effluent lines, and 116-H-7 Retention Basin was about 1.4 million kg (about 3 million lb). Of this mass, some fraction leaked directly into the vadose zone. Of these sources, only 116-H-3 (which received decontamination solutions) has reported concentrations (700 kg [1,500 lb] in 400,000 L [100,000 gal] or 1.75 g/L) above coolant levels. The persistent Cr(VI) concentrations near the 183-H solar evaporations basins suggest contamination is being mobilized into groundwater.

The 183-H Solar Evaporation Basin, waste site 116-H-6, (Chapter 2) has been modified closed under RCRA and is in post-closure care (RL-TPA-90-0001). Accepted WIDS site 100-H-33 was created to address the radiological contamination that is within the same footprint as 116-H-6. Since removal of the source of contamination (the basin liquids) in the late 1980s, contaminant concentrations in the groundwater have generally declined. However, fluoride, nitrate, Cr(VI), Tc-99, and uranium remain constituents of interest and have been monitored under the revised plan for corrective action groundwater monitoring (PNNL-11573). The radiological contamination will be addressed according to Data Gap No. 1 in this Chapter. Data Gap No. 1 addresses how waste sites will be characterized and cleaned up according to the interim action ROD. Data Gap No. 2 addresses how contaminated vadose zone beneath remediated waste sites will be characterized in this remedial investigation.

4.5.2 Hexavalent Chromium Transport in the Vadose Zone

Vadose soil sampling data and experiment leaching data provide the current basis for understanding Cr(VI) transport in the vadose zone. Sampling data have been collected in all three reactor areas and leaching data were collected for 100-D soils. In this section, discussion is organized in terms of the waste solution characteristics and discharge histories rather than reactor area because differences in vadose zone transport characteristics are likely distinguished by these properties. Sampling data have generally been focused in the more shallow portions of the vadose zone.

This data set shows a minority of sampled sites contains measurable contamination and suggests limited presence in the vadose zone. However, because deep vadose zone data are sparse, contamination occurrences at depth are uncertain. Leaching data suggest large range of chromium mobility in vadose zone sediments and the ratio of mobile versus non-mobile varies, depending on location. The leaching data suggest that despite apparently limited chromium deposits in the vadose zone, leachate solutions in excess of groundwater target goals can be exceeded at least on a local scale.

The process to identify unidentified waste sites including soil staining is addressed by the TPA-MP-14 process and the orphan site evaluation process. In the process, any stained area would be identified as a discovery site and considered by Ecology for approval as an accepted waste site.

4.5.2.1 Chromium Product Transport in the Vadose Zone (Center of 100-D Area)

Following discharge of chromium product into the subsurface (as described in this Chapter), vertical penetration commenced. The current database provides three general observations about the resulting distribution of Cr(VI) within the vadose zone.

- First, some portion of chromium product passed completely through the vadose zone in discrete locations and contaminated the unconfined aquifer. Those portions of the unconfined aquifer contaminated by chromium product are clearly indicated by Cr(VI) contamination levels well above maximum reactor coolant levels of up to 700 µg/L. The spatial orientation of the surface points of entry and the most highly contaminated areas in the unconfined aquifer suggest essentially vertical migration through the vadose zone with little lateral migration. That is, the current hot spots and the apparent plume origin locations are slightly downgradient of the chromium product discharge locations. In the southern plume, the hot spot is just south of the sodium dichromate transfer station

where chromium product was discharged directly into a French drain. In the northern plume, the hot spot lies just north of various facilities around the 105-D Reactor that released chromium product or other chromium-rich fluids. Plausible facilities are 185-D where an estimated 3,800 L (1,000 gal) of 70 percent solution (about 1,700 kg [3,700 lb]) of Cr(VI) leaked from a defective transfer line and the 116-D-1a and 116-D-1b Trenches east of the 105-D Reactor where an estimated 1,000 and 700 kg (2,200 and 1,500 lb), respectively, of sodium dichromate were discharged.

- Second, numerous factors point to rapid and efficient migration of Cr(VI) through the vadose zone. These include the high solubility of Cr(VI) (either in these solutions or in any subsurface water that mixed with the acid solutions during transport), the generally anionic aqueous speciation of Cr(VI) and associated low sorption capability, and the high permeability of the Hanford formation, which makes up the majority of the vadose zone, particularly under 100-D-12. Limited vadose zone sediment characterization data support these expectations. Available chemical analyses of vadose zone soils support the hypothesis of limited Cr(VI) in the vadose zone. These data show few locations where Cr(VI) is present above background levels. Maximum total chromium contamination levels have been measured in tests pits at 100-D-12 (516 mg/kg at 1.5 m [5 ft] bgs) and at 100-D-100, stained soil site just south of 100-D-12 near railroad tracks (a maximum of 1,310 mg/kg near surface). These sites clearly received highly concentrated source material but appear to have retained little contamination in the near surface.

- Third, leaching studies of chromium contaminated near surface soils have shown that sequestered chromium continues to be leachable. The major fraction of the chromium in these soils leached rapidly after contact with a few pore volumes while a minor fraction leached at a much slower rate. The presence of the more leachable fraction suggests physical sequestration either by capillary attraction in silty sediments or diffusion into soil grain coatings and incomplete flushing of the vadose zone with infiltrating water following deposition in the 1950s and 1960s. The less leachable fraction appears to be chromium that has been sequestered by chemical processes such as local reduction by natural iron (II) species or precipitation, perhaps in barium chromate phases. The apparent small volumes of contaminated soil indicated by the vadose zone characterization database suggest that these processes have affected only a small portion of the total Cr(VI) released into the subsurface and have been most effective near the points of entry.

Despite these observations, substantial uncertainties remain about the Cr(VI) distribution in the vadose zone. In particular, little characterization data exist from the deeper parts of the vadose zone, particularly the portion of the Ringold Unit E present above the water table, a thickness of about 3 to 9 m (10 to 30 ft), depending on the location. If current groundwater Cr(VI) contamination is being derived from the vadose zone source, it is most likely coming from contamination present in the deep vadose zone. Future contamination would also derive from the deep vadose zone, assuming that near surface remediation will effectively remove those source terms.

Given the uncertainties about levels of deep vadose zone contamination, three conceptualizations can be considered. First, the chromium product, because of its density and recharge from flushing water discharged simultaneously through the French drain, penetrated nearly completely through the vadose zone and into the unconfined aquifer or lower, leaving a small residue. Second, recharge conditions were insufficient to drive some unknown fraction of the chromium product into the unconfined aquifer, leaving that fraction as a residue in the Ringold Unit E. In this option, the residual mass could be large. Third, some fraction of the Ringold Unit E vadose zone residue deposited per conceptual model two was subsequently flushed from initial deposition location by unique discharge events. In this option, the residual mass would be substantially removed from its initial deposition area, leaving behind a small residue. These events are discussed in the groundwater section.

The three options described previously are not mutually exclusive and all provide the potential for providing current and future aquifer contamination, although the extent and severity of vadose zone contamination as a source term would appear to vary, both in terms of total chromium mass still present in the deep vadose zone and its level of reactivity. In any case, existing vadose zone contamination is subject to leaching by natural infiltration and nearby waste site remediation efforts that require application of water to the surface (e.g., for dust suppression).

Data Gap No. 10: *The mechanism to explain the persistence of the Cr(VI) plume is unknown.*

4.5.2.2 Reactor Coolant Transport in the Vadose Zone (Northern 100-D Area, the Horn and 100-H Area)

Transport of reactor coolant through the vadose zone was characterized by high volume losses through leaks in the retention basins, effluent transfer lines that carried reactor coolant from the reactors to the retention basins and auxiliary liquid waste disposal trenches. Given the high volume discharges and the highly permeable Hanford formation through which transport occurred (at reactor coolant transport locations, the Ringold E Unit is rarely present), drainage was rapid, causing observable buildup and maintenance of large groundwater mounds in the 100 D/H Areas and the Horn throughout the reactor operations period. Limited shallow characterization just beneath discharge facilities revealed measurable total chromium above background (less than 50 mg/kg) only under the retention basins at less than 6.1 m (less than 20 ft) bgs. Subsequent leaching tests involving contact of several pore volumes with the contaminated soils released less than 1 percent of the contaminant, showing how strongly fixed the chromium was to the soil.

Given these conditions and the low initial Cr(VI) concentrations, the opportunity for significant residual vadose zone contamination is considered minimal and the residual contamination that does exist is not capable of providing additional significant aquifer contamination. Essentially the Cr(VI) from this source term is considered present in the unconfined aquifer or the Columbia River.

A relatively small area of low Cr(VI) contamination (less than 50 μg/L) in the unconfined aquifer remains in 100-H, adjacent to the river (Figure 2-39). This area of Cr(VI) has been reduced in concentration and size since operation of the pump-and-treat system was started in 1996. However, the low concentration and relatively small area remaining may persist due to 1) incomplete capture from the existing pump-and-treat well network (DOE/RL-2009-15, page 2-34), 2) Cr(VI) remaining in the RUM beneath the unconfined aquifer at concentrations greater than 50 μg/L (Table 4-3) that is transported upward from the RUM to the unconfined aquifer when hydraulic gradients from the RUM to the unconfined aquifer are upward, or 3) a combination of the incomplete capture and upward transport from the RUM, and 4) a vadose zone source of Cr(VI) exists near the 183-H Solar Evaporation Basins.

4.5.3 Hexavalent Chromium Transport in the Unconfined Aquifer and the RUM Aquitard

Cr(VI) contamination of the unconfined aquifer likely began with the onset of significant reactor coolant leakage from retention basins (107-D, 107-DR, 1-7-H), liquid discharge facilities (116-DR-1 and 116-DR-2), and effluent lines connecting these facilities with the reactors. These discharges introduced Cr(VI) into the unconfined aquifer and dominated groundwater flow patterns throughout the reactor operations period. It is also presumed that some discharge of chromium product into the unconfined aquifer underneath the central 100-D occurred concurrently, although those discharges likely had minimal impact on groundwater flow patterns. Subsequently, with the cessation of operations, natural gradients were reestablished and river stage fluctuations from dam-controlled manipulations became the controlling processes for groundwater flow patterns. The mixture of operational and natural influences on groundwater flow patterns affected Cr(VI) distribution in the unconfined aquifer derived from both

chromium product and reactor coolant. These effects are conceptualized in the following sections for each type of waste stream.

4.5.3.1 Chromium Product Transport in the Unconfined Aquifer and the RUM

The various, plausible conceptual models of chromium product transport through the vadose raise uncertainty about the timing and rate of chromium product entry into the unconfined aquifer. Nevertheless, it seems likely that some Cr(VI) from these waste sources entered the unconfined aquifer in the early period of reactor operations at locations near the current hot spot heads of the north and south plumes. With the advent of 100-D-12 operations around 1959, aquifer contamination with Cr(VI) may have increased substantially. As soon as chromium product began to enter the unconfined aquifer in central 100-D in the early 1950s, water table mounding from discharges, primarily in the retention basin area, was creating gradients that superseded natural gradients and controlled Cr(VI) migration pathways.

From 1950 through 1967, chronic losses from the 107-D and 107-DR Retention Basins and the 116-DR-1&2 Cribs caused widespread groundwater mounding (see Table 2-2 for volume estimates). Near central 100-D, leakage from the 182-D Reservoir added to groundwater mounding. Head data at groundwater monitoring Well 199-D5-12 just east of the 105-D Reactor (Figure 4-5) show the effects of groundwater mounding in the early 1960s with water table elevations about 1.8 m (6 ft) above current levels. Because these discharges occurred near the Columbia River, the resultant groundwater mounds largely reversed natural gradients throughout much of 100-D (Figure 2-12a) and pushed Cr(VI) entering the unconfined aquifer at the chromium product points of entry toward the south and west.

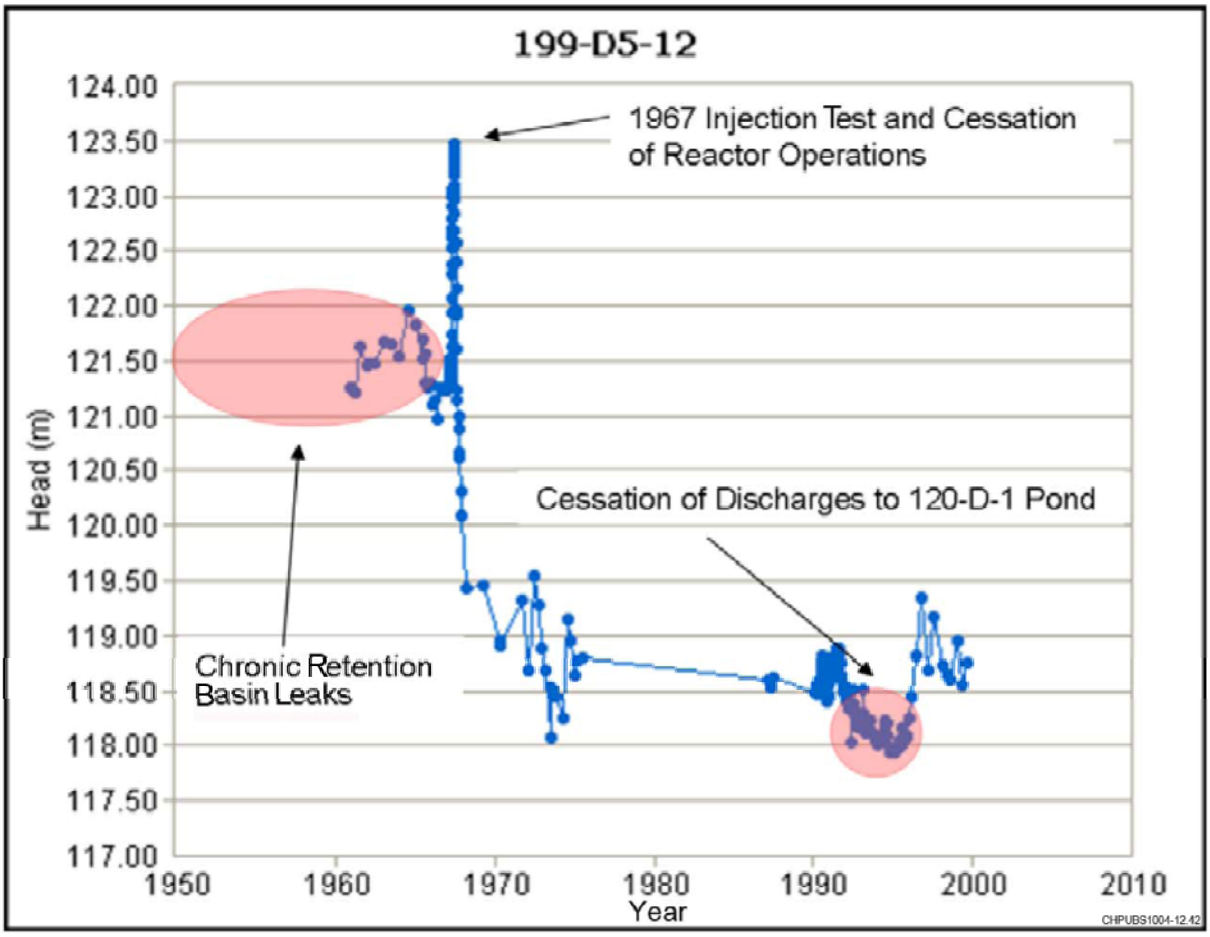


Figure 4-5. Chronology of Head Measurements at Groundwater Monitoring Well 199-D5-12 in the Central 100-D Area

In early 1967, a temporary and intense hydraulic gradient created by the 4-month-long discharge of reactor coolant into 116-DR-1&2 enhanced the gradients to the south and west (Figure 2-12). This event raised the water table temporarily about another 2.7 m (9 ft) at groundwater monitoring Well 199-D5-12. At the same, 105-D and 105-DR Reactor operations ceased and the associated groundwater mounding quickly dissipated (see Figure 2-10). After 1967, the 182-D Reservoir continued to provide a relatively smaller southerly and westerly gradient, with additional mounding from the 120-D-1 Pond releases between 1977 and 1992. Given the smaller water losses from these facilities, gradient effects were not as strong or as widespread as retention basin leaks during reactor operations. Well coverage around these facilities has not been sufficiently extensive, either spatially or temporally, to accurately the level or extent of gradient influence caused by these discharges. However, the reduction in head level at groundwater monitoring Well 199-D5-12 after 1992 (Figure 4-5) is likely related to the cessation of discharges at the 120-D-1 Pond.

Data Gap No. 14: *Leakage (current and future) from the 182-D Reservoir and export water lines may affect groundwater flow, contaminant transport, and effectiveness of remedies.*

During the reactor operations period, migration rates of Cr(VI) in the unconfined aquifer were maximized because of the larger gradients imposed by the groundwater mounds. How much of the total Cr(VI) in the

chromium product would have entered the unconfined aquifer and spread inland depended on the dominant vadose zone migration rates that controlled aquifer contamination rates. The plausible migration scenarios are as follows:

- If the chromium product maintained its high density and inclination for rapid vertical migration, vertical penetration through the unconfined aquifer to the RUM and even into the RUM may have occurred, thereby reducing Cr(VI) availability for inland migration. A stratigraphic feature that may have aided the sequestration of chromium product in the RUM is a surface depression in the RUM (Figure 2-5) that could have acted as sink for the dense fluid.
- If chromium product lost its density by mixing with the groundwater or reached the part of the lower vadose zone temporarily incorporated into the unconfined aquifer because of water table elevation from operational discharges, inland migration and Cr(VI) depletion in central 100-D could have been substantial.
- Finally, if chromium product did not descend into that part of the vadose saturated by reactor operation discharge, the Cr(VI) in this source term is likely still present in the vadose zone and subject to leaching from ongoing recharge from natural precipitation or remediation efforts.

With the cessation of operational discharges in 1967, natural gradients were restored quickly and began to control Cr(VI) migration. Natural gradient flow in central 100-D is toward the Columbia River and roughly perpendicular to the shoreline. In addition, river stage fluctuations routinely cause variations in flow direction. These fluctuations primarily result from discharge through Priest Rapids Dam, located approximately 19 km (12 mi) upstream of the 100-D, which vary seasonally, daily, and hourly, depending on dam operations. Changing the river stage influences the groundwater elevations several hundred meters inland from the river, although wells further inland demonstrate a delayed response to river stage changes. During the year when river stage is relative low (e.g., in the fall), natural groundwater flow is toward the river. During the year when river stage is relatively high (e.g., in the spring), groundwater movement is inland away from the river. An analysis of the variations in groundwater flow direction showed seasonal changes as much as 70 degrees upriver and 20 degrees downriver from perpendicular (PNNL-14111, *Fiscal Year 2003 Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project*). The analysis used three points inland of the ISRM barrier and three points on the riverward side of the barrier (Figure 4-6).

In addition to the natural gradient and river stage fluctuations, other features that are influencing flow directions locally are continued leakage of stored river water beneath the 182-D Reservoir and more recently, injection/extraction well operations along the shoreline and just west of 105-D Reactor. In addition, recent watering at remediation waste sites for dust suppression (e.g., during the removal of the 185-D Building and underlying soils) may have created a localized increase in recharge, a temporary increase vadose contamination leaching and discharge into the unconfined aquifer. Variations in the surface of the RUM (e.g., paleochannels) that create preferential pathways for groundwater flow, particularly during periods of low groundwater elevation, and operation of groundwater extraction and injection wells, may also be providing local influence.

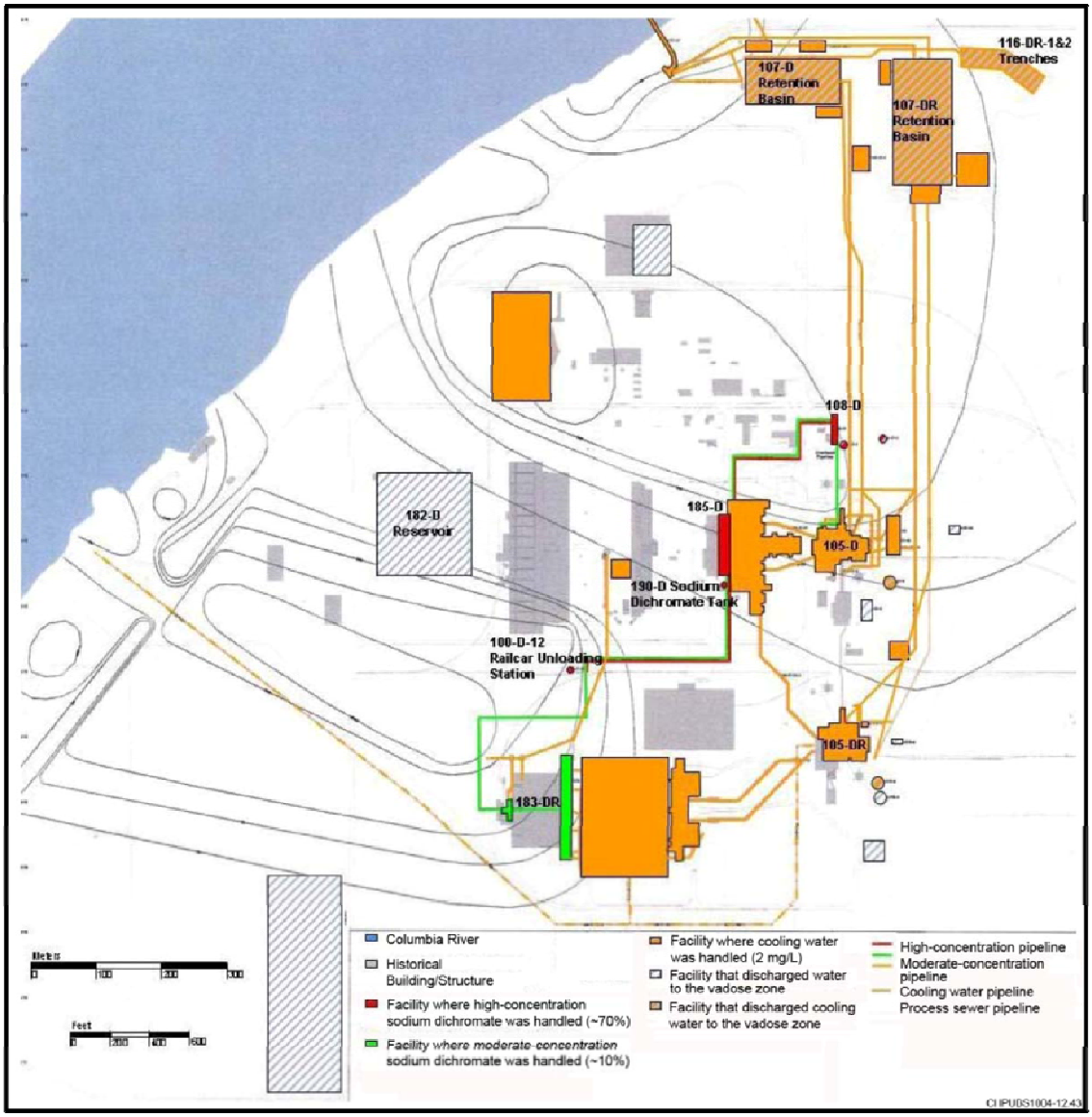


Figure 4-6. Seasonal Variability in Groundwater Flow Directions near the Columbia River in the Southern Portion of the 100-D Area

The current configuration of the Cr(VI) plume in central 100-D (Figure 2-37) appears to reflect the groundwater migration pattern of chromium product Cr(VI) that has been imposed since the late 1960s and the surface discharges that occurred during reactor operations. Two distinct hot spot areas are present that currently correspond reasonably well in terms of vertical alignment with the two areas of focused chromium product discharge indicated by historical record. In addition, the more concentrated hot spot in the southern plume is consistent with the hypothesis that the most concentrated chromium product was discharged in higher volumes through the sodium dichromate transfer station. Each hot spot forms the head of a plume, referred to as the southern plume and the northern plume. The heart of the southern plume is a persistent high Cr(VI) concentration zone (up to 40,000 µg/L) that extends in a westerly orientation toward the river from 100-D-12. The axis of the northern plume is oriented in a northerly orientation with a persistent high Cr(VI) concentration zone that is not as concentrated as the southern plume (greater than 500 and less than 3,000 µg/L). These preferential flow directions are consistent with

several decades of flow dominated by the natural gradient with small deflections from the natural gradient direction imposed by chronic leakage from the 182-D Reservoir (i.e., more westerly for the southern plume and more northerly for the northern plume). The hot spots also appear to have moved toward the Columbia River relative to the apparent original point of entry into the unconfined aquifer. The reservoir leakage has also maintained a separation of the two plumes.

Data Gap No. 9: *The rate of chemical and hydraulic exchange between the aquifer and the river in the near shore is unknown (Section 4.8).*

Cr(VI) discharge into the Columbia River began to occur sometime after the restoration of natural gradients. The rate of discharge is not well understood, but migration rates were slower than those during the reactor operations period because of the smaller gradient imposed by natural conditions versus reactor operations. It is likely that the contamination zone extended into the Columbia River before remediation efforts began in the late 1990s. Currently, discharge into the Columbia River is being partially mitigated by the ISRM and extraction wells along the shoreline. The persistence of the plumes despite these removal efforts indicates continued presence of sources that are leaching Cr(VI) into the unconfined aquifer. Given the various migration options considered previously, plausible sources are contamination still present in the lower vadose zone, the unconfined aquifer, and the RUM.

Penetration of waste into the RUM has not yet been fully evaluated. It is plausible that this has occurred under 100-D-12 or along the migration path toward the Columbia River from central 100-D. Given the potential quantities of discharged waste, significant Cr(VI) contamination may be present under 100-D-12. If so, relatively slow release of Cr(VI) into the unconfined aquifer from the RUM, combined with release of trapped Cr(VI) in the aquifer sediment, may have been acting since the early 1950s as a chronic source term for spreading aquifer contamination. Some transport through the RUM is also plausible.

If Cr(VI) is present in the RUM near the Columbia River, it could be an active source for current shoreline contamination. This hypothesis is supported by vertical groundwater gradient calculations based on groundwater elevations measured in Wells 199-D8-54A and 199-D8-54B. Water levels fluctuate in a similar fashion in magnitude of groundwater fluctuation and temporally, indicating that groundwater levels in the RUM and upper aquifer respond similarly to changing river stage in 100-D. During the time that water levels were available before Well 199-D8-54A was converted to a groundwater extraction well, the downward vertical gradients (from the upper aquifer to the RUM) were measured 6 percent of the time, upward vertical gradients (from the RUM to the upper aquifer) were measured 92 percent of the time, and no vertical gradient was measured 2 percent of the time (48 total measurements from 1992 to 1996). Given the predominantly upward hydraulic gradient measured from the RUM to the unconfined aquifer, a source of Cr(VI) from a relatively high density liquid could continue to act as a source to the persistent Cr(VI) south plume in 100-D.

Data Gap No. 8: *It is unknown if contamination within the RUM will adversely impact aquatic receptors in the Columbia River (Section 4.8).*

4.5.3.2 Reactor Coolant Transport In the Unconfined Aquifer and the RUM Aquitard

Reactor coolant discharged to the subsurface in two areas—the retention basin complexes in the northern corner of 100-D and in the eastern portions of 100-H. The following text discussed the effects of these releases on groundwater flow and Cr(VI) migration in the unconfined aquifer.

4.5.3.3 Hexavalent Chromium—100-D Area and Horn

Reactor coolant solutions that once passed through the D and DR Reactors were routed to the north into the 107-D and 107-DR Retention Basins and 116-DR-1&2 Trenches, and then piped into the

Columbia River through the outfalls. The larger fraction of the coolant volume discharged into the Columbia River through the outfalls, but a significantly smaller fraction was lost to the subsurface from the leaking infrastructure. These losses occurred between 1945 and 1967. The last and largest discharge of reactor coolant was the intentional release of reactor coolant from March through June 1967 into the 116-DR-1&2 Trenches. The presence of a long-term groundwater mound from chronic releases to the 116-DR-1&2 Retention Basins was present between 1945 and 1967. Snapshots of the mound size from the chronic operational discharges and the 1967 injection test are shown in Figure 2-12 and 2-12. After 1967, release of reactor coolant into the Horn essentially ceased.

Once the reactor coolant released into the subsurface, it migrated rapidly through the vadose zone and into the unconfined aquifer, creating groundwater mounds. Rapid and sustained mounding was due to the sustained high discharge rates and high permeability of the vadose zone, as well as moderate to high permeability of the unconfined aquifer sediments (Ringold Unit E in 100-D and the Hanford formation elsewhere). The discharge rates were high enough to cause groundwater mounding sufficient to transport contaminants across the Horn, from 100-D to 100-H. Cr(VI) at concentrations of between 350 and 700 µg/L moved with the spreading coolant and dispersed, encompassing the entire 100-D area and the western part of the Horn as early as the 1950s. Over time, Cr(VI) continued to disperse outward from the retention basins at some rate and then expanded greatly in 1967 because of the injection test. Not long after the injection test, reactor operations ceased and the groundwater mounds decreased rapidly (Figure 2-12). Chapter 2 describes water table elevations in September 1967 and shows significant reduction in the groundwater mound that had been present in June 1967. These data are consistent with a relatively high-permeability vadose zone and unconfined aquifer east of 100-D. These data also imply that in late 1967, the source providing Cr(VI) contamination from 100-D to the Horn was significantly reduced after the groundwater mounds dissipated.

While this source was a minor contributor to Cr(VI) contamination in those portions of 100-D unconfined aquifer receiving chromium product, it was the primary source of contamination elsewhere in 100-D and in the Horn. The Cr(VI) contamination that might have imbedded in the RUM during these rapid distribution events is poorly understood. However, the potential for this process seems minimal, given the rapid migration in the aquifer and the dilute water chemistry. Recent groundwater data collected in the RUM at three locations support this hypothesis. The largest concentration measured was 29 µg/L, measured 15 m (50 ft) below the RUM surface in Well 699-97-48C (DOE/RL-2008-42). This well is near an old well constructed in 1962 (699-94-49) that penetrated and was perforated in the RUM. Well 699-94-49 could have provided an artificial conduit for Cr(VI) in the reactor coolant discharged into 116-DR-1&2 in 1967.

Following the widespread and rapid distribution of Cr(VI) in the unconfined aquifer, it continued to migrate, although at increasingly slower rates as the groundwater mound created by coolant discharges dissipated. Much of the initial inventory migrating northward and westward likely discharged into the Columbia River relatively quickly. Document BNWL-CC-1352 estimated that 70 percent of the injected fluid migrated almost immediately into the Columbia River. The estimate was based on a calculation of the additional volume underneath the water table that had risen because of the injection. Because groundwater monitoring was minimal between 1967 and the early 1990s, the nature of the migration pathways must be inferred from recent data.

The current Cr(VI) distribution across the Horn and prevailing groundwater flow directions (Chapter 2) suggest that Cr(VI) migration has been primarily to the east after the groundwater mounds dissipated. Water elevation tables provided by BNWL-CC-1352 before, during, and after the 1967 injection test suggest that reassertion of regional groundwater gradients in the Horn would have occurred within months. Figure 1-23 shows a wide band of Cr(VI) contamination oriented along a west-to-east axis

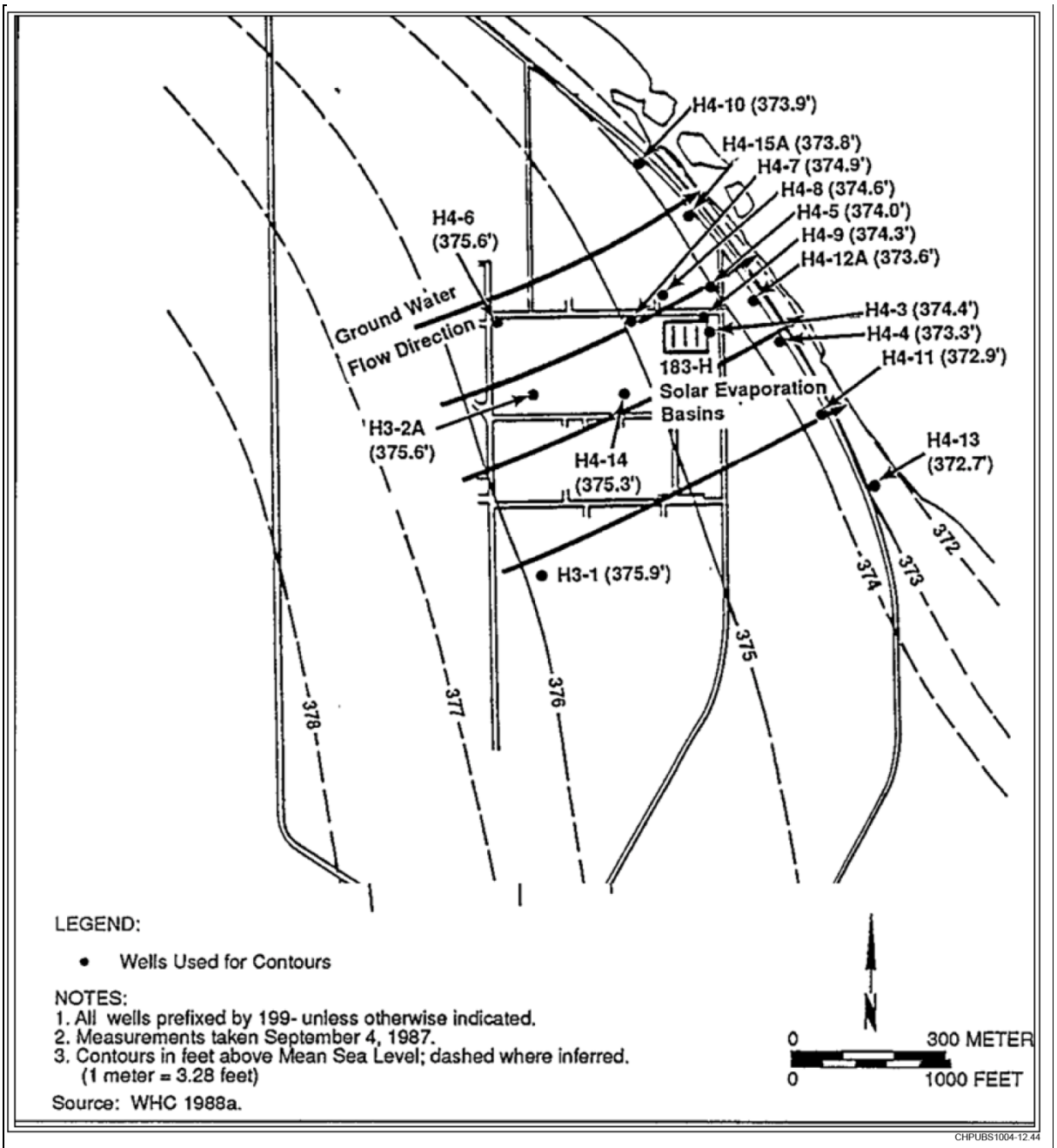
consistent with the general flow pattern that widens downgradient. The plume extends to the Columbia River and includes a dilute outer zone (about 20 to 50 µg/L) and a more concentrated inner zone (about 50 to 100 µg/L). This configuration suggests significant Cr(VI) migration toward and discharge into the Columbia River over the last 40 years. The fact that the maximum groundwater concentrations are substantially below the inferred initial starting concentrations of about 350 µg/L also indicates that the majority of the initial inventory in the Horn has discharged into the Columbia River or has attenuated in the aquifer via dispersion and dilution. The rather abrupt truncation of the plume at the edge of 100-H is attributed to recent pump-and-treat operations in 100-H, which have been ongoing since 1997 to remove Cr(VI) from the 100-HR-3 OU. The zone north of the contamination band that is less than 20 µg/L Cr(VI) roughly coincides with an abrupt thickening of the aquifer, which may be diluting incoming Cr(VI) concentrations and facilitating more rapid migration rates.

Additional migration of the Cr(VI) will continue at some rate. Groundwater monitoring data collected since the early 1990s provide very limited information about the rate of migration across the Horn. Few wells have been sampled over a 10-year period and, of these wells, modest decreases in Cr(VI) concentrations are indicated in some wells around the outer edges of the plume (Chapter 2). Recently, 21 new wells have been added to characterize the groundwater within the Horn area. Groundwater sampling has indicated a diffuse, continuous plume between the D and H Reactor areas (DOE/RL-2008-42).

4.5.3.4 Hexavalent Chromium—100-H Area

Cr(VI) was largely discharged into the subsurface as a dissolved species in reactor coolant and to a lesser degree in facility equipment decontamination fluids. Historical estimates of releases of Cr(VI) from specific sites (116-H-1, 116-H-2, 116-H-3, and 116-H-4) total 1,292 kg (2,848 lb). In addition, some unknown amount of Cr(VI) in reactor coolant was lost to the subsurface through leaks in the 116-H-7 Retention Basin and effluent pipelines. The Cr(VI) mass that passed through the reactor, effluent lines, and 116-H-7 Retention Basin was about 1.4 million kg (about 3 million lb). Of this mass, some fraction leaked directly into the vadose zone. Of these sources, only 116-H-3 (which received decontamination solutions) has reported concentrations (700 kg [1,500 lb] in 400,000 L or 1.75 g/L) above coolant levels.

The highly permeable Hanford formation makes up both the vadose zone and the unconfined aquifer. Once in the aquifer, subsequent migration and discharge into the Columbia River was likely unimpeded by man-made factors such as those noted at 100-D. Significant groundwater mounds from historical or ongoing unintentional discharges between the source locations and the Columbia River have not been present, and the mounding that was sustained would have subsided quickly (e.g., water table contours in 1987 (Figure 4-7 [DOE/RL-88-35, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-1 Operable Unit, Hanford Site, Richland, Washington*]) are uniform, implying a natural gradient). In addition, few (if any) known waste fluids were acidic and dense. Thus, the potential for significant transport of contaminant mass into the RUM is considered minimal. However, additional site investigations are being conducted to address low concentrations of Cr(VI) in the RUM.



Source: DOE/RL-88-35

Figure 4-7. Water Table Map of the 100-H Area in 1987

A geologic feature that also influences contaminant migration toward the Columbia River is the structural high in the RUM that runs through 100-H and lies between the liquid discharge sites and the Horn (Chapter 2). At the ridge, the unconfined aquifer thins and may provide a barrier to westerly flow that may have been induced by mounding from leaking basins. The ridge could also have provided a barrier to incoming Cr(VI) contamination from the Horn. Given these factors, it seems reasonable to assume that a relatively large portion of the postulated source has already discharged into the Columbia River before pump-and-treat operations began. The fact that aquifer contamination has been effectively reduced over

an 11-year period in response to pumping suggests that the remaining source term is relatively small compared to that in 100-D.

Despite the proposed efficiency of Cr(VI) discharge to the Columbia River, Cr(VI) has been detected in the RUM and the underlying confined aquifer, seemingly more prevalent than what has been observed at 100-D or in the Horn beneath the unconfined aquifer. In addition, some contamination of the confined aquifer has been observed. Three hypotheses may explain the more prevalent Cr(VI) observed beneath the unconfined aquifer in 100-H:

- Cross-contamination by a poorly sealed connecting well
- A downward hydraulic gradient created by groundwater mounding from leaking basins
- Sandy lenses in the RUM that are exposed to Cr(VI) contamination in the unconfined aquifer through which contaminants are transported

The cross-contamination of hydrogeologic units from poorly sealed wells is not likely a large source of contamination because few wells connecting different hydrogeologic units have been drilled and the contamination may be more widespread than what might have been supplied by an occasional well. Additional aquifer testing and analysis was performed in 2009 to evaluate this hypothesis (SGW-41302, Rev. 0, *Description of Work for Aquifer Testing in Support of the 100-H Deep Chromium Investigation*, 2009). During the test, Wells 199-H3-2C and 199-H4-12C were pumped at a constant rate for approximately 30 days in the first quarter of FY10. Well H4-12C was pumped at 20 gallons per minute and produced Cr(VI) concentrations of 90-110 µg/L and Well H3-2C was pumped at 40 gallons per minute and produced 15-40 µg/L. The persistence of the elevated concentrations suggests that the presence of the Cr(VI) likely is due to a larger source such as that from reactor operations and associated groundwater mounding of cooling water (700 µg/L). In addition, it appears that the concentration decreases inland away from the reactor, further supporting an origin related to reactor operations and groundwater mounding in an area adjacent to the reactor and between the reactor and the river.

With regard to mounding the RUM, despite containing lenses of more permeable sandy sediments, it is thick, largely silt and clay-rich and, therefore, likely competent overall. There is no evidence of substantial leakage and contaminant transport vertically through the RUM to lower hydrogeologic units. Therefore, mounding during reactor operations most likely contributed very little (if any) contamination to hydrogeologic units beneath the unconfined aquifer. However, groundwater elevations measured in Wells 199-H4-12A and 199-H4-12C in 100-D/H generally fluctuate similarly in response to river stage, indicating that groundwater levels in the RUM and upper aquifer respond similarly to changing river stage in 100-H. Downward vertical gradients (from the upper aquifer to the RUM) were measured 54 percent of the time, upper vertical gradients (from the RUM to the upper aquifer) were measured 43 percent of the time, and no vertical gradient was measured 3 percent of the time (190 total measurements from 1992 to 1996).

Geologic evidence suggests that sandy lenses with the RUM are exposed to Cr(VI) contamination in the unconfined aquifer, which could provide a pathway for contaminant transport into higher permeability zones of the RUM. Such exposures could occur anywhere along the contact between the Hanford formation and the RUM, but the most likely location would be near the shore, where the RUM surface declines steeply (Figure 2-5), presumably because of erosion from the Columbia River channel incision. If some of the more permeable interior sandy lenses are exposed along this erosion face, it is possible that a conduit for Cr(VI) migration into the RUM has taken place. As Cr(VI) migrates across the erosion front, some fraction would contact the exposed lenses. During high-river-stage periods in the spring when water is pushed inland, some Cr(VI) would enter those lenses, migrate toward the west (as long as the high river

stage lasted), and become trapped. The amount of mass that could have been introduced into the RUM in this way, if it occurred, cannot be quantified at present. Conversely, the subsequent discharge of Cr(VI) now in the RUM into the Columbia River is uncertain.

Data Gap No. 8: *It is unknown if contamination within the RUM will adversely impact aquatic receptors in the Columbia River.*

Based on current knowledge of the elevation of the RUM from inland wells and river bathymetry, the top of the RUM intersects the river channel, toward the bottom of the channel in 100-D/H; however, detailed bathymetric data and geologic information are needed to confirm this. The Columbia River RI will be collecting data that will be incorporated into our understanding of the effect of the RUM on groundwater upwelling into the Columbia River.

Additional migration of Cr(VI) will continue at some rate. In addition, the success of pump-and-treat operations in removal of Cr(VI) from the unconfined aquifer suggests that the remaining source term is limited.

4.5.4 Groundwater/River Interactions

Data Gap No. 6: *The level of groundwater contamination entering the Columbia River (in particular, the hyporheic zone) is not well known.*

Data Gap No. 9: *The rate of chemical and hydraulic exchange between the aquifer and the river in the near shore is unknown.*

Groundwater moves in a dynamic process and is assumed to mix with river water. This mixing process is driven by groundwater elevations on both sides of the river in conjunction with daily and seasonal changes in river stage. A wide range of mixing ratios has been observed (SGW-39305, *Technical Evaluation of the Interaction of Groundwater with the Columbia River at the Department of Energy Hanford Site, 100-D Area*) between upwelling water at the bottom of the river and groundwater at near-shore locations. This mixing ratio represents a continuum from pure groundwater to pure river water, depending on where in the groundwater pathway a measurement is taken. Figure 4-8 presents a conceptual model of groundwater/surface water interactions. Flow is hypothesized to enter the river from both the unconfined aquifer and through the less transmissive RUM. Entry to the river can be at river shore seeps and points of upwelling into the river. It is unknown to what extent that upwelling might occur in the areas known to contain salmon redds (Figure 4-9). Groundwater upwelling sampling and analysis in the Columbia River channel is planned for the fall of 2009 (DOE/RL-2008-11, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River*, Rev. 0) and it is expected that these data will provide further insight regarding contaminant levels entering the river and what (if any) undesirable health effects groundwater upwelling may have on people, animals, and plants that use or live in the river.

4.5.5 Pump-and-Treat Operations

The 100-HR-3 OU pump-and-treat system in 100-H has been effective in reducing the concentration and extent of Cr(VI) in groundwater. Compared to the start of pump-and-treat operations in 1997, a relatively small and low-concentration Cr(VI) plume remains adjacent to the river. However, based on the known groundwater flow across the Horn (Figure 2-8), the continued presence of relatively high concentrations (2,000 to 5,000 μg/L) of Cr(VI) in 100-D will continue to impact 100-H.

Since full-time operation of the pump-and-treat systems was initiated in 100-D, the extent and concentrations of contaminants in the groundwater in 100-D have not been substantially reduced.

4.5.6 Potential Alternative Remedial Technologies

Data Gap No. 11: *Potential alternative remedial technologies have not been sufficiently investigated.*

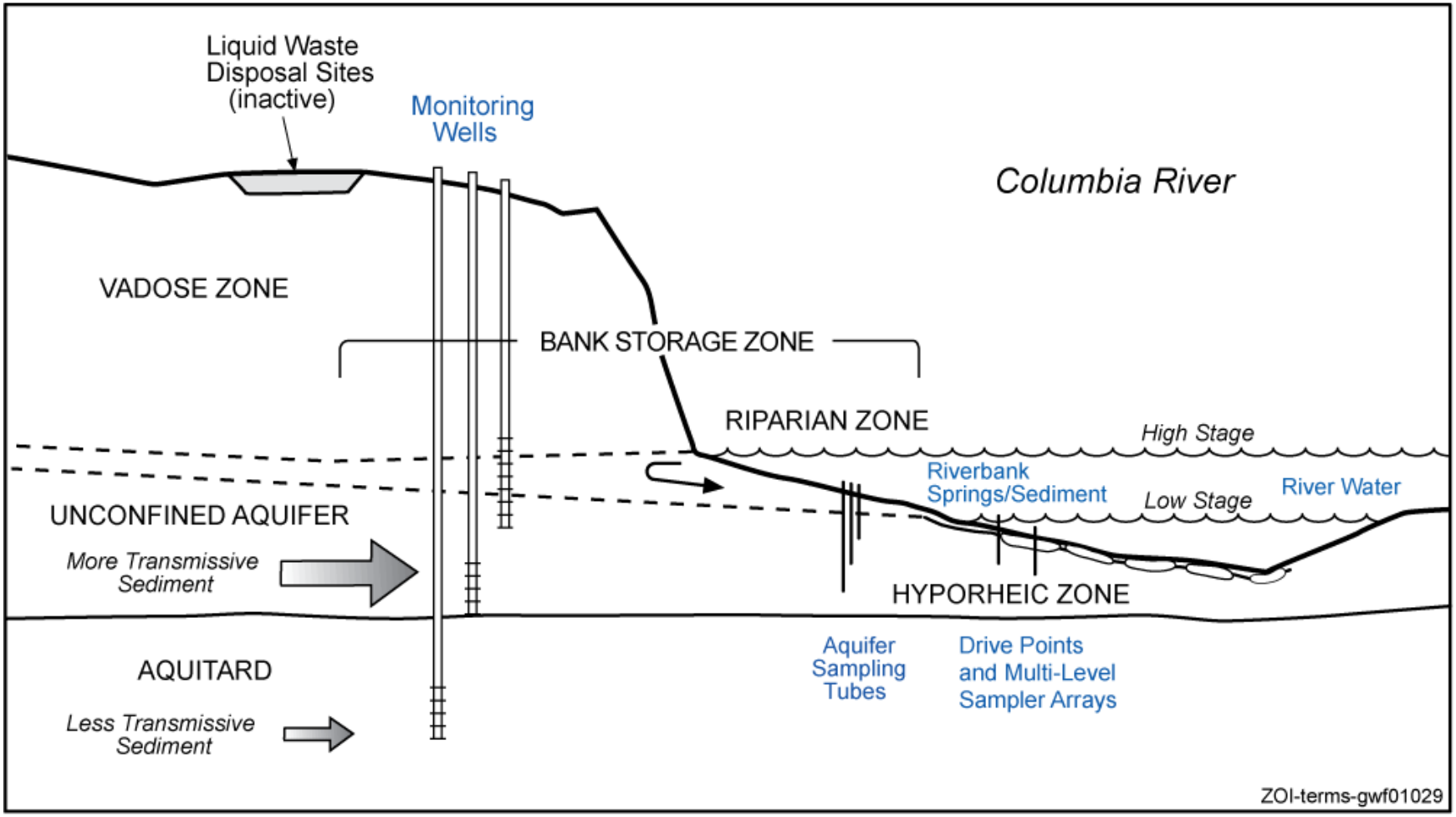


Figure 4-8. Groundwater/Surface Water Flow Path

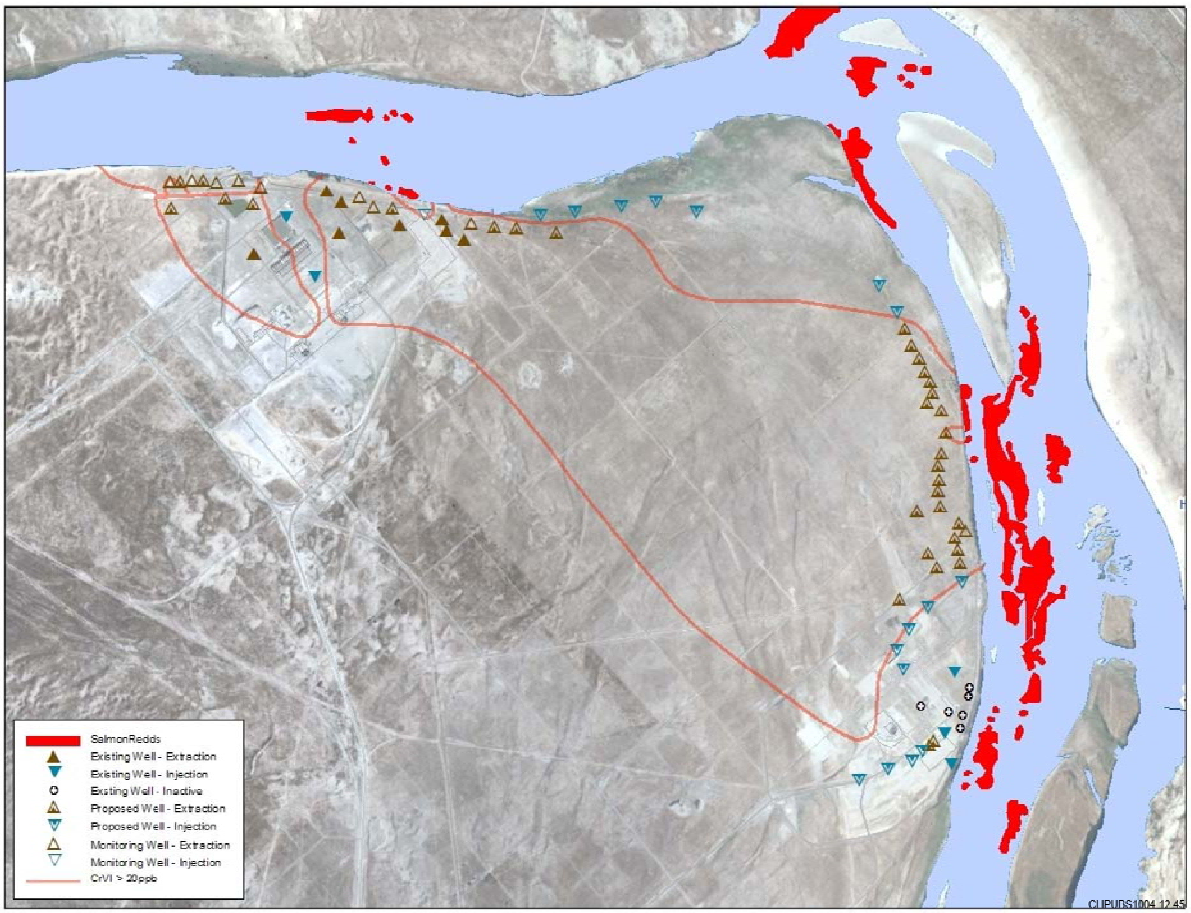


Figure 4-9. 100-D/H Hexavalent Chromium, Showing Salmon Redds

Groundwater contamination above aquatic standards and drinking water maximum contaminant levels has been detected in 100-D/H. Interim remedial actions are currently in operation. Additional data and information are needed to evaluate potential final remedies as part of the future project feasibility study.

4.6 Human Receptors and Exposure Pathways

A number of evaluations of exposure of human receptor pathways to contaminants in the 100 Area have been conducted in support of remediation. Activities performed include the LFIs and qualitative risk assessments (QRAs) to support interim action ROD remedy selection. In addition, the cleanup verification process that follows remedial actions under interim action RODs includes an evaluation of human exposure and assessment of risk for each waste site. Ongoing exposure evaluation and risk assessment activities include the River Corridor Baseline Risk Assessment (RCBRA) (DOE/RL-2007-21, *Risk Assessment Report for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment*), which further evaluates the protection of human health using exposure scenarios that reflect future potential land uses that were not defined during past risk assessment activities. Additional ongoing human health exposure evaluation and risk assessment activities pertaining to 100 Area Hanford Site contamination include the remedial investigation for Hanford releases to the Columbia River. These evaluations are discussed in detail in Chapter 4 of the work plan. In addition, Chapter 4 of the work plan

contains a discussion of uncertainties associated with the risk assessment results and the additional information needed to be developed to reduce uncertainty.

Data Gap No. 13: *Data are needed to better define the spatial and temporal distribution of groundwater contamination.*

4.7 Ecological Receptors and Exposure Pathways

Exposure of ecological receptors to 100 Area contaminants has been characterized in support of remedial action decisions. Initially, to support interim action RODs remedial decisions, a streamlined evaluation of exposure and risk to ecological receptors was conducted in the QRAs. Subsequently, a baseline ecological risk assessment was performed to characterize ecological exposures and risk. These evaluations are discussed in detail in Chapter 4 of the work plan.

4.8 Identification and resolution of Data Needs

Data needs relative to 100-D/H are discussed in this section. The Systematic Planning Process for the identification and resolution of data needs is summarized in the Integrated Work Plan, Chapter 1, Section 1.5. During systematic planning workshops for 100-D/H (which included DOE, EPA, and Ecology), plates describing CSM components were discussed. Uncertainties associated with the CSM led to identification of data gaps. Appendix A provides copies of the component plates developed as part of the systematic planning process. The data gaps and data needs discussed in this section consider the outcome of the component plates developed during the systematic planning process and were further refined during the preparation of this work plan.

Area-specific data needs and potential resolutions to identified data needs are discussed in this section. Data needs in this context include analytical needs (e.g., laboratory sample results), quantitative data (e.g., sample geographical coordinates), and process-related needs (e.g., fate and transport calculations). This section further describes the data and information collection necessary to resolve the data needs, as well as the data gaps described in the CSM that are intended to be addressed.

Table 4-6 lists the data gaps and associated data needs, and summarizes the scope of work proposed to address the need. Further details can be found in the Sampling and Analysis Plan (DOE/RL-2009-40). Tables 4-7 and 4-8 summarize the field program necessary to fill the data gaps.

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Table 4-6. Proposed Sampling Program for Remedial Investigation for 100-D/H

Data Gap	Data Need No.	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 below unremediated waste sites to assess nature and extent of contamination in the vadose zone.	Continue interim remedial actions as they have demonstrated to be efficient in obtaining the necessary data during remediation using the observational approach. Obtain data documenting the remaining residual contamination following completion of the interim remedial action.	Yes	Complete interim remedial action as applicable and sampling at 127 waste sites in 100-D/H. The location of unremediated waste sites is shown in Appendix B. This work will be completed during field remediation and the results for many of the 127 waste sites are expected to be available for use in the D/H RI/FS Report.	The remedial action directed by the interim RODs is needed to protect human health and the environment. Data collected at the completion of interim action are needed to document residual contamination concentrations following interim remedial action and compliance with direct exposure and groundwater protection RAGs presented in the interim RODs.
Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.	2	Characterize beneath and adjacent to remediated waste sites to assess the nature and extent of contamination in the vadose zone.	Drill ten boreholes and two groundwater monitoring wells; also excavate five test pits. Samples will be collected and analyzed to assess vertical extent of contamination in the vadose zone at borehole and well locations. The test pits will be excavated to assess potential Cr(VI) sources and verify potential levels of contamination to a maximum depth of 7.6 m (25 ft). Details are in the SAP (DOE/RL-2009-40). Most of the test pits will be excavated to a depth of approximately 6.1 m (20 ft).	Yes	Drill one borehole in the following waste sites: 116-D-1B Trench, 116-D-7 Retention Basin, 116-DR-1&2 Trench, 116-DR-9 Retention Basin, 116-H-1 Trench, 116-H-4 Pluto Crib, 116-H-6 Solar Evaporation Basin, 116-H-7 Retention Basin, 118-D-6:3 Reactor Fuel Storage Basin, 118-H-6:3 Reactor Fuel Storage Basin (Boreholes B1 to B10, Figure 4-10). Drill one groundwater monitoring well at 100-D-12 French Drain and 116-D-1 A Trench. One trench will be excavated at each of the following waste sites: 100-D-12 French Drain, 100-D- 4 Trench, 116-D-4 Crib, 116-H-2 Trench/Crib, and 1607-H4 Septic System (Location TP1 – TP5, Figure 4-10). Soil samples will be collected and analyzed. Samples will be collected in D Area boreholes at the Hanford/Ringold lithologic change.	Characterization will be performed to validate interim remedial action, address uncertainty regarding nature and extent of residual contamination in soils, refine the conceptual site model (if necessary), and support decision making for the final ROD for 100-D/H. In addition, characterization data collected beneath remediated waste sites will be used to field-validate the current conceptual site model. These data will also be used to confirm RESRAD modeling input parameters, assumptions, and predictions regarding contaminant migration.
Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath and around reactor structures.	3	Characterize beneath and around the reactor structures to assess nature and extent of contamination in the vadose zone.	Drill two boreholes near the reactor structure in an area most likely to contain soil contamination. Samples will be collected and analyzed to assess vertical extent of contamination in the vadose zone.	Yes	Drill one borehole in the boundary of the 118-D-6 Reactor Fuel Storage Basin in 100-D. Drill one borehole in the boundary of the 118-H-6 Reactor Fuel Storage Basin in 100-H (Boreholes B9 and B10, Figure 4-10). Soil samples will be collected and analyzed.	The reactor fuel storage basins were selected for characterization for two or more of the following reasons: documented leaks, remedial action depth of excavation may not be sufficient, contamination may extend beyond the depth of remedial action, contamination detected exceeds WAC 173-340, very high concentrations of radionuclides and chemicals were present in concrete samples, or lack of samples beneath fuel storage basins.
Unidentified waste sites (orphan/ discovery sites) may exist in 100 D/H. Unidentified sites may include chromium contamination in surface soils due to undocumented spills.	4	Identify new waste sites and potential sources of contamination.	Complete orphan site evaluation process in the Horn and supplemental survey of 100-D Operational Area.	Yes	Complete orphan site evaluation process in the D/H Horn Area. In addition, a supplemental post RTD survey will be conducted of the 100-D Operational Area. The survey will consist of an observation-based walk down during the wet season to identify surface stained soil that may indicate chromium contamination.	The orphan site evaluation and waste site discovery processes are performed to identify new waste sites and sources that are not in CERCLA decision documents.

Table 4-6. Proposed Sampling Program for Remedial Investigation for 100-D/H

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The nature and extent of contamination in the unconfined aquifer above cleanup standards has not been defined in select areas.	5	Define the extent of groundwater contamination above cleanup standards in select areas of the unconfined aquifer.	Determine the extent of select contaminants (e.g., Cr(VI)) at concentrations above water quality standards in select locations of the unconfined aquifer in 100-D/H.	Yes	100-D Area: Install three new aquifer tubes and five new wells (Figure 4-10). The three aquifer tubes (sampling point No. 1, Figure 4-10) will be installed at the same location to three different depths to define the extent of Cr(VI). Aquifer tubes are in this area in lieu of a well due to the cultural resource issues associated with citing and drilling a new well. The four wells (sampling points No. 2, No. 3, No. 4, and No. 5) are proposed to define the extent of Cr(VI). Wells No. 4 and No. 5 will also be sampled to define the extent of Sr-90 in groundwater. Well No. 9 is proposed to further define the magnitude of Cr(VI) near the 100-D-56 Pipeline bend. 100-H Area: Install three new aquifer tubes (sampling point No. 8) and five new wells. Sampling points No. 6 and No. 7 will define the extent of Sr-90 in groundwater. Well No. 10 will also be used to monitor nitrate south of the 100-H Reactor Area. Well No. 11 is proposed to monitor nitrate south of 100-H. Well No. 12 is proposed to monitor contaminants downgradient of the 1607-H2 Septic System. The three aquifer tubes will be installed at the same location to three different depths to define the extent of Cr(VI). Aquifer tubes are in this area in lieu of a well due to the cultural resource issues associated with citing and drilling a new well. Samples will be collected in 100-D wells at the Hanford/Ringold lithologic change. The proposed wells will also be sampled for groundwater COPCs presented in the SAP (DOE/RL-2009-40).	100-D Area: New wells and aquifer tubes are proposed to define the extent of Cr(VI) and Sr-90 contamination. The extent of Cr(VI) has not been defined in 100-D to the south, southeast, and east. Aquifer tube set No. 1 and Wells No. 2, No. 5, and No. 9 are proposed to define the extent in these areas. Well No. 3 is proposed to further refine the easterly spilt of the north and south Cr(VI) plumes. The monitoring well with the highest concentrations of Sr-90 measured in 100-D (Well 199-D5-12, located east of D Reactor) was sampled from 1987 to 1999 and was decommissioned in 2002. At well decommissioning, measured Sr-90 concentrations exceeded the maximum contaminant level of 8 pCi/L by approximately five times. Currently, no wells are available for sampling near the former location of Well 199-D5-12. Well 4 is proposed to replace well 199-D5-12 and continue monitoring Sr-90 in this area. Well No. 4 will be installed through the 116-D1-1A Trench to monitor for both Sr-90 and Cr(VI). Wells No. 3 and No. 5 will also be monitored for Sr-90 to define the extent of contamination. Well No. 9 is proposed to investigate chromium sources near the 100-D-56 Pipeline where a hole in the pipeline was noted during remediation activities. The well will also be used to evaluate whether groundwater concentrations are higher near the pipeline than in nearby Wells 199-D5-125 and 199-D5-126 that have Cr(VI) concentrations between 1,500 and 2,000 µg/L. 100-H Area: Wells and aquifer tubes in 100-H are proposed to define the extent of Sr-90 groundwater contamination. Specifically, the extent of the Sr-90 groundwater impact in the vicinity of Wells 199-H4-63 and 199-H4-45, near waste sites 116-H-1 and 116-H-7 and near the river is not defined. Wells No. 6, No. 7, and aquifer tube No. 8 are proposed to define the extent of Sr-90 groundwater contamination in 100-H. Wells No. 10 and No. 11 are proposed to further evaluate the southern extent of Sr-90 groundwater impacts south of Well 199-H6-1 (and the former 107-H Liquid Disposal Trench [Waste Site 116-H-1]) in the southern portion of 100-H (Well 10) and nitrate impacts related to a septic system (1607-H3) near a former guardhouse location (facility 1720-H) south of 100-H. Well No. 12 will characterize nitrate impacts downgradient of the 1607-H-2 Septic System.

Table 4-6. Proposed Sampling Program for Remedial Investigation for 100-D/H

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The level of groundwater contamination entering the Columbia River (in particular, the hyporheic zone) is not well known.	6	Evaluate the utility and/or adequacy of aquifer tubes in supporting the understanding of groundwater contamination entering the Columbia River Collect groundwater upwelling data and information.	Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., Cr(VI)) has been documented in 100-D/H . Aquifer tubes have been installed to analyze groundwater contaminants discharging to the river. Groundwater upwelling sampling and analysis in the Columbia River channel was conducted in the fall of 2009 (as part of the Columbia River remedial investigation) and it is expected that these data will provide further insight regarding contaminant levels entering the river through the hyporheic zone and groundwater/river mixing ratios within the biotic zone (upper ~30.5 cm [~12-in] of substrate).	No	No specific data collection activities are proposed in this RI. Continue collecting aquifer tube data and information per the existing program. Collect groundwater upwelling samples in the Columbia River (DOE/RL-2008-11). In addition, a task is included in the Integrated 100 Area RI/FS Work Plan (DOE/RL-2008-46) for evaluating and developing an approach to obtain data that will demonstrate compliance with ambient water quality criteria in the river, for final ROD decisions. For this task, data may be needed to show representativeness of contaminant concentrations for compliance. This evaluation will include a determination of whether the 1:1 dilution assumption for groundwater entering the river is valid, and may include evaluation of whether data from aquifer tube samples are representative.	Pore water samples collected from within the river sediments and along the river shoreline indicate Cr(VI) concentrations that exceed ambient water quality criteria. Expert panel report (SGW-39305) suggests reevaluation of the current mixing/dilution conceptual model. Data are needed to support the final ROD and target milestone M-016-110-T01.
The nature and extent of contaminants beneath the unconfined aquifer has not been evaluated.	7	Collect physical and hydrogeologic parameters from soil samples to support the determination of contaminant fate and transport beneath the unconfined aquifer.	Cr(VI) has been detected in wells completed beneath the unconfined aquifer above the aquatic and drinking water standards in 100-D/H. The fate and transport of this contamination has not been quantified.	Yes	100-D Area: Drill and sample soil and groundwater from two new boreholes drilled through the RUM and into Ringold Unit B. The locations are shown as boreholes R4 and R5 in Figure 4-10. 100-H Area: Drill and sample soil and groundwater from three new boreholes drilled through the RUM and into Ringold Unit B. Boreholes are shown as R1, R2, and R3 in Figure 4-10. Additional Soil Samples: Split-spoon soil samples at total depth 1.5 m [5 ft] into the RUM will also be collected from eight wells installed as part of the expansion of 100-D/H pump-and-treat systems. These wells are labeled as PT1 to PT8 in Figure 4-10. Samples will be collected in 100-D wells at the Hanford/Ringold lithologic change.	Well Justification – 100-D: Only one Well (199-D8-54B) has been installed in the RUM in 100-D, in an area of relatively low concentrations in the unconfined aquifer in the north chromium plume. Cr(VI) has been detected in the well above water quality standards. Groundwater contaminant concentrations in 100-H remain above the aquatic and drinking water standards in wells completed beneath the unconfined aquifer. Additional contaminant and hydrogeologic information is needed in the RUM to evaluate potential adverse impacts of groundwater discharging from the RUM through seeps and upwelling in the bottom of the river. Additional Soil Sample Justification: Locations were selected to address spatial variability of hydraulic properties of the RUM.
It is unknown if contamination within the RUM will adversely impact aquatic receptors in the Columbia River.	8	Update bathymetric data for the river within 100-D/H to support calculations of contaminant transport to the river and ecological receptors.	Ecological receptors (e.g., salmon redds) have been identified within the river. In order to evaluate flow paths of contaminants to receptors (particularly from the beneath the unconfined aquifer), updated and accurate bathymetric data for the river are needed. Groundwater upwelling sampling and analysis in the Columbia River channel was conducted in the fall of 2009 and it is expected to provide information regarding the effect of the RUM on groundwater upwelling into the Columbia River.	No	The digital bathymetric data are being compiled by Pacific Northwest National Laboratory. These data will be evaluated to better understand the relationship between the evaluation of the riverbed and the groundwater flow in the adjacent aquifer.	Preliminary evaluation (using near-river wells) indicates that the top of the confining unit intersects the Columbia River.

Table 4-6. Proposed Sampling Program for Remedial Investigation for 100-D/H

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The rate of chemical and hydraulic exchange between the aquifer and the river in the near shore is unknown.	9	Collect geochemical and hydrogeologic data to evaluate near-shore area groundwater contaminant fate and transport.	The near shore area is directly affected by river stage. Limited data have been available to adequately understand groundwater flow paths, contaminant migration, and mixing in the near shore area. Tri-Party Agreement milestones state that compliance with cleanup standards in this area is a target.	No	No specific data collection activities are proposed in this RI. Data from other efforts will be used in the RI/FS as defined in the 100-HR-3 RAWP and associated Interim Action Monitoring Plan, aquifer tube SAP, and the Columbia River RI.	Pore water samples collected from within the river sediments and along the river shoreline indicate Cr(VI) concentrations that exceed ambient water quality criteria. Expert panel report (SGW-39305) suggests reevaluation of the current mixing/dilution conceptual model. The near-shore area is directly affected by river stage. Limited data have been available to adequately understand groundwater fate and transport in this area. Data are needed to support the final ROD and target milestone M-016-110-T01.
The mechanism to explain the persistence of the Cr(VI) plume is unknown.	10	Collect soil and water samples from the following units: (1) vadose zone, (2) deep vadose zone, (3) rewetted zone, (4) unconfined aquifer, (5) above the RUM, and (6) within the RUM.	Soil and water analyses are needed to determine the potential for each unit to contain sufficient contamination to be a continuing source of groundwater contamination.	Yes	100-D Area: Through this RI, drill and sample soil and groundwater from two new boreholes drilled through the RUM and into Ringold Unit B. Locations are shown as boreholes R4 and R5 in Figure 4-10. 100-H Area: Through this RI, drill and sample soil and groundwater from three new boreholes drilled through the RUM and into Ringold Unit B. Boreholes are shown as R1, R2, and R3 in Figure 4-10.	These data are needed to evaluate alternative CSM components regarding whether groundwater contamination is from vadose zone sources (in the periodically wetted zone), within the unconfined aquifer, above the RUM, or within the RUM and diffusing to the unconfined aquifer.
Potential alternative remedial technologies have not been sufficiently investigated.	11	Evaluate alternative potential remedial technologies.	Groundwater contamination above aquatic standards and drinking water maximum contaminant levels has been detected in 100-D, 100-H, and the Horn. Interim remedial actions are currently operating to address the contaminated areas in 100-D and 100-H. The current remedial investigation work plan should collect data necessary for comparison of potential final remedies as part of the future feasibility study.	No	N/A	The remedial process optimization process for 100-D/H has evaluated potentially applicable remediation technologies. This evaluation will be used during preparation of 100-D/H feasibility study.
Insufficient data are available to support a fate and transport modeling.	12	Collect additional data to support future fate and transport modeling. Assess the physical and hydraulic properties of soil and confirm contaminant distribution coefficients to support modeling.	On selected soil samples, estimate soil properties, hydraulic properties, determine contaminant levels and perform batch leach test.	Yes	Through this RI, collect and analyze soil samples from (1) each of the five deep boreholes proposed, (2) eight groundwater wells from the expansion of the pump-and-treat systems, (3) seven boreholes drilled through remediated sites and (4) one trench. Perform batch leach test.	These data will be used in fate and transport modeling.
Data are needed to better define the spatial and temporal distribution of groundwater contamination.	13	Collect and analyze groundwater samples from select groundwater monitoring wells.	Additional groundwater data that are spatially representative of 100 D/H, reflect river stage influence, and include groundwater COPCs are needed.	Yes	Collect groundwater data that chemically, spatially, and temporally that represent the groundwater beneath 100 D/H. Approximately 53 existing wells will be sampled and analyzed for groundwater COPCs presented in the SAP (DOE/RL-2009-40) for this purpose.	These spatial/temporal groundwater data are needed to address uncertainties associated with the initial groundwater risk results.

Table 4-6. Proposed Sampling Program for Remedial Investigation for 100-D/H

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
Leakage (current and future) from the 182-D Reservoir and export water lines may affect groundwater flow, contaminant transport, and effectiveness of remedies.	14	Evaluate future needs for the 182-D Reservoir. Collect water level and contaminant concentration data in the vicinity of the 182-D Reservoir.	Future operation needs for the 182-D Reservoir may require operation at higher water levels. Data are needed to monitor leakage, affects on groundwater flow and contaminant transport, and potential impacts to remedies.	No	Data will not be collected under this addendum; however, a "water systems master plan" will evaluate future needs and infrastructure solutions for the 182-D Reservoir and export water lines. Automated water level monitoring and quarterly sampling at wells 199-D5-38, 199-D5-33, and 199-D5-34 will continue as part of standard remedy performance evaluation.	Currently, the 182-D reservoir provides water during emergencies. Operation of the reservoir above standby water level would be expected to increase leakage into the aquifer, affecting groundwater flow and transport, which may impact the effectiveness of remedies.

Notes:

DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-D R-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial investigation/Feasibility Study*

SGW-39305, Technical Evaluation of the Interaction of Groundwater with the Columbia River at the Department of Energy Hanford site.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CSM = conceptual site model
COPC = contaminant of potential concern
Cr(VI) = hexavalent chromium
N/A = not applicable
RAWP = Remedial Action Work Plan
RI = remedial investigation
RI/FS = remedial investigation/feasibility study
ROD = record of decision
RTD = removal, treatment, and disposal
RUM = Ringold Upper Mud (Unit)
SAP = sampling and analysis plan
Sr-90 = strontium-90
Tri-Party Agreement = Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order*

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Table 4-7. Proposed 100-D/H Characterization

Type	100-D Area	100-H Area	Total
Accepted and Discovery sites to be evaluated, characterized, and/or remediated (see Tables 2-5 through 2-8)*	81	46	127
New boreholes (vadose zone)	5	5	10
New test pits	3	2	5
New wells (unconfined aquifer)	5	5	10
New wells (extending into the Ringold Unit B)	2	3	5
New aquifer tubes/locations	3	3	6
Current monitoring wells (to support groundwater risk characterization)			53

Notes:

This task is not within the scope of the sampling and analysis plan for this addendum (DOE/RL-2009-40). Accepted and Discovery sites are being evaluated, characterized, and/or remediated according to DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area,* Rev. 5.

Table 4-8. Number of Field Samples and Analyses Proposed for 100-D/H

Source	Soil Samples*	Groundwater Samples	Analyses
New boreholes (vadose zone)	141	10	2,055
Soil sampling of test pit (vadose zone)	54	0	502
New wells (unconfined aquifer)	112	62	1,592
New wells into Ringold B unit	74	49	1,038
New aquifer tubes	0	18	180
Sampling of monitoring wells (to support groundwater risk characterization)	0	159	606

Notes:

Table does not include field quality control or archive samples.

* Includes both chemical and physical property samples.

4.8.1 100-D/H Data Needs – Source Areas

Data needs specific to sources (soils) are identified and described in this section. Data needs include analytical needs (e.g., laboratory sample results), other quantitative data, and qualitative data needs (e.g., decision data needs, policy data needs, and information data needs).

4.8.1.1 Data Need No. 1: Characterize below unremediated waste sites to assess nature and extent of contamination in the vadose zone.

Data Need Description: Continue interim remedial actions as they have demonstrated to be efficient in obtaining the necessary data during remediation using the observational approach. Obtain data documenting the remaining residual contamination following completion of the interim remedial action.

Remediation action in 100-D and 100-H began in 1996 under remedial authority of an interim action ROD and continues to the present day. Cleanup will primarily consist of implementation of the RTD remedy, which will generate additional characterization data to address many of the current data gaps and help refine overall site knowledge. Contaminated soil and debris will be removed and disposed at the ERDF or other offsite facility (as appropriate) until the cleanup levels are met. As part of the remedy, borehole drilling and/or additional test pitting in conjunction with sampling and analysis may be performed to better define the nature and extent of the contamination and identify sources within the vadose zone. Activities are guided during excavation using data obtained through field measurements or in process sampling using quick-turnaround laboratory analyses working concurrently with excavation and used to continually update the site characteristics databases. The observational approach based cleanup also provides opportunities for discovery of new waste sites that will be plugged into the existing remedies for cleanup. It is anticipated that an additional remedy will be authorized to allow use of chemical treatment for specific contaminants (e.g., Cr(VI)) at waste sites that fit specific characteristics to supplement the RTD remedy. Sequencing of waste site cleanup is based on the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989a) milestone framework. Within this framework, knowledge of operational process (e.g., sodium dichromate use) and past releases may be used to target and prioritize specific waste sites or areas with contaminants that presently exist in or potentially impact groundwater. Effective implementation of waste site cleanup prevents further degradation of groundwater, thereby increasing the likelihood for success of cleanup actions (e.g., pump-and-treat) directed specifically at contaminated groundwater.

As of August 28, 2009, there are 235 waste sites (including not accepted waste sites) in 100-D/H. Of these waste sites, 108 have been reclassified as closed, interim closed, no action sites, not accepted, and rejected under regulatory authority to address and mitigate impacts from known and suspected releases into the environment. These reclassified sites are not within the scope of this data need and are addressed according to other data needs in this report.

There are 127 unremediated waste sites (122 accepted and 5 discovery) remaining that will be addressed according to the interim action ROD (EPA/ROD/R10-96/134) and associated with this data need. Data needs associated with soil remedial actions in 100-D/H will be met by planning and scheduling the remedial actions, collecting data to verify cleanup of waste sites, and obtaining concurrence from regulators on the achievement of remedial action goals for direct exposure, protection of groundwater, and protection of surface waters.

Cleanup of approximately 40 unremediated waste sites is currently in progress, which means that closeout documentation is being prepared or in review by Ecology. The design or active remediation of approximately 40 other waste sites is also in progress. Remedial actions and site evaluation are also being planned and scheduled at the remaining 47 sites.

At waste sites of immediate interest, preliminary determinations have been made about site conditions. For example, at 100-D-30 (associated with 185-D, 190-D), source remedial action efforts indicate that soil concentrations are below concentrations protective of the Columbia River. At this site, an interim closed site reclassification is tentatively proposed, with the exception of an area in the southwest portion of the waste site where stained soil is present. This stained area may coincide with an acid neutralization

French drain and sodium dichromate storage tank. Cr(VI) has been detected in this area of stained soil; however, conclusions relative to remedial action goals and objectives have not been finalized.

Based on historical process information and sample data, the 100-D-7, 100-D-73, 100-D-76, 100-D-77, and 100-D-100 waste sites are associated with the 108-D Chemical Pumphouse and are believed to contain hazardous constituents that may exceed remediation goals. The 100-D-77 waste site is associated with the 183-DR facilities. These sites may be sources of Cr(VI). The cleanup decision for these sites is RTD. Cr(VI) was detected at 100-D-7 at 163 ppm during confirmatory sampling. Remedial efforts are also currently being planned and scheduled at 100-D-100; however, data are not available to assess contamination. Although contamination has not been detected at interim closed site 100-D-12 during verification sampling, the site will be further characterized as described in this chapter.

Accepted and discovery waste sites applicable to this data need are identified in Chapter 2. Appendix C provides the description and history for each waste site. The locations of 100-D and 100-H waste sites are shown in Appendix B.

4.8.1.2 Data Need No. 2: Characterize beneath and adjacent remediated waste sites to assess the nature and extent of contamination in the vadose zone.

Data Need Description: Drill ten environmental investigation wells for soil samples (otherwise identified as boreholes in this work plan) and two groundwater monitoring wells, and excavate five test pits. Samples will be collected and analyzed to assess vertical extent of contamination in the vadose zone. The test pits will be excavated to assess potential Cr(VI) sources and verify potential levels of other contaminants. Most of the test pits will be excavated to a depth of approximately 6.1 m (20 ft). The 100-DR test pit will be excavated to approximately 7.6 m (25 ft). In addition, the borehole planned to further characterize the 116-H-7 Retention Basin will also address uncertainties regarding contamination adjacent to the trench.

Characterization of the 100-D/H Areas has been extensive. More than 100 boreholes and test pits (exclusive of groundwater monitoring wells) have been sampled and the soil analyzed to assess subsurface conditions in the vadose zone. Contaminant data are also available from interim remedial actions. Most of the contaminant data collected from the vadose zone were collected from depths no greater than 10.7 m (35 ft) bgs, with few exceptions. The available data indicate that the vadose zone should be better characterized beneath waste sites. There is also a lack of nitrate, tritium, and Cr(VI) data to assess the vertical and lateral extent of vadose zone contamination.

Characterization data collected beneath remediated waste sites will be used to confirm the current conceptual site model. In addition, these data will be used to confirm RESRAD modeling inputs, assumptions, and predictions regarding contaminant migration.

In order to determine which sites required additional characterization, all accepted waste sites having undergone a remedial action (i.e., sites with a WIDS reclassification of Interim Closed) were further evaluated. Further evaluation of these waste sites included consideration of the following:

- Depth of remedial action relative to depth of the site’s engineered structure
- Depth of contamination reported in historical documents relative to depth of remedial action
- Omission of historically reported contaminants during closure sampling analysis
- Closure sample concentrations relative to WAC 173-340 (2007) cleanup levels
- Trends regarding contaminant concentration increases with depth

- Proximity to groundwater contaminant plumes
- Historically documented impacts to groundwater
- Type of waste site (e.g., septic site, high volume liquid effluent site, low volume liquid effluent site, sludge trench)

The initial list of sites selected for characterization was reviewed by Ecology. Based on Ecology concerns, additional sites were selected for characterization. Ecology's justification and notes for site selection are documented by letter and are incorporated in the Hanford Administrative Record (Jones, 2009).

Borehole Drilling:

Ten boreholes and two groundwater monitoring wells will be drilled and sampled in 100-D/H. One borehole/well will be drilled at each of the following waste sites to address Data Need No. 2:

- 100-D-12 French Drain (A groundwater well will be installed at this location)
- 116-D-1A Trench (A groundwater monitoring well will be installed at this location)
- 116-D-1B Trench
- 116-D-7 Retention Basin
- 116-DR-1&2 Trench
- 116-DR-9 Retention Basin
- 116-H-1 Trench
- 116-H-4 Pluto Crib
- 116-H-6 Solar Evaporation Basin (This waste site also addresses Data Need No. 1)
- 116-H-7 Retention Basin (Borehole placement will also address uncertainty regarding lateral spread of contamination)
- 116-D-6:3 Reactor Fuel Storage Basin (This site will be characterized to address Data Need No. 3)
- 116-H-6:3 Reactor Fuel Storage Basin (This site will be characterized to address Data Need No. 3)

The locations of these waste sites and boreholes are shown in Figure 4-10 (Boreholes B-1 to B-10, groundwater monitoring Well R5 and Well 4). Justification for selection of waste sites for additional characterization is provided in Table 4-6.

Samples will be screened in the field for radiological contamination and Cr(VI). Radiological screening will be conducted with field instruments. Screening for Cr(VI) will be performed visually and assumed present, as indicated by soil staining.

Soil samples for the boreholes and wells discussed previously generally should be collected for chemical analysis at 1.5 m (5-ft) intervals from the bottom of the waste site (or the maximum depth of remedial action). Continuous sampling will be performed within 3 m (10 ft) of the water table. A soil sample and water samples will also be collected 1.5 m (5 ft) into the aquifer. Additional samples may be collected at the discretion of the geologist or sampler based on field screening results. Specific sample intervals are defined in the sampling and analysis plan (DOE/RL-2009-40).

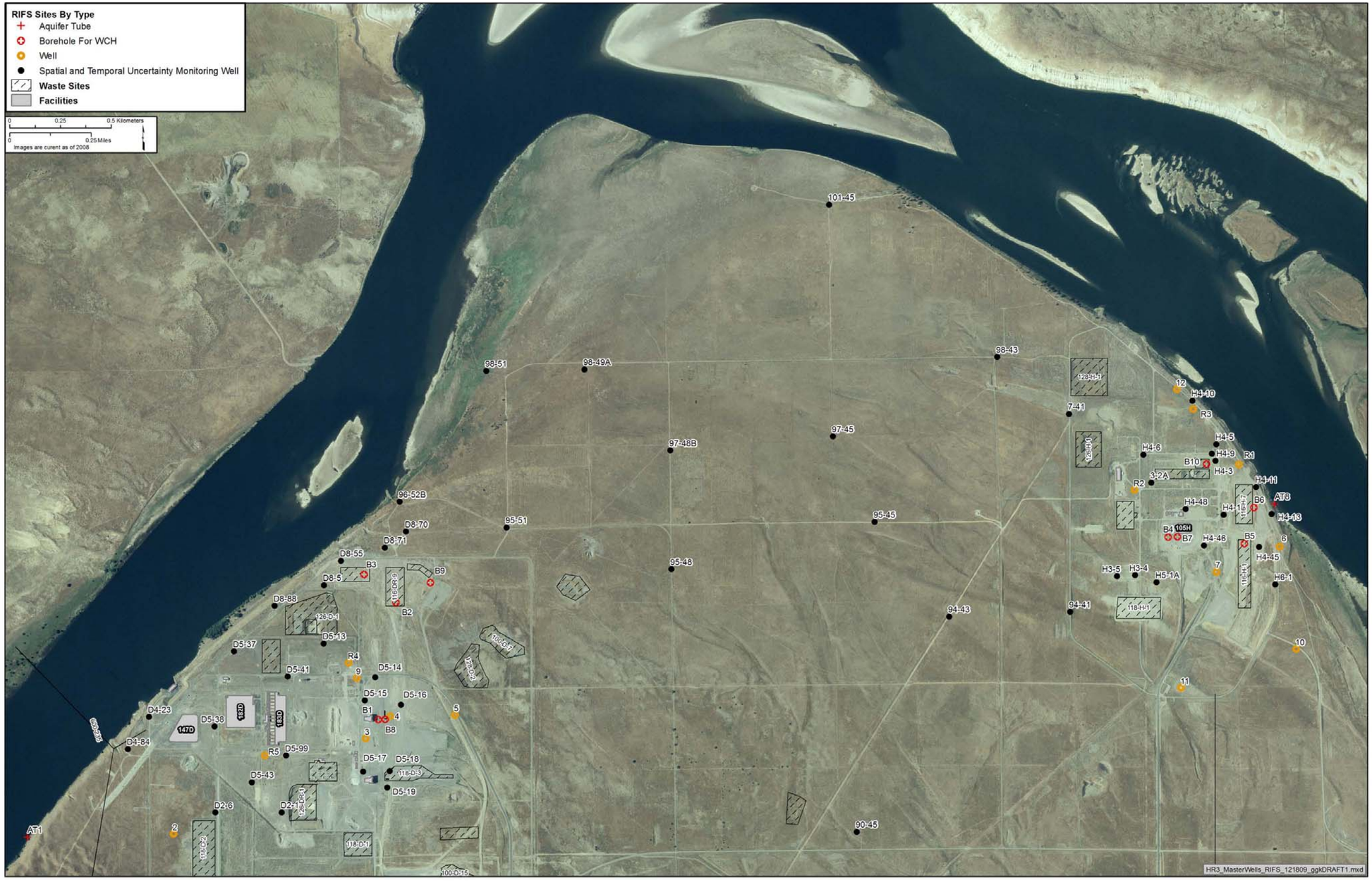

Figure 4-10. Remedial Investigation/Feasibility Study Sampling Locations

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During waste site RTD, vertical and lateral contamination is removed. Contamination is identified using the "observational approach" either by visual (soil stains) or field screening techniques (X-ray fluorescence). Lateral contamination is addressed during remediation through "plume chasing" tasks, where contamination moving beyond the identified edges of the waste sites is removed and disposed in the ERDF.

Trenches:

- Five trenches will be excavated and sampled at waste sites . Excavation and sampling will be conducted at the100-D-12 Sodium Dichromate Railcar and Truck Unloading Station/French Drain, 100-D-4 Trench, 116-D-4 Crib, 1607-H4 Septic Tank and Drain Field, and 116-H-2. The location of these waste sites and test pits are shown in Figure 4-10 (TP-1 to TP-5).
- The 100-D-12 Sodium Dichromate Railcar and Truck Unloading Station/French Drain will be excavated and sampled to a depth of 7.6 m (25 ft). 100-D-4, 116-D-4, 116-H-2, and 1607-H-4 will be excavated and sampled to a depth 5.2 to 6.2.m (17 to 20 ft), depending on field conditions.
- Samples will be screened in the field for radiological contamination and Cr(VI). Radiological screening will be conducted with field instruments. Screening for Cr(VI) will be performed visually and assumed present, as indicated by soil staining.
- Sampling will commence at the maximum depth of remedial action or shallower if native soils are encountered. The maximum depth of remedial action at 100-D-12, 100-D-4, 116-D-4, 116-H-2, and 1607-H4 are 2.4 m (8 ft), 2.9 m (9.5 ft), 2.9 m (9.5 ft), 2.6 m (8.3 ft) and 3.6 m (11 ft), respectively. Samples generally will be collected at 0.6 m (2 ft) intervals and at the discretion of the geologist/ sampler based on field screening results. One sample also will be collected at the bottom of each excavation. Justification for selection of waste sites for characterization is provided in Table 4-9.

Table 4-9. Justification For Selecting Waste Sites for Characterization

Waste Site	Site Form	Type of Characterization Planned	Justification for Inclusion
100-D-4	Sludge Trench	Test pit	RTD less than reported site design depth. Soil levels (PCB) exceeded MTCA 2007 (WAC 173-340). Sludge represents highest radioactive inventory for retention basins. Received sludge from 116-D-7 and 116-DR-7; all COCs from these retention basins not analyzed at this site. Represents "sludge trench" site type.
100-D-12	Pump Station/ French Drain	Groundwater Monitoring Well and test pit vadose zone samples will be collected.	Liquid quantity received unknown; 70% solutions of sodium dichromate discharged. RTD less than reported site design depth. Contamination extends beyond RTD depth. LFI soil levels (Tc-99) exceeded MTCA 2007 (WAC 173-340). LFI contaminants omitted from CVP sampling. Site located proximal to high concentration portion of the southern chromium plume.

Table 4-9. Justification For Selecting Waste Sites for Characterization

Waste Site	Site Form	Type of Characterization Planned	Justification for Inclusion
116-D-1A	Liquid Waste Trench	Groundwater Monitoring Well will be sampled throughout the vadose zone.	RTD less than reported site design depth. Contamination extends beyond RTD depth. Soil concentrations in UNI-946 exceed MTCA 2007 (WAC 173-340). Low volume liquid waste site (less than one pore volume).Therefore, a continuing source of chromium may remain in the soil column. Inventory of sodium dichromate is 1,000 kg (2,204.6 lb). In samples collected during the LFI (DOE/RL-93-29), additional contaminants were detected below the depth of remediation in the borehole drilled into this waste site. The highest concentrations of heavy metals were found at depths of approximately 9 m (30 ft). Chromium, lead, and nickel exhibited this behavior with chromium and lead showing a smaller but distinct high at 4.5 m (15 ft). The highest concentration of Sr-90 was found in the upper 3 m (10 ft). Highest concentrations of radionuclides (Co-60, Eu-152, Eu-154, Pu-239, and Sr-90) are found above 9 m (30 ft) decreasing to near zero by 15 m (50 ft).
116-D-1B	Liquid Waste Trench	Borehole	RTD less than reported site design depth. Contamination extends beyond RTD depth. Soil concentrations exceed MTCA 2007 (WAC 173-340). LFI contaminants omitted from CVP sampling. High volume liquid site. Effluent reached groundwater during operations. Inventory of sodium dichromate is 700 kg (1,500 lb).
116-D-4	Liquid Waste Trench/Crib	Test pit	RTD less than reported site design depth. LFI contaminants omitted from CVP sampling. CVP included only Cr(VI) and U-238. Associated with effluent from 108-D Building (high priority Cr(VI) site).
116-D-7	Retention Basin	Borehole	Contamination extends beyond RTD depth. Contamination increases with depth. Soil concentrations exceeds MTCA 2007 (WAC 173-340). LFI contaminants omitted from CVP sampling. Effluent reached groundwater during operations.

Table 4-9. Justification For Selecting Waste Sites for Characterization

Waste Site	Site Form	Type of Characterization Planned	Justification for Inclusion
118-D-6:3	105-D Reactor Fuel Storage Basin	Borehole	Fuel storage basin walls and floor left in place. High concentrations of radionuclides and chemicals on concrete samples. RTD less than reported site design depth. Reported to have leaked during operations. Contamination detected exceeds MTCA 2007 (WAC 173-340). No soil sampling beneath basin floor.
116-DR-1&2	Liquid Waste Trench/Crib	Borehole	RTD less than reported site design depth. Contamination extends beyond RTD depth. Soil concentration exceeds MTCA 2007 (WAC 173-340). LFI contaminants omitted from CVP sampling. Effluent reached groundwater during operations.
116-DR-9	Retention Basin	Borehole	Identified as the worst-case waste site based on contaminant soil data in the LFI report. RTD less than reported site design depth. Exceeds MTCA 2007 (WAC 173-340) concentrations. Contamination extends beyond RTD depth. Contamination increases with depth. LFI contaminants omitted from CVP sampling. Effluent reached groundwater during operations.
116-H-1	Trench	Borehole	RTD less than reported site design depth. Contamination extends beyond RTD. LFI contaminants omitted from CVP sampling. Effluent reached groundwater during operations. Site is located proximal to Sr-90 plume.
116-H-2	Liquid Waste Trench/Crib	Test Pits	Contamination extends beyond RTD depth. LFI contaminants omitted from CVP sampling. High volume liquid waste site (6 million L [1.6 million gal]).
116-H-4	Crib	Borehole	This site was exhumed during the construction of the 117-H Building in 1960. The depth of soil removal is not well documented. It is unknown whether the contamination in the soil column beneath this site was removed. Data does not exist to determine the nature and extent of contamination. This site was a significant source of chromium and sodium dichromate.

Table 4-9. Justification For Selecting Waste Sites for Characterization

Waste Site	Site Form	Type of Characterization Planned	Justification for Inclusion
116-H-6 (100-H-33)	Solar Evaporation Basin	Borehole	This TSD not "cleaned closed" due to nitrate and fluoride remaining in the soil column. Site may be a Cr(VI) source to groundwater. Radiological contamination below RTD depth.
116-H-7	Retention Basin	Borehole	RTD less than reported site design depth. Contamination extends beyond RTD depth. LFI contaminants omitted from CVP sampling. Soil concentrations exceed MTCA 2007 (WAC 173-340). High volume liquid site reported to have leaked. Lateral contamination was reported during other investigations (e.g., UNI-946); therefore, this borehole will be placed to address uncertainty regarding the lateral extent of remediation.
118-H-6	105-H Reactor Fuel Storage Basin	Borehole	Known location of a fuel storage basin leak. Identified data need in systematic planning. RTD less than reported site design depth. Contamination extends beyond RTD depth.
1607-H4	Septic System	Test Pits	Elevated PAH and metals in tank sludge. Elevated PAH in CVP samples. Shallow depth to groundwater 3.6 m (11.8 ft). Represents "septic system" site type.

WAC 173-340, Model Toxics Control Act – Cleanup
COCs = contaminate of concerns
Cr(VI) = hexavalent chromium
CVP = cleanup verification package
LFI = limited field investigation
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
RTD = removal, treatment, and disposal
Sr-90 = strontium-90
TSD = treatment, storage, and/or disposal
U-238 = uranium-238

4.8.1.3 Data Need No. 3: Characterize beneath and around reactor structures to assess nature and extent of contamination in the vadose zone.

Data Need Description: The *National Environmental Policy Act of 1969* (NEPA) ROD alternative selected for the 100 Area reactors was to place them into an ISS condition for up to 75 years and then transport them in one piece to a specially prepared burial facility in the 200 West Area of the Hanford Site. The NEPA ROD assumed that soils under the ISS structures are not considered active sources and, therefore, it was intended that the soils would be addressed in the future under the NEPA ROD. For a more complete discussion of 100 Area reactor agreements, see Section 1.2.4 of the 100 Area Integrated Work Plan. It should be noted that a five-year inspection of the ISS D Reactor is underway.

The ISS process for the 105-D, 105-DR, and 105-H Reactors reduced their original footprint area by approximately 78 percent and included utility and drain isolation (only fire hydrants inside the reactor

fence remain active), hazardous material and equipment removal, ancillary facility demolition (above- and below-grade structures), and proximity waste site cleanup. Waste sites near the reactor structures were remediated to interim ROD standards in conjunction with the ISS process. Cleanup verification packages (i.e., CVP-2003-00016, *Cleanup Verification Package for the 188-DR-2:2, 105-DR Reactor Below-Grade Structures and Underlying Soils, and the 100-D-49:4 Reactor Cooling Water effluent Underground Pipeline,* Rev. 0); CVP-2005-00003, *Cleanup Verification Package for the 116-D-6:2, 105-D Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils; the 118-D-6:3, 105-D Reactor Fuel Storage Basin and Underlying Soils; and the 132-D-4, 105-D Reactor Exhaust Stack Foundation;* and CVP-2006-00003, *Cleanup Verification Package EDMC for the 118-H-6:2, 105-H Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils; the 118-H-6:3, 105-H Reactor Fuel Storage Basin and Underlying Soils; the 118-H-6:6 Fuel Storage Basin Deep Zone Side-Slope Soils; the 100-H-9, 100-H-109 and 100-H-13 French Drains; the 100-H-11 and 100-H-12 Expansion Box French Drains; and the 100-H-14 and 100-H-31 Surface Contamination Zones*) document the status of removal action for below grade structures, underlying soils, and pipelines from the area around the ISS reactor facilities.

Additional characterization is needed for interim closed areas adjacent to the ISS reactor facilities and will be needed for soils underlying the remaining ISS reactors to support the final ROD. Boreholes will be drilled at the FSBs adjacent to the 118-H-6 (H Reactor) and 118-D-6 (D Reactor). Additional information will be obtained from ISS inspections. Advances in borehole drilling and sampling technologies may result in alternatives for characterization.

Justification for characterization at these two reactors include reports of leakage from FSBs during reactor operations, reports of contamination beyond the depth of remedial actions, quantity of liquids managed, and the lack of sampling performed beneath the FSBs and around/beneath the reactors. The RI/FS report generated from these activities will include a discussion and analysis of options for reactor removal. If actions are needed to address potential environmental releases associated with reactor footprints before reactors are removed, those actions will be specified in the CERCLA decision. Characterization under this addendum will support the determination of whether sufficient data are available to make conclusions regarding releases to the environment.

To address Data Need No. 3, boreholes will be drilled within the boundary of the two reactor FSBs. Samples will be collected and analyzed to assist the vertical extent of contamination and refine the 100-D/H CSM. Remediation of the 118-H-6 Reactor FSB included removing the below-grade structure and disposing of contaminated materials, including the soil underlying the former FSB floor and the side slopes. The 118-D-6 below grade structure remains in place; thus, the borehole will be drilled as close as possible to the FSB.

During drilling, samples will be screened in the field for radiological contamination, VOCs, oils, and Cr(VI). Radiological and VOC screening will be conducted with field instruments. Screening for oils and Cr(VI) will be performed visually and are assumed to be present as indicated by soil staining. Contaminants of potential concern for laboratory analysis are specified in the Sampling and Analysis Plan.

Soil samples will be collected for chemical analysis at 1.5 m (5-ft) intervals from the bottom of the waste site (or maximum depth of remedial action). Continuous sampling will be performed within 3 m (10 ft) of the water table. A soil sample and water samples will also be collected 1.5 m (5 ft) into the aquifer. In addition, a soil sample will be collected immediately above the water table from the periodically rewetted zone. Additional samples may be collected at the discretion of the geologist or sampler, based on field screening results. Specific sample intervals are defined in the Sampling and Analysis Plan (DOE/RL-2009-40).

Table 4-9 presents additional justification for selecting FSBs 118-H-6 and 118-D-6:2 for characterization.

4.8.1.4 Data Need No. 4: Identify new waste sites and potential sources of contamination.

Data Need Description: Complete orphan site evaluation process in the Horn and supplemental survey of 100-D operational area.

The orphan site evaluation process is performed to identify new waste sites (discovery sites) and sources that are not in CERCLA decision documents. The process may identify new waste sites and potential sources of contamination in the 100-D/H Horn Area. In addition, a supplemental post RTD survey will be conducted of 100-D operational area. The survey will consist of an observation-based walkdown during the wet season to identify surface stained soil that may indicate chromium contamination.

4.8.2 100-D Area Data Needs – Groundwater

Data needs specific to groundwater are identified and described in this section. Data needs include analytical needs (e.g., laboratory sample results), other quantitative data (e.g., hydrogeologic, geochemical parameters), and qualitative data needs (e.g., decision data needs, policy data needs, and information data needs). Where applicable, the data needs are discussed with respect to type, time, quantity, and quality of data and information needed to address each data need.

4.8.2.1 Data Need No. 5: Define the extent of groundwater contamination above cleanup standards in select areas of the unconfined aquifer.

Data Need Description: Determine the extent of select contaminants (e.g., Cr(VI)) at concentrations above water quality standards in select locations of the unconfined aquifer in 100-D/H.

100-D Area: Three new aquifer tubes and five new wells will be installed in 100-D (Figure 4-10). The three aquifer tubes (sampling point No. 1) will be installed at the same location to three different depths to define the vertical extent of Cr(VI). Aquifer tubes are used in this area in lieu of a well due to the cultural resource issues associated with siting and drilling a new well. The four wells (sampling points No. 2, No. 3, No. 4, and No. 5) are proposed to define the horizontal extent of Cr(VI). Wells No. 4 and No. 5 in the figure will also be sampled to define the extent of Sr-90 in groundwater. Well No. 9 is proposed to further define the magnitude of Cr(VI) near the 100-D-56 Pipeline. These new wells and aquifer tubes in conjunction with the existing monitoring well network are expected to satisfy the data need. In addition, wells No. 4 and No. 9 (and wells drilled for 100-D remedial process optimization) will serve to provide information on chromium source in northern 100-D.

Justification for 100-D Area: New wells and aquifer tubes are proposed to define the extent of Cr(VI) and Sr-90 contamination. The extent of Cr(VI) has not been defined in 100-D to the south, southeast, and east. Aquifer tube set No. 1 and wells No. 2, No. 5, and No. 9 are proposed to define the extent in these areas. Well No. 3 is proposed to further refine the easterly spilt of the north and south chromium plumes.

The monitoring well with the highest concentrations of Sr-90 measured in 100-D (Well 199-D5-12, located east of D Reactor) was sampled from 1987 to 1999 and was decommissioned in 2002. At well decommissioning, measured Sr-90 concentrations exceeded the maximum contaminant level of 8 pCi/L by approximately five times. Currently, no wells are available for sampling near the former location of Well 199-D5-12. Well No. 4 is proposed to replace Well 199-D5-12 and continue to monitor Sr-90 in this area. Well No. 4 will be installed through the 116-D1-1A Trench to monitoring for both Sr-90 and Cr(VI). During drilling, soil samples will be collected to evaluate vadose zone target analytes. This well, proposed as a replacement to Well 199-D5-12, will be located approximately 46 m (150 ft) from former Well 199-D5-12. Based on the location of the proposed well with respect to groundwater flow in this area, the well is expected to be hydraulically downgradient of the location of former Well 199-D5-12, and will therefore monitor contaminants that may have sources located near former Well 199-D5-12.

Wells No. 3 and No. 5 will be monitored for Sr-90 to define the extent of contamination. Additionally, Well No. 5 will be sampled for groundwater COPCs from potential sources southeast of the 105-D Reactor. Groundwater flow near the 105-D Reactor is generally to the northeast toward proposed well No. 5.

Well No. 9 is proposed to investigate chromium sources near the 100-D-56 Pipeline where a hole in the pipeline was noted during remediation activities. The well will also be used to evaluate whether groundwater concentrations are higher near the pipeline than in nearby Wells 199-D5-125 and 199-D5-126, which have Cr(VI) concentrations between 1,500 and 2,000 µg/L.

100-H Area: Three new aquifer tubes (sampling point No. 8, Figure 4-10) and five new wells are proposed for 100-H. Two wells (sampling points No. 6 and No. 7, Figure 4-10) proposed to define the extent of Sr-90 in the groundwater will be installed in 100-H. Proposed Well No. 10 will also be used to monitor Sr-90 and nitrate south of the 100-H Reactor Area. Proposed Well No. 11 will be installed to monitor nitrate south of 100-H. Well No. 12 is proposed to monitor groundwater impacts from the 1607-H2 Septic System. The three aquifer tubes (Figure 4-10) will be installed at the same location to three different depths to define the extent of Cr(VI). Aquifer tubes are used in this area in lieu of a well due to the cultural resource issues associated with citing and drilling a new well.

These new wells and aquifer tubes, in conjunction with the existing monitoring well network, are expected to satisfy the data need.

Justification for 100-H Area: Wells and aquifer tubes in 100-H are proposed to define the extent of Sr-90 groundwater contamination and monitor nitrate. Specifically, the extent of the Sr-90 groundwater impact in vicinity of Wells 199-H4-63 and 199-H4-45, near waste sites 116-H-1 and 116-H-7, and near the river is not defined. Wells No. 6, No. 7 and No. 10 and aquifer tube No. 8 are proposed to define the extent of Sr-90 groundwater contamination in 100-H.

Wells No. 10 and No. 11 are proposed to further evaluate the southern extent of Sr-90 groundwater impacts south of Well 199-H6-1 (and the former 107-H Liquid Disposal Trench [Waste Site 116-H-1]) in the southern portion of the H Area (Well 10) and nitrate impacts related to a septic system (1607-H3) near a former guard house location (facility 1720-H south of 100-H (Wells No. 10 and No. 11).

Well No. 12 is proposed to evaluate groundwater impacts north of the waste site (1607-H2 Septic System) upgradient of Well 199-H4-10 where sufficient well coverage is not currently available and new RPO wells are not currently planned in this area. In addition, this well will be monitored for polychlorinated biphenyl (PCBs) (specifically Aroclor-1254), which was detected at a concentration of 8.3 µg/L from a groundwater sample collected on November 25, 2005 from Well 199-H4-10. Aroclor-1254 was also detected in cleanup verification samples collected during remediation of 1607-H2 waste site.

The proposed wells in 100-D and 100-H will be sampled for groundwater COPCs (see SAP, DOE/RL-2009-40 for list of COPCs).

4.8.2.2 Data Need No. 6: Evaluate the utility and/or adequacy of aquifer tubes in supporting the understanding of groundwater contamination entering the Columbia River. Collect groundwater upwelling data and information.

Data Need Description: Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., for Cr(VI)) has been documented in 100-D/H. Aquifer tubes have been installed to analyze for groundwater contaminants discharging to the river. These aquifer tubes are typically analyzed for contaminants twice per year. More frequent groundwater aquifer tube data collection may be necessary to evaluate seasonal transport of groundwater contaminants to the river.

Groundwater upwelling sampling and analysis in the Columbia River channel was conducted in the fall of 2009. It is expected that these data will provide further insight regarding contaminant levels entering the river and groundwater/river mixing ratios within the biotic zone (upper ~30 cm (~12 in). of substrate).

Additional methods (e.g., new rounds of pore water samples, horizontal aquifer tubes in the biotic zone) will be evaluated in appropriate 100-D/H locations to validate/update the pore water sampling conducted in 1995, which serves as the basis for the 1:1 minimum mixing ratio assumed for groundwater/river water in the River Corridor (Work Plan Section 2.3.3.4). A Tri-Party Agreement (Ecology et al. 1989a) milestone has been negotiated to expand the current pump-and-treat activities in 100-D/H, focusing on recovering contaminants adjacent to the river.

4.8.2.3 Data Need No. 7: Collect physical and hydrogeologic parameters from soil samples to support the determination of contaminant fate and transport beneath the unconfined aquifer.

Data Need Description: Cr(VI) has been detected in wells completed beneath the unconfined aquifer and remains above the aquatic and drinking water standards in 100-D/H. The fate and transport of this contamination has not been quantified.

Cr(VI) and other contaminants have been identified in the unconfined aquifer (Ringold Unit E and Hanford formation) in 100-D/H. The RUM is recognized as the base of the unconfined aquifer in 100-D and 100-H. Cr(VI) in 100-D has been detected intermittently in the past above the aquatic cleanup standard in the only Well (199-D8-54B) completed in the RUM in 100-D. Well 199-D8-54B is completed in an area of relatively low Cr(VI) concentrations in the north plume in the unconfined aquifer. Data have not been collected to evaluate RUM impacts in the south plume, which exhibits Cr(VI) concentrations more than 10 times greater than those detected in the north plume. Cr(VI) in 100-H in and beneath the RUM remains above both the aquatic and drinking water cleanup standards.

Groundwater from the RUM may discharge to aquatic receptors, or portions may be considered an aquifer capable of use as a drinking water resource. Data collection is proposed to further define the extent of contamination in the RUM and to collect local information to support an evaluation of contaminant fate and transport.

Five boreholes are proposed: two in the D Reactor area (Boreholes R4 and R5, Figure 4-10), and three in the H Reactor area (Boreholes R1, R2, R3, Figure 4-10). The two boreholes in the D Reactor area will be completed as monitoring wells in a water-producing unit within the RUM. One of the three wells in H Reactor area will also be completed as a monitoring well in a water-producing unit in the RUM. Water samples will be taken during drilling through the unconfined aquifer, within producing units of the RUM, and within the Ringold Unit B. Soil collection (split-spoons) will begin above the groundwater and intermittently sampled until total depth is reached. Liquid samples will be analyzed for all groundwater COPCs. Splits from the split-spoon samples will be analyzed for the following data:

- Soil property information (e.g., density, porosity, and sieve fraction) will be obtained.
- Contaminant information will be collected from a distilled water leach and from the soil fraction. Analytes will include Cr(VI), total chromium, metals, and radionuclides.
- Hydraulic information will be collected, including hydraulic conductivity (permeameter testing) for saturated samples.

Split-spoon samples will be collected above the water table, within the unconfined aquifer, at the base of the RUM, immediately on drilling into the RUM, at two additional locations within the RUM outside of

any producing zone, and within the Ringold Unit B. Details of the data collection and sampling can be found in the Sampling and Analysis Plan (DOE/RL-2009-40).

For new wells near waste sites, additional split-spoon samples will be collected above and below the Hanford formation/Ringold Unit E contact. Details of the data collection and sampling can be found in the Sampling and Analysis Plan (DOE/RL-2009-40).

100-D Area: Drill and sample soil and groundwater from two new boreholes drilled through the RUM and into Ringold Unit B. Locations are shown as Boreholes R4 and R5 in Figure 4-10.

100-H Area: Drill and sample soil and groundwater from three new boreholes drilled through the RUM and into Ringold Unit B. Boreholes are shown as R1, R2, and R3 in Figure 4-10.

Additional Soil Samples: Split-spoon soil samples at total depth of 1.5 m (5 ft) into the RUM will also be collected from eight wells installed as part of the expansion of the pump-and-treat systems (Figure 4-10). Split-spoon samples will be analyzed as previously described.

Well Justification for 100-D Area: Only one Well (199-D8-54B) has been installed in the RUM in 100-D. Cr(VI) has been detected in the well above water quality standards, but not since 2005 (Figure 4-11). However, this well is located in an area of relatively low concentrations in the unconfined aquifer in the north chromium plume. Groundwater contaminant concentrations in 100-H remain above the aquatic and drinking water standards in wells completed beneath the unconfined aquifer. Additional contaminant and hydrogeologic information is needed in the RUM to evaluate potential adverse impacts of groundwater discharging from the RUM through seeps and upwelling in the bottom of the river.

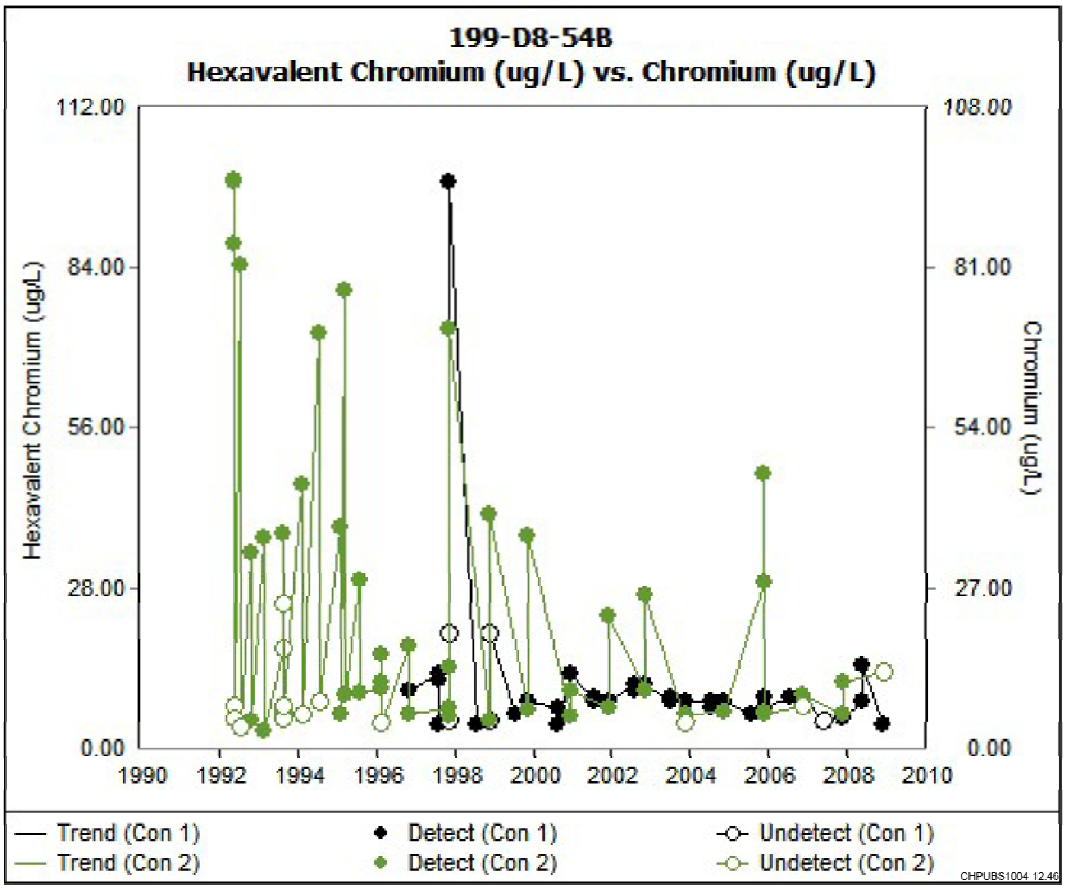

Figure 4-11. Total Chromium and Hexavalent Chromium Trends in Well 199-D8-54B

Additional Soil Sample Justification: Locations were selected to address spatial variability of hydraulic properties of the RUM.

4.8.2.4 Data Need No. 8: Update bathymetric data for the river within 100-D/H to support calculations of contaminant transport to the river and ecological receptors.

Data Need Description: Ecological receptors (e.g., salmon redds) have been identified within the river. In order to evaluate flow paths of contaminants to receptors (particularly from the beneath the unconfined aquifer), updated and accurate bathymetric data for the river are needed.

Hexavalent chromium and other contaminants have been identified in the RUM and deeper Ringold units in 100-D and 100-H. Some of these contaminants (e.g., Cr(VI)) have been detected above cleanup standards for drinking water and protection of aquatic receptors. An insufficient number of wells (e.g., only one well installed in the RUM in 100-D) has been installed to evaluate the fate and transport of contaminants in the RUM and discharge points of RUM groundwater.

Ecological receptors (e.g., salmon redds) that may be adversely impacted by groundwater contamination have been identified in the river. To evaluate flow paths of contaminants to receptors, updated and accurate bathymetric data for the river are needed. The bathymetric data will be combined with groundwater fate and transport analysis to evaluate contaminant risks to specific ecological receptors and related portions of the river.

Bathymetric data adjacent to 100-D/H have been collected and are undergoing evaluation. Preliminary evaluation of the top of the RUM surface using near-river wells indicates that the top of the RUM intersects the Columbia River. Therefore, no new data are proposed for the area; however, the existing data will be evaluated to further define the river bathymetry.

4.8.2.5 Data Need No. 9: Collect geochemical and hydrogeologic data to evaluate near-shore area groundwater contaminant fate and transport.

Data Need Description: The near-shore area is directly affected by river stage. Limited data have been available to adequately understand groundwater flow paths, contaminant migration, and mixing in the near shore area. Tri-Party Agreement (Ecology et al. 1989a) milestones state that compliance with cleanup standards in this area is a target.

Scenarios for plume discharge to the river vary widely because of seasonality and dynamic conditions in the zone of interaction between groundwater and river water. The greatest contaminant flux and highest concentrations at exposure locations are postulated to occur during periods of low-river-stage conditions, when the hydraulic gradient toward the river is steepest and mixing between river water and groundwater is minimal. Additional physical, chemical, and biological process data and ongoing monitoring information may be needed to understand the features and transport processes associated with the zone of interaction, their impact to aquatic receptors, and to support remedy decisions.

A Tri-Party Agreement (Ecology et al. 1989a) milestone has been negotiated to prevent contaminant discharge to the river with the goal of achieving river protection by 2012. No RI data are proposed. However, river protection will be demonstrated through data collected as defined in the 100-HR-3 RAWP and associated Interim Action Monitoring Plan (DOE/RL-2009-56 (pending) and DOE/RL-2009-57 (pending), respectively), aquifer tube sampling, and upwelling groundwater sampling in the Columbia River.

4.8.2.6 Data Need No. 10: Collect soil and water samples from the following units: (1) vadose zone, (2) deep vadose zone, (3) rewetted zone, (4) unconfined aquifer, (5) above the RUM, and (6) within the RUM.

Data Need Description: Soil and water analyses are needed to determine the potential for each unit to contain sufficient contamination to be a continuing source of groundwater contamination.

Five boreholes are proposed: two in the D Reactor area, and three in the H Reactor area. The two boreholes in the D Reactor area will be completed as monitoring wells in a water-producing unit within the RUM. One of the three wells in the H Reactor area will also be completed as a monitoring well in a water-producing unit in the RUM. Water samples will be taken during drilling through the unconfined aquifer, within producing units of the RUM, and within Ringold Unit B. Soil collection (split-spoons) will begin above the groundwater and intermittently sampled until total depth is reached. Liquid samples will be analyzed for all groundwater COPCs. Splits from the split-spoon samples will be analyzed for the following data:

- Soil property information (e.g., density, porosity, and sieve fraction) will be obtained.
- Contaminant information will be collected from a distilled water leach as described in the SAP (DOE/RL-2009-40) and from the soil fraction. Analytes will include those listed in the SAP tables.
- Hydraulic information will be collected, including hydraulic conductivity (permeameter testing) for saturated samples.

Split-spoon samples will be collected above the water table, within the unconfined aquifer, at the base of the RUM, immediately on drilling into the RUM, at two additional locations within the RUM outside of

any producing zone, and within Ringold Unit B. Details of the data collection and sampling can be found in the Sampling and Analysis Plan (DOE/RL-2009-40).

100-D Area: Drill and sample soil and groundwater from two new boreholes drilled through the RUM and into Ringold Unit B. Locations are shown as Boreholes R4 and R5 in Figure 4-10.

100-H Area: Drill and sample soil and groundwater from three new boreholes drilled through the RUM and into Ringold Unit B. Boreholes are shown as R1, R2, and R3 in Figure 4-10.

Well Justification: The data are needed to evaluate alternative CSM components regarding whether groundwater contamination is from vadose zone sources (in the periodically wetted zone), within the unconfined aquifer, above the RUM, or within the RUM and diffusing to the unconfined aquifer.

4.8.2.7 Data Need No. 11: Evaluate alternative potential remedial technologies.

Data Need Description: Groundwater contamination above aquatic standards and drinking water maximum contaminant levels has been detected in 100-D and 100-H and the Horn. Interim remedial actions are currently operating to address the contaminated areas in 100-D and 100-H. The current RI work plan should collect data necessary for comparison of potential final remedies as part of the future project FS.

As part of the RI/FS study process, a comparison of potential groundwater remediation technologies will be necessary if groundwater contamination above applicable cleanup and/or risk levels remains after completion of the remedial actions. The project expectation is that the aquifer will be returned to its beneficial use (i.e., drinking water). Thus, the list of likely potential remedial technologies should be drafted, and groundwater data and information necessary to support a comparison of potential remedies should be collected.

The remedial process optimization process has evaluated potentially applicable remediation technologies. This evaluation will be used during preparation of 100-D/H FS. Therefore, no new data or information collection is proposed.

4.8.2.8 Data Need No. 12: Collect additional data to support future fate and transport modeling. Assess the physical and hydraulic properties of soil and confirm contaminant distribution coefficients to support modeling.

Data Need Description: On selected soil samples, estimate soil properties, hydraulic properties, determine contaminant levels, and perform leach contacting tests.

Efforts to assess the fate and transport of Cr(VI) in the vadose zone have been performed in the 100 Area. The fate and transport of Cr(VI) in the environment is largely dependent on the effluent volume discharge and its contaminant distribution coefficient. Cr(VI) typically has a very low contaminant distribution coefficient (distribution coefficient = 0). Thus, the contaminant moves in the vadose zone with the effluent discharged to the soil column. Studies also indicate that this constituent can be retarded in the environment depending on the source of the contaminant and available iron. The contaminant distribution coefficient of Cr(VI) should be verified to support assessments of contaminant fate and transport in the environment.

Batch leach tests will be performed on selected soil and aquifer sediment samples to determine site-specific soil partitioning coefficient values. The leachate will be analyzed for pH, conductivity, and metals or other contaminants of interest. Details of the test will be discussed with the laboratory personnel before analysis. Details of the collection and analysis can be found in the Sampling and Analysis Plan, Section 2.2.4 (DOE/RL-2009-40).

4.8.2.9 Data Need No. 13: Collect and analyze groundwater samples from select groundwater monitoring wells.

Data Need Description: Additional groundwater data are needed that are spatially representative of 100 D/H, reflect river stage influence, and include groundwater COPCs.

Collect and analyze groundwater samples from 53 groundwater monitoring wells (Table 4-10) to characterize the spatial, temporal, and chemical extent of groundwater contamination. Wells are shown in Figure 4-10. Sampling details and COPCs are found in the SAP (DOE/RL-2009-40).

Three rounds of groundwater samples will be collected for analysis to support the remedial investigation for each contaminant. A sampling round, or event, will be conducted for each seasonal high, low, and transition river stages, for a total of three samples per well. Each round of monitoring in the network of wells and aquifer tubes for will be completed within 30 consecutive calendar days to minimize statistical variability in water levels.

Table 4-10. Spatial and Temporal Uncertainty Monitoring Well Network

199-D2-6	199-D5-37	199-H3-5	199-H4-5	699-95-51
199-D2-11	199-D5-38	199-H4-3	199-H5-1A	699-96-49
199-D4-23	199-D5-41	199-H4-10	199-H6-1	699-96-52B
199-D4-84	199-D5-43	199H4-11	699-101-45	699-97-41
199-D5-13	199-D5-99	199-H4-13	699-87-55	699-97-45
199-D5-14	199-D8-5	199-H4-16	699-90-45	699-97-48B
199-D5-15	199-D8-55	199-H4-6	699-93-48A	699-98-43
199-D5-16	199-D8-70	199-H4-45	699-94-41	699-98-49A
199-D5-17	199-D8-71	199-H4-46	699-94-43	699-98-51
199-D5-18	199-D8-88	199-H4-48	699-95-45	
199-D5-19	199-H3-2A	199-H4-9	699-95-48	

To determine spatial and temporal risk uncertainty for potential human and ecological receptors, the RI process requires that the groundwater be sampled, providing representative data of aquifer conditions (EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*, Interim Final, OSWER Directive 9355.3-01, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, DC, Chapter 2, pages 2-1 through 2-17). If there are temporal changes in groundwater conditions, samples must be collected to capture these varying stages to properly delineate temporal risk uncertainties to potential receptors.

For analyzing risk and planning a sampling program, sampling networks should represent locations where human or ecological receptors could potentially encounter groundwater. The potential primary pathway for human exposure is through direct contact with groundwater obtained from a residential or community water well, assuming development of the land for future human habitation.

Based on interim remedial action goals identified in DOE/RL-96-17, the assumption for future habitation is families will live on the land, grow a garden, and raise livestock to provide approximately 25 percent of the family's food requirements. This land usage places specific state and daily water requirements for

each residence. The interim remedial action goals are based on groundwater restored to a beneficial use (i.e., drinking water). It is also assumed that at least a 5-acre plot per unit is necessary to raise livestock. Thus, each residence in the following scheme assumes a family plot size of 5 acres. However, additional exposure scenarios will be included in the RCBRA (DOE/RL-2007-21, Vol. 1).

To provide the number of sampling points for the well network, the average groundwater yields, calculated from pump tests conducted are used to determine the number of residences supported on one supply well. Thus, the grid size specific to each area is determined. Use of a random grid generator provides approximate locations for sampling points based on the final number of sampling points and the total area of 100 D/H (EPA/540/G-89/004).

In addition to determining the maximum number and location of potential exposure pathways, additional wells were added to networks to define potential exposures associated with known contaminant plumes and potential contamination from waste site sources. Current monitoring wells were chosen to provide data on maximum contaminant levels and to define plume extents, and to evaluate potential releases from waste sites. For 100 D/H that has active remedial activities, extraction/injection and chemical treatment wells were not included in any of the well networks. The pump and treat wells are not configured for routine sampling and the chemical treatment wells are not representative of ambient groundwater conditions.

4.8.2.10 Data Need No. 14: Evaluate future needs for the 182-D Reservoir. Collect water level and contaminant concentration data in the vicinity of the 182-D Reservoir.

Data Need Description: future operation needs for the 182-D Reservoir may require operations at higher water levels. Data are needed to monitor leakage, effects on groundwater flow and contaminant transport, and potential impacts to remedies.

Currently, the 182-D Reservoir provides water during emergencies. Operation of the reservoir above the standby water level would be expected to increase leakage into the aquifer, affecting groundwater flow and transport, which may impact the effectiveness of remedies.

A water systems master plan will evaluate the future needs and infrastructure for the reservoir and export water lines. Automated water level monitoring and quarterly sampling at wells 199-D5-38, 199-D5-33, and 100-D5-34 will continue as part of the standard remedy performance evaluation. No new data or information collection is proposed.

5 Project Schedule

The project schedule for activities discussed in this addendum is shown in Figure 5-1. This schedule will serve as the baseline for the work planning process and will be used to measure the implementation progress of this process. Milestones associated with the activities described in this addendum are provided in Appendix C of the work plan and are based on current agreements. Any updates to the project schedule will be reflected in the annual work planning process and are not anticipated to require a revision to this addendum.

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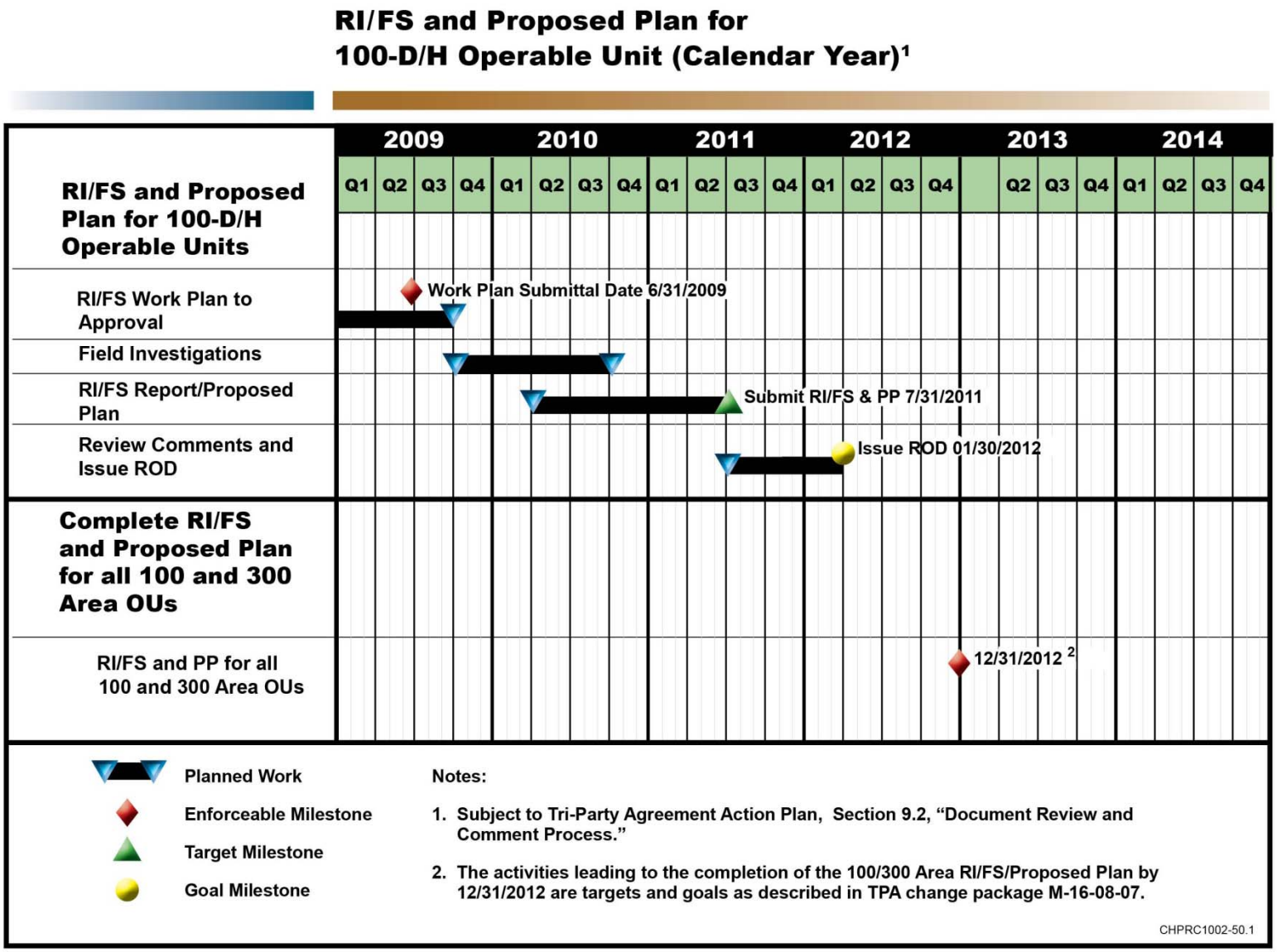

Figure 5-1. 100-D/H Project Schedule

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Appendix A

100-D/H Conceptual Site Model Component Plates

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A1 Introduction

Identifying and structuring key components of the conceptual site model (CSM) is a fundamental activity during the Systematic Planning Process. Each component is evaluated to understand its importance in the decision making process, the level of current understanding about the component, and the uncertainties that should be resolved. During multiple workshops, presentations, and meetings leading up to the development of the 100-D/H RI/FS workplan important aspects of the key components of the 100-D/H CSM were summarized into figures to provide a focusing tool and act as aids in discussions. The figures went through multiple revisions based on the input that was received. The last revision of the component figures was December 31, 2008. These have been captured in this appendix.

A2 Crosswalk from CSM Data Concerns to Workplan Data Gaps

As the CSM key components were being developed, a large set of preliminary concerns with various aspects of the available data were identified. These have been included in each of the figures in this appendix under the subtitle "Data Gaps." These are not the final set of formal data gaps that are contained in Chapter 4 of the workplan. Further evaluation was necessary to refine and focus this preliminary set due to many factors such as overlap, duplication of concern, and the fact that some are not gaps at all. These remaining data concerns were collated and organized into the formal list of 14 data gaps and data needs described in Table 4-6. The following discussion maps a number of these data concerns to Table 4-6 for selected figures in Appendix A.

Figure A-3, 100-D Area Export Water System: The data concerns listed in Figure A-3 resulted in the addition of formal Data Gap 14, 182-D Reservoir Impacts.

Figure A-7, 100-D Area Ringold Formation Upper Mud Contamination:

- The item listed as Data Gap 19 is a compliance issue that will be established through the decision making process. The fulfillment of Data Needs 5, 10, and 13 will assist this effort.
- Data Concern 7 maps to Table 4-6 Data Gap 7. The field activities that will be performed to satisfy Data Gap 7 are described in the table. In addition, a study is being conducted in 100-H to better define the persistence of CRVI in the RUM and data is being collected from the RUM as part of the RPO drilling to support the RI/FS process. Collectively, these data will provide adequate information for the development compliance criteria.

Figure A-8, 100-D Area Interaction Between Groundwater and River Water:

- The ZOI mass flux of contaminants to groundwater could be estimated using characterization information obtained to address Table 4-6 Data Needs 2, 3, and 10, and an estimated initial mass. The ZOI is of concern with respect to the potential flushing of contaminants that may be located near the base of the vadose zone.
- The year-round monitoring of river fluctuation is associated with Data Needs 6 and 9 in Table 4-6.
- The effects of river stage on inland risk needs to be quantified and is addressed by Table 4-6 Data Need 13.
- The completion of bathymetric data reduction is associated with Table 4-6 Data Need 8.
- Identifying technically defensible models via the appropriate application of model selection criteria to develop the RI/FS Report is associated with Table 4-6 Data Need 12. Likewise Table 4-6 Data Need 12 addresses the role of models to contribute to CSM refinement.

- Maintaining flexibility to accommodate new results into the environmental evaluation phase is incorporated across all of the Table 4-6 Data Needs.
- The need to update the sampling frequency for aquifer tubes to produce consistent data sets is being addressed through revisions to the aquifer tube SAP. These revisions are being coordinated with the RI/FS process.

Figure A-9, 100-D Area Periodically Rewetted Zone:

- Establishing a method to estimate the contamination mass in the periodically rewetted zone and the seasonal or more-frequent (temporal) mass flux from the deep vadose zone to groundwater could be estimated using characterization information obtained to address Data Needs 2 (vadose zone) and 10 (Chromium persistence) in Table 4-6, and an estimated initial mass.
- Evaluating the potential effects of water table fluctuations on contaminant concentrations in the upper unconfined aquifer is associated with Table 4-6 Data Needs 2 and 10. This evaluation may include modeling of varying conditions of water table fluctuations into the periodically rewetted zone and the potential for adsorbed contaminants to mobilize and reach groundwater. This evaluation includes the collection of additional deep vadose zone data and information, such as how subsurface geological characteristics may influence contaminant mobility to groundwater. These issues are directly related to Table 4-6 Data Needs 2, 10, and 12. A related subject is the need to record frequent observations of changes in water quality and hydraulic pressure to predict contaminant movement, as reflected by to Table 4-6 Data Needs 6 and 9.
- The ability to locate and characterize “relic,” former, hot liquid discharge areas, and evaluate the potential for the remaining contaminants to reach groundwater, and if necessary, simulate contaminant residence time in the periodically rewetted zone before contaminants enter groundwater is associated with Table 4-6 Data Needs 2 and 12.
- There are several concerns in Figure A-9 that address the need to be innovative, flexible, and timely in data collection activities (e.g., follow-through phases of environmental evaluation need to be flexible to accommodate the results of newly conducted investigation tasks, and Evaluate and consider using non-traditional alternative to collecting contaminant migration data (i.e., ‘interface’ samplers). Emerging information from the RI investigation will be incorporated into the analysis and RI report. Innovative techniques to look at the interface between the vadose zone and the saturated zone will be utilized to the extent practicable.

Figure A-11, 100-D Area North Plume: Hexavalent Chromium and Nitrate:

- Definition of the extent of the upper unconfined aquifer contaminant plume, is directly associated with Table 4-6 Data Need 5.
- The nature and extent of RUM contamination is addressed as described by scope of work for Table 4-6 Data Need 7.
- The cyclical rise and fall of the water table, the river’s influence on those levels, and the need to collect additional information to anticipate plume characteristics and behaviors through these dynamic occurrences and the potential for deep vadose zone contamination to be remobilized during periods of high groundwater is addressed as described by the scope of work for Table 4-6 Data Need 10.

- Development of final cleanup goals to drive remedy selection and design is described by Data Need 11 in Table 4-6 and is also related to concerns about final ROD compliance criteria to demonstrate that final cleanup goals have been achieved.

- The post processing and display of the RI data (e.g., Portray figure data, such as contaminant concentrations, water table elevations, and other graphic information, so that the procedures for data selection, assessment, and illustration are systematic and consistent) is a general concern that covers most of the data needs. All spatial data will be registered to the standard Hanford coordinate system and prepared through a formal graphic information system (GIS) process that will apply consistent methods of cartography, symbology, and date rendering.

- As noted in Figure A-9, there are several concerns in Figure A-11 that address the need to be innovative, flexible, and timely in data collection activities (e.g., Follow-through phases of environmental evaluation need to be flexible to accommodate the results of newly conducted investigation tasks, and evaluate data collection and analytical methods before implementation of investigation activities under the work plan). Emerging information from the RI investigation will be incorporated into the analysis and RI report. Data collection and analytical methods will be evaluated before the implementation of any RI activities. Many of these activities are being planned in the Sampling and Analysis Plan (SAP) for this RI.

- Develop and adhere to regular, consistent sampling schedules for aquifer tube monitoring, also is reiterated in Figure A-11 and as described by Data Need 6 in Table 4-6. Data collection requirements will be captured in the Aquifer Tube SAP, which will be updated in parallel with RI/FS activities.

Figure A-12, 100-D Area South Plume: Hexavalent Chromium:

- The focus of Figure A-12 Data Gaps are on the reactor areas and adjacent facilities, including the 182-D Reservoir. These include the need to evaluate the effects of liquid leakage from current reactor features on groundwater movement and vadose zone transport as well as to resolve whether to accelerate and/or modify maintenance actions and schedules to minimize leakage, and determine whether maintenance actions have influenced contaminant migration and groundwater movement. These concerns are addressed as described by scope of work for Data Needs 2, 3, and 14 in Table 4-6.

- The need to develop exposure risk maps and determine the additional ecological receptor data needed to define risks in those mapped areas that are affected by the South Plume are related to and addressed as described by scope of work for Table 4-6 Data Needs 2, 5, and 7.

- The results of newly conducted investigation need to be accommodated. This broad overarching concern applies to all data needs. Similarly, using alternative data collection methods to assess river impacts. Technologies such as the Trident Probe being employed by WCH to sample the river bed and hyporehic zone off shore in the Columbia River adjacent to the OUs is one potential alternative. This information directly relates to Data Need 8 in Table 4-6 and provides an important co-data set to augment the bathymetry data.

Figure A-13, 100-D Area Groundwater Remediation:

- The need to define the extent of the groundwater contaminant plume related to Table 4-6 Data Needs 5 and 7, to understand the extent of contamination in the unconfined aquifer and beneath the unconfined aquifer, respectively.

- The need to revise the COPC list for use in establishing cleanup levels is being addressed via the 100 Area Integrated Work Plan (DOE/RL-2008-46) as agreed to through the interagency process. The final list will be reflected in the SAP.
- Explore and evaluate potential groundwater remedial technologies and evaluate the effectiveness of the ISRM barrier and other remedial alternatives that may be implemented as part of a final IROD." This data concern is associated with the evaluation of potential alternative remediation technologies as described in Table 4-6 Data Need 11.
- Figure A-13 raises several data-related concerns that are common to several previous figures. A common method and format for portraying groundwater data contours is being implemented to incorporate standard methods and will be displayed using standard cartography and symbology.
- Establishing appropriate, final cleanup levels that are protective of human health and develop a project definition of compliance is a concern outlined in this figure. Data will be collected relative to the constituent distributions and levels across the OU. The final ROD will then identify cleanup levels and compliance criteria to assess progress towards attainment of cleanup levels.
- As noted in reference to previous figures, the concern is to develop and adhere to regular, consistent sampling schedules for aquifer tube monitoring as is described by Data Need 6 in Table 4-6. Data collection requirements will be captured in the Aquifer Tube SAP, which will be updated in parallel with RI/FS activities. Similarly, alternative data collection methods to assess river impacts is an important data concern noted as 21 in Figure A-13. Technologies such as the Trident Probe being employed by WCH to sample the river bed and hyporehic zone off shore in the Columbia River adjacent to the OUs is one potential alternative. This information is directly related to Data Need 8 in Table 4-6, providing an important set of auxiliary data that augments the bathymetry data.

Figure A-14, 100-H Area General Information:

- The data concerns at the base of the figure states: "100-H Area data gaps fit 5 general categories: 1) upper unconfined aquifer; 2) RUM; 3) contaminant fate and transport; 4) adaptive data collection; and 5) non-sampling data gaps." These concerns are addressed by the Data Needs in Table 4-6 as follows: Data Concern 1 by Data Need 5, Data Concern 2 by Data Need 7, and Data Concern 3 by Data Need 12. Adaptive data collection and non-sampling data gaps are more general concepts that are addressed across Table 4-6. Adaptive data collection is being employed to address several data gaps. As the data gaps narrow with continued sampling and analysis, the data collection will become more focused. For example, undetected constituents may be dropped from future sampling rounds to focus on detectable significant quantities. Non-sampling data gaps include Table 4-6 Data Needs 4 and 11, which require identification of sites and evaluation of potential remediation technologies.

Figure A-16, 100-H Area Geology of the Vadose Zone:

- The main focus of the gaps in this figure is on the ZOI fate and transport analysis and risk assessment and the observation that inconsistent soil logging has occurred in the past that might impact characterization of the ZOI. These gaps are addressed across several Data Needs in Table 4-6. They are associated with Data Need 3 for the vadose zone but also Data Need 5 for the aquifer and Data Need 12 relative to transport properties. Improved soil logging also points to the need for additional coordination in the data collection process to ensure that data requirements are being met. Finally, uncertainty reductions in a number of data areas is needed to better quantify inventory estimates, initial conditions, and flow and transport model parameters. These overarching data needs are inherently incorporated into several Data Needs in Table 4-6, including 2, 5, 7, and 12.

Figure A-17, 100-H Area Hydrogeology and Contaminant Mobility:

- The viability of the RUM as a groundwater source, is addressed by Table 4-6 Data Need 7. The threat to 100-H from the plume originating in 100-D is addressed by Data Need 5.
- The installation of new groundwater monitoring wells and aquifer tubes in 100-H, use groundwater data collected from the wells to augment the baseline for the upper unconfined aquifer, performing risk analysis and feasibility study level analysis for remediation, as necessary for each COPC are addressed as described in by scope of work for Data Needs 5 and 13.
- Organize and conduct consistently and regularly scheduled groundwater monitoring to support a well-rounded groundwater quality database for monitoring wells and aquifer tubes, is addressed as described by scope of work for Data Need 13.
- Establishing a technically defensible, independently reproducible contouring method for evaluating and presenting contaminant concentration and groundwater elevation contours for the project and, visual representation of the contour boundaries should be reconsidered to illustrate the uncertainty inherent at 100-H is related to and addressed by both Data Needs 5 and 7. Standard contouring methods will be used that are reproducible and the resulting maps will be drawn incorporating GIS methods that employ standard cartography and symbology.
- The evaluation of groundwater in the new “Horn” wells for COPCs is addressed as described by scope of work for Data Need 13. A selected subset of the Horn wells were included in the baseline risk assessment of existing groundwater monitoring wells as described in the SAP.
- The contaminant fate and transport beneath the unconfined aquifer in the RUM and Ringold Formation is characterized as described by scope of work for Table 4-6 Data Need 7.
- Characterize hydraulic conductivity in these hydrogeologic units is determined as described by scope of work for Table 4-6 Data Need 7.
- When possible, aquifer tubes are installed in sets of three, with shallow, medium, and deep locations vertically. The data concern is addressed as described by scope of work for Data Need 6 in Table 4-6.

Figure A-18, 100-H Area Source Remediation and Residual Contamination:

- Data are needed to assess nature and extent of contamination throughout (i.e., from waste site to groundwater) the vadose zone for conceptual site model development and support an assessment of risk as described by Data Needs 2, 5, and 7 in Table 4-6.
- Data are needed from “unremediated waste sites” (i.e., accepted waste sites) to assess risk for direct exposure and protection of groundwater as guided by interim action RODs. “Unremediated waste sites” require completion of interim remedial action as applicable and sampling at 127 waste sites as described by scope of work for Data Need 1 in Table 4-6.
- Data may be needed to assess the nature and extent of contamination beneath the 105-H Reactor structures as described by Data Need 3.
- Data are needed to assess the physical properties of soils to support modeling efforts. This particular concern is broad and applicable to Table 4-6 Data Needs 2, 5, 7, and 12.
- Data are needed to confirm contaminant distribution coefficients to support modeling, and is applicable to Data Needs 2, 5, 7, and 12.

Figure A-19, 100-H Groundwater Remediation:

- The extent of the groundwater plume should be defined, and this is described in Data Needs 5 and 7 in Table 4-6.
- The COPC list can be found in the SAP.
- Potential groundwater remedial technologies should be evaluated to address 100-H groundwater contamination and the threat from the plume migrating from 100-D is reflected by Table 4-6 Data Need 11.
- A standard method should be developed for portraying groundwater contour data. Standard contouring methods will be used that are reproducible and the resulting maps will be drawn incorporating GIS methods that employ standard cartography and symbology. These techniques will be applied to Table 4-6 Data Needs 5 and 7 and other cases as appropriate.
- Additional ecological receptor data may need to be collected and assessed. The data should be used to develop exposure risk maps and used in targeting areas that require remediation and designing a remedial approach to address those areas and that the Risk Assessment should be completed for 100-H. These concerns are being worked in conjunction with the RCBRA. Emerging information will be incorporated as appropriate. The actual Risk Assessment in 100-H will be supported as described by scope of work for Data Need 13 in Table 4-6.
- Figure A-19 lists the following: Final cleanup levels should be developed that are protective of human health and ecological receptors. Incorporate these goals into remedial technology performance criteria. If necessary, alternative data collection methods may need to be developed to assess river impacts and use the data to evaluate remedial technology performance. These concerns are complex, applicable to several data needs, and are addressed as described by scope of work for several Table 4-6 Data Needs, including 6, 9, and 11.
- The need to be flexible to accommodate the results of newly conducted investigations. Emerging information from the RI investigation will be incorporated into the analysis and RI report. New information will be used to guide ongoing data collection activities.

A3 References

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PROBLEM STATEMENT

- Large quantities of radioactive and hazardous liquid and solid waste were disposed in the 100-D Area subsurface vadose zone soil. Contaminant concentrations from these wastes in vadose zone soil and groundwater exceed established standards and may pose a threat to human and ecological receptors.
- After initial demolition and dismantling (1973-1989) have been applied to remove soil contamination and contain CrVI in groundwater, residual and additional contamination remain.
- The distribution, mass, and location of CrVI in the vadose zone are not well understood.
- ISS is a long-term, temporary measure that protects the D and DR Reactors from environmental degradation and limits surface contamination. The incorporation of the remedy for the D and DR Reactors into the final ROD will be determined.

MULTIPLE CONTAMINATION SOURCES

Liquids	Disposal Disposition
Contaminated Cooling Water	Cribs, Retention Basins, Trenches, Ponds, Outfalls
Water Treatment Preparation	Trenches, French Drains
Decontamination Waste	Trenches, French Drains
Laboratory Waste	Trenches, French Drains, Burn Pits
Septic Waste	French Drains, Septic Fields
Sludge	Basins, Pits
Emergency Discharges	Cribs, Retention Basins, Trenches, Ponds, Outfalls
Solids	**Disposal Disposition**
Construction & Maintenance Debris	Burial Grounds, Pits, Burn Pits
Drums	Burial Grounds, Pits
Boxes & Miscellaneous	Burial Grounds, Pits, Burn Pits
Spent Nuclear Fuel	Burial Grounds
Fly Ash	Fly Ash Disposal Unit Mound

Note: Unintended releases leading to residual long-term contamination are not disposal methods. Select, unplanned releases are addressed in 100-D Area CSM-Component 12.

IMPLEMENTED INTERIM ACTIONS AND RESPONSES

- The 1996 ROD for Interim Actions for the 100-HR-3 OU Identified the following COPCs for groundwater for the 100-D Area.

Chemical COPCs (inorganic and anions) included:

- Ammonia (as N)
- Iron (Fe)
- Nitrate (NO_3 as N),
- Sulfate (SO_4),
- Hexavalent Chromium (CrVI)
- Barium (Ba),
- Manganese (Mn),
- Vanadium (V)
- Sulfide (S^{-2})

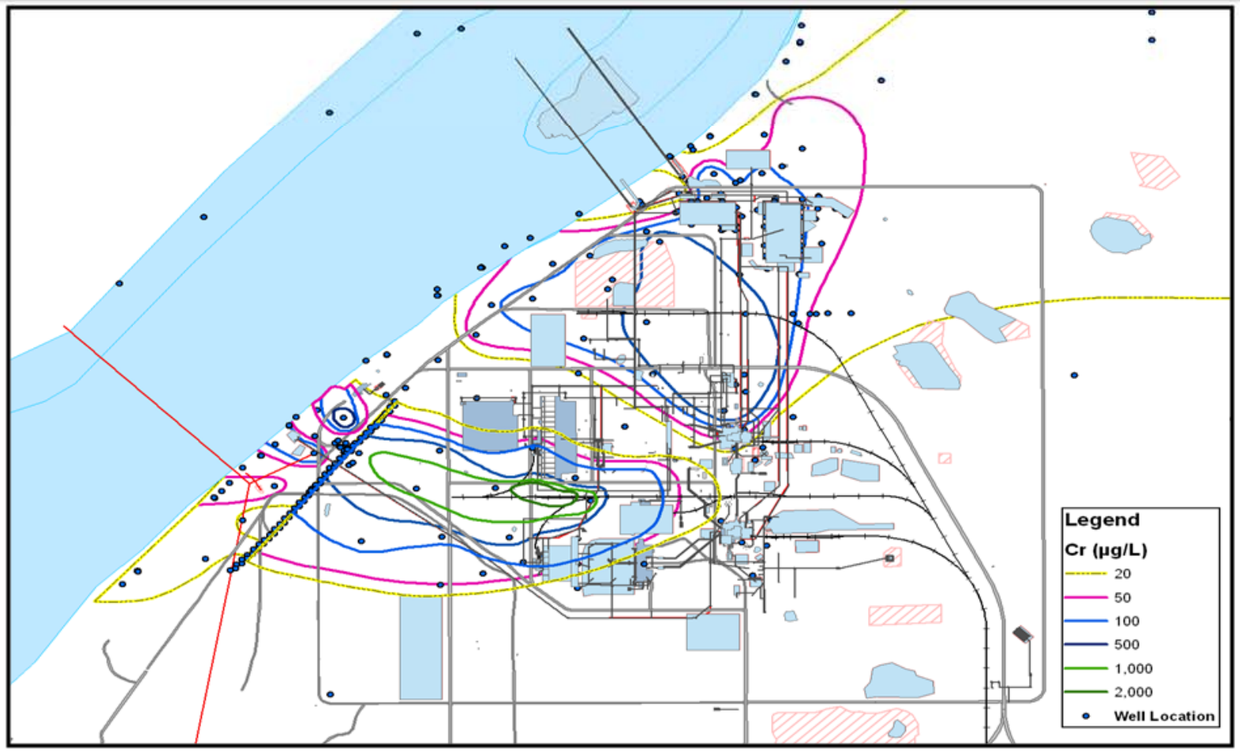
Radionuclide COPCs included:

- Tritium (H3)
- Strontium-90 (Sr90)
- Uranium-233/234 (U233-234)
- Uranium-238 (U238)+

CHROMIUM CONCENTRATION TRENDS IN GROUNDWATER

Activity	Start Date	Actual or Anticipated Completion
Source Remediation	1996	2011 - Interim Completion; Final ROD Remedy TBD
Pump and Treat	1997	2011 - Interim Completion Final ROD Remedy TBD
In Situ Redox Manipulation	2000	2011 - Interim Completion Final ROD Remedy TBD
Interim Safe Storage (ISS)	1998 DR Reactor 2000 D Reactor	2002 - DR Reactor 2004 - D Reactor
Fire Suppression Water Storage &Facility Maintenance	2007	To be Determined
Incorporate Remedy into Final ROD	To be Determined	To be Determined

CRVI PLUME CONTAMINANT DISTRIBUTION IN FALL 2007



DATA GAPS

1 Define the Extent of Groundwater Contaminant Plume
2 Revise the COPC List
3 Determine Potential Groundwater Remedial Technologies
4 Define the RUM Nature and Extent of Contamination
5 Define RUM Contaminant Concentrations
6 Define RUM Hydrogeological and Geochemical Parameters
7 Determine RUM Groundwater Discharge Areas
8 Determine RUM Groundwater Cleanup Levels
9 Standardize Groundwater Contouring Methods
10 Periodically Evaluate Re-wetted Zone Contamination
11 Develop Exposure Risk Maps
12 Determine Ecological Receptor Data
13 Determine Release Bathymetric Data to Database
14 Determine Zone of Interaction Fate and Transport
15 Complete Risk Assessment
16 Determine Land Use and Beneficial Use of Natural Resources
17 Determine Final Cleanup Levels
18 Adapt Data Collection Strategies
19 Define Compliance
20 Determine Aquifer Tube Sampling Frequency
21 Evaluate Alternative Data Collection Methods to Assess River Impacts

Figure A-1. 100-D Area General Information

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PROBLEM STATEMENT

- Operation of the 105-D and 105-DR Reactors produced radioactive and hazardous contaminated liquids and solid wastes that were disposed to the soil column in and around the 100-D Area.
- Inactive, active, and demolished facilities may have historically contributed to vadose and groundwater contamination in the 100-D Area.
- Active and not yet demolished facilities may continue to contribute to vadose and groundwater contamination in the future.

FACILITY DESCRIPTION AND PROCESSING

- The 105-D/DR Reactor facilities are located in the 100-D/DR Area of the Hanford Site. The reactors were used to produce plutonium for nuclear weapons. Both reactors are water-cooled, single pass, and graphite moderated.
- Construction of the D Reactor was initiated in November 1943. Initial startup of the reactor was achieved in December 1944. The reactor was shut down in June 1967 and put on a condition of minimum surveillance and maintenance.
- Construction of the DR reactor was initiated in December 1947. Initial startup of the reactor was achieved in October 1950. The reactor was shut down in December 1964.
- Past operations, disposal practices, spills, and unplanned releases have resulted in contamination of the 105-D/DR Reactor facility structures, underlying soil, and groundwater in the 100-D/DR Area.
- The Tri-Parties have determined that hazardous substances in the facilities present a potential threat of release that pose a substantial risk to human health and the environment to the extent that a removal action is warranted.

FACILITY CERCLA REMOVAL PLAN

- Alternatives for conducting a non time-critical removal action for various facilities in the 100-D/DR Area were considered in DOE/RL-2000-45, *Engineering Evaluation/Cost Analysis for the 105-D Reactor Facility and Ancillary Facilities* and *Engineering Evaluation/Cost Analysis for the 105-DR and 105-F Reactor Facilities and Ancillary Facilities.*
- The selected remedy was to:
  - D&D the reactor buildings and the ancillary facilities.
  - Construct the ISS over the reactors for up to 75 years, with final one-piece removal to a burial site in the 200 West Area.
- The Action Memorandums documented approval of the recommendation in July 1998 for 105-DR Reactor and October 2000 for 105-D Reactor.
- DOE/RL-2000-57, *Removal Action Work Plan for 105-D and 105-H Building Interim Safe Storage Projects and Ancillary Buildings* and DOE/RL-98-37, *Removal Action Work Plan for 105-DR and 105-F Buildings Interim Safe Storage Projects and Ancillary Buildings* directed the implementation, and served as the decommissioning plan and project management plan of the removal and activities.
- The RAWP outlined the decommissioning activities as follows:
  - Initiate site mobilization and preparation activities
  - Remove hazardous substances (chemical and radiological)
  - Remove facility equipment and miscellaneous piping
  - Characterize Site
  - D&D various facility structures
  - Dispose of waste
  - Construct the Safe Storage Enclosure
  - Restore Site
  - Demobilize
- The 105-D ISS Project was completed in September 2004. BHI-01741, *105-D Reactor Interim Safe Storage Project Final Report* documented the D&D process of the reactor and the ancillary facilities.
- The 105-DR ISS Project was completed on September 2002. BHI-01663, *105-DR Reactor Interim Safe Storage Project Final Report* documented the D&D Process of the reactor and the ancillary facilities.

INTERIM REMOVAL ACTIONS -100 D/DR AREA

Figure A-2. 100-D Area Facilities

FACILITY REMOVAL STATUS

Total Facilities:	60	Demolished Facilities:	46
Active Facilities:	16	Removed:	19
Inactive Facilities:	5	Status Unknown:	26

Reference: SIS, 11/12/2008

DATA GAPS

- The orphan sites evaluation process is a systematic approach involving historical review and field investigation to identify new source unit waste sites that are not identified for characterization or cleanup within existing decision documents. This process has identified three potentially new waste sites (discovery sites) associated with various 100-D Area facilities. If these discovery sites are accepted as WIDS waste sites, the data gaps associated with each site are to evaluate the nature and extent of contamination and impact to groundwater. (See 100-D Area Data Needs Source Area in Chapter 4.0). The three discovery site are listed in the 100-D Area Orphan Sites Evaluation Report, OSR-2006-0001, 2009 Rev. 0.

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PROBLEM STATEMENT

- Existing facilities in the 100-D Area are used to move and store water for ongoing site uses, such as fire and dust suppression. These facilities comprise the EWS.
- Old pipelines and reservoirs are used to transport water from the river to various locations at Hanford. Some of these EWS facilities leak and may impact the distribution and movement of contaminants.
- The proximity of unremediated waste sites to the relatively fragile EWS represents a potential contaminant transport pathway.
- The range and magnitude of water losses from active and latent infrastructure on contaminant fate and transport remains unquantified.

EXPORT WATER SYSTEM USES

- The EWS is required for maintaining the potable and export system supply for various sites at the Hanford Site.
- Made up of multiple reservoirs located in the 100 Area and the 200 Area, one large reservoir (182-D) is located in the 100-D Area. The 182-D Reservoir is a critical piece of the EWS.
- The 182-D Reservoir has a 95 million liters (25-million-gallon nominal capacity and serves to store river-derived water to be used for safety purposes (fire and dust suppression) and various operations, and as a potable water supply. The scale and redundancy provided by the EWS are necessary to ensure an adequate water source for its intended uses.
- The water in the EWS reservoirs supplies water through a network of large-diameter pipelines (approximately 40 km [25 miles] total length) to moderately sized distribution reservoirs located on the Central Plateau (200 Area). The 200 Area reservoirs supply water to the 200 East and West Area facilities and systems.

SYSTEM LEAKS AND RELEASES

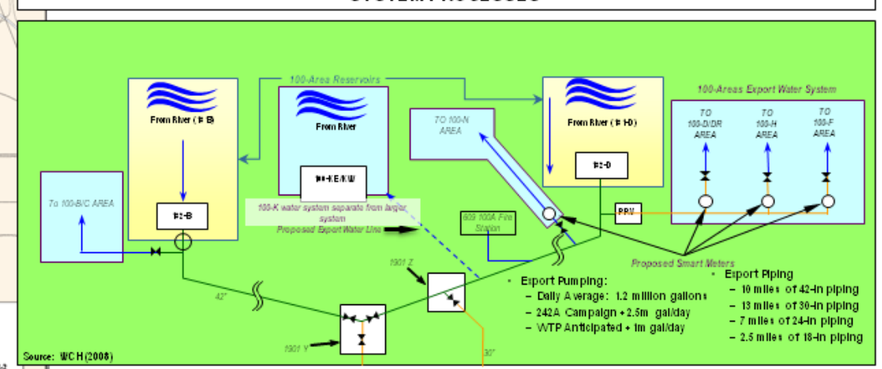
- The EWS reservoirs and associated piping are antiquated and have leaked and failed in some areas. Substantial water losses from the 182-D Reservoir have been monitored for several years.
- Latent infrastructure may be inadvertently pressurized to further water loss to the subsurface.
- Leakage of raw water from the 182-D Reservoir has perturbed groundwater flow and may have impacted remediation efforts. Administrative controls on reservoir operation (instituted in 2004) have significantly reduced the leak rate.
- When failures and leaks occur near contaminant sources and waste disposal sites, the risk is increased for contaminant mobilization from un-remediated areas.
- Reservoir leaking can be somewhat controlled by maintaining a reduced water level.

EXPORT WATER SYSTEM OVERVIEW

WASTE SITE LOCATIONS AND IDENTIFIED INFRASTRUCTURE

SYSTEM PLAN VIEW

SYSTEM PROCESSES



MAINTENANCE

- Many EWS components have had to be replaced or repaired. However, the deterioration of the EWS increases the risk for additional leaks and component failures.
- In recent years, efforts to upgrade the system have included:
  - Pump replacement
  - Facility modifications and reliability enhancements
  - Aerial thermal imaging photography (2003) and ground-truthing to confirm suspected leak locations
  - System conditions and life expectancy evaluations
  - New technology investigations to refurbish damaged underground water lines in place
  - Analysis of power supply
- Additional upgrades are planned to begin in 2010.

DATA GAPS

- Data and information are needed to confirm potential contamination derived from the EWS. Estimate whether potential water losses occur along the EWS infrastructure system and calculate potential losses. Determine whether potential leaks may affect groundwater flow and, therefore, contaminant mobility (Data Gap #1).
- Determine the potential and magnitude for possible leakage from the 183-D Reservoir to adversely impact groundwater (Data Gap #1).
- Follow-through phases of environmental evaluation need to be flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).

Figure A-3. 100-D Area Export Water System

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PROBLEM STATEMENT

- As a result of dichromate use at the 100-D Area, CrVI contamination is present at levels that pose risk to human health and environmental receptors in groundwater and is a suspected source in the vadose zone.
- The nature and extent of CrVI contamination appears to be much greater than initially thought, and has proven difficult to characterize.
- In the 100-D Area, CrVI contamination conditions and remediation responses are unique in the 100 Area. This situation results from a combination of factors. Substantial suspect source areas have not been identified and/or remediated, and active, potentially leaking water export system lines may be promoting contaminant transport.
- Multiple high-discharge locations have been identified but not quantified. Unplanned or latent infrastructure discharges are not quantified.

CHROMIUM USES

- Sodium dichromate and chromic acid were used in large quantities at the Hanford Site 100-D Area and discharged to the environment as a result of planned and unplanned releases.
- Chemical uses include:
  - Corrosion control in the reactors
  - Process engineering laboratory experiments
  - Equipment decontamination.

CHROMIUM DISCHARGES

- Discrepancies in documented descriptions of specific waste sites pose a risk as unidentified and unknown waste sites. Laboratory and decontamination discharges likely did not use cribs and retention basins, as intended, because their piping was not interconnected.
- While concentrated, liquid sodium dichromate disposal locations are identified and/or suspected; other areas received dichromate waste in solid form.
- Process sewers and outfalls intermittently received concentrated dichromate solutions in a diluted process water. Concentrated discharge amounts and mixing conditions are not quantified.
- Because of their locations, burial ground wastes are not considered to contribute substantially to CrVI groundwater contamination.

HEXAVALENT CHROMIUM PROCESS FLOW

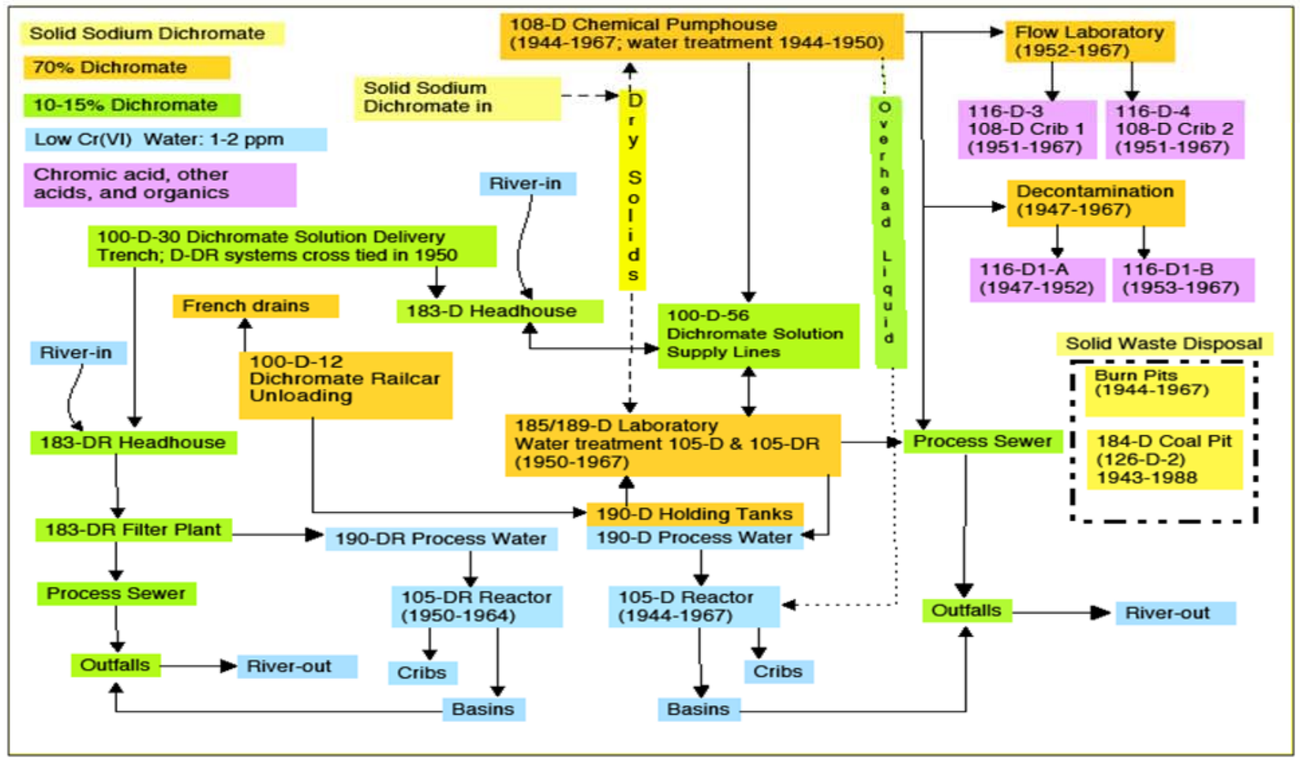

Figure A-4. 100-D Area Sodium Dichromate Lifecycle

PROCESS AND DECOMMISSIONING RELEASES

- The dichromate process flow has distinct features that resulted from facility evolution, timing, and operation activities that may account for source contamination.
- Process losses during operations were inconsistently detected and rectified.
- In 1950, corrosion control process operations changed from the use of dry chemicals to liquids, and operations were relocated to other sites.
- Dichromate source concentrations varied as a function of time and process method changes.
- Documented decommissioning activities vary from activities actually performed. This inconsistency has resulted in an apparent risk of unidentified source areas.
- Dichromate source terms from decontamination and Flow Laboratory activities were distinct and separate from water treatment.

DATA GAPS

- Evaluate the potential scale for the suspected use of dichromate and chromic acid and their potential disposal at 116-D-1A, 105-D Storage Basin Trench #1; 116-D-1B, 105-D Storage Basin Trench #2; 116-D-3, 108-D, Crib #1; and 116-D-4, 108-D Crib #2, based on historical records of decontamination activities and Flow Laboratory process and discharge records. Evaluate the potential for liquid leakage from the fire suppression water system at the100-D Area. Identify potential sources of chromium in groundwater derived from former processes and decommissioning release information, and from facility layout information (Data Gap #1).
- Follow-through phases of environmental evaluation need to be flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).

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PROBLEM STATEMENT

- Radiological and non-radiological contaminants, released to the subsurface as a result of the Hanford Site operations, have been detected in the 100-D Area vadose zone. Some of the contaminants have reached groundwater. Vadose zone source areas have not been entirely defined.
- The fate and transport of residual contamination below remediated areas may continue to migrate to groundwater. Until the reactor buildings are removed in the future, potential contamination left in the reactor building footprints may pose continuing sources to contamination transport through the vadose zone to groundwater.
- Historically high liquid waste discharges may have served as a driver for CrVI migration laterally (radially due to mounding) and downward. This past process resulted in higher, relative permeability moisture content deeper in the vadose zone than in undisturbed areas.
- Source area remediation continues, but remaining contaminants may continue to migrate to groundwater or other receptors.

GEOLOGICAL SETTING AND STRUCTURE

- Hanford is located in the Pasco Basin, a physical and structural depression that was created by tectonic activity and folding of the Columbia River basalts.
- The following geographical features bound the Pasco Basin:
  - North by the Saddle Mountains
  - West by Umtanum Ridge, Yakima Ridge, and the Rattlesnake Hills
  - South by Rattlesnake Mountain and the Rattlesnake Hills
  - East by the Palouse Slope
- The Columbia Basin has four structural subprovinces, two of which are important to the Pasco Basin and the Hanford Site: the Yakima Fold Belt and the Palouse Slope.
- Cut by rivers, Hanford formation plateaus are separated by ridges that rise up to 1,200 m (4,000 ft) above sea level.
- Depositional and erosional processes have formed a landscape of rolling hills.
- The Columbia River divides the terrace plains and ridges south of the river from the 244 m (600-ft) high White Bluffs, which rise abruptly on the north bank.

STRATIGRAPHY

- The 100-D Area stratigraphic units in the vadose zone, in descending order, are as follow:
  - Surface Deposits: Surface deposits consist of mixed windblown and water-lain silt, sand, and gravel that form a thin, surface veneer at a thickness of several feet.
  - Hanford formation: The Hanford formation is made of pebble- to boulder-sized gravel, sand, and silt deposited from 10 to 20 m (33 to 66 ft) at the 100-D Area, caused by cataclysmic glacial floods.
  - Ringold Formation: The Ringold Formation was formed where coarse-grained sediments were deposited in migrating, ancestral river channels. Periodically blocked river flow formed fine-grained, overbank flood sediments up to 150 m (492 ft) thick as backwater lakes formed and drained. These units are identified as Units A through E.
  - The gravelly Ringold Unit E is the deepest portion of the vadose zone at the 100-D Area, above the relatively low-permeability RUM. The RUM is composed of silt and clay-rich overbank and paleosol deposits 18 to 32 m (59 to 104 ft) deep and up to 22.5 m (74 ft) thick.
  - Unit E is the uppermost Ringold Formation unit and supports almost the entire aquifer at the 100-D Area, except where generally absent near the river. Thus, the Hanford formation overlies the RUM near the river.

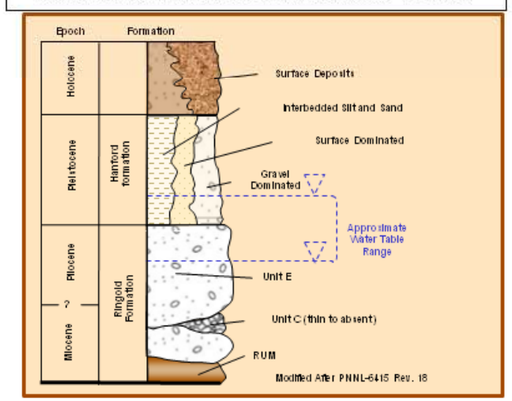
VADOSE ZONE CONTAMINANT MOBILITY

- Downwardly mobile contaminants may eventually enter the unconfined aquifer.
- Structurally controlled flow occurs when contaminants migrate through more porous media, such as the backfill around buried tanks and piping.
- Liquid waste releases likely followed the path of least resistance by way of moving through more porous and permeable infrastructure backfill materials, voids, and openings in the upper vadose zone.
- Predominantly uniform flow through the unsaturated matrix is a dominant flow mechanism at arid sites with unconsolidated sediments, such as the Hanford Site.
- Vadose zone CrVI likely would be suspended in interstitial soil moisture, rather than adsorbed to soil grains, based on its hydraulic conductivity and other factors. Therefore, appropriate sample collecting and testing methods are needed to detect CrVI in the interstitial soil moisture, including soil moisture concentrations.

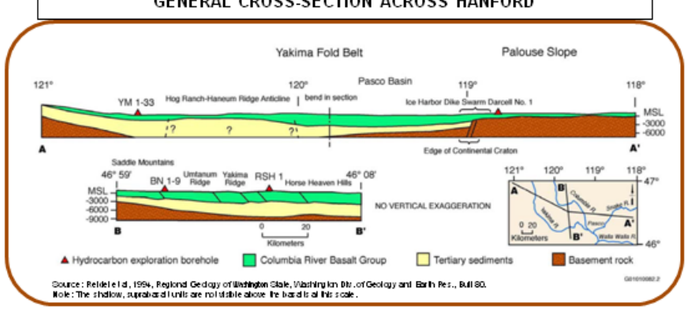
DATA GAPS (VADOSE ZONE)

- Amounts of laboratory analytical data for subsurface soil decrease with increasing depth. Collect additional deep vadose zone contaminants and transport parameter data to understand vadose zone contaminant transport to groundwater. Complete interim actions and obtain verification data (Vadose Zone Data Gap #1).
- Using historical and 2007 investigation data, define the nature and extent of contamination in the vadose zone (Vadose Zone Data Gap #2). Assess CrVI in ambient soil moisture; include deep vadose zone samples. Evaluate whether Hanford formation material heterogeneity affects permeability and the potential downward migration of CrVI.
- Investigate additional sources of vadose zone chromium at the 100-D Area (Vadose Zone Data Gap #3).
- Collect geological, hydrogeological, and bulk geochemistry data to support final remediation decisions via the final ROD. Evaluate the nature and extent of contamination beneath reactor structures and assess hydrogeological characteristics, such as potentially affected by past liquid waste disposal (Vadose Zone Data Gap #4).
- Confirm contaminant distribution coefficients to support modeling (Vadose Zone Data Gap #5).

100-D AREA GENERALIZED STRATIGRAPHIC COLUMN



GENERAL CROSS-SECTION ACROSS HANFORD



PHYSICAL AND STRUCTURAL GEOLOGY ACROSS HANFORD

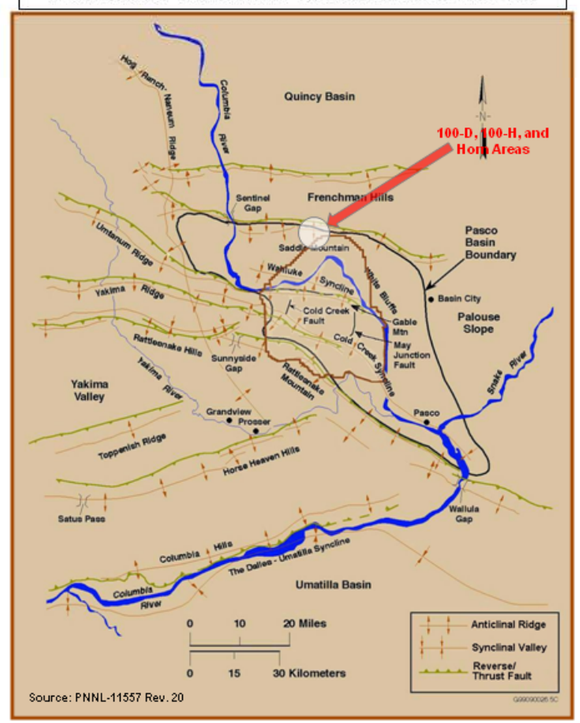


Figure A-5. 100-D Area Geology of the Vadose Zone

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PROBLEM STATEMENT

- The geology of the 100-D Area vadose zone consists of Hanford formation sandy and gravelly deposits overlying Ringold Unit E gravels. Discharges of liquid wastes from past disposal practices resulted in contaminants in the vadose zone and transportation of contaminants to groundwater. Planned liquid discharges in the 100-D Area were terminated in 1967, and in the 100-DR Area in 1964.
- Residual vadose zone contamination remains and these contaminants may continue to be transported to groundwater.
- Lateral spreading of contaminants from waste disposal appears to be relatively limited. However, groundwater contamination at concentrations greater than drinking water standards and aquatic cleanup standards (CrVI) is persistent in groundwater. Vadose zone source areas and transport mechanisms appear to be continuing to contribute to the groundwater plumes within the 100-D Reactor Area.

HYDROGEOLOGICAL SETTING

- Water beneath the 100 Area uppermost aquifer exists in unconfined conditions in a relatively thick sequence of stream-, lake-, and glacial-derived sands and gravels. The base of the unconfined aquifer is the contact with the low-permeability RUM.
- In the 100-D Area, the Ringold Unit E supports the upper unconfined aquifer, except near the river, where this unit has been eroded. In this area, the Hanford formation is in contact with the RUM.
- Where present below the water table, the coarse-grained Hanford formation makes up the most permeable zones of the unconfined aquifer system.
- Downward migration of contaminants in the aquifer is slowed by the RUM.
- Seasonal and diurnal fluctuations of the river affect the water table elevations, groundwater flow directions and flow rates, hydrogeochemistry, contaminant concentrations, and the periodically rewetted zone.

HISTORICAL LIQUID WASTE DISCHARGE TO SUBSURFACE

- Large volumes of liquid waste had moved through the subsurface beneath the D/DR Reactor areas during facility operation. Liquid waste discharge volumes and locations influenced groundwater flow directions and flow rates.
- Groundwater levels were greater in the past, rising from up to 3 m (10 ft) above water-table positions, as a result of the Hanford Site operations. Other artificial recharge sources included discharges to drain fields, injection wells, and septic systems.
- These processes suggest groundwater plume flow from the 100-D Area across the horn area to the 100-H Area.
- Influence from the 100-D/DR Reactor areas across the horn area was observed.

CONTAMINANT MOBILITY

- Some vadose zone liquid waste migrates downward to the 100-D Area unconfined aquifer and moves with the groundwater toward the river.
- Initially, large volumes of infiltrated liquid waste enhanced vadose zone contaminant flow to groundwater and the river. Groundwater contaminants continue to reach the river.
- Soil contamination is a continuing source for further downward migration to groundwater, at rates and concentrations dependent on physical, chemical, and other factors.
- Waste CrVI concentrations in the pump-and-treat extraction wells near the river decrease during high river stage, as the groundwater gradient reverses, and as river water dilutes the contaminants.
- Groundwater flow shifts direction from spring high levels to fall lower groundwater levels. Fall river levels enhance groundwater flow toward the river, while spring levels redirect groundwater flow across the horn area eastward to the 100-H Area.
- Some 100-D Area groundwater is captured by the pump-and-treat system. Away from the system, groundwater flows from the 100-D Area across the horn area.

DATA GAPS

- Determine whether additional spatial and temporal data may be needed to assess the impact of subsurface excavation or naturally occurring scour and fill environment pathways on contaminant concentrations and subsurface mobility (Data Gap #1).
- Develop and implement an approach to estimate and calculate the possible mass flux of contamination (Data Gap #1).
- Evaluate groundwater contaminant concentration trends and transport (Data Gap #1).
- Complete source identification in the vadose zone. Evaluate groundwater contaminant concentrations trends and analyze potential explanations such as influences from source removal, dust suppression, or other contaminant interception or mobilization activities (Data Gap #1).
- Revise the COPC list and evaluate contaminant transport for those COPCs (Data Gap #2).
- Differentiate between variations in data quality and differences in how data are illustrated and represented graphically for use in decision-making and risk evaluation (Data Gap #9).
- Examine geologic, hydrogeological, and chemical data to predict potential preferential pathways for contaminated groundwater flow.
- Ensure follow-through phases of environmental evaluation are flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).
- Use Alternative Data Collection Methods to Assess River Impacts (Data Gap #21)
- Evaluate the extent and magnitude of contamination at visibly stained areas in the vadose zone.

HISTORICAL LIQUID WASTE DISCHARGE TO SUBSURFACE

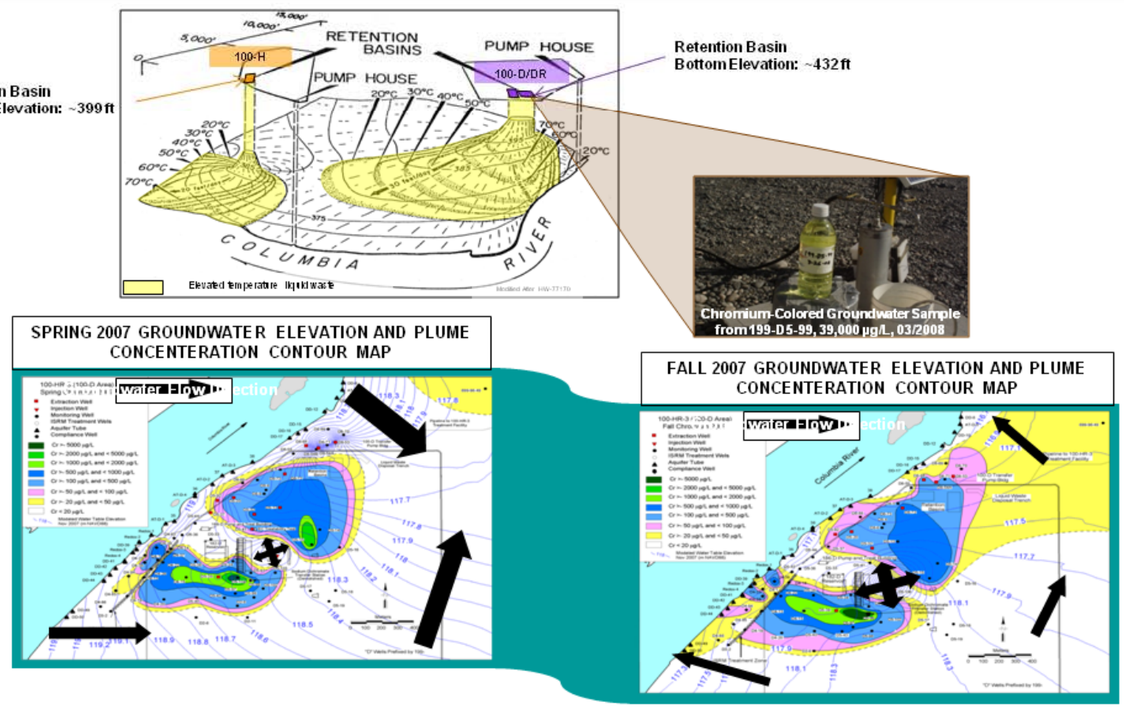

Figure A-6. 100-D Area Hydrology and Contaminant Mobility

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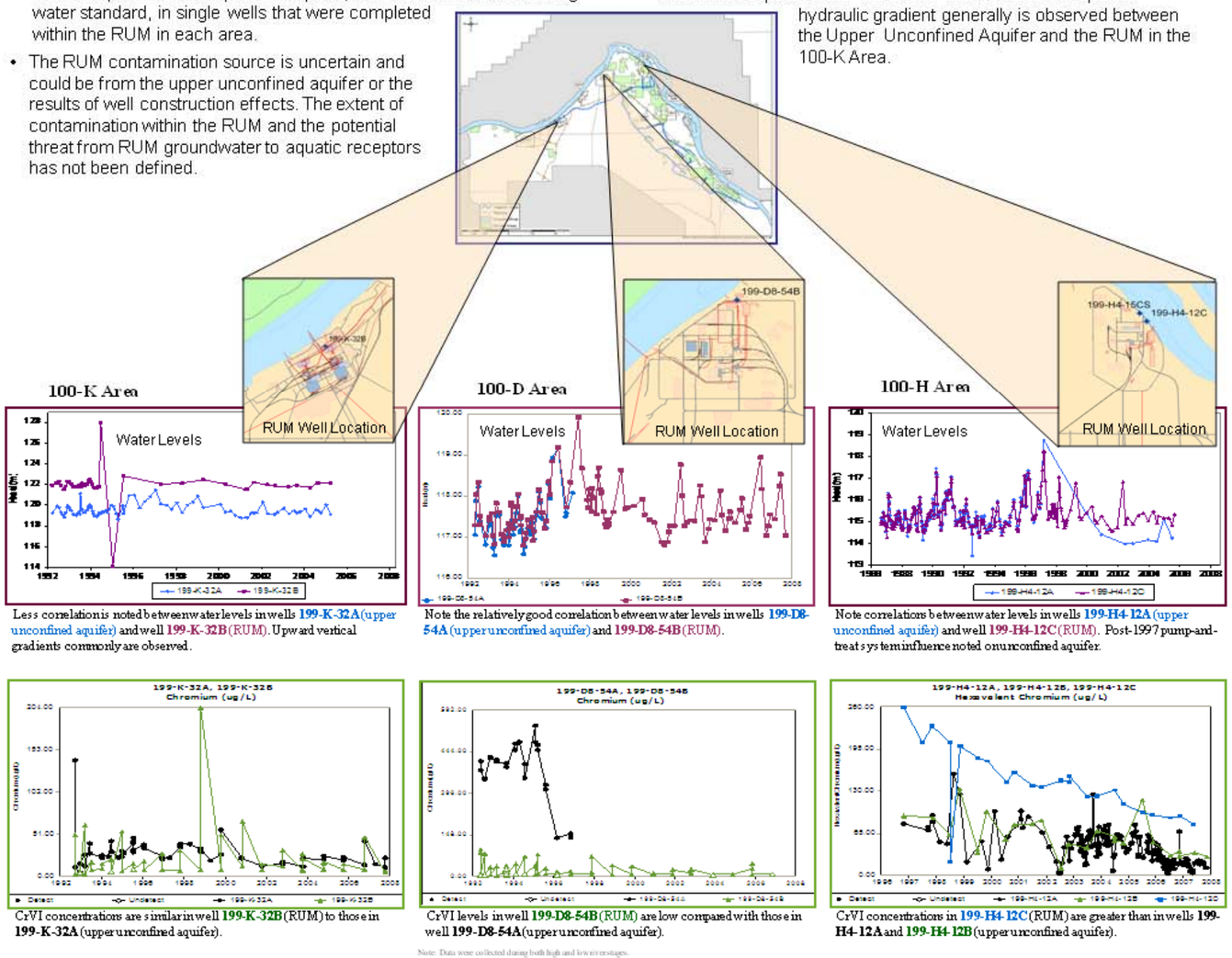
PROBLEM STATEMENT

- CrVI and other contaminants have been identified in the upper unconfined aquifer (Ringold Unit E and Hanford formation) in the 100-D Area. The RUM is generally recognized as the base of upper unconfined aquifer in the 100-D and 100-H Areas. CrVI contamination has been detected in the RUM at relatively low concentrations above the cleanup standards of 20 and 22 µg/L established in interim action RODs as protective of aquatic receptors, but less than federal drinking water standard, in single wells that were completed within the RUM in each area.
- The RUM contamination source is uncertain and could be from the upper unconfined aquifer or the results of well construction effects. The extent of contamination within the RUM and the potential threat from RUM groundwater to aquatic receptors has not been defined.

RUM HYDROGEOLOGY IN THE 100 AREAS

- Beneath the 100-HR-3 OU, the top of the RUM surface expresses approximately 11 m (35 ft) of relief.
- Water level data indicate a hydraulic connection between the upper unconfined aquifer and the RUM at the 100-D and 100-H Areas.
- No consistent hydraulic gradient is observed between the upper unconfined aquifer in the 100-D and 100-H Areas. An upward hydraulic gradient generally is observed between the Upper Unconfined Aquifer and the RUM in the 100-K Area.



Less correlation is noted between water levels in wells **199-K-32A** (upper unconfined aquifer) and well **199-K-32B** (RUM). Upward vertical gradients commonly are observed.

Note the relatively good correlation between water levels in wells **199-D8-54A** (upper unconfined aquifer) and **199-D8-54B** (RUM).

Note correlations between water levels in wells **199-H4-12A** (upper unconfined aquifer) and well **199-H4-12C** (RUM). Post-1997 pump-and-treat system influence noted on unconfined aquifer.

CrVI concentrations are similar in well **199-K-32B** (RUM) to those in **199-K-32A** (upper unconfined aquifer).

CrVI levels in well **199-D8-54B** (RUM) are low compared with those in well **199-D8-54A** (upper unconfined aquifer).

Note: Data were collected during both high and low river stages.

CrVI concentrations in **199-H4-12C** (RUM) are greater than in wells **199-H4-12A** and **199-H4-12B** (upper unconfined aquifer).

CHROMIUM CONCENTRATIONS AND OBSERVATIONS IN RUM GROUNDWATER

- CrVI concentrations in excess of regulatory standards in RUM well 199-H4-12C at the 100-H Area may be the result leaching caused by salts added during well completion.
- Data from the horn area Investigation indicate that chromium contamination is present in the RUM.
- CrVI concentrations in the RUM typically are less than 100 ug/L.
- Water level data indicate a hydraulic connection between the upper unconfined aquifer and the RUM at the 100-D and 100-H Areas. Although a lower correlation is noted for the 100-K Area, similar chromium concentrations are observed between the 100-K Area confined and unconfined aquifers.
- Cleanup to drinking water standards or protection of aquatic receptors should be evaluated during the RI/FS process (based on the level contamination and degree of hydrogeological communication between the RUM, the unconfined aquifer, and aquatic receptors).

POTENTIAL WELL CONSTRUCTION EFFECTS ON CHROMIUM CONCENTRATIONS IN GROUNDWATER

- Sodium and chloride are known to leach chromium from stainless steel well materials to groundwater. While RUM well 199-H4-12C was constructed with stainless steel materials and salts were added during well completion, sodium and chloride concentrations decreased within ~ 2 years.
- Salt corrosion of the well screen may have contributed to the initial chromium concentrations detected in RUM well 199-H4-12C. However, data analysis results strongly support the presence of a contaminant source in the RUM.

DATA GAPS

- Evaluate the extent of contamination (e.g., CrVI) in the RUM and integrate long-term data needs with 5-year CERCLA reviews (Data Gap #1).
- Finalize the contaminant suite (COPCs) for monitoring in the RUM (Data Gap #2), and establish RUM groundwater cleanup levels that need to be met (drinking water or aquatic protection; Data Gap #8).
- Establish the level of data quality and quantity needed to confirm contamination in the RUM (Data Gap #5) and to support remedial decisions for groundwater (Data Gap #3).
- Evaluate the site-specific relationship between total chromium and CrVI, and use the results to define the nature and extent of these contaminants in the RUM (Data Gap #4). Apply the results of the evaluation (Data Gap #5) to assess the hydrogeologic communication between the RUM and the Hanford formation for the horn area (Data Gaps #4 and 6).
- Define the hydrogeological communication between the RUM and aquatic receptors (Data Gap #7).
- Establish a clear definition of compliance and the regulatory confirmation process to recognize compliance for RUM contaminants in groundwater (Data Gap #19).

Figure A-7. 100-D Area Ringold Formation Upper Mud Contamination

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PROBLEM STATEMENT

- The ZOI is directly affected by river stage, and by historical and recent disposal practices. Limited data have been 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 conditions, when the hydraulic gradient toward the river is steepest, and mixing between river water and groundwater is minimal.
- Changes in plume characteristics may occur as groundwater contamination passes through the ZOI before discharging into the free-flowing stream.
- These changes may have implications regarding
  - The understanding of contaminant dispersion
  - Performing risk assessment
  - The selection, design, and implementation of a remediation technology.
- Contaminated groundwater discharges from groundwater to the river via riverbed pore water and riverbank springs.

RIVER STAGE AND FLOW

- River stage fluctuations change hydraulic and geochemical conditions in the ZOI between the river system and the groundwater system. The highest river stages occur during spring runoff, typically in May to late June. The lowest river stages occur during the late summer and early fall months.
- River stage elevations at the Hanford Site range from 120 to 104 m (394 to 341 ft) above mean sea level, from the northwestern to the southwestern boundary, respectively. Along the Hanford Reach, average annual river flow is ~120,000 ft^3/sec.
- Fluctuations in river stage are regulated by upstream releases from Priest Rapids Dam. The river stage fluctuates in daily to seasonal cycles that range from 0.5 m (1.6 ft) to several meters, respectively. These fluctuations correlate with water-level fluctuations in near-river wells, with lesser effects observed inland. The groundwater average linear flow velocities through Ringold Unit E may be .03 to 0.3 m/day (0.1 to 1.0 ft/day). The "net" velocity for a plume to migrate from a source to the river may be slowed. 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.

INTERACTION BETWEEN GROUNDWATER AND RIVER WATER

- 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. Groundwater movement primarily is perpendicular to the shoreline, with a semi-parallel flow component to river flow.
- Groundwater flow in the unconfined aquifer is estimated to range from 0.15 to 0.3 m (0.5 to 1.0 ft/day), and is highest, along with flow rates, 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 discharge 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.
- Dissolved CrVI 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.

EVOLVING CSM EFFORTS

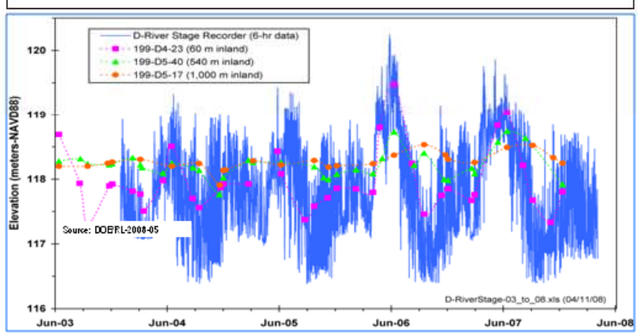
- DOE manages extensive groundwater and river water monitoring programs to support RCRA and CERCLA programs, and also Public Safety and Resource Protection programs.
- Current knowledge of the zone of interaction has contributed to:
  - Assessing the risk of contaminants discharging to the river
  - 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

- Develop data that contain consistent records of pressure and specific conductance for times covering those cycles, to characterize the various cycles in water movement and mixing in the ZOI, (Data Gap #10).
- Evaluate risks to ecological receptors and human health (Data Gap #12).
- Identify worst- to best-case scenarios of risk to human and ecological receptors to evaluate timing of risk to receptors, and determine the time period(s) at which ecological receptors are most vulnerable to contamination exposure (Data Gap #12).
- Focus river fluctuation data collection on year-round monitoring with an emphasis on exposure to ecological receptors (Data Gap #12). Update the sampling frequency for aquifer tubes to generate consistent data sets (Data Gap #20).
- Determine whether modeling may help reveal how the quickly changing river stage on the unconfined aquifer geochemistry, hydraulic characteristics, contaminant transport, and discharge to the river affect Chinook salmon redds and other sensitive ecological receptors (Data Gap #12).
- Process raw bathymetric data, which are available for the Hanford Reach but have not yet been conditioned for accessibility for computer simulations and geographic information system maps (Data Gap #13).
- Identify technically defensible models. Select numerical model packages within the appropriate regulatory context, such that model results would provide information for use in the protection of groundwater and reduction of the risk to receptors. Follow appropriate guidelines, rules, and regulations for model selection (Data Gap #14).
- Identify site-specific physical features and plume characteristics that control contaminant transport and fate at a local level. Computer simulations of groundwater flow paths and velocities could contribute substantial information to the CSM for environmental contamination. (Data Gap #14).
- Evaluate the ZOI mass flux of contaminants to groundwater (Data Gap #10).
- Quantify the effects of river stage on inland risk for use in remedial design and decision-making (Data Gap #14). Evaluate alternative data collection methods (Data Gap #21).
- Ensure follow-through phases of environmental evaluation are flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).

100-D AREA RIVER STAGE AFFECTS ON GROUNDWATER

COMPARISON OF RIVER AND GROUNDWATER LEVELS



UPSTREAM PRIEST RAPIDS DAM

STEEP RIVERBANK OF HANFORD REACH

PRINCIPAL FEATURES AND MONITORING SITES FOR ZONE OF INTERACTION

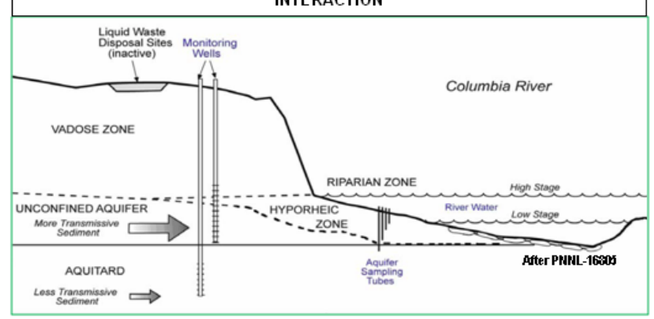


Figure A-8. 100-D Area Interaction Between Groundwater and River Water

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PROBLEM STATEMENT

- Deep vadose zone source areas remain unremediated and/or undiscovered. Their CrVI mass has not been quantified. Therefore, the overall impact to the periodically rewetted zone, the aquifer, and potential receptors is not well understood.
- Unidentified contaminant masses in the deep vadose zone and/or periodically rewetted zone are continuing sources to groundwater.
- Contamination in "relic" rewetted zones may pose a groundwater contaminant source.
- Consistently and inconsistently fluctuating (i.e., daily, weekly, seasonally, and episodic) contaminant conditions in groundwater may pose anomalous exposure risks.
- The persistence of the groundwater plume, which has not significantly decreased after 10 years of pump-and-treat operations, indicates unidentified deep vadose zone or periodically rewetted zone sources.
- CrVI does not adsorb easily onto soil and is easily mobilized when sources come into contact with high groundwater.

DESCRIPTION

- The water table rises and falls through the periodically rewetted zone:
  - Beneath the reactor areas, this zone is up to several meters thick.
  - During historical operations, the zone was much thicker.
  - The river stage is the primary driver for water table elevation changes.
- Two mechanisms may introduce contamination to the periodically rewetted zone:
  - Downward migration from the vadose zone.
  - Movement of contaminated groundwater upward into the vadose zone during high water table conditions.

RELEVANCE TO REMEDIAL ACTION DECISIONS

- Design and implementation of remedial technologies:
  - Vadose zone contamination may pass through this zone of dynamic hydrologic and geochemical processes, and alter mobility characteristics.
- Implications for a Monitored Natural Attenuation remedy:
  - The cyclical nature of contaminated groundwater moving into and out of the periodically rewetted zone may extend the residence time of the plume.

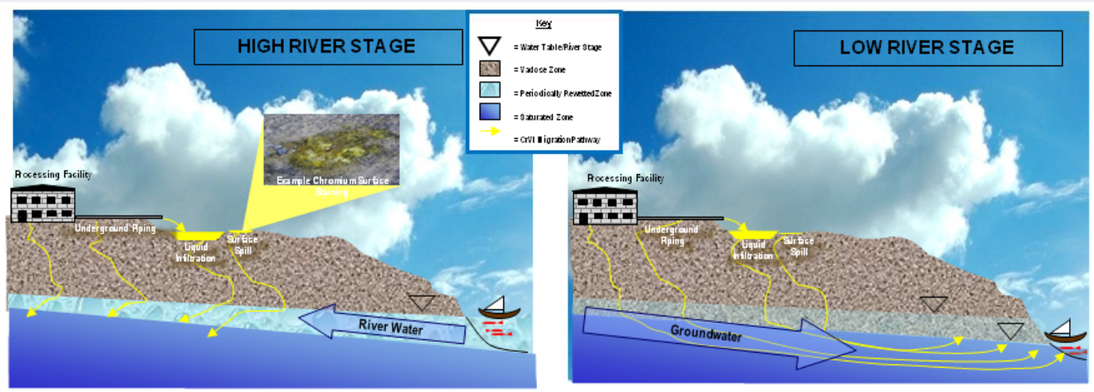
CHARACTERISTICS

- Groundwater levels and gradients are affected by river stage changes, episodic precipitation events, rapid snowmelt, and seasonal fluctuations. During low river stage, contaminants migrate toward the river. During high river stage, mobile contaminants are driven inland by river water influx into the aquifer. With this rise and fall of river stage, contaminants mobilize back and forth in the aquifer.
- Under high water conditions, CrVI is mobilized inland, away from the river.
- Large CrVI groundwater plumes in the 100 Area suggest that CrVI adsorbs onto sediment grains in the Hanford formation at a very low rate.
- The water table elevation varies by daily, weekly, seasonal, and multi-year cycles. During high groundwater, CrVI suspended in the periodically rewetted zone is flushed to the aquifer at unknown rates and concentrations.
- Variable degrees of saturation, ranging from ~5 percent to ~25 percent by volume, depending on the textural characteristics and porosity of the sediment.
- Two mechanisms may introduce contamination to the periodically rewetted zone: downward migration from the vadose zone and movement of contaminated groundwater upward into the vadose zone during high water table conditions.
- The ability of the periodically rewetted zone to sequester 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 fractures in mineral grains.

DATA GAPS

- Evaluate the potential effects of water table fluctuations on contaminant concentrations in the upper unconfined aquifer (Data Gap #10).
- Establish a method to estimate the contamination mass in the periodically rewetted zone and the seasonal or more-frequent mass flux from the deep vadose zone to groundwater (Data Gap #1).
- Evaluate and possibly model varying conditions of water table fluctuations into the periodically rewetted zone and the potential for adsorbed contaminants to mobilize and reach groundwater. Collect additional deep vadose zone data and information, such as how subsurface geological characteristics may influence contaminant mobility to groundwater (Data Gap #10).
- Identify and characterize deep vadose zone sources by collecting geological, geotechnical, and/or geophysical data, as necessary, that help define stratigraphic features that are relevant to contaminant transport (Data Gap #10).
- Near the river, record frequent observations of changes in water quality and hydraulic pressure to predict contaminant movement (Data Gaps #1 and #20).
- Locate and characterize "relic", former, hot liquid discharge areas and evaluate the potential for the remaining contaminants to reach groundwater. If necessary, simulate contaminant residence time in the periodically rewetted zone before contaminants enter groundwater (Data Gap #10).
- Identify the thickness, sediment textural parameters, and fluctuation range at specific locations on a scale necessary to support decision making, where contaminant transport in the periodically rewetted zone is being evaluated (Data Gap #10).
- Evaluate and consider using non–traditional alternatives to collecting contaminant migration data, i.e., "interface" samplers (Data Gap #21).
- Determine the need for additional quantification of risks of low and high river stage plume concentrations, groundwater flow direction and gradient, and other ZOI properties. Assess the inland reach of river water and the river pressure wave to further the overall understanding of contaminant fate and transport (Data Gap #10).
- Ensure follow-through phases of environmental evaluation are flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).

HEXAVALENT CHROMIUM MOBILITY DURING LOW AND HIGH RIVER STAGE



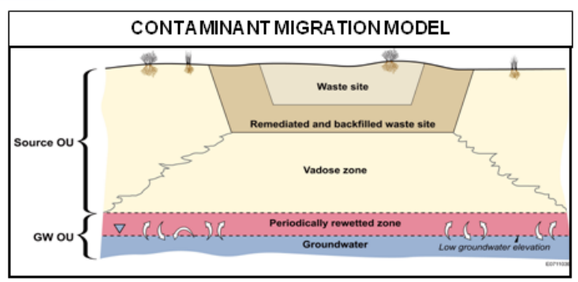


Figure A-9. 100-D Area Periodically Rewetted Zone

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PROBLEM STATEMENT

- Reactor operations associated with discharging effluent to the soil column and managing solid waste have contaminated the vadose zone. There may be current and future impacts to groundwater from the vadose zone.
- The contaminant distribution within the vadose zone has not been completely characterized.
- The physical properties of soil that influence the fate and transport of contaminants in the vadose zone have not been fully characterized.

PRIMARY AND SECONDARY SOURCES

- The history of the 100-D Area indicates that radiological and hazardous chemicals were released to the soil column.
- The source of contamination is 149 waste sites in the 100-D Area. A total of 72 waste sites have been remediated/addressed according to interim record of decision and TPA-MP-14. A total of 77 waste sites remain and shall be evaluated for interim remedial action.
- Sample data collected from the soil column indicate that contamination is present above cleanup levels.
- Groundwater samples collected indicate that contamination is present in the aquifer above MCLs. There may be a continuing source of vadose zone contamination.

INCOMPLETE CHARACTERIZATION

- The nature and extent of contamination is better characterized in the upper portion of the vadose zone.
- Few data are available deep within the vadose zone.
- Where interim remedial actions have been completed, waste sites are well characterized 0 to 4.6 m (0-15) ft below ground surface. Existing modeling efforts suggest that groundwater impacts are not expected at remediated waste sites.
- Very little data have been collected where remedial actions are planned. A total of 77 waste sites remain on the remedial action evaluation path.
- CrVI, nitrate, and tritium are not well characterized in the vadose zone.
- The physical properties of soil that influence the fate and transport of contaminants in the vadose zone have not been fully characterized.

100-D AREA INTERIM REMEDIAL ACTION LOCATIONS

Figure A-10. 100-D Area Source Remediation and Residual Contamination

CHARACTERIZATION BENEATH REACTOR STRUCTURES

- Very few data have been collected beneath reactor structures to evaluate the nature and extent of contamination.
- Soil beneath the D Reactor fuel storage basin has been characterized to a depth of 4.6 m (15 ft).
- Interim remedial actions are currently ongoing.

DATA GAPS

- Assess nature and extent of contamination throughout (i.e., from waste site to groundwater) the vadose zone for CSM development and support an assessment of risk. Very little data have been collected to evaluate CrVI, nitrate, and tritium contamination.
- Data are needed from "unremediated waste sites" (accepted waste sites) to assess risk for direct exposure and protection of groundwater as guided by interim action RODs.
- As required by the 5-year review (Action 8-1), complete investigation of additional source in the 100-D Area. In accordance with Action 8-1 in the 5-year review, additional source area investigation activities begun in 2008 have continued throughout 2009.
- Assess the nature and extent of contamination beneath the 105-D and 105-DR Reactor structures.
- Data are needed to assess the physical properties of soils to support modeling efforts.
- Data are needed to confirm contaminant distribution coefficients to support modeling.

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PROBLEM STATEMENT

- While several groundwater COPCs have been identified within the plume, two COPCs provide useful examples regarding the behavior of this plume. CrVI is of greatest concern for risk exposures, but nitrate is persistent across the site as well. This CSM focuses on these two COPCs.
- CrVI and nitrate concentrations exceed groundwater action levels at the central 100-D Area. Unidentified sources are suspected in addition to areas pending remediation that may contribute to this behavior.
- After waste site remediation containing chromium above current cleanup levels is completed, groundwater contamination temporarily increases in downgradient wells throughout the 100-D Area. This phenomenon typically is followed by a downward trend. These temporary increases likely are the result of increased infiltration from dust suppression water and from natural recharge from precipitation runoff directed to open excavations. However, the CrVI concentration increases beginning in 2003 are more difficult to attribute to this condition, unless there are active excavations close by impacting the wells or before backfilling the sites.

HEXAVALENT CHROMIUM AND NITRATE IN GROUNDWATER

- The 116-D-1A , 105-D Storage Basin Trench #1 and 116-D-1B, 105-D Storage Basin Trench #2 are suspected chromium source areas. Chromium-contaminated wastes were spread by reactor cooling water to discharges to 116-DR-1, Emergency Crib Trench, and 116-DR-2, Emergency Crib Trench, and leaks from the 116-D-7, 107-D Retention Basin and 116-DR-9, 107-DR Retention Basin.
- The primary waste sites believed to be responsible for the North Plume chromium contamination were remediated between 1996 and 2007.
- The 182-D Reservoir and its export water system leak and maintain a divide between the North and South Plumes.
- CrVI and nitrate are water-coincident contaminants and demonstrate similar geochemical behavior in groundwater. However, their sources are not consistently co-located.
- From the mid-1990s through 2000, CrVI and CrIII concentrations decreased in wells near the D Reactor. Around 2000, distinct behavior changes were noted.
- An upward trend in CrVI concentrations is observed in Wells 199-D5-14 and 199-D5-15. Although a decreasing trend has been noted since February 2006, the previous concentrations displayed a generally downward concentration trend in Well 199-D5-16.
- Other wells show decreasing trends in contaminant concentrations over time. The trends are interpreted to result from source remediation and groundwater interim actions.
- A chromium-ion-exchange pump-and-treat system contains and reduces North Plume chromium concentrations. Such interim action and source remediation have resulted in decreasing chromium trends in many 100-D Wells. The pump-and-treat system continues to reduce chromium concentrations discharged by springs and seeps to the river.
- The differences observed in groundwater contamination levels demonstrate a complex, dynamic relationship between vadose zone and groundwater contamination, and their response to remedial actions. Data for both types of chromium exhibit downward trends in wells near the -D Reactor.

CHROMIUM CONCENTRATION TRENDS IN GROUNDWATER

- From the mid-1990s through 2000, hexavalent and trivalent chromium concentrations in groundwater decreased near the D Reactor. Around 2000, the trend of decreasing concentrations changed to a less distinctive, but notably different, pattern.
- A temporary, increasing trend is noted after vadose zone sources are remediated, generally returning to a decreasing trend. These temporary increases likely are caused by focused infiltration, such as dust suppression water application and/or precipitation runoff in open excavations. Since 2003, other increases in groundwater concentrations have been noted.
- The 2007/2008 concentrations are similar to those reported in 1995 for well 199-D5-14; however, an increasing trend is noted since 2003. Concentrations in well 199-D5-15 have increased by several orders of magnitude. Since 1999, concentrations have continued to decrease in well 199-D5-16 (see adjacent charts).
- Since 1995, CrVI concentrations generally have increased in wells 199-D5-14 and 199-D5-15 (see charts), and concentrations have remained relatively stable in well 199-D5-16. An upward trend is noted from 2007 to 2008. Source remediation has accounted for decreasing concentrations in some 100-D wells.
- A chromium-ion-exchange pump-and-treat system continues to reduce concentrations and thereby reduce chromium discharges to the river.

NITRATE CONCENTRATION TRENDS IN GROUNDWATER

- Groundwater nitrate concentrations in wells 199-D5-14 and 199-D5-15 have slightly increased since 1995, with more variations in well 199-D5-15 through 2003. From 2003 to 2008, concentrations remained stable, similar to 1995 levels (see charts).
- Concentrations in well 199-D5-16 have varied little since 1995 (see chart).
- With few exceptions (well 199-D5-15), concentrations have remained in excess of the groundwater action threshold of 45 mg/L. Since 2003, concentrations have remained between approximately 60 and 70 mg/L in wells 199-D5-14 and 199-D5-15, and between approximately 70 and 80 mg/L in well (199-D5-16).
- Long-term, relatively stable concentrations indicate a persistent vadose zone source.
- Nitrate concentrations in groundwater remain relatively stable across the 100-D Area. Agricultural and historic operational sources both are likely.

DATA GAPS

- Define the extent of upper unconfined aquifer contaminant plume (Data Gap #1), the nature and extent of RUM contamination (Data Gap #4), and the relationship between contaminants in both.
- Evaluate plume data and update the CSM to facilitate accelerating remedial decisions and corresponding risk reduction activities. Incorporate new data collected in 2007-2008 into the decision process (Data Gap #1).
- Identify potential and known, unremediated North Plume source areas, and develop measures for risk mitigation (Data Gap #3) through data collection and review (Data Gaps #18).
- Evaluate whether nitrate is derived from point or non-point sources (Data Gap #1). Select future actions regarding remediation and/or monitoring, and use the results to develop steps toward risk reduction.
- Portray figure data, such as contaminant concentrations, water table elevations, and other graphic information, so that the procedures for data selection, assessment, and illustration are systematic and consistent (Data Gap #9).
- With the cyclical rise and fall of the water table, and the river's influence on those levels, collect additional information to anticipate plume characteristics and behaviors through these dynamic occurrences and the potential for deep vadose zone contamination to be remobilized during periods of high groundwater (Data Gap #10).
- Develop exposure risk maps to be used as tools for limiting risks of exposure to the North Plume (Data Gap #11).
- Collect and quantify data for use in limiting exposures to ecological receptors (Data Gap #12).
- Develop final cleanup goals to drive remedy selection and design (Data Gaps #3 and #17).
- Ensure follow-through phases of environmental evaluation are flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).
- Develop and adhere to regular, consistent sampling schedules for aquifer tube monitoring (Data Gap #20).
- Evaluate data collection and analytical methods before implementation of investigation activities under the work plan (Data Gap #21).

HEXAVALENT CHROMIUM AND NITRATE DISTRIBUTION AND CONCENTRATION TRENDS

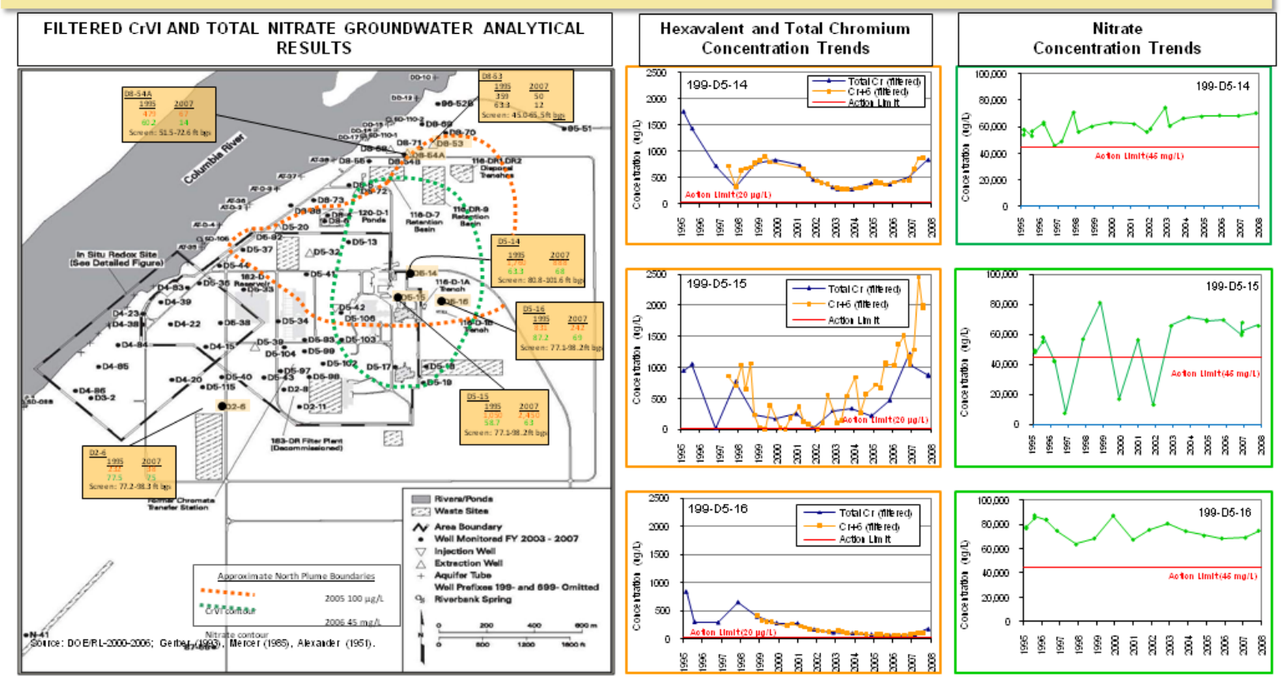

Figure A-11. 100-D Area North Plume: Hexavalent Chromium and Nitrate

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PROBLEM STATEMENT

- The nature and extent of the CrVI contamination at the 100-D Area appears to be greater than suspected with the discovery of the South Plume. Sources of chromium contamination in the vadose zone responsible for the South Plume are not well known.
- The contamination source fate and transport mechanisms for South Plume are not as well assessed as are the North Plume. Few groundwater monitoring wells were located in upgradient areas until after this chromium plume was discovered.
- Groundwater data indicate the groundwater plume is persistent over time, with routine detection in various locations since 1996.
- The 100-D Area facilities had both planned and unplanned discharges of dichromate that occurred during operations in the vicinity of the South Plume. Chromium concentrations upgradient from the ISRM Barrier have remained nearly unchanged due to the passive nature of the remedy and slow flow rates through the barrier.

TECHNICAL SUMMARY

- The South CrVI Plume was discovered as a result of spring and seep sampling performed in 1996. High chromium concentrations were identified in springs upriver from the locations associated with discharges from the North Plume.
- Only limited information exists on actual disposal locations within the South Plume area. In addition, few sites in this area have undergone remedial action. Current surveillance indicates chromium concentrations within the South Plume are far higher than those found in the North Plume.
- In 1999, an ISRM Barrier was installed to intercept chromium from the South Plume that has been migrating toward the river. Groundwater flow through the ISRM Barrier has been slower than predicted for this remedy.
- Few wells provide the data necessary to appropriately monitor conditions that would be useful in predicting the full extent of the South Plume.
- A connection between the North and South Plumes is undemonstrated.

LIKELY HEXAVALENT CHROMIUM SOURCES

- Receiving and transferring dichromate by railcar and truck unloading station (100-D-12, Sodium Dichromate/Acid Railcar and Truck Unload Station and Associated French Drain, Undocumented Liquid Waste Site; local French drains).
- Piping cross-tie from 185-D fed the DR Reactor water treatment facilities.
- Transfer piping near 100-D-30, Sodium Dichromate Trench and Sump and receipt tanks at 183-DR.
- Water treatment processing—DR Reactor: 183-DR Head House and Filter Building.
- High concentration discharge/disposal locations: 100-D-8 (Process Sewer Outfall Site, Undocumented Liquid Waste Site, 1907-DR), 116-DR-5 (1907-DR Outfall).
- A single plume is divided by hydrological forces affected by the pump-and-treat system and complex transport pathways.
- Disposal location information is limited for the South Plume area. Few sites in this area have been remediated.

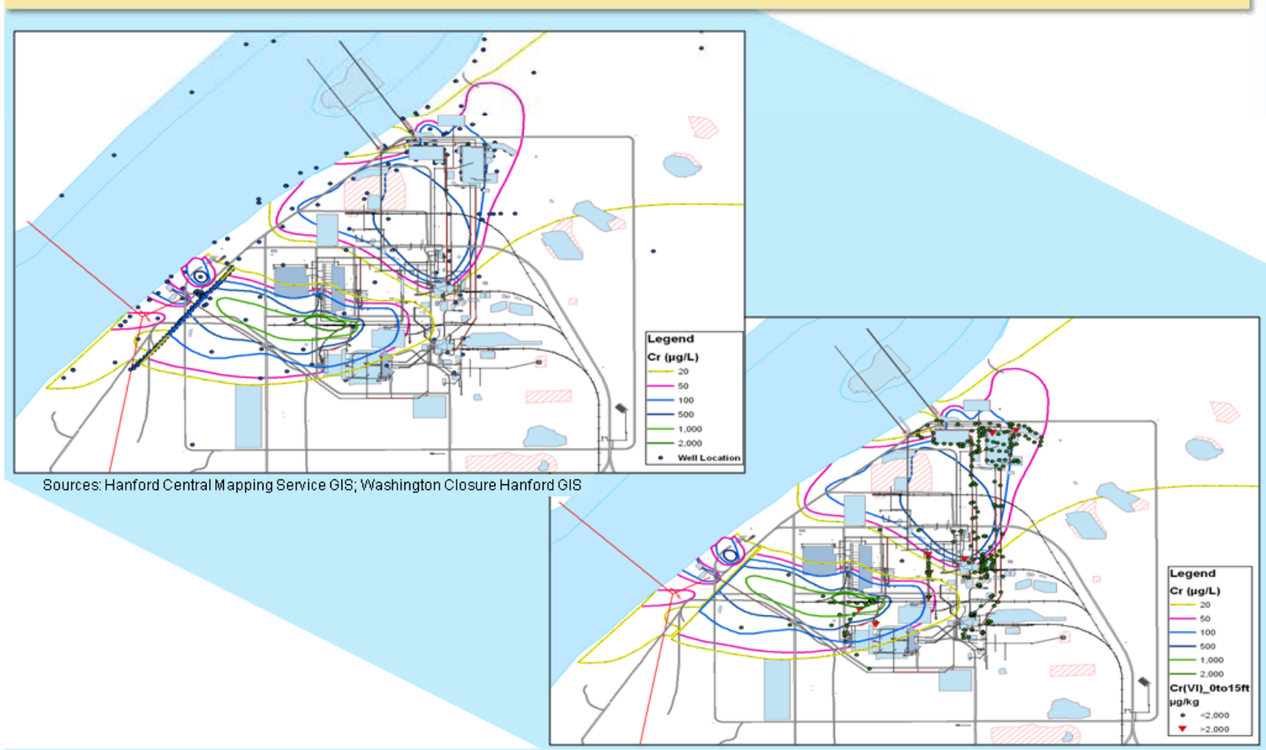
GOVERNING HYDROGEOLOGICAL FORCES

- 182-D Reservoir:
  - Leakage divides a single large plume or prevents merging of two plumes.
  - The level has been reduced from 4.6 to 1.2 m (15 to 4 ft) to minimize leakage.
- River stages impact contaminant fate and transport:
  - High river stage reduces groundwater flux to the river.
  - Low river stage exposes seeps.
- Natural recharge and groundwater movement:
  - Seasonal recharge, high short-term flux from the river.
  - Altered and diverted by the introduction and removal of impermeable surfaces (e.g., roads, parking lots, ISS cocoons).
  - Localized effects from active pump and treat systems.
  - Preferential pathways in upper vadose zone result from infrastructure installation, and Hanford formation gravels are highly permeable.

DATA GAPS

- Evaluate adequacy of monitoring well network to provide South Plume contaminant nature and extent data for decision making and risk reduction (Data Gap #1).
- Evaluate effects of liquid leakage from current reactor features on groundwater movement and vadose zone transport (Data Gap #1).
- Resolve whether to accelerate and/or modify maintenance actions and schedules to minimize leakage, and determine whether maintenance actions, have influenced contaminant migration and groundwater movement (Data Gap #1).
- Locate process piping and tanks, and remove remaining dichromate material. Evaluate whether releases from these features have provided sources to the vadose zone and groundwater (Data Gap #1).
- Evaluate potential groundwater remedial technologies (Data Gap #3).
- Develop exposure risk maps (Data Gap #11) and determine the additional ecological receptor data needed to define risks in those mapped areas that are affected by the South Plume (Data Gap #12).
- Condition bathymetric data to project database to refine anticipated aquatic exposure areas (Data Gap #13). Compare the data to river flow and stage, and contaminant characteristics to augment knowledge of potential exposure areas (Data Gap #20).
- Complete the Risk Assessment (Data Gap #15).
- Ensure follow-through phases of environmental evaluation are flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).
- Explore alternative data collection methods to assess river impacts (Data Gap #21).

100-D NORTH AND SOUTH HEXAVALENT CHROMIUM PLUME WELL COVERAGE



Sources: Hanford Central Mapping Service GIS; Washington Closure Hanford GIS

Figure A-12. 100-D Area South Plume: Hexavalent Chromium

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PROBLEM STATEMENT

- A pump-and-treat system was designed, installed, and started in 1994 to reduce the flux of CrVI to river aquatic receptors at concentrations greater than protective standards (22 ug/L in compliance wells) established in the ROD for interim action. Remediation of other COPCs (Sr-90, tritium, U, and Tc-99) was deferred to the final ROD.
- Since year-round operation of the pump-and-treat starting in 1997, the pump-and-treat system, relatively high CrVI concentration cores of the North and South Plumes have been delineated. In addition, a large dilute (e.g., concentrations less than 100 mg/L) CrVI Plume has been delineated across the horn area. The pump-and-treat system operating in the 100-D Reactor Area has not significantly reduced the concentrations of CrVI in groundwater, potentially due to unidentified or unremediated source areas in the vadose zone that continue to leach CrVI to the groundwater.
- A second groundwater remediation treatment action, ISRM was started in 2000 in response to the discovery of a second CrVI plume located southwest of the plume that was treated by the pump-and-treat system. Over time, the efficiency and effectiveness of the ISRM has been reduced, resulting in discharges of CrVI to aquatic receptors in the river at concentrations exceeding remedial action goals.
- In 2004, a second pump-and-treat system was installed to address contamination in the South Plume.
- During spring, when the inland gradient is less steep, the pump-and-treat system has less influence on the groundwater flow direction and gradient, and the areal extent of the contaminant plume.

IN SITU REDOX MANIPULATION (ISRM)

- The ISRM technology consists of creating a permeable subsurface treatment zone to reduce concentrations of mobile CrVI in groundwater. To create the treatment zone, sodium dithionite was injected into a series of injection wells. The goal of the system is to reduce ferric iron to ferrous iron within the aquifer. Under reducing conditions, CrVI precipitates from solution as trivalent chromium. Trivalent chromium is much less mobile in the environment than CrVI. As part of the ISRM treatment process, dissolved oxygen levels are reduced and sulfate concentrations are increased in groundwater.
- In November 1995, pore water and near-shore groundwater sampling revealed CrVI at concentrations greater than interim ROD cleanup levels southwest of the plume that was the target of the interim ROD for the 100-D pump-and-treat system.
- From spring 1997 to spring 1999, an ISRM treatability test was performed in five wells. Groundwater samples collected during the treatability test showed that the system was effective in reducing CrVI concentrations in groundwater.
- A proposed plan was published and a ROD amendment was finalized that described implementing the ISRM system to remediate the CrVI groundwater plume west of the 100-D Pump-and-Treat system. The goal of the ISRM was to prevent discharge of CrVI to the river and riverbed sediments at concentrations greater than those considered protective of aquatic receptors (20 µg/L in compliance wells).
- Currently, laboratory testing, numerical modeling, and associated field work related to injection of nZVI into the subsurface at the 100-D Area is being conducted. The purpose of this work is to evaluate the feasibility of using nZVI to repair portions of the ISRM barrier.

PUMP-AND-TREAT PROCESS DESCRIPTION and CHRONOLOGY

- pump-and-treat is the process of extracting groundwater from the subsurface using pumping wells, treating the contaminated water removed from the wells, then discharging the treated water. Water from the 100-DR-5 pump-and-treat system is re-injected in the 100-D Area. Water from the 100-HR-3 pump-and-treat system located in the north portion of the 100-D Area is routed via piping the 100-H Area into injection wells that inject the treated water into the groundwater aquifer.
- A LFI for the 100-HR-3 OU was completed in 1994. The 100-HR-3 OU includes the 100-D Reactor Area.
- In 1993, a qualitative RA was completed (WHC-SD-EN-RA-007). Contaminants detected as part of the LFI were evaluated with respect to human health and ecological receptors. Seven COPCs were identified.
- On August 26, 1994, startup of a pilot-scale treatability study was initiated in the 100-DR Reactor Area and consisted of a pump-and-treat system, with three groundwater extraction wells and two injection wells, and treatment of extracted water before re-injection with an ion-exchange system.
- In 1995, a Focused Feasibility Study concluded that a groundwater pump-and-treat system combined with an ion-exchange treatment system was the most effective interim remedial method for the 100-HR-3 OU. The study focused on remediation of CrVI because it was evaluated to be the most toxic to aquatic organisms.
- A proposed plan was published, and an interim ROD was finalized that outlined a pump-and-treat system for extracting CrVI from groundwater in the 100-HR-3 OU.

SYSTEM CONFIGURATION AND STATUS

- System Placement/Startup: Spring 1997, Barrier Length ~ 170m; Barrier Width ~ 15m; Barrier Depth ~ 5 to 6m.
- The 41 to 46 groundwater monitoring wells are monitored quarterly to assess system performance.
- As of FY06, the southwestern portion of the barrier appeared to be effectively mitigating CrVI transport to the river. Areas of the northwest portion of the barrier had lost reductive capacity and CrVI was migrating to the river.
- During FY06, dissolved oxygen concentrations in compliance wells ranged from 2.40 to 7.19 mg/L downgradient of the treatment zone. Concentrations less than 6.0 mg/L are possibly harmful to aquatic organisms.
- During FY06, 10 wells revealed sulfate concentrations in groundwater greater than the secondary MCL of 250 mg/L. Increased sulfate concentrations are expected as part of the ISRM treatment process.

DATA GAPS

- Define the Extent of Groundwater Contaminant Plume (Data Gap #1).
- Revise the COPC list to use in establishing cleanup levels (Data Gap #2).
- Explore and evaluate potential groundwater remedial technologies. Evaluate the effectiveness of the ISRM barrier and other remedial alternatives that may be implemented as part of a final ROD (Data Gap #3).
- Develop a standard method and format for portraying groundwater data contours methods (Data Gap #9).
- Collect and assess ecological receptor data (Data Gap #12). Use the data to develop exposure risk maps (Data Gap #11) for use in targeting areas that require remediation and designing a remedial approach to address those areas (Data Gap #3).
- Complete the Risk Assessment (Data Gap #15).
- Establish appropriate, final cleanup levels that are protective of human health and ecological receptors. Incorporate these goals into remedial technology performance criteria (Data Gap #17). If necessary, develop alternative data collection methods to assess river impacts and use the data to evaluate remedial technology performance (Data Gap #21).
- Ensure follow-through phases of environmental evaluation are flexible to accommodate the results of newly conducted investigation tasks (Data Gap #18).
- Develop a project definition of "compliance" (Data Gap #19).
- Determine the optimal, consistent aquifer tube sampling frequency that will provide the most advantageous data for evaluating remediation effectiveness (Data Gap #20).

IN SITU REDOX MANIPULATION SYSTEM CONFIGURATION

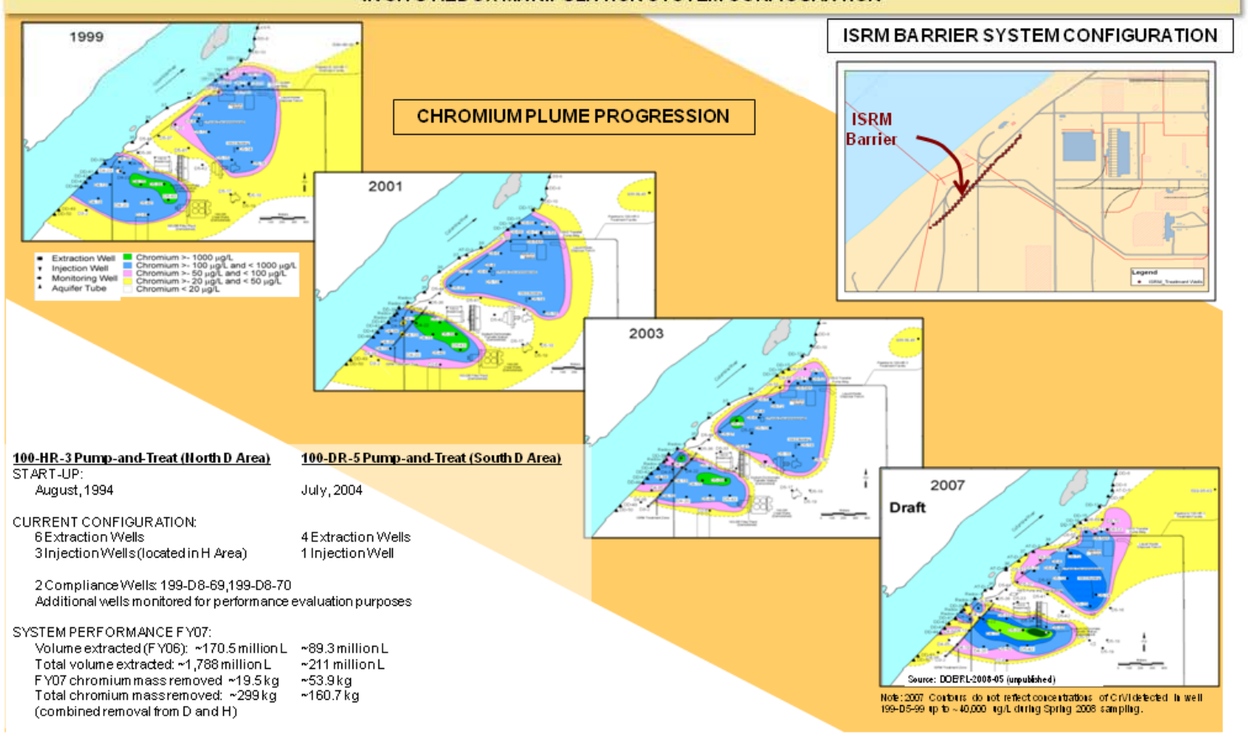

Figure A-13. 100-D Area Groundwater Remediation

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PROBLEM STATEMENT

- Large quantities of radioactive and hazardous liquid and solid waste were generated from the operation of H Reactor and were disposed to the 100-H Area subsurface soils.
- Concentration of contaminants in vadose zone soil, and groundwater are present in levels greater than established standards and may present a threat to human health, and fish and other ecological receptors in the river.
- Residual contamination may remain in groundwater and the vadose zone in excess of action levels, after interim actions have been implemented to remove contaminated soil and contain and contaminated groundwater.
- An updated conceptual exposure model is needed as part of a new CSM for the identified contaminants to guide the next work plan and ROD.
- The driver for remedial action for groundwater is the protection of human health and ecological receptors (e.g., Chinook salmon and other salmonids) in the river.

CONTAMINATION SOURCES

Liquids	Disposal Disposition
Contaminated Cooling Water	Cribs, Trenches, Retention Basin to River
Water Treatment Preparation	Trenches, French Drains, Cribs, Retention Basin to River
Decontamination Waste	Cribs, French Drains
Laboratory Waste	Trenches, French Drains, Burn Pits
Septic Waste	Septic Systems, Drain Fields
Sludge	Basins, Pits, Burial Sites
Emergency Discharges	Cribs, Retention Basin to River, Trenches, Ponds, Outfalls
Solids	**Disposal Disposition**
Construction & Maintenance Debris	Burial Grounds, Pits, Burn Pits
Drums	Burial Grounds, Pits
Boxes & Miscellaneous	Burial Grounds, Pits, Burn Pits
Spent Nuclear Fuel	Burial Grounds
Fly Ash	Fly Ash Disposal Unit Mound

Note: Unintended releases leading to residual long-term contamination are not disposal methods.

SITE SUMMARY

- The Hanford Site 100-H Area contains one single-pass plutonium production reactor, and associated support infrastructure located east of the horn area of the river. Most treatment/storage reactor cooling water structures were deactivated with the reactor and have been decommissioned. Of the approximately dozen reactor-related structures, only the 105-H Reactor Building, 107-H Retention Basin Sludge Burial Site, 1713 Warehouse, and portions of the 183-H Water Treatment and storage facilities remain.
- The 1996 Interim Action ROD Identified the following groundwater COPCs:

Inorganic and Anion COPCs included:
- Ammonia (as N)
- Chloroform
- Fluoride (F)
- Manganese (Mn)
- Sulfide (S^{-2})
- CrVI
- Barium (Ba)
- Chromium (Cr)
- Iron (Fe)
- Nitrate (NO_3 as N)

Radionuclide COPCs included:
- Americium-241 (Am-241)
- Carbon-14 (C-14)
- Strontium-90 (Sr-90)
- Technetium-99 (Tc-99)
- Tritium (H-3)
- Uranium-233/234 (U-233/234)
- Uranium-238 (U-238)

- Disposed cooling waters contained fission and neutron-activation products, chemicals and actinides. Tritium, Sr-90, nitrate, and chromium migrate through the vadose zone to groundwater, and ultimately, to the river.
- As of 2007, groundwater in wells near the 100-KE Floodplain and 100-KW Floodplain basins does not indicate leakage from either basin.

Facility/Activity	Operated	Deactivation/Conclusion
H Reactor	1949	1965
Decommissioning	1965	1965
Initial Remediation	1974	1986

INTERIM ACTIONS AND RESPONSES

Activity	Start Date	Actual or Anticipated Completion
Source Remediation	1996	2011 - Interim Completion; Final ROD Remedy TBD
Pump and Treat	1997	Reconfigured - 2004 2011 - Interim Completion; Final ROD Remedy TBD
Interim Safe Storage (ISS)	2000 (H Reactor)	2005 – (H Reactor)
183-H RCRA Post-Closure Monitoring	2002	Modified closure plan; Review 2008 for closure decision
Incorporation of Remedy into Final ROD	To be Determined	To be Determined

DATA GAPS

- 100-H Area data gaps fit 5 general categories: 1) upper unconfined aquifer; 2) RUM; 3) contaminant fate and transport; 4) adaptive data collection, and 5) non-sampling data gaps.

100-H AREA PLAN VIEW

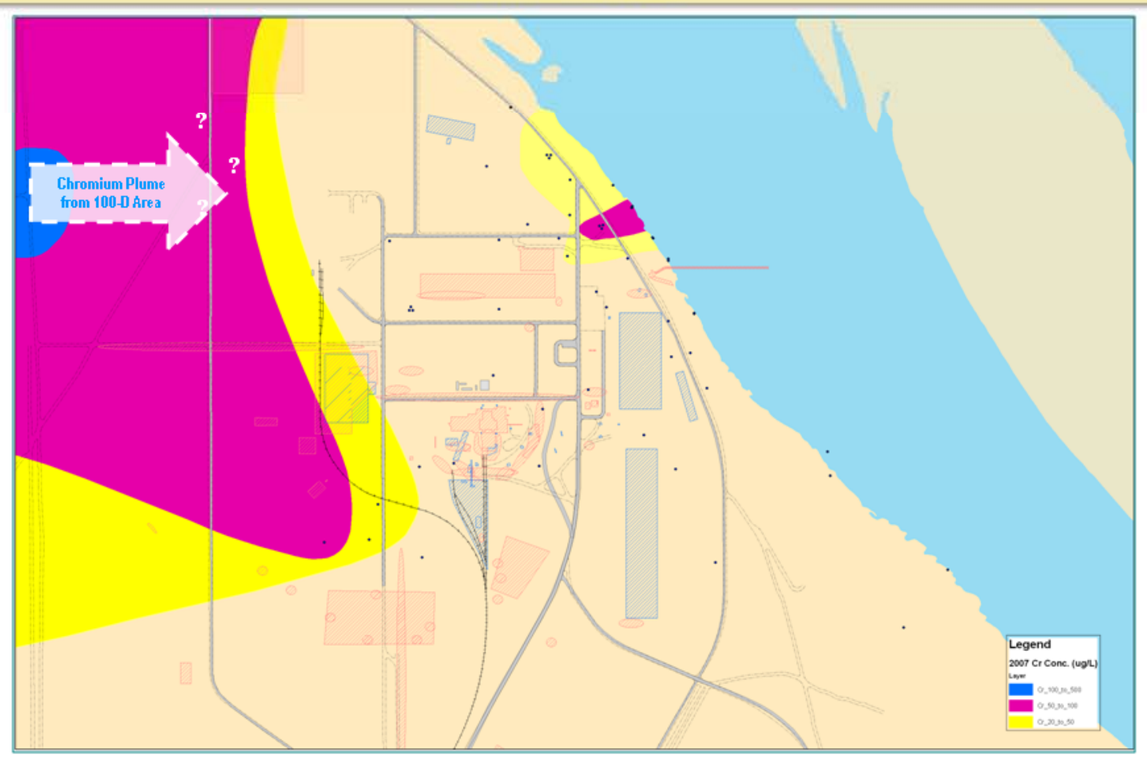

Figure A-14. 100-H Area General Information

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PROBLEM STATEMENT

- Operation of the 105-H Reactor produced radioactive and hazardous liquids and solid wastes that were discharged to the soil column in and around the 100-H Area.
- Inactive, active, and demolished facilities may have historically contributed to vadose zone and groundwater contamination in the 100-H Area.
- Sources at active and un-demolished facilities my continue to contribute to vadose zone and groundwater contamination.

FACILITY DESCRIPTION AND PROCESSING

- The 105-H Reactor facility is located at the 100-H Area on the Hanford Site. The reactor was used to produce plutonium for nuclear weapons. The reactor is water-cooled, single pass, and graphite moderated.
- Construction of the H Reactor was begun in 1948. Initial startup of the reactor was in October 1948. The reactor was shut down in April 1965 and put on a condition of minimum surveillance and maintenance.
- Past operations, disposal practices, spills, and unplanned releases have resulted in contamination of the H Reactor facility structures, underlying soil, and groundwater.

FACILITY CERCLA REMOVAL PLAN

- Alternatives for conducting a non-time critical removal action for various facilities in the 100-H Area were considered in DOE/RL-2000-46, *Engineering Evaluation/Cost Analysis for the 105-H Reactor Facility and Ancillary Facilities.*
- The recommended remedy was to:
  - Removal to a burial site in the 200 West Area.
  - Decontaminate and demolish the reactor building and the ancillary facilities.
  - Construct an ISS over the reactor for up to 75 years, with final one-piece removal to a burial site in the 200 West Area.
- The Action Memorandum documented approval of the recommendation in October 2000.
- DOE/RL-2000-57, *Removal Action Work Plan for the 105-D and 105-H Building Interim Safe Storage Projects and Ancillary Buildings* directed the implementation, and served as the decommissioning plan and project management plan of the removal activities.
- The RAWP outlined the decommissioning activities as follows:
  - Initiate site mobilization and preparation activities
  - Remove hazardous substances (chemical and radiological)
  - Remove facility equipment and miscellaneous piping
  - Characterize Site
  - D&D various facility structures
  - Dispose of waste
  - Construct the Safe Storage Enclosure
  - Restore Site
  - Demobilize
- The 105-H ISS Project was completed in October 2005. WCH-33,*105-H Reactor Interim Safe Storage Project Final Report* documented the D&D process of the reactor and the ancillary facilities.

AERIAL VIEW OF THE 100-H AREA INTERIM REMOVAL ACTION LOCATIONS

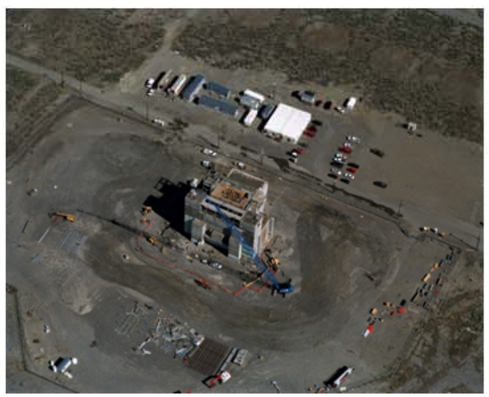

Figure A-15. 100-H Area Facilities

FACILITY REMOVAL STATUS

Total Facilities:	60
Active Facilities:	10
Inactive Facilities:	2
Demolished Facilities:	26
Removed:	8
Status Unknown:	14

Reference: SIS, 11/12/2008

DATA GAPS

- The orphan sites evaluation process is a systematic approach involving historical review and field investigation to identify new source unit waste sites that are not identified for characterization or cleanup within existing decision documents. This process has identified 18 potential new waste sites (discovery sites) associated with various 100-H Area facilities.
- If these discovery sites are accepted as WIDS waste sites, the data gaps associated with each site is to evaluate the nature and extent of contamination and impact to groundwater. The 18 discovery sites are listed in the 100-H Area Orphan Sites Evaluation Report, OSR-2008-0002, Rev. 0.

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PROBLEM STATEMENT

- Former liquid waste discharge sites in the vadose zone remain possible sources of groundwater contamination. Given the proximity of the sites to the river, and therefore, a shallower depth to water, travel times to groundwater for vadose zone contaminants such as CrVI are relatively shorter than in internal areas.
- Source identification ("orphan" site process) is continuing within the 100-D/H Area Decision Unit.
- Site characterization and remediation generally has focused on soils less than 6 m (20 ft) deep. Less investigation work has been performed deeper in the vadose zone. Therefore, the quantity of CrVI data decreases with increasing depth in the vadose zone.
- The quantity of 100-H-Area-specific geochemistry data is limited.
- Because some liquid waste disposal sites are a relatively short distance from the river, river stage fluctuations over time may have played a more significant role than at the 100-D Area because residual vadose zone contamination from the periodically rewetted zone may have been leached and released into the river routinely over long periods of time.

GEOLOGIC SETTING

- The 100-H Area lies on a relatively flat, level semi-arid area south of the river, on the east side of the horn area, at elevations that range from approximately 116 to 140 m (380 to 460 ft) above mean sea level. The land surface slopes gradually toward the river, with a bank of up to 9 m (30 ft) at the river's edge. The general river shoreline elevations fall approximately 3 m (10 ft) across the horn area between the 100-D and 100-H Areas.
- The stratigraphic units present at the 100-H Area are described similarly to the same units present at the 100-D Area. In descending order, the stratigraphic units in the horn area vadose zone are Holocene and Plio-Pleistocene surface deposits, the Hanford formation, the Ringold Formation Unit E, and the RUM.
- In the 100-H Area, the Hanford formation consists of pebble-cobble gravel and thin interbeds of sand and silt. It is locally carbonate cemented at 5.6 m (~18.5 ft).
- The Ringold Unit E has been eroded toward the 100-H Area, as noted between Wells 699-97-48C and 699-97-43C. In deep, basalt well 199-H4-15C, the Hanford formation contacts the RUM at 30 m (100 ft) of depth. Ringold Unit E is absent at the 100-H Area likely because of removal by erosion.
- The base of the vadose zone (water table) is located in the Hanford formation at 100-H Area at ~15 to 27 m (50 to 90 ft) in inland portions of the aquifer, and reaches the surface where the aquifer intersects the Columbia. The lower-permeability RUM serves as the base of the vadose zone at depths of over 33 m (100 ft) across the horn area.
- Across the horn area, the base of the vadose zone spans a depth of ~14 to 20 m (60 to 66 ft) and transitions from the Ringold Unit E toward the west to the Hanford formation near the 100-H Area, and released into the river routinely over long periods of time.

VADOSE ZONE CONTAMINANTS

- Vadose zone, radionuclide COPCs identified in the interim action ROD include Tc-99, Sr-90, U, and tritium.
- Non-radionuclide COPCs identified in the interim action ROD are CrVI, total chromium, nitrate, and sulfate. While other contaminants have been identified as groundwater contamination sources, CrVI has been the focus of an interim action ROD for groundwater because of a high risk of exposure to ecological (aquatic) receptors.
- Contaminants from waste discharges have reached groundwater. Some of the contaminants in groundwater have been discharged to the Columbia River.
- Vadose-zone stratigraphy controls the rate and direction of movement of liquid through the soil column vertically and laterally, depending on the influence of variations in conductivity and local perched water zones. Such movement is further controlled by heterogeneities within individual geologic units and their impact on hydraulic properties.
- Subsurface disturbances such as buried pipelines, tanks, and excavations may promote preferential flow through the resulting, more-permeable material. The vadose zone contaminant inventory and the nature and extent of vadose zone contaminant distribution around waste sites have not been adequately characterized.

VADOSE ZONE CONTAMINANT MIGRATION

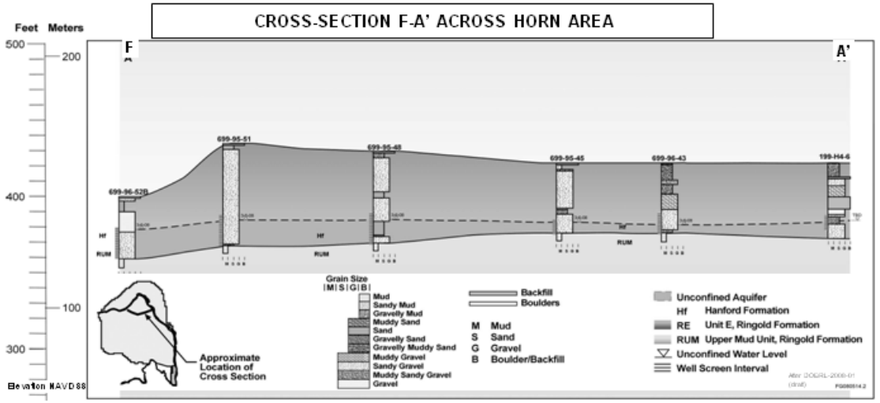
- Contaminants from historical operations may remain in the vadose zone, with relatively limited lateral movement away from waste sites based on waste site remediation data and information. Hanford formation materials are highly heterogeneous. Relatively few data are available regarding large-scale heterogeneities across the 100-H Area and their effect on the migration of CrVI through the vadose zone to groundwater.
- Contamination remaining in the soil may be a potential source for further downward migration to the water table, depending on contaminant and soil properties, contaminant mass, and subsurface geochemistry.
- Seasonal and diurnal fluctuations of the Columbia River affect the water table elevations and, therefore, the time and place at which vadose zone contaminants reach groundwater (periodically rewetted zone).
- Contaminants in the near-river periodically rewetted zone may have been previously leached out long ago by water table fluctuations and the relatively thinner vadose zone.

DATA GAPS

- Within the ZOI, fate and transport processes, and contamination nature and extent are not adequately characterized. Data collection is needed to support characterization, data analysis, fate and transport calculations and/or modeling, and risk assessment.
- Inconsistent soil logging practices have been implemented during borehole drilling. Continuous logging to the bottom of the new boreholes is recommended during drilling to maximize information and observations of ZOI materials.
- Uncertainty reduction is needed to better quantify inventory estimates, initial conditions, and flow and transport model parameters.

100-H AND HORN AREAS VADOSE ZONE GEOLOGY

CROSS-SECTION F-A' ACROSS HORN AREA



REMEDIATED SITES AT 100-H AREA

CROSS-SECTION LOCATION MAP

Figure A-16. 100-H Area Geology of the Vadose Zone

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PROBLEM STATEMENT

- Hydrogeological units of the 100-H Area vadose zone consist of Hanford formation sand and gravel overlying the RUM, which overlies the Ringold Formation's Unit B and Lower Mud. Past liquid discharges to the vadose zone reached groundwater and migrated toward the river. Near-river contamination has reached the river.
- Unidentified, residual vadose zone contamination may remain at 100-H Area. Near the river, river stage fluctuations over time may have caused leaching and released much residual vadose zone contamination from the periodically rewetted zone, and directed it the relatively short distance to the river.
- The 100-H Area pump-and-treat system has reduced the concentration and extent of the groundwater chromium plume.
- Residual contamination from the concentrated solutions and settled salts associated with the 183-H Solar Evaporation Basin and other sources pose a long-term threat to groundwater.
- The broad, groundwater chromium plume originating at the100-D Area has migrated across the horn area to the 100-H Area at levels greater than the 20 µg/L regulatory aquatic quality standard. This plume is approaching and is separate from CrVI in groundwater at the100-H Area.
- Near the river, groundwater flow directions display seasonal influences of river water dominating bank storage (see figures). In spring, river water dominates bank storage, while groundwater dominates bank storage in fall. In the fall, the contaminated groundwater reaches the river at a higher gradient and flow velocity than in the spring. The concentrations of chromium in groundwater near the river in this area are generally between 20 and 50 µg/L.

HYDROGEOLOGIC SETTING

- The geology and hydrogeology of the 100-H Area is similar to that of the 100-D Area, with the following exceptions:
- The Ringold Unit E has not been identified at the 100-H Area.
- The Hanford formation overlies, and is in direct contact with, the irregular surface of the RUM and underlying units.
- High river stages can raise the river surface up to 3 m (10 ft) or more and raise groundwater elevations near the river by nearly as much.
- The 100-H Area aquifer thickness varies from 1.5 to 6 m (~5 to 20 ft).
- Before some 100-H Area wells were converted to extraction wells, upward vertical gradients (from the RUM to the upper unconfined aquifer) were observed approximately half of the time, and downward vertical gradients were observed approximately the other half of the time.
- In the central 100-H Area, horizontal groundwater gradients during the spring generally slope less steeply, where a pump-and-treat remediation system is operating. Hydraulic gradients generally slope more steeply in the 100-H Area southern portion, away from the remedial action area.

GROUNDWATER FLOW

- Groundwater flows generally toward the river between the injection well field (see figures) and the river, and flows parallel to the river away from the injection wells.
- Groundwater flow dynamics near the river change seasonally. Flow is responsive to river stage, which may rise up to 3 m (~10 ft) within a few hours during high groundwater in late spring and early summer. River stage can affect the water table inland up to several hundred meters.
- Groundwater flows radially from areas of high hydraulic head created by the grouping of injection wells.
- High volumes of elevated-temperature liquids were discharged to the vadose zone and reached groundwater forming a mound. Its magnitude varied based on the amount of liquid discharge to the subsurface.
- Relic, higher permeability areas may have been formed that could serve as a driver for CrVI migration in the vadose zone.
- The migration rate of the approaching 100-D Area CrVI plume may be enhanced by a series of 100-H Area extraction wells.

GROUNDWATER CONTAMINANT DISTRIBUTION

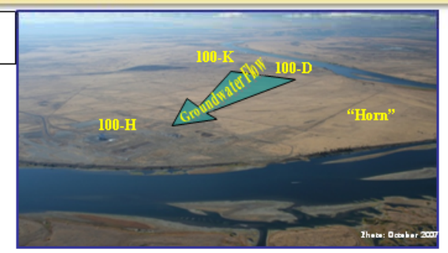
- Leaks from the 183-H Solar Evaporation Basin (116-H-6) may be responsible for most of the uranium, Tc-99, nitrate, and CrVI in the 100-H Area vadose zone and groundwater.
- At the 100-H Area, lateral spreading of CrVI appears to be localized at vadose zone source areas. The 100-H Area CrVI concentrations are monitored in extraction wells, compliance wells, monitoring wells, and aquifer tubes.
- The location and size of the CrVI plume has decreased substantially since pump-and-treat operations began in 1997.
- The 100-H Area plumes CrVI concentrations in the upper unconfined aquifer in recent years have diminished and recently (2007) ranged from ~20 to 50 µg/L. As of 2007, the 100-H Area plume has been reduced in aerial extent to a relatively narrow strip along the river shoreline.
- CrVI contamination has been identified beneath the RUM in the 100-H Area.

DATA GAPS

- Quantify the viability of the RUM as a groundwater resource.
- Quantify the threat to the 100-H Area from the 100-D Area originated chromium plume.
- Install new groundwater monitoring wells and aquifer tubes in the 100-H Area. Use the groundwater data collected from the wells to augment the baseline for the upper unconfined aquifer. Perform risk analysis and feasibility study level analysis for remediation, as necessary for each COPC.
- Organize and conduct consistently and regularly scheduled groundwater monitoring to support a well-rounded groundwater quality database for monitoring wells and aquifer tubes.
- Establish a technically defensible, independently reproducible contouring method for evaluating and presenting contaminant concentration and groundwater elevation contours for the project. Visual representation of the contour boundaries should be reconsidered to illustrate the uncertainty inherent at the 100-H Area.
- Evaluate groundwater in the new horn area wells for the COPCs identified in the qualitative risk assessment for the 100-D Area, 100-H Area, and horn area.
- Define the horizontal and vertical extent of groundwater contamination within the RUM and in the Ringold Formation beneath the RUM. Install groundwater monitoring wells at two depth intervals in the RUM, based on contaminants detected in the RUM and deeper at the100-H Area. Collect sufficient groundwater quality data for use in identifying risk.
- Conduct aquifer testing to characterize hydraulic conductivity in each existing well and new RUM well at the 100-H Area. Use the data to calculate and simulate plume behavior. Collect relevant groundwater and physical data as necessary to support the calculations.
- Within each new borehole, install aquifer tubes to multiple depths. Base the depth of each aquifer tube screen on previously collected aquifer tube and well data, and adaptive data collection strategies.
- Develop and use consistent contouring methods for the identification of data gaps and data needs for the project.

GROUNDWATER FLOW AND CONTAMINANT MIGRATION

CONTAMINATION MIGRATION ACROSS THE HORN AREA



MEASURED WATER TABLE AND CHROMIUM PLUME

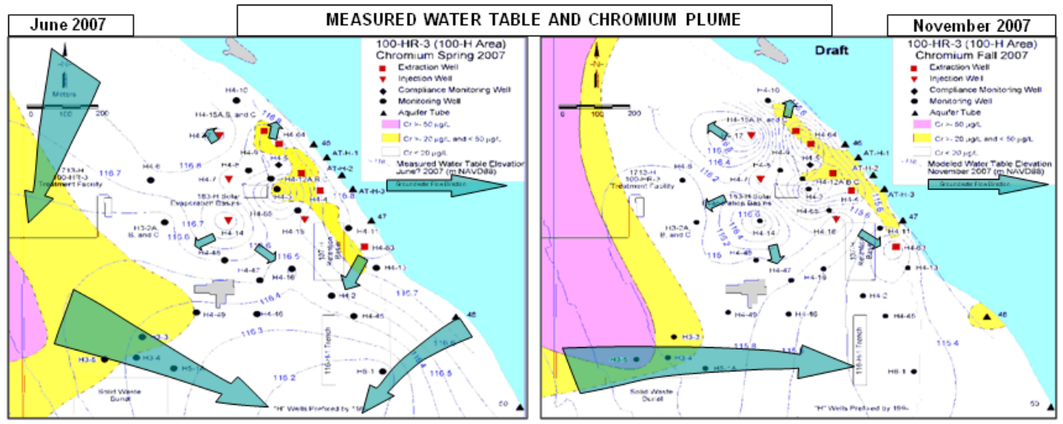


Figure A-17. 100-H Area Hydrogeology and Contaminant Mobility

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PROBLEM STATEMENT

- Reactor operations associated with discharging effluent to the soil column and managing solid waste have contaminated the vadose zone. There may be current and future impacts to groundwater from the vadose zone.
- The contaminant distribution within the vadose zone has not been completely characterized.
- The physical properties of soil that influence the fate and transport of contaminants in the vadose zone have not been fully characterized.

PRIMARY AND SECONDARY SOURCES

- The history of the 100-H Area indicates that radiological and hazardous chemicals were released to the soil column.
- Sources of contamination may be associated with 77 waste sites in the 100-H Area. Of these, 52 waste sites have been remediated and addressed in accordance with the interim action record of decisions and TPA-MP-14. Further, 25 waste sites remain for evaluation and interim remedial action.
- Data collected from soil column samples indicate that contamination is present at concentrations above cleanup levels.
- Groundwater data indicate that contamination is present in the aquifer at concentrations above MCLs. A continuing source of vadose zone contamination is suspected.

CONTAMINANT DISTRIBUTION CHARACTERIZATION

- The nature and extent of contamination is better characterized in the upper portion of the vadose zone.
- Few data are available for deep vadose zone contaminant characterization.
- Where interim remedial actions have been completed, waste sites are well characterized from 0 to 4.5 m (0 to 15 ft) below ground surface. Modeling results suggest that contamination impacts to groundwater are not expected at remediated waste sites.
- Very little data have been collected where remedial actions are planned. A total of 25 waste sites remain on the remedial action evaluation path.
- CrVI, nitrate, and tritium are not well characterized in the vadose zone.

CONTAMINATION BENEATH REACTOR STRUCTURES

- Data have not been collected beneath reactor structures to evaluate the nature and extent of contamination.

SOIL PROPERTY CHARACTERIZATION

- The physical properties of soil that influence the fate and transport of contaminants in the vadose zone have not been fully characterized.

DATA GAPS

- Data are needed to assess nature and extent of contamination throughout (i.e., from waste site to groundwater) the vadose zone for conceptual site model development and to support an assessment of risk. Very little data have been collected to evaluate CrVI, nitrate, and tritium contamination.
- Data are needed from "unremediated waste sites" (i.e., accepted waste sites) to assess risk for direct exposure and protection of groundwater as guided by interim action RODs.
- Data may be needed to assess the nature and extent of contamination beneath the 105-H Area reactor structures.
- Data are needed to assess the physical properties of soils to support modeling efforts.
- Data are needed to confirm contaminant distribution coefficients to support modeling.

100-H AREA WASTE SITES

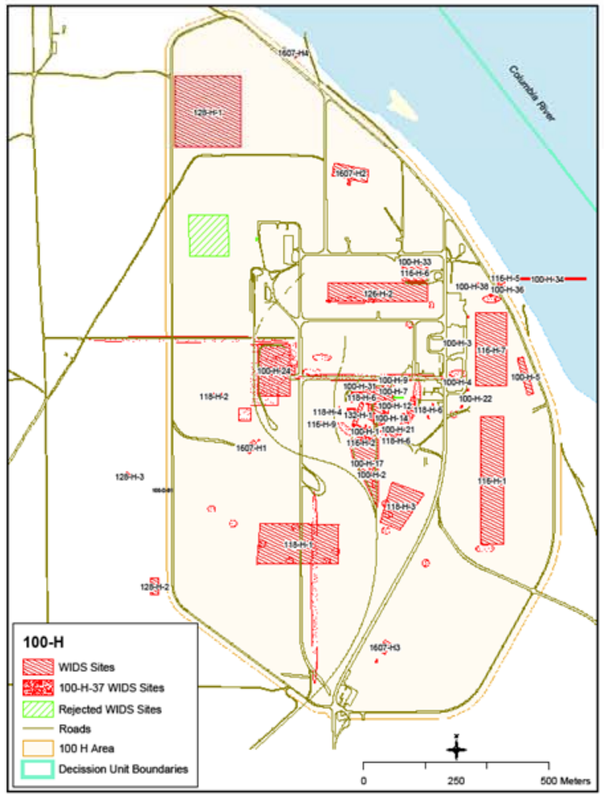

Figure A-18. 100-H Area Source Remediation and Residual Contamination

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PROBLEM STATEMENT

- Remedial investigations from the early 1990s revealed elevated levels of CrVI in groundwater beneath the 100-H Area. The CrVI plume discharges to the river have exposed aquatic receptors to concentration levels above the established ecological risk threshold.
- The goal of an IRM was to prevent discharge of CrVI to the river and riverbed sediments at concentrations exceeding those considered protective of aquatic receptors (22 µg/L in compliance wells).
- Remedial actions affecting co-contaminants (e.g., Sr-90, tritium, uranium, and Tc-99) have been deferred to the final ROD.
- As the pump-and-treat system has reduced the extent of CrVI in groundwater at the 100-H Area, the 100-D Area CrVI plume is approaching the 100-H Area at rates that are enhanced by the pump and treat system's extraction wells.

PUMP-AND-TREAT SYSTEM

- Pump and treat is the process of extracting groundwater using pumping wells, treating the extracted water, and returning the treated water back to its source. In this system, the treated water is routed from the 100-D Area via piping to the 100-H Area to injection wells that return the treated water to the aquifer.
- CURRENT CONFIGURATION:
  - 5 Extraction Wells; 4 Injection Wells
- SYSTEM PERFORMANCE:
  - 4 Compliance Wells: 199-H4-4,199-H4-5, 199-H4-63, 199-H4-64
  - 14 Additional wells monitored for performance evaluation purposes
  - Average well extraction rate:~59 L/min
  - System extraction rate: 2,975 L/min
- SYSTEM PERFORMANCE FY06
  - Volume extracted (FY06): ~155.9 million L
  - Total chromium mass removed (FY06): ~5.2 kg
- OVERALL SYSTEM PERFORMANCE
  - Total volume extracted: ~1.4 billion L (July 1997 to Sept 2006)
  - Total chromium mass removed: ~47 kg (July 1997 to Sept 2006) (combined removal from 100-D Area and 100-H Area).

INTERIM REMEDIAL ACTION

- In 1993, a QRA was completed, and an LFI for the 100-HR-3 OU was completed in 1994.
- In 1994, a pilot-scale pump-and-treat treatability study was initiated in the 100-DR Reactor area. The treatability test consisted of three groundwater extraction wells, two injection wells, and an ion-exchange effluent treatment system.
- In 1995, the results of a Focused Feasibility Study concluded that a groundwater pump-and-treat system combined with an ion-exchange effluent treatment system for the COPCs was the most effective IRM for the 100-HR-3 OU. The study focused on remediation of CrVI because it was evaluated to be the most toxic to aquatic organisms.
- A proposed plan was published, and an interim ROD was established directing installation of a pump-and-treat system for extracting CrVI from groundwater in the 100-HR-3 OU. A pump-and-treat system was designed, installed, and activated in July 1997 to reduce the flux of CrVI to aquatic receptors within the river.

HORN AREA INVESTIGATION

- As additional information from the 2007/2008 well installation becomes available, a summary will be presented here.

DATA GAPS

- The extent of the groundwater plume should be defined.
- The COPC list should be revised to establish cleanup levels.
- Potential groundwater remedial technologies should be evaluated to address the 100-H Area groundwater contamination and the threat from the plume migrating from the 100-D Area.
- A standard method and format should be developed for portraying groundwater data contours.
- Additional ecological receptor data may need to be collected and assessed. The data should be used to develop exposure risk maps and used in targeting areas that require remediation and designing a remedial approach to address those areas.
- The Risk Assessment should be completed for the 100-H Area.
- Final cleanup levels should be developed that are protective of human health and ecological receptors. Incorporate these goals into remedial technology performance criteria. If necessary, alternative data collection methods may need to be developed to assess river impacts and use the data to evaluate remedial technology performance.
- Follow-through phases of environmental evaluation need to be flexible to accommodate the results of newly conducted investigation tasks.

HEXAVALENT CHROMIUM PLUME HISTORY

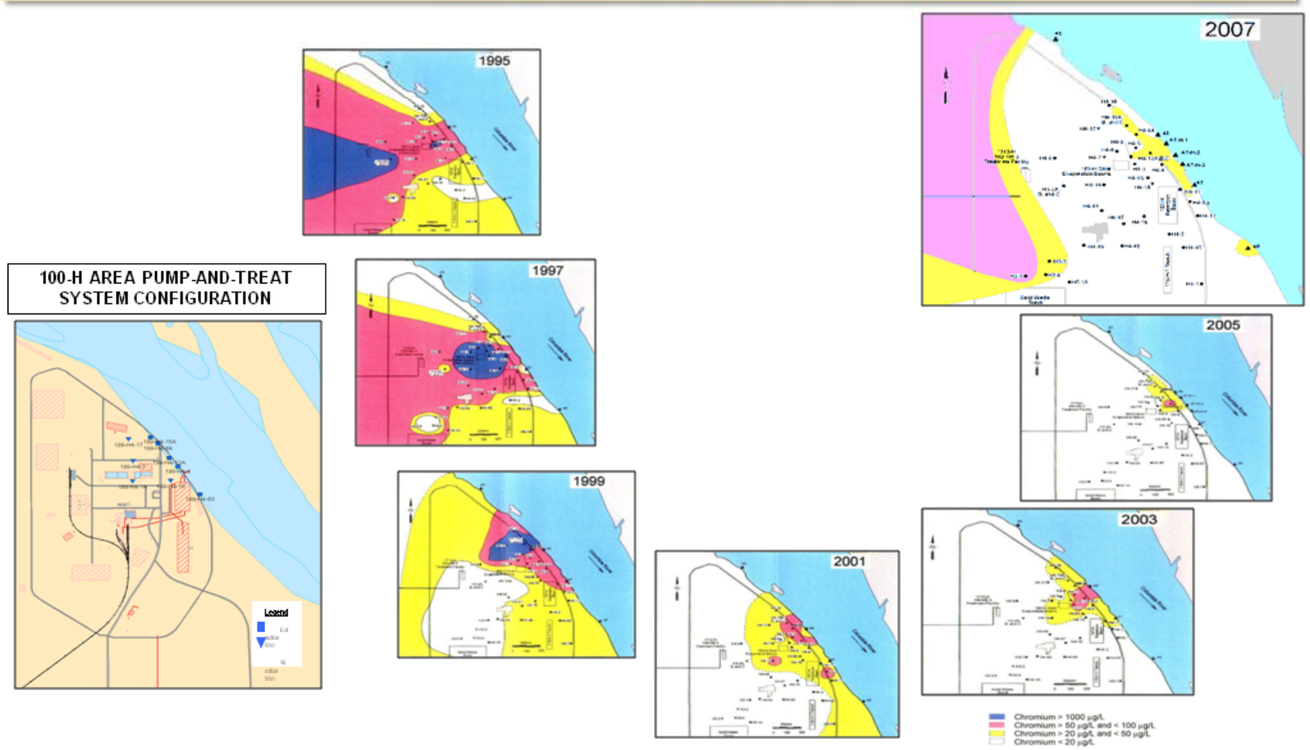

Figure A-19. 100-H Area Groundwater Remediation

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Appendix B

100-D Area and 100-H Area Maps

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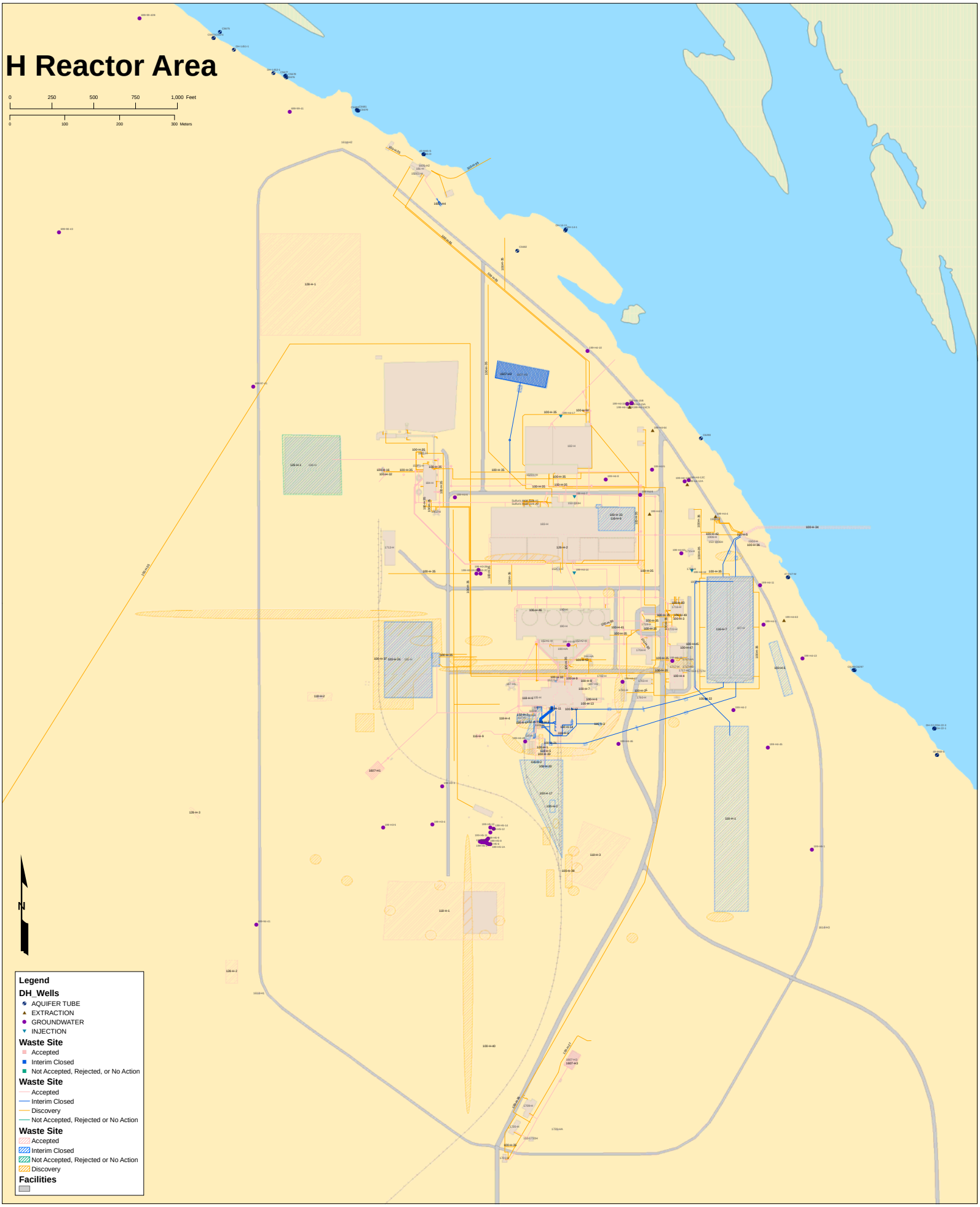
H Reactor Area



100H Area
Operable Units
100-HR-1 & 100-HR-2

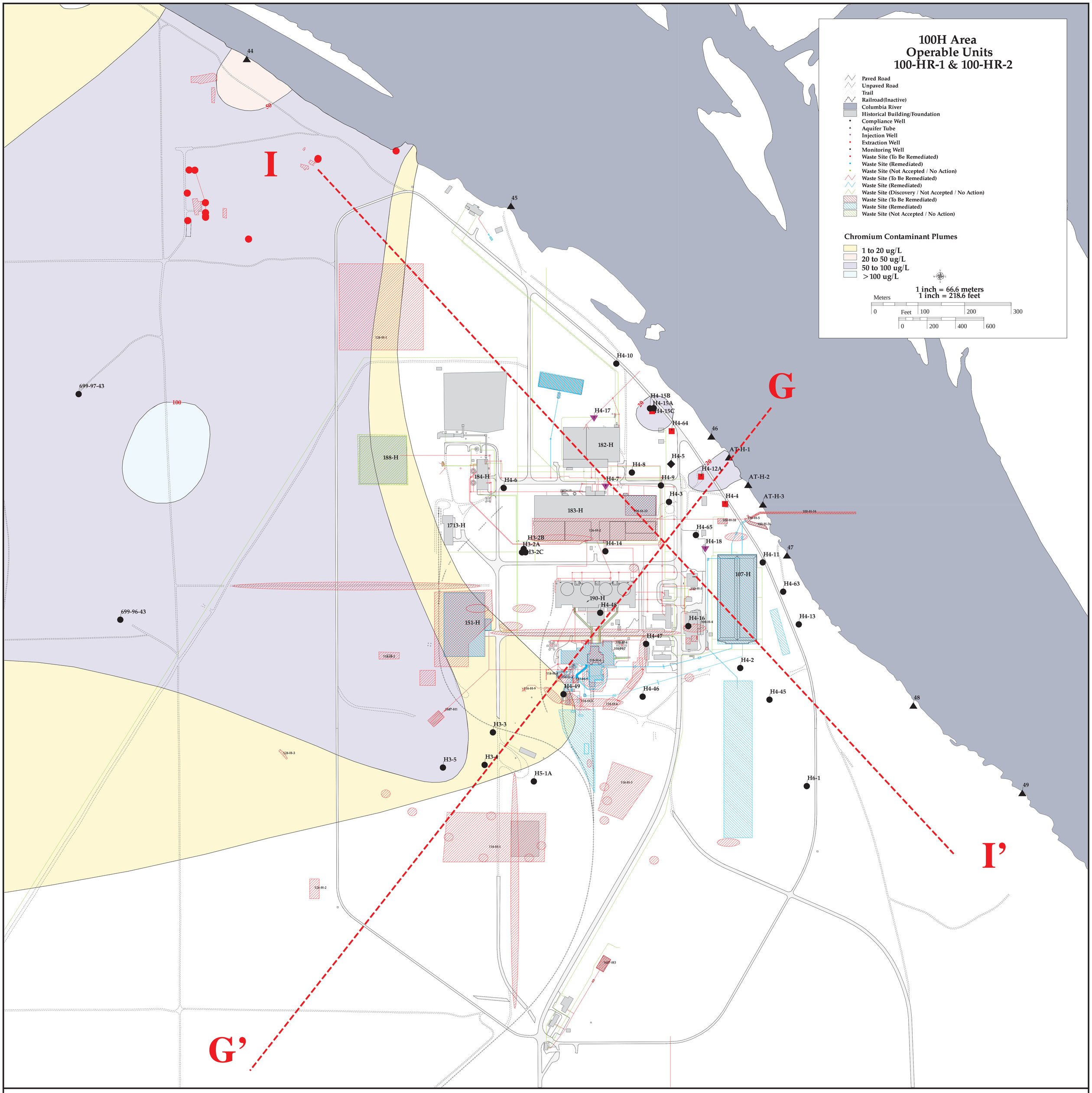
- Paved Road
- Unpaved Road
- Trail
- Railroad(Inactive)
- Columbia River
- Historical Building/Foundation
- Compliance Well
- Aquifer Tube
- Injection Well
- Extraction Well
- Monitoring Well
- Waste Site (To Be Remediated)
- Waste Site (Remediated)
- Waste Site (Not Accepted / No Action)
- Waste Site (To Be Remediated)
- Waste Site (Remediated)
- Waste Site (Discovery / Not Accepted / No Action)
- Waste Site (To Be Remediated)
- Waste Site (Remediated)
- Waste Site (Not Accepted / No Action)

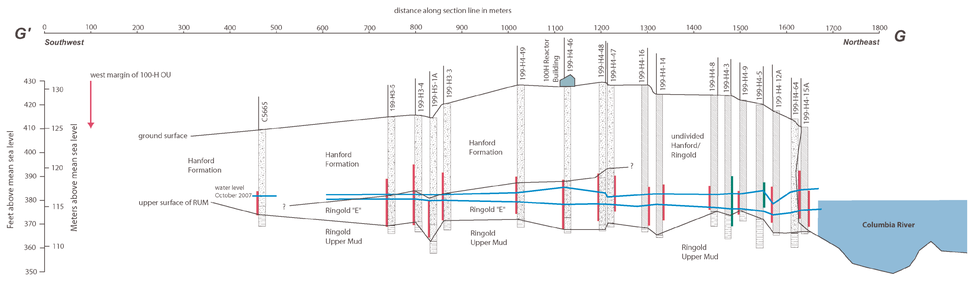
Chromium Contaminant Plumes

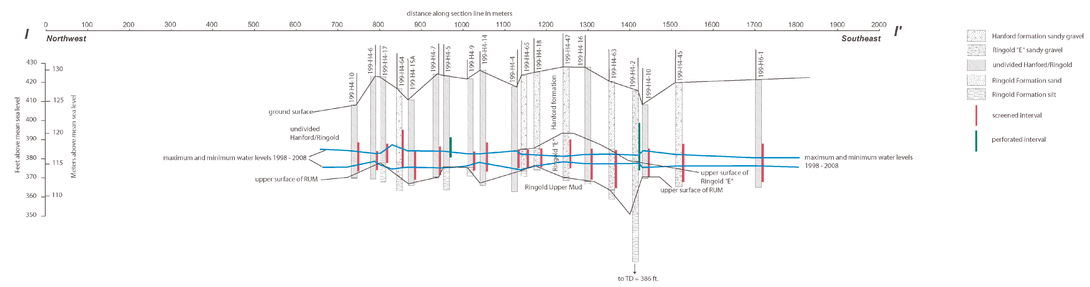
- 1 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- >100 ug/L

1 inch = 66.6 meters
1 inch = 218.6 feet

Meters: 0, 100, 200, 300
Feet: 0, 200, 400, 600







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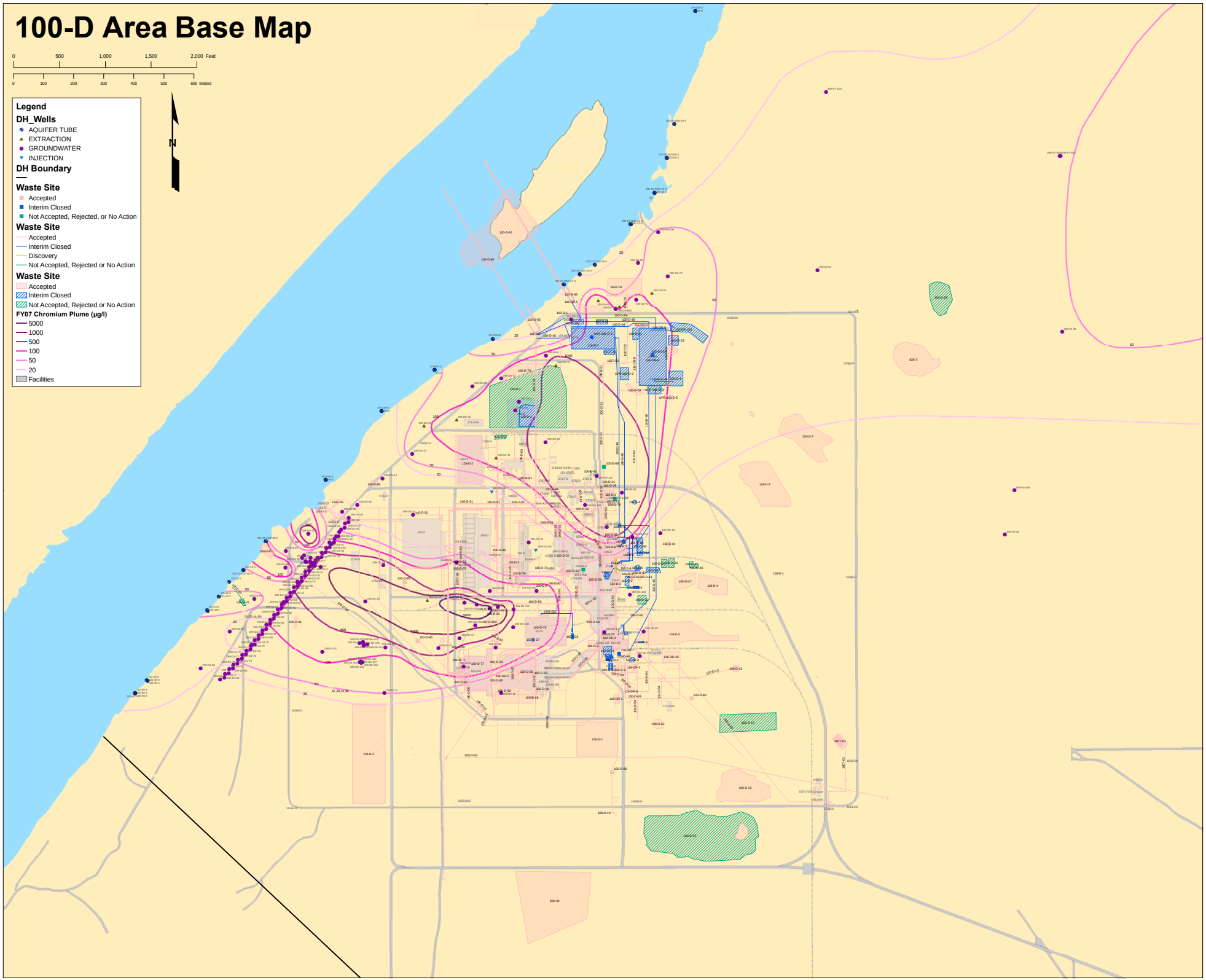
100-D Area Base Map



D Reactor Area

0 250 500 750 1,000 Feet

0 100 200 300 Meters

Legend

DH_Wells
- AQUIFER TUBE
- EXTRACTION
- GROUNDWATER
- INJECTION

Waste Site
- Accepted
- Interim Closed
- Not Accepted, Rejected, or No Action

Waste Site
- Accepted
- Interim Closed
- Discovery
- Not Accepted, Rejected or No Action

Waste Site
- Accepted
- Interim Closed
- Not Accepted, Rejected or No Action

Facilities

N

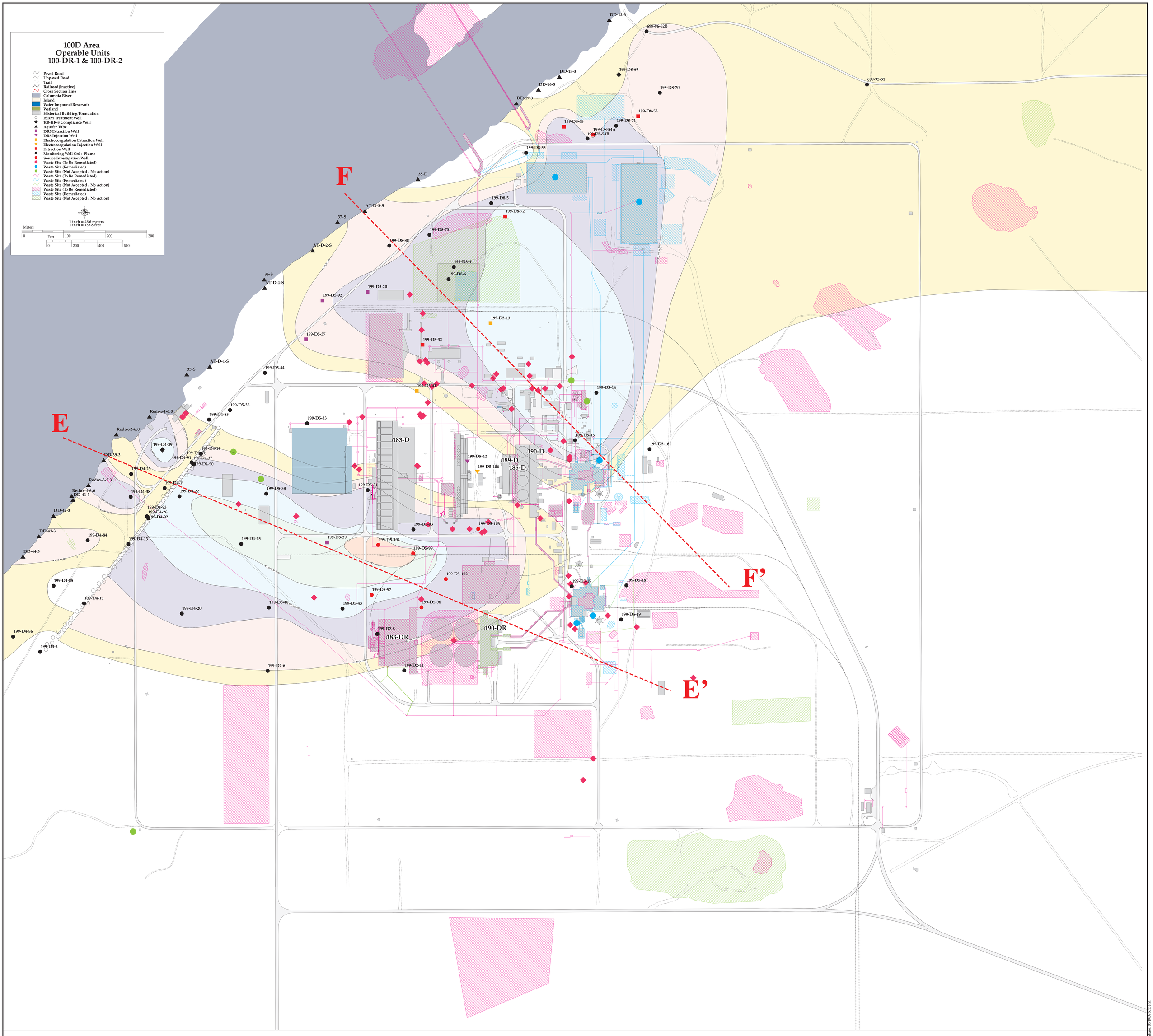
100D Area
Operable Units
100-DR-1 & 100-DR-2

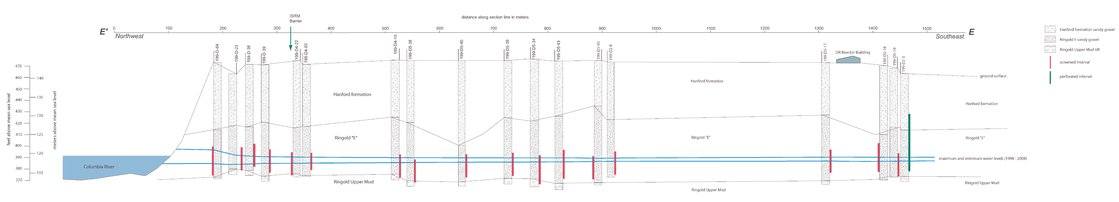
- Paved Road
- Unpaved Road
- Trail
- Railroad(Inactive)
- Cross Section Line
- Columbia River
- Island
- Water Impound/Reservoir
- Wetland
- Historical Building/Foundation
- ISRM Treatment Well
- 100-HR-3 Compliance Well
- Aquifer Tube
- DR5 Extraction Well
- DR5 Injection Well
- Electrocoagulation Extraction Well
- Electrocoagulation Injection Well
- Extraction Well
- Monitoring Well Cr6+ Plume
- Source Investigation Well
- Waste Site (To Be Remediated)
- Waste Site (Remediated)
- Waste Site (Not Accepted / No Action)
- Waste Site (To Be Remediated)
- Waste Site (Remediated)
- Waste Site (Not Accepted / No Action)
- Waste Site (To Be Remediated)
- Waste Site (Remediated)
- Waste Site (Not Accepted / No Action)

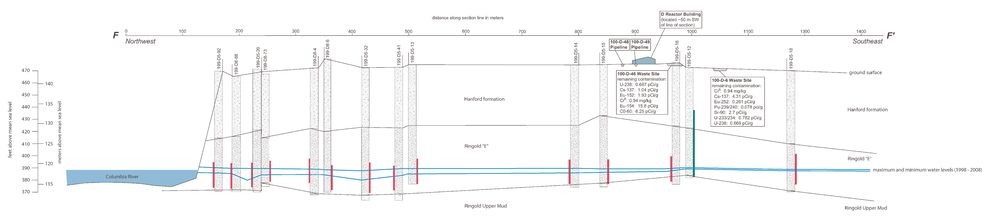
1 inch = 46.6 meters
1 inch = 152.8 feet

Meters: 0 100 200 300

Feet: 0 200 400 600







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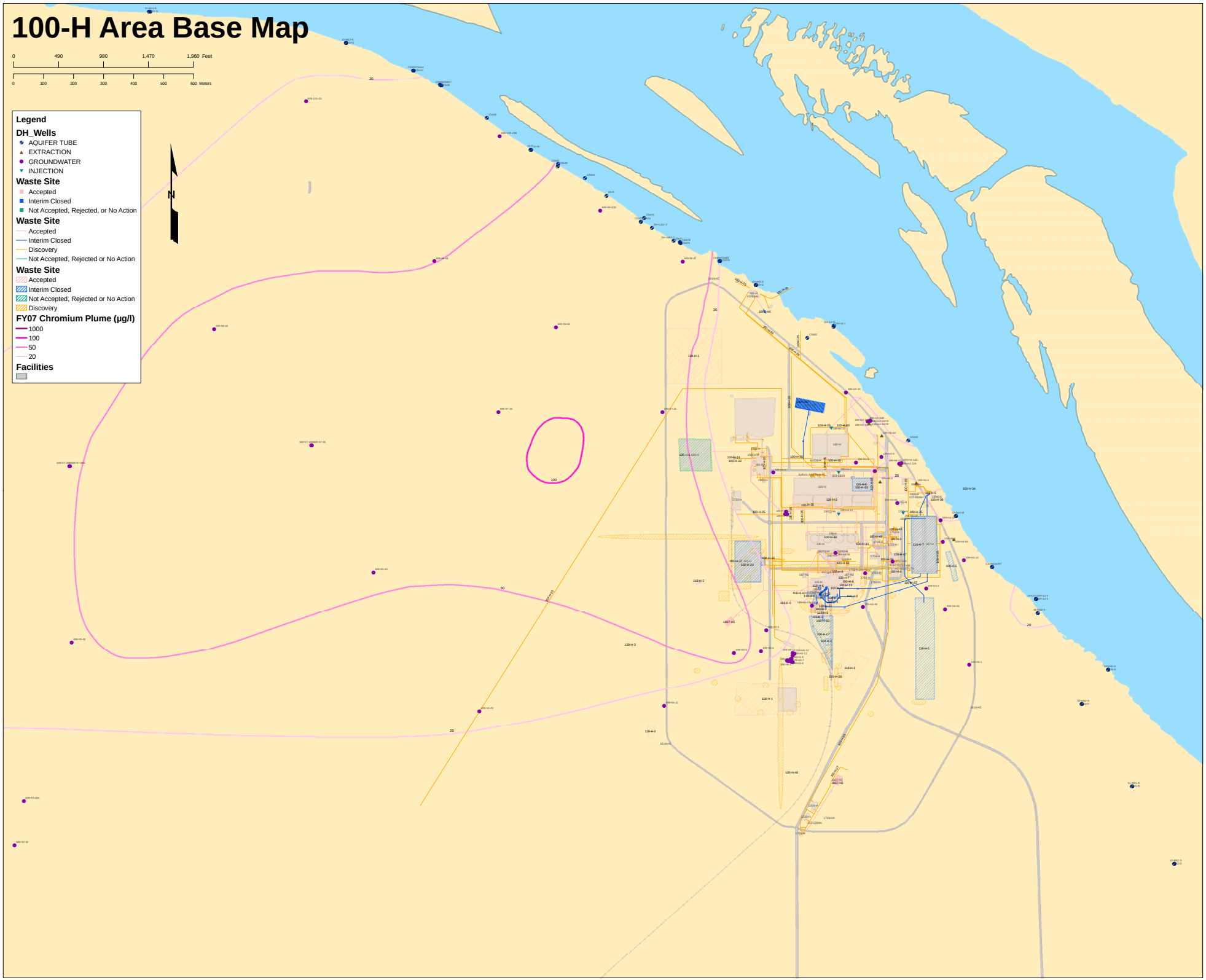
100-H Area Base Map



Appendix C

100-D/H Waste Sites Description and History

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Introduction

Waste sites described in this section include subsites. During remedial action planning, larger waste sites were occasionally segmented into smaller manageable sub units called subsites to facilitate safe and cost-effective field operations. Therefore, the waste site count identified in this section is different from those presented in the main body of the addendum.

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Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D Area Waste Sites																
100-D-1	Process Sewer	100-DR-1	Accepted	1.1 x 0.9 x 0.9	Not Documented	Located just north of the patrol road between the 1904-D and 1904-DR Outfall Structures. Small concrete storm drain system, box covered with steel plate. Posted with surface radioactive contamination signs. Provided drainage via underground piping from the south side of the patrol road to the river shoreline.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-10	Depression/ Pit (nonspecific)	100-DR-1	Not Accepted	251.43 m^2	Not Documented	This site is a storm drain outfall. The site received nondangerous and nonradioactive stormwater runoff from the 190-DR Tank Pit. Therefore, this site is reclassified as not accepted.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-100	Unplanned Release	100-DR-2	Accepted	319 m^2	Not Documented	This site is contaminated soil near the former sodium dichromate/ acid railcar and truck unloading station (100-D-12). The waste is contaminated soil. The waste consists of hexavalent-contaminated soil.	Not Documented	N/A								
100-D-101	Sump	100-DR-1	Discovery	2.7 x 11 Each (Sulfuric Tanks) 2.1 x 3.9 x 2.5 (Acid Neutralization Pit structure)	Before 1952	The site consists of four chemical storage tanks, an acid neutralization pit/sump, a sodium silicate sump, two sets of pumps, and a car spot. All located to the west of the 108-D building. Two chemicals were stored near 108-D, sulfuric acid and sodium silicate, which each had its own set of two large storage tanks.	Not Documented	N/A								
100-D-11	Unplanned Release	100-DR-2	Not Accepted	16,266.31 m^2	1950	This site is suspected of being a temporary garage and gasoline-dispensing station. Because the site cannot be located, potential USTs cannot be verified, and no releases have been documented, this site is rejected as a waste site.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-12	Pump Station/ French Drain	100-DR-2	Interim Closed	4.10 x 3.50 0.91 x 6	Not Documented	Received sodium dichromate and sulfuric acid solutions in water from flushing and draining hoses and pipelines connected to railcars and trucks for unloading.	CVP-2000-00016	Nov-99	Apr-00	34.5	2.40	Cr+6	0.56 U	/	0.56[c]	/

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-13	Septic Tank	100-DR-2	Accepted	7.9 x 3.7 x 7.3 7.7 x 3.6 60 x 45	1947-1949	Septic system installed for use during construction of the 105-DR Reactor. Consisted of an Imhoff tank, a chlorinated house, a dosing tank, a filter bed, and associated piping.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-14	Septic Tank	100-DR-2	Accepted	3.8 x 2.1 x 91.6	Not Documented	Concrete tank with drain field. Received sanitary sewage from the 105-DR Reactor construction badgehouse before relocation. The site appears as a vegetation-covered field. A small depression may indicate the presence of the tank. A 10 cm (4-in.) cement pipe is likely to be a vent pipe to the drain field. The site is adjacent to a small soil pile.	Not Documented	N/A								
100-D-15	Dumping Area	100-DR-2	Accepted	16,266.3 m^2	Not Documented	Received debris and miscellaneous waste described as nonradioactive and nonhazardous, including paint cans, solvent cans, and construction materials. Waste material has been dumped at two locations in a large borrow pit southeast of the 100-DR Reactor Facilities (Gravel Pit No. 21).	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-17	Burn Pit	100-DR-2	Rejected	10,837.90 m^2	Not Documented	This site is a burn pit.	WSRF 97-005	N/A								
100-D-18	Trench	100-DR-1	Interim Closed	604.02 m^2	1953	Received sludge and effluent containing radioactive and hazardous materials from the 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.	CVP-2000-00001	Sep-97	Dec-98	8,702	6.60	Am-241	/	0.54 U	/	0.49
												Co-60	/	1.16	/	1.06
												Cs-137	/	12.8	/	17.7
												Eu-152	/	9.8	/	9.75
												Eu-154	/	1.1	/	1.12
												Eu-155	/	0.029 U	/	0.22
												Pu-238	/	0.016 U	/	0.048
												Pu-239/240	/	0.127	/	0.099
												Sr-90	/	0.729 J	/	0.0445
												Cr+6	/	2.6	/	2.4
												Aroclor-1016	/	0.034 UJ	/	0.033 UJ
												Aroclor-1221	/	68	/	0.067 UJ
												Aroclor-1232	/	0.034 UJ	/	0.033 UJ
												Aroclor-1242	/	0.034 UJ	/	0.033 UJ
												Aroclor-1248	/	0.034 UJ	/	0.033 UJ
												Aroclor-1254	/	0.034 UJ	/	0.033 UJ
												Aroclor-1260	/	0.034 UJ	/	0.033 UJ

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-19	Trench	100-DR-1	Interim Closed	Refer to 100-D-48:1	1953	Received sludge from the 107-D Retention Basin to facilitate repairs to the retention basin.	CVP-2000-00003	Refer to 100-D-48:1				Am-241	/	0.366 J	/	0.464
												Co-60	0.061 U	7.33	0.05	5.29
												Cs-137	0.809	39.5	0.251	28.2
												Eu-152	0.402	64.2	0.3	34.2
												Eu-154	0.15 U	8.01	0.12	4.25
												Ni-63	/	817		1,060
												Pu-239/240	0.24 U	1.31	0.13	0.449
												Sr-90	0.196 J	1.14	0.15	0.607
												U-233/234	0.713 J	0.933 J	0.5	0.57
												U-238	0.676 J	0.873 J	0.42	0.554
												Hg	/	1.6	/	2
												Cr+6	0.64 U	5	0.64	5
												PCB	/	U	/	/
100-D-2	Foundation	100-DR-1	Interim Closed	1.2 x 1.2	Not Documented	Small lead sheet covering a concrete pad southwest of the 185-D Building. Purpose unknown. Contaminant of potential concern is lead.	RSVP-2007-30	12-Apr-07	17-Oct-07	216	1.3	As	2.1 (<BG)	/	/	/
												Ba	65 (<BG)	/	/	/
												Be	0.19 (<BG)	/	/	/
												Bo	3.3	/	/	/
												Cd	0.31 (<BG)	/	/	/
												Cr (total)	7.3 (<BG)	/	/	/
												Co	6.7 (<BG)	/	/	/
													14.5 (<BG)	/	/	/
												Cr+6	0.41	/	/	/
												Pb	8.9 (<BG)	/	/	/
												Li	4.7 (<BG)	/	/	/
												Mn	294 (<BG)	/	/	/
												Mo	0.92	/	/	/
												Ni	11.8 (<BG)	/	/	/
												St	24.6	/	/	/
												Ti	2.4	/	/	/
												Va	50.1 (<BG)	/	/	/
												Zn	51.3 (<BG)	/	/	/

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-20	Trench	100-DR-1	Interim Closed	575 m^2 x 2.1	1953	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.	CVP-98-00003	Jul-97	Apr-97	9,710	2.10	Am-241	0.205 J	/	0.134[d]	/
												Co-60	0.11 U	/	0.072[d]	/
												Cs-137	2.24	/	1.23[d]	/
												Eu-152	1.91	/	0.473[d]	/
												Eu-154	0.32 U	/	0.083[d]	/
												Eu-155	0.145 U	/	0.045[d]	/
												Pu-238	0.13 U	/	0.012[d]	/
												Pu-239/240	0.0407	/	0.041[d]	/
												Sr-90	0.0868 U	/	0.087[d]	/
												Cr+6	0.083 U	/	0.030 U[d]	/
												PCB	/	/	0.035 U[d]	/
												Aroclor-1260	0.035 U	/	0.035 U[d]	/
100-D-21	Trench	100-DR-1	Interim Closed	891 m^2 x 3.0 Other sources suggest depth is 4.5 m	1953	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.	CVP-98-00002	Dec-97	Mar-98	9,943	4.50	Am-241	0.0242 U	/	0.0242[d]	/
												Co-60	0.15 U	/	0.0074[d]	/
												Cs-137	0.0281 J	/	0.0281[d]	/
												Eu-152	0.17 U	/	0.0723[d]	/
												Eu-154	0.54 U	/	0.0198[d]	/
												Eu-155	0.28 U	/	0.0341[d]	/
												Pu-238	0.022 U	/	0.0119[d]	/
												Pu-239/240	0.0074 U	/	0.0074[d]	/
												Sr-90	0.061 U	/	0.061[d]	/
												Cr+6	0.81 U	/	0.030 U[d]	/
												Aroclor-1260	0.034 U	/	0.034 U[d]	/
100-D-22	Trench	100-DR-1	Interim Closed	340 m^2 x 3.0 Other sources suggest depth is 4.8 m	1953	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.	CVP-98-00001	Mar-97	Nov-97	9,710	4.80	Am-241	0.059	/	0.059	/
												Co-60	0.0334 J	/	0.031	/
												Cs-137	0.21	/	0.164	/
												Eu-152	0.374	/	0.303	/
												Eu-154	0.045 U	/	0.045	/
												Eu-155	0.0396 U	/	0.04	/
												Pu-238	0.00621 U	/	0.006	/
												Pu-239/240	0.0351 U	/	0.032	/
												Sr-90	0.304 J	/	0.237	/
												Cr+6	0.81 UJ	/	0.030 U	/
												Pb	/	/	3.9	/
												PCB	7.2 N	/	0.035 U	/
												Aroclor-1260	47	/	0.035 U	/

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-23	French Drain	100-DR-2	Interim Closed	0.67 m^2	1959-1964	Received sludge from 107-DR Retention Basin to facilitate repairs to the retention basin.	CVP-2003-00018	Refer to 122-DR-1:2								
100-D-24	French Drain/ Dry Well	100-DR-1	No Action	0.87 m^2	1959	This site is a dry well that received drainage from a floor drain in the 119-D Sample Building. Confirmation sampling demonstrated that residual contaminant concentrations support unrestricted land use. Therefore, this site is reclassified as a no action site.	WSRF 2006-004	N/A								
100-D-25	Unplanned Release	100-DR-1	Interim Closed	Refer to 116-DR-9	1951	Site is located beneath the 107-DR Retention Basin. Release is the result of retention basin leaks. The effluent volume release is unknown.	Refer to 116-DR-9	Refer to 116-DR-9								
100-D-26	Depression/ Pit (nonspecific)	100-DR-1	Not Accepted	100 m diameter	Not Documented	The borrow pit may have been used as a source of fill at reactor or at the 107-DR Retention Basins (116-DR-9) during construction. The site may also have been used later as a source of fill for the nearby 628-3 burn pit.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-27	Unplanned Release	100-DR-2	Closed Out	59.08 m^2	6/1/1995	Site consists of an unplanned release within the 151-D Electrical Substation. 400 L (106 gal) of PCB was released. The concentration of PCB in the liquid was 42 ppm. The transformer was repaired, facility was power washed, all contaminated material was shoveled into seven 208-L (55-gal) drums, and the site backfilled with clean gravel.	WSRF 2005-014	N/A	N/A	1,456 L (385 gal) of contaminated material drummed.	N/A	No more than 0.016 kg (0.04 lb) of PCB was released, which is significantly less than the CERCLA requirement of 0.45 kg (0.04 lb).				
100-D-28	Septic Tank	100-DR-2	Accepted	1.1 x 2.3 x 1.5	Not Documented	Site consists of two septic systems; the original and the replacement. 100-D-28:1 is the replacement system and consists of a 2,730-L (720-gal) steel septic tank and vitrified clay pipe drain field. 100-D-28:2 is the original system and consists of a 2,839-L (750-gal) septic tank and drain field.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-29	Unplanned Release	100-DR-1	Accepted	80.7 x 11	1951	This site is an unplanned release of effluent water from the reactor-cooling water (effluent line leak No. 2) and is located southeast of the 107-DR Basin (116-DR-9).	Proximity	N/A								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-3	Burial Ground	100-DR-1	No Action	384.9 m^2	Not Documented	Small covered trench with concrete marker and brass cap. Disposal of silica gel from the 115-D/DR Drying Towers. Potentially contaminated with radioactive and hazardous materials.	WSRF 2008-017	There is little historical information available to identify the precise location of the 100-D-3 waste site. Considerable effort was made to identify and investigate possible locations where the silica gel may have been buried. The primary location for the silica gel pit was excavated during remediation of waste site 116-D-2. The alternate locations based on interpretation of geophysical survey data were excavated and sampled. Neither location contained evidence of silica gel.								
100-D-30	Unplanned Release	100-DR-1	Accepted	92.7 x 1 x 3 117 x 11.6	1945-1967	Sodium dichromate contamination was discovered in the soil along the entire length of the 185-D Sodium Dichromate Trench.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-31	Process Sewer	100-DR-1	Accepted	7,567.2	1944-1994	Reinforced-concrete piping system from 100-D/DR Water Treatment Facility buildings 182-D, 183-D, 186-D, 185/189/ 190-D, 105-D, 108-D, 182-DR, and 183-DR. Carried process sewer waste and rain runoff to process effluent outfall (116-D-5) until 1977. The process sewer drainage was diverted to the 120-D-1 D Ponds from 1977 to 1994.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-32	Burial Ground	100-DR-1	Rejected	15.2 x 15.2	1956	This site was used for the disposal of contaminated equipment from the 105-D Reactor and effluent system equipment. During the March 1999 visit, there was no evidence of the site.	EPA/ROD/ R10-00/121	N/A								
100-D-33	Burial Ground	100-DR-1	Rejected	30.48 x 15.24	1954	This site originally was considered to be a low-level waste burial ground for reactor waste. After performance of geophysical surveys and trenching, the site could not be located. 100-D-33 has been rejected as a waste site.	WSRF-2007-023	N/A								
100-D-34	Unplanned Release	100-DR-1	Not Accepted	Not Documented	Not Documented	This rejected waste site includes the grounds surrounding the 100-D/DR Deactivated Areas, Exclusion Areas.	Not Documented	N/A								
100-D-35	Burial Ground	100-DR-1	Rejected	30.5 x 15.2 x 7.6	1954	This site originally was considered to be a low-level waste burial ground for reactor waste. After performance of geophysical surveys and trenching, the site could not be located. 100-D-35 has been rejected as a waste site.	WSRF-2007-024	N/A								

Table C-1. Waste Sites

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-36	Foundation	100-DR-2	Not Accepted	2.06 x 2.06; also documented as 1.8 x 1.8 m	Not Documented	This site is the concrete pad of an environmental monitoring station.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-37	Foundation	100-DR-2	Not Accepted	2.06 x 2.06	1943	This site is the concrete pad of an environmental monitoring station.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-38	Septic Tank	100-DR-1	Not Accepted	276.55 m^2	Not Documented	This site originally was considered a junction box and manhole associated with the 1607-D2 Septic System. The site has been rejected as a waste site because it is not the septic tank as identified. The drop manhole and associated piping are part of the 1607-D2 Septic System.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-4	Trench	100-DR-1	Interim Closed	630 m^2 x 3.0 Other sources suggest dimension is 244 x 2.44 x undocumented depth	1953	Received sludge and effluent containing radioactive and hazardous materials from 116-D-7 (107-D/DR) Retention Basins. This site is not documented as a high-volume liquid waste site.	CVP-98-00004	Mar-97	Mar-97	1,678	2.90	Am-241	0.445 U	/	0.022[d]	/
												Co-60	0.0328 U	/	0.007[d]	/
												Cs-137	0.128	/	0.119[d]	/
												Eu-152	0.288 U	/	0.265[d]	/
												Eu-154	0.067 U	/	0.016[d]	/
												Eu-155	0.0703 U	/	0.03[d]	/
												Pu-238	0.0163 U	/	0.003[d]	/
												Pu-239/240	0.0269 U	/	0.007[d]	/
												Sr-90	0.0836 U	/	0.126[d]	/
												U-238	1.16	/	/	/
												Cr+6	1.32 J	/	0.179[d]	/
												Aroclor-1260	0.12	/	0.071[d]	/
												Aroclor-1254	0.071	/	0.12[d]	/
100-D-40	Burial Ground	100-DR-2	Rejected	6.1 (depth) x 12.19 (dia.)	1956	This site originally was considered to be a low-level waste burial ground for reactor waste. After performance of geophysical surveys and trenching, the site could not be located. 100-D-40 has been rejected as a waste site.	WSRF-2007-025	N/A								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-41	Burial Ground	100-DR-1	Rejected	22.86 x 12.19	1944-1967	This site originally was considered to be a low-level waste burial ground for reactor waste. After performance of geophysical surveys and trenching, the site could not be located. 100-D-41 has been rejected as a waste site.	WSRF-2007-026	N/A								
100-D-42	Burial Ground	100-DR-1	Accepted	276.6 m^2	1955	Consists of a solid waste burial ground that contains vertical safety rod thimbles. Located east of the two reactor effluent pipelines in 100-D.	Not Documented	N/A								
100-D-43	Burial Ground	100-DR-2	Accepted	21.3 x 7.6 x 4.6	1953-1967	This site received irradiated reactor components (vertical safety rods) and hardware from modification made to the 105-D Reactor.	EPA/ROD/ R10-00/121	N/A								
100-D-45	Burial Ground	100-DR-1	Accepted	24.7 x 7.3 x 5.2	Not Documented	This site received irradiated reactor components (vertical safety rods).	EPA/ROD/ R10-00/121	N/A								
100-D-46	Burial Ground	100-DR-2	Interim Closed	45.7 x 6.1 x 7.6	1967	This site received radioactive and nonradioactive solid wastes and construction debris from various reactor modifications in the 105-D Reactor.	CVP-2000-00010	Refer to 116-D-1A				Am-241	0.150 U	4.32	0.173	1.12
												Co-60	0.043 U	7.81	0.0351	6.3
												Cs-137	1.28	409	0.724	324
												Eu-152	0.348	193	0.248	157
												Eu-154	0.15 U	15.8	0.109	12.8
												Pu-239/240	0.02 U	19	0.0797	8.76
												Sr-90	0.315 J	36.8	0.202	19.1
												U-238	0.607 J	0.56	0.476	0.437
												Cr+6	0.61	4.7	0.61	2.6
100-D-47	Burial Ground	100-DR-2	Accepted	69.5 x 57.0	Not Documented	The site is a burial ground used to dispose of waste during Project CG-558 rod burial.	EPA/ROD/ R10-00/121	N/A								
100-D-48	Radioactive Process Sewer	100-DR-1	Interim Closed	Varies	1944-1967	The 100-D-48 site included those underground pipelines that transported radioactive treated and untreated waste water from the 105-D Reactor Building to the 116-D-7 (107-D) Retention Basin and the 116-D-5 Outfall.	See Subsites	See Subsites								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-48:1	North Pipelines	100-DR-1	Interim Closed	Varies	1944-1967	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-D Reactor to the 107-D Retention Basin and the 116-D-5 Outfall. Consists of four subsites as follows: 100-D-48:1, North Pipelines from 116-D-7 to Outfalls.	CVP-2000-00003	Dec-98	Jul-00	107,266	6.00	Co-60	0.061 U	7.33	0.05	5.29
												Cs-137	0.809	39.5	0.251	28.2
												Eu-152	0.402	64.2	0.3	34.2
												Eu-154	0.15 U	8.01	0.12	4.25
												Pu-239/240	0.24 U	1.31	0.13	0.449
												Sr-90	0.196 J	1.14	0.15	0.607
												U-233/234	0.713 J	0.933 J	0.5	0.57
												U-238	0.676 J	0.873 J	0.42	0.554
												Cr+6	0.64 U	5	0.64	5
100-D-48:2	Pipelines	100-DR-1	Interim Closed	Varies	1944-1967	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-D Reactor to the 107-D Retention Basin and the 116-D-5 Outfall. Consists of four subsites as follows: 100-D-48:2, West Pipelines from D Avenue to 116-D-7.	CVP-2000-00005	Jul-97	Aug-99	57,106	6.00	Co-60	0.154	7.58	0.0437[c]	1.72[c]
												Cs-137	40.6	61.6	0.499[c]	7,530[c]
												Eu-152	2.21	24.4	0.4[c]	327[c]
												Eu-154	0.894	2.93	0.11[c]	1.44[c]
												Pu-239/240	0.046	0.63 J	0.04[c]	0.103[c]
												Sr-90	0.42	1.77 J	0.21[c]	0.692[c]
												U-233/234	0.748	0.854 J	0.47[c]	0.49[c]
												U-238	0.783	8.06 J	0.45[c]	0.52[c]
												Cr+6	0.42	3.65	0.42[c]	1.3[c]
100-D-48:3	Pipelines	100-DR-1	Interim Closed	Varies	1944-1967	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-D Reactor to the 107-D Retention Basin and the 116-D-5 Outfall. Consists of four subsites as follows: 100-D-48:3, Effluent Pipelines from D Avenue to 105-D Reactor.	CVP-2000-00034	Oct-99	Jul-00	55,561	5.7	Co-60	0.053 U	0.059 U	0.4	0.05
												Cs-137	4.31	2.82	0.632	1
												Eu-152	0.261	0.848	0.12	0.604
												Eu-154	0.180 U	0.18 U	0.13	0.161
												Pu-239/240	0.078 J	0.697 J	0.06	0.126
												Sr-90	2.7	4.59	0.491	0.121
												U-233/234	0.782 J	0.711 J	0.52	0.411
												U-238	0.669 J	0.473 J	0.51	0.382
												Cr+6	0.94	0.93	0.94	0.53
100-D-49	Radioactive Process Sewer	100-DR-1	Interim Closed	Varies	1950-1967	There are four subsites associated with this site. The entire site included those underground pipelines that transported radioactive treated and untreated waste water from the 105-DR Reactor Building, and the 132-DR-1 (1608-DR) Building to the 116-DR-9 (107-DR) (107-DR) Retention Basin and both of the 116-D-5 and 116-DR-5 Outfalls.	See Subsites	See Subsites									

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-49:1	North Pipelines	100-DR-1	Interim Closed	Varies	1944-1967	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-DR Reactor and the 1608-DR Building to the 107-DR Retention Basin and the Outfalls. Consists of four subsites as follows: 100-D-49:1, North Pipelines from 116-DR-9 to Outfalls.	Refer to 100-D-48:1					Co-60	0.061 U	7.33	0.05	5.29
												Cs-137	0.809	39.5	0.251	28.2
												Eu-152	0.402	64.2	0.3	34.2
												Eu-154	0.15 U	8.01	0.12	4.25
												Pu-239/240	0.24 U	1.31	0.13	0.449
												Sr-90	0.196 J	1.14	0.15	0.607
												U-233/234	0.713 J	0.933 J	0.5	0.57
												U-238	0.676 J	0.873 J	0.42	0.554
												Cr+6	0.64 U	5	0.64	5
100-D-49:2	Pipelines	100-DR-1	Interim Closed	Varies	1944-1967	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-DR Reactor and the 1608-DR Building to the 107-DR Retention Basin and the Outfalls. Consists of four subsites as follows: 100-D-49:2, East Pipelines from D Avenue to 116-DR-9.	CVP-2000-00005	Refer to 100-D-48:2		57,106	Refer to 100-D-48:2	Co-60	0.154	7.58	0.0437[c]	1.72[c]
												Cs-137	40.6	61.6	0.499[c]	7,530[c]
												Eu-152	2.21	24.4	0.4[c]	327[c]
												Eu-154	0.894	2.93	0.11[c]	1.44[c]
												Pu-239/240	0.046	0.63 J	0.04[c]	0.103[c]
												Sr-90	0.42	1.77 J	0.21[c]	0.692[c]
												U-233/234	0.748	0.854 J	0.47[c]	0.49[c]
												U-238	0.783	8.06 J	0.45[c]	0.52[c]
												Cr+6	0.42	3.65	0.42[c]	1.3[c]
100-D-49:3	Pipelines	100-DR-1	Interim Closed	Varies	1944-1967	Site consisted of underground pipelines that transported radioactive treated and untreated wastewater from the 105-DR Reactor and the 1608-DR Building to the 107-DR Retention Basin and the Outfalls. Consists of four subsites as follows: 100-D-49:3, Effluent Pipelines from D Avenue to near 105-DR Reactor.	Refer to 100-D-48:3									
100-D-5	Burial Ground	100-DR-1	Interim Closed	3 x 3 x 4.3	1950	This site is identified as a burial ground in WIDS. However, this site is an effluent tie-in line on the north side of the 105-D Reactor.	CVP-2000-00034	Refer to 100-DR-48:3								
100-D-50	Process Sewer	100-DR-1	Accepted	8,593.1	1950-1965	Abandoned underground pipelines that carried treated and untreated wastewater from the 183-DR Building, the 183-DR Clearwells, and the 105-DR Reactor to the 100-D-8 Outfall. Consists of 10 subsites.	Not Documented	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-52	French Drain	100-DR-1	Interim Closed	1 x 6.71	1955	Received condensate or cooling water leakage from the concrete enclosure for the 105-D Downcomer. Volume and inventory are not documented.	CVP-2000-00018	Jan-00	Mar-00	199	7.60	Cs-137	0.065 J	/	0.0472[c]	/
												Eu-152	0.099 U	/	0.181[c]	/
												U-233/234	0.576 J	/	0.461[c]	/
												U-238	0.588 J	/	0.451[c]	/
												Cr (total)	7.4 U	/	5.6[c]	/
												Pb	4.3 U	/	3.1[c]	/
100-D-53	Process Unit/ Plant	100-DR-2	Interim Closed	21 x 12 x 10	1998	The ventilation exhaust filter building housed blowers and particulate filters used to treat the ventilation exhaust from the 105-DR Reactor.	CVP-2003-00018	Refer to 122-DR-1:2								
100-D-54	French Drain	100-DR-2	Interim Closed	56 cm x 1.5 m	1959-1964	Drywell near sodium fire facility gravel scrubber. Consisted of a 56 cm (28-in.) drywell constructed of concrete pipe with a steel cover. Approximately 1.5 m (4.9 ft) deep with a 5 cm (2-in.) pipe entering near the bottom.	CVP-2003-00018	Refer to 122-DR-1:2								
100-D-55	Depression/ Pit (nonspecific)	100-DR-2	Not Accepted	50,069.96 m^2	Not Documented	This site is not a waste site. It is a gravel pit used to supply clean fill dirt.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-56	Product Piping	100-DR-1	Accepted	1,695.9	Not Documented	Consists of two abandoned 7.6 cm (3-in.) underground supply lines that carried concentrated sodium dichromate between the 108-D, 185-D, 189-D, 190-D, and 183-DR Buildings and the 100-D Sodium Dichromate Transfer Station.	Not Documented	N/A								
100-D-57	Crib	100-DR-1	Not Accepted	4.27 x 4.27	1955	Through examination of Ground Penetrating Radar results, other documents, and excavation of 116-DR-9, 100-D-4, and 100-D-49, which effectively removed soil and subsurface structures in this area, it has been determined that 100-D-57 does not exist. Therefore, this site has been rejected as a waste site.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-58	Septic Tank	100-DR-2	Accepted	27.8 x 33 x 1.6	1998	Site includes a septic tank, drain field, two-compartment tank, and associated risers supporting MO980.	Not Documented	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-59	French Drain	100-DR-1	Rejected	0.45 (dia.) x 0.25	Not Documented	This French drain received overflow sulfuric acid from railroad car transfer operations. Any waste acid was assumed to be neutralized in the Hanford Site's alkaline soil. Therefore, the site is rejected as a waste site.	WSRF 2002-042	N/A								
100-D-6	Burial Ground	100-DR-1	Interim Closed	42 x 17	1944-1967	This site received contaminated thimbles and other solid reactor materials related to the Ball 3X installation project.	Refer to 100-DR-48:3	Refer to 100-DR-48:3								
100-D-60	Radioactive Process Sewer	100-DR-1	Accepted	2,294.7 m^2	1944-1967	This site includes the river effluent pipelines (river lines) that extend from the two outfalls in the 100-D/DR area into the main channel of the Columbia River.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-61	Dumping Area	100-DR-1	Accepted	30 (dia.)	Not Documented	Site is a debris pile that includes treated wood, lead-tipped bolts, and miscellaneous other debris from tearing down electrical utility poles.	Not Documented	N/A								
100-D-62	Septic Tank	100-DR-2	Accepted	2.1 x 1.2 x 1.8 8.2 x 4.3	1950	Site includes a septic tank with a capacity of 2,271 L (600 gal), a drain field, and related piping.	Not Documented	N/A								
100-D-63	Product Piping	100-DR-1	Accepted	27,191.6	Not Documented	The site encompasses the clean water pipelines upstream of the 100-D and 100-DR Reactors, including underground pipelines used to transport raw, fire, export, and sanitary water from the river pumphouse, to the water treatment facilities and to 100-D facilities and fire hydrants.	Not Documented	N/A								
100-D-64	Laboratory	100-DR-2	Interim Closed	33.4 m^2	Refer to 122-DR-1:2	This prefabricated metal structure housed most of the instrumentation for the Large Sodium Fire Facility Exhaust Air System.	CVP-2003-00018	Refer to 122-DR-1:2								
100-D-65	Outfall	100-DR-1	Accepted	6.4 (width) x 1.5 (depth)	Not Documented	The site is the concrete spillway (also referred to as a flume) that led from the 116-D-5 Outfall Structure and terminated at the river shoreline.	Not Documented	N/A								
100-D-66	Outfall	100-DR-1	Accepted	3.7 (width) x 1.5 (depth)	Not Documented	The site is the concrete spillway (also referred to as a flume) that led from the 116-DR-5 Outfall Structure and terminated at the river shoreline.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-67	Unplanned Release	100-DR-1	Accepted	213 x 268	1944-1967	D Island is a small island located near the southeast shore of the Columbia River and opposite the 100-D Reactor operating area. Historically, D Island has been submerged by high river flow. The site consists of soil contamination spread from vent risers that extended from the buried river effluent pipelines (100-D-60). The island is contaminated with particles of Co-60.	Not Documented	N/A								
100-D-68	Process Unit/ Plant	100-DR-2	No Action	128.02 x 36.6	1950	The Process Water Pumphouse provided high-volume treated water to the 105-DR Reactor for cooling. The facility contained eight electric primary water pumps that pumped treated water from the clearwell tanks to the reactor. Before demolition, all friable asbestos was removed, including all asbestos-containing material and all potential asbestos-containing material from ventilation fan housings, pipes, and loose materials that had fallen to the ground. The abovegrade portion of the facility was demolished and the belowgrade portion of the facility was demolished to 1 m (3 ft) belowgrade. The remainder of the concrete facility was left in place. The two valve houses were also demolished. The water tunnels were left in place and are currently being used as bat habitat. Site closure samples indicate residual contaminant levels are well below cleanup standards for direct exposure. Residual contaminants are not predicted to impact groundwater in 1,000 years.	WSRF 2005-034	N/A								
100-D-69	Unplanned Release	100-DR-1	Discovery	156.1 m^2	Not Documented	This site consists of sodium dichromate-contaminated concrete on a foundation. The soil is also potentially contaminated. The source of contamination is unknown.	Not Documented	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-7	Dumping Area	100-DR-1	Accepted	215 x 80 20 x 11	Not Documented	Solid waste dumping area containing nonradioactive, nonhazardous waste including vitrified clay pipe, concrete cores, metal paint cans, and wood debris.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-70	French Drain	100-DR-1	Accepted	121.92 (dia.)	1968	Site consists of a 122 cm- (48-in.-) diameter drywell located on the south side of the former 184-DA Building. It received steam separator discharge from equipment within the former 184-DA Building (demolished).	Not Documented	N/A								
100-D-71	Laboratory	100-DR-1	Accepted	5.5 x 5.5 x 38.1	1957	Site consists of components of the 195-D Vertical Safety Rod Tower. It is unknown if the components remain in the ground. The site had a 1.2 m- (4-ft-) diameter by 2.2 m- (7-ft-) deep concrete drywell, a belowgrade pit approximately 30.5 cm (12 in.) square, and a 7.6 cm- (3-in.-) diameter underground cast iron pipe.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-72	Process Unit/ Plant	100-DR-1	Accepted	39 x 0.76	1944	The waste site consists of multiple components on the south side of the 183-D Head House. All activities associated with the waste site are related to the unloading, storage, and use of acid to support water treatment in the 183-D Head House.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-73	Process Unit/ Plant	100-DR-1	Accepted	47 x 10 (Main Facility) 11 x 10 (Extension) 4 x 4 (Belowgrade Elevator Shaft) 2 (depth) x 1.8 (dia.) (Acid Mixing Tank) 1.2 (depth) Piping	1943	Soil and possibly the demolition debris under the former 108-D Building. This building was used to store and mix sodium dichromate.	Not Documented	N/A								
100-D-74	French Drain	100-DR-1	Accepted	0.3 m^2	1949	A French drain located on the north side of 105-D Reactor footprint. The dry well was connected to a flash tank located inside the 105-DR Reactor wall by a small-diameter drain line.	Not Documented	N/A								
100-D-75	Electrical Substation	100-DR-1	Accepted	137.6 x 91.25 8.6 x 13.6	1944	Site is the 151-D Primary and the 152-CI-D Secondary Electrical Substations.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-76	Crib	100-DR-1	Accepted	Estimated to range from 1 x 1.5 to 2.4 x 2.4 x 5 m	1951-1967	The waste site is either a French drain or crib, formerly known as 116-D-3. Historical documentation, a construction drawing, and ground-penetrating radar results indicate Waste Site 116-D-3 probably remains near the southeast corner of the 108-D Building. This site may have received 0.08 Ci of Cs-134 and 30,000 L (7,925 gal) of effluent.	Not Documented	N/A								
100-D-77	Process Unit/ Plant	100-DR-2	Accepted	40.9 x 10.6 (Acid facility) 34 x 24 (Head House) 112.5 x 58.5 x 6 (Basins) 171 x 15 (Filter Plant) 9.3 x 8.3 (Sample Room)	1952-1964	The waste site consists of the 183-DR Acid Facility, 183-DR Head House, the six 183-DR Flocculation Basins, the six 183-DR Sedimentation Basins, and the 183-DR Filter Building, all of which were components of the cooling water treatment system that supported the 105-DR Reactor. These components are of interest because they stored, mixed, or processed liquid contaminants of concern, especially sodium dichromate and sulfuric acid.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-78	Dumping Area	100-DR-2	Accepted	66 x 4 x 1.2 65 x 9 x 1.2 1 x 1 2 x 2	Not Documented	Site consists of four areas of yellow-stained soils between the 183-D and 186-D Buildings. The staining is in the vicinity of the acid trench and waste acid reservoir.	Not Documented	N/A								
100-D-79	Dumping Area	100-DR-1	Accepted	88 x 21.6 151.7 x 39.5	Not Documented	This site consists of two areas of posted soil contamination areas within 100-D.	Not Documented	N/A								
100-D-8	Outfall	100-DR-1	Accepted	728.4 m^2	1949-1968	Constructed in 1949 as a spillway for an emergency discharge for the DR Reactor. Consisted of a 1.8 m- (72-in.-) diameter reinforced-concrete pipe. The pipe discharged into a concrete box flume that spilled onto a grouted riprap surface and extended about 13.1 m (43 ft) beyond the low water level of the Columbia River.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-D-80	Dumping Area	100-DR-1	Accepted	0.6096 x 6.4 (dia.) 1 x 1 1 x 2 1 x 1	Not Documented	This site consists of patches of tar-stained soil and miscellaneous debris. The site is divided into four areas (light bulb, tar, oil-stained area, and wood structure with piping) based on waste discovered at the site.	Not Documented	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-81	Dumping Area	100-DR-1	Accepted	8.6 x 9.911.3 x 20.55.8 x 9.310.5 x 4111 x 162.4 x 2.52.4 x 2.5	Not Documented	This site consists of seven subsites that contain burned areas, stained soil, scattered concrete, oil staining, and quartz sand.	Not Documented	N/A								
100-D-82	Dumping Area	100-DR-1	Accepted	29.5 x 31.5 31.9 x 21.3 3.9 x 3.9	Not Documented	The site consists of three areas of garnet sand.	Not Documented	N/A								
100-D-83	Process Sewer	100-DR-1	Accepted	1,987.5	Not Documented	100-D area water treatment pipelines not included in 100-D-63.	Not Documented	N/A								
100-D-84	Sanitary Sewer	100-DR-1	Accepted	1,086.4	Not Documented	Sanitary sewer pipelines that carried sewage to various septic systems within 100-D.	Not Documented	N/A								
100-D-85	Radioactive Process Sewer	100-DR-1	Accepted	299.5	Not Documented	Reactor effluent pipelines from the 105-D and 105-DR Reactors not included in 100-D-48 and 100-D-49 Sites.	OSR-2008-0001	N/A								
100-D-86	Process Sewer	100-DR-1	Accepted	394.8	1945	Site consists of the process sewer pipelines not included in other sites within 100-D.	Not Documented	N/A								
100-D-87	Dumping Area	100-DR-1	Accepted	57 x 5	1945	The waste site is a surface liquid spill near the acid railroad car spot. A liquid discharge occurred in 1945 at the railroad car spot. The liquid is believed to be acid. No evidence of a spill or stained ground was observed during the orphan site field walkdown conducted in 2006.	OSR-2008-0001	N/A								
100-D-88	Product Piping	100-DR-1	Accepted	111.5	Not Documented	Site consists of various miscellaneous pipeline segments.	Not Documented	N/A								
100-D-89	Dumping Area	100-DR-2	Not Accepted	0.2 x 1.5 (height)	Not Documented	This site consists of two surface debris areas containing abandoned electrical components. The surface debris observed consisted of a downed electrical utility pole and an electrical service box. The electrical box was used as a junction box and should not have contained PCBs. This site is recommended for transition to WCH Miscellaneous Restoration upon completion of the deposition through the TPA-MP-14 process.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-9	Storage Tank	100-DR-1	Interim Closed	18.10 m^2	1967-1985	Former location of an UST for fuel oil for the 184-DA Boiler House. Site was excavated in 1994 to confirm tank removal and determine no soil contamination existed.	WSRF 2006-030	N/A	N/A	N/A	N/A	The site was first excavated on February 18, 1994, by the Decontamination and Decommissioning Engineering group to verify the tank had been removed. There was no indication of soil contamination in any of the Decontamination and Decommissioning Engineering records related to the excavation. However, there were no confirmatory sampling results for the site. This site was submitted for reclassification. Ecology reviewed the soil-gas data but was not satisfied with results.				
100-D-90	Unplanned Release	100-DR-1	Accepted	1.83 x 6.10	1944-?	The site is the soil located below two transformers sitting on railroad ties located west of the 183-D Facility. They are identified as C4814E and C4815E. They are/were transferred to WCH for final disposition by FH Electrical Utilities.	Not Documented	N/A								
100-D-91	Depression/ Pit (nonspecific)	100-DR-1	Not Accepted	1.82 x 1.82 x 1.82	Not Documented	The site consists of an area of chromium observed in a pit under the DR Water Tower. Water towers did not normally receive water treated with chromium. The pit and yellow material were removed in 2003. No samples were taken from the material that was removed. Not enough information is available to confirm if the material observed or removed was chromium. It was reported only as “yellow material” observed in the pit directly under the DR Water Tower.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-D-92	Product Piping	100-DR-1	Accepted	12.2 x 4.5 x 0.6	1944-1967	This site is the location of an underground concrete utility encasement and underlying soil located below a rail line. The potential COC is hexavalent chromium.	Not Documented	N/A								
100-D-93	Product Piping	100-DR-1	Accepted	12.2 x 4.5 x 0.6	1944-?	This site is the location of an underground concrete utility encasement and underlying soil located below a rail line. The site originally was reported as part of a geophysical investigation as a potential UST. A detailed spatial analysis was conducted, and it determined the feature was a known piping encasement below the railroad tracks.	Not Documented	N/A								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-D-94	Depression/ Pit (nonspecific)	100-DR-2	Accepted	1.82 x 1.82 x 1.82	Not Documented	The site consists of an area of chromium observed in a pit under the DR Water Tower. This site served as a valve pit for process water stored in the 187-DR Water Tower. The water tower provided emergency cooling water to the 105-DR Reactor.	Not Documented	N/A								
100-D-95	Septic Tank	100-DR-1	Accepted	67.0 (sewer line)	1943-?	This is the site of what is believed to have been two septic tanks and a tile field.	Not Documented	N/A								
100-D-96	French Drain	100-DR-1	Accepted	Diameter range from 0.45 to 0.91 m	1944-?	The site consists of seven French drains, one dry well location, and their underlying soil. Each of the facilities with which the French drains are associated were nonradioactive buildings.	Not Documented	N/A								
100-D-97	Storage Tank	100-DR-1	Accepted	2.0 x 1.25	1968-1995	This site consists of the underlying soil, a potential fuel UST, and associated fuel oil supply and fuel oil return piping (1.27 cm- [1.5-in.-] diameter). It is believed that these items were removed in 1985/1986 as part of the 100-D/DR general demolition efforts. It now appears as a cobble-covered field with vegetation on the surface.	Not Documented	N/A								
100-D-98	Electrical Substation	100-DR-1	Accepted	Concrete pads varied from 0.61 to 2.1 m (2 to 7 ft) wide, and from 0.9 to 6.4 m (3 to 21 ft) long	1944-?	This site consists of two active (C4S17 and 152-D1-D) and nine historical locations of electrical substations and underlying soil.	Not Documented	N/A								
100-D-99	Septic Tank	100-DR-1	Accepted	Not Documented	1944-?	The site is a possible septic system and the underlying soils.	Not Documented	N/A								
116-D-1A	Trench	100-DR-1	Interim Closed	39.6 x 3.05 x 1.83 Depth at this site also reported to be 3 m (10 ft) and 6.4 m (21 ft)	1947-1952	Received 200,000 L (52,834 gal) contaminated water and sludge from the 118-D-6 Fuel Storage Basin; 1,000 kg (2,200 lb) of sodium dichromate; 4.7 Ci.	CVP-2000-00010	Oct-99	Aug-00	10,987	4.60	Am-241	0.150 U	4.32	0.173	1.12
												Co-60	0.043 U	7.81	0.0351	6.3
												Cs-137	1.28	409	0.724	324
												Eu-152	0.348	193	0.248	157
												Eu-154	0.15 U	15.8	0.109	12.8
												Pu-239/240	0.02 U	19	0.0797	8.76
												Sr-90	0.315 J	36.8	0.202	19.1
												U-238	0.607 J	0.56	0.476	0.437
												Cr+6	0.61	4.7	0.61	2.6

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Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-D-1B	Trench	100-DR-1	Interim Closed	39.6 x 3.05 x 6.4 Depth at this site also reported as 1.8 and 5 m	1953-1967	Received 8,000,000 L (2,113,376 gal) of contaminated water and sludge from the 118-D-6 Fuel Storage Basin. Radiological inventory is 2.6 Ci.	CVP-2000-00010	Refer to 116-D-1A				Am-241	0.150 U	4.32	0.173	1.12
												Co-60	0.043 U	7.81	0.0351	6.3
												Cs-137	1.28	409	0.724	324
												Eu-152	0.348	193	0.248	157
												Eu-154	0.15 U	15.8	0.109	12.8
												Pu-239/240	0.02 U	19	0.0797	8.76
												Sr-90	0.315 J	36.8	0.202	19.1
												U-238	0.607 J	0.56	0.476	0.437
												Cr+6	0.61	4.7	0.61	2.6
116-D-10	Pond	100-DR-1	Accepted	10.7 x 6.7 x 0.9 (West) 15.2 x 7.3 x 1.2 (East)	1984	The unit consists of two open excavated pits (ponds) with a crossover channel connecting them. The small size of the excavation (west pond) only allowed for the discharge of one holding tank per day 75,708 L (20,000 gal). The east pit (pond) was larger, to support an increase in discharge capacity. The unit received processed water from the 105-D Fuel Storage Basin.	EPA/ROD/ RI0-99-039	N/A								
116-D-2	Crib	100-DR-1	Interim Closed	3.1 x 3.1 x 3.1	1950-1956	Site was used to isolate coolant flow from process tubes containing ruptured fuel elements. Effluent volume received is 4,000 L (1,057 gal). Inventory includes 0.004 kg (0.008 lb) of sodium dichromate.	CVP-2000-00013	Nov-99	Nov-99	623	4.60	Am-241	0.33 U	/	0.274[c]	/
												Co-60	0.33 U	/	0.041[c]	/
												Cs-137	0.068	/	0.057[c]	/
												Eu-152	0.29 U	/	0.096[c]	/
												Eu-154	0.26 U	/	0.126[c]	/
												Pu-238	0.054 U	/	0.019[c]	/
												Pu-239/240	0.019 U	/	0.088[c]	/
												Sr-90	0.06 U	/	0.175[c]	/
												U-233/234	0.64 J	/	0.514[c]	/
												U-238	0.644 J	/	0.457[c]	/
												Cr+6	0.43 U	/	0.43 U[c]	/

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Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-D-3	Crib	100-DR-1	No Action	2.44 x 2.44 x 2.44	1951-1967	116-D-3 has been investigated at all historically reported locations by excavation. Initial excavation at the contract design coordinates (N151739, E573774) occurred on 10/20/99; however, the excavation showed no engineered structure or contamination (using field instruments). Excavation activities occurred on 11/4/99 at location coordinates N151757, E573768, which is also referenced as a possible location for 116-D-3. No evidence of a structure or contamination (using field instruments) was found. Excavation also occurred on 12/30/99 at coordinates N151725, E573807 and N151731, E573832. No structures or contamination (using field instruments) were found. It has been determined that 116-D-3 is actually the same site as 116-D-4. Remediation of 116-D-4 was complete on 10/2/99. Therefore, the crib is identified as a no-action site. The crib was suspected of receiving low-level fission product wastes in contaminated wash water from the 108-D Shipping Cask Handling Facility.	WSRF 2002-060	N/A								
116-D-4	Crib/French Drain	100-DR-1	Interim Closed	2.4 x 2.4 x 5 0.9 x 1.7 also reported	1956-1967	This site is also described as a rock-filled French drain. Received 30,000 L (7,925 gal) of contaminated liquid from the 108-D Maintenance and Technical Laboratory. Contaminated effluent also included decontamination solutions, solvents, and low-level fission products.	CVP-2000-00008	Oct-99	Oct-99	Not documented in CVP	2.80	U-238	0.668 J	/	0.412[c]	/
												Cr+6	0.43 U	/	0.43 U[c]	/
116-D-5	Outfall	100-DR-1	Accepted	18.3 x 7.3	1944-1975	Structure was an open concrete compartmentalized weir structure located at the top of the riverbank west of the 107-D Retention Basin. Received effluent from the retention basins before release to the Columbia River.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-D-6	French Drain	100-DR-1	Interim Closed	1 (dia.) x 1	1953-1967	Received 100,000 L (26,417 gal) of domestic wastewater from the change room and mask decontamination station.	CVP-2000-00009	Oct-99	Jan-00	200	4.60	Am-241	/	0.097 U	/	0.141[c]
												Cs-137	/	0.538	/	0.478[c]
												Eu-152	/	2.87	/	2.54[c]
												Eu-154	/	0.170 U	/	0.155[c]
												Pu-239/240	/	0.038	/	0.056[c]
												U-233/234	/	0.68 J	/	0.504[c]
												U-238	/	0.604 J	/	0.429[c]
												Cr (total)	/	10.7	/	9[c]
												Hg	/	0.05 U	/	0.05[c]
												Pb	/	3.8	/	3.8[c]
116-D-7	Retention Basin	100-DR-1	Interim Closed	142 x 70 x 5.7	1944-1967	Site was an open concrete basin that retained cooling water effluent from the 105-D Reactor for radioactive decay and thermal cooling before release to the Columbia River. Total radionuclide inventory in the vicinity ranged from 5 to 400 Ci.	CVP-99-00007	May-97	Feb-99	178	7.40	Am-241	0.34 U	0.43	0.055	0.231
												Co-60	0.077 U	40	0.039	17.9
												Cs-137	0.34	45	0.181	30.1
												Eu-152	0.52	370	0.355	176
												Eu-154	0.26 U	53	0.066	24.4
												Eu-155	0.19 U	2.6	0.051	1.5
												Ni-63	15.7 J	1,300 J	4.4	547
												Pu-238	0.02 U	0.049	0.03	0.038
												Pu-239/240	0.037 U	1.8	0.028	0.801
												Sr-90	0.037 U	2.1	0.211	1.57
												Cr+6	1.3	8.5	1.3	3.26
												Cr (total)	10.4	339	8	206
												Hg	0.11 U	2.4	0.02	1.13
												Pb	4.8	10.3	3.5	7.55
116-D-8	Storage	100-DR-2	Accepted	1,049.5 m^2	1946-1975	Concrete pad with two drains that stored shipping and handling casks and is covered with grey grout.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
116-D-9	Crib	100-DR-1	Interim Closed	3 x 3 x 3	1960-1967	Site was the seal pit crib. Received 420,000 L (110,952 gal) of effluent from the Confinement System 117 Building seal pits.	CVP-2000-00012	Oct-99	Sep-00	7	5.50	Sr-90	0.556 J	/	0.306	/
												U-238	0.662 J	/	0.507	/
												Cr+6	0.49 U	/	0.49	/

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-DR-1 & 2	Trench	100-DR-1	Interim Closed	137 x 4.5 x 6.0 Depth is from technical baseline report Depth also reported as 3.2 and 4.57 m	1950-1967	Sites consisted of two trenches that were later joined to form a single trench. Received effluent from the 116-D-7 and 116-DR-9 Retention Basins when cooling water was contaminated due to ruptured fuel elements. Received 40,000,000 L (10,556,882 gal) of effluent; 40 kg (88 lb) sodium dichromate. Radiological inventory is 3.1 Ci.	CVP-2000-00002	Nov-96	Oct-99	82,768	5.00	Am-241	0.94 U	1.30 U	0.32[c]	0.682[c]
												Co-60	0.14 U	3.52	0.05[c]	1.86[c]
												Cs-137	1.24	110	0.305[c]	69.3[c]
												Eu-152	0.28 U	126	0.16[c]	64.8[c]
												Eu-154	0.46 U	8.06	0.18[c]	4.23[c]
												Eu-155	0.36 U	0.59 U	0.13[c]	0.432[c]
												Ni-63	1.65 U	70.4	2[c]	44.1[c]
												Pu-238	0.404 J	0.077	0.103[c]	0.0452[c]
												Pu-239/240	0.055 U	5.82	0.05[c]	2.66[c]
												Sr-90	106	28.8 J	0.17[c]	13.2[c]
												Cr+6	0.47 U	0.9	0.47 U[c]	0.9[c]
116-DR-10	Pond	100-DR-2	Accepted	24.4 x 15.2 x 1.8 59 x 38	1984	Site received radioactive shielding water from the 105-DR Fuel Storage Basin.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
116-DR-3	Trench	100-DR-2	Accepted	18.3 x 12.2 x 3.0	1955	Site consists of a trench that received water and sludge pumped from the fuel storage basin via an overground pipeline.	EPA/AMD/ R10-97/044	N/A								
116-DR-4	Crib	100-DR-2	Interim Closed	3 x 3 x 3	1950-1956	The crib was a wooden structure and gravel filled. Received 4,000 L (1,056 gal) of effluent from 105-DR Fuel Storage Basin. Radiological inventory is 0.06 Ci.	CVP-2000-00015	Nov-99	Jan-00	523	4.50	Co-60	0.051 U	/	0.0477[c]	/
												Cs-137	0.0836 J	/	0.186[c]	/
												Eu-152	0.11 U	/	0.0578[c]	/
												Sr-90	0.167 U	/	0.105[c]	/
												Cr+6	0.45 U	/	0.45 U[c]	/
116-DR-5	Outfall	100-DR-1	Accepted	8.2 x 4.3	1956-1967	Structure was an open concrete compartmentalized weir structure located at the top of the riverbank west of the 107-D Retention Basin. Received effluent from the retention basins before release to the Columbia River.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-DR-6	Trench	100-DR-2	Interim Closed	15 x 3 x 3	1953-1965	Received 7,000,000 L (1,849,204 gal) of 105-DR Reactor cooling water and decontamination fluids during upgrade of the reactor emergency shutdown system.	CVP-2000-00014	Nov-99	Feb-00	2,140	4.80	Co-60	0.07 U	0.308	0.0546[c]	0.277[c]
												Cs-137	0.091 U	6.51	0.0795[c]	5.74[c]
												Eu-152	0.482	14.4	0.341[c]	12.8[c]
												Eu-154	0.24 U	1.4	0.197[c]	1.26[c]
												Sr-90	0.425	1.12	0.265[c]	0.265[c]
												U-238	0.617 J	0.855 J	0.447[c]	0.447[c]
												Cr+6	0.44 U	0.45 U	0.44 U[c]	0.45 U[c]
116-DR-7	Crib	100-DR-2	Interim Closed	1.5 x 1.5 x 3	1953	This crib was used to receive the liquid potassium borate solution that was drained from the 3X system before the Ball 3X upgrade. The crib is also described as a tank of unknown size buried under 1.8 m (6 ft) of soil. Received 4,000 L (1,056 gal) of effluent.	CVP-2000-00019	Dec-99	Dec-99	59	4.8	Co-60	0.055	/	0.0629	/
												Cs-137	0.073	/	0.0716	/
												Eu-152	0.218	/	0.18	/
												Eu-154	0.15	/	0.187	/
												Sr-90	0.141	/	0.178	/
												U-233/234	0.699	/	0.564	/
												U-238	0.547	/	0.454	/
116-DR-8	Crib	100-DR-2	Accepted	3.0 x 3.0 x 5.2	1960-1964	A crib with a large steel vent cap surrounded by red steel posts. Received radioactive wastes consisting of beta gamma from the 117-DR Building Seal Pits.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
116-DR-9	Retention Basin	100-DR-1	Interim Closed	183 x 83 x 6	1950-1967	Site was an open concrete basin that retained cooling water effluent from the 118-DR-2 (105-DR Reactor) for radioactive decay and thermal cooling before release to the Columbia River. Also received ruptured fuel element waste after 1954. Total radionuclide inventory in the vicinity ranged from 5 to 400 Ci.	CVP-99-00006	Oct-97	Dec-98	201,519	4.75	Co-60	0.056	1.88	0.041	3.21
												Cs-137	10	19.5	2.84	25.8
												Eu-152	0.627	38.1	0.405	25.2
												Eu-154	0.071 J	7.12	0.0732	3.47
												Eu-155	0.041 U	0.21	0.0528	0.26
												Ni-63	4.99 J	182	3.37	53.2
												Pu-238	0.359	0.039 U	0.15	0.08
												Pu-239/240	0.724	1.08	0.304	0.32
												Sr-90	0.287 J	2.23 J	0.266	2.01
												Cr+6	1.9	7.8	1.9	0.55
												Aroclor-1242	0.035 U	0.11	0.035	0.11
												Aroclor-1260	0.035 U	0.18	0.035	0.11

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-D-1	Burial Ground	100-DR-2	Accepted	137.2 x 114.3 x 6.1	1944-1967	The waste site contains four trenches that trend north and south. This burial ground was used for the disposal of irradiated dummies, thimbles, horizontal control rods, gun barrels, 12 steel drums of irradiated expendable dummies, and other contaminated solid waste. The waste site has the potential to contain spent nuclear fuel elements. The breakdown of other waste items includes 259.2 tons of soft waste, 1.5 tons of desiccant, 19.25 ton of miscellaneous waste, and 0.03 ton of thermo-couple waste.	EPA/ROD/ R10-00/121	N/A								
118-D-2	Burial Ground	100-DR-2	Accepted	304.8 x 109.7 x 6.1	1949-1970	This site contained several trenches that trend east to west and five pairs of disposal pits. The site was the primary burial ground for the disposal of 105-D Reactor operations waste, including irradiated dummies, splines, rods, thimbles, and gun barrels. The metallic waste disposed in the waste site consists of 16,329 kg (35,924 lb) of aluminum tubes, 36,287 kg (79,831 lb) of aluminum spacers, 89,040 kg (195,888 lb) of lead poison slugs, 3,719 kg (8,182 lb) of cadmium poison slugs, 54 kg (119 lb) of graphite, 14 kg (31 lb) of desiccant, 5,987 kg (2,721 lb) of aluminum poison slugs, 816 kg (371 lb) of boron poison splines, 58,966 kg (26,803 lb) of lead, and 16,329 kg (7,422 lb) of miscellaneous metallic waste. Large volumes of water were required to extinguish a fire at this site in 1960.	EPA/ROD/ R10-00/121	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-D-3	Burial Ground	100-DR-2	Accepted	304.8 x 79.2 x 6.1	1956-1973	This site contains multiple trenches oriented east and west. The burial ground was the primary disposal site for 105-DR Reactor operations waste, including irradiated dummies, splines, rods, thimbles, and gun barrels. The burial ground has the potential to contain spent nuclear fuel elements. The site also contained a burning pit used to dispose of low-level radioactive combustible materials. The eastern boundary was used for the disposal of 100-N Area solid wastes. The waste site received 23.8 tons of lead, 97 tons of aluminum, 137.7 tons of lead/cadmium, 1 ton of boron, and 0.06 ton of graphite.	EPA/ROD/ R10-00/121	N/A								
118-D-4	Burial Ground	100-DR-2	Accepted	182.9 x 61.0 x 6.1	1953-1967	The construction burial ground contains several non-uniform trenches that received contaminated material generated during Project CG-558. The contaminated material consists mainly of reactor components and hardware from the 105-D Reactor.	EPA/ROD/ R10-00/121	N/A								
118-D-5	Burial Ground	100-DR-2	Accepted	12.2 x 3.0 x 3.0	1954	This waste site is referred to as the Ball 3X Burial Ground. The site consists of two burial trenches located parallel to each other. The burial ground received vertical safety rod thimbles from the 105-DR Reactor during the Ball 3X Project in 1954. Sludge from the 105-DR Storage Basin has been buried at the west end of the waste site. There is disagreement about the exact location and size of these trenches.	EPA/ROD/ R10-00/121	N/A								
118-D-6	Reactor	100-DR-1	Accepted	3,948 m^2	1944-1967	Concrete building including the reactor block, irradiated fuel storage basin, work areas, and reactor control room. Site consists of four subsites: (1) concrete facility with reactor block; (2) ancillary support areas; belowgrade structures and underlying soils; (3) fuel storage basin and underlying soils; and (4) 105-D Fuel Storage Basin side slope soils.	CCN 087896	N/A								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-D-6:3	Reactor	100-DR-1	Interim Closed	43,000	1944-1967	This subsite includes the fuel storage basin and the underlying soil.	CVP-2005-00003	Jan-00	Dec-01	21,613	4.6 (Fuel Storage Basin floor—left in place)	Am-241	/	515	0.01[e]	190
												C-14	/	2,630	0.098[e]	1,800
												Co-60	/	2,260	0.082[e]	1,500
												Cs-137	/	16,700	0.77[e]	14,000
												Eu-152	/	2,780	0.13[e]	2,400
												Eu-154	/	518	0.022[e]	400
												Eu-155	/	27 U	U	U
												H-3	/	1,480	0.048[e]	870
												Np-237	/	0.68	U	U
												Ni-63	/	72,500	2.5[e]	46,000
												Pu-238	/	14.90	0.0006[e]	11
												Pu-239	/	/	0.018[e]	323
												Pu-240	/	/	0.0042[e]	77
												Pu-239/240	/	490	/	/
												Sr (total)	/	3,620	/	/
												Sr-90	/	/	0.16[e]	3,000
												Th-228	/	0.953 U	0.000054[e]	0.98
												Th-232	/	0.852 J	0.000039[e]	0.72
												U-234	/	23.20	0.00088[e]	16
												U-235	/	0.891 U	U	U
												U-238	/	2.58 U	0.000055[e]	1
												Ur (total)	/		0.00094[e]	17
												Cr+6	/	0.40	0.0000219[e]	0.40
												Pb	/	91.80	0.00392[e]	71.70
												Hg	/	16.1 U	0.000711[e]	13
												Aroclor-1254	/	4.9 J	0.000166[e]	3.04
118-DR-1	Burial Ground	100-DR-2	Accepted	24.4 x 13.1 x 4.9	1963-1964	The waste site is a gunnite-lined trench (pond) that trends north and south. There appears to be a 0.9 m (3-ft) section in the bottom, lined with 5 cm (2 in.) of sand and no gunnite. This unit contains irradiated metal assemblies from the 105-DR Gas Loop. The burial ground received approximately 20 m^3 (706 ft^3) of irradiated metal assemblies.	EPA/ROD/ R10-00/121									

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-DR-2	Reactor	100-DR-2	Accepted	3,948 m^2	1950-1964	Concrete building including the reactor block, irradiated fuel storage basin, work areas, and reactor control room. The facility contains radioactive (Cs-137) and hazardous chemical substances (e.g., lead, asbestos, and cadmium). The Boron 3X balls remain in place. The fuel storage basins were cleaned out and coated with an asphalt emulsion. Site consists of two subsites: (1) 105-DR Reactor core, and (2) 105-DR Reactor belowgrade structures and underlying soils.	Not Documented									
118-DR-2:2 Zone 1	Reactor	100-DR-2	Interim Closed	83 x 96 x 32	1950-1964	This subsite includes the 105-DR Reactor belowgrade structures and underlying soils. It was divided into five zones and the decon areas. Zone 1 consists of the 400 Fuel Storage Basin, 410 Storage and Transfer Area, 412 Storage Area, and the 413 Transfer Bay; and the soils underlying the fuel storage basin. This zone is entirely within the deep zone. Concrete and soil samples were taken at the fuel storage basin floor. Concrete sample values are located in the shallow section.	CVP-2003-00016	Sep-98	Sep-01	7,220	4.60	Am-241	75.5	0.269	73.3	0.09
												Ba-133	3.5 U	0.13 U	1.58	0.04
												C-14	3,300	15.8	2,000	7.83
												Co-60	720	4.29	58.8	1.26
												Cs-137	11,000	17.4	910	6.74
												Eu-152	2,810	15.2	1,940	4.45
												Eu-154	518	2.24	377	0.72
												Eu-155	21.5	0.22 U	16.8	0.07
												H-3	8.09	N	7.19	N
												Ni-63	11,900	102	10,200	32.50
												Pu-238	6.83	0.021 U	6.62	0.01
												Pu-239/240	358	1.23	291.2	0.10
												Sr-90	4,500	/	4,290	13.7[f]
												Tc-99	1.94	1.12	1.53	0.52
												U-233/234	3.1	0.557	1.39	<BG
												U-235	0.321	0.079	0.13	<BG
												U-238	3.19	0.458	1.6	<BG
												Cr+6	2.8	0.43 U	2.5	0.44
												Pb	60	3.5	53	3.5
												Hg	1.1	2.1	0.91	0.05
												PCBs	1.1	0.18 U	0.91	0.18

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-DR-2:2 Zones 2 and 3	Reactor	100-DR-2	Interim Closed	83 x 96 x 32	1950-1964	This subsite includes the 105-DR Reactor belowgrade structures and underlying soils. It was divided into five zones and the decon areas. Zone 2 consists of the valve pit that received wastewater from the reactor and within the deep zone. Zone 3 consisted of the 228c solids feed area, the north water tunnel, and the trench under the accumulator room. This zone is within the shallow zone.	CVP-2003-00016	Sep-98	Sep-01	7,220	4.60	Am-241	0.58	0.413	0.0596	0.0851
												Ba-133	25.3	0.0406 U	1.93	0.0202
												C-14	7.5	0.609 U	1.62	0.371
												Co-60	3.75	0.804	0.582	0.816
												Cs-137	8.84	11.7	1.24	2.8
												Eu-152	29.9	39	4.73	8.16
												Eu-154	6.13	7.18	0.756	1.77
												Eu-155	0.47 U	0.362	0.0778	0.1
												Ni-63	225	155	31	31
												Pu-238	0.233	0.118	0.0275	0.0275
												Pu-239/240	1.95	0.285	0.0619	0.0619
												Sr-90	12.4	14.7	2.65	2.65
												Tc-99	0.936	1.36	0.342	0.342
												U-233/234	N	0.376	N	<BG
												U-235	N	0.0271	N	<BG
												U-238	N	0.388	N	<BG
												Cr+6	N		N	1.3
												Pb	63	5.9	19	34
												Hg	2.9	3.2	0.84	1.7
												PCBs	N	2.1	N	0.76

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-DR-2:2 Zones 4 and 5	Reactor	100-DR-2	Interim Closed	83 x 96 x 32	1950-1964	This subsite includes the 105-DR Reactor belowgrade structures and underlying soils. It was divided into five zones and the decon areas. Zone 4 consisted of the 105 Gas Tunnel, 316 Exhaust Plenum, 103 Gas Recirculation Tunnel, and the 104 Instrument Room. This zone is entirely within the deep zone. Zone 5 consisted of the side slope soils around the fuel storage basin, the south effluent pipelines, and the soil under the 224b Slab. This zone is within the shallow zone.	CVP-2003-00016	Sep-98	Sep-01	7,220	4.60	Am-241	0.074 U	1.14	0.0314	0.556
												Ba-133	0.035 U	0.65 U	0.0162	0.153
												C-14	4.73 U	357	3.04	178
												Co-60	0.122	2.41	0.0507	1.04
												Cs-137	1.98	146	0.892	18.4
												Eu-152	0.608	52.2	0.369	4.26
												Eu-154	0.16 U	11.9	0.0642	0.263
												Eu-155	0.13 U	1.2 U	0.0536	0.263
												Ni-63	4.75	29.5	0.81	15
												Pu-238	0.035 U	0.285	0.00911	0.11
												Pu-239/240	0.059	2.11	0.0722	0.608
												Sr-90	6.19	26.1	0.479	9.54
												Tc-99	0.419 U	0.628 U	0.174	0.196
												U-233/234	0.676	N	<BG	N
												U-235	0.081 U	1.5 U	<BG	N
												U-238	0.581	86	<BG	N
												Cr+6	0.88	N	0.88	N
												Pb	7.2	130	6.4	49
												Hg	0.04	N	0.04	N
												PCBs	0.051	N	0.05	N
120-D-1	Pond	100-DR-1	Closed Out	50 x 67 x 9	1977-1994	The pond was a *Resource Conservation and Recovery Act of 1976* (RCRA)-permitted TSD unit. It received 170,293 L/day (45,000 gal/day) of nonhazardous, nonradioactive effluent from the 183-D Sand Filter and 185-D/ 189-D Building. The effluent contained alum-precipitated sand filter back flush and chlorinated water. Site did receive corrosive effluent up to three times a year; mercury and PCB detected above background.	CCN 072569, "100-D Ponds Closure (TSD No. D-1-1)," from W. Soper (Ecology) to K. Klein (DOE), 08-27-99	N/A	N/A	N/A	N/A	Chromium, lead iron, mercury, manganese, arsenic, pH, sulfate, trichloroethane (WHC-EP-0666)				

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
120-D-2	Surface Impoundment	100-DR-1	Accepted	28.1 x 28.1 x 7.3	1945-1979	Constructed of acid-proof brick, waterproof membrane, vitrified pipe, No. 8 lead flashing, and gunnite. Facility never used (no records found to document use). Structure demolished in place in 1979. Designated as a waste site because the lead flashing was not removed.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
122-DR-1	Laboratory	100-DR-2	Closed Out	See Subsites	1972-1986	The 105-DR Large Sodium Fire Facility (LSFF) was established to study fire fighting and safety aspects associated with large sodium or other metal alkali fires in the Liquid Metal Fast Breeder Reactor (LMFBR) facilities.	See Subsites	See Subsites								
122-DR-1:2	Tunnel	100-DR-2	Interim Closed	Not Documented	1972-1986	Exhaust tunnel is located within the Large Sodium Fire Facility. The building was used to study fire and safety aspects associated with sodium and other alkali metal fires for application to liquid metal reactors.	CVP-2003-00018	Jul-03	Aug-03	14,011	5.00	Am-241	0.05 U	0.082 U	0.0331	0.00908
												C-14	1.22 U	1.66 U	0.927	1.12
												Co-60	0.031 U	0.045 U	0.0146	0.0219
												Cs-137	0.063	0.05 U	0.0518	0.0459
												Eu-152	0.068 U	0.092 U	0.0326	0.0446
												Eu-154	0.098 U	0.15 U	0.0472	0.0711
												Eu-155	0.1 U	0.098 U	0.0427	0.0542
												Ni-63	2.56 U	4.34 U	1.08	1.63
												Pu-238	0.037 U	0.106 U	0.024	0.0759
												Pu-239/240	0.037 U	0.053 U	0.0245	0.0234
												Sr-90	0.0568 U	0.02 U	-0.003	0.00061
												U-233/234	0.686	0.668	0.608	0.612
												U-235	0.0983	0.52 U	0.0551	0.0499
												U-238	0.918	0.857	0.573	0.612
												As	3.1	2.6	2.9	2.4
												Ba	68	65	65	58
												Cd	0.19	0.21	0.19	0.21
												Cr	93	99	11	10
												Cr+6	0.42 U	0.42 U	0.42	0.42
												Pb	7.4	4.2	6.5	9.9
												Li	13	14	12	9.9
												Hg	0.02 U	0.02 U	0.02	0.02
												Se	0.3	0.33 U	0.3	0.33
												Ag	0.08	0.085 U	0.08	0.08
												Na	450	400	400	390

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Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
122-DR-1:4	Laboratory	100-DR-2	Interim Closed	20.7 x 11.9 x 10.4	1972-1986	The Large Sodium Fire Facility was used to study fire and safety aspects associated with sodium and other alkali metals for application to liquid metal reactors. A RCRA-permitted TSD unit.	CVP-2003-00018	Refer to 122-DR-1:2								
122-DR-1:5	Stack	100-DR-2	Interim Closed	4.9 dia. x 61 high; 5.3 below grade	1972-1986	Exhaust stack for the Large Sodium Fire Facility.	CVP-2003-00018	Refer to 122-DR-1:2								
126-D-1	Coal Ash Pit	100-DR-1	Rejected	79 x 88.5 x 4	1950-1960	This site received coal ash. Studies have concluded that ash from Hanford Site power plants is nonradioactive and nondangerous (DOE/RL-92-71). Additionally, ash has been determined by testing in accordance with WAC 173-303, “Dangerous Waste Regulations,” to be well below concentrations required for designation as EP toxic material. Therefore, this site is rejected as a waste site.	WSRF 98-006	N/A								
126-D-2	Inert/ Demolition Landfill	100-DR-1	Accepted	152.4 x 79.2 x 4.6 The length and depth of this site is also reported as 88.4 m and 4.1 m	1943-1986	The site is an excavated pit that originally was used to store coal for the 184-D Powerhouse. It was later used as a demolition and inert waste landfill. This unit is full of debris and covered with about 0.3 m (1 ft) of backfill material. In the 1970s, the coal pit was used for the disposal of solid waste. The coal pit received materials from D&D activities for about 20 years. The site has also received waste from the 100-N Area and from the 189-D Maintenance Facility. In 1983 and 1984, spray paint cans, paint buckets, drums, and other similar materials were found and removed from this landfill. At that time, approximately 80 percent of the landfill was full and covered with backfill. Suspected sodium dichromate crystals were spread over this site prior to backfilling.	EPA/ROD/ R10-00/121	N/A								

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Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
126-D-3	Sump	100-DR-1	Rejected	9.45 x 5.49 x 3.66		These salt-dissolving pits and brine pump pit were part of a single, belowgrade concrete structure that provided brine for the 184-D Powerhouse. The brine was used to regenerate the zeolite ion exchange demineralizers that were part of the powerhouse water treatment system. The site was demolished in situ in March 1988. Before demolition, the pits were surveyed for radiological and nonradiological hazardous materials. The water analysis from the salt-dissolving pits indicated no radioactivity above background and no reportable concentrations of heavy metals. The sodium chloride concentrations were greater than 10 percent (hazardous material limit). The dissolving pits also contained approximately 6.3 m^3 (8.3 yd^3) of salt cake (sodium chloride). Northwest Environmental Services, Inc., removed water and salt cake from the pits and disposed of them as hazardous waste. Holes were punched into the bottom of the pits to facilitate drainage. The pits were then partially backfilled with rubble, which was compacted in place to minimize subsidence.	WSRF 97-004	N/A									
126-DR-1	Clearwell Dumping Area	100-DR-2	Interim Closed	12.8 x 160.0 x 6.1 179 x 135	1975	This site originally contained four 1.42E+07 L (3.75E+06 gal) steel water tanks that have been removed. The site was subsequently used as a burial ground. The waste site contains demolition and inert waste from demolished facilities, including rubble from released portions of the 115-D/DR, and some rubble from 183-DR. The debris was removed during the site remediation and the pads and surrounding soils (including sidewalls) will be remediated as part of the 100-D-50:6 waste site. Remediation of the 100-D-50 waste site is anticipated to occur between 2010 and 2011.	WSRF-2008-046	4/5/2007	7/24/2008	23,790	N/A	Cr+6	1.1	/	/	/

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
128-D-1	Burn Pit	100-DR-2	No Action	30.5 x 30.5 x 3.05	1944-1967	Historical information indicates that this burn pit does not exist. This site is a duplicate of either 628-3 or 128-D-2.	WSRF 2003-009	N/A								
128-D-2	Burn Pit	100-DR-1	Accepted	73.2 x 73.2	Not Documented	Large landfill area that shows evidence of surface burning. Some pieces of uncontaminated reactor hardware were found at the site.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
130-D-1	Storage Tank	100-DR-1	Accepted	3.7 x 1.2 (dia.)	1944-1968	Site had been a steel UST with a capacity of 15,140 L (4,000 gal). Tank was removed in 1989. Tank was used for storage of leaded gasoline. Site was contaminated with petroleum hydrocarbons. Site was backfilled with clean soil without removal of contaminated soil.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
132-D-1	Process Unit/ Plant	100-DR-1	Accepted	51.2 x 29.9 x 3.4 46 x 20	1944-1967	The facility was built in 1943 to house the equipment used to recirculate, filter, dry, and inject the cover gases for the 105-D and 105-DR Reactor cores. The concrete facility was demolished in place in 1986.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
132-D-2	Process Unit/ Plant	100-DR-1	Interim Closed	18 x 11.9 x 8.2 (high)	1961-1967	Concrete structure built to receive exhaust discharges from the 105-D Reactor and filter the exhaust before the exhaust stack release into the atmosphere. The facility was demolished in 1986.	WSRF 2005-024	N/A	N/A	N/A	N/A	The site was decommissioned using allowable residual contamination level methodology. The demolition and site grading were performed in January and February 1986. The building and ducts were excavated and demolished in situ. The contaminated rubble was buried at least 1 m (3.3 ft) deep, except for rubble from the seal pits, which was buried under a minimum of 5 m (16.4 ft) of clean earth. The filters, frames, and turning vanes were buried in the 200 West Area burial grounds. Aboveground metal ducts were used as burial containers and were also buried in the 200 West Area burial grounds.				
132-D-3	Pump Station	100-DR-1	Interim Closed	6.1 x 6.1 x 9.75	1944-1965	Received liquid waste from reactor drains containing low-level radionuclides, sodium fluoride, oxalic acid, and citric acid. Concrete structure that extended 9.8 m (32 ft) below grade and 1.2 m (4 ft) above grade. Demolished in place in 1986 and 1987.	WSRF 2005-033	N/A	N/A	N/A	N/A	Decommissioning was performed in two phases. Phase 1 consisted of water removal (910 L [240 gal]), asbestos removal/disposal (1.1 m^3 [40 ft^3]), and pump and piping removal, and was completed April 4, 1986. Phase 2 consisted of in situ demolition and site grading and was completed January 6, 1987. The facility was covered with 1 m (3.3 ft) of soil.				
132-D-4	Stack	100-DR-1	Interim Closed	60.9 x 5.05 dia.	1944-1967	Site contains concrete rubble from demolition of the 105-D (116-D) Reactor Stack. The stack was used to exhaust confinement air from the work areas of the 105-D Reactor and was demolished in 1999. The stack and its foundation were demolished with explosives and buried in a trench.	CVP-2005-00003	N/A	N/A	N/A	0.90	N/A				

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
132-DR-1	Pump Station	100-DR-2	Interim Closed	10.97 x 10.4 x 8.53	1950-1964	This facility functioned as a sump to collect radioactive liquid wastes from the 105-DR Reactor.	WSRF 2005-035	N/A	N/A	N/A	N/A	The site was released for unrestricted use based on the post-decontamination characterization results and the dose assessment of in situ burial of the 1608-DR Lift Station. Consequently, demolition and site grading were performed in 1987 using conventional heavy equipment. The structure was reduced to 5 m (16.4 ft) below grade using a wrecking ball; the rubble was buried under 5 m (16.4 ft) of clean fill.				
132-DR-2	Stack	100-DR-2	Interim Closed	60.9 x 5.05 dia.	1961-1986	Former concrete structure that contained pumps, sumps, and accumulation chambers. Demolished in place in 1999. Received liquid waste from reactor drains containing low-level radionuclides, sodium fluoride, oxalic acid, and citric acid.	CVP-2003-00018	Refer to 122-DR-1:2								
1607-D1	Septic Tank	100-DR-2	Accepted	5.8 x 2.1 x 3.4 21 x 37	1944-1965	This site is a concrete tank (capacity of 130 L [35 gal]) with drain field that received sanitary sewage from 1701-D Badgehouse and 1709-D Fire Headquarters Building. This septic system is not known to have received hazardous or radioactive wastes.	Not Documented	N/A								
1607-D2	Septic Tank	100-DR-1	Accepted	8.1 x 3.7 x 4.1	1944-1996	This site was a concrete tank with drain field that received sanitary waste from the 190-DA, 189-D, 185-D, 182-D, 183-D, 1700-D Administration and Services Buildings, and the 105-D Reactor. The site has been divided into four subsites: (1) 1607-D2:1 Abandoned Tile Field; (2) 1607-D2:2 Replacement Tile Field; (3) 1607-D2:3 Septic Pipelines, and (4) 1607-D2:4 Septic Tank. Sites 1, 3, and 4 are interim closed.	Interim Remedial ROD	N/A								
1607-D3	Septic Tank	100-DR-2	Closed Out	1.83 x .91 x 3	1944-2000	This site is a concrete tank with drain field. Received 3,970 L (1,048 gal)/day sanitary sewage from the 151-D Electrical Distribution Substation.	WSRF 2000-017	N/A	N/A	N/A	N/A	Tank was abandoned in accordance with WAC 246-272-18501 and closed out.				
1607-D4	Septic Tank	100-DR-1	Interim Closed	0.6 x 1.2 x 2.5	1944-1968	This site is a concrete tank with drain field. Received sanitary sewage from 115-D/DR Gas Recirculation Building.	WSRF 2005-036	N/A	N/A	N/A	N/A	There were no COCs at this site. All COPC concentrations were less than risk assessment guidelines, except for Aroclor-1254 (0.034 mg/kg).				
1607-D5	Septic Tank	100-DR-1	Accepted	1.2 x 0.6	1944	This site is a concrete tank (capacity of 130 L [35 gal]) with drain field. Received sanitary sewage from the 181-D Pump House.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
600-30	Dumping Area	100-DR-2	Accepted	213 x 183	Not Documented	Based on physical and photograph evidence, it appears to have been a lay-down yard during construction of 105-DR. Waste consists of broken sheet asbestos, buckets of tar, steel, galvanized pipe, rebar, angle iron, and so forth. There is also evidence of burning throughout the unit.	Interim Action Record of Decision, 100 Area Remaining Sites (1999)	N/A								
628-3	Burn Pit	100-DR-1	Accepted	130 x 123	Not documented	The depression shows signs of severe plant stress and soil discoloration. The depression, as well as the area around it, is littered with debris.	Interim Action Record of Decision, 100 Area Remaining Sites (1999)	N/A								
UPR-100-D-1	Unplanned Release	100-DR-1	No Action	0.61 (diameter)	Not Documented	The site was an unplanned release that appeared as a small depression surrounded by oil-contaminated soil. Based on historical documentation and site walkdown, a reclassification status of no action is assigned.	WSRF 2005-020	N/A								
UPR-100-D-2	Unplanned Release	100-DR-1	Interim Closed	Refer to 100-D-48:2	1951	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.	CVP-2000-00005	Refer to 100-D-48:2				Co-60	0.154	7.58	0.0437[a]	1.72[a]
												Cs-137	40.6	61.6	0.499[a]	7,530[a]
												Eu-152	2.21	24.4	0.4[a]	327[a]
												Eu-154	0.894	2.93	0.11[a]	1.44[a]
												Pu-239/240	0.046	0.63 J	0.04[a]	0.103[a]
												Sr-90	0.42	1.77 J	0.21[a]	0.692[a]
												U-233/234	0.748	0.854 J	0.47[a]	0.49[a]
												U-238	0.783	8.06 J	0.45[a]	0.52[a]
												Cr+6	0.42	3.65	0.42[a]	1.3[a]
UPR-100-D-3	Unplanned Release	100-DR-1	Interim Closed	Refer to 100-D-48:2	Refer to 100-D-48:2	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.	CVP-2000-00005	Refer to 100-D-48:2								
UPR-100-D-4	Unplanned Release	100-DR-1	Interim Closed	Refer to 100-D-48:1	1950	Site was an unplanned release from pipelines 100-D-48 and 100-D-49.	CVP-2000-00003	Refer to 100-D-48:1				Co-60	0.061 U	7.33	0.05	5.29
												Cs-137	0.809	39.5	0.251	28.2
												Eu-152	0.402	64.2	0.3	34.2
												Eu-154	0.15 U	8.01	0.12	4.25
												Pu-239/240	0.24 U	1.31	0.13	0.449
												Sr-90	0.196 J	1.14	0.15	0.607
												U-233/234	0.713 J	0.933 J	0.5	0.57
												U-238	0.676 J	0.873 J	0.42	0.554
												Cr+6	0.64 U	5	0.64	5

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
UPR-100-D-5	Unplanned Release	100-DR-1	Accepted	449.7 m^2	1951	This site is an unplanned release of effluent water from the reactor-cooling water (effluent line leak No. 4) and is located southeast of 116-DR-9 (107-DR Retention Basin).	Interim Remedial Action ROD (EPA/ROD/ R10-95/126)	N/A								
100-H Area Waste Sites																
100-H-1	Storage	100-HR-1	Interim Closed	12.2 x 2.1 x 1.4	1949-1965	Site was used during the operation of the 105-H Reactor for temporary storage of irradiated reactor control rods and tools used in rod removal and installation.	CVP-2000-00029	Refer to 100-H-22								
100-H-10	French Drain	100-HR-1	Interim Closed	1.22 (dia.)	1949-1965	Site was a vertically buried 1.22 m- (48-in.-) diameter vitrified clay pipe with steel lid. It is suspected to be a French drain.	CVP-2006-00003	See 118-H-6 Subsites				The 100-H-10 Site is analogous to reactor French drains at 118-C-3:3 and 100-F-12. Evaluation of analogous reactor French drains indicates that possible residual soil contamination at 100-H-10 meets remediation action objectives and goals.				
100-H-11	French Drain	100-HR-1	Interim Closed	0.76 (dia.)	1949-1965	Site was a vertical 0.76 m- (30-in.-) diameter steel manhole set in concrete that provided access to a French drain at the bottom of the box. It appears the drain was installed to provide drainage for any leaks in an expansion box.	CVP-2006-00003	See 118-H-6 Subsites				Evaluation of the fuel storage basin soils (118-H-6:3) and deep zone side slopes (118-H-6:6) also refers to soils underlying waste site 100-H-11. Refer to 118-H-6:3 and 118-H-6:6 for COC data.				
100-H-12	French Drain	100-HR-1	Interim Closed	0.76 (dia.)	1949-1965	This site is a vertical 0.76 m- (30-in.-) diameter steel manhole set in concrete that provided access to a French drain at the bottom of a concrete expansion box. The French drain appears to have been installed to provide drainage for any leakage that might occur in the expansion box.	CVP-2006-00003	See 118-H-6 Subsites				Evaluation of the fuel storage basin soils (118-H-6:3) and deep zone side slopes (118-H-6:6) also refers to soils underlying waste site 100-H-11. Refer to 118-H-6:3 and 118-H-6:6 for COC data.				
100-H-13	French Drain	100-HR-1	Interim Closed	1.23 (dia.)	1949-1965	Site was a French drain constructed of vitrified clay pipe with two metal lids that suggest the possibility of drainage from the reactor. The purpose of this drain is unknown.	CVP-2006-00003	See 118-H-6 Subsites				The 100-H-13 Site is analogous to reactor French drains at 118-C-3:3 and 100-F-12. Evaluation of analogous reactor French drains indicates that possible residual soil contamination at 100-H-13 meets remediation action objectives and goals.				
100-H-14	Unplanned Release	100-HR-1	Interim Closed	0.3 x 0.6	Not Documented	Surface contamination area located next to the south wall of the 105-H Reactor.	CVP-2006-00003	See 118-H-6 Subsites				Evaluation of the fuel storage basin soils (118-H-6:3) and deep zone side slopes (118-H-6:6) also refers to soils underlying waste site 100-H-11. Refer to 118-H-6:3 and 118-H-6:6 for COC data.				

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Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-15	Septic Tank	100-HR-2	Not Accepted	45.7 x 9.1	Not Documented	The site appears in a photograph as a line of disturbed soil near the southeast corner of the 151-H Electrical Substation. The authors of the technical baseline report concluded this site had the appearance of a septic tank. There was no evidence of a septic system during a walkdown. On March 29, 1996, the manhole was opened and determined to be the tie-in from the 151-H and 105-H Buildings to the 1607-H1 Septic System. There was no evidence of a line running to the west from the manhole. It has been concluded that 100-H-15 and 118-H-2 are the same site.	Not Documented	N/A								
100-H-16	Sump	100-HR-2	Rejected	9.45 x 5.49 x 3.66	1948-?	The salt-dissolving pits and brine pump pit were part of a single, belowgrade concrete structure that provided brine for the 184-H Powerhouse. No evidence of the structure can be seen today. The site was probably demolished in place. No documentation has been located related to cleanup. It is not known if salt cake was left in the structure.	WSRF 97-003	N/A								
100-H-17	Unplanned Release	100-HR-1	Interim Closed	159.7 x 58.5 x 1.8	1953	Site was a triangular area that received overflow from the 1608-H Liquid Waste Disposal Trench.	CVP-2000-00031	Refer to 116-H-2								
100-H-18	Unplanned Release	100-HR-1	Not Accepted	Not Documented	1955	The waste consisted of airborne radioactive particulates released through the 105-H stack. The 105-H stack emitted approximately 0.6 curies of filterable gross beta contamination on May 3, 1955, when two ruptured slugs were removed from the reactor.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-H-19	Unplanned Release	100-HR-1	Not Accepted	Approx. 7 mi^2 S of 100-H	1-Nov-55	The waste consisted of airborne radioactive particulates released through the 105-H Stack. Approximately 0.8 Ci of filterable gross beta contamination, mostly barium and rare earth plus yttrium, was emitted from the 105-H Stack.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-H-2	Burial Ground	100-HR-2	Interim Closed	12.2 (length)	1953	Inactive, low-level solid waste burial ground said to consist of two north-south backfilled trenches.	CVP-2000-00031	Refer to 116-H-2								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-20	Unplanned Release	100-HR-1	Not Accepted	Area extending from around the 100-H Water Towers, swallow flight path toward White Bluffs	15-May-56	Discovered swallows were making nests out of contaminated mud taken from the 107-H Liquid Waste Disposal Trench. The mud used by the swallows would have contained radioactive contamination from fuel element rupture.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-H-21	Radioactive Process Sewer	100-HR-1	Interim Closed	893.7 (length) x 4.2 (depth) x 1.5 (dia.) 306.6 (length) x 0.5 (dia.) 1,244.498 (length) x 2.438 (depth)	1949-1965	This site includes two former 1.5 m- (5-ft-) diameter steel pipelines that carried 105-H Reactor cooling water effluent from the Reactor to the 116-H-7 Retention Basin and from the basin to the 116-H-5 Outfall. The site also includes a 0.5 m- (1.6-ft-) diameter steel pipeline that was used to divert reactor-cooling water from the retention basin to the 116-H-l Trench and a 0.5 m- (1.6-ft-) diameter steel pipeline along the west side of the retention basin and pipelines from the reactor to the 1608-H Pump House and the 116-H-2 Trench.	CVP-2000-00029	Refer to 100-H-22								
100-H-22	Unplanned Release	100-HR-1	Interim Closed	Not Documented	1949-1965	Soil contaminated by leakage from 100-H-21 Reactor effluent pipelines.	CVP-2000-00029	19-Oct-99	12-Dec-00	32,725	5.6	Co-60	0.054 U	0.281	0.04	0.125
												Cs-137	0.826	10.8	0.184	3.7
												Eu-152	0.558	2.41	0.21	1.24
												Eu-154	0.19 U	0.408	0.15	0.229
												Eu-155	0.15 U	0.2 U	0.12	0.155
												Ni-63	3.20 U	25 J	3.07	9.16
												Pu-238	0.072 J	0.137	0.07	0.0927
												Pu-239/240	0.075 J	0.0999 U	0.05	0.0879
												Sr-90	0.142 U	0.512 J	0.183	0.28
												U-238	0.704 J	0.712 J	0.5	0.535
												Arsenic	26.0	11.0	14.0	6.0
												Cr+6	0.7	2.2	0.7	1.4
												Pb	95.0	32.0	42.0	16.0

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-24	Electrical Substation	100-HR-1	Interim Closed	137.2 x 87.2 x 0.3	1948-1978	This site is the area of the demolished 151-H Electrical Substation including the former 151-H Building and adjacent switchyard. Supplied all electrical power to 100-H.	CVP-2000-00030	Nov-99	Dec-00	19,294 (CVP-2000-00030)	4.6	Aroclor-1016	0.17 U	/	/	/
												Aroclor-1221	0.34 U	/	/	/
												Aroclor-1232	0.17 U	/	/	/
												Aroclor-1242	0.17 U	/	/	/
												Aroclor-1248	0.17 U	/	/	/
												Aroclor-1254	0.17 U	/	/	/
												Aroclor-1260[g]	0.35	/	0.35	/
												Arsenic	5.7	/	/	/
100-H-26	Unplanned Release	100-HR-1	Not Accepted	Not Documented	Not Documented	The site consists of grounds within the 100-H Exclusion Area that are not part of other waste sites.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-H-27	Ditch	100-HR-2	Not Accepted	91.4 x 0.9 x 0.46[a] 102.3 (length)[b]	Not Documented	The site is a ditch that receives stormwater runoff from a nearby asphalt parking area. The ditch runs northward from a 15 cm (6-in.) vitrified clay pipe that discharged at a headwall.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-H-28	Process Sewer	100-HR-1	Accepted	Consists of eight subsites: Refer to 100-H-28:1 through 100-H-28:8	1949-1965	Site includes upstream (pre-reactor) process sewers for the 100-H Reactor, including all underground water lines used to transport reactor-cooling water between water treatment facilities and the 105-H Reactor. Consists of eight subsites.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-H-3	Storage Tank	100-HR-1	Accepted	5.4 x 2.4 (dia.)	1949-1965	Site may contain one or more USTs used to supply fuel to the 1716-H Garage. This building served as an automotive service station from 1949 to 1965. The automotive service area included gas pumps with USTs and, possibly, an oil pit.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-H-30	Trench	100-HR-1	Interim Closed	Not Documented	Not Documented	Site was a sanitary sewer trench and feed pipeline believed to support the demolished 110-H Building.	CVP-2000-00031	Refer to 116-H-2								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-31	Unplanned Release	100-HR-1	Interim Closed	5.89 m^2	Not Documented	Site was soil contaminated with PCB at the north side of the 105-H Reactor.	CVP-2006-00003	See 118-H-6 Subsites			4.6	Removal of top soil and 4.6 m (15 ft) of underlying soil has been determined to have sufficiently removed all the PCB contamination. Residual soil contamination is protective of groundwater and the Columbia River due to the low mobility of Aroclor-1260 (K_d = 530 mL/g).				
100-H-32	French Drain	100-HR-2	Rejected	1.2 (depth) x 0.6 (dia.)	Not Documented	The site was a French drain that received sump drainage from the 184-H Brine Pit (100-H-16). There is no visual evidence of a French drain at this location. It likely was removed with the associated brine pit (100-H-16).	WSRF 2002-041	N/A								
100-H-33	Retention Basin	100-HR-1	Accepted	39.0 x 16.5 x 5.0	1949-1985	This site was created to address the radionuclide component of the 183-H Solar Evaporation Basins (116-H-6, which is the TSD component).	Not Documented	N/A								
100-H-34	Radioactive Process Sewer	100-HR-1	Accepted	229.5 x 4.0 x 1.55 (dia.)	Not Documented	This site includes the river effluent pipelines (river lines) that extend from the outfall (116-H-5) into the main channel of the Columbia River. The river effluent pipelines discharged reactor coolant water to the river. Effluent was received from the 107-H Retention Basin and the area process sewer system to the outfall structure.	Not Documented	N/A								
100-H-35	Product Piping	100-HR-1	Accepted	10,796.61	Not Documented	The site encompasses the clean water pipelines for 100-H, including underground pipelines used to transport raw water from the river pumphouse to the water treatment facilities and to 100-H facilities and fire hydrants. The waste from the clean water system is considered non-hazardous.	Not Documented	N/A								
100-H-36	Outfall	100-HR-1	Accepted	7.0 (width)	Not Documented	The site is an underground concrete spillway (also referred to as a flume) that led from the 116-H-5 Outfall Structure to the river shoreline. The spillway could have received reactor coolant effluent when the 100-H-34 River Pipelines were blocked, damaged, or undergoing maintenance. There is no corroborated physical or historical evidence that the spillway was ever used.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-37	Unplanned Release	100-HR-2	Discovery	35 individual sites covering 25 acres	51,690.43 m^2	This site is contamination from mud dauber wasps. The nests are estimated to cover approximately 10.1 ha (25 ac) throughout 100-H.	Not Documented	N/A								
100-H-38	Burial Ground	100-HR-1	Discovery	Not Documented	Not Documented	Not documented.	Not Documented	N/A								
100-H-39	Trench	100-HR-1	Accepted	60 x 12 60.05 x 20.12 54.86 x 20.12 29.87 x 9.14	1950-?	The site is four possible thimble pit or trench locations (areas). The sites were used to bury thimbles (process tube components) or materials related to the removal of thimbles.	OSR-2008-0002	N/A								
100-H-4	Maintenance Shop	100-HR-1	Accepted	12.9 x 9.6 (Hot Shop) 12.89 x 12.5 (Hot Shop) 5.9 x 5 (Contaminated Storage Area) 0.7 (dia.) (French Drain)	1948	The site is a hot shop, French drain, and contaminated storage. The French drain was located under additional storage (Butler type) areas that were added to the east side of the 1717-H Building.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-H-40	Trench	100-HR-1	Accepted	Not Documented	Not Documented	The site is a possible pit used for the disposal of maintenance shop waste such as paint cans and auto repair waste.	OSR-2008-0002	N/A								
100-H-41	Unplanned Release	100-HR-1	Accepted	1 x 1	Not Documented	Concrete structure within radiologically contaminated area.	OSR-2008-0002	N/A								
100-H-42	Process Unit/ Plant	100-HR-1	Accepted	12.50 x 20.70 x 13.70	1949-?	The site consists of the underground reinforced-concrete flume/reservoir filled with building rubble and clean soil. The concrete structure may be in contact with surrounding soil contaminated by past leaks from the structure.	OSR-2008-0002	N/A								
100-H-43	Maintenance Shop	100-HR-1	Accepted	28.0 x 23.0 x 6.0 (original building) 8.40 x 1.44 x 1.37 (below grade service pit) 10.0 (pipeline) 4.0 (pipeline) 42.75 (cylinder)	1943-1974	This site contains the belowgrade remnants of the 1716-H Maintenance Garage following its demolition and site leveling in 1974. The facility was used to service the area vehicles.	OSR-2008-0002	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-44	Process Unit/ Plant	100-HR-1	Accepted	2.56 x 1.95 x 2.0	Not Documented	This site consists of potentially contaminated soils and possibly a concrete structure, acid brick, and piping that may contain contamination associated with the 183-H Neutralization Pit. The Neutralization Pit received sulfuric acid from two storage tanks and one acid head tank and lime slurry from the 183-H Head House.	OSR-2008-0002	N/A								
100-H-45	Unplanned Release	100-HR-1	Accepted	0.73 x 0.67	1966-?	The site includes a suspect propane UST location, associated belowgrade piping or features, and potentially contaminated soil. The waste would be the tank, piping, or any contaminated soil (if the tank remains in place).	OSR-2008-0002	N/A								
100-H-46	Process Unit/ Plant	100-HR-1	Accepted	Not Documented	Not Documented	This site consists of potentially contaminated soils, concrete structures, and drain pipes that were beneath the sodium dichromate process equipment, piping, unloading dock, and railroad spur. This site is within the footprint of the 190-H Pumphouse, which was demolished and removed to 1 m (3 ft) below grade in 1977 (WHC-EP-0478).	OSR-2008-0002	N/A								
100-H-47	Unplanned Release	100-HR-1	Accepted	1.0 x 1.34	Not Documented	The site is a potential UST that by 2008 may have leaked. This feature was located as an anomaly during a geophysical investigation for another discovery site. The feature has the distinct character of a buried manmade feature, potentially a tank.	OSR-2008-0002	N/A								
100-H-48	Product Piping	100-HR-1	Accepted	1.5 (width)	1965-?	The site consists of potentially remaining fuel oil piping that was associated with two former fuel oil USTs that supported the 184-HA Boilerhouse Building. Potentially, fuel oil piping and contaminated underlying soil could be remaining.	OSR-2008-0002	N/A								
100-H-49	French Drain	100-HR-1	Accepted	French drains range in size from 5.1 cm to 1.22 m	1949-?	This site consists of 19 discrete locations for French drains, the underlying soil of the potentially contaminated French drains, and their associated belowgrade piping components.	OSR-2008-0002	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-5	Burial Ground	100-HR-1	Interim Closed	99.97 x 15.8 x 4.6	1953	Site contains unknown amount of sludge removed from the 116-H-7 Retention Basin in 1953.	CVP-2000-00028	27-Sep-99	8-Jun-00	23,525	5.1	Co-60	0.044 U	0.041 U	0.028	0.0401
												Cs-137	0.072 J	0.035 U	0.0427	0.0345
												Eu-152	0.095 U	0.077 U	0.0655	0.0761
												Eu-154	0.16 U	0.13 U	0.101	0.126
												Pu-238	0.024 U	0.034 U	0.0509	0.0459
												Pu-239/240	0.028 U	0.014 U	0.0371	0.0271
												Arsenic[h]	7.8	5.9	/	/
												Pb	17.0	4.2	8.3	4.3
												Sr-90	/	0.045 U	0.192	0.401
												Sr (total)[i]	0.093 U	/	/	/
												Total PCBs	U	U	/	/
100-H-50	French Drain	100-HR-1	Accepted	French drains range in size from 0.46 m to 1.0 m	1949-?	This site consists of 15 discrete locations, underlying soil, and associated belowgrade piping components for clean "proposed not accepted" French drains.	OSR-2008-0002	N/A								
100-H-51	Process Sewer	100-HR-1	Accepted	633.3 m (length)	Not Documented	This site encompasses the additional 52 potentially contaminated segments, totaling 633.3 m (2,080 ft), of underground miscellaneous pipelines discovered during the orphan site evaluation that were not previously identified within existing waste sites. The waste includes the pipelines and any potentially contaminated soil.	OSR-2008-0002	N/A								
100-H-52	Drain/Tile Field	100-HR-1	Accepted	4.90 x 4.90	1965-1974	The site consists of a drain field and associated piping that supported the 184-HA Boiler Annex. The waste is remaining pipelines and any potentially contaminated soil.	OSR-2008-0002	N/A								
100-H-53	Process Sewer	100-HR-1	Accepted	1.8 (length) 0.25 (diameter)	Not Documented	This site is a 25-cm- (10-in.-) diameter, 1.8 m- (6-ft-) long (exposed portion) carbon steel pipe that runs northeast toward the river shore. The process associated with this pipe is unknown. The pipeline may have been related to pre-Hanford Site activities because this type of debris is associated with Site 600-258. Site 600-258 is located on top of the bank and the pipe is located toward the south end of 600-258.	OSR-2008-0002	N/A								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-H-54	Unplanned Release	100-HR-1	Discovery	Not Documented	Not Documented	The site is an area of systematically elevated radiological activity, generally less than twice background measurements, as shown in the GPERS plot (Image No. 1, Image No. 2). No survey data have been located for the area between the survey area shown in the images (Image No. 1, Image No. 2) and the 116-H-7 (107-H Retention Basin) remediation footprint.	Not Documented	N/A								
100-H-55	Unplanned Release	100-HR-2	Accepted	Not Documented	Not Documented	The waste consists of the pipe and underlying soil. Since the pipe cannot be related to any particular human activity, the contaminants of potential concern are unknown.	OSR-2008-0002	N/A								
100-H-6	Unplanned Release	100-HR-1	Not Accepted	43.80 m^2	Not Documented	The site is a contaminated concrete ramp connected to the 105-H Reactor. Site has been rejected because it is connected to the 105-H Reactor and included with the 118-H-6 Waste Site.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A								
100-H-7	French Drain	100-HR-1	Accepted	0.762 (dia.)	Not Documented	This site is a vertical vitrified clay pipe with metal lid (at surface grade) suspected to be a French drain.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
100-H-8	French Drain	100-HR-1	Accepted	0.91 (dia.)	Not Documented	This site is a vertical 91 cm-(36-in.-) diameter concrete pipe (filled with gravel) with steel lid (at surface grade) suspected to be a French drain.	RS ROD (EPA/ROD/ R10-99/039)									
100-H-9	French Drain	100-HR-1	Interim Closed	0.61 (dia.)	1949-1965	Site was a vertical 0.61 m-(24-in.-) diameter concrete pipe with a rusted metal lid suspected to be a French drain.	CVP-2006-00003	See 118-H-6 Subsites				The 100-H-9 site is analogous to reactor French drains at 118-C-3:3 and 100-F-12. Evaluation of analogous reactor French drains indicates possible residual soil contamination at 100-H-9 meets remediation action objectives and goals.				
116-H-1	Trench	100-HR-1	Interim Closed	245.9 x 20.1 x 4.6	1952-1965	Trench received mixed waste effluent from the 116-H-7 Retention Basin during reactor shutdown caused by fuel element ruptures and water/sludge during the basin deactivation. Received 9 x 10^7 L of effluent; 90 kg (41 lb) sodium dichromate. Radiological inventory is 33 Ci.	CVP-2000-00026	29-Jun-99	25-Jul-00	82,706	4.6	Co-60	0.058 U	2.12	0.048	1.29
												Cs-137	0.689	66.0	0.393	37.7
												Eu-152	0.836	88.8	0.665	52.2
												Eu-154	0.18 U	66.0	0.167	3.88
												Eu-155	0.13 U	0.55 U	0.118	0.331
												Pu-239/240	0.068 J	1.64	0.073	1.09
												Sr-90 (total)	1.35	4.16	0.698	2.53
												Pb[j]	18.0	23.0	11.7	16.0, 0.98
												Cr+6	0.54	0.42 U	0.42	0.42
												Arsenic[h]	9.6	8.5	/	/

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Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-H-2	Trench	100-HR-1	Interim Closed	9.1 x 3.0 x 1.8	1953-1965	Open trench fed by a vitrified clay pipe that originated from the 1608-H Pumphouse. Received 600,000,000 L of effluent; 600 kg (273 lb) sodium dichromate. Radiological inventory is 1.4 Ci.	CVP-2000-00031	2-Feb-00	24-Aug-00	19,920	2.6	Co-60	0.058 U	/	0.05	/
												Cs-137	0.526	/	0.22	/
												Eu-152	0.15 U	/	0.11	/
												Eu-154	0.18 U	/	0.15	/
												Pu-239/240	0.069 U	/	0.1	/
												Sr-90	/	/	0.5	/
												Sr (total)[i]	1.07	/	/	/
												U-238	1.05	/	0.62	/
												Cr+6	0.47	/	0.47	/
116-H-3	French Drain	100-HR-1	Interim Closed	4.6 (depth) x 0.9 (dia.)	1950-1965	Received rinse water and nitric acid from the decontamination of fuel spacers, process tube caps, and other reactor hardware. Consisted of two 0.9 m- (3-ft-) diameter gravel-filled clay pipes. Received 400,000 L (105,669 gal) of effluent; 2,000 kg (909 lb) sodium dichromate. Radiological inventory is 7.0 x 10^{-2} Ci.	CVP-2000-00032	17-Feb-00	1-Aug-00	2,707	4.6	Co-60	0.055	0.836	0.0474	0.902
												Cs-137	0.053 J	10.2	0.0505	9.01
												Eu-152	0.658	23.1	0.464	20.6
												Eu-154	0.13 U	2.1	0.113	1.87
												Cr+6	0.43 U	2.0	0.43	2.0
												Arsenic[h]	11.5	3.9	/	/
116-H-4	Crib	100-HR-1	Accepted	3.0 x 3.0 x 3.0	1950-1952	Mixed liquid waste site that received about 1,000 L (254.2 gal) of contaminated cooling water from reactor process tubes containing ruptured fuel elements. A 1953 document reported ~270 Ci and 1,000 kg (454 lb) of sodium dichromate were released into the crib. There are some controversies about these values. After its use was discontinued in 1952, this pluto crib was covered with about 3.0 m (10 ft) of soil and marked with permanent concrete monuments. The pluto crib was uncovered and exhumed in 1960, during construction of the 105-H Confinement System, so that the 117-H Filter Building could be constructed at the same location.	Interim Remedial ROD	N/A									
116-H-5	Outfall	100-HR-1	Accepted	8.2 x 4.3 x 6.1	1949-1965	The outfall was a reinforced-concrete weir box that directed the 105-H Reactor coolant water either through the river discharge pipelines (100-H-34) or through the spillway (flume) (100-H-36). Received effluent from the 107-F Retention Basins.	RS ROD (EPA/ROD/ R10-99/039)	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-H-6	Retention Basin	100-HR-1	Closed Out	39.0 x 16.5 x 5.0	1949-1985	Site was a concrete water and treatment basin divided and subdivided for treatment of liquid waste by solar evaporation. Site has been closed out via modified closure certificate. Received 1,514,160 L (399,998 gal) of effluent per year. The retention basin was a RCRA-permitted TSD unit.	Closure Letter 046651, "Acceptance of Closure Certification for the 183-H Solar Evaporation Basins (T-1-4), 96-EAP-246"	1995	13-May-97	Not Documented	6.1	Clean closure of the site was not achieved due to levels of fluoride and nitrate remaining in the soil. Therefore, the unit was closed under the partial closure option with specified remedial measures provided under postclosure care. Remedial measures included placing a vapor barrier at the bottom of the excavation and replacing the excavated soils with clean, compacted backfill. Postclosure groundwater monitoring will continue at the unit under a WAC 175-303-645, "Releases from Regulated Units," final status permit and compliance monitoring program.				
116-H-7	Retention Basin	100-HR-1	Interim Closed	194.5 x 86.0 x 7.3 (height) Depth estimated to be 4.6 meters below ground surface (bgs)	1949-1965	Site was a concrete-lined rectangular structure that received cooling water effluent from the 105-H Reactor for radioactive decay and thermal cooling.	CVP-2000-00027	17-Mar-99	24-Aug-00	218,130	4.8	Co-60	0.053 U	10.2	0.04	19.7
												Cs-137	0.234	48.6	0.114	19.2
												Eu-152	0.676	116.0	0.272	241.7
												Eu-154	0.17 U	11.6	0.128	18.8
												Eu-155	0.14 U	0.84 U	0.102	0.51
												Ni-63	3.14 U	1,530.0	3.093	1,224.0
												Pu-238	0.013 U	0.486 J	0.059	0.147
												Pu-239/240	0.011 U	5.55	0.042	1.6
												Sr-90 (total)	0.0753 U	4.26	0.17	2.47
												U-238	0.71 J	0.591 J	0.482	0.46
												Pb	31.0	16.0	19.3	9.17
												Cr+6	1.1	10.0	0.898	4.07
												Cr (total)	32.0	110.0	18.5	57.1
												Aroclor-1242	0.33 U	0.336	0.033	0.33
												Aroclor-1260	0.66	0.66	0.084	0.24
116-H-9	Crib	100-HR-1	Accepted	6.1 x 6.1 x 4.6	1960-1965	Site was designed to receive drainage from the 117-H Filter Building seal pits. Received 300,000 L of effluent from 132-H-2 Reactor Exhaust Air Filter building seal pits.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
118-H-1	Burial Ground	100-HR-2	Accepted	213.4 x 106.7 x 6.1	1949-1965	The site received activated components and miscellaneous solid wastes (surface contaminated). This is the primary solid waste burial ground for 100-H. The wastes disposed of in it include process tubing, contaminated lead bricks, dummy fuel elements, and miscellaneous hardware.	EPA/ROD/ R10-00/121	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-H-2	Burial Ground	100-HR-2	Accepted	42.7 x 15.2	1955-1965	This site consists of two in-line concrete vaults. The east vault received one stainless steel double tube removed from the reactor in 1955 after several years of irradiation. Within the same area, there are solutions that were used to clean the tube and miscellaneous capsule components. The west vault was constructed in 1958 and used during deactivation of the 105-H Reactor for disposal of a small amount of contaminated pipe.	EPA/ROD/ R10-00/121	N/A									
118-H-3	Burial Ground	100-HR-2	Accepted	30 x 114 x 95 x 122 (uneven polygon) x 6.096 (depth)	1953-1957	The burial ground received components and hardware from reactor modification programs. The site contains sections of contaminated 41 cm- (16.1-in.-) diameter pipe used as chutes for removal of thimbles from the 105-H Building during outages, reactor hardware, and components from reactor modification programs.	EPA/ROD/ R10-00/121	N/A								
118-H-4	Burial Ground	100-HR-2	Accepted	45.7 x 9.1 x 3.0	1953	This site received solid waste from the Ball 3X Project in 1953 and contains thimbles, guides, and radioactive materials removed from the 100-H Reactor.	EPA/ROD/ R10-00/121	N/A								
118-H-5	Burial Ground	100-HR-2	Accepted	9.1 x 0.6 x 3.0	1953-1960	The site consists of one trench that was covered to grade with soil and marked with cement monuments. This site received a single experimental thimble assembly in 1953 and contaminated soil from the 105-H Pluto Crib in 1960.	EPA/ROD/ R10-00/121	N/A								
118-H-6	Reactor	100-HR-1	Accepted	Consists of six subsites: Refer to 118-H-6:1 through 118-H-6:6	1949-1965	Inactive plutonium production reactor that has been placed in interim safe storage. Site consists of six subsites.	Action Memorandum 087896	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-H-6:3	105-H Fuel Storage Basin	100-HR-1	Interim Closed	1,387 m^2	1949-1965	This site is the soil underlying the former fuel storage basin floor. Sample design was developed specifically to address potential contamination from the known leakage of the fuel storage basin. Soils below the fuel storage basin were collected 0.3 m (1 ft) and 2.4 to 3.1 m (8 to 10 ft) bgs.	CVP-2006-00003	Not Documented	2004	73,966	6	Am-241	0.765	0.143 U	0.369	0.077 U
												C-14	25.4 J	3.00 U	7.6	1.59 U
												Cs-137	29.0	1.19	11.3	0.216
												Co-60	0.374	0.11 U	0.199	0.037 U
												Eu-152	6.42	0.38 U	2.76	0.088 U
												Eu-154	0.893	0.36 U	0.35	0.12 U
												Eu-155	0.40 U	0.23 U	/	/
												H-3	0.247	0.568	0.092	0.332
												Ni-63	57.5	14.5	25.9	1.79 U
												Np-237	0.048 J	0.033	0.03	0.01 U
												Pu-238	0.091 U	0.036 U	/	/
												Pu-239/240	1.65	0.252 U	0.726/0.174	0.059 U/ 0.014 U
												Sr-90	12.6	0.570	5.9	0.174
												Th-228	0.949 J	0.591	0 (<BG)	0 (<BG)
												Th-230	1.06	0.892	0.64	0.59
												Th-232	1.16 J	0.888	0 (<BG)	0 (<BG)
												U-233/234	0.665	0.589	0 (<BG)	0 (<BG)
												U-235	0.047	0.095 U	0 (<BG)	0 (<BG) U
												U-238	0.665	0.550	0 (<BG)	0 (<BG)
												Hg	0.034 U	0.034 U	/	/
												Pb	34.8	2.9	18.9	2.6 U
												Cr+6	0.94	0.21 U	0.94	0.21 U
												Aroclor-1016	0.014 UJ	0.014 U	/	/
												Aroclor-1221	0.014 UJ	0.014 U	/	/
												Aroclor-1232	0.014 UJ	0.014 U	/	/
												Aroclor-1242	0.014 UJ	0.014 U	/	/
												Aroclor-1248	0.014 UJ	0.014 U	/	/
												Aroclor-1254	0.024 J	0.014 U	0.024	0.014 U
												Aroclor-1260	0.014 UJ	0.014 U	/	/

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-H-6:6	105-H Fuel Storage Basin Deep Zone Side Slopes	100-HR-1	Interim Closed	1,387 m^2	1949-1965	The fuel storage basin side slopes are located in the south side of the original Reactor Building. The side slope soils include the shallow soil (118-H-6:4) and deep zone soil (118-H-6:6) located on the east, west, and south boundary of the fuel storage basin excavation.	CVP-2006-00003	Not Documented	2004	73,966	6	Am-241	/	0.273	/	0.257
												C-14	/	4.32 U	/	4.43 U
												Cs-137	/	5.01	/	5.36
												Co-60	/	0.195	/	0.19
												Eu-152	/	1.26	/	1.26
												Eu-154	/	0.34 U	/	0.15 U
												Eu-155	/	0.25 U	/	/
												H-3	/	12.8	/	-0.02 U
												Ni-63	/	14.8	/	16.0
												Np-237	/	0.052	/	0.035
												Pu-238	/	0.036 U	/	/
												Pu-239/240	/	0.969	/	0.806/0.193
												Sr-90	/	5.64	/	5.56
												Th-228	/	0.674	/	0 (<BG)
												Th-230	/	1.04	/	0.932
												Th-232	/	1.12	/	0 (<BG)
												U-233/234	/	0.697	/	0 (<BG)
												U-235	/	0.116 U	/	0 (<BG) U
												U-238	/	0.768	/	0 (<BG)
												Hg	/	0.02 U	/	/
												Pb	/	22.9	/	20.1
												Cr+6	/	1.5	/	1.5
												Aroclor-1016	/	0.014 U	/	/
												Aroclor-1221	/	0.014 U	/	/
												Aroclor-1232	/	0.014 U	/	/
												Aroclor-1242	/	0.014 U	/	/
												Aroclor-1248	/	0.014 U	/	/
												Aroclor-1254	/	0.014 U	/	0.014
												Aroclor-1260	/	0.014 U	/	/
126-H-1	Coal Ash Pit	100-HR-2	Rejected	76.2 x 76.2 x 3.7	1948-1965	The site is a large ash disposal pit and ash pile. Coal ash from the 184-H Powerhouse was mixed with raw river water and sluiced in slurry to the ash pit. Unknown amounts of coal ash were sluiced to the pit with raw river water. Ash from other Hanford Site ash pits has been analyzed using the EP Toxicity Test in accordance with WAC 173-303, and no hazardous materials were found.	WSRF 98-08	N/A								

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
126-H-2	Dumping Area	100-HR-1	Accepted	261.5 x 40.8 265 x 43	1975	Concrete basins used to store reactor coolant water. Eastern half contains D&D rubble (west half still intact).	RS ROD (EPA/ROD/ R10-99/039)	N/A								
128-H-1	Burn Pit	100-HR-2	Accepted	30.48 x 30.48 x 3.048 Also reported as 172 x 163	1949-1965	Site is a large depression used for burning nonradioactive combustible materials, paint, office waste, solvents. Site also contains surface debris such as wood, metal, chunks of concrete, and so forth.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
128-H-2	Burn Pit	100-HR-2	Accepted	36.6 x 24.4 Also reported as 86 x 47	1965	The site is in a depression cut into the hillside that appears to be a former borrow area. The site received combustible materials such as vegetation, office waste, paint waste, and chemical solvents. Evidence of burning is not readily visible, but the following surface debris was observed in 2000: wood, metal cables, cans, lighting fixtures, concrete, and a battery.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
128-H-3	Burn Pit	100-HR-2	Accepted	24.5 x 4	N/K	Site is a pit resembling a trench with little to no evidence of burning other than charred rocks.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
132-H-1	Burial Ground	100-HR-1	Interim Closed	61.0 x 9.1 x 5.5	1945-1965	Site contains concrete rubble from demolition of the 105-H (116-H) Reactor Stack. The stack was used to exhaust confinement air from the work areas of the 105-H Reactor and was demolished in 1983. The stack and its foundation were demolished with explosives and buried in a trench.	WSRF 2006-053	16-Sep-83	2006?	Left in place	5.49	C-14	249	/	/	/
												Cs-137	69.4	/	/	/
												Co-60	4.07	/	/	/
												Eu-152	5.77	/	/	/
												H-3	22.4	/	/	/
												Pu-239/240	27.2	/	/	/
												Sr-90	9.49	/	/	/
132-H-2	Burial Ground	100-HR-2	Interim Closed	16.9 x 7.0	1961-1965	This site was a concrete building that housed reactor exhaust filters. The building was built over the excavated 116-H-4 Pluto Crib. It was demolished in 1984 and left in place.	WSRF 2006-049	1983	Oct-84	Left in place	9.6	C-14	7	/	/	/
												Cs-137	104	/	/	/
												Co-60	56	/	/	/
												Eu-152	63			
												Eu-154	19	/	/	/
												H-3	41	/	/	/
												Pu-239/240	40	/	/	/
												Sr-90	53	/	/	/

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
132-H-3	Pump Station	100-HR-1	Accepted	11.0 x 10.4 x 9.6	1949-1965	This site received water from reactor building drains and irradiated fuel storage drains containing trace amounts of low-level radionuclides and decontamination chemicals, primarily Turco (a commercial chemical compound with a proprietary composition). Site collected low-level contaminated wastewater from 105-H sumps and drains and pumped it to either the 1608-H Disposal Trench or effluent pipelines. Site was a concrete building that was D&D'd in place in 1987.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
1607-H1	Septic Tank	100-HR-2	Accepted	4.6 x 1.7 x 4.4 (Septic Tank) 17.1 x 15.2 (Tile Field)	1948	Site is a concrete tank with a 50-person capacity and tile field that received sanitary sewage from the 151-H and 105-H Reactors.	RS ROD (EPA/ROD/ R10-99/039)	N/A								
1607-H2	Septic Tank	100-HR-1	Interim Closed	11.8 x 4.1 x 4.8 (Septic Tank), 93.3 x 30.8 x 0.9 (Drain Field)	1949-1965	Site was a concrete tank with a 500-person capacity, drain field, and associated piping that received sanitary sewage from the 182-H, 183-H, 190-H, and other offices and maintenance buildings.	CVP-2000-00024	21-Oct-99	5-May-00	12,207	5.6[k]	U-233/234	1.38	/	0.886	/
												U-238	1.05	/	0.73	/
												Cs-137	0.11	/	0.0591	/
												Cr+6	0.68	/	0.68	/
												Cr (total)	204	/	83.2	/
												Arsenic[h]	11.1	/	/	/
												Hg	3.5	/	1.34	/
												Pb	48.5	/	36	/
												Aroclor-1254	0.16	/	0.16	/
1607-H3	Septic Tank	100-HR-1	Accepted	5.8 x 2.4 x 3.7 (Septic Tank) 30 x 15 (Tile Field)	1948-1968	Site is a concrete tank with a 100-person capacity and tile field and received sanitary sewage from 1701-H Badgehouse, 1709-H Fire Station, and 1720-H Patrol Office. The 1701-H Badgehouse included a darkroom for film badge processing. Liquids from the darkroom were disposed to the 1607-H Septic System.	Interim Remedial ROD	N/A								

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
1607-H4	Septic Tank	100-HR-1	Interim Closed	1.6 x 1.0 x 2.9 (Septic Tank), 7.3 x 2.4 x 0.9 (Drain Field)	1948-1965	Site was a concrete tank with a six-person capacity, drain field, and associated piping that received sanitary sewage from 181-H Pumphouse Building.	CVP-2000-00025	5-Nov-99	31-Jul-00	2,078	3.6	U-233/234	0.705 J	/	0.484	/
												U-238	0.764 J	/	0.505	/
												Cs-137	0.137	/	0.114	/
												Cr (total)	12	/	/	/
												Cr+6	0.44 U	/	0.44	/
												Arsenic[h]	7.5	/	/	/
												Pb	44	/	36	/
												Hg[h]	0.11 U	/	/	/
												Fluoranthene	1.3	/	0.96	/
												Pyrene	1.2	/	0.9	/
												Benzo(a) anthracene	0.33 U	/	0.059	/
												Benzo(a)pyrene	0.33 U	/	0.065	/
												Benzo(b) fluoranthene	0.33 U	/	0.031	/
												Benzo(k) fluoranthene	0.33 U	/	0.031	/
												Chrysene	0.33 U	/	0.11	/
												Dibenzo(a,h) anthracene	0.33 U	/	0.022	/
												Indeno(1,2,3-cd) pyrene	0.33 U	/	0.039	/
600-151	Dumping Area	100-HR-2	Accepted	45,000 m^2	Not Documented	The site is the debris remaining from a military installation that was located northwest of the 100 H Area.	Interim Action Record of Decision, 100 Area Remaining Sites (1999)	N/A								
600-152	Septic Tank	100-HR-2	Accepted	Not Documented	Not Documented	The site is one or more septic tanks left from a military camp that was once located in the area. Three separate inline concrete covers and two manholes identify the site. As a result of sampling results, the site was posted with Underground Radioactive Material signs.	Not Documented	N/A								

Table C-1. Waste Sites

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													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
600-258	Dumping Area	100-HR-2	Not Accepted	828.8 x 7.3	Pre-Hanford	The site is surface debris from pre-Hanford activities. It is on the riverbank, facing the White Bluffs, and is covered with vegetation matching the surrounding terrain. The material consists of rusted metal wire used to wrap wooden irrigation pipes, old bedsprings, food cans, a small concrete box (filled in with soil), and a little broken glass.	TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators	N/A									
600-105	Burial Ground	100-IU-4	Closed Out	30.48 x 15.24 X 4.6 Depth also reported as 4.1	1945	The site contained approximately 5,000 crushed 55-gallon drums containing sodium-dichromate residue. It is estimated, assuming that 1% of the original quantity of sodium dichromate remained in the drum on disposal, that 30.9 tons of sodium dichromate were disposed. The 1993 Sodium Dichromate Expedited Response Action removed the crushed barrels. During the removal activities, small quantities of asbestos, waste oil and batteries were found. These items were disposed of as hazardous waste. The field screening and off site laboratory results did not identify chromium (VI) or total chromium levels that constituted a hazardous condition. The MTCA (WAC 173-340-740) Method A chromium cleanup level for soil is 100 milligrams/kilogram or 100 parts per million. The maximum concentration of chromium detected is 86.7 mg/kg, which is below interim remedial action goals.	Record of Decision, 100-IU-1, 100-IU-3, 100-IU-4, 100-IU-5 (1996)	3/17/1993	4/26/1993	N/A	N/A	Cr+6	86.7	/	/	/

Notes:

a. Shallow zone: soil 0 to 4.6 m (0 to 15 ft) in depth.
b. Deep zone: soil greater than 4.6 m (15 ft) in depth.
c. Unadjusted Statistical Values.
d. COC typically represented the 95% UCL.
e. To determine compliance with the RAGs, the residual radioactivity in the 105-D FSB floor concrete was modeled with the RESRAD dose assessment model in the post-drilling rural-residential exposure scenario.
f. There were no results reported for the COC Sr-90 in the deep zone soil. Sr-90 and Ni-63 have similar partition coefficients (Sr-90 Kd = 25, Ni-63 Kd = 30) and Ni-63 was measured in both the deep zone concrete and soil. Therefore, Sr-90 in the soil was estimated by applying the equation [Sr-90(soil) = Ni-63 (soil)* Sr-90 (concrete)/Ni-63 (concrete)].
g. Aroclor-1260 is the only identified COC for this site.
h. COPC for this site but was not detected above Washington State background (WAC 173-340).
i. Total strontium results are used as a conservative representation of Sr-90.

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]

j. Because a more detailed analysis of lead was required to demonstrate groundwater and river lead, deep zone was divided into two levels.

k. Very few areas of the excavation site were greater than 4.6 m (15 ft) and because field screening for radionuclides indicated that those areas met direct exposure RAGs, all of the RAGs were applied to the entire site.

/ = no data collected
BG = background
CERCLA = *Comprehensive Environmental Response, Compensation and Liability Act of 1980*
COC = contaminant of concern
COPC = contaminant of potential concern
D&D = decontamination and decommissioning
Ecology = Washington State Department of Ecology
ERDF = Environmental Restoration Disposal Facility
FH = Fluor Hanford
FSB = Fuel Storage Basin
GPERS = Global Positioning Environmental Radiological Surveyor
J = associated value is an estimated quantity
N = not a COC for this zone (DOE/RL-99-35)
N/A = not applicable
PCB = polychlorinated biphenyl
pH = acidity or alkalinity of an aqueous solution
RAG = remedial action goal
RESRAD = RESidual RADioactivity (computer code)
ROD = record of decision
RS = remaining site
SD = treatment, storage, and/or disposal (unit)
U = analyte is below the detection limits of the methods and instruments used (undetected)
UCL = upper confidence limit
UST = underground storage tank
WCH = Washington Closure Hanford, LLC
WIDS = Waste Information Data System database

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CVP-98-00002, *Cleanup Verification Package for the 100-D-21 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00003, *Cleanup Verification Package for the 100-D-20 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-98-00004, *Cleanup Verification Package for the 100-D-4 Sludge Pit*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00006, *Cleanup Verification Package for the 116-DR-9 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-99-00007, *Cleanup Verification Package for the 116-D-7 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00001, *Cleanup Verification Package for the 100-D-18 Sludge Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00002, *Cleanup Verification Package for the 116-DR-1&2 Process Effluent Trenches*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00003, *Cleanup Verification Package for the D and DR Group 2 North Pipelines (100-D-48:1/49:1), 100-D-19 Sludge Trench and UPR-100-D-4 Unplanned Release Site*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00005, *Cleanup Verification Package for the D and DR Group 2 Pipelines (100-D-48:2/49:2) and Unplanned Release Sites (UPR-100-D-2 and UPR-100-D-3)*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00008, *Cleanup Verification Package for the 116-D-4 Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00009, *Cleanup Verification Package for the 116-D-6 French Drain*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00010, *Cleanup Verification Package for the 116-D-1A/116-D-1B Storage Basin Trenches and 100-D-46 Burial Ground*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00012, *Cleanup Verification Package for the 116-D-9 Crib and Pipeline*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00013, *Cleanup Verification Package for the 116-D-2 Pluto Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00014, *Cleanup Verification Package for the 116-DR-6 Liquid Disposal Trench*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00015, *Cleanup Verification Package for the 116-DR-4 Pluto Crib*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00016, *Cleanup Verification Package for the 100-D-12 Sodium Dichromate Pump Station,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00018, *Cleanup Verification Package for the 100-D-52 Drywell*, Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00019, *Cleanup Verification Package for the 116 DR 7 Inkwell Crib,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00024, *Cleanup Verification Package for the 1607 H 2 Septic System,* Bechtel Hanford, Inc., Richland, Washington.

Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]

CVP-2000-00025, *Cleanup Verification Package for the 1607 H 4 Septic System,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00026, *Cleanup Verification Package for the 116 H 1 Process Effluent Trench,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00027, *Cleanup Verification Package for the 116 H 7 Retention Basin,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00028, *Cleanup Verification Package for the 100 H 5 Sludge Disposal Trench,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00029, *Cleanup Verification Package for the 100 H 21 Reactor Effluent Pipelines, 100 H 22 Effluent Pipeline Leakage, and 100 H 1 Rod Cave,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00030, *Cleanup Verification Package for the 100 H 24 Substation,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00031, *Cleanup Verification Package for the 100 H 17 Overflow, 116 H 2 Liquid Waste Disposal Trench, 100 H 2 Buried Thimble Site, and the 100 H 30 Sanitary Sewer Trench,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00032, *Cleanup Verification Package for the 116 H 3 French Drain,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2000-00034, *Cleanup Verification Package for the 100 D and 100 DR Group 3 Pipelines (100 D 48:3 and 100 D 49:3) and 100 D 5 and 100 D 6 Burial Grounds,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2003-00016, *Cleanup Verification Package for the 118-DR-2:2, Below-grade Structures and Underlying Soils, and the 100-D-49:4 Reactor Cooling Water Effluent Underground Pipeline,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2003-00018, *Cleanup Verification Package for the 105-DR Large Sodium Fire Facility (122-DR-1:2, 100-D-53/122-DR-1:4, 132-DR-2/122-DR-1:5), the 119-DR Exhaust Stack Sampling Building (100-D-64), and the 100-D-23 and 100-D-54 Dry Wells,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2005-00003, *Cleanup Verification Package for the 118-D-6:2, 105-D Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils; and the 132-D-4, 105-D Reactor Exhaust Stack Foundation,* Bechtel Hanford, Inc., Richland, Washington.

CVP-2006-00003, *Cleanup Verification Package for the 118-H-6:2, 105-H Reactor Ancillary Support Areas, Below-Grade Structures, and Underlying Soils; the 118-H-6:3, 105-H Reactor Fuel Storage Basin and Underlying Soils; the 118-H-6:6 Fuel Storage Basin Deep Zone Side-Slope Soils; the 100-H-9, 100-H-10, and 100-H-13 French Drains; the 100-H-11 and 100-H-12 Expansion Box French Drains; and the 100-H-14 and 100-H-31 Surface Contamination Zones*, Washington Closure Hanford, LLC, Richland, Washington.

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Table C-1. Waste Sites

Site Code	Site Type	Operable Unit	Reclass Status	Site Dimensions (m)	Dates of Operation	Site History	Decision/ Close-Out Report	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Maximum Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
													Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
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Table C-2. Facility Waste Cross-Walk

Facility	Waste Site
100-D	
105-D Reactor Building	118-D-6 Reactor
105-DR Reactor Building	118-DR-2 Reactor
107-D Retention Basin	116-D-7 Retention Basin
107-DR Retention Basin	116-DR-9 Retention Basin
108-D Chemical Pump House	100-D-73 Process Unit/Plant
115-DR Gas Recirculating Facility	132-D-1 Process Unit/Plant
116-D Reactor Exhaust Stack	132-D-4 Stack
116-DR Reactor Exhaust Stack	132-DR-2 Stack
117-D Filter Building	132-D-2 Process Unit/Plant
117-DR Filter Building	100-D-53 Process Unit/Plant, 122-DR-1 Laboratory
119-DR Sample Building	100-D-64 Laboratory
151-D Electric Substation	100-D-75 Electrical Substation
152-D Substations	100-D-98 Electric Substation
1608-D Waste Water Pump Station	132-D-3 Pump Station
1608-DR Waste Water Pump Station	132-DR-1 Pump Station
1614-D-1 Monitoring Station	100-D-36 Foundation
1614-D-3 Monitoring Station	100-D-37 Foundation
183-D Acid Facility	100-D-72 Process Unit/Plant
183-DR Water Treatment Facility	100-D-77 Process Unit/Plant
184-D Power House Ash Pit	126-D-1 Coal Ash Pit
184-DA Fuel Storage Tank	100-D-97 Storage Tank
185-D/190-D Complex	100-D-30 Sodium Dichromate Transfer Trench
186-D Waste Acid Surface Impoundment	120-D-2 Surface Impoundment
1904-D Outfall Structure	100-D-65 Spillway, 116-D-5 Outfall
1904-DR Outfall Structure	100-D-66 Spillway, 116-DR-5 Outfall
190-DR Process Water Pump House	100-D-68 Process Unit/Plant
100-H	
105-H Reactor	118-H-6 Reactor
107-H Retention Basin	116-H-7 Retention Basin
110-H Pressure Test House	100-H-30 Sanitary Sewage Trench

Table C-2. Facility Waste Cross-Walk

Facility	Waste Site
116-H Reactor Exhaust Stack Burial Site	132-H-1 Process Unit/Plant
117-H Filter Building	132-H-2 Process Unit/Plant
151-H Electrical Facilities	100-H-24 Electric Substation
1608-H Waste Water Pumping Station	132-H-3 Pump Station
1716-H Maintenance Garage	100-H-3 Storage Tank, 100-H-43 Maintenance Shop
1717-H Maintenance Hot Shop	100-H-4 Maintenance Shop
183-H Solar Evaporation Basin	100-H-33, 116-H-6 Retention Basin
184-H Powerhouse Ash Pit	126-H-1 Coal Ash Pit
1904-H Outfall Structure	100-H-36 Spillway, 116-H-5 Outfall
1906-H Drainage Lift Station	100-H-42 Process Unit/Plant
190-H Pump House	100-H-46 Pump House Drain

Appendix D

Summary of 100-D/H Facilities

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D1 Introduction

Table D-1 provides a summary of the buildings/facilities that have existed in 100-D/H 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

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Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
100-D Area							
103-D	Storage	100-DR-1	17.7 x 8.2 x 5.2	Demolished	1943	2001	The 103-D Fresh Metal Storage Building, also referred to as the Nonirradiated Fuel Storage Building and the Fuel Element Storage Building, was used for pallet storage of fuel elements prior to use in the reactor. In later years, the building was used for miscellaneous storage.
105-D	Reactor	100-DR-1	34.1 x 22.9	Inactive	1944	2004	It was designed as a graphite-moderated, water-cooled reactor to produce weapons-grade plutonium. The building is a non-airtight industrial structure with reinforced concrete in the lower portion and concrete block in the upper portion. Its contaminated components included the reactor block, a storage basin for irradiated fuel, and other contaminated portions of the reactor building. The reactor block, located near the center of the building, has 2,004 horizontal, aluminum-lined process channels, six experimental test channels, nine horizontal control rod channels, and 29 vertical safety rod channels. The fuel storage basin served as an underwater collection, storage, and transfer facility for the irradiated fuel elements discharged from the reactor block. The total area of the storage basin was 930 m^2 (10,000 ft^2), and the basin contained 6 m (20 ft) of water during operation. Uranium fuel slugs were pushed through the more than 2,000 aluminum-lined process channels, exiting the reactor block as spent fuel into the storage basin. After an appropriate cooling period, the spent fuel was moved by railroad for reprocessing in the 200 Areas. Auxiliary buildings were removed and reactor Interim Safe Storage completed in 2004.
105-DR	Reactor	100-DR-2	4,656.3 m^2	Inactive	1950	2003	It was designed as a graphite-moderated, water-cooled reactor to produce weapons-grade plutonium. It consisted of a reactor block, irradiated fuel storage, and associated work and equipment rooms. In 1973, 117-DR, 119-DR, and 105-DR (lunch room, restroom, and fan room only) were utilized by the Hanford Engineering Development Laboratory (HEDL) to conduct sodium burning experiments to obtain data required in the design and operation of the Fast Flux Test Facility (FFTF). Experimental work was expected to be completed by June 1975. The CVP documents completion of the removal action for subsite 118-DR-2:2, 105-DR Reactor Below-Grade Structures, and Underlying Soils in support of the 105-DR Reactor Interim Safe Storage (ISS) Project. The ISS of the 105-DR Reactor included removing all portions of the reactor facility outside the reactor block shield walls. The 105-DR ISS Project began in January 1998 and was completed in January 2003. The areas to be removed included the Fuel Storage Basin (FSB), outer rod room, control room, electrical room, switchgear room, lunch room, office space, fan supply and exhaust rooms, sample rooms, ready room, upper reactor framing and roofing, and other miscellaneous rooms and tunnels. Prior to cocooning activities, the structure contained an estimated 13,500 Ci of radionuclides, 85 metric tons (94 tons) of lead, 30 m^3 (100 ft^3) of asbestos, and 230 kg (500 lb) of cadmium. How much of this may have been removed by cocooning was not determined.
107-D	Retention Basin	100-DR-1	151.2 x 73.2 x 6.1	Demolished	1944	1998	The concrete retention basin was located about 700 m (2,300 ft) north of the 105-D Reactor building. It was a large, rectangular structure with intake chamber and shelter at one end and pump house and water-sampling laboratory at the other (discharge). The retention basin received cooling water effluent from the 105-D Reactor and reactor floor wastes from the 1608-D Process Waste Lift Station via a 1.5 m- (5-ft-) diameter pipe. After the DR Area was completed, it was cross-tied to allow transfers from the 105-DR and 107-DR facilities. Cooling water effluent was allowed to remain in the basin for as long as possible to allow for the decay of short-lived fission products, and to cool thermally, before discharge to the center of the river bottom. Remediation was conducted from May 1, 1997, until the end of 1998. During remediation, about two-thirds of the basin floor area was dug at least 7 m (23 ft) below grade because of high dichromate levels.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
107-DR	Retention Basin	100-DR-1	192.3 x 83.8 x 6.1	Demolished	1950	1999	The concrete retention basin was located approximately 950 m (3,100 ft) north of the 105-DR Reactor building. It was a large, rectangular structure with a shelter on the intake end, and a sampling lab at the discharge end. In the 1950s it was cross-tied to the 107-D Retention Basin, as well as the 105-D Reactor Building. The retention basin received cooling water effluent from the 105-DR Reactor, and reactor floor wastes from the 1608-DR Wastewater Pump House. The cooling water was held in the basin for as long as operating time would permit, allowing the water to thermally cool and for short-lived radionuclides to decay. The water was then discharged to the center of the river via the outfall structures and associated pipelines. The basin experienced several unplanned liquid releases during its lifetime. Total estimated radionuclide inventory in the vicinity of the basin ranged from 5 to over 400 curies. About 10 curies had leached into the concrete walls and floor. At completion of remedial actions, the excavation area floor was approximately 16,300 m^2 (53,500 ft^2) at a depth of 4.75 m (15.6 ft). Institutional controls are needed to ensure no drilling is performed in the future at depths below 4.75 m (15.6 ft).
108-D	Process Unit/Plant	100-DR-1	46 x 10 x 18	Demolished	1943	1978	The building was three stories, steel frame, concrete block walls with reinforced-concrete floors that contained a ground floor, chemical floor (second floor), and a chemical storage floor (third floor). The 108-D Building was initially designed to provide special chemical treatment for process water prior to its use in the D-Reactor. It was constructed to receive and store various chemicals for the preparation of the water treatment solutions that were then piped to the 105-D Reactor and the 185-D Building. From about 1944 until 1950, the receiving and mixing of sodium dichromate was conducted in the 108-D Building. The 108-D Facility received, stored, and prepared various chemicals for the preparation of solutions and slurries. At a later unknown date, the mixing of sodium dichromate was moved to the 185-D Building. It then became a Mechanical Development Laboratory for special tool development and decontamination. It contained various reactor mock-up facilities such as segments of C and K reactor lattices, flow mock-ups, and simulated elevator and reactor face equipment. It handled mildly contaminated equipment. It was demolished and aboveground portions buried in the 184-D Coal Pit.
110-D	Storage Tank	100-DR-1	27 x 27	Demolished	1943	1986?	The 110-D Gas Storage Tanks facility is a series of tanks containing helium and carbon dioxide, which were the gas covers for the reactor pile. There were originally two low-pressure (50-psig) tanks, and 33 high-pressure (700-psig) tanks in the facility, all resting on concrete piers. Supporting structures included a car spot, loading platform, and wooden, elevated walkways. The gas tanks were piped and valved to provide a continuous flow of makeup gas to the 115-D Gas Purification. As tanks were emptied, they were refilled via the railroad tank cars.
115-D/DR	Process Unit/Plant	100-DR-1	51 x 30 x 10	Demolished	1943	1986	The 115-D Purification Building, was a single-story concrete building that operated from 1944 to 1967, adding equipment in 1950 to support 105-DR. The building was designed to remove moisture (using silica gel) and gases from the reactor, transfer heat from the graphite to the process tubes, control reactivity, detect water leaks within the reactor, and minimize oxidation of the graphite moderator. In 1986, the superstructure was demolished and the debris taken to the 190-DR Clearwell Pit for disposal. The tunnels were collapsed in place. At, and below grade structures were excavated to 1 m (3 ft), and the remainder collapsed into the basement, or put into the tunnel before it was collapsed. Excavations were backfilled with clean soil. Miscellaneous radioactive material, process equipment, and associated piping were removed from the process cells and disposed of as radioactive waste. No contaminated rubble was left closer than 1 m (3 ft) to the final grade surface.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
116-D	Stack	100-DR-1	60.1 (depth) x 5.0 (diameter)	Demolished	1944	1967	The reinforced-concrete 116-D Reactor Exhaust Stack discharged ventilation air 61 m (200 ft) above grade from the 105-D Building. Originally, exhaust air from the reactor work areas flowed through concrete ducts directly out the stack. Following completion of the confinement project in the 1950s, the air was diverted through underground, reinforced-concrete ducts to the 117-D Filter Building before being routed to the stack. The stack was demolished and buried in a trench, and the base demolished down 1 m (3 ft) below grade, leaving more than 4 m (13 ft) of the base in place.
116-DR	Stack	100-DR-2	61 (depth) x 5.0 (diameter)	Demolished	1950	1967	The stack discharged 105-DR Work Area air. Originally, 105-DR Work Area exhaust air flowed directly from the 105-DR Building to the stack. Following completion of the confinement project in 1960, the exhaust air was diverted to the 117-DR Filter Building, via underground concrete ducts, prior to release through the stack. The stack was demolished and buried in a trench and the base demolished down to 1 m (3 ft). Rubble was hauled to Environmental Restoration Disposal Facility (ERDF). The site was backfilled and leveled. At completion of remedial actions, the total excavation was 1,010 m^2 (3,300 ft^2) with an approximate depth of 5 m (16 ft). Institutional controls are required to prevent future drilling at the site below 5 m (16 ft).
117-D	Process Unit/Plant	100-DR-1	17.98 x 11.9 x 10.7	Demolished	1960	1986	The 117-D Filter Building was constructed of reinforced concrete almost entirely below grade. Reactor building ventilation gases went directly through the Filter Building, where the air passed through a High-Efficiency Particulate Air (HEPA) -type filter, and an activated charcoal filter prior to discharge through the 116-D Stack. The site was decommissioned in 1986 using Allowable Residual Contamination Level (ARCL) methodology; filters, frames, and turning vanes were sent to the 200 Areas for burial. The building was excavated to 1 m (3 ft) below grade, and the duct ceiling and walls collapsed inward. The site was then partially backfilled with contaminated rubble, then brought to grade with clean fill. Before backfilling, holes were punched in the basement floor to drain any potential rainwater infiltration. The aboveground metal ducts were removed and used as burial containers, and also buried in 200 West. Much of the building and contaminated rubble remain below minus 1 m (3 ft).
117-DR	Process Unit/Plant	100-DR-2	18 x 11.9 x 10.7	Demolished	1960	1986	Located directly south of the 105-DR Reactor, the 117-DR Filter Building was designed to filter ventilation air from the confinement zone of the reactor before being discharged into the atmosphere through the 116-DR Stack. The building housed blowers and particulate filter used to treat the ventilation exhausted for the 105-DR Building. Beginning in 1972, the northern half of the building was used as part of the Large Sodium Fire Facility. The site was decommissioned using ARCL methodology; filters, frames, and turning vanes were sent to the 200 Areas for burial; the duct roofs and upper portion of the walls were caved in then backfilled with clean earth (H-1-19835; H-1-19836). Much of the building, and contaminated rubble remain below minus 1 m (3 ft). In 1973, 117-DR, 119-DR, 105-DR (lunch room, restroom, and fan room only) were utilized by the HEDL to conduct sodium burning experiments to obtain data required in the design and operation of the FFTF. Experimental work was expected to be completed by June 1975 (AEC6121973).
119-D	Laboratory	100-DR-1	7.3 x 4.6 x 2.5	Not documented	1960	1986?	The 119-D Sample Building was built in 1960 and located over the ventilation ducts that connected from the 105-D Reactor to the 117-D Filter Building. The purpose of the building was to monitor the air quality of the exhaust that was released through the 116-D Stack. A small stream of air was diverted from the main flow and routed to this building for sampling. Two separate detectors were used to measure the quantity of airborne Iodine-131, including a fog-spray scintillation chamber detector and a halogen charcoal sampler system. An automatic filter sampler was used to measure the radiation levels in airborne particulate matter. The 119-D Building also housed equipment that measured the radiation levels, pressure differential, and air flow in the 117-D Filter Building. Abnormal readings from these various detectors would trigger alarms within the 105-D Building.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
119-DR	Laboratory	100-DR-2	5 x 8	Demolished	1960	1999	The 119-DR Building was a small corrugated metal shack on top of the stack air ducts. The building was used to monitor for radioactivity in the exhaust air that was released via the 116-DR Stack. A sample stream of exhaust air was routed through a continuous air monitoring system in the 119-DR Building. In 1973, the 119-DR Building was utilized by the HEDL to conduct sodium burning experiments to obtain data required in the design and operation of the FFTF. By 1984, the sampling equipment had been removed and the facility was being used by HEDL for the sodium burning experiments.
151-D	Electrical Substation	100-DR-2	24.4 x 9.1 x 3.3	Active	1944	N/A	The 151-D Electrical Distribution Switch House is located along the northern fence line of the 151-D Primary Substation. The 151-D Primary Substation supplied 13.8-KV electrical power to the 100-D and DR Areas. More than 100 concrete pads of various sizes protruded from the crushed gravel bed throughout the yard, supporting a variety of electrical equipment, including transformers, oil circuit breakers, and power line towers and stands. Up to five circuit breakers were also in service in the switchyard. PCB-containing oil was transferred from railroad cars through overground hoses and piping to these transformers and circuit breakers. The site is still active, although some electrical deactivation activities have been completed (as of 2006). Documentation of such events before 1985 was inconsistent. Aerial photographs taken over the past 50 years show what appears to be extensive dark soil staining. For these reasons, the switchyard should be considered contaminated with PCBs, until proven otherwise.
152-D	Electrical Substation	100-DR-1	Not Documented	Demolished	1944	Not Documented	Twelve secondary substations were located in the D-Reactor Area. Each secondary substation was constructed as an open wooden pole structure surrounded by picket fences. The 152 Structure associated with 181-D was replaced in 1955 with a new substation that was located closer to the Pump House, 152-E2-D.
152-DR	Electrical Substation	100-DR-2	Not Documented	Demolished	1950	Not Documented	During the construction of the DR Reactor, additional substations were built to service the new buildings. The transformers associated with 105-DR were located on the west side of the building. For 190-DR, the substation was on the east side. 183-DR had transformers between the head house and the reservoir. At least three facilities had transformer banks located near them, including 105-DR, 190-DR, and 183-DR.
153-D	Electrical Substation	100-DR-1	Not Documented	Not Documented	1944	Not Documented	Six distribution substations were located in the D-Reactor Area. Each distribution substation was constructed as an open wood pole structure surrounded by picket fences.
1601-D	Pump Station	100-DR-2	26.6 m^2	Active	1997	Not Documented	The 1601-D Facility was a pre-engineered metal building erected on a concrete floor slab. The facility housed pumping equipment, with a large water storage tank located just west of the building. The 1601-D Building was used to transfer well water extracted from Wells 199-D8-68, 199-D8-72, 199-D8-53, and 199-D8-54A to the 1713-H Building in 100-H for dichromate removal. Water was stored in the tank before being pumped in an aboveground pipe to 100-H.
1605-D	Control Structure	100-D	4.4 x 4.4 x 3.9	Demolished	1944	Not Documented	Ten guard towers were located in the D-Reactor Area, including one on top of the 181-D River Pump House. Guard towers were numbered 1605-D-1 though 1605-D-10. Each guard tower was located near the perimeter road. Each tower measured 4.4 m by 4.4 m by 3.9 m (14 ft by 14 ft by 13 ft) high, and was an elevated one-room, flat-roofed structure, with wood flooring, shake siding, searchlight, and external stairway access.
1608-D	Pump Station	100-DR-1	15.2 x 15.2 x 10.4 (with 3.7 m above grade and 9.8 below grade)	Demolished	1944	1967	The Process Waste Lift Station received wastewater from reactor drains, as well as fuel storage basin overflows. The facility was designed to pump these collected effluents to the 107-D Retention Basin. The facility served as a sump for the collection of liquid wastes and provided facilities for pumping water into effluent lines for disposal. It contained a valve room, four distribution sumps, and three pump sumps. The facility was demolished and buried in place, with work completed in 1987.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1608-DR	Pump Station	100-DR-2	11 x 10.4 x 13.5	Demolished	1950	1987	The Process Waste Lift Station received wastewater from reactor drains, containing trace amounts of low-level radionuclides (fission products and activation products) and decon chemicals (sodium fluoride, oxalic acid, citric acid). The facility contained three sumps to collect contaminated floor wastes. These liquid wastes were then pumped via a 41 cm-(16-in-) diameter pipe to the 107-D/DR Basins. The facility was demolished and buried in place, with work completed in 1987. Residual sump water went to 1325-N, and all solid wastes went to the 200 West burial grounds. Institutional controls are required to prevent uncontrolled drilling or excavation into the deep zone.
1614-D	Monitoring Station	100-D	2.1 x 2.1 x 3.0	Demolished	1944	Not Documented	The three buildings, numbered 1614-D1 through -D3, were each wooden facilities on a concrete pad, containing 3.7 m^2 (12 ft^2). Their function was to house the environmental monitoring equipment that sampled airborne process wastes.
1621-D	Electrical Substation	100-D	1.5 x 2.9 x 3.4	Demolished	1944	Not Documented	Three Emergency Gasoline Electric Generators were located in the D Area, 1621-DA through 1621-DC. Each contained a gasoline-powered electrical generator designed to automatically activate in the case of a power failure. Fuel was stored outside the building and placed on tall concrete saddles for gravity feeding.
1701-D	Office	100-DR-2	12.5 x 7 x 7	Demolished	1944	1990	This building was an area badge house and security patrol station designed to verify the identification of employees entering for work or anyone else entering the area and also used by employees to punch time clocks in the clock alley. It contained a guard room, equipment room, and clock alley on the first floor. The second floor contained a laboratory, two storage rooms, office, and restroom. The facility was demolished in 1990. Asbestos lagging was removed and disposed. The building was buried in the 183-H Clearwells.
1701-DA	Office	100-DR-1	7.6 x 7.6 x 3.7	Demolished	1966	1990	This facility replaced the 1702-D Gate House in 1966. The badge house served as an area badge house and security patrol station. It was a single-story, wood-frame building. In August 1974, it was rented to Battelle Northwest (BNW) to house computers.
1702-D	Office	100-DR-1	6.1 x 6.1 x 3.7	Not Documented	1944	1966	This one-story, wood-frame structure with shake siding, on a concrete pad, provided entrance to the D Reactor exclusion area. This building was replaced in 1966 with the 1701-DA Badge House during the D Area fence relocation project.
1702-DR	Office	100-DR-2	6.1 x 6.1 x 3.7	Demolished	1950	1994	The 1702-DR Building is a one-story wood-framed structure with a concrete floor and foundation. The 1702-DR Area Badge House provided a sheltered security check point for entrance to the 105-DR Exclusion Area. During a 2006 field walkdown, no visual evidence of this facility was found.
1703-D	Office	100-DR-1	52.1 x 10.1 x 6.1	Demolished	1951	1993	One-story, L-shaped wood-frame on concrete pad with shake siding. Main offices for area administrative and technical personnel. Utilized after reactor shutdown to support research and development for the 100-N Reactor. Also contained the Engineering Library. In 1973, the office building was being used by personnel involved in the Plenum Filling Experiments. BNW was to vacate this building at the completion of their test program in June 1975, and the United Nuclear Industries (UNI) engineers following the final shutdown of the N Reactor.
1704-D	Office	100-DR-1	44.8 x 35.4 x 7.9	Demolished	1944	1979	This building is a wood-frame, T-shaped structure on a concrete pad with shake siding. It contained 28 offices, concrete-enclosed laboratory, regular laboratory, locker room, air conditioning equipment, and restrooms.
1707-D	Office	100-DR-1	9.1 x 20.3 x 4.9	Demolished	1944	1975	This building was a one-story, wood-frame structure on concrete pad with asbestos siding. It was originally used as a change house, then finally as an office for Hanford Labs personnel. The building included a locker room, lunch room, wash room, shower room, hot water heater room, restroom, and three vestibules.
1707-DA	Office	100-DR-1	9.1 x 20.3 x 4.9	Demolished	1944	Not Documented	This building is a wood frame on concrete slab structure with shake siding. It contained lockers, showers, and lunch room facilities.
1709-D	Office	100-DR-2	15.5 x 12.9 x 3.9	Demolished	1944	Not Documented	A one-story, wood-frame structure on concrete pad with shake siding. It was originally the fire headquarters, but later used as a technical lab for radiation protection and ambulance parking. It contained garage space for three fire trucks, a hose room and hose tower, a fire extinguisher filling room, dormitory, office, restroom, and kitchen.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1712-D	Storage	100-DR-1	61.2 m^2	Demolished	Not Documented	1993	The 83 m^2 (270 $ft^{2)}$ Instrument Warehouse was attached to the 1713-D Store House, and provided instrument equipment storage. In 1973, the 1712-D Building was used for storage of instruments and only one item remained in the building.
1713-D	Laboratory	100-DR-1	23.5 x 16.5 x 5.0	Demolished	1944	1975	This single-story, wood-frame on concrete slab with asbestos shake siding measured 24.8 m by 17.4 m by 5 m (81 ft by 57 ft by 16 ft) high. It was originally a storeroom and warehouse, and later provided technical office and laboratory space. In about 1958, it was converted to an instrument/electrical development laboratory; it provided light lab facilities and technical offices for the strategic materials production mission including electronic system and instrument developmental work, system testing, system analysis and calibrations for the safety systems, and instrumentation on the reactor. In 1973, the equipment in the 1713-D Building was being used by UNI Instrument Engineering in support of the 105-N Reactor in the area of instrumentation. The equipment was normally used on day shift and plans had been formulated to move this equipment to the N Reactor by 1975.
1713-DA	Storage	100-DR-1	24.4 x 64.4	Demolished	Not Documented	Not Documented	The Essential Materials Storehouse was converted from the Temporary Construction Receiving and Warehouse Building, TC-31, with a wooden frame and a post-and-girder construction (HAN-10970, *Construction of Hanford Engineer Works: History of the Project*). In addition, three loading docks were associated with the building.
1713-DR	Storage	100-DR-2	30.5 x 12.2 x 4.9	Demolished	1950	Not Documented	Single-story frame structure on concrete slab and slip-lap siding, with a wooden unloading platform. It was used for storage of essential materials, spare parts, and testing equipment.
1714-D	Storage	100-DR-1	67.51 m^2	Demolished	Not Documented	1979	This building was used to store solvent materials. No information is available regarding the quantity or type of chemicals it housed. The exact size and construction of the 1714-D Building is unknown. The building was demolished in 1978-1979 and buried in the 100-D solid waste landfill. According to DOE/RL-89-09, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-1 Operable Unit, Hanford Site, Richland, Washington*, solvent materials inside the building were taken to other areas prior to its destruction.
1714-DR	Storage	100-DR-2	13 x 26	Demolished	1950	Not Documented	A sheet metal Butler building on concrete slab; only used for storage; had no services.
1715-D	Storage	100-DR-1	12.8 x 4.3 x 5.5	Demolished	1944	Not Documented	Single-story frame on concrete foundation, with asbestos shake siding. Oils, paints, and solvents used for maintenance were stored in the building. Contained two rooms; one for paint storage and one for oil storage.
1716-D	Maintenance Shop	100-DR-1	16.3 x 12.2 x 5.5	Demolished	1944	1978	Single-story frame on concrete slab, with asbestos shake siding. The “L”-shaped building contained one large rectangular room and a small adjoining room. Potential for solvents, gasoline, battery, and automotive coolants in the soil around the facility and in drains. In July 1978, it was excessed and removed except for the foundation.
1717-D	Maintenance Shop	100-DR-1	45.7 x 24.4 x 7.6	Demolished	1944	1978	A single-story frame on concrete slab with asbestos shake siding and housed carpenters, millwrights, welders, and painters. A large machine shop, a pipe shop, and a forge shop occupied one end of the building, while the carpenter shop, electric shop, and sheet metal shop occupied the other end. Offices and a tool room were located in the central part of the building. A 2-ton monorail crane and hoist ran the entire length of the building between the shops, while a second monorail perpendicular to the first extended above the electric shop. Contamination within the building was reported as up to 200 c/m on flanges and pump impellers and approximately 2.5 mrep/hr on a tool box and tray in 1947. Upon demolition, useable portions were sold; foundation, floor, roof, and siding were disposed of in the 184-D Coal Pit.
1719-D	Office	100-DR-1	25.0 x 7.8 x 5.9	Demolished	1944	1978	Single-story frame on concrete slab with asbestos shake siding. Contained first aid room, examination room, laboratory, ward, office, and sanitary facilities. In 1978 it was excessed, dismantled, and removed. The 1719-D Annex was a 12.3 m by 3.9 m (40.4 ft by 13 ft) structure of similar construction to 1719-D Building, which served as a storage building for janitorial supplies. It had a flat-topped roof, and was also believed to be where document duplicating was conducted.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1720-D	Office	100-DR-2	24.1 x 9.8 x 4.6	Demolished	1944	Not Documented	A single-story frame on concrete with asbestos shake siding. It served as patrol and security headquarters for the D Area. The building included a locker room, assembly room, two offices, shower room, wash room, hot water heater room, toilet, and telephone room.
1720-DR	Storage Tank	100-DR-2	7.3 x 4.9 x 4.9	Removed	1971	1997	1720-DR was a single-story steel building located near the 105-DR Reactor Building. This facility was used to store sodium for the sodium fire project in the 105-DR Reactor Building. Initially 17,400 L (4,600 gal) of sodium was purchased for this facility in the early 1970s. The majority of the interior was filled with a large sodium storage vessel. Inside the building, the concrete foundation was covered with 3.8-cm- (1.5-in.-) thick sheet metal to protect it from contact with molten sodium. The sodium tank itself measured approximately 4.6 by 2.4 m (15 ft by 8 ft) and could hold up to 22,700 L (6,000 gal) of liquid sodium. No services such as heating, ventilation, or electricity were provided for the building. As of 1995, none of this sodium had been used and it all remained frozen in the tank.
1722-D	Maintenance Shop	100-DR-1	12.2 x 9.1 x 4.6 12.9 m x 9.7 m x 4.8 m high	Demolished	1944	1993	A single-story frame on concrete slab with asbestos shake siding. Contained a riggers loft and paint storage room. The facility provided auxiliary capability for small repair jobs on 100 Area equipment and parts. Was originally temporary construction building TC-30, Electrical Shop. Converted to Equipment Development Lab about 1958, and included light lab facilities, setup, and assembly work space for systems and equipment development supporting the strategic materials production mission at 100-N. In 1973, the building contained a small chemical and materials laboratory used by the UNI Engineering Section to investigate the chemistry of processes and materials in support of 105-N Reactor operation. A small maintenance shop in this building was used by UNI engineers to test and adjust prototype tools and equipment for use on the N Reactor. Technical baseline document (WHC-SD-EN-TI-181, *100-D Area Technical Baseline Report*) stated there is a potential for solvents and paint contamination in the soil and drains. Contamination within the building was reported as up to 2.5 mrep/hr on a rope, and 900 c/m on two safety bolts in 1947.
1722-DA	Maintenance Shop	100-DR-1	24.4 x 43.9 x 4.0	Demolished	1944	1945	This facility was originally the temporary construction building TC-31 Millwright Shop. Unlike many of the other TC buildings, the floor of this facility was partially made of concrete.
1724-D	Laboratory	100-DR-1	112.44 m^2	Demolished	1963	1995	Attached to the southeast side of the 190-D Building, the 1724-D Underwater Test Facility (also known as the Fuel Discharge Test Facility) was built above the 190-D Reuse Water Reservoir. The facility was designed to conduct trials directed at improving the irradiated fuel discharge procedures at the N Reactor. The "tip-off" testing was conducted because of the fuel-retention problems that the tip-offs were designed to prevent during discharge. The other problem concerned the "trampolines" (chain-link metallic nets) that were installed to break the fall or irradiated fuel elements as they were discharged into the basins. Among the issues examined were new springs for the trampolines, new tip-off designs and installation procedures, anti-flush devices, and design criteria for a new automatic refueling system. The facility was demolished in 1994-1995. Visual evidence of a foundation was recorded during the 2006 field walkdown.
1724-DA	Pump Station	100-DR-1	34.7 x 17.1 x 11.9	Demolished	1949	1995	This facility was built in 1949 as an extension to the 190-D Building. It included three new pumping units, and was designed to support the 105-DR Reactor building. Two fan rooms and two air conditioning units were required for ventilation. In the original 105-DR Reactor plans, process water was to be pumped through an underground tunnel from this facility. However, the 190-DR Building appears to have superseded the original purpose of this facility, and there is no indication that the 190-D Extension was ever used to support the DR Reactor. Later on, this facility appears to have been renamed to 1724-DA, in support of the nearby 1724-D Underwater Test Facility. It is unclear what sort of tests would have been conducted in this facility.
1725-D	Office	100-DR-1	18.3 x 7.3	Removed	1983	Not Documented	The 1725-D Building was one of several mobile offices that were placed in 100-D circa 1983. It was used as an office for engineering personnel in 100-D.
1726-D	Office	100-DR-1	7.1 x 15.1	Removed	1983	Not Documented	The 1726-D Building was one of several mobile offices that were placed in 100-D circa 1983. The 1726-D Building was used as a conference facility while it was located in 100-D.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1727-D	Office	100-DR-1	115.9 m^2	Removed	1983	Not Documented	The 1727-D Building was one of several mobile offices that were placed in 100-D circa 1983. The 1727-D Facility was used as an office for engineering personnel in 100-D.
1728-D	Office	100-DR-1	7.1 x 15.1	Removed	1983	Not Documented	The 1728-D Building was one of several mobile offices that were placed in 100-D circa 1983. The 1728-D Building was used as a lunch room facility for personnel in 100-D.
1729-D	Storage	100-DR-1	12.2 x 54.9 x 3.4	Demolished	1944	Not Documented	The 1729-D Building was originally the TC-30 Pipe Storage Warehouse for 100-D. It had a wood-frame and post-and-girder construction with a shed roof. It was originally used as a pipe storage facility during the initial construction of 100-D. After 1945, it was used to store extra machinery. No visual evidence of the facility was noted during the 2006 field walkdown.
1729-DA	Office	100-DR-1	119.25 m^2	Removed	1983	Not Documented	The 1729-D Building was one of several mobile offices that were placed in 100-D circa 1983. The 1729-D Facility was used as an office for engineering personnel in 100-D. The facility code 1729-DA is being used to differentiate this facility from the 1940s 1729-D Building.
1730-D	Office	100-DR-1	Not Documented	Removed	1983	Not Documented	The 1730-D Building was one of several mobile offices that were placed in 100-D circa 1983. It was a double-wide trailer facility that was located between the 190-D and 1704-D Buildings. The 1730-D Facility was used as an office for engineering personnel in 100-D.
1731-D	Office	100-DR-1	186.9 m^2	Removed	1983	Not Documented	The 1731-D Building was one of several mobile offices that were placed in 100-D circa 1983. It was a double-wide trailer facility that was located east of the 1703-D Building. The 1731-D Facility provided computing workspace for engineers in 100-D.
1734-D	Storage	100-DR-1	7.3 x 3.1 x 3.7	Demolished	1944	Not Documented	The walls, which were open at both the bottom and top of the structure, were vertical 2.2 cm (0.87-in.) tar and gravel sheathing. The flat, built-up roof that overhung the sides and ends of the building had a tar and gravel surface. The building contained four small cylinder storage spaces; one for live oxygen storage, one for live hydrogen and acetylene storage, and two for dead cylinder storage. Within each storage area were wooden storage racks, cylinder-shaped to fit the curvature of the cylinders. During the 2006 field walkdown, the foundation was observed and recorded.
1735-D	Office	100-DR-1	23.5 x 16.5 x 5.0	Demolished	1944	1944	Originally temporary construction building, TC-31, Division Engineer's Office. This is the only training facility built in the 100 Areas. Its function was to provide a training center for personnel to receive instruction in safety, reactor operations, company policies, and other required training course work. No visual evidence of this facility was found during the 2006 field walkdown.
1760-D	Office	100-DR-1	38.5 x 10.6 x 8.7	Removed	Not Documented	1974	The 1760-D Building was a two-story, wood-frame structure with drop siding, concrete slab, and concrete blocks. It was formerly a barracks facility before being moved to 100-D in 1957. The 1760-D Building was used as an office facility in 100-D. The 1760-D Building was removed from 100-D in 1974, when it was transported to the 300 Area and became the 3764 Facility.
1784-D	Office	100-DR-1	9.3 m^2	Removed	Not Documented	Not Documented	The Coal Handler Building was likely used as a change room.
181-D	Pump Station	100-DR-1	55.0 x 20.6 x 25.8	Active	1944	N/A	The river pump house is located on the east bank of the Columbia River, 350 m (1,148 ft) west of the 182-D Reservoir. A guard tower was erected on the roof. The facility originally supplied water from the Columbia River to the reservoir as well as the 183-D and 183-DR Filter Plants. Pumps were vertical deep well types with submerged bowls and impellers. A water intake channel was dredged in front of the pump house and lined with rock and concrete to form a forebay. When it was modified in 1950 to support simultaneous operation of the D and DR reactors, five more 52,000-L (13,700-gal) per minute pumps were added, which were controlled remotely from the 183-D Head house. In 1973, the water pumping facilities were assigned to Atlantic Richfield Hanford Company (ARHCO) and were utilized to supply fire and service water to the 100-D and 100-F Areas and for backup supply for the export water system to the 200 Areas. As of 2006, it still supplies water to the 182-D Reservoir, which serves as the 200/300 Areas backup export water system.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
182-D	Process Unit/Plant	100-DR-1	157.9 x 131.7 x 5.5 139 x 167 x 6	Active	1944	N/A	The facility is due west of the 183-D Filter Plant. The reservoir is a rectangular, sloped, reinforced-concrete basin, varying from 0.2 m (0.7 ft) to 0.3 m (1 ft) thick and holds 95 million L (26 million gal). The pump house is below grade, reinforced concrete, and concrete block. Raw river water arrived from the 181-D River Pump House where it was chlorinated, and stored in the working or reserve reservoir to be provided to the D and DR Filter Plants. In 1973, the water pumping facilities were assigned to ARHCO and were utilized to supply fire and service water to the 100-D and 100-F Areas and for backup supply for the export water system to the 200 Areas. The 182-D South Reservoir was also leased from the Atomic Energy Commission (AEC) by BNW for use in conducting oil containment experiments for the government and for privately sponsored customers. It currently (2006) is the backup to 182-B for 200 Areas export water. Although the throughput is greatly diminished from what it was during reactor site operations, the facility is mostly intact. The water level is kept below a known leak site in the reservoir. There were no plans to vacate this facility.
183-D	Process Unit/Plant	100-DR-1	19,734.3 m^2	Inactive	1944	N/A	The 183-D Filter Plant, located directly west of the 105-D Reactor Building, was designed to treat raw river water before it entered the reactor. As of August 2006 it is inactive, but still intact. It consists of the following structures: Head House, Flocculation and Sedimentation Basins, Filter Building, and Clearwells and Pump House. Water from the 182-D Reservoir was pumped to the Flocculation Basins, where water treatment chemicals (chlorine, sulfuric acid, flocculants, and lime) were added from the Head House. The treated water then passed to the adjacent Sedimentation Basins where heavier particulate matter was settled out before the filters. The treated and settled water then overflowed the sedimentation basins into the filters in the Filter Building. The filters were layers of anthracite coal, sand, and gravel. The clarified process water then gravity fed into the underground Clearwells for temporary storage. Finally, the process cooling water was pumped on demand to storage tanks in the 190-D Building. Filtered water also supplied the two 105-D high tanks that were used for emergency loss of cooling water. After 1950, it was cross-tied to 183-DR. In 1993, two sections of the flocculation system remained in service, providing sanitary water to the remaining occupied facilities at 100-F, 100-H, and 100-D, including the fire lines. In 1973, the water pumping facilities were assigned to ARHCO and were utilized to supply fire and service water to 100-D and 100-F and for backup supply for the export water system to the 200 Areas. The majority of the facility superstructure remains intact, including the head house, flocculation basins, and filter plant.
183-DR	Process Unit/Plant	100-DR-2	11,626.25 m^2	Demolished	1950	1978	The 183-DR Filter Plant was designed to treat raw river water before it entered the reactor. It consisted of the following structures: Head House, Flocculation and Sedimentation Basins, and Filter Building. After 1950 it was cross-tied to 183-D. The head house was a three-story concrete-block building used for the storage, preparation, and addition of alum, sulfuric acid, ferrous sulfate, sodium dichromate, sodium silicate, and chlorine for water treatment. It also contained a chlorine room, laboratory, restrooms, janitor's room, electrical switchgear room, and locker room. Attached to the head house were two, 3 m- (9.8-ft-) diameter 16 m- (52.5-ft-) high silos for storage of lime and ferrous sulfate. Water from the 182-D Reservoir was pumped to this facility where the water was filtered and treated. The process cooling water was then pumped on demand via the 190-DR Complex to the reactor. Process water was also supplied the two 105-DR High Tanks, for emergency loss of cooling water. In 1978, the head house was excessed and removed except for the foundation. It was buried in the sedimentation basins, and the basins were backfilled. During deactivation, the floc basins were cleaned out of silt and beta gamma readings were less than 500 c/m. Demolition debris was placed in the tank pit and sedimentation basins.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
184-D	Process Unit/Plant	100-DR-1	14,992.47 m^2	Demolished	1944	1979	The facility contained the main power house, ash removal system, boiler feed water system, two (three after 1950) 97 m (300-ft) concrete smoke stacks, coal handling system, crusher house, two transfer houses and track hoppers, open coal pit salt dissolving pit, and brine pump house, electrical system, piping system, steam generation, and water treatment system. The building contained three floors covering 5,290 m^2 (491.5 ft^2) and included a conveyor ramp. The 184-D Building powerhouse provided steam throughout 100-D and emergency electrical power for the secondary coolant systems located in 181-D, 182-D, 183-D, 190-D, 181-DR, 183-DR, and 190-DR. It also supplied office heat and other heating needs through overhead steam lines that looped throughout 100-D. A small turbine generator in the building also supplied emergency power for the area building lights and motors. In 1978, the steam poles were removed and sold at a public sale. The anchor blocks were pulled out of the ground and buried in the 184-D Coal Pit. In the same year, the stacks were demolished using explosives. The stacks fell on the ground and were pushed into the coal pit. The 184-D Power House was sold in fiscal year 1979. The equipment was removed and the building demolished to grade level. Prior to final decommissioning, Operational Health Physics conducted initial site surveys and found no significant radioactivity above background. Final decommissioning for the 184-D Power House began the second week of February 1988. The power house foundation and pad were demolished and the waste buried in situ.
184-DA	Process Unit/Plant	100-DR-1	331.02 m^2	Demolished	1968	Not Documented	The 184-DA Building was a metal building constructed about 1968 and was designed as a steam-generating facility. The facility contained a steam generator, fuel oil storage tank, fuel oil pump, deaerator, water softener, chemical treatment, fuel tank, steam separator, heater, diesel generator, liquid level gauges, and steam flow meter. A 1,900-L (500-gal) fuel oil tank was located near the southeast corner of the 184-DA Building. Within the floor of the 184-DA Building were three trenches that contained pipelines used to transport fuel oil and vent lines associated with the fuel oil tanks. In 1973, the building was assigned to ARHCO and contained a package boiler that was used to provide steam heat for the occupied facilities in 100-D, and steam for turbine-driven pumps in 183-D that are used to provide fire and service water to the areas in case of electrical power outage. The facility was required to remain in service as long as the area was occupied.
185-D	Process Unit/Plant	100-DR-1	93.3 x 14.6 x 55.5 99 x 15.5 x 19.4	Demolished	1944	1994	The 185-D De-aeration Building and the 189-D Refrigeration Building were parts of the original Hanford Site construction in 1944 and shared a common wall. It was originally intended as a deaerating plant for the reactor cooling water, but was never used for this purpose. Instead, a sodium dichromate system was located in the 185-D Building. It consisted of mixing facilities, transfer pumps, feed tanks, and injection pumps. After the reactors shut down, it was converted to laboratories in support of the 100-N Reactor. UNI operated a New Production Reactor (NPR) loop facility that was the original test facility for the N Reactor. PNL operated a thermal hydraulics lab to study critical heat flux, boiling studies, two-phase pressure drop, etc. It also contained numerous shop and crafts facilities and storage areas. Potential contaminants include solvents, paints, and radioactive contaminants. In 1993, two electrical transformers and an electrical reactor located in the 185-D/189-D combined facility began to leak. All three contained PCB dielectic fluid at 560,000 ppm. The building was inactive, thus, the decision was made to remove all three units. In 1994, the facility was demolished and the subgrade foundations removed to 0.9 m (3 ft) below grade. Sodium dichromate was found in the acid trench and sump in the eastern portion of the facility. Sodium dichromate was present at depths greater than 0.9 m (3 ft) under the trench sump.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
186-D	Process Unit/Plant	100-DR-1	216 x 41 x 28 176 x 18 x 10 (clearwell with associated pump room, 7 below grade)	Demolished	1944	1979	Unique to D Area, this facility was originally intended as a demineralization system for reactor cooling water, but was never used for that purpose. It was a two-story steel frame and concrete block structure on reinforced-concrete foundation. Along the west wall was an acid-proof brick trench approximately 1 m (3 ft) deep by 2 m (6 ft) wide and running nearly the entire length of the facility. It also had an acid reservoir on the west side. Along the east side is the Clearwell. Adjacent to and east of the center portion of the Clearwell is a pump house that contained seven stainless steel corrosive water pumps. Directly above this pump house were the electrical rooms containing the switchgear equipment. The facility was later used as a warehouse by three of the Hanford contractors. The facility was demolished in 1979. No written documentation has been found concerning the disposal of the lead flashing that was used in the construction of the waste acid reservoir (Waste Site 120-D-2), but it is assumed the lead flashing was disposed in situ during the demolition of the 186-D Facility.
187-D1	Storage Tank	100-DR-1	256.8 m^2	Demolished	1944	Not Documented	There were two elevated process water tanks in the D-Reactor Area. The tanks were located near and on opposite sides of the 105-D Reactor, and provided emergency cooling water to the reactor. The tanks were of identical design and constructed of 0.0095 m- (0.03-ft-) thick steel plate. Each tank was 12.5 m (41 ft) in diameter, 11.9 m (39 ft) high, with a capacity of 1,140,000 L (301,000 gal). Each stood 51.6 m (169 ft) above grade, and had a 1.5 m- (5-ft-) diameter central riser.
187-D2	Storage Tank	100-DR-1	Not Documented	Demolished		Not Documented	Two elevated process water tanks were located in the D-Reactor Area. The tanks were located near and on opposite sides of the 105-D Reactor, and provided emergency cooling water to the reactor. The tanks were of identical design and constructed of 0.0095 m- (0.03-ft-) thick steel plate. Each tank was 12.5 m (41 ft) in diameter, 11.9 m (39 ft) high, with a capacity of 1,140,000 L (301,000 gal). Each stood 51.6 m (169 ft) abovegrade, and had a 1.5 m- (5-ft-) diameter central riser.
187-DR1	Storage Tank	100-DR-2	127.86 m^2	Demolished	1950	1964	Two elevated process water tanks were located in the DR-Reactor area. The tanks were located near and on the north and south sides of the 105-Reactor. The tanks were of identical design and constructed of 0.0095 m- (0.03-ft-) thick steel plate. Each stood 50 m (164 ft) above grade, and had a 0.4 m- (1.3-ft-) diameter drain. These tanks contained emergency cooling water for the 105-DR Reactor in the event the normal flow of cooling water was disrupted.
187-DR2	Storage Tank	100-DR-2	128.95 m^2	Demolished	1950	1964	Two elevated process water tanks were located in the DR-Reactor Area. The tanks were located near and on the north and south sides of the 105-Reactor. The tanks were of identical design and constructed of 0.0095 m- 0.03-ft-) thick steel plate. Each stood 50 m (160 ft) above grade, and had a 0.4 m- (1.3-ft-) diameter drain. These tanks contained emergency cooling water for the 105-DR Reactor in the event the normal flow of cooling water was disrupted.
188-D	Coal Ash Pit	100-DR-1	79.2 x 88.4 x 4.1 84 x 94 x 4.5	Inactive and will remain in place. The waste site (126-D-1) associated with this site is rejected.	1944	Not Documented	Ashes were pumped directly from the sluice pit in the power house to the basin by means of a 0.2 m (0.7 ft) cast-iron underground pipe line. The basin had a 0.3 m (1 ft) overflow pipe that connected to the process sewer system. The site was modified in 1979 to form a two-compartment pond, one overflowing to the other. The north pond was a percolation pond and the south pond was a settling pond. Named the 100-D Ponds, they received corrosive waste from the regeneration of ion exchange columns located in the 185/189-D Complex. The ponds also received non-hazardous 183-D sandfilter backwash, small quantities of filtered chlorinated water from hydraulic test loops, and fuel discharge trampoline tests. In August 1996, contaminated sediment was removed from the 100-D Ponds as part of a DOE/RL voluntary cleanup action (DOE/RL-92-71, *100 D-Ponds Closure Plan*). Sampling indicates the potential for mercury and PCB contamination.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
189-D	Process Unit/Plant	100-DR-1	93.6 x 23.2 x 16.2	Demolished	1944	1995	The 189-D Facility was one of the original structures built in 1944 that became known as the 190-D Complex. The 190-D Complex was extensively modified to become a research and development laboratory for all of the plutonium production reactors at the Hanford Site. The facilities were heavily modified from their original as-built conditions, as only the outer structures and foundations remained from the original construction. The 190-D Complex was shut down following the closure of the N Reactor in 1987 and 1988. Several types of hazardous materials were present in the 190-D Complex. These materials included asbestos-containing materials, PCBs, lead, oils, sodium dichromate, and mercury. These contaminants were integral parts of the original. The facility was demolished by 1995, along with the other buildings associated with the 190-D Complex. No visual evidence of the facility was found during the 2006 field walkdown. The 190-D Complex was extensively modified to become a research and development laboratory for all of the plutonium production reactors at the Hanford Site.
1901-D	Storage Tank	100-DR-1	36.6 (height) 283,900 L (capacity)	Demolished	1944	1954	The 1901-D Soft Water Tank was an elevated cylindrical storage tank with a conical roof. Water from the 183-D Filter Plant was pumped to the 184-D Power House, where it was conditioned into soft water, stored in this high tank, then used as feed water for the power house boilers.
1902-D	Storage Tank	100-DR-1	36.6 (height) 283,900 L (capacity)	Inactive	1944	Not Documented	The 1902-D Sanitary Water Tank was an elevated cylindrical storage tank with a conical roof. Water was pumped from the 183-D Filter Building to this high tank, where its primary function was backup water for the fire system in the D Area.
1904-D	Outfall	100-DR-1	8.2 x 4.3 x 7.9	Demolished	1944	1998	The 1904-D Outfall was a concrete feature that received reactor effluent water from the 107-D Retention Basin and discharged into the river. After the construction of the DR Reactor, the DR effluent pipelines were also cross-tied to this outfall structure as an alternate to the 1904-DR Outfall used in 1975 for the disposal of 100-D process sewer effluents. The outfall structure was demolished in 1998 and backfilled with clean soil. During a 2004 geophysical investigation of the site, it was noted that there were large areas of what were believed to be buried remains from the outfall structure. During a 2005 field walkdown, there was no visible evidence of the structure. COCs include C-14, Cs-137, Sr-90, U-235, U-238, and Pu-239/240.
1904-DR	Outfall	100-DR-1	Not Documented	Inactive	1950	1978	The 1904-DR facility consists of three major components: an outfall structure, a spillway, and a river effluent pipeline. Process cooling water effluent was transferred from the 107-D and/or 107-DR Retention Basins to the outfall structure. During routine operations, the effluent gravity flowed from the outfall structure to the bottom center of the river via the river effluent pipeline. During upset conditions or maintenance activities, the effluent could be diverted to the river's edge via the spillway. No evidence was found that the spillway was ever used. The outfall fence and aviary were removed. The structure was demolished and backfilled with soil in 1978. At the same time, the majority of the spillway was covered with soil. During 2004, a radiological survey was conducted along the D Area shoreline, utilizing the Global Positioning Environmental Radiological Surveyor (GPERS) mobile sodium iodide crystal. No gamma readings above background were found in the vicinity of the spillway.
1907-DR	Outfall	100-DR-1	Not Documented	Demolished	1949	1978	The outfall structure was part of a spillway for an emergency discharge for the DR Reactor. It was used to discharge wastewater from the 183-DR and 190-DR Water Treatment Facilities and from rain runoff drains. Discharges to this outfall ceased in 1968, and the structure was demolished in 1978. There was potential for radioactive contamination from 100-D Cask Pad storm drains. In 1996, four characterization test pits were excavated. No radiological contamination was found in any of the pits during field screening. Field screening of soil samples did not detect any chemical contamination. Analytical results of the soil samples showed the presence of hexavalent chromium at the lowest detection limit of 0.5 mg/kg.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
190-D	Pump Station	100-DR-1	190-DA Annex: 60 X 24 x 10	Demolished	1944	1995	The 190-D Complex was constructed as a process water treatment plant that supplied the 105-D Reactor with non-radioactive cooling water. The 190-DA Annex was constructed to increase the pumping capacity of the 190-D Main Pump House and thus provide additional cooling water to the 105-D Reactor. The Annex contained eight 37,850 L/min pumps. After the reactor shut down in 1967, it became a service building, containing several large test mock-ups, material storage for the 185/189-D Labs, and a large bay for fabrication assembly. It supported the development work, testing, and training needed to support the N-Reactor. In 1978, the tanks and associated piping and equipment were excessed and removed. The building and all associated facilities were demolished during 1994-1995. During the 2006 field walkdown, one small foundation was observed near the southeast corner of the facility.
190-DR	Pump Station	100-DR-2	14,299.67	Demolished	1950	2005	The Main Process Water Pump House consisted of the four 14-million-L (3.75-million-gal) process water storage tanks, the original Pump House, and the Pump House Annex, which pumped process cooling water to the 105-DR Reactor. Treated process water was gravity fed from the Filter Building into the storage tanks located in the tankwell pit. The water was then pumped via the pump house and annex to the DR Reactor as needed for core cooling. All process water treatment chemicals, including dichromate, were added prior to the storage tanks. Unlike process water treatment plants at other reactor sites, there were no clearwells associated with 183-DR. Concentrated dichromate solution was pumped via an overhead line from the head house, across the flocculation basins, and discharged into a mixing flume that ran the width of the Filter Building. The mixing flume gravity fed the process water storage tanks. Prior to demolition, all friable asbestos was removed, including all asbestos-containing material and all potential asbestos-containing material from ventilation fan housings, pipes, and loose materials that had fallen to the ground. Additionally, biological hazards (i.e., bird droppings, small dead birds, and eggshells) were removed. The debris went to ERDF. In spring 2005, the above-grade portion of the facility was demolished and the below-grade portion of the facility was demolished to 1 m (3 ft) below grade. The remainder of the concrete substructure was left in place. The two valve houses were also demolished. The water tunnels were left in place and are currently being used as bat habitat. All of the piping was removed and recycled. After the tanks were removed from the tankwell pit, the area was used as a dump site for decontamination and decommissioning (D&D) rubble and pipe insulation containing asbestos. This site was also suspected of containing hazardous materials, including low-level radioactive waste because of uncontrolled dumping. Other waste that has been observed includes paint and solvent cans, oil drums, sodium dichromate crystals, alum, creosote drums, herbicide cans, carbon tetrachloride containers, methanol containers, acetone containers, welding materials, laboratory glassware, furniture, and other solid wastes. This site may contain chromates in both the soil and underground piping.
195-D	Test Facility/ Component	100-DR-1	84.88 m^2	Demolished	1957	1995	The structure was a steel tower built to replace the original wooden vertical safety rods (VSR) at White Bluffs. It was built next to 189-D because that is where the rest of the pile technology work was occurring. The facility was used to test vertical safety rods and associated equipment. It was later converted into a ball drop test tower, testing all aspects of the safety ball system including ball hoppers, channel, and the balls themselves. Following these tests, very little work was done in the building. The tower was needed until the N Reactor was shut down. The tower was demolished on August 17, 1995. No visual evidence of the building was found during the 2006 field walkdown.
MO-200	Office	100-D	6 x 15	Demolished	Not Documented	2006	The MO-200 Building was originally located in 100-N, where it was known as the 1153-N Building. In the late-1990s it was moved to a site near ERDF, and it was relocated to 100-D on April 29, 2000. It was a double-wide trailer used as an office facility in 100-D. In particular, the building was used to support In Situ Redox Manipulations (ISRM) operations. It was also used to house equipment relating to the nearby microwave pole. The MO-200 building was demolished in 2006 by the Washington Closure Hanford (WCH) Reactor Interim Safe Storage (RISS) group. Ten containers were used to transport 60 cubic meters of waste to ERDF.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
MO-225	Office	100-D	2.4 x 3.0	Inactive	1980	N/A	The MO-225 Building was originally located in 200-W, where it was associated with the 233-S Facility. It was most likely relocated to 100-D in 2000. The MO-225 Building had been used as a counting trailer in 200-W, so it is possible it served a similar purpose in 100-D. The trailer and the items within have no history of being exposed to contamination. The only time during which it had known associated radiological controls was between February 1991 and July 1992, when it was used to store soil samples from low-risk wells.
MO-374-D	Office	100-D	2.4 x 7.3	Demolished	Not Documented	Not Documented	MO-374 was a single-wide modular office trailer building. MO-374 had previously been located in 100-N (DOE/RL-96-91, *N Reactor Comprehensive Treatment Report*) and 200-W (HPCR201R). It likely contained various kinds of detectors and laboratory equipment. The MO-374 Building was used at 100-D in support of the ISRM project. It is labeled as "Mobile Lab Trailer" in drawing 0100D-DD-E0083, suggesting the building may have contained laboratory equipment in addition to providing office space. According to Pacific Northwest National Laboratory (PNNL) Contract No. DE-RP27-07RV14800M, *Tank Operations Contract*, the MO-374 building has been removed from the site.
MO-399	Office	100-D	Not Documented	Not Documented	Not Documented	Not Documented	Not Documented
MO-422-D	Office	100-D	3.7 x 9.8	Removed	Not Documented	2007	The MO-422 Building was a single-wide modular office trailer. Before being located in 100-D, the MO-422 Facility had been located in 200-W. It served as the Field Support Trailer in 100-D. The MO-422 Building was disconnected from utilities in late 2006 or early 2007. In 2007, it was relocated to 100-K.
MO-544-D	Office	100-D	2.4 x 9.8	Removed	Not Documented	2005	The MO-544 Facility was originally located in 200-W in the mid-1990s and was later moved to the 100-F Area, before it was eventually relocated to 100-D in 2004. It was a single-wide trailer building and was used as an RCT Office Building while at 100-D. MO-544 was relocated to 100-N in 2005.
MO-561	Office	100-D	156.1 m^2	Demolished	Late 1970s or early 1980s	2006	The MO-561 Building was most likely constructed in the late 1970s or early 1980s and was previously located in the 300 Area. MO-561 was the central support facility for 100-D during remedial action activities. Its primary purpose was to provide office space for administrative personnel. The facility was relocated from the 300 Area to 100-D in 1996. Sampling conducted in 1997 determined the MO-561 Facility contained asbestos. In 2002, an underground septic holding tank was installed to the northwest of the building to support the restrooms within the facility. The MO-561 Building was demolished in 2006.
MO-718	Office	100-D	2.4 x 4.3	Removed	Not Documented	2006	This was a single-wide modular office building. The MO-718 Building was originally located at 200-E, where it served as a lunch room trailer. The purpose of the MO-718 Building at 100-D is unknown. It may have served as a lunch room. The MO-718 Building was removed from 100-D prior to 2006 (Fluor facility listing).
MO-758	Office	100-D	18.3 x 7.3	Removed	Not Documented	2004	MO-758 was a modular office facility. The MO-758 Facility was installed in 100-D in 2004 as part of the 105-D SSE project. This facility provided office space and a lunch room for personnel involved in the project. The MO-758 building was removed from 100-D in September 2004.
MO-759	Change House	100-D	12.2 x 3.0	Removed	Not Documented	2004	MO-759 was a modular office facility. The MO-759 Facility was installed in 100-D in 2004 as part of the 105-D SSE project. This facility provided a change room for personnel involved in the project. The MO-759 Building was removed from 100-D in September 2004.
MO-769-D	Office	100-D	3.1 x 12.2	Removed	2006	2006?	The MO-769 Building was originally located in 100-B, and was moved to 100-D in 2006. It was a single-wide trailer and powered by a portable generator. In 100-D, the trailer was used as a Craft Personnel Protection Equipment (PPE) storage and lunch room building to support change notice work for the 100-D-56 Waste Site. A Fluor facility listing places this building in 100-F in 2006. However, this would seem to contradict the Fire Marshal permits for this facility.
MO-784	Office	100-D	Not Documented	Active	Not Documented	N/A	The MO-784 Facility was a single-wide mobile officer trailer building that was located south of the 186-D Pump-and-Treat Facility. The MO-784 Facility was used to support operations within the 186-D Pump-and-Treat Facility.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
MO-785	Office	100-D	2.4 x 7.3	Active	2006	N/A	The MO-785 Facility was installed in 100-D in 2006. It was a single-wide trailer building and was used as a mobile change facility and office in 100-D. In particular, it was used for PPE operations.
MO-786	Office	100-D	8.5 x 19.5	Active	2006	N/A	The MO-786 Facility was installed in 100-D in 2006. It was a double-wide trailer building and was used as an SEC office in 100-D in support of the 100-D Remaining Sites project.
MO-787	Change House	100-D	8.5 x 12.2	Active	2007	N/A	The MO-787 Facility was installed in 100-D in 2007. It was a double-wide trailer building and was used as a shower facility by WCH and subcontract personnel during the 100-D Remaining Sites project.
MO-788	Office	100-D	2.4 x 7.3	Active	2007	N/A	The MO-788 Facility was installed in 100-D in 2007. It was a single-wide trailer building and was provided with a propane heater. It was used as a mobile change house and office trailer in support of the 100-D Remaining Sites project.
MO-789	Office	100-D	8.5 x 19.5	Active	2006	N/A	The MO-789 Facility was installed in 100-D in 2006. It was a double-wide trailer building and was used as the Plan of the Day/Crew trailer during the 100-D Remaining Sites project.
MO-790	Office	100-D	3.0 x 9.1	Active	2006	N/A	The MO-790 Facility was installed in 100-D in 2006. It was a modular office trailer building and was used as the RCT Office trailer during the 100-D Remaining Sites project.
MO-791	Office	100-D	3.0 x 9.1	Active	2006	N/A	The MO-791 Facility was installed in 100-D in 2006. It was a single-wide trailer building and was used as an RCT counting facility.
MO-792	Office	100-D	27.85 m^2	Active	Not Documented	N/A	The MO-792 Facility was a single-wide trailer structure.
MO-793	Office	100-D	3.0 x 9.1	Active	2007	N/A	The MO-793 Facility was installed in 100-D in 2007. It was a single-wide modular office trailer building and was used as the Transportation Office during the 100-D Remaining Sites project. It also contained offices for personnel involved in sampling and shipping.
MO-794	Storage	100-D	2.4 x 7.3	Active	2007	N/A	The MO-794 Facility was installed in 100-D in 2007. It was a single-wide modular office trailer building and was used as a tool storage trailer in support of the 100-D Remaining Sites project.
MO-829-D	Office	100-D	8.5 x 18.3	Demolished	Not Documented	2007	MO-829 was a double-wide mobile office constructed of sheet metal and plywood on a metal frame. Prior to arriving at 100-D, the office was used during ISS at the 105-C Reactor. Before that it had been located at 200-E. MO-829 was last utilized as an administrative office during ISS of the 105-DR Reactor. The MO-829 Building was demolished in 2007, after it had been temporarily relocated to 100-N.
MO-848-D	Office	100-D	Not Documented	Removed	Not Documented	2006	The MO-848 Building was a single-wide mobile office facility. It served as an office facility in the group of trailers located northwest of the 105-DR Reactor Building. It had previously been located at slab yards in 200-E. MO-848 was removed from 100-D and relocated to 100-H by 2006. MO-422 was later installed in the location that had previously been occupied by MO-848.
MO-889	Storage Tank	100-D	Not Documented	Active	Not Documented	N/A	The MO-889 Building was a single-wide mobile office facility and served as a water trailer associated with the MO-980 Facility and its septic system.
MO-929-D	Office	100-D	Not Documented	Active	Not Documented	N/A	The MO-929 Building was a single-wide mobile office facility. The MO-929 Building located in 100-D appears to have been distinct from the MO-929 Facility that was located in the 300 and 400 Areas, which was a double-wide office facility. This MO-929 Facility was used as a water trailer.
MO-980	Office	100-D	171.7 m^2	Active	1998	Not Documented	The MO-980 Building had previously been located in the 300 Area at a site near the Environmental and Molecular Sciences Laboratory (EMSL) building and was moved to 100-D in 1998. It was a double-wide mobile office facility. The MO-980 Building was used as an office facility during its time in 100-D. While it was located in 100-D, the facility was serviced by a new septic system that was also installed in 1998.
MO-999-D	Office	100-D	Not Documented	Removed	Not Documented	Not Documented	The MO-999 Facility was a single-wide office trailer located in 100-D and served as the supervisor's office during work for the 105-DR Reactor ISS project. The MO-999 facility was relocated to 100-N by 2003.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
100-H Area							
105-H	Reactor	100-HR-1	34.7 x 27.4 x 11.3	Inactive	1949	2005	The site of this facility is also known as *Waste Information Data System* (WIDS) Waste Site 118-H-6. The facility housed the nuclear reactor and associated equipment associated with the reactor. It was a non-airtight industrial structure made of reinforced concrete in the lower portions and concrete block in the upper portions. The facility contained offices, shops, a work area, a common area, a laboratory, and storage. The facility began operation on October 29, 1949, and was permanently shut down on April 21, 1965. The 105-H Reactor was unique in its time because it had the inert gas system constructed as an integral part of the facility. The charging face (front face) of the reactor faced the 190-H Building, which supplied cooling water to the reactor via two concrete-reinforced underground tunnels. When facing the front face, the horizontal control rods entered the reactor core from the left, and experimental holes were accessed from the right. The control room was beneath the horizontal rods. Spent fuel was discharged from the rear face, and collected in the underwater fuel discharge and storage areas. In 1986, asbestos was removed from clean and contaminated zones, packaged, and disposed of in the respective approved burial ground. The facility was placed in ISS in 2005.
106-H	Storage	100-H	15.2 x 7.6 x 3.7	Not Documented	Not Documented	Not Documented	The building's catalog stated the building provided storage for contaminated equipment. It was described as a galvanized-iron Quonset hutment with plywood flooring. The only record of the building is its mention in the building's catalog and the technical baseline document. It has not yet been located on any H Area map. If it did exist, it would have been located within the Reactor Exclusion Area.
107-H	Retention Basin	100-HR-1	189.0 x 85.3 x 5.0 the depth of the structure was 14.2 ft bgs with a 68,137 m^3 capacity	Demolished	1949	1985	This facility is also known as WIDS waste site 116-H-7. The facility provided temporary retention of reactor cooling water prior to its return to the river. It was a reinforced-concrete structure and had a small pump house (1907-H) that allowed diversion of the basin's contents to a very large disposal trench. The concrete facility is known to have leaked. By 1962, there was a 6.1 m- (20-ft-) high mound of 70 degree centigrade effluent in the groundwater directly below the reservoir. In early 1975, 25 radiological sample holes were drilled in the vicinity of the basin. Contamination appeared to be most extensive on the east side of the basin, and was discovered at a depth of 7.6 m (25 ft) below grade and 13.7 m (45 ft) from the basin's east wall. Sludge waste from the basin was removed in 1953 and again in 1965. The sludge material from 1953 was placed in an adjacent trench (116-H-7). Some of the sludge removed in 1965 was placed in the 116-H-1 Trench. In 1985, the standing walls of the basin were demolished into the basin, along with radioactive sludge already present, and the basin was backfilled with soil. There was an estimated 118 curies of radionuclides in and around the facility, principally Eu-152, Eu-154, Eu-155, Co-60, Cs-137, Sr-90, and Ni-63. Approximately 13 curies of that was leached into the concrete walls and floor. In 2000, the site was remediated, and closed out in 2001. Contaminated materials were sent to ERDF for disposal.
110-H	Storage Tank	100-HR-2	3.2 x 4.4	Demolished	1949	1979	Originally, this facility consisted of a one-story concrete-block building. The facility contained two 6.1-metric-ton- (6.7-ton-) liquid storage refrigeration units, electrical controls, compressors, and coolers. Helium and carbon dioxide gasses were stored in large gas cylinders, then transferred as required for makeup into the reactor's inert gas blanket system for the graphite pile.
116-H	Stack	100-HR-1	61 (height), 5.1 (diameter)	Demolished	1949	1983	It was a reinforced-concrete stack for discharge of Reactor Building gasses. Originally, air moving from the least-contaminated zones through increasingly contaminated zones in the Reactor Building was discharged to the stack unfiltered. By 1960, each of the Hanford reactors had constructed a filter building (117 Building) that housed HEPA filters. In 1983, the stack was demolished and buried in place. It was toppled into a 61 m- (200-ft-) long by 9.1 m- (30-ft-) wide by 5.5 m- (18-ft-) deep trench.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
117-H	Process Unit/Plant	100-HR-1	18.0 x 11.9 x 10.7	Demolished	1960	1984	The facility filtered ventilation air from the Reactor Building confinement zone, prior to its discharge to the environment via the 116-H Stack. The facility was reinforced concrete, and almost completely below grade. The building consisted of two identical filter cells with an operating gallery between them. Each filter cell contained two filter banks in series: the first bank removed 99.95 percent of 0.3-micron particles; and the second bank was activated charcoal. In 1983, the filters and other fixtures were removed and the building was decontaminated as Phase I work in preparation for demolition. The demolition was completed in 1984, and the debris was buried in place. The building was closed under a determination of allowable residual contamination levels (ARCL).
119-H	Laboratory	100-HR-1	4.6 x 7.3 x 3.0	Demolished	1960	1983	This facility sampled and monitored the air for radionuclides as it passed through the underground ducts. It was a small prefabricated metal building located over the ventilation ducts leading to and from the 117-H Exhaust Air Filter Building. Potentially contaminated air from the Reactor Building passed through underground ducts to the Filter Building, then back to the stack for discharge. This facility was likely removed when the filter building and stack were removed in 1983-1984.
151-H	Electrical Substation	100-HR-2	13.5 x 25.0 x 3.3	Demolished	1949	1978	The 151-H Building supplied auxiliary lighting and power to buildings around 100-H via overhead and underground cables. In 1973, the building (switch house) was used to overhaul electrical switchgear from the deactivated areas for use at the FFTF. The work was to have been completed and the facility deactivated by January 1, 1974. In 1978, the building was demolished, debris placed in the basement cavity, and the cavity backfilled. The switchgear was reused in 151-B. Seven surface samples were taken from the switchyard on December 9, 1991, as part of the 100-HR-1 LFI. These samples indicated PCB levels were below *Toxic Substances Control Act of 1976* cleanup levels.
152-H	Electrical Substation	100-H	Not Documented	Demolished	1949	Not Documented	The exact number and location of these secondary substations is not known. However, electrical drawings related to the 151-H Substation suggest one or more of these 152-H Substations existed at 181-H, 182-H, 183-H, 184-H, 190-H, and 105-H. In general, these substations were fed from the 151-H Substation via underground concrete-encased conduits.
153-H	Electrical Substation	100-H	Not Documented	Demolished	1949	Not Documented	These are the smaller substations that would have been associated with each of the administrative and support buildings and facilities in the H Area. Very little is known about the number and locations of these substations.
1601-H	Pump Station	100-H	26.6 m^2	Active	1997	Not Documented	The 1601-H Facility was a pre-engineered metal building erected on a concrete floor slab. The facility housed pumping equipment, with a large water storage tank located just north of the building. The 1601-H Building was used to transfer well water extracted from wells to the 1713-H Building for dichromate removal. Water was stored in the tank before being pumped in an aboveground pipe to 1713-H.
1605-H	Control Structure	100-H	Not Documented	Demolished	Not Documented	Not Documented	The exact number and location of these structures is unknown. However, one guard tower was known to have been constructed on top of the 181-H River Pump House. Presumably, the 1605-H Structures would have had a similar design to those existing in other areas.
1608-H	Pump Station	100-HR-1	13.4 x 11.0 x 10.4	Demolished	1949	1987	The facility served as a collection basin and lift station for the reactor floor drain system. Floor drain waste from the 105-H Reactor Building was gravity drained to the underground reservoir. From there it was pumped, as required, through underground lines to the 107-H Retention Basin, before being routed to the river. In 1986, the contaminated fixtures and radioactive sludge were removed. Waste was packaged and buried in the 200 West Burial Ground. Residual water was disposed of in the 1325-N Liquid Waste Disposal Facility. The structure was demolished and buried in place in 1987.
1614-H	Monitoring Station	100-H	2.1 x 2.1 x 2.4	Demolished	1949	Not Documented	Three monitoring stations were built for H Area. Each was a wooden structure with a 10 cm (4-in.) concrete floor slab and wall footings, and contained instrumentation for sampling the ambient air.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1621-H	Electrical Substation	100-H	Not Documented	Demolished	Not Documented	Not Documented	The exact type of facility and generator sets it contained could not be determined. The facility likely contained at least one emergency electric generator, gasoline motor driven, which were provided for buildings requiring continuous lighting service and were equipped for automatic starting in case of power failures. The emergency generating house for the fire department and patrol was abandoned well before 1964. There is no indication that a generator set was located near the 105-H Building such as in the 100B/D/F. System No. 1621-1-1 (the check off sheet) suggests the structure may have been used for storage.
1701-H	Office	100-HR-2	4.3 x 2.1 x 2.1	Demolished	1949	1974	This building served as the H Area Badgehouse. It was a two-story frame structure and contained a waiting room, offices, patrol search and badge control rooms, a mechanical room, and a laboratory. In 1974, the footings and foundation were left in place after building demolition, and the site leveled. The septic tank at the 1701-H Site and the area burning pit and tile field were also demolished and backfilled.
1702-H	Office	100-HR-1	4.3 x 4.7	Demolished	1949	Not Documented	This building provided the security entrance to the Reactor Exclusion Area. It was a one-story wooden frame structure set on 20 cm (8-in.) continuous curb wall footings with asbestos shake siding and gable wooden roof covered with roll-roofing.
1703-H	Office	100-HR-1	32.3 x 11.1 x 7.9	Demolished	1949	1974	This facility provided offices for area administrative and technical personnel. It was a single-story frame structure with asbestos shake siding and concrete block foundation. The footings and foundations remaining after demolition of the building were buried and leveled.
1704-H	Office	100-HR-1	27.6 x 11.3 x 6.1	Demolished	1949	1974	This was also known as the Supervisor's Office Building. It was a single-story T-shaped wood frame structure with asbestos shake siding and concrete block foundation. The footings and foundation were left in place after demolition of the building were buried and leveled.
1709-H	Office	100-HR-2	34.1 x 17.7 x 3.7	Demolished	1949	1974	This facility served as the area fire station. It was a single-story frame structure with asbestos shake siding, concrete floor, and foundation. By 1964, this building was being used for office space. The footings and foundation left in place after the building was demolished were buried and leveled.
1713-H	Storage	100-HR-2	47.6 x 18.9 x 18.3	Active	Not Documented	N/A	The 1713-H Facility was originally used as a warehouse in 100-H. In the mid-1990s, it was converted into the treatment center for the 100-HR-3 Pump-and-Treat program. New equipment was added to the secondary wing of the facility, including ion exchange modules, two storage tanks, a resin dewatering sump, and pumping equipment. Groundwater was extracted from several wells in 100-D/H and pumped to the transfer buildings (1601-H and 1601-D) before being sent to the 1713-H Facility. The water was stored in the influent storage tank before being passed through the ion exchange modules and IX skid to remove hexavalent chromium. The treated water was then stored in the effluent storage tank before being pumped to injection wells in 100-H. The building was still intact in July 1995.
1715-H	Storage	100-HR-1	9.8 x 7.0 x 6.1	Demolished	1949	1974	The building was divided into three rooms for storage of oils for use by the Power and Transportation Departments. It was a wood-frame structure with asbestos shake siding and concrete floor. The footings and foundation left in place after the building was removed were buried and leveled.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1716-H	Maintenance Shop	100-HR-1	28.3 x 23.3 x 6.1	Demolished	Not Documented	Not Documented	This one-story wood-frame structure contained a tire shop, battery room, compressor and oil storage room, mechanical equipment room, office, parts, locker, and lunch room. It was equipped as a service station, and for light maintenance and repair. At one point, about one half of the building was converted to shops for maintenance, calibration, and repair of electrical and electronic instruments. A lubrication pit running east-west contained an oil collection sump. This sump pumped directly north to a 2,080-L (550-gal) capacity waste oil disposal tank located about 1.5 m (5 ft) below grade. No record was found that the sump, piping, or disposal tank were ever remediated. The facility also contained two floor drains that discharged via the process sewer to 1904-H Facility. Approximately 6.7 m (22 ft) directly south of the building were two 18.9 m^3 (670 ft^3) USTs: one for diesel fuel and one for gasoline. The pump island was located 6.7 m (22 ft) from the south end of the west wall. The two tanks are WIDS waste site 100-H-3, 1716-H Garage Fuel Tanks. To the northeast of the building was a large propane UST. No record was found that the tank was ever removed. The footings and foundation remaining after the building removal were buried and the site leveled.
1717-H	Maintenance Shop	100-HR-1	75.6 x 25.0 x 6.1	Demolished	1949	1974	The 1717-H Building was a concrete and steel structure and housed a machine shop, sheet metal shop, fabrication shop, and carpenter shop that provided services for all of the 100 Area operations. The fabrication shop was used for fabrication and repairs of reactor system components, in particular those associated with water treatment and pumping systems. A portion of the 1717-H Building was also used as a hot shop for work on very low-level radioactive materials. In 1974, there was a general cleanup of the maintenance facility. Thereafter, it was used as the J.A. Jones shop headquarters, and for the ARHCO cleanup program outside the area and across the river. The 1717-H Building was removed during general D&D of 100-H facilities in 1974. The 100-H-4 Site currently exists as a flat, vegetated area.
1719-H	Office	100-HR-1	209.03 m^2	Demolished	1949	1974	The T-shaped facility provided for minor medical care for area personnel. It was a single-story wood-frame structure with asbestos shake siding, concrete foundation and floor, and wood gable roof with composition shingles. Facilities included first aid room, examination room, x-ray room, laboratory, ward, and office. The footings and foundation left in place after the building removal were buried and the site leveled.
1720-H	Office	100-HR-2	27.6 x 9.8 x 4.6	Demolished	1949	1974	This building provided office and associated facilities for the area security patrol. It was a single-story wood-frame structure with concrete foundation and floor, and asbestos shake siding. Facilities included a large locker room, assembly room, Lieutenant's office, ordnance room, lunch room, wash and shower rooms, offices, and radio room. Attached was an emergency lighting generator building of wood-frame construction. The footings and foundation remaining after building removal were buried and the site leveled.
1720-HA	Storage	100-HR-2	3.7 (length) x 2.4 (height)	Demolished	1949	2003	During the operating period, the facility held munitions for the security forces. Later it stored explosives that were used for decommissioning projects. The facility was reported to still be intact as late as July 1995.
1722-H	Maintenance Shop	100-HR-1	9.1 x 15.2	Demolished	1949	1974	This facility provided for small painting projects. It was a single-story frame structure with concrete foundation and floor, and asbestos shake siding. In addition to typical painting equipment, the building was outfitted for metal-spraying and sign painting. The footings and foundation remaining after building removal were buried and the site leveled.
1734-H	Storage	100-HR-1	3.7 x 10.1	Demolished	1949	Not Documented	The structure consisted of reinforced-concrete foundation walls, supported with continuous wall footings. The shed had five compartments for storing five types of gas cylinders. A 1.8 m- (5.9-ft-) wide, 3.6 m- (12-ft-) long concrete ramp provided access to the platform from the south.
1760-H	Office	100-HR-1	36.4 x 10.1 x 8.2	Demolished	Not Documented	1974	This building provided office space for area personnel. It was a two-story wood-frame structure with drop siding, concrete footing, concrete block foundation, wood flooring, and hipped roof with composition shingles. The footings and foundation remaining after building removal were buried and the site leveled.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1761-H	Office	100-HR-1	36.4 x 10.1 x 8.2	Removed	1957	1974	It was a two-story wood frame structure. Originally the facility was a barracks facility before it was moved to 100-H in 1957. This building provided office space for area personnel. In 1974, the 1761-H Building was removed from 100-H and relocated to the 300 Area, where it became the 3761 Building.
1784-H	Office	100-H	3.0 x 3.0	Demolished	1949	Not Documented	Referred to as the Coal Handler's Shack, it contained a refrigerator, stove, drinking fountain, wash basin, table and chairs, steam space heater, and lights. The actual function of the building is not known, although it is believed this is where the coal delivery operators would change into their work clothing.
181-H	Pump Station	100-HR-1	40.8 x 19.5 x 24.4	Demolished	1949	1978	The facility provided raw river water to the 182-H Reservoir and the 183-H Filter Plant. It was constructed of reinforced concrete and concrete block. A guard tower was also erected on the roof. Screened, raw river water was pumped via 91.4 cm (36-in.), 106.7 cm (42-in.), and 121.9 cm (48-in.) lines to the 182-H Reservoir and the 183-H Head House for eventual use as reactor cooling water, and sanitary and fire use. In 1974, demolition of the facility occurred to ground level (referred to as Phase I). The tar and gravel roof was buried in the 182-H Reservoirs. The remaining concrete block walls of the building were demolished into the pump wells, which were backfilled with soil to grade. In 1977, the remainder of the facility was demolished, and the debris was buried in the 183-H Clearwells.
182-H	Process Unit/Plant	100-HR-1	38-million L capacity rectangular-shaped reservoir	Demolished	1949	1974	The facility stored reserve process water for the 183-H Filter Plant, and exported water to the 200 Areas and other 100 Area sites as needed. The pump house, located along the south wall of the reservoir, was below grade, and contained both electric and steam turbine pumps. In 1974, the facility was demolished and backfilled to ground level. Approximately 95,600 m^3 (314,000 ft^3) of earth, and 57,300 m^3 (188,000 ft^3) of cinders from the 184-H Cinder Pile were used to fill the reservoir. In addition, the tar and gravel roof from 181-H was buried here. The pump house, adjacent valve houses, and reservoirs were demolished to ground level, and the underground portions of these facilities were backfilled to ground level.
183-H	Process Unit/Plant	100-HR-1	12,656.81 m^2	Demolished	1949	1974	This facility was a *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal facility (TSD). It treated, filtered, and provided reserve capacity cooling water for the reactor. The facility consisted of a head house and chemical building, mixing, flocculation and subsidence basins, a filter building, and clearwell storage and pump room. There were 16 18,900-L (4,990-gal) capacity, reinforced-concrete basins that connected to the filter building by pipelines. The facility prepared, dispensed, and/or stored alum, sulfuric acid, and chlorine. In 1974, the head house, sedimentation basins, and filter plant were demolished and backfilled to ground level. Four bays of the sedimentation basins were left in place to be used as a solar evaporation facility. The clearwells were left intact for use as a disposal site for debris from the demolition of the 190-H Building, as well as from the 151-H Substation demolition. In 1977, the demolition debris from 181-H River Pump House was buried in the 183-H Clearwells. A former employee believes sedimentation basins may have been filled with asbestos roofing, siding, and shingles from the demolition of the 1700s H Building in the 1970s and early 1980s.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
184-H	Process Unit/Plant	100-HR-2	61.0 x 18.3 x 24.4	Demolished	1949	1978	This facility provided steam and emergency electrical power to the H Area. It contained four drum-type coal-fired boilers with super heaters. The coal handling system included the crusher houses, transfer houses and track hoppers, coal storage pit, salt dissolving pit, and brine pump house. Boiler water treatment chemicals, sodium sulfite and tri-sodium phosphate, were delivered to the power house in bags and stored in the chemical mixing room. Sodium chloride was delivered in carload lots and unloaded into the brine pits. Furnace ash was removed by dumping it into a pit beneath the furnace. This ash and the fly ash were sluiced into a trench running through the building and emptying into a sump. The wet ash was then pumped from the sump into the ash pit. It also had a 116 m^2 (380 ft^2) building housing pumps for lifting wastewater to the river. In 1974, the smokestacks were demolished and buried, boiler foundations were removed, the coal pit retaining wall was removed, as well as the overhead steam lines and support poles. Two 45,425 L (12,008 gal) oil USTs adjacent to this building (oil supply for the auxiliary boiler house) were removed, and the site was leveled.
184-HA	Process Unit/Plant	100-HR-1	8.2 x 9.8 x 4.3	Demolished	1965	Not Documented	The building was a prefabricated galvanized steel panel structure with steel panel siding and roof. This facility was built to provide steam to the administration buildings and central shops. This included H Buildings 1703, 1704, 1716, 1717, 1719, 1722, 1760, and 1761.The facility was complete with water-softening equipment, feedwater pump, fuel oil storage for 1 week at full boiler capacity, and stack. The facility was built to allow the 184-H Power House to be deactivated.
187-H1	Storage Tank	100-HR-1	46.9 (height), 12.5 (diameter) 1,136,000 L (capacity)	Demolished	1949	Not Documented	The two emergency water tanks (187-H1 and 187-H2) provided an adequate supply of gravity-fed cooling water to the reactor core when all other pump-fed sources may have been lost.
187-H2	Storage Tank	100-HR-1	46.9 (height), 12.5 (diameter) 1,136,000 L (capacity)	Demolished	1949	Not Documented	The two emergency water tanks (187-H1 and 187-H2) provided an adequate supply of gravity-fed cooling water to the reactor core when all other pump-fed sources may have been lost.
188-H	Coal Ash Pit	100-HR-2	76.2 x 115.8 x 5.5	Inactive	Not Documented	Not Documented	This facility is also a WIDS waste site 126-H-1. The 184-H Power House was equipped with an Allen-Sherman-Hoff ash disposal system. Coal furnace ash was collected in four ash pits on the ground floor of the facility. From here, with the help of 5,300-liters per minute (LPM) sluice pumps, the ashes were transferred via trenches below the steel ash pits into a sump. With the help of 1,514 LPM ash pumps, the ash and fly ash are then transferred to the 188-H Facility via the 20 cm (7.9-in.) steel line. There was an overflow line approximately 30.5 cm (12 in.) from the top of the pit that discharged to the process sewer. Following its disuse as an ash disposal pit, it became a disposal site for a variety of demolition rubble and other wastes.
1901-H	Storage Tank	100-HR-2	378,541 L (capacity)	Demolished	Not Documented	Not Documented	Water from the 183-H Filter Plant was pumped to the 184-H Power House, where it was conditioned into soft water, stored in this high tank, then used as feed water for the power house boilers. There is very little information that was found about the exact purpose and functioning of this soft water storage tank.
1902-H	Storage Tank	100-HR-2	378,541 L (capacity)	Demolished	1949	Not Documented	Water was pumped from the 183-H Filter Building to this high tank, where its primary function was backup water for the fire system in the H Area.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
1904-H	Outfall	100-HR-1	4.3 x 8.2 x 6.1	Demolished	Not Documented	Not Documented	The site of this facility is also known as WIDS waste sites 116-H-5, 100-H-34, and 100-H-36. This site includes the open-topped, compartmentalized, reinforced-concrete outfall structure. The outfall was a weir box that directed process sewer wastes and reactor cooling water either through the river discharge pipelines (100-H-34) or through the spillway (flume) (100-H-36). The river effluent pipelines (river lines) extend from the outfall (116-H-5) into the main channel of the Columbia River. By late 1965, a small stream of drainage water from the 184-H Power House still discharged into the facility, and the dose rate 0.3 m (1 ft) from the bottom was 30 mR/hr. The aboveground portion of the outfall has been demolished into its base. The base has been backfilled with soil to a level approximately 0.61 m (2 ft) above grade. The upper portion of the structure was demolished, and the cavity filled to grade with clean soil. During a site visit in 2005, the soil-filled outline of the outfall structure was visible, as was the spillway outlet at the river shoreline.
1906-H	Pump Station	100-HR-1	10.7 x 20.7 x 13.7	Demolished	1949	1974	The facility was designed to receive process sewer (primarily floor drains) discharges from all of the non-radioactive buildings in the H Area and discharged into the 1904-H Outfall Structure. This included the administrative buildings, shops, and the cooling water treatment buildings. The underground facility, associated piping, and surrounding soil were potentially exposed to a number of chemical contaminants that were used, transferred through, or stored in the buildings that had floor drains discharging to this facility. In 1974, the lift station was demolished to ground level and backfilled. The building itself was demolished into the pump wells.
1907-H	Pump Station	100-HR-1	3.6 x 4.3 x 8.1	Demolished	Not Documented	2000	This facility was a below-grade reinforced-concrete structure with a concrete roof that housed two electric pumps that could be used to pump water from the 107-H Retention Basin to the retention cribs. Whenever the contents of the 107-H Retention Basin were judged to be too contaminated for direct discharge to the river via the 1904-H Diversion Station, it was pumped via this facility to the retention cribs directly to the south. Although not specifically addressed in the closeout verification package, this facility lies within the cleanup footprint for the 100-H-21 Reactor Effluent Pipelines, and is therefore assumed to have been removed in 2000.
1908-H	Monitoring Station	100-HR-1	6.4 x 6.7	Demolished	1949	1974	The original purpose for the facility was to sample and monitor cooling water process effluent that was being discharged to the river via the 1904-H Diversion Box. The 1904-H received process waste from two primary sources: 107-H, which handled the spent reactor cooling water, and 1906-H, which received the floor drain wastes from the non-radioactive buildings. No unplanned releases were reported, however, it is not unreasonable to assume the tank and/or the aboveground sampling and monitoring systems and piping could have leaked. Potential COCs would include Cr+6, long-lived fission products, and various chemical contaminants known to be present in several of the 1700-series buildings. Some time before 1964 it was converted to a rigger loft and cement finisher's storage. In 1974, the station was demolished and buried in the 200 West Area burial grounds. It is not known if the concrete foundations and/or any potentially contaminated soil were removed.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
190-H	Pump Station	100-HR-1	51.8 x 17.7 x 7.6 11.3 x 11.6 x 3.1 (annex)	Demolished	1949	1977	The facility was the final lag storage for treated cooling water prior to pumping it through the reactor core. The main pump house was a steel-frame, high-bay building with reinforced-concrete foundation. The high-bay portion contained four steel water storage tanks with a total capacity of 34 million L (9 million gal). Sodium dichromate was added to the tanks at each tank inlet line. The annex, which was added in the 1950s to increase cooling water throughput, was structural steel with corrugated asbestos and cement construction. In 1974, there was a general cleanup of the facility inside and outside. Hazards left by the salvage operators were eliminated. By the end of 1975, both the high bay and the annex were reported as empty, except for an overhead crane and air conditioners. In FY 1977, the 190-H Building was demolished and the debris buried in the 183-H Clearwells. In 1980, the 190-HA Building Annex was sold. Dismantlement of this building began in fiscal year 1981 and completed during fiscal year 1982. The hole left from removal of the 190-HA Annex was filled with rubble from the 1717-H Building Removal, backfilled, and the area leveled to blend with the adjacent terrain. In 1986, the pipe tunnels between the facility and 105-Reactor Building were uncovered and filled to grade with clean soil.
1713-HA	Storage	100-HR-2	36.6 x 9.8	Demolished	1949	Not Documented	Nothing definitive has been found on the function of the building. It was believed to have been a temporary building, because it did not have a building number common to permanent buildings. The project completion report suggests this was an Atkinson-Jones Construction Company temporary warehouse. This subcontractor was responsible for the major portion of the buildings constructed at the H Area. They had joint responsibility with General Electric for procurement of building materials and equipment, small tools, and construction equipment.
MO-229	Office	100-H	253.6 m^2	Active	1998/early 1999	N/A	The MO-229 Building was originally the 1134-N Building in 100-N, but was relocated to 100-H in late 1998/early 1999. It consisted of four sheet metal and plywood trailers on I-beam trailer frames. In 2008, mud daubers were found under and inside vents in the trailer. The trailer was marked as internally contaminated, although a radiological survey did not detect any contamination above background levels.
MO-316	Office	100-H	3.0 x 9.1	Removed	Mid-1990s	Not Documented	The MO-316 Building was a trailer facility that was located near the 105-H Reactor in the mid-1990s. MO-316 served as an office facility, most likely in support of work being done in the 105-H Reactor Building. The MO-316 Facility was scheduled to be excessed in 1999, and was presumably removed from the site shortly thereafter.
MO-338	Change House	100-H	3.0 x 9.1	Removed	Mid-1990s	Not Documented	The MO-338 Building was a trailer facility that was located near the 105-H Reactor in the mid-1990s. MO-338 was used as a change house, most likely in support of work being done in the 105-H Reactor Building. The MO-338 Facility was scheduled to be excessed in 1999, and was presumably removed from the site shortly thereafter.
MO-668	Office	100-H	3.0 x 15.8	Removed	Mid-1990s	Not Documented	The MO-668 Building was a trailer facility that was located near the 105-H Reactor in the mid-1990s. MO-668 served as an office facility, most likely in support of work being done in the 105-H Reactor Building. The MO-668 Facility was scheduled to be excessed in 1999, and was presumably removed from the site shortly thereafter.
MO-757		100-HR-2	Not Documented	Active	Not Documented	N/A	The MO-757 Building was a single-wide mobile office trailer facility in 100-H. The facility was used to support the pump-and-treat operation that was being conducted in the 1713-H Building.
MO-776	Office	100-H	Not Documented	Active	2005	N/A	The MO-776 Building was a mobile office trailer facility that was placed in 100-H in 2005. MO-776 was used as a subcontractor office facility in support of the Safe Storage Enclosure (SSE) project at the 105-H Reactor.
MO-777	Change House	100-H	Not Documented	Active	2005	N/A	The MO-777 Building was a mobile office trailer facility that was placed in 100-H in 2005. MO-777 was used as a change room facility in support of the SSE project at the 105-H Reactor.

Table D-1. Summary of 100-D/H Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition/ Removal/Cocooned Date	Facility Description
MO-778	Office	100-H	Not Documented	Active	2005	N/A	The MO-778 Building was a mobile office trailer facility that was placed in 100-H in 2005. MO-778 was used as a lunch room facility in support of the SSE project at the 105-H Reactor.
MO-796	Office	100-HR-1	8.5 x 19.5	Active	2008	N/A	MO-796 was a double-wide mobile office trailer facility that provided office space for the subcontractor FE&C. It also provided a lunch area for personnel in 100-H. It was placed in 100-H in 2008.
MO-797	Change House	100-HR-1	8.5 x 12.2	Active	2008	N/A	MO-797 was a double-wide mobile office trailer facility that served as a restroom and shower trailer for personnel in 100-H. It was placed in 100-H in 2008.
MO-798	Office	100-HR-1	8.5 x 19.5	Active	2008	N/A	MO-798 was a double-wide mobile office trailer facility that provided office space for RCT personnel in 100-H. It was placed in 100-H in 2008.
MO-848-H	Office	100-HR-1	Not Documented	Active	Not Documented	N/A	The MO-848 Building was a single-wide mobile office facility. The MO-848 Building served as a field office for work occurring on the 105-H Reactor Building. It had previously been located in 100-D during work on the 105-DR Reactor and at 200-E slab yards.

Note:

AEC = U.S. Atomic Energy Commission
ARHCO = Atlantic Richfield Hanford Company
BNW = Battelle Northwest
COC = Contaminant of Concern
D&D = decontamination and decommissioning
DOE = U.S. Department of Energy
EMSL = Environmental and Molecular Sciences Laboratory
ERDF = Environmental Restoration Disposal Facility
FFTF = Fast Flux Test Facility
FSB = Fuel Storage Basin
FY = fiscal year
GPERS = Global Positioning Environmental Radiological Surveyor
HEDL = Hanford Engineering Development Laboratory
HEPA = high-efficiency particulate air (filter)
ISRM = in situ redox manipulation
ISS = Interim Safe Storage
LFI = limited field investigation
PCB = polychlorinated biphenyl
PNL = Pacific Northwest Laboratory
PNNL = Pacific Northwest National Laboratory
PPE = personal protective equipment
RCRA = *Resource Conservation and Recovery Act of 1976*
RCT = radiological control technician
RISS = Reactor Interim Safe Storage
RL = U.S. Department of Energy, Richland Operations Office
SSE = Safe Storage Enclosure
TSD = treatment, storage, and/or disposal (unit)
UNI = United Nuclear Industries
WCH = Washington Closure Hanford
WIDS = Waste Information Data System database

Appendix E

100-D/H Soil, Groundwater, and Aquifer Tube Data

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Introduction

A CD is attached. This CD contains data for soil, groundwater, and aquifer tubes. Text containing explanations of these datasets is also included.

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