0083296

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09-AMCP-0217

SEP 2 5 2009

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Hanford Project Office
U.S. Environmental Protection Agency
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Dear Mr. Faulk:

INTEGRATED 100 AREA REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN, ADDENDUM 3: 100-BC DECISION UNIT, DOE/RL-2008-46-ADD3, DRAFT A, AND SAMPLING AND ANALYSIS PLAN FOR THE 100-BC DECISION UNIT REMEDIAL INVESTIGATION/FEASIBILITY STUDY, DOE/RL-2009-44, DRAFT A, AND TREATABILITY STUDY FOR IN SITU HEXAVALENT CHROMIUM TREATMENT AT 100-C-7, WCH-348, DRAFT A

This letter transmits the Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC Decision Unit, DOE/RL-2008-46-ADD3, Draft A, and Sampling and Analysis Plan for the 100-BC Decision Unit Remedial Investigation/Feasibility Study, DOE/RL-2009-44, Draft A, and Treatability Study for In Situ Hexavalent Chromium Treatment at 100-C-7, WCH-348, Draft A for your review and comment.

The purpose of these documents is to describe the setting and establish the objectives, tasks, and schedule for conducting an integrated groundwater and soil RI/FS for the 100-BC Decision Unit. Please provide comments on these documents to the U.S. Department of Energy, Richland Operations Office within 60 days of receipt of this letter.

This work plan addendum is submitted in accordance with Tri-Party Agreement Milestone M-015-67, "Submit CERCLA RI/FS Work Plan for the 100-BC-1, 100-BC-2 and 100 BC-5 Operable Units for Groundwater and Soil" by September 30, 2009.

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

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:GLS

Attachments

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DOE/RL-2008-46-ADD3
Draft A

Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC Decision Unit

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

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Draft A

Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC Decision Unit

Date Published
August 2009

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

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J. D. Aardal 08/31/2009
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Title: *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC Decision Unit*

Concurrence

U.S. Department of Energy, Richland Operations Office

Signature Date

Briant Charboneau

U.S. Environmental Protection Agency

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Executive Summary

This document is Addendum 3 of the *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan.* 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 the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[1] (CERCLA). This document supports final remedy selection under CERCLA for the 100-BC Decision Unit at the Hanford Site. The CERCLA RI/FS results are also intended to address Resource Conservation and Recovery Act (RCRA) corrective action requirements for areas of RCRA concern. Five 100 Area decision units (Figure ES-1) have been defined for the River Corridor:[2] 100-BC Area, 100-K Area, 100-D and 100-H Areas, 100-N Area, and 100-F Area combined with 100-IU-2 and 100-IU-6 Operable Units (OUs). An additional decision unit is defined for the 300 Area. Planning for the 300 Area Decision Unit will be addressed separately. These decision units combine groundwater contamination, soil contamination sites, and facilities in geographic areas that encompass the 100 Area National Priorities List[3] 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 decision units. This document, Addendum 3 to the work plan, provides site-specific information for the 100-BC Decision Unit. The 100-BC Decision Unit includes the 100-BC-1 and 100-BC-2 source OUs. The 100-BC-5 OU is a groundwater OU located in the 100-BC Area. Figure ES-1 shows the location of the 100-BC Decision Unit and proximity to other decision units.

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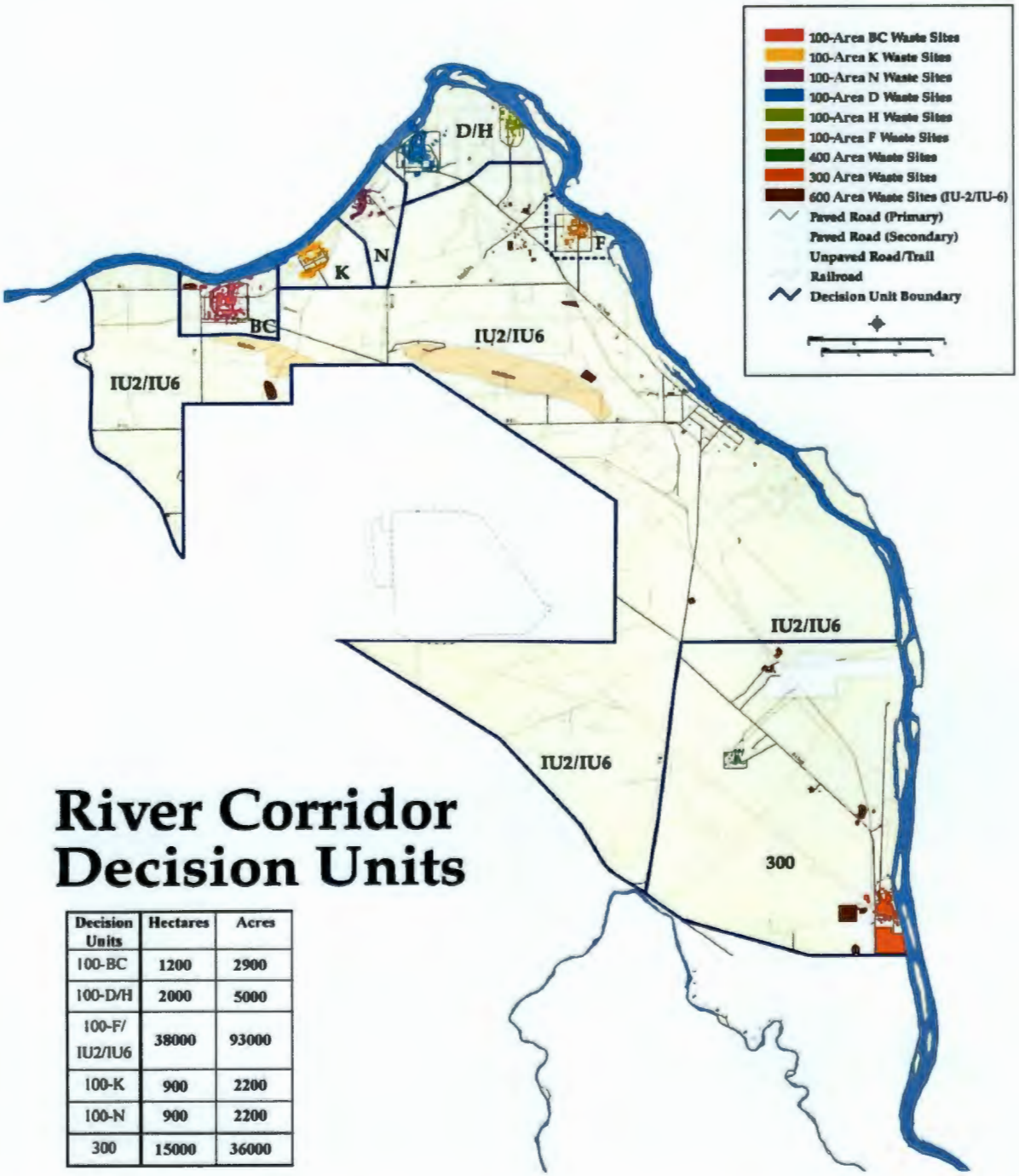
1 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq. http://www4.law.cornell.edu/uscode/42/usc_sec_42_00009601----000-.html
2 Decision unit is a term developed as part of this cleanup strategy to enable coordinated decisions for contiguous source and groundwater operable units.
3 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*. http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr300_08.html



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

Figure ES-1. River Corridor Decision Unit Boundaries

This addendum is based on the premise that there are data gaps and uncertainties that should be addressed to support final remediation decisions. In the 100-BC Decision Unit, substantive work to monitor groundwater, 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.

A systematic planning process was used to develop a program for data collection and analysis to support final remediation decisions at the 100-BC Decision Unit. The following sections discuss key elements that were identified during this systematic planning process.

Site Background and Environmental Setting

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; the known geohydrologic information; source and groundwater remedial actions and their effectiveness; and the results of any treatability and characterization studies.

CrVI, Sr-90, and tritium have been identified as the main remaining environmental threats in the 100-BC Decision Unit. Appendix B presents maps of the facilities and source sites. As of February 9, 2009, a total of 60 sites have been dispositioned according to the interim action record of decision (ROD), and 36 additional sites require no action (17 No Action and 19 Not Accepted). "No action" indicates that the site does not require any further remedial action under RCRA. Corrective Action, CERCLA or other cleanup standards., While the "interim closed out" remedial actions satisfied the interim action RODs, they may not satisfy final CERCLA remediation and/or RCRA corrective action requirements due to vadose zone and/or groundwater contamination remaining after the interim action ROD removal action. An additional 20 (13 Accepted and seven Discovery) sites to be dispositioned remain, either through retrieval or treatment. (Table 2-3.) These 20 sites are scheduled to be dispositioned by 2012.

Identification of Investigation Requirements

Investigation work at the 100-BC Decision Unit will be conducted in accordance with the Integrated 100 Area RI/FS Work Plan (DOE/RL-2008-46). No exceptions are noted in this addendum.

Conceptual Site Model

The Conceptual Site Model (CSM) is a site description 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 about remediation. The CSM was used to identify data and information gaps, establish data needs, and design a field program to address the gaps.

The primary sources of contamination in the 100-BC Decision Unit are two water-cooled nuclear reactors (105-B and 105-C) and the structures (e.g., fuel storage basins [FSB]) and processes (e.g., sodium dichromate process) associated with reactor operations. The reactors and processes associated with operations generated large quantities of liquid and solid wastes.

CrVI, Sr-90, and tritium are recognized as primary contaminants of concern in groundwater. In addition, contaminants such as aluminum, iron, and manganese exceed secondary drinking water standards (DWS). 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. Wastes released to the environment created secondary sources of contamination where contaminants could be retained in the subsurface and released over long periods of time, such as ponds, ditches, and cribs; burial grounds; and unplanned release sites. Both natural (fluctuating river stage) and anthropogenic hydrologic processes (leakage from retention basins, cribs, and trenches) have influenced the distribution of contaminants in the subsurface. Water mounding from leakage at these facilities during operations was considered the greatest factor in the widespread observation of groundwater chromium, Sr-90, and tritium contamination at the 100-BC Decision Unit in the subsurface. Once discharges ceased in 1968, the mound dissipated in the Hanford formation with preferential drainage into the Columbia River under the influence of the natural flow direction.

Unlike the CrVI contamination observed in groundwater at the 100-D Area, the 100-BC Area does not have a substantial concentrated groundwater plume. Known releases of concentrated sodium dichromate exist in the soil at the 100-BC Decision Unit (Section 4.3.4), but, as yet, these releases do not appear to have substantially affected groundwater. The historical record for the C Reactor indicates sodium dichromate use

was converted to liquid dichromate addition quickly and does not appear to have the same evidence of handling difficulties as 100-D Area due to newer equipment and maintenance upgrades to the water treatment plant. Widespread, relatively low concentration CrVI concentrations extended farther inland during operations because of the magnitude of groundwater mounding and its high mobility. In recent studies (Dresel et al., 2008), a portion of the CrVI releases much more slowly because of its interaction with the soil, potentially providing a relatively slow releasing continuing source. Future migration of CrVI will continue toward the Columbia River, but higher levels of CrVI contamination are not expected.

Sr-90 was also present in solid waste disposed at various burial grounds and contamination is limited to the upper part of the unconfined aquifer. Continued relatively slow dispersion and migration of Sr-90 in groundwater occurs because of its moderate adsorption to aquifer soils. The plume may continue to persist in groundwater due to Sr-90 sorbed to soil within the periodically re-wetted zone.

The persistence and high concentration of tritium in the unconfined aquifer in the 100-BC Decision Unit suggests a more concentrated source than is common at other 100 Area reactors. Solid waste residue from the tritium production and separation line is considered to be the most likely source for the tritium, and historical transport from other areas of the Hanford Site may have also occurred.

The CSM describes several hypotheses regarding whether inland CrVI and Sr-90 contamination in groundwater is the result of: (1) continuing vadose zone sources from beneath waste sites, (2) vadose zone contamination (mass) within the periodically rewetted zone, (3) contamination within the unconfined aquifer, (4) contamination within the Ringold Upper Mud (RUM), or (5) a combination of some or all of the above. The soil and groundwater data collected during the proposed work will be used to further evaluate these hypotheses.

Data Gaps and Needs

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:

- Assess 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 CrVI contamination in the groundwater in areas of the decision unit
- Hydraulic properties of the RUM
- Potential adverse affects from remaining undiscovered sites.

Each of the data gaps are defined by a data need that, when filled, provides information to reduce or eliminate the uncertainty associated in the data gap to the degree needed to make a final cleanup decision.

A summary of the data gaps and needs, as well as the specific work proposed for this work plan, is presented in Table ES-1. The proposed field sampling locations are shown in Figure ES-2. Several ongoing programs (e.g., facility demolition, waste site remediation) are also expected to provide data that will resolve many of the uncertainties identified for the 100-BC Decision Unit. The sampling and analysis plan (DOE/RL-2009-44) identifies only those data collection activities that these ongoing programs will not address. The RI/FS report developed for the 100-BC Decision Unit will take full advantage of data and information developed by ongoing groundwater monitoring and remediation programs that are available during the development of the report. The results of ongoing deactivation, decommissioning, decontamination, and demolition (D4), waste site interim remediation actions and groundwater monitoring activities, 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 ROD.

Project Schedule

The project schedule for activities discussed in this addendum is presented in Section 5.

Table ES-1. 100-B/C Decision Unit Data Needs

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 been 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 contaminated soil removal and sampling at 24 waste sites in the 100-BC Decision Unit. The location of unremediated waste sites is shown in Appendix B.	Remediation is needed to protect human health and the environment. Data collected at the completion of remediation is needed to assess risk for direct exposure, protection of groundwater, and protection of the Columbia River.
Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.	2	Characterize beneath remediated waste sites to assess the nature and extent of contamination in the vadose zone.	Drill six boreholes. Samples will be collected and analyzed to assess the vertical extent of contamination in the vadose zone at borehole locations.	Yes	During the RI, drill one borehole in the following waste sites: 100-B-5 Trench, 116-B-5 Crib, 116-B-6B Crib, 116-B-11 Retention Basin, 116-C-6 Process Pit, and 118-B-6 Burial Ground. Soil samples will be collected and analyzed as described in the SAP (DOE/RL-2009-44). The location of these sites is shown in DOE/RL-2009-44.	Characterization will be performed to validate interim remedial action, address uncertainty regarding the nature and extent of residual contamination in soils, refine the CSM (if necessary), and support decision making for the final ROD for the 100-B/C Decision Unit.
Vadose zone contaminant nature and extent needed to assess protection of groundwater around reactor structures.	3	Characterize around reactor structures to assess the nature and extent of contamination in the vadose zone.	Data are needed to determine the nature and vertical extent of the contamination in the vadose zone around the 100-B and 100-C Reactor Structures.	Yes	Continue contaminated soil removal and sampling at waste sites associated with the 105-B and 105-C Reactor sites. The location of these waste sites is shown in Appendix B.	Continue remediation to protect human health and environment. Data collected during and at completion of remediation is needed to assess the nature and extent of vadose zone contamination.
Unidentified waste sites (orphan and discovery sites) may exist in the decision unit.	4	Identify new waste sites and potential sources of contamination.	The orphan site evaluation process in the 100-BC Decision Unit has been completed. Discovery sites may be identified during ongoing remediation (facilities or waste sites).	Yes	Continue discovery process as remedial actions continue.	Discovery sites may be identified during ongoing remediation (facilities or waste sites).
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 contaminants (CrVI, Sr-90, and tritium) in the unconfined aquifer.	Groundwater contamination has been detected at concentrations above water quality standards in the unconfined aquifer in the 100-BC Decision Unit. The extent of contamination (e.g., CrVI) has not been defined spatially in the unconfined aquifer.	Yes	Install four new groundwater monitoring wells (Figure 4-18). ***CrVI:*** Proposed well 1 (Figure 4-18) will be monitored for CrVI to define the extent in the unconfined aquifer west of the 100-B-27 Site. Proposed Well 5 will be monitored for CrVI in the southeastern portion of the 100-BC area. Wells C7505, C7507, C7508 (Figure 4-18) to be installed per SAP DOE/RL-2009-61 will also be monitored for CrVI. ***Tritium:*** Two wells (wells 2 and 3, Figure 4-18) are proposed to define the extent of tritium in the unconfined aquifer. Wells C7507 and C7508 to be installed per SAP DOE/RL-2009-61 will also be monitored for tritium. ***Sr-90:*** Wells C7505 and C7506 to be installed per SAP DOE/RL-2009-61 will be monitored for Sr-90 ***Additional work***: In addition, groundwater samples will be collected from boreholes drilled as part of data needs 2 and 3, near waste sites that are possible sources for groundwater contamination. Groundwater samples will also be collected as part of ongoing activities related to CrVI contamination associated with the 100-C-7 Waste Site. These groundwater samples will not be collected by this RI.	New wells are proposed to define the extent of CrVI, Sr-90, and tritium contamination. The extent of CrVI has not been defined in the 100-B/C Area. Sr-90 concentrations have not been defined to the east and west, downgradient of the 105-B Reactor. Tritium concentrations in the unconfined aquifer have not been defined near the 118-1 Burial Ground or the 100-C-7 Site.

Table ES-1. 100-B/C Decision Unit Data Needs

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The level of contamination entering the Columbia River is not well known.	6	Increase sampling frequency of aquifer tubes.	Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., CrVI) has been documented in the 100-BC Decision Unit. Aquifer tubes have been installed to analyze groundwater contaminants discharging to the river. These aquifer tubes are typically analyzed for contaminants once 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 is planned for fall 2009, and it is expected these data will provide additional insight regarding contaminant levels entering the river.	Yes	Modify aquifer tube construction to allow sampling of the tubes at the same frequency as monitoring well sampling described in Data Need No. 13. Monitor aquifer tubes for CrVI, Sr-90, and tritium. Collect groundwater upwelling samples in the Columbia River.	Samples collected during limited aquifer tube sampling show impacts of CrVI, Sr-90, and tritium. More frequent sampling of the aquifer tubes will provide better temporal data to assess potential impacts to aquatic receptors.
The fate and transport of contaminants beneath the unconfined aquifer has not been evaluated.	7	Collect physical and hydrogeologic parameters from soil samples to support fate and transport of contaminants beneath the unconfined aquifer.	The RUM unit is currently considered an aquitard. The integrity of the aquitard unit and potential transport within the aquitard have not been evaluated in the 100-BC Decision Unit.	Yes	Split-spoon soil samples at total depth of 1.5 m [5 ft] into the RUM will be collected from the five new proposed wells (wells 1, 2, 3, and 5, Figure 4-18 proposed for data need 5, and well 4 proposed for data need 9), and the four new wells that are being installed in per SAP DOE/RL-2009-61 (wells C7505, C7506, C7507, and C7508, Figure 4-18). Drill one well (well R1, Figure 4-18) 50 ft into the RUM and collect soil and groundwater samples. Sampling details are listed in DOE/RL-2009-44.	Only one well has been completed within the RUM aquitard unit in the 100-BC Decision Unit. Data are not available to evaluate the integrity of the aquitard unit, or fate and transport within the aquitard.
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 the 100-BC Decision Unit 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.	No	NA	The preliminary evaluation base of the unconfined aquifer surface using near-river wells indicates the top of the aquitard (RUM) beneath the unconfined aquifer is more than 15 m (49 ft) below the bottom of the Columbia River (i.e., the top of the RUM does not intersect the Columbia River).
The rate of exchange of groundwater between the groundwater and the river 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.	Yes	Drill two characterization wells (wells 4 and R1, Figure 4-18 near the river). Drill R1 50 ft into the RUM near aquifer tubes AT-B-3D, M, and S. Screen well R1 within the first water-bearing zone of the RUM. Screen well 4 within the unconfined aquifer. Soil samples will be collected within the vadose zone, unconfined aquifer, and RUM. Groundwater samples will be collected from the unconfined aquifer and the RUM (if sufficient water is available for sampling). Details of the sampling are found in the SAP (DOE/RL-2009-44). Sample groundwater from the aquifer tubes AT-B-3-D, M, S and wells 8 and R1. Sample groundwater from aquifer tubes AT-06-D, M, S and wells 199-B2-12 and 199-B3-47.	Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., CrVI) has been documented in the 100-BC Decision Unit. Additional data are needed to evaluate the potential impacts to the river.

Table ES-1. 100-B/C Decision Unit Data Needs

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The mechanism to explain the persistence of the chromium, Sr-90, and tritium plumes is unknown.	10	Collect soil and water samples from the (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	Drill and sample soil and groundwater from six (4 wells for Data Need 5 and 2 wells for Data Need 9) proposed groundwater wells (wells 1 to 5 and R1, Figure 4-18). Details are found in the SAP (DOE/RL-2009-44). Sample boreholes B1 to B6 (Figure 4-18) within vadose zone, deep vadose zone, and rewetted zone.	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 remedial technologies have not been sufficiently investigated.	11	Potential groundwater remedial technologies	Groundwater contamination above aquatic standards and DWS maximum contaminant levels has been detected in the 100-BC Decision Unit. No interim remedial actions are currently in operation. The current RI will use the data collected during this RI (e.g., soil physical properties) for comparison of remedial alternatives, and evaluate information from other remedial technology evaluations from other 100 Area OUs necessary for comparison of potential final remedies as part of the future project FS.	No	Evaluate remedial technologies using soil and groundwater data gathered as part of this RI, information and evaluations from other 100 Area and Hanford OU remedial technology evaluations. Evaluate data and information from treatability tests including the planned in situ treatability test for CrVI at the 100-C-7 Waste Site.	Remedy and remedial technology evaluations are needed as part of the FS. The remedial process optimization activity for the 100-D/H Decision Unit has evaluated potentially applicable remediation technologies for CrVI. Evaluations related to Sr-90 have been completed for the 100-NR-2 groundwater OU. These evaluations will be used during preparation of the 100-BC Decision Unit FS.
Data are not available for an improved understanding of contaminant transport.	12	Insufficient data are available to assess the physical and hydraulic properties of soil and confirm contaminant distribution coefficients to support modeling and analysis.	On selected soil samples, estimate soil properties and hydraulic properties, determine level of contamination and perform batch leach contacting test.	Yes	Drill and sample soil and groundwater from six proposed groundwater wells (wells 1 to 5, Figure 4-18), and well R1 (Figure 4-18). Details are found in the SAP (DOE/RL-2009-44).	Support 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 20 groundwater monitoring wells in the 100-BC Decision Unit (16 existing wells and four new wells to be installed in per SAP DOE/RL-2009-61).	Groundwater data are needed that are spatially representative of a decision unit, representative of river stage influence and inclusive of all COPCs.	Yes	Collect and analyze groundwater samples from 20 groundwater monitoring wells to characterize the spatial, temporal, and chemical extent of groundwater contamination. Wells are shown in Figure 4-18. Details are found in the SAP (DOE/RL-2009-44).	Groundwater data are needed to address uncertainties associated with the RCBRA.

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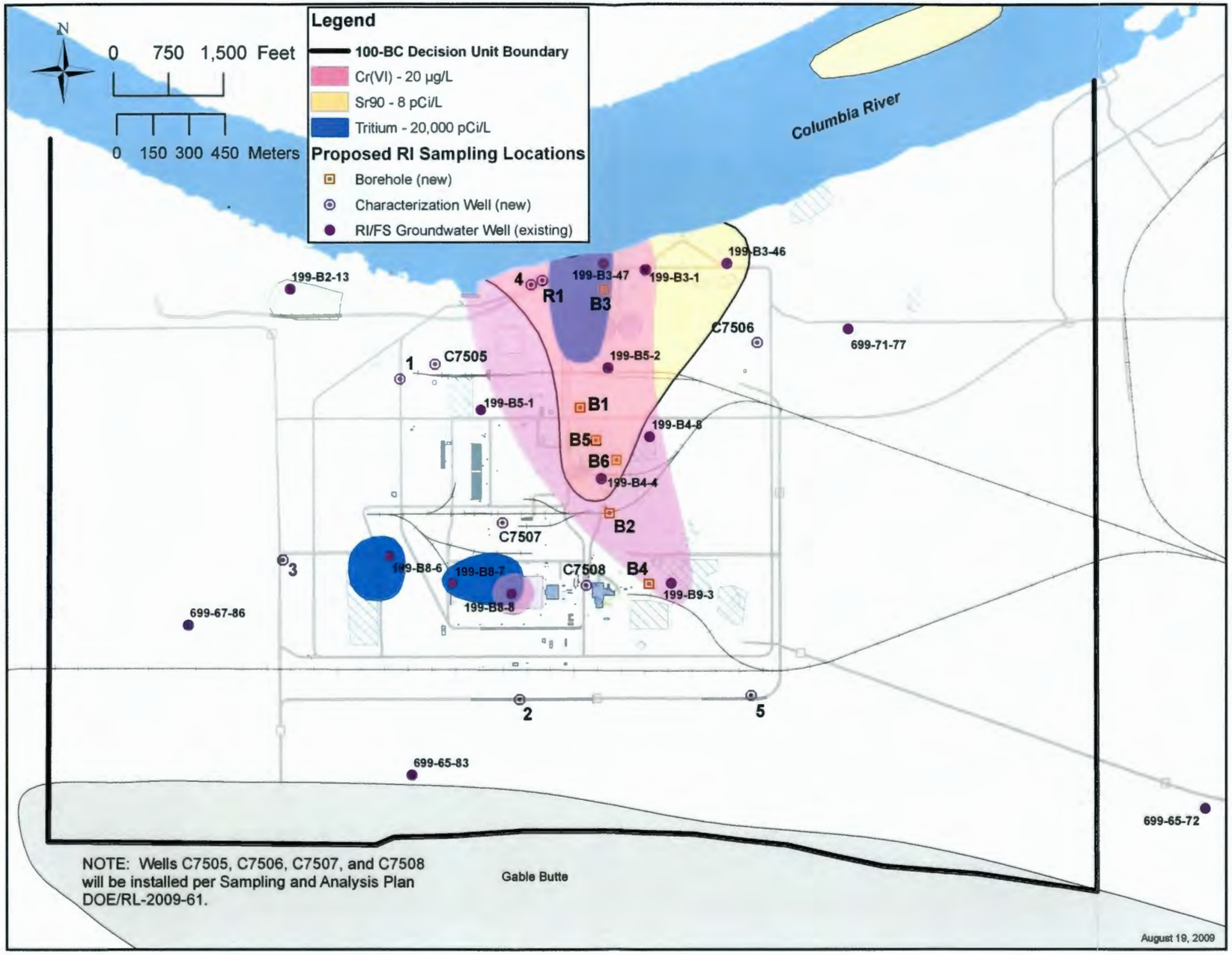

Figure ES-2. Proposed Remedial Investigation/Feasibility Study Sampling Locations for Soil and Groundwater for 100-BC Decision Unit

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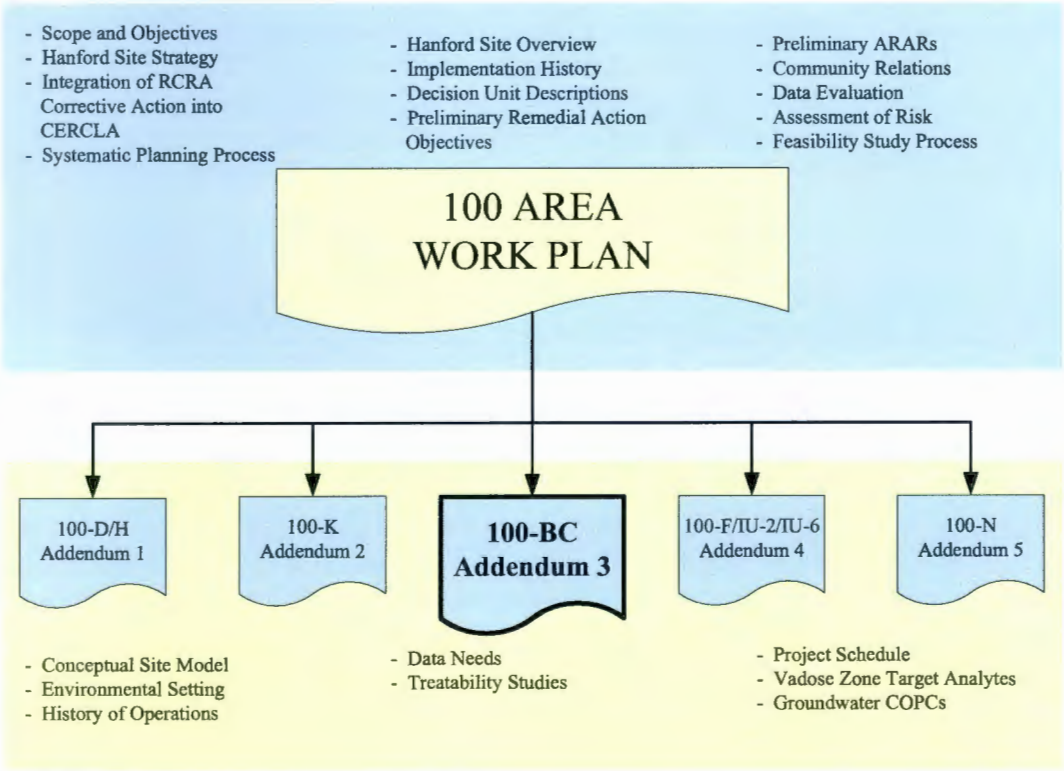
Terms

AEA	*Atomic Energy Act of 1954*
ARAR	applicable or relevant and appropriate requirement
BCM	Bank Cubic Meters
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
CVP	cleanup verification package
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DQO	data quality objectives
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
EWS	Export Water System
FS	feasibility study
GPR	ground-penetrating radar
GPS	Global Positioning System
HAER	Historic American Engineering Record
IC	ion chromatography
ICP	inductively coupled plasma
ISS	interim safe storage
K_d	soil distribution coefficient
LFI	limited field investigation
MCLs	maximum contaminant levels

mg/L	milligrams per liter
NHRP	National Register of Historic Places
OU	operable unit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RCBRA	River Corridor Baseline Risk Assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
ROD	record of decision
RTD	removal, treatment, and disposal
RUM	Ringold Upper Mud
SAP	sampling and analysis plan
SMEs	subject matter experts
TCLP	Toxicity Characteristic Leaching Procedure
Tri-Party Agreement	Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*
UCL	upper confidence limit
VOA	volatile organic analyte
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

1 Introduction

This document is Addendum 3 to the DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan*, hereafter referred to as the work plan. This addendum describes the 100-BC Decision Unit and planned efforts to conduct a remedial investigation (RI) in support of a final record of decision (ROD) for the 100-BC Decision Unit. The 100-BC Decision Unit includes the 100-BC-1 and 100-BC-2 Source Operable Units (OUs) and the 100-BC-5 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.



ARAR applicable or relevant and appropriate requirement
CERCLA *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC contaminant of potential concern
RCRA *Resource Conservation and Recovery Act of 1976*

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

This addendum was developed through multiple interview sessions, workshops, and task team work organized through the Systematic Planning Process with the participation of subject matter experts (SMEs). 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 the 100-BC Decision Unit. Figure 1-2 shows the location of the 100-BC Decision Unit and its proximity to other decision units.

This addendum identifies data needs and a process to address those needs significant to remediation. A useful tool to guide characterization and identify effective remediation actions for the 100-BC Decision Unit 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, 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-BC Decision Unit CSM.

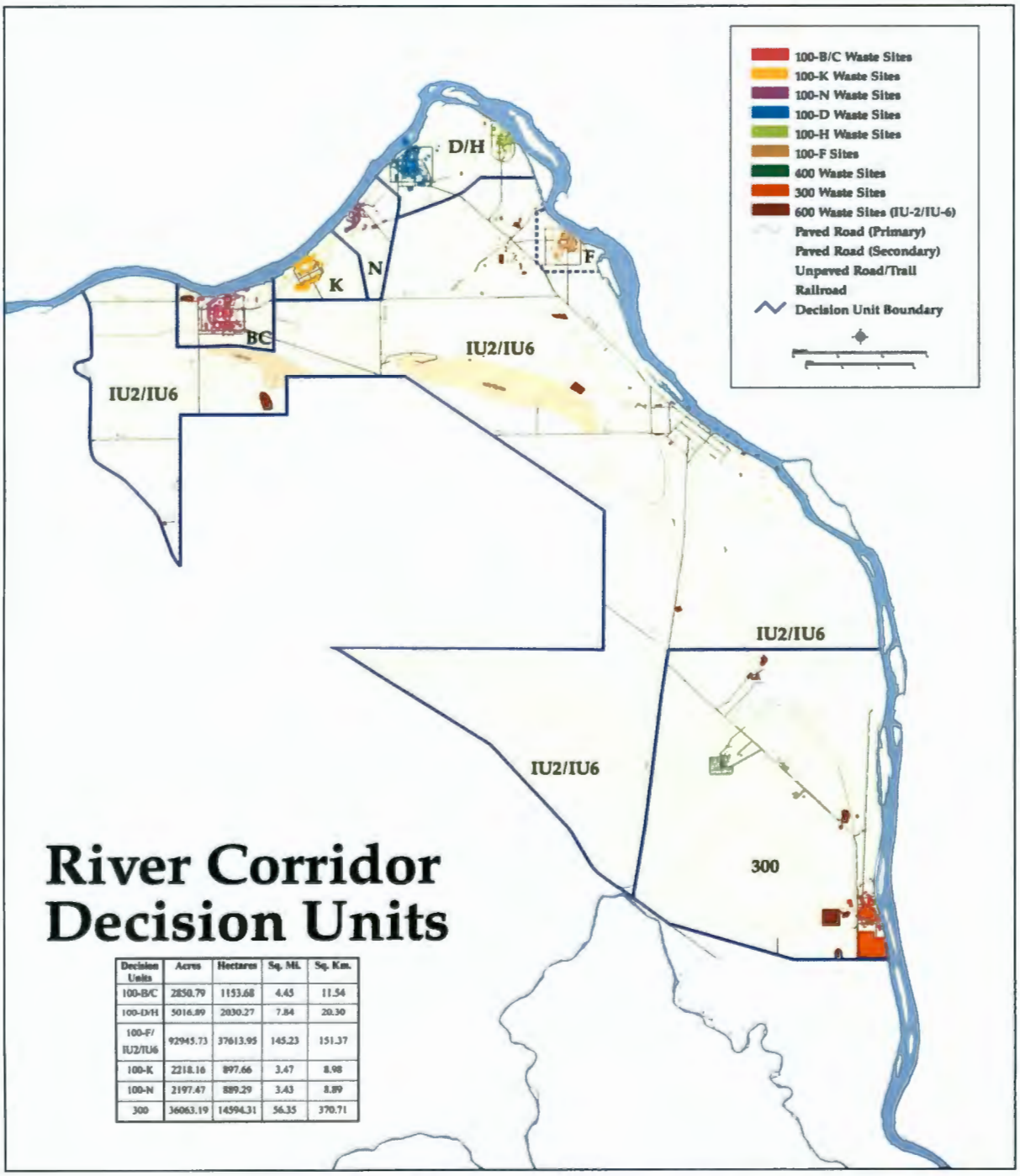
During two meetings, CSM component summaries were displayed on plates and used to identify and foster discussion of issues of concern to the participants. Appendix A contains the plates, which were used to solicit input from regulators, agencies, and SMEs. During one of the meetings, the soil target analyte and groundwater contaminant of potential concern (COPC) selection process was discussed. Chapter 4 presents the CSM and a data gap needs table for the 100-BC Decision Unit. The target analyte and COPC selection process is described in Chapter 4 of the work plan.

Most importantly, the identification of data needs led to development of a sampling and analysis plan (SAP) that establishes characterization activities specific to the 100-BC Decision Unit. The SAP (DOE/RL-2009-44, *Sampling and Analysis Plan for the 100-BC Decision Unit Remedial Investigation/Feasible 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 (QAPjP) to ensure that collected data meet the appropriate QA and quality control (QC) requirements.

1.2 100-BC Decision Unit Remediation Accomplishments

A considerable amount of environmental remediation and restoration has been completed and 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.

Information about the cleanup progress that has already taken place in the 100-BC Decision Unit is provided in the following subsections.



Decision Units	Acres	Hectares	Sq. Mi.	Sq. Km.
100-B/C	2850.79	1153.68	4.45	11.54
100-D/H	5016.89	2030.27	7.84	20.30
100-F/ IU2/IU6	92945.73	37613.95	145.23	151.37
100-K	2218.16	897.66	3.47	8.98
100-N	2197.47	889.29	3.43	8.89
300	36063.19	14594.31	56.35	370.71

Figure 1-2. River Corridor Decision Unit Boundaries

1.2.1 100-BC Decision Unit Deactivation, Decommissioning, Decontamination, and Demolition Actions

Since original construction, the 100-BC Decision Unit has included 87 facilities, including two reactors. The 105-B Reactor was the first of three original Hanford reactors built during World War II as part of the Manhattan Project. The C Reactor was built 8 years after the B Reactor. In addition to its plutonium production mission, the C Reactor was used for reactor physics and operations testing, and was a pilot-

scale version for the reactors at the 100-K Area. The reactors were supported by multiple facilities associated with services for water treatment, air filtration, nuclear fuel handling, effluent disposal, laboratories, and various other buildings.

Initial cleanup activities began as soon as the reactors were deactivated in 1968 (B Reactor) and 1969 (C Reactor). Follow-on housekeeping and decommissioning activities began as part of a site-wide initiative in 1973. This effort progressed, as resources allowed, through 1990 with buildings demolished; surplus equipment salvaged or redeployed; and minimal active operations maintained. Access to some sources is hindered by overlying facilities. Therefore, facility removal is sometimes necessary. The majority of the reactor ancillary and support facilities have been demolished and/or removed. Table 1-1 summarizes the current status of the 100–BC Decision Unit Facilities.

Table 1-1. 100-BC Decision Unit Facility Status (April 2009)

Facility Status	Total Number of Facilities
Active (151-B Electric Substation, 181-B Pump Station, 182-B Reservoir, and a Mobile Office)	4
Demolished and/or Removed	78
Inactive (B and C Reactors, 116-B Exhaust Stack, and 119-B Laboratory)	4
Total 100-BC Decision Unit Facilities	**86**

Figure 1-3. C Reactor During Interim Safe Storage Implementation in 1998

Figure 1-4. Reactor After Interim Safe Storage (2007) and 116-C-3 Chemical Waste Tanks Excavation (Foreground)

Figure 1-5. 105-B Reactor in 2005

The C Reactor has been placed in interim safe storage (ISS) until its final disposition. The ISS process was initiated in 1996, and completed in 1998 (Figures 1-3 and 1-4). The ISS process is a series of actions taken to protect a retired reactor from environmental degradation and to prevent the spread of contamination by placing in ISS or 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 peripheral reactor buildings and equipment, and disposing of the debris. In contrast, the

B Reactor is slated for historic preservation, with conversion of the facility into a public museum (Figure 1-5).

1.2.2 100-BC Decision Unit Waste Site Remediation

Through February 2009, 116 waste sites were recognized in the 100-BC Decision Unit. Of these, remediation is completed or was not required at 96 waste sites, mainly trenches, ditches, cribs, ponds, burial grounds, and unplanned releases. Only 20 waste sites remain, where interim dispositioning has not been completed (Table 2-3.). Figures 1-6 through 1-8 show the progress made on the 100-BC Decision Unit waste site remediation. Additional information is provided in Section 2.2.3 and Table 2-3 of this Addendum.

Figure 1-6. 116-B-9 French Drain During Remediation in 1997

1.2.3 100-BC Decision Unit Orphan Site Evaluation

An orphan site evaluation was initiated in April 2004, in the 100-B/C Area to identify and address orphan sites. Orphan sites are artificial features, items, or activity areas within the river corridor. The first areas selected for these activities were the 100-BC-1 and 100-BC-2 OUs. A historical review and field walk-down of the area was conducted, the resulting data were compiled and evaluated, and new waste sites were entered into the Waste Information Data System (WIDS) database.

The historical review included examining the construction, operation, decontamination and decommissioning, and remedial action activities conducted in the area from 1943 to 2004. This included reviewing and evaluating reports, drawings, and photographs relevant to those activities. The initial 2004 field walk-down has been supplemented over the past year to cover the entire decision unit, a total of 11.54 km^2 (4.45 mi^2). Global Positioning System (GPS) technology has been used to define the locations of artificial features and to digitally photograph them. For select sites, ground-penetrating radar (GPR) was also employed. Figure 1-9 presents the areas covered in the field walk-downs.

The historical review identified five new waste sites, while the field walk-down identified three new waste sites and modified an existing waste site. The GPR activities identified one new waste site. A number of sites were also identified as potential WIDS sites, including railroad tracks, underground electrical cables, and active facilities such as the 151-B Substation, and the Hanford Water Transport

System (181-B River Pump House, 182-B Reservoir, and associated piping). The status of these sites has not been determined at this time and their disposition will not be addressed in this work plan. The discovery process will continue at the 100-BC Decision Unit until all identified sites are dispositioned.

Figure 1-7. 100-BC Decision Unit Showing Primary Liquid Waste Disposal Features Under Remediation in April 2002

Figure 1-8. 100-B-27
Under Remediation (May 2009)

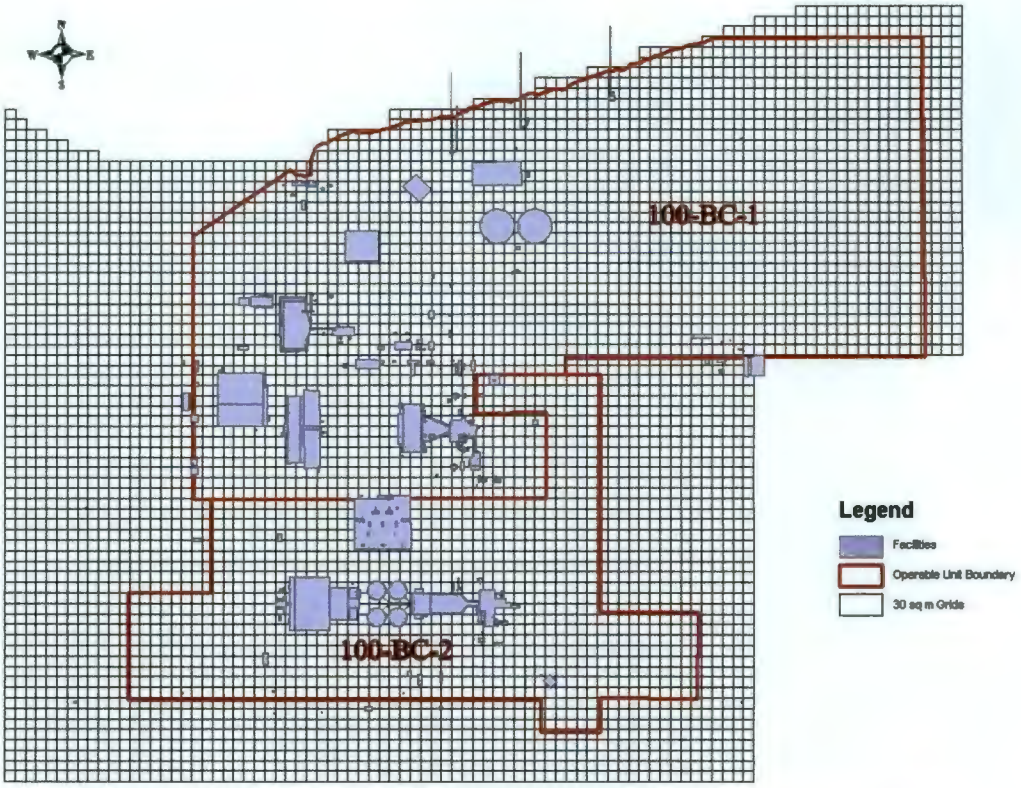


Figure 1-9. Area Addressed by 100-BC Orphan Sites Evaluation Process

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-BC Decision Unit includes two of these reactors. This section provides the background and environmental setting of the 100-BC Decision Unit and includes information about the waste generated and contamination, both known and potential.

Information in this section primarily comes from: WHC-SD-EN-TI-220, *100-B Area Technical Baseline Report*; WHC-SD-EN-RPT-004, *Summary of 100 B/C Reactor Operations and Resultant Wastes; Characterization of the Retired 100 Areas, UNI-946 (Radiological Characterization of the Retired 100 Areas)*; DOE-RL-93-06, *Limited Field Investigation Report for the 100-BC-1 Operable Unit*; DOE-RL-93-42, *Limited Field Investigation Report for the 100-BC-2 Operable Unit*; DOE-RL-93-37, *Limited Field Investigation Report for the 100-BC-5 Groundwater Operable Unit*; and other contemporary sources documenting interim remedial actions (e.g., WIDS).

2.1 100-BC Decision Unit 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 2-2). The 100 Area is divided into five decision units, each of which is composed of source and groundwater OUs (Figure 2-2). The 100-BC Decision Unit consists of the 100-B/C Area and its underlying groundwater.

The 100-BC Decision Unit is located in the northern portion of the Hanford Site adjacent to the Columbia River. The Columbia River is the largest river in the Pacific Northwest, with an average flow of approximately 3,400 m^3/s (120,000 ft^3/s).

The 100-BC Decision Unit is the westernmost of the 100 Area reactor facilities. It covers more than 3.5 km^2 (1.4 mi^2) of land along the southern shore of the Columbia River. The river stretch along the 100-BCDecision Unit is a part of the Hanford Reach National Monument, which is an important ecological, cultural, historical, and recreational resource.

For cleanup purposes, the 100-B/C Area previously was divided into source and groundwater OUs. The 100-BC-1 and 100-BC-2 source OUs are concerned with liquid, solid, and radioactive waste disposal sites. The 100-BC-5 OU groundwater OU comprises groundwater beneath the 100-B/C Area. Each of these OUs is included in the 100-BC Decision Unit (Table 2-2). A final ROD has not yet been developed for the100-BC Decision Unit and active groundwater remediation measures have not been initiated. Key boreholes and wells related to the 100-BC Decision Unit are listed in Table 2-1 and shown in Figure 2-1. Other key features and wells within the 100-BC Decision Unit are shown in Figure 4-18 and in Appendix B.

Table 2-1. Key Wells and Boreholes related in the 100-BC Decision Unit

Well ID	Well Name	Drill Date	Drill Depth (ft)	Status
A4550	199-B2-12	05/28/1992	178.8	In-Use
A4551	199-B2-13	03/24/1992	40	In-Use
A4552	199-B3-1	04/13/1953	63	In-Use
A9505	199-B3-2	09/21/1953	790	Decommissioned
A9825	199-B3-2P	09/21/1953	790	Decommissioned
A9808	199-B3-2Q	09/21/1953	790	Decommissioned
A4553	199-B3-46	02/28/1992	66.77	In-Use
A4554	199-B3-47	06/23/1992	61	In-Use
A4555	199-B4-1	02/23/1949	90	In-Use
A5539	199-B4-2	02/28/1949	90	Decommissioned
A4556	199-B4-3	02/23/1949	91	Decommissioned
A4557	199-B4-4	09/13/1960	105	In-Use
A4559	199-B4-8	02/21/1992	90.4	In-Use
A4560	199-B4-9	05/28/1992	92.8	Decommissioned
A4561	199-B5-1	08/31/1962	151	In-Use
A4562	199-B5-2	06/23/1992	75	In-Use
A4563	199-B8-6	07/08/1992	91	In-Use
C5671	199-B8-7	07/23/2007	92	Candidate For Decommissioning
C5672	199-B8-8	08/02/2007	112	Candidate For Decommissioning
A4564	199-B9-1	07/10/1952	117	Decommissioned
A4565	199-B9-2	06/15/1992	118	In-Use
A4566	199-B9-3	06/09/1992	109	In-Use
A8956	699-63-89	04/11/1973	220	Decommissioned
A5302	699-65-72	na	216	In-Use
A5303	699-65-83	04/30/1967	121	In-Use
A5311	699-66-91	05/31/1973	190	In-Use
A5313	699-67-86	10/09/1962	467	In-Use
A5322	699-71-77	09/10/1962	300	In-Use
A5323	699-72-73	09/20/1961	200	In-Use
C4947	C4947	08/09/2005	96	Decommissioned

* Drilling date not available

Table 2-2. 100-BC Decision Unit Site Location Information

Decision Unit Sub-Area	Site Information
100-BC	The 100-B/C Area is located on the Columbia River upstream of the 100-K Decision Unit. This location has two production reactors, the B and C Reactors, with their associated infrastructure. Source area OUs include 100-BC-1 and 100-BC-2.
Groundwater	The 100-BC-5 OU encompasses the groundwater in a portion of the 100-B/C Area within the decision unit.

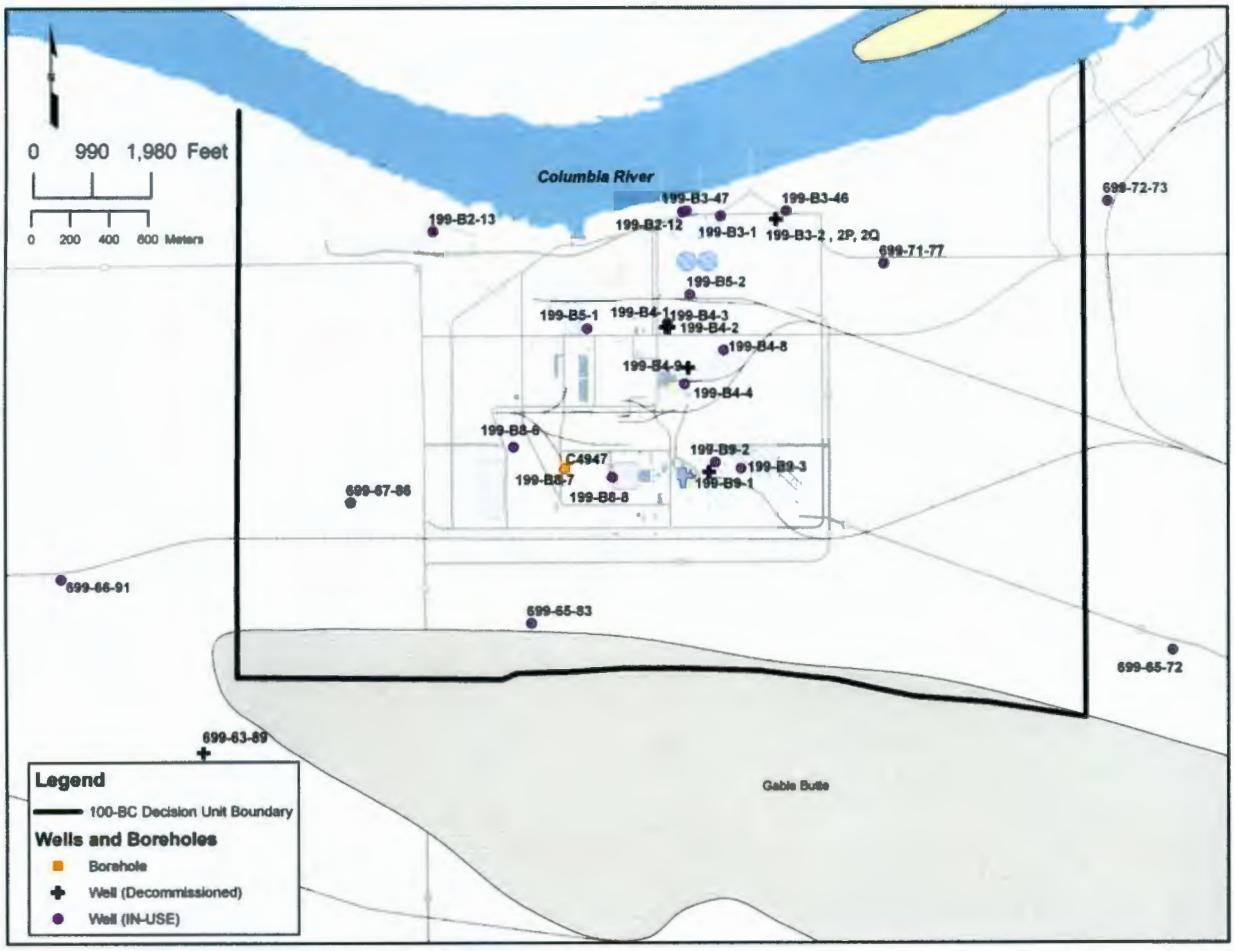


Figure 2-1. Location of Key Wells and Boreholes in the 100-BC Decision Unit

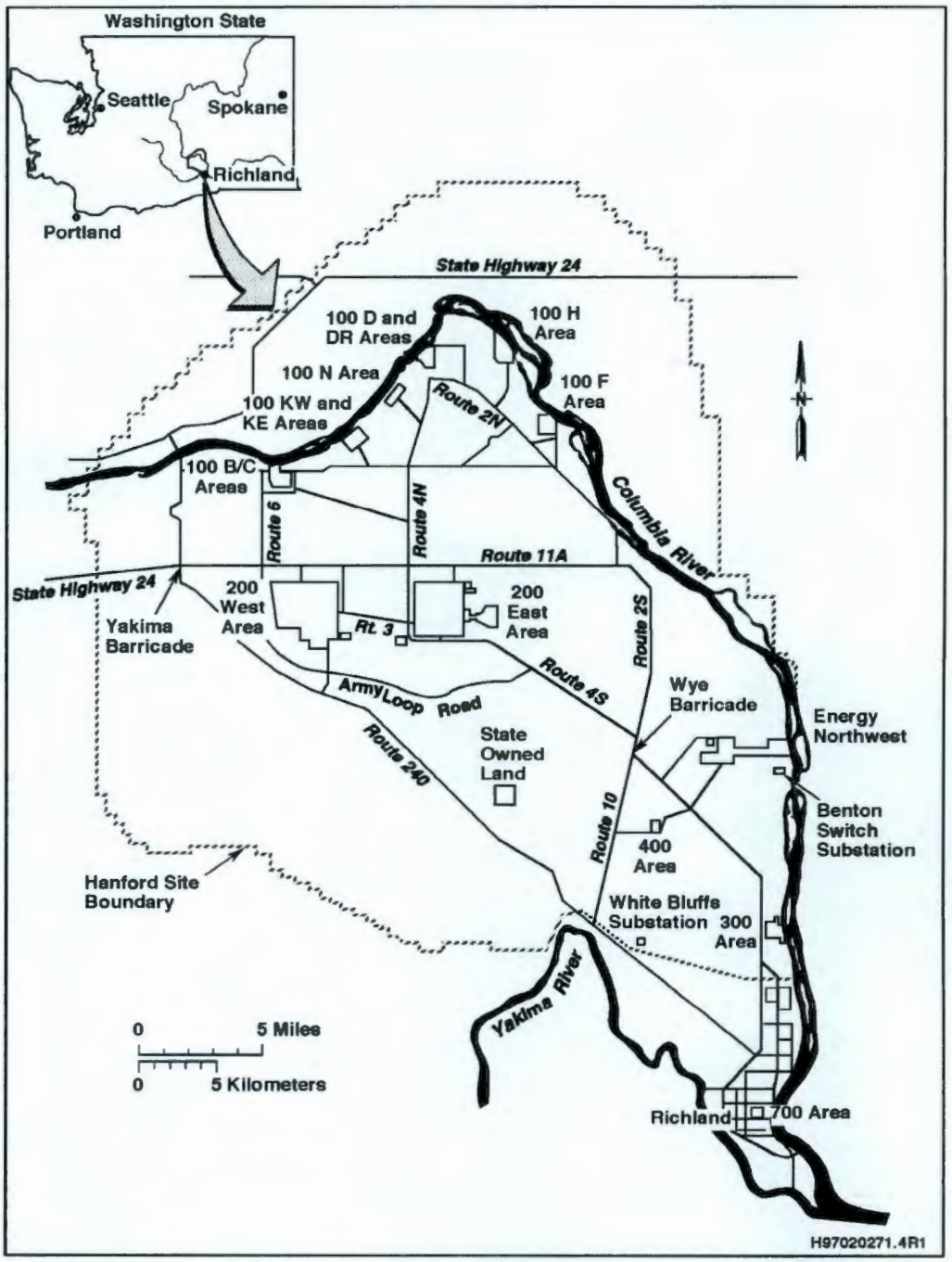


Figure 2-2. Location of the Hanford Site and the 100 Area Decision Units

The B Reactor construction started in March 1943, and was completed in 13 months (Figure 2-3; P-7834-NEG). After comprehensive equipment testing, the reactor was first activated in September 1944. The B Reactor was the first of three original Hanford reactors built during World War II as part of the Manhattan Project to build an atomic bomb. The design, operations, and waste management processes at the B Reactor were the first of its kind in practice. The original Hanford reactors represented the basis for subsequent reactor design and conduct of operations, especially with regard to handling radioactive materials and waste management.

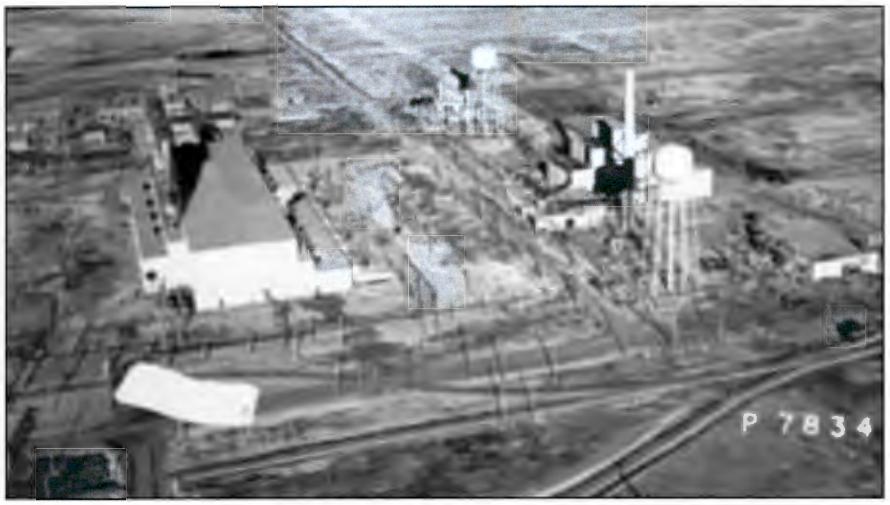


Figure 2-3. Northeastern Aerial View of the B Reactor in 1944

After its war-time production, the B Reactor was thought to be nearing the end of its effective operational life because of growth and distortion of its graphite core. From March 1946 to June 1948, the reactor was taken offline to preserve its capability. Subsequent improvements in processes and technologies allowed its restart and continued use of the reactor after 1948. The B Reactor was deactivated in 1968.

Once the plutonium production and other missions at the reactors ended, a ROD for the decommissioning of eight surplus production reactors at the Hanford Site was issued by the DOE (58 FR 48509, "Record of Decision: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington").

The C Reactor was constructed in 1951 and 1952 with initial startup in November 1952. In addition to its plutonium production mission, the C Reactor was used for reactor physics and operations testing, and as a pilot-scale version for the next-generation of reactors at the 100-K Area (Gerber, 1993; Carpenter, 1994). The C Reactor was deactivated in April 1969. ISS for the C Reactor was initiated in 1996 and completed in 1998 (DOE/RL-2005-45, *Surplus Reactor Final Disposition Engineering Evaluation*). Figures 2-4 (1658-NEG) and 2-5 and show views of the C Reactor from 1953, and during ISS.

Figure 2-4. Northeastern Aerial View of the C Reactor (at right) in 1953

Figure 2-5. The C Reactor during Interim Safe Storage Implementation in 1998

Figures 2-6 (1966) and 2-7 contrast the condition of the 100-B/C Area during production versus the recent status of facilities and waste sites. Waste sites and facilities have been largely removed at the 100-B/C Area and scarring of the landscape from past construction and remedial activities is evident in both photos.

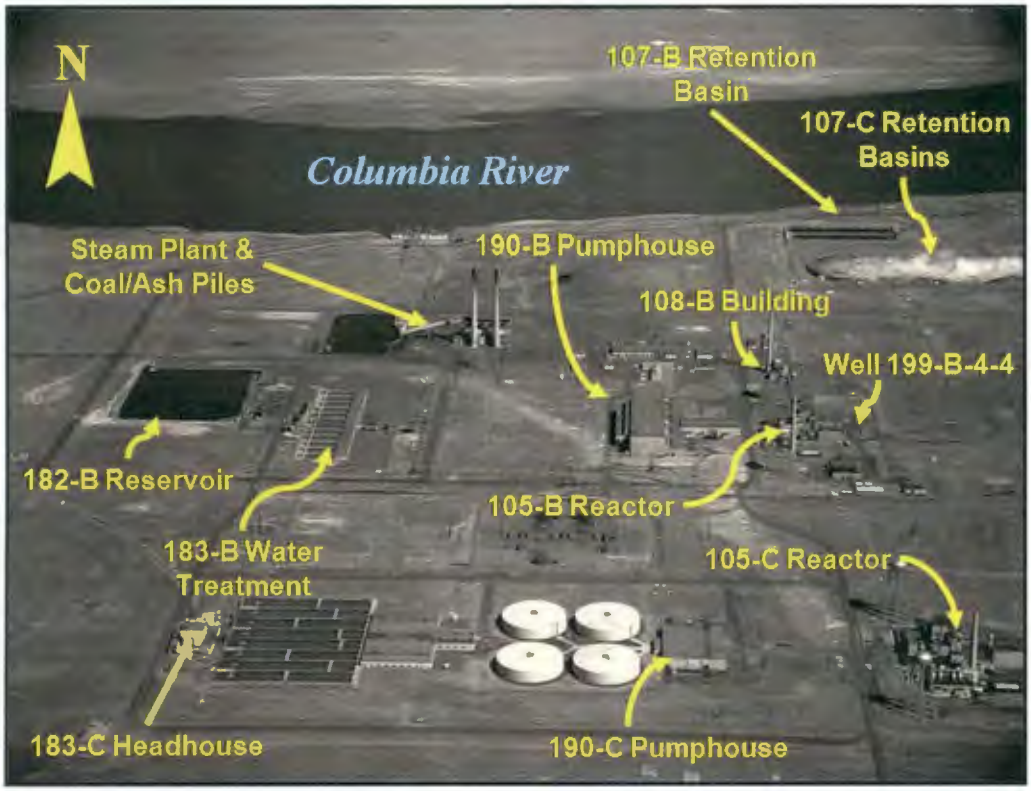


Figure 2-6. 100-B/C Area Major Features During Reactor Operations in 1966

Figure 2-7. Recent Conditions at the 100-B/C Area

2.2 Environmental Setting

Information common to the 100 Area is provided in detail in Chapter 2 of the work plan. Numerous environmental, geologic, and hydrogeologic investigations have been conducted in the 100-BC Decision Unit. A summary of the findings of these investigations, and the factors that affect contamination impacts at the Hanford Site, are presented in the following sections. Information specific to the 100-BC Decision Unit is included here. The environmental setting dictates much of the behavior of contamination within and through the vadose zone and groundwater. Wells and boreholes discussed in this section are shown in Figures 2-1, 4-18, or in Appendix B.

2.2.1 Topography

Much of the surface and subsurface of the topography of the 100-BC Decision Unit 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 surface elevations range from approximately 149 m (490 ft) above mean sea level at the southern border to 131 m (430 ft) near the river. The surface topography changes are greatest in the vicinity of the Columbia River where the riverbank slopes steeply (10:1 grade) to the river shoreline, and drops approximately 9 m (30 ft) from the edge of the terrace toward the river to an elevation of approximately 122 m (400 ft).

The 100-BC Decision Unit lies on a relatively flat, semi-arid bench south of the Columbia River near the center of the Pasco Basin. Significant topographic features near the 100-BC Decision Unit include Gable Butte to the south. During periods of low river stage, an extensive gravel beach is exposed along the north boundary of the decision unit along the Columbia River. On the upstream end of the decision unit, the bank is less steep, and broadens into a gently sloping (50:1 grade), 150 m (492 ft) wide shoreline (PNL-8143).

2.2.2 Geology

An overview of the regional geology of the 100 Areas is provided in the work plan (DOE/RL-2008-46, Section 2.4). Additional information specific to the 100-BC Decision Unit is provided in this section.

The 100-BC Decision Unit is underlain by Miocene (approximately 17 to 8.5 million years before present) volcanic (molten rock) flows of the Columbia River Basalt Group and late Miocene to Pleistocene sediments (approximately 10.5 million to 12,000 years before present) that overlie the basalts. The Columbia River Basalt Group is greater than 3,000 m (9,800 ft) thick. Late Miocene to Holocene sediments overlay the basalts.

Most of this sedimentary sequence can be divided into two main units important to understanding contaminant fate and transport: the Ringold Formation of late Miocene to middle-Pliocene age (approximately 10.5 million to 3 million years before present) and the Hanford formation of Pleistocene to Recent age (approximately 1 million to 12,000 years before present). The Hanford formation, and upper sections of the Ringold Unit E constitute the vadose zone in the 100-B/C Area. Holocene surficial deposits of silt, sand, and gravel form the veneer at the surface. Figure 2-8 shows the generalized stratigraphy of the 100-BC Decision Unit.

2.2.2.1 Ringold Formation

The Ringold Formation lies directly above the Columbia River Basalt Group. The Ringold Formation was formed by fluvial-lacustrine (stream-lake) processes. The Ringold Formation is composed of units of non-indurated and semi-indurated (loose to semi-hardened) clay, silt, fine- to coarse-grained sand, or

granule to cobble-size gravel. Within the Ringold Formation, understanding the physical and chemical behavior of two units is most important to remedial decision making: the RUM and Unit E.

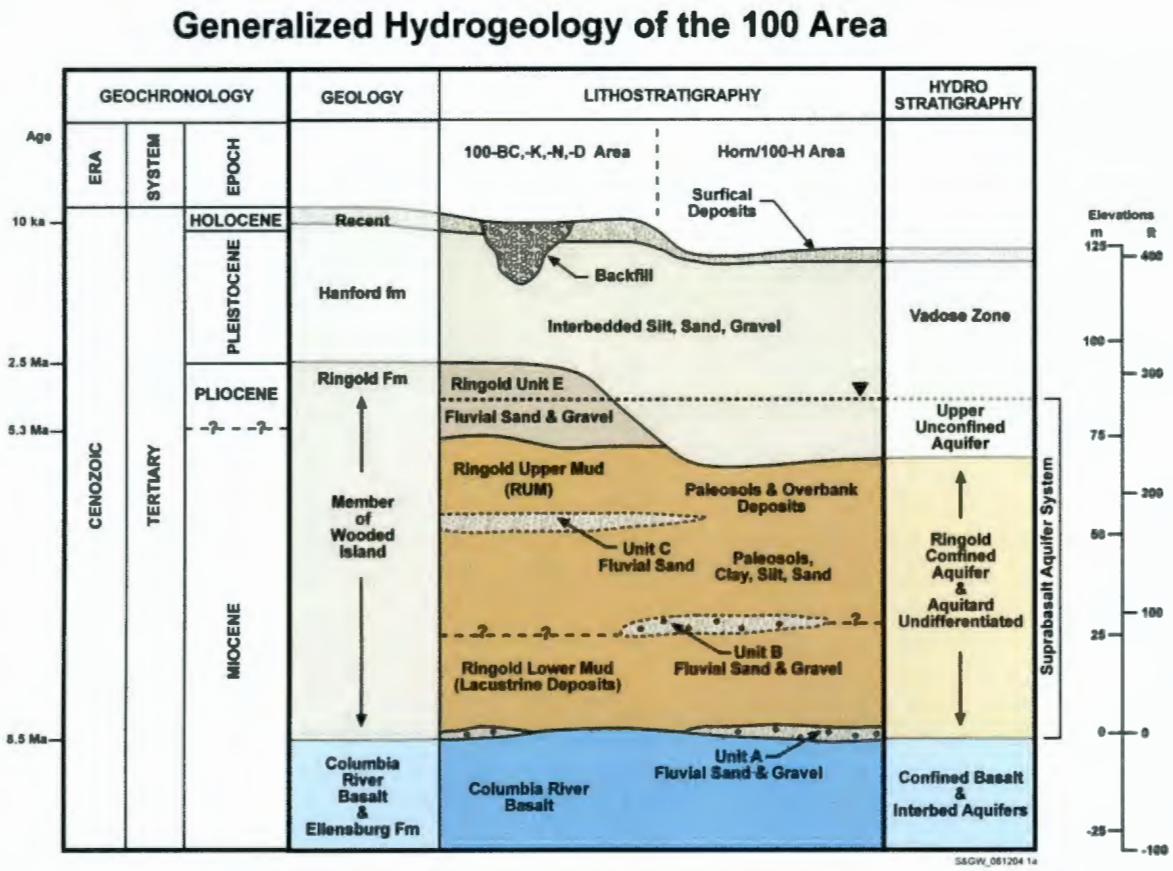


Figure 2-8. Stratigraphy and Hydrologic Units of the 100-BC Decision Unit

In the 100-BC Decision Unit, the Ringold Formation consists of semi-indurated clay, silt, fine- to coarse-grained sand, and pebble- to cobble-size gravel. These are described in five sediment facies' associations that are defined on the basis of lithology, petrology, stratification, and pedogenic alteration in the work plan (DOE/RL-2008-46).

Based on the log for monitoring well boring 199-B3-2 (see Figure 2-1), the Ringold Formation is estimated to be approximately 182 m (600 ft) thick in the 100-BC Area. In contrast, the Ringold Formation at boreholes 699-63-89 and 699-66-91 (see Figure 2-1), located in the southwestern portion of the 100-BC Decision Unit, is thinner at 21 and 12 m (70 and 40 ft) thick, respectively (WHC-SD-EN-TI-133). This reflects a thinning relative to the Umtanum-Gable Mountain basalt anticline or its subsidiary anticlines.

Paleosol and overbank deposits of the RUM reach 34 m (110 ft) in thickness at the 100-BC Decision Unit, where the top of the RUM is encountered at depths ranging from 47 m (154 ft) to 62 m (203 ft) (DOE/RL-2009-61). The RUM serves as a low-permeability feature, the top of which defines the base of the unconfined aquifer. The Hanford formation overlies the gravel-dominated Ringold Formation Unit E in this area.

Beneath the RUM, the Ringold Formation is composed of a series of low-flow (fine-grained sediments) and water-bearing (coarse-grained sediments) zones (DOE-RL-93-37). Groundwater within these units is confined to semi-confined. The transmissivity of the water-bearing zones beneath the RUM are typically lower than that of the unconfined aquifer.

2.2.2.2 Hanford Formation

The Hanford formation ranges in thickness from more than 30 m (100 ft) in the southern and southeastern portions of the 100-BC Area, to less than 15 m (50 ft) near the Columbia River (WHC-SD-EN-TI-133). 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*).

The Hanford formation is divided into three facies: (1) gravel-dominated, (2) sand-dominated, and (3) silt-dominated (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for the Post-Ringold-Formation Sediments within the Central Pasco Basin*). While the gravel-dominated facies are observed throughout the 100-BC Decision Unit, the sand-dominated facies were observed to occur locally and cannot be correlated between boreholes.

The Hanford formation is often difficult to differentiate from the Ringold Unit E. The units are differentiated based on characteristics such as a basalt clast content, gravel content, coloration, and cementation. The Hanford formation typically is less cemented than the Ringold Formation and has greater gravel content, but cable tool drilling can disrupt the integrity of these features.

The Hanford formation is characterized by large to very large, cobble to boulder-size clasts in open-framework gravels that include discrete 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 contains little to no cementation (WHC-SD-EN-TI-132). Boulder gravel in the upper 6 to 15 m (20 to 50 ft) demonstrates the high-energy depositional environment created during the Missoula Floods (Hanford formation). These deposits prove difficult to penetrate by drilling activities (WHC-SD-EN-TI-133). Silt-dominated facies are not significant in the 100-BC Decision Unit.

2.2.2.3 Hanford/Ringold Contact

The Hanford formation generally is more transmissive and permeable than the Ringold Formation, and the contact between the two formations potentially affects contaminant transport in the vadose zone and groundwater. 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.

Cable-tool drilling methods have often rendered it difficult to account for differences near the contact between the Ringold Formation gravel-dominated facies and the overlying Hanford formation gravels. The gravel material is thoroughly pulverized and the fines are washed away as a result of cable-tool drilling, making it difficult to identify the characteristics used to differentiate between the two units. Therefore, the Hanford/Ringold contact has not been determined in many boreholes because of poor preservation of these characteristics during borehole logging and past inconsistent logging practices.

The contact between Ringold Formation Unit E and the Hanford formation is important because the saturated hydraulic conductivity for the gravel-dominated sequence of the Hanford formation is one to two orders of magnitude higher than the more compacted and locally cemented Ringold Unit E. Because

hydraulic conductivity varies with the formation, different groundwater level responses may occur where channels now filled with the Hanford formation have been scoured into the Ringold Unit E. These buried channels could become preferential pathways for contaminated groundwater during high river stages (PNNL-14702).

2.2.2.4 Surface Deposits

Recent localized surficial deposits and backfill overlie the Hanford formation and the Ringold Formation. These Holocene surficial deposits consist of silt, sand, and gravel that form a thin (less than 4.9m [16 ft]) veneer across much of the Pasco Basin. These sediments were deposited by a mix of eolian and alluvial processes during the past 10,000 years.

2.2.3 Hydrogeology

Liquid waste, including radionuclides and hazardous chemicals, has been discharged to the surface and subsurface in the 100-BC Decision Unit. A portion of these contaminants has reached groundwater. An understanding of groundwater flow is necessary to properly monitor groundwater on the Hanford Site, track the spread of these contaminants, and evaluate remedial actions.

Between 1949 and 1962, eight wells (199-B3-1, 199-B3-2, 199-B4-1, 199-B4-2, 199-B4-3, 199-B4-4, 199-B5-1, and 199-B9-1 [see Figure 2-1] were completed at the 100-B/C Area boundaries (DOE/RL-90-08). The deepest well (199-B3-2) was drilled to 241 m (790 ft) below ground surface (bgs). This is the only well at the 100-B/C Area to penetrate the surface of the basalt surface. Other 100-B/C Area wells were completed at much shallower depths, near the unsaturated/saturated sediment interface at approximately 30 m (100 ft) bgs. Data collected from these well borings are used to discuss the hydrogeology of the 100-BC Decision Unit in this section.

In the 100-BC Decision Unit, the groundwater system is composed of several hydrostratigraphic units (DOE/RL-93-37). From deepest to shallowest (Figure 2-8), these units include the following:

- Confined aquifer in the Columbia River Basalt (Rattlesnake Ridge Interbed)
- Basalt confining zone
- Confined and semi-confined lower transmissivity zones (Ringold Formation, with the exception of Unit E)
- Unconfined aquifer, higher transmissivity zone
- Unsaturated zone (vadose zone).

In the 100 Area, the hydrogeologic framework of the unsaturated zone (vadose) is complex and can be divided into two primary hydrostratigraphic units:

- The gravel-dominated facies association of the Hanford formation
- The conglomeratic member of the Ringold Formation (DOE/RL-2002-39; BHI-00917; WHC-SD-EN-EV-027; WHC-SD-EN-TI-133 Rev. 0-A; WHC-SD-EN-TI-155; WHC-SD-EN-TI-132).

The unconfined aquifer is composed primarily of the Ringold Formation Unit E, with a thickness of 33.5 m (110 ft) near the river. Near the Columbia River, the water table rises into the overlying Hanford formation where the Ringold Unit E has been eroded (WHC-SD-EN-TI-133), during time periods of high river stage. Below the unconfined aquifer, the Ringold Formation consists of a series of aquitards and

water-bearing zones. The low permeability of the RUM provides the characteristics needed to define the base of the unconfined aquifer. The RUM is encountered at depths ranging from 47 m (154 ft) to 62 m (203 ft) (DOE/RL-2009-61).

The hydrogeology of the 100-BC Decision Unit reflects the interactions among surface water (Columbia River), groundwater (unconfined to confined aquifers), and the vadose zone. Of key importance is the Columbia River, which has played a major role in the depositional and erosional processes that helped to produce the sediment and geologic features at the 100-BC Decision Unit. Groundwater flow directions and gradients are highly dependent on river stage, with greater effects near the river. Diminished gradient effects are delayed, diminishing effects up to several hundred meters from the shoreline. These gradients affect both the short-term and long-term movement of contaminants to the river.

Although the long-term net transport of contaminants in groundwater is toward the river, groundwater movement toward the river is impeded or reversed during high river stage as river water infiltrates the near-river groundwater as bank storage. During these high river stage (spring) conditions, groundwater contaminants are displaced inland by river water, and contaminant discharge to the river is reduced.

Groundwater elevations range over 1.8 m (6 ft) near the river, while inland the range diminished to approximately 0.4 m (1.3 ft). This range is largely due to the effects of river stage. Groundwater data have been collected from the 100-BC groundwater monitoring wells and aquifer tubes during quarterly to biennial monitoring events for more than 10 years. Figure 2-9 shows the current groundwater monitoring well and aquifer tube locations (DOE/RL-2008-01). Decommissioned groundwater monitoring wells are shown in Appendix B.

River data are collected from a Columbia River gauge installed at the 100-BC Decision Unit. These data are compared with water table elevation data continuously recorded at wells 199-B3-1, 199-B4-1, and 199-B4-4 (DOE/RL-93-37) (for well locations see Figure 2-1). While river stage effects are observed in well 199-B3-1 (near the river), no relationship between river stage and water table levels is apparent for 199-B4-1 and 199-B4-4 (located inland, nearer the B Reactor) (DOE/RL-93-37).

Across the 100 Area, during river stage fluctuations, water flow has been observed to reverse in those wells that enter but do not completely penetrate the basalt unit. The 100-B/C Area water table depth ranges from approximately 12 m (40 ft) at the northern portions of the site to approximately 30 m (100 ft) at its southern margins. Based on these depths, the water table elevation is estimated at approximately 120 to 122 m (395 to 401 ft) above mean sea level (Figure 2-10; DOE/RL-2008-66).

The water table is located in the Ringold Formation across most of the site. Near the river, the water table may extend into the overlying Hanford formation.

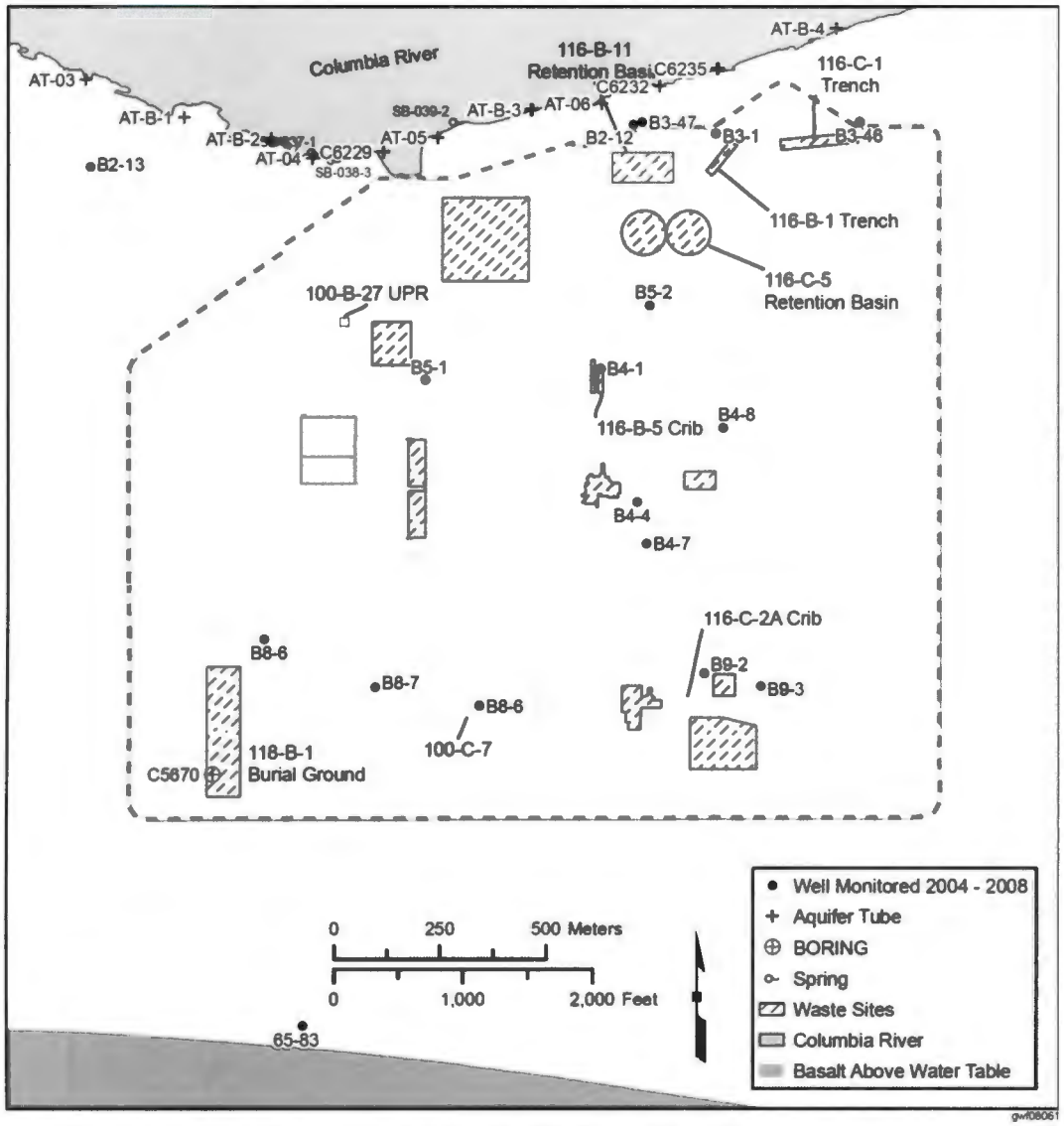


Figure 2-9. Map of Monitoring Wells and Aquifer Tubes in the 100-BC Decision Unit

2.2.3.1 Groundwater Flow

The unconfined aquifer is of most immediate concern regarding potential risk to humans and aquatic receptors from groundwater contamination. Groundwater flows away from the reactor areas toward the river with low river stage groundwater discharges observed as shoreline seeps and springs. Generally, 100-BC Decision Unit groundwater flow in the unconfined aquifer is to the north toward the Columbia River, as shown in Figure 2-11 (WHC-EP-0394-5; DOE/RL-2008-01).

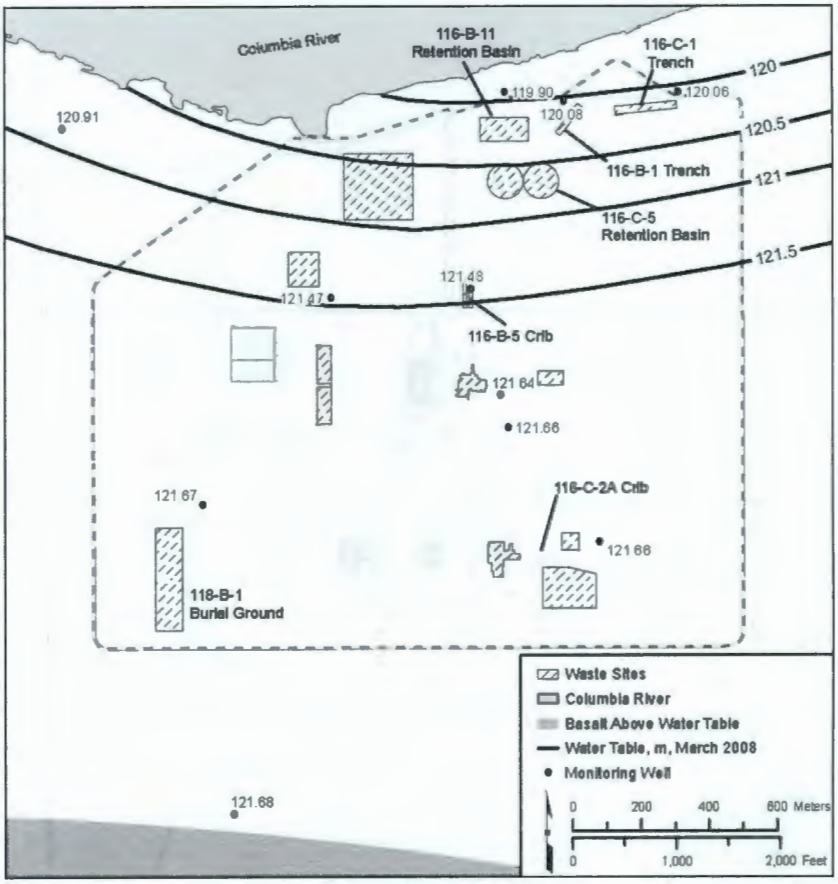


Figure 2-10. 100-BC Decision Unit Water Table Map 2008

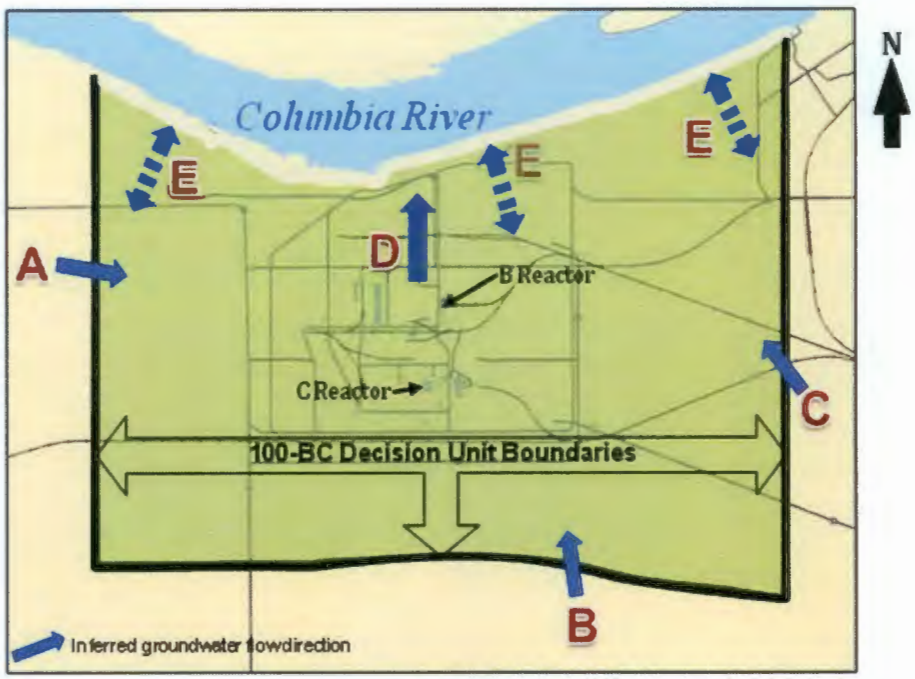


Figure 2-11. Illustration of 100-BC Decision Unit Groundwater Flow Patterns

The groundwater in the 100-BC Decision Unit flows as follows:

- Groundwater enters the 100-BC Decision Unit primarily from the west (A), where the Columbia River provides partial recharge to groundwater, and from Gable Butte (B) and Gable Gap (C).
- Groundwater flows northward from the reactor areas (D) toward the Columbia River, with some discharge occurring at seeps and springs along the shoreline. During high river stage, recharge occurs from the Columbia River as indicated by a much shallower gradient and reversed flow direction (E).

When river stage is high, the flow direction periodically shifts toward the southeast (PNNL-14287). The aquifer is characterized by approximately 30 m (100 ft) of coarse-grained fluvial sediment. The water table defines the base of the unconfined aquifer. The typical water table elevation varies from approximately 121,57m (399.3 ft) in the southern portion of the 100-BC Decision Unit to over 119.9 m (393.4 ft) near the river (Figure 2-10).

2.2.3.2 Hydraulic Gradients

Hydraulic gradients and flow directions change over various time scales and magnitudes based on changes in river stage. River stage is primarily a function of controlled releases from the Priest Rapids Dam upstream of the Hanford Site. Diurnal fluctuations range up to 1.5 m (5 ft) based on hourly variations in water release rates controlled by the Priest Rapids Dam (WASH-1538). River stage fluctuates seasonally up to approximately 3 m (10 ft). Similar to the other 100 Area reactor sites, the flow directions and gradients at the 100-BC Decision Unit are highly influenced by fluctuations in river stage near the shoreline. The delayed effects of river stage fluctuations are more than 900 m (3,000 ft) inland (WHC-EP-0394-5). Wells discussed in this section are shown in Figure 2-1.

The hydraulic gradient is generally relatively low in the southern 100-B/C Area (DOE/RL-2008-66). During low river stage, groundwater flows toward the Columbia River. During high river stage, groundwater gradients in the near river area are generally reversed and away from the river. Further, hydraulic gradients are directly affected by seasonal, deep percolation of precipitation and rapid snow melt; river stage; upward leakage from deeper groundwater systems; and lateral flow of the unconfined aquifer from elsewhere at the Hanford Site. During high river stage, the vertical hydraulic gradients near the river are generally downward, and during low river stage, vertical hydraulic gradients are generally upward. The magnitude of vertical hydraulic gradients inland in the 100-BC Decision Unit has not been evaluated.

In March 2008, relatively steep gradients were observed near the river (DOE/RL-2008-66) in the western, eastern, and northern regions of the Hanford Site. Shallower gradients extend in a broad arc from the 100-BC Decision Unit eastward to the southeastern portion of the 100-F Area. The steeper gradients likely are related to the water table's presence in the Ringold Formation (lower permeability than the Hanford formation) compared with shallower gradients of the Hanford formation, where the water table is present in the Hanford formation (DOE/RL-2008-01).

The Ringold Formation uppermost confined aquifer occurs within a water-bearing zone of the upper paleosols and overbank deposits (RUM). Water level elevation data collected during the 1993 LFI (DOE/RL-93-37) indicate the hydraulic potential is generally upward between monitoring well 199-B2-12 (screened in this water-bearing unit of the RUM) and adjacent shallow monitoring well 199-B3-47 (screened in the upper portion of Unit E). However, during low river stage, a slight downward potential was observed. At this time, the water level elevation in well 100-B2-12 ranged from 0.02 m (0.07 ft) lower to 0.77 m (2.5 ft) higher than in well 199-B3-47 (DOE/RL-93-37). While piezometers 199-B3-2P and 199-B3-2Q were completed and screened in the basalt Ringold Formation unit and the Saddle Mountain Basalts, respectively, water level data from these wells sometimes were identical. This

suggested leakage across the well seal material (cement) between the two piezometers (PNL-6894). Therefore, their water level data were not dependable for estimating the vertical hydraulic gradient.

The vertical hydraulic gradient has been estimated based on water level data from well 199-B2-12, completed in the uppermost confined aquifer, and shallow well 199-B3-47. Generally, an upward vertical gradient is observed, but a slight reversal is observed during times of low water level elevations (DOE/RL-93-37). Additional data are needed to further characterize the vertical gradient between geologic units at the 100-BC Decision Unit.

2.2.3.3 Hydrogeologic Characteristics

Data were collected from boreholes and wells across the 100 Area to provide area-wide physical properties data for characterization and to initiate cleanup planning (DOE/RL-93-37). Twelve soil samples collected from four depths in wells 199-B3-47, 199-B4-9, and 199-B9-2 (see Figure 2-1) were analyzed for bulk density, particle-size distribution, moisture content, moisture retention, saturated hydraulic conductivity, and unsaturated hydraulic conductivity at 10 percent moisture content after full saturation. However, the analytical results were recognized as potentially biased toward finer-grained sediment because of the influences of the cable-tool sampling methods used.

2.2.3.4 Hydraulic Conductivity

In 1988 (Bouwer and Rice, 1976), slug tests were conducted at several wells across the 100-BC Decision Unit. Data from wells 199-B2-12, 199-B2-13, and 199-B3-46 (well locations shown in Figure 2-1) were used to calculate representative hydraulic conductivity.

2.2.3.5 Recharge and Discharge

Groundwater enters the 100-BC Decision Unit from upgradient areas along the river and the gaps between Umtanum Ridge, Gable Butte, and Gable Mountain. Shallow groundwater beneath the 100-BC Decision Unit receives recharge from the river along reaches to the north and northwest (DOE/RL-2008-66). Additional recharge may occur by deep percolation of precipitation and rapidly melting snow, upward leakage from deeper groundwater systems, and lateral flow of unconfined groundwater from elsewhere at the Hanford Site. Shallow groundwater discharges to the river along the northern margin of the decision unit (Figure 2-11). The volumes and durations of such discharge are not quantified (DOE/RL-93-37).

If leakage occurred from past liquid disposal to the 182-B Reservoir, resulting groundwater mounding may have affected groundwater flow and potentially contaminant transport. Drainage in vadose zone soils in areas of former high liquid waste discharge sites may still be occurring, although the drainage rate would be much lower than under higher moisture content conditions that were present during reactor operations.

2.2.4 Environmental Resources

Environmental resources are widespread across the Hanford Site, with significant cultural and historical heritage resources established from the riverfront environment to the ridge tops (DOE/EIS-0119F, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington [Final Environmental Impact Statement]*). The Hanford Reach National Monument was formed to place high priority on shrub-steppe community habitat maintenance and enhancement for native species throughout the Monument. Washington state has designated shrub-steppe communities as priority habitat because of their significance to a number of wildlife species and the scarcity of this habitat type. In addition, the U.S. Department of the Interior has identified native shrub and grassland steppe in Washington and Oregon as an endangered ecosystem.

2.2.4.1 Flora

Before regulation of river flows by dams, trees were generally not found along river shoreline habitat, with the exception of small willows and a few juniper trees near the 100-B/C Area and Riverlands. The most common tree to establish itself along the shoreline is mulberry (PNNL-6415, Rev. 18).

Large tracts of land adjacent to the 100-B/C Area that were farmed are now dominated by stands of cheatgrass. Despite these old fields, many locations on the Hanford Site are relatively free of non-native species and are extensive enough to retain characteristic populations of shrub-steppe plants and animals. Unaffected areas support desert shrubs and drought-resistant grasses and forbs. The predominant plant community at the 100-BC Decision Unit is sagebrush/ Sandberg's bluegrass/cheatgrass. Other shrub communities are dominated by bitterbrush, hopsage, and rabbitbrush (PNNL 6415 Rev. 18). A relatively narrow riparian zone supports grasses, sedges, and scattered deciduous shrubs and trees such as willow, mulberry, and Siberian elm along the banks of the river.

No plant species on the Hanford Site are currently listed as threatened or endangered under the Endangered Species Act of 1973. Several plant species listed as threatened or endangered by Washington state, including the awned halfchaff sedge (*Lipocarpha aristulata*), grand redstem (*Ammannia robusta*), lowland toothcup (*Rotala ramosior*), and persistentsepal yellowcress (*Rorippa columbiae*) are restricted to wetlands in the riparian zone of the Columbia River, such as may be found in or near the 100-BC Decision Unit (PNNL-6415 Rev. 18).

2.2.4.2 Fauna

General 100 Area fauna are described in Section 2.3.4.2 of the Work Plan (DOE/RL-2008-46) and no other fauna specific to the 100-BC Decision Unit have been identified.

2.2.4.3 Critical Habitats

Two species of federal listed endangered fish, the Upper Columbia River spring-run Chinook salmon and steelhead, occur in the Hanford Reach. The spring-run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead spawning has been observed in the Hanford Reach. The bull trout is listed as threatened by the National Marine Fisheries Service but is not considered a resident species and is rarely observed in the Hanford Reach (DOE/RL-2005-40, *100-B/C Pilot Project Risk Assessment Report*).

2.2.5 Human Resources

Some of the most important archaeological sites in the region are located at the Hanford Site. Many of these sites are listed on the National Register of Historic Places (NHRP) as individual sites or as archaeological districts. Restricted access to the Hanford Site has facilitated the preservation of these sites. Furthermore, hydroelectric and agricultural development have not destroyed these culturally significance sites, as has been experienced elsewhere in the Columbia River Basin. In addition, other natural resources and sacred sites important to the Native American communities with ancestral ties to the Hanford Site also have been preserved (PNL-9785, *Data Compendium for the Columbia River Comprehensive Impact Assessment*). Through the Cultural Resources Review process, DOE-RL, river corridor closure contractor cultural resource specialists, Tribal representatives, and project and site planners work together to protect resources important to the Native American community and other interested parties.

Cultural, environmental, and historical information of the 100 Area is provided in detail in the work plan. To understand impacts to cultural resources and to reduce the need to perform extensive reviews on

highly disturbed areas, disturbance maps and reports have been completed for the 100-B/C Area (PNNL-6415 Rev. 18). Information specific to the 100-BC Decision Unit is included in this section.

2.2.5.1 Prehistoric Archaeological Resources

A high density of archaeological resources is associated with the Native American cultural landscape in the 100-B/C Area. Three are located partially within the 100-B/C Area, and 35 have been recorded within the immediate vicinity of the 100-B/C Area during archaeological surveys completed during 1995 (PNNL-6415 Rev. 18).

Three archaeological sites (45BN447, 45BN446, and 45BN1422) located near the 100-B/C Area have been investigated. Test excavations conducted in 1991 at archaeological site 45BN447 revealed large quantities of deer and mountain sheep bone, and projectile points dating from 500 to 1,500 years ago. Archaeological site 45BN446 is considered to be eligible for listing in the NHRP partially because it may contain new information about the Frenchman Springs and Cayuse Phases of mid-Columbia prehistory.

Data recovery efforts conducted in 2006, at archaeological site 45BN1422, documented a discrete activity area (dating between approximately 2,860 and 2,450 years ago) marked by three interrelated features associated with freshwater mussel shell processing.

Farther downriver, as recorded in 1968, site 45BN118 consisted of 18 to 24 housepits and associated artifacts including cobble tools and hopper mortars. The site was considered to be a large, open-air camp or village. This site was determined to be a contributing element to the Savage Island Archaeological District, listed on the NHRP in 1976. However, by 1989, surface evidence of the housepits was lacking, but fire-cracked rock, a few flakes, anvil stones, bits of fish and mammal bones, and mussel shell fragments were observed in an area extending along the shoreline. The shell layers were described as extending from 1 m (3.2 ft) to over 2 m (6.4 ft) below the surface (PNNL, 1989). By 2001, grasses and bushes had grown over the site to the extent that only two possible housepits were located, with none of the previously recorded artifacts observed (PNNL, 2001).

2.2.5.2 Traditional Cultural Resources

Many sites related to hunting and religious activities are located at the west end of Gable Butte. These sites are associated with the Gable Mountain-Gable Butte Cultural District (PNNL-64154, Rev. 18).

2.2.5.3 Historic Cultural Resources

Three 100-B/C Area sites associated with early settlers are the Fry and Conforth Farm, Bruggerman's Warehouse, and the Coyote Rapids Hydroelectric Pumping Plant—all of which are eligible for listing on the NRHP (PNNL-6415, Rev. 18).

Historic archaeological resources include the remains of Haven Station, a small stop on the former Chicago, Milwaukee, St. Paul, and Pacific Railroad, located to the west of the 100-B/C Area.

2.2.5.4 Cold War Resources

The only structure associated with the Early Settlers/Farming landscape in the 100-B/C Area is the Hanford Irrigation and Power Company pumping plant built at Coyote Rapids during 1908 and located east of the 100-B/C Area.

The 105-B Reactor was the world's first full-scale plutonium production reactor and is recognized as a National Historic Mechanical Engineering Landmark by the American Society of Mechanical Engineers (1976), a Nuclear Historic Landmark by the American Nuclear Society (1993), and a National Civil Engineering Landmark by the American Society of Civil Engineers (1994). The B Reactor has been listed on the NHRP since 1992, and was recorded by the Historic American Engineering Record (HAER) in

2000. It was named a National Historic Landmark in 2008 (PNNL-6415, Rev. 18). Conversion of the facility into a public museum with an interpretive center is planned.

HAER documentation of the B Reactor was completed in 1999 (DOE/RL-2001-16). Fourteen buildings and structures within the reactor area have been recorded on historic property inventory forms. Of that number, 10 were selected as representative examples of buildings and structures eligible for the NHRP as contributing properties within the Historic District, and recommended for individual documentation. These include:

- 104-B-1 Tritium Vault
- 104-B-2 Tritium Laboratory
- 105-B Reactor
- 105-B-Rod Tip Cave
- 116-B Reactor Exhaust Stack
- 117-B Exhaust Air Filter Building
- 118-B-1 Solid Waste Burial Trench
- 181-B River Pump House
- 182-B Reservoir
- Pump House.

An assessment of the contents of the B Reactor was conducted to locate and identify Manhattan Project and Cold War era artifacts that may have interpretive or educational value in potential exhibits. Thirty-nine industrial artifacts were identified and tagged, with many displayed as interpretive exhibits in the reactor building. Tagged artifacts from the D and F Reactors were transferred to the B Reactor for display as interpretive exhibits (PNNL-6415 Rev. 18).

2.3 Process History

The reactors in the 100-B/C Area were supported by multiple facilities associated with services for water treatment, air filtration, nuclear fuel handling, effluent disposal, and laboratories; with various other administrative buildings (WHC-SD-EN-TI-220). 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 DOE/RL-2008-46, Chapter 2. A complete listing of 100-BC Decision Unit facilities and waste sites, including descriptions, histories, and classification status, is provided in Appendices C and D.

CrVI contamination is of particular concern because of its widespread use in water treatment in the 100 Area reactors. It is present in groundwater at levels above the aquatic standard, although CrVI contamination at the 100-B/C Area is not exhibiting the same persistence and magnitude as observed at the 100-D Area.

Production at the B Reactor ended in 1968, and at the C Reactor in 1969. Other infrastructure networks were placed in standby mode or decommissioned. These activities occurred in phases according to their ages and capabilities of the facilities and as resources allowed (PNL-MA-588, *Resource Book–Decommissioning of Contaminated Facilities at Hanford*; WHC-EP-0478, *Summary of the Hanford Site Decontamination, Decommissioning, and Cleanup—FY 1974 through FY 1990*).

2.3.1 Facilities History and Description

This section provides the description and history of facilities used in the 100-BC Decision Unit and identifies the current status of these structures. Eighty-seven facilities were used or constructed in the 100-BC Decision Unit. Most of the facilities have a status of active, inactive, removed, or demolished (fully defined in the work plan, Chapter 2). Table 2-3 summarizes the status of facilities within the 100-BC Decision Unit. Appendix D contains a description and history of each decision unit facility.

Table 2-3. Summary Information on the Status of the 100-BC Decision Unit Facilities

Decision Unit	Total Number of Facilities	Reclassification Status*			
		Demolished	Removed	Active	Inactive
100-BC Decision Unit	87	62	16	4	5

This summary is current as of January 6, 2009.

*Reclassification 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.

Facilities that were used during operation of the reactor make up most of the demolished and removed facilities. These structures consist of the retention basins, reactor stacks, office and storage building, maintenance shops, process plants, electric substations, storage tanks, and pump stations. Active facilities include a mobile office (MO-474), an electric substation (151-B), and a pump station (181-B) and process reservoir (182-B) that supplies water to the 200 Area. The five inactive facilities in the decision unit are: (1) the B Reactor Building, (2) the C Reactor Building, (3) the 116-B Exhaust Stack, and (4) the 119-B Laboratory, and (5) the 181-C Pump Station.

One facility of particular interest regarding its potential contribution to groundwater contaminant distribution is the Export Water System (EWS) (Figure 2-12). The EWS (including the 182-B Reservoir) is an operating system that could affect contaminant transport and groundwater flow.

Raw water is used in large quantities (millions of L/day [gal./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 (1.07 m [42 in.]) pipelines to smaller pipelines traversing the 100 Area and connecting to moderately sized distribution reservoirs located on the Central Plateau. A key component of this system is the 182-B Reservoir. It is one of two remaining structures at the Hanford Site that is used to store large quantities of untreated, raw water, and it is the primary reservoir. The other reservoir used for this purpose is located in the 100-D Area and is the backup facility (FH-2008, *November 6 & 7 Facilitated Session and the 182D Reservoir Repair and Modification Report and Long Term Export Water Supply System Alternatives Study, Fluor Hanford, Richland, Washington*).

The 182-B Reservoir is one of the few facilities still in operation at Hanford that dates back to the Manhattan Project era. Therefore, its age and condition are of potential concern. During its operation water may have leaked from the reservoir, possibly resulting in higher than normal groundwater elevations beneath the reservoir.

Although numerous buildings and waste sources have been removed or demolished since reactor deactivation, EWS components are close to facilities and waste sites that were demolished in place before current regulatory standards were applicable, and possibly contain residual contamination. Rapid repair or replacement of the EWS facilities is not currently planned, and the proximity of some waste sites to aging EWS components represents a potential, enhanced means of contaminant transport in the vadose zone to groundwater. The repairs and changes necessary to provide continued reliable EWS service to maintain Hanford Site operations are anticipated to take substantial time and resources (several years and an estimated order of magnitude project cost of $30 to $50 million (FH 2008, *November 6 & 7 Facilitated Session and the 182D Reservoir Repair and Modification Report and Long Term Export Water Supply System Alternatives Study, Fluor Hanford, Richland, Washington*).

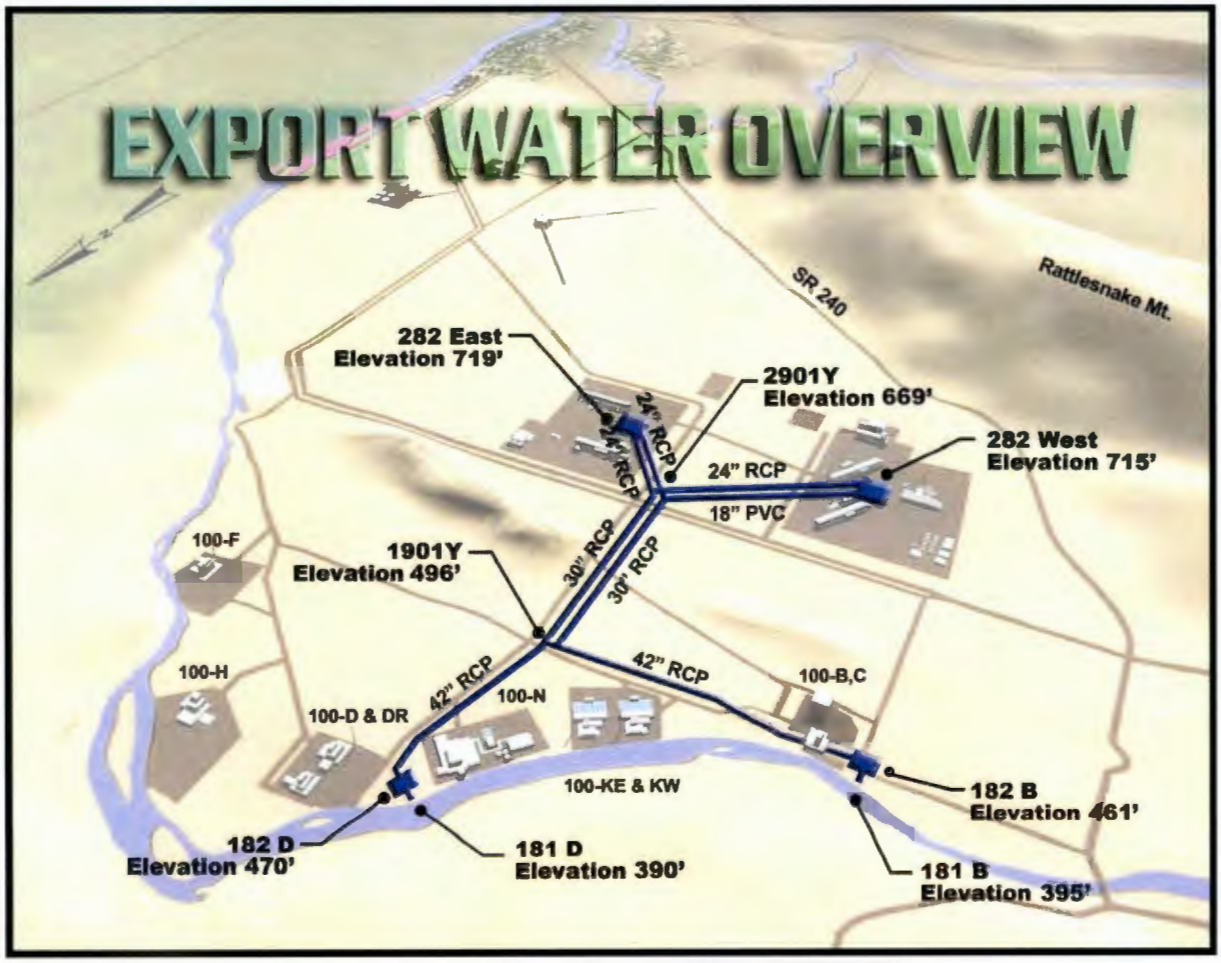


Figure 2-12. Export Water System Plan View

2.3.2 Process History Description

Producing plutonium for national defense was the primary mission of the Hanford Site reactors. Materials that had passed through the reactors for manufacture or materials contacting items that had passed through the reactors 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 to be 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:
  - Product and waste isotopes, such as Pu-239 and Sr-90, respectively
  - 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 and tritium production and separation were performed in the 100 Area. Also, during production, fuel elements failures and infrastructure failures (e.g., pipe leaks) led to losses of contaminated materials to the environment.

Other substantial infrastructure (e.g., office buildings, laboratories, and subsurface piping) was installed at the 100-B/C Area to support reactor maintenance and operation. Wastes resulting from supporting production operations were similarly disposed to each area according to phase, quantity, radioactivity, and composition (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 handle these materials consistently. However, facilities and waste sites used for discarding non-radiologically contaminated waste materials (e.g., solvents, chemicals) were relatively small in magnitude.

2.3.2.1 Dichromate Life Cycle

In the 100-BC Decision Unit, one of the primary contaminants of interest is CrVI. CrVI has been detected in the vadose zone during source removal excavations and RI boreholes. CrVI is present in 100-BC Area groundwater at concentrations that exceed the Model Toxics Control Act – Cleanup (WAC 173-340) using the Method B concentration of 48 μg/L for ingestion of groundwater and concentrations that are considered protective of aquatic receptors (DOE/RL-2008-66). Additional information about the nature and extent of CrVI in the vadose zone and groundwater is provided in Sections 2.4 and 4.3. Facilities and waste sites where CrVI was handled, transferred, or disposed to the 100-BC Area are shown in Figure 2-13.

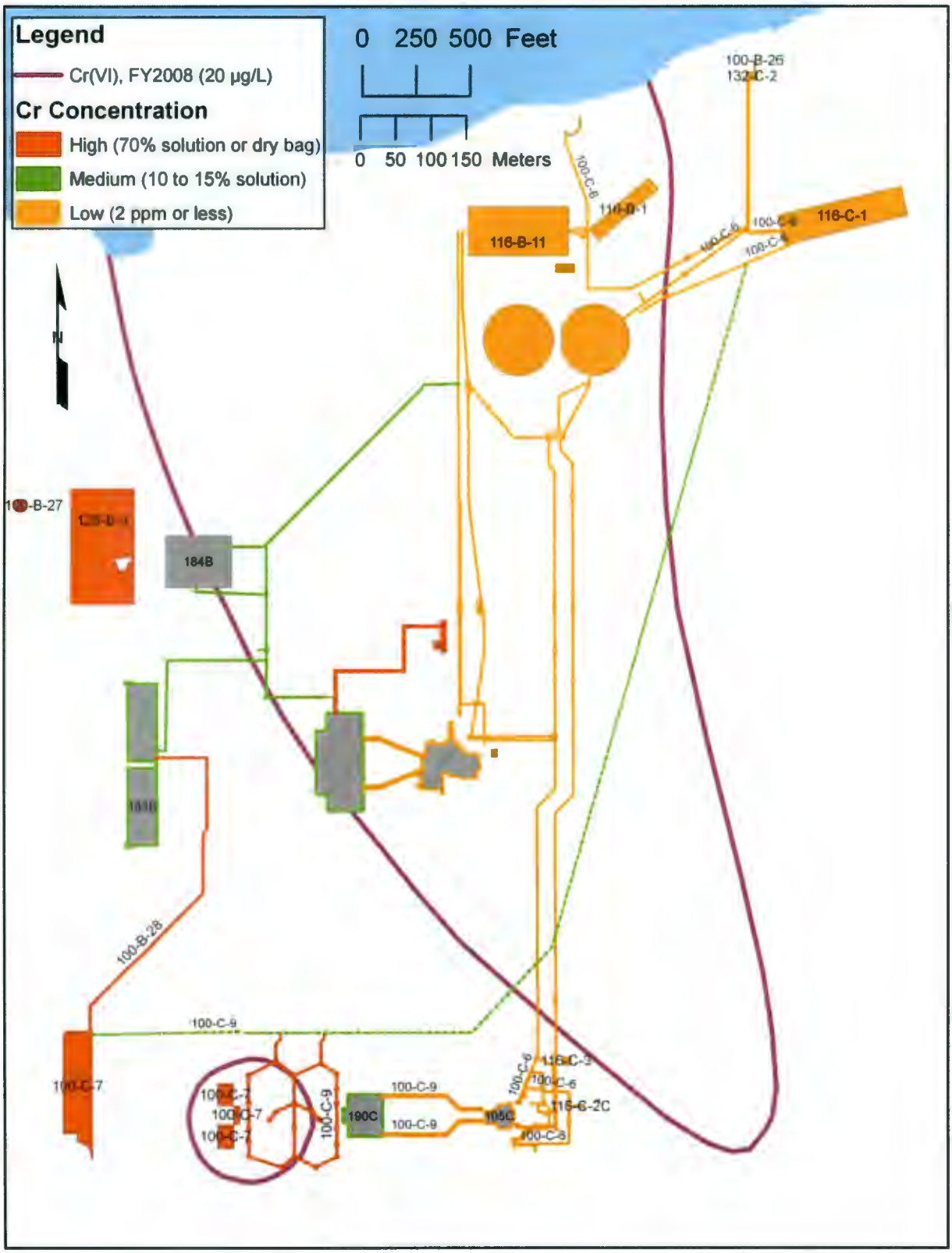


Figure 2-13. Key Hexavalent Chromium Facilities and Waste Sites in the 100-BC Area

Sodium dichromate, the source of the CrVI, was delivered and used in both dry chemical powder and concentrated liquid forms. CrVI was used in the form of sodium dichromate salts and aqueous solutions of varying concentrations. The principal use for sodium dichromate was as a cooling water corrosion inhibitor during reactor operations. Records indicate that 100-B/C Area water treatment processes mixed dichromate with cooling water concentrations to between 1.8 and 2 ppm dichromate concentration initially, with diminishing concentrations being implemented at each plant over time (decreased to 1.0 ppm at the C Reactor in 1960, and 0.5 ppm in 1967; DUN-4847, *Quarterly Report Contamination Control—Columbia River April - June 1968).* Consumption likely ranged from approximately 20,000 kg (44,000 lb) of sodium dichromate per month initially for each reactor, to between 5,000 and 10,000 kg (11,000 and 22,000 lb) per month toward the end of each reactor's operating lifetime.

Bulk sodium dichromate salt and high-concentration sodium dichromate solutions were used as stock materials to make 10 to 15 percent process solution batches. Initially, dry materials were used at both water treatment plants, with the use of concentrated dichromate liquid phased in over time. High concentration (greater than 70 weight percent) sodium dichromate solutions were used as the stock material after 1953 at the C Reactor and 1956 as part of Project CG-558 at the B Reactor (WHC-SD-EN-RPT-004) until closure of the reactors. These materials were received by rail and truck tankers.

The moderate-concentration solution was then metered into the cooling-water stream downstream of the flocculation/sedimentation basin as the water was prepared for use in the reactor. Locations where concentrated sodium dichromate was used or transferred at the B and C Reactors include the following:

- Water Treatment Processing – B Reactor
  - 108-B Chemical Pumphouse
  - 100-B-14 Sodium dichromate and sodium silicate lines (no photo, below ground)
  - 185-B/190-B Process Pumphouse
- Water Treatment Processing – C Reactor
  - 183-C Head House and Filter Building
  - Process sewer piping (100-C-9:1) is believed to have been the pathway for a large sodium dichromate spill that occurred in 1966 (DUN-1295; CCN 141284).

Conversion to a liquid dichromate feed system was believed to be implemented at the B Reactor by the end of 1960 and earlier at the C Reactor, between 1953 and 1959 (CCN 141284; HW-64555). Pipelines and other plant modifications required to stage and transfer dichromate liquid include the following:

- Modifying an existing underground pipeline (100-B-28) between the 183-C Head House (100-C-7:1) to transfer dichromate solution between an external 132,450 L (35,000 gal.) storage tank there to feed tanks in the 183-B Filter Plant Pump House (100-B-22).
- Converting a soft water line leading from the 184-B Power House, connecting the 183-C Head House (100-C-7) and 183-B Filter Plant Pump House (100-B-22), to transfer liquid dichromate solution. This line was installed during the construction of the 183-C Head House and Filter Building.

Cooling water treatment accounted for the majority of sodium dichromate used. Reactor-cooling water was generated, passed through the reactors, and discharged at an average rate of about 230,000 L/min (62,000 gal/min) per reactor (DOE/RL-97-1047, *The Hanford Site Historic District*). Reactor coolant-grade water was also used to fill the fuel storage pool. The effluent from the fuel storage basins was disposed to trenches close to the reactors. Cooling water and fuel storage basin effluents had the much lower CrVI concentration of 0.5 to 2 ppm. Decontamination solutions using higher concentrations

of dichromate were also used at the 100-B/C Area, but management and disposition of these spent solutions was not always clear from process documentation. Several other avenues for disposal were available including to the soil column (Chapter 1, Figure 1-6) and to the process sewer and outfall piping discharging to the river. In Figure 2-14, hot water vapor is visible rising from the 116-C-1 Crib at left and 116-C-5 Retention Basins at right. Facility 1904-C is visible to the right, and Facility 1904-B-2 is visible to the left.

Figure 2-14. River Effluent Outfalls

2.3.2.2 Secondary Missions: Tritium and Isotope Production at B Reactor and Reactor Physics Testing at C Reactor

Each reactor often had a specific secondary mission that was dictated by Hanford's general production stance. Secondary missions at the 100-B/C Area included other isotope production (B Reactor) and reactor physics testing and pilot scale-up (C Reactor) (WHC-SD-EN-RPT-004; WHC-SD-EN-TI-220). As they emerged, secondary operational missions were considered critical as part of the primary defense mission.

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

The secondary mission of the B Reactor was to produce tritium and other isotopes related to national defense, and for potential commercialization. In 1949, tritium extraction began in the 108-B Building (P-10 Plant) in the 100-B/C Area (Figure 2-15; 107-NEG). The lithium-aluminum, and, for a short period,

lithium-fluoride, target elements were transferred to the 108-B Facility after irradiation in one of the Hanford Site production reactors.

Intermittent tritium extraction operations were performed at 100-B/C Area between 1949 and 1952. Tritium separation operations were terminated at the B Reactor in 1952, when that process was transferred to the Savannah River Plant in South Carolina. Other isotopes produced at B Reactor include Po-210, Tm-170, Ir-192, lanthanum-140, and Np (Gerber, 1993).

Figure 2-15. 108-B Chemical Pumphouse/Tritium (P-10) Facility in Foreground at Right, with 105-B and 190-B in Background in 1950

In the case of the B Reactor operations, and as a result of its tritium manufacture and separation mission, large quantities of tritium-contaminated material were disposed to the vadose zone (CVP-2007-00006, *Cleanup Verification Package for the 118-B-1, 105-B Solid Waste Burial Ground Rev. 0*). Tritium concentrations in groundwater continue to exceed DWS in the decision unit. Residual solid wastes containing tritium disposed in the vadose zone have been identified and removed at the 100-B/C Area, thereby reducing the threat to groundwater and the environment.

In addition to solid and liquid wastes, gaseous emissions were also discharged into the environment during production (DOE/RL-2005-49, *RCBRA Stack Air Emissions Deposition Scoping Document*; PNWD-0222, *Radionuclide Releases to the Atmosphere from Hanford Operations, 1944-1972*). However, gaseous emissions are not suspected of being a major contributor to groundwater contamination in the 100-B/C Area.

The C Reactor's secondary mission was as the chief test facility at Hanford for conducting experiments to examine the effects of system-wide power level increases for both new and older reactors. Additionally, the C Reactor was furnished with a metal examination facility capable of holding and shielding bare irradiated fuel elements for metallurgical testing. Wastes from these tests were discharged to underground

tanks for disposal, as shown in Figure 2-16. The C Reactor is visible in Figure 2-16 after ISS implementation.

Figure 2-16. 116-C-3 Chemical Waste Tanks in 2007

2.3.3 Waste Sites Description and History

As of February 9, 2009, 116 waste sites exist within the 100-BC Decision Unit These waste sites consist mainly of inactive past-practice waste sites described as trenches, ditches, cribs, burial grounds, and unplanned releases (Figure 2-17 [02040098-42CN] and Appendix B).

Table 2-4 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 historic COPC associated with each site. Appendix B shows the locations of 100-B/C Area waste sites. Table 2-5 provides the classification/reclassification of the source OU waste sites and lists waste sites identified through the orphan sites process. Waste sites associated with sodium dichromate handling or usage, or where CrVI was detected during site evaluation and/or remediation, are also identified.

The closed/interim closed waste site status indicates that, as a result of actions taken, a waste management unit meets applicable interim cleanup standards or closure requirements. Not accepted indicates that all the Tri-Parties (DOE, EPA, and Ecology) agree that the site is not a waste management unit.

Table 2-4. Summary Information on the Status of 100-BC Decision Unit Waste Sites

Operable Unit	Total Number of Waste Sites*	Closed Out	Interim Closed	No Action	Not Accepted	Accepted	Discovery
100-BC-1	78	2	35	14	12	10	5
100-BC-2	38	0	23	3	7	3	2
Total in 100- BC Decision Unit*	116	2	58	17	19	13	7

This summary is current as of February 9, 2009.
Additional information is provided in Appendix C.
Total number of sites includes discovery sites and not accepted sites.
*The total does not include subsites.

Table 2-5. Classification and Reclassification of 100-BC Decision Unit Waste Sites*

Reclassification Status	Waste Sites	Total*** (151)
Closed Out	1607-B3, 1607-B4	2
Interim Closed	100-B-1, 100-B-5**, 100-B-8, 100-B-8:1**, 100-B-8:2**, 100-B-12, 100-B-14, 100-B-14:1**, 100-B-14:2, 100-B-16, **100-B-18**, **100-B-20**, 100-B-21:2, **100-B-23**, 116-B-1**, 116-B-2, 116-B-3**, 116-B-6A, 116-B-4, 116-B-5, 116-B-6B, 116-B-7**, 116-B-9, 116-B-10, 116-B-11**, 116-B-12, 116-B-13**, 116-B-14**, 116-B-16, 118-B-1**, 118-B-2**, 118-B-3, 118-B-4, 118-B-5, 118-B-6, 118-B-10, 120-B-1, 126-B-3**, 128-B-2**, 128-B-3**, 132-B-6**, 1607-B2, 1607-B2:1, 1607-B2:2, 1607-B7, 1607-B8, 1607-B9, 1607-B10, 1607-B11, 100-C-3, 100-C-6:1**, 100-C-6:2**, 100-C-6:3**, 100-C-6:4**, 100-C-9, 100-C-9:1**, 100-C-9:2,100-C-9:3**, 116-C-1**, 116-C-2A**, 116-C-2B**, 116-C-2C**, 116-C-3**, 116-C-5**, 116-C-6, 118-C-1**, 118-C-2, 118-C-3:2, **118-C-3:3**, 118-C-4**, 128-C-1**, 132-C-2**, 600-232, 600-233	74
No Action	100-B-2, 100-B-3, 100-B-10, 100-B-11**,**100-B-21:1**, **100-B-22:**1, 100-B-24, 100-B-26**, 116-B-15, 118-B-9, **126-B-2**, 132-B-1, 132-B-3, 132-B-4, 132-B-5, 1607-B1,100-C-9:4**, 132-C-1, 132-C-3, 600-230, 100-B-14:3, 100-B-14:4**, 100-B-14:5**, 100-B-14:6, 100-B-14:7**	25
Not Accepted	100-B-4, 100-B-7, 118-B-7, 126-B-1, 126-B-4, 128-B-1, 600-231, 600-252, 600-253, 600-264, 600-33, 600-34, 600-56, 600-67, 100-C-2, 100-C-4, 100-C-5, 100-C-8, 124-C-4	19
Accepted	100-B-15, 100-B-21:3, **100-B-19**, 100-B-21, **100-B-21:4**, **100-B-22**, **100-B-22:2**, 100-B-22:3, 100-B-25**, 100-B-28**,118-B-8, 118-B-8:1, **118-B-8:2**, 118-B-8:3**, 1607-B5, 1607-B6, 132-B-2,100-C-6, 100-C-6:5, 100-C-7, 100-C-7:1,118-C-3, 118-C-3:1, 100-C-7:2	23
Discovery	100-B-17, 100-B-27**, 100-B-29, 100-B-30, 100-B-31, 100-B-32, 100-B-33	8

This summary is current as of February 9, 2009.
* Additional information provided in Appendix C.
** Sites received CrVI waste stream.
*** Total includes subsites.
Bold text denotes an orphan site.

Figure 2-17. Southern View of 100-BC Decision Unit Showing Primary Liquid Waste Disposal Features, April 2002

2.3.4 Decommissioning Activities

Initial cleanup activities began in the 100-B/C Area as soon as the reactors were deactivated. Follow-on housekeeping and decommissioning activities began in the 100-B/C Area as part of a site-wide initiative in 1973, after deactivation of the remaining single-pass reactors. This effort progressed as resources allowed from 1974 through 1990, with building demolition, surplus equipment salvage or redeployment, and active operations maintenance at a minimal level.

Building and facility wastes remaining in the 100 Area sometimes exist in demolished ductwork, concrete, paint, equipment, insulation, cracks, crevices, and remaining process piping and tanks that were left in place after earlier demolition. More contemporary remediation efforts result in contaminated debris being hauled to the Environmental Restoration Disposal Facility (ERDF) and uncontaminated debris demolished and left in place (BHI-01399, *108-F Biological Laboratory D&D Closeout Report*).

2.4 Known and Potential Contamination

This section describes previous investigations and the understanding of the nature and extent of vadose zone and groundwater contamination in the 100-BC Decision Unit.

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 sources of contamination such as liquid waste sites (i.e., ponds, ditches, and cribs), burial grounds, unplanned release sites, facilities/ structures, pipelines/outfalls, and remaining or orphan sites that may continue to impact soil, groundwater, and the river.

Other activities that contributed substantially to environmental contamination at the 100-B/C Area as part of the production effort include infrastructure leaks associated with water treatment and corrosion control

for reactor cooling water, material losses from chemical spills and ruptured fuel slugs; and waste discharges from decontamination of the reactor and maintenance equipment (Backman, 1965; UNI-946).

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 (LFI) conducted in the 1990s provided additional information about the vadose zone. The results indicate where elevated levels of contamination (radionuclides and metals) can be found in the 100-BC Decision Unit. However, remediation and characterization of the waste sites began in 1996, and the remedial actions implemented have significantly reduced contaminant inventories and resulting impact to the environment.

2.4.1.1 Initial Vadose Zone Radiological Characterization–1975

The purpose of characterization was to establish approximate radionuclide inventories, distribution, and concentrations at inactive solid and liquid wastes sites, reactors, and associated facilities. The focus of the sampling activities was liquid waste-receiving sites and retention basins. Shallow boreholes were drilled in and adjacent to waste site boundaries to a maximum depth of 11.6 m (38 ft) below grade. Samples were analyzed for the following constituents:

C-14	Co-60	Ce-134	Cs-137	Eu-152
Eu-154	Eu-155	Ni-63	Pu-238	Pu-239/240
Sr-90	Tritium	Uranium		

Table 2-6 summarizes the results of the investigation.

Table 2-6. Summary of Borehole Locations Used in the Initial Radiological Characterization–1975

Waste Site	Number of Boreholes	Media	Maximum Depth of Investigation (feet)
116-B-11 (107-B) Retention Basin	22	Soil	38
116-B-1 Trench	4	Soil	20
116-C-5 (107-C) Retention Basin	4	Soil	23
116-C-1 Trench	15	Soil	35
100-B Junction Box Leak	6	Soil	30
100-B Effluent Line Leak	4	Soil	35
116-B-2 Trench	4	Soil	25
116-B-3 Crib	1	Soil	15
116-B-5 Crib	3	Soil	22.5
116-B-6-1 Crib	1	Soil	22.5
116-C-2 Crib	3	Soil	50
116-C-2-1 Effluent Line Leak	1	Soil	30
116-C-2-2 Crib	2	Soil/Sludge/Concrete	30
118-B-1 Burial Ground	14	Soil	33

This early study was narrow in its scope in that only concentrations and inventories of the selected radionuclides were reported, and no chemical contaminants were assayed. In particular, Ni-63, which is generally present at activities on the same order of magnitude as Co-60, was reported for only some samples; Tc-99, detected in 100-B/C Area groundwater wells, was not evaluated; and daughter product radionuclides of Sr-90 and Cs-134, which have approximately the same activities as the parent nuclides, were not included in summaries of total activity (DOE-RL-90-07).

Contaminants detected in significant concentrations (> 1 picocuries per gram [pCi/g]) during this investigation include:

C-14	Cs-134	Cs-137	C-60	Eu-152
Eu-154	Eu-155	Ni-63	Pu-238	P-239/240
Sr-90	Tritium	Uranium		

An additional part of this study collected samples from retention basin sludge and concrete, and from effluent line scale and sludge. The samples were analyzed for radionuclides and the inventories of radionuclides for the facilities and sites were calculated.

Sample holes drilled through the floor of the 116-B-11 and 116-C-5 Retention Basins indicate that the majority of contamination was within a few meters of the basin floor (UNI-946). The 116-B-11 Retention Basin contained a calculated inventory of approximately 118 Ci in 1976, of which 92 Ci were attributed to the 6.4 cm (2.5 in.) thick sludge layer, and the remaining 26 Ci were attributed to the soil fill and the basin concrete. Based on the sampling results, the 116-C-5 Basin was estimated to contain a radionuclide inventory of approximately 13 Ci in 1975. Of this total, the sludge contributed 9 Ci and the soil fill contributed 4 Ci.

Samples collected near the bottom of the 116-B-1 Trench indicate the calculated radionuclide inventory for the trench and soil column as of 1976, based on the radionuclides analyzed, was 3.1 Ci, contributed primarily by Eu-152. Radionuclide contamination was significant to the sampled depth of 6 m (20 ft) (UNI-946). In addition to radionuclide contamination, approximately 7 kg (15 lb) of sodium dichromate are estimated to have been disposed to this trench with cooling water discharges (Stenner et al., 1988).

Investigation of the 116-C-1 Trench also indicates contamination was found in and beneath the trench along the entire length, and consisted primarily of Sr-90, Co-60, Eu-152, Eu-154, and Cs-137. In many borings, concentrations of radionuclides were still increasing at depths of 9 to 11 m (30 to 36 ft), indicating the limits of the contaminated soil column may not have been reached. Thus, the estimated radionuclide inventory is for the trench and soil column to 9 m (30 ft) below grade (UNI-946).

2.4.1.2 100-B/C Area Limited Field Investigations

Limited field investigations were performed in the 100-BC-1, 100-BC-2, and 100-BC-5 OUs in the early 1990s. Results of these investigations are presented in DOE/RL-93-06, *Limited Field Investigation Report for the 100-BC-1 Source Operable Unit*; DOE/RL-94-42, *Limited Field Investigation Report for the 100-BC-2 Source Operable Unit* and DOE/RL-93-37, *Limited Field Investigation Report for the 100-BC-5 Operable Unit*. These reports summarize characterization efforts performed mainly to assess impacts associated with discharging effluent to the soil column.

In the 100-BC Decision Unit, 29 sites were identified as high-priority waste sites, and 24 sites were identified as low-priority waste sites. Based on the work plan, all 29 high-priority waste sites were investigated during the LFI.

- 116-B-1 Liquid Waste Disposal Trench
- 116-B-2 Fuel Storage Basin Trench
- 116-B-3 Pluto Crib
- 116-B-4 Dummy Decontamination French Drain
- 116-B-5 Crib
- 116-B-6A Crib
- 116-B-6B Crib
- 116-B-7 Outfall Structure
- 116-B-9 French Drain
- 116-B-10 Dry Well
- 116-B-11 Retention Basin
- 116-B-12 Crib
- 116-B-13/14 Sludge Burial Trenches
- 100-B-8 Process Effluent Pipes
- 100-C-6 Process Effluent Pipes
- 116-C-2A Pluto Crib
- 116-C-2B Pluto Crib Pump Station
- 116-C-2C Pluto Crib Sand Filter
- 116-C-5 Retention Basin
- 118-B-5 Ball 3X Burial Ground
- 118-B-7 Solid Waste Burial Ground
- 118-B-10 Solid Waste Burial Ground
- 126-B-2 Clear Wells
- 128-B-3 Burn Pit
- 132-B-4 Filter Building
- 132-B-5 Gas Recirculation Facility
- 132-B-6 Outfall Structure
- 132-C-2 Outfall Structure
- 116-C-1 Process Effluent Trench

These sites were investigated using cable-tool drilling of boreholes, backhoe excavation of test pits, and soil sampling and analysis. Geophysical logging was also performed in boreholes. Table 2-7 provides a brief description of the vadose zone borehole sampling conducted at the 100-BC Decision Unit.

Table 2-7. Summary of 100-B/C Area Limited Field Investigation (Vadose Zone)

Waste Site	Number of Boreholes	Maximum Investigation Depth of investigation (ft)	Analyte List	
116-B-1 Trench	1	27	ICP/AA Metals Mercury VOA Semi-VOA PCBs Pesticides Gross alpha Gross beta Tritium	Gamma Spectroscopy Strontium-90 Technetium Carbon-14 Alpha Spectroscopy Total activity Anions/IC Fluorides Sulfates Nitrates Nitrites
116-B-2 Trench	1	22.5		
116-B-3 Crib	1	16.8		
116-B-5 Crib	1	17		
116-C-5 Retention Basin	1	20		
116-C-2A Crib	1	57		
116-C-1 Trench	Test Pit	20		

ICP = inductively coupled plasma
VOA = volatile organic analyte
IC = ion chromatography

The LFI report concluded that the radiological contamination of vadose zone soils is the primary concern, as previously suspected. The principal radionuclides detected in soil samples during the LFI include the following:

Am-241	C-14	Cs-137	Co-60	Eu-152
Eu-154	Pu-238	Pu-239	K-40*	Ra-226
Sr-90	Th-228	Tritium	Ur-233/234	U-238

* K-40 is a naturally occurring radionuclide that was not increased by Hanford processes.

The principal metals detected in soil samples during the LFI include chromium, barium, mercury, zinc, and iron. Volatile and semi-volatile organic compounds detected during the LFI include the following.

acetone*	benzo(A)anthracene	benzo(B)fluoranthene
benzo(K)fluorathene	chrysene	diethylphthalate*
di-n-butylphthalate*	flouranthene	pentachlorophenol

* Common analytical laboratory contaminants

Contaminant concentrations and locations generally confirm historical information documented in UNI-946. The vertical distributions of contamination beneath the 116-C-2A Crib and the 116-B-2 Trench are shown in Figures 2-19 and 2-20, with correlation to stratigraphy and their engineered structures. Conditions at these waste sites represent the worst-case sites based on effluent volumes discharged, sample data, or both. Some data were available to assess the lateral extent of contamination. The depth of remedial action is inserted into the profile as an indicator of soil removed during remedial actions conducted approximately 8 years after LFI completion.

The profile of the 116-B-2 Trench shows that contaminant concentrations generally decrease with depth in soil. Higher concentrations were present generally within 5.5 m (18 ft) bgs. However, to a depth of 7.3 m (24 ft), concentrations were low and less than cleanup levels for groundwater protection with the exception of chromium and lead.

The profile of the 116-C-2A Crib shows the non radioactive metal contaminant concentrations generally decrease with depth below the depth of remedial action. Higher concentrations generally were present approximately 15.2 m (50 ft) bgs with chromium and lead exceeding soil cleanup remedial action goals for groundwater protection. Total chromium and lead exceed remedial action screening criteria throughout the profile. Other constituent concentrations were less than remedial action goals for groundwater protection.

2.4.1.3 Interim Remedial Actions and Existing Waste Site Contamination

Remediation and characterization of the waste sites in the 100-B/C Area under the authority provided by the interim action ROD began in 1996, and continues to the present. Remediation consists mainly of removal, segregation, storage, transportation, and disposal of contaminated soil, debris, and other waste material and backfilling remediated waste sites. To date, all of the high-priority 100-B/C Area liquid waste sites, including cribs, ditches, trenches, retention basins, and solid waste burial grounds have been remediated and backfilled with clean soil. As of 2008, approximately 992,000,000 kg (1,100,000 tons) of contaminated soil and debris have been removed from the 100-B/C Area to mitigate and reduce potential impacts to human health and the environment.

Large-scale clean-up initially focused on sites that received liquid wastes because they were believed to have the greatest influence on groundwater quality (BHI-01706). The majority of liquid waste sites in the 100-B/C Area have undergone remedial action where contamination was removed and a minimum of 4.6 m (15 ft), backfilled to the general elevation of the surrounding area with clean soil was used to

backfill the excavated sites. Many of the pipelines have been removed and the low-priority waste sites have been evaluated. Most high-priority liquid waste sites were remediated by 2004, and work began on the solid waste burial grounds with remediation completed in 2007.

Removal, treatment, and disposal (RTD) is the standard remedy selected for waste sites in the 100 Area. Remedial actions are designed to achieve remedial action objectives (RAO) and goals specified in interim action RODs for direct exposure from 0 to 4.6 m (0 to 15 ft) bgs, and protection of groundwater and the Columbia River. In practice, this has involved excavating wastes and soil in which contaminant concentrations exceed cleanup criteria, treating as necessary, and disposing the waste to the ERDF. Residual contamination remaining after the selected remedy is sampled and modeled to assess impact to groundwater and the Columbia River. Where remedial action goals and objectives are achieved, the waste site is considered reclassified as interim closed with the approval of the lead agencies.

In a few cases, physical cleanup is not warranted based on site evaluation and sites were closed with no action. Characterization of waste sites consisted mainly of sample collection (i.e., confirmation and verification sampling) and analysis for purposes of determining the need for remedial action, assessing the nature and extent of contamination, and verifying achievement of RAOs by attaining site remedial action goals. Achievement of RAOs is based on attaining remedial action goals for direct exposure, protection of groundwater, and protection of surface waters. Interim action RAOs, as described in the work plan, were achieved at the interim closed and no action waste sites. The RDR/RAWP specifies verification sampling, even at no action sites (DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004).

After the implementation of remedial actions, contaminant inventories and impacts 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. The process of removing contaminated material from waste sites has the net effect of changing the nature and extent of waste site contamination. Therefore, information from previous investigations presented in UNI-946 and the LFI reports for the OUs are not applicable, at least to the depths of remedial actions. For example, in Figures 2-19 and 2-20, relationships are shown between the stratigraphy, the engineered structure, the depth of remedial action, and contamination at waste sites. Documentation shows that all material to the depth of remedial action has been removed. Thus, contaminant distribution has been significantly modified, and impact to the environment is mitigated because of the interim action.

Data used to interim close waste sites are documented in cleanup verification packages or in analogous remaining sites verification packages. These data also describe the current nature and extent of contamination at interim closed waste sites. The primary statistical calculation to evaluate compliance with cleanup standards is the 95 percent upper confidence limit on the arithmetic mean of the data. The data in Appendix C generally include the maximum concentrations and/or concentrations representing the 95 percent upper confidence limit of waste site contaminant of concern (COC) for both the shallow zones to 4.6 m (to 15 ft) and zones deeper than>4.6 m (15 ft).

With some exceptions, the cleanup 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.

From 2000 to 2002, aggressive batch leach testing was performed for soils from CrVI-contaminated liquid effluent waste sites in the 100-D, 100-F, and 100-H Areas to evaluate actual leachability from soil to groundwater (and, subsequently, the Columbia River). These aggressive single batch leach tests were not meant to represent actual site leaching conditions, but rather provide a simple and conservative method for assessing leaching potential and RAO attainment in the 100 Area. This evaluation was

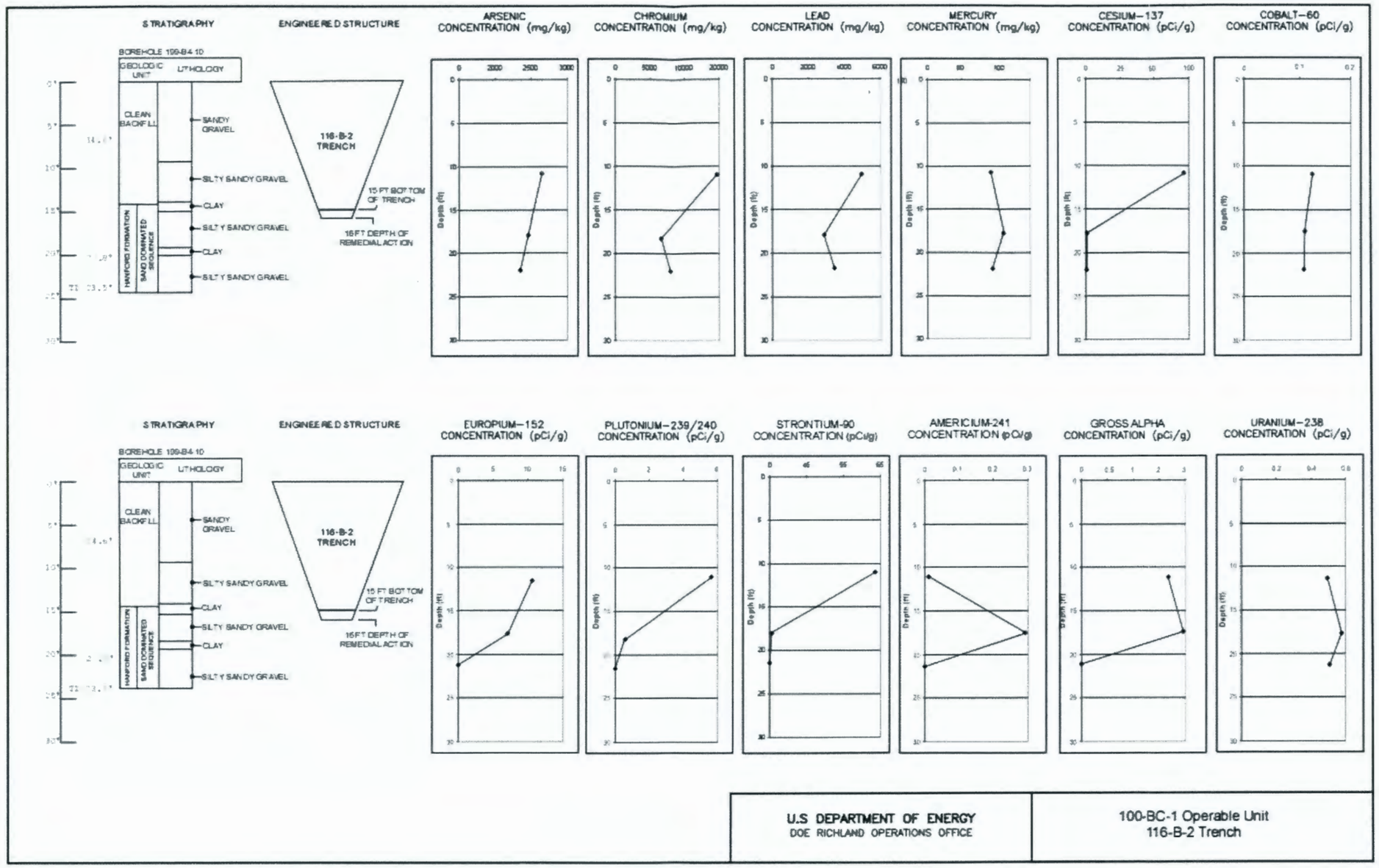


Figure 2-18. Vertical Profile of 116-B-2 Trench

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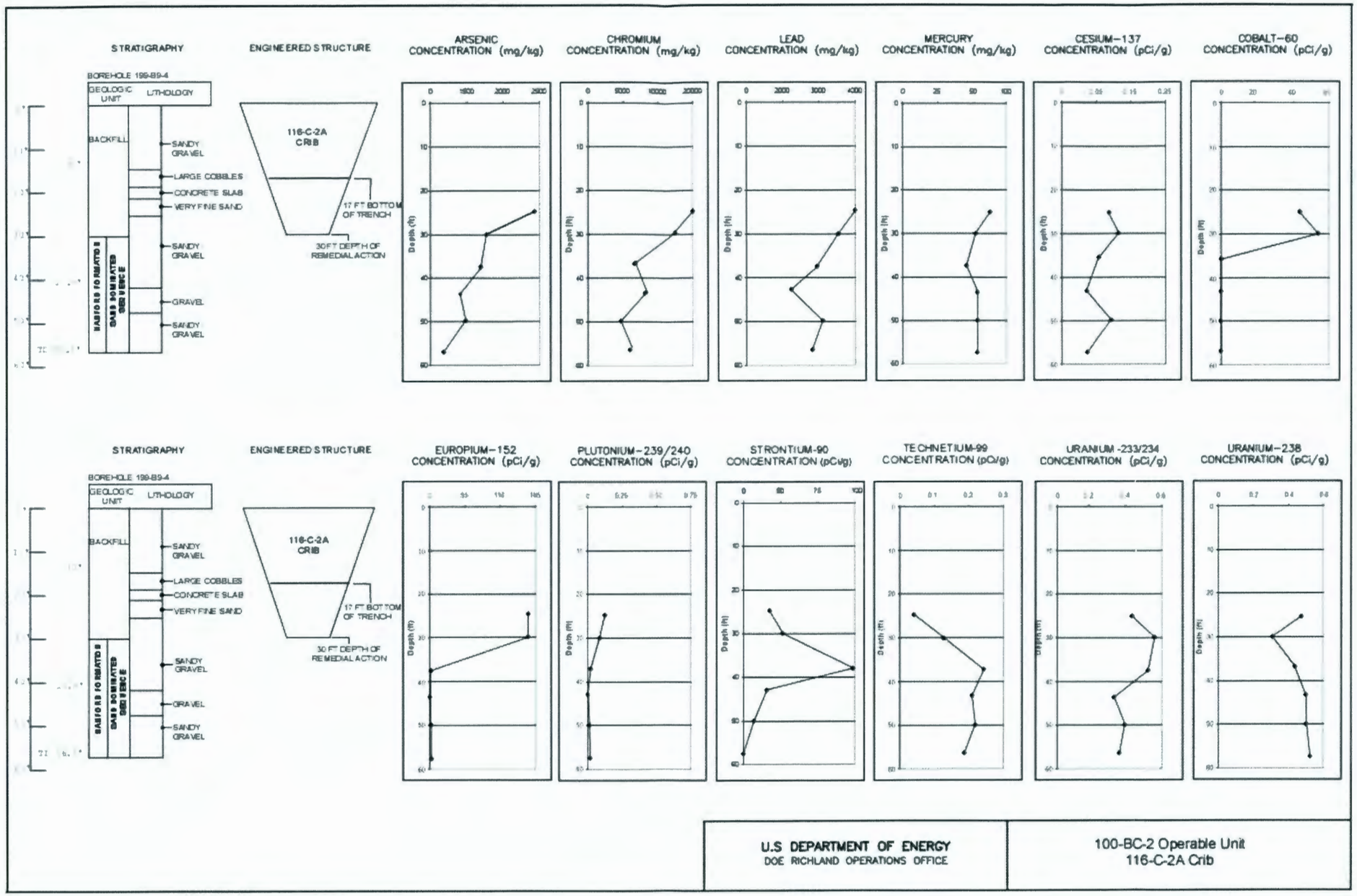

Figure 2-19. Vertical Profile of 116-C-2A Crib

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performed by analyzing the total and CrVI concentrations in soils; performing laboratory leaching using site groundwater; and analyzing the total and CrVI concentrations of the corresponding leachate.

These initial studies showed CrVI contamination in soils from 100 Area retention basins shows relatively low leachability in batch leach tests.

- An average 100-D Area CrVI soil concentration of 6.1 mg/kg is predicted to meet the river protection criteria by producing a leachate that averages 20 µg/L (*Estimation of Distribution Coefficients and Leachability of Hexavalent Chromium in 100-D Area Hanford Formation Sediments, Appendix D of Cleanup Verification Package for the 116-D-7 Retention Basin*, CVP-99-00007, Rev. 0).
- In the 100-F Area, 7.2 mg/kg CrVI was determined to be the soil concentration that will produce a leachate concentration of less than 20 ug/L (*Cleanup Verification Package for the 100-F-19:1 North Pipelines, 100-F-34 Biology Facility French Drain, and 116-F-12 148-F French Drain*, CVP-2001-00002, Rev. 0).
- The 100-H Area leach testing data predicts that a 5.7 mg/kg CrVI soil concentration will produce a leachate concentration of less than 20 ug/L (*Cleanup Verification Package for the 116-H-7 Retention Basin*, CVP-2000-00027, Rev. 0.).

Therefore, retention basin CrVI soil concentrations in the range of 5.7 to 7.2 mg/kg are considered protective of the Columbia River throughout the 100 Area, including the 100-BC Decision Unit. Characterization efforts planned in this addendum will be used to verify the distribution of remaining contamination and to refine the 100-BC Decision Unit CSM.

2.4.1.4 Previous Treatability Tests

In April 1990, a treatability test using in situ vitrification was conducted at the 116-B-6A Crib site. In situ vitrification is a thermal treatment process that converts contaminated soil into a chemically inert and stable glass and crystalline product (PNL-8281, *In Situ Vitrification of a Mixed Waste Contaminated Soil Site: The 116-B-6A Crib*). This test was a technology demonstration rather than a remedial action to stabilize waste.

The in situ vitrification melt at this site reached 4.3 m (14 ft) bgs and produced a block of vitrified material between 10.7 and 12.2 m (35 to 40 ft) in diameter, approximately 3.8 (12 ft) high, and weighing between 726 and 86 metric tons (800 and 900 tons) . The vitrified material was removed during remediation of the 116-B-6A/116-B-16 Site and was disposed of to ERDF (CVP-99-00011, *Cleanup Verification Package for the 116-B-6A Crib and 116-B-16 Fuel Examination Tank, Rev. 0*). Further treatment using in situ vitrification has not been performed.

Another treatability study was conducted in 1994. It involved the 118-B-1 Solid Waste Burial Ground (DOE/RL-94-43), in which test pit excavation locations were based on geophysical surveys (WHC-SD-EN-TI-137). Using these surveys to guide excavation provided positive results for identifying waste anomalies and excavation boundaries in a few locations.

In 2001, a pilot risk assessment study was initiated in the 100-B/C Area to begin evaluation of the protectiveness of remedial actions under interim action RODs. These activities provided lessons learned and helped refine the approach for assessment of risk in the remainder of the River Corridor (DOE/RL-2005-40, Draft B *100-B/C Pilot Project Risk Assessment Report*). The impacts of source area and groundwater contamination to human health and ecological risk were addressed. The shoreline areas within the 100-BC Decision Unit were sampled according to the River Corridor Baseline Risk Assessment (RCBRA) sample design (DOE/RL-2004-37, *Risk Assessment Work Plan for 100 Area and*

300 Area Component of RCBRA) to support a consistent risk characterization approach for the entire Hanford Site shoreline. Data from characterization of waste sites within 100-BC were also used to support risk characterization for the RCBRA.

2.4.1.5 100-BC Decision Unit Hexavalent Chromium Leach Test Studies

Results of additional targeted batch leach studies are presented in PNNL-17674, *Geochemical Characterization of Chromate Contamination in the 100 Area Vadose Zone at Hanford*. In this report, column leach tests were performed to evaluate the adsorption and desorption of CrVI in contaminated and uncontaminated soils (from the 100-B and 100-D Areas) using dichromate solutions of varying concentrations and synthetic groundwater to represent the transport medium.

Results indicated at least four categories (or "pools") of chromium with different leaching behavior were present in the tested, contaminated sediments. The first pool contained highly mobile and readily removed CrVI, dominant in all sediments (over 95 percent of total chromium was present in this pool). Adsorption of CrVI to sediments from spiked CrVI solution was low, and calculated retardation coefficients were close to one. The fine-grained surface coatings served as a porous, but restricted medium that was accessible to chromate by diffusion from migrating chromate-laden water.

The second pool contained CrVI held in physical and mineralogical remote sites that provide a longer-term continuing source of contaminant chromium. The third pool consisted of reduced immobile trivalent chromium most likely by surface-mediated redox reaction of aqueous CrVI and aqueous, sorbed, or structural Fe(II). The fourth pool was composed of CrVI in the form of barium chromate precipitates that apparently did not contribute to the overall transport of CrVI.

CrVI concentrations in the leachate remained greater than the federal MCL for total chromium of 100 μg/L for many (more than 20) pore volumes. However, the significance of this for groundwater concentrations would depend on the mass flux of recharge to the water table. The working hypothesis of the mechanism is vadose zone retention of CrVI as a chromate anion (CrO_4^{2-}) in the 100 Area of the Hanford Site. This vadose zone retention probably resulted from physical matrix potential effects holding chromate (CrO_4^{2-}) contaminated pore water against gravimetric force.

Soil water content reduces with time (up to 40 or 50 years) to more typical vadose zone conditions (~15 percent by weight), rather than the enriched moisture environment created during production (where higher soil moisture existed as a result of high-volume liquid waste discharges). Under these conditions, the formation of very soluble and slightly soluble CrVI phases and/or CrVI reduce CrVI to relatively insoluble trivalent chromium. The soluble forms then act as long-term sources for groundwater CrO_4^{2-} contamination.

Experiment results indicated most of the chromium solution traveled quickly through the sediments and appeared as CrVI. Leach testing conducted to investigate desorption from contaminated sediments showed a small, retained component of CrVI with degraded solubility. That component could provide a long-term source, which is consistent with observations from cleanup verification packages and groundwater monitoring data. Thus, the contaminant chemical behavior is well quantified with regard to 100 Area soils.

In these recent experiments, however, peak concentrations of CrVI 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 CrVI at work in various locations may be needed.

2.4.2 Nature and Extent of Contamination in the Groundwater

This section describes the nature and extent of groundwater contamination within the 100-B/C Decision Unit. The 100-BC-5 groundwater OU is located within the 100-B/C Area boundaries. More detailed information on the groundwater within the 100-B/C Decision Unit is presented in the Annual Hanford Site Groundwater Monitoring Reports (e.g., DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*).

The following subsections describe groundwater contaminant conditions focusing on the most recent sampling performed in FY 2008 and reported in the *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-66). The 100-B/C Decision Unit groundwater monitoring wells are shown in Figure 2-20).

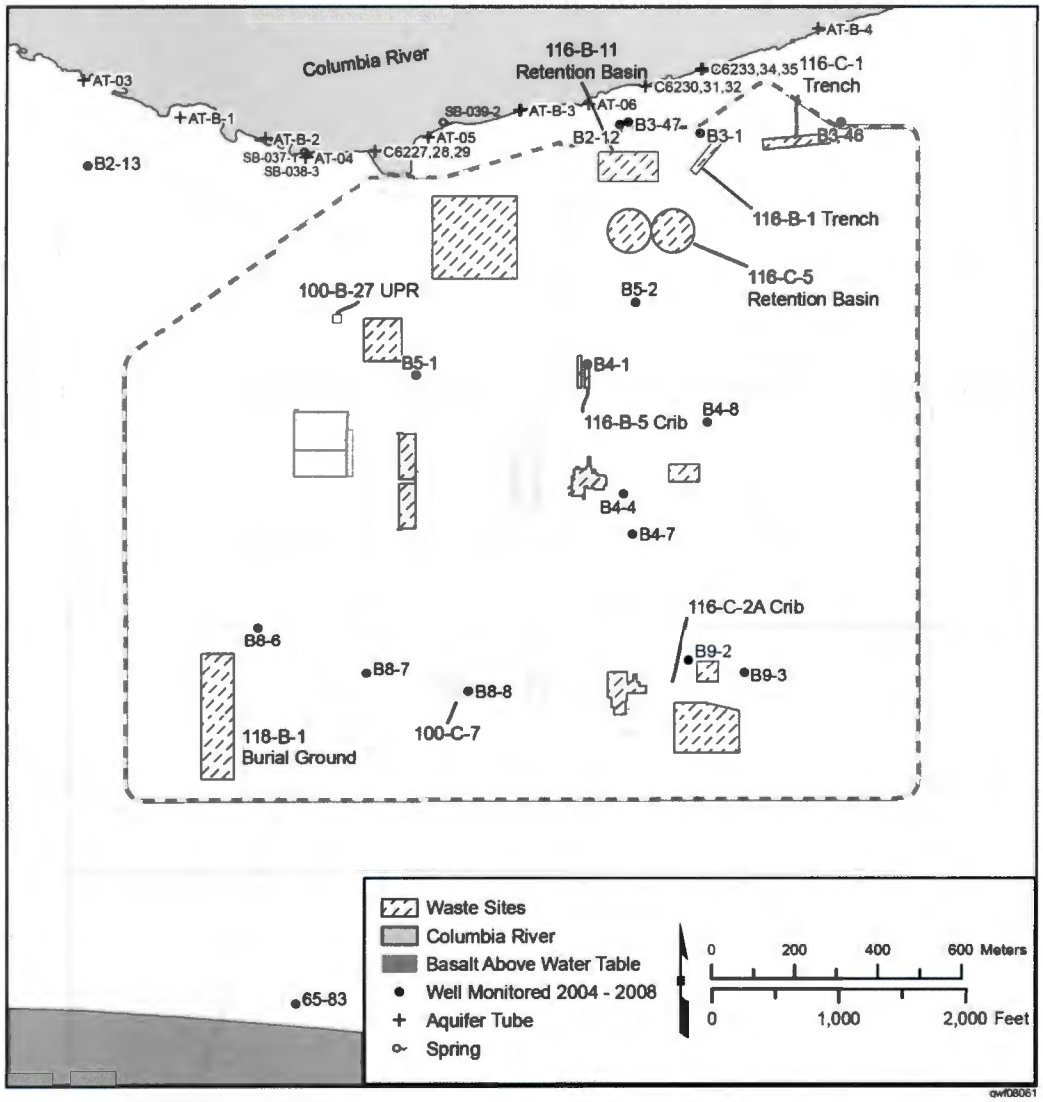

Figure 2-20. Monitoring Well Locations in the 100-BC Area

Groundwater is sampled at various intervals (typically quarterly to biennially) for select contaminants of interest to describe the nature and extent of contamination at the 100-BC Decision Unit. The sampling frequency was recommended in the groundwater SAP for this decision unit (PNNL-13326) and as the result of the data quality objectives (DQO) process (PNNL-14287). This regularly scheduled sampling includes analysis for Sr-90, tritium, and CrVI. Table 2-8 l lists the areal extent of these plumes. Figure 2-10 is a high water table map (circa March 2008) for the 100-BC Decision Unit.

Water near the river is sampled annually (usually in the late fall) in aquifer tubes when accessible, and in riverbank seeps. Water samples collected at these sampling points are analyzed for chromium, gross beta, nitrate, specific conductance, Sr-90, and tritium. The results are documented in annual groundwater monitoring reports prepared for the Hanford Site (e.g., DOE/RL-2008-66). Groundwater monitoring has continued since the initial RI (DOE/RL-93-37) and during waste site remedial actions.

Table 2-8. Plume Areas at 100-BC-5 Groundwater Operable Unit

Contaminant	Standard	Plume Area (km^2)	Plume Area (mi^2)
CrVI*	20 µg/L*	0.82	0.32
Sr-90	8 pCi/L**	0.63	0.24
Tritium	20,000 pCi/L**	0.23	0.09

* Cleanup level based on ambient surface water quality criteria with 1:1 dilution applied (EPA/ROD/R-10/134). Cleanup level potentially applicable to 100-BC Decision Unit. CrVI area based on dissolved total chromium analytical analyses (DOE/RL-2008-66).

** Federal MCL

Source: DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008.*

Chromium

Two areas of hexavalent and total chromium contamination are present in the 100-BC Area (Figure 2-21). Total chromium concentrations were reported at less than federal DWS of 100 µg/L, in recent years in the 100-BC Decision Unit. Dissolved total concentrations (inferred to be representative of CrVI) have exceeded the state Model Toxics Control Act – Cleanup (WAC 173-340) Method B concentration considered protective of ingestion of drinking water of 48 µg/L. CrVI concentrations have also exceeded the 20 µg/L groundwater concentration considered protective of aquatic receptors in the northern portion of the 100-BC Area. The CrVI ambient surface water quality criterion is 10 µg/L. Applying a near-shore 1:1 dilution to the surface water quality concentration results in a remedial action goal of 20 µg/L with the river protection compliance point as groundwater (i.e., the groundwater at levels greater than 20 µg/L is considered protective for demonstrating CrVI river protection at 10 µg/L). Figure 2-21 provides FY 2008 information on the average chromium concentrations in the 100-BC Decision Unit (DOE/RL-2008-66). The highest concentration detected in samples from monitoring wells in FY2008 was 54.8 µg/L (CrVI) in well 199−B3−47, downgradient of the 116−B−11 Retention Basin. This result was within the range observed since 1999.

In the southern 100-B/C Area, waste site investigations discovered chromium contamination in the vadose zone at the 100-C-7 Waste Site (Figure 2-20). Chromium concentrations for groundwater samples from wells 199-B8-7 and 199-B8-8 initially were under 20 µg/L. The concentration increased to 49 µg/L in well 199-B8-8 in July 2008 (Figure 2-22), but declined in October 2008. This well will be sampled monthly in FY 2009 to monitor chromium levels.

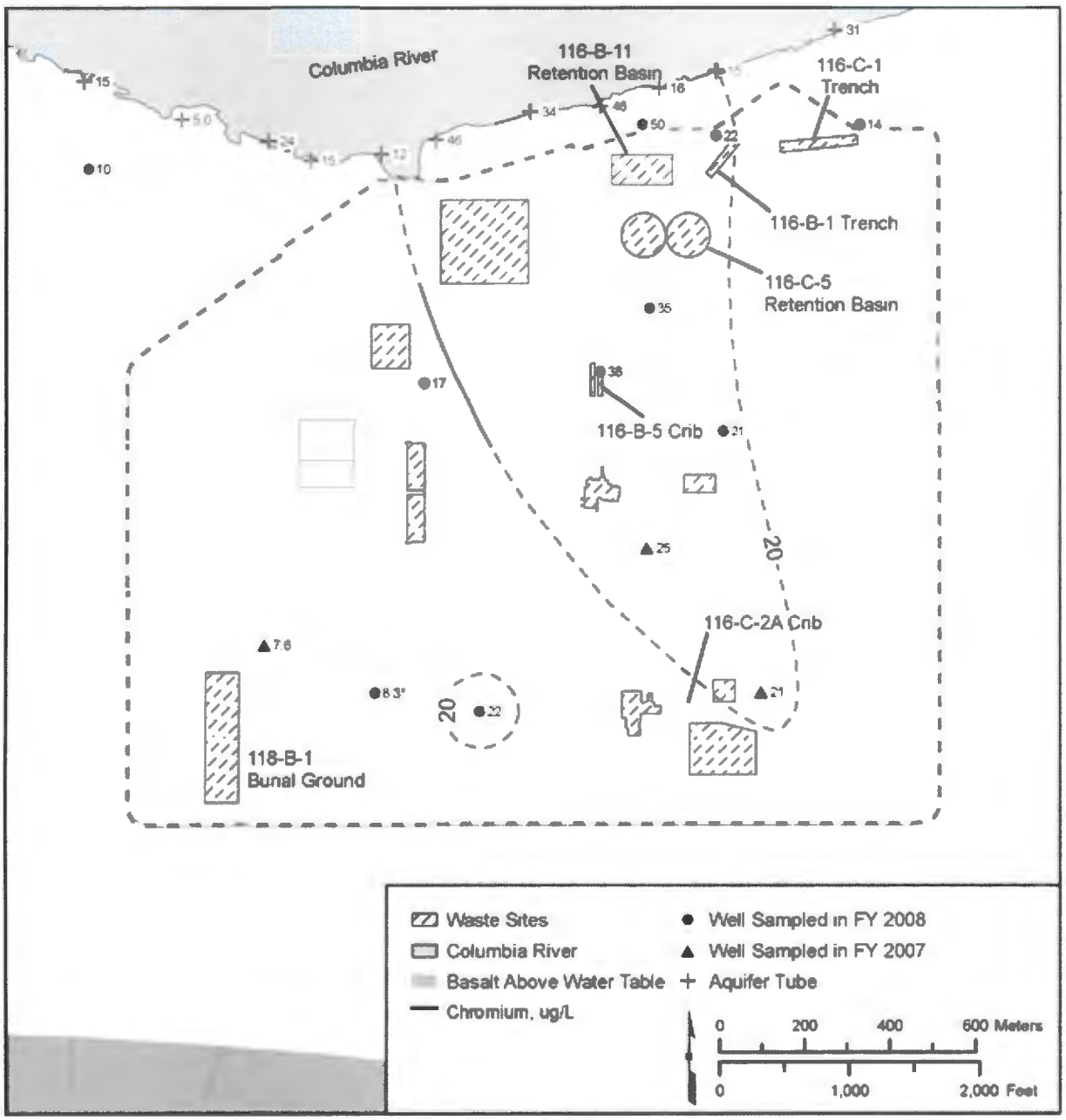

Figure 2-21. FY 2008 Average Hexavalent Chromium Concentrations in 100-B/C Area, Top of Unconfined Aquifer

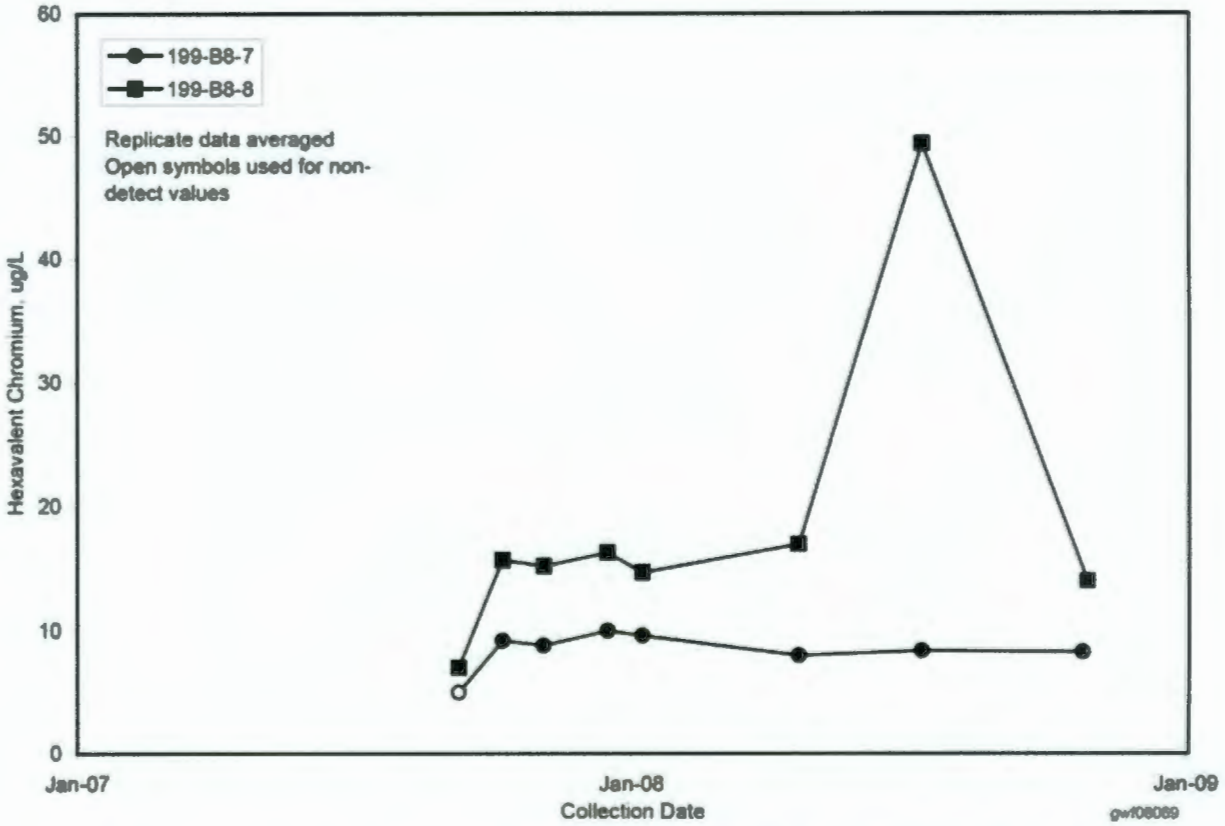

Figure 2-22. Hexavalent Chromium Concentrations in Wells Near the 100-C-7 Waste Site

Another waste site, 100−B−27 sodium dichromate spill, located in the northwestern 100−B/C Area, also had chromium contamination in the vadose zone. The DOE drilled a characterization borehole and collected soil and groundwater samples from this waste site (WCH−225, Sampling and Analysis Instruction for Evaluation of Residual Hexavalent Chromium Contamination in the Subsurface Soil at 100−B−27). Chromium levels in groundwater were low (6.5 μg/L in a filtered sample).

Deep monitoring well 199-B2-12, located adjacent to shallow well 199-B3-47, has no detectable chromium. Figure 2-23 illustrates the distribution of chromium concentrations with depth for the 100-B/C Area aquifer tubes and nearby wells. In FY 2008, the highest concentrations in aquifer tubes were in shallow tube AT-05-S and mid-depth tube AT-06-M (both 46 μg/L).

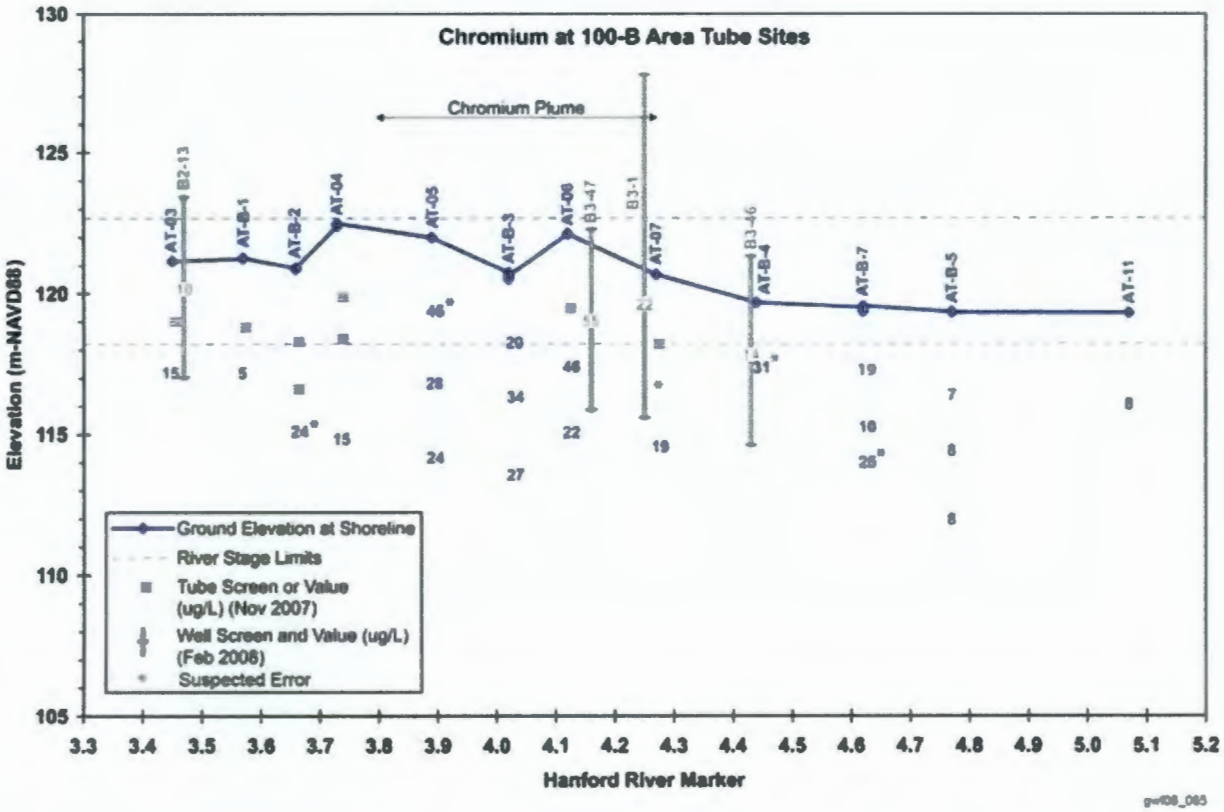

Figure 2-23. Cross Section of Chromium Concentrations and Screen Elevations in Wells and Aquifer Tubes in 100-B/C Area

Strontium-90

An Sr-90 plume extends from the central 100-B/C Area north toward the Columbia River (Figure 4-3). The Sr-90 DWS is 8 pCi/L. The plume size and ranges in concentrations have not changed significantly for more than 10 years. Figure 2-24 shows Sr–90 concentration trends in wells near the 116-B-1 Trench, the 116-C-1 Trench, and cribs in the central 100–B/C Area. The highest concentration in fiscal year (FY) 2008 was 44.7 pCi/L in well 199–B3–46, near the 116–C–1 Trench. Concentrations in FY 2008 were similar to those reported for FY 2007 and several previous years.

Near-shore groundwater monitoring is conducted through sampling and analysis in aquifer tubes (SGW-35028). In 2008, Sr-90 concentrations continued the trend to exceed the 8 pCi/L DWS in aquifer tubes at the 100-BC Decision Unit. Sr-90 levels in four aquifer tubes exceeded the DWS in FY 2008, with a maximum of 16 pCi/L in new tube C6230, sampled for the first time in September 2008. Concentration trends in the older aquifer tubes are steady to gradually declining.

Sr-90 appears to be limited to the upper part of the unconfined aquifer. Deep well 199-B2-12 consistently has no detectable Sr-90, while its shallow counterpart, well 199-B3-47, has levels above the DWS. Similarly, deep aquifer tubes C6332, AT-05-D, and AT-06-D had undetectable Sr-90 concentrations, while their shallower counterparts had concentrations above the DWS (DOE/RL-2008-66).

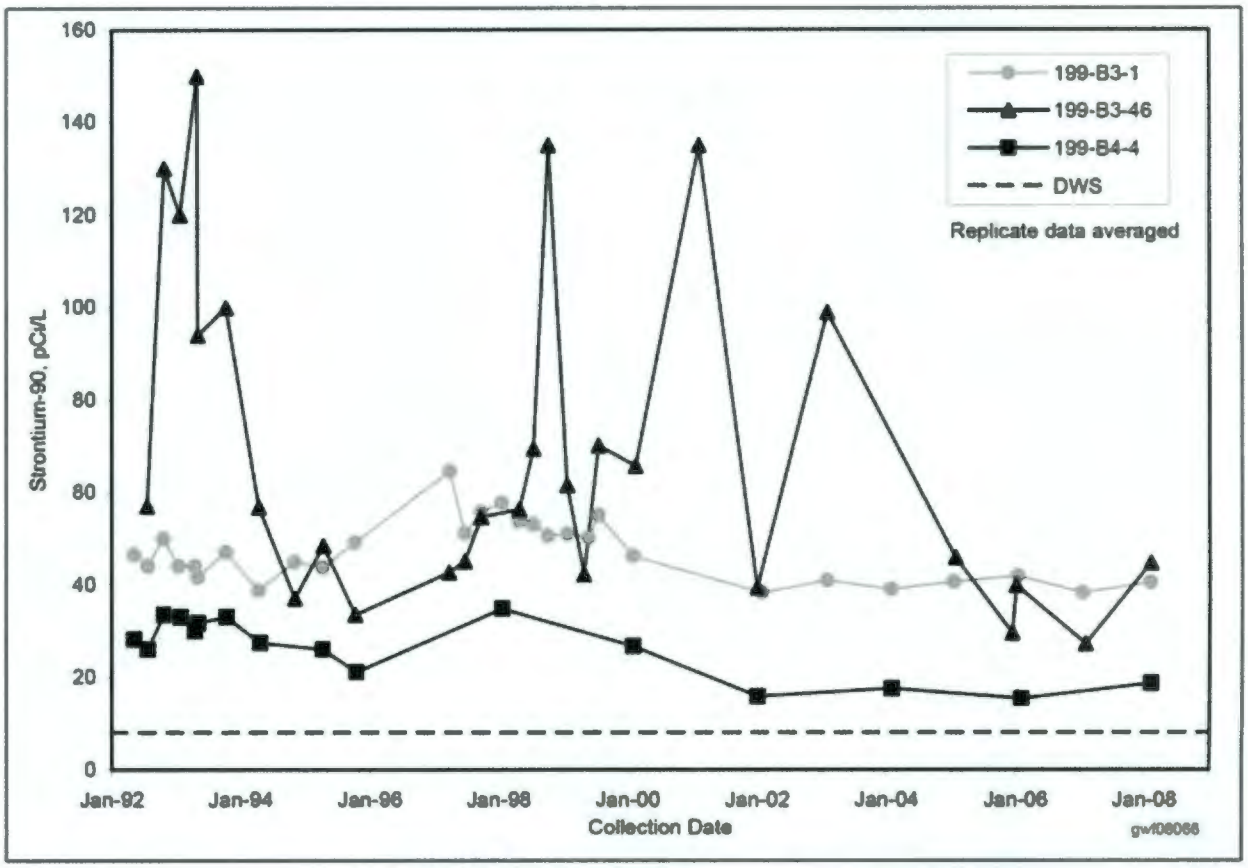

Figure 2-24. Strontium-90 Concentration Trends in the 100-B/C Area

Tritium

The upper part of the unconfined aquifer beneath the 100-B/C Area is contaminated with tritium at concentrations that exceed the DWS (20,000 pCi/L) in several wells (Figure 2-25). The distribution of tritium currently is interpreted as three separate plumes (DOE/Rl-2008-66).

In 2008, tritium concentrations exceeded DWSs (20,000 pCi/L) in several groundwater monitoring wells. In the northern 100-B/C Area, only one well (199-B3-47) had a tritium concentration greater than the DWS during FY 2008 (45,000 pCi/L). The FY 2008 increase in well 199-B3-47 may represent the pulse of tritium seen in well 199-B5-2 in 2005 and 2006. Tritium concentration trends in wells within the northern portion of the 100-BC Area are shown in Figure 2-26.

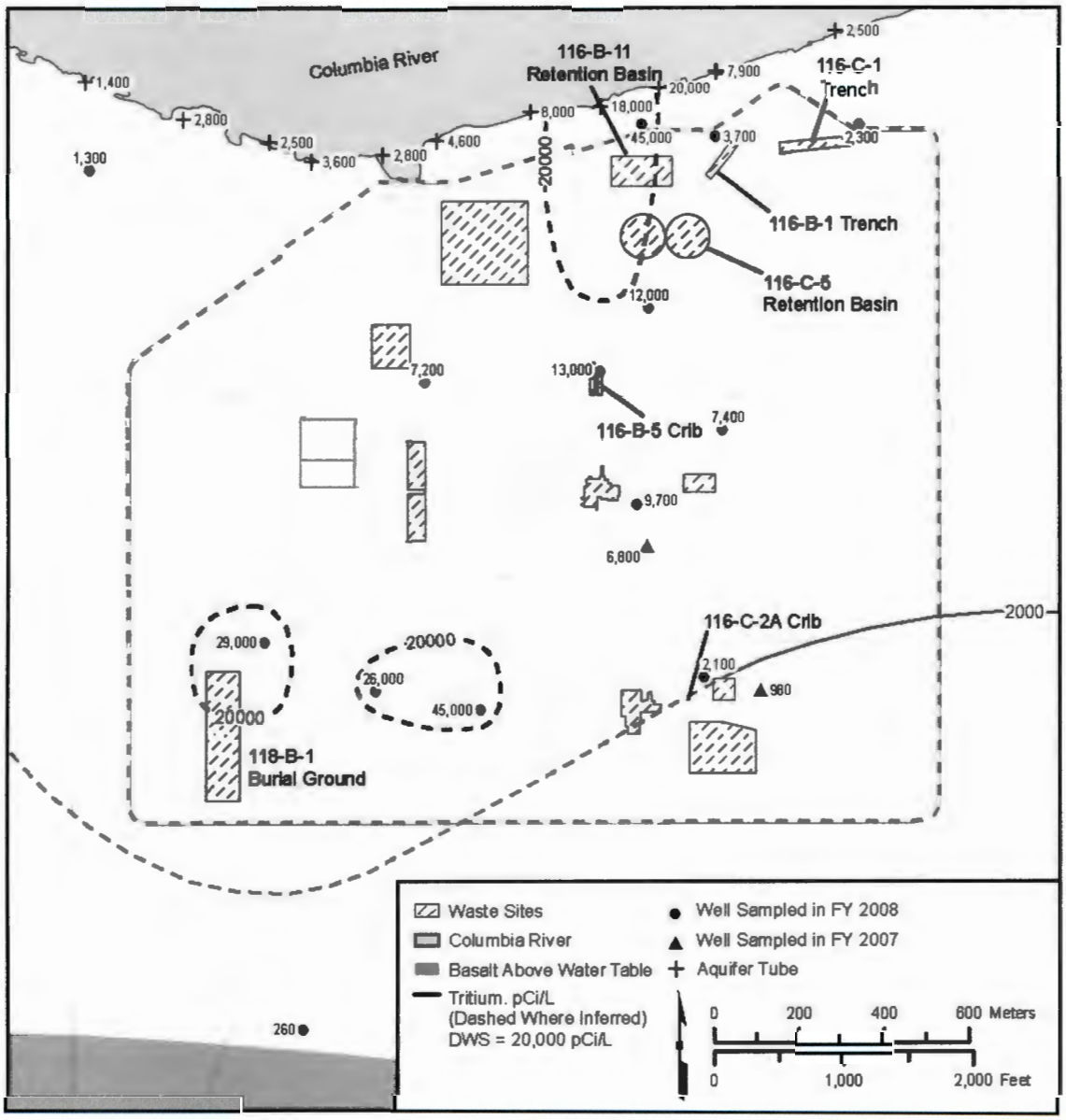

Figure 2-25. FY 2008 Average Tritium Concentration in the 100-BC Decision Unit and Upper Part of the Unconfined Aquifer

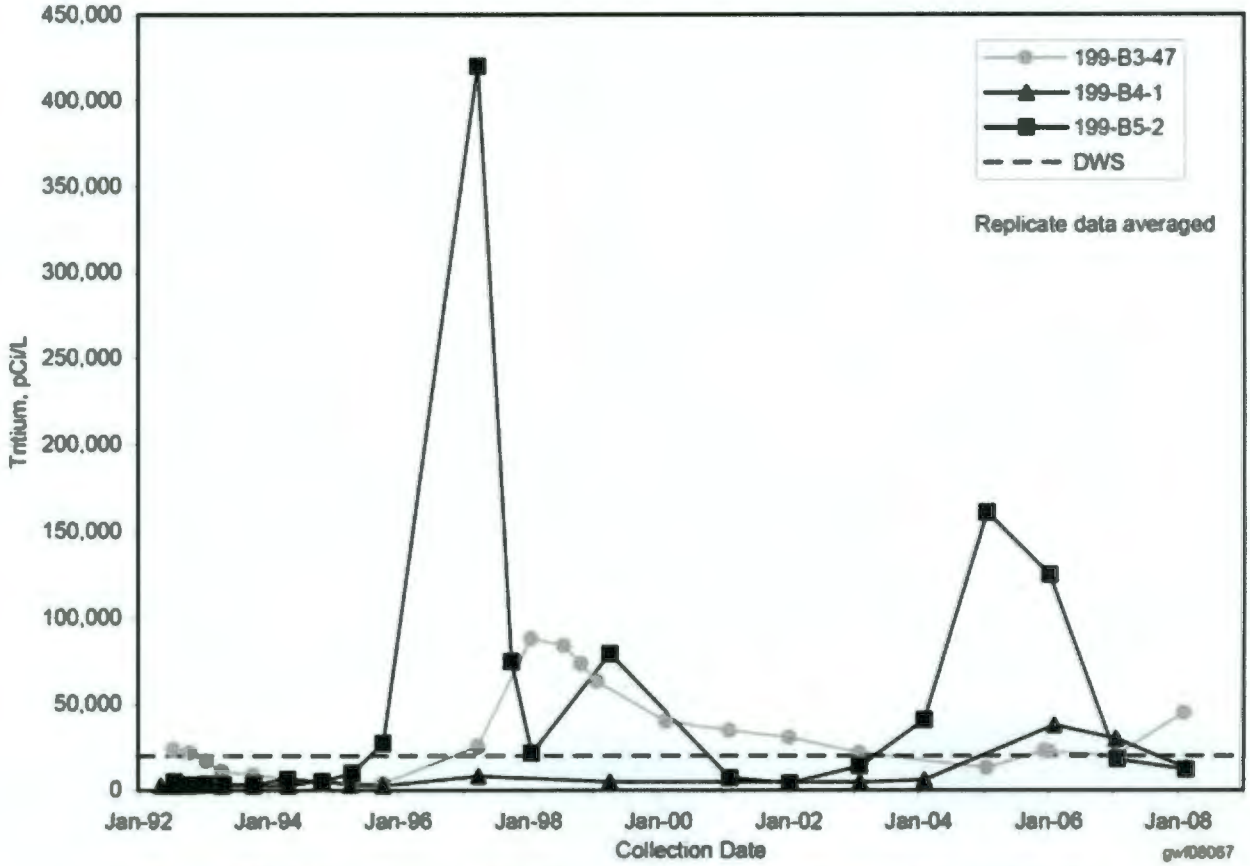

Figure 2-26. Tritium Concentration Trends in the Northern Portion of the 100-BC Area

Tritium concentrations in three wells in the southern 100-B/C Area exceed the DWS (Figure 2-25). The current interpretation is that there are two separate plumes in this region. Because the area has only three monitoring wells, these plumes are not well defined. Well 199-B8-6 (near the 118-B-1 Burial Ground) had tritium concentrations of ~29,000 pCi/L, with a flat trend over the past few years. New wells 199-B8-7 (between wells 199-B8-6 and 199-B8-8) and 199-B8-8 (in the 100-C-7 Waste Site) also had tritium levels above the standard (Figure 2-25) (DOE/RL-2008-66). Tritium concentration trends in wells within the southern portion of the 100-BC Area are shown in Figure 2-27.

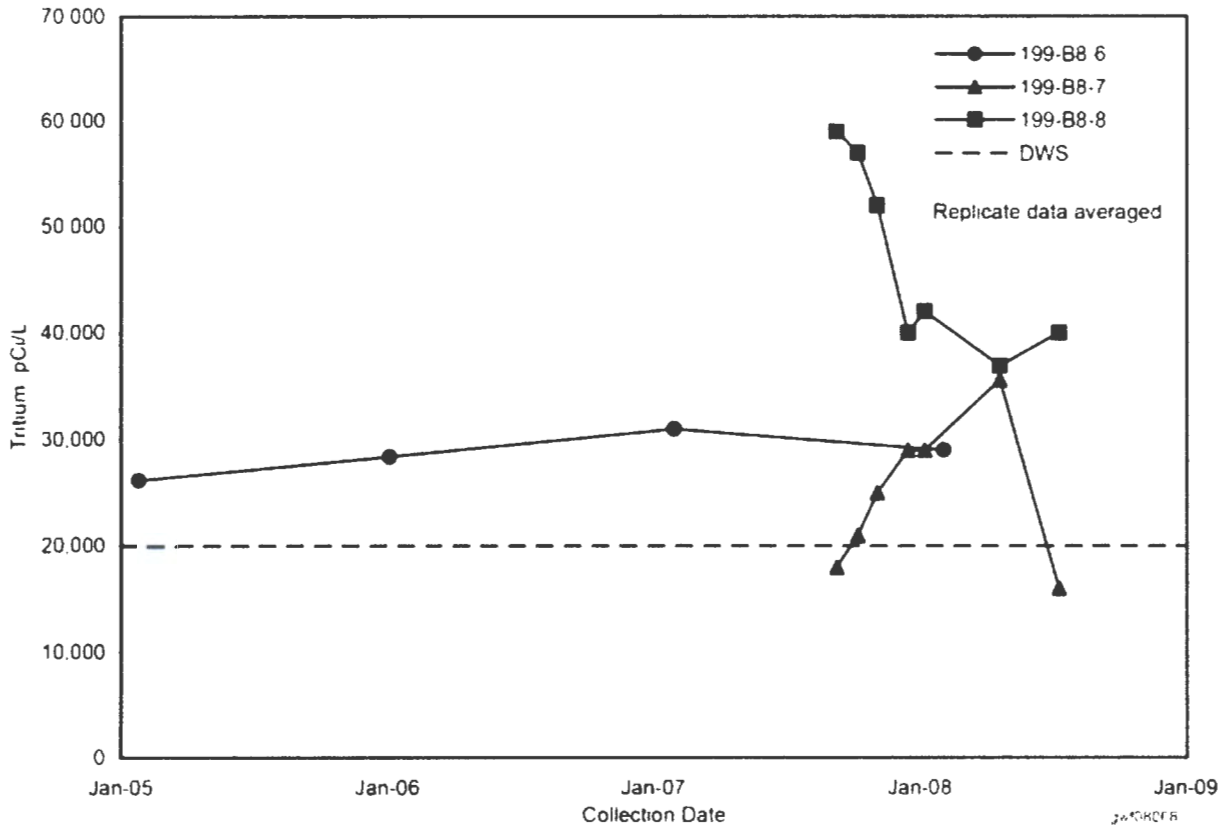

Figure 2-27. Tritium Concentration Trends in the Southern Portion of the 100-BC Area

Tritium concentrations in two new wells (199-B8-7 and 199-B8-8) in the southern 100-BC Decision Unit were unexpectedly high, and exceeded the DWS in one well. Wells 199-B4-1 and 199-B5-2 had concentrations below the standard, although they have exceeded the standard in the past (DOE/RL-2008-66).

In the past, groundwater mounds in the 200 Area pushed contaminant plumes north, through the gap between Gable Butte and Gable Mountain. The plumes can be traced from their sources in the 200 East Area to a region between the 100-B/C and 100-K Areas. The historic transport of contaminants from the 200 Areas is not currently impacting BC groundwater above DWSs.

Other Contaminants

Other contaminants within the 100-BC Decision Unit have been detected in groundwater monitoring wells (DOE/RL-93-37, PNNL-14287) including:

- Volatiles and semi-volatiles: Acetone, trichloroethene, bis(2-ethylhexyl)phthalate
- Inorganics: Aluminum, antimony, barium, calcium, cadmium, chromium, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, vanadium, and zinc
- Radionuclides: Am-241, C-14, gross beta, Sr-90, Tc-99, tritium, U-233/234, U-238
- Nitrate.

In 2003, DQOs were developed to guide groundwater sampling for the 100-BC Groundwater OU (PNNL-14287). Groundwater samples collected from 1992 to 2002 were evaluated. Contaminants such as

C-14, Tc-99, antimony, lead, cadmium, and mercury that were never detected above DWSs were not considered as future COPCs for the area. Other contaminants such as aluminum, iron, and nickel no longer exceed groundwater standards as of 1995 and were also not considered as future COPCs for the area.

With respect to nitrate, the 100-B/C Pilot Project Risk Assessment Report (DOE/RL-2005-40) identified nitrate as a COC because of 1998 and 1999 concentrations that exceeded the DWS of 45 mg/L in well 199-B3-47. Concentrations since 1995 have declined in 100-BC Area monitoring wells. The highest nitrate concentration in FY 2008 was 39.5 mg/L in well 199-B3-47, similar to the FY 2007 value.

3 Identification of Investigation Requirements

This chapter is included for completeness to satisfy *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (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 Areas (Section 4.2)
- Preliminary Remedial Action Objectives (Section 4.3)
- Preliminary Remediation Goals (Section 4.4)
- Potential Applicable or Relevant and Appropriate Requirements (Section 4.5)
- Preliminary Remedial Actions (Section 4.7).

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 current CSM for the 100-BC Decision Unit. The CSM expresses the current understanding of site conditions in the decision unit and allows for the identification of data gaps and data needs in conjunction with the systematic planning process described in the work plan. Data gaps specific to the 100-BC Decision Unit are listed in the following sections, followed by supporting information about what specific CSM uncertainty the data gap addresses. The CSM is developed as a discussion of contaminant sources, contaminant distribution, contaminant fate and transport, and exposure pathways and receptors. Geology and hydrogeology of the 100-BC Decision Unit are discussed in Chapter 2, Sections 2.2.2 and 2.2.3. The goal of the CSM is to synthesize decision unit knowledge to support development of project needs and decision-making requirements, including the design of remedial actions. The CSM will evolve through the RI/FS process; the development and implementation of a remedy is improved through the collection of data and the development of an improved understanding of the key uncertainties. A well-developed CSM provides clear statements describing the uncertainties with the specifications required for a satisfactory answer result. The data and information requirements necessary to develop and implement the remedy are developed directly from the process of resolving the uncertainties through the CSM.

The following key elements of the CSM are discussed in the following sections.

- The primary contaminants of interest in the 100-BC Decision Unit are CrVI, Sr-90, and tritium.
- Waste sites remain in the Decision Unit that have not been remediated, but will be remediated at a future date. These waste sites are part of ongoing interim actions.
- The nature and extent of soil and groundwater contaminants is influenced by past waste disposal practices, historic groundwater flow patterns (e.g., groundwater mounding), natural influences on groundwater flow (e.g., river stage fluctuations), and geochemical conditions in the soil and groundwater.
- Uncertainty remains regarding the extent of contamination beneath select waste sites that have been interim closed. Additional data collection is proposed to address this uncertainty as part of this RI.
- The nature and extent of groundwater contamination for select constituents is uncertain. Additional groundwater sample collection activities are proposed to address this uncertainty.
- Past soil and groundwater sample data were evaluated and through a process described in the work plan, soil and groundwater samples will be sampled for many contaminants of interest. The list of contaminants of interest for the 100-BC Decision Unit is provided in the SAP (DOE/RL-2009-44).

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 the vadose zone and groundwater and has migrated to the Columbia River.

4.2.1 Primary Sources of Contamination and Releases Mechanisms

The primary sources of contamination in the 100-BC Decision Unit are two water-cooled nuclear reactors (105-B and 105-C) and the structures (e.g., fuel storage basins [FSB]) and processes (e.g., sodium dichromate process) 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 CrVI (used as a corrosion inhibitor). CrVI, Sr-90, and tritium are recognized as primary COCs in groundwater. 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.

Deliberate and unintended releases of waste resulting from operations are the primary contaminant release mechanisms. Liquid contaminants were released directly to the environment by discharging effluent to temporary surface impoundments, cribs, ditches, and the Columbia River. Solid waste was placed in unlined burial grounds.

The SAP (DOE/RL-2009-44) provides a complete description of the target analytes (chemical and radionuclides) associated with area operations, based on initial investigations and systematic planning activities.

4.2.2 Secondary Sources of Contamination and Release Mechanisms

Wastes released to the environment created secondary sources of contamination where contaminants could be retained in the subsurface and released over long periods of time, such as ponds, ditches, and cribs; burial grounds; and unplanned release sites. Secondary sources can also impact the environment through the following secondary release mechanisms:

- Re-suspension 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., waste sites and facilities) are listed in Appendices C and D. Contaminant sources for CrVI, Sr-90, and tritium are provided in Tables 4-1 through 4-4 and Figures 4-1 through 4-3. Process knowledge and historical research, including the orphan site process, have identified primary and secondary sources across most of the decision unit.

Data Gap #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 typical depth of remedial action is generally 4.5 m (15 ft) or less. However, not all waste sites in the 100-BC Decision Unit 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 COPCs associated with the vadose zone are identified in the SAP (DOE/RL-2009-44). The list of COPCs was developed using the methodology described in Chapter 4 of the work plan. Field data (described in Chapter 2, Section 2.4) indicate contaminant distributions at high-volume, retrieved liquid waste sites for contaminants (e.g., arsenic, total chromium, mercury, CrVI, 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 disposal facility and generally decrease with depth. Soil samples collected and analyzed during interim remedial actions indicate residual contamination is located well above the water table and the periodically re-wetted zone. Table 4-1 lists the high-volume liquid waste sites. Appendix B provides maps of the waste site locations.

Waste sites that received small amounts of liquid are generally found 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, Section 2.3.3) has been removed and/or confirmed to meet remedial action goals for direct exposure, protection of groundwater, and protection of the Columbia River in soils 0 to 4.5 m (0 to 15 ft) bgs. At these sites, contaminated soil to a depth of 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/R10-99/039, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington*. The inventory of contaminants remaining in the soil column has been significantly reduced by interim remedial actions. Contaminated soil removal and disposal in the 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. Leach tests and/or verification sampling from soils collected at the bottom of the remediated waste sites combined with modeling, suggest the residual contaminants are protective of groundwater and the Columbia River. However, a review of available contaminant data shows the understanding of contaminant distribution is based mainly on data collected less than 11 m (35 ft) within a vadose zone that is in some locations 21 m (70 ft) thick. The lack of contaminant analytical data below depths of approximately 11 m (35 ft) results in uncertainty regarding contaminant migration to groundwater.

Table 4-1. 100-BC Decision Unit High Volume Radioactive Liquid Effluent Disposal Sites*

Site Code	Description
100-B-8	The 105-B Reactor Effluent Pipelines.
116-B-1	Site is a liquid waste disposal trench that received effluent routed from the 107-B Retention Basin.
116-B-2	Trench was used to receive ~4.1 million L (~1.1 million gal.) of storage basin water that had been contaminated when a fuel rod was accidentally cut in half in the 105-B Fuel Storage Basin.
116-B-3	Wooden pluto crib received 105-B Reactor cooling water wastes that had been contaminated by cladding ruptures of fuel elements.
116-B-4	Crib received spent acid and rinse water from the 105-B Dummy (fuel element spacers and reactor hardware) Decontamination Facility.
116-B-5	Crib received liquid wastes from the 108-B Building.
116-B-6A	Crib received radioactive liquid wastes from fuel element spacer decontamination, and equipment decontamination performed in the 111-B Building.
116-B-6B	Crib received radioactive liquid wastes from fuel element spacer decontamination, and equipment decontamination performed in the 111-B Building.
116-B-9	French drain received wastewater from the P-10 Storage Building drain.
116-B-10	Quench tank was used to collect liquid decontamination wastes from the 108-B Tube Examination and Experimental Facility.
116-B-11	Retention basin was used to hold 105-B Reactor cooling water effluent to allow for thermal cooling and radioactive decay prior to release to the Columbia River.
116-B-12	Crib received drainage from the confinement system in the 117-B Building seal pits.
116-B-13	Trench received low-level sludge waste from the bottom of the 107-B Retention Basin.
116-B-14	Trench received low-level sludge waste from the bottom of the 107-B Retention Basin.
100-C-6	Pipelines include the 105-C Reactor cooling water effluent pipelines.
116-C-1	Trench received effluent overflow from the 107-C Retention Basin during reactor outages due to ruptured fuel elements.
116-C-2A	105-C Pluto Crib and associated processes.
116-C-5	Basins received 105-B Reactor and 105-C Reactor cooling water effluent for radioactive decay and thermal cooling prior to release to the Columbia River.

* Based on the Radioactive Liquid Effluent Waste Sites Interim Action ROD.

Table 4-2. 100-BC Decision Unit Hexavalent Chromium Disposal Sites

Site Code	Description
100-B-5	Effluent Vent Disposal Trench resulted from leakage that occurred at a junction box in multiple events over at least a 2-year period.
100-B-8 100-B-8:1 100-B-8:2	Pipelines are 105-B Reactor cooling water effluent pipelines.
100-B-11	Purpose of the caisson site is unknown; however, the contents include a yellowish-colored soil with sample analytical results showing 7 to 8% chromium contamination prior to demolition. Confirmatory sampling was conducted at the 100-B-11 Site in September 2003. The maximum detected results from the four soil samples were used to support site reclassification.
100-B-14:1 100-B-14:4 100-B-14:5 100-B-14:7	Pipelines carried a variety of non-radioactive waste fluids, product (sodium dichromate), and sanitary waste.
100-B-25	Emergency overflow spillway associated with the 1904-B-2 Reactor Outfall.
100-B-26	Emergency overflow spillway associated with the 1904-C-2 Reactor Outfall.
100-B-27	Sodium dichromate spill.
100-B-28	Sodium dichromate transfer pipeline.
100-C-6:1 100-C-6:2 100-C-6:3 100-C-6:4 100-C-6:5	105-C Reactor cooling water effluent pipelines.
100-C-7 100-C-7:1	183-C Water Treatment Facilities and nearby contaminated soils.
116-B-1	Site is a liquid waste disposal trench that received effluent routed from the 107-B Retention Basin.
116-B-3	Wooden pluto crib received 105-B cooling water wastes that had been contaminated by cladding ruptures of fuel elements.
116-B-7	Site is an outfall structure that directed cooling water from the reactor into the river discharge pipelines.
116-B-11	Retention basin was used to hold 105-B Reactor cooling water effluent to allow for thermal cooling and radioactive decay prior to release to the Columbia River.
116-B-13	Trench received low-level sludge waste from the bottom of the 107-B Retention Basin.
116-B-14	Trench received low-level sludge waste from the bottom of the 107-B Retention Basin.
118-B-1	Burial ground received 105-B Reactor waste, 108-B Reactor solid wastes, and materials from P-10.
118-B-2	Burial ground received dry waste from the 107-B Basin repairs and from the 115-B Recirculation Facility alterations. Note: consolidated with the 118-B-3 Burial Ground.

Table 4-2. 100-BC Decision Unit Hexavalent Chromium Disposal Sites

Site Code	Description
116-C-2A 116-C-2B 116-C-2C	105-C Pluto Crib and associated processes.
116-C-3	105-C Chemical (fuel dejacketing) Waste Tanks.
126-B-3	An unlined pit used to store coal for the 184-B Powerhouse. Following shutdown of the reactors and beginning in the early to mid 1970s, the coal pit was used to dump demolition debris from decommissioned 100-B facilities.
132-B-6	1904-B-2: Site is an outfall structure that directed cooling water from the reactor into the river discharge pipelines.
100-C-9:1 100-C-9:3 100-C-9:4	Pipelines are process sewers associated with the 105-C Reactor operations.
100-C-6	Pipelines are 105-C Reactor cooling water effluent pipelines.
116-C-1	Trench received effluent overflow from the 107-C Retention Basin during reactor outages due to ruptured fuel elements.
116-C-2A 116-C-2B 116-C-2C	105-C Pluto Crib and associated processes.
116-C-3	105-C Chemical (fuel dejacketing) Waste Tanks.
116-C-5	Basins received 105-B and 105-C Reactor cooling water effluent for radioactive decay and thermal cooling prior to release to the Columbia River.
118-C-1	Burial ground received general wastes from the operation of the 105-C Reactor.
118-C-4	The 105-C Horizontal Control Rod Storage Cave is a tunnel used for temporary storage to allow radioactive decay prior to disposal.
128-B-2	Site was a burning pit containing debris.
128-B-3	Site was a burning pit containing debris.
128-C-1	Site was a burning pit containing debris.
132-C-2	1904-C: site is an outfall structure that directed cooling water from the reactor into the river discharge pipelines.

Table 4-3. 100-BC Decision Unit Tritium Receipt Disposal Sites

Site Code	Description
100-B-14:1	Pipelines carried process effluent from the 108-B Tritium Separation Facility, 105-B Facilities, 185/190-B Facilities, and the main collection line to the 116-B-7 Outfall, and sanitary sewer effluent from the 115-B Gas Recirculation site, known to be potential sources of radioactive and chemical contaminants.
116-B-5	Crib received 108-B liquid wastes from P-10.
116-B-7 132-B-6 132-C-2	Site is an outfall structure that directed cooling water from the reactor into the river discharge pipelines.
118-B-1	Burial ground received 105-B Reactor waste, 108-B solid wastes, and materials from P-10. Burial ground received solid tritium wastes and high-level tritium wastes that were sealed in iron pipe.
118-B-9	Site consisted of two facilities identified as the 104-B-1 Tritium Vault and 104-B-2 Tritium Laboratory
118-B-6	Burial ground received wastes from P-10.

Table 4-4. 100-BC Decision Unit Strontium-90 Disposal Sites

Site Code	Description
100-B-5	Effluent Vent Disposal Trench.
100-B-8	105-B Reactor Effluent Pipelines.
100-B-11	Purpose of the caisson site is unknown; however, the contents include a yellowish-colored soil with detected total beta radiostrontium sample analytical results.
116-B-1	Site is a liquid waste disposal trench that received effluent routed from the 107-B Retention Basin.
116-B-2	Trench was used to receive ~4.1 million L (~1.1 million gal.) of storage basin water that had been contaminated when a fuel rod was accidentally cut in half in the 105-B Fuel Storage Basin.
116-B-3	Wooden pluto crib received 105-B Reactor cooling water wastes that had been contaminated by cladding ruptures of fuel elements.
116-B-6A	Crib received radioactive liquid wastes from fuel element spacer decontamination, and equipment decontamination performed in the 111-B Building.
116-B-6B	Crib received radioactive liquid wastes from fuel element spacer decontamination, and equipment decontamination performed in the 111-B Building.
116-B-7	Site is an outfall structure that directed cooling water from the reactor into the river discharge pipelines.
116-B-10	Quench tank was used to collect liquid decontamination wastes from the 108-B Tube Examination and Experimental Facility.
116-B-11	Retention basin was used to hold 105-B Reactor cooling water effluent to allow for thermal cooling and radioactive decay prior to release to the Columbia River.

Table 4-4. 100-BC Decision Unit Strontium-90 Disposal Sites

Site Code	Description
116-B-13	Trench received low-level sludge waste from the bottom of the 107-B Retention Basin.
116-B-14	Trench received low-level sludge waste from the bottom of the 107-B Retention Basin.
118-B-1	Burial ground received 105-B Reactor waste, 108-B Reactor solid wastes, and materials from P-10.
118-B-2	Burial ground received dry waste from the 107-B Basin repairs and from the 115-B Recirculation Facility alterations. Note: consolidated with the 118-B-3 Burial Ground.
100-C-6	105-C Reactor Effluent Pipelines.
116-C-1	Trench received effluent overflow from the 107-C Retention Basin during reactor outages due to ruptured fuel elements.
116-C-2A	Trench received reactor cooling effluent after fuel cladding failures, wash water from decontamination of dummy fuel elements, and liquid wastes from the 105-C Reactor rear face. Estimated waste volume received is ~ 7.5 million L (~2 million gal.).
116-C-5	Basins received 105-B Reactor and 105-C Reactor cooling water effluent for radioactive decay and thermal cooling prior to release to the Columbia River.
118-C-1	Burial ground received general wastes from the operation of the 105-C Reactor.
118-C-4	The 105-C Horizontal Control Rod Storage Cave is a tunnel used for temporary storage to allow radioactive decay prior to disposal.

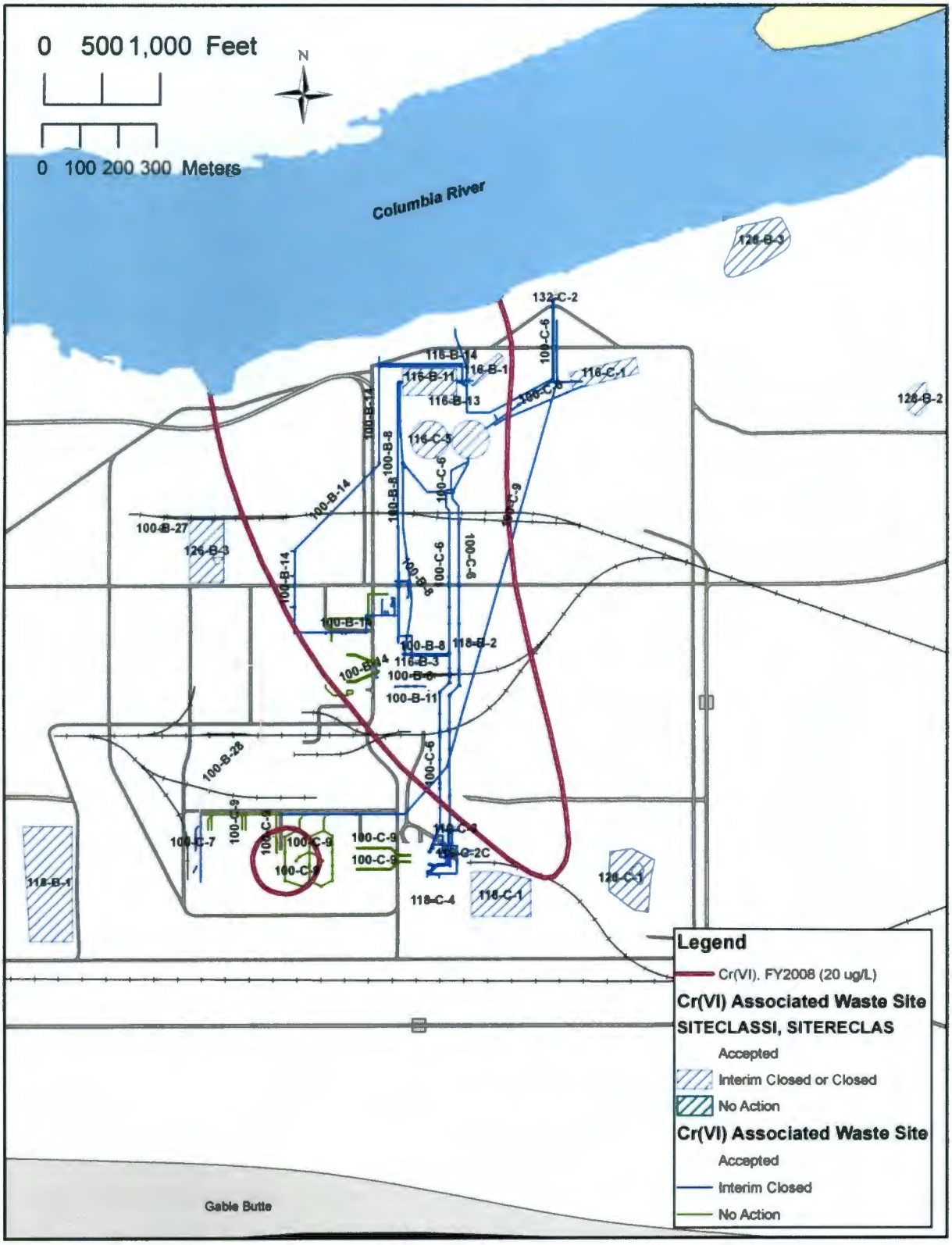


Figure 4-1. 100-BC Decision Unit Hexavalent Chromium Related Waste Sites

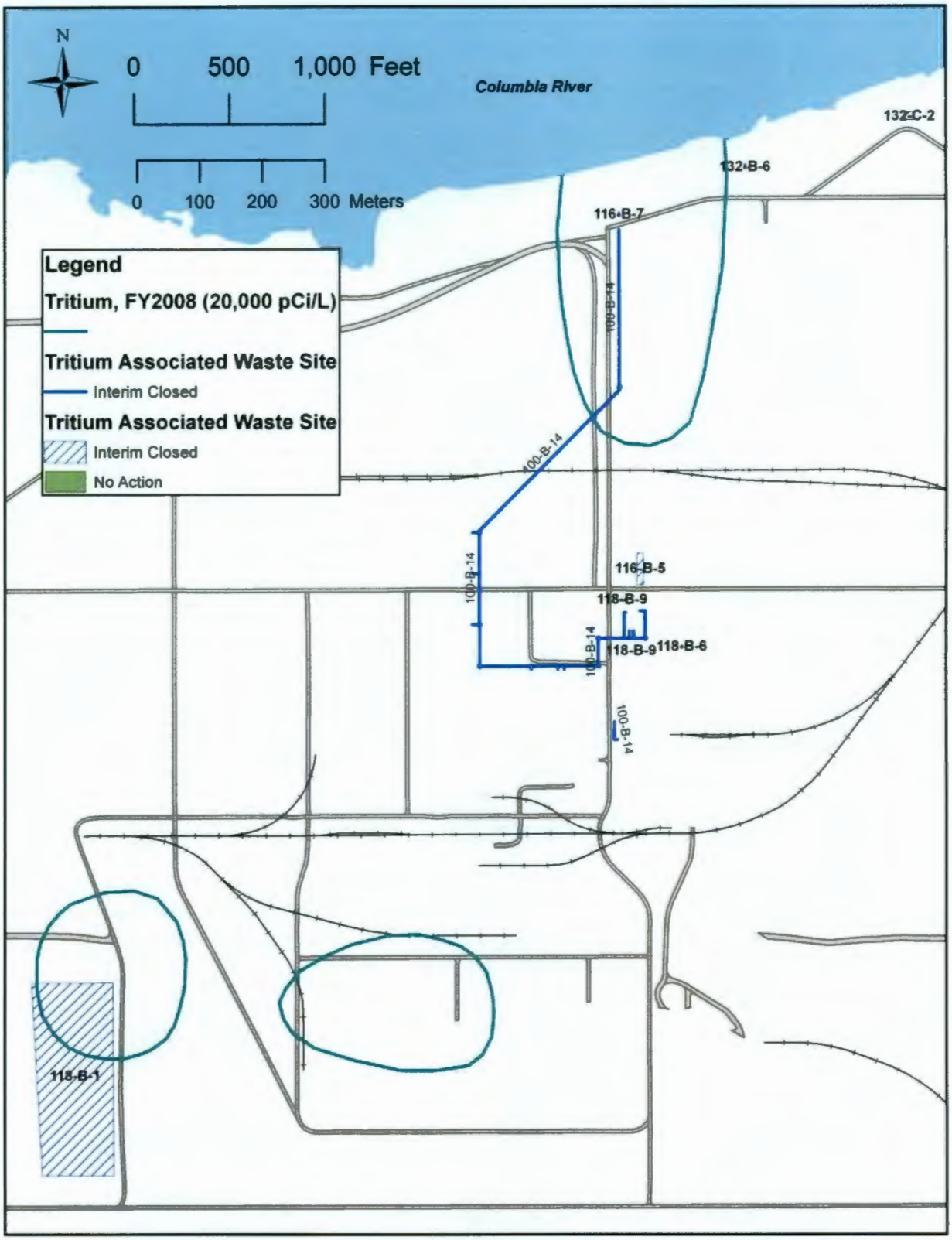


Figure 4-2. 100-BC Decision Unit Tritium Related Waste Sites

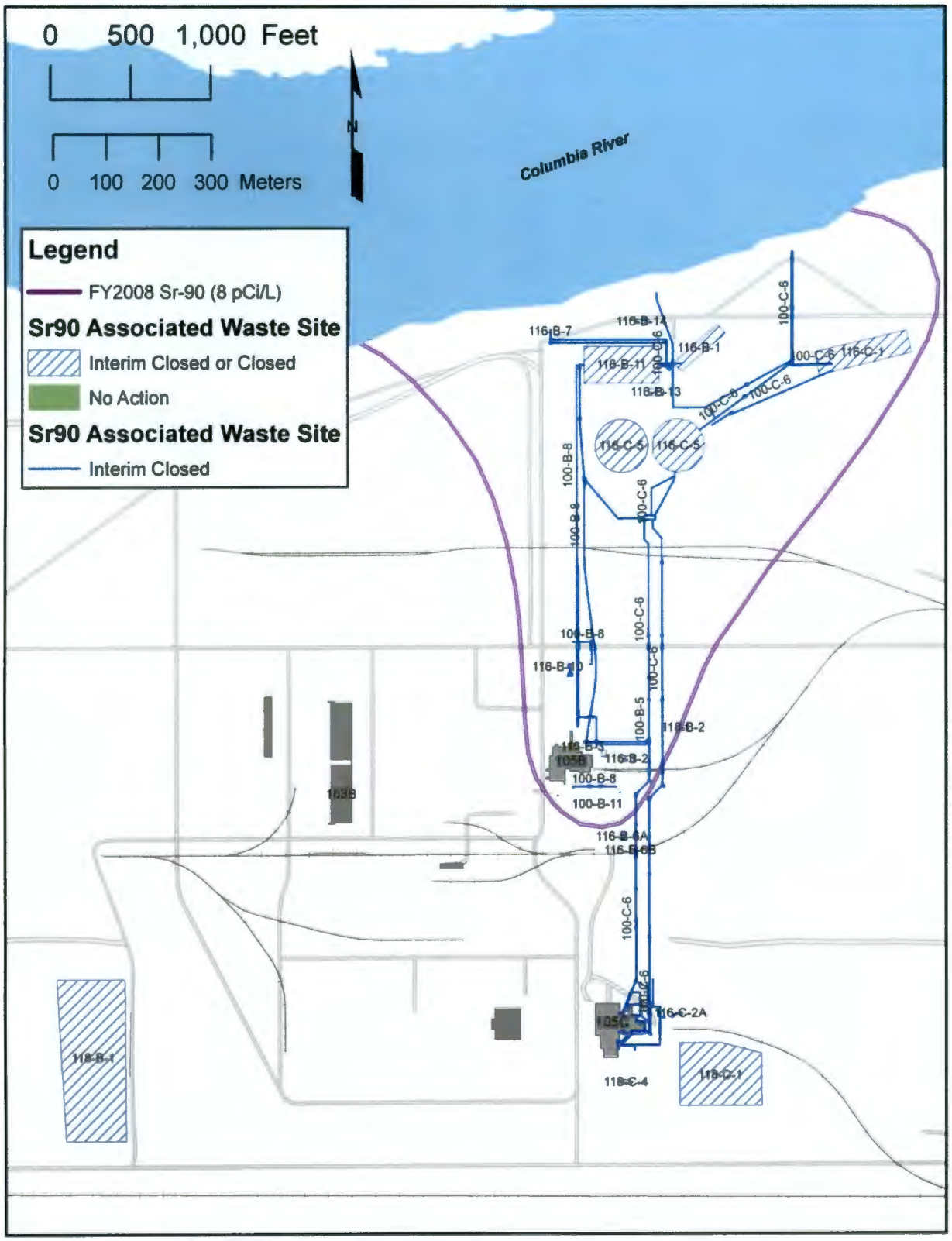


Figure 4-3. 100-BC Decision Unit Strontium-90 Related Waste Sites

4.3 Contaminant Distribution

This section summarizes the understanding of the nature and extent of contamination in the 100-BC Decision Unit.

4.3.1 Vadose Zone Contamination

The distribution of contaminants in the vadose zone beneath waste sites depends 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 the 100-BC Decision Unit 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 addition of water for dust suppression.

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 0) such as CrVI have migrated through the vadose zone and into the groundwater when the waste sites were operational. The available data indicate residual concentrations of CrVI remain in the vadose zone, however very little data are available to quantify total vadose zone quantities and distribution. Data are also not available to evaluate the extent of other mobile contaminants such as tritium and nitrate across the thickness of the vadose zone. Concentrations of less-mobile contaminants generally decrease with depth below the disposal structure.

Waste sites that received small amounts of dilute liquids are generally found to have soil contamination extending limited distances into the vadose zone beneath waste sites (i.e., burial ground, reactor structures, and some unplanned releases). Adverse impacts to groundwater from these sources are not expected where the vadose zone is substantially thick.

CrVI, Sr-90, and tritium have been identified as the main environmental threats in the 100-BC Decision Unit since groundwater contaminated with these constituents is discharging to the river (based on DOE/RL-2003-38). More than 60 target analytes are identified for soil waste sites. The complete list of target analytes is provided in the SAP (DOE/RL-2009-44).

The CSM for waste sites incorporates the following:

- <u>High-soil partitioning (distribution) coefficient (K_d) contaminants</u>: The highest soil contaminant concentrations are expected within and near the bottom of the waste site. Sufficiently high volumes of liquids discharged into a waste site can modestly expand the depth of contamination in the vadose zone. When little or no liquid effluents were discharged to a waste site, soil contamination is expected to remain within and only slightly below the waste site.

- <u>Low-soil partitioning (distribution) coefficient (K_d) contaminants</u>: The highest levels of soil contamination are expected to be found within the waste site, but may also continue at elevated levels through the vadose zone to groundwater, depending on the discharge volume and infiltration rate. Soil contaminant levels generally decrease with depth, but contamination can be found at higher levels in

lenses of fine materials. Mobility is relative to infiltration at the site. The current infiltration rate suggests impeded contaminant mobility. Limited data are available to evaluate contaminant distribution behavior for several contaminants including nitrate, tritium, and CrVI.

Contaminated soil at 96 waste sites has been removed or evaluated to meet the interim remedial action goals and objectives (two closed, 58 interim closed, 17 no action, and 19 not accepted; [Table 2-3]). Analytical data are needed to verify the vertical extent of contamination beyond the depth of remedial action. There is a lack of site data on mobile contaminants such as nitrate, tritium, and CrVI to assess the vertical extent of residual contamination.

Data Gap #2: Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites. Many facilities within the 100-BC Decision Unit have undergone deactivation, decommissioning, decontamination, and demolition (D4), and reactor buildings have been placed in 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.

- No contaminated soil remains in the remediated portion of a waste site. Modeling analysis suggests the residual contaminants remaining in the soil column are protective of the groundwater and the Columbia River. Soil samples have not been collected to the depth of the current water table to confirm this portion of the CSM.
- Little or no contaminant data has been collected at unremediated waste sites.

Data Gap #3: Vadose zone contaminant nature and extent needed to assess protection of groundwater around reactor structures. Details regarding the distribution of the primary contaminants within the 100-BC Decision Unit are provided as follows.

CrVI: More than 500 samples from the vadose zone have been analyzed for CrVI in the 100-BC Decision Unit. A majority of the samples have been collected from sites in the downstream process of the 105-B and 105-C Reactors. CrVI contamination was detected in soil samples near the 116-C-1 Trench, 116-C-5 Retention Basins, and 100-C-7 Water Treatment Facilities. In 2007, in the southern 100-B/C Area, CrVI was detected in vadose zone soil at the 100-C-7 Waste Site and may have reached groundwater. CrVI contamination was also detected at the 100-B-27 Waste Site, located in the northwest portion of the decision unit and is currently undergoing remediation.

Tritium: More than 175 samples from the vadose zone have been analyzed for tritium in the 100-BC Decision Unit. A majority of the samples have been collected around the 105-C Reactor, downgradient of the 105-B Reactor, and in the vicinity of the 116-C-5 Retention Basins, 116-C-1 Trench, and 118-B-1 Burial Ground. At the 118-B-1 Burial Ground, at approximately 17 m (56 ft) bgs, the maximum soil tritium concentration detected was 39,900 pCi/g in a sample collected from a temporary borehole.

Deeper in the vadose zone below this sample, concentrations declined by three orders of magnitude in the soil above the water table at 26 m (86 ft) bgs, where the concentration was 42 pCi/g.

Sr-90: More than 250 samples from the vadose zone have been analyzed for Sr-90 in the 100-BC Decision Unit. A majority of the samples have been collected around the 105-B and 105-C Reactors and

in the vicinity of the 116-B-11 Retention Basin, 116-B-1 Trench, 116-C-5 Retention Basins, 116-C-1 Trench, and 118-B-1 Burial Ground.

Data Gap #4: Unidentified waste sites (orphan/discovery sites) may exist in the decision unit.

Limited characterization has been performed 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 (Section 1.2.3).

4.3.2 Groundwater Contamination

Facilities and waste sites in the 100-B/C Area received or discharged chemicals and radionuclides from the 1940s to the 1960s. Previous groundwater investigations indicate contaminants have reached the groundwater from vadose zone sources at concentrations in excess of federal and/or DWS and aquatic standards—including CrVI, Sr-90, and tritium. In addition, contaminants such as aluminum, iron, and manganese exceed secondary DWSs.

The groundwater contaminants are generally found in the vicinity of and downgradient of the 105-B and 105-C Reactors and associated support infrastructure and the 118-B-1 Burial Ground.

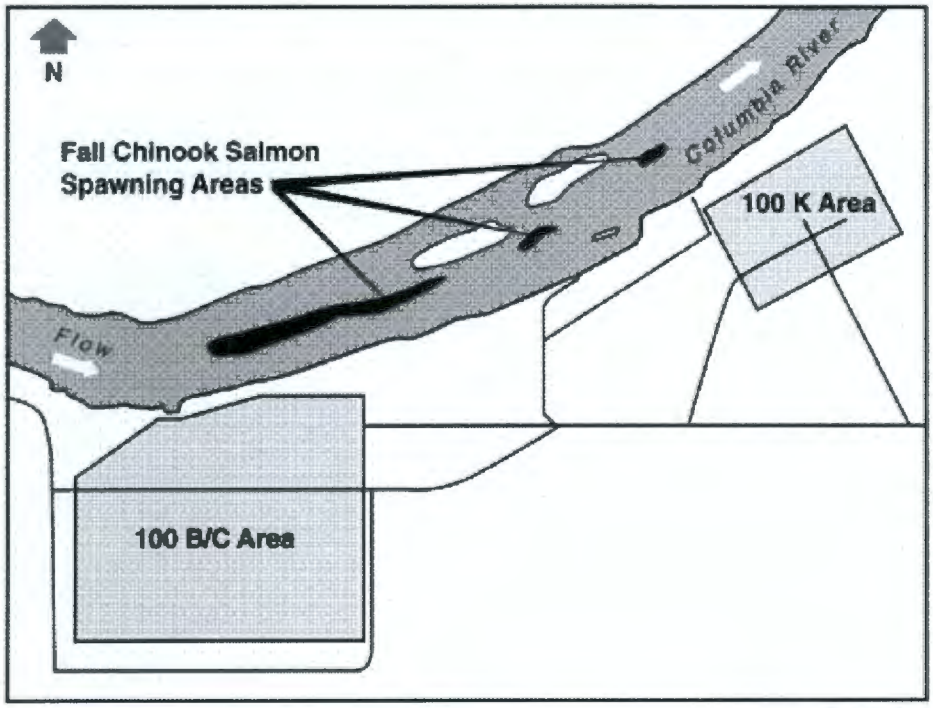
Data Gap #5: The nature and extent of contamination in the unconfined aquifer above cleanup standards has not been defined in select areas.

4.3.2.1 Hexavalent Chromium

Similar to other 100 Area sites, CrVI contamination is of concern to salmon and other aquatic life. Fall Chinook salmon spawning areas have been recorded downstream and toward the center of the river channel, but not adjacent to the 100-BC Decision Unit (Figure 4-4). Shoreline areas provide rearing habitat for young salmon and steelhead, as well as for many of the other species of fish in the river (DOE/RL-2005-40).

CrVI concentrations in groundwater do not exceed the federal DWS for total chromium of 100 µg/L in groundwater (which includes both trivalent and hexavalent chromium), but do exceed the Washington state Model Toxics Control Act – Cleanup (WAC 173-340) Method B standard of 48 µg/L and the 20 µg/L CrVI concentration considered protective of aquatic receptors at the Hanford Site. The highest concentrations of CrVI detected in monitoring wells during FY2007 and 2008 were 64 µg/L (unfiltered; January 2007) and 55 µg/L (filtered; February 2008) in 199-B3-47 (see 100-BC Decision Unit Map, Appendix B for well locations), downgradient of the 116-B-11 Retention Basin.

At other 100 Area locations, the chromium level protective of the river has been set at 20 µg/L or less at each compliance well to achieve the protective level of 10 µg/L at the river using the preliminary dilution factor of 1:1 (EPA/AMD/R10-00/122, *EPA Superfund Record of Decision Amendment: Hanford 100-Area [USDOE], EPA ID: WA3890090076, OU 02, Benton County, WA, 10/24/1999*). This aquatic cleanup level of 20 µg/L for CrVI was exceeded in monitoring wells and aquifer tubes in the eastern half of the 100-BC Decision Unit. Figure 4-5 illustrates average concentrations for various monitoring locations in the 100-BC Decision Unit aquifer tubes and wells. Chromium was not detected in deep monitoring well 199-B2-12, located adjacent to 199-B3-47.



SOURCE: DOE/RL-2005-40, *100-BC Pilot Project Risk Assessment Report*

Figure 4-4. 100-BC Decision Unit Location with Respect to Mapped Salmon Redds

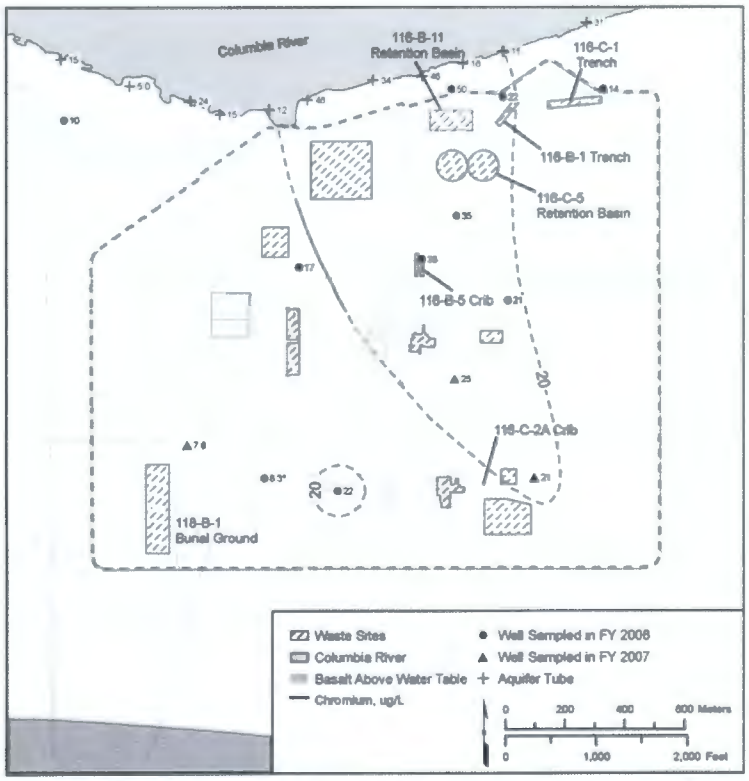
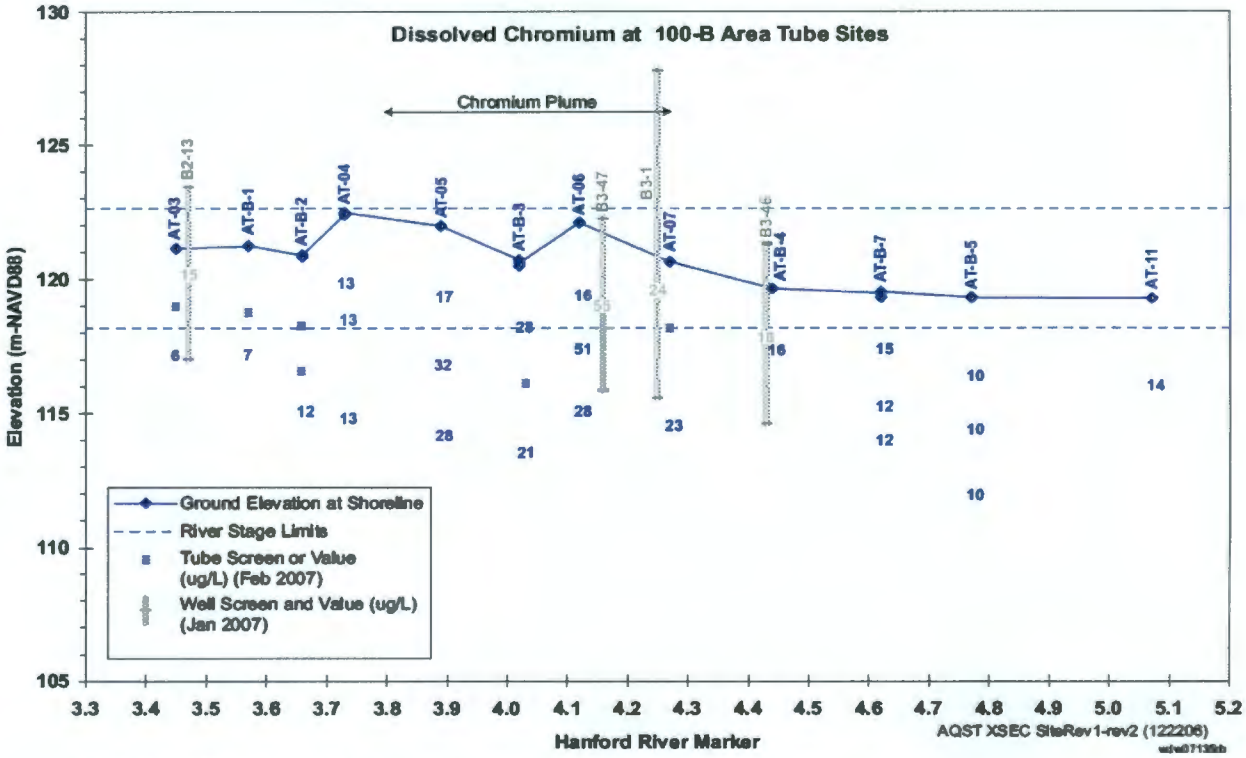


Figure 4-5. FY2008 Average Hexavalent Chromium Concentrations in 100-BC Area, Top of Unconfined Aquifer

Figure 4-6 illustrates chromium concentrations with depth in the aquifer for the 100-BC Decision Unit aquifer tubes and nearby wells. Highest concentrations in FY2007 were in mid-depth tubes, with a maximum of 51 µg/L in AT-06-M (DOE/RL-2008-05). The plume area for CrVI above the 20 µg/L CrVI concentration considered protective of aquatic receptors is approximately estimated 0.85 km^2 (0.328 mi^2) (DOE/RL-2008-05).



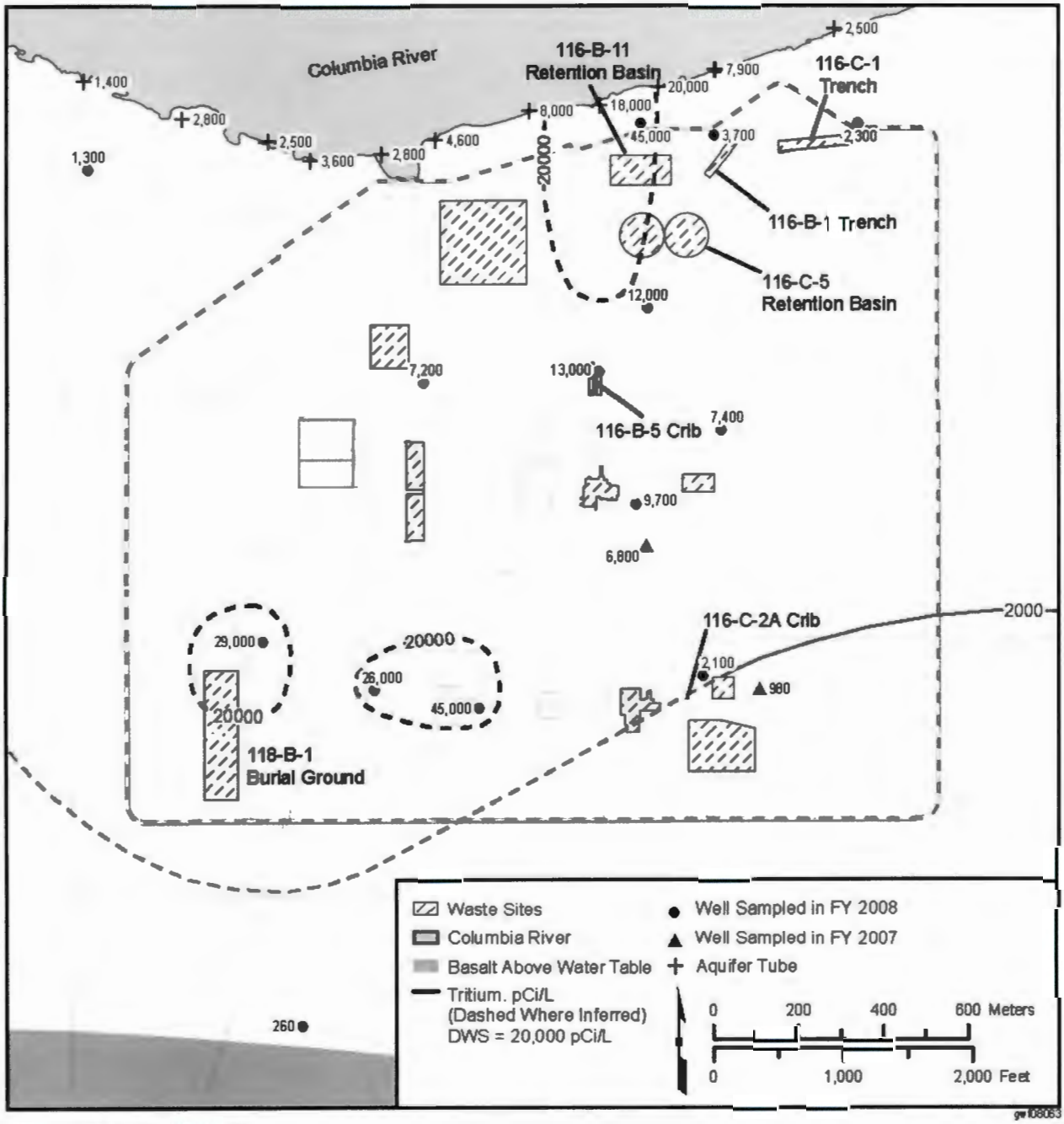
Modified from SGW-35028

Figure 4-6. Sample Elevations and Chromium Concentrations in Wells and Aquifer Tubes in 100-BC Decision Unit

Tritium: Tritium concentrations have varied widely in some wells (e.g., 199-B5-2) in recent years. Tritium has impacted the upper portion of the unconfined aquifer at concentrations that exceed the 20,000 pCi/L DWS. Tritium above 20,000 pCi/L covers an estimated 0.22 km^2 (0.085 mi^2) (DOE/RL-2008-66) in the 100-BC Decision Unit. The tritium concentrations in several wells exceed the DWS and are observed as three separate plumes (Figures 4-7). The two plumes on the southwest portion of the 100-BC Area are interpreted as two plumes for the following reasons. Early tritium data from well 199-B8-7 was below the DWS, while concentrations of tritium in wells 199-B8-6 and 199-B8-8 were above the DWS. In addition, assuming the source for the western-most plume is the 116-B-1 Burial Ground, inferred groundwater flow directions in the area do not suggest eastward movement of the plume toward wells 199-B8-7 and 199-B8-8.

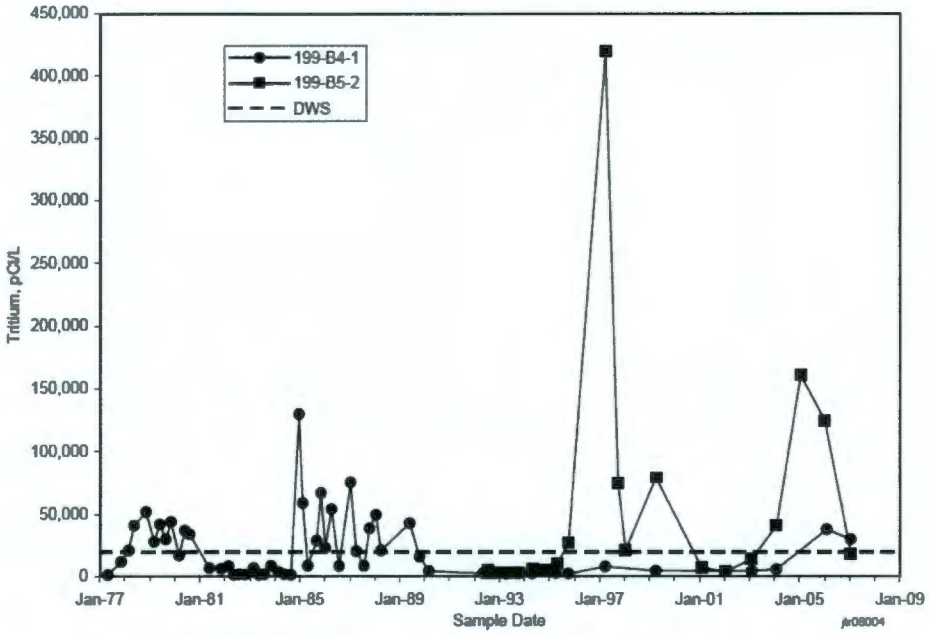
In one plume, tritium concentrations exceeded the DWS (FY2008) from near the 116-B-11 Retention Basin to the Columbia River shoreline. Although tritium spikes have been observed in downgradient wells 199-B4-1 and 199-B5-2 in recent years, overall the FY2008 concentrations were less than their peak values. Fluctuations and spikes in tritium concentrations have not been sufficiently explained (Figure 4-8).Tritium within this plume has reached the river, as evidenced by detection in aquifer tubes. In FY2008, tube C6231 had the highest concentration of 20,000 pCi/L in an aquifer tube. Concentrations

have declined in the past 10 years in nearby tube AT-06-D. In 1998, the concentration in this aquifer tube was 66,000 pCi/L and in FY2008 18,000 pCi/L.



Source: DOE/RL-2008-66

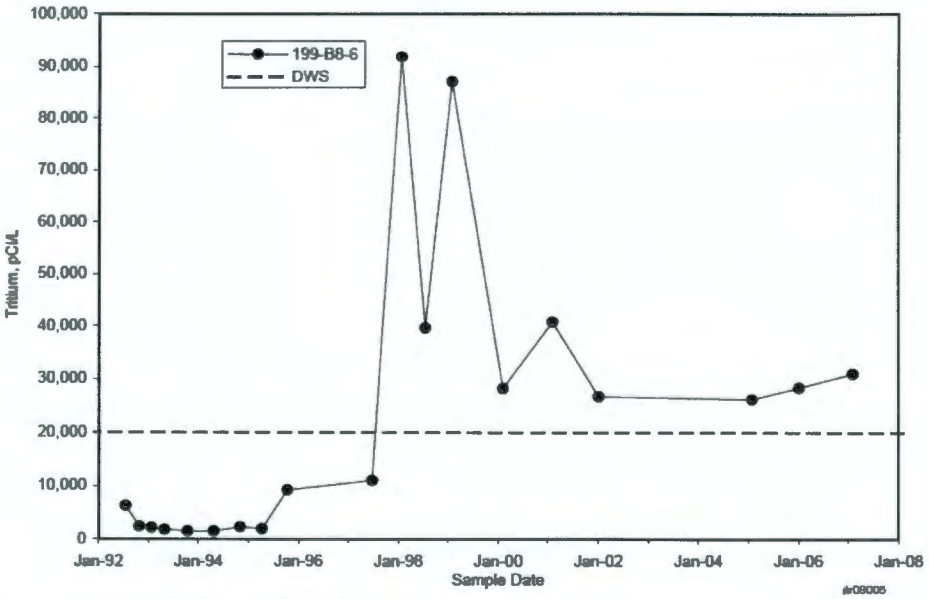
Figure 4-7. Average Tritium Concentrations in 100-BC Decision Unit, Upper Part of Unconfined Aquifer



Source: DOE/RL-2008-01

Figure 4-8. Tritium Concentrations Downgradient of the 116-B-5 Crib

Concentrations of tritium exceeding the DWS are also observed near the 118-B-1 Burial Ground and in a third plume to the east approximately halfway to the 105-C Reactor (Figure 4-7) near the 100-C-7 Waste Site. The plume around the former 118-B-1 Burial Ground in the southwestern portion of the 100-BC Decision Unit is evaluated from groundwater data collected from the only nearby well 199-B8-6 (Figure 4-9). The average FY2008 concentration in well 199-B8-6 was 29,000 pCi/L and was similar to that of the previous 3 years. The plume near the 100-C-7 site is monitored by two new wells, 199-B8-7 and 199-B8-8.



Source: DOE/RL-2008-01

Figure 4-9. Tritium Concentrations Downgradient of the 118-B-1 Burial Ground

Sr-90: A plume of Sr-90 extends from the central 100-BC Decision Unit north toward the river. The shape of the plume has not changed substantially in more than 10 years and covers approximately 0.63 km^2 (0.243 mi^2) at concentrations above the 8 pCi/L DWS (DOE/RL-2008-05). Based on groundwater concentrations from 100-BC Area aquifer tubes completed at different depths monitoring groundwater within the unconfined aquifer, Sr-90 above the DWS appears to be limited to the upper portion of the unconfined aquifer.

In comparison to the DWS of 8 pCi/L, the highest concentrations in FY2007 were 37 pCi/L in well 199-B3-47 near the 116-B-11 Retention Basin and 38 pCi/L in well 199-B3-1 near the 116-C-1 Trench. These concentrations were nearly five times the DWS and are similar to those reported for FY2006. Long-term concentration trends appear to be steady or declining.

The highest Sr-90 concentrations detected in aquifer tubes were from shallow tubes AT-05-S with 26 pCi/L and AT-06-S with 45 pCi/L.

Nitrate: The *100-BC Pilot Project Risk Assessment Report* (DOE/RL-2005-40) identified nitrate as a COC based on its exceedance of the 45 milligrams per liter (mg/L) DWS in well 199-B3-47 in 1998 and 1999. Concentrations have since decreased over time, but nitrate in groundwater continues to be routinely monitored as a supporting parameter (DOE/RL-2008-05).

The highest nitrate concentration in FY2007 was 39 mg/L in well 199-B3-47 (for well location, see Figure 2-1), observed at a 5-year increasing trend. Nitrate was detected at an elevated concentration of 28.4 mg/L in nearby aquifer tube AT-06-M (for aquifer tube location, see Figure 2-1) in 2007. Nitrate was detected at a concentration of 24.7 mg/L in 2007 in well 699-72-73 (for well location, see Figure 2-1), located between the 100-BC Decision Unit and the 100-K Area. Elevated nitrate concentrations of 26.6 mg/L and 25.2 mg/L were detected in aquifer tubes AT-14-D and AT-B-5-D (for aquifer tube locations, see Appendix B, 100-BC Base Map), respectively.

4.3.3 Significant Waste Release Events Causing Environmental Contamination

The primary activities associated with environmental contamination in the 100-BC Decision Unit were the production and use of treated Columbia River water to cool the reactors during operations. Over the operational lifetime of the 105-B and 105-C Reactors, approximately 5 trillion L (about 1.3 trillion gal.) of coolant were produced and passed through these reactors. As cooling water was produced and used, intentional effluent disposal and unintentional discharges of process chemicals introduced contaminants directly into the soil column underlying the production facilities and into the Columbia River.

4.3.4 Reactor Processes

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 constituent in this water was sodium dichromate, added for purposes of minimizing process tube corrosion. More than 7,270 metric tons (7.27E+06 kg) of sodium dichromate were estimated to have been used between 1944 and 1969. The great majority of this mass was used in the manufacture of reactor coolant.

Other contaminants picked up or carried during passage of cooling water through the reactors included activation products in the water (e.g., Cr-51), activation products from targets or reactor components (e.g., tritium, and Co-60), and products released through breached fuel cladding (e.g., Cs-137, Sr-90, uranium, and plutonium isotopes).

The processes and facilities used to generate, use, and discharge reactor coolant after use are essentially the same for both reactors, described in DOE/RL-91-07, and summarized as follows.

To produce reactor coolant for the 105-B and 105-C Reactors, Columbia River water was pumped to the 183-B/C facilities to remove impurities by conventional physical and chemical water treatment processes (Figure 2-14 and Figure 4-10) and then pumped to the 190-B/C Facility where sodium dichromate was added to the treated water. Available documentation does not describe the method of sodium dichromate addition exactly over time, but the process solution mixed with the cooling water was derived from either solid sodium dichromate or highly concentrated stock solutions.

It is unclear when the routine use of concentrated liquid sodium dichromate solution to make process solutions was implemented at the 100-B/C Area, but the change in process was probably introduced as part of the Project CG-558 upgrades at the 105-B Reactor around 1960 (WCH-CCN 141284) and possibly earlier, around 1953 at the 05-C Reactor (HW-27270; WCH CCN 141284). Once these solutions were generated, they were pumped through the 190-B/C Water Treatment Facilities to their respective reactors and then to the outlet piping. Figure 4-5 illustrates FY2007 CrVI concentrations in groundwater.

Initially, a sodium dichromate concentration of about 1.8 to 2 mg/L (about 700 µg/L to 800 µg/L of CrVI) was used in coolant water. Over time, the starting chromium concentrations at the 105-C Reactor were reduced to 350 µg/L (half plant, 1960; full plant, 1964) and 175 µg/L (full plant, late 1967); however, no corresponding reduction in dichromate concentration/usage is noted at the 105-B Reactor (DUN-4847). Conversely, the volume of flow through the reactors was increased over time (DeNeal, 1970; DUN-6888). From these data, an approximate total coolant volume of 5.01E+12 L (1.33E+12 gal.) passed through the reactors containing about 2.78E+6 kg (6.12E+6 lb) of CrVI (Table 4-5), assuming the lower concentration threshold of 700 µg/L.

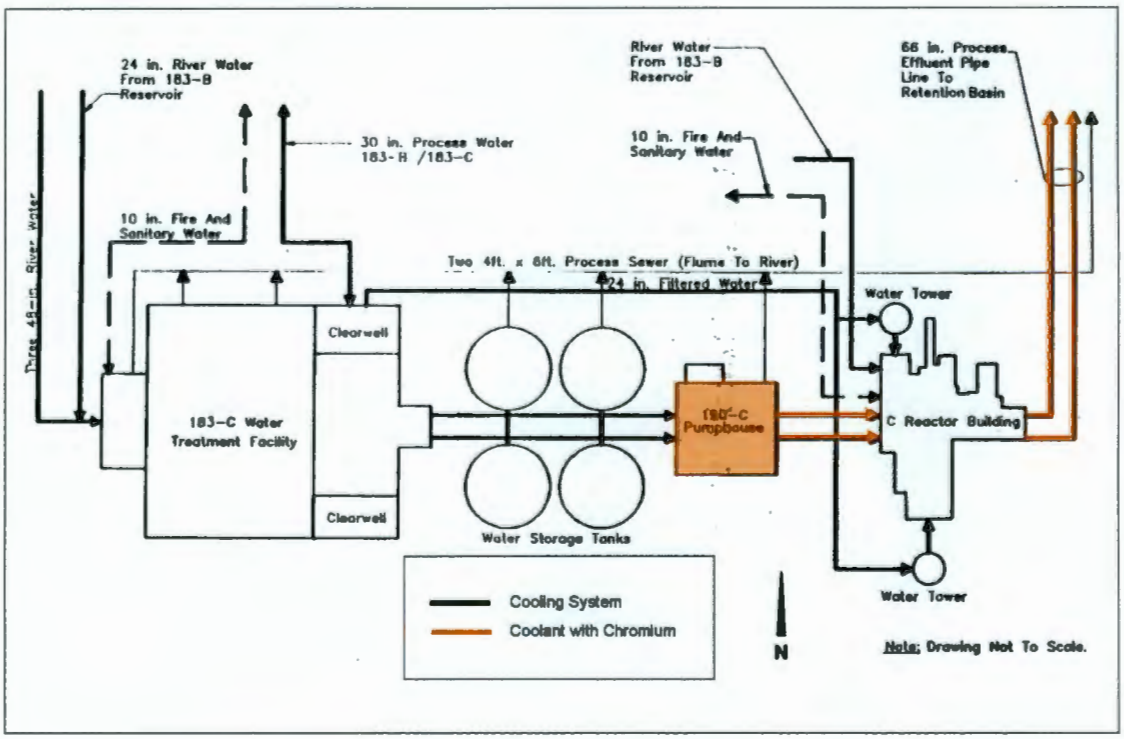


Figure 4-10. Production Facilities at 105-C for Reactor Coolant

Table 4-5. Chromium Mass Discharge Estimates Based on 105-B and 105-C Reactor Coolant Throughput

Year	[a]Estimated Yearly Throughput (L/yr)			[b,c]Chromium Inventory (kg)	Calculated dry Sodium dichromate (kg/yr)
	105-B Reactor	105-C Reactor	Coolant Volume Total		
1944	2.27E+10	0	2.27E+10	1.59E+04	4.15E+04
1945	9.08E+10	0	9.08E+10	6.36E+04	1.66E+05
1946	9.08E+10	0	9.08E+10	6.36E+04	1.66E+05
1947	0	0	0.00E+00	0.00E+00	0.00E+00
1948	4.54E+10	0	4.54E+10	3.18E+04	8.30E+04
1949	9.08E+10	0	9.08E+10	6.36E+04	1.66E+05
1950	9.08E+10	0	9.08E+10	6.36E+04	1.66E+05
1951	9.08E+10	0	9.08E+10	6.36E+04	1.66E+05
1952	9.08E+10	1.17E+10	1.03E+11	7.18E+04	1.87E+05
1953	9.08E+10	1.41E+11	2.32E+11	1.62E+05	4.24E+05
1954	9.08E+10	1.41E+11	2.32E+11	1.62E+05	4.24E+05
1955	9.08E+10	1.41E+11	2.32E+11	1.62E+05	4.24E+05
1956	9.08E+10	1.41E+11	2.32E+11	1.62E+05	4.24E+05
1957	1.4E+11	1.41E+11	2.81E+11	1.97E+05	5.14E+05
1958	1.4E+11	1.41E+11	2.81E+11	1.97E+05	5.14E+05
1959	1.4E+11	1.41E+11	2.81E+11	1.97E+05	5.14E+05
1960	1.4E+11	1.59E+11	2.99E+11	1.56E+05	4.09E+05
1961	1.4E+11	1.59E+11	2.99E+11	1.56E+05	4.09E+05
1962	1.4E+11	1.59E+11	2.99E+11	1.56E+05	4.09E+05
1963	1.4E+11	1.59E+11	2.99E+11	1.56E+05	4.09E+05
1964	1.4E+11	1.59E+11	2.99E+11	1.56E+05	4.09E+05
1965	1.4E+11	1.59E+11	2.99E+11	1.04E+05	2.70E+05
1966	1.4E+11	1.59E+11	2.99E+11	1.04E+05	2.70E+05
1967	1.4E+11	1.59E+11	2.99E+11	1.04E+05	2.70E+05
1968	1.17E+10	1.59E+11	1.71E+11	1.38E+04	3.59E+04
1969	0	5.31E+10	5.31E+10	9.29E+02	2.43E+03
Totals			**5.01E+12**	**2.78E+06**	**7.27E+06**

a. Yearly throughput taken from DeNeal (1965)

b. Inventory estimate is based on an threshold concentration of 700 µg/L (7E-7 kg/L) at the 105-B Reactor

c. In 1960, 105-C Reactor reduced concentration to 350 µg/L and 175 µg/L in 1968 (DUN-4847).

kg = kilogram
L = liter
µg = microgram
yr = year

Radioactively contaminated coolant was discharged to the 116-B-1 Overflow Trench between 1946 and 1955 and to the 116-C-1 Trench between 1952 and 1968. Stenner et al. (1988) estimated total coolant volume estimates of 6E+07 L (2E+7 gal.) and 1E+08 L (3E+07 gal.) containing 60 kg (132 lb) and 100 kg (220 lb) of CrVI at 116-B-1 and 116-C-1, respectively. These estimates assume a CrVI concentration of about 350 µg/L—a lower concentration level not reached during operations at the 105-C Reactor until about 1960. These estimates are therefore probably somewhat low, but by no more than a factor of 2.

A significant loss of concentrated CrVI occurred during operations in 1966, a transfer pump was left on overnight and 53,980 L (14,280 gallons) of concentrated sodium dichromate solution flooded a sump, flowing into the process sewer and to the river outfall from there (DUN-1295, *Douglas United Nuclear, Inc. Monthly Report, September, 1966*). The entire contamination field resulting from this event is uncertain, but all evidence is that the flooding occurred at 183-C and went out through the 100-C-9:1 Sewer (Figure 2-14). Residue from this event is considered a very likely potential source for soil contamination observed at 100-C-7 (the pumphouse end). However, much of it may have flowed out to the river.

Other sources of chromium discharges were leaks or overflows in and around the outfall structure, and releases from small liquid discharge facilities, piping that carried reactor coolant, and some solid wastes (e.g., sludges).

- 100-C-7 (183-C Pumphouse Area) – Elevated CrVI is present in deep soil beneath the pumphouse, and the remaining concrete foundation is heavily stained with dichromate.
- 100-C-7:1 (183-C Headhouse Area) – Elevated CrVI is present in deep soil north of the headhouse. Several potential sources are located here, but the most likely candidates are either a leak/seal issue on the 100-B-28 Dichromate Transfer Pipeline and/or general spillage in the railcar unloading area.
- 100-B-27 – This plume extends to groundwater west of 126-B-3. A few potential avenues for this contamination are associated with water treatment process losses. Contaminants observed in and around this location could be the result of uncontrolled solid waste disposal during operations. Remediation for this waste site is currently in progress.
- 185/190-B Facility – During demolition "extensive" dichromate staining was observed within parts of the facility.

Radioactive coolant discharge also occurred at two Pluto cribs near the reactors. The 116-B-3 Crib east of the 105-B Reactor received waste briefly from 1951 to 1952, while the 116-C-2 Facility east of the 105-C Reactor received waste between 1952 and 1968. An estimated 4E+03 L (1E+3 gallons) containing 4E-03 kg (8E-3 lb) of chromium were discharged to 116-B-3 and 7.5E+06 L (2.0E+6 gal.) containing 990 kg (2,180 lb) of chromium were discharged to 116-C-2. This relatively long operating time for the 116-C-2 Pluto Crib is considered to have affected the nature and extent of other contaminants (e.g., Sr-90) at the waste site.

Finally, decontamination fluids used to clean radioactively contaminated equipment and containing CrVI in the form of chromic acid were discharged at several facilities near the reactors including the 116-B-4 French drain and the 116-B-6 Crib near the 105-B Reactor and the 116-C-2 Pluto Crib near the 105-C Reactor. Reported discharges at the 105-B Reactor were 3.1E+05 L (8.2E+4 gal.) containing 1,100 kg (2,420 lb) of chromium. The quantity of decontamination fluids discharged at the 116-C-2 Pluto Crib is not known, however the relatively higher concentrations of CrVI and entrainment of radioactive materials in these wastes make this waste stream important to understand for this site.

4.4 Contaminant Fate and Transport

This section discusses the fate and transport of contaminants in the vadose zone and groundwater within the 100-BC Decision Unit. Contaminants remaining in the vadose zone may migrate to groundwater and ultimately to the Columbia River.

4.4.1 Groundwater Flow

Both natural and anthropogenic hydrologic processes have influenced the distribution of contaminants in the subsurface, groundwater flow. Natural processes affecting contaminant migration continue (e.g., changing river stage), while the effects of local anthropogenic alterations to groundwater flow have diminished over time with the cessation of reactor operations (e.g., no more coolant disposal).

Groundwater flow and elevations within the 100-BC Decision Unit are influenced by fluctuating river stage. These changes are largely controlled by operation of the upgradient Priest River Dam. During the spring, the river surface rises because snowmelt requires more flow through the dam. The surface water rise displaces groundwater inland and causes water table rises throughout the 100-BC Decision Unit. 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.

In the 100-B/C Area, the primary historical local influences on groundwater flow patterns were chronic unintentional losses of fluids from retention basins and intentional discharges to cribs and trenches. The facilities that released large quantities of fluid, generally over long time periods, are summarized in Table 4-1. The effect of these long-term discharges was to create groundwater mounds under the discharge facility. In the 100-B/C Area, historical groundwater mounding that developed was quite extensive. Figure 4-11 provides locations and water table elevations over time for three groundwater monitoring wells with long-term records.

During operations, the large volume of liquid discharged was sufficient to create water mounds 6 to 9 m (20 to 30 ft) above the nominal water table directly under the retention basins and other liquid waste disposal facilities at the 100-B/C Area (PNNL-14702 R1). Some groundwater contamination may have been directed inland because of the influence of the mounds, only to resume moving toward the river, once groundwater mounds dissipated after termination of liquid waste discharge to the subsurface. Water mounding from leakage at these facilities during operations was considered the greatest factor in the widespread observation of groundwater chromium, Sr-90, and tritium contamination at the 100-BC Decision Unit in the subsurface.

All three wells show the effects of groundwater mounding, particularly at well 699-65-72 nearly 3.2 km (2 mi) inland from the retention basins, where the record is most complete and seasonal variations from river stages provide little interference. At this well, the water table rose from the first measurement in February 1950 until it peaked in the spring of 1968.

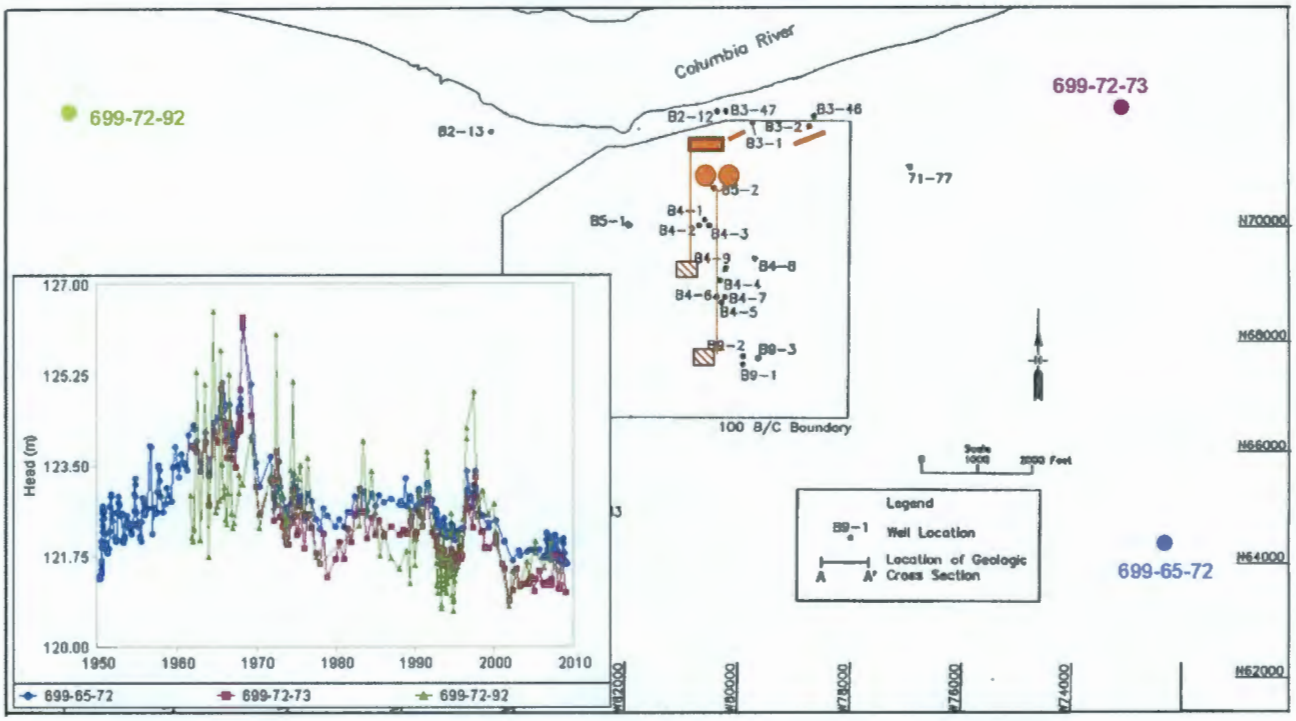
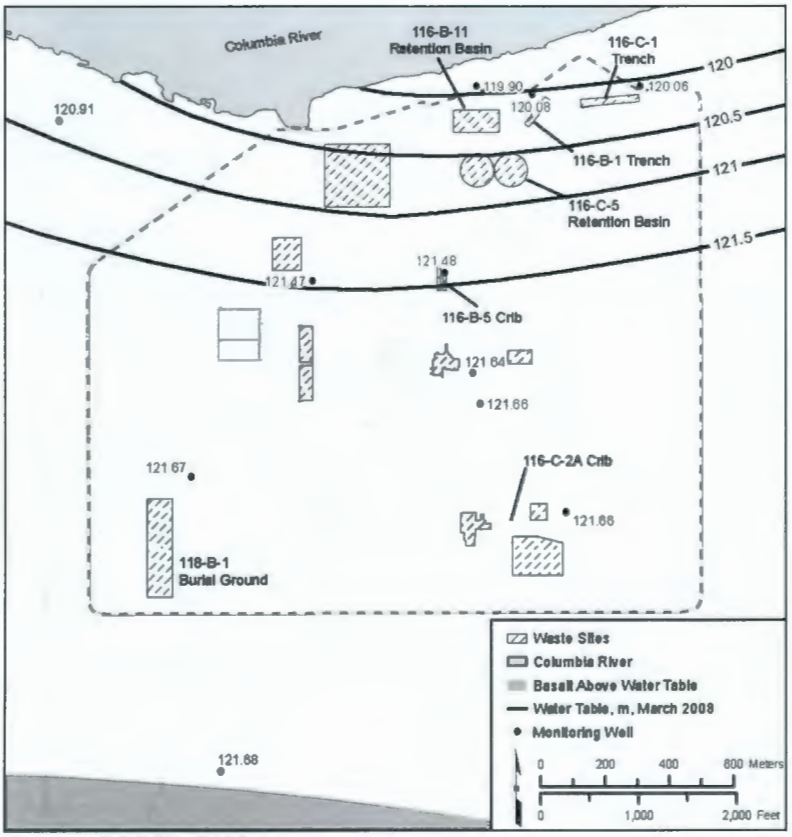


Figure 4-11. History of Water Table Elevations in the 100-B/C Area During Reactor Operations to the Present

Total elevation increase was about 5 m (16 ft) during this time. The timing of this trend coincides almost precisely with that of combined discharges of reactor coolant to the subsurface from leaking effluent pipes/retention basins and intentional discharges to the overflow trenches. The water elevation histories also show a relatively rapid reduction of the groundwater mound after operations ended.

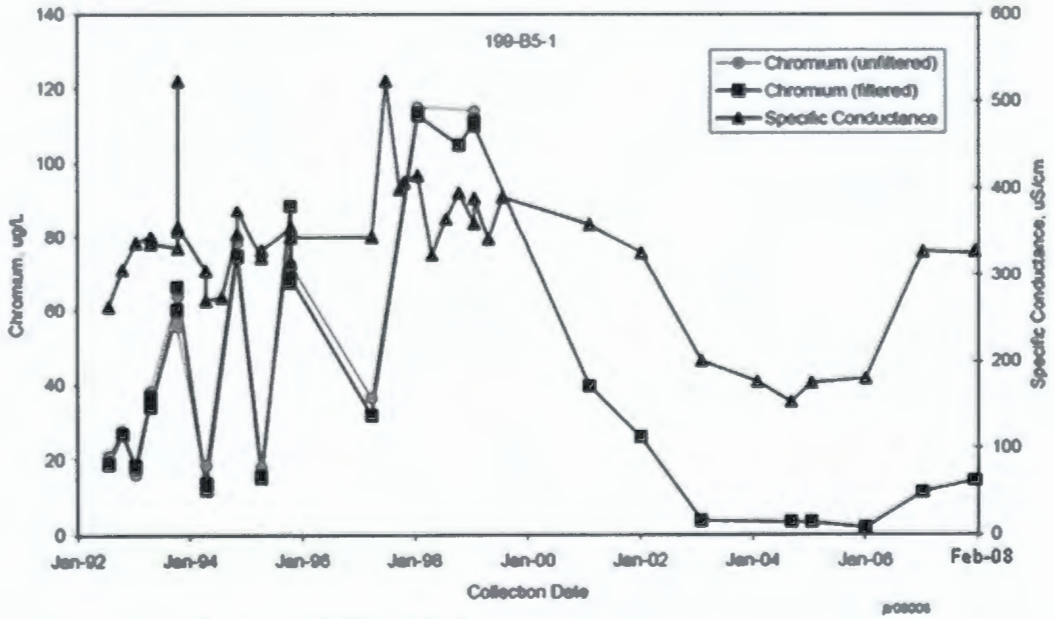
Once discharges ceased, the mound dissipated in the Hanford formation with preferential drainage into the Columbia River under the influence of the natural flow direction. Thus, the current conditions show essentially no remnant effects on groundwater flow resulting from the long groundwater mounding process that ended in 1968 (Figure 4-12).

Local effects of water leakage have also been observed within the 100-BC Decision Unit. Increases in CrVI concentrations after the repair of the leaking fire hydrant line close to well 199-B5-1 in 2006 (for well location see Figure 4-11) were observed after several years of dilution to 11 µg/L (January 2007) (Figure 4-13). Specific conductance measurements returned to pre-leak values.



Source: DOE/RL-2008-01

Figure 4-12. 100-BC Decision Unit Area Water Table 2008



Source: modified from DOE/RL-2008-01

Figure 4-13. Chromium Concentration and Specific Conductance in Well 199-B5-1, Northwest 100-BC Decision Unit

4.4.2 Current Field Characterization Summary

On April 5, 2005, a pothole was excavated at the bottom of the 100-C-7:1 excavation. The pothole had a starting elevation of 4.6 m (15 ft) below surrounding grade and was excavated another 5.5 m (18 ft) for a total depth of 10 m (33 ft) bgs. Samples were collected to evaluate the vertical distribution of sodium dichromate contamination. Residual soil contamination was present at 10 m (33 ft) with CrVI at 1,620 mg/kg. Discolored soil was observed in the sidewalls of the pothole.

In order to further evaluate the vertical distribution of contamination at this site, a characterization borehole (C4947 [for borehole location, see Figure 2-14]) was drilled in August 2005 to collect soil and groundwater samples. The borehole was to be drilled in the location of the pothole; however, after placement of gravels to stabilize the site for mobilization of the drill rig, the borehole was placed approximately 10 m (33 ft) northeast of the actual pothole. No groundwater monitoring wells are located around the 183-C Water Treatment Facilities; therefore, a groundwater sample was collected prior to abandonment of the borehole to assist in future groundwater characterization.

In July 2007, eight characterization test pits (TP-1 through TP-8) were excavated at the bottom of the 100-C-7:1 Excavation, and one borehole, C5671 (BH-1, and well 199-B8-7, Appendix B, BC Reactor Area Map), was drilled in the location of the original pothole. In August 2007, a borehole, C5672 (BH-2, and well 199-B8-8, Appendix B, Reactor Area Map), was drilled at the 100-C-7 (183-C Pumphouse) waste site. Samples were collected at various depths and analyzed for inductively coupled plasma (ICP) metals (e.g., total chromium), CrVI, and pH. Toxicity Characteristic Leaching Procedure (TCLP) analyses were requested based on total chromium results. Characterization of TP-5 had the maximum CrVI (concentration at 1,970 mg/kg). These results were from the 1 m (3 ft) depth of TP-5 (approximately 5.6 m [18 ft] bgs). Note that borehole C5672 had a starting elevation matching the surrounding grade. The pothole, test pits, and boreholes C4947 and C5671 had a starting elevation of 4.6 m (15 ft) below the surrounding grade, due to the previous excavation activities performed at the 100-C-7:1 Site.

Current groundwater monitoring in the 100-BC-5 groundwater interest area includes integrated CERCLA (1980) and *Atomic Energy Act of 1954* (AEA) monitoring. Twenty-five wells within the 100-BC Decision Unit are scheduled for quarterly to biennial sampling. Fourteen aquifer tube sites and two seeps are scheduled for annual sampling. Nine new aquifer tubes were installed and sampled in FY2008 and are scheduled for annual sampling (SGW-36398, *Installation and Sampling Analysis Instructions for Fiscal Year 2008 Aquifer Tubes*). In FY2008, groundwater sampling activities continue to the show the presence of CrVI, Sr-90, and tritium above groundwater cleanup levels. Concentrations of these contaminants detected in groundwater do not suggest a high concentration residual source in the vadose zone or aquifer.

4.5 Contaminant Specific Conceptual Site Model Description

The following discussion postulates the evolution of CrVI, Sr-90, and tritium distribution in the subsurface with emphasis on the hydrologic system characteristics and processes controlling contaminant distribution.

4.5.1 Hexavalent Chromium

The great majority of CrVI was discharged into the surrounding environment as a dissolved species in various liquids. The historical records information described in a previous section show CrVI was released into the environment primarily as a dissolved species in two types of solutions: stock solutions used to make reactor coolant and reactor coolant itself. The differences in solution chemistry, associated production facilities, and discharge locations have had a substantial effect on current chromium distribution in the subsurface.

In the CSM initially developed for 100-BC-5 OU, an estimated volume of 42,500 m^3/day (1,500,000 ft^3/day) of spent coolant was estimated to have infiltrated into the soil column during operations at 116-B-11 and the other nearby high-volume locations receiving spent cooling water (both waste sites and pipelines). Sodium dichromate that was used to treat the cooling water dissociated to create a concentration range between 700 µg/L to 800 µg/L of CrVI. At this leakage volume and the lower concentration threshold, it is estimated that approximately 30 kg /day (66 lbs/day) per day of CrVI was released to the soil column, migrated downward, and reached groundwater (BH1-00917). This value represents a conventionally accepted order of magnitude estimate.

The total amount of CrVI used during production is estimated to be 2,78 million kg (6.13 million lb) (Table 4-5), however, this quantity includes both mass discharged to the river as well as mass remaining in the soil and groundwater. Based on reactor operations and liquid discharge history, it is estimated that a large portion of the mass discharged to the river.

After operations ceased and there was no longer the large-scale infiltration from the effluent discharges, the groundwater mound dissipated. As the groundwater mound diminished, inland migration of chromium also diminished. By the mid 1970s, the natural groundwater gradient was essentially reestablished with the seasonal impacts of high and low river stage controlling groundwater flow, but no long-term trend with regard to CrVI movement is observed. This behavior is indicated from comparing chromium (total/hexavalent) concentrations in monitoring wells from 1992 (DOE/RL-90-08) to 2008 (DOE/RL-2008-66) as they have moved up and down within a narrow concentration interval during that time (e.g., 199-B5-1. 199-B-4-1, and 199-B3-1 [for well locations, see Figure 2-14). At this point, CrVI migration began to reverse and move relatively slowly toward the Columbia River.

The rapid formation of the groundwater mound shortly after discharges began suggests that CrVI, and other mobile contaminants, migrated quickly through the vadose zone into the unconfined aquifer. The large quantities of coolant discharged changed the local groundwater gradient direction and relatively quick transport through the vadose zone occurred. Some portion of the source term discharged into the Columbia River and is no longer present in the subsurface. However, evidence of substantial infiltration along the river shore and farther inland indicates a widely dispersed contaminant source in the subsurface.

This remainder of the source of CrVI was pushed inland by the growing groundwater mound. Well data from 699-65-72 (for well location, see Figure 2-14) suggests the hydraulic effects from the mound extended as much as 3.2 km (2 mi) inland and the highly soluble CrVI would have been present throughout the impacted area, although at concentration levels less than 700 µg/L, the threshold concentration assumed in the early reactor coolant. At the outer edges of the groundwater mound, it is postulated that dispersion from mixing with groundwater would have limited maximum concentrations to smaller values (e.g., less than 100 µg/L CrVI).

Unlike the CrVI contamination observed in groundwater at the 100-D Area, the 100-B/C Area does not have a substantial concentrated groundwater plume. There are known releases of concentrated sodium dichromate to the soil at 100-BC (Section 4.3.4), but these releases do not appear to have yet substantially affected groundwater. At the 100-BC Decision Unit, for example, CrVI concentrations up to 1,620 mg/kg were detected soil samples from a borehole drilled to groundwater beneath the 100-C-7 Waste Site to a depth of 10 m (33 ft). Concentrations from 10 m (34 ft) bgs to groundwater generally decreased to a concentration of 2.9 mg/kg just above the water table. Groundwater concentrations in this area have been detected up to 49 µg/L in a nearby well (199-B8-8 [for well location, see Appendix B, BC Reactor Area Map]). CrVI was detected at another waste site, 100-B-27 sodium dichromate spill, located in the northwestern 100-B/C Area, (WCH-225, *Sampling and Analysis Instruction for Evaluation of Residual Hexavalent Chromium Contamination in the Subsurface Soil at 100-B-27*).

The historical record for the C Reactor indicates sodium dichromate use was converted to liquid dichromate addition quickly and does not appear to have the same evidence of handling difficulties as 100-D Area for much the same reason; newer equipment and maintenance upgrades to the water treatment plant.

Delivery of the 70 percent solution into the storage tank at 183-C (DUN-1818, *Discharge of Sodium Dichromate Solution, Compliance with Executive Order 11258*, October 27, 1966) was not completely efficient and yellowish-stained soils around the storage tank location indicate some losses. The fraction of delivered 70 percent solution lost to the subsurface is not known, however the current concentrations observed in groundwater do not indicate a highly concentrated, persistent source in the subsurface.

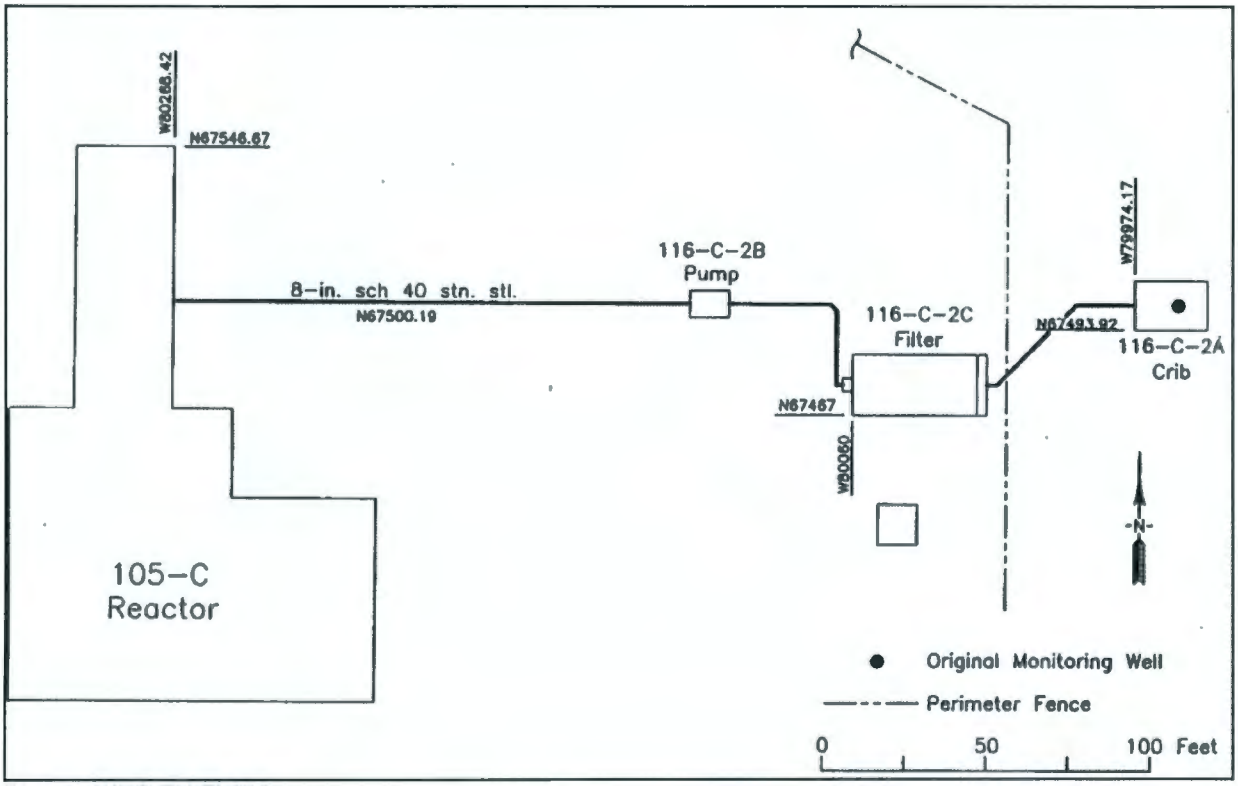
Widespread, relatively low CrVI concentrations extended farther inland during operations because of the magnitude of groundwater mounding and its high mobility. Most of the initial coolant discharge probably stayed in or near the Hanford formation. However, the coolant and its residue are largely absent because of waste discharges and groundwater flow to the Columbia River. In recent studies (Dresel et al., 2008), there is a portion of the CrVI that releases much more slowly because of its interaction with the soil, potentially providing a relatively slow-releasing continuing source. Future migration of CrVI will continue toward the Columbia River, but higher levels of CrVI contamination are not expected.

4.5.2 Strontium-90

Sr-90 is a moderately leachable fission product in ruptured fuel element debris that would have been present routinely in radioactively contaminated fluids (e.g., reactor coolant and decontamination fluids). In the largest quantities of liquid waste, such as reactor coolant, it was present at relatively low concentrations. For example, PNL-6456 Vol. 2 estimates an inventory of 1.64 Ci in the 1E+08L of contaminated reactor cooling water disposed in the 116-C-1 for an average concentration of 1.6E-08Ci/L (1.6E+04 pCi/L).

The largest estimated inventories associated with a liquid discharge site are at the 116-C-2 Pluto Crib, which consisted of a crib and a sand filter that strained particulate from reactor coolant, and decontamination solutions from the 105-C Metal Examination Facility and the 105-C Decontamination Wash Pad (Figure 4-14). The 116-C-2 Waste Site operated over a long period of time (17 years) and received more highly contaminated effluents than the retention basins

PNL-6456 Vol. 2 estimated quantities of Sr-90 of 1.8 Ci and 0.98 Ci at the sand filter and crib, respectively. Given the estimated volume of 7.5E+06 L, the estimated average concentration is 3.7E-07 Ci/L (3.7E+05 pCi/L). This contamination concentration estimate is greater than one order of magnitude than at 116-C-1, which received only reactor coolant. This estimate was supported by measurements of residual radioactivity taken in 1976 (UNI-946).



Source: WHC-EN-TI-220

Figure 4-14. Configuration of the 116-C-2 Pluto Crib East of 105-C Reactor

Sr-90 was also present in solid waste disposed at various burial grounds. The largest estimated inventories were at the 118-B-1 and 118-C-1 Solid Waste Burial Grounds (1.5 and 1.3 Ci) located east of the 105-B and 105-C Reactors, respectively. These are also possible sources of current aquifer contamination, although solid waste burial grounds are much less likely to contribute to Sr-90 in the aquifer compared to liquid discharge sites because the potential for infiltration for vertical contaminant transport is limited from burial grounds. Sr-90 in groundwater wells near the burial grounds has not been detected above the DWS.

A variety of waste sites and former facilities are located within the estimated plume boundary, which could contribute to the persistence of Sr-90 observed and the configuration of the plume. Waste sites that received radioactively contaminated waste streams include 116-B-5 (108-B Crib) and 116-B-16 (111-B Fuel Examination Tank) thus the plume may be the result of several contributing locations gradually releasing contamination to the aquifer. The uncertainty regarding the actual quantity of Sr-90 disposed at these locations, principally from decontamination solutions and particularly contaminated reactor coolant or fuel storage basin liquid is relatively high because of the presence of contaminated particulate, which is far more challenging to measure as a contribution in an effluent stream, rather than soluble Sr-90.

Although 116-C-2 is a potential contributing source with a significant inventory, it is not the most likely reason for the persistence of the Sr-90 plume. 116-C-2 worked as a sand filter, so Sr-90-contaminated particulates would have been present, but the amount of waste discharged there was not large (7.5E+06 L) compared to the estimated infiltration that occurred during operations from the retention basins (Section 4.5.1) and the filtering action of the sand would have minimized particulate movement.

Waste site 116-C-2 is not close to where groundwater mounding occurred, but it may have been impacted by the widespread inland infiltration resulting from leaking retention basins and other effluent disposal.

When operations ended, the dissipation of the groundwater mound as it receded, and the reassertion of natural groundwater flow over time coupled with any alterations to the subsurface have shaped the current configuration and behavior of the plume.

Thus, the impact and influence from effluent leakage 116-B-11, 116-B-1, 116-C-1, and 116-C-5 introduce several complicating factors in describing Sr-90 contaminant fate and transport. The current geochemistry does not appear to promote Sr-90 mobility, however during operations, the combination of acidic decontamination liquids and large volumes of hot, contaminated infiltrating liquid that temporarily saturated the vadose zone may have increased Sr-90 solubility. This increased mobility may have transported some Sr-90 from the near-surface vadose zone deeper, toward the rewetted zone.

Source removal actions have reduced the amount of Sr-90 remaining at the 100-BC Decision Unit (several of the prospective waste sites noted previously are now 'Interim Closed'). Sr-90, being much less mobile than CrVI, did not migrate as far during the mounding/infiltration process and likely did not disperse to the same degree as CrVI, since the end of reactor operations, but as previously noted, there were processes at work that may have mobilized some Sr-90 deeper into the vadose zone.

There does not appear to be a large Sr-90 inventory remaining at the 100-BC Decision Unit (likely less than 100 Ci), but it is significant enough for concentrations to locally and chronically exceed the DWS within the plume boundary. Attenuation of Sr-90 from decay will also continue to occur in both soil and groundwater. Continued relatively slow dispersion and migration of Sr-90 in groundwater will occur because of its moderate adsorption to aquifer soils and the modest natural infiltration rate. Thus, the plume is anticipated to be persistent in groundwater due to widely distributed Sr-90 sorbed to soil within the deeper vadose zone and periodically re-wetted zone.

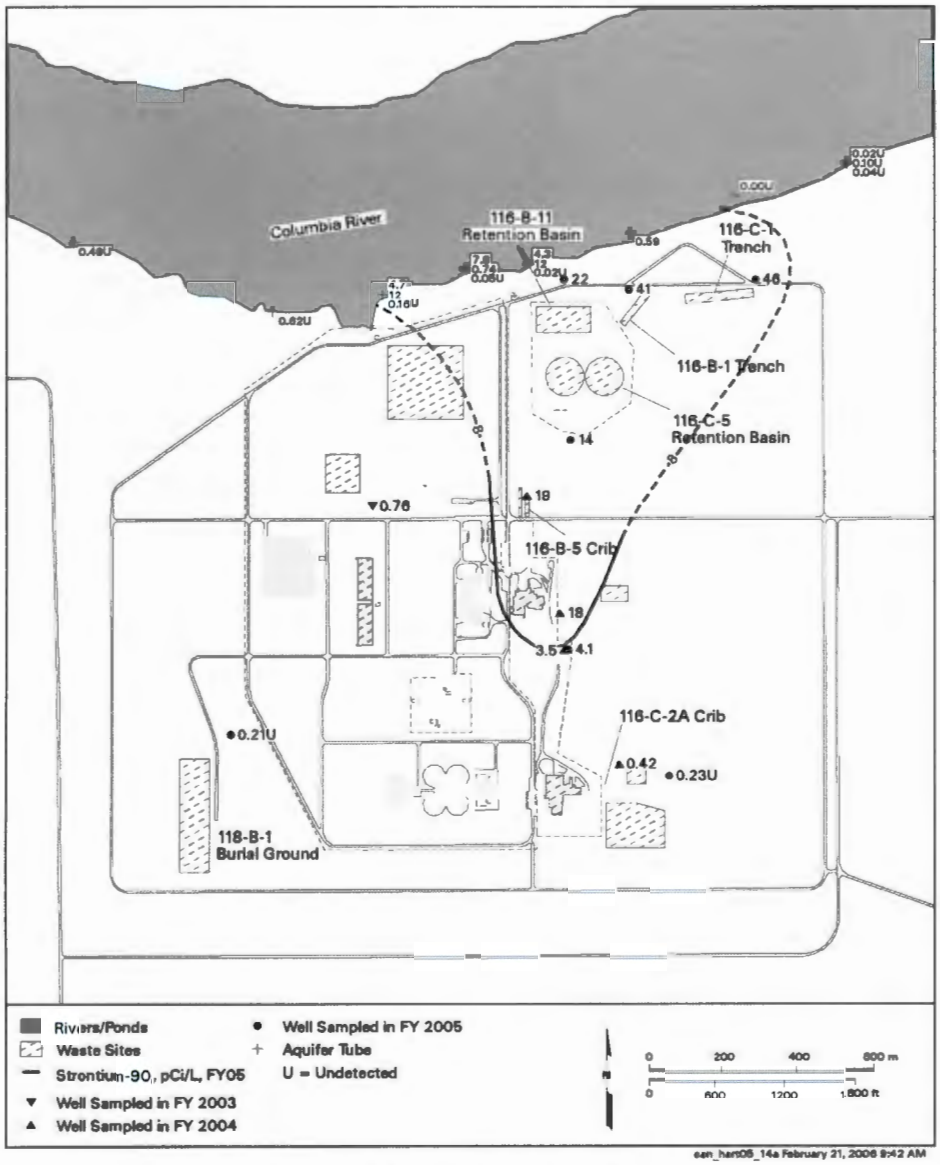


Figure 4-15. 100-BC Strontium-90 Plume Boundary

4.5.3 Tritium

The presence of tritium in the unconfined aquifer in the 100-B/C Area is not totally unexpected. However, its persistence and high concentration suggest a more concentrated source than is common at other 100 Area reactors. Tritium remains at elevated levels (> 20,000 pCi/L) in groundwater after almost five half-lives after the end of the P-10 Tritium Separation Project process. At the 100-B/C Area, solid waste residue (e.g., extraction traps containing palladium and mercury with adsorbed tritium; and glass tubes containing tritium gas) from the tritium production and separation line at 108-B disposed at the 118-B-1 and 118-B-6 Burial Grounds is considered to be the most likely source for the tritium. Most of these solid waste residue sites were excavated and removed during remediation of 118-B-1, but other traps or contaminated components and scrap could be present in the remaining accepted/discovery sites. These additional sites could potentially contribute to the observed contamination. Table 4-3 lists the currently identified tritium receipt waste sites.

The 116-B-6 Waste Site was remediated in 2006. Since that time, the groundwater plume has migrated to the south (downgradient), which supports the recognition that 116-B-6 Waste Site was a source. Since the source has been removed, groundwater concentrations in this area are expected to decrease in the future.

4.5.4 Ringold Upper Mud and Lower Hydrogeologic Units

Data Gap #7: The fate and transport of contaminants beneath the unconfined aquifer has not been evaluated. Underlying the unconfined aquifer in the 100-BC Decision Unit is the RUM. The RUM has been described as primarily clayey silt and silty clay, with lenses of silty sand and sandy silt. Only one well (199-B2-12) in the 100-BC Decision Unit has been completed in the RUM (or hydrogeologic units beneath the RUM). Since only one well in the 100-B/C Area has been completed beneath the unconfined aquifer, groundwater flow directions and velocities are relatively undefined.

Groundwater in the RUM has been sampled for constituents that include organics, inorganics, and radionuclides from well 199-B2-12 (Figure 4-17) located downgradient of the 105-B and 105-C Reactors and relatively close to the shoreline. Concentrations of contaminants in groundwater samples from 199-B2-12 have not exceeded DWS.

Data Gap #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 (the upper aquifer thickness) and river bathymetry, the top of the RUM is more than 15 m (49 ft) below the bottom of the river channel (i.e., the top of the RUM does not intersect the river channel). Therefore, it is not expected that contamination (if any) within the RUM or lower units will impact aquatic receptors. However, detailed bathymetric data are needed to confirm the depth of the top of the RUM surface below the bottom of the river channel.

Because of the lack of wells completed beneath the upper aquifer in the 100-BC Decision Unit, current discharge points for groundwater beneath the upper aquifer are not known. The RUM is not currently considered as a potential DWS. However, additional hydrogeologic data (e.g., hydraulic conductivity and hydraulic gradient information) are needed to confirm the current CSM hypothesis that the RUM cannot support a drinking water resource.

4.5.5 Groundwater/River Interactions

Data Gap #6: The level of contamination entering the Columbia River is not well known.

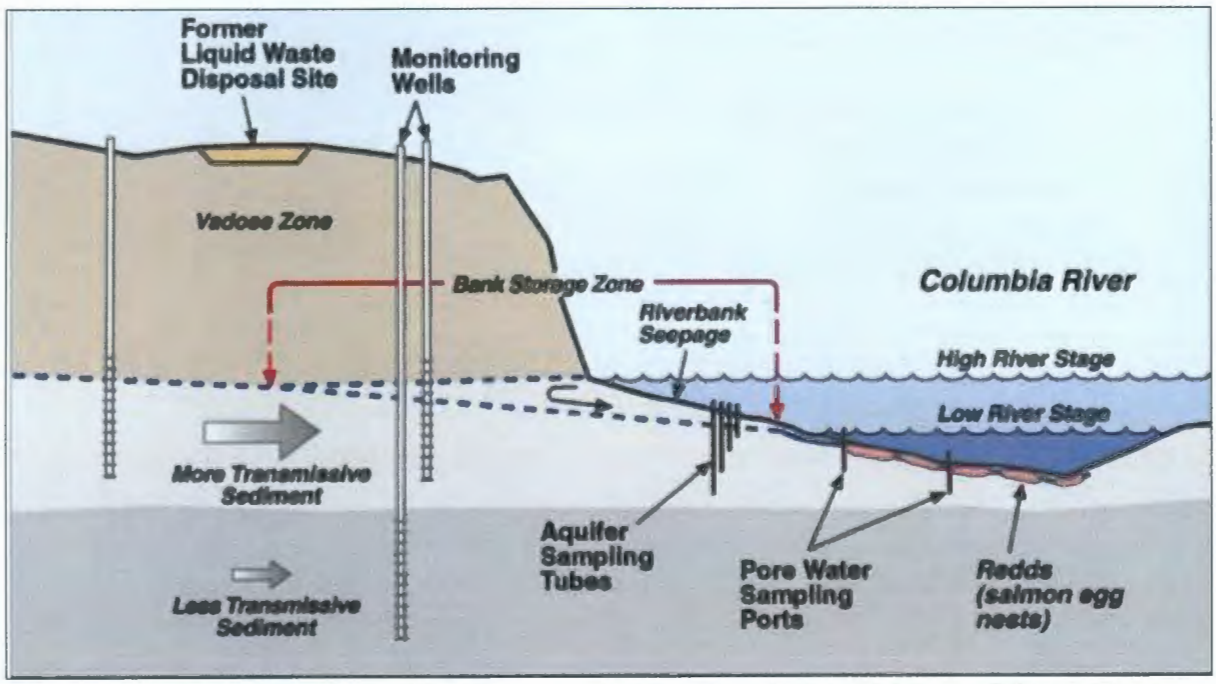
Data Gap #9: The rate of exchange of groundwater between the groundwater and the river is unknown.

Intermingling of groundwater and river water in the zone of interaction and locations of groundwater discharges into the river channel are key issues to understanding the rates and magnitudes of contaminants potentially entering the Columbia River. The working hypothesis is that mixing between groundwater and infiltrating river water may cause dilution of contamination potentially present in the groundwater to considerable depths within the aquifer.

Discharge into the river environment may occur across the riparian zone as seeps and within the river channel substrate. Riverbank seepage creates a potential human health risk through exposure to contaminants and the introduction of contaminants to the food chain. Upwelling of groundwater into the channel substrate poses a potential risk to river substrate biological communities and fish spawning habitat. Groundwater upwelling sampling and analysis in the Columbia River channel is planned for fall 2009, and it is expected that this data will provide further insight regarding contaminant levels entering the river.

Near the river, groundwater flow is strongly influenced by river stage, which is directly controlled by the upstream Priest Rapids Dam that dominates daily to seasonal stage fluctuations. This rise and fall of river stage creates a dynamic zone of interaction between the groundwater and river water, and influences flow patterns, transport rates, contaminant concentrations, and attenuation rates within the system (PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*).

Riverbank seep discharges to the river are visible during low river stage. Conversely, during high river stage, the seeps are submerged as river water infiltrates into the riverbanks and forms either a layered system or a mixture during interaction with approaching groundwater. Data indicate riverbank storage water composition oscillates dramatically from nearly completely river water during high river stage, to primarily groundwater during low river stage (PNNL-13674). Figure 4-16 shows an illustrated model of the zone of interaction.



Source: PNNL-13674, Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River.

Figure 4-16. Principal Features and Monitoring Sites for Zone of Interaction

In the channel substrate, sediment pore water may be influenced by the entrainment of river water and the gradual influx of groundwater that upwells from the underlying aquifer. Physical, chemical, and biological characteristics of this interface have been the focus of research in aquatic biology (i.e., Geist and Dauble, 1998, *Redd Site Selection and Spawning Habitat Use by Fall Chinook Salmon: The Importance of Geomorphic Features in Large Rivers*; Geist, 2000, *The Interaction of Ground Water and Surface Water within Fall Chinook Salmon Spawning Areas in the Hanford Reach of the Columbia River*).

Physical, chemical, and biological processes occur within the zone of interaction that potentially alter the characteristics of approaching groundwater. Data suggest physical processes dominate influences on contaminant concentrations and fluxes, where groundwater discharges into the free-flowing river. Chemical processes may render contaminants as less mobile as they adsorb to sediment or precipitates. Zone of interaction biological activity may also capture contaminants and immobilize them, or introduce them into the food chain (PNNL-13674).

Columbia River elevations have varied by up to as much as 2.7 m (9 ft) in a single day (PNL-9437, *Monitoring Groundwater and River Interaction Along the Hanford Reach of the Columbia River*). Groundwater elevations have varied by up to 0.9 m/day (3 ft/day) in some wells nearest the river and up to approximately 1.8 m (6 ft) over the season in a few wells (PNL-9437)

4.6 Human Receptors and Exposure Pathways

The EPA risk assessment guidance describes an exposure pathway as being the course that a contaminant takes from a source to a receptor (EPA/540/1-89/002, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A, Interim Final*). Exposure pathways integrate information relating to sources and/or releases of contamination, contaminant transport pathways in the environment, exposure media, and exposure routes for receptors. Exposure pathways must contain all of the following elements; otherwise, the pathway is not complete and does not present a risk or hazard (EPA/540/1-89/002, EPA/540/1-89/001, *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final*):

- Known and potential sources and/or releases of contamination
- Contaminant migration pathways
- Potential exposure scenarios
- Potential exposure media
- Potential exposure routes and receptors.

Known and potential sources and/or releases of contamination include shallow-zone soil, deep-zone soil, sediment, and groundwater. Migration of contaminants from one source media may affect other media such as biota, air, groundwater, and surface water.

Data Gap #13: Data are needed to better define the spatial and temporal distribution of groundwater contamination.

The analysis presented in Chapter 3 of the work plan identifies only the groundwater pathway as a remaining data gap needed to address RCBRA uncertainties regarding groundwater risk to a human receptor.

4.7 Ecological Receptors and Exposure Pathways

The *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the RCBRA* (DOE/RL-2004-37) identifies and describes the ecological receptors and exposure pathways for the 100 Area. A remaining ecological exposure pathway uncertainty for the 100-BC Decision Unit involves the discharge of contaminated groundwater to ecological receptors within the Columbia River.

This uncertainty is documented in Data Gap #6 (*The level of groundwater contamination entering the Columbia River is not well known*). The data needed to address Data Gap #6 is summarized in Table 4-8 and is also addressed in Section 4.8.2.

4.8 Identification and Resolution of Data Needs

Table 4-6 tallies the number of field investigation locations for soil and water sampling. Table 4-7 summarizes the approximate number of analytical tests that would result from the proposed sampling programs. Table 4-8 also summarizes the data needs necessary to fill the data gaps, and the specific work proposed for this work plan at the 100-BC Decision Unit. As described in previous sections, other remediation activities and characterization efforts associated with the interim action ROD will also make a significant contribution to the quantity of data collected in the 100-BC Decision Unit.

Table 4-6. Proposed 100-BC Decision Unit Field Characterization

Type	Number
To Be Remediated Source Sites (see Tables 2-3, 2-4)*	24
New boreholes (vadose zone) (see Section 4.8.1)	6
New wells (unconfined aquifer) (see Section 4.8.2)	9**
New wells (screened the Ringold Upper Mud Unit) (see Section 4.8.2)	1
Monitoring wells (sampling to support risk characterization) (see Section 4.8.2)	20***

* This task is not within the scope of the SAP in this addendum. Accepted and Discovery sites are being evaluated, characterized, and/or remediated according to DOE/RL-96-17, Remedial Design Report/Remedial Action Work Plan.

** Four new wells will be installed as described in Sampling and Analysis Plan DOE/RL-2009-61, and five new wells will be installed in FY10 as part of this RI as described in Sampling and Analysis Plan DOE/RL-2009-44 (see Section 4.8.2).

*** The twenty wells to be sampled to support risk characterization include 16 existing monitoring wells and 4 new wells to be installed as described in Sampling and Analysis Plan DOE/RL-2009-61 (see Section 4.8.2).

Table 4-7. Number of Field Samples and Analytes Proposed for the 100-BC Decision Unit (Estimated)

Source	Soil Samples	Groundwater Samples	Analyses
New boreholes (vadose zone)	98	6	1,041
New wells (unconfined aquifer)	45	54**	800**
New wells (extending into the Ringold Upper Mud Unit)	12	8	135
Current monitoring wells (sampling to support risk characterization)	0	60	480

* See DOE/RL-2009-44, Tables 2-2 and 2-3.

** Includes groundwater sampling from 4 new wells installed in FY2009 (DOE/RL-2009-61).

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Table 4-8. 100-B/C Decision Unit Data Needs

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 been 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 contaminated soil removal and sampling at 24 waste sites in the 100-BC Decision Unit. The location of unremediated waste sites is shown in Appendix B.	Remediation is needed to protect human health and the environment. Data collected at the completion of remediation is needed to assess risk for direct exposure, protection of groundwater, and protection of the Columbia River.
Vadose zone contaminant nature and extent needed to assess protection of groundwater beneath remediated waste sites.	2	Characterize beneath remediated waste sites to assess the nature and extent of contamination in the vadose zone.	Drill six boreholes. Samples will be collected and analyzed to assess the vertical extent of contamination in the vadose zone at borehole locations.	Yes	During the RI, drill one borehole in the following waste sites: 100-B-5 Trench, 116-B-5 Crib, 116-B-6B Crib, 116-B-11 Retention Basin, 116-C-6 Process Pit, and 118-B-6 Burial Ground. Soil samples will be collected and analyzed as described in the SAP (DOE/RL-2009-44). The location of these sites is shown in DOE/RL-2009-44.	Characterization will be performed to validate interim remedial action, address uncertainty regarding the nature and extent of residual contamination in soils, refine the CSM (if necessary), and support decision making for the final ROD for the 100-B/C Decision Unit.
Vadose zone contaminant nature and extent needed to assess protection of groundwater around reactor structures.	3	Characterize around reactor structures to assess the nature and extent of contamination in the vadose zone.	Data are needed to determine the nature and vertical extent of the contamination in the vadose zone around the 100-B and 100-C Reactor Structures.	Yes	Continue contaminated soil removal and sampling at waste sites associated with the 105-B and 105-C Reactor sites. The location of these waste sites is shown in Appendix B.	Continue remediation to protect human health and environment. Data collected during and at completion of remediation is needed to assess the nature and extent of vadose zone contamination.
Unidentified waste sites (orphan and discovery sites) may exist in the decision unit.	4	Identify new waste sites and potential sources of contamination.	The orphan site evaluation process in the 100-BC Decision Unit has been completed. Discovery sites may be identified during ongoing remediation (facilities or waste sites).	Yes	Continue discovery process as remedial actions continue.	Discovery sites may be identified during ongoing remediation (facilities or waste sites).
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 contaminants (CrVI, Sr-90, and tritium) in the unconfined aquifer.	Groundwater contamination has been detected at concentrations above water quality standards in the unconfined aquifer in the 100-BC Decision Unit. The extent of contamination (e.g., CrVI) has not been defined spatially in the unconfined aquifer.	Yes	Install four new groundwater monitoring wells (Figure 4-17). ***CrVI:*** Proposed well 1 (Figure 4-17) will be monitored for CrVI to define the extent in the unconfined aquifer west of the 100-B-27 Site. Proposed Well 5 will be monitored for CrVI in the southeastern portion of the 100-BC area. Wells C7505, C7507, C7508 (Figure 4-17) to be installed per SAP DOE/RL-2009-61 will also be monitored for CrVI. ***Tritium:*** Two wells (wells 2 and 3, Figure 4-17) are proposed to define the extent of tritium in the unconfined aquifer. Wells C7507 and C7508 to be installed per SAP DOE/RL-2009-61 will also be monitored for tritium. ***Sr-90:*** Wells C7505 and C7506 to be installed per SAP DOE/RL-2009-61 will be monitored for Sr-90 ***Additional work***: In addition, groundwater samples will be collected from boreholes drilled as part of data needs 2 and 3, near waste sites that are possible sources for groundwater contamination. Groundwater samples will also be collected as part of ongoing activities related to CrVI contamination associated with the 100-C-7 Waste Site. These groundwater samples will not be collected by this RI.	New wells are proposed to define the extent of CrVI, Sr-90, and tritium contamination. The extent of CrVI has not been defined in the 100-B/C Area. Sr-90 concentrations have not been defined to the east and west, downgradient of the 105-B Reactor. Tritium concentrations in the unconfined aquifer have not been defined near the 118-1 Burial Ground or the 100-C-7 Site.

Table 4-8. 100-B/C Decision Unit Data Needs

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The level of contamination entering the Columbia River is not well known.	6	Increase sampling frequency of aquifer tubes.	Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., CrVI) has been documented in the 100-BC Decision Unit. Aquifer tubes have been installed to analyze groundwater contaminants discharging to the river. These aquifer tubes are typically analyzed for contaminants once 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 is planned for fall 2009, and it is expected these data will provide additional insight regarding contaminant levels entering the river.	Yes	Modify aquifer tube construction to allow sampling of the tubes at the same frequency as monitoring well sampling described in Data Need No. 13. Monitor aquifer tubes for CrVI, Sr-90, and tritium. Collect groundwater upwelling samples in the Columbia River.	Samples collected during limited aquifer tube sampling show impacts of CrVI, Sr-90, and tritium. More frequent sampling of the aquifer tubes will provide better temporal data to assess potential impacts to aquatic receptors.
The fate and transport of contaminants beneath the unconfined aquifer has not been evaluated.	7	Collect physical and hydrogeologic parameters from soil samples to support fate and transport of contaminants beneath the unconfined aquifer.	The RUM unit is currently considered an aquitard. The integrity of the aquitard unit and potential transport within the aquitard have not been evaluated in the 100-BC Decision Unit.	Yes	Split-spoon soil samples at total depth of 1.5 m [5 ft] into the RUM will be collected from the five new proposed wells (wells 1, 2, 3, and 5, Figure 4-17 proposed for data need 5, and well 4 proposed for data need 9), and the four new wells that are being installed in per SAP DOE/RL-2009-61 (wells C7505, C7506, C7507, and C7508, Figure 4-17). Drill one well (well R1, Figure 4-17) 50 ft into the RUM and collect soil and groundwater samples. Sampling details are listed in DOE/RL-2009-44.	Only one well has been completed within the RUM aquitard unit in the 100-BC Decision Unit. Data are not available to evaluate the integrity of the aquitard unit, or fate and transport within the aquitard.
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 the 100-BC Decision Unit 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.	No	NA	The preliminary evaluation base of the unconfined aquifer surface using near-river wells indicates the top of the aquitard (RUM) beneath the unconfined aquifer is more than 15 m (49 ft) below the bottom of the Columbia River (i.e., the top of the RUM does not intersect the Columbia River).
The rate of exchange of groundwater between the groundwater and the river 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.	Yes	Drill two characterization wells (wells 4 and R1, Figure 4-17 near the river). Drill R1 50 ft into the RUM near aquifer tubes AT-B-3D, M, and S. Screen well R1 within the first water-bearing zone of the RUM. Screen well 4 within the unconfined aquifer. Soil samples will be collected within the vadose zone, unconfined aquifer, and RUM. Groundwater samples will be collected from the unconfined aquifer and the RUM (if sufficient water is available for sampling). Details of the sampling are found in the SAP (DOE/RL-2009-44). Sample groundwater from the aquifer tubes AT-B-3-D, M, S and wells 8 and R1. Sample groundwater from aquifer tubes AT-06-D, M, S and wells 199-B2-12 and 199-B3-47.	Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., CrVI) has been documented in the 100-BC Decision Unit. Additional data are needed to evaluate the potential impacts to the river.

Table 4-8. 100-B/C Decision Unit Data Needs

Data Gap	Data Need No.	Data Need	Description	Additional Data Collection Recommended?	Scope of Work	Justification
The mechanism to explain the persistence of the chromium, Sr-90, and tritium plumes is unknown.	10	Collect soil and water samples from the (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	Drill and sample soil and groundwater from six (4 wells for Data Need 5 and 2 wells for Data Need 9) proposed groundwater wells (wells 1 to 5 and R1, Figure 4-17). Details are found in the SAP (DOE/RL-2009-44). Sample boreholes B1 to B6 (Figure 4-17) within vadose zone, deep vadose zone, and rewetted zone.	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 remedial technologies have not been sufficiently investigated.	11	Potential groundwater remedial technologies	Groundwater contamination above aquatic standards and DWS maximum contaminant levels has been detected in the 100-BC Decision Unit. No interim remedial actions are currently in operation. The current RI will use the data collected during this RI (e.g., soil physical properties) for comparison of remedial alternatives, and evaluate information from other remedial technology evaluations from other 100 Area OUs necessary for comparison of potential final remedies as part of the future project FS.	No	Evaluate remedial technologies using soil and groundwater data gathered as part of this RI, information and evaluations from other 100 Area and Hanford OU remedial technology evaluations. Evaluate data and information from treatability tests including the planned in situ treatability test for CrVI at the 100-C-7 Waste Site.	Remedy and remedial technology evaluations are needed as part of the FS. The remedial process optimization activity for the 100-D/H Decision Unit has evaluated potentially applicable remediation technologies for CrVI. Evaluations related to Sr-90 have been completed for the 100-NR-2 groundwater OU. These evaluations will be used during preparation of the 100-BC Decision Unit FS.
Data are not available for an improved understanding of contaminant transport.	12	Insufficient data are available to assess the physical and hydraulic properties of soil and confirm contaminant distribution coefficients to support modeling and analysis.	On selected soil samples, estimate soil properties and hydraulic properties, determine level of contamination and perform batch leach contacting test.	Yes	Drill and sample soil and groundwater from six proposed groundwater wells (wells 1 to 5, Figure 4-17), and well R1 (Figure 4-17). Details are found in the SAP (DOE/RL-2009-44).	Support 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 20 groundwater monitoring wells in the 100-BC Decision Unit (16 existing wells and four new wells to be installed in per SAP DOE/RL-2009-61).	Groundwater data are needed that are spatially representative of a decision unit, representative of river stage influence and inclusive of all COPCs.	Yes	Collect and analyze groundwater samples from 20 groundwater monitoring wells to characterize the spatial, temporal, and chemical extent of groundwater contamination. Wells are shown in Figure 4-17. Details are found in the SAP (DOE/RL-2009-44).	Groundwater data are needed to address uncertainties associated with the RCBRA.

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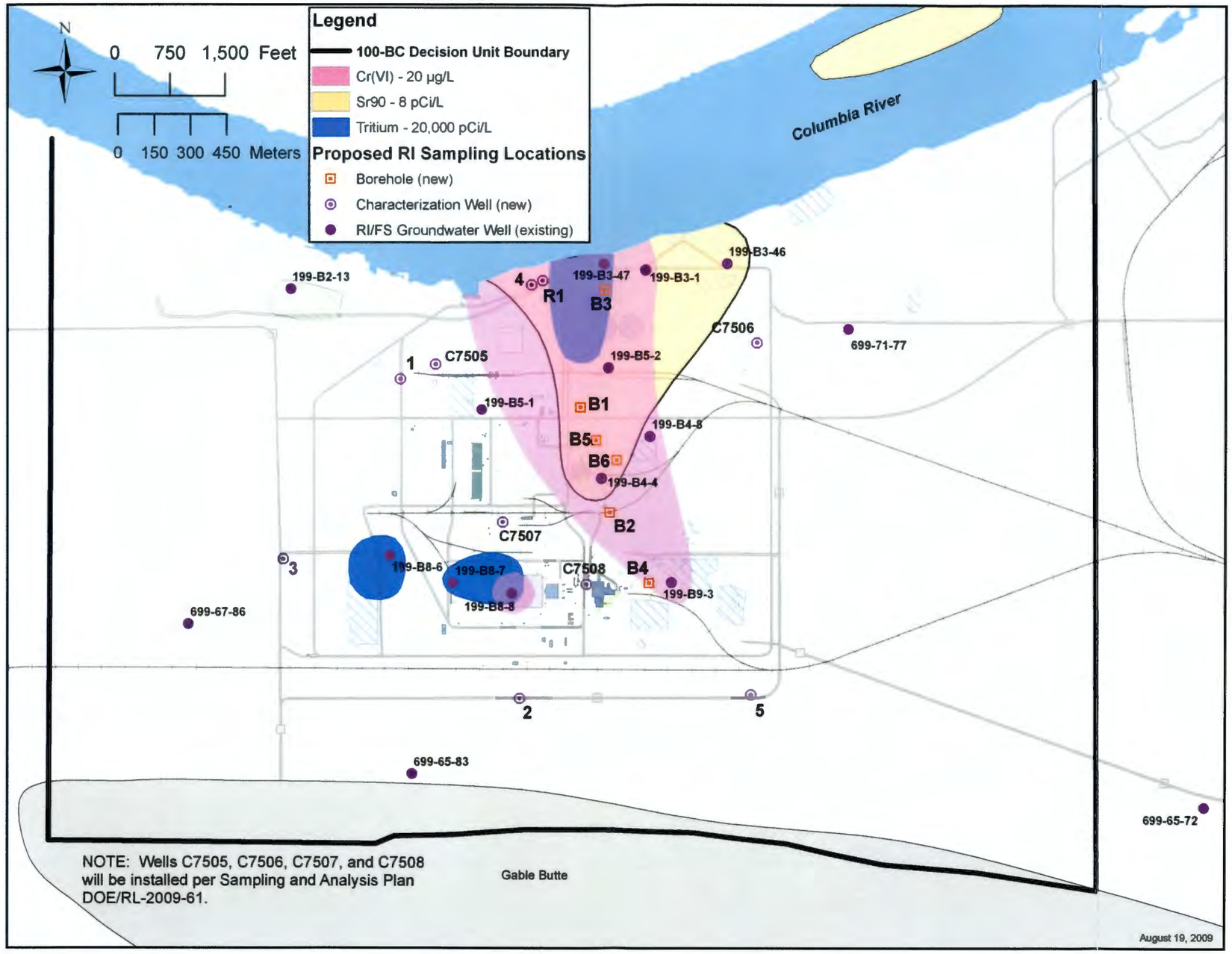

Figure 4-17. Proposed Remedial Investigation/Feasibility Study Sampling Locations for Soil and Groundwater for 100-BC Decision Unit

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4.8.1 100-BC Decision Unit Data Needs – Source Area

Data Need 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 been 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 the 100-B/C Area began in 1996 under remedial authority of an interim action ROD and continues to the present. Remedial action efforts, as currently implemented, consist mainly of remedial action planning, remedial action operations, site verification and interim closeout, backfill, and revegetation. Excavation during remedial actions at each waste site continues until the remedial action goals for protection of groundwater and the Columbia River have been attained. Schedules for remedial action are driven by enforceable milestones that have been established as part of the *Ecology et al., 1989a, Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) and a CERCLA (1980) statutory requirement.

Data needs associated with source remedial actions in the 100-B/C Area include planning and scheduling the remedial actions, collecting data to verify cleanup of waste sites, documenting action, and obtaining concurrence from the regulators. These activities are controlled according to ongoing source area remedial action and interim closeout processes; therefore, sampling and analysis requirements for these activities are not included in this work plan. The *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17) provides detailed discussion and specific information about the 100 Area remediation process. Achievement of cleanup goals is based on remedial action goals for direct exposure, protection of groundwater, and protection of surface waters. Final cleanup actions will be specified in a final ROD for the decision unit.

Quantitative analytical data collection (i.e., soil chemistry) is guided by the *100 Area Remedial Action Sampling and Analysis Plan* (DOE/RL-96-22), *100 Area Burial Ground Remedial Action Sampling and Analysis Plan* (DOE/RL-2001-35), and DOE/RL-96-17, or similarly relevant CH2M HILL Plateau Remediation Company (CHPRC) procedures.

Data Need 2: Characterize beneath remediated waste sites to assess the nature and extent of contamination in the vadose zone.

Data Need Description: Drill six boreholes. Samples will be collected and analyzed to assess the vertical extent of contamination in the vadose zone at borehole locations.

Contaminant data are available from boreholes and interim remedial actions completed in the 100-BC Decision Unit. Most of the contaminant data collected from the vadose zone were collected from depths no greater than 9.1 m (30 ft) bgs, with few exceptions. The available data indicate the vadose zone should be better characterized beneath waste sites. There is also a lack of nitrate, Sr-90, tritium, and CrVI data to assess the vertical and lateral extent of vadose zone contamination.

Available 100-BC Decision Unit information indicates that 117 of 151 waste sites have been interim closed or dispositioned in accordance with an interim action ROD or other regulatory guidance. These locations have been sampled and the soil analyzed to assess subsurface conditions in the vadose zone. To evaluate the current status of all 151 sites and to determine those sites that may require additional characterization to address CSM uncertainties, a decision tree (i.e., work plan) was used to sort the 100-BC Decision Unit sites into three general categories:

- No further characterization required
- Further characterization needed under other programs (cleanup verification package or remaining site verification package; not the RI/FS)
- Further characterization indicated under the 100-BC Decision Unit RI/FS.

To establish which sites to consider for further soil characterization under the 100-BC Decision Unit RI/FS, waste sites or facilities that had been previously remediated and interim closed, but had one or more of the following characteristics, were identified:

- Sites that historically affected groundwater quality
- Sites with soils concentrations above screening levels for groundwater protection
- Sites with evidence of deep soil contamination
- Sites that were not remediated to the bottom of the engineered structure
- Sites identified in orphan site reports
- Sites in or near high concentration groundwater plumes
- Sites where low volumes of high concentration liquids were disposed
- Sites where possible data needs were identified in the systematic planning workshop.

The data and information available for the sites with the above characteristics were reviewed and evaluated by SMEs in contaminant fate and transport, site remediation, risk assessment, cleanup verification packages, and environmental modeling. Based on the evaluation, six waste sites were identified for further soil characterization to address CSM uncertainties regarding contaminant distribution in the vadose zone and groundwater protection.

Borehole Drilling:

- Six boreholes in the 100-BC Decision Unit. One borehole at each of the following waste sites:
  - 100-B-5 Trench
  - 116-B-5 Crib
  - 116-B-6B Crib
  - 116-B-11 Retention Basin
  - 116-C-6 Process Pit
  - 118-B-6 Burial Ground.

These waste sites were selected for additional characterization because of two or more of the following reasons.

- Residual contamination remaining in the soil column after the completion of the interim remedial action is above screening levels for groundwater protection.
- Depth of remedial action is approximate to or less than the depth of the engineered structure.
- Lack of data exists to support an assessment of the vertical distribution of contamination beneath the waste site.
- Location of waste sites relative to high concentration areas of CrVI groundwater plumes.
- Contaminant inventory and effluent volume received suggest there was impact to groundwater when the waste site was operational. Data will be collected in the contaminant pathway to groundwater.

- Contaminant inventory and effluent volume received suggest groundwater has not been impacted. In some cases, there may be a contaminant source remaining in the vadose zone.

Soil samples 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. One soil sample and water samples shall 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 SAP in DOE/RL-2009-44.

Five additional waste sites (100-C-9:1, 100-B-18, 100-B-23, 118-B-1, and 100-B-14:2) have residual contamination above screening criteria protective of groundwater and were considered for further characterization in the RI. However, these five sites were not selected for additional characterization for one or more of the following reasons:

- Residual contaminant concentrations were/are typically low.
- Contaminant distribution coefficients (e.g., K_d) associated with contaminants suggest limited fate and transport beneath the waste site.
- Close out reports and other balancing factors (leach testing) suggest no current future impacts to groundwater or the Columbia River at these sites.
- Six waste sites selected for additional characterization were deemed credible to verify the adequacy of completed interim remedial actions.
- Six waste sites selected for additional characterization were deemed adequate for the purpose of refining the CSM for the decision unit and decision making to support a final ROD.

Table 4-9 presents data and information associated with the seven waste sites not selected for additional characterization.

Table 4-9. Rationale for Not Selecting Five Waste Sites for Additional Characterization

Waste Sites Exceeding Action Levels	Contaminants (95% UCL or Maximum Concentrations mg/kg or pCi/g)	Screening Levels for Groundwater Protection	Justification for Exclusion
100-B-14:2	Aroclor-1254 (0.33)	0.0664	High K_d value and closeout reports indicate no significant human health risk or impacts to groundwater or the Columbia River.
	Benzo(a)anthracene(1.2)	0.0856	
100-B-18	Sb (9.3)	5.4	Close out reports suggest no significant impacts to groundwater or the Columbia River.
	Cd (13.2)	0.69	
	Hg (2.2)	2.09	
100-B-23	Cd (1.7)	0.69	Close out reports suggest no significant impacts to groundwater or the Columbia River.
	Hg (8.2)	2.09	

Table 4-9. Rationale for Not Selecting Five Waste Sites for Additional Characterization

Waste Sites Exceeding Action Levels	Contaminants (95% UCL or Maximum Concentrations mg/kg or pCi/g)	Screening Levels for Groundwater Protection	Justification for Exclusion
118-B-1	Tritium (158)	15.8	Tritium is the only contaminant above screening levels. Close out reports suggest no significant impacts to groundwater or the Columbia River with additional institutional controls implemented by an explanation of significant difference.
100-C-9:1	Hg (22.7)	2.09	Mercury is the only constituent above action levels. High K_d value and close out reports suggest no significant impacts to groundwater or the Columbia River.

K_d = distribution coefficient
mg/kg = milligram per kilogram
pCi/g = picocuries per gram
UCL = upper confidence limit.

Data Need 3: Characterize around reactor structures to assess the nature and extent of contamination in the vadose zone.

Data Need Description: Data are needed to determine the nature and vertical extent of contamination in the vadose zone around reactor structures (100-B and 100-C Reactors).

These data needs will be partially filled by obtaining verification data associated with the 105-B and 105-C Reactors. After cleanup verification data are available to characterize the subsurface beneath these facilities, further evaluation will be performed to assess the need for additional characterization. The need to further determine the extent of contamination beneath the reactors will generally be guided by soil concentration, as compared to screening criteria for protection of groundwater and protection of the Columbia River. Further, decisions regarding characterization in the vadose zone within the decision unit will be made as decisions regarding the B Reactor are also made.

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

Data Need Description: The orphan site evaluation process in the 100-BC Decision Unit has been completed. Discovery sites may be identified during ongoing remediation (facilities or waste sites). These processes may identify new waste sites and potential sources of contamination in the 100-BC Decision Unit.

4.8.2 100-BC Decision Unit 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). Proposed groundwater monitoring wells are summarized in Table 4-10, and discussed in the following data need descriptions.

Table 4-10. Summary of Proposed Groundwater Wells

Well	Justification
1	Define the western extent of CrVI in the vicinity of the 100-B-12 Waste Site.
2	Define the southern extent of the southern CrVI and tritium plumes near 183-C.
3	Define the western extent of tritium in the southwest portion of the 100-BC Area.
4	Install near the river shore to gather additional data about the rate of exchange between groundwater and the river.
5	Define the extent of CrVI in the southeastern portion of the 100-BC Area.
C7505*	Characterize CrVI groundwater impacts from the 100-B-12 Waste Site, further define the western extent of Sr-90 groundwater contamination from the north central portion of the 100-BC Area.
C7506*	Better define the eastern extent of CrVI and Sr-90 groundwater contamination.
C7507*	Define the northern extent of the southern CrVI and tritium plumes near 183-C
C7508*	Define the eastern extent of the southern CrVI and tritium plumes near 183-C, define the western extent of the eastern CrVI plume in the 100-BC Area, evaluate groundwater contamination near the 105-C Reactor Building.
R1	Collect physical and hydrogeologic parameters to support fate and transport evaluations of contaminants, collect physical properties from the RUM to support potential evaluations of contaminant transport within the aquitard, gather additional data about the rate of exchange between groundwater and the river.

* Well planned for installation in FY2009 per SAP DOE/RL-2009-61.

Data Need 5: Define the extent of groundwater contaminants (CrVI, Sr-90, and tritium) in the unconfined aquifer.

Data Need Description: Groundwater contamination has been detected at concentrations above water quality standards in the unconfined aquifer in the 100-BC Decision Unit. The extent of contamination (e.g., CrVI) has not been defined spatially in the unconfined aquifer.

Concentrations of several contaminants in groundwater are greater than DWS or standards for protection of aquatic receptors. Washington state regulations and federal EPA guidance indicate groundwater always should be evaluated for the "highest beneficial use," i.e., drinking water, unless the aquifer is nonpotable because of reasons other than contamination (e.g., high natural total dissolved solids) or the water yield is insufficient for pumping (WAC 173-340).

In addition to evaluating the highest beneficial use, groundwater plume movement must be evaluated to assess whether there will be impacts on surface water. If impacts are occurring or might reasonably be expected to occur in the future, human exposures to surface water and groundwater must be evaluated. The results of the baseline risk assessment will be used to support comparisons of remedial action scope and cost estimates for the FS.

A total of eight new wells in the unconfined aquifer are proposed to be drilled and installed to define the extent of groundwater contamination as follows, for the RI Work Plan. Four of the wells (C7505, C7506, C7507, and C7508) will be installed per the SAP (DOE/RL-2009-61).

CrVI: Two new wells (wells 2 and 5, Figure 4-17) are proposed to define the extent of CrVI in the 100-BC area. Proposed well 1 will be monitored for CrVI west of the 100-B-27 site. Proposed well #5

will be monitored CrVI in the southeast portion of the 100-BC area. Well C7507 (Figure 4-18) that will be installed in as described in the SAP (DOE/RL-2009-61) will also be monitored for CrVI.

Tritium: Four wells (wells 2, 3, C7507 and C7508, Figure 4-17) are proposed to define the extent of tritium in the unconfined aquifer. Wells C7507 and C7508 are described in SAP DOE/RL-2009-61. Wells #4 and R1 proposed as part of data need #9 will also be sampled for tritium..

Sr-90: Wells C7505 and C7506 will be installed as described in SAP DOE/RL-2009-61 and monitored for Sr-90.

During well installation, the following data will be collected:

1. Soil data (spit spoons) above the unconfined aquifer, within the aquifer, prior to entering the RUM, and after entering the RUM.
2. Water samples within the unconfined aquifer to determine vertical distribution of contamination within the aquifer.

In addition, groundwater elevation data will be used to evaluate groundwater and plume flow directions. Groundwater samples will be collected from nine new wells (the four new wells described previously, the one new well proposed for installation in the unconfined aquifer in data need 9 (well 4), and the four wells to be installed in FY2009 (DOE/RL-2009-61). Details of the SAP are found in DOE/RL-2009-44.

Additional work: In addition, groundwater samples will be collected from boreholes drilled as part of Data Needs 2 and 3, near waste sites that are possible sources for groundwater contamination.

Groundwater samples will also be collected as part of ongoing activities related to CrVI contamination associated with the 100-C-7 Waste Site. These groundwater samples will not be collected by this RI.

Data Need 6: Increase sampling frequency of aquifer tubes.

Data Need Description: Groundwater discharge to the river at concentrations above aquatic cleanup levels (e.g., CrVI) has been documented in the 100-BC Decision Unit. Aquifer tubes have been installed to analyze groundwater contaminants discharging to the river. These aquifer tubes are typically analyzed for contaminants once 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 is planned for fall 2009, and it is expected that these data will provide further insight regarding contaminant levels entering the river.

It is proposed that aquifer tube construction be modified by extending the sample tubing to allow sampling of the tubes during higher river stage and at the same frequency as monitoring well sampling (if possible) described in Data Need 13. The aquifer tubes should be monitored for CrVI, Sr-90, and tritium.

Data Need 7: Collect physical and hydrogeologic parameters from soil samples to support fate and transport of contaminants beneath the unconfined aquifer.

Data Need Description: The RUM unit is currently considered an aquitard. The integrity of the aquitard unit and potential transport within the aquitard have not been evaluated in the 100-BC Decision Unit. Contaminants in the unconfined aquifer in the 100-BC Decision Unit remain above the DWS or standards for protection of aquatic receptors. Only one well has been installed beneath the upper aquifer to define the vertical extent of contamination. Low levels of groundwater contaminants (e.g., CrVI) have been detected in this well, but not at levels exceeding cleanup standards since 1997.

The one well installed and sampled beneath the unconfined aquifer in the 100-B/C Area is located in the downgradient portions of the CrVI, Sr-90, and the northern tritium plume.

Groundwater from the RUM may discharge to aquatic receptors or to an aquifer that will be used as a drinking water resource in the future. Because the RUM as an aquitard has not been evaluated in the 100-BC Decision Unit, additional data collection is proposed to evaluate contamination in the RUM, hydrogeologic characteristics of the RUM, and evaluate contaminant fate and transport.

Samples from the RUM will be collected from the five new proposed wells (wells 1, 2, 3, and 5, Figure 4-18 proposed for data need 5), and well 4 proposed for data need 9. The four new wells that are being installed per SAP DOE/RL-2009-61 (wells C7505, C7506, C7507, and C7508, Figure 4-18), will also be sampled.

During the drilling of each of the four proposed new wells:

1. Water samples should be collected to determine the variability of contamination through the unconfined aquifer and in any water-producing unit found within the upper portion RUM.

2. Soil samples (split spoons) should be collected above the unconfined aquifer, within the unconfined aquifer, above the RUM, immediately on penetrating the RUM, and at total depth of approximately 1.5 m (5 ft) below the top of the RUM, and to 15 m (50 ft) into the RUM in well R1.

Soil samples within the RUM should be analyzed for physical, chemical, and hydraulic properties and the presence and leachability of contamination. DOE/RL-2009-44 provides details of sampling and analyses requirements for the groundwater and soil samples collected during drilling.

Data Need 8: Update bathymetric data for the river within the 100-BC Decision Unit 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 beneath the unconfined aquifer), 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 the 100-BC Decision Unit have been collected, but not yet evaluated. Preliminary evaluation of the top of the RUM surface using near-river wells indicates the top of the RUM does not intersect the Columbia River; therefore, no new data collection is proposed for the area. However, the existing data should be evaluated to better define the river bathymetry.

Data Need 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. A wide range of mixing ratios has been observed (SGW-39305) 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 measurement is taken. The current near-shore dilution attenuation factor is 2. Proposed Tri-Party Agreement milestones under negotiation indicate compliance with cleanup standards in the hyporheic zone will be required, thus more data from near-shore wells and aquifer tubes will be gathered to quantify groundwater-river water mixing behavior, addressing this uncertainty in establishing remediation goals.

Scenarios for plume discharge to the river vary widely because of seasonality and dynamic conditions in the zone of interaction. 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 adequately understand the features and transport processes associated with the zone of interaction, their impact to aquatic receptors, and to support remedy decisions.

Two characterization wells (wells 4 and R1, Figure 4-17) are proposed for installation near the river to address this data need. The wells will be installed near aquifer tubes AT-B-3D, M, and S. Soil samples (split spoons) should be collected above the unconfined aquifer, within the unconfined aquifer, above the RUM, immediately on penetrating the RUM, and at total depth of approximately 1.5 m (15 ft) for well 4 and 15 m (50 ft) below the top of the RUM for well R1. Groundwater samples will be collected from the unconfined aquifer and the RUM (if sufficient water is available for sampling). Details of the sampling are found in the SAP (DOE/RL-2009-44).

Sample groundwater from the aquifer tubes AT-B-3-D, M, S, and proposed wells 4 and R1. Sample groundwater from aquifer tubes AT-06-D, M, S, and wells 199-B2-12 and 199-B3-47.

Data Gap 10: Collect soil and water samples from the (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. Multiple hypotheses have been proposed to explain the persistent nature of CrVI and Sr-90 found in groundwater.

An uncertainty exists as to whether persistent inland CrVI in groundwater is the result of the following.

- Continuing vadose zone sources from beneath waste sites
- Vadose zone contamination (mass) within the periodically rewetted zone
- Contamination within the unconfined aquifer
- Contamination within or even below the RUM
- A combination of some or all of the above.

The periodically rewetted zone is the area in which the water level in a well fluctuates throughout the year. Adjacent to the 100-BC Decision Unit, river stage changes relatively rapidly on various time scales (e.g., hourly, daily, and seasonally). Groundwater levels in the upper aquifer and the RUM respond to changes in river stage. The water table in the aquifer responds to changing river stage up to several hundred meters inland, including areas where the highest CrVI concentrations have been detected in the 100-BC Decision Unit. During high river stage and, therefore, high groundwater table, contaminants such as CrVI suspended in the periodically rewetted zone can be remobilized to groundwater at unknown rates and concentrations, which may be a continuing source of the relatively high concentrations of chromium observed in groundwater. Conversely, during low river stage, contaminants in groundwater are left suspended on the soil matrix and are dissolved within residual soil moisture.

Sampling from six wells (described in DATA NEEDS 5 and 9) are proposed to address this need. Soil data will be collected and analyzed for leachable chromium from the following locations:

- Above the unconfined aquifer
- Within the aquifer
- Above the RUM

- Immediately on entering the RUM
- Within the RUM.

Well locations can be found in Figure 4-17 and the details of the sampling plan can be found in the SAP (DOE/RL-2009-44).

Data Need 11: Potential groundwater remedial technologies

Data Need Description: Groundwater contamination above aquatic standards and drinking water maximum contaminant levels (MCLs) has been detected in the 100-BC Decision Unit. No interim remedial actions. are currently in operation. Remedy and remedial technology comparisons are needed to support the FS.

The current RI will use the data collected during this RI (e.g., soil physical properties) for comparison of remedial alternatives, and evaluate information from other remedial technology evaluations from other 100 Area OUs necessary for comparison of potential final remedies as part of the future project FS. The RI/FS will also evaluate data and information from treatability tests including the planned in situ treatability test for CrVI at the 100-C-7 Waste Site. Data and information are needed for comparison of potential final remedies as part of the future project FS.

Groundwater contamination (e.g., Sr-90) has been detected at concentrations above the aquatic and drinking water cleanup standards in the 100-BC Decision Unit. Mitigating exposure to environmental receptors from contaminated groundwater is a critical element of the remedial action.

As part of the RI/FS 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 RI. The project expectation is that the aquifer will be returned to highest 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.

A list of remedial technologies that are applicable to the 100-BC Decision Unit should be generated. Soil samples from new boreholes and wells should be archived so that future analysis on the soil could be performed to support specific data needed for technology and remedy comparison. Data collected during the RI, including soil physical properties and groundwater data, will be used to support remedy comparisons. In addition, the remedial process optimization activity for the 100-D/H Decision Unit has evaluated potentially applicable remediation technologies for CrVI. Evaluations related to Sr-90 and tritium have been completed for the 100-NR-2 and the 200-ZP-1 Groundwater OUs. These evaluations will be used during preparation of the 100-BC Decision Unit FS.

Data Need 12: Insufficient data are available to assess the physical and hydraulic properties of soil and confirm contaminant distribution coefficients to support modeling and analysis.

Data Need Description: On selected soil samples, estimate soil properties and hydraulic properties, determine level of contamination and perform batch leach contacting test. The contaminant distribution coefficient of CrVI and other contaminants considered key risk drivers should be verified to support assessments of contaminant fate and transport in the environment. Specific field values for soil properties are needed to support input parameters for fate and transport calculations and modeling. Collect soil samples from new boreholes and wells for determination of porosity, density, pH, and hydraulic conductivity, grain size distribution, bulk density, and moisture content. Samples will be collected from boreholes specified in Data Need 1 and groundwater wells identified in Data Needs 5 and 9.

Efforts to assess the fate and transport of CrVI in the vadose zone have been performed in the 100 Area. The fate and transport of CrVI in the environment is largely dependent on the effluent volume discharge and its contaminant distribution coefficient.

CrVI typically has a very low contaminant distribution coefficient. Thus, the contaminant moves in the vadose zone at a similar rate as the effluent discharged to the soil column. Studies also indicate this constituent can be retarded in the environment, depending on the source of the contaminant and available iron. The contaminant distribution coefficient of CrVI should be verified to support assessments of contaminant fate and transport in the environment. In addition, the distribution coefficients of the final COPCs should be evaluated.

Specific data requirements:

- Batch leach contacting tests will be performed on soil and aquifer sediment samples and analyzed for pH, conductivity, metals, and other contaminants of interest to evaluate contaminant mobility.
- Soil samples should be collected during the drilling of boreholes defined in Data Need 1 and wells identified in Data Needs 5 and 9.
- Five samples shall be collected from each borehole/well.
- Soil samples should generally be collected for chemical analysis within the sample intervals.

Estimate soil and hydraulic properties necessary for modeling on soil samples (split spoons) collected during drilling.

Data needed for modeling include:

1. Unsaturated soils
    a. Moisture content
    b. Grain size distribution
    c. Bulk density
    d. Porosity
2. Saturated soils
    a. Grain size distribution
    b. Bulk density
    c. Porosity
    d. Saturated hydraulic conductivity

Soil data will also be analyzed for chemical and radiological contamination and leachability of contamination. DOE/RL-2009-44 contains a detailed description of the analyses planned.

Data needs specific to risk assessment 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). The relationship of the data needs to the data gaps presented in the CSM is provided in Table 4-10.

***Data Need 13*:** Collect and analyze groundwater samples from 20 groundwater monitoring wells in the 100-BC Decision Unit.

Data Need Description: Groundwater data are needed that is spatially representative of a decision unit, representative of river stage influence, and inclusive of all COPCs. Groundwater samples will be

collected that chemically, spatially, and temporally represent the groundwater decision unit. Twenty monitoring wells, including 16 existing monitoring wells (Figure 4-19) and four new wells to be installed per SAP DOE/RL-2009-61 (Wells C7505, C7506, C7507, and C7508 Figure 4-18) will be sampled and analyzed for this purpose. Details of the SAP are found in DOE/RL-2009-44.

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5 Project Schedule

Figure 5-1 is the project schedule for activities discussed in this addendum. 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 the work plan. 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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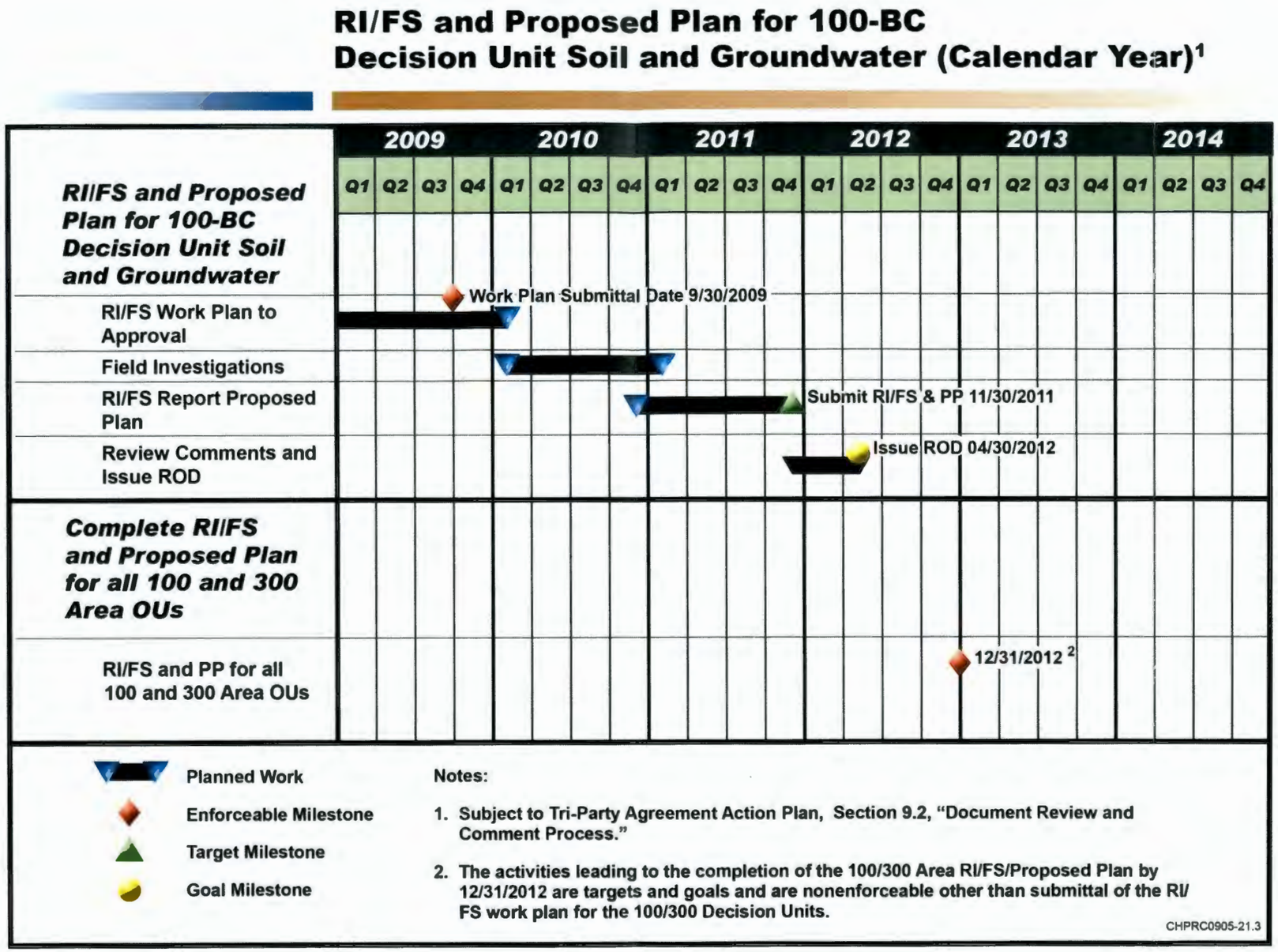

Figure 5-1. 100-BC Decision Unit Project Schedule

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Appendix A

100-B/C Decision Unit Conceptual Site Model Component Plates

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A1 Introduction

The plates for the 100-BC Decision Unit, used to solicit input from regulators, agencies, and subject matter experts, are provided here.

The original intent of the plates was to foster discussion during the Systematic Planning Process to identify uncertainties for the 100-BC Decision Unit and guide development of the work plan. The plates were used to capture discussions and decisions made during this process. The uncertainties, data gaps, and data needs were used to develop the scope for activities that are presented within this addendum.

A2 References

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PROBLEM STATEMENT

- Although most facilities and waste sites have been removed from the 100-B/C Decision Unit, active and remaining facilities/sites may be sources of contamination and /or provide pathways to groundwater.
- Residual hazardous and radioactive wastes generated during production are contained within the 100-B/C Decision Unit and have contributed to groundwater contamination, which has impacted the river.

DESCRIPTION

- The primary mission of both the B Reactor and C Reactor was the production of plutonium, which generated hazardous and radioactive waste. Legacy waste disposal practices and inadvertent material releases impacted 100-B/C Decision Unit soil and groundwater (Exhibit 1).
- The Hanford Site's Export Water System main reservoir is located at the 182-B Reservoir.

100-B/C DECISION UNIT LIFECYCLE

- The design, operation, and waste management processes at the B Reactor were the first-of-a-kind in practice. They represented the basis for subsequent reactor design and conduct of operations, especially with regard to working with radioactive/contaminated materials during production and managing wastes from these processes.
- The 100-B/C Decision Unit lifecycle can be categorized into distinct eras that are defined by different conditions and processes that affected contaminant fate and transport. Changes to radiological release requirements, facility and waste site conditions, and analytical instrument sensitivities during these times have impacted decisions regarding various operational and cleanup actions.
  - Production activities included reactor construction and operations (B Reactor from 1943 to 1968; C Reactor from 1952 to 1969).
  - D4 activities were conducted from 1968 to 1989.
  - Post-Tri-Party Agreement (Ecology et al., 1989) Cleanup activities were implemented from 1989 to 2005, including reactor and support facility decommissioning and demolition. As a result, much of the solid waste disposed to the 100-B/C Decision Unit was removed, reducing potential contamination sources and risk to the environment.
  - Restoration activities (including further source removal), started in 2005, continue under the Tri-Party Agreement (Ecology et al., 1989).

EXHIBIT 1 - 100-B/C DECISION UNIT MAJOR FEATURES BEFORE TERMINATION OF REACTOR OPERATIONS (1966)

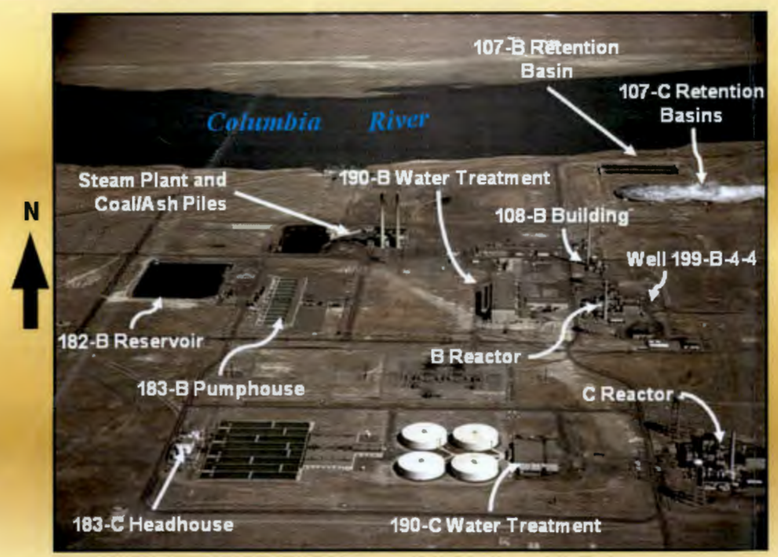

Figure A-1. 100-B/C Decision Unit Process Description and History

B REACTOR-SPECIFIC CHARACTERISTICS AND PROCESSES

- The B Reactor also had a secondary mission to produce tritium, Po-210, radiolanthanum, Tm-170, Ir-192, and Np-237 for national defense and prospective commercial uses.
- The 108-B Building originally was used as a chemical pumphouse for water treatment, similar to facilities at the 100-D Area and 100-F Area.
- Around 1948, 108-B water treatment operations were moved to allow this building to serve as a tritium separation facility.
  - Around the same time and in the same fashion, water treatment operations at the 100-D Area and the 100-F Area were moved and changed.
  - Neither the 100-BC Area nor the 100-F Area exhibit the magnitude and persistence of CrVI groundwater contamination observed at the 100-D Area.
- The 107-B Retention Basin provided management of spent reactor coolant generated during production, allowing short-half-life isotopes to decay and thermal cooling to occur before discharge to the Columbia River. This basin chronically leaked during its entire service life.
- In 1959, the 107-B Retention Basin leakage peaked at a loss rate of ~37,843 L (~10,000 gal.) per minute. This degree of leakage was believed to potentially cause subsurface voids beneath inland and shoreline structures, and threaten their structural integrity.
- In 1959, the basin was temporarily taken out of service and was repaired. Leakage was substantially reduced, but the subsurface flow patterns in the area were altered. In 1960, temperatures over 130°F were noted in well 199-B4-4 (~1 km [3 mi] inland).

C REACTOR-SPECIFIC CHARACTERISTICS AND PROCESSES

- The C Reactor was completed several years after the B Reactor, and included several design upgrades to test systemwide changes to reactor operations, especially those focused on increased power levels:
  - Larger nameplate design level (650 MW) and coolant flow capability, increased discharge volumes to closely spaced liquid waste disposal facilities.
  - Irradiated fuel examination facility with discharge to underground waste tanks.
  - The 70 tons (140,000 lbs) of sodium dichromate solution were released at 189-C to the river in 1966. This loss of material resulted in a 24-hour shutdown of municipal water intakes in Richland, Kennewick, and Pasco, while the spill dispersed.

NATIONAL HERITAGE STATUS OF B REACTOR

- In 2008, the B Reactor was designated as a U.S. National Historic Landmark. This designation will expand opportunities for visitors to learn about and reflect on the contribution made by Hanford and the Tri-Cities during World War II and the Cold War. A Museum is planned, which will house collections for inspiration, education, and enjoyment, and will safeguard and make accessible artifacts and specimens to be held in trust for society. An Interpretive Center is proposed for the City of Richland to become a transition point for visitors, providing the necessary facilities to house artifacts and displays related to the B Reactor, Hanford, and the Hanford Reach National Monument.

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PROBLEM STATEMENT

- Operation of the B and C Reactors produced radioactive and hazardous liquids and solid wastes in and around the 100-B/C Decision Unit facilities.
- Inactive, active, and demolished facilities may have historically contributed to vadose and groundwater contamination in the 100-B/C Decision Unit.
- Active and remaining facilities may continue to contribute to vadose and groundwater contamination in the future.
- Past operations, disposal practices, spills, and unplanned releases from facilities have resulted in contamination around structures, underlying soil, and groundwater in the 100-B/C Decision Unit, and the Columbia River.

DECISION UNIT

- Over time, 62 of the 87 facilities identified in the 100-B/C Decision Unit have been demolished, and 16 of the facilities have been removed. Three active and six inactive facilities remain.
- Most pre-Hanford farming structures have also been removed.

FACILITY DESCRIPTION AND PROCESSING

- The B and C Reactor facilities are located in the 100-B/C Decision Unit and were used to produce plutonium for nuclear weapons.
- Construction of the B Reactor began in October 1943, and operations began in 1944.
- The B Reactor was shut down and held in standby from March 1946 to June 1948; after which it was restarted and operated until February 1968, when it was shut down permanently.
- Following ISS activities, the B Reactor was listed on the National Register of Historic Places.
- Construction of the C Reactor began in June 1951, it started operations the next year, and was shut down in 1969.
- The Tri-Parties have determined that hazardous substances in the facilities present a potential threat of release that poses a substantial risk to human health and the environment to the extent that a removal action is warranted.

100-B/C DECISION UNIT FACILITY CERCLA REMOVAL PLAN

- The primary goal of CERCLA removal actions is to minimize or eliminate threats to public health of the environment caused by the presence of hazardous substances.
- Alternatives were considered for conducting a removal action for various facilities at the 100-B/C Decision Unit. In 1997, the remedy selected was to:
  - Decontaminate and demolish 100-B/C Decision Unit ancillary facilities
  - Remove, decontaminate, contain, or encapsulate hazardous substances in publically accessible areas of the B Reactor Facility
  - Provide ISS for the reactors.
- Removal, surveillance, and maintenance activities are established for the B Reactor to minimize or eliminate threats to public health from the environment caused by the presence of hazardous substances DOE/RL-2001-68.
- The C Reactor ISS was completed in 1998. ISS is a robust but temporary measure that will protect the reactor from environmental degradation and limits the spread of surface contamination.

AERIAL VIEW OF INTERIM REMOVAL ACTIONS AT THE 100-B/C DECISION UNIT

Exhibit 1. 100-BC Area Facilities, Before C Reactor ISS.

Exhibit 2. 100-BC Area Facilities.

FACILITY REMOVAL STATUS

Summary Information on the Status of the 100-B/C Decision Unit Facilities

Facilities	No. of Facilities
Active	3
Inactive	6
Demolished	62
Removed	16
Total Facilities	**87**

DATA GAPS

- Select inactive (i.e., 181-B/C, 151-B, and 182 B) and not yet demolished facilities at the 100-B/C Decision Unit may provide a continuing driver for vadose zone and groundwater contamination.
- Insufficient data are available to assess the nature and extent of contamination around the B and C Reactor structures.

Figure A-2. 100-B/C Decision Unit Facilities

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PROBLEM STATEMENT

- Reactor operations associated with discharging effluent to soil, and solid waste management practices have contaminated the vadose zone.
- Soil analytical data indicate that contamination for identified species is present at concentrations greater than cleanup levels at some waste sites.

DESCRIPTION

- A total of 141 waste sites have been identified in the 100-B/C Decision Unit. Not all of them have qualified for remedial action or are part of a waste management area. Almost half (72 sites) of these waste sites have met the regulatory requirements for interim closure, pending establishment of a final ROD (Exhibit 1).
- Results of RESRAD numerical modeling suggest that future groundwater impacts are not anticipated at remediated waste sites (e.g., 118-B-1). These waste sites were reclassified as "interim closed." Data used to categorize "interim closed" waste sites are documented in cleanup verification packages and remaining site verification package.

CONTAMINATION SOURCES

- Contamination sources include the following:
  - Radiological and hazardous liquids were released to soil. Liquid waste sites include retention basins, trenches, cribs, French drains, and pipelines.
  - Low-level, solid radioactive waste associated with reactor operations was buried in solid waste burial grounds.
  - River effluent pipelines were used to transfer reactor cooling water to the Columbia River.
  - Remaining sites include liquid and solid waste sites that received low levels of contaminants, oil spills, burn pits, foundations of previously removed facilities, and septic systems.
  - The risk to direct exposure and groundwater have not been evaluated for unremediated waste.
  - Contaminants that have been detected in groundwater include CrVI, tritium, and Sr-90.

CONTAMINANT DISTRIBUTION CHARACTERISTICS

- The nature and extent of contamination is better characterized to the extent of waste site excavations (e.g., upper part of the vadose zone).
- Waste sites are well characterized to the vertical and lateral extent of remedial excavations. Few data are available for the vadose zone evaluation deeper than the excavations.
- Existing modeling efforts suggest groundwater impacts are not expected at remediated waste sites.
- Few data have been collected where remedial actions are planned.

SUMMARY OF WASTE SITE STATUS

Summary Information on the Status of the 100-B/C Decision Unit Waste Sites

Waste Sites	No. of Sites	
	B/C-1	B/C-2
Interim Closed Out	38	30
No Action	20	4
Accepted (to be remediated)	11	3
Not Accepted	12	7
Discovery	8	2
Closed Out	5	1
Total Sites	**94**	**47**

This summary is current as of February 9, 2009.

DATA GAPS

- Additional data are needed from the vadose zone beneath the base of remedial actions at select waste sites to confirm residual soil contamination is protective of groundwater.
- Data are needed from accepted waste sites to assess the risk for direct exposure and the protection of groundwater.
- Discovery sites associated with the facilities at the 100-B/C Decision Unit require additional evaluation and characterization to determine their potential impact on vadose zone contamination.

EXHIBIT 1. 100-B/C DECISION UNIT WASTE SITES

Map of Waste Sites in the 100-B/C Decision Unit.

Cleanup Activities at the100-B/C Decision Unit.

The 100-C-7 CrVI Waste Site.

Figure A-3. 100-B/C Decision Unit Waste Sites

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PROBLEM STATEMENT

- Final remedial decisions for the 100-B/C Decision Unit will consider how geology and hydrogeology control contaminant fate and transport in the vadose zone and groundwater.
- The technical basis for remedial decisions will require information on numerous characteristics of the subsurface that support an understanding of geologic and hydrogeologic features contributing to the CSM.
- Information needed for remedial selection and design decisions include:
  - The size and properties of the vadose zone
  - The Hanford formation and Ringold Formation properties
  - Variations and fluctuations in hydraulic gradients describing communication between these formations
  - The interaction of groundwater with the Columbia River.

DESCRIPTION

- Fluvial and alluvial processes of deposition and erosion, and structural deformation define the geology and hydrogeology of the 100-B/C Decision Unit. These processes resulted in a sequence of sedimentary strata over a relatively thick series of flood basalt flows interbedded by sedimentary sequences.

GEOLOGY

- The 100-B/C Decision Unit lies on a relatively flat, semi-arid bench south of the Columbia River near the center of the Pasco Basin. Significant topographic features near the 100-B/C Decision Unit include Gable Butte to the south.
- The majority of the 100-B/C Decision Unit lies at ~131 to 149 m (430 to 490 ft) above mean sea level. A steeply eroded embankment drops ~9 m (30 ft) to a river elevation of ~122 m (400 ft).
- The deepest rocks are the basalts (Exhibit 1, basalt patterning) and sedimentary interbeds (Ellensburg Formation, Exhibit 1, pink shading) of the CRBG. The top of the basalt is encountered at ~207 m (681 ft) of depth.
- The sedimentary Ringold Formation (Exhibit 1, purple shading) overlies the CRBG at ~180 m (600 ft) in thickness. This unit is composed of sands, gravels, and paleosol/overbank deposits. The RUM reaches ~35 m (110 ft) in thickness at the 100-B/C Decision Unit.
- The sandy gravels of the Hanford formation (Exhibit 1, brown shading) overlies the Ringold Formation at a thickness of ~17 m (56 ft).
- Undisturbed areas display a thin veneer (less than 3 m [10 ft]) of native Holocene aeolian silt and sand (Exhibit 1, green surface line) and are disrupted by areas of fill (Exhibit 1, green shading).
- The vadose zone includes the entire Hanford formation and the upper portion of the Ringold Unit E (sandy gravel), except near the river, where the Unit E has been eroded. Unit E varies from a near-river thickness of ~6.6 m (21.7 ft) to greater than 30.5 m (100 ft) inland.

HYDROGEOLOGY

- The unconfined aquifer primarily is composed of the Ringold Unit E (Exhibit 1). Below the unconfined aquifer, the Ringold Formation consists of a series of aquitards and water-bearing zones.
- The unconfined aquifer is ~33.5 m (110 ft) thick near the river.
- The RUM's low permeability provides the characteristics needed to define the base of the unconfined aquifer. The RUM is encountered at ~45 m (150 ft) of depth ("Aquitard" in Exhibit 1).
- Groundwater gradients, flow directions, and magnitudes can change hourly to seasonally based on changes in river stage levels that are controlled by the upstream Priest Rapids Dam.
- The water table depth ranges from ~12 m (40 ft) at the northern portions of 100-B/C to ~30 m (100 ft) at its southern margins.
- Groundwater elevations fluctuate over 1.8 m (6 ft) near the river and diminish inland. Groundwater elevations can fluctuate from hourly to daily to seasonally.

GROUNDWATER PROPERTIES AND FLOW

- On average, groundwater flows north within the 100-B/C Decision Unit toward the river. Groundwater contaminants that are migrating toward the river have been detected near reactor waste sites and adjacent to the river at concentrations greater than action levels.
- The average annual groundwater gradient is ~0.0019. Vertical groundwater gradients are not well characterized
- Greater direct response to river stage is observed in deeper wells screened in the first producing horizon just below the top of the RUM than from wells in the unconfined aquifer.
- Permeability is much greater in the Hanford formation than in the Ringold Formation Unit E.

DATA GAPS

- Updated river data are needed to evaluate bathymetric influences on contaminant fate and transport to the river at the 100-B/C Decision Unit.
- The communication between the RUM and the unconfined aquifer have not been quantified at the 100-B/C Decision Unit.

EXHIBIT 1. CONCEPTUAL CROSS SECTION THROUGH THE 100-B/C DECISION UNIT

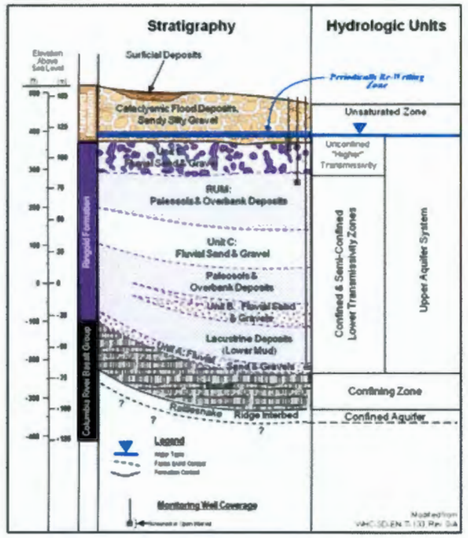

Figure A-4. 100-B/C Decision Unit Geology and Hydrogeology

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PROBLEM STATEMENT

- The technical basis for remedial decisions requires understanding the nature and extent of contamination in the vadose zone and groundwater. These are defined in the 100-B/C Decision Unit by quantifying releases from past on site operations and waste disposal practices, and determining the effect of contaminant fate and transport processes.
- Some flow paths may reach groundwater. Based on the heterogeneous nature of the vadose zone soils (native, fill, and reworked material), contaminant dispersion is anticipated with depth.

DESCRIPTION

- Groundwater contaminants have been detected downgradient of the 116-B/C Crib and the B Reactor Building, in the southwestern portion of the 118-B-1 Burial Ground, and the 100-C-7 Waste Site. Tritium, Sr-90, and chromium plumes have either reached the Columbia River to the north or have remained concentrated in specific areas.
- The Limited Field Investigation (1993) identified Carbon-14, Sr-90, Tc-99, and tritium as risks to human health, and aluminum, chromium, iron, and nickel as risks to ecological receptors. However, no groundwater remedial actions have been implemented at the 100-B/C Decision Unit as part of the Interim Action ROD for the 100-B/C-5 OU.

GROUNDWATER MONITORING

- Groundwater monitoring in the 100-B/C-5 Groundwater interest area includes integrated CERCLA and AEA monitoring.
  - The 25 wells are scheduled for quarterly to biennial sampling.
  - The 14 aquifer tube sites and two seeps are scheduled for annual sampling.
  - The nine new aquifer tubes were installed and sampled in FY 2008; they are scheduled for annual sampling.

TRITIUM – Exhibit 1

- Tritium concentrations have varied widely in some wells (e.g., 199-B5-2) in recent years. Tritium has impacted the upper portion of the unconfined aquifer at concentrations that exceed the 20,000 pCi/L drinking water standard.
- Tritium concentrations exceed the drinking water standard (FY 2008) from the 116-B-5 Crib to the Columbia River shoreline (Exhibit 1).
- Similarly, non-compliant concentrations are observed near the 118-B-1 Burial Ground and in a third plume to the east approximately halfway to the C Reactor (FY 2008). In this same area, tritium was detected in borehole soil at 39,900 pCi/g at approximately 17 m (56 ft) below land surface. However, this concentration dropped three orders of magnitude in another 8 m (26 ft) of depth.
- The drinking water standard for tritium is met in the west-central portion of the 100-B/C Decision Unit.

STRONTIUM-90 – Exhibit 2

- A Sr-90 plume is observed from south of the B Reactor north toward the Columbia River. This plume is spread over an area of ~0.63 km² (0.24 mi²). The plume size and general concentrations have remained relatively stable for several years (Exhibit 2). Concentrations in groundwater wells fluctuate over time.
- In FY 2008, Sr-90 was detected at concentrations greater than the 8 pCi/L drinking water standard) near the 116-C-1 Trench.
- The highest concentrations detected were approximately five times the federal drinking water standard.
- The plume is limited to the upper portions of the unconfined aquifer, where it is monitored quarterly to biennially.

HEXAVALENT CHROMIUM – Exhibit 3

- Chromium concentrations in groundwater do not exceed the drinking water standard of 100 µg/L in groundwater (Exhibit 3) but do exceed the10 µg/L standard for the protection of aquatic receptors in a large portion of the 100-B/C Groundwater Plume, including in aquifer tubes.
- The highest FY 2008 concentration was 64 µg/L (B3-46), downgradient of the 116-B-11 Retention Basin.
- In 2007, in the southern 100-BC Area, chromium was detected in vadose zone soil at the 100-C-7 Waste Site and may have reached groundwater. Concentrations of CrVI in an adjacent well were as high as 49 µg/L in FY2008. Chromium contamination was also detected at the 100-B-27 Waste Site. Further exploration in this area is anticipated.
- DOE plans to collect groundwater upwelling data within the river.

DATA GAPS

- Additional groundwater monitoring wells may be needed to define the extent of groundwater contamination relative to:
  - CrVI downgradient of 100-B-27
  - Potential groundwater mounding and contaminant plumes downgradient of the182-B Reservoir
  - Central 100-BC Area CrVI and tritium
  - Possible contamination adjacent to the 118-B-1 Waste Site, pending exploration results in the central 100-BC Area
  - Potential effluent piping leaks downgradient of the C Reactor.
- Additional spatial and temporal data for the groundwater COPCs are needed from existing groundwater monitoring wells.
- Additional soil physical parameter measurements are needed to support vadose zone and groundwater fate and transport evaluations.

GROUNDWATER CONTAMINANT DISTRIBUTION

Exhibit 1. Average Tritium Concentrations in the 100-BC Area, Top of Unconfined Aquifer.

Exhibit 2. Average Sr-90 Concentrations in the 100-BC Area, Top of Unconfined Aquifer.

Exhibit 3. Average Chromium Concentrations in the 100-BC Area, Top of Unconfined Aquifer.

Figure A-5. 100-B/C Decision Unit Contamination Nature and Extent

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PROBLEM STATEMENT

- Contaminants remaining in the vadose zone may migrate to groundwater and from there to the Columbia River. Evaluations of contaminant fate and transport through the 18 to 24 m (60 to 80 ft) thick vadose zone can be used to describe influences of small-scale heterogeneities, site-specific transport parameters, and groundwater/river interaction, and identify associated geochemistry issues (such as for Sr-90).
- No vadose zone sources have been identified for mobile contaminants (e.g., CrVI) that continue to be present since liquid discharges ceased in the late 1960s, and natural recharge has been the principal source of groundwater since then.

DESCRIPTION

- Standard CSM approaches are described using available data that identified mechanisms that explain contamination fate and transport.
- Contamination such as CrVI is expected to be transported from vadose zone sources (e.g., waste sites) through preferential flow paths.
- The transport of contaminants through soil and groundwater pose potential risks to human and ecological receptors.

CONTAMINATION SOURCES AND TRANSPORT MECHANISMS

- Contamination sources arose from the planned and/or unplanned discharge of liquid effluent to the surface and subsurface via temporary surface impoundments (e.g., cribs and ditches) and through solid waste burial. Contaminant sources and transport mechanisms include:
  - Mobilization of contaminants in the periodically re-wetting zone
  - Re-suspension and/or dispersion of contaminated soils via wind or excavation activities
  - Migration of contaminated liquids through the soil column via infiltration or percolation from a discharge point/area, via infiltration of precipitation
  - Migration of contaminated groundwater off site and to the river
  - Biomechanical (biological) transport.

GEOCHEMISTRY

- Aquifer background geochemistry is important to describe the interaction of aquifer sediments, groundwater, and river water. The groundwater background conceptual model identifies the significance of relationships between various media (i.e., rock, water, and air), water composition, residence time of water in the aquifer, vertical mixing within the aquifer, and microbial processes.
- Extended contact with sediments during transport to the deep vadose zone will significantly affect the contaminant geochemistry in the deep vadose zone.

GROUNDWATER FLOW – Exhibit 1

- Groundwater enters the 100-B/C Decision Unit primarily from the west (A), where the Columbia River provides partial recharge to groundwater, and from Gable Butte (B) and Gable Gap (C).
- Groundwater flows northward from the reactor areas (D) toward the Columbia River, with some discharge occurring at seeps and springs along the shoreline. During high river stage, recharge occurs from the Columbia River, as indicated by a much shallower gradient and reversed flow direction (E).
- Major contributors to groundwater recharge are from seasonal and episodic meteoric events (i.e., rapid snowmelts), lateral flow of unconfined groundwater from elsewhere at the Hanford, Site and fluctuating river stage.
- The discharge rate of contaminants to the river is controlled by hydraulic gradients, aquifer transmissivity, and river stage.
- Groundwater mounding from past liquid disposal has influenced groundwater flow and contaminant transport. Possible leakage from the 182-B Reservoir may also have contributed water to the vadose zone. These conditions potentially affect contaminant migration through the vadose zone and groundwater, similar to conditions observed at the 182-D Reservoir.

RIVER STAGE

- Priest Rapids Dam directly controls river stage fluctuations. River stage varies ~3 m (10 ft) during the year and affects the near-river gradient up to two orders of magnitude. River stage fluctuations hourly to daily, and seasonally.
- Groundwater flow directions and gradients are highly dependent on river-stage, with greater effects near the river and diminishing effects up to several hundred meters from the shoreline. These gradients affect both the short-term and long-term movement of contaminants to the river.
- While the long-term net transport of contaminants in groundwater is toward the river, during high river stage, groundwater movement toward the river is impeded or reversed, as river water infiltrates the near-river groundwater as bank storage. During relatively high conditions, groundwater contaminants are displaced inland by river water, and contaminant discharge to the river is reduced.

DATA GAPS

- The groundwater sampling network may not be sufficient to detect groundwater contamination downgradient of potential sources at the 100-B/C Decision Unit.
- The rate of exchange between the groundwater and the river is not known.

EXHIBIT 1. GROUNDWATER FLOW DIRECTION AT THE 100-B/C DECISION UNIT

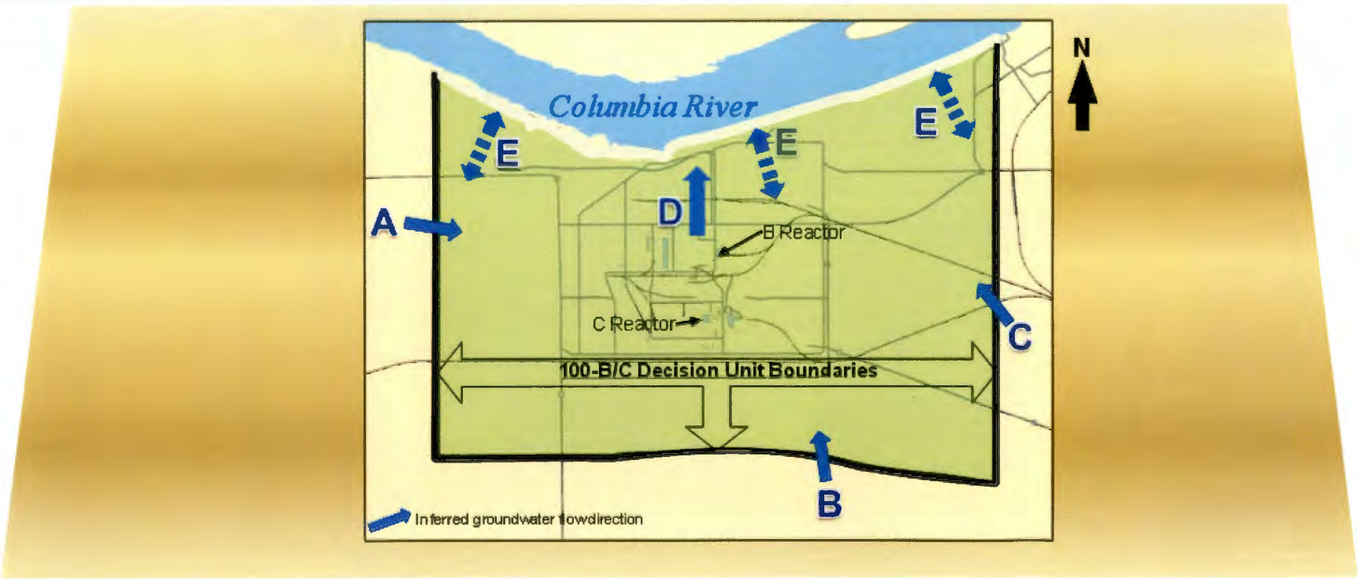

Figure A-6. 100-B/C Decision Unit Contamination Fate and Transport

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Appendix B

100-BC Area and 100-BC-2/BC-6 Operable Unit Maps

(Provided on CD)

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B1 Introduction

Maps showing the facilities and waste sites located in the 100-BC Area and 100-BC-2/BC-6 Operable Unit are provided on CD.

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Appendix C

100-BC Decision Unit Waste Sites Description and History

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C1 Introduction

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

CVP-98-00006, 1999, *Cleanup Verification Package for the 116-C-1 Process Effluent Trench*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D199128695

CVP-98-00009, 2000, *Cleanup Verification Package for the 105-C Reactor Building Below-Grade Structures and Underlying Soils*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8444938

CVP-99-00001, 1999, *Cleanup Verification Package for the 116-B-11 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8354878

CVP-99-00002, 1999, *Cleanup Verification Package for the 116-B-13 South Sludge Trench*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158738

CVP-99-00003, 1999, *Cleanup Verification Package for the 116-B-14 North Sludge Trench*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D199158739

CVP-99-00004, 1999, *Cleanup Verification Package for the 116-C-5 Retention Basin*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8354930

CVP-99-00008, 2000, *Cleanup Verification Package for the 116-B-12 Seal Pit Crib*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8848990

CVP-99-00009, 2000, *Cleanup Verification Package for the 116-B-9 French Drain*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355822

CVP-99-00010, 2000, *Cleanup Verification Package for the 116-B-10 Dry Well/Quench Tank*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355882

CVP-99-00011, 2000, *Cleanup Verification Package for the 116-B-6A Crib and 116-B-16 Fuel Examination Tank*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8373186

CVP-99-00012, 1999, *Cleanup Verification Package for the 116-B-1 Process Effluent Trench*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355511

CVP-99-00013, 2000, *Cleanup Verification Package for the 116-B-3 Pluto Crib*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355764

CVP-99-00014, 2000, *Cleanup Verification Package for the 116-B-4 French Drain*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355775

CVP-99-00015, 2000, *Cleanup Verification Package for the 116-B-2 Fuel Storage Basin Trench*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355726

CVP-99-00017, 2000, *Cleanup Verification Package for the 116-B-6B Crib*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8355810

CVP-99-00019, 2000, *Cleanup Verification Package for the 116-C-2A Pluto Crib, 116-C-2B Pump Station, 116-C-2C Sand Filter, and Overburden Soils from Group 3 Sites at the 100-B/C Area*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D8373207

CVP-2003-00004, 2003, *Cleanup Verification Package for the Landfill 1607-B7 Septic Tank System*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2651846

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CVP-2003-00007, 2003, *Cleanup Verification Package for the Landfill 1607-B10 Septic Tank System*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2696246

CVP-2003-00008, 2003, *Cleanup Verification Package for the Landfill 1607-B11 Septic Tank System*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2696534

CVP-2003-00009, 2003, *Cleanup Verification Package for the 100-C-3, 119-C Sample Building*, Bechtel Hanford, Inc., Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2696922

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-1	Dumping Area	100-BC-2	303 x 296 x 1.86	100-B-1, Surface Chemical and Solid Waste Dumping Area, Laydown Yard	Interim Closed Out	WSRF-2006-003	6/9/2003	5/12/2005	51,099	4	bis(2-Ethylhexyl)phthalate	0.045	\	0.045	\
											Di-n-butylphthalate	0.024	\	0.024	\
											Diethylphthalate	0.048	\	0.048	\
100-B-2	Trench	100-BC-1	70.1 x 6.1 x 3.05	The site is a trench that was constructed to receive backwash filter backflush from the 181-B Pumphouse. Based on the review of the historical data and facility information, no sampling is necessary to confirm the status of this site because the vertical thimble that was buried in 1952 was removed before 1956, and contamination remaining in the excavation when the thimble was removed was short-lived radionuclides (less than 5.27 years). After 10 half-lives have elapsed, a radionuclide is considered to have decayed away. The geophysics over a large area, including the site, showed no evidence of a remaining buried thimble or the conclusive location of an old burial site.	No Action	WSRF-2003-101	N/A								
100-B-3	Burial Ground	100-BC-1	Not Documented	The site was described as a trench where a highly radioactive vertical control thimble was buried. No sampling was necessary to confirm the status of this site because original documentation explained that the vertical thimble was buried in 1952 and removed before 1956. Also, the contamination remaining in the excavation when the thimble was removed was short-lived radionuclides, all with half-lives of less than 5.27 years.	No Action	WSRF-2003-008	N/A								
100-B-4	Spoils Pile/Berm	100-BC-1	8.5 x 13.1 x 0.3	The site was possibly associated with farming or some type of military activity. The authors of the 100B Technical Baseline Report believe the site may be the remains of a building foundation.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-5	Trench	100-BC-1	30.5 x 3 x 3	The site was the result of leakage that occurred at a junction box. The site was believed to be located east of the 105-B Reactor Building, west of the 100-C Reactor effluent pipeline, north of the 100-B Reactor effluent crosstie pipeline, and north of the junction box where the east-west 100-B Effluent Pipeline joined the north-south 100-C Effluent Pipeline. The junction box (part of site 100-C-6, 100-C Reactor Cooling Water Effluent Underground Pipelines, but pertinent to this site) was a concrete structure. Two sides of the structure were double-walled, providing the structure with two chambers.	Interim Closed Out	CVP-2003-00014	May-03	May-03	16,320	8.5	Americium-241	0.168	0.332	0.15	0.452
											Cesium-137	0.15 U	22.4	0.0507	20.3
											Cobalt-60	0.1 U	1.46	0.0457	1.5
											Europium-152	0.25 U	15.3	0.102	14.8
											Europium-154	0.37 U	1.44	0.136	1.38
											Europium-155	0.25 U	0.61 U	0.103	0.292
											Plutonium-238	0 U	0.264	0.0291	0.233
											Plutonium-239/240	0.352	3.4	0.0954	3.08
											Strontium-90	0.034 U	1.93	-0.00252	1.86
											Uranium-238	0.804	0.749	0.616	0.732
											Lead	9.4	8.2	8.2	8.4
											Mercury	0.02	5	0.02	4.5
											Chromium	15	300	13	280
											Chromium VI	0.43 U	1.9	0.43	1.8
100-B-7	Product Piping	100-BC-1	Not Documented	The site encompasses the clean water upstream pipelines for the 100-B Area, including underground pipelines used to transport raw, fire, export, and sanitary water from the river pumphouse to the water treatment facilities and to 100-B Area facilities and fire hydrants. The 100-B Service Water Pipelines pumped reactor cooling water from the Columbia River; the water was settled and treated to remove minerals, and pumped to the reactor core at a rate of 1.93E+05 L (51,000 gal.) to 2.69E+05 L (71,000 gal.) per minute.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								
100-B-8	Radioactive Process Sewer	100-BC-1	See subsites	The site encompassed the underground 100-B Reactor Cooling Water Effluent Pipelines. These included the effluent pipelines that transported 118-B-8 (105-B Reactor) cooling water from the reactor core to the 116-B-11 (107-B) Retention Basin, and from the basin to the 116-B-7 (1904-B) Outfall Structure.	Interim Closed Out	See subsites	See subsites								

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-8:1	Radioactive Process Sewer	100-BC-1	466.9	This subsite includes the underground effluent pipelines surrounding the 105-B Reactor (excluding a 7.6 m [25 ft] buffer zone) of the reactor foundation, and running north from the reactor to B Avenue.	Interim Closed Out	CVP-2003-00022	9/9/2002	11/7/2003	79,339	8.5	Americium-241	0.229 U	0.442	0.0342	0.183
											Cesium-137	1.15	20.7	0.188	8.95
											Cobalt-60	0.085 U	0.308	0.0189	0.12
											Europium-152	0.854	5.03	0.1	2.09
											Europium-154	0.28 U	0.354	0.0617	0.152
											Europium-155	0.17 U	0.18 U	0.051	0.0599
											Plutonium-238	0.064 U	0.071 U	0.0126	0.0198
											Plutonium-239/240	0.037	0.745	0.0178	0.36
											Strontium-90	0.316	3.5	0.0218	2.12
											Uranium-238	1	0.877	0.546	0.556
											Lead	250	12	22	7.3
											Mercury	0.33	0.51	0.33	0.18
											Chromium	46.5	94.7	15.9	53.6
											Chromium VI	0.36	1.1	1.3	0.95
100-B-8:2	Radioactive Process Sewer	100-BC-1	2791.47	This subsite includes the 105-B Reactor Effluent Pipelines from B Avenue north to the 116-B-11 Trench, the pipelines from the 116-B-11 Trench to the 116-B-7 Outfall, and the east-west connecting pipeline from 100-B-8:2 to the diversion box for the 100-C-6 Pipelines, which is just south of the 116-C-5 Retention Basins. It also includes the pipeline connecting to the 116-C-5 Retention Basin; this pipeline (the part outside of the excavation/ sampling area footprint) was removed as part of the 116-C-5 Remedial Action but not sampled for cleanup verification at that time.	Interim Closed Out	CVP-2003-00019	2/26/2001	2/6/2003	244,656	7.5	Americium-241	0.374 J	1.11	0.0521	0.193
											Cesium-137	4.15	7.94	0.378	7.55
											Cobalt-60	0.174	0.728	0.0335	0.276
											Europium-152	1.83	9.85	0.292	3.19
											Europium-154	0.382	1.28	0.0937	0.449
											Europium-155	0.23 U	0.33 U	0.0549	0.0881
											Plutonium-238	0.081 U	0.128 U	0.0142	0.0392
											Plutonium-239/240	0.359 J	3.12	0.0367	0.567
											Strontium-90	2.67	6.32	0.201	1.7
											Uranium-238	0.943 J	0.733	0.551	0.518
											Lead	15	6	5.4	3.7
											Mercury	0.05	0.17	0.05	0.13
											Chromium	44	140	16	45
											Chromium VI	3.4	3.5	1.8	1.8

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-10	Unplanned Release	100-BC-1	Not Documented	This is not a site where wastes have been disposed or spilled, but was the place where groundwater contaminated from the 116-B-11 Retention Basin exited the riverbank. This spring no longer exists and the precise location is unknown. The groundwater that fed the spring is a separate OU (100-BC-5).	No Action	WSRF-2001-021	N/A								
100-B-11	Storage Tank	100-BC-1	1.2 m^2	The site was a steel pipe structure (caisson) about 1.2 m (4 ft) in diameter and 1.5 m (5 ft) deep with a bottom and a steel plate placed over the top. The site was self-contained without any incoming or outgoing piping. Its original purpose is not known, but it was located just outside of Dryer Room #1 of the 115-B/C Facility. The no-action decision for the 100-B-11 Site is supported based on reviews of site history, field observations, and characterization results. The maximum detected results from underlying soil samples collected at locations suspected of having the greatest potential for residual contamination levels were shown to meet the cleanup objectives for direct exposure, groundwater protection, and river protection.	No Action	WSRF-2004-003	9/2003 (confirmatory samples	N/A	N/A	N/A	Strontium-90	0.247	\	\	\
											Antimony	1.4	\	\	\
											Arsenic	4.9	\	\	\
											Barium	74.4	\	\	\
											Boron	5.7	\	\	\
											Cadmium	0.224	\	\	\
											Chromium	11.6	\	\	\
											Cobalt	8.1	\	\	\
											Copper	20.5	\	\	\
											Lead	11.6	\	\	\
											Manganese	318	\	\	\
											Molybdenum	0.551	\	\	\
											Vanadium	55	\	\	\
											Zinc	65	\	\	\
100-B-12	Storage	100-BC-1	289.59 m^2	The site was a filter box radiological materials area with four metal boxes containing filters, resting on shoring that sat on the bare soil. An additional six filter frames, marked as having fixed contamination, rested directly on the soil. These came from the 100-N Area in the 1980s. The basis for reclassification was the disposal of all contaminated filter frames at the ERDF. Because the frames were solid waste, no releases to the soil were expected. A radiation survey was completed at the site after the frames were removed to document that the radiological materials area could be downposted; the survey results met the requirement for downposting a radiological materials area.	Interim Closed Out	WSRF-2001-016	N/A								

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-14	Process Sewer	100-BC-1	See Subsites	The 100-B-14 Waste Site, in its entirety, which encompasses the underground process pipelines and process and sanitary sewers associated with the 100-B Area Pre-Reactor Cooling Water Treatment Facilities. For confirmatory sampling efforts, the 100-B-14 Site was administratively divided into seven subsites. The seven subsites are as follows: • 100-B-14:1 Main Process Sewer Collection Pipeline • 100-B-14:2 Sanitary Sewer Pipelines • 100-B-14:3 West Process Sewer Feeder Lines (182-B and 183-B) • 100-B-14:4 190-B/105-B Cooling Water Tunnel Pipelines • 100-B-14:5 Sodium Dichromate And Sodium Silicate Pipelines • 100-B-14:6 184-B Powerhouse Pipelines • 100-B-14:7 185-B/190-B Sump And Process Sewer Pipelines.	Interim Closed Out	See subsites	See subsites								
100-B-14:1	Process Sewer	100-BC-1	1599.53	Main Process Sewer Collection Pipeline.	Interim Closed Out	WSRF-2004-005	Jan-05	Sep-06	Not Documented	7.6	Carbon-14	258	1.1 U	0.16	0.49
											Cesium-137	0.061	0.23	0.159	0.493
											Cobalt-60	0.061 U	0.050 U	0.021	0.018
											Europium-152	0.15 U	0.13 U	0.044	0.042
											Europium-154	0.46 U	0.16 U	0.07	0.057
											Europium-155	0.21 U	0.16 U	0.06	0.053
											Tritium	0.721 U	0.0183 U	\	0.83
											Chromium VI	2.6	0.350 U	0.91	0.21
100-B-14:2	Process Sewer	100-BC-1	1389.52	115-B Gas Recirculation Sanitary Sewer Pipelines.	Interim Closed Out	WSRF-2006-055	Jan-05	Jul-06	Not Documented	2.5		Area 2 (Shallow)	Area 5 (Shallow)	Area 4 (Shallow)	
											Cesium-137	0.107	\	0.107	\
											Strontium-90	0.311	2.1	0.181	\
											Tritium	0.151 U	0.296	\	\
											Antimony	0.5 UJ	0.47	0.64	\
											Arsenic	7.5	3.8	4.1	\
											Barium	998	141	163	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Beryllium	0.5	0.55	0.5	\
											Boron	5	3.6	4.7	\
											Cadmium	1.5	0.21	0.43	\
											Chromium	67.8	12.8	11.2	\
											Chromium VI	0.74	0.98	0.74	\
											Cobalt	8.8	9.2	8.5	\
											Copper	102	18.1	34	\
											Lead	279	26.1	27.1	\
											Manganese	388	351	362	\
											Mercury	7.2	0.47	0.47	\
											Molybdenum	1.7	0.6	0.8	\
											Nickel	34	12.5	15.8	\
											Strontium	118	57.1	57	\
											Tin	13.5	1.3	1.3	\
											Titanium	1860	1490	1637	\
											Vanadium	53.6	47.4	48.6	\
											Zinc	223	49.6	82	\
											Aroclor-1254	0.33	0.0062	0.33	\
											Aroclor-1260	0.0067	0.011	0.0067	\
											bis(2-Ethylhexyl)phthalate	1.6	1.1	1.6	\
											2-Methylnaphthalene	0.034	\	0.034	\
											Chrysene	1.1	0.26	1.1	\
											Di-n-butylphthalate	0.07	0.08	0.07	\
											Diethylphthalate	\	0.018	\	\
											Di-n-octylphthalate	0.095	\	0.095	\
											Dibenz(a,h)anthracene	0.66	\	0.66	\
											Dibenzofuran	0.082	\	0.082	\
											Fluoranthene	10.4	0.032	10.4	\
											Fluorene	0.13	\	0.13	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Indeno(1,2,3-cd)pyrene	0.9	0.087	0.9	\
											Naphthalene	0.055	\	0.055	\
											Phenanthrene	3	0.42	3	\
											Pyrene	9.1	0.71	9.1	\
											Phenol	0.017	0.027	0.017	\
											alpha-Chlordane	0.00087	\	0.00087	\
											alpha-BHC	\	0.002	\	\
											beta-BHC	0.0019	0.0043	0.0019	\
											4,4'-DDD	0.0021	\	0.0021	\
											4,4'-DDE	0.018	0.00044	0.018	\
											4,4'-DDT	0.017	0.016	0.017	\
											Dieldrin	\	0.0007	\	\
											Endosulfan I	0.0069	\	0.0069	\
											Endosulfan II	0.0034	\	0.0034	\
											Endosulfan sulfate	0.0033	\	0.0033	\
											Endrin	0.0013	\	0.0013	\
											Endrin aldehyde	0.0074	0.0022	0.0074	\
											Endrin ketone	0.0011	\	0.0011	\
											Heptachlor epoxide	0.0006	\	0.0006	\
											gamma-Chlordane	0.0013	\	0.0013	\
											Methoxychlor	0.049	\	0.049	\
											Anthracene	\	0.39	\	\
											Benzo(a)anthracene	1.2	1.6	1.2	\
											Benzo(a)pyrene	1.1	1.5	1.1	\
											Benzo(b)fluoranthene	0.8	1.3	0.8	\
											Benzo(g,h,i)perylene	0.8	1.2	0.8	\
											Benzo(k)fluoranthene	0.9	1.3	0.9	\
											Carbazole	0.25	\	0.25	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-14:3	Process Sewer	100-BC-1	1227.37	Process Sewer Feeder Pipelines from 182-B and 183-B, West Process Sewer Pipelines. The sample results demonstrated that the subsite has achieved the RAOs and remedial action goals.	No Action	WSRF-2004-007	10/2003 (confirmatory samples)	N/A	N/A	N/A	Arsenic	2.4	\	\	\
											Barium	59.8	\	\	\
											Beryllium	0.31	\	\	\
											Boron	1.4	\	\	\
											Chromium	5.6	\	\	\
											Chromium VI	0.42	\	\	\
											Cobalt	9.9	\	\	\
											Copper	15.1	\	\	\
											Lead	3.9	\	\	\
											Manganese	355	\	\	\
											Mercury	0.01	\	\	\
											Molybdenum	0.53	\	\	\
											Nickel	8.5	\	\	\
											Silver	0.5	\	\	\
											Vanadium	64.4	\	\	\
											Zinc	45.9	\	\	\
											Sulfate	6.2	\	\	\
											bis(2-Ethylhexyl)phthalate	0.046	\	\	\
100-B-14:4	Process Sewer	100-BC-1	365.7	Cooling Water Pipelines and Tunnels from 190-B. The 100-B-14:4 Pipelines were removed and the tunnels collapsed in 1993 during D&D of the 190-B Pumphouse. There is no history of radiological contamination associated with the 100-B Reactor cooling water tunnels and no radiological contamination was detected during decommissioning of the tunnels.	No Action	WSRF-2004-008					Chromium VI	0.18			

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-14:5	Process Sewer	100-BC-1	928.89	Sodium Dichromate and Sodium Silicate Pipelines. The sample results demonstrated that the subsite has achieved the RAOs and remedial action goals.	No Action	WSRF-2004-009	10/2003 (confirmatory samples)	N/A	N/A	N/A	Antimony	0.31	\	\	\
											Arsenic	3.3	\	\	\
											Barium	82.1	\	\	\
											Beryllium	0.36	\	\	\
											Boron	4.4	\	\	\
											Cadmium	0.19	\	\	\
											Chromium	16.5	\	\	\
											Cobalt	9.9	\	\	\
											Copper	17.7	\	\	\
											Lead	7.3	\	\	\
											Manganese	395	\	\	\
											Molybdenum	0.56	\	\	\
											Nickel	11.6	\	\	\
											Silver	0.09	\	\	\
											Vanadium	69.4	\	\	\
											Zinc	76.2	\	\	\
100-B-14:6	Process Sewer	100-BC-1	453.86	Process Sewer Feeder Pipeline from 184-B and 184-B Ash Slurry Line. The waste site evaluation for 184-B Powerhouse Pipelines sample results demonstrated that the site has achieved the RAOs and remedial action goals.	No Action	WSRF-2004-010	2003 (confirmatory samples)	N/A	N/A	N/A	Arsenic	3.8	\	\	\
											Barium	364	\	\	\
											Beryllium	0.47	\	\	\
											Boron	5.8	\	\	\
											Cadmium	0.25	\	\	\
											Chromium	49.1	\	\	\
											Cobalt	9.6	\	\	\
											Copper	16.7	\	\	\
											Lead	10.8	\	\	\
											Manganese	446	\	\	\
											Mercury	1.4	\	\	\
											Molybdenum	0.94	\	\	\
											Nickel	25.1	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Silver	0.09	\	\	\
											Vanadium	53.9	\	\	\
											Zinc	57	\	\	\
100-B-14:7	Process Sewer	100-BC-1	143.92	Process Sewer Feeder Pipeline from 185-B and 190-B. The waste site evaluation for 184-B Powerhouse Pipelines sample results demonstrated that the site has achieved the RAOs and remedial action goals.	No Action	WSRF-2004-011	10/2003 (confirmatory samples)	N/A	N/A	N/A	Antimony	0.79	\	\	\
											Arsenic	5.4	\	\	\
											Barium	128	\	\	\
											Beryllium	0.43	\	\	\
											Boron	5.4	\	\	\
											Cadmium	0.52	\	\	\
											Chromium	25.4	\	\	\
											Cobalt	9.6	\	\	\
											Copper	22.1	\	\	\
											Lead	13.6	\	\	\
											Manganese	408	\	\	\
											Mercury	0.08	\	\	\
											Molybdenum	0.76	\	\	\
											Nickel	22.7	\	\	\
											Zinc	88.3	\	\	\
100-B-15	Radioactive Process Sewer	100-BC-1	643 x 0.01	This site includes the 100-B/C Area river effluent pipelines (river lines) that extend from each of the three outfalls into the main channel of the Columbia River. All three outfall structures have been remediated; however, the river pipelines remain in place.	Accepted	Not Documented	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-16	Dumping Area	100-BC-1	927.52 m^2	The site consisted of four surface piles of debris. The exact history of this site is unknown. The surface debris materials consisted of telephone poles (grouped mostly together) and associated utility debris in piles adjacent to the telephone poles.	Interim Closed Out	WSRF-2005-009	Nov-04	Mar-05	774 BCM	3	Arsenic	3.3	\	\	\
											Barium	226	\	\	\
											Cadmium	0.36	\	\	\
											Chromium	15.4	\	\	\
											Lead	8.7	\	\	\
											Mercury	0.03	\	\	\
											Silver	1.5	\	\	\
											Phenanthrene	0.06	\	\	\
											Fluoranthene	0.15	\	\	\
											Pyrene	0.12	\	\	\
											Chrysene	0.11	\	\	\
											Benzo(b)fluoranthene	0.06	\	\	\
											Benzo(k)fluoranthene	0.05	\	\	\
											Benzo(a)pyrene	0.02	\	\	\
											Benzo(a)anthracene	0.03	\	\	\
											Aroclor-1260	0.02	\	\	\
100-B-17	Dumping Area	100-BC-1	24.38 x 9.14	The site is an old dumping area. The waste is a mixture of material ranging from corrugated transite, fire brick, milk bottles, concrete form fittings, small rebar, pipe fittings, chunks of vitrified clay, nuts, and bolts. The source of the debris is unknown.	Discovery	Not Documented	N/A								
100-B-18	Dumping Area	100-BC-1	30 x 15	The site consists of a debris pile containing miscellaneous demolition waste from the decommissioning activities of the 184-B Power House. Demolition, including the smoke stacks, was completed by 1983. All the above ground structures were removed, leaving the foundation slabs, footprints, tunnels, pits, and other associated concrete structures at or near grade level. During 1988, the foundation and the other below grade features were demolished to at least 0.9 m (3 ft) below grade, backfilled with rubble, and buried in situ.	Interim Closed Out	WSRF-2007-020	Jun-07	Jul-07	70 bank cubic meters	Not documented	Antimony	9.3	\	\	\
											Arsenic	4.1	\	\	\
											Barium	1300	\	\	\
											Beryllium	0.64	\	\	\
											Boron	34.2	\	\	\
											Cadmium	13.2	\	\	\
											Chromium	11.3	\	\	\
											Cobalt	8.2	\	\	\
											Copper	18.9	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Lead	25.3	\	\	\
											Manganese	356	\	\	\
											Mercury	2.2	\	\	\
											Molybdenum	0.96	\	\	\
											Nickel	12.1	\	\	\
											Selenium	0.73	\	\	\
											Vanadium	46.5	\	\	\
											Zinc	77.6	\	\	\
											TPH	194	\	\	\
											Aroclor-1260	0.095	\	\	\
											Acetone	0.018	\	\	\
											Acenapthene	0.17	\	\	\
											Acenaphylene	0.079	\	\	\
											Anthracene	0.55	\	\	\
											Benzo(a)anthracene	0.25	\	\	\
											Benzo(a)pyrene	0.3	\	\	\
											Benzo(b)fluoranthene	0.24	\	\	\
											Benzo(g,h,i)perylene	0.15	\	\	\
											Benzo(k)fluoranthene	0.1	\	\	\
											Chrysene	0.27	\	\	\
											Dibenzo(a,h)anthracene	0.03	\	\	\
											Fluoranthene	0.3	\	\	\
											Fluorene	0.53	\	\	\
											Indeno(1,2,3-cd)pyrene	0.19	\	\	\
											Napthalene	0.44	\	\	\
											Phenanthrene	0.12	\	\	\
											Pyrene	0.51	\	\	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-19	Unplanned Release	100-BC-1	Area 1: 3 x 5 Area 2: 5 m dia. Area 3: 3 x 6 Area 4: 27.20 m dia. Area 5: 13.6 x 4 Area 6: 2 m dia.	The site consists of six areas of disturbed soil with little or no vegetation and/or discoloration. The soil sites have a visible yellow or red-to-purple surface discoloration seen at analogous sites in the locations in the 100 Area. The red-purple staining is possibly garnet grit, which was commonly used in grit-blasting operations to clean the surface of metal components of rust, paint, or contamination. The garnet material itself is not a hazardous substance, but there is a potential for contamination from the surface material that was cleaned by grit blasting. Yellow stains on soil in this area may be due to spills of concentrated sodium dichromate solution CrVI and/or concentrated sulfuric acid used at the water treatment plants for reactor coolant water cleaning and for corrosion control.	Accepted	OSR-2007-0001	N/A								
100-B-20	Maintenance Shop	100-BC-1	16.31 x 12.19 x 5.49	The site is the 1716-B Maintenance Garage Underground Tank. The shop was built in 1944 and provided automotive repair, light vehicle maintenance, and lubrication service for 100- BC Area vehicles (du Pont, 1945) until deactivation of the 105-B Reactor in 1968.	Interim Closed Out	WSRF-2006-019	Jan-06	Jan-06	Not Documented	2.1	Arsenic	2.8	\	\	\
											Barium	72.7	\	\	\
											Beryllium	0.32	\	\	\
											Boron	3.7	\	\	\
											Chromium	12.1	\	\	\
											Cobalt	11.2	\	\	\
											Copper	43.3	\	\	\
											Lead	20.9	\	\	\
											Manganese	354	\	\	\
											Mercury	0.33	\	\	\
											Molybdenum	0.6	\	\	\
											Nickel	10.8	\	\	\
											Selenium	0.44	\	\	\
											Vanadium	53.9	\	\	\
											Zinc	326	\	\	\
											Aroclor-1260	0.0085	\	\	\
											Benzo(a)anthracene	0.029	\	\	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Benzo(a)pyrene	0.032	\	\	\
											Benzo(b)fluoranthene	0.035	\	\	\
											Benzo(g,h,i)perylene	0.023	\	\	\
											Benzo(k)fluoranthene	0.035	\	\	\
											Chrysene	0.031	\	\	\
											Di-n-butylphthalate	0.15	\	\	\
											Fluoranthene	0.043	\	\	\
											Indeno(1,2,3-cd)pyrene	0.021	\	\	\
											Pyrene	0.04	\	\	\
100-B-21	Process Sewer	100-BC-1	See Subsites	The site consists of a variety of underground pipelines uncovered during removal of effluent pipelines and soils. The subsites associated with this site have been separated into like groups of piping.	Accepted	See subsites	See subsites								
100-B-21:1	Process Sewer	100-BC-1	11.47	The site is potentially contaminated soil and two pipeline segments.	No Action	WSRF-2005-052	1/7/2003 (confirmatory samples)	9/24/2003 (confirmatory samples)	N/A	1.5 (depth of samples)	Arsenic	13.9 (<BG)	\	\	\
											Barium	37.8 (<BG)	\	\	\
											Cadmium	0.24 (<BG)	\	\	\
											Chromium	26.4	\	\	\
											Lead	48.4	\	\	\
											Mercury	0.05 (<BG)	\	\	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-21:2	Process Sewer	100-BC-1	1.5 (length) 2.5 cm (diameter)	The subsite is potentially contaminated soil and a pipeline segment. This is an approximately 1.5 m (5 ft) asbestos-wrapped, 2.5 cm (1 in.) metal pipeline protruding from the ground. The history of the 100-B-21:2 Pipeline, before its discovery in 2003, is unknown. The location and orientation of the pipeline suggests that it was associated with the 116-B-11 Retention Basin and discharged to the river embankment. It is smaller than most drain lines, suggesting it was a pressurized water pipe, though the exact purpose remains unknown.	Interim Closed Out	WSRF-2008-003	6/11/2007	6/18/2007	91	0.3		Shallow Soil	Over-burden	Shallow Soil UCL	
											Cesium-137	\	0.048	0.048	\
											Arsenic	7.9	4.8	5.9	\
											Barium	107	89.8	89.4	\
											Beryllium	0.19	0.19	0.19	\
											Boron	2.7	-	2.4	\
											Cadmium	0.31	0.33	0.31	\
											Chromium	19.7	15.8	16	\
											Chromium VI	0.32	0.26	0.26	\
											Cobalt	8.6	8.6	7.9	\
											Copper	24	20.6	20.9	\
											Lead	7.2	6.5	6.3	\
											Manganese	371	363	355	\
											Molybdenum	2.5	0.83	2.5	\
											Nickel	18.3	17.8	16.4	\
											Silver	0.39	-	0.39	\
											Vanadium	59.4	17.8	51	\
											Zinc	48.7	48.7	43.6	\
											Di-n-butylphthalate	0.022	-	0.022	\
											Pyrene	0.021	-	0.021	\
100-B-21:3	Process Sewer	100-BC-1	Not Documented	Asbestos-Wrapped Steel Pipeline	Discovery	Not Documented	N/A								
100-B-21:4	Process Sewer	100-BC-1	91.87	Pipeline from 105-C Reactor East to 116-C-2B Pump	Accepted	Not Documented	N/A								
100-B-22	Dumping Area	100-BC-1	See Subsites	This site consists of the 100-B Area Water Treatment Facilities, soils associated with these facilities, and any remaining piping not already associated with existing sites.	Accepted	See subsites	See subsites								

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-22:1	Process Sewer	100-BC-1	1841.42	Piping between 183-B and 185-B/195-B. The pipelines in this waste site were uncovered during the removal of effluent pipelines and soils. As pipeline removal progressed, an effort was made to photograph, accurately locate, and in some cases perform limited chemical and radiological investigations of the pipelines. The basis for no-action determination was process history, which indicates the only additive to the process water in the pipelines came from the 183-B Facility. Chemicals added at the 183-B Facility included chlorine, sulfuric acid, alum, ferric sulfate, separan (a coagulant), and lime. Trace contamination from the sulfuric acid that was added to adjust the pH of the water, would be diluted in the cooling water. There was no evidence to suggest that the pipelines were ever a source of human-health risk due to the addition of sulfuric acid.	No Action	WSRF-2006-042	N/A								
100-B-22:2	Process Unit/Plant	100-BC-1	Not Documented	Most of 183-B, 185-B, and 195-B Water Treatment Facilities	Accepted	Not Documented	N/A								
100-B-22:3	Process Unit/Plant	100-BC-1	Not Documented	183-B Pump Room	Accepted	Not Documented	N/A								
100-B-23	Dumping Area	100-BC-2	Varies between sites	The 100-13-23 waste site, located in the 100- BC-1 OU of the Hanford Site, consisted of multiple locations of surface debris and chemical stains that were identified in 2004 as part of an Orphan Site Evaluation of the 100-B/C Area.	Interim Closed Out	WSRF-2008-027	Jun-07	Feb-08	680	Varies between sites	Antimony	0.27	\	\	\
											Arsenic	4.4	\	\	\
											Barium	118	\	\	\
											Beryllium	0.45	\	\	\
											Boron	14.1	\	\	\
											Cadmium	1.7	\	\	\
											Chromium	14	\	\	\
											Cobalt	7.7	\	\	\
											Copper	21.6	\	\	\
											Lead	73.8	\	\	\
											Lithium	8.6	\	\	\
											Manganese	352	\	\	\
											Mercury	8.2	\	\	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Molybdenum	0.71	\	\	\
											Nickel	13.6	\	\	\
											Selenium	0.57	\	\	\
											Strontium	25.1	\	\	\
											Tin	3.2	\	\	\
											Vanadium	42.9	\	\	\
											Zinc	1310	\	\	\
											TPH	173	\	\	\
											Aroclor-1254	0.0054	\	\	\
											Aroclor-1260	0.021	\	\	\
											Acenapthene	0.2	\	\	\
											Anthracene	1.9	\	\	\
											Benzo(a)anthracene	0.49	\	\	\
											Benzo(a)pyrene	0.22	\	\	\
											Benzo(b)fluoranthene	0.27	\	\	\
											Benzo(g,h,i)perylene	0.05	\	\	\
											Benzo(k)fluoranthene	0.29	\	\	\
											Bis(2-ethylhexyl)phthalate	0.21	\	\	\
											Butylbenzylphthalate	0.02	\	\	\
											Carbazole	0.37	\	\	\
											Chrysene	1.4	\	\	\
											Di-n-butylphthalate	0.031	\	\	\
											Dibenzo(a,h)anthracene	0.05	\	\	\
											Dibenzofuran	0.22	\	\	\
											Fluoranthene	1.6	\	\	\
											Indeno(1,2,3-cd)pyrene	0.083	\	\	\
											Phenanthrene	2.4	\	\	\
											Pyrene	1.2	\	\	\

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-24	Outfall	100-BC-1	126.19 x 3.66 x 2.7	The 1904-B1 Spillway (Flume) was an alternate discharge point for the 116-B-7 Outfall Structure. The spillway was to have been used for an emergency effluent release or if the river effluent pipelines (100-B-15) were blocked, damaged, or undergoing maintenance. There is no corroborated physical or historical evidence that the spillway was ever used.	No Action	WSRF-2006-051	1/17/2006 (confirmatory samples)	N/A	N/A	N/A	Cesium-137	0.419	\	\	\
											Cobalt-60	0.108	\	\	\
											Europium-152	0.182	\	\	\
											Nickel-63	3.78	\	\	\
											Uranium-233/234	0.713	\	\	\
											Uranium-238	0.479	\	\	\
											Antimony	6.4	\	\	\
											Arsenic	31.6	\	\	\
											Barium	133	\	\	\
											Beryllium	0.59	\	\	\
											Boron	15.1	\	\	\
											Cadmium	0.29	\	\	\
											Chromium	13.8	\	\	\
											Cobalt	10.2	\	\	\
											Copper	38.4	\	\	\
											Lead	14.9	\	\	\
											Manganese	326	\	\	\
											Mercury	0.02	\	\	\
											Molybdenum	1.9	\	\	\
											Nickel	12.1	\	\	\
											Vanadium	52.9	\	\	\
											Zinc	228	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-25	Outfall	100-BC-1	37 x 3.66 x 1.5	The 1904-B2 Spillway was an alternate discharge point for the 132-B-6 Outfall Structure. It was planned to be used only if the 100-B-15 River Effluent Pipelines were blocked, damaged, or undergoing maintenance. The upper portion of the spillway was removed in 2001 as part of remediation of the 132-B-6 Outfall Structure, and the remainder of the spillway and riprap has been backfilled with clean soil. Based on results of the 2002 and 2003 GPERS field radiological survey measurements, the 100-B-25 Site was determined to contain radiological contamination at levels above the remedial action goals. Based on this determination, remedial action was recommended for the site.	Accepted	EPA/ROD/R10-99/039	N/A								
100-B-26	Outfall	100-BC-1	14.2 x 3.05 x 3	The spillway was an alternate discharge point for the 132-C-2 Outfall Structure. It was planned to be used as an alternate for effluent only if the 100-B-15 River Effluent Pipelines were blocked, damaged, or undergoing maintenance. There is no historical information that the spillway was ever used.	No Action	WSRF-2006-052	1/17/2006 (confirmatory samples)	N/A	N/A	N/A	Cesium-137	3.14	\	\	\
											Uranium-233/234	1.44	\	\	\
											Uranium-238	1.18	\	\	\
											Arsenic	5.2	\	\	\
											Barium	84.7	\	\	\
											Beryllium	0.44	\	\	\
											Boron	1.8	\	\	\
											Cadmium	0.5	\	\	\
											Chromium	39.3	\	\	\
											Chromium VI	2	\	\	\
											Cobalt	6.4	\	\	\
											Copper	20.2	\	\	\
											Lead	17.6	\	\	\
											Manganese	262	\	\	\
											Mercury	0.02	\	\	\
											Molybdenum	0.21	\	\	\
											Nickel	16.5	\	\	\
											Selenium	0.51	\	\	\
											Vanadium	33.7	\	\	\
											Zinc	108	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-27	Unplanned Release	100-BC-1	10.67 x 7.62 Depth uncertain	The site is an unplanned release of sodium dichromate that was discovered while removing the western staging pile associated with the cleanup of the 126-B-3 Coal Pit. About 1.2 m (4 ft) of below grade ash was scraped off during the removal of the staging pile. A stained soil area was observed in the middle of the north one-third of the staging pile area. Because the contamination was unrelated to disposal or remediation staging activities at the 126-B-3 Waste Site, and because the extent of contamination was unknown, this area was classified as a new site and subsequently designated as the 100-B-27.	Discovery	EPA/AMD/R10-97/044	N/A								
100-B-28	Product Piping	100-BC-1	600.46 7.6 cm (diameter)	The 183-C to 183-B Sodium Dichromate Transfer Pipeline. Sodium dichromate solids and concentrated solutions were received, stored, and mixed with the reactor cooling water as a corrosion inhibitor for the reactor fuel and piping. Initially, granular sodium dichromate was mixed with water to prepare a 15% weight solution that was metered into the volute of the primary pumps in the 190-B Pump House to provide a 2-ppm concentration of sodium dichromate in the reactor cooling water. Later, the solid sodium dichromate feedstock was replaced with a concentrated (70% by weight) sodium dichromate solution that was metered into the cooling water to produce the 2-ppm concentration of sodium dichromate.	Accepted	Not Documented	N/A								
100-B-29	Dumping Area	100-BC-1	3 (length) 0.15 (diameter)	While excavating 100-B-28 in February 2009, a pipeline was uncovered that matched the pipe remnant lying on the surface. The northwesterly end was jagged metal suggesting that it may have been severed during an excavation.	Discovery	137127, Four Discovery Sites in the 100-B/C Area	N/A								
100-B-30	Product Piping	100-BC-2	4 (length) 0.08 (diameter)	The waste is a single segment of pipe. There is no evidence of staining or any additional pipe or piping systems in the area, and is located in an area of other scattered surface debris outside the 100-BC perimeter fence. The pipe is believed to be surficial debris only.	Discovery	137127, Four Discovery Sites in the 100-B/C Area	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-B-31	Unplanned Release	100-BC-2	134.11 x 121.92 x 0	The site is a garnet sand release. The exact process that caused the garnet sand to be located at the 183-C Clearwell Pads is unknown. However, garnet sand (grit) was used in sandblasting operations.	Discovery	137127, Four Discovery Sites in the 100-B/C Area	N/A								
100-B-32	Unplanned Release	100-BC-1	Not Documented	The site is a surface contamination area. Contamination at this location is matrixed with the asphalt and is believed to be a legacy of past practices and operations.	Discovery	137127, Four Discovery Sites in the 100-B/C Area	N/A								
100-B-33	Unplanned Release	100-BC-1	150 m^2	The site is a surface contaminated area. The waste is contaminated soil. The site was discovered during the surface soil surveys of the northeast quadrant of the 100-B/C Area in July through August 2007. The readings found showed an elevated area averaging 15,000 cpm over a 150 m^2 (5,297 ft^2) area with a maximum reading of 93,000 cpm.	Discovery	Not Documented	N/A								
116-B-1	Trench	100-BC-1	112.78 x 15.24 x 4.57	The site received effluent from the 107-B Retention Basin at times of high activity due to fuel element failures. The fission products of 54 fuel ruptures were routed to this site.	Interim Closed Out	CVP-99-00012	10/6/1998	1/6/1999	43,033	4.6	Americium-241	0.086 J	0.065 U	0.047	0.042
											Cesium-137	0.25	3.16	0.15	0.163
											Cobalt-60	0.106	0.196	0.053	2.89
											Europium-152	1.41	8	0.69	6.35
											Europium-154	0.177	0.487	0.11	0.453
											Nickel-63	2.25 U	2.81 U	4	8.56
											Plutonium-238	0.023 U	0 UJ	0.039	0.06
											Plutonium-239/240	0.031 J	0.179	0.037	0.158
											Strontium-90	0.066 U	1.55	0.16	1.23
											Uranium-238	0.84 J	1.06	0.74	0.91
											Chromium	14.6	17	12.4	16.1
											Chromium VI	1.7	7.1	1.18	0.363

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-B-2	Trench	100-BC-1	22.86 x 3.05 x 4.57	The 105-B Storage Basin Trench was only used once in 1946 to receive contaminated basin water after a fuel element was accidentally cut in half in the 105-B Fuel Storage Basin.	Interim Closed Out	CVP-99-00015	2/17/1999	6/24/1999	9,393	4.9	Cesium-137	1.22	47.2	0.967	44
											Europium-152	0.098 U	0.87	0.0821	0.643
											Europium-154	0.084 U	0.079 U	0.0743	0.0789
											Strontium-90	0.323 J	11.5	0.28	7.22
											Uranium-238	0.707 J	0.67 J	0	0
											Uranium-233/234	0.603 J	0.78 J	0	0
											Chromium VI	0.42 U	0.42 U	0.42	0.42
116-B-3	Crib	100-BC-1	3.05 x 3.05 x 6.10	The 105-B Pluto Crib received 105-B Cooling Water Wastes that had been contaminated by cladding ruptures of fuel elements. Cooling water diversion occurred when a fuel element rupture was detected within a process tube. The water was diverted from the affected process tube through a valve on the rear of the reactor face known as a "pluto valve" and through rubber hose to the crib. The wooden crib was buried so that its upper surface was approximately at grade. A hatch on the upper surface was opened to receive the rubber hose and the crib was allowed to flood.	Closed Out	CVP-99-00013	2/17/1999	5/12/1999	244	4.6	Cesium-137	0.061	19.7 J	0.0423	17.8
											Strontium-90	0.157 J	3.16	0.0495	2.85
											Uranium-233/234	0.745 J	0.558	0	0
											Chromium VI	0.42 U	0.42 U	0.42 U	0.42 U
116-B-4	French Drain	100-BC-1	2.27 m^2 4.57 (depth)	The 105-B Dummy Decontamination French Drain received spent acid rinse water from the 105-B Dummy Decontamination Facility, which was used for the decontamination of fuel element spacers and other reactor hardware. The French drain was fed by a single, underground stainless steel pipe. Acids were neutralized within the 105-B Dummy Decontamination Facility before discharge to the French drain.	Interim Closed Out	CVP-99-00014	7/11/1995	4/4/1999	8,700	4.6	Cesium-137	0.049 J	372.16	0.0437	39.9
											Cobalt-60	0.027 UJ	23.803	0.024	5.4
											Europium-152	0.056 UJ	315.36	0.0518	77
											Europium-154	0.091 UJ	37.886	0.0791	9.02
											Europium-155	0.075 UJ	0.527	0.0595	0.241
											Plutonium-239/240	0.353 J	0.011 U	0.244	0.0502

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-B-5	Crib	100-BC-1	27.03 x 2.44 x 2.70	The 116-B-5 Crib began operations in 1950 to receive liquid waste from the 108-B Building P-10 Project. The P-10 Project was initially a pilot-plant tritium separations project to derive tritium products for the U.S. Nuclear Weapons Program. It was estimated that hundreds of gallons of mercury were disposed of to the 116-B-5 Crib along with solvents and degreasers, such as carbon tetrachloride, methyl alcohol, and trichloroethylene. After the tritium project ended in 1951, portions of the facility were used for destructive examination of ruptured fuels and damaged irradiated process tube examinations. These laboratory examinations likely generated chemical wastes common to decontamination of radioactive components. These chemicals included oxalic and nitric acids, sodium hydroxide, and solvents such as acetone, methyl ethyl ketone, carbon tetrachloride, and methyl and ethyl alcohols. The 108-B Facility also housed a photographic darkroom at its north end that may have discharged waste to the crib.	Interim Closed Out	WSRF-1998-064	6/26/1995	Not Documented	$300m^3$	5	Cesium-137	1.82	\	0.23	\
											Cobalt-60	1.032	\	0.17	\
											Europium-152	10.7	\	1.26	\
											Europium-154	0.882	\	1.02	\
											Tritium	680	\	48.48	\
											Mercury	16	\	2.17	\
											Barium	1000	\	407.62	\
116-B-6A	Crib	100-BC-1	3.66 x 2.44 x 4.57	The 116-B-6A Crib received radioactive liquid wastes from equipment decontamination performed in the 111-B Building, as well as from the decontamination of fuel element spacers.	Closed Out	CVP-99-00011	Not Reported	5/12/1999	5,072	4.6	Cesium-137	37.1	2.04	2.92	1.84
											Cobalt-60	0.046 U	0.022	0.032	0.023
											Europium-152	0.19 U	0.061 U	0.1	0.065
											Europium-154	0.13 U	0.078 U	0.099	0.079
											Strontium-90	3.77	21.1	1.81	10.8
											Uranium-233/234	1.38	0.586 J	0.867	0.506
											Uranium-238	0.662 J	0.639 J	0.529	0.524
											Mercury	0.11	0.02 U	0.08	0.02 U
											Chromium VI	0.42 U	0.41 U	0.42 U	0.41 U
116-B-6B	Crib	100-BC-1	3.66 x 2.44 x 4.57	The 111-B Crib No. 2 was an unlined crib that received radioactive wastes from equipment decontamination performed in the 111-B Decontamination Station, as well as liquid wastes from the decontamination of fuel element spacers.	Interim Closed Out	CVP-99-00017	3/11/1999	3/12/1999	263	3	Lead	7.9	\	5.48	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-B-7	Outfall	100-BC-1	8.23 x 4.27 x 6.4	The 1904-B-1 Outfall Structure was an open, reinforced-concrete structure that directed the water either through the river discharge pipelines or through spillways. The spillways were concrete flumes used when the river pipelines were blocked, damaged, or undergoing maintenance. The cooling water discharged into the upper chamber of the concrete outfall structure, flowed through a bar grillwork, and fell about 6 m (20 ft) to the lower chamber of the outfall structure. The cooling water then overflowed from the lower chamber into the discharge pipe to the river.	Interim Closed Out	CVP-2002-00003	Jun-01	Jan-02	17,233	8.3	Americium-241	0.076 U	0	0.028	0.022
											Cesium-137	1.2	3.5	0.31	3.2
											Cobalt-60	0.25	0.18	0.072	0.16
											Europium-152	1.9	1.4	0.4	1.3
											Europium-154	0.21	0.33 U	0.12	0.15
											Europium-155	0.23 U	0.23 U	0.079	0.11
											Nickel-63	3.6	3.3 J	0.59	3.1
											Plutonium-238	0 U	0 U	0.011	0
											Plutonium-239/240	0 U	0 U	0.06	0.068
											Tritium	0.072 U	0.039 U	0.072	0.016
											Strontium-90	0.18	0.4 J	0.15	0.4
											Uranium-234	0.9 J	1.1 J	0.64	0.92
											Uranium-235	0.05 J	0.097 J	0.2	0.097
											Uranium-238	0.92 J	1.1 J	0.69	0.67
											Lead	11	8.8	7.1	8.8
											Mercury	0.24	0.75	0.24	0.67
											Chromium	25	25	19	21
											Chromium VI	0.81	2.1	0.81	2.1
116-B-9	French Drain	100-BC-1	2.32 m^2	The 104-B-2 French Drain was in the 104-B-2 Building, which was associated with the P-10 Project that involved tritium production. The 104-B-2 Building was used to store casks containing irradiated lithium targets for tritium production and product tritium. The facility contained an inspection laboratory and an annex on the east end that contained air-sampling equipment.	Interim Closed Out	CVP-99-00009	3/10/1999	3/11/1999	Not Documented	2.44	Cesium-137	0.028 U	\	0.0252	\
											Cobalt-60	0.023 U	\	0.0221	\
											Europium-152	0.053 U	\	0.047	\
											Strontium-90	0.115 U	\	0.17	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-B-10	Sump	100-BC-1	3.68 m^2 0.91 (Diameter)	The 108-B Dry Well Quench Tank was used to collect liquid decontamination wastes from the 108-B Tube Examination and Experimental Facility.	Interim Closed Out	CVP-99-00010	3/10/1999	5/19/1999	692	2.44	Cesium-137	0.034	\	0.028	\
											Cobalt-60	0.08	\	0.0597	\
											Europium-152	0.053	\	0.0601	\
											Europium-154	0.094 U	\	0.0854	\
											Strontium-90	0.146 U	\	0.196	\
											Uranium-233/234	0.687 J	\	0	\
											Uranium-238	0.713 J	\	0	\
											Mercury	0.3 J	\	0.92	\
											Chromium VI	0.42 U	\	0.42 U	\
116-B-11	Retention Basin	100-BC-1	142.34 x 70.1 x 6.10	The 116-B-11 Retention Basin was constructed to hold cooling water effluent from the 105-B Reactor to allow for thermal cooling and radioactive decay before release to the Columbia River. This unit was a concrete-lined basin with wooden baffles. The basin was divided lengthwise into two halves designed to operate independently. The floor and walls consist of concrete slabs; their joints were originally closed with neoprene water seals. The unit was backfilled with soil to a depth of almost 1.2 m (4 ft).	Interim Closed Out	CVP-99-00001	11/26/1997	10/28/1998	165,178	5	Americium-241	0.0944 J	14.2	0.064	6.54
											Strontium-90	0.02 U	0.106 U	0.206	0.149
											Cesium-137	1.27	238	0.815	165
											Cobalt-60	0.401	94.9	0.211	80
											Europium-152	3.37	844	1.76	532
											Europium-154	0.473 U	104	0.111	70.8
											Europium-155	0.0947 U	3.49	0.078	5.66
											Nickel-63	22.4 J	6140 J	11.5	4816
											Plutonium-238	0.0104 U	1.35 J	0.023	1.63
											Plutonium-239/240	0.102	51.3	0.067	28
											Strontium-90	0.236 J	7.15	0.204	5.17
											Uranium-238	1.49	2.8 J	1.28	1.42
											Lead	7.5 B	21.5	5.3	13.1
											Mercury	0.19	14.5	0.1	11.2
											Chromium	19.1	449	13.3	314
											Chromium VI	1.67	2.03	1.67	1.23
116-B-12	Crib	100-BC-1	28.04 x 18.9 x 3.05	The 117-B Seal Pit Crib received drainage from the confinement system seal pits in the 132-B-4 Air Filtration Ventilation Building.	Interim Closed Out	CVP-99-00008	2/17/1999	3/5/1999	8696	4.6	Uranium-238	7.23 J	5.85 J	0	0
											Chromium VI	0.42 U	0.86	0.42 U	0.809

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-B-13	Trench	100-BC-1	30.48 x 9.14	The unit received low-level sludge waste from the bottom of 116-B-11 (107-B Retention Basin). During maintenance cleanout operations, sludge was disposed of to the trench. There is no indication from available records that this site directly received any regular and/or high-volume effluent wastes.	Interim Closed Out	CVP-99-00002	8/7/1998	11/6/1998	6,340	4.3	Americium-241	0.493	\	0.419	\
											Cesium-137	0.0492	\	0.066	\
											Cobalt-60	0.0172 U	\	0.042	\
											Europium-152	0.138	\	0.098	\
											Europium-154	0.043 U	\	0.118	\
											Europium-155	0.0401 U	\	0.066	\
											Plutonium-238	0.0107 UJ	\	0.032	\
											Plutonium-239/240	0.0398	\	0.036	\
											Strontium-90	0.407 J	\	0.308	\
											Uranium-238	0.991 J	\	0	\
											Lead	4.4	\	2	\
											Mercury	0.02 J	\	0.02	\
											Chromium	4.1 J	\	5	\
											Chromium VI	0.84 U	\	0.03	\
116-B-14	Trench	100-BC-1	36.58 x 3.05 x 3.05	The unit received low-level sludge waste from the bottom of 116-B-11 (107-B Retention Basin). During maintenance cleanout operations, sludge was disposed of to the trench. There is no indication from available records that this site directly received any regular and/or high-volume effluent wastes. After its use, the waste site was covered with about 1.8 m (6 ft) of soil.	Interim Closed Out	CVP-99-00003	5/27/1998	9/17/1998	3,795	6	Americium-241	0.263	0.008	0.182	0.036
											Cesium-137	1.14	5.88	0.785	5.37
											Cobalt-60	0.043	0.034 J	0.057	0.028
											Europium-152	4.43	1.34	1.31	1.21
											Europium-154	0.191 U	0.117	0.164	0.631
											Europium-155	0.087	0.0417 U	0.109	0.081
											Plutonium-238	0.0554	0.008 U	0.027	0.038
											Plutonium-239/240	0.37	0.101	0.267	0.068
											Strontium-90	1.55	1.6	1.14	1.35
											Lead	20	5.3	18.7	5
											Mercury	0.03 J	0.018	0.03	0.02
											Chromium	33.6 J	18.6	31.2	17.9
											Chromium VI	0.297	0.252	0.253	0.231

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-B-15	Pond	100-BC-1	30.48 x 15.24 x 1.83	During the cleaning of the 105-B Fuel Storage Basin, the radiologically contaminated shielding water was processed through a system that used ion exchange columns. Before the water was discharged to the 105-B Fuel Storage Basin Cleanout Percolation Pit (105-B Pond), composite samples were taken to ensure that radionuclide concentrations were below release criteria.	No Action	WSRF-2003-052	8/8/2003 (confirmatory samples)	N/A	N/A	N/A	Nickel-63	20.8	\	\	\
											Radium-228	1.22	\	\	\
											Uranium-233/234	0.672	\	\	\
											Uranium-238	0.666	\	\	\
											Arsenic	6.8	\	\	\
											Barium	89	\	\	\
											Chromium	14.4	\	\	\
											Lead	9.3	\	\	\
											Mercury	0.02	\	\	\
											Selenium	0.5	\	\	\
116-B-16	Storage Tank	100-BC-1	3.25 x 1.75 x 2.74	The 116-B-16 Fuel Examination Tank was a low-level liquid waste disposal site that was operational during the lifetime of the 111-B Metallurgical Examination Building. The tank received liquid wastes from the decontamination of fuel element spacers and other equipment as well as from other 111-B Building activities.	Closed Out	CVP-99-00011	See 116-B-6A								
118-B-1	Burial Ground	100-BC-2	740 x 90 x 6.1	The original 105-B Burial Ground contained six to eight trenches, but was expanded over its operational lifetime to 23 trenches. The site was to have received general reactor waste from the B Reactor including the following: aluminum tubes, lead bricks, thermocouples, vertical and horizontal aluminum thimbles, stainless-steel gun barrels, and expendables (e.g., plastic, wood, and cardboard). Spline silos were also constructed at the burial ground, which were vertical metal culverts, 3 to 3.7 m (10 to 12 ft) in diameter, built presumably to receive reactor poison splines and other metal wastes. In 1952, the burial ground received contaminated tritium pots, irradiated process tubing, contaminated fuel spacers (perfs), solid tritium wastes, and high-level liquid tritium wastes that were sealed in a 7.6 cm (3 in.) diameter iron pipe. In 1956, the second extension to the burial ground was added and was used for the burial of contaminated	Interim Closed Out	CVP-2007-00006	2/2/2004	6/7/2007	120,000	10	Carbon-14	3.44	2.46 U	1.93	\
											Cesium-137	3.6	0.478	2.4	0.159
											Cobalt-60	0.049	0.164	0.039	0.05
											Europium-152	1.24	0.143	0.695	0.068
											Strontium-90	4.42	0.412	2.56	0.12
											Tritium	239	7.32	158	\
											Uranium-233/234	0.718	0.874	0.671	0.564
											Uranium-235	0.055	0.167	0.051	0.039
											Uranium-238	0.756	0.715	0.725	0.587
											Arsenic	4.5	4.8	4.1	3.7
											Barium	145	75.4	132	60.8
											Beryllium	0.66	0.62	0.64	0.56
											Boron	18.1	2.9	13.7	1.8
											Chromium	9.59	9.5	8.9	8.1

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
				yokes from B Reactor. In the mid-1960s, the third extension was added to the north side of the original burial ground. Historical data on the contents of these trenches are not as detailed as with earlier extensions but are presumed to include "general" reactor and construction waste from modifications to the B Reactor. Waste materials from the Tritium Separation (P-10) Project were also buried here, including lithium-aluminum alloy, lead, mercury, aluminum cladding, and palladium.							Chromium VI	0.33	0.36	0.29	0.24
											Cobalt	14.5	10.9	10.2	9.2
											Copper	25.7	17.2	22.2	15.9
											Lead	12.9	6.5	11	5.1
											Manganese	411	418	381	366
											Mercury	2	0.03	1.3	0.03
											Molybdenum	2.1	0.5	2.1	0.43
											Nickel	19	12.5	15.9	11.1
											Selenium	0.68	1	\	1
											Vanadium	68.7	54.2	54.5	48.8
											Zinc	49.1	45	45.8	41.4
											Aroclor-1254	0.08	0.047 J	0.08	\
											bis(2-Ethylhexyl)phthalate	0.6	0.28	0.41	0.08
											Butylbenzylphthalate	0.024	0.34 U	0.024	\
											2-Methylnaphthalene	0.026	0.34 U	0.026	\
											Di-n-butylphthalate	0.084	0.049	0.16	0.13
											Diethylphthalate	0.025	0.019	0.025	0.019
											4-Methyl-2-pentanone	0.008	0.007	0.006	0.007
											Naphthalene	0.019	0.34 U	0.019	\
											Phenol	0.026	0.027	0.17	0.034
											Toluene	0.005 U	0.001	\	0.001
											Xylenes	0.010 U	0.001	\	0.001
											Acetone	0.023	0.02	0.017	0.02
											Carbon tetrachloride	0.017	0.032	0.016	0.011
											Methylene chloride	0.026	0.018	0.019	0.014
											alpha-Chlordane	0.012	0.0013 U	0.012	\
											beta-BHC	0.0078	0.0022	0.0078	0.0022
											4,4'-DDE	0.016	0.0013 U	0.016	\
											4,4'-DDT	0.0013 U	0.0016	\	0.0016

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Aldrin	0.0013 U	0.017 U	0.0005	\
											Dieldrin	0.0038	0.0013 U	0.0038	\
											Endosulfan I	0.0013 U	0.0049	\	0.0049
											Endosulfan sulfate	0.0022	0.0084	0.0022	0.00084
											Endrin	0.0015	0.0017 U	0.0015	\
											Endrin aldehyde	0.0055	0.0015	0.0055	0.0015
											Endrin ketone	0.0078	0.0014	0.0078	0.0014
											Heptachlor	0.0017 U	0.00043	\	0.00043
											gamma-Chlordane	0.0025	0.017 U	0.0025	\
											Methoxychlor	0.0091	0.0053	0.0091	0.0053
											2,4-D	0.062	0.081 U	0.062	\
											2,4-DB	0.043	0.0098	0.043	0.0098
											2,4,5-TP	0.012	0.020 U	0.012	\
											Dalapon	0.048	0.048	0.037	0.048
											Dicamba	0.013	0.013	0.013	0.013
											Dichloroprop	0.19	0.21	0.14	0.21
											Pentachlorophenol	0.014	0.017 U	0.014	\
											Picloram	0.014	0.017 U	0.014	\
118-B-2	Burial Ground	100-BC-2	18.29 x 9.14 x 3.05	The Minor Construction Burial Ground No. 1 received dry waste from the 107-B Basin repairs and from the 115-B Gas Recirculation Facility alterations. Operation of the unit began in 1952 and ended in summer 1956.	Interim Closed Out	CVP-2005-00001	4/19/2004	6/24/2004	9,525	4.6	Cesium-137	0.182	0.1 U	0.094	\
											Cobalt-60	0.19 U	0.11 U	0.068	\
											Europium-152	2.47 UJ	0.21 U	0.16	\
											Europium-154	0.026 U	0.32 U	0.15	\
											Europium-155	0.026 U	0.21 U	0.091	\
											Nickel-63	0.095 U	0.807 UJ	1.8	\
											Plutonium-238	11.5	0.029 U	0.0086	\
											Plutonium-239/240	.3 J	0 U	0.0086	\
											Strontium-90	5.2	0.03 U	0.05	\
											Chromium	0.02 U	12.7	10	11
											Chromium VI	\	0.322 J	0.3	0.32
											Lead	0.1 U	6.7	4.9	6.5
											Mercury	0.25	0.02 U	0.02	0.02 U

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-B-3	Burial Ground	100-BC-2	106.68 x 83.82 x 6.10	The Construction Burial Ground No. 2 was in operation from summer 1956 until 1960 and was used for disposal of solid waste from effluent pipeline modifications and for disposal of reactor-generated solid waste during various modification programs.	Interim Closed Out	CVP-2005-00001	See 118-B-2 Data								
118-B-4	Burial Ground	100-BC-2	15.24 x 9.14 x 4.57	The unit was used for disposal of fuel spacers dummies. The 105-B Spacer, or 105-B Dummy Burial Ground, received irradiated aluminum fuel spacers from the 105-B Reactor.	Interim Closed Out	CVP-2004-00002	11/14/2003	12/22/2003	3,171	3.9	Cobalt-60	0.054 U	\	0.054	\
											Chromium VI	0.87 U	\	0.25	\
118-B-5	Burial Ground	100-BC-1	15.24 x 15.24 x 6.10	The Ball 3X Burial Ground received irradiated equipment and metallic wastes removed from the 105-B Reactor during the Ball 3X Project. The 118-B-5 (Ball 3X) Burial Ground contained one trench, which was covered with 1.5 m (5 ft) of soil after its use was discontinued. The site appeared as a vegetation-free "L" shaped mound of cobbles, about 0.9 m (3 ft) high, that was surrounded by permanent concrete markers and was outside the reactor exclusion area.	Interim Closed Out	CVP-2004-00003	Nov-03	Dec-03	5,046	4.8	Carbon-14	241 J	\	0.0465	\
											Cobalt-60	7.7	\	0.023	\
											Nickel-63	0.08	\	0.51	\
118-B-6	Burial Ground	100-BC-2	4.57 x 3.05 x 6.10	The 108-B Solid Waste Burial Ground No. 2 was used for disposal of wastes from the "metal line" of the P-10 Tritium Separation Project. One of the pipes was filled with waste and capped, and the other was partially filled with waste and capped. Finally, both pipes were capped with a concrete pad.	Interim Closed Out	CVP-2006-00002	Nov-04	Jun-05	577	7	Tritium	241 J	2780 J	160	1996
											Lead	7.7	5.1	6.7	4.9
											Mercury	0.08	0.035 U	0.08	0.02 U
118-B-7	Burial Ground	100-BC-1	2.44 x 2.44 x 2.44	The 111-B Solid Waste Burial Site received decontamination materials and assorted equipment from the 111-B Decontamination Facility and workshop from 1951 to 1968. After researching photos and documentation of the area, a GPS survey was conducted. Verification sampling indicated that contaminants were at or below background levels.	Rejected	EPA/ROD/R10-00/121	N/A								
118-B-8	Reactor	100-BC-1	3866.08 m^2	The site is an inactive plutonium production reactor. The unit consists of a reactor block with associated shielding and controls, an irradiated fuel storage basin, and contaminated portions of the reactor building.	Accepted	Not Documented	N/A								

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

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-B-9	Storage	100-BC-1	104-B-1 tritium vault: 3.96 x 3.05 104-B-2 tritium laboratory: 7.32 x 3.66	The site consisted of two concrete masonry facilities identified as 104-B-1 Tritium Vault and 104-B-2 Tritium Laboratory. Both structures were demolished and their associated foundations removed to 1 m (3 ft) below grade in 1996. The Tritium Laboratory contained 63 special cells recessed in the laboratory floor. These were used to store the vacuum casks, which contained the irradiated target elements for the P-10 Project. The sample results demonstrate that the site achieves RAOs and remedial action goals.	No Action	WSRF-2004-004	Sep-03	N/A	N/A	N/A	Antimony	0.695	\	\	\
											Arsenic	4.9	\	\	\
											Barium	141	\	\	\
											Beryllium	0.177	\	\	\
											Boron	9.7	\	\	\
											Cadmium	0.435	\	\	\
											Chromium	15.7	\	\	\
											Cobalt	9.5	\	\	\
											Copper	20.5	\	\	\
											Lead	26.9	\	\	\
											Manganese	354	\	\	\
											Mercury	0.225	\	\	\
											Molybdenum	0.4	\	\	\
											Nickel	14.8	\	\	\
											Vanadium	71.6	\	\	\
											Zinc	250	\	\	\
118-B-10	Storage Tank	100-BC-1	14.63 x 5.49	The waste is a radioactive metal storage tank used to store radioactive boron balls from the ball 3X system.	Interim Closed Out	CVP-2004-00004	12/1/2003	12/2/2003	266	3.21	Cobalt-60	0.31	\	\	\
											Nickel-63	81.1	\	\	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
120-B-1	Sump	100-BC-1	6.47 m^2	The 120-B-1 Battery Acid Sump is a standard limestone acid neutralization pit with metal cover plates at grade. It was used from approximately 1944 to 1969 to neutralize the spent sulfuric acid from lead cell batteries of emergency power packs and the emergency lighting system.	Interim Closed Out	WSRF-2006-057	6/1/2006	6/13/2006	32 BCM	3	Arsenic	5	\	\	\
											Barium	135	\	\	\
											Beryllium	0.31	\	\	\
											Boron	8.1	\	\	\
											Chromium	273	\	\	\
											Chromium VI	0.38	\	\	\
											Cobalt	9.1	\	\	\
											Copper	19.8	\	\	\
											Lead	15.4	\	\	\
											Manganese	336	\	\	\
											Mercury	0.09	\	\	\
											Molybdenum	2.3	\	\	\
											Nickel	13.8	\	\	\
											Silver	0.23	\	\	\
											Vanadium	55.9	\	\	\
											Zinc	72.2	\	\	\
											Sulfates	5,960	\	\	\
											Aroclor-1221	0.0098	\	\	\
											Aroclor-1260	0.17	\	\	\
126-B-1	Coal Ash Pit	100-BC-1	200 x 200	Coal ash from the 184-B Powerhouse was mixed with raw river water and sluiced in slurry form to the ash pit via a 20 cm (8 in.) ashcolite pipe. Coal ash from analogous sites has been analyzed using the extraction procedure toxicity test in accordance with WAC 173-303, and no hazardous materials were found.	Rejected	Not Documented	N/A								

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
126-B-2	Dumping Area	100-BC-1	228.9 x 41.15 x 5.18	The site consists of two underground concrete reservoirs, or clearwells, separated in the center by the remains of a demolished pump room. A concrete piping structure remains above ground at the southeast corner of the clearwell site. The 126-B-2, 183-B Clearwells waste site is limited to the clearwells themselves. The remainder of the 183-B Facility (i.e., head house, flocculation and sedimentation basins, and pump house) and the pipelines around the original 183-B Facility are all part of the 100-B-22 Waste Site, the 100-B-14 Waste Site, or the 100-B-28 Waste Site, and are not addressed in this site. The basis for reclassification to no action is process knowledge, historical documents, and historical drawings. Under the original and final configurations of the water treatment facilities, sodium dichromate was added to the process water in the 190-B Facility, which is downstream of the 126-B-2 Clearwells. Therefore, water in the 126-B-2 Clearwells would not have been expected to contain CrVI or radionuclides, even at low concentrations.	No Action	WSRF-2007-004	N/A								
126-B-3	Dumping Area	100-BC-1	152.4 x 79.25 4..57	The 126-B-3, 184-B Coal Pit received coal that was crushed and sized for use in the 184-B Power House Boilers. Following shutdown of the reactors and beginning in the early to mid-1970s, the coal pit was used to dump demolition debris from decommissioned 100-B Facilities. In May 1985, demolition D&D of the 108-B Building were completed and the clean rubble and debris were disposed to the 184-B Coal Pit (126-B-3). Radioactively contaminated debris was sent to the 200 Area burial grounds.	Interim Closed Out	WSRF-2005-028	Sep-03	Sep-03	43,100 BCM	7	Arsenic	12	\	5.9	\
											Barium	163	\	93.4	\
											Beryllium	0.76	\	0.56	\
											Boron	7.8	\	4.9	\
											Chromium	20.7	\	12.2	\
											Cobalt	15.6	\	11.6	\
											Copper	36	\	23.4	\
											Lead	18.1	\	8.3	\
											Manganese	689	\	467	\
											Mercury	0.03	\	0.03	\
											Molybdenum	1.4	\	1.4	\
											Nickel	26.2	\	15.9	\
											Vanadium	76.1	\	66.9	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Zinc	84.4	\	62.4	\
											Aroclor-1260	0.017	\	0.017	\
											1,2,4-Trichlorobenzene	0.052	\	0.052	\
											2-Methylnaphthalene	0.39	\	0.39	\
											Acenaphthene	0.055	\	0.055	\
											Anthracene	0.15	\	0.15	\
											Benzo(a)anthracene	0.35	\	0.35	\
											Benzo(a)pyrene	0.27	\	0.27	\
											Benzo(b)fluoranthene	0.19	\	0.19	\
											Benzo(g,h,i)perylene	0.17	\	0.17	\
											Benzo(k)fluoranthene	0.24	\	0.24	\
											Carbazole	0.075	\	0.075	\
											Chrysene	0.37	\	0.37	\
											Dibenzofuran	0.099	\	0.099	\
											Dibenz(a,h)anthracene	0.088	\	0.088	\
											Fluorene	0.071	\	0.071	\
											Fluoranthene	0.73	\	0.73	\
											Indeno(1,2,3-cd)pyrene	0.16	\	0.16	\
											N-nitrosodiphenylamine	0.1	\	0.1	\
											Naphthalene	0.12	\	0.12	\
											Phenanthrene	0.62	\	0.62	\
											Pyrene	0.7	\	0.7	\

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
126-B-4	Sump	100-BC-1	15.19 m^2	The salt-dissolving pits and brine pump pit were part of a single below-grade concrete structure that provided brine for the 184-D Powerhouse. The structure has been demolished and buried in situ. No evidence of the site remains at the surface. 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, no reportable concentrations of heavy metals, and a sodium chloride concentration less than 1%.	Rejected	Not Documented	N/A								
128-B-1	Burn Pit	100-BC-1	30.48 x 30.48	The site has been described as a burn pit. During a field investigation on October 17, 1995, it was noted that the area is covered with cheatgrass and appears undisturbed with no evidence of burning.	Not Accepted	Not Documented	N/A								
128-B-2	Burn Pit	100-BC-1	100 x 60 x 3.05	The site received nonradioactive, combustible materials. Old paint cans and sandblast sand can still be seen at the site. Office waste, paint waste, chemicals, and solvent were burned at this site. It appears that clean fill material has been added to the site, indicating that the site may have also been used as a solid waste landfill.	Interim Closed Out	WSRF-2005-038	Nov-04	Apr-05	5,627 BCM	3.5	Radium-226	0.674	\	0.461	\
											Uranium-233/234	0.891	\	0.658	\
											Uranium-238	0.953	\	0.792	\
											Arsenic	3.1	\	\	\
											Barium	83.5	\	59.9	\
											Beryllium	1.3	\	1.11	\
											Boron	4.9	\	\	\
											Chromium	35.8	\	10.7	\
											Cobalt	9.1	\	8.9	\
											Copper	19.3	\	16.6	\
											Lead	77.7	\	11.3	\
											Manganese	397	\	362	\
											Molybdenum	1.7	\	\	\
											Nickel	12.7	\	12.2	\
											Vanadium	60.7	\	52.9	\
											Zinc	61.9	\	47.4	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Aroclor-1260	0.022	\	\	\
											Bis(2-ethylhexyl)phthalate	0.62	\	\	\
											Di-n-butylphthalate	0.018	\	\	\
											Toluene	0.004	\	\	\
128-B-3	Burn Pit	100-BC-1	17046.55 m^2	The 128-B-3 Coal Ash and Demolition Waste Site is an area where dumping and burning of waste material has occurred. No markers or signs are present at the site. The site is visible in a 1968 aerial photo and appears to have been divided into a construction debris dumping area to the south and a combustible waste burning area to the north.	Interim Closed Out	WSRF-2006-058	Nov-04	May-06	21,000 BCM	Not Documented	Arsenic	22.4	\	3.5 <BG	\
											Barium	264	\	88.3 <BG	\
											Beryllium	0.4	\	0.35 <BG	\
											Boron	9.3	\	2.8	\
											Chromium (Total)	70.6	\	13.6 <BG	\
											Chromium IV	1.8	\	1.3	\
											Cobalt	9.1	\	6.5 <BG	\
											Copper	52.3	\	16.7 <BG	\
											Lead	464	\	5.6 <BG	\
											Manganese	1230	\	309 <BG	\
											Mercury	0.64	\	0.07 <BG	\
											Nickel	26.4	\	13.4 <BG	\
											Vanadium	48	\	34.9 <BG	\
											Zinc	132	\	40.5 <BG	\
											Petroleum Hydrocarbons	291	\	157	\
											Aroclor-1254	0.014 U	\	0.19	\
											Endrin	0.0014 UD	\	0.0024	\
											Benzo (a) anthracene	0.350 U	\	0.024	\
											Benzo (a) pyrene	0.350 U	\	0.017	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
132-B-1	Process Unit/Plant	100-BC-1	45.11 x 9.25	Also known as the 108-B Tritium Separation Facility, which was converted to a tritium recovery processing facility and was used as such until 1954. After the tritium recovery processing facility was closed down, operational activity was limited to the first floor. The tube examination hot cell and laboratory rooms located there were used until the early 1970s. All hazardous material was removed and disposed of separately during the decommissioning process. Post-decommissioning contamination levels were at or near background. The contamination exists in a thin layer on the inner concrete surfaces of the building. Based on data collected to support release and demolition of other 100 Area buildings, the contamination penetration depth is expected to be less than 1 cm (0.4 in.). The release surveys indicated that residual contamination levels do not present unacceptable risk to the maximally exposed individual, and RESidual RADioactivity(RESRAD) modeling indicates they are protective of groundwater and the Columbia River.	No Action	WSRF-2003-044	N/A							
132-B-2	Stack	100-BC-1	60.96 (length)	The unit is part of the 105-B Reactor Gas and Exhaust Air System. The unit is still standing and constructed of reinforced concrete with a base diameter of approximately 4.9 m (16 ft).	Accepted	Not Documented	N/A								
132-B-3	Burial Ground	100-BC-1	76.2 x 9.14 x 5.5	The site consisted of a trench, which was used to bury low-level contaminated rubble from the demolition of the 108-B Ventilation Exhaust Stack, also known as the 108-B Tritium Pilot Facility Ventilation Exhaust Stack. The stack foundation was found to be free of contamination. It was destroyed separately, buried in place, and covered with clean fill material.	No Action	WSRF-2003-011	N/A							

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
132-B-4	Process Unit/Plant	100-BC-1	16.76 x 7.01 x 11.0 2.4 m above grade	The Ventilation Exhaust Filter Building housed blowers and particulate filters used to treat the ventilation exhausted from the B Reactor Building. Included in this site were the 117-B Building, the intake ventilation duct from the 105-D Reactor Building, and the exhaust ventilation ducts to the 116-B Reactor Exhaust Stack. Historical radiological survey and sampling data indicate that the majority of the contamination for the 117-B Filter Building and inlet/outlet ducts was found upstream of the filter cells. The highest level of contamination is below 4.6 m (15 ft) and does not pose a direct exposure risk. The contamination is not present in the concrete, but in a thin paint layer, and RESRAD evaluation indicates residual contamination levels are protective of groundwater and the Columbia River.	No Action	WSRF-2003-010	N/A								
132-B-5	Process Unit/Plant	100-BC-1	51.21 x 29.87 x 3.35	The 115-B/C Gas Recirculation Facility filtered and recirculated the inert gas that surrounded the core of the reactors. The recirculation cycle included cooling, drying, and filtering of the large gas volumes before re-entry into the reactors. The 110-B Pressurized Gas Storage Facility provided the source gas for the recirculation facility. A no-action decision is supported based on reviews of the facility information, historical data, and allowable residual contamination level and RESRAD modeling results. Contaminated process equipment and materials were removed from the facility during decommissioning and packaged for disposal as radioactive or hazardous waste, as applicable. Residual contamination, present in a thin 1 cm (0.4 in.) layer on concrete surfaces and within sealed process piping, were shown in RESRAD results to not present an unacceptable level of risk to the maximally exposed individual, and are protective of groundwater and the Columbia River.	No Action	WSRF-2003-027	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
132-B-6	Outfall	100-BC-1	8.23 x 4.27	The 1904-B2 Outfall was built in 1954 to supplement the 116-B-7 Outfall, which was no longer adequate to receive 100-B Reactor effluents after the completion of Project CG-558. It was an open, reinforced-concrete sump, with a new 168 cm (66 in.) effluent line that ran from the downcomer to the outfall and extended 137 m (450 ft) into the Columbia River.	Interim Closed Out	CVP-2002-00003	See 116-B-7 data								
1607-B1	Septic Tank	100-BC-1	4.27 x 2.13 x 3.35	The waste site includes a septic tank, drain field, and associated connecting pipelines and influent sanitary sewer lines that serviced the former 1701-B Badgehouse, 1720-B Patrol Building/Change Room, and 1709-B Fire Headquarters. The septic tank was constructed of reinforced concrete and has a 125-person capacity (132 L [35 gal.] per capita) with an average detention period of 24 hours. The results of the confirmatory sampling show that residual contaminant concentrations do not preclude any future uses and allow for unrestricted use of shallow zone soils. The current site conditions achieve the RAOs and the corresponding remedial action goals established in EPA/ROD/R10-99/039.	No Action	WSRF-2007-015	5/21/2007 (confirmatory samples)	N/A	N/A	3.7 (Depth of confirmatory sample)	Cesium-137	0.122	\	\	\
											Arsenic	4.2	\	\	\
											Barium	138	\	\	\
											Beryllium	0.27	\	\	\
											Boron	2.4	\	\	\
											Cadmium	0.12	\	\	\
											Chromium VI	0.3	\	\	\
											Chromium	9.6	\	\	\
											Cobalt	8.9	\	\	\
											Copper	20.2	\	\	\
											Lead	8.6	\	\	\
											Manganese	304	\	\	\
											Mercury	0.23	\	\	\
											Molybdenum	0.57	\	\	\
											Nickel	11.6	\	\	\
											Vanadium	42.2	\	\	\
											Zinc	93.9	\	\	\
											Aroclor-1260	0.011	\	\	\
											alpha-BHC	0.00052	\	\	\
											4,4'-DDD	0.001	\	\	\
											4,4'-DDT	0.021	\	\	\
											Bis(2-ethylhexyl)phthalate	0.098	\	\	\
											Di-n-butylphthalate	0.026	\	\	\
											Pyrene	0.021	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
1607-B2	Septic Tank	100-BC-1	See Subsites	The site includes a septic tank and drain field. This unit received sanitary sewage from the 100-B/C Area office buildings, the 105-B Reactor Building, and the 190-B Pumphouse. All office buildings have been removed; however, the sewer lines to the respective buildings still exist.	Interim Closed Out	WSRF-2006-055	See subsites								
1607-B2:1	Septic Tank	100-BC-1	3159.9 m^2 (Drain Field)	The 1607-B2 Septic System included a large-capacity (59,620 L [15,750 gal.]) septic tank and drain field located north of the 105-B Reactor Building. The system was initially designed to support waste loading from 450 users at a rate of 133 L (35 gal.) per capita per day with a 24-hour cell retention time. The 1607-B2 Waste Site has been administratively divided into two subsites for the purposes of verification sampling: the drain field is designated as the 1607-B2:1 Subsite, and the collection main, septic tank, and discharge line to the drain field are collectively designated as the 1607-B2:2 Subsite.	Interim Closed Out	WSRF-2006-055	Jan-05	Jul-06	Not Documented	4	Antimony	0.49	\	0.58	\
											Arsenic	5.3	\	7.2	\
											Barium	101	\	258	\
											Beryllium	0.47	\	0.8	\
											Boron	2.3	\	8.3	\
											Cadmium	0.13	\	0.13	\
											Chromium	14.6	\	19.8	\
											Chromium VI	0.24	\	0.33	\
											Cobalt	8	\	12.9	\
											Copper	17.5	\	29.6	\
											Lead	6.6	\	10.2	\
											Manganese	357	\	588	\
											Mercury	\	\	0.02	\
											Molybdenum	0.61	\	1.2	\
											Nickel	14.4	\	21.2	\
											Silver	0.09	\	0.2	\
											Vanadium	40	\	54.9	\
											Zinc	42.5	\	69	\
											4,4'-DDD	\	\	0.0017	\
											Dieldrin	\	\	0.0017	\
											Endrin aldehyde	\	\	0.0022	\
											2,4-D	\	\	0.11	\
											2,4-Db	\	\	0.25	\
											2,4,5-T	0.049	\	0.041	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											2,4,5-Tp (Silvex)	\	\	0.023	\
											Dinoseb	\	\	0.027	\
											2-Methylnaphthalene	\	\	0.15	\
											Di-n-butylphthalate	\	\	0.021	\
											Dibenzofuran	\	\	0.034	\
											Diethylphthalate	\	\	0.026	\
											Indeno(1,2,3-cd)pyrene	\	\	0.024	\
											Naphthalene	\	\	0.11	\
											Phenanthrene	\	\	0.037	\
											Acetone	0.009	\	0.01	\
1607-B2:2	Septic Tank	100-BC-1	10.77 x 4.01 x 4.40 (Septic Tank)	The 1607-B2 Septic System included a large-capacity (59,620 L [15,750 gal.]) septic tank and drain field located north of the 105-B Reactor Building. The system was initially designed to support waste loading from 450 users at a rate of 133 L (35 gal.) per capita per day with a 24-hour cell retention time. The 1607-B2 Waste Site has been administratively divided into two subsites for the purposes of verification sampling: the drain field is designated as the 1607-B2:1 Subsite, and the collection main, septic tank, and discharge line to the drain field are collectively designated as the 1607-B2:2 Subsite.	Interim Closed Out	WSRF-2006-055	Jan-05	Jun-06	Not Documented	4	Cesium-137	\	\	0.107	\
											Strontium-90	2.1	\	0.181	\
											Antimony	0.47	\	0.51	\
											Arsenic	3.6	\	4.1	\
											Barium	91	\	112	\
											Beryllium	0.39	\	0.44	\
											Boron	2.8	\	4.7	\
											Cadmium	0.1	\	0.43	\
											Chromium	12.8	\	10.5	\
											Chromium VI	0.28	\	0.35	\
											Cobalt	8.2	\	8.5	\
											Copper	16	\	34	\
											Lead	8.9	\	10.1	\
											Lithium	7.7	\	8.3	\
											Manganese	340	\	362	\
											Mercury	0.14	\	0.92	\
											Molybdenum	0.36	\	0.37	\
											Nickel	12.5	\	12.5	\
											Strontium	31	\	48.2	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Titanium	1330	\	1509	\
											Vanadium	46.6	\	46.4	\
											Zinc	49.6	\	51.5	\
											Aroclor-1254	0.0062	\	0.33	\
											Aroclor-1260	0.011	\	0.0067	\
											alpha-Chlordane	\	\	0.00087	\
											beta-BHC	\	\	0.0019	\
											4,4'-DDE	0.00044	\	0.018	\
											4,4'-DDT	0.016	\	0.017	\
											Endosulfan I	\	\	0.0069	\
											Endosulfan II	\	\	0.0034	\
											Endosulfan sulfate	\	\	0.0005	\
											Endrin aldehyde	0.0022	\	0.0074	\
											Endrin ketone	\	\	0.0011	\
											gamma-Chlordane	\	\	0.00043	\
											Heptachlor epoxide	\	\	0.0006	\
											Methoxychlor	\	\	0.015	\
											2-Methylnaphthalene	\	\	0.019	\
											Benzo(a)anthracene	\	\	0.041	\
											Benzo(a)pyrene	\	\	0.033	\
											Benzo(b)fluoranthene	0.018	\	0.041	\
											Benzo(g,h,i)perylene	\	\	0.03	\
											Benzo(k)fluoranthene	\	\	0.035	\
											Bis(2-ethylhexyl)phthalate	1.1	\	1.6	\
											Chrysene	\	\	0.064	\
											Di-n-butylphthalate	0.08	\	0.07	\
											Dibenz(a,h)anthracene	\	\	0.022	\
											Fluoranthene	0.032	\	0.079	\
											Indeno(1,2,3-cd)pyrene	\	\	0.028	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Naphthalene	\	\	0.017	\
											Phenanthrene	\	\	0.046	\
											Phenol	0.027	\	0.017	\
											Pyrene	0.026	\	0.066	\
1607-B3	Septic Tank	100-BC-1	2.9 x 1.37 x 3.17	The site is a closed-out septic system that includes a septic tank, tile field, and associated piping. This unit received an unknown amount of sanitary sewage from the 184-B Powerhouse. The site is no longer apparent and appears as a cobble-covered field with natural vegetation growing on its surface. The septic tank was demolished and buried in situ between January and March 1988. According to WIDS, before demolition, the contents of the tank were sampled, and no significant radioactivity was found above background, and there were no reportable concentrations of heavy metals.	Closed Out	WSRF 2001-015	N/A								
1607-B4	Septic Tank	100-BC-1	1.83 x 0.91 x 2.54	The site is a closed-out septic system associated with the 151-B Substation. This unit received sanitary sewage from the 151-B Electrical Distribution Facility. The flow rate to the unit was estimated at less than 132 L (35 gal.) per day. Closure of the septic tank was completed in 2000. According to WIDS, the tank contents were sampled and analyzed for radiological contaminants, with results lower than detection limits. The tank contents were pumped out and the tank was filled with clean material. A letter was sent to notify the Washington State Department of Health of the abandonment.	Closed Out	WSRF 2000-121	N/A								
1607-B5	Septic Tank	100-BC-1	1.22 x 0.61 x 2.54	The 1607-B5 Septic Tank System received sanitary sewage from the 181-B/C Pumphouse.	Accepted	DOE/RL-94-61, Appendix N	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
1607-B6	Septic Tank	100-BC-1	2.44 x 1.22 x 2.54	This system includes the feed pipeline from the 183-B Filter House, the septic tank, and the drain field. This unit receives 130 L/day (35 gal./day) of sanitary sewage from the 182-B Pump Station and cooling water and leakage from pumps located in the 182-B Facility. It also received sewage from the 183-B Headhouse, which was decommissioned in 1987.	Accepted	DOE/RL-94-61, Appendix N	N/A								
1607-B7	Septic Tank	100-BC-1	1.83 x 0.91 x 2.51	The 1607-B7 Septic Tank System had a 12-person capacity (130 L [35 gal.] per capita) with an average detention period of 24 hours. This unit received an unknown amount of sanitary sewage from the 183-B Water Treatment Plant.	Interim Closed Out	CVP-2003-00004	Mar-03	Mar-03	198	3.5	Cesium-137	0.3 U	\	0.0428	\
											Cobalt-60	0.2 U	\	0.0464	\
											Europium-152	0.42 U	\	0.103	\
											Europium-154	55	\	0.129	\
											Europium-155	0.0021	\	0.0903	\
											Chromium VI	0.12	\	0.42	\
											Lead	0.13 U	\	27	\
											Beta-BHC	0.19 U	\	0.0021	\
1607-B8	Septic Tank	100-BC-2	7.27 m^2	The site consisted of a septic tank and tile field. The vertical tank was constructed of steel and had a 1,325 L (350 gal.) capacity. The tile field was oriented north-south and was located to the south of the septic tank. The tile field was constructed of 20 cm (8 in.) vitrified clay pipe laid with open joints. This unit received an unknown quantity of sanitary sewage from the 190-C Pumphouse.	Interim Closed Out	CVP-2003-00005	Mar-03	Mar-03	361	2.5	Cesium-137	0.26 U	\	0.0602	\
											Cobalt-60	0.2 U	\	0.0446	\
											Europium-152	0.43 U	\	0.0949	\
											Europium-154	170	\	0.129	\
											Europium-155	0.027	\	0.0997	\
											Chromium VI	0.38	\	0.43	\
											Lead	0.0264	\	118	\
											DDT	0.16 U	\	0.0194	\
											Aroclor-1254	0.23 U	\	0.273	\
1607-B9	Septic Tank	100-BC-2	4.27 x 0.91	The site was a septic tank and tile field. This unit received an unknown amount of sanitary sewage from the 105-C Reactor Building. The system tank had a 9,085 L (2,400 gal.) capacity. Effluent from the tank was routed a short distance (about 16 m [52 ft]) through a pipeline to the tile field. The tile field located southeast of the tank was constructed of 20 cm (8 in.) diameter vitrified clay pipe laid with open joints.	Interim Closed Out	CVP-2003-00006	Apr-03	May-03	3,060	3.5	Cesium-137	0.29 U	\	0.0551	\
											Cobalt-60	0.2 U	\	0.0586	\
											Europium-152	0.41	\	0.0989	\
											Europium-154	15	\	0.125	\
											Europium-155	0.0046	\	0.0868	\
											Chromium VI	0.054	\	0.44	\
											Lead	0.074 U	\	10.3	\
											Dieldrin	0.17 U	\	0.0046	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
1607-B10	Septic Tank	100-BC-2	74.85 m^2	The site consisted of a septic tank and tile field. The unit received only sanitary sewer wastes from the headhouse of the 183-C Water Treatment Plant. There were no known discharges of hazardous chemicals or radionuclides.	Interim Closed Out	CVP-2003-00007	Mar-03	Mar-03	328	2.5	Cesium-137	0.21 U	\	0.042	\
											Cobalt-60	0.22 U	\	0.0356	\
											Europium-152	0.61	\	0.0755	\
											Europium-154	18	\	0.0957	\
											Europium-155	0.38	\	0.0978	\
											Chromium VI	25	\	0.42	\
											Lead	0.0045	\	18	\
											Mercury	0.057	\	0.29	\
											Chromium	25	\	20	\
											DDT	0.0045	\	0.0041	\
											Aroclor-1254	0.057	\	0.047	\
1607-B11	Septic Tank	100-BC-2	74.58 m^2	The site consisted of a septic tank and drain field. There were no known discharges of hazardous chemicals or radionuclides into the unit. The unit received only sanitary sewer wastes from the 183-C Filter Building and Pump Room (183-C Water Treatment Plant).	Interim Closed Out	CVP-2003-00008	Mar-03	Mar-03	146	3	Cesium-137	0.0308	\	0.0426	\
											Cobalt-60	0.1 U	\	0.0465	\
											Europium-152	0.21 U	\	0.0961	\
											Europium-154	0.27 U	\	0.127	\
											Europium-155	0.19 U	\	0.0951	\
											Lead	10.3	\	9.4	\
											Chromium VI	0.38	\	0.42	\
											bis(2-Ethylhexyl)phthalate	0.68	\	0.68	\
100-C-2	Foundation	100-BC-2	1.83 x 1.83	The site is the foundation of a general monitoring station (614 Structure). Its function was to house the environmental monitoring equipment that sampled airborne process wastes.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								
100-C-3	French Drain	100-BC-2	0.61 m^2	The 119-C Sample Building French Drain was a 0.61 m (2 ft) diameter gravel-filled pit that received effluent from the 119-C Sample Building. The 119-C Sample Building was built in 1960 and contained water-cooled air sample monitoring equipment. Effluent from the sampling equipment, the building's swamp cooler, and possibly janitorial waste would have been disposed to the 100-C-3 French Drain.	Interim Closed Out	CVP-2003-00009	3/19/2003	3/19/2003	49	3	Cesium-137	0.147	\	0.113	\
											Cobalt-60	0.092 U	\	0.0396	\
											Europium-152	0.19 U	\	0.0874	\
											Europium-154	0.29 U	\	0.121	\
											Europium-155	0.18 U	\	0.0755	\
											Chromium VI	0.42 U	\	0.42	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-C-4	Valve Pit	100-BC-2	1.8 x 1.8	The site is a valve pit located along the export water line. The export water line distributes clean river water from 100-B Area to the 200 Area. The site was identified in the 100-B Area Technical Baseline Report as a "Hazardous Site," by which the authors meant that the site was a safety hazard due to its disrepair. The site has not been used for waste management activities.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								
100-C-5	Product Piping	100-BC-2	10567.33	The site encompasses the clean water upstream pipelines for the 100-C Area, including underground pipelines used to transport raw, fire, export, and sanitary water from the river pumphouse, to the water treatment facilities and to 100-C Area facilities and fire hydrants.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								
100-C-6	Radioactive Process Sewer	100-BC-2	See subsites	The waste was contaminated steel piping, concrete, and soil. The site includes the underground 105-C Reactor cooling water effluent pipelines. These include those effluent pipelines that transported 105-C Reactor cooling water from the reactor to the 116-C-5 (107-C Retention Basin), and from the basin to the 132-B-6 and 132-C-2 Outfall Structures and/or to the 116-C-1 Liquid Waste Disposal Trench (see subsites).	Accepted	See subsites	N/A								
100-C-6:1	Radioactive Process Sewer	100-BC-2	Not Documented	100-C Area South Effluent Pipelines	Interim Closed Out	CVP-2003-00022	See 100-B-8:1								
100-C-6:2	Radioactive Process Sewer	100-BC-2	Not Documented	100-C Area North Effluent Pipelines	Interim Closed Out	CVP-2003-00019	See 100-B-8:2								
100-C-6:3	Radioactive Process Sewer	100-BC-2	Not Documented	100-C Retention Basin to Outfalls Effluent Pipelines	Interim Closed Out	CVP-2003-00019	See 100-B-8:2								
100-C-6:4	Radioactive Process Sewer	100-BC-2	700.91	100-B/C Pipelines Discovery Areas	Interim Closed Out	CVP-2003-00019	See 100-B-8:2								
100-C-6:5	Radioactive Process Sewer	100-BC-2	30.5	Pipelines Sections Under Export Water Lines	Accepted	EPA/ROD/R10-95/126	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-C-7	Dumping Area	100-BC-2	92.96 x 88.16	Also known as 183-C Filter Building/Pumproom Facility Foundation and Demolition Waste. One of the purposes of the 183-C Pumproom was to treat the cooling water with sodium dichromate, a rust inhibitor, before storage in the four exterior 1.89E+07 L (5E+06 gal.) tanks (183-C Clearwells). Water was drawn from the 183-C Filter Building clearwells and injected with sodium dichromate in the pumproom before being pumped to the four, large tanks for storage. During past practices, the sodium dichromate was stored, mixed, and spilled in various locations throughout the building.	Accepted	EPA/ROD/R10-99/039	N/A								
100-C-8	Unplanned Release	100-BC-2	Not Documented	An excavator broke a main hydraulic line while dismantling a concrete pad at 105-C. A large area was sprayed due to the hydraulic system being under pressure. The exact quantity was not known at the time of the hose failure and was believed to be below the DOE reportable threshold of 160 L (42 gal.). The hydraulic oil is not designated as a hazardous substance.	Not Accepted	WSRF 2002-001	N/A								
100-C-9	Process Sewer	100-BC-2	See Subsites	The 100-C-9 Waste Site includes the underground sanitary and process sewers and process pipelines associated with the 100-C Area pre-reactor water treatment facilities. The waste site was administratively divided into four subsites based on the intended use of the pipes (e.g., sanitary or process sewer), expected sources of contamination, and potential differing remedial action requirements. The four 100-C-9 subsites are as follows: 1. 100-C-9:1 Main Process Sewer Collection Line 2. 100-C-4:2 Sanitary Sewers 3. 100-C-9:3 Clearwell Pipes 4. 100-C-9:4 Cooling Water Transfer Pipelines and Tunnels.	Interim Closed Out	See Subsites	See Subsites							

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
100-C-9:1	Process Sewer	100-BC-2	2066.11	100-C Main Process Sewer Collection Line	Interim Closed Out	WSRF-2004-012	11/22/2004	4/19/2006	20,490	0.3		Excavation Footprint	Over-burden	Excavation Footprint UCL	
											Arsenic	9.1	5.3	5	\
											Antimony	0.62	1.4	0.62	\
											Barium	102	78.1	75.9	\
											Beryllium	0.48	1.8	0.4	\
											Boron	2.2	1.8	1	\
											Cadmium	0.26	0.26	0.26	\
											Chromium	60.6	15.4	15.9	\
											Chromium VI	1.8	0.39	1.8	\
											Cobalt	12.5	11.5	9.7	\
											Copper	21.1	26.5	18	\
											Lead	10.7	6.8	6.4	\
											Manganese	497	390	400	\
											Mercury	8.8	0.04	22.7	\
											Molybdenum	0.32	0.8	0.42	\
											Nickel	17	14.9	12.8	\
											Selenium	0.46	\	0.47	\
											Vanadium	77	65	48.9	\
											Zinc	57.9	65.1	48.2	\
100-C-9:2	Process Sewer	100-BC-2		100-C-9:2, 100-C Sanitary Sewer Lines. Subsite 100-C-9:2 is a collection of the feeder pipelines for the former 1607-B8, 1607-B9, 1607-B10, and 1607-B11 Septic Systems. Each of the systems consisted of a septic tank, vitrified clay sanitary sewer pipe, and a drain field.	Interim Closed Out	WSRF-2004-013	Early 2005	9/29/2006	3,701	1607-B8: 2m 1607-B9: 3.5m 1607-B10: 9m 1607-B11: 4m		1607-B8 Feed Line	1607-B9 Overburden	1607-B9 Feed Line	
											Arsenic	4.4	2.4	2.9	\
											Antimony	0.97	\	\	\
											Barium	74.1	56.7	64.3	\
											Beryllium	0.51	0.48	0.46	\
											Boron	5.1	\	\	\
											Cadmium	0.5	0.17	0.24	\
											Chromium	16.5	7.2	8.7	\
											Chromium VI	0.83	0.27	0.28	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Cobalt	8.9	7.6	7.7	\
											Copper	17.6	14.6	15.6	\
											Lead	152	8.8	12.8	\
											Lithium	7.2	5.1	7	\
											Manganese	456	345	343	\
											Mercury	0.85	\	0.04	\
											Molybdenum	1.9	0.38	0.42	\
											Nickel	22	10	10.9	\
											Strontium	32.7	20.6	22.7	\
											Titanium	1,960	1,720	1,570	\
											Vanadium	58.4	50.3	47.5	\
											Zinc	111	43.6	162	\
											Aroclor-1254	0.12	0.039	0.028	\
											4,4-DDE	0.014	0.0007	0.0012	\
											4,4'-DDD	0.0035	\	\	\
											4,4-DDT	0.0051	\	\	\
											Dieldrin	\	0.0099	0.0017	\
											Endrin	0.0036	\	\	\
											Endrin aldehyde	0.0029	\	0.00097	\
											Endrin ketone	0.00074	\	\	\
											gamma-Chlordane	0.0016	\	\	\
											Endosulfan I	0.00064	\	\	\
											Endosulfan sulfate	0.0037	\	\	\
											Benzo(a)anthracene	\	\	0.041	\
											Benzo(a)pyrene	0.022	0.018	0.048	\
											Benzo(b)fluoranthene	0.073	\	0.041	\
											Benzo(g,h,i)perylene	0.023	0.018	0.037	\
											Benzo(k)fluoranthene	0.023	\	0.045	\
											bis(2-Ethylhexyl)phthalate	0.25	\	\	\

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Chrysene	0.082	0.02	0.055	\
											Di-n-butylphthalate	0.04	\	\	\
											Fluoranthene	\	0.024	0.081	\
											Indeno(1,2,3-cd)pyrene	\	\	0.03	\
											Methoxychlor	0.0073	\	\	\
											Phenanthrene	\	\	0.056	\
											Pyrene	\	\	0.094	\
100-C-9:3	Process Sewer	100-BC-2	1657.66	This sub-unit includes the process sewer pipes surrounding the 183-C Clearwells (demolished) to the point of junction with the main process sewer collection line. The confirmation sampling results from scale and soil samples support no-action reclassification of the 100-C-9:3 Site.	No Action	WSRF-2004-014	10/2003 (confirmatory samples)	N/A	N/A	N/A	Arsenic	6.5	\	\	\
											Antimony	2.1	\	\	\
											Barium	66.7	\	\	\
											Beryllium	0.33	\	\	\
											Boron	1.3	\	\	\
											Cadmium	0.2	\	\	\
											Chromium	12.8	\	\	\
											Chromium VI	0.61	\	\	\
											Cobalt	9.2	\	\	\
											Copper	19.6	\	\	\
											Lead	6.3	\	\	\
											Manganese	412	\	\	\
											Molybdenum	0.64	\	\	\
											Nickel	14.5	\	\	\
											Silver	0.14	\	\	\
											Vanadium	63.9	\	\	\
											Zinc	54.9	\	\	\
											4-Methylphenol (cresol, p-)	1.1	\	\	\
											Acenaphthene	6.8	\	\	\
											Anthracene	1.3	\	\	\
											Benzo(a)anthracene	20	\	\	\
											Benzo(a)pyrene	13	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Benzo(b)fluoranthene	11	\	\	\
											Benzo(g,h,i)perylene	5.4	\	\	\
											Benzo(k)fluoranthene	12	\	\	\
											Carbazole	7.3	\	\	\
											Chrysene	20	\	\	\
											Dibenzofuran	3	\	\	\
											Dibenz(a,h)anthracene	22	\	\	\
											Fluorene	5.8	\	\	\
											Fluoranthene	52	\	\	\
											Indeno(1,2,3-cd)pyrene	5.6	\	\	\
											Isophorone	0.28	\	\	\
											Naphthalene	2.1	\	\	\
											Phenanthrene	46	\	\	\
											Pyrene	35	\	\	\
100-C-9:4	Process Sewer	100-BC-2	895.45	This sub-unit includes the cooling water transfer lines located in tunnels between the 190-C Pump House and the 105-C Reactor Building. Confirmatory sample collection at the waste site was not possible because the existing structures were sealed to prevent entry following previous D&D activities. The data from the 105-B Valve Pit Feedwater Valves were used to close the 100-C-9:4 site, as it was considered an analogous site.	No Action	WSRF-2004-015	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-C-1	Trench	100-BC-1	152.4 x 15.24 x 6.10	The 107-C Liquid Waste Disposal Trench was a former process effluent disposal trench (unlined) that received 700 million L (184 million gal.) of contaminated cooling water from the 100-B/C Area Retention Basins after ruptured fuel elements were detected in the reactors. The 116-C-1 Site continued to receive contaminated cooling water until reactor operations ceased in 1968. An additional 40 billion L (more than 10 billion gal.) of high-temperature reactor cooling water was discharged to the site during a 150-day infiltration test in 1967. After the soil plume excavation was completed, a test pit was excavated down to groundwater to further characterize the subsurface. The test pit was centered at an area of elevated activity (identified by radionuclide field surveys) near the 116-C-1 Inlet Pipes. Soil samples were taken from each quadrant of the test pit and composited for each of the eight 1 m (3 ft) test pit lifts.	Interim Closed Out	CVP-98-00006	7/15/1996	11/15/1996	97,515	5	Americium-241	0.0469	52.4	0.024	17.3
											Cesium-137	2.07	2030	0.803	625
											Cobalt-60	0.0741	63.8	0.074	24.2
											Europium-152	1.62	434	0.643	185
											Europium-154	0.258	59.9	0.258	25.3
											Europium-155	0.0837	2.53	0.084	2.53
											Nickel-63	3.08	1540	1.54	645
											Plutonium-238	0.033	3.31	0.017	1.19
											Plutonium-239/240	0.215	89.9	0.215	31
											Strontium-90	0.689	135	0.345	44.1
											Uranium-238	0.913	12.5	0.793	0.853
											Lead	5	38.5	4.41	16.4
											Mercury	0.03 B	3.1	0.03	1.44
											Chromium	14.2	159	12.3	67.5
											Chromium VI	0.115 UJ	0.246 J	0.058	0.246
116-C-2A	Crib	100-BC-2	6.78 x 4.66 x 5.10	This was the largest of the 100 Area Pluto Cribs and was unique in that effluents passed through a settling tank and sand filter before being discharged to the crib. The Pluto Crib was constructed of concrete ties that were notched and stacked in a log cabin formation. Walls of concrete ties were constructed to divide the crib into 12 sections. Spaces between the ties were filled with sand. The crib was covered over by concrete roof slabs.	Interim Closed Out	CVP-99-00019	3/3/1999	5/7/1999	15,939	9.15	Americium-241	0.026 U	0.71 J	0.073	0.607
											Cesium-137	0.58	25.3	0.404	20.4
											Cobalt-60	0.227	12.2	0.0887	10.4
											Europium-152	0.484	29.6	0.211	24.5
											Europium-154	0.087 U	3.29	0.0785	2.68
											Europium-155	0.059 U	0.25 U	0.0504	0.204
											Plutonium-238	0 U	0.332 J	0.0805	0.126
											Plutonium-239/240	0.1 J	3.99 J	0.0652	1.24
											Strontium-90	1.85	6.18	0.725	4.38
											Uranium-238	0.599 J	0.75 J	0.444	0.445
											Chromium VI	0.41 U	0.848	0.41 U	0.0308
116-C-2B	Pump Station	100-BC-2	3.05 x 2.94 x 9.14	This unit was a rectangular-shaped, concrete sump. The unit received waste from the 105-C Reactor and pumped it into the 116-C-2C (105-C Pluto Crib Sand Filter).	Interim Closed Out	CVP-99-00019	See 116-C-2A data								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-C-2C	Sand Filter	100-BC-2	12.65 x 5.49 x 5.49	The structure was an open-bottom concrete box placed in a sand and gravel pit. It was covered with concrete shielding slabs. Contaminated water was spread over the surface of the sand filter media by distribution trays. The site included the underground pipelines from the 105-C Pluto Crib Sand Filter to the 116-C-2A Pluto Crib. Effluent passed through the 105-C Pluto Crib Sand Filter before being discharged to the soil column of the 116-C-2 Crib.	Interim Closed Out	CVP-99-00019	See 116-C-2A data								
116-C-3	Storage Tank	100-BC-2	Each tank was 10.9 m in length, 3.5 m in diameter and 3.4 m below grade	The 116-C-3 Chemical Waste Tanks consisted of two below grade chemical waste storage tanks designed to receive mixed waste from the 105-C Reactor Metal Examination Facility dejacketing process. This process consisted of immersing irradiated the fuel slugs in a 50% sodium hydroxide solution, draining the resulting solution, and rinsing the dejacketed slugs with water. The slugs were then cleaned with a 10% nitric acid solution, followed with multiple water rinses. These solutions were discharged into the 116-C-3 Tank System.	Interim Closed Out	WSRF-2008-002	Feb-07	Dec-07	3,767	8.5		Northern Tank	Southern Tank	Over-burden	
											Americium-241	0.273	\	\	\
											Cesium-137	14.1	0.084	0.091 <BG	\
											Plutonium-239/240	0.912	\	\	\
											Strontium-90	18.2	\	\	\
											Tritium	4.02	\	3.89	\
											Uranium-233/234	0.901 <BG	0.873 <BG	0.684 <BG	\
											Uranium-235	0.042 <BG	\	0.048 <BG	\
											Uranium-238	0.860 <BG	0.788 <BG	0.695 <BG	\
											Arsenic	6.4 <BG	5.2 <BG	2.6 <BG	\
											Barium	196	106 <BG	68.5 <BG	\
											Beryllium	0.42 <BG	0.71 <BG	0.25 <BG	\
											Boron	24.3	2.4	1.8	\
											Cadmium	0.36 <BG	\	\	\
											Chromium (Total)	26.4	18.1 <BG	10.4 <BG	\
											Chromium IV	1.5	\	1.7	\
											Cobalt	6.7 <BG	7.7 <BG	7.3 <BG	\
											Copper	20.4 <BG	15.3 <BG	15.3 <BG	\
											Lead	9.1 <BG	7.5 <BG	6.3 <BG	\
											Manganese	346 <BG	328 <BG	319 <BG	\
											Molybdenum	1.1	\	\	\
											Nickel	18.1 <BG	18.2 <BG	13.6 <BG	\
											Vanadium	42.4 <BG	38.6 <BG	39.1 <BG	\
											Zinc	49.5 <BG	51.4 <BG	42.4 <BG	\
											Nitrate (As nitrogen)	2.8	0.48 <BG	16.5	\

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Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
116-C-5	Retention Basin	100-BC-1	7946.0 m^2	The 116-C-5 Retention Basins were constructed to hold cooling water effluent from the 105-C Reactor to allow for thermal cooling and radioactive decay before release to the Columbia River. When in operation, the retention basins were two circular, 3.8E+07 L (1.0E+07 gal.), open-topped tanks. Each tank had a diameter of 100 m (330 ft), a depth of 4.9 m (16 ft), and had internal baffles to prevent water from channeling across the tanks into the discharge lines. The tanks were constructed of welded carbon steel and were set on a reinforced-concrete foundation with a crushed rock subfloor.	Interim Closed Out	CVP-99-00004	9/21/1996	3/21/1998	224,709	4.6	Americium-241	0.456 J	7.24 J	0.256	5.11
											Cesium-137	1.75	209	1.12	114
											Cobalt-60	0.197	55.7	0.145	21.4
											Europium-152	2.36	303	1.59	135
											Europium-154	0.359	41.7	0.244	23.8
											Europium-155	0.0947 U	1.93	0.066	0.71
											Nickel-63	8.89 J	1790	7.52	677
											Plutonium-238	0.0083 U	0.42	0.029	0.19
											Plutonium-239/240	0.15	16.5	0.192	5.1
											Strontium-90	0.696 J	22	0.37	5.11
											Uranium-238	1.13	1.2	0.927	0.94
											Lead	11.2	49.2	7.3	20.9
											Mercury	0.04	6.2	0.04	1.47
											Chromium	16.2	78.8	12.9	43.2
											Chromium VI	0.239	2	0.239	2.28
116-C-6	Process Pit	100-BC-2	30.48 x 30.48 x 1.83	The 105-C Fuel Storage Basin Cleanout Percolation Pit was constructed to receive liquid from the clean out of the 105-C Fuel Storage Basin. The radiologically contaminated shielding water in the basin was processed through an ion exchange column and filter system. After being sampled to determine if the radioactivity was below release criteria, the water was discharged to the pit. Chemical analysis for hazardous substances was not a standard practice and there was no evidence that it was performed. The water percolated into the soil as fast as it was discharged to the site.	Interim Closed Out	WSRF-2003-034	3/2004 (confirmatory samples)	Not Documented	Not Documented	Not Documented	Americium-241	0.642	\	\	\
											Cesium-137	1.9	\	\	\
											Europium-152	0.251	\	\	\
											Nickel-63	5.35	\	\	\
											Plutonium-239/240	0.528	\	\	\
											Total strontium	0.463	\	\	\
											Radium-228	0.603	\	\	\
											Uranium-233/234	0.535	\	\	\
											Uranium-235	0.041	\	\	\
											Uranium-238	0.523	\	\	\
											Arsenic	3.4	\	\	\
											Barium	44.7	\	\	\
											Chromium	6.7	\	\	\
											Lead	4.3	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-C-1	Burial Ground	100-BC-2	155.45 x 121.92 x 6.10	The 118-C-1, 105-C Burial Ground, is the primary burial ground for general wastes from the operation of the 105-C Reactor. It received process tubes, aluminum fuel spacers, control rods, reactor hardware, and soft wastes.	Interim Closed Out	CVP-2006-00011	2/2/2004	5/27/2006	75,300	5	Cesium-137	1.19	0.437	0.81	0.352
											Carbon-14	11.7	0.472 U	8	\
											Cobalt-60	1.48	0.04 U	0.99	\
											Europium-152	0.281	0.1 U	0.199	\
											Nickel-63	35.8	0.29 U	26.1	\
											Strontium-90	0.323	2.1	0.268	1.41
											Uranium-233/234	1.09	0.575	0.83	0.523
											Uranium-235	0.027	0.02 U	0.084	\
											Uranium-238	0.825	0.508	0.666	0.505
											Tritium	7.71	2.09 U	4.76	\
											Arsenic	33.9	2.3	4.5	2.4
											Barium	286	58.4	206	55.2
											Beryllium	0.93	0.69	0.88	0.68
											Boron	4.9 J	2.1 U	3.4	\
											Cadmium	0.12	0.21 U	0.12	\
											Chromium	9.2	6.8	8.7	6.5
											Cobalt	13.1	7.8	8.8	8.7
											Copper	286	15.8	13.7	15
											Lead	130	5.2	18.6	5
											Manganese	362	329	349	340
											Molybdenum	54.9	0.85 U	4.5	\
											Nickel	13	9.6	12	9.9
											Vanadium	62.7	45.7	51.6	51.6
											Zinc	296	37.5	74.8	41
											Aroclor-1254	0.062	4.9 J	0.054	0.013
											Benzo(a)anthracene	0.18 J	0.038 J	0.18	0.13
											Benzo(a)pyrene	0.12 J	0.024 J	0.12	0.083
											Benzo(b)fluoranthene	0.14 J	0.033 J	0.14	0.11
											Benzo(g,h,i)perylene	0.051 J	0.330 U	0.051	0.037

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Benzo(k)fluoranthene	0.14 J	0.029 J	0.14	0.092
											Butylbenzylphthalate	0.038 J	0.330 U	0.038	\
											bis(2-Ethylhexyl)phthalate	0.4 B	0.330 U	0.28	0.017
											Chrysene	0.21 J	0.052 J	0.21	0.17
											Di-n-butylphthalate	0.063 J	0.330 U	0.13	0.026
											Fluoranthene	0.32 J	0.11 J	0.32	0.33
											Indeno (1,2,3-cd)pyrene	0.046 J	0.330 U	0.046	0.035
											Phenanthrene	0.097 J	0.330 U	0.097	0.097
											Pyrene	0.35	0.037 J	0.35	0.35
											Benzene	0.001 J	0.012 J	0.001	0.001
											Xylenes	0.001 J	0.006 J	0.001	0.001
											Acetone	0.013 J	0.012 J	0.012	0.012
											Methylene chloride	0.014 B	0.013 B	0.014	0.014
118-C-2	Storage Tank	100-BC-2	26.9 m^2	Operation of the 105-C Ball Storage Tank (Ball 3X Storage Tank) began in 1969, coinciding with the Ball 3X Project work. The project operation ended that same year. During Ball 3X Project work with a prototype-contaminated ball sorter, the tank received highly radioactive, irradiated, nickel-plated boron-steel, and carbon-steel balls. The tank served as temporary storage until the balls decayed radiologically before burial. The storage box had a slope with vents at each end. One vent was used to put the balls into the tank and the other was used to remove them (following a cool down period). Approximately 9,070 kg (20,000 lb) of highly activated balls remained in the storage tank. Approximately 70% of the balls remaining are boron-steel and 30% are carbon-steel.	Interim Closed Out	CVP-2004-00005	11/10/2003	12/3/2003	470	3.14	Cobalt-60	0.1	\	0.044	\
											Nickel-63	78.9 B	\	70.9	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-C-3	Reactor	100-BC-2	5,528 m^2	The site is an inactive plutonium production reactor that has been placed in ISS. The original facility consisted of the reactor block, which included the graphite core, biological and thermal shields, pressure tubes, and the safety and control systems. The irradiated fuel storage basin was constructed below grade.	Accepted	EPA/ROD/R10-95/126	N/A								
118-C-3:1	Reactor	100-BC-2	Not Documented	The 105-C Reactor Facility was a water-cooled, graphite-moderated nuclear reactor that irradiated uranium fuel rods. The plutonium byproduct was extracted from the irradiated rods in the 200 Area Fuel Separations plants.	Accepted	EPA/ROD/R10-95/126	N/A								
118-C-3:2	Reactor	100-BC-2	Not Documented	The remedial action involved the D&D of associated structures and soils at the 105-C Reactor to the extent required leaving only the reactor core to be placed in interim safe storage status. Remediation included the removal of hazardous and radiologically contaminated material from below grade rooms, tunnels, and contaminated soils.	Closed Out	CVP-98-00009	Not Documented	Not Documented	15600 tons	15	Americium-241	\	31.1	\	\
											Cesium-137	\	1.4	\	\
											Cobalt-60	\	6.2	\	\
											Europium-152	\	3.3	\	\
											Europium-154	\	3	\	\
											Europium-155	\	125	\	\
											Nickel-63	\	4,026	\	\
											Plutonium-238	\	37.4	\	\
											Plutonium-239/240	\	33.9	\	\
											Strontium-90	\	4.5	\	\
											Uranium-234	\	1.1	\	\
											Uranium-235	\	1	\	\
											Uranium-238	\	1.1	\	\
											Chromium VI	\	2.2	\	\
											Lead	\	353	\	\
											Mercury	\	24	\	\
											PCBs	\	1	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
118-C-3:3	French Drain	100-BC-2	Not Documented	The 118-C-3:3 Site is a collection of four French drains roughly located at the four corners of the 105-C Reactor Building. The 118-C-3:3 French drains were likely condensate drains from the sealed steam heating system that would not have been subject to contamination from within the reactor building. However, the exact history of the 118-C-3:3 Drains is unknown. Excavation at the four French drain locations found three of the four drains partially intact. The fourth drain, #4 to the southeast, was not found in the excavation. The three French drains found were excavated and sampled just below the bottom of the drain. The southeast location was excavated to 4.6 m (15 ft) below ground surface and sampled at the bottom of the excavation.	Interim Closed Out	WSRF-2006-016	1/4/2006 (confirmatory samples)	Not Documented	Not Documented	4.6	Uranium-233/234	0.625	\	\	\
											Uranium-235	0.051	\	\	\
											Uranium-238	0.676	\	\	\
											Arsenic	3.4	\	\	\
											Barium	80	\	\	\
											Beryllium	0.69	\	\	\
											Boron	1.4	\	\	\
											Chromium	16.4	\	\	\
											Chromium VI	0.54	\	\	\
											Cobalt	7.4	\	\	\
											Copper	38.3	\	\	\
											Lead	7.9	\	\	\
											Manganese	297	\	\	\
											Mercury	0.8	\	\	\
											Nickel	14.4	\	\	\
											Selenium	0.37	\	\	\
											Vanadium	48.7	\	\	\
											Zinc	50.2	\	\	\
											Aroclor-1254	0.0051	\	\	\
											Aroclor-1260	0.0065	\	\	\
											Benzo(a)anthracene	0.075	\	\	\
											Benzo(a)pyrene	0.073	\	\	\
											Benzo(b)fluoranthene	0.059	\	\	\
											Benzo(g,h,i)perylene	0.059	\	\	\
											Benzo(k)fluoranthene	0.068	\	\	\
											Chrysene	0.1	\	\	\
											Fluoranthene	0.16	\	\	\
											Indeno (1,2,3-cd)pyrene	0.052	\	\	\
											Phenanthrene	0.11	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Pyrene	0.17	\	\	\
											bis(2-Ethylhexyl)phthalate	0.065	\	\	\
											Di-n-butylphthalate	0.026	\	\	\
118-C-4	Storage	100-BC-2	12.19 x 7.62	The 105-C Horizontal Control Rod Storage Cave included tunnels used for temporary storage of control rods, and possibly miscellaneous equipment, to allow radioactive decay before disposal. Three French drains were located along the center of the structure floor for the removal of precipitation runoff that could potentially percolate and collect between the tunnels.	Interim Closed Out	CVP-2003-00015	Mar-03	Mar-03	453	0.85	Americium-241	0.169	\	0.045	\
											Cesium-137	0.034 U	\	0.015	\
											Cobalt-60	0.033 U	\	0.0151	\
											Europium-152	0.076 U	\	0.0338	\
											Europium-154	0.12 U	\	0.519	\
											Europium-155	0.095 U	\	0.0446	\
											Plutonium-238	0.06 U	\	0.0397	\
											Plutonium-239/240	0.0726 U	\	0.0238	\
											Strontium-90	0.004 U	\	0.00245	\
											Uranium-234	0.835	\	0.55	\
											Uranium-235	0.054 U	\	0.0463	\
											Uranium-238	0.936	\	0.59	\
											Arsenic	2.5	\	2.5	\
											Barium	45	\	44	\
											Cadmium	0.51 U	\	0.4	\
											Chromium	7.8	\	7.5	\
											Chromium VI	0.44 U	\	0.44	\
											Lead	20	\	16	\
											Mercury	0.034	\	0.02	\
											Selenium	0.51 U	\	0.42	\
											Silver	0.0084 B	\	0.12	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
124-C-4	Sanitary Sewer	100-BC-2	Not Documented	This site was assigned based on the information from Bechtel Hanford, Inc., D&D in the 1995 RARA Summary Report. D&D could not identify the site location nor could the Bechtel Hanford, Inc., historian. The site is thought to be either 1607-B10 or 1607-B11 as they are the only remaining septic systems in the 100-B Area that have a 124 alias assigned to them. If a determination can be made that it is one of above-referenced septic systems, the 124-C-4 will be added to the site as an alias. This site reference (as a separate site) will then be removed from the database.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A							
128-C-1	Burn Pit	100-BC-2	150 x 110 x 4.6	The 100-C Burning Pit was a vegetation and ash-covered field strewn with pieces of green, clear, and bright blue glass; small glass bottles; metallic wastes such as rusted cans, auto parts, and assorted scrap metal; chunks of concrete; and pieces of asbestos transite. The site was divided into four areas for evaluation, with a total of three trenches and three test pits excavated.	Interim Closed Out	WSRF-2005-019	Sep-04	Feb-05	8,750 BCM	1.8 - 4.6	Arsenic	7.2	\	4.4	\
											Antimony	2.7	\	\	\
											Barium	82.3	\	62.4	\
											Beryllium	1.1	\	0.8	\
											Boron	22.9	\	6.9	\
											Cadmium	2.3	\	0.6	\
											Chromium	37.7	\	18.5	\
											Cobalt	10.2	\	7.3	\
											Copper	114	\	51.2	\
											Lead	73.5	\	35	\
											Lithium	8.9	\	6.9	\
											Manganese	395	\	313	\
											Mercury	0.1	\	0.07	\
											Molybdenum	1.9	\	\	\
											Nickel	17.5	\	11.7	\
											Selenium	1.3	\	\	\
											Silver	6.6	\	\	\
											Vanadium	58.5	\	40.9	\
											Zinc	170	\	69.5	\
											Aroclor-1254	0.54	\	0.12	\
											Aroclor-1260	0.011	\	\	\

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Benzo(a)anthracene	0.029	\	\	\
											Benzo(a)pyrene	0.031	\	\	\
											Benzo(b)fluoranthene	0.032	\	\	\
											Benzo(g,h,i)perylene	0.024	\	\	\
											Benzo(k)fluoranthene	0.03	\	\	\
											bis(2-Ethylhexyl)phthalate	3.1	\	\	\
											Chrysene	0.038	\	\	\
											Di-n-butylphthalate	0.053	\	0.099	\
											Fluoranthene	0.059	\	\	\
											Indeno (1,2,3-cd)pyrene	0.021	\	\	\
											Phenanthrene	0.033	\	\	\
											Pyrene	0.047	\	\	\
132-C-1	Burial Ground	100-BC-2	60.96 x 9.14 x 5.49	This site was a burial area that contained rubble from the 105-C Reactor Stack, also known as the 116-C Reactor Exhaust Stack. A no-action decision is supported based on reviews of the facility information, historical data, and allowable residual contamination level and RESRAD modeling results. Residual contamination, present in a thin layer not more than 1 cm (0.4 in.) thick, was shown in RESRAD results to not present an unacceptable level of risk to the maximally exposed individual, and is protective of groundwater and the Columbia River.	No Action	WSRF-2003-026	N/A								
132-C-2	Outfall	100-BC-1	16 x 8.2	The 132-C-2 Outfall is located north of the 107-B Retention Basin and downstream from the 116-B-7 Outfall. In addition to two steel pipelines that discharged at the center of the Columbia River, it was designed with a concrete overflow flume that spilled effluent water onto a large basalt boulder riprap flume that extended to the river shoreline. In 1979, the outfall was reduced to near grade and backfilled.	Interim Closed Out	CVP-2002-00003	See 116-B-7 data								

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
132-C-3	Process Unit/Plant	100-BC-2	16.86 x 7.01	The 117-C Filter Building began operation in 1961 to filter 105-C Reactor exhaust air before it was routed to the 116-C Exhaust Stack. The building was shut down in 1969. A no-action decision is supported based on reviews of the facility information, historical data, and allowable residual contamination level and RESRAD modeling results. Low-level radioactive waste removed from the facility was packaged and shipped to the 200 West Area burial grounds for disposal. No asbestos, mercury, or any other nonradioactive hazardous materials were found in the 117-C Facility. Residual contamination, present in a thin 1 mm (04 in.) paint layer, was shown in RESRAD results to not present an unacceptable level of risk to the maximally exposed individual, and is protective of groundwater and the Columbia River.	No Action	WSRF-2003-024	N/A								
600-33	Burial Ground	100-BC-2	12.2 x 6.1 x 3.0	The waste site was a burial site for the 105-C Reactor Test Loop. The selected design for the test loop was a tube within a tube (annular design). The outer tube was a 3.8 cm (1.5 in.) inside diameter Schedule 160 stainless steel tubing. The inner tube was 2.5 cm (1 in.) inside diameter with 0.17 cm (0.065 in.) wall thickness within a 12 m (40 ft) carbon steel shield tube. The test loop was inserted into the south side of the C Reactor core (one of the channels) and was used to test the effects of ionization on various chemicals being considered for reactor process tube scaling and cleaning.	Rejected	EPA/ROD/R10-00/121	N/A								
600-34	Dumping Area	100-BC-1	300 x 150 x 4.6	The site is a dumping area used for disposal of miscellaneous waste. Visible wastes include wood (timbers and ties), piles of a silt-like material, sheet metal, cardboard, roofing material, concrete, electrical insulators, and a 10 L (5 gal.) plastic bucket. Pre-Hanford Site waste is also evident including barbed wire, what appears to be old farm equipment, and remnants of wire-wrapped wooden irrigation pipe.	Rejected	Not Documented	N/A								

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												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
600-56	Dumping Area	100-BC-1	Not Documented	The site is the abandoned waste from what appears to be a pre-Manhattan Engineering District farm. The site is identifiable by scattered debris, piles of rocks, and an excavated pit.	Rejected	Not Documented	N/A								
600-67	Storage	100-BC-1	33.83 x 14.02	The Bruggemann's Warehouse site is the remaining one-story warehouse, associated foundations, piping, and debris surrounding the site. The building is considered culturally significant because of its good condition and use of native materials for construction. It is in the process (as of January 2001) for listing on the National Register of Historic Places.	Rejected	Not Documented	N/A								
600-230	Dumping Area	100-BC-1	15.24 x 6.1	The RCRA General Inspection 200WFY97 Item #4 Historic Disposal Site is believed to be a pre-Manhattan Project dump that represents an opportunistic event to dispose of primarily unwanted household items. The location of the dump near the edge of the upper terrace above the Columbia River indicates someone dumped garbage near the edge of the terrace and over time some of the items have moved downslope. The basis for reclassification to no action is a cultural resource review that concluded the site was the result of pre-Hanford Site dumping activities. The only noted suspect hazardous material, a single battery, was removed from the site and disposed. Residual material (debris, soil) at the site achieves the established RAOs and corresponding remedial action goals.	No Action	WSRF-2006-041	N/A								
600-231	Dumping Area	100-BC-1	12.19 x 3.05	The site contains pre-Hanford Site debris, including several rusty metal food containers, empty paint cans, buckets, glass, small pieces of concrete, cable, barbed wire, sheet metal, and a rubber tire.	Not Accepted	Site Closed using 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]
600-232	Dumping Area	100-BC-2	24772.23 m^2	The site has several weathered utility poles in various conditions ranging from poor to good. The treated wood ends of the utility poles are categorized as dangerous waste. The site also contained various electrical utility materials such as steel cable, aluminum high-voltage wire, aluminum beams, aluminum poles, and insulators.	Interim Closed Out	WSRF-2004-066	2/19/2004	4/16/2004	9,005	0.3	Arsenic	2.4	\	\	\
											Barium	68.2	\	\	\
											Cadmium	0.1	\	\	\
											Chromium	9.8	\	\	\
											Lead	4.9	\	\	\
											Mercury	0.02	\	\	\
											Aroclor-1254	0.023	\	\	\
											bis(2-Ethylhexyl)phthalate	0.036	\	\	\
											Carbazole	0.028	\	\	\
											Chrysene	0.24	\	\	\
											Di-n-octylphthalate	0.028	\	\	\
											Dibenz[a,h]anthracene	0.018	\	\	\
											Fluoranthene	0.52	\	\	\
											Indeno (1,2,3-cd)pyrene	0.043	\	\	\
											Pentachlorophenol	0.15	\	\	\
											Phenanthrene	0.14	\	\	\
											Pyrene	0.54	\	\	\
											Total petroleum hydrocarbons	10.9	\	\	\
600-233	Storage Tank	100-BC-2	First pipe: 1.7 (depth) 6.4 cm (diameter) Second pipe: 1.9 cm (diameter)	These pipes were identified during the Ecology RCRA inspection at 100-B. They appear to be old water supply pipes. A search of old pipeline drawings of the 100-B/C Area shows no known pipelines in this area. There are no facilities other than the railroad near this location, so it is likely the pipes are an extension of the fire control system and used for the railroad and laydown area.	Interim Closed Out	WSRF-2005-041	Not Documented	Not Documented	Not Documented	0.5	Barium	51.2	\	\	\
											Beryllium	0.41	\	\	\
											Boron	1.5	\	\	\
											Cadmium	0.28	\	\	\
											Chromium	7.9	\	\	\
											Cobalt	6.3	\	\	\
											Copper	11.5	\	\	\
											Lead	4.9	\	\	\
											Manganese	270	\	\	\
											Nickel	8.3	\	\	\

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
											Selenium	3	\	\	\
											Vanadium	37	\	\	\
											Zinc	33.8	\	\	\
											Anthracene	0.047	\	\	\
											Benzo(a)anthracene	0.29	\	\	\
											Benzo(a)pyrene	0.18	\	\	\
											Benzo(b)fluoranthene	0.22	\	\	\
											Benzo(k)fluoranthene	0.18	\	\	\
											Butylbenzylphthalate	0.028	\	\	\
											Chrysene	0.34	\	\	\
											Dibenz[a,h]anthracene	0.061	\	\	\
											Fluoranthene	0.69	\	\	\
											Indeno (1,2,3-cd)pyrene	0.11	\	\	\
											Phenanthrene	0.34	\	\	\
											Pyrene	0.51	\	\	\
600-252	Dumping Area	100-BC-2	2.44 1.07 (diameter)	The site is an old, rusty, corrugated steel tank lying on its side. The site was visited on September 26, 2000, with a cultural resource specialist familiar with the history of the farms in this area. The tank was identified as a water tank because of the lack of any oil staining inside of or below the tank, and the cuts for the pipes fit irrigation piping but not typical oil heating or storage systems.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								
600-253	Depression/Pit (nonspecific)	100-BC-1	Not Documented	Gravel Pit #24 is a large excavated area that is actively used as a source of gravel and sand material. Because the bottom of the pit reached groundwater, a wetland was deliberately created in 1999 by excavating a little deeper and contouring the bottom to form islands and different depths of water. There is no evidence of hazardous or radioactive wastes disposed at this site.	Not Accepted	Site Closed using TPA-MP-14 WIDS Discovery Site Evaluation checklist approved by the Regulators.	N/A								

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

Site Code	Site Type	Operable Unit	Site Dimensions (m)	Site History	Reclassification Status	Closure Document	Remedial Action Start Date	Remedial Action End Date	Contaminated Waste Volume to ERDF (metric tons)	Maximum Depth of Remedial Action (m)	COC	Max Concentration (pCi/g, mg/kg)		95% UCL (pCi/g, mg/kg)	
												Shallow[a]	Deep[b]	Shallow[a]	Deep[b]
600-264	Dumping Area	100-BC-1	8.9 x 7.5	The site consisted of a 55-gal. drum lying on its side, surrounded by orchard smudge pots. The drum was removed from the old orchard site to a DynCorp 90-Day Waste Accumulation Area on April 18, 2000. The oil-crusted soil around the drum was removed on June 28, 2001, as a voluntary DOE cleanup action.	Rejected	Not Documented	N/A								

a Shallow zone: soil above 4.6 m above ground surface
b Deep zone: soil below 4.6 m above ground surface
BCM = bank cubic meter
BG = background
COC = contaminant of concern
D&D = decommission and decontaminate
D&D = decontamination and decommissioning
DOE = Department of Energy
ERDF= Environmental Restoration Disposal Facility
GPERS = will you see if this is in the doc? YES
ISS = Interim Safe StorageN/A = not applicable
OU = operable unit
ppm = parts per million
RAO = remedial action objective
RARA = radiation area remedial action
RCRA = Resource Conservation and Recovery Act
RCRA = *Resource Conservation and Recovery Act of 1976*
RESRAD = RESidual RADioactivity
RESRAD = RESidual RADioactivity (dose model)
UCL = upper confidence limit
WAC = Washington Administrative Code
WIDS = Waste information data system
WIDS = Waste Information Data System
/ = no data collected.

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Appendix D

Summary of 100-BC Decision Unit Facilities

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D1 Introduction

Table D-1 provides a summary of the buildings/facilities that have existed in the 100-CD Decision Unit of the Hanford Site. Many of these buildings/facilities have been demolished or are no longer used. Table D-1 also provides physical dimensions and a brief history for each building/facility.

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Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
103-B	Storage	100-BC-1	17.68 x 8.23 x 5.18	Demolished	1943	1996	The 103-B Fresh Metal Storage Building is located just north of 105-B. This rectangular-shaped building consists of one storage room and a loading platform, and was used for pallet storage of fuel elements before use in the reactor. In 1985, it was decontaminated and cleaned out. More recently, it was used as a rigger's loft for storing rigging equipment.
104-B1	Storage	100-BC-1	12.2 m^2	Demolished	1950	1996	The 104-B1 Tritium Vault was constructed to support the P-10 Project. The vault contained storage racks on the north and south walls, and the storage racks were used to hold shipping flasks containing tritium gas.
104-B2	Laboratory	100-BC-1	47.9 m^2	Demolished	1950	1996	The 104-B2 Tritium Laboratory was constructed to support the P-10 Project (the irradiation of lithium-aluminum fuel targets). The facility had 63 special cells recessed in the laboratory floor, used to store vacuum casks that contained the irradiated target elements.
105-B	Reactor	100-BC-1	75 x 55	Inactive	1943	Not Available	The B Reactor provided housing for the nuclear reactor and equipment directly associated with the reactor operations. The two main components are the reactor block and the storage basin. The reactor block is located near the center of the building. When facing the reactor front face, the horizontal control rod penetrations are on the left side of the reactor block, and the safety rod penetrations are on the top of the reactor. Fuel discharge and storage areas are located adjacent to the rear face of the reactor block. Experimental test penetrations are on the right side. The reactor block consists of a graphite moderator stack encased in cast iron thermal shielding and a biological shield rests on a massive concrete foundation. The fuel storage basin served as a collection, storage, and transfer facility for the irradiated fuel elements discharged from the reactor. Irradiated fuel elements were sorted in the pickup area, transferred to buckets, transported by monorail to the storage area, and held to allow decay of short-lived radionuclides before reprocessing. Following storage, the buckets of fuel elements were moved to the transfer area, placed in lead-shield casks, and moved into compartmented, water-filled railroad well cars for transport to the chemical processing facilities. A wash pad, which was used for equipment decontamination, and an underwater inspection facility are also in the storage basin area. The B Reactor, the first full-size reactor in the world, was the first reactor built on Hanford Site. It has received several national awards as a Nuclear and Mechanical Engineering Landmark, and is listed on the National Register of Historic Places. A community effort is currently under way to use the B Reactor as a museum.
105-C	Reactor	100-BC-2	105.5 x 45.7 x 36.6 and 45.7 x 27.4 x 6.1	Inactive	1952	ISS -1998	The C Reactor provided housing for the nuclear reactor and equipment directly associated with the reactor operations. The two main components are the reactor block and the storage basin. The reactor block is located near the center of the building. When facing the reactor front face, the horizontal control rod penetrations are on the left side of the reactor block, and the safety rod penetrations are on the top of the reactor. The reactor block consists of a graphite moderator stack encased in cast iron thermal shielding, a biological shield consisting of alternating layers of masonite and steel on the four sides, and a heavy aggregate poured shield on top. The entire block rests on a massive concrete foundation. The fuel storage basin served as an underwater collection, storage, and transfer facility for the irradiated fuel elements discharged from the reactor. Irradiated fuel elements were sorted and placed in storage containers in the pickup area, transported by monorail to the storage area, and held to allow decay of short-lived radionuclides before reprocessing. Following storage, the buckets of fuel elements were moved to the transfer area, placed in lead-shield casks, and moved into a railroad well car for transport to the chemical processing facilities. A wash pad, which was used for equipment decontamination, and an underwater inspection facility are also in the storage basin area.
106-B	Storage		15 x 5.7 x 3.6	Demolished	1943	Not Available	The 106-B Contaminated Equipment Storage Building was a galvanized iron Quonset hut with a plywood floor. During the historical research for the BC Area, the exact location of the 106-B Building was not discovered. A review of construction drawings and historical photographs did not support its existence. Although not confirmed, this building may not have been constructed.
107-B	Retention Basin	100-BC-1	70 x 142	Demolished	1944	1954	The purpose of the retention basin was to retain reactor cooling water to allow for decay of short-lived radionuclides and cooling of water before its return to the river. It discharged to an outfall at the river and had a crosstie to 107-C. Because of a crack in the basin in 1954, extensive leaks occurred to the soils in the area, ending operations of the facility.
107-C	Retention Basin	100-BC-1	2 tanks, ea. 101 m dia.	Demolished	1952	1999	The 107-C Retention Basin consisted of two circular open-topped tanks with a capacity of 37.9 million L (10 million gal.). The facility held effluent water from the B and C Reactors for cooling and decay before its release into the Columbia River.

Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
108-B	Process Unit/Plant	100-BC-1	40 x 10 x 12	Demolished	1944	1985	The intended use of this facility was for the chemical mixing and addition to the reactor cooling water; however, it was soon determined this function could be better performed elsewhere in the cooling water supply system. The 108-B Building was then converted to a tritium recovery processing facility. The tritium separation facility was designed to support reactor operations by recovering tritium from irradiated lithium-aluminum target elements.
110-B	Storage Tank	100-BC-1	2 tanks, ea. 2.4 m dia. 2 tanks, ea. 0.6 m dia.	Demolished	1944	Not Available	The 110-B Gas Storage Tanks held the helium and carbon dioxide used for the reactor atmosphere. The tanks were supported by concrete cradles. Pipe extended from the tanks to the circulation system and equipment in the 115-B Building.
111-B	Laboratory	100-BC-1	24 x 19 x 4.4	Demolished	1944	1984	The 111-B Metal Examination Facility was a one-story, wood frame "L" shaped building built on a concrete floor slab. The facility served as a failed fuel inspection facility. Irradiated fuel pieces were stored and examined in two below grade stainless steel-lined concrete tanks filled with water for shielding purposes. The facility was demolished to slab-on-grade in 1984 and the slab and below grade tanks removed in 1999.
115-B	Process Unit/Plant	100-BC-1	1413 m^2	Demolished	1944	1989	The 115-B Gas Recirculation Facility filtered and recirculated the inert gas that surrounded the core of the reactors. The recirculation cycle included cooling, drying, and filtering of the large gas volumes before reentry into the reactors.
116-B	Stack	100-BC-1	height: 61; dia. 5	Inactive	1943	Not Available	The unit is part of the 105-B Reactor Gas and Exhaust Air System. Following completion of the confinement project in 1960, the air was diverted via an aboveground aluminum duct and an underground, reinforced-concrete duct to the 117-B Filter Building. After flowing through the filters, the air flowed through a below grade concrete duct and an above grade aluminum duct into the exhaust stack.
116-C	Stack	100-BC-2	height: 61; dia. 5	Demolished	1952	1983	Exhaust air flowed through concrete ducts from the 105-C Building directly out the exhaust stack. Following completion of the confinement project in the 1950s, the air was diverted via underground, reinforced-concrete ducts to the 117-C Filter Building. After flowing through the filters, the air went through below and above grade concrete ducts into the exhaust stack.
117-B	Process Unit/Plant	100-BC-1	17 x 11 x 10.6	Demolished	1960	1988	This building was a below grade, bermed (earth and gunite) structure with large steel hatch covers that served as the roof. The building was 2.4 m (7.8 ft) above grade, 8.2 m (26 ft) below grade, 17 m (56 ft) long, and 11 m wide. The building filtered ventilation air from the confinement zone of the B Reactor Building through HEPA and activated charcoal filters, before its discharge to the atmosphere through the 116-B Stack.
117-C	Process Unit/Plant	100-BC-2	17 x 11 x 10.6	Demolished	1960	1988	The building received exhaust fan discharge through an inlet duct from the C Reactor Building and discharged the filtered air (HEPA and activated charcoal filters) through a discharge duct and out the 116-C Stack.
119-B	Laboratory	100-BC-1	25.8 m^2	Inactive	1960	Not Available	The purpose of the 119-B Sample Building was to monitor the air quality of the exhaust that was released through the 116-B 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 quality 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. Additional equipment was provided for monitoring the radiation and pressure conditions in the 117-B Filter Building.
119-C	Laboratory	100-BC-2	21.9 m^2	Demolished	1960	Not Available	The purpose of the 119-C Sample Building was to monitor the air quality of the exhaust that was released through the 116-C 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 quality 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. Additional equipment was provided for monitoring the radiation and pressure conditions in the 117-C Filter Building.
151-B	Substation	100-BC-2	12,667 m^2	Active	1944	Not Available	The 151-B Primary Substation supplies electrical power for the pumping facilities in 100-B Area and electricity for the 100-B Area standby facilities. The substation was expanded in 1951 to support the C Reactor. This facility is needed as long as the 200 Area needs water service from the 100-B Area.
152-B	Substation	Not Documented	62.2 m^2	Demolished	1944	Not Available	There were 10 secondary substations located in 100-B Area.

Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
152-C	Substation	Not Documented	Not Available	Demolished	1952	Not Available	For the construction of the C Reactor, additional substations were built to support the 183-C, 190-C, and 105-C Buildings.
153-B	Substation	Not Documented	Not Available	Demolished	Not Available	Not Available	There were eight distribution stations located in the B Reactor area. Each distribution substation was constructed as an open wood pole structure surrounded by a picket fence.
1605-B	Guard Towers	Not Documented	11 towers ea. 4.4 x 4.4 x 3.9	Demolished	1944	Not Available	There were 11 guard towers in the 100-BC Area, located along the perimeter fence on the east, south, and west sides of the area, and along the river to the north.
1614-B	Monitoring Station	Not Documented	3.8 m^2	Demolished	Not Available	Not Available	There were three environmental monitoring stations, used to house the equipment that sampled airborne process wastes.
1621-B	Substation	Not Documented	1.5 x 2.9 x 3.4	Demolished	Not Available	Not Available	Three emergency generators were built for the 100-B Area. Each one contained a gasoline-powered electrical generator designed to automatically activate in the case of a power failure. Fuel was stored outside of the building in tanks placed on tall concrete saddles for gravity feeding.
1701-B	Office	100-BC-2	12 x 6.7 x 7	Demolished	1944	Not Available	The 1701-B Badge House provided entrance into the exclusion area and was later used as a lunchroom and restroom facility. The facility was designed to house personnel who verified employee identification entering the work area. The facility contained a guard, equipment, clock alley, laboratory, storage, office, and restrooms.
1701-BA	Office	100-BC-1	6.1 x 6.1 x 3.7	Demolished	1966	1996	This facility was constructed in 1966 to replace the 1702-B Gate House during the fence relocation project. It provided a shelter for a security checkpoint before entrance to the exclusion area.
1702-B	Office	100-BC-1	6.1 x 6.1 x 3.7	Demolished	1944	1966	The facility provided entrance to the 105-B Exclusion Area. The building was replaced in 1966 by the 1701-BA Building.
1702-C	Office	100-BC-1	19.5 m^2	Demolished	Not Available	1997	The facility provided entrance to the 105-C Exclusion Area.
1703-B	Office	100-BC-1	367.5 m^2	Demolished	1950	Not Available	The facility was located near the 108-B Facility, and is believed to have been an office building built to house personnel for the C Reactor, or to support the tritium project in 108-B.
1704-B	Office	100-BC-1	45 x 35 x 8	Removed	1944	NA	The one-story 1704-B Office Building was used as a supervisor's office and a laboratory. The facility was later moved to the 200 Area in the 1970s.
1707-B	Office	100-BC-1	9 x 20 x 5	Demolished	1944	Not Available	The 1707-B Building was originally used as a change house and lunchroom and later as office space located along the main gatehouse road.
1707-BA	Office	100-BC-1	170.7 m^2	Demolished	1944	Not Available	The 1707-BA Building provided locker space, shower facilities, and a lunchroom.
1709-B	Office	100-BC-1	331 m^2	Demolished	1944	Not Available	The 1709-B Fire Headquarters Building was located near the main gate entrance to the B Reactor area. The facility was designed to provide living quarters for firefighters and included truck storage.
1713-B	Storage	100-BC-1	23.5 x 16 x 5	Demolished	Not Available	Not Available	The one-story 1713-B Building was used for storeroom and warehouse space. All 100-B Area supplies were received and dispersed from this building. Later it was converted to an instrument and development testing facility.
1713-BA	Storage	100-BC-1	24.4 x 63.4 x 4.3	Demolished	Not Available	Not Available	The 1713-BA Essential Materials Storage building was converted from the Temporary Construction Receiving and Warehouse Building.
1713-BB	Storage	100-BC-1	4.6 x 39.3 x 3	Demolished	Not Available	Not Available	The 1713-BB Facility was converted from the Temporary Construction TC-30 Division Engineer's Office.
1713-C	Storage	100-BC-1	3.8 x 3.8	Demolished	1952	Not Available	The 1713-C Solvent Storage Building was located east of the 108-B Building.
1714-C	Storage	100-BC-2	3.7 x 5.5	Demolished	1952	1996	The 1714-C Building was located south of 105-C, near 117-C, and was used as an oil house to store miscellaneous oil and solvents.
1715-B	Storage	100-BC-1	13 x 4.2 x 5.5	Demolished	Not Available	Not Available	The 1715-B Oil and Paint Storage building was one-story tall with a concrete foundation.

Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
1716-B	Maintenance Shop	100-BC-1	16 x 12 x 5.5	Demolished	Not Available	Not Available	The 1716-B Automotive Repair Building was equipped for service station function and light maintenance of vehicles.
1717-B	Maintenance Shop	100-BC-1	46 x 24 x 7.6	Demolished	Not Available	Not Available	The one-story 1717-B Maintenance Shop was located along the main entrance road and contained a large machine, carpenter, pipe, sheet metal, electric and forge shops, a tool room, several offices, and a restroom.
1719-B	Office	100-BC-1	9.7 x 7.8 x 5.9	Demolished	Not Available	Not Available	The 1719-B First Aid Station was a one-story structure located near the center of the process area. It contained a first aid room, cot room, laboratory, office, and restrooms.
1720-B	Office	100-BC-1	24 x 9.7 x 4.6	Removed	Not Available	NA	The 1720-B Building was a one-story building originally used as the area patrol headquarters and later for office space.
1722-B	Maintenance Shop	100-BC-1	12 x 9.1 x 4.6	Demolished	Not Available	Not Available	The 1722-B Paint Shop was a one-story building that contained a rigger's loft and paint storage room.
1722-BA	Maintenance Shop	100-BC-1	12.2 x 29 x 3	Demolished	Not Available	Not Available	This facility was originally the TC-30 Electrical Shop. In 1945, it had telephone, lighting, water, and heating utilities.
1729-B	Storage	100-BC-1	669 m^2	Demolished	Not Available	Not Available	The 1729-B Storage Building was used to house extra machinery. It was converted from the TC Pipe Storage Warehouse.
1734-B	Storage	100-BC-1	22.3 m^2	Demolished	Not Available	Not Available	The 1734-B Gas Cylinder Storage Building contained four small cylinder storage spaces, one for oxygen storage, one for hydrogen and acetylene storage, and two for empty cylinder storage.
1736-B	Storage	100-BC-1	6.1 x 12.2	Demolished	Not Available	Not Available	The 1736-B Building was used to store maintenance tools and equipment.
1736-C	Storage	100-BC-1	74.3 m^2	Demolished	Not Available	Not Available	The 1736-C Building may not have ever have been constructed, however, there is some evidence to support the location of 1736-B as being next to the B Reactor, and it can be supposed that this building may have been located adjacent to 105-C. If so, it was likely used to store maintenance tools and equipment.
1784-B	Office	100-BC-1	9.3 m^2	Demolished	Not Available	Not Available	The building is the 1784-B Coal Handlers' Office.
181-B	Pump Station	100-BC-1	75 x 15 x 6	Active	1944	NA	The facility supported both B and C Reactors by pumping raw river water to water treatment plants. This facility had 10 electric-driven pumps with a capacity of about 40,000 L/min (10,570 gal./min).
181-C	Pump Station	100-BC-1	15.2 x 5.5 x 5.5	Inactive	1952	Not Available	The facility provided raw river water to the 182-B Reservoir and the 183-C Filter Plant Headhouse. This facility was actually an addition to the 181-B River Pump House with a concrete intake and trash rack running along the north side, and a pipe tunnel 2.7 by 34.4 m (8.8 by 112.8 ft) running along the south side of the building. The addition included a lighting system, power system, motor control center, the 181-B Substation, and the necessary building service, together with the piping system and pumping equipment to support a 272,550 L/min (72,021 gal./min) pumping rate. It had 12 pump bays, two of which were designed for future planned expansion.
182-B	Process Unit/Plant	100-BC-1	147 x 94 x 12	Active	Not Available	Not Available	The reservoir and pumphouse provided reserve water for reactor cooling and raw export water for the 100 Area and 200 Area. The river pumphouse (181-B) supplied water to the two storage reservoirs, and the reservoir capacity was9.5 million L (25 million gal.). Seven pumps were located in the pump room, each capable of pumping 23,000 L/min (6,077 gal./min). Water was treated to reduce corrosion and film formation in the water cooling tubes and the canned uranium slugs in the reactor.
183-B	Process Unit/Plant	100-BC-1	73 x 114 x 6	Demolished	Not Available	1988	The 183-B Filter Plant contained water treatment and filtering facilities and served as a reservoir for treated water. The facility consisted of a head house and chemical building, flocculation and sedimentation basins, filter building, and clearwell storage with pump room. The filter plant contained the chemical feeding equipment, mechanical mixing and flocculating chambers, gravity filters, sedimentation basins, and a 38 million L (13 million/gal.) clearwell used for the storage of filtered water. The filter plant was designed to remove suspended materials from the water by mixing chemicals followed by a sedimentation period and filtration through a bed of Anthrafilt, sand, and gravel. Chemicals used for water treatment in the facility included lime, aluminum or ferric sulfate, activated carbon, chlorine, and Calgon. The total capacity of the 183-B Pumping Facility was 439,000 L/min (116,006 gal./min).

Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
183-C	Process Unit/Plant	100-BC-1	64.6 x 23.8 x 24.4	Demolished	1952	1982	The 183-C Facility was a complete chemical storage and handling facility (head house) with flocculation and sedimentation basins, mixers, sample and analyses facilities, flow control devices, and four steel clearwell tanks with the capacity for 11.4 million L (3 million gal.) of storage. It supplied treated water to the C Reactor.
184-B	Process Unit/Plant	100-BC-1	64.6 x 23.8 x 24.4	Demolished	1943	1983	The building was called the Power House, but was primarily a Boiler House, containing only a small turbine generator for emergencies, capable of supplying building lights and motors that must be maintained in continuous service. The building consisted of the following structures: Main Power House, two 91 m (300 ft) reinforced-concrete smoke stacks, coal-handling conveyor system, including crusher house, two transfer houses and track hoppers, an open coal storage pit, salt dissolving pit, and brine pump house. The 184-B-Building Powerhouse provided steam and emergency electrical power for the secondary coolant system located in 181-B. It also supplied office heat and other heating needs through overhead steam lines that looped throughout the 100-B Area.
185-B	Process Unit/Plant	100-BC-1	94 x 15 x 18	Demolished	1944	Not Available	The 185-B Deaeration Facility (i.e., 185-B Water Treatment Plant) was designed to receive filtered water from underground clearwells, remove the dissolved gases and entrained air, and pump the deaerated water to steel storage tanks in the 190-B Process Pumphouse. Although originally constructed as a deaeration facility, it was never used for this purpose. The facility provided coolant water for the B Reactor and was later used to store resin for the N Reactor.
187-B1	Storage Tank	100-BC-1	height: 12; dia. 12.5	Demolished	1944	1982	The 187-B1 Storage Tank was one of two elevated process water tanks in the B Reactor area. The tanks were located near and on opposite sides of the 105-Reactor. The tanks were of identical design and constructed of 0.95 cm (0.37 in.) thick steel plate.
187-B2	Storage Tank	100-BC-1	height: 12; dia. 12.5	Demolished	1944	1982	The 187-B2 Storage Tank was one of two elevated process water tanks in the B Reactor area. The tanks were located near and on opposite sides of the 105-Reactor.
187-C1	Storage Tank	100-BC-2	37	Demolished	Not Available	Not Available	The 187-C1 Storage Tank was made of steel and mounted on a 37 m (121 ft) high tower. Its capacity was 1,100,000 L (290,675 gal.) .
187-C2	Storage Tank	100-BC-2	37	Demolished	Not Available	1996	The 187-C2 Storage Tank was made of steel and mounted on a 37 m (122 ft) high tower. Its capacity was 1,100,000 L (290,657 gal.).
188-B	Coal Ash Pit	100-BC-1	97.5 x 103.6 x 3.5	Demolished	1943	1969	188-B is an open rectangular-shaped pit and dike-type basin that was dug or constructed for the disposal of ashes from the 184-B Power House. The powerhouse was equipped with automated removal of ash by pumping ash directly from the sluice pit in the power house to the Ash Disposal Basin by a 20.3 cm (8 in.) chrome-iron alloy (ashcolite) underground pipeline, which was abandoned in place. The ash pit was filled with ash, covered over with dirt and cobble, and abandoned in place.
190-B	Pump Station	100-BC-1	139 x 56	Demolished	1944	1993	The 190-B Pump House provided primary coolant water to the B Reactor Building. It contained four large steel water tanks. Each one was capable of storing 26.5 million L (7 million gal.) of treated water. There were also 12 pumping units, each containing a steam-driven primary and an electrically driven secondary. Together, the two pumps in one unit operated at 1,135 L/min (299 gal.). The 190-BA Annex was constructed to increase the capacity of the 190-B Main Pump House and thus provide additional cooling water to the B Reactor. It contained eight electrically driven 39,368 L/min (10,403 gal./min) pumps, of which seven were needed to reach the desired flow rate.
190-C	Pump Station	100-BC-2	48.6 x 18.3 x 9.8	Demolished	Not Available	1999	The 190-C Facility pumped water to the C Reactor as part of the reactor-cooling process after the water was treated/filtered in the 183-C Filter Building/Pump Room. The building contained approximately 380 linear m (1,246 linear ft) of asbestos-lagged pipes and valves. Ten pumping stations were located on the main floor with a 37,800 L/min (9,988 gal.) capacity each, electrical switchgear room, control room, survey room, lunchroom, change room, bathroom, shop area, and filter storage area. The basement contained cooling water, compressed air and steam piping, fluid coupling heat exchanger, solids injection system, valve pits, and the entrances to the 105-C Water Tunnels. Each tunnel contained the piping used to supply water to C Reactor and a steam supply pipe to 190-C. The tunnels are located at the northeast and southeast corners of the building and are approximately 3.0 m (9 ft) by 3.6 (12 ft) by 150 m (492 ft) long.

Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
1901-B	Storage Tank	100-BC-1	36.6	Demolished	Not Available	Not Available	The 1901-B Soft Water Tank was an elevated cylindrical storage tank with a conical roof used to store water that was then used as feed water for the power house boilers. The total height of the structure was approximately 36.6 m (120 ft), with the steel tank itself accounting for about 7.5 m (24 ft). The capacity of the tank was 283,900 L (48,596 gal.).
1902-B	Storage Tank	100-BC-1	36.6	Demolished	Not Available	Not Available	The 1902-B Sanitary Water Tank was an elevated cylindrical storage tank with a conical roof used to store backup water for the fire system in the B Area. The total height of the structure was approximately 36.6 m (120 ft), with the steel tank accounting for about 7.5 m (24 ft). The capacity of the tank was 283,900 L (48,596 gal.).
1904-B1	Outfall	100-BC-1	Not Available	Demolished	Not Available	Not Available	The 1904-B1 Outfall was located north of the 107-B Building, and was used to direct reactor-cooling water into the river through either the discharge pipeline or the spillway. Water from 107-B discharged into the outfall structure, then into the discharge pipe to the river. The spillway was a concrete flume used to release the water when the discharge pipelines were out of service.
1904-B2	Outfall	100-BC-1	Not Available	Demolished	Not Available	Not Available	The 1904-B2 Outfall was located north of the 107-B Building, and was used to direct reactor-cooling water into the river through either the discharge pipeline or the spillway. Water from 107-B discharged into the outfall structure, then into the discharge pipe to the river. The spillway was a concrete flume used to release the water when the discharge pipelines were out of service.
1904-C	Outfall	100-BC-1	261 m^2	Demolished	Not Available	Not Available	The 1904-C Outfall was used to direct reactor-cooling water into the river through either the discharge pipeline or the spillway. Water from 107-C discharged into the outfall structure, then into the discharge pipe to the river. The spillway was a concrete flume used to release the water when the discharge pipelines were out of service.
1908-C1	Monitoring Station	100-BC-1	13.3 m^2	Demolished	Not Available	Not Available	The 1908-C1 Monitoring House was used to monitor the cooling water as it was being discharged to the river.
1908-C2	Monitoring Station	100-BC-1	13.3 m^2	Demolished	Not Available	Not Available	The 1908-C2 Monitoring House was used to monitor the cooling water as it was being discharged to the river.
MO-390-C	Office	100-BC-2	3.1 x 9.8	Removed	1997	NA	The MO-390 Building was relocated to the 100-BC Area in 1997, to a site west of the C Reactor. It was used as the RCT office during the ISS Project for the C Reactor.
MO-417-C	Office	100-BC-2	8.5 x 20.1	Removed	1996	NA	The MO-417 Building was a double-wide mobile office that was located near the C Reactor. It was used as an office facility during the ISS Project for the 105-C Reactor Building. The building was later moved to the 100-F Area.
MO-474	Office	100-BC-1	234 m^2	Active	Not Available	Not Available	The MO-474 Building is a double-wide mobile trailer serving as the primary field trailer in the 100-BC Area. The building has been in place in the 100-BC Area since at least 1996.
MO-474A	Office	100-BC-1	Not Available	Removed	2002	NA	The MO-474A Building was a single-wide mobile trailer used to house offices for the subcontractor RCI Environmental. The building was removed in 2002.
MO-474B	Office	100-BC-1	Not Available	Removed	2002	NA	The MO-474B Building was a single-wide mobile trailer serving used to house offices for RCT personnel in the 100-BC Area. The building was removed in 2002.
MO-761	Office	100-BC-1	7.3 x 18.3	Removed	2002	Not Available	The MO-761 Building was a double-wide mobile office facility located in the 100-BC Area near the MO-474 Central Support Facility. The building was used to house offices for RCT personnel.
MO-762	Office	100-BC-1	19.5 x 8.5	Removed	2002	Not Available	The MO-762 Building was a double-wide mobile office facility located in the 100-BC Area near the MO-474 Central Support Facility. The building was used to house offices for RCT personnel.
MO-763	Change House	100-BC-1	3 x 12	Removed	2004	NA	The MO-763 Building was a single-wide trailer used as a change house in the 100-BC Area. The building was removed from the 100-BC Area in September 2004.
MO-764	Change House	100-BC-1	9.1 x 3.7	Removed	2005	Not Available	The MO-764 Facility is a restroom trailer in support of the 100-BC Administration trailers that is located in the 100-BC Area near the MO-474 Facility. It has two external structures associated with it, including an above ground portable water tank to the north, and an underground septic holding tank to the west. Underground piping connected the MO-764 Building to both structures.

Table D-1. Summary of 100-BC Decision Unit Facilities

Facility Code	Facility Type	Operable Unit	Site Dimensions (m)	Facility Status	Construction Date	Demolition Date	Facility Description
MO-769	Change House	100-BC-2	3 x 12	Removed	2004	NA	The MO-769 Building was a single-wide trailer that served as a change house while in the 100-BC Area. The building was moved to the 100-D Area in 2004.
MO-770	Office	100-BC-2	4.9 x 20.1	Removed	2007	NA	The MO-770 Building was a mobile office facility located near the C Reactor used by RCT personnel during the 100-B/C Area Remaining Pipelines and Sewers Project. The building had been removed by 2007.
MO-771	Office	100-BC-2	7.9 x 20.1	Removed	2007	NA	The MO-771 Building was a mobile office facility located near the C Reactor used by Bechtel Hanford, Inc., personnel during the 100-B/C Area Remaining Pipelines and Sewers Project. The building had been removed by 2007.
MO-772	Office	100-BC-2	18.3 x 6.1	Removed	2007	NA	The MO-772 Building was a mobile office facility located near the C Reactor used by Federal Engineers and Constructors personnel during the 100-B/C Area Remaining Pipelines and Sewers Project. It contained offices and a lunchroom. The building had been removed by 2007.
MO-773	Change House	100-BC-2	3.1 x 12.2	Removed	2007	NA	The MO-773 Building was a restroom trailer located near the C Reactor that supported nearby trailers during the 100-B/C Area Remaining Pipelines and Sewers Project. An underground septic holding tank was located to the east of this facility. The building had been removed by 2007.
MO-829-C	Office	100-BC-2	8.5 x 18.3	Removed	1998	NA	MO-829 was a double-wide mobile office located west of the C Reactor. It served as an administrative office during the ISS Project at the C Reactor. The building was removed from the 100-BC Area in 1998.

NA = not applicable
HEPA = high-efficiency particulate air
ISS = Interim Safe Storage
RCI = RCI Environmental
RCT = Radiological Control Technician

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DOE/RL-2009-44
Draft A

Sampling and Analysis Plan for the 100-BC Decision Unit Remedial Investigation/Feasibility Study

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Draft A

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Date Published
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Title: *Sampling and Analysis Plan for the 100-BC Decision Unit Remedial Investigation/ Feasibility Study*

Concurrence B. Charboneau

U.S. Department of Energy, Richland Operations Office

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L. Buelow

U.S. Environmental Protection Agency

Signature Date

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Terms

aG	amber glass
aGs	amber glass septum; no headspace
AEA	alpha energy analysis
ALARA	as low as reasonably achievable
ASTM	American Society for Testing and Materials
bgs	below ground surface
CAS	Chemical Abstracts Service
CCC	criterion continuous concentration
CFR	*Code of Federal Regulations*
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DQA	data quality assessment
Ecology	Washington State Department of Ecology
EQL	estimated quantitation limit
EPA	U.S. Environmental Protection Agency
FS	feasibility study
G	glass
GC	gas chromatograph
GEA	gamma energy analysis
GW	groundwater
HEIS	Hanford Environmental Information System
IC	ion chromatography
ICP	inductively coupled plasma
ICP/MS	inductively coupled plasma/mass spectrometry
LSC	liquid scintillation counter
MCL	maximum contaminant level
NTU	nephelometric turbidity unit

NV	no value
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
RUM	Ringold upper mud
SAP	sampling and analysis plan
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UKPA	total uranium by kinetic phosphorescence analysis
VOA	volatile organics analysis
VOC	volatile organic compound
WAC	*Washington Administrative Code*

1

1 Introduction

This sampling and analysis plan (SAP) supports the remedial investigation (RI)/feasibility study (FS) process for the 100-BC Decision Unit. The 100-BC Decision Unit is located on the Hanford Site in southeastern Washington and is associated with two source operable units, 100-BC-1 and 100-BC-2. The 100-BC-5 Groundwater Operable Unit underlies the two-source operable units. This SAP describes the sampling and analysis to be performed associated with geotechnical test borings (boreholes) and groundwater monitoring wells. Figure 1-1 shows the location of the planned and existing boreholes and groundwater monitoring wells within the scope of this SAP. Table 1-1 presents the intersection of data needs discussed in the addendum and sampling and analysis activities. Addendum 3, Chapter 2 describes the site background and, environmental setting of the 100-BC Decision Unit.

Table 1-1. Plan Activities and Data Needs

Planned Activity	100-B/C Area		Data Needs No.
	Quantity	Location	
New boreholes (vadose zone)*	6	100-B-5 Trench 116-B-5 Crib 116-B-6B Crib 116-B-11 Retention Basin 116-C-6 Process Pit 118-B-6 Burial Ground	2, 3
New wells (unconfined aquifer)*	5	Well #1 Well #2 Well #3 Well #4 Well #5	5
New well (Water-bearing Ringold upper mud)*	1	Well #R1	9
Sample spatial/temporal uncertainty groundwater monitoring wells		20 existing locations	13

* Boreholes and groundwater monitoring wells will be logged with a neutron moisture tool and the high-resolution, spectral gamma ray logging system. Geologic samples also will be logged.

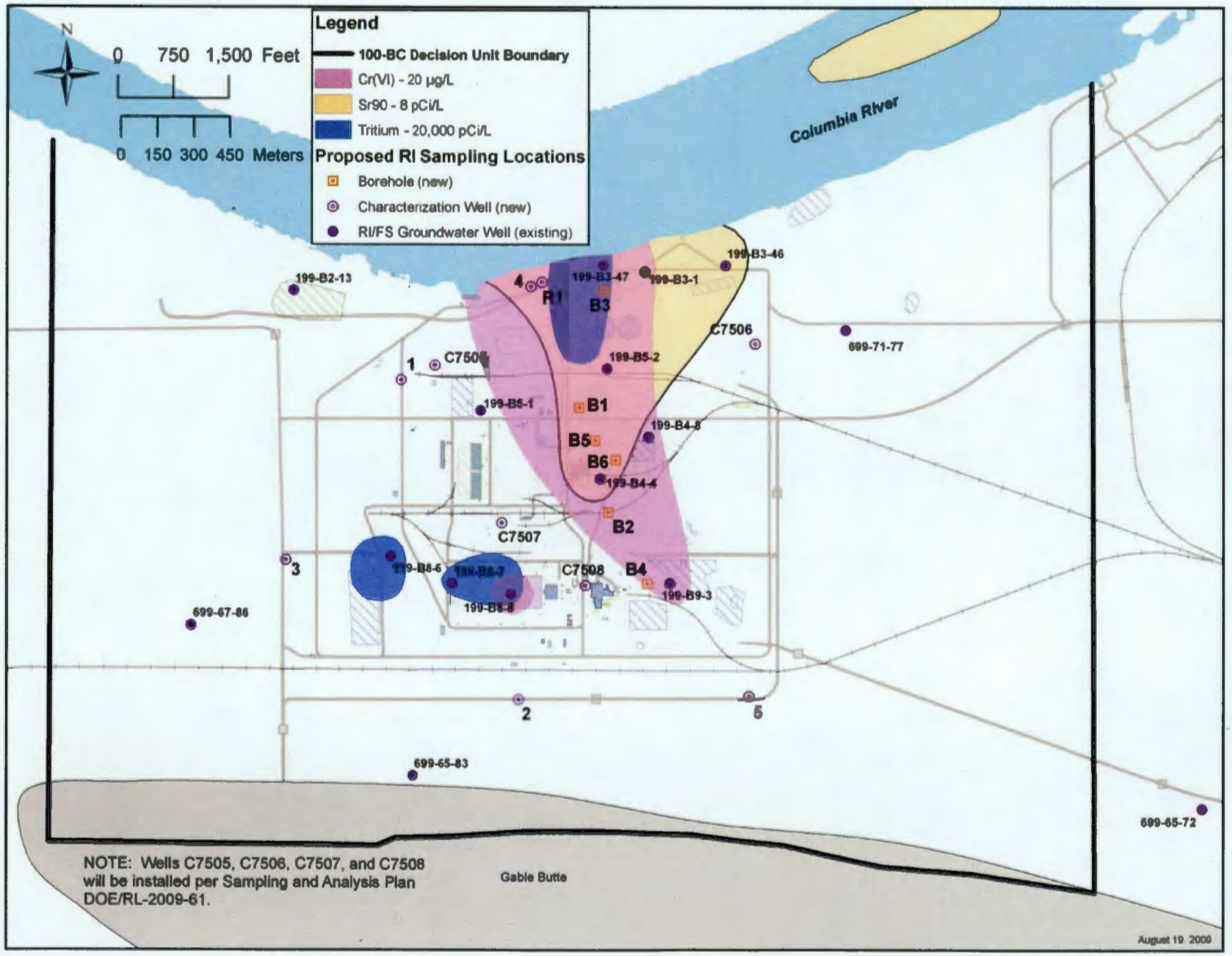

Figure 1-1. 100-BC Decision Unit Planned New Sampling Locations

1.1 Vadose Zone Characterization

This SAP describes activities planned to characterize the vadose zone at six waste sites within the decision unit and at six groundwater monitoring well locations. The following waste sites will be characterized by drilling a borehole to groundwater within the waste site boundary:

- 100-B-5 Trench
- 116-B-5 Crib
- 116-B-6B Crib
- 116-B-11 Retention Basin
- 116-C-6 Process Pit
- 118-B-6 Burial Ground.

Groundwater wells drilled as part of the 100-BC Decision Unit RI also will have vadose zone soil samples collected during drilling. Samples will be collected and analyzed to evaluate the nature and extent of contamination at the subject waste sites.

1.2 Groundwater Characterization

Groundwater samples will be collected and analyzed from new and existing groundwater monitoring wells. The groundwater monitoring wells will be sampled and analyzed to define the extent of contamination and to support evaluation of contaminant transport. Where possible, new well locations and construction have been selected to satisfy multiple project data needs, such as delineating vadose zone and groundwater contamination.

1.3 Target Analytes and Contaminants of Potential Concern

Method based analysis addresses the suites of analytical methods that will yield results for the target analytes or contaminants of potential concern (COPC) needed. This method of laboratory analysis tends to provide an umbrella effect in that analyses are provided for the target analytes or COPCs, as well as for any related constituents. Method-based analysis will be performed for all chemical soil/aquifer sediment and water samples analyzed for this decision unit.

Standard laboratory method reporting lists (presented in Appendix A) that are used when running Hanford samples under current contractual agreements will be input into the Hanford Environmental Information System (HEIS) database. The tables in Appendix A have been provided to define the analytes which will be reported when using a method-based analysis approach. In addition, tentatively identified compounds will be reported for SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B,* Methods 8260 and 8270.

1.3.1 Soil/Aquifer Sediment Target Analytes

Table 1-2 presents the soil/aquifer sediment target analytes. WCH-329, *100-BC Decision Unit Target Analyte List Development for Soil,* presents the approach used for development of the master list and waste site-specific target analytes. Waste site-specific constituents for analysis are based on the master list.

Table 1-2. Master Soil/Aquifer Sediment Target Analytes

Radionuclides	Nonradionuclides		
Americium-241	1,2,3,4,5,6-hexachlorocyclohexane (Gamma-BHC [lindane])	Dalapon	Lithium
Carbon-14	1,2,4-Trichlorobenzene	DB; 2,4- [4-(2,4-dichlorophenoxy) botanic acid] (Butoxone)	Manganese
Cesium-137	2-Methylnaphthalene	Dibenzo(a,h)anthracene	Mercury
Cobalt-60	2,4-Dichlorophenoxyacetic acid	Dibenzofuran Dicamba	Methoxychlor
Europium-152	2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	Dichloroprop	Molybdenum
Europium-154	2,4,5-TP- (silvex; 2-(2,4,5-Trichlorophenoxy)propionic acid)	Dichlorodiphenyldichloroethane (4,4'-DDD)	n-Nitrosodiphenylamine
Europium-155	4-Methyl phenol	Dichlorodiphenyldichloroethylene (4,4'-DDE)	Naphthalene Nickel
Iodine-129	4-Methyl-2-pentanone	Dichlorodiphenyltrichloroethane (4,4'DDT)	Nitrate (as N)
Nickel-63	Acenapthene	Dieldrin Diethylphthalate	Nitrite (as N)
Plutonium-238	Aldrin	Di-n-butylphthalate Di-n-octylphthalate	Polychlorinated biphenyls (Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260)
Plutonium-239/240	Aluminum	Dinoseb	Pentachlorophenol
Plutonium-241	Anthracene	Endosulfan I	Phenanthrene
Silver-108m	Antimony	Endosulfan II	Pyrene
Strontium-90	Arsenic	Endosulfan sulfate	Selenium
Technetium-99	Asbestos	Endrin	Silver
Tritium	Barium	Endrin aldehyde	Strontium
Uranium-233/234	Benzene	Endrin ketone	Technical chlordane
Uranium-235	Benzo(a)anthracene	Fluoranthene	Tin
Uranium-238	Benzo(a)pyrene	Fluorene	Titanium
	Benzo(b)fluoranthene	Heptachlor	Toluene
	Benzo(k)fluoranthene	Heptachlor epoxide	Total petroleum hydrocarbons
	Benzo(g,h,i)perylene	Hexachlorocyclohexane; alpha (alpha-BHC, HCH)	Uranium
	Beryllium	Hexachlorocyclohexane; beta- (beta-BHC, HCH)	Vanadium
	Boron	Hexachlorocyclohexane; delta- (delta-BHC, HCH)	Xylenes (total)
	Butylbenzylphthalate	Indeno(1,2,3-cd)pyrene	Zinc
	Cadmium	Isophorone	
	Carbazole	Lead	
	Carbon tetrachloride		
	Hexavalent chromium		
	Chromium (total)		
	Chrysene		
	Cobalt		
	Copper		

1.3.2 Groundwater COPCs

Table 1-3 presents the groundwater COPCs. Chapter 4 of the work plan states the approach used for development of the COPCs.

Table 1-3. Groundwater Contaminants of Potential Concern

Radionuclides	Nonradionuclides		
Iodine-129 Strontium-90 Tritium	Antimony Arsenic Benzene Beryllium 1,1-Dichloroethane 1,1,2,2-Tetrachloroethane Cadmium Carbon tetrachloride	Chloroform Hexavalent chromium Chromium (total) Cobalt Copper Lead Manganese Mercury	Nickel Nitrate (as N) Selenium Tetrachloroethene Thallium Vinyl chloride Zinc

1.4 Data Needs

A systematic planning process was used to identify 100-BC Decision Unit problem statements and data gaps. The identified data needs resulting from the systematic planning process are discussed in Chapter 4 of 100-BC Decision Unit RI/FS Work Plan (Addendum 3).

1.5 Sampling Design

The type of sampling design is judgmental (e.g., based on prior knowledge and professional judgment/expertise). The locations of waste sites and groundwater monitoring were defined to address the uncertainties and data needs identified during systematic planning. Figures 1-1 and 1-2 show the locations of geotechnical test borings (boreholes) and groundwater monitoring wells described in this SAP. Tables 2-2 through 2-9 present the selected analytical methods to meet the estimated quantitation limits (EQLs) and the analytical performance requirements.

1.6 Project Schedule

The 100-BC Decision Unit RI field efforts will occur between March 2010 and October 2010. The drilling lead will prepare the relative borehole and groundwater well schedule for new installations. A spatial and temporal uncertainty sample round, or event, will be collected from each of the following: a seasonal "high" water level, a seasonal "low" water level, and a mid-point water level, for a total of three samples per well. Each round of monitoring in the network of wells for this decision unit will be completed within 30 consecutive calendar days to minimize statistical variability in water levels. The RI report will document the results provided by sampling and analysis in this plan.

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2 Quality Assurance Project Plan

The QAPjP establishes the quality requirements for environmental data collection, including planning, implementation, and assessment of sampling, field measurements, and laboratory analysis. This QAPjP complies with the requirements of the following:

- DOE/RL-96-98, Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)
- DOE O 414.1C, Quality Assurance
- 10 CFR 830, Subpart A, "Quality Assurance Requirements"
- EPA/240/B-01/003, EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5.

Sections 6.5 and 7.8 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b), require that quality assurance (QA)/quality control (QC) and sampling and analysis activities specify the QA requirements for treatment, storage, and disposal units, as well as past-practice processes. Therefore, this QAPjP follows the QA elements of EPA/240/B-01/003. The QAPjP demonstrates conformance to Part B requirements of ANSI/ASQC E4-2004, *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use.*

In addition to the requirements cited above, the following reference also was used as a resource for identifying QAPjP elements:

- EPA-505-B-04-900A, *Intergovernmental Data Quality Task Force, Uniform Federal Policy for Quality Assurance Project Plans, Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs, Part 1: UFP-QAPP Manual.*

EPA-505-B-04-900A is not imposed through the Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). However, EPA-505-B-04-900A is a valuable resource and provides a comprehensive treatment of quality elements that should be addressed in any SAP. EPA-505-B-04-900A also was designed to be compatible with EPA/240/B-01/003, which forms the basis for this QAPjP.

The QAPjP is divided into the following four sections, which describe the quality requirements and controls applicable to this investigation.

Section 2.1 Project Management – This section addresses project management, including the project history and objectives, roles, and responsibilities of the participants. These elements ensure the project has a defined goal, participants understand the goal and the approach to be used, and planning outputs are documented.

Section 2.2 Data Generation and Acquisition – This section addresses aspects of project design and implementation. Implementing these elements ensures appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and properly documented.

Section 2.3 Assessment and Oversight – This section addresses the activities for assessing the effectiveness of implementing the project and associated QA and QC activities. The purpose of assessment is to ensure the QAPjP is implemented as prescribed.

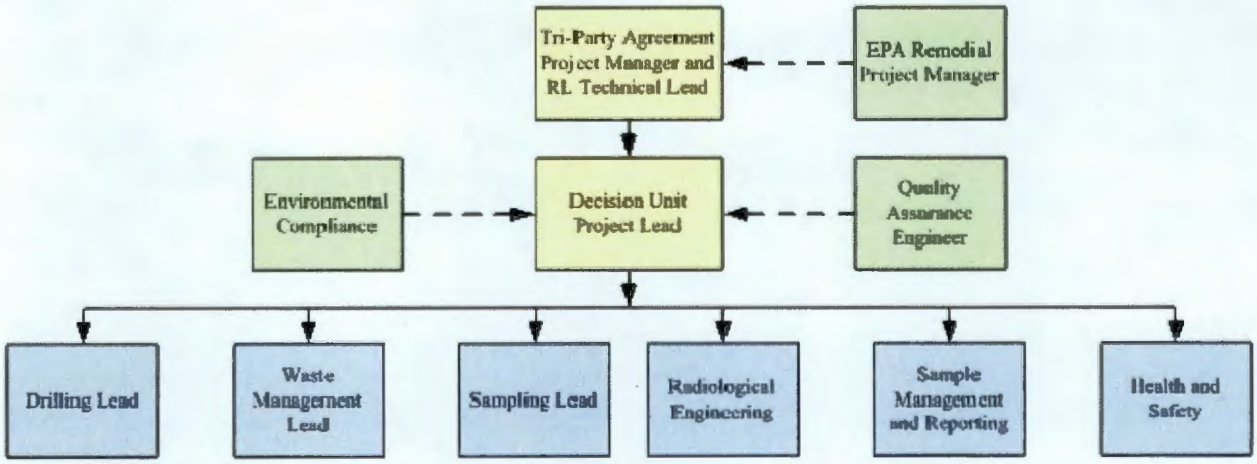
Section 2.4 Data Validation and Usability – This section addresses the QA activities occurring after the data collection or generation phase of the project is completed. Implementing these elements ensures data conform to the specified criteria, thus achieving the project objectives.

2.1 Project Management

The following sections address the basic aspects of project management, ensuring that the project has defined goals, the project team understands the goals and the approaches used, and the planned outputs are appropriately documented. Project management roles and responsibilities discussed in this section apply to the major activities covered under the SAP.

2.1.1 Project and Task Organization

The Plateau Remediation Contractor and River Corridor Closure Contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, preparing, packaging, and shipping samples to the laboratory. The following sections describe the project organization concerning sampling and characterization, also shown in Figure 2-1. The project lead maintains a list of individuals or organizations as points of contact for each functional element shown in Figure 2-1. For each functional primary contractor role, a corresponding oversight role exists within the U.S. Department of Energy (DOE).



EPA= United States Environmental Protection Agency
RL = U.S. Department of Energy, Richland Operations Office
Tri-Party Agreement = Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*

Figure 2-1. Project Organization

EPA Project Manager. The U.S. Environmental Protection Agency (EPA) has assigned project managers responsible for oversight of the cleanup projects and activities. EPA has approval authority as the lead regulatory agency for the work being performed under this SAP. EPA will work with the U.S. Department of Energy, Richland Operations Office (RL) to resolve concerns over the work as described in this SAP in accordance with the Tri-Party Agreement (Ecology et al., 1989a).

Tri-Party Agreement Project Manager and RL Technical Lead. The Tri-Party Agreement Project Manager is responsible for authorizing RI/FS activities for the 100 Area decision units. The Tri-Party Agreement Project Manager also is responsible for obtaining lead regulatory approval of the work plan and SAP that authorize the RI/FS activities under the Tri-Party Agreement. The RL technical lead is

responsible for overseeing the contractor in performing the work scope, working with the contractor and the regulatory agencies to identify and work through issues, and providing technical input to the Tri-Party Agreement Project Manager.

Environmental Compliance. The environmental compliance officer provides technical oversight, direction, and acceptance of project and subcontracted environmental work and develops appropriate mitigation measures with a goal of minimizing adverse environmental impacts. The environmental compliance officer also reviews plans, procedures, and technical documents to ensure environmental requirements have been addressed; identifies environmental issues affecting operations and develops cost-effective solutions; and responds to environmental/regulatory issues or concerns raised by RL and/or the regulatory agencies. The environmental compliance officer also may oversee project implementation for compliance with applicable internal and external environmental requirements.

Decision Unit Project Lead. The project lead is responsible for direct managing of sampling documents and requirements, field activities, and subcontracted tasks and for ensuring the project file is properly maintained. The project lead ensures the sampling design requirements are converted into field instructions (e.g., work packages) providing specific direction for field activities. The project lead works closely with QA, Health and Safety, the drilling lead, and the sampling lead to integrate these and the other lead disciplines in planning and implementing the work scope. The project lead maintains a list of individuals or organizations filling each of the functional elements of the project organization (Figure 2-1). In addition, the project lead is responsible for version control of the SAP to ensure personnel are working to the most current job requirements. The project lead also coordinates with RL and the primary contractor management on sampling activities. The project lead supports RL in coordinating sampling activities with the regulators.

Quality Assurance Engineer. The QA point of contact is matrixed to the project lead and is responsible for QA issues on the project including overseeing implementation of the project QA requirements; reviewing project documents, including data needs summary reports, SAPs, and the QAPjP; and participating in QA assessments on sample collection and analysis activities, as appropriate. The QA point of contact must be independent of the unit generating the data.

Drilling Lead. The drilling lead has overall responsibility for the planning, coordinating, and executing drilling activities. Specific responsibilities include coordinating with the geological and drilling contractors. The drilling lead also communicates with the decision unit project lead designee to identify field constraints or emergent conditions affecting sampling design/execution, and directs the procurement and installation of materials and equipment needed to support fieldwork.

Waste Management Lead (Waste Coordinator). The waste management lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe, cost-effective manner. In addition, Waste Management is responsible for identifying waste management sampling/characterization requirements to ensure regulatory compliance, interpreting the characterization data to generate waste designations and profiles, and preparing and maintaining other documents that confirm compliance with waste acceptance criteria.

Sampling Lead. The sampling lead has overall responsibility for planning, coordinating, and executing sampling activities. Specific responsibilities include converting the sampling design requirements into field task instructions providing specific direction for field activities, as well as directing training, mock-ups, and practice sessions with field personnel to ensure the sampling design is understood and can be performed as specified. The sampling lead also communicates with the decision unit project lead designee to identify field constraints or emergent conditions affecting sampling design and execution, directs the procurement and installation of materials and equipment needed to support fieldwork, and

prepares data packages based on instructions from the decision unit project lead designee and information contained in this SAP. The shipping lead reports to the sampling lead for shipment authorization. No sample material will be transported on or off the Hanford Site without permission from an authorized shipper or designee.

Radiological Engineering. The Radiological Engineering lead is responsible for the radiological/health physics support within the project. Specific responsibilities include conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for work planning. In addition, the Radiological Engineering lead identifies radiological hazards and implements appropriate controls to maintain worker exposures ALARA (e.g., requiring personal protective equipment). The radiological engineering lead also interfaces with the project Health and Safety contact, and plans and directs radiological control technician support for activities.

Sample Management and Reporting. Sample Management and Reporting coordinates laboratory analytical work, ensuring the laboratories conform to Hanford Site internal laboratory QA requirements, or their equivalent, as approved by DOE, EPA, and Washington State Department of Ecology (Ecology). Sample Management and Reporting receives analytical data from the laboratories, performs data entry into HEIS, and arranges for data validation. Sample Management and Reporting is responsible for informing the project lead of any issues reported by the analytical laboratory. Sample Management and Reporting develops and oversees the implementation of the letter of instruction to the analytical laboratories, oversees data validation, and works with the project lead to prepare a characterization report on the sampling and analysis results.

The sample management and reporting organization is also responsible for the performance of the data needs process, or equivalent.Additional related responsibilities include development of the SAP, including documentationof the data needs and the sampling design, preparation of associated presentations, resolution of technical issues, and any revisions to the SAP. Samples taken in the field and released to River Corridor Closure Contractor for shipping and analysis, as well as the resulting data, will be managed in accordance with applicable procedures, and work plans.

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

Health and Safety. Health and Safety is responsible for coordinating industrial safety and health support within the project, as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulation or by internal primary contractor work requirements. In addition, Health and Safety assists project personnel in complying with applicable health and safety standards and requirements. Health and Safety coordinates with Radiological Engineering to determine personal protective clothing requirements.

2.1.2 Problem Definition and Background

This SAP describes the sampling and analysis to be performed associated with geotechnical test borings (boreholes) and groundwater monitoring wells. The specific problems to be solved, background information, and general information are provided in the work plan. Media to be sampled include water, aquifer sediment, and soil. Figure 1-1 shows the locations of the planned and existing boreholes and groundwater monitoring wells within the scope of this SAP. Regulatory drivers and reference to agreement documents for the activity are provided in the work plan.

2.1.3 Project and Task Description

Chapter 3 presents the field sampling plan. Tables 1-2 and 1-3 present the target analytes and COPCs. Section 1.6 provides guidance on the implementation schedule.

2.1.4 Quality Objectives and Criteria

The QA objective of this plan is to develop implementation guidance providing data of known and appropriate quality. Data quality indicators describe data quality, by evaluation against identified data needs, and by evaluation against the work activities identified in this SAP. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. The principal data quality indicators are precision, bias or accuracy, representativeness, comparability, completeness, and sensitivity. These data quality indicators are defined for the purposes of this document in Table 2-1. The data quality indicators will be evaluated during the data quality assessment (DQA) process (Section 2.4.3).

Analytical performance requirements are presented in Tables 2-2 through 2-9. Laboratory operations and analytical services shall be in compliance with Volume 4 of HASQARD (DOE/RL-96-98) and any specific criteria identified in Tables 2-2 through 2-9 below. Criteria in Tables 2-2 through 2-9 take precedence over similar criteria in HASQARD. In consultation with the laboratory, the project lead, and/or others as appropriate, Sample Management and Reporting can approve changes to analytical methods.

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Precision	The measure of agreement among repeated measurements of the same property under identical or substantially similar conditions; calculated either as the range or as the standard deviation. May also be expressed as a percentage of the mean of the measurements, such as relative range, relative percent difference, or relative standard deviation (coefficient of variation).	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory or have two or more laboratories analyze identical samples with the same method. Split a sample in the field and submit both for sample handling, preservation and storage, and analytical measurements. Collect, process, and analyze co-located samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	Field precision: At randomly selected locations, duplicate samples will be taken 1 per 20 samples per media. Laboratory precision: analysis of laboratory duplicate or matrix spike duplicate.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity) • Request re-analysis or re-measurement • Qualify the data before use.
Accuracy	A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of sampling and analytical operations.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample); usually expressed either as percent recovery or as a percent bias.	Laboratory accuracy determination based on matrix spikes and matrix spike duplicates.	If recovery does not meet objective: • Qualify the data before use • Request reanalysis or re-measurement.

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Representativeness	A qualitative term to express "the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition." (ANSI/ASQC S2-1995)	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	Samples will be collected as described in the sampling design. Judgment sampling ensures areas most likely to be contaminated, based on current information, will be evaluated.	If results are not representative of the system sampled: • Identify the reason for result not being representative • Reject the data, or, if data are otherwise usable, qualify the data for limited use and define the portion of the system the data represent • Redefine sampling and measurement requirements and protocols • Resample and reanalyze.
Comparability	A qualitative term expressing the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.	Compare sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.	Sampling personnel will use the same sampling protocols. Samples will be submitted to the same laboratories when possible (based on laboratory contracts) for analysis by the same methods, thus data results will be comparable.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability.

Table 2-1. Data Quality Indicators

Data Quality Indicator	Definition	Example Determination Methodologies	Project Specific Information*	Corrective Action Examples
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's data needs.	The percent complete will be determined during data validation.	If data set does not meet completeness objective: • Identify appropriate changes to data collection and/or analysis methods • Identify quantifiable bias, if applicable • Qualify the data as appropriate • Resample and/or reanalyze if needed • Revise sampling/analysis protocols to ensure future comparability.
Sensitivity	The capability of a method or instrument to discriminate among measurement responses representing different levels of the variable of interest.	Determine the minimum concentration or attribute to be measured by a method (method detection limit), by an instrument (instrument detection limit), or by a laboratory (quantitation limit). The practical quantitation limit is the lowest level that can be routinely quantified and reported by a laboratory.	Ensure that sensitivity, as measured by detection limits, is appropriate for the action levels.	If sensitivity does not meet objective: • Request reanalysis or re-measurement • Qualify/reject the data before use.

* Field sampling requirements are noted. Laboratories will follow requirements for use and interpretation of laboratory control samples.

ANSI/ASQC S2-1995, *Introduction to Attribute Sampling*

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV[c]	NV[c]	GEA	±30[d]	70-130[d]
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV[c]	NV[c]			
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV[c]	NV[c]			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV[c]	NV[c]			
10098-97-2	Strontium-90	1 pCi/g	4.5 pCi/g	NV[c]	NV[c]	Gas Flow Proportional Counting	±30[d]	70-130[d]
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV[c]	NV[c]	Isotopic-Pu, AEA	±30[d]	70-130[d]
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV[c]	NV[c]			
15046-84-1	Iodine-129	2 pCi/g[e]	2 pCi/g	2 pCi/g	2 pCi/g	Low Energy-GEA	±30[d]	70-130[d]
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV[c]	NV[c]	LSC-C14	±30[d]	70-130[d]
14133-76-7	Technetium-99	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.46 pCi/g	LSC-TC99		
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g	LSC-H3		

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Laboratory Measurements (Nonradiological)								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	Anions by IC 300.0	±30[f]	70-130[f]
14797-65-0	Nitrite	2.5 mg/kg	8,000 mg/kg	4 mg/kg	8 mg/kg			
91728-14-2	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg	EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-36-0	Antimony	6 mg/kg[g,e]	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg[e]	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV[c]			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg[g,e]	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg[g,e]	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-24-6	Strontium	1 mg/kg	48,000 mg/kg	2,920 mg/kg	N/A[c]			
7440-28-0	Thallium	5 mg/kg [e]	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV[c]			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
18540-29-9	Hexavalent Chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[f]	70-130[f]
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Hg cold vapor)	±30[f]	70-130[f]
84-66-2	Diethylphthalate	0.33 mg/kg	64,000 mg/kg	72.2 mg/kg	259 mg/kg			
84-74-2	Di-n-butylphthalate	0.33 mg/kg	8,000 mg/kg	56.5 mg/kg	191 mg/kg	EPA 8270 Semivolatile	±30[h]	70-130[h]
117-84-0	Di-n-octylphthalate	0.33 mg/kg	1,600 mg/kg	532,000 mg/kg	NV[c]			
71-43-2	Benzene	0.005 mg/kg[e]	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg			
56-23-5	Carbon tetrachloride	0.005 mg/kg[e]	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg	EPA 8260 (VOCs)	±30[h]	70-130[h]
108-88-3	Toluene	0.005 mg/kg	6,400 mg/kg	4.65 mg/kg	99.0 mg/kg			
79-01-6	Trichloroethylene	0.005 mg/kg[e]	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
1330-20-7	Xylenes (total)	0.01 mg/kg[e]	16,000 mg/kg	14.6 mg/kg	183 mg/kg			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[f]	70-130[f]

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[f]	70-130[f]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
			Performance Requirements for Physical Properties					
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, Methods for Chemical Analysis of Water and Wastes. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,* Third Edition; Final Update IV-B.

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. The generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years.

d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include

Table 2-2. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 100-B-5 Trench

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)

analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. Precision criteria shown are for batch laboratory replicate sample relative percent differences.

e. Calculated cleanup goals are below established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

f. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

g. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/MS methods if EQLs are met.

h. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for Method SW-846 8260 and 8270.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

AEA	=	Alpha energy analysis	IC	=	ion chromatography	N/A	=	not applicable
CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma	NV	=	no value
dpm	=	disintegrations per minute	ICP/MS	=	inductively coupled plasma/mass spectrometry	RESRAD	=	RESidual RADioactivity (dose model)
GEA	=	gamma energy analysis	LSC	=	liquid scintillation counter	VOC	=	volatile organic compound

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV[c]	NV[c]	GEA	±30[d]	70-130[d]
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV[c]	NV[c]			
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV[c]	NV[c]			
10098-97-2	Strontium-90	1 pCi/g	4.5 pCi/g	NV[c]	NV[c]	Gas Flow Proportional Counting	±30[d]	70-130[d]
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV[c]	NV[c]	Isotopic-Pu, AEA	±30[d]	70-130[d]
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV[c]	NV[c]			
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV[c]	NV[c]	LSC	±30[d]	70-130[d]
14133-76-7	Technetium-99	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.46 pCi/g			
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g			
Performance Requirements for Laboratory Measurements (Nonradiological)								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	Anions by IC 300.0	±30[e]	70-130[e]
14797-65-0	Nitrite	2.5 mg/kg	8,000 mg/kg	4 mg/kg	8 mg/kg			

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
91728-14-2	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg			
7440-36-0	Antimony	6 mg/kg[f,g]	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg[g]	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV[c]			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg	EPA 6010 (ICP metals)	±30[e]	70-130[e]
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg[f,g]	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg[f,g]	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-24-6	Strontium	1 mg/kg	48,000 mg/kg	2,920 mg/kg	N/A[c]			
7440-28-0	Thallium	5 mg/kg[g]	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV[c]			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[e]	70-130[e]

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Hg cold vapor)	±30[e]	70-130[e]
84-66-2	Diethylphthalate	0.33 mg/kg	64,000 mg/kg	72.2 mg/kg	259 mg/kg	EPA 8270 Semivolatile	±30[h]	70-130[h]
84-74-2	Di-n-butylphthalate	0.33 mg/kg	8,000 mg/kg	56.5 mg/kg	191 mg/kg			
117-84-0	Di-n-octylphthalate	0.33 mg/kg	1,600 mg/kg	532,000 mg/kg	NV[c]			
71-43-2	Benzene	0.005 mg/kg[g]	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg	EPA 8260 (VOCs)	±30[h]	70-130[h]
56-23-5	Carbon tetrachloride	0.005 mg/kg[g]	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
108-88-3	Toluene	0.005 mg/kg	6,400 mg/kg	4.65 mg/kg	99.0 mg/kg			
79-01-6	Trichloroethylene	0.005 mg/kg[g]	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
1330-20-7	Xylenes (total)	0.01 mg/kg[g]	16,000 mg/kg	14.6 mg/kg	183 mg/kg			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[e]	70-130[e]
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[e]	70-130[e]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. The generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years.

d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. Precision criteria shown are for batch laboratory replicate sample relative percent differences.

Table 2-3. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-5 Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)

e. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

f. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/MS methods if EQLs are met.

g. Calculated cleanup goals are below established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

h. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for Method SW-846 8260 and 8270.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

AEA	=	Alpha energy analysis	ICP	=	inductively coupled plasma	N/A	=	not applicable
CAS	=	Chemical Abstracts Service	ICP/MS	=	inductively coupled plasma/mass spectrometry	NV	=	no value
dpm	=	disintegrations per minute	LSC	=	liquid scintillation counter	RESRAD	=	RESidual RADioactivity (dose model)
GEA	=	gamma energy analysis	IC	=	ion chromatography	VOC	=	volatile organic compound

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-6B Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV[c]	NV[c]	GEA	±30[d]	70-130[d]
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV[c]	NV[c]			
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV[c]	NV[c]			
10098-97-2	Strontium-90	1 pCi/g	4.5 pCi/g	NV[c]	NV[c]	Gas Flow Proportional Counting	±30[d]	70-130[d]
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV[c]	NV[c]	Isotopic-PU, alpha energy analysis	±30[d]	70-130[d]
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV[c]	NV[c]			
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV[c]	NV[c]	LSC	±30[d]	70-130[d]
14133-76-7	Technetium-99	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.46 pCi/g			
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g			
Performance Requirements for Laboratory Measurements (Nonradiological)								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	Anions by IC 300.0	±30[e]	70-130[e]
14797-65-0	Nitrite	2.5 mg/kg	8,000 mg/kg	4 mg/kg	8 mg/kg			

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-6B Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
91728-14-2	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg			
7440-36-0	Antimony	6 mg/kg[f,g]	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg [g]	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV[c]			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg	EPA 6010 (ICP metals)	±30[e]	70-130[e]
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg[f,g]	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg[f,g]	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-24-6	Strontium	1 mg/kg	48,000 mg/kg	2,920 mg/kg	N/A[c]			
7440-28-0	Thallium	5 mg/kg [g]	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV[c]			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[e]	70-130[e]

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-6B Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Hg cold vapor)	±30[e]	70-130[e]
84-66-2	Diethylphthalate	0.33 mg/kg	64,000 mg/kg	72.2 mg/kg	259 mg/kg	EPA 8270 Semivolatile	±30[h]	70-130[h]
84-74-2	Di-n-butylphthalate	0.33 mg/kg	8,000 mg/kg	56.5 mg/kg	191 mg/kg			
117-84-0	Di-n-octylphthalate	0.33 mg/kg	1,600 mg/kg	532,000 mg/kg	NV[c]			
71-43-2	Benzene	0.005 mg/kg[g]	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg	EPA 8260 (VOCs)	±30[h]	70-130[h]
56-23-5	Carbon tetrachloride	0.005 mg/kg[g]	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
108-88-3	Toluene	0.005 mg/kg	6,400 mg/kg	4.65 mg/kg	99.0 mg/kg			
79-01-6	Trichloroethylene	0.005 mg/kg[g]	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
1330-20-7	Xylenes (total)	0.01 mg/kg[g]	16,000 mg/kg	14.6 mg/kg	183 mg/kg			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[e]	70-130[e]
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-6B Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[e]	70-130[e]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area,* predicts the contaminant will not reach groundwater within 1,000 years.

d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for

Table 2-4. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-6B Crib

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)

batch laboratory replicate sample relative percent differences.

e. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

f. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/MS methods if EQLs are met.

g. Calculated cleanup goals are below established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

h. Accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for Method SW-846 8260 and 8270.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

AEA	=	Alpha energy analysis	IC	=	ion chromatography	N/A	=	not applicable
CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma	NV	=	no value
dpm	=	disintegrations per minute	ICP/MS	=	inductively coupled plasma/mass spectrometry	RESRAD	=	RESidual RADioactivity (dose model)
GEA	=	gamma energy analysis	LSC	=	liquid scintillation counter	VOC	=	volatile organic compound

Table 2-5. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-11 Retention Basin

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV[c]	NV[c]	GEA	±30[d]	70-130[d]
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV[c]	NV[c]			
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV[c]	NV[c]			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pGi/g	NV[c]	NV[c]			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV[c]	NV[c]			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV[c]	NV[c]			
10098-97-2	Strontium-90	1 pCi/g	4.5 pCi/g	NV[c]	NV[c]	Gas Flow Proportional Counting	±30[d]	70-130[d]
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV[c]	NV[c]	Isotopic-PU, AEA	±30[d]	70-130[d]
—	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV[c]	NV[c]			
13981-37-8	Nickel-63	30 pCi/g	4,026 pCi/g	NV[c]	NV[c]	LSC	±30[d]	70-130[d]
7440-61-1	Uranium-238	1 pCi/g	1.1 pCi/g	1.1 pCi/g	1.1 pCi/g	AEA	±30[d]	70-130[d]

Table 2-5. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-11 Retention Basin

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Laboratory Measurements (Nonradiological)								
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg	EPA 6010 (ICP metals)	±30[e]	70-130[e]
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[e]	70-130[e]
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Hg cold vapor)	±30[e]	70-130[e]
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[e]	70-130[e]
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[e]	70-130[e]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[e]	70-130[e]

Table 2-5. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-11 Retention Basin

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years.

d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.

e. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. Precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

Table 2-5. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-B-11 Retention Basin

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.*								

AEA = Alpha energy analysis
CAS = Chemical Abstracts Service
dpm = disintegrations per minute
GEA = gamma energy analysis
ICP = inductively coupled plasma
LSC = liquid scintillation counter
N/A = not applicable
NV = no value
RESRAD = RESidual RADioactivity (dose model)

Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-6 Process Pit

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
14596-10-2	Americium-241	1 pCi/g	31.1 pCi/g	NV[c]	NV[c]	GEA	±30[d]	70-130[d]
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV[c]	NV[c]			
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV[c]	NV[c]			
14391-16-3	Europium-155	0.1 pCi/g	125 pCi/g	NV[c]	NV[c]			
15046-84-1	Iodine-129	2 pCi/g[e]	2 pCi/g	2 pCi/g	2 pCi/g	Low Energy-GEA	±30[d]	70-130[d]
10098-97-2	Strontium-90	1 pCi/g	4.5 pCi/g	NV[c]	NV[c]	Gas Flow Proportional Counting	±30[d]	70-130[d]
13981-16-3	Plutonium-238	1 pCi/g	37.4 pCi/g	NV[c]	NV[c]	Isotopic-Plutonium, AEA	±30[d]	70-130[d]
	Plutonium-239/240	1 pCi/g	33.9 pCi/g	NV[c]	NV[c]			
14762-75-5	Carbon-14	2 pCi/g	5.16 pCi/g	NV[c]	NV[c]	LSC	±30[d]	70-130[ed]
13981-37-8	Nickel-63	30 pCi/g	4,026 pCi/g	NV[c]	NV[c]			
14133-76-7	Technetium-99	0.25 pCi/g	5.7 pCi/g	0.46 pCi/g	0.46 pCi/g			
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g			

Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-6 Process Pit

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
Performance Requirements for Laboratory Measurements (Nonradiological)								
14797-55-8	Nitrate (as N)	2.5 mg/kg	128,000 mg/kg	40 mg/kg	80 mg/kg	Anions by IC 300.0	±30[f]	70-130[f]
14797-65-0	Nitrite	2.5 mg/kg	8,000 mg/kg	4 mg/kg	8 mg/kg			
91728-14-2	Aluminum	5 mg/kg	80,000 mg/kg	480,000 mg/kg	960,000 mg/kg	EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-36-0	Antimony	6 mg/kg[e,g]	32 mg/kg	5.4 mg/kg	25.3 mg/kg			
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-39-3	Barium	2 mg/kg	16,000 mg/kg	1,650 mg/kg	3,300 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg[e]	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-48-4	Cobalt	2 mg/kg	24 mg/kg	15.7 mg/kg	NV[c]			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg[e,g]	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg[e,g]	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-24-6	Strontium	1 mg/kg	48,000 mg/kg	2,920 mg/kg	N/A[c]			
7440-28-0	Thallium	5 mg/kg [e]	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV[c]			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			

Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-6 Process Pit

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[f]	70-130[f]
84-66-2	Diethylphthalate	0.33 mg/kg	64,000 mg/kg	72.2 mg/kg	259 mg/kg	EPA 8270 Semivolatile	±30[h]	70-130[h]
84-74-2	Di-n-butylphthalate	0.33 mg/kg	8,000 mg/kg	56.5 mg/kg	191 mg/kg			
117-84-0	Di-n-octylphthalate	0.33 mg/kg	1,600 mg/kg	532,000 mg/kg	NV[c]			
71-43-2	Benzene	0.005 mg/kg[e]	18.2 mg/kg	0.00448 mg/kg	0.014 mg/kg	EPA 8260 (VOCs)	±30[h]	70-130[h]
56-23-5	Carbon tetrachloride	0.005 mg/kg[e]	7.69 mg/kg	0.031 mg/kg	0.0046 mg/kg			
67-66-3	Chloroform	0.005 mg/kg	164 mg/kg	0.038 mg/kg	0.0607 mg/kg			
108-88-3	Toluene	0.005 mg/kg	6,400 mg/kg	4.65 mg/kg	99.0 mg/kg			
79-01-6	Trichloroethylene	0.005 mg/kg[e]	11.2 mg/kg	0.00323 mg/kg	0.0355 mg/kg			
1330-20-7	Xylenes (total)	0.01 mg/kg[e]	16,000 mg/kg	14.6 mg/kg	183 mg/kg			
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[f]	70-130[f]
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]

Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-6 Process Pit

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[f]	70-130[f]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[f]	70-130[f]
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years.

d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.

e. Calculated cleanup goals are below established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

Table 2-6. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 116-C-6 Process Pit

			Preliminary Cleanup Goals					
CAS	Analyte	EQL	Direct Exposure	Groundwater Protection	River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)

f. The accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

g. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite furnace or ICP/MS methods if EQLs are met.

h. The accuracy criteria shown are the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional accuracy criteria include analyte-specific evaluations performed for matrix spike, and surrogate recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate matrix spike analysis relative percent differences. Tentatively identified compounds will be reported for Method SW-846 8260 and 8270.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

AEA	=	Alpha energy analysis	IC	=	ion chromatography	N/A	=	not applicable
CAS	=	Chemical Abstracts Service	ICP	=	inductively coupled plasma	NV	=	no value
dpm	=	disintegrations per minute	ICP/MS	=	inductively coupled plasma/mass spectrometry	RESRAD	=	RESidual RADioactivity (dose model)
GEA	=	gamma energy analysis	LSC	=	liquid scintillation counter	VOC	=	volatile organic compound

Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-6 Burial Ground

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
10028-17-8	Tritium	10 pCi/g	510 pCi/g	15.8 pCi/g	15.8 pCi/g	LSC	±30[c]	70-130[c]
Performance Requirements for Laboratory Measurements (Nonradiological)								
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg	EPA 6010 (ICP metals)	±30[d]	70-130[d]
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[d]	70-130[d]
7439-97-6	Mercury	0.2 mg/kg	24 mg/kg	2.09 mg/kg	0.33 mg/kg	EPA 7471 or 200.8 (Hg cold vapor)	±30[d]	70-130[d]
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]

Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-6 Burial Ground

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[d]	70-130[d]
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[d]	70-130[d]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[d]	70-130[d]
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D2937	N/A	N/A

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for

Table 2-7. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from 118-B-6 Burial Ground

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)

batch laboratory replicate sample relative percent differences.

d. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

CAS = Chemical Abstracts Service
dpm = disintegrations per minute
GEA = gamma energy analysis
ICP = inductively coupled plasma
LSC = liquid scintillation counter
N/A = not applicable

Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals: Direct Exposure	Preliminary Cleanup Goals: Groundwater Protection	Preliminary Cleanup Goals: River Protection	Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
Performance Requirements for Field Measurements								
—	Gross gamma	10 pCi/g	N/A	N/A	N/A	Portable sodium iodide detector	±50	—[b]
—	Gross alpha	100 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
—	Gross beta	5,000 dpm/ 100 cm^2	N/A	N/A	N/A	Portable contamination detector	±50	—[b]
Performance Requirements for Laboratory Measurements (Radiological)								
10045-97-3	Cesium-137	0.1 pCi/g	6.2 pCi/g	NV[c]	NV[c]	GEA	±30[d]	70-130[d]
10198-40-0	Cobalt-60	0.05 pCi/g	1.4 pCi/g	NV[c]	NV[c]			
14683-23-9	Europium-152	0.1 pCi/g	3.3 pCi/g	NV[c]	NV[c]			
15585-10-1	Europium-154	0.1 pCi/g	3.0 pCi/g	NV[c]	NV[c]			
10098-97-2	Strontium-90	1 pCi/g	4.5 pCi/g	NV[c]	NV[c]	Strontium-90	±30[d]	70-130[d]
Performance Requirements for Laboratory Measurements (Nonradiological)								
7440-36-0	Antimony	6.0 mg/kg[e,f]	32 mg/kg	5.4 mg/kg	25.3 mg/kg	EPA 6010 (ICP metals)	±30[g]	70-130[g]
7440-38-2	Arsenic	10 mg/kg	20 mg/kg	20 mg/kg	20 mg/kg			
7440-41-7	Beryllium	0.5 mg/kg	160 mg/kg	63.2 mg/kg	126 mg/kg			
7440-43-9	Cadmium	0.5 mg/kg[f]	80 mg/kg	0.69 mg/kg	0.25 mg/kg			
7440-47-3	Chromium (total)	1 mg/kg	120,000 mg/kg	2,000 mg/kg	2,600 mg/kg			
7440-50-8	Copper	1 mg/kg	3,200 mg/kg	284 mg/kg	1,150 mg/kg			
7439-92-1	Lead	5 mg/kg	250 mg/kg	3,000 mg/kg	840 mg/kg			
7439-96-5	Manganese	5 mg/kg	3,760 mg/kg	512 mg/kg	512 mg/kg			

Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7440-02-0	Nickel	4 mg/kg	1,600 mg/kg	130 mg/kg	357 mg/kg			
7782-49-2	Selenium	10 mg/kg[e,f]	400 mg/kg	5.2 mg/kg	1.04 mg/kg			
7440-22-4	Silver	1 mg/kg[e,f]	400 mg/kg	13.6 mg/kg	0.884 mg/kg			
7440-28-0	Thallium	5 mg/kg[f]	5.6 mg/kg	1.59 mg/kg	4.46 mg/kg			
7440-62-2	Vanadium	2.5 mg/kg	560 mg/kg	2,240 mg/kg	NV[c]			
7440-66-6	Zinc	1 mg/kg	24,000 mg/kg	5,970 mg/kg	226 mg/kg			
18540-29-9	Hexavalent chromium	0.5 mg/kg	240 mg/kg	18.4 mg/kg	7.7 mg/kg	EPA 7196 (Cr VI)	±30[g]	70-130[g]
7440-38-2	Arsenic	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]
7440-39-3	Barium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]
7440-43-9	Cadmium	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]
7440-47-3	Chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]
18540-29-9	Hexavalent chromium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7196	±30[g]	70-130[g]
7439-92-1	Lead	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]
7439-97-6	Mercury	50 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 7470 or 200.8	±30[g]	70-130[g]
7440-22-4	Silver	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]

Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

CAS	Analyte	EQL	Preliminary Cleanup Goals			Analytical Method[a]	Precision Requirement (%)	Accuracy Requirement (%)
			Direct Exposure	Groundwater Protection	River Protection			
7782-49-2	Selenium	100 µg/L	N/A	N/A	N/A	Batch leach followed by EPA 6010 (ICP metals)	±30[g]	70-130[g]
—	Distribution coefficient for EPA 6010/6020/7196/ 7470 or 200.8 metals	N/A	N/A	N/A	N/A	Desorption distribution coefficient using 1:1 water extract and acid leach	N/A	N/A
Performance Requirements for Physical Properties								
—	Grain size (sieve) analysis	N/A	N/A	N/A	N/A	Field procedure	N/A	N/A
—	Porosity	N/A	N/A	N/A	N/A	Calculation	N/A	N/A
—	Sediment moisture content	N/A	N/A	N/A	N/A	ASTM D2216	N/A	N/A
—	Saturated hydraulic conductivity	N/A	N/A	N/A	N/A	ASTM D5084 for soil with low hydraulic conductivity (silt or a mud) ASTM D2434 for soil with high hydraulic conductivity (sand or sandy gravel)	N/A	N/A
—	Bulk density	N/A	N/A	N/A	N/A	ASTM D 2937	N/A	N/A

a. Equivalent methods may be substituted. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. Generic RESRAD modeling reported in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, predicts the contaminant will not reach groundwater within 1,000 years.

d. Accuracy criteria shown are for associated batch laboratory control sample percent recoveries. Except for GEA, additional accuracy criteria include analysis-specific evaluations performed for matrix spike, tracer, and/or carrier recoveries as appropriate to the method. The precision criteria shown are for batch laboratory replicate sample relative percent differences.

e. To meet or approach calculated cleanup goals, laboratories must use axial-based ("trace") ICP analytical methods. The laboratory also may substitute graphite

Table 2-8. Analytical Performance Requirements for Soil/Aquifer Sediment Samples from Groundwater Wells

furnace or ICP/MS methods if EQLs are met.

f. Calculated cleanup goals are below established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

g. Accuracy criteria specified are for calculated percent recoveries for associated analytical batch matrix spike samples. Additional accuracy evaluation based on statistical control limits for analytical batch laboratory control samples also is performed. The precision criteria shown are for batch laboratory replicate matrix spike or replicate sample relative percent differences.

ASTM D2216-05, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*

ASTM D2434-68, *Standard Test Method for Permeability of Granular Soils (Constant Head)*

ASTM D2937-04, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*

ASTM D5084-03, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

CAS = Chemical Abstracts Service
dpm = disintegrations per minute
GEA = gamma energy analysis
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma/mass spectrometry
N/A = not applicable
RESRAD = RESidual RADioactivity (dose model)

Table 2-9. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method[a]	EQL	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
Performance Requirements for Field Measurements							
—	Oxidation reduction potential	REDOX PROBE	N/A	—[b]	—[b]	N/A	N/A
—	pH measurement	PROBE	0.5 pH unit	—[b]	—[b]	N/A	N/A
—	Specific conductance	PROBE	1 µS/cm	—[b]	—[b]	N/A	N/A
—	Temperature	PROBE	--	—[b]	—[b]	N/A	N/A
—	Dissolved oxygen	PROBE	--	—[b]	—[b]	N/A	N/A
—	Turbidity	PROBE	0.1 NTU	—[b]	—[b]	N/A	N/A
Performance Requirements for Laboratory Measurements (Radiological)							
15046-84-1	Iodine-129	Iodine-129 – Low Level	1 pCi/L[c]	±30	70-130	1 pCi/L	40 CFR 141.66
10098-97-2	Strontium-90	Strontium 89/90 – Sr-90	2 pCi/L	±30	70-130	8 pCi/L	Federal MCL
10028-17-8	Tritium	Tritium (H-3)	400 pCi/L	±30	70-130	20,000 pCi/L	Federal MCL
Performance Requirements for Laboratory Measurements (Nonradiological)							
7440-36-0	Antimony	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	5 µg/L[d]	±20	80-120	5.6 µg/L	Human health water + organism
7440-38-2	Arsenic	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L[d]	±20	80-120	0.018 µg/L	Human health water + organism
7440-41-7	Beryllium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L	±20	80-120	4.0 µg/L	MCL
7440-43-9	Cadmium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L[d]	±20	80-120	0.25 µg/L	Freshwater CCC
7440-47-3	Chromium	EPA 6010 (ICP metals)	10 µg/L	±20	80-120	74 µg/L	Freshwater CCC

Table 2-9. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method[a]	EQL	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
7440-48-4	Cobalt	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L[d]	±20	80-120	4.8 µg/L	WAC 173-340-720(4)
7440-50-8	Copper	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	8 µg/L[d]	±20	80-120	9 µg/L	Freshwater CCC
18540-29-9	Hexavalent chromium	EPA 7196 (chromium hex)	10 µg/L	±20	80-120	10 µg/L	Freshwater CCC
7439-92-1	Lead	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L[d]	±20	80-120	2.5 µg/L	Freshwater CCC
7439-97-6	Mercury	EPA 7470 or 200.8 (mercury)	0.5 µg/L[d]	±20	80-120	0.012 µg/L	WAC 173-21A Freshwater CCC
7439-96-5	Manganese	EPA 6010 (ICP metals)	5 µg/L	±20	80-120	50 µg/L	Secondary MCL
7440-02-0	Nickel	EPA 6010 (ICP metals)	40 µg/L	±20	80-120	52 µg/L	Freshwater CCC
7782-49-2	Selenium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	4 µg/L[d]	±20	80-120	5 µg/L	Freshwater CCC
7440-28-0	Thallium	Trace – ICP (6010) or ICP/MS (6020 or 200.8)	2 µg/L[d]	±20	80-120	0.24 µg/L	Human health water + organism
7440-66-6	Zinc	EPA 6010 (ICP metals)	10 µg/L	±20	80-120	120 µg/L	Freshwater CCC
75-35-4	1,1-Dichloroethene	EPA 8260 (VOCs)	2 µg/L[d]	±20	80-120	0.0729 µg/L	WAC 173-340-720(4)
79-34-5	1,1,2,2-Tetrachloroethane	EPA 8260 (VOCs)	1.5 µg/L[d]	±20	80-120	0.17 µg/L	WAC 173-340-720(4)
71-43-2	Benzene	EPA 8260 (VOCs)	1.5 µg/L[d]	±20	80-120	0.795 µg/L	WAC 173-340-720(4)
56-23-5	Carbon tetrachloride	EPA 8260 (VOCs)	1 µg/L[d]	±20	80-120	0.23 µg/L	Human health water + organism
67-66-3	Chloroform	EPA 8260 (VOCs)	5 µg/L	±20	80-120	5.7 µg/L	Human health water + organism

Table 2-9. Analytical Performance Requirements for Water Samples

CAS	Analyte	Analytical Method[a]	EQL	Precision Requirement (%)	Accuracy Requirement (%)	Action Level	Action Level Basis
127-18-4	Tetrachloroethene	EPA 8260 (VOCs)	5 µg/L[d]	±20	80-120	0.081 µg/L	WAC 173-340-720(4)
79-01-6	Trichloroethene	EPA 8260 (VOCs)	1 µg/L[d]	±20	80-120	0.49 µg/L	WAC 173-340-720(4)
75-01-4	Vinyl chloride	EPA 8260 (VOCs)	5 µg/L	±20	80-120	0.029 µg/L	Human health water + organism
14797-55-8	Nitrate (as N)	EPA 300.0 (anions by IC)	250 µg/L	±20	80-120	10,000 µg/L	Federal MCL

a. Equivalent methods may be substituted. For EPA Method 300.0, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For EPA Method 200.8, see EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*. Tentatively identified compounds will be reported for Method SW-846 8260 and 8270.

b. Field measurements have no specific QC except to perform checks to verify manufacturer's expected performance.

c. Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation based on statistical control of laboratory control samples also is performed. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analyses.

d. Calculated cleanup goals are below established analytical methodology capabilities. The analytical detection limits will be used for working levels, and will be periodically reviewed to establish if lower detection limit capabilities have become available.

WAC 173-340-720(4), "Method B Cleanup Levels for Potable Ground Water"

CAS = Chemical Abstracts Service
CCC = criterion continuous concentration
IC = ion chromatography
ICP = inductively coupled plasma
ICP/MS = inductively coupled plasma/mass spectrometry
MCL = maximum contaminant level
N/A = not applicable
NTU = nephelometric turbidity unit
VOC = volatile organic compound

2.1.5 Special Training and Certification

A graded approach is used to ensure workers receive a level of training commensurate with responsibilities and complies with applicable DOE orders and government regulations. The sampling lead and drilling lead, in coordination with line management, will ensure that field personnel meet special training requirements.

Typical training requirements or qualifications have been instituted by the primary contractor management team to meet training requirements imposed by the contract, regulations, DOE orders, DOE contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers, and *Washington Administrative Code*. For example, the environmental, safety, and health training program provides workers with the knowledge and skills necessary to execute assigned duties safely. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Hanford general employee training
- Radiological worker training.

Project-specific safety training, geared specifically to the project and the day's activity, will be provided. Project-specific training includes the following:

- Training requirements or qualifications needed by sampling personnel will be in accordance with QA requirements.
- Samplers are required to have training and/or experience in the type of sampling being performed in the field, soil/aquifer sediment sampling and water sampling.
- The Radiation Protection Program establishes qualification requirements for radiological control technicians. Radiological control technicians assigned to these activities will be qualified through the prescribed training program and will undergo ongoing training and qualification activities.

In addition, pre-job briefings will be performed to evaluate an activity and its hazards by considering many factors, including the following:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required
- Safety procedures applicable to the job
- Training requirements for individuals assigned to perform the work
- Level of management control
- Proximity of emergency contacts.

Training records are maintained for each individual in an electronic training record database. The contractor training organization maintains the training records system. Line management will be used to confirm an individual employee's training is appropriate and up-to-date before performing any fieldwork.

2.1.6 Documents and Records

The project lead is responsible for ensuring the current version of the SAP is being used and for providing any updates to field personnel. The administrative document control process maintains version control. Before implementation, DOE and the regulatory agency will review and approve changes to the sampling plan that affect the data needs. Information pertinent to sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols in accordance with Hanford Analytical Services Quality Assurance Requirements Documents (HASQARD) (DOE/RL-96-98).

The sampling lead or drilling lead is responsible for ensuring the field instructions are maintained up-to-date and aligned with any revisions to the SAP. The sampling lead or drilling lead will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook or on nonconformance report forms) in accordance with internal corrective action procedures.

The project lead, drilling lead, sampling lead, or designee will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities. Table 2-10 presents the change control for this project.

Table 2-10. Change Control for the 100-BC Decision Unit Project

Type of Change	Action	Documentation
By drilling lead or sampling lead: • Increasing sampling frequency based on field screening results or visual observations.	No SAP revision necessary	Field logbooks or operational records
By project management: • Change in target analytes or COPCs • Adding/removing wells • Significant increases or decreases in sampling frequency.	Revise SAP (can be accomplished with Tri-Party Agreement Change Notice); obtain regulatory approval; distribute plan	Revised plan or approved Tri-Party Agreement Change Notice

Logbooks are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for logbooks will be listed. Only authorized persons may make entries in logbooks. Logbooks will be signed by the sampling lead, drilling lead, cognizant scientist/engineer, or other responsible individual. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason.

Logbook entries will be made in indelible ink. Corrections will made by marking the erroneous data through with a single line, entering the correct data, and initialing and dating the changes.

The project lead is responsible for ensuring a project file is properly maintained. The project file will contain the records or references to their storage locations. The project file will include the following, as appropriate:

- Field logbooks or operational records
- Data forms

- Global Positioning System data
- Chain-of-custody forms
- Sample receipt records
- Inspection or assessment reports and corrective action reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract.
- Laboratory data packages
- RI report
- Verification and validation report

The laboratory is responsible for maintaining, and having available upon request, the following:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information.

Records may be stored in either electronic or hard copy format. Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes to ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement will be managed in accordance with the requirements of the Agreement.

2.2 Data Generation and Acquisition

The following sections address data generation and acquisition to ensure the project methods for sampling, measurement, and analysis; data collection or generation; data handling; and QC activities are appropriate and documented.

2.2.1 Sampling Process Design (Experimental Design)

The sampling design is judgmental sampling. In judgmental sampling, sampling unit selection (e.g., the number and location and/or timing of collecting samples) is based on knowledge of the feature or condition under investigation and professional judgment. Judgmental sampling is distinguished from probability-based sampling in that inferences are based on professional judgment, not statistical scientific theory. Therefore, conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment; probabilistic statements about parameters are not possible. Section 3.5 provides the types, number, and location of samples.

2.2.2 Sampling Methods

Section 3.6 describes the sampling methods. The specific information includes the following:

- Field sampling methods
- Corrective actions for sampling activities (ultimately, the task lead will be responsible for corrective action)
- Decontamination of sampling equipment
- Radiological field data.

2.2.3 Sample Handling and Custody

A sampling and data tracking database is used to track the samples from the point of collection through the laboratory analysis process. Samplers should note any anomalies (e.g., sample appears unusual or sample is sludge) with the samples to prevent batching across dissimilar matrices. If anomalies are found, the samplers should write "DO NOT BATCH" on the chain-of-custody form and inform Sample Management and Reporting.

Laboratory analytical results are entered and maintained in HEIS. HEIS sample numbers are issued to the sampling organization for the project. Each chemical, radiological, and physical properties sample is identified and labeled with a unique HEIS sample number.

Section 3.7 provides the following specific sample handling information:

- Container packaging
- Container labeling
- Sample custody requirements
- Sample transportation.

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

2.2.4 Analytical Methods

Tables 2-2 through 2-9 provide information on analytical methods. These analytical methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP. The primary contractor, or vadose zone contractor as applicable, participates in oversight of offsite analytical laboratories to qualify them for performing Hanford Site analytical work.

If the laboratory uses a nonstandard or unapproved method, the laboratory must provide method validation data to confirm the method is adequate for the intended use of the data. This includes information such as determination of detection limits, quantitation limits, typical recoveries, and analytical precision and bias. Deviations from the analytical methods noted in Tables 2-2 through 2-9 must be approved by Sample Management and Reporting in consultation with the project lead.

Laboratories providing analytical services in support of this SAP will have in place a corrective action program addressing analytical system failures and documents on the effectiveness of corrective actions. Issues affecting analytical results are to be resolved by Sample Management and Reporting in coordination with the project lead.

Batch leaching contacting tests will be performed on soil and aquifer sediment samples. Standardized batch leach tests are done using a leach procedure based on ASTM D3987, *Standard Test Method for Shake Extraction of Solid Waste with Water*. The procedure recommends using soil screened through 9.5 mm (3/8-inch) mesh. Demineralized water will be used as the leaching liquid. Selected soil samples will be leached at soil to water weight ratios of 1 to 1, 1 to 2.5, and 1 to 5 with one test in each series duplicated. Soil/water mixtures are placed in clean, watertight sample containers (extraction vessels) and rotated end-over-end through the vessel centerline at a rate of about 30 rotations per minute for 18 hours. Following 18 hours of mixing, the soil/water slurry is pressure-filtered using a 0.45-µm filter. 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.

Desorption distribution coefficient determinations using reagent water extract aliquots and results of soil analysis from EPA SW-846 Methods 6010, 6020, 7196, 7470, or 200.8 metals as applicable will support modeling needs. Details of the test will be discussed with the laboratory personnel before analysis.

2.2.5 Quality Control

QC procedures must be followed in the field and laboratory to ensure reliable data are obtained. Field personnel will collect QC samples to evaluate the potential for cross-contamination and to provide information pertinent to field variability. Field QC for sampling will require the collection of field duplicates, trip or field transfer blanks, equipment blanks, and field splits. Laboratory QC samples estimate the precision and bias of the analytical data. Table 2-11 summarizes field and laboratory QC samples.

Table 2-11. Project Quality Control Checks

QC Sample Type	Purpose	Frequency
Field Quality Control		
Full trip blank	Assess contamination from containers or transportation.	One per 20 samples *per media sampled.*
Field transfer blank	Assess contamination from sampling site.	One per day when volatile organic components are sampled *per media sampled.*
Equipment rinsate blank	Verify adequacy of sampling equipment decontamination.	As needed.[a] If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment rinsate blank is not required. Otherwise, 1 per 20 samples *per media sampled.*
Field duplicates	Estimate precision, including sampling and analytical variability.	One per batch,[b] 20 samples maximum, *per media sampled.*
Field split	Estimate precision, including sampling, analytical, and inter-laboratory variability.	One for every analytical method, except for Pacific Northwest National Laboratory specific tests, *per media sampled.*
Laboratory Quality Control[b]		
Method blank	Assess response of an entire laboratory analytical system.	One per batch,[b] 20 samples maximum, or as identified by method guidance *per media sampled.*
Matrix spike	Identify analytical (preparation and analysis) bias; possible matrix affect on the analytical method used.	One per batch,[b] 20 samples maximum, or as identified by the method guidance *per media sampled.*

Table 2-11. Project Quality Control Checks

QC Sample Type	Purpose	Frequency
Matrix duplicate or matrix spike duplicate	Estimate analytical bias and precision.	One per batch,[b] 20 samples maximum, or as identified by the method guidance *per media sampled.*
Laboratory control samples	Assess method accuracy.	One per batch,[b] 20 samples maximum, or as identified by the method guidance *per media sampled.*
Surrogates	Estimate recovery/yield.	As identified by the method guidance *per media sampled.*

a. When a new type of non-dedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less-frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

2.2.5.1 Field QC Samples

The Field QC sample types are discussed within this section.

Full trip blanks are samples prepared by the sampling team before traveling to the sampling site. The preserved bottle set is identical to the set collected in the field, but it is filled with reagent water or silica sand, as appropriate to the primary sample media. The bottles are sealed and transported, unopened, to the field in the same storage container used for samples collected the same day. Full trip blanks are typically analyzed for the same constituents as the samples from the associated sampling event. However, the analytical list for full trip blanks on soil may be limited to volatile organic analysis (VOA), semivolatile organic analysis, and total petroleum hydrocarbons, depending on resolution/determination of the target analyte list. Full trip blanks are not required on aquifer sediments being analyzed for metals, mercury, and hexavalent chromium.

Field transfer blanks are preserved VOA sample containers filled at the sample collection site with reagent water or silica sand transported to the field. The samples are prepared during the sampling to evaluate potential contamination caused by field conditions. After collection, field transfer blank bottles are sealed and placed in the same storage container with the samples from the associated sampling event. Field transfer blank samples are analyzed for volatile organic compounds (VOCs) only.

A minimum of one field transfer blank will be collected at each borehole where the samples will undergo VOA. The field transfer blank will consist of reagent water or silica sand, as appropriate to the primary sample media, added to clean sample containers at the location where the VOC sample was collected. The field transfer blank will be batch analyzed with samples for which VOA is being requested.

Equipment rinsate blanks are collected for sampling devices reused to assess the adequacy of the decontamination process. Equipment blanks will consist of silica sand or reagent water poured over the decontaminated sampling equipment and placed in containers, as identified on the project sampling authorization form. If disposable (e.g., single-use) equipment is used, equipment blanks will not be required.

For the field transfer blanks (e.g., full trip blank, field transfer blank, and equipment rinsate), results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate

esters, the limit is five times the method detection limit. For radiological data, blank results are flagged if they are greater than two times the total minimum detectable activity.

Field duplicate samples are used to evaluate sample consistency and the precision of field sampling methods. Field duplicates are independent samples that are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently.

A minimum of one soil and one aquifer sediment field duplicate will be collected for each day of sampling. The duplicate should be collected generally from an area expected to have some contamination, so valid comparisons between the samples can be made (e.g., at least some of the constituents will be above the detection limit). When sampling is performed from a split spoon, VOC samples and VOC duplicate samples are collected directly from the sampler. The remaining soil/aquifer sediment is then composited in a stainless steel mixing bowl. The soil/aquifer sediment sample and duplicate sample are collected from this composited material.

Evaluation of the results can provide an indication of intra-laboratory variability. Large relative percent differences can be an indication of laboratory performance problems and should be investigated. Only those field duplicates with at least one result greater than five times the method detection limit or minimum detectable activities are evaluated.

A **field split** is a representative sample from a sampling event sent to a third party laboratory (i.e., reference laboratory). Evaluation of the results can provide an indication of inter-laboratory variability. Large relative percent differences can be an indication of laboratory performance problems and should be investigated. Only those results greater than five times the method detection limit or minimum detectable activity at both laboratories are evaluated.

2.2.5.2 Laboratory QC Samples

The laboratory QC samples (e.g., method blanks, laboratory control sample/blank spike, and matrix spike) are defined for three-digit EPA methods (EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*, and EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1*) and four-digit EPA methods (SW-846), and will be run at the frequency specified in the respective reference. QC checks outside of control limits will be reflected in the data validation process and during the DQA described in Section 2.4.

2.2.5.3 QC Requirements

If only disposable equipment is used or equipment is dedicated to a particular well, an equipment rinsate blank is not required. If no VOC samples are collected, a field transfer blank is not required.

Field duplicates must agree within 20 percent, as measured by the relative percent difference, to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results also are flagged with a "Q" qualifier in the HEIS database.

For chemical analyses, the acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are stated in Tables 2-2 through 2-9.

Holding time is the elapsed time period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the analytical method, as specified for

three- and four-digit EPA methods (EPA/600/4-79/020; EPA/600/R-94/111; SW-846). Data associated with exceeded holding times are flagged.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The laboratories participate in national studies such as the EPA-sanctioned water pollution and water supply performance evaluation studies. The Soil and Groundwater Remediation Project periodically audits the analytical laboratories to identify and solve quality problems or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report (e.g., DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*). Failure of QC will be determined and evaluated during data validation and the DQA process. Data will be qualified as appropriate.

2.2.6 Instrument and Equipment Testing, Inspection, and Maintenance

Equipment used for collection, measurement, and testing should meet the applicable standards (e.g., American Society for Testing and Materials) or have been evaluated as acceptable and valid in accordance with the procedures, requirements, and specifications. The sampling lead or equivalent will ensure that the data generated from instructions using a software system are backed up and/or downloaded regularly. Software configuration will be acceptance tested before use in the field.

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (such as documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with three- and four-digit EPA methods (EPA/600/4-79/020; EPA/600/R-94/111; SW-846), or with auditable Hanford Site and contractual requirements. Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use.

2.2.7 Instrument and Equipment Calibration and Frequency

Section 3.4 provides specific field equipment calibration information. Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratory's QA plan.

2.2.8 Inspection and Acceptance of Supplies and Consumables

Supplies and consumables used in support of sampling and analysis activities will be procured in accordance with internal work requirements and processes described in the contractor acquisition system. Responsibilities and interfaces necessary to ensure items are procured/acquired for the contractor to meet the specific technical and quality requirements must be in place. The procurement system ensures purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users before use. Supplies and consumables procured by the analytical laboratories are procured, checked, and used in accordance with the laboratories' QA plans.

2.2.9 Non-Direct Measurements

Non-direct measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. Non-direct measurements will not be evaluated as part of this activity.

2.2.10 Data Management

Sample Management and Reporting, in coordination with the project lead, is responsible for ensuring analytical data are appropriately reviewed, managed, and stored in accordance with the applicable programmatic requirements governing data management procedures. Electronic data access, when appropriate, will be through a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b).

Laboratory errors are reported to Sample Management and Reporting routinely. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with contractor procedures. This process is used to document analytical errors and establish resolution with the project lead. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

Planning for sample collection and analysis will be in accordance with the programmatic requirements governing fixed laboratory sample collection activities, as discussed in the sampling procedures. If specific procedures do not exist for a particular work evolution, or it is determined additional guidance is needed to complete certain tasks, a work package will be developed to adequately control the activities, as appropriate. Examples of the sampling procedure requirements include activities associated with the following:

- Chain-of-custody/sample analysis requests
- Project and sample identification for sampling services
- Control of certificates of analysis
- Logbooks
- Checklists
- Sample packaging and shipping.

When this SAP is implemented, approved work control packages and procedures will be used to document field activities, including radiological and nonradiological measurements. Field activities will be recorded in the field logbook. Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection"
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of primary contractor radiological records
- Minimum standards and practices necessary for preparing, performing, and retaining radiological related records
- Indoctrination of personnel on the development and implementation of sample plans
- Requirements associated with preparing and transporting regulated material
- Daily reports of radiological surveys and measurements collected during field investigation activities. Data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpreting the investigation results.

2.3 Assessment and Oversight

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

2.3.1 Assessments and Response Actions

Contractor management, regulatory compliance, quality, and/or Health and Safety organizations may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, the QAPjP, procedures, and regulatory requirements. Section 2.4 discusses the only planned assessment, a DQA, for the activities identified in this SAP. The results of the DQA will be provided to the project lead.

If circumstances arise in the field dictating the need for additional assessment activities, then additional assessments would be performed. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiencies in accordance with the contractor QA program, the corrective action management program, and associated procedures that implement these programs.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The contractor conducts oversight of offsite analytical laboratories and qualifies the laboratories for performing Hanford Site analytical work.

2.3.2 Reports to Management

Reports to management on data quality issues will be made if these issues are identified. Issues reported by the laboratories are communicated to Sample Management and Reporting, which initiates a sample issue resolution form in accordance with contractor procedures. This process is used to document analytical or sample issues and to establish resolution with the project lead. At the end of the project, a DQA report will be prepared to determine whether the type, quality, and quantity of collected data met the quality objectives described in this SAP.

2.4 Data Validation and Usability

The elements under data validation and usability address the QA activities occurring after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying the project objectives.

2.4.1 Data Review, Verification, and Validation

The criteria for verification include, but are not limited to, review for completeness (samples were analyzed as requested), use of the correct analytical method/procedure, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

Data validation will be performed to ensure that the data quality goals established during the planning phase have been achieved. Data validation will be in accordance with internal procedures; the criteria for data level validation are based on a graded approach. The primary contractor has defined five levels of validation, Level A through Level E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of data (e.g., calibration data or calculations of representative samples from the dataset).Validation will be performed to contractor Level C, which is a review of the QC data. Level C validation specifically requires verification of deliverables; requested versus reported analyses; and

qualification of the results based on analytical holding times, method blank results, matrix spike/matrix spike duplicates, surrogate recoveries, duplicates, and analytical method blanks. Level C validation will be performed on at least 5 percent of the data by matrix and analyte group. Analyte group refers to categories, such as radionuclides, VOCs, semivolatile organic compounds, polychlorinated biphenyls, metals, and anions. The goal is to cover the various analyte groups and matrices during the validation.

Relative to analytical data in sample media, physical data and/or field screening results are of lesser importance in making inferences of risk. Field QA/QC will be reviewed to ensure physical property data and/or field screening results are usable.

2.4.2 Verification and Validation Methods

Validation activities will be based on EPA functional guidelines. Validation will be performed on target and non-target analytes from each method as part of the methods-based analysis. Data validation may be performed by the analytical laboratory, Sample Management and Reporting, and/or by a party independent of both the data collector and the data user. Data validation qualifiers must be compatible with the HEIS database.

When outliers or questionable results are identified, additional data validation will be performed. The additional validation will be performed for up to 5 percent of the statistical outliers and/or questionable data. The additional validation will begin with Level C and may increase to Levels D and E as needed to ensure data are usable. Level C validation is a review of the QC data, while Levels D and E include review of calibration data and calculations of representative samples from the dataset. Data validation will be documented in data validation reports. An example of questionable data is if the positive detections are greater than the practical quantitation limit or reporting limit in soil/aquifer sediment from a site that should not have exhibited contamination. Similarly, results below background would not be expected and could trigger a validation inquiry. The determination of data usability will be conducted and documented in a DQA report. Data validation will be documented in data validation reports, which will be included in the project file.

2.4.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. The results of the DQA will be used in interpreting the data and determining whether the objectives of this activity have been met. The DQA will be in accordance with EPA/240/B-06/002, *Data Quality Assessment: A Reviewer's Guide,* and EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners.*

2.4.4 Corrective Actions

The responses to data quality defects identified through the DQA process will vary and may be data- or measurement-specific. Some pre-identified corrective actions are identified in Table 2-1.

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3 Field Sampling Plan

Additional details regarding field-specific collection requirements are provided in the following sections.

3.1 Site Background and Objectives

Site background information is contained in the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100 BC Decision Unit*. The target analytes and COPCs are presented in Tables 1-2 and 1-3. Section 1.6 of this SAP provides a schedule for implementation. The objective of the field sampling plan is to clearly identify project sampling and analysis activities. The field sampling plan uses the sampling design identified during the systematic planning process and presents the design to identify sampling locations, the total number of samples to be collected, and analyses to be performed.

3.2 Documentation of Field Activities

Logbooks or data forms are required for field activities. Section 2.1.6 provides logbook requirements. Data forms may be used to collect field information. However, the data forms must follow the same requirements as those for logbooks presented below and the data forms must be referenced in the logbooks. The following is a summary of information to be recorded in logbooks:

- Purpose of activity
- Day, date, time, weather conditions
- Names, titles, organizations of personnel present
- Deviations from the QAPjP or procedures
- All site activities, including field tests
- Materials quality documentation (e.g., certifications)
- Details of samples collected (preparation, splits, duplicates, matrix spikes, blanks)
- Location and types of samples
- Chain-of-custody details and variances relating to chain-of-custody
- Field measurements
- Field calibrations and surveys and equipment identification numbers as applicable
- Equipment decontaminated, number of decontaminations, and variations to any decontamination procedures
- Equipment failures or breakdowns and descriptions of any corrective actions
- Telephone calls relating to field activities.

3.3 Sampling Design

As Section 2.2.1 presents, the sampling design is judgmental sampling.

3.4 Calibration of Field Equipment

The sampling lead is responsible for ensuring field equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance with manufacturer operating instructions, internal work requirements and processes, and/or work packages that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from instrument calibration activities are recorded in logbooks and/or work packages. Hard copy or electronic versions are acceptable.

Calibrations must be performed as follows:

- Before initial use of a field analytical measurement system
- At the frequency recommended by the manufacturer or procedure, or as required by regulations
- Upon failure to meet specified QC criteria.

Field instrumentation, calibration, and QA checks will be performed in accordance with the following:

- As specified in its program documentation, Pacific Northwest National Laboratory calibrates radiological field instruments on the Hanford Site.
- Daily calibration checks will be performed and documented for each instrument used to characterize areas under investigation. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.

3.5 Sample Location and Frequency

The purpose of this section is to identify the sampling locations and frequencies and define the sampling and analysis requirements for samples and measurements to be collected. Figure 1-1 shows the approximate locations of boreholes and groundwater monitoring wells described in this SAP. The actual locations will be determined based on a field walkdown of current site conditions to avoid Hanford Site National Historic restrictions, roads, and other obstructions.

3.5.1 Vadose Zone Characterization

Samples will be collected from boreholes and groundwater monitoring wells to support characterization of the vadose zone and groundwater as outlined in Table 1-1. The vadose zone will be characterized by performing intrusive investigations at six waste sites: 100-B-5 Trench, 116-B-5 Crib, 116-B-6B Crib, 116-B-11 Retention Basin, 116-C-6 Process Pit, and 118-B-6 Burial Ground. Intrusive investigations consist mainly of collecting and analyzing samples from planned boreholes in areas of known or suspected contamination. Each groundwater well will also have deep vadose zone samples collected for vadose zone characterization. These activities are planned to characterize the nature and vertical extent of contamination in the vadose zone beneath waste sites, characterize the physical properties of soil/aquifer sediments, locate potential sources, and verify contaminant distribution coefficients to support modeling and an assessment of risk. The data from these activities will be used to verify the adequacy of interim remedial actions and refine the preliminary conceptual site model of the 100-BC Decision Unit.

The scope of vadose zone characterization efforts includes field screening, collecting and analyzing soil samples from the vadose zone, collecting and analyzing aquifer sediment, performing groundwater sampling and analysis, and performing geophysical logging. The general intent of the borehole sampling design is to begin sample collection at the maximum depth of remedial action or bottom of the engineered structureand sample at 1.5 m (5 ft) intervals. The sampling frequency will be continuous within 3.1 m (10 ft) of the vadose zone-groundwater interface. Vadose zone samples will be collected according to the

sampling scheme shown in Table 3-1. The sampling scheme for each borehole or groundwater monitoring well includes collecting soil samples periodically throughout the vadose zone, collecting one sample of aquifer sediments 1.5 m (5 ft) into the water table, and collecting one filtered groundwater sample. Additional samples may be collected based on observations made in the field.

Physical property samples will be collected to provide site-specific values to support modeling efforts. The physical property samples will be collected from lithologies representing major facies in the vadose zone. The physical property samples will be collected in conjunction with split-spoon sample intervals, where possible.

3.5.1.1 Field Screening

Radiological field screening data, visual observation of lithologies, visual observation of contamination, or site geologist professional judgment may be used to adjust sampling points presented in Table 3-1, assist in determining sample shipping requirements, and support worker health and safety monitoring. Section 3.6.3 describes radiological field screening methods.

3.5.1.2 Geophysical Logging

The planned boreholes and groundwater monitoring wells will be geophysically logged with the high-resolution, spectral gamma-ray logging system to determine the vertical distribution and concentration of gamma-emitting radionuclides. Soil moisture will be determined using a neutron logging tool. The boreholes and groundwater monitoring wells will be logged before the casing is telescoped and before the borehole is decommissioned. The starting point for logging will be recorded; this is usually at the ground surface or the top of the casing. Boreholes will be decommissioned after geophysical logging and all sampling is completed in accordance with WAC 173-160 unless Tri-Parties direct otherwise.

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
100-B-5 Trench One borehole to 5 ft below groundwater (approximately 73 ft bgs) Justification: The 100-B-5 Trench was selected for characterization because mercury and chromium are above screening levels for groundwater protection at a depth of 28 ft below surface. No other contaminants were above screening levels for protection of groundwater. Although, strontium and hexavalent chromium were detected below screening for groundwater protection, this site is also selected because it is located correlative to the two respective groundwater plumes. A portion of the 100-B-8 and 100-C-6 effluent pipelines are located adjacent to this site, therefore data will also be provided to characterize process pipelines.	28-30.5, 33-35.5, 38-40.5, 43-45.5, 48-50.5, 53-55.5, 58-60.5, 63-65.5, 65.5-68, 68-70.5, 70.5-73 (75.5-78 aquifer sediment sample[b]) by split spoon (12 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-2 Aquifer sediment sample will only be analyzed for metals, hexavalent chromium, and mercury	During drilling 75.5 ft to 78 ft bgs, collect one filtered groundwater sample from unconfined aquifer[b] (1 sample)	Metals, hexavalent chromium, and mercury in accordance with Table 2-9
	Major formation and lithology changes samples by split spoon (2 samples)	Physical properties in accordance with Table 2-2		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
116-B-5 Crib One borehole to 5 ft below groundwater (approximately 65 ft bgs) Justification: The 116-B-5 Trench was selected for characterization because tritium, mercury, and barium are above screening levels for groundwater protection at a depth of approximately 16 ft bgs. No other contaminants were above screening levels for protection of groundwater. This site is also located correlative to the tritium, hexavalent chromium, and Sr-90 groundwater plumes and the site is a likely source of the tritium groundwater contamination. Process information indicates that 2.6 million gallons of tritiated effluent containing hundreds of gallons of mercury along with solvents and degreasers such as carbon tetrachloride, methyl alcohol, and trichloroethylene were released to the soil column. The volume of effluent release was sufficient to affect the entire vadose zone beneath the waste site.	15-17.5, 20-22.5, 25-27.5, 30-32.5, 35-37.5, 40-42.5, 45-47.5, 50-52.5, 55-57.5, 57.5-60, 60-62.5, 62.5-65 (67.5-70 aquifer sediment sample[b]) by split spoon (13 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-3 Aquifer sediment sample will only be analyzed for tritium, metals, hexavalent chromium, and mercury	During drilling 67.5 ft to 70 ft bgs[b], collect one filtered groundwater sample from unconfined aquifer (1 sample)	Tritium, metals, hexavalent chromium, and mercury in accordance with Table 2-9
	Major formation and lithology changes samples by split spoon (2 samples)	Physical properties in accordance with Table 2-3		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
116-B-6B Crib One borehole to 5 ft below groundwater (approximately 84 ft bgs). Justification: The 116-B-6B Crib was selected for characterization because it received 100 kg of sodium dichromate in 4,000 L of effluent. Based on the soil column pore volume of 198 m^3, the volume discharged was not sufficient to affect groundwater. Thus, the volume of effluent discharged to the soil column remains in the vadose zone and may be a future source of groundwater contamination. Because the engineered structure is approximately 5 ft below the depth of remedial action, contamination above screening levels for protection of groundwater may be present near the bottom of the waste site at 15 ft. Verification data indicate contaminants did not exceed screening criteria for groundwater protection. This site is also located correlative to the Sr-90 and hexavalent chromium groundwater plumes.	10-12.5, 15-17.5, 20-22.5, 25-27.5, 30-32.5, 35-37.5, 40-42.5, 45-47.5, 50-52.5, 55-57.5, 60-62.5, 65-67.5, 70-72.5, 75-77.5, 77.5-80, 80-82.5, 82.5-85 (86.5-89 aquifer sediment sample[b]) by split spoon (18 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-4 Aquifer sediment sample only will be analyzed for metals, hexavalent chromium, and mercury	During drilling 86.5 ft to 89 ft bgs, collect one filtered groundwater sample from unconfined aquifer [b] (1 sample)	Metals, hexavalent chromium and mercury in accordance with Table 2-9
	Major formation and lithology changes samples by split spoon (2 samples)	Physical properties in accordance with Table 2-4		
116-B-11 Retention Basin One borehole to 5 ft below groundwater (approximately 43 ft bgs). Justification: The 116-B-11 Retention Basin was selected for characterization because nickel-63, U-238, lead, mercury, and chromium are above screening levels for groundwater protection at a depth of 15 ft below surface. The site is also located correlative to the hexavalent chromium, tritium, and strontium groundwater plumes adjacent to the Columbia River.	15.5-18, 20.5-23, 25.5-28, 30.5-33, 33-35.5, 35.5-38, 38-40.5, 40.5-43, (45.5-48 aquifer sediment sample[b]) by split spoon (9 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-5 Aquifer sediment sample only will be analyzed for Sr-90, metals, hexavalent chromium, and mercury	During drilling 45.5 ft to 48 ft bgs, collect one filtered groundwater sample from unconfined aquifer [b] (1 sample)	Sr-90, metals, hexavalent chromium, and mercury in accordance with Table 2-9
	Major formation and lithology changes samples by split spoon (2 samples)	Physical properties in accordance with Table 2-5		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
116-C-6 Process Pit One borehole to 5 ft below groundwater (approximately 95 ft bgs). Justification: The 116-C-6 Process Pit was selected for characterization because it is the likely sources of the hexavalent chromium plume in the 100-B/C Area. This site received 5.5 million gallons of effluent from the fuel storage basin. Although this site is interim closed, soil removal was not performed at this site as an interim action.	0-2.5, 5-7.5, 10-12.5, 15-17.5, 20-22.5, 25-27.5, 30-32.5, 35-37.5, 40-42.5, 45-47.5, 50-52.5, 55-57.5, 60-62.5, 65-67.5, 70-72.5, 75-77.5, 80-82.5, 85-87.5, 87.5-90, 90-92.5, 92.5-95 (97.5-100 aquifer sediment sample[b]) by split spoon (22 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-6 Aquifer sediment sample only will be analyzed for metals, hexavalent chromium, and mercury	During drilling 97.5 ft to 100 ft bgs, collect one filtered groundwater sample from unconfined aquifer[b] (1 sample)	Metals, hexavalent chromium, and mercury in accordance with Table 2-9
	Major formation and lithology changes samples by split spoon (2 samples)	Physical properties in accordance with Table 2-6		
118-B-6 Burial Ground One borehole to 5 ft below groundwater (approximately 71 ft bgs). Justification: The 118-B-6 Burial Ground was selected for characterization because tritium in the soil column at a depth of 23 ft is approximately 200 times the soil concentration that is protective of groundwater. This site is also located relative to the Sr-90 and hexavalent chromium groundwater plumes.	23.5-26, 28.5-31, 33.5-36, 38.5-41, 43.5-46, 48.5-51, 53.5-56, 58.5-61, 63.5-66, 66-68.5, 68.5-71 (73.5-76 aquifer sediment sample[b]) by split spoon (12 samples)	Target analytes, field screening parameters, and batch leach contacting test in accordance with Table 2-7 Aquifer sediment sample only will be analyzed for tritium, metals, hexavalent chromium, and mercury	During drilling 73.5 ft to 76 ft bgs, collect one filtered groundwater sample from unconfined aquifer[b] (1 sample)	Tritium, metals, hexavalent chromium, and mercury in accordance with Table 2-9
	Major formation and lithology changes samples by split spoon (2 samples)	Physical properties in accordance with Table 2-7		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Well #1 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in the 100-B/C Area.	During drilling, archive samples of drill cuttings will be grab collected every 5 ft, or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples[c]	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (estimated 22 samples).	Table 1-3 constituents (in accordance with Table 2-9) Field screening parameters (in accordance with Table 2-9)
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon (8 samples)	In accordance with Table 2-8: • Batch leach contacting test • Distribution coefficient • Radiological methods • Physical properties • EPA Methods 7196 and 6010	During drilling, 5 ft below water table[b] (1 filtered groundwater sample)	Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-9
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples)	Physical properties in accordance with Table 2-8		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Well #2 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in the 100-B/C Area	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples[c]	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (estimated 22 samples)	Table 1-3 constituents (in accordance with Table 2-9) Field screening parameters (in accordance with Table 2-9)
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, at the bottom of the unconfined aquifer, and 5 ft into the RUM within a non-water-bearing unit by split spoon (8 samples)	In accordance with Table 2-8: • Batch leach contacting test • Distribution coefficient • Radiological methods • Physical properties • EPA Methods 7196 and 6010	During drilling, 5 ft below water table[b] (1 filtered groundwater sample)	Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-9
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples)	Physical properties in accordance with Table 2-8		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Well #3 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in the 100-B/C Area	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples[c]	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (estimated 22 samples)	Table 1-3 constituents (in accordance with Table 2-9) Field screening parameters (in accordance with Table 2-9)
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon (8 samples)	In accordance with Table 2-8: • Batch leach contacting test • Distribution coefficient • Radiological methods • Physical properties • EPA Methods 7196 and 6010	During drilling, 5 ft below water table[b] (1 filtered groundwater sample)	Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-9
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples)	Physical properties in accordance with Table 2-8		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Well #4 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in the 100-B/C Area	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples[c]	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (estimated 22 samples)	Table 1-3 constituents in accordance with Table 2-9 Field screening parameters in accordance with Table 2-9
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon (8 samples)	In accordance with Table 2-8: • Batch leach contacting test • Distribution coefficient • Radiological methods • Physical properties • EPA Methods 7196 and 6010	During drilling, 5 ft below water table[b] (1 filtered groundwater sample)	Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-9
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples)	Physical properties in accordance with Table 2-8		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Well #5 Install borehole reaching a total depth approximately 5 ft within the RUM and screened in the unconfined aquifer in the 100-B/C Area	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples[c]	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer (estimated 22 samples). During drilling, 5 ft below water table[b] (1 filtered groundwater sample).	Table 1-3 constituents (in accordance with Table 2-9). Field screening parameters (in accordance with Table 2-9). Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-9.
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, and at the bottom of the unconfined aquifer and 5 ft into the RUM within a non-water-bearing unit by split spoon (8 samples)	In accordance with Table 2-8: • Batch leach contacting test • Distribution coefficient • Radiological methods • Physical properties • EPA Methods 7196 and 6010		
	Major formation and lithology changes, and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples)	Physical properties in accordance with Table 2-8.		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Well #R1 to be drilled to a total depth approximately 50 ft within the RUM and screened in the first water bearing unit of the RUM in the 100-B/C Area	During drilling, archive samples of drill cuttings will be grab collected every 5 ft or where lithology changes occur in a pint jar and a chip tray.	Geologic archive samples[c]	During drilling, samples to be collected at 5-ft intervals throughout unconfined aquifer and from water-bearing intervals of the RUM unit if sufficient water is available (24 samples)	Table 1-3 constituents (in accordance with Table 2-9) Field screening parameters (in accordance with Table 2-9)
	During drilling, samples to be collected 15, 10, 5, and 2 ft above water table, at the water table, 5 ft below the water table, at the bottom of the unconfined aquifer and from the top, middle, and bottom of the non-water-bearing units of the RUM unit by split spoon (10 samples)	In accordance with Table 2-8: • Batch leach contacting test • Distribution coefficient • Radiological methods. • Physical properties • EPA Methods 7196 and 6010	During drilling,from water-bearing unit in RUM[b] (1 filtered groundwater sample)	Metals, hexavalent chromium, Sr-90, and mercury in accordance with Table 2-9
	Major formation and lithology changes and 10 ft and 5 ft above the Hanford Ringold contact, at the Hanford Ringold contact, and 5 ft below the Hanford Ringold contact by split spoon (6 samples)	Physical properties in accordance with Table 2-8		

Table 3-1. Sample/Measurement Locations and Depths

Sampling Location	Soil/Aquifer Sediment Sample/Measurement[a]		Water Sample/Measurement	
	Sample Interval Depth (ft bgs)	Analyte/ Property List	Sample Interval Depth (ft bgs)	Analyte List
Sample 20 spatial/temporal uncertainty monitoring wells (Table 3-2); multiple rounds	None	None	Multiple sampling rounds to support remedial investigation. (20 wells × 3 rounds = 60 samples)	Table 1-3 constituents at standard turnaround time in accordance with Table 2-9 Field screening parameters in accordance with Table 2-9
Number of samples	Soil/aquifer sediment chemical: 136 Physical property: 48 Geologic archive samples: variable		Water samples collected during drilling: 146 Spatial/temporal uncertainty samples: 60	
Minimum number of field QC samples	Soil/aquifer sediment chemical: 22 (7 equipment blank, 7 field blank, 7 duplicate, 1 split) Physical property: 0 Geologic archive samples: 0		Water samples collected during drilling: 25 (8 equipment blank, 8 field blank, 8 duplicate, 1 split) Spatial/temporal uncertainty samples: 10 (3 equipment blank, 3 field blank, 3 duplicate, 1 split)	
Total number of samples	Soil/aquifer sediment chemical: 158 Physical property: 48 Geologic archive samples: variable		Water samples collected during drilling: 171 Spatial/temporal uncertainty samples: 70	

a. Upon visual observation of contamination, a depth discrete sample will be collected for applicable analysis. For example, if hexavalent chromium contamination is observed at any interval other than those stated for sampling, a depth discrete sample would be collected for hexavalent chromium analysis.

b. This aquifer sediment sample will be collected from the unconfined aquifer, 5 ft below the water table.

c. Archive samples may be omitted at the discretion of the field geologist due to radiological field data.

For the four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

bgs = below ground surface

GEA = gamma energy analysis

RUM = Ringold upper mud

3.5.2 Groundwater Characterization

Groundwater characterization, including well activities, identification of wells to be sampled, well depth and screen placement, and well drilling and completion procedures, is discussed in this section.

3.5.2.1 New Groundwater Wells

Table 3-1 summarizes groundwater monitoring well activities. From the new wells screened in the Ringold upper mud unit, slug testing and pump testing will be performed to characterize hydraulic conductivity.

Well Depth and Screen Placement

For the five new groundwater wells in the unconfined aquifer in the 100-B/C Area, a 6.1 m (20 ft) screen or longer will be installed.

For the one new groundwater well in the 100-B/C Area to be drilled into the uppermost water-bearing unit within the Ringold upper mud, up to a 6.1 m (20 ft) length screen will be installed based on the thickness and ability to produce water in the water-bearing Ringold upper mud unit.

Well Drilling and Completion Procedures

Well drilling will be performed in accordance with WAC 173-160. The wells will be drilled using 25-cm (10 in.) diameter (or larger) casing to total depth. The drilling method will be determined based on discussions between the drilling lead and drilling contractor.

The wells will be constructed as 15.24 cm (6-in.) wells with Schedule 10, Type 304 or 316 stainless steel, V-slot continuous wire wrap screen, atop a 0.6 m (2 ft) long stainless steel sump with end cap. A Schedule 10 stainless steel riser will be used to extend the permanent well into the vadose zone, with Schedule 10 stainless steel casing through the vadose zone to ground surface. Colorado silica sand will be used for the sand pack; sodium bentonite pellets and/or natural sodium bentonite chunks, crumbles, or powdered bentonite will be used for bentonite sealing material; and Type I/II Portland cement will be used for cement grout.

Surface construction consisting of protective casing, protective guard posts, and cement pad must be in place before job completion. The protective casing will be a minimum of 5 cm (2 in.) larger in diameter than the permanent casing. Protective casing will rise approximately 0.9 m (3 ft) above the ground surface. Permanent casing will rise to approximately 0.3 m (1 ft) below the top of the protective casing. Protective casing will have a lockable well cap extending approximately 38.1 cm (15 in.) above the top of the protective casing.

Final well design, including screen placement and length, will be determined by concurrence of the field geologist, drilling lead, and operable unit lead based on field conditions. If the completion differs from WAC 173-160 requirements, variances will be obtained from Ecology.

3.5.2.2 Groundwater Network to Evaluate Spatial and Temporal Uncertainty

Table 3-1 summarizes groundwater monitoring activities to address spatial and temporal uncertainties. Table 3-2 presents the wells to be sampled. Multiple rounds of groundwater samples will be collected for analysis to support the remedial investigation in the existing groundwater wells for each contaminant identified in Table 1-3.

Table 3-2. Spatial and Temporal Uncertainty Groundwater Monitoring Well Network

C7505 (new)	199-B3-46	199-B4-4	199-B5-1	199-B8-7	199-B9-3	699-67-86
199-B2-13	199-B3-47	C7507 (new)	199-B5-2	199-B8-8	699-65-72	699-71-77
199-B3-1	C7506 (new)	199-B4-8	199-B8-6	C7508 (new)	699-65-83	

To determine the 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, both spatially and temporally. It is required the groundwater be sampled throughout a decision unit without regard to the location of surface facilities or known groundwater plumes. 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. The following discussion explains the method used to develop both the number and location of sampling points along with the sampling frequency for the decision units associated with the River Corridor RI/FS investigations. The resulting well network data will be used to evaluate the groundwater risk information presented in DOE/RL-2007-21, *Risk Assessment Report for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment.* Observations and conclusions regarding the data collected and the DOE/RL-2007-21 evaluation will be documented in the RI report (e.g., risk uncertainties associated with temporal and spatial representativeness, verifying groundwater risk conclusions, ensuring no contaminants were inadvertently overlooked, and establishing a "present condition" dataset that can be used to measure the progress of future cleanup actions).

Sample Number and Location

Sampling well locations within a groundwater decision unit must be identified to spatially represent all of the areas within a decision unit, regardless of facility or known contaminant plume locations. These sampling networks should represent locations where human or ecological receptors could potentially encounter groundwater. The primary pathway for human exposure is through direct contact with groundwater obtained from a residential or community water well. Identification of sampling locations to assess the direct exposure pathways is to assume development of the land for future human habitation. With this scenario as a guide to assessing a viable sampling grid of plausible groundwater pathways, land use regulations were used to develop a reasonable network of supply wells for each decision unit based on state regulations and site-specific hydrologic properties. This approached resulted in a sampling grid and corresponding network of monitoring wells tailored for each decision unit. As part of this semi-quantitative approach, the locations of community water delivery systems were developed to meet not only the negotiated Tri-Party land use needs but also, the State of Washington requirements.

Rules and regulations of the Washington State Department of Health (DOH) regarding public water supplies, WAC 246-290, "Group A Public Water Supplies," are explained in the associated guidance document, DOH 331-123, *Water System Design Manual.* This manual is maintained by the DOH and provides the necessary information on specifications to develop groundwater resources for human use. By applying these specifications to the possible locations of water supply wells that might act as complete exposure pathways, the number and spacing of sampling locations is determined with credibility for each decision unit, providing justified and defensible monitoring networks.

Based on remedial action goals for the interim ROD, 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. Because the remedial action goals are based on groundwater restored to highest beneficial use

(i.e. drinking water), the *Washington Growth Management Act* requires each residence occupy at least one acre of land. 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.

Therefore, residential water usage must be sufficient to supply not only in-house needs but also to irrigate a large garden and to water livestock. For a water well that supplies one residence, Ecology requires a minimum of 1,514.2 liters per day (L/day) (400 gallons per day [gal./day]. Thus, an extreme lower limit is established for in-house use. However, for a communal system, which the DOH regulates, guidance on the daily water use is found in DOH 331-123. One of the key parameters for estimating potential water use is the lot size of the individual residence.

Another important consideration is location of the well within the state because of climate differences east and west of the Cascade Mountains. Based on utility records in eastern Washington, which has a dominantly arid climate, a residence's maximum day demand is 5,675 L/day (1,500 gal./day) for lot sizes in excess of 2.5 acres. Although a caution is added that values as high as 30,283.3 L/day (8,000 gal./day) have been recorded, the historical sizing guideline of 5,675 L/day (1,500 gal./day) has generally been adequate. With the information on requirements for residential water supplies, the number of possible supply wells and thus the number of sampling points is calculated based on how much water the local aquifer is expected to produce.

To provide the number of sampling points for the well network, the average groundwater yields, calculated from pump tests conducted at each decision unit, are used to determine the number of residences supported on one supply well. Thus, the grid size specific to each decision unit 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 each decision unit. To the degree possible, one well within each grid was chosen to represent the potential exposure pathway; thereby providing a network of sampling points to provide a spatially representative sampling network of groundwater wells.

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. Current monitoring wells were chosen to provide data on maximum contaminant levels and to define plume extents. For decision units with 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.

Sampling Frequency

To capture baseline aquifer conditions fully, it is required that samples represent not only spatial variations but also changes that occur over time. Near the river, these varying conditions are observed as changes in groundwater flow, both direction and rate, causing temporary movement of contaminants through different portions of the unconfined aquifer. For decision units bordering on the Columbia River, the changing aquifer conditions are caused by fluctuating river elevations associated with flood control and hydroelectric production. For representing baseline groundwater conditions, samples are required to represent these varying aquifer conditions associated with high, low and mid-point or transitional river elevations. The date and frequency of sample collection is based on measurements of the river elevation to optimize collection of samples representing these temporal changes in groundwater conditions.

Effect of River Elevation on Groundwater Conditions

Along the Columbia River, rapid, periodic or cyclic elevation fluctuations of the river occur in controlled response to flood conditions, hydroelectric production, and salmon spawning programs at a series of dams and reservoirs upriver of the Hanford site. These rapid elevation changes in the river cause periodic

influences on flow conditions within the aquifer. For example, there are two times during a calendar year when the river elevation peaks and two times the river elevation is low. The highest river elevation occurs in early June when water is released from reservoirs that have reached capacity from the melting snow pack in the Cascade Mountains. The lowest river elevation is engineered in late September to early October to encourage salmon spawning in low pockets of the river bottom along the Hanford Reach.

When water is released upriver, the river elevation rises above the elevation of the local aquifer causing movement of water from the river into the aquifer. At this time, the flow direction in the aquifer is modified from the ambient condition and varies with local conditions along the river. This flow from the river brings cleaner river water into the groundwater causing a temporary reduction in contaminant levels in monitoring wells near the river.

When the river elevation is artificially lowered to a level below the aquifer by holding water back in the upriver reservoirs, groundwater moves from the aquifer into the river. The river then recharges from the aquifer, causing a change in the flow direction to roughly perpendicular to the river's edge, once again varying with specific locations along the river. These changes in direction may bring contaminated groundwater through observation wells at certain places and into the river. Thus, near the river/ groundwater interface, the flow direction and rate change with time. The effect on aquifer conditions is greatest when the river peaks in June and, again, at its lowest level in late September to early October. To capture these temporal effects on contaminant plumes within the aquifer from the low river elevation, groundwater sampling should be conducted prior to late October.

Inland from the river, the rapid river elevation changes form a pressure pulse that appears to be transmitted along the free surface of the unconfined aquifer. This effect causes groundwater elevation changes in wells not affected by actual movement of aquifer water. For some places, the elevation increase may allow the groundwater to interact with contaminated soils located just above the water table. The timing of these periodic or cyclic river elevation changes determines the sampling frequency required to represent the temporal variations in groundwater conditions.

Groundwater Sampling Dates

Because the goal of the temporal uncertainty groundwater sampling is to determine groundwater conditions when the river has the maximum effect on flow rate and direction, sampling is scheduled for late May to mid-June during the highest peak and from late September to late October during the time of the lowest elevation. From the second week in June to mid-September, the river elevation is in transition, decreasing from the maximum elevation to the lowest elevation. Also from March through April, elevations change from low to the high that occur in the first week of June. Consequently the best opportunity to capture transitional conditions occurs during the months of March and April or July and August.

Based on the previous discussion, three sampling events are recommended to represent the temporal fluctuations in groundwater conditions at each of decision units located along the river corridor. One sampling event captures the effect on the aquifer when the river stage is highest and the greatest increase in aquifer elevation occurs (May to mid June). The second sampling interval ranges from mid-September to mid-October when the river is at the lowest elevation for the year. This period is when contamination from the aquifer might be affecting the river. The third sampling point represents the mid-point or transitional aquifer conditions occurring from either March through April or July through August. Thus, the groundwater sampling schedules, which support the temporal uncertainty evaluation for the RI/FS at each decision unit along the river, captures the maximum effects of changing river elevations on aquifer conditions as well as the transitional time between the maximum and minimum changing conditions.

3.6 Sampling Methods

Soil/aquifer sediment sampling will be performed in accordance with approved procedures for soil and aquifer sediment sampling using a 10.2-cm (4 in.) split-spoon sampler. The split-spoon samplers will be equipped with separate stainless steel or polycarbonate liners. Site personnel will not overdrive the sampling device. Samples for VOCs will be packaged first. Next, the remaining soil/aquifer sediment will be transferred to a pre-cleaned, stainless steel mixing bowl or other suitable pre-cleaned container, homogenized, then containerized in accordance with the sampling procedure. If sample volume requirements cannot be met, samples will be collected according to the following priority: hexavalent chromium, metals (including mercury and uranium), batch leach contacting test, tritium, nitrate, strontium-90, technetium-99, other radionuclides, polychlorinated biphenyls, semivolatile organic compounds, hydraulic properties, and other anions.

Groundwater samples collected during drilling, before development, will be pumped from selected intervals. The pump will be operated long enough to provide stabilized field readings, but not necessarily three casing volumes.

For the groundwater monitoring well network, prior to sample capture, the pump will be operated for a period of time sufficient to provide stabilized field readings, and at least three casing volumes.

3.6.1 Corrective Actions and Deviations for Sampling Activities

The project lead, sampling lead, drilling lead, or designee must document deviations from procedures or other problems pertaining to sample collection, chain-of-custody, target analytes, COPCs, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected because of field conditions, changes in sample locations because of physical obstructions, or additions of sample depth(s).

As appropriate, such deviations or problems will be documented in the field logbook or on nonconformance report forms in accordance with internal corrective action procedures. The project lead, sampling lead, drilling lead, or designee will be responsible for communicating field corrective action requirements and for ensuring immediate corrective actions are applied to field activities.

More significant changes in sample locations not affecting the data needs will require notification and approval of the project lead. Changes to sample locations resulting in impacts to meeting the data needs will require concurrence with DOE and regulatory project leads. Changes to the SAP will be documented as noted in Section 2.1.6.

3.6.2 Decontamination of Sampling and Drilling Equipment

Sampling equipment will be decontaminated in accordance with the sampling equipment decontamination procedure. To prevent contamination of the samples, care should be taken to use clean equipment for each sampling activity. Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample container by setting the equipment/sample container on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events. Field decontamination (e.g., field washing and reuse) is not appropriate for sampling equipment

The drill rig derrick, all downhole equipment, and temporary casing will be field decontaminated (e.g., high pressure and temperature), at a minimum, before mobilization and demobilization.

3.6.3 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used as needed to support sampling and analysis efforts. Generally, cuttings from boreholes (excluding slough) will be field screened for evidence of radiological contamination. Screening will be conducted visually and with field instruments. Radiological screening will be performed by the radiological control technician or other qualified personnel. The radiological control technician will record field measurements, noting the depth of the sample and the instrument reading. Measurements will be relayed to the field geologist for inclusion into the field logbook or operational records daily, as applicable.

The following information will be distributed to personnel performing work in support of this SAP.

- Instructions to radiological control technicians on the methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate.
- Information regarding the Geiger-Müller, portable alpha meter, dual phosphors beta/gamma, and sodium iodide portable instruments, will include a physical description of the instruments, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. These instruments are commonly used on the Hanford Site for obtaining measurements of removable surface contamination measurements and direct measurements of the total surface contamination.
- Information on the characteristics associated with the hand-held probes to be used in the performance of direct radiological measurements will include a physical description of the probe, the radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The hand-held probe is an alpha detection instrument commonly used on the Hanford Site for obtaining removable surface contamination measurements and direct measurements of the total surface contamination.

3.7 Sample Handling

Sample handling, including container packaging, container labeling, sample custody, and sample transportation, is discussed in this section.

3.7.1 Container Packaging

Level I EPA pre-cleaned sample containers will be used for soil/aquifer sediment and water samples collected for chemical analysis. Container sizes may vary depending on laboratory specific volumes and requirements for meeting analytical detection limits. Radiological Engineering will measure the contamination levels and dose rates associated with the sample containers. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the sampling lead, in consultation with Sample Management and Reporting, can send smaller volumes to the laboratory. Preliminary container types and volumes are identified in Tables 3-3 and 3-4.

Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size[a]
Alpha speciation	None	6 months	G/P	10 g
Gamma energy analysis	None	6 months	G/P	750 g
Liquid scintillation counter	None	6 months	G	33 g
Isotopic – plutonium	None	6 month	G/P	5 g
Strontium-90	None	6 months	G/P	5 g
Gas flow proportional counting	None	6 months	G/P	5 g
Chem separation – Low Energy Photon Spectroscopy	None	6 months	G/P	150 g/250 mL
EPA 200.7	None	6 months	G/P	15 g
EPA 6010	Cool ~4° C	6 months	G/P	15 g
EPA 7196	Cool ~4° C	30 days	G/P	50 g
EPA 7471	None	28 days	G/P	15 g
UKPA	None	6 months	G/P	10 g
EPA 8260[b]	Cool ~4° C	14 days	G	50 g
EPA 8270	Cool ~4° C	14/40 days	aG	250 g
EPA 300.0	Cool ~4° C	48 hours/28 days	G/P	50 g
ASTM D2216	None	None	Moisture-proof container	200 g
ASTM D2937	None	None	G/P	1,000 g
ASTM D2434	None	None	P	1,000 g
ASTM D5084	None	None	P	1,000 g
Batch leaching contacting test	Cool ~4° C	28 days from field to extraction	G	100 g/120 mL
Distribution coefficient	Cool ~4 °C		Moisture-proof container	250 g

a. Based on minimum QC requirements.

b. Field preservation EPA 5035A also may be used.

For EPA Method 300.0, see EPA/600/4-79/020, Methods for Chemical Analysis of Water and Wastes.

For the four-digit EPA methods, see SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.

ASTM D2216-05, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM D2434-68, Standard Test Method for Permeability of Granular Soils (Constant Head)

ASTM D2937-04, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

ASTM D5084-03, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

48 hours/28 days = 48 hours for nitrate, nitrite, and phosphate; others, 28 days

Table 3-3. Sample Preservation, Container, and Holding Time for Soil/Aquifer Sediment Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size[a]

14/40 days = 14 days to extraction, then 40 days for analysis

aG = amber glass

G = glass

P = plastic

UKPA = total uranium by kinetic phosphorescence analysis

Table 3-4. Sample Preservation, Container, and Holding Time for Water Samples

Method	Preservation Requirement	Holding Time	Bottle Type	Minimum Sample Size*
Iodine-129 – Low Level	None	6 months	G/P	2000 mL
Strontium 89/90 – Sr-90	HNO_3 to pH <2	6 months	G/P	2,000 mL
EPA 6020 or 200.8	HNO_3 to pH <2	6 months	G/P	300 mL
Tritium (H-3)	None	6 months	G	60 mL
EPA 6010	HNO_3 to pH <2	6 months	G/P	300 mL
EPA 7196	Cool ~4° C	24 hours	aG	500 mL
EPA 7470 or 200.8	HNO_3 to pH <2	28 days	G	500 mL
EPA 8260	Cool ~4° C, HCl or H_2SO_4 to pH <2	14 days	aGs[a]	40 mL
EPA 300.0	Cool ~4° C	48 hours/28 days	P	125 mL

* Based on minimum QC requirements.

For EPA Method 200.8, see EPA/600/R-94/111, Methods for the Determination of Metals in Environmental Samples, Supplement 1.

For EPA Method 300.0, see EPA/600/4-79/020, Methods for Chemical Analysis of Water and Wastes.

For the four-digit EPA methods, see SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.

48 hours/28 days = 48 hours for nitrate, nitrite, and phosphate; others, 28 days.

aG = amber glass G = glass

aGs = amber glass septum; no headspace P = plastic

3.7.2 Container Labeling

The sample location, depth, and corresponding HEIS numbers are documented in the sampler's field logbook. A custody seal (e.g., evidence tape) is affixed to each sample container and/or the sample collection package in such a way as to indicate potential tampering. Each sample container will be labeled with the following information on firmly affixed, water-resistant labels:

- HEIS number
- Sample collection date and time

- Analysis required
- Preservation method (if applicable)
- Sampling authorization form number.

In addition to the above information, sample records must include the following:

- Analysis required
- Source of sample
- Matrix
- Field data (pH, radiological readings).

Except for VOA samples, a custody seal (i.e., evidence tape) will be affixed to the lid of each sample container. The custody seal will be inscribed with the sampler's initials and the date. Custody seals are not applied directly to VOA bottles collected because of a potential for affecting analytical results and/or fouling of laboratory equipment. Custody seals and any other required labels or documentation can be fixed to the exterior of a plastic bag holding vials in such a manner to detect potential tampering.

3.7.3 Sample Custody Requirements

Sample custody will be maintained in accordance with existing Hanford Site protocols to ensure the maintenance of sample integrity throughout the analytical process. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to Sample Management and Reporting within 48 hours of shipping.

The following information is required on a completed chain-of-custody form:

- Project name
- Signature of sampler
- Unique sample number
- Date and time of collection
- Matrix
- Preservatives
- Signatures of individual involved in sample transfer
- Requested analyses or reference thereto.

3.7.4 Sample Transportation

Sample transportation will be in compliance with the applicable regulations for packaging, marking, labeling, and shipping hazardous materials, hazardous substances, and hazardous waste mandated by the U.S. Department of Transportation (49 CFR 171, "General Information, Regulations, and Definitions," through Part 177, "Carriage By Public Highway") in association with the International Air Transportation Authority, DOE requirements, and applicable program specific implementing procedures.

3.8 Management of Waste

All waste (including unexpected waste) generated by sampling activities will be managed in accordance with DOE/RL-2004-30, *Waste Control Plan for the 100-BC-5 Operable Unit*. Pursuant to 40 CFR 300.440, "Procedures for Planning and Implementing Off-Site Response Actions," approval from the DOE Remedial Project Manager is required before returning unused samples or waste from offsite laboratories. To simplify management of returned samples, authority is granted through the RL signature on this SAP that unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the project site.

4 Health and Safety

Field operations will be performed in accordance with health and safety requirements and appropriate Soil and Groundwater Remediation Project requirements. Additionally, work control documents will be prepared to further control site operations. Safety documentation will include an activity hazard analysis and, as applicable, radiological work permits. The sampling procedures and associated activities will implement ALARA practices to minimize the radiation exposure to the sampling team, consistent with the requirements defined in 10 CFR 835.

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5 References

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Appendix A

Laboratory Standard Compound List

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A1 Laboratory Standards Compound List

Tables A-1 through A-6 provide the laboratory standard compound list.

A2 References

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Table A-1. U.S. Environmental Protection Agency Method 300.0

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
24959-67-9	Bromide	250	2,500	±20%/±30%	80-120%/70-130%
16887-00-6	Chloride	200	2,000	±20%/±30%	80-120%/70-130%
16984-48-8	Fluoride	500	5,000	±20%/±30%	80-120%/70-130%
14797-55-8	Nitrate*	250	2,500	±20%/±30%	80-120%/70-130%
14797-65-0	Nitrite*	250	2,500	±20%/±30%	80-120%/70-130%
NO3-N	Nitrogen in nitrate*	75	750	±20%/±30%	80-120%/70-130%
NO2-N	Nitrogen in nitrite*	75	750	±20%/±30%	80-120%/70-130%
14265-44-2	Phosphate*	500	5,000	±20%/±30%	80-120%/70-130%
14808-79-8	Sulfate	500	5,000	±20%/±30%	80-120%/70-130%

* Nitrate, nitrite, and phosphate suite or nitrogen in nitrate, nitrogen in nitrite, and phosphorus in phosphate suite may either be reported.

EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*

CAS = Chemical Abstract Services

EQL = estimated quantitation limit

Table A-2. U.S. Environmental Protection Agency SW-846 Method 6010

CAS #	Constituent	Water RDL (pCi/L)	Soil RDL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
7439-92-1	Lead	50	5,000	±20%/±30%	80-120%/70-130%
7439-93-2	Lithium	25	2,500	±20%/±30%	80-120%/70-130%
7439-98-7	Molybdenum	20	2,000	±20%/±30%	80-120%/70-130%
7440-28-0	Thallium	50	5,000	±20%/±30%	80-120%/70-130%
7440-38-2	Arsenic	100	10,000	±20%/±30%	80-120%/70-130%
7440-41-7	Beryllium	2	500	±20%/±30%	80-120%/70-130%
7440-42-8	Boron	20	2,000	±20%/±30%	80-120%/70-130%
7782-49-2	Selenium	100	10,000	±20%/±30%	80-120%/70-130%
7440-09-7	Potassium	4,000	400,000	±20%/±30%	80-120%/70-130%
7429-90-5	Aluminum	50	5,000	±20%/±30%	80-120%/70-130%
7439-89-6	Iron	50	5,000	±20%/±30%	80-120%/70-130%
7439-95-4	Magnesium	750	75,000	±20%/±30%	80-120%/70-130%
7439-96-5	Manganese	5	5,000	±20%/±30%	80-120%/70-130%
7440-02-0	Nickel	40	4,000	±20%/±30%	80-120%/70-130%
7440-22-4	Silver	10	1,000	±20%/±30%	80-120%/70-130%
7440-23-5	Sodium	500	50,000	±20%/±30%	80-120%/70-130%
7440-36-0	Antimony	60	6,000	±20%/±30%	80-120%/70-130%
7440-39-3	Barium	20	2,000	±20%/±30%	80-120%/70-130%
7440-43-9	Cadmium	2	500	±20%/±30%	80-120%/70-130%
7440-47-3	Chromium	10	1,000	±20%/±30%	80-120%/70-130%
7440-48-4	Cobalt	4	2,000	±20%/±30%	80-120%/70-130%
7440-50-8	Copper	8	1,000	±20%/±30%	80-120%/70-130%
7440-62-2	Vanadium	25	2,500	±20%/±30%	80-120%/70-130%
7440-66-6	Zinc	10	10,000	±20%/±30%	80-120%/70-130%
7440-70-2	Calcium	1,000	100,000	±20%/±30%	80-120%/70-130%
7440-31-5	Tin	100	10,000	±20%/±30%	80-120%/70-130%
7440-69-9	Bismuth	100	10,000	±20%/±30%	80-120%/70-130%
7723-14-0	Phosphorus	100	50,000	±20%/±30%	80-120%/70-130%
7440-21-3	Silicon	20	2,000	±20%/±30%	80-120%/70-130%
7440-24-6	Strontium (elemental)	10	1,000	±20%/±30%	80-120%/70-130%

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service EQL = estimated quantitation limit

Table A-3. U.S. Environmental Protection Agency Method 200.8 or SW-846 Method 6020

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
7439-92-1	Lead	2	500	±20%/±30%	80-120%/70-130%
7440-22-4	Silver	2	200	±20%/±30%	80-120%/70-130%
7440-28-0	Thallium	2	500	±20%/±30%	80-120%/70-130%
7440-36-0	Antimony	5	600	±20%/±30%	80-120%/70-130%
7440-38-2	Arsenic	4	1,000	±20%/±30%	80-120%/70-130%
7440-39-3	Barium	5	500	±20%/±30%	80-120%/70-130%
7440-41-7	Beryllium	2	200	±20%/±30%	80-120%/70-130%
7440-43-9	Cadmium	2	200	±20%/±30%	80-120%/70-130%
7440-47-3	Chromium	2	200	±20%/±30%	80-120%/70-130%
7782-49-2	Selenium	4	1,000	±20%/±30%	80-120%/70-130%

For EPA Method 200.8, see EPA/600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement 1.*

For Method 6020, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

Table A-4. U.S. Environmental Protection Agency SW-846 Method 8260

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
100-41-4	Ethylbenzene	5	5	±20%/±30%	80-120%/70-130%
100-42-5	Styrene	5	5	±20%/±30%	80-120%/70-130%
10061-01-5	cis-1,3-dichloropropene	5	5	±20%/±30%	80-120%/70-130%
10061-02-6	trans-1,3-dichloropropene	5	5	±20%/±30%	80-120%/70-130%
107-06-2	1,2-dichloroethane	5	5	±20%/±30%	80-120%/70-130%
108-10-1	4-methyl-2-pentanone	10	10	±20%/±30%	80-120%/70-130%
108-88-3	Toluene	5	5	±20%/±30%	80-120%/70-130%
108-90-7	Chlorobenzene	5	5	±20%/±30%	80-120%/70-130%
124-48-1	Dibromochloromethane	5	5	±20%/±30%	80-120%/70-130%
127-18-4	Tetrachloroethene	5	5	±20%/±30%	80-120%/70-130%
1330-20-7	Xylenes (total)	10	10	±20%/±30%	80-120%/70-130%

Table A-4. U.S. Environmental Protection Agency SW-846 Method 8260

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
540-59-0	1,2-dichloroethene(total)	10	5	±20%/±30%	80-120%/70-130%
591-78-6	2-hexanone	20	20	±20%/±30%	80-120%/70-130%
67-64-1	Acetone	20	20	±20%/±30%	80-120%/70-130%
71-43-2	Benzene	1.5	5	±20%/±30%	80-120%/70-130%
71-55-6	1,1,1-trichloroethane	5	5	±20%/±30%	80-120%/70-130%
74-83-9	Bromomethane	10	10	±20%/±30%	80-120%/70-130%
74-87-3	Chloromethane	10	10	±20%/±30%	80-120%/70-130%
75-00-3	Chloroethane	10	10	±20%/±30%	80-120%/70-130%
75-01-4	Vinyl chloride	5	5	±20%/±30%	80-120%/70-130%
75-09-2	Methylene chloride	5	5	±20%/±30%	80-120%/70-130%
75-15-0	Carbon disulfide	5	5	±20%/±30%	80-120%/70-130%
75-25-2	Bromoform	5	5	±20%/±30%	80-120%/70-130%
75-27-4	Bromodichloromethane	5	5	±20%/±30%	80-120%/70-130%
75-34-3	1,1-dichloroethane	2	10	±20%/±30%	80-120%/70-130%
75-35-4	1,1-dichloroethene	10	10	±20%/±30%	80-120%/70-130%
78-87-5	1,2-dichloropropane	5	5	±20%/±30%	80-120%/70-130%
78-93-3	2-butanone	10	10	±20%/±30%	80-120%/70-130%
79-00-5	1,1,2-trichloroethane	2	5	±20%/±30%	80-120%/70-130%
79-34-5	1,1,2,2-tetrachloroethane	5	5	±20%/±30%	80-120%/70-130%
56-23-5	Carbon tetrachloride	1	5	±20%/±30%	80-120%/70-130%
79-01-6	Trichloroethene	1	5	±20%/±30%	80-120%/70-130%
67-66-3	Chloroform	5	5	±20%/±30%	80-120%/70-130%
106-46-7	1,4-Dichlorobenzene	5	5	±20%/±30%	80-120%/70-130%
156-59-2	cis-1,2-Dichloroethylene	5	5	±20%/±30%	80-120%/70-130%

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service

EQL = estimated quantitation limit

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8270

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
100-01-6	4-Nitroaniline	10	330	±20%/±30%	80-120%/70-130%
100-02-7	4-Nitrophenol	20	660	±20%/±30%	80-120%/70-130%
101-55-3	4-Bromophenylphenyl ether	10	330	±20%/±30%	80-120%/70-130%
105-67-9	2,4-Dimethylphenol	10	330	±20%/±30%	80-120%/70-130%
106-44-5	4-Methylphenol (cresol, p-)*	10	330	±20%/±30%	80-120%/70-130%
106-46-7	1,4-Dichlorobenzene	10 (5)	330	±20%/±30%	80-120%/70-130%
106-47-8	4-Chloroaniline	10	330	±20%/±30%	80-120%/70-130%
108-39-4	3-Methylphenol (cresol, m-)*	20	660	±20%/±30%	80-120%/70-130%
108-60-1	Bis(2-chloro-1-methylethyl)ether	10	330	±20%/±30%	80-120%/70-130%
108-95-2	Phenol	10	330	±20%/±30%	80-120%/70-130%
111-44-4	Bis(2-chloroethyl) ether	10	330	±20%/±30%	80-120%/70-130%
111-91-1	Bis(2-Chloroethoxy)methane	10	330	±20%/±30%	80-120%/70-130%
117-81-7	Bis(2-ethylhexyl) phthalate	10	330	±20%/±30%	80-120%/70-130%
117-84-0	Di-n-octylphthalate	10	330	±20%/±30%	80-120%/70-130%
118-74-1	Hexachlorobenzene	10	330	±20%/±30%	80-120%/70-130%
120-12-7	Anthracene	10	330	±20%/±30%	80-120%/70-130%
120-82-1	1,2,4-Trichlorobenzene	10	330	±20%/±30%	80-120%/70-130%
120-83-2	2,4-Dichlorophenol	10	330	±20%/±30%	80-120%/70-130%
121-14-2	2,4-Dinitrotoluene	10	330	±20%/±30%	80-120%/70-130%
129-00-0	Pyrene	10	330	±20%/±30%	80-120%/70-130%
131-11-3	Dimethyl phthalate	10	330	±20%/±30%	80-120%/70-130%
132-64-9	Dibenzofuran	10	330	±20%/±30%	80-120%/70-130%
191-24-2	Benzo(ghi)perylene	10	330	±20%/±30%	80-120%/70-130%
193-39-5	Indeno(1,2,3-cd)pyrene	10	330	±20%/±30%	80-120%/70-130%
205-99-2	Benzo(b)fluoranthene	10	330	±20%/±30%	80-120%/70-130%
206-44-0	Fluoranthene	10	330	±20%/±30%	80-120%/70-130%
207-08-9	Benzo(k)fluoranthene	10	330	±20%/±30%	80-120%/70-130%
208-96-8	Acenaphthylene	10	330	±20%/±30%	80-120%/70-130%
218-01-9	Chrysene	10	330	±20%/±30%	80-120%/70-130%
50-32-8	Benzo(a)pyrene	10	330	±20%/±30%	80-120%/70-130%

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8270

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
51-28-5	2,4-Dinitrophenol	25	825	±20%/±30%	80-120%/70-130%
534-52-1	4,6-Dinitro-2-methylphenol	10	330	±20%/±30%	80-120%/70-130%
53-70-3	Dibenz[a,h]anthracene	10	330	±20%/±30%	80-120%/70-130%
541-73-1	1,3-Dichlorobenzene	10	330	±20%/±30%	80-120%/70-130%
56-55-3	Benzo(a)anthracene	10	330	±20%/±30%	80-120%/70-130%
59-50-7	4-Chloro-3-methylphenol	10	330	±20%/±30%	80-120%/70-130%
606-20-2	2,6-Dinitrotoluene	10	330	±20%/±30%	80-120%/70-130%
621-64-7	n-Nitrosodi-n-dipropylamine	10	330	±20%/±30%	80-120%/70-130%
65794-96-9	3+4 Methylphenol (cresol, m+p)*	10	330	±20%/±30%	80-120%/70-130%
67-72-1	Hexachloroethane	10	330	±20%/±30%	80-120%/70-130%
7005-72-3	4-Chlorophenylphenyl ether	10	330	±20%/±30%	80-120%/70-130%
77-47-4	Hexachlorocyclopentadiene	10	330	±20%/±30%	80-120%/70-130%
78-59-1	Isophorone	10	330	±20%/±30%	80-120%/70-130%
83-32-9	Acenaphthene	10	330	±20%/±30%	80-120%/70-130%
84-66-2	Diethylphthalate	10	330	±20%/±30%	80-120%/70-130%
84-74-2	Di-n-butylphthalate	10	330	±20%/±30%	80-120%/70-130%
85-01-8	Phenanthrene	10	330	±20%/±30%	80-120%/70-130%
85-68-7	Butylbenzylphthalate	10	330	±20%/±30%	80-120%/70-130%
86-30-6	n-Nitrosodiphenylamine	10	330	±20%/±30%	80-120%/70-130%
86-73-7	Fluorene	10	330	±20%/±30%	80-120%/70-130%
86-74-8	Carbazole	10	330	±20%/±30%	80-120%/70-130%
87-68-3	Hexachlorobutadiene	10	330	±20%/±30%	80-120%/70-130%
87-86-5	Pentachlorophenol	10	330	±20%/±30%	80-120%/70-130%
88-06-2	2,4,6-Trichlorophenol	10	330	±20%/±30%	80-120%/70-130%
88-74-4	2-Nitroaniline	10	330	±20%/±30%	80-120%/70-130%
88-75-5	2-Nitrophenol	20	660	±20%/±30%	80-120%/70-130%
91-20-3	Naphthalene	10	330	±20%/±30%	80-120%/70-130%
91-57-6	2-Methylnaphthalene	10	330	±20%/±30%	80-120%/70-130%
91-58-7	2-Chloronaphthalene	10	330	±20%/±30%	80-120%/70-130%
91-94-1	3,3'-Dichlorobenzidine	10	330	±20%/±30%	80-120%/70-130%

Table A-5. U.S. Environmental Protection Agency SW-846 Method 8270

CAS #	Constituent	Water EQL (µg/L)	Soil EQL (µg/kg)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
95-48-7	2-Methylphenol (cresol, o-)	10	330	±20%/±30%	80-120%/70-130%
95-50-1	1,2-Dichlorobenzene	10	330	±20%/±30%	80-120%/70-130%
95-57-8	2-Chlorophenol	10	330	±20%/±30%	80-120%/70-130%
95-95-4	2,4,5-Trichlorophenol	10	330	±20%/±30%	80-120%/70-130%
98-95-3	Nitrobenzene	10	330	±20%/±30%	80-120%/70-130%
99-09-2	3-Nitroaniline	10	330	±20%/±30%	80-120%/70-130%

* May report as 3-Methylphenol (cresol, p-) and 4-Methylpheonl (cresol, m-) or a 3+4 Methylphenol (cresol, m+P) total.

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*

CAS = Chemical Abstracts Service EQL = estimated quantitation limit

1

Table A-6. Gamma Spectroscopy, Germanium High-Energy Detectors (Gamma Energy Analysis)

CAS #	Constituent	Water EQL (pCi/L)	Soil EQL (pCi//g)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
14331-83-0	Actinium-228	—	—	±30%	70-130%
14596-10-2	Americium-241	50	1	±30%	70-130%
14234-35-6	Antimony-125	50	0.3	±30%	70-130%
13981-41-4	Barium-133	—	0.2	±30%	70-130%
13966-02-4	Beryllium-7	50	0.3	±30%	70-130%
14913-49-6	Bismuth-212	—	—	±30%	70-130%
14733-03-0	Bismuth-214	—	—	±30%	70-130%
CE/PR-144	Cerium/Praseodymium-144	—	—	±30%	70-130%
10045-97-3	Cesium-137	15	0.1	±30%	70-130%
10198-40-0	Cobalt-60	25	0.05	±30%	70-130%
14683-23-9	Europium-152	50	0.1	±30%	70-130%
15585-10-1	Europium-154	50	0.1	±30%	70-130%
14391-16-3	Europium-155	50	0.1	±30%	70-130%
14596-12-4	Iron-59	—	—	±30%	70-130%
15092-94-1	Lead-212	—	—	±30%	70-130%
15067-28-4	Lead-214	—	—	±30%	70-130%
14681-63-1	Niobium-94	—	—	±30%	70-130%

Table A-6. Gamma Spectroscopy, Germanium High-Energy Detectors (Gamma Energy Analysis)

CAS #	Constituent	Water EQL (pCi/L)	Soil EQL (pCi//g)	Precision Requirement Water/Soil	Accuracy Requirement Water/Soil
13966-00-2	Potassium-40	—	—	±30%	70-130%
13982-63-3	Radium-226	—	0.1	±30%	70-130%
15262-20-1	Radium-228	—	0.2	±30%	70-130%
14274-82-9	Thorium-228	—	—	±30%	70-130%
TH-232	Thorium-232	—	—	±30%	70-130%
15065-10-8	Thorium-234	—	—	±30%	70-130%
15832-50-5	Tin-126	—	—	±30%	70-130%
15117-96-1	Uranium-235	50	0.5	±30%	70-130%
U-238	Uranium-238	500	10	±30%	70-130%
14391-65-2	Silver-108m		0.2	±30%	70-130%

Where EQL is not specified, current EQLs of laboratories contracted to the Hanford Site are applicable.

CAS = Chemical Abstract Services EQL = estimated quantitation limit

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Draft A

River Corridor
Closure Contract

Treatability Study for In Situ Hexavalent Chromium Treatment at 100-C-7

September 2009

Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor

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River Corridor Closure Contract

Treatment Study for In Situ Hexavalent Chromium Treatment at 100-C-7

September 2009

Author:

T. M. Blakley

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1.0 INTRODUCTION

1.1 PURPOSE

An in situ hexavalent chromium reduction treatability test will be conducted in the 100-BC-2 Operable Unit (Figure 1) at the Hanford Site. The U.S. Department of Energy (DOE) is the lead agency and the U.S. Environmental Protection Agency is the lead regulatory agency of this operable unit as described in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

The overall objective of in situ treatment is to reduce hexavalent chromium (Cr VI) to trivalent chromium (Cr III) in the soil. Trivalent chromium is less toxic and less mobile than hexavalent chromium. This treatability test will provide the data needed for a detailed analysis of this alternative during the feasibility study for the 100-B/C Area.

The treatability test will occur within the 100-C-7:1 waste site, approximately 400 m inland from the Columbia River in an area that is not expected to be culturally or ecologically sensitive.

This treatability study report describes the following:

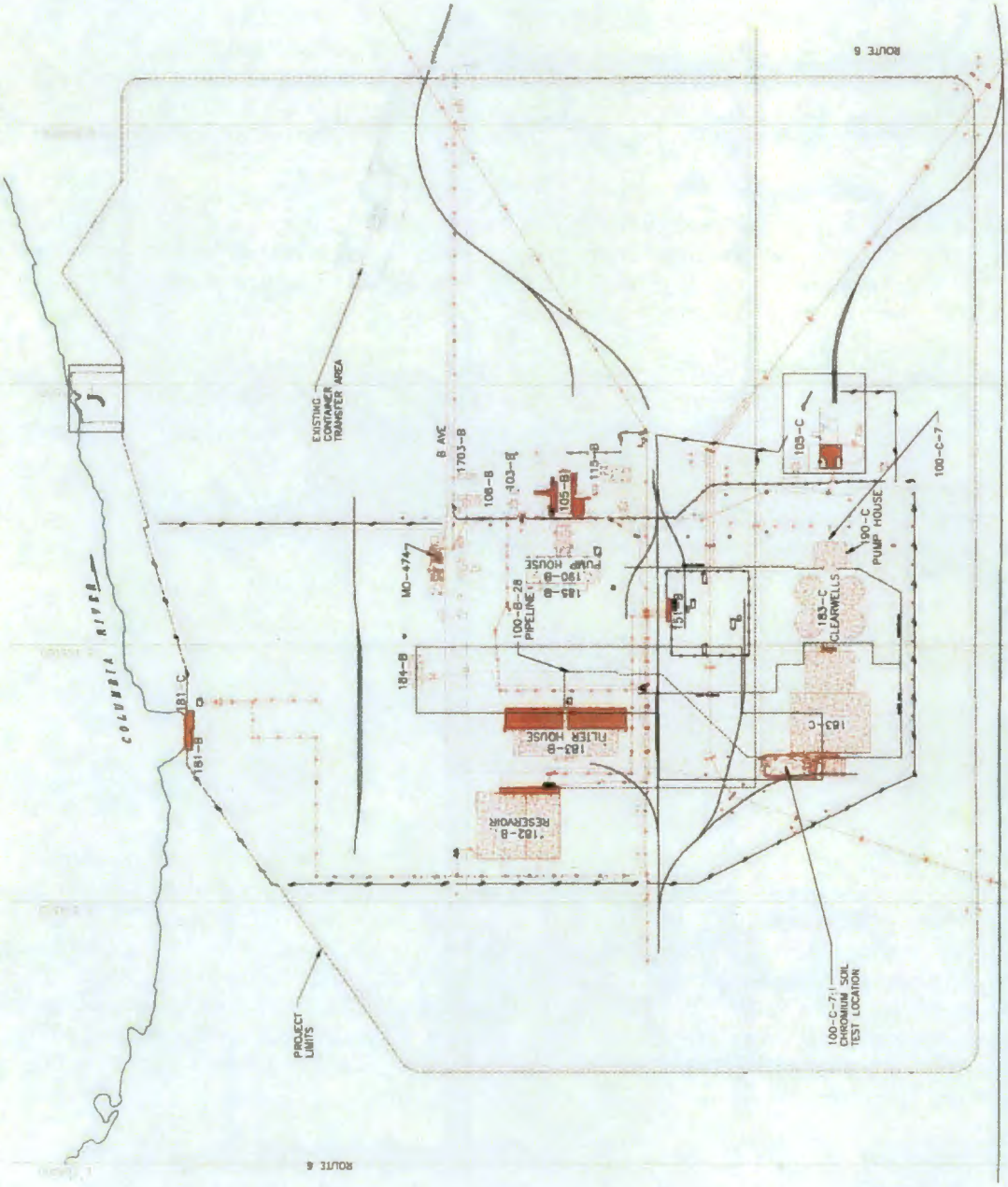
1. Treatment technology to be tested
2. Selection process used to make that determination
3. Conceptual treatability test design
4. Test objectives
5. Performance and data quality requirements
6. Implementation plan for performance of the treatability test.

1.2 BACKGROUND

1.2.1 Site Description

The 100-C-7 waste site is located in two geographic areas (100-C-7 and 100-C-7:1) in the southwestern portion of the 100-B/C Area, approximately 1,115 ft west of the 105-C Reactor Building, and is associated with the decommissioned 183-C water treatment filter building facilities and surrounding soils. The 100-C-7 waste site consists of the residual sodium dichromate contamination associated with concrete that was left in place after the 1997 decommissioning of the 183-C Filter Building/Pumproom. The 100-C-7:1 waste site consists of stained surface soil that was observed in 2002 just north of the 183-C Headhouse and adjacent to the northwest corner of the 183-C Sedimentation Basins. The treatability test will be located at the site of 100-C-7:1.

Figure 1. 100-B/C Area.



1.2.2 Previous Remediation Activities

Remediation at the 100-C-7:1 waste site was initiated in December 2004 with excavation of a stained soil area located north of the 183-C Headhouse to a depth of approximately 15 ft. Excavation also proceeded to a depth of 15 ft in the area approximately 250 ft south of the stained surface soil and adjacent to the north side of the former 183-C Headhouse, where the outdoor chemical storage tanks were once located, because in-process sampling indicated residual hexavalent chromium contamination exceeding cleanup criteria. Suspect hexavalent chromium staining was also observed on the outside foundation wall of the 183-C Sedimentation Basins exposed in the east sidewall of the excavation.

1.2.3 Summary of Characterization Activities

To support preparation of the engineering design for remediation activities, eight characterization test pits and three boreholes were constructed in the vicinity of the 100-C-7 and 100-C-7:1 waste sites to help determine the extent of hexavalent chromium contamination at depth and to evaluate remediation alternatives.

A more detailed summary of the findings of these characterization activities is documented in *100-C-7 and 100-B-27 Test Pit and Borehole Data Summary Report*, (WCH 2008). Analytical results specifically relevant to this treatability study are summarized in Section 2.2. A cross-section showing the original borehole and test pit constructed at the 100-C-7:1 waste site, along with the sampling results at depth, is shown in Figure 2. The location of this cross-section is just to the south of test pit 5, one of the locations for performance of treatability testing.

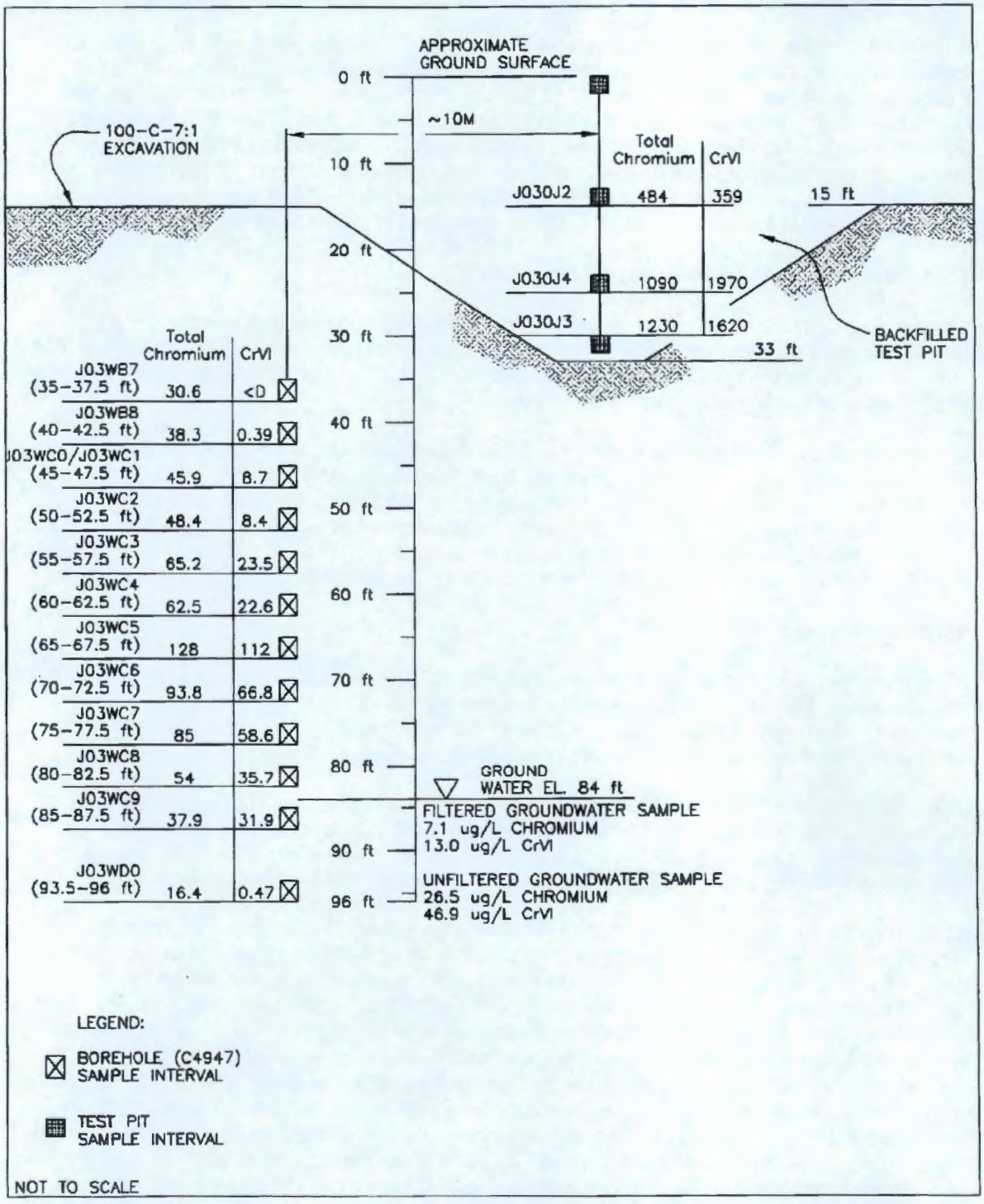
1.2.4 Site Hydrogeology

A detailed description of the geologic setting of the 100-B/C Area is included in *Geology of the 100-B/C Area, Hanford Site, South-Central Washington*, WHC-SD-EN-TI-133, Rev. 0 (Lindberg 1993). The following is a summary of the hydrogeology associated with performing in situ treatment of hexavalent chromium at the 100-C-7 waste site.

The vadose zone at the 100-B/C Area includes some very minor backfill in limited areas, Holocene surficial deposits, the Hanford formation, and the uppermost part of the Ringold Formation. The depth to groundwater beneath the 100-C-7 waste site was 83 ft below ground surface (bgs) during drilling of characterization boreholes in July and August 2007.

The vast majority of the vadose zone lies within the gravel-dominated facies of the Hanford formation. The "uppermost aquifer system" (Delaney et al. 1991) is found within the lowermost part of the Hanford formation and the entire Ringold Formation and includes a series of confining and water-producing zones. The upper part of the "uppermost aquifer system" is an unconfined zone of higher transmissivity and is mainly within unit E of the Ringold Formation and occasionally within the lowest part of the Hanford formation (usually gravel-dominated facies). Below unit E, the "upper aquifer system" is unconfined or semiconfined, has lower transmissivity zones, and lies within alternating layers of coarse and fine Ringold Formation sediments (i.e., fluvial gravels and sands, and paleosols or overbank deposits). The "uppermost aquifer system" is underlain by the various Columbia River Basalt Group aquifers, which consist of alternating confining zones and confined aquifers. These alternating confining zones and confined aquifers correspond with alternating basalt flow interiors and higher transmissive zones associated with flow tops, rubbly and scoriacious zones, or sedimentary interbeds.

Figure 2. Cross-Section of Borehole C4947 and Adjacent Test Pit.



The groundwater table is relatively flat with a hydraulic gradient of 0.0008 reported across the 100-B/C Area (DOE-RL 1994, 2009). A steeper gradient exists near the river, especially during periods of low river level.

1.2.5 Suitability of 100-C-7 for Demonstration of In Situ Treatment

The 100-C-7 waste site was selected for demonstrated of in situ biological and chemical treatability tests based on a result of the nature and extent of contamination found and characterization data collected as part of previous remedial action performed at the site (Section 1.2.3). The following is a summary of the major factors used to make this determination:

- Remove, treat, dispose (RTD) may not be most cost-effective remediation remedy due to the depth of contamination, the presence of an active export water line, and extensive concrete sub-structures adjacent to the waste site (depth of contamination extends from 15 ft bgs to approximately 83 ft in places).
- Total chromium and hexavalent chromium are the only contaminants above remedial action goals.
- Existing groundwater monitoring wells in the vicinity of the site have not shown a significant presence of hexavalent chromium contamination above groundwater protection levels.

1.2.6 Groundwater Protection During Performance of Treatability Test

Unlike other areas of the Hanford Site, hexavalent chromium is not currently a demonstrated source of significant groundwater contamination in the 100-B/C Area. Therefore, it is necessary to ensure that groundwater is not impacted as a result of the treatability test. The following groundwater protection measures will be taken during the treatability test:

1. Groundwater monitoring well 199-B8-7, which currently exists within the footprint of the waste site, will be monitored before, during, and after performance of the treatability test.
2. New monitoring wells downgradient of the waste site that are currently planned for construction during the fall of 2009 will also be monitored periodically.
3. The depth of each of the four test locations will extend no greater than 20 ft below the bottom of the existing waste site, which is currently 15 ft bgs. This leaves an additional 50 ft of vadose zone between the bottom the test site and groundwater. The volume of the reagents in solution to be used during performance of the treatability test will be absorbed by the surrounding soils and are not sufficient to reach groundwater.
4. Following successful completion of the treatability test, the soils impacted by the test are expected to consist of treated soil, in which hexavalent chromium will have been reduced to trivalent chromium. Further remediation (i.e., RTD) at the test site locations will not be required.

2.0 TREATMENT/TECHNOLOGY DESCRIPTION

2.1 TECHNOLOGY SELECTION

A technical evaluation for hexavalent chromium treatment technologies beyond the current RTD and ex situ pump-and-treat alternatives implemented in the 100 Areas of the Hanford Site was initiated in April 2008. The results of that evaluation narrowed the broad field of technology options to in situ reduction of hexavalent chromium for deep vadose zone and groundwater contamination. A 2-day workshop was held on November 12 and 13, 2008, for the purpose of bringing subject matter experts, DOE, regulators, and other interested parties (e.g., the Hanford contractors) together to discuss and evaluate treatment options for deep vadose zone hexavalent chromium contamination at the 100-C-7:1 waste site (WCH 2009). For the most part, technologies that screened out in the site-wide evaluation were assumed to be inapplicable to the 100-B/C hexavalent chromium as well, and therefore were not addressed by the workshop. However, unlike the other waste sites being considered for in situ hexavalent chromium reduction, 100-C-7:1 has no evidence of groundwater hexavalent chromium contamination. Therefore, deep soil mixing, which is a vadose zone-only technology, was carried forward for further evaluation at 100-C-7:1.

Additionally, a document prepared by Pacific Northwest National Laboratory, *Review of Techniques to Characterize the Distribution of Chromate Contamination in the Vadose Zone of the 100 Areas at the Hanford Site* (Dresel et al. 2007) was also used as guidance in identifying technologies that would be most applicable to the 100-B/C vadose zone hexavalent chromium contamination.

The technologies deemed potentially applicable and carried forward for discussion at the 100-C-7:1 workshop included the following:

1. In situ chemical reduction with calcium polysulfide
2. In situ biological reduction with organic substrates
3. In situ chemical reduction with zero valent iron
4. In situ solidification/stabilization (deep soil mixing with cement/reducing agents).

These technologies were further evaluated and ranked against the 100-C-7 baseline RTD option based on their effectiveness, ability to mitigate risk, cost, ease of implementation, and time to complete full-scale treatment. Based on these criteria, a combination of biological and chemical reduction of hexavalent chromium via infiltration was selected as the preferred technology.

Option 3 was eliminated due to a determination that ease of implementation (e.g., delivery) was less favorable than the other technologies and because of a slightly longer time frame for implementing the technology. Option 4 was ruled out because the vadose zone at 100-B/C is deeper and more heterogeneous than soils where this technology has been successful. Options 1 and 2 were retained for further evaluation in this treatability test.

2.2 TEST SITE SELECTION

The treatability test will be performed at two different locations within the footprint of the previously excavated 100-C-7:1 waste site (Figure 3). The purpose of the first three treatability scenarios is to help determine the most appropriate reducing agents: biological, chemical, or a combination of the two. The primary location for implementation of the first three treatability test scenarios is the area near test pit 2 (Figure 4). This was the location of the original soil staining observed prior to initial excavation at the site, which had results consistently above remedial action goals for both total chromium and hexavalent chromium through the depth of the test pit (WCH 2008). Implementation of the treatability test at this location is expected to provide a good indication of the performance of each reagent combination.

Figure 3. 100-C-7:1 Test Site.

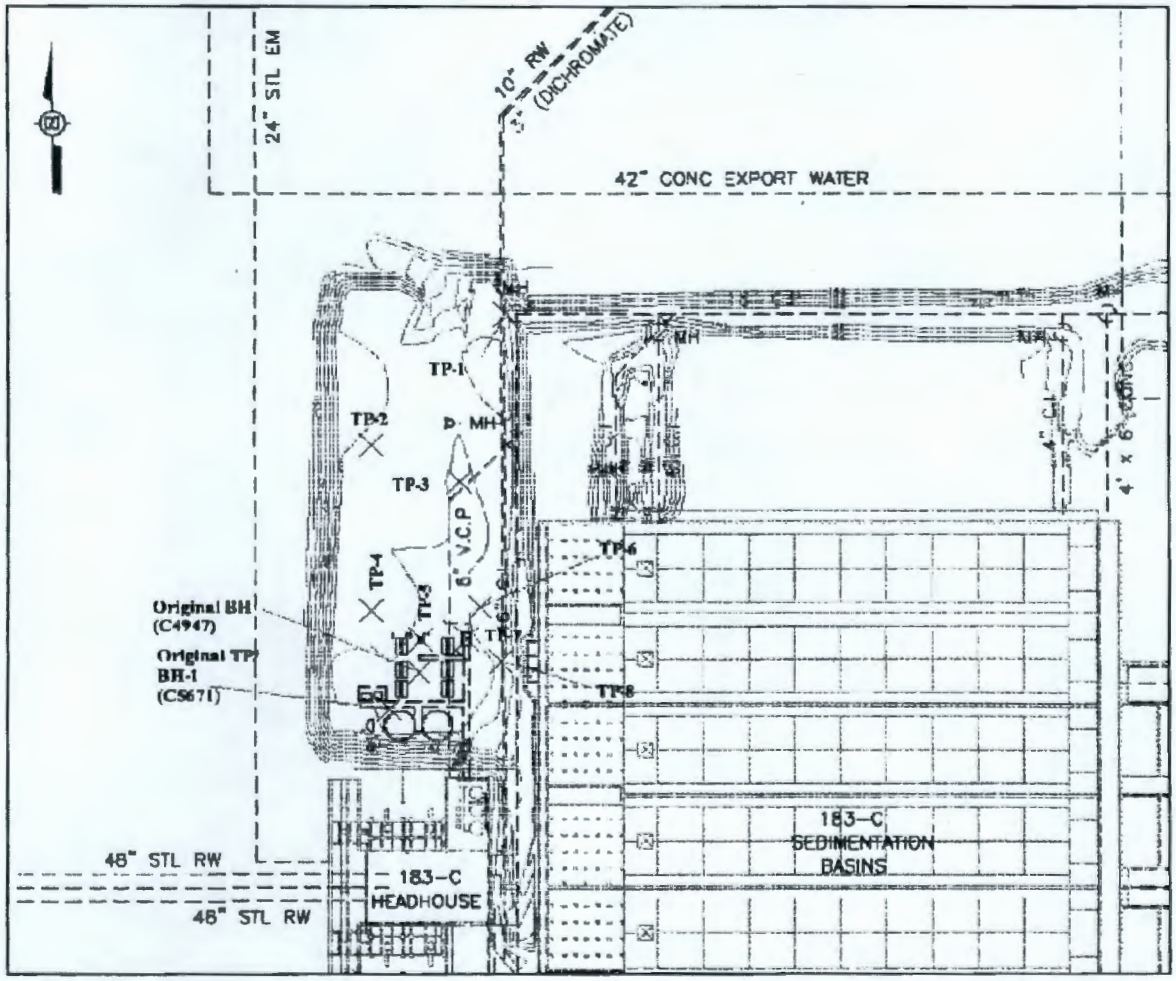
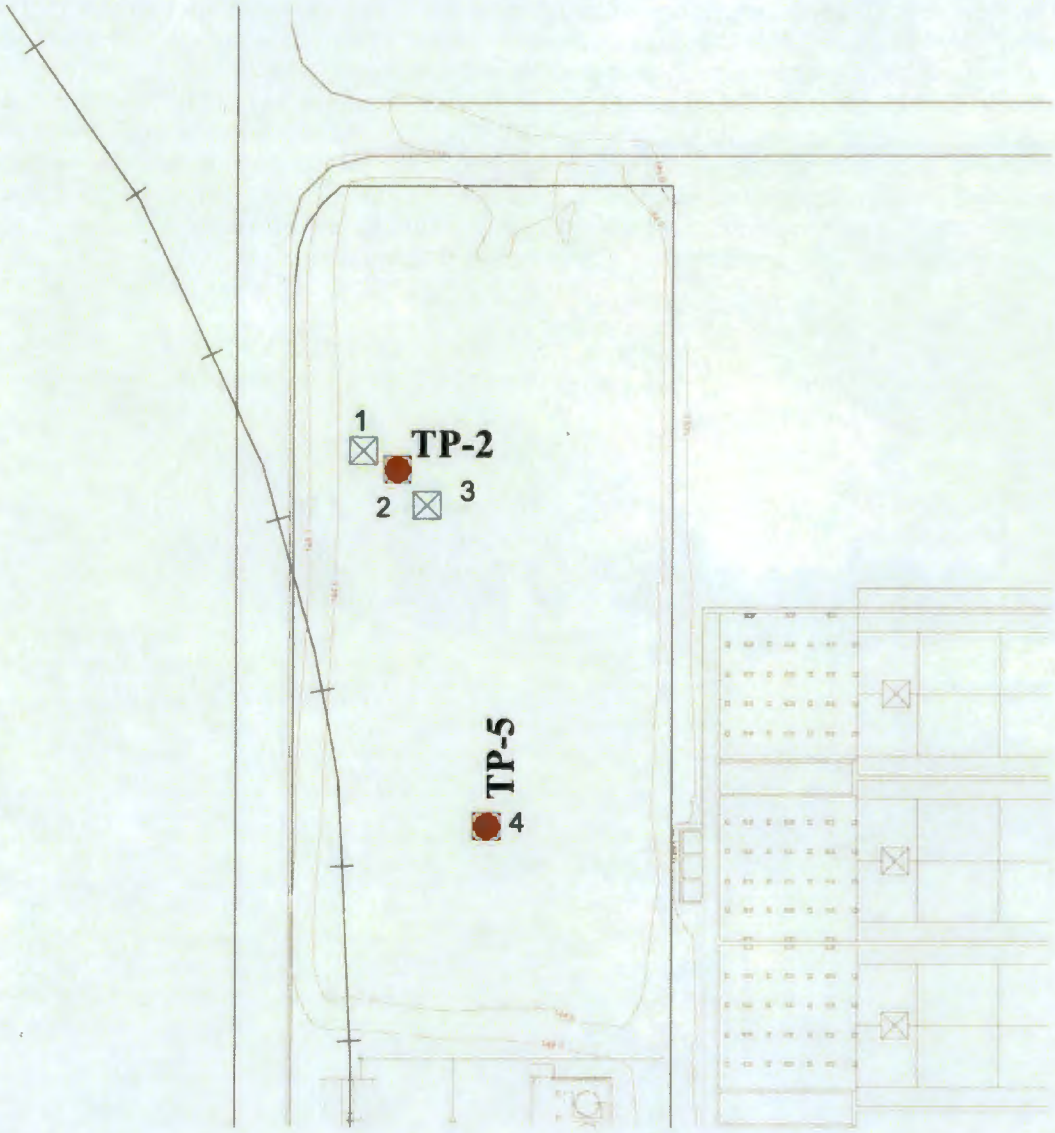


Figure 4. Treatability Test Locations.



A secondary site for implementation of the fourth treatability test scenario is the area near test pit 5, which was the site of the sulfuric acid storage tanks (Figure 4). This location also had results consistently above remedial action goals for both total chromium and hexavalent chromium through the depth of the test pit (WCH 2008). Implementation of the treatability test scenario at this location is expected to provide a good indication of the potential leachability of trivalent chromium and other metals located in this low pH soil.

Each of the in situ treatability test scenarios are described below.

Test Number	Location	In Situ Reductant	Delivery System
1	TP-2	Biological	Drip-emitter system
2	TP-2	Chemical	Shallow, gravel-filled infiltration basin
3	TP-2	Biological and chemical	Drip-emitter system
4	TP-5	Chemical	Shallow, gravel-filled infiltration basin

The biological reductant will be molasses and the chemical reactant will be calcium polysulfide. See Sections 4.1.2.4 and 4.1.2.5 for further discussion of these reductants.

A summary of the total chromium and hexavalent chromium results at test pits 2 and 5 are shown in Tables 1 and 2, respectively.

Table 1. Summary of Results for Test Pit 2.

Sample Location	Depth (Below Pad/Top of Test Pit) (ft)	Depth (ft bgs)	Date	HEIS	Total Cr (mg/kg)	Total Cr (TCLP) (mg/L)	Cr(VI) (mg/kg)	pH
Test pit 2	3	18	2/26/2007	J14JP1	53	–	51.4	8.5
	7	22	2/26/2007	J14JP2	104	1.85	88.8	8.2
	10	25	2/26/2007	J14JP3	204	2.52	83.6	8.1
	13	28	2/26/2007	J14JP4	201	3.32	207	8.3
	16	31	2/26/2007	J14JP5	187	4.4	208	7.9
	20	35	2/26/2007	J14JP6	279	7.09	371	7.9
	23	38	2/26/2007	J14JP7	279	6.34	186	8.0

bgs = below ground surface
HEIS = Hanford Environmental Information System
TCLP = toxic characteristic leaching procedure

Table 2. Summary of Results for Test Pit 5.

Sample Location	Depth (Below Pad/Top of Test Pit) (ft)	Depth (ft bgs)	Date	HEIS	Total Cr (mg/kg)	Total Cr (TCLP) (mg/L)	Cr-6 (mg/kg)	pH
Test pit 5	3	18	2/22/2007	J14JL6 [TP5 (eq. blank for J14JL7)]	0.17	--	0.2	--
	3	18	2/22/2007	J14JL7 (main)	1480	5.84	1290	5
	3	18	2/22/2007	J14JM9 (dup)	1140	6.2	884	5.1
	7	22	2/22/2007	J14JL8	323	2.8	380	5.5
	10	25	2/22/2007	J14JL9	63.3	--	18.9	5.4
	13	28	2/22/2007	J14JM0	5.8	--	2.3	6.7
	16	31	2/22/2007	J14JM1	24.2	--	5.7	7.3
	20	35	2/22/2007	J14JM2	4.4	--	1.6	7.3
	23	38	2/22/2007	J14JM3	10.4	--	3.2	7.0
	26	41	2/22/2007	J14JM4	5.9	--	0.93	8.2

bgs = below ground surface
HEIS = Hanford Environmental Information System
TCLP = toxic characteristic leaching procedure

3.0 PERFORMANCE AND DATA QUALITY OBJECTIVES

The purpose of this treatability study is to provide performance and cost information needed to evaluate and select in situ hexavalent chromium reduction as a treatment alternative. The results of this treatability test will provide the data needed for the detailed analysis of in situ hexavalent chromium reduction during the 100-B/C feasibility study.

3.1 TEST PERFORMANCE OBJECTIVES

The specific objectives of the treatability test are as follows:

- Demonstrate reduction of hexavalent chromium to trivalent chromium.
- Determine the most effective reducing agent or combination of reducing agents.
- Determine the most effective system configuration (e.g., overland drip-emitter system or gravel-filled basin) for use in full-scale design and implementation.
- Determine if non-chromium contaminants present within the soil may become leachable and the extent of mobilization as a result of implementation of the treatment technology.

- Determine what, if any, effect variable pH levels may have on the successful implementation of the treatment technology.
- Confirm that there will be minimal, if any, migration of trivalent chromium as a result of performance of the treatability test.
- Develop design parameters (e.g., reagent infiltration and reaction rates, drip rate, spacing of drip lines) for use in full-scale design and implementation.

This section summarizes the decisions that will be addressed by the treatability test. Table 3 shows the key decisions for implementing in situ hexavalent chromium treatment and the type of data that will be collected to address these items. These data items are incorporated into the treatability test operation herein and associated sampling and analysis plan (Section 5.0) that guide how the test will be conducted.

Table 3. Summary of Key Decisions.

Key Decision Statement	Treatability Study Implementation Approach
1. Determine the effect of pH may have on treatment implementation.	Treatability test to be performed at two locations: • pH levels representative of the majority of the waste site (test pit 2) • Low pH levels due to operational spills from the sulfuric acid tanks. No groundwater contamination is expected from the treatability test.
2. Excavation beneath the wall may be required to determine if leaching/wicking has occurred.	Test pitting will be performed during the treatability test.
3. Stratigraphy below site could preferentially convey treatment materials and influence treatment performance.	Although this may be of concern during full-scale implementation, it is not of concern for the treatability test due to the relatively shallow depth of test conditions.
4. Treatment may mobilize other contaminants.	Perform batch contacting tests to include inductively coupled plasma (ICP) metals to determine potential leachability of nonchromium contaminants.
5. How will a "successful" treatment scenario be determined?	Success for the treatability test will be indicated by comparison of pre-treatment and post-treatment batch contacting results from each of the scenarios to be modeled during this treatability test. In addition, feedback on material handling, delivery system performance, and other nonanalytical results will be used in selecting the most effective treatment scenario.

3.2 DATA EVALUATION

Treatment goals are primarily associated with reducing hexavalent chromium in the test soil column to its less mobile, less toxic trivalent state. Measurement of successful treatment will be made via a comparison of the total change in hexavalent chromium between the pre-treatment baseline analytical results and the post-treatment results. This will be performed for each of the four scenarios in order to select the most effective reducing agent (including combination of both) and the delivery system.

3.3 CONSIDERATIONS FOR IMPLEMENTATION

The following sections provide a summary of known limitations, restrictions, and other information for consideration during implementation of the treatability test.

3.3.1 Concentrations/Application Rate of Biological/Chemical Reductants

1. Liquid application of molasses solution should use relatively high concentrations of molasses in solution and a slow application rate. The solution may also use pulsed applications to treat a broad spectrum of pore throats with an increase in application rate at the end of the treatment process.

2. Higher concentrations of reductants are used to maintain reactive levels of reductant over greater distances during vadose zone application. Lower concentrations of reductants will lose their reductive effect over shorter distances and do not form a residual reductive soil/aquifer effect.

3. Higher concentrations of reductants may lead to formation of other reduced soil/aquifer matrix forms including reduced iron or sulfide compounds. Unnecessary overloading can lead to methanogenesis. Therefore, an appropriate mixture of chemical and biological reductants, in solution, is beneficial for overall reduction of hexavalent chromium.

4. The spacing between drip lines can affect coverage; closer spacing achieves better coverage.

5. Application rate of biological and chemical reductants can affect the percent saturation achieved, transport velocity in the vadose zone, and hydraulic residence time.

3.3.2 Production of Secondary Byproducts/Mobilization of Contaminants

1. Application of reductants may temporarily mobilize hexavalent chromium (in the first pore volume) toward groundwater; however, the volume of reagents in solution to be released into the waste site is not sufficient to reach groundwater. Additional applications/pore volumes are expected to treat hexavalent chromium temporarily mobilized in the initial application of reductants.

2. Application of reductants may cause localized secondary byproduct generation within the treatment area.

3. Although reduction of hexavalent chromium is permanent as long as soil chemistry does not change, any form of reduction has the potential for local and temporary mobilization of

other metals. Mobilization of other metals by any means of reduction is a temporary and local factor that must be acknowledged, planned for, and investigated.

3.3.3 Other Considerations

1. Measurement of hexavalent chromium in soil is not sensitive enough to determine whether successful treatment of vadose zone soils has been accomplished. A more appropriate approach would be to sample pore water to determine when successful treatment has been accomplished.

2. Successful treatment requires contact between reagent and contamination. This may be difficult to achieve in low-permeable soils and in unsaturated materials.

3. Reagent consumption by nitrate is a factor to consider. Biological reduction of nitrate to nitrogen gas is a process known as denitrification. Denitrification will reduce the nitrate concentration in the pore water, but will consume a portion of the carbon source added to treat chromium. In the case of inorganic reduction, the sulfide is directly oxidized to elemental sulfur and the nitrate is reduced to nitrogen gas.

4.0 CONCEPTUAL DESIGN

4.1 TREATABILITY TEST ACTIVITIES

4.1.1 General

Implementation of four separate treatability tests using a biological, chemical, and a combined biological/chemical reduction of hexavalent chromium via infiltration will include the following:

1. Construction of appropriate treatment system at the identified locations (Figure 4).

2. Installation of lysimeters to consist of "clusters" of lysimeters (four lysimeters per cluster for a total of 16 lysimeters per test location) installed vertically at depths of 5, 10, 15, and 20 ft, to monitor the rate of advance of a reaction front, as the reductant reacts with reducible species in the vadose zone. Clusters will be installed adjacent to each test area. Each of the four clusters is noted as LC-1-5 (lysimeter cluster #1, at 5-ft depth), LC-2-10, etc.

3. Construction of an infiltration basin at identified locations (Figure 4) to a depth of 2 ft, installation of piping from calcium polysulfide source, and filling the basin with gravel.

4. Installation of a drip-emitter system and poly-tubing at identified locations (Figure 4) and installation of piping from molasses source.

5. Reductants were selected based on evaluation of in situ treatment of hexavalent chromium being planned/performed at other areas of the Hanford Site. The reductants selected for implementation in the treatability test at 100-C-7:1 include molasses as the organic carbon source (biological reductant) and calcium polysulfide (chemical reductant).

6. The delivery methods to be tested include both an overland drip-emitter system and a gravel-filled infiltration basin. Application rate of the reductant mixture shall be substantially below what would create saturation (50% to 70% target) at the test locations to a maximum depth of 20 ft. This rate will be evaluated and refined during implementation of the treatability test scenarios for both the drip-emitter system and the infiltration basin. The rate of application will be between 2 to 50 gal of solution per ft^2 per day, to be increased until soils are observed to be at 50% to 70% saturation levels. For a 10-ft by 10-ft test area, operating 24 hr/day, this gives a range of flow rates between 0.14 to 3.5 gal/min.

4.1.2 Setup and Implementation

4.1.2.1 Site Location, Utilities, and Interferences. Currently, the 100-C-7:1 site consists of a 15-ft-deep excavation with bottom dimensions of approximately 100 ft wide and 300 ft in length. Along the eastern edge of the excavation is a concrete wall, which is the remaining below-grade portion of the 183-C Sedimentation Basin. An access roadway runs along the length of the western edge of the excavation. To the south of the excavation are the concrete footings and remaining below-grade portions of the 183-C Headhouse. To the north of the excavation is another access roadway and beyond that is an active, high-pressurized, high-volume export water line. Overhead electric power lines are also located to the north of the excavation.

Portable generators will be used to power pumps, lighting, and other electrical needs during implementation of the treatability test.

A groundwater monitoring well is located within the excavation footprint in the southern portion of the excavation. This well is at the location of a previous characterization borehole (BH-1) shown in Figure 3. This well will remain operational during the treatability test.

Each treatability test will be located at the bottom of the excavation and will consist of a 10-ft by 10-ft square area, with reductant introduction planned to occur to a maximum 20 ft depth from the bottom of existing excavation, centered on the locations of test pit 2 and test pit 5 (Figure 4). The vadose zone beneath the test site bottom and groundwater (approximately 50 ft) is not anticipated to be significantly impacted as a result of implementing this treatability study. A photograph showing the current configuration of the waste site is shown in Figure 5.

4.1.2.2 System Description. The following is a summary of the treatability test treatment system component installation.

1. Pressure/vacuum lysimeters arranged in clusters (four lysimeters at varying depths per cluster) will be placed vertically adjacent to the test area to sample the interstitial fluids.

2. Poly-tubing with drip emitters will be spaced every 2 ft (see Figure 6 for an example of a drip-emitter configuration). The drip system shall be laid on the existing ground surface and covered with 6 in. of soil, to prevent degradation of calcium polysulfide by sunlight.

3. The infiltration basin will be constructed to a depth of 2 ft and filled with gravel to prevent degradation of calcium polysulfide by sunlight.

4. Storage tanks, pumps, and a pipe transport system will connect reductant supplies to the drip system.

Figure 5. Photograph of Current 100-C-7:1 Excavation.

Figure 6. Example Drip-Emitter Configuration.

4.1.2.3 Injection Volume, Reagent Concentrations, and Injection Rates. Reducing agents in solution will be applied at a rate that will keep the test area soils in an unsaturated condition (Figure 7). For basis of design, the following is assumed and planned.

1. The soils are primarily sandy gravels that are well drained, with mean conditions of approximately 5% moisture on a volumetric basis, approximately 70% rock/soil on a volumetric basis, and the remaining volume occupied by soil gas. In general, soil particles 1 mm or finer will retain moisture and coarser particles will be essentially fully drained with a thin layer of soil moisture coating the particles. Note: The base amount of moisture is not critical to performance of this in situ treatment. Moisture will be added to exceed the specific retention capacity of the native soils, hence causing a percolation of moisture down through the vadose zone. The resultant reductant solution will react with residual hexavalent chromium retained on the soil particles and in the capillary throats, and there will be some plug-flow displacement of hexavalent chromium-contaminated vadose zone fluids. Thus, there will be an advancing wetted front and a slower advancing reaction front. The vadose zone beneath the test site bottom and groundwater (approximately 50 ft) is not anticipated to be significantly impacted as a result of implementing this treatability study.

2. Grain size distributions will be visually determined from soil samples obtained during lysimeters installation. These data will be used to control the fluid application rate and to determine the variation in fluid application rate to treat high-permeability zones as well as (and likely more importantly) the lower permeability zones dominated by fines.

3. The proposed range of expected fluid application rates is from 2 to 50 gal/ft^2/day (0.14 to 3.5 gal/min), starting at the lower rate and gradually increasing until the soils are observed to become -50% to 70% saturated (i.e., slight puddling on surface is observed at drip system locations). The application of fluids at this rate will marginally wet the soil horizon, increasing the solution thickness coating the soil particles, and allowing reductive chemistry to occur on the surface of soil particles and within soil capillaries.

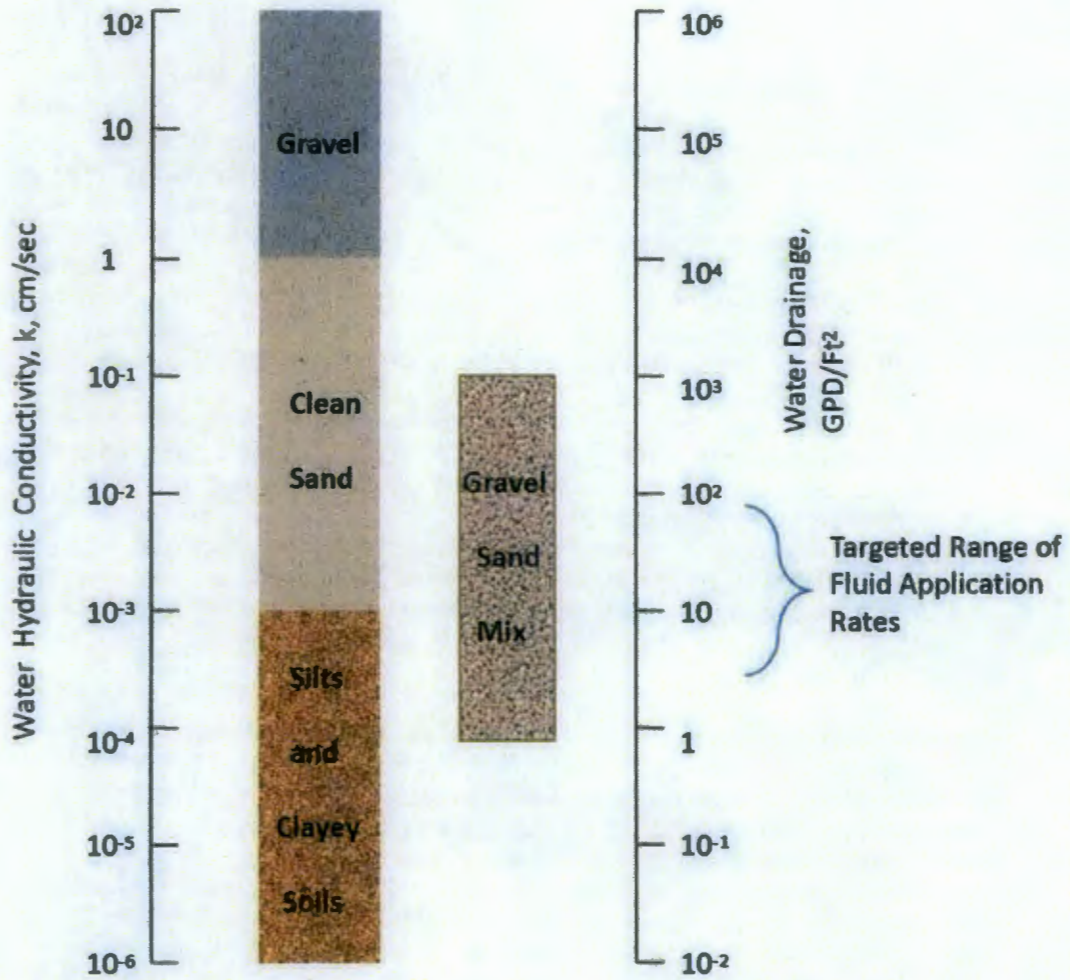
4. Reagent solutions would initially be added at low fluid flow rates per unit area so that the shallow soils become treated prior to percolation of depleted solutions downward (Figure 7).

5. Application using this strategy will primarily achieve treatment in the fine-grained soils initially, where hexavalent chromium is expected to have been sorbed from spills during operation of the water treatment plant, or where it has not been drained or rinsed by infiltration of water from other sources. By starting at reduced fluid application rates and ramping up toward fluid application rates that will target coarser soil horizons, migration during the initial wetting phase would be minimized, and hence mobilization of hexavalent chromium toward groundwater would be limited.

6. Solution application as planned will provide days of reaction time within the 20-ft test treatment zone. The migration front at the planned application rates will be in the range of a few inches per day initially, increasing to several feet per day toward the end of the test.

7. The treatment solutions (calcium polysulfide and molasses) would initially be of a sufficiently high concentration to allow for reaction of the reagents with the hexavalent chromium contained in soil moisture and hexavalent chromium coating soil particles such that the leading edge of the moisture migration front would contain treatment reagents. In time, as the leading edge of the reagent has reacted with the readily accessible hexavalent chromium in the soil horizon, the reagent concentration will be substantially reduced.

Figure 7. Unsaturated Flow.



8. The application of reagents will continue until 5 to 10 average pore volumes have passed through the soil column at each test site. The vadose zone beneath the test site bottom and groundwater (approximately 50 ft) is not anticipated to be significantly impacted as a result of implementing this treatability study.

A pore volume (PV) is the volume of water required to replace (flush out) water in a certain volume of saturated porous media. PV = effective porosity (n_e) x Volume (V).

For example, if the total volume is V=2,000 ft^3 (10-ft^2 surface area x 20-ft depth) and the effective porosity for sandy/gravely soils is estimated to be ne=0.25, one pore volume equals 500 ft^3 of water. Therefore, for this treatability test, the application of reagents will continue until between 2,500 ft^3 and 5,000 ft^3 (18,700 to 37,400 gal) of solution have passed through the soil column.

The majority of the hexavalent chromium is expected to be soluble in the first pore volume (500 ft^3 [3,740 gal]). Leaching tests performed on Hanford Site soils containing hexavalent chromium using a saturated leaching approach showed that the bulk of the hexavalent chromium, perhaps as high as 95%, was leached from the column in the first pore volume.

4.1.2.4 Summary of Chemical Reagent – Calcium Polysulfide. The chemical reagent selected for this treatability test is calcium polysulfide in a 29% aqueous solution, which is typically sold as an approximately 29% aqueous solution of CaSx (where "x" is from 3 to 7). Commercial quantities are available from Tessandero Kerley, which is located in Finley, Washington, and in Fresno, California. Also referred to as "lime sulfur solution," it is a deep orange-red alkaline solution with a pH between 11.3 and 11.5 and a specific gravity of 1.273.

The following is a discussion of chemical processes associated with calcium polysulfide, as it relates to treatment of hexavalent chromium, which is excerpted from DOE/RL-2006-17 *Treatability Test Report for Calcium Polysulfide in the 100-K Area* (DOE-RL 2006):

> Calcium polysulfide is a water-soluble compound that has been shown to be a cost-effective and environmentally protective alternative in varied geohydrological regimes such as cavernous limestone in Australia; glacial outwash sand in the north-central part of the United States; and alluvial sand, silt, and clay in California (Rouse 2001). Cation metals such as arsenic, lead, cadmium, and copper are precipitated as non-toxic sulfides in the presence of calcium polysulfide. Oxidized metals such as hexavalent chromium are reduced in the presence of calcium polysulfide and then precipitated readily, typically as a chromium hydroxide.
>
> Manufactured mostly for use as an agricultural soil conditioner and to prevent fungal infections in fruit trees, the National Sanitation Foundation (NSF) has approved calcium polysulfide for application in potable water systems. In concentrated form, polysulfide is corrosive as a result of its elevated pH, but it is not highly alkaline in the dilute concentrations used in remedial activities. Calcium polysulfide is sold as an approximately 29 percent aqueous solution of CaS_x, (where "x" is from 3 to 7). Commercial quantities are available from at least two manufacturers, one of which is located in Finley, Washington. Also referred to as "lime sulfur solution," it is a deep orange-red, alkaline solution with a pH between 11.3 and 11.5 and a specific gravity of 1.273.
>
> When mixed with water, polysulfide dissociates to form the hydrogen sulfide ion or dissolved hydrogen sulfide gas, with the relative percentage a function of the solution pH. The sulfide ion then is capable of direct reduction of hexavalent chromium, as well as the reduction of ferric iron to the ferrous form, which itself is capable of reducing hexavalent chromium. Equation 1 shows a generalized equation describing the overall process:
>
> $$2CrO_4^{2-} + 3CaS_5 + 10H^+ \Rightarrow 2Cr(OH)_3 + 15S + 3Ca^{2+} + 2H_2O \qquad \text{Equation 1}$$
>
> Chromium hydroxide is relatively insoluble in the neutral pH region between 7 and 9, with solubility increasing under acidic and alkaline conditions. Reducing conditions created following the addition of calcium polysulfide enable reduction

of other oxidized species such as Fe^{3+} to Fe^{2+}, which in turn enhances the reduction of hexavalent chromium, as shown in Equation 2:

$$3Fe^{2+} + CrO_4^{2-} + 3e^- + 5H+ \Rightarrow 4Cr(OH)^3 + 3Fe^{3+} + H_2O. \qquad \text{Equation 2}$$

4.1.2.5 Summary of Biological Reagent. A biological reagent (i.e., molasses) will be used in conjunction with the calcium polysulfide described above in order to enhance treatment by biological hexavalent chromium reduction and to support microbial creation of ferrous iron in the soil matrix, which is an effective method for treating hexavalent chromium present in the soil. The added carbon source will also mitigate the depletion of the native total organic carbon concentrations as described above, supporting reduction of sulfate formed from oxidation of calcium polysulfide. For this treatability test, the carbon source will consist of molasses, which has been considered for use on the Hanford Site.

The biological reagent/carbon source selected for this treatability test is food-grade molasses diluted in a water to make an easily pumped solution (e.g., 1 part molasses in 3 parts water). The application rate of molasses in the infiltrated water will be 0.2%, which is approximately 500 ppm total organic carbon. This equates to 75 gal of molasses in 37,400 gal of applied solution.

Biological reduction of hexavalent chromium results in the formation of relatively insoluble chromium hydroxide species, similar to those formed during calcium polysulfide treatment. In addition, the sustained addition of organic carbon in a soil horizon results in reduction of iron oxide minerals in the soil, creating ferrous iron-containing soil minerals, such as green rust, magnetite, and ferrous iron sorbed on iron oxide or other minerals. These ferrous iron-containing soil minerals become long-term reactants for any portions of the soil matrix that are not treated during the primary treatment phase (the 5 to 10 pore volumes of reagent addition). This ferrous iron in the soil matrix provides a protective geochemical phase that would prevent hexavalent chromium mobilization if there were zones that were incompletely treated. During subsequent precipitation events, chromium dissolved into the soil moisture in these incompletely treated zones would encounter ferrous iron on the soil particulates, which would precipitate as insoluble chromium-iron hydroxide.

4.1.2.6 Pretest Tasks.

1. Install lysimeter clusters at depths of 5-, 10-, 15- and 20-ft intervals within each test area.

   a. Construct boreholes (or use other excavation method that provides minimal disturbance to test area soils) to allow placement of lysimeters.

   b. Stockpile soil from excavation activities, as required.

   c. Sample and analyze soil at each lysimeter location to determine baseline.

   d. Conduct large-scale (e.g., 5-kg samples) batch contacting tests of test area soils for hexavalent chromium and other metals that have the potential to remobilize during performance of the treatability test to develop a pre-treatment baseline. Although these other metals are present at the waste site below remedial action goals and are not predicted to reach groundwater in 1,000 years, the conceptual model used to develop those remedial action goals and modeling assumptions were based on natural desert conditions, not accounting for large quantities of water to be introduced.

2. Perform a geophysical baseline survey (electrical resistance tomography [ERT]).

3. For test areas utilizing a drip-emitter system, install transmission piping, pumps, mixing and storage tanks, and emitter system.

4. For test areas utilizing an infiltration basin, excavate to a depth of 2 ft over the entire test area; install transmission piping, pumps, and mixing and storage tanks; and backfill basin with gravel from a local borrow source.

4.1.2.7 Performing Treatability Test.

1. Infiltrate biological and chemical reagents at each of the test sites for up to 3 months. For drip-emitter application, reductant may be pulsed and concentrations and flow rates adjusted to vary the distribution and contact time of soluble carbon to target various particle size zones. Faster flow rates will primarily treat the coarser materials and have shorter contact times. Slower flow rates will primarily treat the finer materials and have relatively longer contact times.

2. Conduct ERT during infiltration (drip system and infiltration basin) to monitor infiltration front and reaction zones.

3. Monitor lysimeters during infiltration to monitor reaction fronts. The timing of chemical changes, such as reduction in chromium, nitrate, and sulfate concentrations and the formation of dissolved iron or other metals, will be an indication of reaction front migration. The treatability test is not expected to impact deep vadose zone soils; therefore, no monitoring of groundwater monitoring wells will be performed as part of this treatability test.

4. Monitoring of the reductant percolation through the vadose zone can best be accomplished by means of clusters of pressure/vacuum lysimeters. The most telling parameters are oxidation reduction potential field readings and test-kit or laboratory determination of hexavalent chromium concentrations. If the lysimeters produce sufficient sample volume, they should also be tested for iron, manganese, and arsenic as indicators of potential mobilization of these elements by modification in geochemical conditions. By determination of the time of conversion from oxidizing to reducing conditions, at each of the various lysimeter installation depths, it is possible to determine the rate of advance of the reaction front.

4.1.2.8 Post-Test Tasks.

1. Conduct large-scale (e.g., 5-kg samples) batch contacting tests of test area soils for hexavalent chromium as well as other metals (Table 4) that may have been remobilized during performance of the treatability test and compare to pre-test baseline.

2. Conduct sampling of pressure/vacuum lysimeters 2 weeks after cessation of reductant infiltration.

3. Produce report following completion of field implementation and data evaluation.

Table 4. Analytical Performance Requirements for Soil Samples.

Analytical Method	Analyte	Interim Soil Remedial Action Goal Values [a]		RDL Requirement	Accuracy (% Recovery)	Precision (% RPD)
		Direct Exposure	Groundwater/River Protection [b]			
EPA Method 6010 (trace)	Arsenic	20 mg/kg	20 mg/kg	10 mg/kg	70-130	±30
	Total chromium	120,000 mg/kg	18.5 mg/kg	1 mg/kg	70-130	±30
	Manganese	11,200 mg/kg	512 mg/kg	5 mg/kg	70-130	±30
EPA Method 7196	Hexavalent chromium	2.1 mg/kg	2 mg/kg	0.5 mg/kg	70-130	±30
TCLP EPA Method 1311/ 6010 [c]	Arsenic	NA	NA	0.5 mg/L	70-130	±30
	Total chromium	NA	NA	0.5 mg/L	70-130	±30
SPLP EPA Method 1312	Arsenic	NA	NA	0.5 mg/L	70-130	±30
	Total chromium	NA	NA	0.5 mg/L	70-130	±30

[a] Interim soil RAG values are specified in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 2005).
[b] The more restrictive of the groundwater protection or Columbia River protection value is provided.
[c] TCLP may be performed on samples selected by the project after a review of the preliminary sample results. SPLP may be performed in lieu of TCLP or in conjunction with TCLP. SPLP is intended to model an acid rain leaching environment rather than model conditions that might be encountered in a hazardous waste landfill, as is done by TCLP.

EPA = U.S. Environmental Protection Agency
NA = not applicable
RDL = required detection limit
RPD = relative percent difference
TCLP = toxicity characteristic leaching procedure
SPLP = synthetic precipitation leaching procedure

4.1.3 Batch Contacting Testing

4.1.3.1 Previously Performed Batch Contacting Testing. Leachate data were obtained from samples that were collected from test pits 2 and 5 excavated at the 100-C-7:1 waste site (WCH 2008). Although the samples were collected from the excavated area, they varied widely in physical and chemical characteristics. Sample J14JP4 (test pit 2) was from an area that had a surface spill contamination, and sample J14JL7 (test pit 5) was from an area that contained sulfuric acid tanks.

Chromium mobility (as indicated by the distribution/partitioning coefficient [K_d] value) typically shows that hexavalent chromium has a K_d of near zero, which indicates it moves with water. The K_d value for total chromium or trivalent chromium is typically expected to be around 200 mL/g, which indicates near immobility.

The leach study results for the 100-C-7:1 soils show the site-specific K_d values for hexavalent chromium range between 0.36 and 36.81 as shown in Appendix C, Tables C-1 and C-2 of WCH (2008). The site-specific K_d values for total chromium ranged between 2.19 and 51.81 and are included in Appendix C, Tables C-3 and C-4 of WCH (2008). However, the total

chromium is predominantly hexavalent chromium, so a K_d for trivalent chromium cannot be accurately determined.

Because the site-specific K_d values for total chromium/trivalent chromium differ from expected values, further evaluation of leachability of total chromium/trivalent chromium during performance of the treatability test will be performed.

4.1.3.2 Treatability Test Batch Contacting Testing. Batch contacting tests will be performed on test area soils from pre-treatment (i.e., baseline) and post-treatment treatability test soils, and testing for hexavalent chromium and other metals that have the potential to remobilize during performance of the treatability test will be conducted. The information obtained from these batch contacting test results will be used to verify that hexavalent chromium has been successfully reduced to the trivalent state. See Section 4.1.3 for batch contacting testing methods.

4.1.4 Summary of Materials and Equipment for Treatability Test

The following sections provide a summary of materials and equipment required for implementation of the treatability test.

4.1.4.1 Poly-Tubing and Drip Emitters. Drip-system piping shall be poly-tubing manufactured by Ore-Max, Toro, or approved equivalent. Poly-tubing with drip emitters shall be spaced every 2 ft (see Figure 6 for an example of a drip-emitter configuration). The drip system shall be laid on existing ground surface and covered with up to 6 in. of soil. Polytubing shall be formulated for chemical resistance and exterior use and resistant to environmental stress cracking and ultraviolet degradation. Tubing connectors and drip emitters shall be selected for use consistent with the following polytubing minimum specifications:

- Material: polyethylene tubing, black
- Inside diameter: 0.49 in.
- Outside diameter: 0.70 in.
- Wall thickness: 0.10 in.
- Rating: up to 120 lb/in^2
- Drip emitters: plug resistant.

Transfer piping between the individual biological and chemical storage containers and solution storage tank and between the storage tank and the piping network shall be compatible with the manufacturer's storage containers and the materials and equipment listed in this treatability study.

4.1.4.2 Pump(s). Low-horsepower pump(s) shall be used to transfer biological/chemical reductants in solution from the storage tank to the piping network. Pump(s) shall be suitable for use with the identified chemical and biological reagents and shall be capable of operating at a variable flow rate of between 0.14 to 3.5 gal/min. A manual flow gauge shall be installed in the vicinity of the storage tanks.

4.1.4.3 Lysimeters. Four lysimeter clusters of four lysimeters each shall be installed in the test area. The lysimeters shall be consistent with the equipment requirements for the model shown below or approved equivalent (Figure 8).

- Pressure/vacuum soil water samplers, Model No. 1920F1 manufactured by Soilmoisture Equipment Corp. (www.soilmoisture.com) (see Figure 8 for product details).
- Lysimeters shall be suitable for installation at depths between 5 ft and 30 ft. Lysimeters shall be selected, installed, and sampled in accordance with the requirements of ASTM D4696-92, *Standard Guide for Pore-Liquid Sampling from the Vadose Zone.*
- Pressure/vacuum pump: A pressure vacuum hand pump compatible with the lysimeter shall be required (Model 2006G2 or approved equivalent).

5.0 SAMPLING AND ANALYSIS

The sampling and analysis to be performed following completion of the treatability test shall be consistent with the applicable requirements identified in WCH-154, *Sampling and Analysis Instruction for Evaluation of Residual Chromium Contamination in the Subsurface Soil at 100-C-7* (WCH 2007). Soil sampling will be performed in accordance with ENV-1, *Environmental Monitoring & Management*, ENV-1-2.16, "Soil and Sediment Sampling."

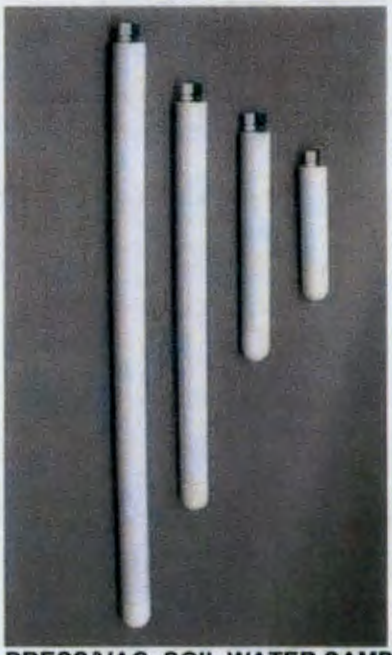
Soil samples will be collected from test areas sample locations to perform batch contacting testing to determine K_d values. The leach procedure is based on ASTM D3987, *Standard Test Method for Shake Extraction of Solid Waste with Water.* Functional deviations from ASTM D3987 are associated with the extraction fluid used and the solid-to-liquid ratios used. Preliminary laboratory results for the test pit soil samples will be reviewed to select specific samples on which to perform batch contacting tests. Samples selected for batch contacting tests will be analyzed in quadruplicate for total chromium and hexavalent chromium. Each of the three samples will be leached at soil/water ratios of 100/100, 100/250, and 100/500, with one test in each series duplicated and one duplicate performed at 100/100, one at 100/250, and one at 100/500. These solid-to-liquid ratios are deviations from ASTM D3987 in order to more closely model expected field conditions. In addition, the materials being leached only exist in very small amounts as coatings or adsorbed material on the mineral grains that make up the soil. The leachate will be analyzed for pH, specific conductance, ICP metals, and hexavalent chromium.

6.0 HEALTH AND SAFETY

Safety and health issues relating to performance of the treatability test will be addressed in site-specific safety documents that will industrial safety and health hazards, as well as control measures for those hazards. Safety documents will include specific training requirements for all site workers and visitors.

Figure 8. Lysimeter Model 1920F1 Series.

Product Number: 1920F1 Series
PRESS/VAC. SOIL WATER SAMPLER



PRESS/VAC. SOIL WATER SAMPLER

Weight: 0.38-1.5 lbs (0.17-0.68 kgs)

Dimensions:

The 1920F1 Pressure/Vacuum Soil Water Sampler consists of a PVC body with a ceramic cup epoxy bonded to one end. The porous ceramic cup has an outside diameter of 1.9" (4.8 cm) and is 2.0" (5.0 cm) in length. The 1920F1 is normally supplied with a 2 bar (200 kPa) ceramic cup, but 0.5 bar (50 kPa) and 1 bar (100 kPa) cups are also available. Nylon compression fittings are threaded into the top cap and are used to attach lengths of Polyethylene tubing to a remote sampling station. A pressure-vacuum hand pump, Model 2006G2, is used for evacuating the sampler and recovering the sample. For situations where specific cleaning operations are required, the 1920F1K1, which has a removable ceramic cup, is available.

Please specify ceramic cup:

B0.5M2 1/2 BAR POROUS CERAMIC CUP

B02M2 2 BAR POROUS CERAMIC CUP

B01M3 1 BAR HIGH FLOW POROUS CERAMIC CUP

Select options:

Part number	Description
1920F1L06-B02M2	Pressure/Vacuum SOIL WATER SAMPLER, 6 inch, 2 bar std cup.
1920F1L12-B02M2	**Pressure/Vacuum SOIL WATER SAMPLER, 12 inch, 2 bar std cup.**
1920F1L24-B02M2	Pressure/Vacuum SOIL WATER SAMPLER, 24 inch, 2 bar std cup.
1920F1L36-B02M2	Pressure/Vacuum SOIL WATER SAMPLER, 36 inch, 2 bar std cup.

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