1 Introduction

The Hanford Site, part of the U.S. Department of Energy's (DOE's) nuclear weapons complex, encompasses approximately 1,500 km^2 (579 mi^2) northwest of the city of Richland along the Columbia River in southeastern Washington State (Figure 1-1). In 1943, as part of the top secret Manhattan Project, the federal government took possession of the Site to build the world's first large-scale plutonium-production reactor. Between 1943 and 1963, nine nuclear reactors were built, mainly to produce weapons-grade plutonium. The last reactor operated through 1987.

During the operation of the reactors, large amounts of chemical and radioactive wastes were released into the environment that have contaminated the soil and groundwater beneath portions of the Hanford Site. Groundwater at the Site flows towards the Columbia River; the primary exposure route for contaminants to reach human, environmental, and ecological receptors.

DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed a comprehensive cleanup and compliance agreement in 1989. The *Hanford Federal Facility Agreement and Consent Order*, or Tri-Party Agreement, is an agreement for achieving compliance with the *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA) remedial action provisions and with the *Resource Conservation and Recovery Act* (RCRA) treatment, storage, and disposal (TSD) unit regulations and corrective action provisions. More specifically, the Tri-Party Agreement (1) defines and ranks CERCLA and RCRA cleanup commitments, (2) establishes responsibilities, (3) provides a basis for budgeting, and (4) reflects a concerted goal of achieving full regulatory compliance and remediation, with enforceable milestones.

The Tri-Party Agreement is a legally binding agreement consisting of two main documents:

- The "Legal Agreement," which describes the roles, responsibilities and authority of the three agencies, or "Parties," compliance, and permitting processes. It also sets up dispute resolution processes and describes how the agreement will be enforced.
- The "Action Plan," which includes milestones for initiating and completing specific work and procedures the three agencies will follow.

Additionally, an associated plan called the "Public Involvement Plan" describes how the public will be informed and involved throughout the cleanup process.

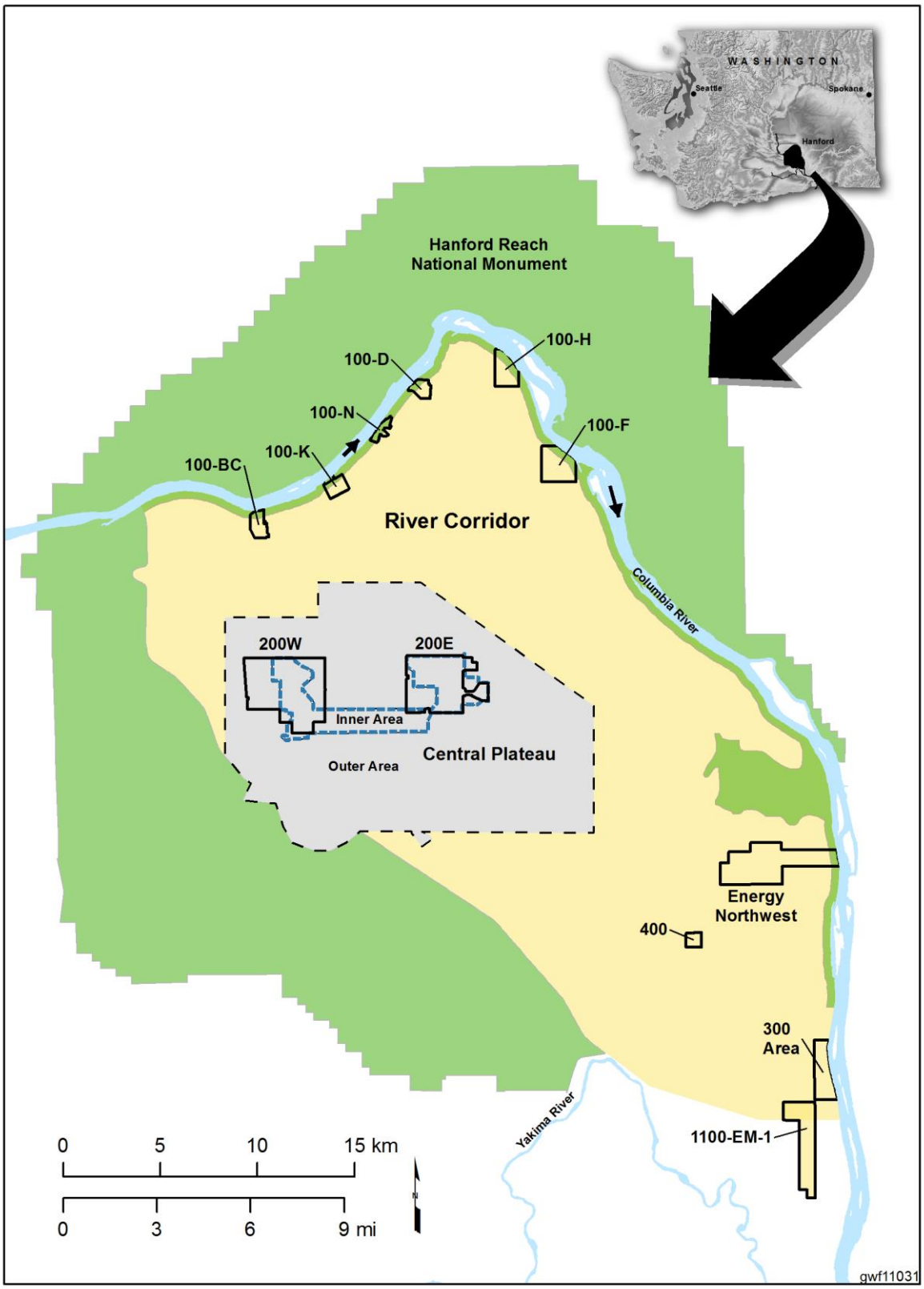

Figure 1-1. DOE Hanford Site

Since the 1990s, in accordance with the Tri-Party Agreement, DOE has worked to characterize, remove, treat, and dispose of contamination from past operations. Key elements associated with managing the Site's groundwater and vadose zone contamination are to (1) protect the Columbia River and groundwater, and (2) achieve final cleanup restoring groundwater to usable condition (e.g., restore groundwater to highest beneficial use):

- **Protect the Columbia River and groundwater.** DOE has already taken many actions to protect the Columbia River and groundwater, including the following:
  - Cease discharge of all unpermitted liquid effluents
  - Remediate waste sites near the Columbia River to reduce the potential for future groundwater contamination
  - Contain groundwater plumes and reduce the mass of contaminants through remedial actions such as pump and treat (P&T)
- **Attain cleanup.** Substantial progress has been made toward cleanup of waste sites near the Columbia River (i.e., the River Corridor). Strategies used for making decisions in these areas will provide a basis for attaining similar decisions for the central portion of the Site (i.e., the Central Plateau).

1.1 Purpose and Scope

Hanford Site Groundwater Monitoring for 2014 presents the calendar year results of groundwater monitoring, providing the primary means to report monitoring results for RCRA TSD units; CERCLA groundwater operable units (OUs); and the *Atomic Energy Act of 1954* (AEA) as required by DOE orders (Table 1-1). Appendices A, B, and C provide supporting information on CERCLA, RCRA, and aquifer tube monitoring, respectively. Appendix D summarizes results of monitoring confined aquifers, and Appendix E summarizes installation and maintenance of groundwater wells in 2014. The results of a 2014 data quality assessment are presented in Appendix F.

This report focuses on 2014 groundwater monitoring results and changes from the previous years. Details of previous studies (e.g., remedial investigations [RIs]) are published in separate reports that are cited in applicable chapters of this report. Readers are referred to other documents for details of hydrogeology, characterization results, detailed conceptual site models, and descriptions of waste sites and the shallow vadose zone. Chapter 2 of *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01) contains a summary of Hanford hydrogeology and geochemistry.

Results of groundwater remediation activities in CERCLA groundwater OUs are published in separate annual reports prepared by DOE. Information for 2014 is summarized here, and the reports are cited and provided electronically.

Table 1-1. Reporting Requirements for Groundwater Monitoring

Operable Unit or Facility	Formal Report	Supplemental Report or Summaries
CERCLA		
100-BC-5, 100-FR-3, 200-BP-5, 200-PO-1, 300-FF-5 and 1100-EM-1	This report	Unit managers' meeting presentations
100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, and 200-ZP-1	Separate, interim action annual report summarized in this report	Unit managers' meeting presentations; this report
ERDF	Separate annual report summarized in this report	This report
RCRA		
Operating RCRA units (IDF, LERF, and LLBG)	This report	Informal quarterly presentations
Closure RCRA units (116-N-1 and 116-N-3; 120-N-1 and 120-N-2)	This report	Informal quarterly presentations
Post-closure RCRA units (116-H-6 and 316-5)	Semiannual reports to Ecology; this report	Informal quarterly presentations
Interim status groundwater quality assessment RCRA sites (WMAs A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U)	This report	Informal quarterly presentations
Interim status indicator evaluation RCRA sites (216-A-29, 216-A-36B, 216-A-37-1, 216-B-63, 216-S-10 Pond, and NRDWL)	This report	Informal quarterly presentations
Other Facilities		
AEA sites (K Basins; Richland North, 400 Area water supply wells, and confined aquifers)	This report	Unit managers' meeting presentations
SALDS (WAC 173-216)	Quarterly discharge monitoring reports; annual report (latest is SGW-58210)	This report
SWL (WAC 173-350)	This report	FY report prepared by MSA

Note: WAC 173-216, "State Waste Discharge Permit Program;" WAC 173-350, "Solid Waste Handling Standards."

AEA = Atomic Energy Act of 1954
CERCLA= Comprehensive Environmental Response Compensation and Liability Act
ERDF = Environmental Restoration Disposal Facility
FY = Fiscal Year
IDF = Integrated Disposal Facility
LERF = Liquid Effluent Retention Facility
LLBG = Low-Level Burial Ground
MSA = Mission Support Alliance
NRDWL = Nonradioactive Dangerous Waste Landfill
RCRA = Resource Conservation and Recovery Act of 1976
SALDS = State-Approved Land Disposal Site
SWL = Solid Waste Landfill
WMA = Waste Management Area

Groundwater monitoring objectives of RCRA, CERCLA, and AEA differ slightly, and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on nonradioactive dangerous waste constituents. While radionuclides (source, special nuclear, and byproduct materials) may be monitored in some wells associated with RCRA units to support objectives of monitoring under AEA and/or CERCLA, they are not subject to RCRA regulation. Pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are instead regulated by DOE, acting pursuant to its AEA authority. Therefore, while this report is used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in the Hanford Sitewide RCRA Permit (WA7890008967).

The Hanford Site is broadly divided into the "River Corridor" and "Central Plateau" regions (Figure 1-1). As the names imply, the River Corridor is the portion of the Site located along the Columbia River, and the Central Plateau is in the middle of the Site. Within these broad regions, this report is organized by groundwater interest areas and groundwater OUs (Figure 1-2).

- CERCLA groundwater OUs include groundwater beneath one or more source OUs, and may include larger regions where contaminated groundwater has migrated.
- The formal groundwater OUs do not cover the entire Hanford Site. DOE has defined informal groundwater interest areas, which include the groundwater OUs and the intervening regions, to provide scheduling, data review, and data interpretation for the entire Site.

Other geographic divisions are sometimes used to describe aspects of the Hanford Site:

- The Site's former operational areas were given numerical names (Figure 1-1). These include the 100-BC, 100-K, 100-N, 100-D, 100-H, and 100-F Areas, which housed the nuclear reactors; and the 200 West and 200 East Areas, where chemical separation occurred. The 300 Area was home to the fuel manufacturing operations as well as the experimental and laboratory facilities, and the 400 Area housed a research nuclear reactor.
- For purposes of remediation under CERCLA, waste sites have been sorted into source OUs, which include sites that received waste from the same or similar sources. The source OUs include contamination in the vadose zone.
- The Central Plateau "Inner Area" encompasses the region where chemical processing and waste management activities occurred and the "Outer Area" includes much of the open area where limited processing activity occurred (Figure 1-1). The Inner Area is the final footprint area of the Hanford Site that will be dedicated to waste management and containment of residual wastes. The Outer Area is the remainder of the Central Plateau.

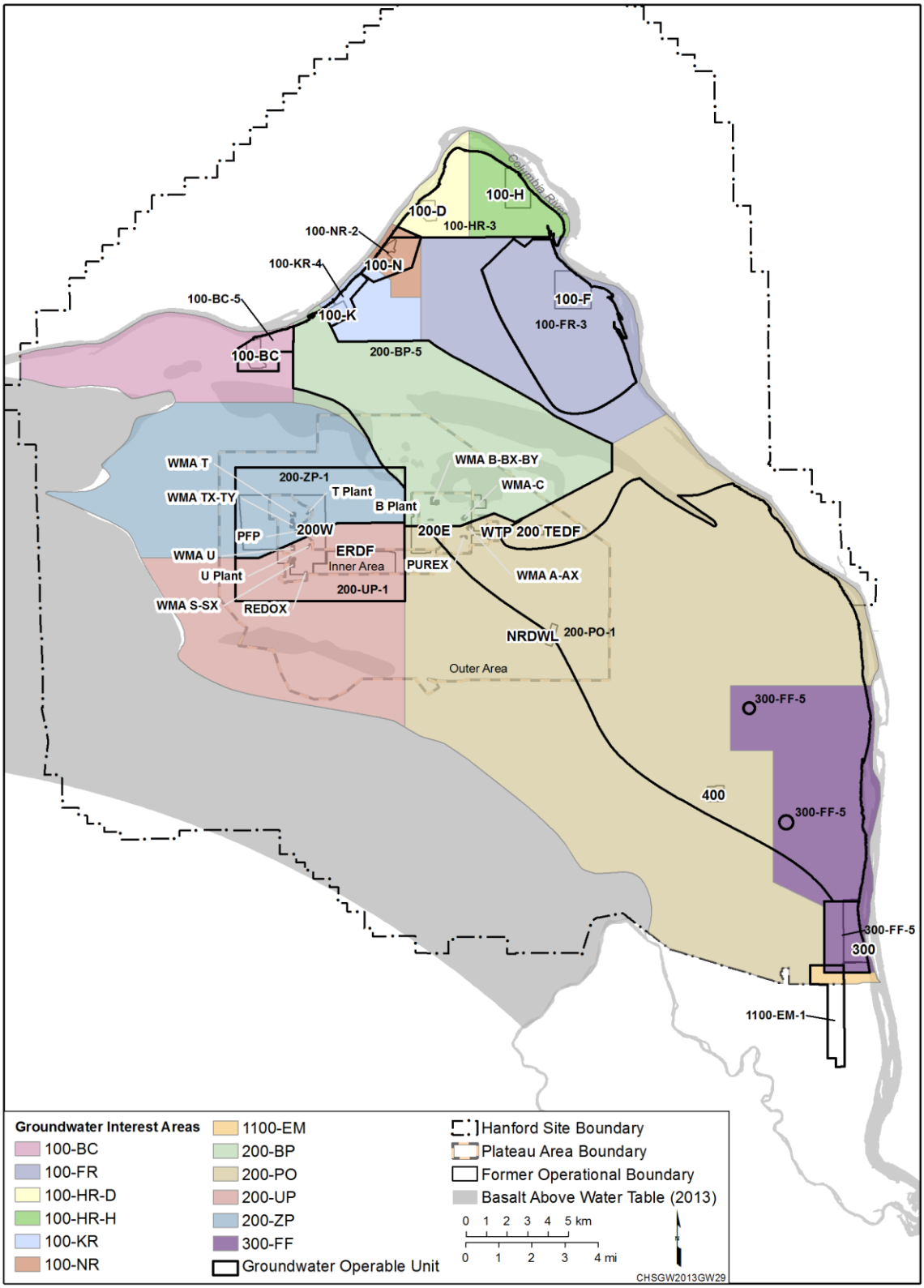

Figure 1-2. Groundwater Interest Areas and Groundwater OUs

1.2 Groundwater Monitoring

Specific groundwater monitoring plans and sampling and analysis plans (SAPs) define which wells to sample, how often to sample, and how to analyze the samples. These choices are based on the data needs for various monitoring purposes, such as complying with regulations, evaluating the performance of remediation activities, defining plumes and concentration trends, or identifying emerging contaminants.

RCRA regulates the management of solid waste, hazardous waste, and certain underground storage tanks. It applies to active or recently active TSD units. Monitoring is required at some units to determine if they are affecting groundwater quality in the uppermost aquifer. The uppermost aquifer is the unconfined aquifer beneath most of the Hanford Site. Groundwater monitoring requirements for the Site's RCRA units fall into one of two broad categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in Washington State's dangerous waste regulations (WAC 173-303-645). The RCRA units not currently incorporated into a permit require interim status monitoring.

RCRA groundwater monitoring is conducted under one of three possible phases: (1) contaminant indicator evaluation (or detection) monitoring, (2) groundwater quality assessment (or compliance) monitoring, or (3) corrective action monitoring. In the interim status contaminant indicator evaluation monitoring, four indicator parameters (pH, specific conductance, total organic carbon [TOC], and total organic halides [TOX]) are monitored and evaluated against statistically derived threshold values calculated from upgradient wells. In final status detection monitoring, site-specific indicators are evaluated using statistical methods identified in the respective permit. Groundwater quality assessment (interim status) or compliance (final status) monitoring occurs when a facility appears to have impacted groundwater quality. The objective of the monitoring program shifts from detection to assessing the nature and extent of the problem. If contaminant concentrations in groundwater have exceeded a permit concentration limit, groundwater remediation is required and corrective action monitoring is initiated. The goal of a corrective action groundwater monitoring program is to determine if the corrective action is effective.

Executive Order 12580 assigns DOE the responsibility and authority (under CERCLA Section 104) to conduct cleanup of contamination at the Hanford Site, and CERCLA Section 120 gives EPA an oversight role at Hanford and other federal facilities placed on the CERCLA National Priorities List (NPL). Cleanup decisions are based on the results of environmental investigations that include the vadose zone and groundwater. CERCLA groundwater monitoring on the Hanford Site includes monitoring of contaminants and water levels, and monitoring the effectiveness of groundwater remedial actions, such as P&T systems.

DOE orders implement requirements of the AEA at DOE sites. These requirements include groundwater monitoring to detect, characterize, and respond to releases of radionuclides.

Groundwater sampling is coordinated among the RCRA, CERCLA, and AEA programs to avoid duplication. Data collected during groundwater monitoring activities are used to interpret the extent of groundwater contamination, evaluate vertical distribution of groundwater contaminants, refine the geologic understanding (when new wells are drilled), and evaluate groundwater remedies.

In March of each year, field crews measure water levels from an extensive network of wells monitoring the unconfined aquifer system and the underlying confined aquifers. In many areas of the Hanford Site, water levels are measured more frequently to evaluate seasonal changes. The water-level data are used for the following purposes:

- Prepare maps that indicate the general direction of groundwater movement within each aquifer
- Determine hydraulic gradients, which in conjunction with the hydraulic properties of the aquifer are used to estimate groundwater flow velocities
- Interpret sampling results

Water Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project (SGW-38815) describes the collection and analysis of manual water-level measurements at the Hanford Site.

The automated water-level network (AWLN) is an array of remote monitoring stations connected by a telemetry network to a central base station (*Automated Water Level Network Functional Requirements Document*, SGW-53543). Each monitoring station consists of a pressure transducer connected to a data collection telemetry unit. Pressure data from the AWLN are used to calculate water levels, which are used for the following purposes:

- Estimating the level of hydraulic containment achieved by P&T systems
- Determining hydraulic gradients in areas with variable conditions
- Measuring changes in the stage of the Columbia River in the 100 and 300 Areas

In 2014, DOE began to restore the AWLN, which had been unfunded for most of 2012 and 2013. When inspecting the stations in 2014, instrument technicians encountered dead batteries, damaged transducer cables, data loggers that were not functioning, and data transmission problems. By the end of 2014, DOE had visited most of the approximately 130 stations, upgrading the operating systems and replacing components, as needed. Fifty of the stations were made functional again, 30 had data management issues to resolve, and another 50 had other problems. In addition, DOE began to install 35 new stations to support the 100-KR-4 and 100-HR-3 OUs. By the end of December 2014, 30 of the new stations had been installed and were operating. DOE is continuing to resolve remaining issues with the intent of restoring full operations in 2015.

1.3 Conventions Used in this Report

This section describes conventions for creating maps and trend plots and for expressing contaminant concentrations.

Maps of the extent of groundwater contamination, referred to as contaminant plume maps, are developed by interpolating sample data using computer software and a statistical method called kriging. Details regarding the development of the groundwater plume maps for 2014 are provided in ECF-Hanford-15-0003. The following general rules were applied to select representative data sets:

- Used data collected during 2014 (or a specific portion of 2014 [e.g., low river-stage months]) from monitoring wells, injection wells, extraction wells, and aquifer tubes
- If more than one data point were available for a well in 2014 (or shorter time period of interest), used the average value
- If no data were collected from a well in 2014, data from 2013 or 2012 were used and denoted on the maps
- For aquifer tubes used the maximum value for each cluster of tubes for the period of interest
- Excluded data flagged “R” (rejected)

- Excluded data from wells not screened in the aquifer zone of interest, or other measurements that were not representative of the contaminant distribution pattern in the aquifer
- Non-detect data are displayed and interpreted at the method detection limit (chemical constituents) or minimum detectable activity (radionuclides)

In some instances older measurements or data based on other site-specific information were included to improve the interpretations. These supplemental data are shown on the plume maps as Type 1, Type 2, and Type 3 data. A brief description of each type of information is as follows:

- Type 1 data are point values based on contaminant concentration measurements that are outside the data selection rules. Examples of Type 1 information include P&T effluent concentrations (at injection wells), contaminant measurements outside the 2012 to 2014 data selection time frame, and data provided from other sources (e.g., U.S. Ecology).
- Type 2 data are point values determined by geology. Examples of Type 2 data include "zero" concentrations in locations where basalt above the water table is a barrier to contaminant migration, and estimated concentrations in locations where zones of higher hydraulic conductivity may be conduits of contaminant migration.
- Type 3 data are point values based on site specific or historical information, and are not direct groundwater contaminant measurements. Examples of Type 3 data include estimated concentrations based on knowledge of plume sources and disposal history, calculations of inferred plume migration, and decay calculations of radionuclide concentrations from wells that are no longer available for sampling.

Groundwater remediation goals (cleanup levels), set as part of the CERCLA process, are often based on water quality standards such as those listed in Table 1-2. However, cleanup levels vary among the groundwater OUs. For consistency in plume maps, contour levels are chosen as follows:

- Drinking water standards (DWS) and multiples of 10 (e.g., 5, 50, and 500 µg/L for carbon tetrachloride)
- Intermediate levels to help define plumes (e.g., 100 µg/L for carbon tetrachloride)
- Additional contour levels for hexavalent chromium
    - Aquatic standard (10 µg/L near the Columbia River)
    - Model Toxics Control Act (MTCA) (48 µg/L)

In addition to DWS (Table 1-2), radionuclide concentrations also may be compared with DOE derived concentration standards and risk based concentrations (Table 1-3).

Unless specified otherwise, maps showing chromium include total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples. Dissolved chromium in Hanford Site groundwater is nearly all hexavalent (Chapter 7 of WHC-SD-EN-TI-302; Appendix C of DOE/RL-2008-01), so filtered, total chromium data effectively represent hexavalent chromium.

Nitrate concentrations in this document are expressed as the NO_3^- ion. The federal and state DWS for nitrate is 10 mg/L expressed as NO_3-N. Converting NO_3-N values to nitrate as the NO_3^- ion requires the NO_3-N value to be multiplied by 4.43. Nitrate data provided in this report reflect the converted values

and, as such, DWS is equivalent to approximately 45 mg/L as NO_3^-. Similarly, nitrite is expressed as the NO_2 ion.

The trend plots presented in this report use open symbols to show values below the laboratory detection limit. These results are typically plotted as values that represent the detection limit for chemical parameters and reported values for radiological parameters (negative values are converted to zero). Discussion of increasing or decreasing trends is generally based on qualitative observation and not on statistical evaluation.

When potential anomalies are encountered during a review of analytical data or water-level measurements, groundwater project staff initiate a formal "request for data review" process. Resolution of the request for data review may involve a laboratory recheck, sample reanalysis, review of sampling documents, or other actions. Data are corrected (and flagged "G") if possible, otherwise they are flagged "Y" (suspect), "R" (reject), or with another flag, as appropriate. "R" flagged data are excluded from plume maps in this report. "Y" flagged data are excluded from plume maps or trend plots if they do not provide the best interpretation of the data. Data excluded from plume maps are listed in ECF-Hanford-15-0003, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2014 (CY2014) Hanford Site Groundwater Monitoring Report* . All of the data, with appropriate data quality flags, are included in the data files accompanying this report and are available in the Hanford Environmental Information System (HEIS) database.

Table 1-1. Water Quality Criteria and Background for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	MTCA[a]	Ambient Water Quality Criteria[b]	Background[c]
Chemical Constituents					
Aluminum	µg/L	50 to 200[d]	16,000	—	11.7
Antimony	µg/L	6	6.4	—	69.8
Arsenic	µg/L	10	0.058	190	11.8
Barium	µg/L	2,000	3,200	—	149
Cadmium	µg/L	5	8.0	Hardness dependent	1.29
Carbon tetrachloride	µg/L	5	0.63	—	ND
Chloride	mg/L	250[d]	—	230	19.58
Chloroform (TTHM)[e]	µg/L	80	1.41	--	ND
Chromium	µg/L	100[f]	24,000/48[e,f]	10[g]	3.17
cis-1,2-Dichloroethene	µg/L	70	16	—	ND
Copper	µg/L	1,300[h] 1,000[d]	640	Hardness dependent	1.04
Cyanide	mg/L	200	4.8	5.2	9.52
Fluoride	mg/L	4	960	—	1.298
		2[d]	—	—	
Iron	µg/L	300[d]	11,200	—	1,104
Lead	µg/L	15[h]	—	Hardness dependent	1.3
Manganese	µg/L	50[d]	3,840	—	86.4
Mercury(inorganic)	µg/L	2	4.8	0.012	0.006
Methylene chloride (dichloromethane)	µg/L	5	22	—	ND
Nitrate, as NO_3-	mg/L	45[i]	114	—	41.7

Table 1-1. Water Quality Criteria and Background for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	MTCA[a]	Ambient Water Quality Criteria[b]	Background[c]
Nitrite, as NO2-	mg/L	3.31[j]	4.8	—	0.13
pH	--	6.5 to 8.5[d]	—	6.5 to 8.5	8.36
Selenium	µg/L	50	80	5.0	20.7
Silver	µg/L	100[d]	80	—	5.98
Sulfate	mg/L	250[d]	—	—	54.95
Tetrachloroethene	µg/L	5	21	—	ND
Thallium	µg/L	2	—	—	1.87
Total dissolved solids	mg/L	500[d]	—	—	277
1,1,1-Trichloroethane	µg/L	200	16,000	—	ND
Trichloroethene	µg/L	5	0.95	—	ND
Uranium (total)	µg/L	30	48	—	14.4
Zinc	µg/L	5,000[d]	4,800	Hardness dependent	48.9
Radionuclides					
Antimony-125	pCi/L	300	—		0.00827
Beta particle and photon activity	pCi/L	4 mrcm/yr[k]	—	—	8.96
Carbon-14	pCi/L	2,000	—	—	ND
Cesium-137	pCi/L	200	—	—	0.0122
Cobalt-60	pCi/L	100	—	—	0.0447
Iodine-129	pCi/L	1	—	—	0.000131
Ruthenium-106	pCi/L	30	—	—	0.00464
Strontium-90	pCi/L	8	—	—	0.02
Technetium-99	pCi/L	900	—	—	0.988
Total alpha (excluding uranium)	pCi/L	15	—	—	3.50
Tritium	pCi/L	20,000	—	—	142
Uranium	µg/L	30	—	—	14.4

a. Model Toxics Control Act (MTCA), Method B cleanup levels for groundwater (WAC 173-340, "Model Toxics Control Act—Cleanup"). Calculations documents in ECF-100NPL-10-0462, Rev. 2, *Calculation of Standard Method B Groundwater Cleanup Levels for Potable Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*.

b. Criteria for chronic exposure in fresh water, WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington," "Toxic Substances," Table 240(3).

c. DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*. 95th percentile, as corrected.

d. Secondary standards are not associated with health effects, but associated with taste, odor, staining, or other aesthetic qualities.

e. Standard is for total trihalomethanes.

f. Total chromium.

g. Hexavalent chromium.

h. Action level.

i. 45 mg/L as NO_3^- is equivalent to 10 mg/L of nitrate as nitrogen.

j. 3.3 mg/L as NO_2- is equivalent to 1 mg/L of nitrite as nitrogen.

k. Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose greater than 4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr.

Table 1-3. Derived Concentration Standards, 4 mrem Effective Dose Equivalent Concentrations, and Risk-Based Concentrations for Hanford Site Radionuclides

Radionuclide	Derived Concentration Standard[a] (pCi/L)	4 mrem Effective Dose Equivalent[b] (pCi/L)	Risk-Based Concentration[c] (pCi/L)	
			10^{-6} Risk	10^{-4} Risk
Antimony-125	27,000	1,100	12.1	1,210
Carbon-14	62,000	2,500	1.43	143
Cesium-137	3,000	120	1.74	174
Cobalt-60	7,200	290	3.37	337
Iodine-129	330	13	0.358	35.8
Plutonium-239/240	140	6	0.392	39.2
Ruthenium-106	4,100	160	1.25	125
Selenium-79	8,500	340	7.26	726
Strontium-90	1,100	44	0.947	94.7
Technetium-99	44,000	1,800	19.2	1,920
Tritium	1,900,000	76,000	160	16,000
Uranium-234[d]	680	30	0.748	74.8
Uranium-235[d]	720	30	0.760	76.0
Uranium-238[d]	750	30	0.827	82.7

a. Concentration of a specific radionuclide in water that could be continuously consumed at average annual rates and not exceed an effective dose equivalent of 100 mrem/yr. From Table 5 of DOE-STD-1196-2011, *Derived Concentration Technical Standard*.

b. Concentration of a specific radionuclide in water that would produce an effective dose equivalent of 4 mrem/yr if consumed at average annual rates. The EPA DWSs for radionuclides listed in Table 1-2 were derived based on a 4 mrem/yr dose standard using maximum permissible concentrations in water specified in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure* (NBS Handbook 69). The 4 mrem/yr dose standard listed in this table was calculated using a more recent dosimetry system adopted by DOE and other regulatory agencies (see footnote a).

c. From EPA's risk website: "Preliminary Remediation Goals for Radionuclides" (EPA, 2012). These values represent the risk of getting cancer if a person ingested water contaminated with each radionuclide over a lifetime. The tritium and carbon-14 calculation also considers inhalation of tritium in air; for the other radionuclides, this path is insignificant.

d. See Table 1-2 for total uranium.

1.4 River Corridor

The Columbia River flows through the northern Hanford Site before turning south toward the city of Richland. The region of the Site along the shoreline is known as the River Corridor (Figure 1-1). Former operations in the River Corridor included operation of nine nuclear reactors in six different areas. These areas are 100-BC, 100-K, 100-N, 100-D, 100-H, and 100-F. Fabrication of nuclear fuel assemblies,

related research involving the processing of irradiated fuel, and maintenance services occurred in the 300 Area and 1100 Area, respectively.

Between 1943 and 1963, nine plutonium-production reactors were built along the Columbia River. The B Reactor was constructed first, followed in chronological order by D, F, H, DR, C, KE, KW, and N Reactors. Only the N Reactor was constructed with a closed-loop coolant circuit, and a secondary pass for steam production to generate power at the Hanford Generating Plant. Production of special nuclear materials (principally plutonium-239 and tritium) was the primary function of the reactors. Since the Cold War ended, all reactors have been retired from service (DOE/RL-2008-46). Liquid and solid wastes discharged to ground during the reactor operational periods were the primary contaminant sources to soil and groundwater in the reactor areas.

Contaminant sources in the 100 Areas included cooling water conditioning and handling facilities, underground piping, liquid and solid waste disposal sites, and unplanned releases (surface spills). During the operational years, large volumes of effluent were discharged in the 100 Areas, transporting contaminants into the aquifer, creating large groundwater mounds, and modifying flow paths. Sources of groundwater contamination in the 300 Area included routine disposal of liquid effluent associated with fabrication of nuclear fuel assemblies, and research involving the processing of irradiated fuel. The 1100-EM groundwater interest area and the adjacent region encompass a variety of onsite and neighboring offsite land uses. Numerous municipal, industrial, and agricultural activities affect groundwater quality in this area.

The liquid waste was discharged to ponds and trenches designed for infiltration to the underlying soil. Periodic accidental releases from various facilities also occurred. Nearly all of the principal liquid waste disposal facilities in the River Corridor have been remediated, with excavations at some waste sites (e.g., 100-C-7, 100-B-27, 100-D-100, and 100-H-46) extending to groundwater. Six groundwater OUs and 15 source OUs are associated with the River Corridor (Table 1-4).

Groundwater contaminants in the River Corridor include the following (Figure 1-3):

- Hexavalent chromium concentrations exceed the 10 µg/L surface water quality standard in the unconfined aquifer in each of the 100 Areas, and in water-bearing units within the Ringold upper mud unit (RUM) in 100-HR and 100-NR. Concentrations exceed the 100 µg/L DWS for total chromium in 100-HR, 100-KR, and 100-NR.
- Nitrate concentrations exceed the 45 mg/L standard in monitoring wells in all of the 100 Areas. A nitrate plume from agricultural sources south of the Hanford Site affects groundwater in 1100-EM.
- Strontium-90 concentrations exceed the 8 pCi/L DWS in all of the 100 Areas.
- Tritium concentrations exceed the 20,000 pCi/L DWS in 100-HR-D, 100-KR, 100-NR, and an outlying region of 300-FF.
- Trichloroethene (TCE) concentrations exceed the 5 µg/L DWS in 100-FR and 100-KR and within a deeper, finer grained sedimentary unit at 300-FF.
- Other contaminants include uranium in 300-FF, carbon-14 in 100-KR, and petroleum hydrocarbons in 100-NR.2

Sodium dichromate was added to reactor cooling water as an anti-corrosion agent. Typical sodium dichromate concentrations in the cooling water during the early years of reactor operations were 2,000 µg/L (approximately 700 µg/L as hexavalent chromium). They decreased to 1,000 µg/L in the

mid-1960s, and then to 500 µg/L (approximately 170 µg/L as hexavalent chromium) in the last stages of operations.

Table 1-4. River Corridor at a Glance

100 Area	300 Area and Outlying Regions	Former 1100 Area
Five groundwater OUs: 100-BC-5, 100-KR-4, 100-NR-2, 100-HR-3,[a] 100-FR-3	One groundwater OU: 300-FF-5 (includes 300 Area Industrial Complex, 618-10/316-4 and 618-11 facilities)	One former groundwater OU: 1100-EM-1
Nine nuclear reactors and associated facilities	Historically used for nuclear fuel fabrication	Historically used for vehicle maintenance and solid waste disposal
Inactive liquid waste cribs, ditches, trenches, retention basins, pipelines, and spills; four RCRA sites	Inactive liquid waste cribs, trenches, ponds, pipelines, and spills; one RCRA site	Former waste sites remediated
Interim site remediation 88% complete overall[b]	Interim site remediation 91 percent complete overall[b]	Final waste site remediation 100% complete
Interim groundwater remediation active for hexavalent chromium in 100-KR-4 and 100-HR-3, and strontium-90 and petroleum hydrocarbons in 100-NR-2	Monitored natural attenuation of uranium, organics, and tritium	Final groundwater remediation complete
Final ROD in place for 100-FR-3; RI/FS underway for others	Final ROD in place	Final ROD in place
There are a total of 82 km (51 mi) of Columbia River shoreline. River stage is controlled by Priest Rapids Dam. The Hanford Reach National Monument was established in 2000.		

a. The 100-HR-3 OU includes the 100-D and 100-H Areas.

b. Percent of sites that have been remediated or classified as not requiring remediation.

FS = feasibility study
OU = operable unit
RCRA = Resource Conservation and Recovery Act of 1976
RI = remedial investigation
ROD = Record of Decision

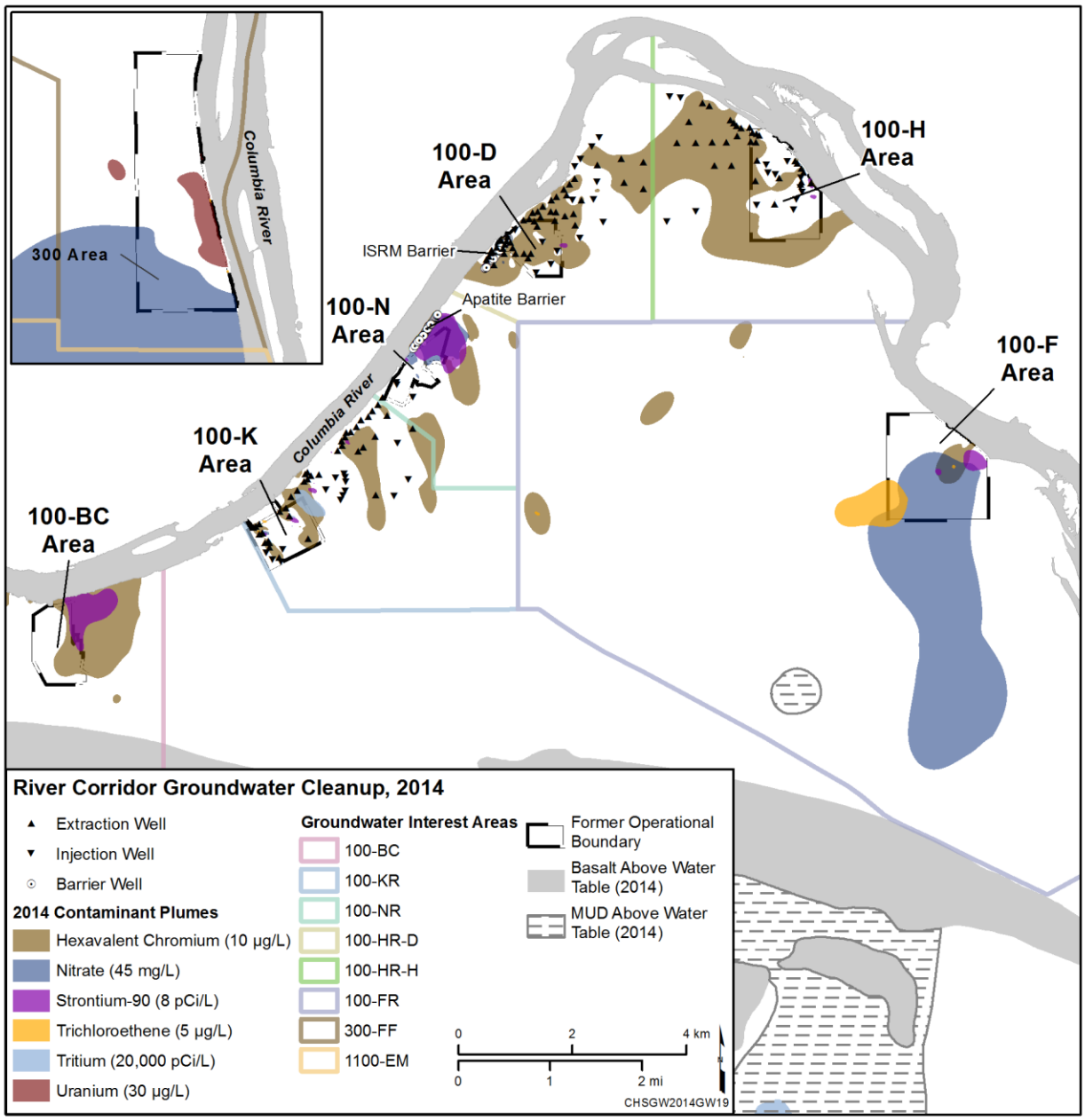

Figure 1-3. River Corridor Plumes and Remediation

Historical process information suggests that small volumes (as compared to long term cooling water discharges) of high concentration solutions (up to 70 percent by weight) of sodium dichromate leaked or spilled in the 100 Areas (e.g., during the transfer of sodium dichromate from rail cars to storage tanks). In some locations in the 100-D and 100-K Areas, concentrations of hexavalent chromium in groundwater have exceeded the concentrations found in reactor cooling water, indicating residuals from the high-concentration sodium dichromate solutions remain in the vadose zone at some locations and provide a secondary source of groundwater contamination.

How far contaminants migrated from waste sites depended on the relative mobility of the contaminant in the ground and the volume of effluent discharged. Low-mobility contaminants, including many

metals and radionuclides, sorbed (i.e., absorb or adsorb) to sediment grains in the vadose zone. These contaminants are found at the greatest concentrations near the areas of discharge. When little or no liquid effluent was discharged to a waste site, soil contamination remained in the shallow sediment. Disposal of high volumes of liquid waste resulted in dispersion of low mobility contaminants deeper in the soil (vadose zone) in comparison to low-volume discharge sites.

Strontium-90 is a slightly mobile contaminant in the subsurface and sorbs to soil. It was present in numerous 100 Area waste sites, including burial grounds and liquid waste sites, principally from decontamination solutions and contaminated reactor coolant or fuel storage basin water. Where large volumes of effluent were discharged, strontium-90 migrated through the vadose zone and moved a limited distance vertically and horizontally in groundwater.

Mobile contaminants common to the 100 Area include tritium, nitrate, and hexavalent chromium (Figure 1-3). Large volumes of water containing these contaminants were discharged to the soil via trenches, cribs, and leaks from pipelines and retention basins. Wastewater was also released through outfall piping to the Columbia River. Large groundwater mounds developed beneath high-volume surface discharge sites and helped spread mobile contaminants in groundwater in a radial pattern during operations. These groundwater mounds dissipated to current groundwater elevations after cessation of reactor operation.

1.4.1 Hydrogeology

The geologic units beneath the River Corridor are a subset of those that underlie the Hanford Site as a whole. The stratigraphy of the 100 Area is distinct from that of the 300 and 1100 Areas.

Figure 1-4 illustrates the general stratigraphy and hydrogeologic units of the 100 Area. The vadose zone comprises the sand and gravel of the Hanford formation and, in some locations, a portion of the Ringold Formation unit E. The vadose zone can be less than a meter thick near the Columbia River to as much as 30 m (98 ft) beneath inland portions of the River Corridor.

The unconfined aquifer consists of the sand and gravel of Ringold unit E and portions of the Hanford formation. This unconfined aquifer is thickest in the western portion of the region (up to 48 m [158 ft] in 100-BC) and thinnest near 100-H and 100-F, where in some places it is less than 2 m (6.6 ft) thick. The base of the unconfined aquifer is one of a number of fine-grained layers of the RUM. Below the contact with the unconfined aquifer, the unit contains numerous distinct layers of sand and gravel. These layers typically contain water and act as local confined aquifers. A series of confined aquifers within and beneath the upper mud are present through most of the 100 Areas. Basalt aquitards and basalt-confined aquifers are present beneath the Ringold Formation.

Beneath the 300 Area and 1100-EM, the vadose zone is entirely within the gravel and sand of the Hanford formation. The unconfined aquifer includes the lower portion of the Hanford formation. Beneath the 300 Area, the undulating contact between the bottom of the saturated Hanford formation and the underlying Ringold unit E sediment reveals paleochannels that act as preferential pathways for groundwater flow. Saturated Hanford formation sediment is much more permeable than the underlying Ringold sediment. The Ringold lower mud unit underlies unit E. Coarse-grained sediments of Ringold unit A underlie the lower mud in some areas; elsewhere, the mud overlies basalt.

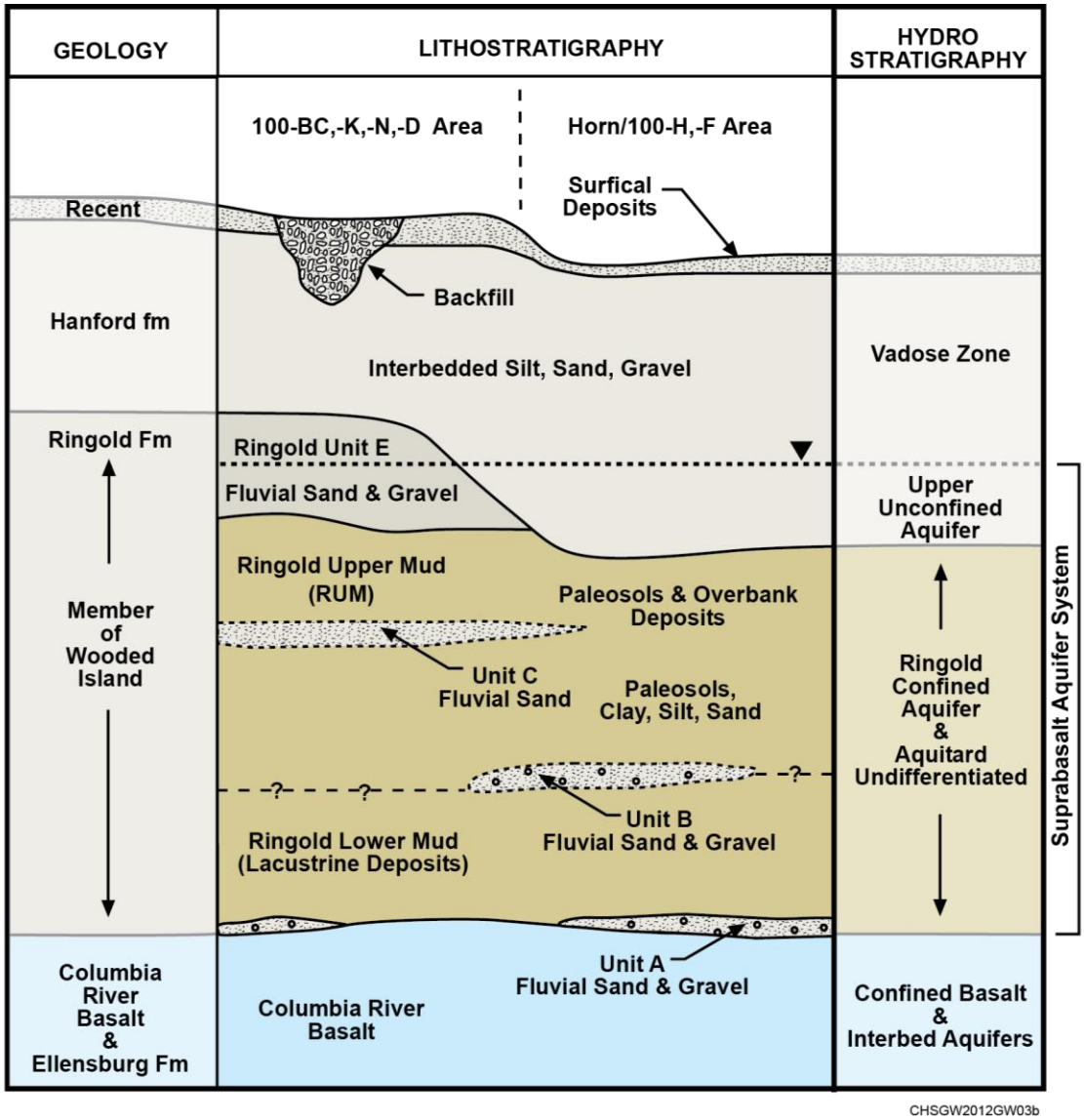

Figure 1-4. River Corridor Geology

As shown on Figure 1-5, groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge area north and east along the Columbia River. Steep hydraulic gradients occur in the western, eastern, and northern regions of the Site. Shallow gradients occur southeast of 100-FR and in a broad arc extending from west of 100-BC toward the southeast between Gable Butte and Gable Mountain (Gable Gap), through the 200 East Area and into the central portion of the Site. In each of the 100 Areas, the local groundwater flow is generally toward the Columbia River, although groundwater P&T systems in 100-KR and 100-HR alter this flow pattern locally to capture contaminants. Detailed water table maps for those areas are included in Chapters 4 and 5.

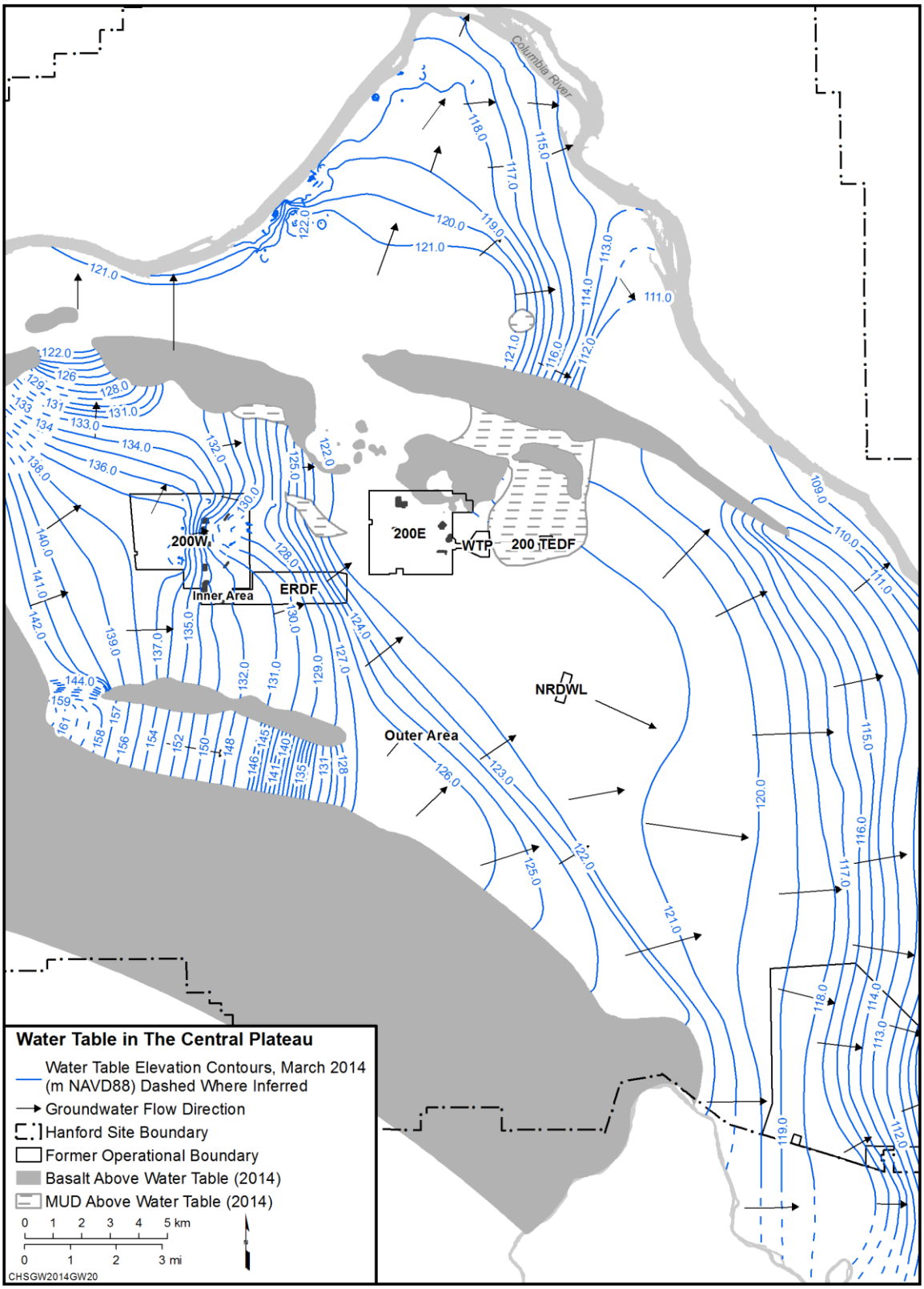

Figure 1-5. Hanford Site Water Table and Groundwater Flow, 2014

1.4.2 Cleanup

Three groundwater OUs in the River Corridor have final cleanup decisions under CERCLA: 1100-EM-1, 100-FR-3, and 300-FF-5. The 1100-EM-1 OU was removed from the NPL (40 CFR 300) in 1996. The selected remedy for groundwater was monitored natural attenuation (MNA) of volatile organic compounds with continuation of institutional controls (ICs) for groundwater and land use at the Horn Rapids Landfill (EPA/ROD/R10-93/063).

A final action Record of Decision (ROD) that included the 100-FR-3 OU was signed in 2014 (EPA and DOE, 2014). The selected remedy is MNA for nitrate, hexavalent chromium, strontium-90, and TCE.

A final action ROD for the 300-FF-5 OU was signed in 2013 (EPA and DOE, 2013). The selected remedy is enhanced attenuation of uranium at the top of the aquifer using uranium sequestration, MNA for nitrate, tritium, TCE, and *cis*-1,2-dichloroethene (DCE), and groundwater monitoring. The interim remedial action (i.e., MNA) is continuing to be performed until a new remedial design/remedial action work plan is approved.

In the early 1990s, DOE, EPA, and Ecology decided that sufficient information about contaminated soil and groundwater in the River Corridor was available to begin interim remediation with a focus on protecting the Columbia River. This decision led to an early start for cleanup of contaminated soil and groundwater. Key components of the interim cleanup included removing contaminated facilities and waste sites near the river, and implementing interim cleanup actions in the 100-KR-4, 100-NR-2, and 100-HR-3 OUs (Figure 1-3). Interim remedial actions in 100-KR-4 and 100-HR-3 focus on hexavalent chromium, and the interim action for 100-NR-2 focuses on strontium-90. The goal of the interim groundwater remediation is to prevent or reduce the movement of contaminated groundwater into the Columbia River, until a final action ROD is approved.

As defined in the current interim action RODs, the remedial action goal for hexavalent chromium in 100-KR and 100-HR is 20 µg/L in compliance wells. The surface water quality standard is 10 µg/L. The remedial action goal is based on the estimated 1:1 mixing of groundwater (and the associated hexavalent chromium) with infiltrated river water before the water is accessible to aquatic life in the river.

The interim action for 100-NR includes a permeable reactive barrier for strontium-90. The goal of the interim groundwater remediation is to prevent or reduce the movement of contaminated groundwater moving into the Columbia River.

With respect to source remediation, DOE has evaluated over 1,800 potential waste sites in the River Corridor. During these evaluations, many of the sites were determined not to be waste sites (classified as “rejected” or “not accepted”). Others were determined to be low-risk sites that did not require remediation (classified as “no action”). Hundreds more sites have undergone remediation under interim action RODs. Interim remediation is complete in 100-BC and 100-F and is underway at the other River Corridor OUs. By the end of 2014, approximately 89 percent of the waste sites in the River Corridor had been remediated or classified as not requiring remediation.

Progress toward final cleanup decisions along the river corridor continued in 2014. Draft RI/FS documents for 100-N, 100-K, and 100-D/H are in various stages of regulatory or public review and revision. These documents will support decisions for groundwater cleanup with a goal to protect human health and the environment. RI studies for the 100-BC-5 OU will conclude in 2016.

1.4.3 Groundwater Monitoring Results

During 2014, DOE sampled 562 wells in the River Corridor groundwater interest areas (Table 1-5). Many of the wells were sampled numerous times, for a total of 3,048 successful well sampling trips. During the year, 324 aquifer tubes were sampled, and many were sampled more than once for a total of 703 sampling trips.

Table 1-5. Number of Wells and Well Sampling Trips in the River Corridor, 2014

Interest Area	Number of Wells Sampled	Number of Successful Well Trips	Number of Aquifer Tubes Sampled	Number of Successful Aquifer Tube Trips
100-BC	36	116	57	216
100-KR	90	758	48	57
100-NR	96	221	59	172
100-HR-D	130	1,043	69	131
100-HR-H	83	580	56	91
100-FR	35	39	11	13
300-FF	84	276	10	9
1100-EM and offsite	8	15	0	0
200-BP*	N/A	N/A	5	5
200-PO*	N/A	N/A	9	9
Total	**562**	**3,048**	**324**	**703**

Note: A successful sampling trip is determined by the presence of data in HEIS. A trip may consist of routine sampling, characterization sampling, or sampling conducted to support groundwater remediation systems.

* Aquifer tubes in 200-BP and 200-PO OUs are reported here as part of the River Corridor. Wells in those operable units are included in the Central Plateau Summary.

Table 1-6 lists maximum concentrations of groundwater contaminants detected in River Corridor wells and aquifer tubes during 2014. The 2014 data did not result in any major reinterpretations of the nature and extent of groundwater contamination. The following paragraphs summarize River Corridor groundwater contamination and results of monitoring.

Hexavalent chromium contaminant plumes with concentrations above the 10 µg/L surface water quality standard (Table 240[3] of WAC 173-201A-240) are present in groundwater in the 100 Areas. The highest concentrations in 2014 were detected in 100-HR. P&T systems in 100-D, 100-H, and 100-K are reducing the concentration and size of these plumes, and minimizing impacts to the Columbia River. Chromium contamination in the unconfined aquifer at 100-NR originated in 100-KR, as discussed in Chapters 5 and 6.

Table 1-6. Maximum Concentrations of Selected Groundwater Constituents in River Corridor Interest Areas, 2014

Contaminant	Water Quality Std.	100-BC		100-FR		100-HR-D		100-HR-H		100-KR		100-NR		1100	300-FF		Offsite
		Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Wells	Tubes	Wells
Radionuclides (pCi/L)																	
Carbon-14	2,000	—	—	—	—	—	—	—	—	14,300	326	51.2	43.1	—	—	—	—
Gross alpha	15	—	2.52	—	—	4.53	—	18.3	—	7.84	3.03	20.2	5.2	21.5	110	21	4.77
Gross beta	50	7.15	28.3	18	—	82	—	58.8	21.5	426	5.94	28,100	3,760	18.1	110	24	9
Strontium-90	8	43	32.1	144	4.64	36.4	5.57	26	9.86	231	7.16	15,500	845	—	1.9	—	—
Technetium-99L	900	—	22.8	—	—	—	—	50.6	—	71.9	—	41.1	—	—	151	25	—
Tritium	20,000	17,000	14,200	5,500	370	20,400	4,200	3,670	—	414,000	9,650	35,100	761,000	—	994,000	8,200	125
Metals (µg/L)																	
Antimony (filtered)[a]	6	1.9	4.17	1.9	—	0.758	4.6	3.72	—	9.78	—	11.2	13.8	—	6.38	—	—
Antimony[a]	6	3.8	5.95	2	—	—	—	—	—	8.8	—	9.96	6.56	—	8.4	—	—
Arsenic (filtered)	10	5.24	8.74	16.1	—	8.44	1.2	8.35	—	14.4	3.56	45	21.9	—	9.14	—	—
Arsenic	10	5.4	10.8	16.7	—	9.06	1.94	8.33	—	17.3	3.28	53.3	21.6	—	15.6	—	—
Cadmium (filtered)[a]	5	0.541	—	—	—	0.13	—	—	—	3.7	0.122	0.5	0.5	—	0.4	—	—
Cadmiuim[a]	5	0.44	—	—	—	0.15	—	0.16	—	5	—	0.5	0.9	—	1.69	—	—
Chromium (filtered)	100	60.5	45.7	28.1	5.26	3,400	9.04	141	5.2	541	25.1	193	8.7	—	24.4	—	—
Chromium	100	76.5	46.8	54	6.05	4,240	10.7	140	5.3	537	22.6	204	14.2	—	45.3	—	—
Hexavalent chromium (filtered)	48	63	33.7	29	10.3	1,120	17.9	120	21.7	241	29	—	2	—	5.6	—	—
Hexavalent chromium	48	63	47	29	10	3,440	70.9	130	48.6	520	44.2	181	10	—	5.4	2.9	—
Nickel (filtered)[b]	100	47.1	2.22	34.4	—	46.9	2.7	4.76	—	114	2.8	390	2.41	—	100	—	—
Nickel[b]	100	11.8	7.66	36.1	3.65	48	9.6	7.43	—	109	3.9	394	3.4	—	110	—	—
Thallium (filtered)	2	0.81	—	0.6	—	1.8	—	1.4	—	1.5	2.2	1.3	—	—	—	—	—
Thallium	2	0.97	—	0.65	—	1.8	—	1.5	—	2.3	1.3	1.1	—	—	—	—	—
Uranium (filtered)	30	8.8	2.19	21	—	5	—	26	—	7.71	6.7	5	—	—	5.75	—	—
Uranium	30	9	2.27	21.1	—	5	—	52.1	1.09	7.55	8.8	6.6	—	28.4	358	127	—
Anions																	
Fluoride (mg/L)	4	0.49	0.47	0.72	0.26	0.46	0.24	0.40	0.23	0.54	0.30	0.62	1.00	1.25	3.40	—	—
Nitrate (mg/L)	45[c]	47	30	146	30	53	23	41	27	74	31	186	47	205	193	25	141
Nitrite (mg/L)	3.3[c]	—	—	—	—	1.64	—	0.19	—	0.45	—	0.75	0.59	—	0.25	—	—

Table 1-6. Maximum Concentrations of Selected Groundwater Constituents in River Corridor Interest Areas, 2014

Contaminant	Water Quality Std.	100-BC		100-FR		100-HR-D		100-HR-H		100-KR		100-NR		1100	300-FF		Offsite
		Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Wells	Tubes	Wells
Organics (µg/L)																	
cis-1,2-Dichloroethylene	70	—	—	—	—	—	—	—	—	—	—	—	—	—	207	—	—
Trichloroethene	5	2.43	—	15.3	—	—	—	—	—	6.78	0.69	—	—	0.71	5.8	83	—

Notes:

Table lists highest values for 2014 for each groundwater interest area, excluding suspect data (flagged "Y"), data under review (flagged "F"), rejected data (flagged "R"), or nonroutine samples (e.g., characterization).

Cells with "—" noted indicate not detected or not analyzed.

Blue-shaded cells indicate that contaminant exceeded the listed water quality standards.

Orange-shaded cells indicate that contaminant exceeded the derived concentration standard (Table 1-3).

a. Antimony, cadmium, and thallium typically have detection limits higher than drinking water standards, creating false exceedances near the detection limits.

b. Nickel may indicate corrosion of stainless steel well screens and casing.

c. As NO_3 and NO_2. Equivalent to drinking water standards of 10 mg/L and 1 mg/L.

Tritium concentrations exceed the 20,000 pCi/L DWS in 100-KR, 100-NR, and 300-FF (at the 618-11 Burial Ground). Tritium was more widespread in the River Corridor in the past, and the plumes are gradually attenuating through radioactive decay, and dispersion in areas without hydraulic containment.

Strontium-90 contamination persists beneath each of the 100 Areas at concentrations above the 8 pCi/L DWS. The most extensive, concentrated plume is in 100-NR where the maximum concentration exceeds the derived concentration standard (1,100 pCi/L). An apatite permeable reactive barrier near the Columbia River in 100-NR is sequestering part of the strontium-90 plume to allow more time for radioactive decay. Most of the strontium-90 plumes tend to be stable in size because this constituent sorbs to sediment grains and is only slightly mobile. Concentrations are gradually declining in most areas as a result of radioactive decay.

Nitrate is a common groundwater contaminant in the River Corridor. Contaminant plumes with concentrations exceeding 45 mg/L are present in 100-KR, 100-NR, 100-HR, 100-FR, 300-FF (at the 618-11 Burial Ground), and 1100-EM, though the latter plume originated offsite. The largest plume in the River Corridor is in 100-FR. Nitrate concentrations in the River Corridor are generally steady or declining.

Carbon-14 exceeds the 2,000 pCi/L DWS in portions of 100-KR. The plumes did not change significantly in 2014.

Uranium forms a persistent plume with levels above the 30 µg/L DWS in portions of 300-FF. Concentrations vary with seasonal changes in the water table elevation in some wells. The positive correlation between water table elevation and uranium concentration suggests that at or near these locations, uranium remains in the lower portion of the vadose zone and is available to be remobilized during periods of high water table conditions. Uranium is also found in groundwater beneath the former 183-H Solar Evaporation Basins in the 100-H Area, where it is monitored as a waste indicator. This unit is undergoing RCRA post-closure monitoring.

TCE concentrations exceed the 5 µg/L DWS in the unconfined aquifer in a few wells at 100-FR, 100-KR, and 300-FF. The plume is naturally attenuating at 100-FR. At 100-KR, the TCE is being recirculated through the aquifer by the P&T system. In 300-FF, TCE concentrations exceed the cleanup level identified in the final action ROD (4 µg/L) in several aquifer tubes screened within or near low-permeability sediments.

DCE concentrations at 300-FF continued to exceed the cleanup level identified in the final action ROD (16 µg/L) at one well in the lower portion of the unconfined aquifer and at one well in the mid-portion of the unconfined aquifer.

RIs have provided additional information about the vertical distribution of groundwater contamination in the River Corridor. The unconfined aquifer becomes thinner from west to east, from up to 48 m (158 ft) thick at 100-BC to less than 2 m (6.6 ft) thick beneath portions of 100-H and 100-F Areas. In addition, aquifer characterization revealed that younger, more permeable sediment (i.e., Hanford formation) forms the majority of the unconfined aquifer in the eastern portion of the River Corridor. In most locations and for most constituents, concentrations are highest near the top of the unconfined aquifer and decrease with depth. An exception includes hexavalent chromium concentrations in portions of 100-BC, which are highest at the top and bottom of the unconfined aquifer, and lower in between. This exception may indicate different periods of contaminant release. In some locations in 100-KR, hexavalent chromium concentrations were higher in the lower half of the aquifer. In 100-HR, vertical distribution of

contaminants in the unconfined aquifer was not consistent and no pattern was discernible. In the 100-H Area, the aquifer is thin, making vertically variable distribution less likely.

Interim action performance monitoring continued to indicate that the groundwater remediation systems are functioning as designed and are meeting remedial action objectives (RAOs). Contaminant concentrations in compliance wells remained above threshold values at some locations in 2014, and the remediation systems will continue to operate in 2015.

RCRA groundwater monitoring continued in 2014 at facilities in the 100-NR, 100-HR, and 300-FF (Table 1-7). Results did not reveal any new impacts to groundwater. The sites will continue to be monitored under existing requirements.

Table 1-7. RCRA Monitoring Status for the River Corridor, 2014

RCRA Unit	Status for Reporting Period
1301-N (116-N-1) LWDF	Continued indicator evaluation*
1324-NA (120-N-1) and 1324-N (120-N-2) Ponds	Continued indicator evaluation*
1325-N (116-N-3) LWDF	Continued indicator evaluation*
116-H-6 (183-H) Evaporation Basins	Corrective action alternative program during interim remedial action; chromium and nitrate
316-5 (300 Area) Process Trenches	Compliance/corrective action; organics

* Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with dangerous waste or dangerous waste constituents from the unit.

LWDF = Liquid Waste Disposal Facility

1.4.4 Shoreline Monitoring

Groundwater is a potential pathway for contaminants to enter the Columbia River. Groundwater flows into the river from springs located above the water line and through areas of upwelling in the river bed. Hydrologists estimate that groundwater currently flows from the Hanford unconfined aquifer to the Columbia River at a rate of approximately 0.000012 m^3/s (0.00042 ft^3/s) (Section 4.1 of PNNL-13674). For comparison, the average flow of the Columbia River is approximately 3,400 m^3/s (120,000 ft^3/s).

The rise and fall of the Columbia River creates a zone of interaction of surface water and groundwater. River stage varies over short (e.g., hourly) and long (e.g., seasonal) intervals in response to natural influences and the operation of dams on the Columbia River system. Groundwater-level and sample data exhibit time-varying patterns that are qualitatively similar in frequency to variations in Columbia River stage. These relationships are most evident in wells that are located closest to the Columbia River, although apparent relationships are also evident in water levels and sample data obtained from wells hundreds of meters inland of the shoreline.

Groundwater-level responses to cyclical river stage fluctuations increasingly attenuate in amplitude and lag in time with increasing distance to the river (Figure 1-6). This attenuation in amplitude and time lag, ranging from days to months, can be used to estimate aquifer parameters or can be incorporated within trend analyses of water-level data and sampled concentrations. Additional details are provided in *Evaluation of the Relationship Between River Stage and Sampled Value for Several Analytes in the Hanford 100 Areas* (ECF-Hanford-12-0076). With some exceptions and with some variability, the following broad patterns emerge:

- Locations at 100-D, 100-N, and 100-K Areas generally exhibit the longest lag times per unit distance.
- Locations in 300-FF and 1100-EM generally exhibit the shortest lag times per unit distance.
- Locations at 100-BC, 100-F, and 100-H Areas generally exhibit intermediate lag times per unit distance.

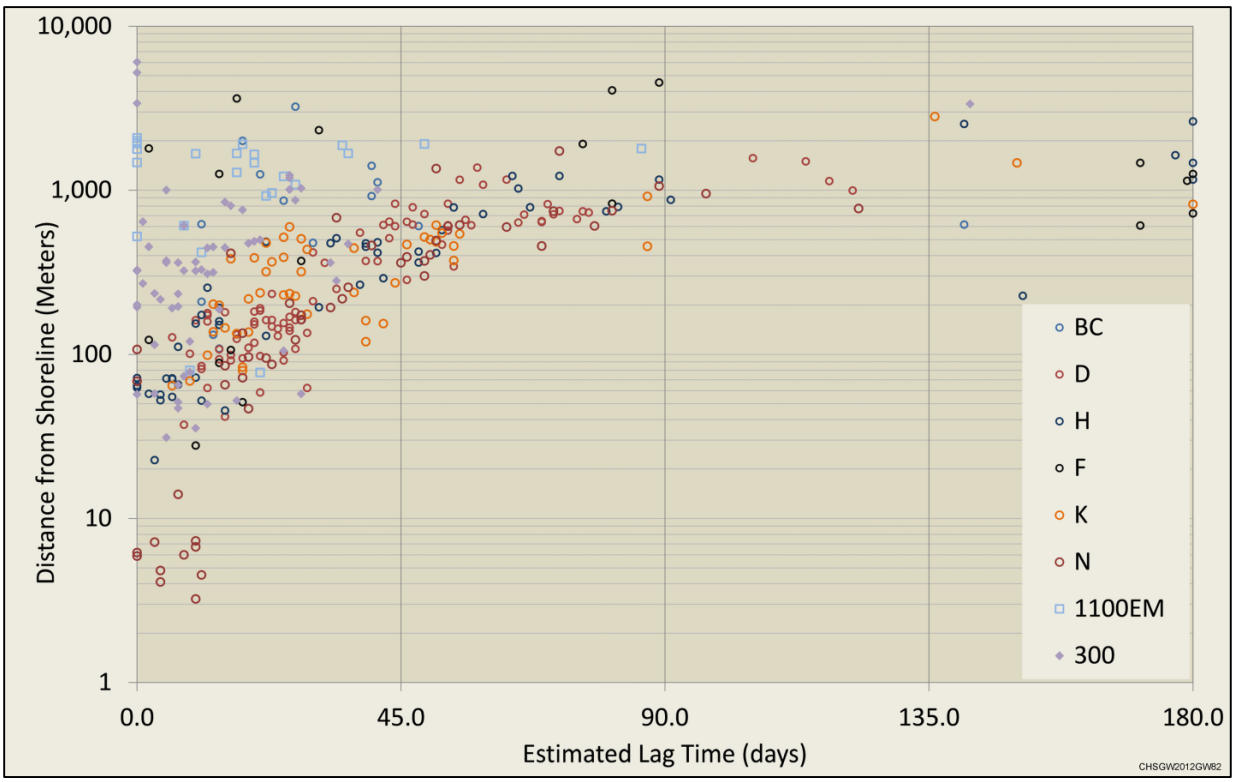

Figure 1-6. Relation of Lag Time to Distance from the Columbia River

DOE samples water near the Columbia River shoreline via near-shore monitoring wells, natural seeps (riverbank springs) and aquifer tubes. Aquifer tubes are small diameter, flexible tubes that have a screen on one end. The tubes are installed in the aquifer along the river shoreline, and groundwater is withdrawn with a portable peristaltic pump. Most aquifer tube sites include two or three individual tubes monitoring different depths, from about 1 to 8 m (3.3 to 26 ft) below land surface. They are not constructed as resource protection wells as specified in WAC 173-160 and are not used as compliance points for groundwater decisions. Appendix C provides additional information for the aquifer tubes.

Seeps represent groundwater leaving the aquifer in areas where the groundwater elevation remains higher than the river elevation for some period of time. DOE collects samples from seeps in the fall when the river stage is low. Table 1-8 lists concentrations of contaminants of interest in seeps along each shoreline segment sampled in fall 2014. Concentrations of hexavalent chromium exceeded the 10 μg/L surface water quality standard in three 100-D seeps and one 100-BC seep. Carbon-14, nitrate, strontium-90, TCE, and tritium concentrations were below the DWS in all 2014 seep samples. Uranium exceeded its DWS in a 300 Area seep.

DOE monitors Columbia River water by collecting samples along several cross-river transects and at near-shore river locations adjacent to groundwater plumes, where humans and aquatic biota are potentially exposed to contaminants. The surveillance data provide a historical record of radionuclides and chemicals in the environment. The results of water quality monitoring along the shoreline and in the river are presented annually in the Hanford Site environmental report (DOE/RL-2013-47). Publication of the 2014 environmental report follows publication of this groundwater report, so 2013 results are summarized here. Table 1-9 lists results of composite samples collected upstream and downstream of the Hanford Site. Except for tritium and uranium isotopes, radionuclides were undetected in upstream and downstream samples. The average tritium concentration downstream of the Site, near the City of Richland, was 48 pCi/L compared to 18 pCi/L upstream of the Site. The average concentration of uranium-238 downstream of the Site was 0.22 pCi/L, compared to 0.18 pCi/L upstream of the Site. Chromium was undetected in upstream and downstream samples.

Table 1-8. Hanford Site Contaminants in Columbia River Seeps, 2014

GWIA	Seep	Sample Date	Carbon-14 (pCi/L)	Hexavalent Chromium (µg/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Tritium (pCi/L)	TCE (µg/L)	Uranium (µg/L)
100-BC	100-B SPRING 37-1	10/20/14	—	6.2	—	—	905	—	—
	100-B SPRING 38-3	9/24/14	—	6.45 B[a]	6.95	0.00782 U	1,030	—	3.08
	100-B SPRING 39-2	10/20/14	—	15.3 P	—	—	3,780	—	—
100-KR	100-K SPRING 057-3	10/21/14	—	3.4 B[a]	5.31	—	687	—	—
	100-K SPRING 63-1	10/8/14	414	2.41 B[a]	—	-0.00705 U	196 U	0.86 J	1.09
		10/21/14	254	5.2 B	3.36	0.0625 U	132 U	0.3 J	1.1
	100-K SPRING 68-1	10/8/14	22.1 U	6.1 B[a]	—	0.0692	2,360	0.3 U	0.475
		10/27/14	16.2	12.1[a]	6.2	0.417 U	1,100	0.25 U	0.49
	SK-077-1	2/25/14	—	5 U[a]	1.2	—	-25 U	—	—
	100-K SPRING 82-2	10/27/14	0.126 U	1 U[a]	1.67	—	-13.3 U	—	—
100-NR	100-N SPRING 8-13	9/24/14	—	7.06 B	16.6	0.0144 U	4,160	—	1.28
100-HR-D	SD-098-1	10/28/14	—	11.1[a]	—	—	—	—	
	100-D SPRING 110-1	9/30/14	—	17.1[a]	21.5	2.71	2,450	—	3.37
		10/9/14	—	—	15.4	—	—	—	—
		12/12/14	—	2.1 B	—	—	—	—	—
	SD-110-2	2/25/14	—	23[a]	—	—	—	—	—
		12/19/14	—	7.2	—	—	—	—	—

Table 1-8. Hanford Site Contaminants in Columbia River Seeps, 2014

GWIA	Seep	Sample Date	Carbon-14 (pCi/L)	Hexavalent Chromium (µg/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Tritium (pCi/L)	TCE (µg/L)	Uranium (µg/L)
100-HR-H	SH-144-1	11/3/14	—	2.3 B	—	—	—	—	—
	100-H SPRING 145-1	2/25/14	—	8 U	—	—	—	—	—
		10/2/14	—	2.28 B[a]	3.78	-0.0219 U	145 U	—	5.02
		11/4/14	—	1.5 U	—	—	—	—	—
	100-H SPRING 150-1	11/6/14	—	3.5 B	—	—	—	—	—
	100-H SPRING 153-1	11/12/14	—	1.7 B	—	—	—	—	—
100-FR	100-F SPRING 207-1	10/1/14	—	7.48 B[a]	22.4	-0.0318 U	454	—	4.75
300-FF	300 AREA SPRING 42-2	9/23/14	—	—	14.1	—	4,390	0.3 U	19.46[b]
	300 AREA SPR DR 42-2	9/25/14	—	—	12.8	—	5,370	0.3 U	75.1[b]

a. Filtered total chromium (no hexavalent chromium data).

b. Approximation of total uranium based on sum of isotopic results.

Blue-shaded cells indicate that contaminant exceeded the applicable water quality standards.

Data qualifiers:

B = less than required detection limit but greater than method detection limit (inorganics)

J = less than required detection limit but greater than method detection limit (organics)

P = potential problem (unfiltered hexavalent chromium sample not corrected for turbidity; may be biased high)

U = less than detection limit

Table 1-9. Comparison of Contaminant Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site, 2013

Constituent	Upstream of Hanford Site			Downstream of Hanford Site		
	Number of Samples	Number of Detections	Average Concentration*	Number of Samples	Number of Detections	Average Concentration*
Cesium-137	11	0	Not detected	10	0	Not detected
Gross alpha	1	0	Not detected	1	0	Not detected
Gross beta	1	0	Not detected	1	0	Not detected
Plutonium-238	4	0	Not detected	4	0	Not detected
Plutonium-239/240	4	0	Not detected	4	0	Not detected
Strontium-90	12	0	Not detected	12	0	Not detected
Technetium-99	12	0	Not detected	12	0	Not detected
Tritium	12	12	18±7.4	12	12	***48±14***
Uranium-234	12	12	0.28±0.065	12	12	0.27±0.058
Uranium-235	12	1	0.0082±0.018	12	1	0.011±0.019
Uranium-238	12	12	0.18±0.018	12	12	***0.22±0.063***
Chromium	4	0	Not detected	5	0	Not detected

Source: Tables C.8, C.9, and C.10 of DOE/RL-2013-47.

Note: Concentrations shown in bold/italic are higher downstream of the Hanford Site than upstream of the Site.

* Concentrations in pCi/L, except chromium in µg/L.

1.4.5 River Corridor Baseline Risk Assessment and Columbia River Component Risk Assessment

Two DOE studies addressed the entire River Corridor in order to support the multiple River Corridor RI/FS documents. The 100 Area and 300 Area components of DOE's River Corridor baseline risk assessment address post-remediation, residual contaminant concentrations in these areas, as well as the Hanford and White Bluffs town sites. The assessment also investigated the risks related to the potential transport of Hanford Site contaminants into Columbia River riparian and near-shore environments adjacent to the operational areas.

DOE completed an investigation of Hanford Site contaminant releases in the Columbia River in 2010. Samples were collected of pore water (i.e., groundwater upwelling beneath the river bottom into the space between rocks and sediment of the river bed), river sediment, river water, fish, and island soil. Pore water in some 100 Area samples had concentrations of hexavalent chromium above the aquatic standard, and strontium-90 exceeded DWS in some 100-N Area samples. Tritium concentrations exceeded DWS in some pore water samples near the former Hanford town site, and uranium exceeded DWS near the

300 Area. The information obtained from this investigation will ultimately be used to help make final cleanup decisions for each of the River Corridor OUs.

Documents associated with these efforts include the following:

- DOE/RL-2007-21, Volume I, Part 1, *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment* (August 2011)
- DOE/RL-2007-21, Volume II, Part 2, *River Corridor Baseline Risk Assessment Volume II: Human Health Risk Assessment* (August 2011)
- DOE/RL-2010-117, *Columbia River Component Risk Assessment, Volume I: Screening Level Ecological Risk Assessment* (2012)
- DOE/RL-2010-117, *Columbia River Component Risk Assessment, Volume II: Human Health Risk Assessment* (2012)

1.5 Central Plateau

When the Hanford Site was operating, spent fuel reprocessing, isotope recovery operations, and associated waste management activities occurred within the 200 East and 200 West Areas located in the central portion of the Site. Waste disposal within the 200 Areas began with startup of plutonium separation operations in late 1944 (Chapter 4.0 of WHC-MR-0521). Three separations processes were used. The earliest was the bismuth phosphate process, which was used between 1944 and 1956 at T Plant in the 200 West Area (200-ZP groundwater interest area), and between 1945 and 1952 at B Plant in the 200 East Area (200-BP groundwater interest area). The reduction-oxidation (REDOX) process was used between 1952 and 1967 at the REDOX Plant in the 200 West Area (200-UP). Finally, the plutonium-uranium extraction (PUREX) process was used from 1956 to 1972, and again from 1983 to 1989 at the PUREX Plant in the 200 East Area (200-PO).

Beginning in 1949, the product from the separations plants was further processed at the Plutonium Finishing Plant (PFP) (located within 200-ZP), which operated until 1989. Other chemical processes performed in the 200 Areas included uranium recovery, using the tributyl phosphate process at U Plant (200-UP) between 1952 and 1957, and radionuclide recovery by various methods at B Plant (200-BP) between 1963 and 1983 (PNL-SA-23121-S, *Hanford Technical Exchange Program: Process Chemistry at Hanford [Genesis of Hanford Wastes]*; DOE/RL-98-28). Each chemical processing facility generated multiple waste streams and used multiple waste sites for waste management and disposal. This has resulted in a complex mixture of soil and groundwater contamination that complicates the process of interpreting specific contaminant sources for specific plumes.

Four groundwater OUs, 15 source OUs, and one vadose zone OU are associated with the Central Plateau (Figure 1-2 and Table 1-10). The groundwater OUs encompass groundwater contamination from the 200 East and 200 West Areas and regions into which this contamination has migrated beyond the Central Plateau.

Table 1-10. Central Plateau Groundwater and Source OUs

OU	OU Type	Description
200-UP-1	Groundwater	Groundwater contamination in the southern 200 West Area and surrounding 600 Area primarily originating from U Plant and REDOX Plant waste sites.
200-ZP-1	Groundwater	Groundwater contamination in the northern 200 West Area and surrounding 600 Area primarily originating from T Plant and Plutonium Finishing Plant waste sites.
200-BP-5	Groundwater	Groundwater contamination in the northern 200 East Area and surrounding 600 Area primarily originating from B Plant.
200-PO-1	Groundwater	Groundwater contamination in the southern 200 East Area and surrounding 600 Area primarily originating from PUREX Plant.
200-DV-1	Vadose zone	Addresses waste sites with deep vadose zone contamination posing a threat to groundwater quality and for which standard surface-based remedies cannot be used. It currently consists of waste sites in the vicinity of WMA B-BX-BY in the 200 East Area, and WMA T, WMA TX-TY, and WMA S-SX in the 200 West Area, although other waste sites may be added in the future.
200-PW-1/3/6 & 200-CW-5	Source	Key plutonium bearing waste sites in the Inner Area.
200-WA-1 200-BC-1	Source	Majority of the waste sites in the 200 West Inner Area and the BC Cribs and Trenches.
200-EA-1 200-IS-1	Source	Majority of the waste sites in the 200 East Inner Area and pipelines in the Inner Area.
200-SW-2	Source	Burial grounds and landfills located in the Inner Area.
200-CB-1	Source	B Plant canyon and associates waste sites.
200-CP-1	Source	PUREX Plant canyon and associates waste sites.
200-CR-1	Source	REDOX Plant canyon and associates waste sites.
200-OA-1 & 200-CW-1/3	Source	Waste sites located in the Outer Area.

OU = operable unit
PUREX = Plutonium-Uranium Extraction
REDOX = Reduction Oxidation
WMA = Waste Management Area

The following groundwater contaminants occur in substantial plumes within the Central Plateau groundwater interest areas:

- Carbon tetrachloride is widespread in the 200 West Area at concentrations up to 400 times the 5 µg/L DWS.
- Nitrate concentrations exceed 45 mg/L in numerous wells within all four Central Plateau interest areas, but the 200 West Area plumes are the largest in areal extent.
- Tritium concentrations exceed the 20,000 pCi/L DWS in all four interest areas. The plumes with the largest areal extent occur within 200-UP and 200-PO.
- Iodine-129 concentrations exceed the 1 pCi/L DWS in all four interest areas. The plume with the largest areal extent occurs within 200-PO.
- Technetium-99 occurs above the 900 pCi/L DWS in all four interest areas, although it is mostly associated with tank farm and uranium-recovery waste sites.
- Hexavalent chromium occurs in concentrations above the 48 µg/L cleanup level and the 100 µg/L DWS for total chromium in the 200 West Area (200-UP and 200-ZP). The plume in 200-UP is the largest in areal extent.
- Uranium concentrations exceed the 30 µg/L DWS in all areas except 200-ZP. The highest concentrations occur in 200-BP.

Figure 1-7 illustrates the major groundwater contaminant plumes under the Central Plateau. Residual contamination continues to enter the aquifer beneath some source areas, although at a lower rate than historically defined. Also, constituents of lower mobility in the vadose zone beneath the ponds and cribs may reach the water table in the future.

The 200 Areas contain seven single-shell tank waste management areas (WMAs): A-AX, B-BX-BY, and C within the 200 East Area and S-SX, T, TX-TY, and U within the 200 West Area. Unplanned releases (e.g., leaks or overfill events) associated with some of the tanks have contaminated the vadose zone, and some of this contamination has migrated downward to the groundwater (e.g., PNNL-11810). Migration through the vadose zone may have been facilitated in the past by additions of water from various sources, most notably nearby wastewater ditches and cribs, water supply pipeline leaks, and rainfall/snowmelt runoff events. Nitrate, technetium-99, and chromium from many of the tank farms, as well as uranium specifically from the B-BX-BY Tank Farms, form substantial groundwater plumes. These plumes generally are expanding in areal extent and exhibit increasing constituent concentrations indicating that contaminants continue to enter the groundwater from the vadose zone. This situation is being addressed, in part, by the P&T systems (e.g., the S-SX Tank Farms, PFP, and T Tank Farm). To minimize the probability of future leaks, all of the single-shell tanks at the Hanford Site have been interim stabilized, such that the pumpable liquid in each tank has been largely removed and transferred to double-shell tanks.

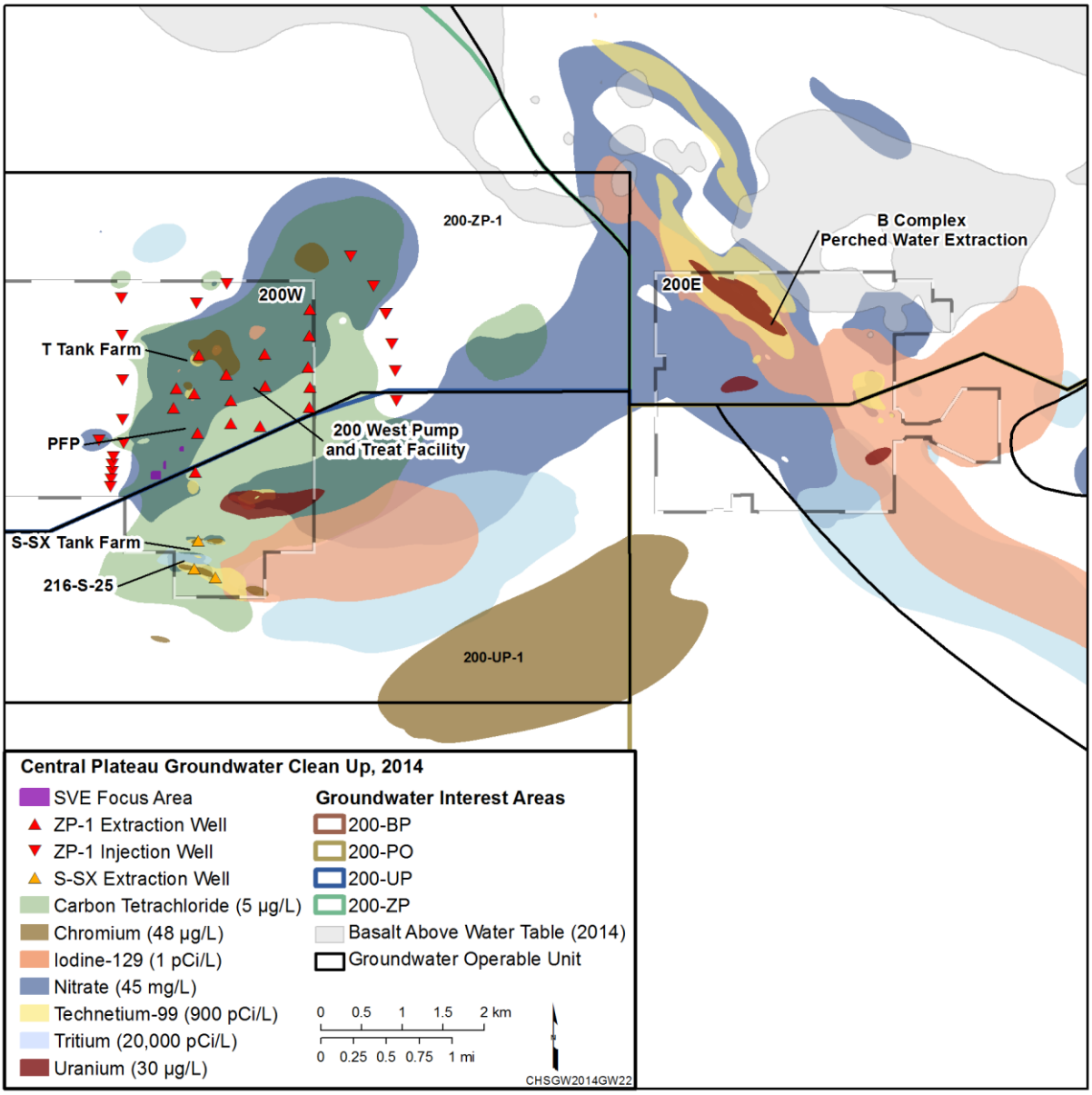

Figure 1-7. Central Plateau Plumes and Remediation

1.5.1 Hydrogeology

Important elements of the Central Plateau hydrogeology are the distribution and properties of the geologic units, structural features, and presence of mud units and basalt bedrock above the water table. The stratigraphic units present beneath the Central Plateau consist of (in ascending sequence) bedrock of the Saddle Mountains Basalt, semiconsolidated sand and gravel of the Ringold Formation unit A, silt and clay of the Ringold lower mud unit, semiconsolidated sand and gravel of the Ringold Formation unit E, fine- to coarse-grained Cold Creek unit, and unconsolidated sand and gravel of the Hanford formation (Figure 1-8). Section 2.1 of DOE/RL-2011-01 describes these units in detail. The unconfined aquifer occurs mostly within the Hanford formation and Ringold unit E. The low-permeability Ringold lower mud unit forms the base of the unconfined aquifer in most areas. The thickness of the unconfined aquifer varies substantially within the Central Plateau from over 200 m (656 ft) southeast of the 200 East Area to zero where the aquifer pinches out against mud units and basalt above the water table.

The depths from land surface to the water table range from zero adjacent to the Columbia River (i.e., the eastern boundary of 200-PO) to 106 m (348 ft) between the 200 East and 200 West Areas. Confined aquifers occur within Ringold Formation unit A between the lower mud unit and basalt and within sedimentary interbeds and interflow zones within the basalt.

Figure 1-5 shows the March 2014 water table map for the Hanford Site (low river stage), including the Central Plateau. Groundwater in the unconfined aquifer flows from upland areas in the west and southwest toward the Columbia River to the north and east, which is the regional discharge area. Within the Central Plateau, natural recharge to the unconfined aquifer comes from the Cold Creek Valley, Dry Creek Valley, Rattlesnake Hills, and infiltrating precipitation. Groundwater generally flows from west to east, although the 200 West P&T system disrupts this pattern, as discussed in Chapter 12. The Hanford Site water table has changed substantially since operations began in 1944 (PNNL-13080; DOE/RL-2011-01).

The dominant source of water in the unconfined aquifer beneath the 200 East Area and vicinity is inflow from the west. However, some water also comes from beneath the mud units to the east and from the underlying aquifers where the confining units have been removed or thinned by erosion. Formerly, the direction of groundwater flow diverged beneath the 200 East Area, with some water flowing toward the north through Gable Gap and some flowing southeast through 200-PO. For several years, effects of high river stage reversed the gradient between the 100 Areas and Gable Gap (southward flow). In 2014, the gradient resumed its slope toward the north across Gable Gap. Flow beneath 200 East Area remains to the southeast, although the gradient lessened in 2014 due to lower river stage and a resumption of effluent disposal to the Treated Effluent Disposal Facility (TEDF) located east of the 200 East Area.

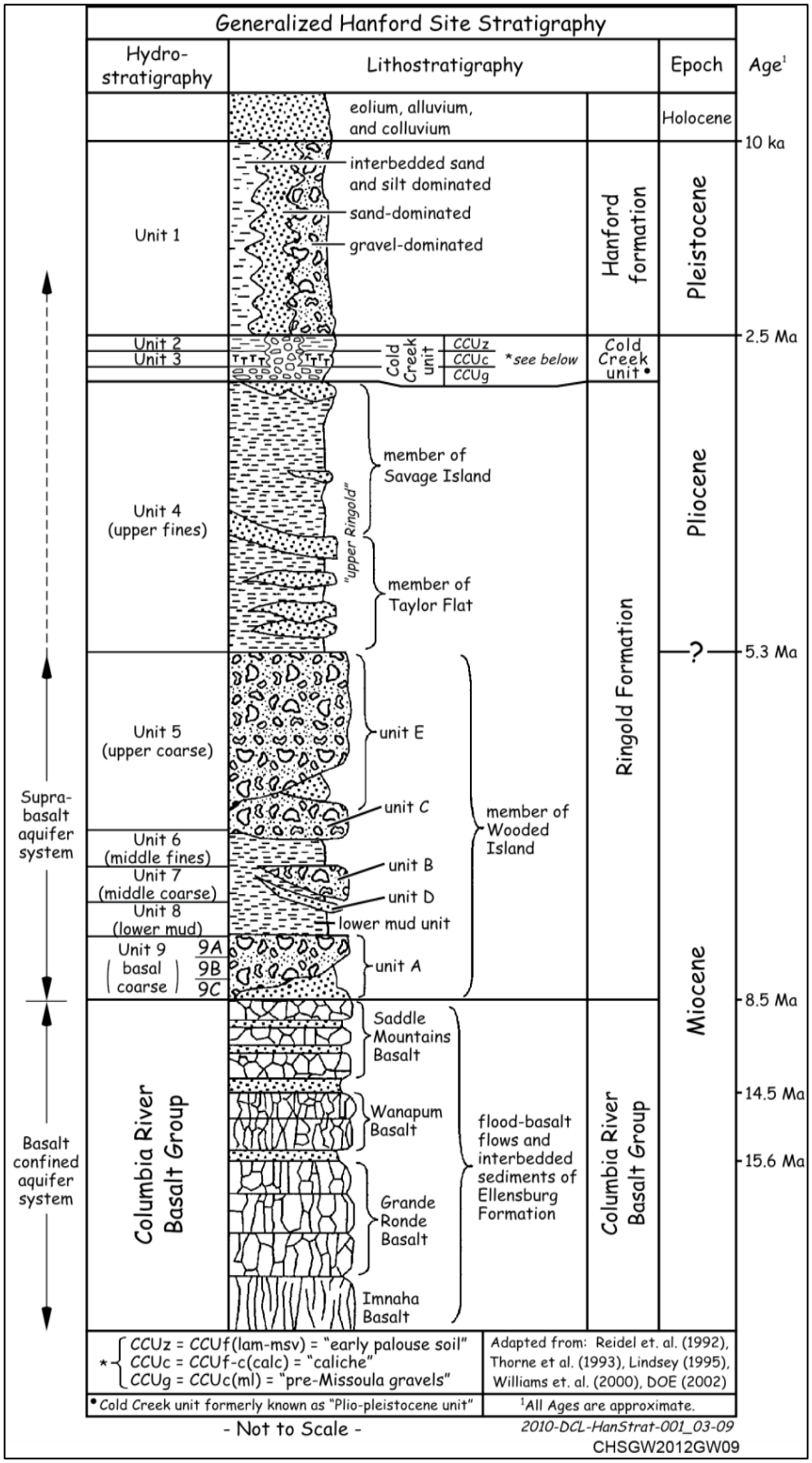

Figure 1-8. Central Plateau Geology

1.5.2 Cleanup

More progress has been made remediating waste sites within the River Corridor as compared to the Central Plateau in order to protect the river and reduce the active cleanup footprint to the 120 km^2 (75 mi^2) in the center of the site (DOE/RL-2009-10). Remediation of the Central Plateau waste sites is expected to accelerate as cleanup activities at the River Corridor waste sites are completed. Until then, cleanup activities on the Central Plateau are focused on completing decision documents, remediating the groundwater plumes in 200 West, facility decontamination and decommissioning (including PFP), and initiating waste site cleanup in the Outer Area.

Groundwater and deep vadose zone remediation on the Central Plateau (Figure 1-7) included the following in 2014:

- **200 West P&T.** The 200 West P&T system addressing carbon tetrachloride and other contaminants in the entire northern half of the 200 West Area began operating during July 2012. The system is designed to remove carbon tetrachloride, chromium, nitrate, and technetium-99 from the groundwater. It is being expanded to treat uranium and other contaminants from the 200-UP-1 OU and the 200 East Area.

- **S-SX extraction system.** A groundwater extraction system addressing contaminant plumes from WMA S-SX began operating during July 2012. The system focuses on technetium-99, chromium, nitrate, and carbon tetrachloride. The water is sent to the 200 West P&T system.

- **Soil vapor extraction.** Active and passive soil vapor extraction to remove carbon tetrachloride from the vadose zone near PFP in the 200 West Area has been used since 1992. Data show reduced carbon tetrachloride concentrations in the vadose zone to below the final soil vapor cleanup level. In 2014 DOE and EPA concurred on a path forward for transitioning operations from the current cycle of active operations and monitoring to shutdown and closure.

- **Deep vadose zone.** A treatability test to remediate the uranium-contaminated perched water zone beneath the B Complex in 200 East began during 2011 as part of the deep vadose zone OU (200-DV-1). In December 2014, DOE, EPA, and Ecology signed an action memorandum that specifies extraction of perched water and transfer to the 200 West P&T for treatment and injection into the aquifer.

1.5.3 Groundwater Monitoring Results

Table 1-11 lists the number of wells sampled and number of sample events (i.e., well trips) for each Central Plateau groundwater interest area. Table 1-12 lists the maximum concentration for selected groundwater constituents by interest area. Figure 1-7 illustrates the distribution of groundwater contamination in 2014.

Within the 200 West Area, the overall extent of the carbon tetrachloride plume during 2014 was less than that observed during 2013. After 16 years of interim P&T operations and 2.5 years of the final remedy, the areal extent of the 2,000 µg/L contour in the upper portion of the aquifer has been reduced significantly. The plume continues to move to deeper parts of the aquifer as it migrates east. The final remedy, the 200 West P&T system, addressing carbon tetrachloride in the entire northern half of the 200 West Area, began operating during July 2012 and continued operating throughout 2014.

TCE and chloroform occur in groundwater beneath the 200 West Area and are associated with the carbon tetrachloride plume. TCE will be remediated by the 200 West P&T system. All chloroform sample results were below the 80 µg/L DWS for total trihalomethanes.

Table 1-11. Groundwater Sampling on the Central Plateau, 2014

Interest Area	Number of Wells Sampled	Number of Successful Well Trips
200-ZP	89	239
200-UP	86	164
200-BP	141	306
200-PO	99	205
Total	**415**	**900**

Note: A successful sampling trip was determined by presence of data in HEIS. This table includes routine sampling, characterization sampling, and sampling conducted to support groundwater remediation systems.

Table 1-12. Maximum Concentrations of Selected Groundwater Constituents in Central Plateau Interest Areas, 2014

Contaminant (units)	Water Quality Standard	200-BP	200-PO	200-UP	200-ZP
Radionuclides (pCi/L)					
Cesium-137	200	1,100	—	—	—
Cobalt-60	100	30.9	—	—	—
Gross alpha	15	181	20	4.8	7.4
Gross beta	50	16,200	1,860	2,600	1,430
Iodine-129	1	6.05	6.49	11	1.88
Plutonium-239/240	6[a]	34	—	—	—
Strontium-90	8	1,100	15	1.15	—
Technetium-99	900	42,000	1,840	86,500	21,500
Tritium	20,000	37,000	510,000	280,000	72,000
Metals[b] (µg/L)					
Arsenic (filtered)	10	51.8	13.3	14	4.29
Arsenic	10	53.4	17.7	8.2	14.3
Antimony (filtered)	6	9.94	11.6	10.1	2.7
Antimony	6	12.6	9.16	8.76	—
Cadmium (filtered)	5	—	0.4	0.4	—
Cadmium	5	0.4	0.7	1.45	0.75

Chromium (filtered)	100	47.5	67.4	460	39.3
Chromium	100	172	167	497	186
Hexavalent chromium (filtered)	48	11.7	—	121	21
Hexavalent chromium	48	25.1	—	122	190
Nickel (filtered)	100	425	23.8	79.5	17.2
Nickel	100	333	228	101	214
Thallium (filtered)	2	—	0.81	—	—
Thallium	2	0.97	1.4	—	2.6
Uranium (filtered)	30	4.67	39.5	2.73	1.62
Uranium	30	4,030	57.8	734	2.7
Anions					
Cyanide (µg/L)	200	1,600	9.7	2.5	—
Fluoride (mg/L)	4	1.70	8.33	0.64	4.57
Nitrate (mg/L)	45[d]	1,480	156	2,270	536
Nitrite (mg/L)	3.3[d]	0.49	0.61	0.05	8.90
Organics (µg/L)					
Carbon tetrachloride	5	1.7	1.8	680	2,000
Chloroform	80[e]	0.56	2.2	10	24
Methylene chloride	5	3.26	0.8	1.5	5.5
Trichloroethene	5	3.97	1.6	8.7	8.6

Notes:

Table lists highest value for 2014 for each groundwater interest area, excluding suspect data (flagged "Y"), data under review (flagged "F), rejected data (flagged "R"), or nonroutine samples (e.g., characterization).

Cells with "—" noted indicate not detected or not analyzed.

Blue-shaded cells indicate that contaminant exceeded the listed water quality standards.

Orange-shaded cells indicate that contaminant exceeded the derived concentration standard (Table 1-3).

a. 4 mrem effective dose equivalent

b. Antimony, cadmium, and thallium typically have detection limits higher than drinking water standards, creating false exceedances near the detection limits.

c. Nickel may indicate corrosion of stainless steel well screens and casing.

d. As NO_3 and NO_2. Equivalent to drinking water standards of 10 mg/L and 1 mg/L.

e. Total trihalomethanes.

Nitrate and tritium occur above DWS within all four Central Plateau groundwater interest areas. These constituents originate from multiple sources. The highest nitrate concentrations are in the southeastern 200 West Area, and the highest tritium concentrations are near the PUREX Cribs in the central part of the 200 East Area. The tritium plume from the PUREX Cribs extends east through the 200-PO interest area

and discharges to the Columbia River at concentrations above 20,000 pCi/L. Concentrations of tritium are declining in many of the Central Plateau wells as the plumes attenuate naturally by radioactive decay and dispersion.

The largest iodine-129 plume occurs within 200-PO, but the highest concentrations generally occur in the 200 West Area. At the 1 pCi/L contour level, the 200-PO plume extends 12 km (7.5 mi) east of the 200 East Area, and its extent has decreased slightly over the last 20 years. While the contaminant continues to migrate downgradient, concentrations at the leading edge of the plume (at the 1 pCi/L level) are reduced by dispersion such that the contour position is stable (i.e., at steady state). Concentrations in wells and aquifer tubes near the Columbia River are generally below detection limits. However, there is no significant reduction in concentrations due to radioactive decay because iodine-129 has a long half-life.

The most substantial uranium plumes within the unconfined aquifer occur within the 200-BP and 200-UP interest areas. Uranium is entering the aquifer from a perched zone beneath the B Complex, and this perched water is being extracted to prevent its reaching the underlying aquifer. The uranium plume in 200-UP occurs near U Plant and originated from the 216-U-1/2 Cribs. Further remediation of this plume is addressed by the ROD issued in September 2012 (EPA et al., 2012), and a groundwater extraction system is currently being designed.

Technetium-99 occurs above the 900 pCi/L DWS in all four interest areas, although it is mostly associated with tank farm and uranium-recovery waste sites. The largest technetium-99 plume occurs within the 200-BP interest area and originated mainly from the BY Cribs. This plume extends to the northwest beyond the 200 East Area, and covers an area of 1.4 km^2 (0.5 mi^2). Technetium-99 plumes also occur in association with the tank farms in both the 200 East and 200 West Areas.

Cesium-137 and plutonium concentrations exceed DWS in 200-BP near a former injection well.

A cyanide plume originated from the BY Cribs in the 200-BP interest area and is attributed to disposal of wastes from isotope recovery processes. This plume extends toward the northwest, but it is now migrating to the southeast.

Chromium plumes on the Central Plateau are associated with waste sites in the 200 West Area. One plume occurs east southeast of the 200 West Area and originated from cribs and ponds associated with the REDOX Plant. Chromium plumes also occur at the 200 West Area tank farms. The largest of these is the plume from the SX Tank Farm, which extends nearly 500 m (1,640 ft) downgradient from the source area. A groundwater extraction system to remove this plume from the aquifer began operating during July 2012 and continued operating during 2014.

Groundwater monitoring regulated by RCRA and the *Washington Administrative Code* (WAC) continued in 2014 at facilities in all four groundwater interest areas (Table 1-13). Within the Central Plateau, 12 sites are monitored under interim status indicator parameter (detection) programs, 7 sites are in assessment, and one site is monitored under final status to collect baseline data. The assessment sites include one site for elevated specific conductance, four sites for elevated concentrations of chromium, and two sites for elevated concentrations of cyanide. During 2014, no sampling results indicated a potential new impact to groundwater quality.

Table 1-13. RCRA Monitoring Status for the Central Plateau, 2014

RCRA Unit	Report Section	Status for Reporting Period
216-A-29 Ditch	200-PO	Continued indicator evaluation[a]
216-A-36B Crib	200-PO	Continued indicator evaluation[a]
216-A-37-1 Crib	200-PO	Continued indicator evaluation[a]
216-B-3 Pond	200-PO	TOC exceedances; verification results pending
216-B-63 Trench	200-BP	Continued indicator evaluation[a]
216-S-10 Pond and Ditch	200-UP	Continued indicator evaluation[a]
IDF	200-PO	Not yet in use; monitoring results added to baseline data set
LERF	200-BP	Continued indicator evaluation;[a] adequacy of monitoring approach under review by DOE and Ecology
LLWMA-1	200-BP	Indicator evaluation[a] reinstated after an assessment "first determination" completed
LLWMA-2	200-BP	Continued indicator evaluation[a]
LLWMA-3	200-ZP	Continued indicator evaluation[a]
LLWMA-4	200-ZP	Continued indicator evaluation[a]
NRDWL	200-PO	Continued indicator evaluation[a]
SST WMA A-AX	200-PO	Continued assessment (elevated specific conductance); assessment plan being revised
SST WMA B-BX-BY	200-BP	Continued assessment (cyanide[b])
SST WMA C	200-BP	Continued assessment (cyanide[b])
SST WMA S-SX	200-UP	Continued assessment (chromium[b])
SST WMA T	200-ZP	Continued assessment (chromium[b])
SST WMA TX-TY	200-ZP	Continued assessment (chromium[b])
SST WMA U	200-UP	Continued assessment (chromium[b])

a. Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with dangerous waste/dangerous waste constituents from the unit.

b. Primary RCRA constituents at this unit.

DOE	=	U.S. Department of Energy	RCRA	=	Resource Conservation and Recovery Act of 1976
Ecology	=	Washington State Department of Ecology			
IDF	=	Integrated Disposal Facility	SST	=	single shell tank
LERF	=	Liquid Effluent Retention Facility	TOC	=	total organic carbon
LLWMA	=	Low-Level Waste Management Area	WMA	=	Waste Management Area
NRDWL	=	Nonradioactive Dangerous Waste Landfill			

1.6 CERCLA 5-Year Review

Whenever contaminants remain in the environment following a remedial action decision, CERCLA regulations require the regulatory agency to conduct a review of the decision at least every 5 years. DOE issued the most recent CERCLA 5-year review report (DOE/RL-2011-56) in 2012. The review covered the period ending September 30 2010 and includes assessments of both source and groundwater OUs. The next CERCLA 5-year review will cover the period ending September 30, 2015.

1.7 Quality Control Summary

Groundwater data quality is assessed and enhanced by a multifaceted quality assurance (QA)/quality control (QC) program. Appendix F presents a detailed description of the data quality assessment for 2014. This assessment evaluates groundwater samples collected during 2014 from wells, aquifer tubes, and seeps and is based on three QA components:

- Field QC samples consisting of field blanks, sample replicates (replicate samples sent to the same laboratory), and sample splits (replicate samples sent to different laboratories). Field blanks provide a measure of possible sample contamination during field sampling and laboratory operations. Sample replicates provide a measure of precision for field sampling and laboratory analysis. Sample splits provide an interlaboratory comparison of sample analysis.
- Laboratory QC samples consisting of method blanks, sample duplicates, laboratory control samples/laboratory control sample duplicates, matrix spikes/matrix spike duplicates, and surrogates/surrogate duplicates. Method blanks provide a measure of possible sample contamination during laboratory analysis. Laboratory control samples, matrix spikes, and surrogates provide a measure of analytical accuracy. The various duplicate samples provide a measure of analytical precision.
- Laboratory performance measures consisting of groundwater monitoring program blind standards and commercial performance evaluation samples. Both the blind standards and performance evaluation samples provide a measure of laboratory analytical accuracy and bias; the blind standards also provide a measure of laboratory analytical precision.

Based on the results of this data quality assessment, sample results appear to accurately represent target analyte concentrations in Hanford Site groundwater, and the analytical data are sufficient in quantity and quality to be usable for the groundwater monitoring program. The percent useable data for the 2014 groundwater monitoring data set is 96.7 percent; this exceeds the DOE/RL-91-50 groundwater monitoring requirement of 85 percent data usability. Furthermore, 98.5 percent of the laboratory QC samples met QC requirements. This high rate of acceptable laboratory QC results indicates that laboratory accuracy, precision, and contamination control during sample preparation and analysis support the use of the data set for the groundwater monitoring program. Field QC samples were collected and laboratory QC samples were analyzed at the frequencies required.

1.8 Sources of Additional Information

Groundwater data presented in this report are provided as electronic files. Users also may retrieve historical and current data via the internet through DOE's Environmental Dashboard Application available at https://ehs.hanford.gov/eda/. AWLN data currently are not available via the dashboard application.

The documents referenced in this report generally are available at the public reading rooms around Washington State. Many documents also are available online as part of the Administrative Record available at http://pdw.hanford.gov/arpir/ or other online libraries. Requests for documents can also be made through inter library loan directly to DOE. References to documents in this report are provided as a direct electronic link when possible. If reports are not accessible through the internet, the document number (if applicable) and full title are provided.

Other reports and databases relating to Hanford groundwater are listed in the following text and cited or summarized in this report as needed.

- The HEIS database is the main environmental database for the Hanford Site. The database is used to store groundwater chemistry data and other environmental data (e.g., soil and surface water chemistry, soil physical properties, and survey data).
- The Hanford Site Groundwater Monitoring Reports for 2012, 2013, and 2014 have been prepared to be accessible through the internet and can be found at: http://www.hanford.gov/c.cfm/sgrp/GWRep12/start.htm, http://www.hanford.gov/c.cfm/sgrp/GWRep13/start.htm, and http://www.hanford.gov/c.cfm/sgrp/GWRep14/start.htm.
- Hanford Site environmental reports present results of monitoring, including groundwater, riverbank seeps, river water, sediment, air, and biota. They also describe environmental management performance and report the status of compliance with environmental regulations. These reports are available through the Mission Support Alliance website at http://msa.hanford.gov/page.cfm/EnviroReports.
- Tank monitoring and groundwater data, and other information is available from the Pacific Northwest National Laboratory PHOENIX dashboard available at: http://phoenix.pnnl.gov/.
- Quarterly RCRA summaries are informal quarterly presentations to Ecology made after groundwater data associated with RCRA have been verified and evaluated. These presentations describe the status of RCRA sampling and analysis, statistical analysis results, and changes or highlights from the quarter.
- Groundwater remediation reports describe the progress of groundwater remediation systems on the Hanford Site. The annual reports discuss the removal and treatment efficiencies for the year, as well as any operational issues for the groundwater remediation systems.
- DOE recently released RI/FS documents for all of the River Corridor OUs except 100-BC, which is planned for late 2016. These documents provide the results of RI studies and make recommendations for remediating the vadose zone and groundwater beneath the River Corridor.