1.0 Introduction

M.J. Hartman

The Hanford Site, part of the U.S. Department of Energy's (DOE's) nuclear weapons complex, encompasses ~1,500 square kilometers 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. It made the plutonium for the Trinity Test and the bomb that was dropped on Nagasaki, Japan, in 1945. Between 1944 and 1963, nine nuclear reactors were built and operated, mainly to produce weapons-grade plutonium.

The Hanford Story: Chapter 1—Overview is a documentary that provides a history of the Hanford Site. Available at: http://www.hanford.gov/page.cfm/HanfordStory.

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 flows towards the Columbia River and is the primary exposure route for contaminants to reach human, environmental, and ecological receptors.

The Hanford Story: Chapter 2—Groundwater provides estimates of the amounts of liquids that were discharged directly into soil, the Columbia River, stored in underground tanks, and quantities of contaminated groundwater. Available at: http://www.hanford.gov/page.cfm/HanfordStory.

Since the 1990s, DOE has worked to characterize, remove, treat, and dispose of contamination from past operations. Key elements associated with managing the Hanford Site's groundwater and vadose zone contamination are to (1) protect the Columbia River and groundwater, (2) develop a cleanup decision process, and (3) achieve final cleanup.

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 former liquid waste sites near the Columbia River to reduce the potential for future groundwater contamination
- Contain groundwater plumes and reduce the mass of primary contaminants through remedial actions such as pump-and-treat.

Develop a process for cleanup decisions. Final decisions will be based on the processes outlined in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and/or the *Resource Conservation and Recovery Act of 1976* (RCRA). Other sections of this report describe CERCLA cleanup in more detail.

Attain final cleanup. Substantial progress has been made toward cleanup of waste sites near the Columbia River. Strategies used for making final decisions in these areas will provide a basis for attaining similar final decisions for the central portion of the Site.

Because of the size and complexity of the Hanford Site, DOE has divided it into smaller units or areas of interest.

This report is designed to meet the following objectives:

- ***Describe the 2011 groundwater conditions on the Hanford Site***
- ***Fulfill regulatory reporting requirements***
- ***Summarize the characterization and remediation of the deep vadose zone***
- ***Summarize the installation, maintenance, and decommissioning of Site monitoring wells during 2011.***

- The 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, at a higher elevation. Groundwater monitoring results for these regions are described in Chapters 2 and 3, respectively.
- The Hanford 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. This also included the 300 Area, which was home to the fuel manufacturing operations at the Site as well as the experimental and laboratory facilities, and the 400 Area, which housed a research nuclear reactor.
- Waste sites have been sorted into **source operable units**, which include sites that received waste from the same or similar sources. The source operable units include contamination in the vadose zone.
- **Groundwater operable units** include groundwater beneath one or more source operable units, and may include larger regions where contaminated groundwater has migrated.
- The formal groundwater operable units do not cover the entire Hanford Site. Groundwater scientists have defined informal **groundwater interest areas**, which include the groundwater operable units and the intervening regions, to provide scheduling, data review, and data interpretation for the entire Site. Chapters 2 and 3 define the boundaries of the groundwater interest areas.
- **River corridor units** have been defined for making final cleanup decisions. These units combine source and groundwater operable units (Chapter 2).
- The **Central Plateau "Inner Area"** (Figure 1-1) is ~ 26 square kilometers in the middle of the Hanford Site, encompassing the region where chemical processing and waste management activities occurred.
- The **Central Plateau "Outer Area"** (Figure 1-1) has an area of more than 168 square kilometers and includes much of the open area where limited processing activity occurred.

1.1 Purpose and Scope

Hanford Site Groundwater Monitoring for 2011 presents the results of groundwater monitoring, providing the primary means to report monitoring results for RCRA treatment, storage, and disposal units; for CERCLA groundwater operable units where no active remediation is currently taking place; and the *Atomic Energy Act of 1954* (AEA) as required by DOE orders (Table 1-1). This report also provides a summary of deep vadose zone remediation and well installation, remediation, and decommissioning

activities. Appendices A, B, and C provide supporting information on CERCLA, RCRA, and aquifer tube monitoring, respectively. Appendix D reports results of the quality control program.

This report focuses on 2011 monitoring results and changes from the previous year. Details of previous studies (e.g. remedial investigations) are published in separate reports that are cited in applicable chapters of this report. Results are summarized if the information is new for 2011. 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. Appendix E (provided electronically) contains a summary of Hanford hydrogeology and geochemistry and is taken from Chapter 2 of *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01).

Results of groundwater remediation in CERCLA groundwater operable units are published in separate annual reports. Information for 2011 is summarized here, and the reports are cited and provided electronically.

Groundwater monitoring objectives of RCRA, CERCLA, and AEA often 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 RCRA unit wells 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 any RCRA Permit.

1.2 Groundwater Monitoring

Specific groundwater monitoring plans and sampling and analysis plans 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 problems. Chapters 2 and 3 provide references to applicable monitoring documents.

In 2011, staff sampled 924 wells and 280 aquifer tubes for radiological and chemical constituents.

In 2011, staff sampled 924 wells and 280 aquifer tubes. Many of the wells and some of the aquifer tubes were sampled more than once, for a total of 4,173 successful sampling events. These numbers include routine sampling and special sampling (i.e., sampling during drilling of new boreholes, performance monitoring of groundwater remediation systems, etc.).

Chromium (total or hexavalent) was the most frequently analyzed constituent. Nitrate, tritium, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds (carbon tetrachloride and trichloroethene) were other commonly analyzed constituents (Table 1-2).

Sampling was delayed at many wells because, in January 2011, a sampler received a mild electrical shock from a groundwater pump and all sampling was stopped as a safety precaution. It was determined that electrically controlled sample pumps were not electrically bonded. To reduce the likelihood of repeating this incident, pumps in ~400 wells were electrically bonded and inspected. The remainder of the electric pumps are operated using an approved, temporary bonding device until permanent modifications can be performed. Sampling work resumed on March 23, 2011.

Groundwater contaminant plumes are often illustrated as maps, that is, they are shown as two-dimensional features. The third dimension, distribution of contaminants with depth, also must be considered. Most of the monitoring wells on the Hanford Site are screened near the top of the unconfined aquifer. In many locations, characterization data show that contaminant concentrations are highest in the upper portion of the aquifer. In some cases, for example, the 200 West Area carbon tetrachloride plume, concentrations vary significantly with depth. Cross sections of contaminant distribution have been created for some regions of the Site, often in support of remedial investigations. These cross sections rely on groundwater samples collected from discrete depths during drilling through the entire aquifer thickness. The completed wells usually have a shorter screen, so routine monitoring results represent a single depth from each well. As such, these cross sections cannot be updated based on new monitoring data. Cross sections are supplied here only if new information is available for 2011. In most areas, some 2011 data are available from monitoring wells screened at different depths. More detailed descriptions of vertical distribution of contaminants can be found in remedial investigation reports or other documents cited in the chapters of this report.

In March 2011, staff measured water levels in an extensive network of wells monitoring the unconfined aquifer system and the underlying confined aquifers. In March, the Columbia River typically is at a moderate stage; and the March measurements represent average conditions near the river. In many areas of the Hanford Site, water levels are measured more frequently to evaluate seasonal changes. The water-level data were used for the following purposes:

- Prepare contour 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.

Results of water-level monitoring are discussed in Chapters 2 through 4. The collection and analysis of manual water-level measurements at the Hanford Site are described in *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project* (SGW-38815).

1.3 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 ~ 0.000012 cubic meter per second (Section 4.1 of PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River, Progress Report for the Groundwater/River Interface Task Science and Technology Groundwater/Vadose Zone Integration Project*). For comparison, the average flow of the Columbia River is ~3,400 cubic meters per second.

The rise and fall of the Columbia River creates a zone of interaction that influences contaminant concentrations and groundwater flow patterns. Water in the ground near the river nearly always represents a mixture of river water and approaching groundwater. In general, the degree of dilution by river water decreases with depth in the aquifer. The degree of dilution also varies by location and with seasonal river cycles (Chapter 3 of PNNL-13674).

Groundwater is a potential pathway for contaminants to enter the Columbia River. DOE monitors water quality near the shoreline.

DOE samples water near the Columbia River shoreline via natural seeps (riverbank springs) and aquifer tubes. Seeps represent water actually discharging to the river, and include a mix of groundwater and river water that previously flowed into the bank. 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 ~1 to 8 meters. Section 2.1 and Appendix C provide additional information for the aquifer tubes. Section 2.9 includes a summary of monitoring results from seeps and river water.

1.4 CERCLA Five-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 five years. DOE issued Revision 1 of *The Hanford Site Third CERCLA Five-Year Review Report* (DOE/RL-2011-56) in March 2012. DOE issued an errata sheet in June 2012 (12-EMD-0070, "Hanford Site Third Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Review Report, April 2012"). The review covers the period ending September 30, 2010. The review provided the following protectiveness determinations for those groundwater operable units with existing records of decision:

- 100-HR-3: The interim remedy is not functioning within the specified remedial action objectives. Contamination has continued to migrate into the horn area between 100-H and 100-D. The new DX and HX pump-and-treat systems are designed to treat this plume.
- 100-KR-4: The interim remedy is functioning within the specified remedial action objectives.
- 100-NR-2: A protectiveness determination of the remedy cannot be made until further information is obtained. Institutional controls prevent human exposure to contaminants.
- 200-UP-1: The final remedy is expected to be protective of human health and the environment. The current interim actions ensure that exposure pathways are being controlled.
- 200-ZP-1: A protectiveness determination of the final remedy cannot be made until further information is obtained.
- 300-FF-5: The interim remedy is not protective because it is not expected to meet the groundwater cleanup standards. As a result, the remedial actions and remedial action objectives for the final remedy are being evaluated. Institutional controls are in place preventing the use of the groundwater.
- 1100-EM-1: The final remedy remains protective of human health and the environment.

The five-year review identified three issues and associated actions (Table 1-3).

1.5 Quality Control Summary

JG Douglas and SL Fitzgerald

Groundwater data quality is assessed and enhanced by a multifaceted quality assurance/quality control program. Major components of the program include performance evaluation studies, field quality control samples, blind standards, laboratory quality control samples, and laboratory audits. Overall,

evaluation of these components indicates that the majority of the data from the reporting period is reliable and defensible. Specific data values that are associated with out-of-limit quality control results (e.g., field blanks, field duplicates, and laboratory blanks) are flagged in the Hanford Environmental Information System (HEIS) database so users can properly assess the utility of the data for their purposes. Appendix D presents a detailed description of the quality control program and the quality control results for 2011; highlights include the following:

- Ninety-seven percent of the groundwater monitoring data was considered complete (i.e., not rejected, suspect, associated with a missed holding time, or out-of-limit quality control criteria). The majority of the incomplete results were associated with field quality control failures.
- The six primary laboratories supporting groundwater monitoring participated in several national performance evaluation studies. Overall, the performance was acceptable.
- Field quality control samples include three types of field blanks (full trip, field transfer, and equipment blanks), field duplicates, and split samples. Approximately 98 percent of the field blanks, 94 percent of the field duplicates, and 84 percent of the split sample results were acceptable, indicating reasonable sampling and analytical performance.
- Recommended holding times were met for 99 percent of nonradiological sample analysis requests.
- Overall, laboratory performance for Soil and Groundwater Remediation Project blind standards was fair; 84 percent of the results were acceptable. Failures for carbon-14, gross alpha, metals, total organic carbon, total uranium, and volatile organic compounds suggest that some groundwater results could also be biased. These problem areas will be investigated further during 2012.
- Approximately 99 percent of the laboratory quality control results for 2011 were within the acceptance limits. This percentage indicates that the analyses were in control and reliable data were generated. Laboratory quality control samples included method blanks, sample duplicates, laboratory control samples/duplicates, matrix spikes/duplicates, and surrogates.
- DOE Consolidated Audit Program audits were performed on four commercial laboratories. A total of 28 new findings, 10 open findings from previous audits, and 26 observations resulted from the four DOE audits. The four laboratories accepted all corrective actions; verification of the corrective actions will be performed in future audits. All of the laboratories have been recommended by the DOE Consolidated Audit Program to continue providing analytical services for samples generated at DOE sites.

1.6 Sources of Additional Information

All of the 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: http://environet.hanford.gov/EDA/.

The documents referenced in this report generally are available at the public reading rooms around Washington State (see Front Matter). Many documents also are available online as part of the Administrative Record available at http://www5.hanford.gov/arpir/ or other online libraries. Requests for documents can also be made through inter-library loan directly to DOE.

Hanford Site groundwater data are available online via the Environmental Dashboard Application available at: http://environet.hanford.gov/EDA/.

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

HEIS database. 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; survey data).

Hanford Site Environmental Reports. The annual environmental report presents results of monitoring, including groundwater, riverbank seeps, river water, sediment, air, and biota. It also describes environmental management performance and reports the status of compliance with environmental regulations.

Quarterly RCRA summary. DOE provides informal quarterly presentations to the Washington State Department of Ecology (Ecology) 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. Independent annual 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.

Remedial Investigation/Feasibility Study (RI/FS) documents. DOE recently released RI/FS reports for all of the River Corridor units (Section 2.1). These documents provide the results of RI studies and make recommendations for remediating the vadose zone and groundwater beneath the river corridor.

River Corridor Baseline Risk Assessment (RCBRA). A critical step in developing final remedial action decisions is the completion of a quantitative baseline risk assessment (Section 2.9).

1.7 Conventions Used in this Report

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

The well location maps presented in this report include any wells used for sampling or water-level measurements over the past 5 years. Wells that have gone dry or that have been decommissioned during this period are shown with symbols that are different from regularly sampled wells. For clarity, the well name prefixes (e.g., “199-” in the 100 Area and “299-” in the 200 Area) are omitted from most of the maps.

For the first time in this report, contaminant plume maps were constructed by computer programs using a method called quantile kriging to produce a continuous spatial illustration of the contaminant distribution. The measured concentrations in wells are interpolated to a grid using a quantile kriging technique based on that described by *Geostatistical Software Library and User’s Guide* (Deutsch and Journel, 1992), “Rank Order Geostatistics: A Proposal for a Unique Coding and Common Processing of Diverse Data” (Journel and Deutsch, 1997), and “Spatial Interpolation Methods for Nonstationary Plume Data” (Reed et. al., 2004), among others. The quantile kriging approach is based upon two-dimensional ordinary kriging of a non-parametric (uniform-score) transform of the concentration, and a subsequent back-transform of the interpolated scores into the original units of measured concentration. Quantile kriging was accomplished using an open-source program based upon the United States Geological Survey kriging routines from *Semi-Variogram Estimation and Universal Kriging Program* (Skrivan and Karlinger, 1980) that incorporates routines to conduct the uniform-score transform/back-transform.

The computer factored in variables such as groundwater flow direction to create more realistic plumes. Limitations of the technique arise because the computer does not account for factors such as the locations of the known sources of contaminants, historical trends in concentrations, or relative mobility of contaminants. To minimize the adverse effects of these limitations, control data points were inserted where necessary, based on historical information and expert knowledge.

The following conventions were applied to create data sets for plume maps.

- For all maps except carbon tetrachloride in 200-ZP-1, wells screened in the upper portion of the unconfined aquifer were used. In most areas, there are insufficient numbers of deeper wells to create contour maps. Vertical distribution of contamination is discussed in the text.
- Data were selected and averaged from the period of interest (all of 2011 for most maps; high or low water-level conditions for some plumes near the Columbia River).
- Aquifer tubes are typically installed in clusters with screens at different depths in the unconfined aquifer. The mapped data sets include only the highest concentration in each cluster.
- If no data were available from a well during the desired time period, data were included from outside the time period.
- Data that appear to be nonrepresentative were excluded. Quality control staff and the project scientist in charge of the operable unit or monitored unit determine data representativeness. The evaluation employs a documented procedure and uses various methods and best professional judgment (Appendix D).
- For all constituents except iodine-129, "U" flagged data (less than detection limits) were counted as zero in averaging. Although this skews the averages low, the effect is insignificant at the current contouring levels with one exception. Reported values were averaged for iodine-129 even if they were flagged because detection limits are so close to the contour interval.

Contour levels for the maps in this report were chosen as follows:

- Drinking water standards and multiples of 10 (e.g., 8, 80, and 800 pCi/L for strontium-90)
- Cleanup levels or interim remedial action goals, where applicable (for example, 20 µg/L for hexavalent chromium)
- Intermediate levels to help define plume shape (for example, 90 µg/L for uranium; 500 µg/L for hexavalent chromium).

Plume maps are interpretations of contaminant distribution, based on data from individual monitoring wells. Computer programs were used to derive the 2011 contours.

Nitrate concentrations in this document are expressed as the NO_3^- ion. The federal and state drinking water standard for nitrate is 10 mg/L expressed as NO_3-N; this relates to the actual nitrogen in nitrate. 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, the drinking water standard appears as 45 mg/L in figures and tables. Similarly, nitrite is expressed as the NO_2^- ion.

Dissolved chromium in Hanford Site groundwater is virtually all hexavalent. Thus, total chromium in filtered samples represents hexavalent chromium.

Unless specified otherwise, maps showing chromium include total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples. Dissolved chromium in Hanford groundwater is virtually all hexavalent (Chapter 7 of WHC-SD-EN-TI-302, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*; Appendix C of DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*), so filtered, total chromium data effectively represent hexavalent chromium. Maps for 100-KR-4 and 100-HR-3 illustrate hexavalent chromium and only include total chromium if a well had no hexavalent data.

Trend plots may omit results that appear to be erroneous if they distort or obscure the scale and data trends; the figure legends note the omission. All of the data, with appropriate data quality flags, are included in the data files accompanying this report and are available in the HEIS database. 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.

Contaminant concentrations are compared with state or federally enforceable drinking water standards (Table 1-4). Although Hanford groundwater is generally not used for the purpose of drinking water, these levels provide perspective on contaminant concentrations. Radionuclide concentrations also are compared with DOE-derived concentration standards and risk-based concentrations (Table 1-5). Note that the derived concentration standards were revised in 2011 based on a new DOE standard (DOE-STD-1196-2011, *Derived Concentration Technical Standard*). Where groundwater cleanup standards have been set, contaminant concentrations are compared to those standards.

The water-table mapping methodology is described in Chapter 4.0 of SGW-38815 (the water-level monitoring plan). In general, water-level measurements are displayed on a map using a geographic information system and contours are hand-drawn by a hydrogeologist. Generation of the March 2011 water-table map differed from the methodology described in SGW-38815 in that computer-generated contours were used as a guide to manual contouring near the groundwater pump-and-treat systems. The software employed, KT3D_H2O, uses the statistical, kriging numerical-grid generation method and includes additional drift terms in the kriging equation to represent extraction and injection wells ("KT3D_H2O: A Program for Kriging Water Level Data Using Hydrologic Drift Terms" [Karanovic et al., 2009]; SGW-42305, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*). This resulted in a better representation of water table drawdown and buildup around extraction and injection wells, respectively, especially in areas where observation wells are lacking.

Table 1-1. Reporting Requirements for Groundwater Monitoring

Operable Unit or Facility	Formal Report	Supplemental Report or Summaries
CERCLA		
Operable Units without interim groundwater RODs (100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1)	This report	Unit managers' meeting presentations
Operable Units with interim action RODs (100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, 200-ZP-1,* and 300-FF-5)	Interim Action annual reports, summarized in this report	Unit managers' meeting presentations; this report
Operable Unit with final action ROD (1100-EM-1)	This report	None
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-51085)	This report
TEDF (WAC 173-216)	Quarterly discharge monitoring reports; this report	None
SWL (WAC 173-350)	This report	None

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

* 200-ZP-1 has both an interim and final groundwater ROD.

Table 1-2. Number of Groundwater Analyses for Selected Constituents, 2011

Constituent	Site Total
Carbon tetrachloride	1,189
Chromium (total)	3,726
Chromium (hexavalent)	3,804
Iodine-129	593
Nitrate	2,324
Plutonium-239/240	78
Strontium-90	930
Technetium-99	1,210
Trichloroethene	1,194
Tritium	1,671
Uranium	1,334

Table 1-3. CERCLA Five-Year Review Issues and Actions

Issues and Actions	Action Due Date
100 Area	
Issue 1: Recent data indicate a low spot in the surface of the Ringold Upper Mud in the 100-HR-3 OU that may trap hexavalent chromium in the aquifer, which in combination with a likely continuing vadose source of hexavalent chromium at the adjacent 100-D-100 waste site results in persistent hexavalent chromium concentrations in groundwater southeast of the 182-D Reservoir	
Action 1.1: Remove, treat, and dispose of the chromium source discovered in the deep vadose zone at 100-D-100.	4/30/2014
Issue 2: Leakage and spills from the 182-D Reservoir and export water system may contribute to movement of contaminants into the vadose zone.	
Action 2.1: Complete the engineering export water scoping study to evaluate whether the 182-D Reservoir and export water system is necessary to support the Hanford Cleanup Mission.	3/31/2012
300 Area	
Issue 3. Remediation approach in interim action ROD (EPA/ESD/R10-00/524) for natural attenuation is not effective in meeting groundwater remediation goals in the 300 Area.	
Action 3.1. Submit proposed plan for a ROD to support meeting groundwater remediation goals.	12/31/2011

Table 1-4. Drinking Water Standards and Groundwater Cleanup Levels for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	DWS Responsible Agency	MTCA[a]	Groundwater Quality Criteria[b]	Ambient Water Quality Criteria[c]
Chemical Constituents						
Aluminum	µg/L	50 to 200[d]	EPA	16,000	--	--
Antimony	µg/L	6	EPA, DOH	6.4	--	--
Arsenic	µg/L	10	EPA, DOH	0.058	50	190
Barium	µg/L	2,000	EPA, DOH	3,200	1,000	--
Cadmium	µg/L	5	EPA, DOH	8.0	10	Hardness dependent
Carbon tetrachloride	µg/L	5	EPA, DOH	0.337	300	--
Chloride	mg/L	250[d]	EPA, DOH	--	250	230
Chloroform (TTHM)[d]	µg/L	80	EPA, DOH	1.41	7.0	--
Chromium	µg/L	100[f]	EPA, DOH	24,000/48[f,g]	50[f]	10[g]
cis-1,2-Dichloroethene	µg/L	70	EPA, DOH	80	--	--
Copper	µg/L	1,300[h] 1,000[d]	EPA, DOH	640	--	Hardness dependent
Cyanide	mg/L	200	EPA, DOH	320	--	5.2
Fluoride	mg/L	4	EPA, DOH	960	4	--
		2[d]	EPA, DOH	--	--	--
Iron	µg/L	300[d]	EPA, DOH	11,200	--	--
Lead	µg/L	15[h]	EPA, DOH	--	50	Hardness dependent
Manganese	µg/L	50[d]	EPA, DOH	2,240	--	--
Mercury(inorganic)	µg/L	2	EPA, DOH	4.8	2	0.012
Methylene chloride (dichloromethane)	µg/L	5	EPA	5.83	--	--
Nitrate, as NO3-	mg/L	45[i]	EPA, DOH	114	45[i]	--
Nitrite, as NO2-	mg/L	3.31[j]	EPA, DOH	4.8	--	--
pH	--	6.5 to 8.5[d]	EPA, DOH	--	--	6.5 to 8.5
Selenium	µg/L	50	EPA, DOH	80	10	5.0
Silver	µg/L	100[d]	EPA, DOH	80	50	--
Sulfate	mg/L	250[d]	EPA, DOH	--	250	--
Tetrachloroethene	µg/L	5	EPA, DOH	0.081	0.8	--
Thallium	µg/L	2	EPA, DOH	--	--	--
Total dissolved solids	mg/L	500[d]	EPA, DOH	--	--	--
1,1,1-Trichloroethane	µg/L	200	EPA, DOH	16,000	200	--
Trichloroethene	µg/L	5	EPA, DOH	0.492	3	--
Uranium (total)	µg/L	30	EPA, DOH	48	--	--
Zinc	µg/L	5,000[d]	EPA, DOH	4,800	--	Hardness dependent

Table 1-4. Drinking Water Standards and Groundwater Cleanup Levels for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	DWS Responsible Agency	MTCA[a]	Groundwater Quality Criteria[b]	Ambient Water Quality Criteria[c]
Radionuclides						
Antimony-125	pCi/L	300[j]	EPA	--	--	--
Beta particle and photon activity	pCi/L	4 mrem/yr[k]	EPA, DOH	--	--	--
Carbon-14	pCi/L	2,000	EPA	--	--	--
Cesium-137	pCi/L	200	EPA	--	--	--
Cobalt-60	pCi/L	100	EPA	--	--	--
Iodine-129	pCi/L	1	EPA	--	--	--
Ruthenium-106	pCi/L	30	EPA	--	--	--
Strontium-90	pCi/L	8	EPA, DOH	--	--	--
Technetium-99	pCi/L	900	EPA	--	--	--
Total alpha (excluding uranium)	pCi/L	15	EPA, DOH	--	--	--
Tritium	pCi/L	20,000	EPA, DOH	--	--	--
Uranium	µg/L	30	EPA, DOH	--	--	--

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, *Calculation of Standard Method B Groundwater Cleanup Levels for Potable Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*.

b. Groundwater quality criteria are regulated by Ecology under WAC 173-200, "Water Quality Standards for Groundwaters of the State of Washington."

c. 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).

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 NO3- is equivalent to 10 mg/L of nitrate as nitrogen.

j. 3.3 mg/L as NO2- 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 >4 mrem/year. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/year. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.

DOH = Washington State Department of Health (WAC 246-290, "Group A Public Water Supplies")

DWS = drinking water standard (maximum contaminant level for drinking water supplies)

EPA = U.S. Environmental Protection Agency (40 CFR 141, "National Primary Drinking Water Regulations;" 40 CFR 143, "National Secondary Drinking Water Regulations;" and EPA 822-R-96-001, *Drinking Water Regulations and Health Advisories*)

Table 1-5. 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/year. 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/year if consumed at average annual rates. The EPA DWSs for radionuclides listed in Table 1-3 were derived based on a 4 mrem/year 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/year 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: http://epa-prgs.ornl.gov/radionuclides/tapwaterimage.html "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 1-3 for total uranium.
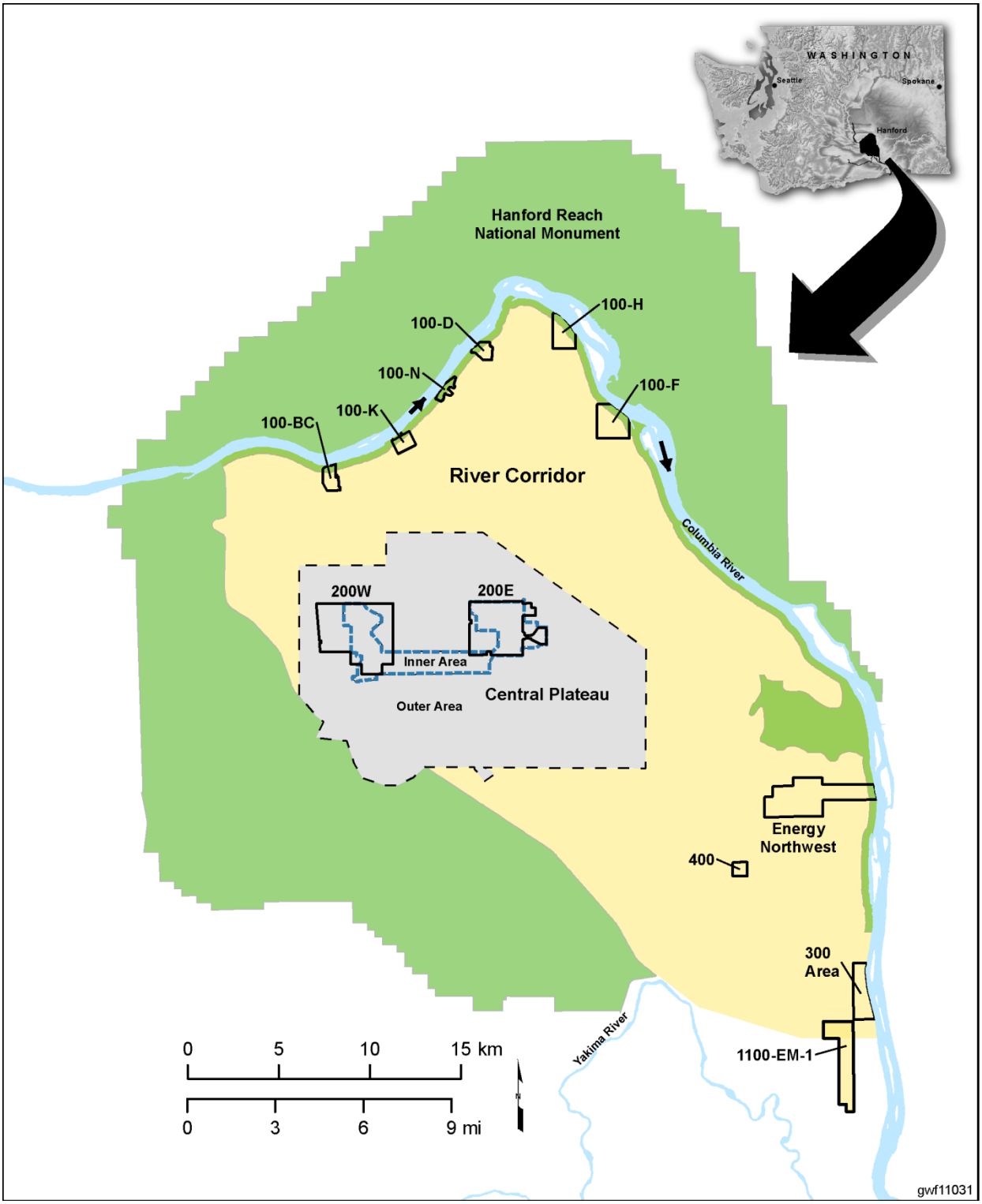
Figure 1-1. The U.S. Department of Energy Hanford Site