1.0 Introduction

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The Hanford Site, part of the U.S. Department of Energy's (DOE's) nuclear weapons complex, encompasses ~1,500 square kilometers in southeastern Washington State (Figure 1-1). The Hanford Site is located in the Lower Columbia Basin and is divided by the Columbia River. The federal government acquired the Hanford Site in 1943 and, until the 1980s, the site was used to produce plutonium and uranium for the national defense mission. Management of waste associated with weapons material production has been a major activity throughout Hanford's history and continues today at a much reduced scale. Beginning in the 1990s, the DOE has focused work efforts primarily on characterization, removal, treatment, and disposal of contamination from past operations at the site.

The DOE's groundwater strategy focuses on protecting groundwater from contaminants, monitoring groundwater conditions, and cleaning up contaminated groundwater.

The DOE is committed to protecting the Columbia River from the Hanford Site's contaminated groundwater. Groundwater is the primary exposure route for site contaminants to reach human and environmental receptors. The *Hanford Integrated Groundwater and Vadose Zone Management Plan* (DOE/RL-2007-20) outlines the steps for addressing groundwater and vadose zone contamination. The DOE developed the plan in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology).

Beginning in the 1990s and continuing today, the DOE has remediated hundreds of waste sites along the River Corridor. The remediation effort has included demolishing structures, excavating contaminated soil, and disposing contaminated material in an engineered landfill in the central portion of the Hanford Site. The former waste sites are being filled in with clean material and the land revegetated. The DOE has identified nearly 1,500 waste sites in the River Corridor, and approximately two-thirds of these waste sites have been remediated to date. Removing the contaminated material eliminates sources of contamination that otherwise could be carried to groundwater by infiltrating precipitation. The DOE has initiated the remedial investigation (RI)/feasibility study (FS) process to collect additional data needed in order to make final decisions regarding cleanup of waste sites and groundwater along the River Corridor.

Key elements associated with managing the Hanford Site's groundwater and vadose zone are to (1) protect the Columbia River and groundwater, (2) develop a cleanup decision process, and (3) achieve final cleanup.

This report is designed to meet the following objectives for the reporting period:

- ***Report on the current groundwater conditions on the Hanford Site***
- ***Fulfill the reporting requirements of RCRA, CERCLA, AEA, and Washington Administrative Code***
- ***Describe the results of monitoring the vadose zone***
- ***Summarize the installation, maintenance, and decommissioning of Hanford Site monitoring wells.***

Protect the Columbia River and groundwater. Many actions have already been taken to address principal threats to the Columbia River and groundwater. These actions include the following:

- Cease discharge of all unpermitted liquids in the central Hanford Site
- Remediate the former liquid waste sites in the 100 and 300 Areas 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). The following five key elements will support the final decisions:

- Gather sufficient characterization data, focusing on waste sites with deep contamination that pose a future risk to groundwater
- Evaluate the performance of early actions (waste site remediation along the River Corridor and groundwater interim actions) to help guide future cleanup
- Identify cleanup goals for waste sites that support long-term groundwater remediation
- Identify new technologies to reduce the mobility of deep contamination and limit its movement to groundwater
- Improve integration of cleanup decisions for waste sites and groundwater.

The Tri-Parties (i.e., DOE, Ecology, and EPA) recently took a major step toward accomplishing these goals in 2010 when they developed a strategy to make final decisions necessary to complete cleanup in the River Corridor. Part of the strategy includes dividing the final cleanup decisions into smaller, more manageable pieces of work.

In January 2010, the DOE released the *Integrated 100 Area Remedial Investigation/ Feasibility Study Work Plan* (DOE/RL-2008-46) and a series of addenda addressing specific segments of the River Corridor. Final cleanup decisions for the 100 Area will be developed for areas associated with the following operable units (OUs): 100-D and 100-H Areas, 100-K Area, 100-B/C Area, 100-F/IU-2/IU-6 Area, and 100-N Area. The 300 Area OUs (300-FF-1, 300-FF-2, and 300-FF-5) are included in a separate work plan (DOE/RL-2009-30, *300 Area Decision Unit Remedial Investigation/ Feasibility Study Work Plan*), which was issued in April 2010.

The work plans, addenda, and related sampling and analysis plans identify data gaps and the data to be collected. During 2010, much of the field work required under the work plan was completed. The data will be used to develop a proposed plan for remedial action. The final decisions for the OUs will address cleanup of contaminated soil, solid waste burial grounds, groundwater, and releases from reactor buildings. The objective for all of these decisions is to protect human health and the environment. The selection of the final action will be documented in Records of Decision (RODs).

Attain final cleanup. The DOE, EPA, and Ecology are committed to complete cleanup of past-practice waste sites at the Hanford Site by September 2024. Substantial progress has been made toward cleanup of the 100 and 300 Areas. Strategies used for making final decisions in the 100 and 300 Areas will provide a basis for attaining similar final decisions for the 200 East and 200 West Areas.

Groundwater monitoring fulfills a variety of state and federal regulations, including the *Atomic Energy Act of 1954* (AEA), RCRA, CERCLA, and various sections of the *Washington Administrative Code* (WAC).

1.1 Purpose and Scope

This document presents the results of Hanford Site groundwater monitoring for calendar year (CY) 2010, providing the primary means to report monitoring results for RCRA treatment, storage, and disposal (TSD) units; for CERCLA groundwater OUs where no active remediation is currently taking place; and the AEA as required by DOE orders (Table 1-1). This report will also provide a summary of vadose zone monitoring, investigations, and results; and well installation, remediation, and decommissioning activities. The report covers the period from January 1, 2010, through December 31, 2010. The following date conventions are used throughout this report:

- FY 2010: Refers to fiscal year (FY) (i.e., October 1, 2009, to September 30, 2010).
- CY 2010: Refers to calendar year (CY) (i.e., January 1, 2010, to December 31, 2010).
- Reporting period: Refers to the CY covered for this report, unless otherwise noted in the text.

Details on the CERCLA remediation activities (e.g., pump-and-treat operations) are presented in separate reports and have been summarized in this report. This report provides Internet links to assist the reader in locating other relevant documents. The layout of this report presents the various OUs and groundwater interest areas in numerical order (100 Area, followed by 200 Area, etc). However, throughout this report certain areas may also be discussed as aggregate units (e.g., Central Plateau and River Corridor). For the purposes of this report, the Central Plateau includes the 200 East and 200 West Areas, off-river sites (400 Area), and the surrounding nonoperational area (600 Area). The River Corridor refers to those portions of the Hanford Site adjacent to the Columbia River and includes the 100 Area, 300 Area, and the 1100-EM-1 groundwater interest area (Figure 1-2). The portion of the River Corridor north of the 300 Area and south of the 100-F Area is discussed as part of the 200-PO-1 OU.

Appendix A includes supporting information for CERCLA monitoring. Appendix B contains tables and figures that support RCRA and other regulated unit monitoring. Appendix C provides supporting information for aquifer tube sampling. The quality assurance and quality control results and issues for the reporting period are provided in Appendix D.

The size of the Hanford Site and the volume of work associated with groundwater monitoring, contamination evaluation, and remediation prohibit detailed discussions of many topics in this report. This report provides data interpretation and discussion of groundwater monitoring results for 2010 data and notable changes in trends from previous data. Background information including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics is provided separately in *Hanford Site Groundwater: Settings, Sources, and Methods* (PNNL-13080), with the most recent update provided in Appendix C of *Hanford Site Groundwater Monitoring for Fiscal Year 2001* (PNNL-13788). Some background information is provided in this report for completeness.

This report attempts to avoid unnecessary repetition of information that is more appropriately included in OU-specific documents for groundwater or contaminant sources. Such information is summarized in this report, where appropriate, but more detailed information is available in other documents. References and/or Internet links to these documents are provided. Detailed information includes the following:

- Details on the design and logic behind the approach, monitoring system design, data collection methods, and quality assurance/quality control requirements are provided in RCRA monitoring plans, work plans, etc.
- Specific descriptions of the groundwater geology and hydrology at specific sites are included in RCRA monitoring plans and in work plans and reports for those sites.
- Details on conceptual models, risk evaluation, and groundwater modeling are provided in work plans and reports for the specific OUs.
- Contaminant capture zone and hydraulic analyses are included in pump-and-treat performance reports for the 100-KR-4 and 100-HR-3 OUs and the 200 West Area OUs.
- Vadose zone contaminant sources are discussed in work plans and reports, both for source OUs and groundwater OUs, as applicable. Deep vadose zone activities are also discussed in those reports.
- Columbia River upwelling and hyporheic zone investigations are discussed in other reports (see Chapter 17.0).

1.2 Groundwater Monitoring

During the reporting period, staff sampled 1,311 wells and 145 aquifer tubes for radiological and chemical constituents.

To streamline cleanup, Hanford waste sites are grouped into source OUs (i.e., sites that received waste from the same or similar source[s]). Because groundwater at a given location may be impacted by multiple waste sites, it is divided into groundwater OUs that do not necessarily coincide with the waste site OUs. The concept of OUs is to group waste sites with similar characteristics/sources into manageable components for investigation and to allow for better prioritization of cleanup work. The groundwater OUs are defined by contamination and, therefore, do not cover the entire Hanford Site (Figure 1-2). Groundwater staff 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. Figure 1-2 illustrates the relationship between the interest areas and the OU boundaries.

Various documents (i.e., monitoring plans or sampling and analysis plans) define the wells to be sampled, sampling frequency, and constituents to be analyzed. 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.

During the reporting period, Hanford Site staff sampled 1,311 wells. Staff collected 335 aquifer tube samples from 145 aquifer tubes in 2010. The large decrease in aquifer tube samples from 2009 is the result of the work stoppage that resulted in most of the fall 2010 aquifer tube sampling being delayed into 2011. Many of the wells and tubes were sampled multiple times, for a combined total of 4,277 successful sampling trips. These numbers include routine groundwater sampling associated with remediation activities.

Groundwater sampling was stopped between September 27, 2010, and November 8, 2010, when a safety-related stop work closed down all sampling activity performed by the Soil and Groundwater Remediation Project. A recovery plan was put in place to address the required sampling at RCRA TSD units. The recovery plan was approved by DOE, EPA and Ecology, and it identified 70 priority wells out of 130 wells scheduled and impacted by the stop work. Collection of most groundwater samples was delayed to December, and 68 of the agreed-upon 70 samples were collected. Two wells that were not sampled required maintenance. In addition, 50 more wells not in the recovery plan were sampled, leaving only 10 of the original 130 scheduled RCRA wells not sampled during the quarter. Of the ten wells, six were sampled in January 2011.

Most of the monitoring wells on the Hanford Site are screened near the top of the unconfined aquifer; however, in the past several years, additional wells have been installed deeper (especially in the 200 West Area) to assess the vertical extent of groundwater contamination. In some locations, these wells have shown significant contamination, primarily carbon tetrachloride, deep in the aquifer. Data from some of the 200 East Area wells installed deep in the aquifer or from samples collected while drilling have indicated contamination deep in the aquifer; this is also true in portions of the 300-FF-5, 100-HR-3, and 100-NR-2 OUs. Some contaminants, most notably carbon tetrachloride, are more dense than water and can be more widespread deeper in the aquifer. Historical downward hydraulic gradients may also have increased contamination at depth in some areas. Studies of contaminant distribution with depth are being conducted for some plumes, particularly in the 200 West Area. Contamination with depth is discussed in those sections where studies indicate (or have shown in the past) the presence of contaminants in the deeper portions of the aquifer. For the most part, however, the shallow portion of the aquifer is the most contaminated. Most of the contaminant plume maps and plume area calculations in this report are based on data from the top of the aquifer (upper ~10 meters).

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

Tritium, nitrate, and iodine-129 are the most widespread contaminants on the Hanford Site.

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Figures 1-3 and 1-4 depict the distributions of these contaminants above the drinking water standard (DWS) in the upper unconfined aquifer. The most prominent portions of these plumes originated at waste sites in the 200 East and 200 West Areas and moved with the regional groundwater flow toward the southeast. Nitrate and tritium also had significant sources in the 100 Area.

Table 1-3 lists the maximum concentrations of selected groundwater contaminants in each groundwater interest area. The electronic data files accompanying this report are included for the reporting period and historical data.

Groundwater monitoring objectives of RCRA, CERCLA, and AEA often differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated TSD 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.

1.3 Compliance Summary for CERCLA Operable Units

This section provides a brief introduction on the status of compliance for each of the Hanford Site groundwater OUs. The OU discussions are presented in the order in which they appear in this report.

1.3.1 100-BC-5 Operable Unit

The CERCLA monitoring requirements for the 100-BC-5 OU are driven by the *100-BC-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-38) and *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) change notices TPA-CN-240 and TPA-CN-293. All wells were sampled as scheduled during the reporting period. Details on CERCLA groundwater monitoring activities for the 100-BC-5 OU are provided in Chapter 4.0, Section 4.2.

An RI/FS work plan addendum was implemented in 2010 to collect additional data needed to support final CERCLA cleanup decisions. New wells and new aquifer tubes are helping to define the extent of contamination both aerially and vertically.

1.3.2 100-KR-4 Operable Unit

The CERCLA activities for the 100-KR-4 OU are conducted in accordance with the requirements presented in the *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units* (EPA/ROD/R10-96/134). The interim ROD focused on remediating hexavalent chromium in the groundwater associated with reactor operations using ion-exchange pump-and-treat systems, as discussed in the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (DOE/RL-96-84). Treatment has been expanded through the installation of two additional ion-exchange systems, KW and KX, described in *The KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action* (DOE/RL-2006-52) and the *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump and Treat System* (DOE/RL-2006-75), respectively. Details on the CERCLA groundwater monitoring activities for the 100-KR-4 OU are provided in Chapter 5.0, Section 5.2. The monitoring requirements for the 100-KR-4 OU pump-and-treat systems are specified in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90).

Hexavalent chromium is distributed in plumes, with concentrations remaining above the 20 µg/L remedial action goal in several near-shore locations. Remedial process optimization is continuing for systematic evaluation and enhancement of site remediation processes to ensure that human health and the environment are being protected over the long term at minimum risk and cost.

Pump-and-treat remediation activities have removed a combined total of almost 576 kilograms of hexavalent chromium from the 100-N Area. The KR4 pump-and-treat system has removed a total of 354.7 kilograms of hexavalent chromium from the area around the 116-K-2 Trench since 1997, while the KW pump-and-treat system has removed a total of 137.4 kilograms of hexavalent chromium from the area around

the KW Reactor since 2007. An additional 83.7 kilograms of hexavalent chromium were removed from the northern end of the 116-K-2 Trench and beneath the N Reactor fence line since the new KX pump-and-treat system came online in 2009.

An RI/FS study is being conducted to support the final ROD for the 100-K Area. Characterization activities began in CY 2010, as described in the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 2: 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units* (DOE/RL-2008-46-ADD2) and implemented through the *Sampling and Analysis Plan for the 100-K Decision Unit Remedial Investigation/Feasibility Study* (DOE/RL-2009-41).

1.3.3 100-NR-2 Operable Unit

The CERCLA monitoring requirements for the 100-NR-2 OU are driven by two documents: the *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit* (DOE/RL-2001-27) (and associated Tri-Party Agreement change notices) for the interim action monitoring program, and *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit* (DOE/RL-2005-96) (and associated Tri-Party Agreement change notices) for the apatite permeable reactive barrier. An integrated monitoring plan combining all monitoring programs will be submitted with the 100-N Area CERCLA RI report and proposed plan, scheduled for September 2012. Additional details on 100-NR-2 OU CERCLA groundwater monitoring activities for the reporting period are provided in Chapter 6.0, Section 6.2.

The sampling schedules dictated by DOE/RL-2001-27 and DOE/RL-2005-96 were met, with two exceptions: (1) one well could not be sampled for interim action monitoring due to technical difficulties with the pump, and (2) shallow (Hanford formation) apatite permeable reactive barrier wells can only be sampled when the river level is high. For the reporting period, at least one sample was taken from the Hanford formation wells during the four quarters.

1.3.4 100-HR-3 Operable Unit

Three CERCLA interim action remedies are currently operating in the 100-HR-3 OU. These include the original HR-3 pump-and-treat system in the 100-H Area (which treats groundwater from both the 100-D and 100-H Areas), the DR-5 pump-and-treat system in the 100-D Area, and the In Situ Redox Manipulation (ISRM) barrier also in the 100-D Area. Details on 100-HR-3 OU CERCLA groundwater monitoring activities for the reporting period are provided in Chapter 7.0, Section 7.2.

The monitoring requirements for the HR-3 pump-and-treat system are specified in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90). Long-term monitoring requirements in the 100-D Area have been modified (expanded) from *Sampling Changes to the 100-HR-3 and 100-KR-4 Operable Units* (Waneck, 1998). There are currently no compliance wells for the DR-5 pump-and-treat system; however, new compliance wells are being determined during revisions to the interim action monitoring plan that is currently under development.

Hexavalent chromium concentrations in two compliance wells for the HR-3 pump-and-treat system were above the 10 µg/L aquatic water quality criterion in both the 100-D and 100-H Areas. Remedial process optimization is being conducted for the 100-HR-3 OU to provide additional treatment capacity and to enhance remediation. A new pump-and-treat facility (referred to as the DX system) will expand the treatment capacity in the 100-D Area to 2,300 liters per minute, while a

new pump-and-treat facility in the 100-H Area (referred to as the HX system) will expand treatment capacity there to 3,000 liters per minute.

Pump-and-treat remediation activities have removed a combined total of 737 kilograms of hexavalent chromium from the northern horn area of the Hanford Site. The DR-5 pump-and-treat system has removed a total of 326 kilograms of hexavalent chromium from the 100-D Area since 2004, while the HR-3 pump-and-treat system has removed a total of 393 kilograms of hexavalent chromium from the 100-H Area since 1997. An additional 18.4 kilograms of hexavalent chromium were removed in December 2010 during pilot testing of the new DX pump-and-treat system.

Remedial action monitoring for the ISRM barrier is described in the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation* (DOE/RL-99-51). Overall, the ISRM barrier continues to help reduce hexavalent chromium in the aquifer; however, during periods of low river flow, hexavalent chromium values above the remedial action goal are observed in some wells. With the addition of the new DX pump-and-treat system, the intent is to reduce the contaminant load impinging on the barrier, as well as to capture and treat any remaining downgradient hexavalent chromium.

An RI/FS study is being conducted to support the final ROD for the 100-D and 100-H Areas. Characterization activities began in CY 2010, as described in the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2008-46-ADD1) and implemented through the *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study* (DOE/RL-2009-40). Data gaps were identified and are currently being addressed through additional data collection and other investigations that will support final remediation decisions. A series of fifteen monitoring wells, six aquifer tubes, ten vadose zone boreholes, and five test pits constitute the subsurface characterization activities. Field work is scheduled for completion by the end of 2011. The RI/FS study report will address the data and information needed to support selection of a final remedy for the 100-D and 100-H Areas. The DOE will finalize the RI/FS study report and issue a proposed plan detailing the proposed final remedy by the Tri-Party Agreement milestone date of July 31, 2011.

1.3.5 100-FR-3 Operable Unit

The CERCLA monitoring requirements for the 100-FR-3 OU are driven by the *100-FR-3 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-49) and change notice TPA-CN-241. All wells were sampled as scheduled during the reporting period. Details on 100-FR-3 OU CERCLA groundwater monitoring activities are provided in Chapter 8.0, Section 8.2.

An RI/FS work plan addendum was implemented in 2010 to collect additional data needed to support final CERCLA cleanup decisions. New wells are helping to define the extent of contamination both aerially and vertically.

1.3.6 200-BP-5 Operable Unit

The CERCLA monitoring requirements for the 200-BP-5 OU are derived from the *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit* (DOE/RL-2001-49). During the reporting period, all but 3 of the 108 wells scheduled were successfully sampled. The primary CERCLA reporting accomplishments for the reporting period included (1) completion of the Tri-Party Agreement

Milestone M-015-082 through submittal of the *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit* (DOE/RL-2010-74, Draft A), (2) initiation of the *Remedial Investigation Report 200-BP-5 Groundwater Operable Unit* (DOE/RL-2009-127), and (3) completion of the *Data Quality Assessment Report for the 200-BP-5 Groundwater Operable Unit: November 2004 through November 2009 Groundwater Data* (SGW-44071). Details on 200-BP-5 OU CERCLA groundwater monitoring activities for the reporting period are provided in Chapter 9.0, Section 9.2.

1.3.7 200-PO-1 Operable Unit

Groundwater monitoring at the 200-PO-1 OU supports the RI/FS process under the direction of *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2007-31) and two sampling and analysis plans. One sampling and analysis plan covers routine groundwater sampling (DOE/RL-2003-04, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* [referred to as the "routine" sampling and analysis plan]), and the other covers short-term characterization to supplement routine groundwater monitoring (Appendix A of DOE/RL-2007-31 [referred to as the "characterization" sampling and analysis plan]). The characterization sampling and analysis plan has been implemented and the results were reported in the *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2* (DOE/RL-2010-11), the *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-66), and the *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2009-85, Draft A [currently being reviewed by Ecology and EPA prior to final publication]). Details on 200-PO-1 OU CERCLA groundwater monitoring activities for the reporting period are provided Chapter 10.0, Section 10.2.

Although 130 wells are listed in the routine sampling and analysis plan, only 111 wells were scheduled for sampling during the reporting period. The remaining wells are sampled only once every 3 years (triennially) and will be sampled again in 2012, or they were triennial wells scheduled in the final quarter of 2010 and affected by the work stoppage. Of the 111 wells scheduled for sampling in 2010, 103 wells were sampled successfully. Six wells were attempted but were unsuccessful due to a variety of reasons, including maintenance issues, wellhead damage, access problems, or dry wells. Two wells were scheduled during the work stoppage in October 2010 and were not sampled prior to February 2011.

1.3.8 200-UP-1 Operable Unit

The CERCLA activities for the 200-UP-1 OU during the reporting period included preparing the draft RI/FS and proposed plan reports, operating an interim remedial action pump-and-treat system, and performing groundwater monitoring. The *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-2009-122, Draft A) and the *Proposed Plan to Amend the 200-ZP-1 Groundwater Operable Unit Record of Decision to Include the Remedial Actions for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-2010-05, Draft A) were released in September 2010, meeting Tri-Party Agreement Milestone M-015-17A.

The revised *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE/RL-97-36, Rev. 3) was released in January 2010. This document was prepared to implement changes made by the *Explanation of Significant Differences for the Interim Record of Decision for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Washington* (EPA et al., 2009a). The work plan included a preliminary design for an interim action pump-and-treat system targeting both the north and south technetium-99 plumes at the S and SX Tank Farms. This system is expected

to be operational by the end of 2011 in support of Tri-Party Agreement Milestone M-016-120. Since 2003, operation of the current U Plant pump-and-treat system has removed a total of 220.3 kilograms of uranium, 127.6 grams (2.17 curies) of technetium-99, 41.3 kilograms of carbon tetrachloride, and 49,667 kilograms of nitrate from the 886 million liters of groundwater pumped.

Groundwater monitoring is governed by the *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, Appendix A), which specifies the wells to be sampled, analytes, and sample frequency. During CY 2010, all wells were sampled as planned with the following exceptions: (1) three of the quarterly samples from extraction wells 299-W19-36 and 299-W19-43 were missed due to pump-and-treat system outages and the sampling stop work, (2) three of the quarterly samples were missed for well 299-W19-101 due to maintenance issues, (3) samples were missed from four wells due to the sampling work stoppage, (4) samples were missed from 299-W18-21 and 699-35-70 because the wells went dry, and (5) samples from several wells were delayed until early 2011 due to the work stoppage. Details on 200-UP-1 OU CERCLA groundwater monitoring activities for CY 2010 are provided in Chapter 11.0, Section 11.2.

1.3.9 200-ZP-1 Operable Unit

The CERCLA groundwater performance monitoring and interim remedial measures at the 200-ZP-1 OU are outlined in the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA/ROD/R10-95/114) and are implemented through the *200-ZP-1 Interim Remedial Measure Remedial Design Report* (DOE/RL-96-07) and the *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE/RL-2002-17). Details on 200-ZP-1 OU CERCLA groundwater monitoring activities for the reporting period are provided in Chapter 12.0, Section 12.3.

The primary contaminants of concern identified in the interim ROD are carbon tetrachloride, chloroform, and trichloroethene. Remediation of elevated technetium-99 at wells east of Waste Management Area (WMA) T prompted interim remedial activity in accordance with the ROD (EPA/ROD/R10-95/114) and *Technetium-99 Pump-and-Treat System to Support the 200-ZP-1 CERCLA Remedial Investigation/Feasibility Study Process* (DOE/RL-2007-23). Remediation activities require removing contaminants from the high-concentration areas (greater than 2,000 µg /L) of carbon tetrachloride and reducing concentrations to the DWS of 900 pCi/L for technetium-99. The primary means to achieve the remedial targets is through withdrawing groundwater and removing contaminant mass via ex situ treatment using pump-and-treat operations. Since 2007, carbon tetrachloride has been reduced in the areas of highest concentration through extraction of over 5.02 billion liters of contaminated water, from which 12,647 kilograms of carbon tetrachloride were removed. A second system treating technetium-99 in the WMA T area has removed 72.7 grams of technetium-99 (1.24 curies), lowering concentrations that once exceeded 113,000 pCi/L to 4,000 pCi/L and 4,500 pCi/L at extraction wells since start up. This system has also removed 71.3 kilograms of carbon tetrachloride and 72,262 kilograms of nitrate.

The design, installation, and operation of the remedial action monitoring network and treatment system is discussed in the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78). Additional tasks performed during CY 2010 to support the final ROD (*Declaration of the Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*

[EPA et al., 2008], issued in September 2008) included installing eleven extraction/injection wells to supply the groundwater treatment facility, and ongoing construction of the radiological process facility and the biological treatment facility to support startup of the treatment facility by the end of 2011. Extraction well 299-W15-44 was removed from the well network and extraction well 299-W15-225 was added, resulting in a 40% increase in production volume for the entire extraction network. Chapter 12.0, Section 12.3.4 discusses the screened depths of wells and the vertical distribution of contamination. Pump-and-treat operations of the existing 200-ZP-1 system since 1994 have reduced contamination in the aquifer through the removal of 12,648 kilograms of carbon tetrachloride from over 5 billion liters of groundwater treated.

1.3.10 300-FF-5 Operable Unit

The 300-FF-5 OU is in the later stages of the RI/FS process. Current activities are directed at assembling information to support decisions for final remedial actions involving groundwater (DOE/RL-2009-30, *300 Area Decision Unit Remedial Investigation/Feasibility Study Work Plan*). The principal contaminant of concern for the 300 Area is uranium, although additional waste indicators also exceed regulatory standards for groundwater in the 300 Area and in two outlying subregions containing the 618-10 and 618-11 Burial Grounds. Details on 300-FF-5 OU CERCLA groundwater monitoring activities for the reporting period are provided in Chapter 13.0, Section 13.2.

While the RI/FS process continues, groundwater is monitored under an operation and maintenance plan, which describes the strategy for monitoring and characterization activities during the period of interim remedial action (DOE/RL-95-73, *Operation and Maintenance Plan for the 300-FF-5 Operable Unit*). The *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2002-11) implements the groundwater monitoring requirements. The period of interim action is governed by the *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-96/143), which was prepared in 1996 and expanded geographically in 2000 to include the two outlying subregions (EPA/ESD/R10-00/524, *EPA Superfund Explanation of Significant Differences: Hanford 300-Area [USDOE]*). Remedial actions during the interim period involve continued monitoring of groundwater and institutional controls to restrict groundwater use. These activities are deemed appropriate while other actions are underway to remediate waste disposal sites, unplanned release sites, and former 300 Area facilities.

Significant activities contributing to the RI/FS are being conducted in the 300 Area, including drilling at sixteen locations, with the primary objective to characterize the contamination remaining in the vadose zone and unconfined aquifer. Field testing is in progress using potential technologies to remediate uranium contamination in the subsurface. Groundwater monitoring via wells and river shoreline aquifer tubes is providing data used to evaluate the nature and extent of contamination, contaminant concentration trends, and associated risk. The DOE's Office of Science supports detailed research on the mobility characteristics of uranium beneath the 300 Area, as well as on the groundwater pathway leading to discharge into the Columbia River. Completion of the RI/FS process and submittal of a proposed plan for final remedial action have a Tri-Party Agreement milestone due date of December 31, 2012.

1.3.11 1100-EM-1 Operable Unit

The 1100-EM-1 OU, including the inactive Horn Rapids Landfill, was delisted from the National Priorities List in 2006 and, therefore, is no longer considered

an active CERCLA site. The results of the CERCLA investigation for the 1100-EM-1 OU are presented in the *Draft Remedial Investigation/ Feasibility Study for the 1100-EM-1 Operable Unit, Hanford* (DOE/RL-92-67) and the *Declaration of the Record of Decision for the 1100 Area* (EPA/ROD/R10-93/063). Details on 1100-EM-1 OU groundwater monitoring activities for the reporting period are provided in Chapter 14.0, Section 14.2.

The selected remedy for groundwater, which consists of monitored natural attenuation of volatile organic compounds with institutional controls on drilling of new water supply wells, continues to be successful. Monitoring includes analysis of trichloroethene and its breakdown products (e.g., vinyl chloride and 1,1-dichloroethene), as well as nitrate in wells downgradient of the Horn Rapids Landfill, as recommended in the *Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit* (PNNL-12220) and TPA-CN-163. Concentrations of trichloroethene and its breakdown products remained below the 5 µg/L DWS.

1.4 Compliance Summary for Sites Regulated Under the Resource Conservation and Recovery Act

The groundwater monitoring requirements for the Hanford Site's RCRA TSD units fall into one of two broad categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." The RCRA units not currently incorporated into a permit require interim status monitoring, as specified in WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards" (based on 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities").

Under the requirements of WAC 173-303-400 (interim status), groundwater monitoring is conducted under one of three programs:

- ***Contaminant indicator evaluation*:** Any interim status facility subject to RCRA regulations initially implements a contamination indicator evaluation monitoring program. This program uses groundwater data from specified indicator parameters (pH, specific conductance, total organic carbon, and total organic halogens) to determine and monitor the impact of the facility, if any, on groundwater. In addition annual sampling for the groundwater quality parameters chloride, sulfate, iron, manganese, sodium, and phenols is also required. A contamination indicator evaluation monitoring program started under interim status continues until a permit is issued or until monitoring results indicate a statistically significant change in one of the specified indicator parameters.
- ***Groundwater quality assessment*:** When contamination indicator evaluation monitoring data confirm a statistically significant change in a specified indicator parameter, then a groundwater quality assessment monitoring program is implemented. If the assessment program identifies that dangerous constituents from the site have impacted groundwater, monitoring continues under groundwater quality assessment. A groundwater quality assessment program has confirmed that an impact to groundwater has occurred, and the objectives change from looking for contamination to assessing the levels, rate, and extent of migration of site-specific contaminants.

- ***Corrective action*:** This phase of RCRA groundwater monitoring may occur if the source of the contamination is determined to be the unit and contaminant concentrations exceed applicable limits. If this occurs, Ecology may then require corrective action. Groundwater is monitored to determine if the corrective action is effective.

The requirements of WAC 173-303-645 (permitted or final status) also are conducted under one of three programs:

- ***Detection monitoring*:** A facility operating permit will include requirements for the final status detection monitoring program. Determination of a statistically significant change is made by comparing the concentrations of site-specific indicator parameters in downgradient wells to a value that is statistically derived from the background wells (usually upgradient wells unless intra-well comparisons are made). The derivation of comparison values is detailed in PNNL-13080. If a statistically significant change in one or more of the site-specific indicator parameters is confirmed and dangerous constituents from the site have impacted groundwater, then the facility is required to move to the second phase of monitoring.
- ***Compliance monitoring*:** When detection monitoring data confirm dangerous constituent(s) from the site have impacted groundwater, a compliance monitoring program is implemented. In this program, the objectives are to determine the levels and extent of contamination, and whether the groundwater concentration limit is exceeded. If a concentration limit is exceeded, corrective action may be required.
- ***Corrective action*:** Groundwater corrective action may be required if the concentration limits established under compliance monitoring are exceeded. This phase of monitoring is performed to determine if the corrective action is effective.

Table 1-4 lists the status of RCRA facility monitoring for each unit during the reporting period. The following discussion presents a compliance summary for these regulated facilities.

1.4.1 1301-N (116-N-1) Liquid Waste Disposal Facility

The 1301-N (116-N-1) Liquid Waste Disposal Facility (LWDF) is included in the Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*). The Permit states that RCRA monitoring during closure activities will follow the requirements of the *100-N Pilot Project: Proposed Consolidated Groundwater Monitoring Program* (BHI-00725). That plan and a supplemental plan (PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*) are similar to an interim status contaminant indicator evaluation program. Indicator parameters remained below their critical mean values in 2010. Upgradient/downgradient comparison values for indicator parameters have been revised based on recent data for use in 2011 comparisons. A summary of the groundwater monitoring activities for the reporting period at the 1301-N LWDF is provided in Chapter 6.0, Section 6.3.1.

1.4.2 1324-NA (120-N-1) Percolation Pond and 1324-N (120-N-2) Surface Impoundment

The 1324-NA percolation pond and the 1324-N surface impoundment are both included in the Hanford Facility RCRA Permit (WA7890008967). The Permit

states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan and a supplemental plan (PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*) are similar to an interim status contaminant indicator evaluation program. The two units are monitored as a single site (WMA) because of their proximity and similar waste types. Average specific conductance values in downgradient wells continued to exceed the critical mean value in 2010 related to increases in the nondangerous constituents sodium, calcium, and nitrate. The average total organic carbon concentration exceeded the critical mean value of 865 µg/L in well 199-N-73 in September 2010 but was below the limit of quantitation of 990 µg/L. No other critical mean exceedances occurred during the reporting period.

Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. A summary of the 1324-NA percolation pond and 1324-N surface impoundment groundwater monitoring activities for the reporting period is provided in Chapter 6.0, Section 6.3.2.

1.4.3 1325-N (116-N-3) Liquid Waste Disposal Facility

The 1325-N LWDF is also included in the Hanford Facility RCRA Permit (WA7890008967). The Permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan and a supplemental plan (PNNL-13914) are similar to an interim status contaminant indicator evaluation program. The average specific conductance values in downgradient well 199-N-41 continued to exceed the critical mean value in 2010 related to increases in the nondangerous constituents sodium, calcium, and nitrate. This exceedance is a continuation of previous exceedances noted through 2009. No other critical mean exceedances occurred in 2010. Detection monitoring will continue in 2011. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011. A summary of the groundwater monitoring activities for the reporting period at the 1325-N LWDF is provided in Chapter 6.0, Section 6.3.3.

1.4.4 183-H (116-H-6) Solar Evaporation Basins

The 183-H solar evaporation basins are the only RCRA site in the 100-H Area. The 116-H-6 solar evaporation basins are incorporated into the Hanford Facility RCRA Permit (WA7890008967) as the "183-H solar evaporation basins." The site is being monitored during the post-closure period under the corrective action monitoring requirements of WAC 173-303-645(11)(g). The RCRA Permit requires annual monitoring of the facility, which includes sampling four wells for chromium, fluoride, nitrate, technetium-99, and uranium. The four wells in the RCRA network were sampled as scheduled per the RCRA recovery schedule for the constituents of interest listed in the groundwater monitoring plan. It should be noted that wells 199-H4-3 and 199-H4-4 also serve as extraction wells for the 100-H Area pump-and-treat system. Well 199-H4-12C began to be used as an extraction well in August 2010. Overall, the contaminant concentrations at the 183-H solar evaporation basins remained below applicable Permit limits during the reporting period except for chromium in well 199-H4-12C. A summary of the 183-H solar evaporation basins groundwater monitoring activities for the reporting period is provided in Chapter 7.0, Section 7.3.

Chromium concentration in well 199-H4-12C exceeded the 122 µg/L Permit concentration limit in December 2010 at 128 and 133 µg/L in filtered and unfiltered samples, respectively. Well 199-H4-12C was converted to an extraction well in August 2010, providing a likely explanation for the increase in chromium. Nitrate

concentrations ranged from 4.83 to 939.8 mg/L during the reporting period. The non-RCRA contaminant technetium-99 was positively detected in at least one sample from each well during the reporting period, with the highest concentration in well 199-H4-12A at 94 pCi/L.

1.4.5 Low-Level Waste Management Area 1

The LLWMA-1 continued to be monitored under RCRA interim status contaminant indicator evaluation monitoring requirements in accordance with WAC 173-303-400. Specific conductance continued to exceed its critical mean value. This is a continuation of previously reported increases associated with non-RCRA constituents. Two additional wells were installed in anticipation of shrinking the footprint of the WMA. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. A summary of the LLWMA-1 groundwater monitoring activities for the reporting period is provided in Chapter 9.0, Section 9.3.1.

1.4.6 Low-Level Waste Management Area 2

The LLWMA-2 continued to be monitored under RCRA interim status contaminant indicator evaluation monitoring requirements in accordance with WAC 173-303-400. All RCRA indicator parameters were below the respective critical mean values. The DOE believes the monitoring network is capable of detecting constituents migrating from the site into the uppermost aquifer because wells are located along the west and south boundaries while the elevation of the basalt rises above the aquifer to the north and east. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. A summary of the LLWMA-2 groundwater monitoring activities for the reporting period is provided in Chapter 9.0, Section 9.3.2.

1.4.7 Waste Management Area B-BX-BY

The WMA B-BX-BY continued under an interim status groundwater assessment program during the reporting period in accordance with WAC 173-303-400. The primary dangerous waste constituent found beneath WMA B-BX-BY is cyanide. It is important to note that the cyanide found beneath WMA B-BX-BY did not originate from the WMA, but rather from an adjacent non-RCRA waste site. Nitrate is monitored as a major supporting constituent. Contaminant levels in network monitoring wells continued general increasing trends during the reporting period, with the non-RCRA constituents nitrate, nitrite, sulfate, technetium-99, and uranium above their respective DWSs in wells monitoring the tank farms. The DOE believes the monitoring network, including five new RI wells installed in FY 2008, will remain capable of monitoring the extent and concentrations of contaminants in 2011. A revised and updated groundwater monitoring plan for this unit was submitted for review to DOE and Ecology in October 2010 (DOE/RL-2009-72, *Interim Status Groundwater Quality Assessment Plan for WMA B-BX-BY*). A summary of the WMA B-BX-BY groundwater monitoring activities for the reporting period is provided in Chapter 9.0, Section 9.3.3.

1.4.8 Waste Management Area C

The RCRA groundwater quality assessment monitoring continued at this WMA in CY 2010 in accordance with WAC 173-303-400. Cyanide, a dangerous waste constituent, was determined to be associated with releases from WMA C. Metals and volatile organics continue to be evaluated. Two wells were added to the well network in CY 2010 and provided sufficient information to establish the extent

of the dangerous waste constituent cyanide. Four non-RCRA constituents were reported above the DWS at WMA C: nitrate, sulfate, iodine-129, and technetium-99. The groundwater quality assessment plan was issued in June 2010 (DOE/RL-2009-77, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C*). A summary of the WMA C groundwater monitoring activities for the reporting period is provided in Chapter 9.0, Section 9.3.4.

1.4.9 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility (LERF) operates under final status Permit conditions agreed to by DOE and Ecology, but statistical analyses are not yet performed on results. Analysis of samples collected during the reporting period indicate that all constituents in the permit were either undetected or were below Permit limits. All four of the wells at the LERF were sampled as required and the DOE believes remain capable of detecting constituents migrating from the site into the uppermost aquifer in CY 2011. A new final status plan was prepared and is pending inclusion in the Permit. A summary of the LERF groundwater monitoring activities for the reporting period is provided in Chapter 9.0, Section 9.3.5.

1.4.10 216-B-63 Trench

The 216-B-63 Trench continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with WAC 173-303-400. The DOE believes the monitoring well network is capable of determining groundwater quality downgradient of the site and for performing required statistical comparisons. To date, the required statistical evaluations of the RCRA contamination indicator parameters have not exceeded critical mean values and do not indicate that the 216-B-63 Trench has affected groundwater quality in the uppermost aquifer beneath the unit. A revised and updated groundwater monitoring plan for this unit was issued in June 2010 (DOE/RL-2008-60, *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench*). The revised plan reduced the number of wells in the network from twelve to seven. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. A summary of the 216-B-63 Trench groundwater monitoring activities for the reporting period is provided in Chapter 9.0, Section 9.3.6.

1.4.11 Integrated Disposal Facility

The Integrated Disposal Facility (IDF) is an expandable, lined, RCRA-compliant landfill in detection monitoring, in accordance with WAC 173-303-645(9). The facility is not yet receiving waste. A Permit modification approved in June 2010 changes the frequency of sample collection to once per year during the pre-active life of the unit. A summary of the IDF groundwater monitoring activities for the reporting period is provided in Chapter 10.0, Section 10.3.1.

1.4.12 RCRA PUREX Cribs

The RCRA Plutonium-Uranium Extraction (PUREX) Cribs remained in interim status groundwater quality assessment monitoring in accordance with WAC 173-303-400. The non-RCRA constituent nitrate remained above the DWS during the reporting period. The 216-A-10 Crib has been removed from the Permit after meeting closure requirements in March 2010. Revised groundwater monitoring plans were written for the 216-A-36B Crib and 216-A-37-1 Crib (DOE/RL-2010-92, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*; DOE/RL-2010-93, *Interim Status Groundwater Monitoring Plan for the 216-A-36B PUREX Plant Crib*). These two units will be monitored under interim status indicator

evaluation programs beginning in 2011. A new set of data will be collected for each of the units to determine the indicator parameter background comparison values. Groundwater samples scheduled for October were obtained in either November or December. A summary of the groundwater monitoring activities for the reporting period at the PUREX Cribs is provided in Chapter 10.0, Section 10.3.2.

1.4.13 Waste Management Area A-AX

During 2010, WMA A-AX remained in interim status groundwater assessment monitoring in accordance with WAC 173-303-400. With the installation of well 299-E25-236 in 2008, the DOE believes the groundwater monitoring well network is capable of assessing groundwater contamination from the site. Two wells scheduled for sampling in December 2010 were not sampled: one well is upgradient and the other well is used for information purposes only and not for RCRA decision purposes. Sampling at these two wells was missed due to the work stoppage in October 2010. A new groundwater monitoring plan (DOE/RL-2009-70, *Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX*) is being reviewed by Ecology. Until the new monitoring plan is approved, WMA A-AX will continue to be monitored under the existing groundwater monitoring plan (PNNL-15315, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*). A summary of the WMA A-AX groundwater monitoring activities for the reporting period is provided in Chapter 10.0, Section 10.3.3.

1.4.14 216-A-29 Ditch

The 216-A-29 Ditch continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with WAC 173-303-400. Required statistical evaluations of the specified indicator parameters continue to show specific conductance above the critical mean in three wells. The elevated specific conductance is from nondangerous constituents. To date, no dangerous waste/dangerous waste constituent subject to WAC 173-303 regulations has affected groundwater quality in the uppermost aquifer beneath the 216-A-29 Ditch. A revised and updated groundwater monitoring plan for this unit was issued in March 2010 (DOE/RL-2008-58, *Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch*). Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. The DOE believes the monitoring well network is capable of determining groundwater quality downgradient of the site and for performing the required statistical comparisons. A summary of the groundwater monitoring activities for the reporting period at the 216-A-29 Ditch is provided in Chapter 10.0, Section 10.3.4.

1.4.15 216-B-3 Pond

The 216-B-3 Pond continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with WAC 173-303-400. To date, the required statistical evaluations of the specified indicator parameters have not exceeded critical mean values and do not indicate that the 216-B-3 Pond has affected the groundwater quality in the uppermost aquifer beneath the unit. A revised and updated groundwater monitoring plan for this unit was issued in September 2010 (DOE/RL-2008-59, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*). The DOE believes the revised monitoring well network continues to be capable of determining groundwater quality downgradient of the site and for performing required statistical comparisons. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011

comparisons. A summary of the 216-B-3 Pond groundwater monitoring activities for the reporting period is provided in Chapter 10.0, Section 10.3.5.

1.4.16 Nonradioactive Dangerous Waste Landfill

During 2010, the Nonradioactive Dangerous Waste Landfill (NRDWL) was monitored under interim status contamination indicator evaluation monitoring in accordance with WAC 173-303-400. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. A summary of the NRDWL groundwater monitoring activities for the reporting period is provided in Chapter 10.0, Section 10.3.6. All wells were sampled during the timeframe scheduled, with the exception of well 699-25-34A; the first semiannual sample for the January through July timeframe was not collected due to limited sampling team resources.

Also in 2010, a new RCRA groundwater monitoring plan was written for the combination of the NRDWL and the Solid Waste Landfill (SWL) (DOE/RL-2010-28, Rev. 1, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill*). Because the two landfills are adjacent, combining the remedial action for the two landfills was considered a reasonable option to maximize available resources. In the new plan, NRDWL groundwater monitoring will move into RCRA final status under WAC 173-303-645. The plan is currently being reviewed by Ecology; until the plan is approved, the NRDWL will continue to be monitored under the current groundwater monitoring plan (PNNL-12227).

1.4.17 Waste Management Area S-SX

The WMA S-SX remained in interim status groundwater quality assessment monitoring in accordance with WAC 173-303-400. The RCRA-regulated dangerous constituent chromium and supporting constituent nitrate exist in two plumes that extend downgradient of the WMA at concentrations above their respective DWSs. A revised monitoring plan (DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*) was issued and will be implemented in January 2011. The revised monitoring system is believed by DOE to be capable of monitoring the distribution of contamination. A summary of the WMA S-SX groundwater monitoring activities for the reporting period is provided in Chapter 11.0, Section 11.3.1.

1.4.18 Waste Management Area U

The WMA U remains in interim status groundwater quality assessment monitoring in accordance with WAC 173-303-400. Nitrate remained above the DWS during the reporting period, while the RCRA-regulated dangerous constituent chromium remained below the analytical detection limit. A revised monitoring plan (DOE/RL-2009-74, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*) was prepared and will be implemented in January 2011. The DOE believes the revised monitoring system is capable of monitoring the distribution of contamination from the WMA. A summary of the WMA U groundwater monitoring activities for the reporting period is provided in Chapter 11.0, Section 11.3.2.

1.4.19 216-S-10 Pond and Ditch

The 216-S-10 Pond and Ditch remain in interim status contaminant indicator evaluation monitoring in accordance with WAC 173-303-400. The period of CY 2009 marked completion for collection of four quarters of RCRA-compliant data from the new upgradient well; thus, new background values were calculated for CY 2010

for the required upgradient/downgradient comparisons. However, due to extreme variability in the total organic carbon results (standard deviation of 2,371), only the parameters of pH, specific conductance, and total organic halides were used from the new well. Additional quarterly sampling was performed during CY 2010, and the data indicate total organic carbon concentrations beginning to stabilize, likely yielding useable values for CY 2011.

To date, RCRA contamination indicator parameters have not exceeded critical mean values and do not indicate that the 216-S-10 Pond and Ditch have affected the groundwater quality in the uppermost aquifer beneath the unit. A revised monitoring plan for this unit was issued in March 2010 (DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*). The DOE believes the revised monitoring system is capable of determining groundwater quality downgradient of the site and for performing the required statistical comparisons. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in 2011 comparisons. A summary of the groundwater monitoring activities for the reporting period at the 216-S-10 Pond and Ditch is provided in Chapter 11.0, Section 11.3.3.

1.4.20 Low-Level Waste Management Area 3

The LLWMA-3 continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with WAC 173-303-400. Statistical evaluations at LLWMA-3 are suspended until the effects of the enhanced 200-ZP-1 OU pump-and-treat system are known and a new upgradient well is installed. A new interim status monitoring plan went into effect during CY 2010 (DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*). A new upgradient monitoring well is planned for construction during CY 2011. During the reporting period, carbon tetrachloride was the only constituent exceeding its DWS. All wells were successfully sampled during the reporting period. Interim status indicator evaluation groundwater monitoring at LLWMA-3 will continue in CY 2011. A summary of LLWMA-3 groundwater monitoring activities for the reporting period is provided in Chapter 12.0, Section 12.4.1.

1.4.21 Low-Level Waste Management Area 4

The LLWMA-4 continued in interim status contaminant indicator evaluation monitoring throughout the reporting period in accordance with WAC 173-303-400. A new interim status monitoring plan went into effect during CY 2010 (DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*). The last active upgradient well, 299-W18-21, went dry in 2010 but sufficient data exist for statistical evaluations to continue for this and future reporting periods using critical means calculated from the most recent several years of data. Construction of an upgradient well is not expected until the effects of the enhanced 200-ZP-1 OU pump-and-treat system are known.

Results of the first determination assessment did not find dangerous waste/dangerous waste constituents in the groundwater; thus, indicator evaluation groundwater monitoring at LLWMA-4 will continue in CY 2011. A summary of LLWMA-4 groundwater monitoring activities for the reporting period is provided in Chapter 12.0, Section 12.4.2.

1.4.22 Waste Management Area T

The WMA T remains in interim status groundwater quality assessment monitoring in accordance with WAC 173-303-400. The primary dangerous waste constituent in

groundwater from WMA T is chromium. Chromium and the supporting constituents fluoride and nitrate each had at least one well that exceeded the DWS for that contaminant during the reporting period. A new interim status assessment monitoring plan (DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*) was approved at the end of the reporting period and went into effect at the beginning of CY 2011. The well network is believed by DOE to be capable of monitoring the distribution of contamination from the WMA, and all wells were sampled as scheduled during the reporting period. A summary of groundwater monitoring activities for the reporting period at WMA T is provided in Chapter 12.0, Section 12.4.3.

1.4.23 Waste Management Area TX-TY

The WMA TX-TY remains in interim status groundwater quality assessment monitoring in accordance with WAC 173-303-400. The primary dangerous waste constituent in groundwater at the WMA is chromium. A new interim status assessment monitoring plan (DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*) was approved at the end of the reporting period and went into effect at the beginning of CY 2011. Chromium and the co-contaminant nitrate each continued to exceed their respective DWS in wells monitoring the WMA during the reporting period. Other non-RCRA contaminants, technetium-99 and iodine-129, also exceeded their respective DWSs in wells at the WMA. The DOE believes the well network remains capable of monitoring the distribution of contamination from the WMA, and all wells were sampled as scheduled during the reporting period. A summary of the WMA TX-TY groundwater monitoring activities for the reporting period is provided in Chapter 12.0, Section 12.4.4.

1.4.24 Former 300 Area Process Trenches (316-5 Waste Site)

Groundwater is monitored under a corrective action program in accordance with the final status requirements of WAC 173-303-645(11). The modified closure plan (DOE/RL-93-73, *300 Area Process Trenches Modified Closure/Postclosure Plan*), which is incorporated into the Hanford Facility RCRA Permit (WA7890008967), states that groundwater remediation is deferred to the 300-FF-5 OU under CERCLA. Sampling and reporting were performed as scheduled during the reporting period. It is the belief of the DOE that the network of one upgradient well (north of the former facility) and three downgradient wells (east, southeast, and south of the facility) remains capable of detecting constituents migrating from the site into the uppermost aquifer.

Concentrations of cis-1,2-dichloroethene in the RCRA network monitoring wells ranged from nondetect to 4.8 µg/L. Analytical results for trichloroethene were all below the detection limit of 1 µg/L during 2010, with the exception of two detections in samples from well 399-1-16B (1.4 and 1.1 µg/L) and one estimated detection at well 399-1-17A (0.31 µg/L). Analytical results for tetrachloroethene were all below the 1 µg/L detection limit during 2010.

1.5 Other Regulated Facilities

This section provides a brief status of compliance for non-RCRA facilities on the Hanford Site that require groundwater monitoring under other regulations (e.g., solid waste rules). Details on sampling at these facilities are in the appropriate chapters of this report.

1.5.1 Solid Waste Landfill

The SWL, located south of the NRDWL, is regulated by Ecology under WAC 173-350, "Solid Waste Handling Standards." The WAC 173-350 constituents and site-specific constituents (including volatile organic compounds and filtered arsenic) are similar to the WAC 173-304 ("Minimum Functional Standards for Solid Waste Handling") requirements for which the groundwater monitoring plan was written in 2000 (PNNL-13014, *Groundwater Monitoring Plan for the Solid Waste Landfill*). The WAC 173-304 requirements were replaced by WAC 173-350. The regulated constituents are analyzed quarterly. Compliance is determined by comparing sampling results from downgradient wells with statistically derived background threshold values from upgradient wells. However, some downgradient wells continue to show chemical oxygen demand, coliform bacteria, specific conductance, and sulfate above compliance limits, as well as pH below the compliance limit. During 2010, the January, April, and July sampling events occurred as scheduled, but the October sampling event was delayed until December 2010 due to the work stoppage. In addition, three of the nine network wells were not sampled in December 2010. A summary of the SWL groundwater monitoring activities for the reporting period is provided in Chapter 10.0, Section 10.4.1.

During CY 2010, a new RCRA groundwater monitoring plan was written, combining groundwater monitoring at the SWL with the NRDWL (DOE/RL-2010-28, Rev. 1). Because the two landfills are adjacent, combining the remedial action for the two landfills was considered a reasonable option to maximize available resources. At the SWL, closure and post-closure groundwater monitoring are subject to the requirements of WAC 173-350-500 ("Solid Waste Handling Standards," "Ground Water Monitoring"); however, compliance with groundwater monitoring requirements for the SWL will be achieved through deferral under WAC 173-350-710(8) to equal or greater requirements within WAC 173-303-645. The combined monitoring plan is currently under review by Ecology. Until the plan is approved, the SWL will continue to be monitored under the existing groundwater monitoring plan (PNNL-13014).

1.5.2 Treated Effluent Disposal Facility

The 200 Area Treated Effluent Disposal Facility is monitored under *State Waste Discharge Permit ST 4502* (Ecology, 2000b), WAC 173-216 ("State Waste Discharge Permit Program"), and the *Groundwater Monitoring Plan for the Hanford Site 200 Area Treated Effluent Disposal Facility* (PNNL-13032). The wells are monitored for three constituents with enforcement limits (lead at 5 µg/L, cadmium at 10 µg/L, and pH of 6.5 to 8.5) as required by the state waste discharge permit. Specific conductance, gross alpha and beta, anions, metals, total dissolved solids, trace metals, and tritium are monitored as indicator parameters. During 2010, all groundwater samples were collected as scheduled, and none of the enforcement limits were exceeded. A summary of the groundwater monitoring activities for the reporting period at the Treated Effluent Disposal Facility is provided in Chapter 10.0, Section 10.4.2.

1.5.3 State-Approved Land Disposal Site

The State-Approved Land Disposal Site is monitored under *State Waste Discharge Permit ST 4500* (Ecology, 2000a), WAC 173-216, and the *Groundwater Monitoring and Tritium Tracking Plan for the 200 Area State-Approved Land Disposal Site* (PNNL-13121). Twelve wells are monitored for tritium, and the three proximal wells are monitored for additional constituents including pH, specific conductance, metals, anions, total dissolved solids, and volatile organic analytes. Concentrations of all

chemical constituents with permit limits were within those limits or below detection limits during the reporting period. During the reporting period, all groundwater samples were collected as scheduled. A summary of the groundwater monitoring activities for the reporting period at the State-Approved Land Disposal Site is provided in Chapter 12.0, Section 12.4.5.

1.6 Shoreline Monitoring

M.J. Hartman

Monitoring groundwater quality along the Columbia River is accomplished by collecting samples from aquifer tubes and riverbank springs.

The DOE monitors groundwater quality along the Columbia River by collecting samples from aquifer tubes and riverbank seeps (springs). In 2010, DOE concluded its study and collection of porewater from within the gravel and sand of the Columbia River bed to define where groundwater is discharging to the river.

Hydrologists estimate that groundwater currently flows from the Hanford Site unconfined aquifer to the Columbia River at a rate between 0.8 and 2.8 cubic meters per second (PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*; PNNL-SA-56038, *Hanford Site Groundwater and the Columbia River, South-Central Washington*). This rate is less than 0.001% of the average flow of the Columbia River, ~3,400 cubic meters per second.

Water samples from aquifer tubes and riverbank seeps represent a mixture of river water and groundwater.

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

Aquifer tubes are small-diameter, flexible tubes that have a screen on one end. The tubes are installed in the aquifer along the Columbia River shoreline. Water is withdrawn from the tube using a portable peristaltic pump. Appendix C provides additional information for the aquifer tubes. Most aquifer tube sites include two or three individual tubes monitoring different depths, from ~1 to 8 meters.

Data from aquifer tubes and seeps are used for the following purposes:

- Data provide indication of the minimum concentrations of contaminants in groundwater approaching the Columbia River.
- Long-term decreases or increases in contamination in aquifer tubes or seeps may indicate real trends in groundwater. Declines could represent movement of the plume, discharge of the plume to the river, dispersion, or the influence of an upgradient remediation system. Increasing concentrations may indicate plume movement or mobilization of contaminants.
- Data from aquifer tubes have helped determine locations for additional monitoring and remediation (e.g., aquifer tube data provided the first indication of the southern 100-D Area chromium plume).

When interpreting these data, the following limitations should be noted:

- Concentrations in aquifer tubes and seeps may vary seasonally and even more frequently based on Columbia River stage (the same is true for near-river wells).
- Dilution of contaminants by mixing with river water can result in lower concentrations; though the amount (mass) of that contaminant is not decreased.

- Because aquifer tubes have much shorter screens than monitoring wells, the data may not be directly comparable to data from near-river wells.
- Aquifer tube and seep data are currently not used in remedial action decision making (i.e., the data are not compliance points for pump-and-treat systems).

In October 2008, the DOE released the *Technical Evaluation of the Interaction of Groundwater with the Columbia River at the U.S. Department of Energy Hanford Site, 100-D Area* (SGW-39305). The report provides an expert panel's observations and suggestions to improve the current understanding of groundwater/surface water interactions in the 100 Area, primarily focusing on the 100-D Area. The recommendations included integrity testing of aquifer tubes. In early 2010, staff evaluated specific conductance data from aquifer tubes collected before and after sampling. The results indicated that pumping the tubes does not cause Columbia River water to migrate down the boring and cause sample dilution (Appendix C).

Aquifer tube sampling is governed by the *Sampling and Analysis Plan for Aquifer Sampling Tubes* (DOE/RL-2000-59). The individual OU sections of this report summarize aquifer tube results and include location maps, and Appendix C provides supporting information for the aquifer tube sampling. Table 1-3 lists the maximum contaminant concentrations in aquifer tubes sampled during the reporting period.

1.7 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 5 years. The DOE released *The Second* CERCLA *Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) in November 2006. The purpose of the review was to determine whether the selected remedies remain protective of human health and the environment, as well as to recommend appropriate corrective actions if the remedy is not achieving the established goals.

The review identified twenty issues and recommended corrective actions to ensure that selected remedies remain protective of human health and the environment. The three actions pertaining to the River Corridor cross OU boundaries and have all been completed (DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*).

1.8 Quality Control Summary

C.J. Thompson

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 are reliable and defensible. Specific data values that are associated with out-of-limit quality control results (field blanks, field duplicates, and laboratory blanks) are flagged in the Hanford Environmental Information System (HEIS) database so users can be circumspect when using such data for interpretation. A detailed description of the quality control program and the quality control results for CY 2010 are provided in Appendix D, and highlights include the following:

Evaluation of the groundwater project quality assurance program indicates that the data for the reporting period are reliable and defensible.

The HEIS database can be accessed through the Environmental Dashboard Application at http://environet.hanford.gov/EDA/.

- Ninety percent of the groundwater monitoring data were 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 low-level detections of metals in laboratory blanks.
- 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 97% of the field blank, 93% of the field duplicates, and 95% of the split sample results were acceptable, indicating good sampling and analytical performance.
- Recommended holding times were met for 99% of nonradiological sample analysis requests.
- Overall, laboratory performance for Soil and Groundwater Remediation Project blind standards was fair; 84% of the results were acceptable. Failures for anions, hexavalent chromium, low-level iodine-129, and total organic carbon suggest that some groundwater results could also be biased. These problem areas will be investigated further during 2011.
- Approximately 98% of the laboratory quality control results were within acceptance limits, indicating that the analyses were in control and reliable data were generated. Specifically, 99.2% of method blanks, 99.6% of the laboratory control samples, and 99% of the matrix spikes and matrix duplicates were within the acceptance limits.
- Audits and assessments of the laboratories were conducted by DOE and its contractors. Several findings and observations were identified, along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

1.9 Other Information Sources

Other reports and databases relating to Hanford Site groundwater are discussed below.

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 chemistry and survey data).

PNNL-20548, Hanford Site Environmental Report for Calendar Year 2010. The annual report summarizes environmental data, including groundwater, riverbank seeps, and river water. It also describes environmental management performance and reports the status of compliance with environmental regulations.

Quarterly RCRA summary. The DOE provides formal quarterly presentations to Ecology after groundwater data 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.

Pump-and-treat reports. The details on operations and effectiveness of the various pump-and-treat operations on the Hanford Site are presented in independent annual reports. The annual reports discuss the removal and treatment efficiencies for the year, as well as any operational issues for the pump-and-treat systems.

RI/FS work plans. The DOE recently released work plans for the 100 Area (DOE/RL-2008-46) and the 300 Area (DOE/RL-2009-30). These documents present a strategy to assist in the decisions to complete cleanup in 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. Some recent documents associated with this effort include the following:

- **DOE/RL-2007-21, *Risk Assessment for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment*:** The risk assessment addresses post-remediation residual contaminant concentrations in the 100 and 300 Areas, as well as the Hanford and White Bluffs town sites.
- **DOE/RL-2005-42, *100 Area and 300 Area Component of the RCBRA Sampling and Analysis Plan*:** The plan presents the rationale and approach for sampling and analysis to support risk characterization.
- **WCH-274, *Inter-Areas Component of the River Corridor Baseline Risk Assessment Sampling Summary*:** This document describes the 2006 to 2007 supplemental data collection effort, including sampling locations, samples collected, and any modifications and additions made to the sampling and analysis plan for the 100 and 300 Areas Component of the baseline risk assessment.

***Freedom of Information Act request*:** As with any public agency, not all data are directly available to the general public. However, most information can be obtained by contacting the operating agency (in the case of the Hanford Site, the DOE Richland Operations Office) and requesting the specific data under the *Freedom of Information Act of 1966*.

1.10 Conventions Used in This Report

The well location maps presented in this report include any well used for sampling or water-level measurements over the past 5 years. Wells that have gone dry or that have been decommissioned during this time 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.

Unless specified otherwise, contaminant plume maps in this report are based on average results for samples collected during CY 2010 for each well shown, excluding data that appear to be nonrepresentative. Data representativeness is determined by the project scientist in charge of the OU or monitored unit using various methods and best professional judgment (Appendix D). Data are averaged to include wells sampled at different times and at different frequencies. In some locations or for certain operations (i.e., pump-and-treat operations), it is advantageous to construct maps based on data from a single sampling event (e.g., chromium in the 100-D Area in spring 2010). Such maps are captioned with the specific timeframe illustrated.

Contour levels for the maps in this report were chosen to meet the following objectives:

- DWSs[1] and multiples of 10 (e.g., 8, 80, and 800 pCi/L for strontium-90)
- Common divisions, such as 50, 100, 500, etc.

1 Although most maps are contoured to a constituent's drinking water standard, the area impacted by the contaminant (i.e., the area with constituent concentrations elevated above background) can be considerably larger.

- Cleanup levels, where applicable (e.g., 20 µg/L for hexavalent chromium)
- Intermediate levels to help define plume shape (e.g., 30, 90, 300, 600, 900, and greater than 2,000 µg/L for uranium).

Uncertainty in plume boundary location is indicated by the use of dashed versus solid contour lines. Where a dense population of wells exists (e.g., within the 200 East Area), the contour lines are shown as solid, indicating good control on the contaminant concentration distribution. Where the well population is less dense, the contour lines may be dashed to indicate a lesser degree of control on the contaminant concentration distribution. Contours are revised based on the previous year's locations and any new data or interpretation of subsurface conditions. In addition, it is important to note that the interface between contaminated and uncontaminated groundwater is not a sharp boundary because of the heterogeneity in pathways followed by groundwater and the diffusion characteristics of the contaminant. Therefore, lines showing equal contaminant concentrations are generalizations with regard to the exact extent of contamination.

Mapped data are rounded to two significant digits. The plume maps are drawn manually and represent the best professional interpretations by project staff using current and historical data, source knowledge, and groundwater flow directions. Staff used data from CY 2008 and CY 2009 if new data were not available for a well in CY 2010. Wells that did not have samples collected during the reporting period and use older data for averaging are given a different symbol than used for wells with current-year data. Older data and data from aquifer tubes along the Columbia River are given less weight than the current well data when maps are contoured. Most maps show data from wells completed in the upper portion of the unconfined aquifer (i.e., generally the top ~10 meters).

Results that were less than detection limits (i.e., flagged as "U" in the HEIS database) are treated in one of two ways when constructing maps:

- For chemical constituents (including total uranium), "U"-flagged values represent the analytical detection limits. These values are treated as zeroes in the data to be averaged. If all of the results (or the only result) for the year were undetected, a "U" qualifier is plotted on the map. If the data represent a mixture of detected and undetected results, the average value is plotted on the map followed by an asterisk (*). If the data represent only detected results, the average value is plotted on the map.
- For radiological parameters, if the counting error is greater than the result, the result is flagged with "U." Other factors may also result in values being "U"-flagged. For plotting on maps, all of the results for the year are averaged, regardless whether or not "U"-flagged, because the reported values are statistically significant. The average values are plotted on the map, followed by "U" (if all results for the year were undetected) or an asterisk (if the data represent a mixture of detected and undetected values). It should be noted that the laboratories correct the results for background radiation, which in some cases can result in values that are negative.

Conventions for handling undetected values do not adversely affect data interpretation for most constituents because the contour intervals are far above detection limits. A notable exception is iodine-129. Iodine-129 is contoured at 1 pCi/L (the DWS), which, in some cases, has been less than the laboratory's detection limit. Historically, the laboratory required that both primary and secondary energy peaks be present before considering iodine-129 as detected. Requiring the secondary

(less sensitive) energy peak added conservatism to the laboratory's report (i.e., the laboratory reports a detection only when certain of the detection); however, review of data indicated that many "U"-flagged values were actual detections and were included in the contours. In FY 2009, groundwater analytical support staff worked with the laboratories to improve the iodine-129 method and resolve the issues identified in FY 2008. The goal was to ensure that the detection levels reported were at or below the 1 pCi/L DWS. This effort was successful, enabling future data to be at or below the DWS. However, 3 years of data are used to support the plume contours. Until sufficient data using the improved technique are obtained, the contour lines will be dashed to show that the distribution of iodine-129 at levels near the DWS is less certain than other contaminants.

The federal and state DWS for nitrate is 10 mg/L (for nitrate measured as nitrogen [NO_3-N]); this relates to the actual nitrogen in nitrate. To convert NO_3-N values to nitrate requires the NO_3-N value to be multiplied by 4.43. Nitrate plume maps provided in this report reflect the converted values and, as such, the DWS appears as 45 mg/L in figures and tables.

Trend plots may omit results that appear to be erroneous if they distort or obscure the scale and data trends; the figure caption and/or text 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. Discussion of increasing or decreasing trends is generally based on qualitative observation and not on statistical evaluation.

This report uses the following conventions for chemical results:

- Text, figures, and tables express nitrate and nitrite as the NO_3^- and NO_2^- ions, respectively.
- Maps showing chromium include total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples. Dissolved chromium in Hanford Site groundwater is virtually all hexavalent (WHC-SD-EN-TI-302, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*), so filtered total chromium data effectively represent hexavalent chromium. Appendix C of DOE/RL-2008-01 compares chromium data from filtered, unfiltered, total, and hexavalent analyses.
- Contaminant concentrations are compared with state or federally enforceable DWSs (Table 1-5). Although Hanford Site 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 guides and risk-based concentrations based on cancer risk coefficients, as well as DWSs (Table 1-6).

Dissolved chromium in Hanford Site groundwater is virtually all hexavalent.

1.11 Sources of Additional Information

All of the data presented in this report are provided on a CD-ROM accompanying this report. Data may also be reviewed on the internet through the DOE's Environmental Dashboard Application at http://environet.hanford.gov/EDA/.

The documents referenced in this report are generally available at the public reading rooms around the state. Some documents are also available online as part

of the Administrative Record at http://www5.hanford.gov/arpir/. Requests for documents can also be made through inter-library loan directly to the DOE or Pacific Northwest National Laboratory libraries.

For additional information on contaminants that are found at the Hanford Site, see Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas (Peterson et al. 2007), available on the Environmental Assessment Division, Argonne National Laboratory website (http://www.ead.anl.gov/pub).

Table 1-1. Reporting Requirements for Groundwater Monitoring

Operable Unit or Facility	Formal Report	Supplemental Report or Summaries
CERCLA		
OUs without RODs (100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1)	This report	Unit managers' meeting presentations
OUs 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
OU 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 (PUREX Cribs; 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-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)	Annual report (latest is SGW-42604)	This report
TEDF (WAC 173-216)	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."

Table 1-2. Number of Groundwater Analyses for Selected Constituents, CY 2010

Constituent	Site Total
Carbon tetrachloride	1,273
Chromium (total)	4,333
Chromium (hexavalent)	4,637
Iodine-129	859
Nitrate	2,883
Plutonium-239/240	55
Strontium-90	861
Technetium-99	1,395
Trichloroethene	1,273
Tritium	1,930
Uranium	1,279

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Table 1-3. Maximum Concentrations of Selected Groundwater Contaminants in Groundwater Interest Areas, January Through December 2010

Contaminant, Units (alphabetical order)	DWS (DCG)[a]	100-BC-5 OU		100-KR-4 OU		100-NR-2 OU		100-HR-3-D		100-HR-3-H		300-FF-5 OU		1100-EM-1		100-FR-3 OU	200-BP-5 OU	200-PO-1 OU	200-UP-1 OU	200-ZP-1 OU	Confined Aquifers
		Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Wells	Wells	Wells	Wells	Wells
1,1,1-Trichloroethane, µg/L	200																	0.21			
1,1-Dichloroethene, µg/L	7																	0.14			
1,2-Dichloroethane, µg/L	5					0.72				0.67						0.82					
1,4-Dichlorobenzene, µg/L	75															0.78	0.39				
Antimony, µg/L	6			**52.8**		**40.2**	**44**			0.862		**54.7**				4.3	**59.7**	**62.2**	**48**	**52**	
Antimony (filtered), µg/L	6			**42.4**		**53.2**		**39.1**		0.932		**51.8**	**50.5**	**56**		**55**	**61.9**	**46.4**	**50**	**49**	
Arsenic, µg/L	10	3.6		7.2	2.6	**101**	**11.1**	7.52	2.53	8.24	1.79	**15.7**		**12.7**		**12.7**	**24.6**	**50**	5.8	**12**	
Arsenic (filtered), µg/L	10	5.37		**68**	2.03	**95**	**10.6**	7.16	2.39	**65**	2.21	**60**		**12.2**		**13.5**	**22.9**	**13.8**	5.6	9.45	
Barium, µg/L	2,000	88	53	100	74.6	616	150	1,070	168	128	56	101	117	161	85.3	153	330	249	125	474	
Barium (filtered), µg/L	2,000	146	34	98	51.2	350	105	1,100	177	121	23	102	91.8	168	82.7	157	233	158	125	431	
Benzene, µg/L	5					1.1					0.095										
Beryllium, µg/L	4	0.127		0.226		1.9	0.129	0.307	0.41					0.188			0.146				
Beryllium (filtered), µg/L	4	0.116		0.192		**20**	0.106	0.164		0.379		0.369						**49**	1.4		
Cadmium, µg/L	5			0.072	0.1	**6.6**		**5.9**	0.43	**7.6**			4.6		**6.4**		**31**	4.4			
Cadmium (filtered), µg/L	5	0.063				**14.4**		0.308		0.392		1.3	4.7			0.059			1.5	4.1	
Carbon tetrachloride, µg/L	5					4.2				0.16		**7.4**	3.3				0.22		**1,200**	**2,900**	
Carbon-14, pCi/L	2,000 (70,000)			**10,100**	92.2		13.8									70.7	436	15.9	12.6		
Cesium-137, pCi/L	200	2.04															**2,180**				
Chlorobenzene, µg/L	100			0.17												0.24					
Chloroform, µg/L	100	3		2.2		7.1		5.1	0.32	1.5	1.8	7.1	2.7			1.9	0.66	1.1	12	17	
Chromium, µg/L	100	68.5	15	**1,010**	65	**217**	24	**61,100**	**228**	**133**	37	23		3.18		98.2	**284**	39	**1,100**	**731**	
Chromium (filtered), µg/L	100	56.1	15	**997**	58	**192**	8.72	**5,730**	**241**	**128**	36	28.2		1.81		93	**333**	**288**	**1,180**	**732**	
cis-1,2-Dichloroethylene, µg/L	70										0.093	**170**	0.22								
Cobalt-60, pCi/L	100			12													79			14	
Cyanide, µg/L	200					4.1						3.7					**1,590**			8.4	
Endrin, µg/L	2					0.16															
Ethylbenzene, µg/L	700					9.4			0.11		0.19										
Fluoride (filtered), µg/L	4,000	222															165	338			
Fluoride, µg/L	4,000	290	126	354	130	784	949	1,430	252	468	89.1	3,520	511	1,320	240	610	**97,200**	**9,220**	587	**4,490**	
Gross alpha, pCi/L	15	6.4	2.7	**18**		**18**		9.1		7.9		**74**	**73**	**24**	8.4	11	**1,800**	**26**	2.3	8.2	
Gross beta, pCi/L	50	**110**	16	**180**	9.4	**30,000**	**2,900**	27	4.8	**69**	11	**140**	**57**	**63**	15	**78**	**21,000**	**2,800**	**1,300**	**4,800**	
Gross beta (filtered), pCi/L	50	15																			
Hexavalent Chromium, µg/L	100	57	34.8	**974**	68.6	**189**	5.2	**59,500**	**270**	**139**	39					91.9	**381**	5.8	70.3	52.9	
Hexavalent Chromium (filtered), µg/L	100	58	34.8	**966**	73.5	**186**	5.3	**63,200**	**294**	**140**	42.2					92.9	**380**	5.9	75.2	52.9	
Iodine-129, pCi/L	1																**6.51**	**9.68**	**8.7**	**39.6**	
Mercury, µg/L	2			0.042													1.35			0.136	
Mercury (filtered), µg/L	2			0.11		1.82											1.39			0.125	
Methylene chloride, µg/L	5					**12**		0.61		0.62		1.6				0.18	0.2	1.2	1.7	**15**	
Nickel, µg/L	100	9	7	**109**	7	**633**	9	**143**	**170**	16		56		7.9		36	98.4	31	**197**	**247**	
Nickel (filtered), µg/L	100	7	6	97.9	4	**1,510**	6	**138**	**171**	19		53.7	4	9.3		30	99.7	25	**183**	91	
Nitrate, µg/L	45,000	44,200	13,800	**84,600**	22,800	**500,000**	**753,000**	**99,200**	37,000	43,700	3,660	**136,000**	**78,200**	**338,000**	**88,000**	**139,000**	**1,540,000**	**172,000**	**1,080,000**	**2,830,000**	
Nitrate (filtered), µg/L	45,000	8,100															40,300	**94,700**			

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Table 1-3. (Cont.)

Contaminant, Units (alphabetical order)	DWS (DCG)[a]	100-BC-5 OU		100-KR-4 OU		100-NR-2 OU		100-HR-3-D		100-HR-3-H		300-FF-5 OU		1100-EM-1		100-FR-3 OU	200-BP-5 OU	200-PO-1 OU	200-UP-1 OU	200-ZP-1 OU	Confined Aquifers
		Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Wells	Wells	Wells	Wells	Wells
Nitrite, µg/L	3,300			690		**5,260**	1,210	3,080	62.4	2,270						328	**4,340**	2,200	281	677	
Nitrite (filtered), µg/L	3,300																342				
Plutonium-238, pCi/L	30															0.26					
Plutonium-239/240, pCi/L	30															1.12	***42.6***				
Radium-226, pCi/L	5					**32.5**															
Radium-228, pCi/L	5																	2.42			
Selenium, µg/L	50	4.2		5.1	2.1	3.94	2.13	6.53	1.76	3.2	0.501	47		3.12		5.38	16.8	13.4		4.54	
Selenium (filtered), µg/L	50	8.31		4.7		45.2	2.11	6.22		2.56		**59**		2.69		5.36	17.5	10.6		47	
Strontium-90, pCi/L	8	**49**	**18**	**45**		***19,000***	**1,200**	5	3.2	**28**	**9.9**					**19**	**4,200**	**16**	2.1	1.4	
Styrene, µg/L	100			0.21		0.24										0.52	0.21				
Technetium-99, pCi/L	900	26		55		45		16		94	6.9	210		13		110	**38,000**	**5,300**	**65,000**	**9,900**	
Technetium-99 (filtered), pCi/L	900	18																			
Tetrachloroethene, µg/L	5					0.5		0.14	0.34	0.16	0.47	0.38	3.2			1.1	0.27		0.12	1.7	
Thallium, µg/L	2	1		**40**	0.98	**64**		**43.6**	0.326	**37.8**		**74**		**67**			**51**	**64**			
Thallium (filtered), µg/L	2	1.2		**41**	1.3	**43**		**39**		**47**		**70**				**52**	**79**	**48**		**35**	
Toluene, µg/L	1,000			0.35		0.31		0.18	0.6	0.062	1.1			0.14		0.17				0.064	
Trichloroethene, µg/L	5	3.3		**7.4**		0.29		0.33		0.44	0.42	3	**430**			**20**	3.9	2.8	**8.8**	**12**	
Tritium, pCi/L	20,000	**69,000**	8,700	**280,000**	6,000	17,500	14,000	9,900	18,000	9,000		**900,000**	6,300	315		3,800	**35,000**	**590,000**	**71,000**	**1,600,000**	
Tritium (filtered), pCi/L	20,000	9,600																			
Uranium, µg/L	30	7.37		9.5	1.55	8.18		4.82	1.44	11	0.701	**188**	**207**	26.5	20.4	15.4	**3,670**	**75.4**	**417**	26.3	
Uranium (filtered), µg/L	30	1.66								12.2							5.29			1.16	
Xylenes (total), µg/L	10,000			0.24		7.1		0.46	0.73		1.4					0.49	0.21				

Notes:

1. Table lists highest value for the 12-month reporting period (January 1, 2010, to December 31, 2010) in each groundwater interest area, excluding those flagged "R" or "Y" or special (non-routine) samples.
2. Concentrations in **bold** exceed federal or state DWS; those in ***bold italics*** exceed derived concentration guideline (DCG).
3. Blank cells indicate a constituent was not detected or not analyzed.

a. Most metals analyses are run both unfiltered and field-filtered samples. Higher concentrations in unfiltered samples indicate particulate matter in the sample. Note that analyses specifically for hexavalent chromium usually are not filtered in the field.

b. There is no DWS for plutonium-239/240. The 4 mrem/year effective dose equivalent is 1.2 pCi/L.

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Table 1-4. RCRA Monitoring Status for the Reporting Period

RCRA Unit	Report, Section	Status for Reporting Period
1301-N (116-N-1) LWDF	Chapter 6.0, Section 6.3.1	Continued indicator evaluation.[a]
1324-NA (120-N-) and 1324-N (120-N-2) ponds	Chapter 6.0, Section 6.3.2	Continued indicator evaluation.[a]
1325-N (116-N-3) LWDF	Chapter 6.0, Section 6.3.3	Continued indicator evaluation.[a]
116-H-6 (183-H) evaporation basins	Chapter 7.0, Section 7.3	Corrective action alternative program during interim remedial action; chromium and nitrate.
216-A-29 Ditch	Chapter 10.0, Section 10.3.4	Continued indicator evaluation.[a]
216-B-3 Pond	Chapter 10.0, Section 10.3.5	Continued indicator evaluation.[a]
216-B-63 Trench	Chapter 9.0, Section 9.3.6	Continued indicator evaluation.[a]
216-S-10 Pond and Ditch	Chapter 11.0, Section 11.3.3	Continued indicator evaluation;[a] completion of first year of RCRA analyses for three new wells; establishment of new background critical mean values.
316-5 (300 Area) Process Trenches	Chapter 13.0, Section 13.3	Compliance/corrective action; organics.
IDF	Chapter 10.0, Section 10.3.1	Not yet in use; monitoring results added to background data set.
LERF	Chapter 9.0, Section 9.3.5	Two new wells monitor fractured basalt flow top; DOE and Ecology pursuing agreement for monitoring.
LLWMA-1	Chapter 9.0, Section 9.3.1	Continued indicator evaluation.[a]
LLWMA-2	Chapter 9.0, Section 9.3.2	Continued indicator evaluation.[a]
LLWMA-3	Chapter 12.0, Section 12.4.1	Statistical evaluations suspended until upgradient wells installed and background values established. New monitoring plan (DOE/RL-2009-68) implemented in CY 2010.
LLWMA-4	Chapter 12.0, Section 12.4.2	Total organic carbon exceeded critical mean value in August 2008; returned to indicator evaluation status CY 2009; remaining upgradient wells went dry in CY 2010. New monitoring plan (DOE/RL-2009-69) implemented in CY 2010.
NRDWL	Chapter 10.0, Section 10.3.6	Assessment showed elevated total organic carbon to be related to constituents other than dangerous waste constituents; returned to indicator evaluation status in CY 2010.
PUREX Cribs	Chapter 10.0, Section 10.3.2	Started 2010 in assessment; nitrate. 216-A-10 dropped from Hanford Site RCRA Permit. Separate new plans written for 216-A-36B and 216-A-37-1. New plans implemented January 1, 2011; in indicator evaluations status.
SST WMA A-AX	Chapter 10.0, Section 10.3.3	Assessment (first determination) showed site responsible for nickel contamination; continued in assessment; new assessment plan under review by Ecology.
SST WMA B-BX-BY	Chapter 9.0, Section 9.3.3	Continued assessment; cyanide.[b]
SST WMA C	Chapter 9.0, Section 9.3.4	Continued assessment; cyanide[b].
SST WMA S-SX	Chapter 11.0, Section 11.3.1	Continued assessment; chromium.[b]
SST WMA T	Chapter 12.0, Section 12.4.3	Continued assessment; chromium.[b]
SST WMA TX-TY	Chapter 12.0, Section 12.4.4	Continued assessment; chromium.[b]
SST WMA U	Chapter 11.0, Section 11.3.2	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 dangerous constituents at this unit.

Table 1-5. Selected Drinking Water Standards and Groundwater Cleanup Levels

Constituent	Unit	DWS	DWS Responsible Agency	MTCA[a]	Groundwater Quality Criteria[b]
Aluminum	µg/L	50 to 200[c]	EPA	16,000	--
Antimony	µg/L	6	EPA, DOH	6.4	--
Arsenic	µg/L	10	EPA, DOH	0.058	50
Barium	µg/L	2,000	EPA, DOH	3,200	1,000
Cadmium	µg/L	5	EPA, DOH	8.0	10
Carbon tetrachloride	µg/L	5	EPA, DOH	0.337	300
Chloride	mg/L	250[c]	EPA, DOH	--	250
Chloroform (TTHM)[d]	µg/L	80	EPA, DOH	7.17	7.0
Chromium	µg/L	100[e]	EPA, DOH	100/48[f]	50
cis-1,2-Dichloroethene	µg/L	70	EPA, DOH	80	--
Copper	µg/L	1,300[g]	EPA, DOH	640	--
		1,000[c]	EPA	--	--
Cyanide	mg/L	200	EPA, DOH	0.320	--
Fluoride	mg/L	4	EPA, DOH	0.960	4
		2[c]	EPA, DOH	--	--
Iron	µg/L	300[c]	EPA, DOH	11,200	--
Lead	µg/L	15[g]	EPA, DOH	--	50
Manganese	µg/L	50[c]	EPA, DOH	752	--
Mercury(inorganic)	µg/L	2	EPA, DOH	4.8	2
Methylene chloride (dichloromethane)	µg/L	5	EPA	5.83	--
Nitrate, as NO^{3-}	mg/L	45[h]	EPA, DOH	115	45[h]
Nitrite, as NO^{2-}	mg/L	3.31[i]	EPA, DOH	5.3	--
pH	--	6.5 to 8.5[c]	EPA, DOH	--	--
Selenium	µg/L	50	EPA, DOH	80	10
Silver	µg/L	100[c]	EPA, DOH	80	50
Sulfate	mg/L	250[c]	EPA, DOH	--	250
Tetrachloroethene	µg/L	5	EPA, DOH	80	0.8
Thallium	µg/L	2	EPA, DOH	1.12	--
Total dissolved solids	mg/L	500[c]	EPA, DOH	--	--
1,1,1-Trichloroethane	µg/L	200	EPA, DOH	16,000	200
Trichloroethene	µg/L	5	EPA, DOH	0.49	3
Uranium (total)	µg/L	30	EPA, DOH	48	--
Zinc	µg/L	5,000[c]	EPA, DOH	4,800	--

a. Model Toxics Control Act (MTCA), Method B cleanup levels for groundwater (WAC 173-340, "Model Toxics Control Act – Cleanup").

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

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

d. Standard is for total trihalomethanes.

e. Total chromium.

f. Total chromium/hexavalent chromium.

g. Action level.

h. 45 mg/L as NO^{3-} is equivalent to 10 mg/L of nitrate as nitrogen.

i. 3.3 mg/L as NO^{2-} is equivalent to 1 mg/L of nitrite as nitrogen.

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 1-6. Derived Concentration Guides, 4-mrem Effective Dose Equivalent Concentrations, Drinking Water Standards, and Risk-Based Concentrations for Hanford Site Radionuclides in Groundwater

Radionuclide	Derived Concentration Guide[a,b,c] (pCi/L)	4-mrem Effective Dose Equivalent[d] (pCi/L)	DWS[e] (pCi/L)	Risk-Based Concentration[f] (pCi/L)	
				Industrial	**Residential**
Antimony-125	60,000	300	300[g]	---[h]	---[h]
Beta particle and photon activity (mrem/yr)	Not applicable	50	4[i], 50[j]	---[k]	---[k]
Carbon-14	70,000	2,800	2,000[g]	1,030	34
Cesium-137	3,000	120	200[g]	60	1.7
Cobalt-60	5,000	200	100[g]	102	3.4
Iodine-129	500	20	1	11	0.36
Plutonium-239/240	30	1.2	None	12	0.39
Ruthenium-106	6,000	30	30[i]	---[h]	---[h]
Strontium-90	1,000	40	8	29	0.95
Technetium-99	100,000	4,000	900[g]	580	19
Tritium	2,000,000	80,000	20,000	2,600	160
Uranium-234[l]	500	20	None	23	0.75
Uranium-235[l]	600	24	None	23	0.76
Uranium-238[l]	600	24	None	25	0.83

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.

b. Values in this column represent the lowest, most conservative derived concentration guides considered potentially applicable to Hanford Site operations, and may be adjusted upward (larger) if accurate solubility information is available.

c. From DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

d. 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 1-5 were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in the *National Bureau of Standards Handbook 69* (NBS 1959). 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 (as implemented in DOE Order 5400.5 in 1993).

e. Concentrations listed in 40 CFR 141, "National Primary Drinking Water Regulations."

f. Based on slope factors from EPA's risk website: "Radionuclide Carcinogenicity Slope Factors" (http://epa.gov/radiation/heastindex.html). In turn, this was based on *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report No. 13 (EPA/402/R-99/001). These slope factors represent the risk of getting cancer if a person ingested water contaminated with each radionuclide over a lifetime (residential) or over a working lifetime (industrial). The tritium calculation also considers inhalation of tritium in air; for the other radionuclides, this path is insignificant.

g. The EPA DWSs for radionuclides were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in *National Bureau of Standards Handbook 69* (NBS 1959).

h. Due to short life (less than 3 years), no risk-based concentration is calculated.

i. 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.

j. Groundwater quality criteria from Table 1C of WAC 173-200-040, "Water Quality Standards for Ground Waters of the State of Washington," "Criteria."

k. See specific radionuclides for risk-based concentrations.

l. See Table 1-5 for total uranium.

Figure 1-1. Location of the Hanford Site

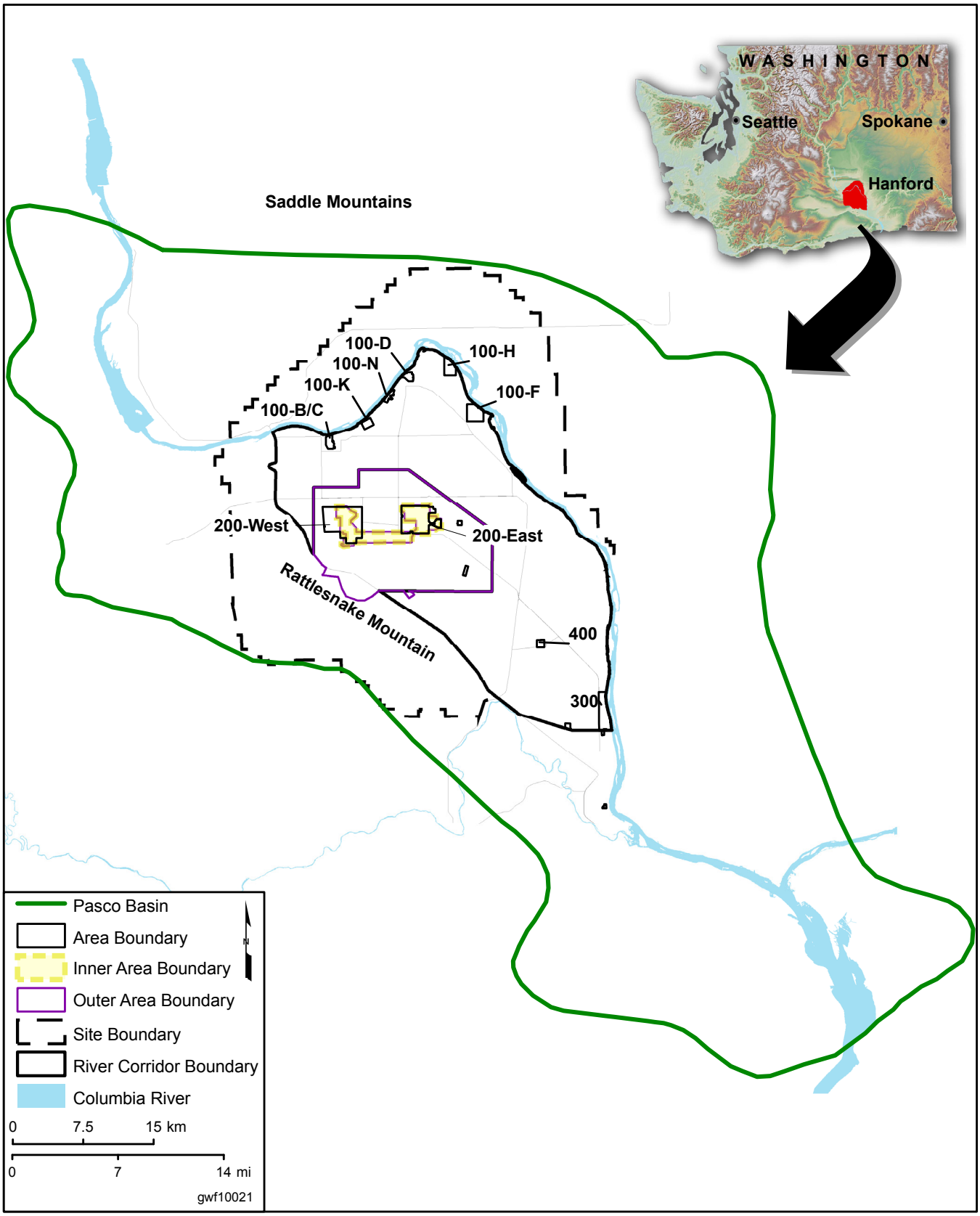


Figure 1-2. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site

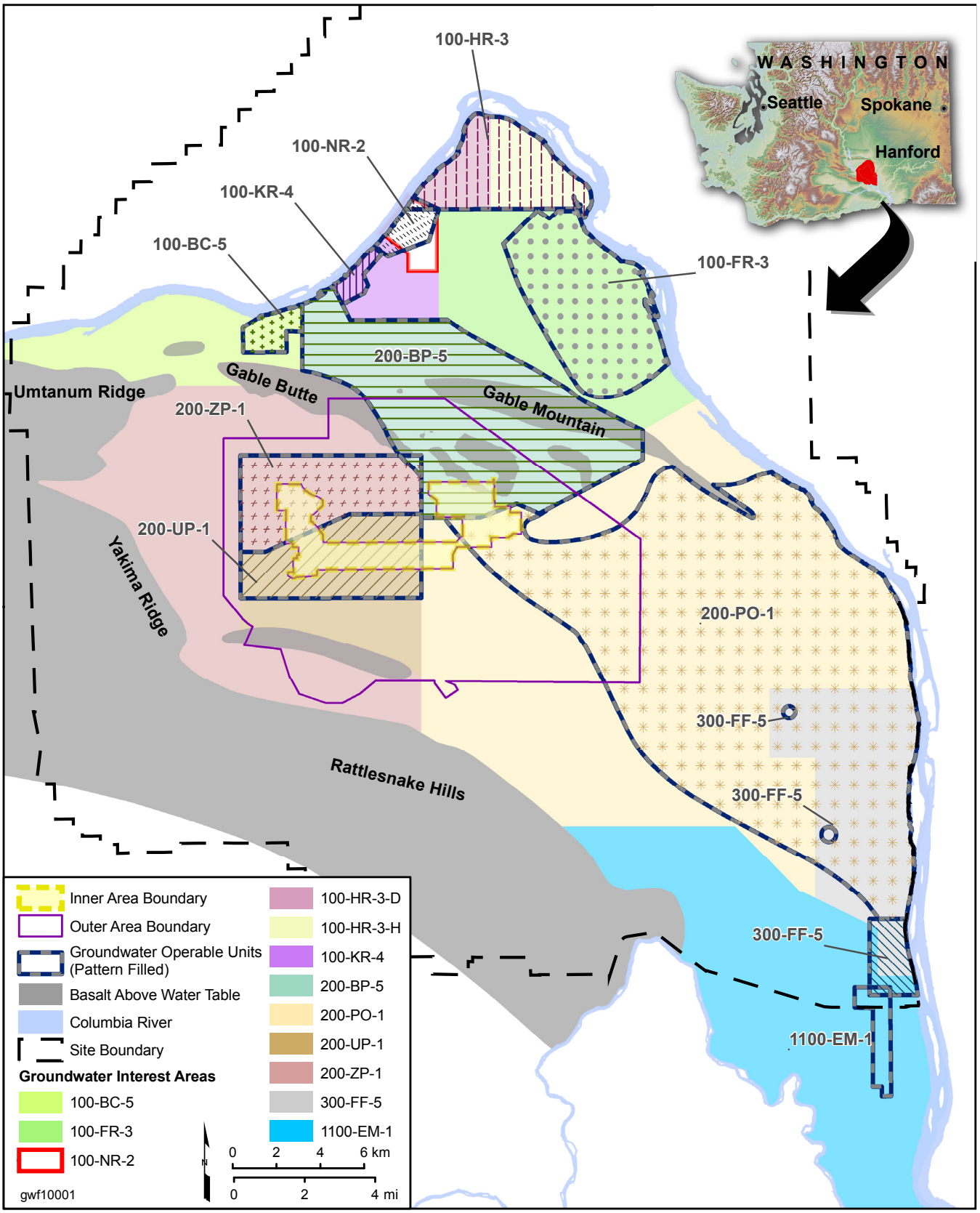


Figure 1-3. Average CY 2010 Tritium Concentrations on the Hanford Site, Upper Portion of Unconfined Aquifer

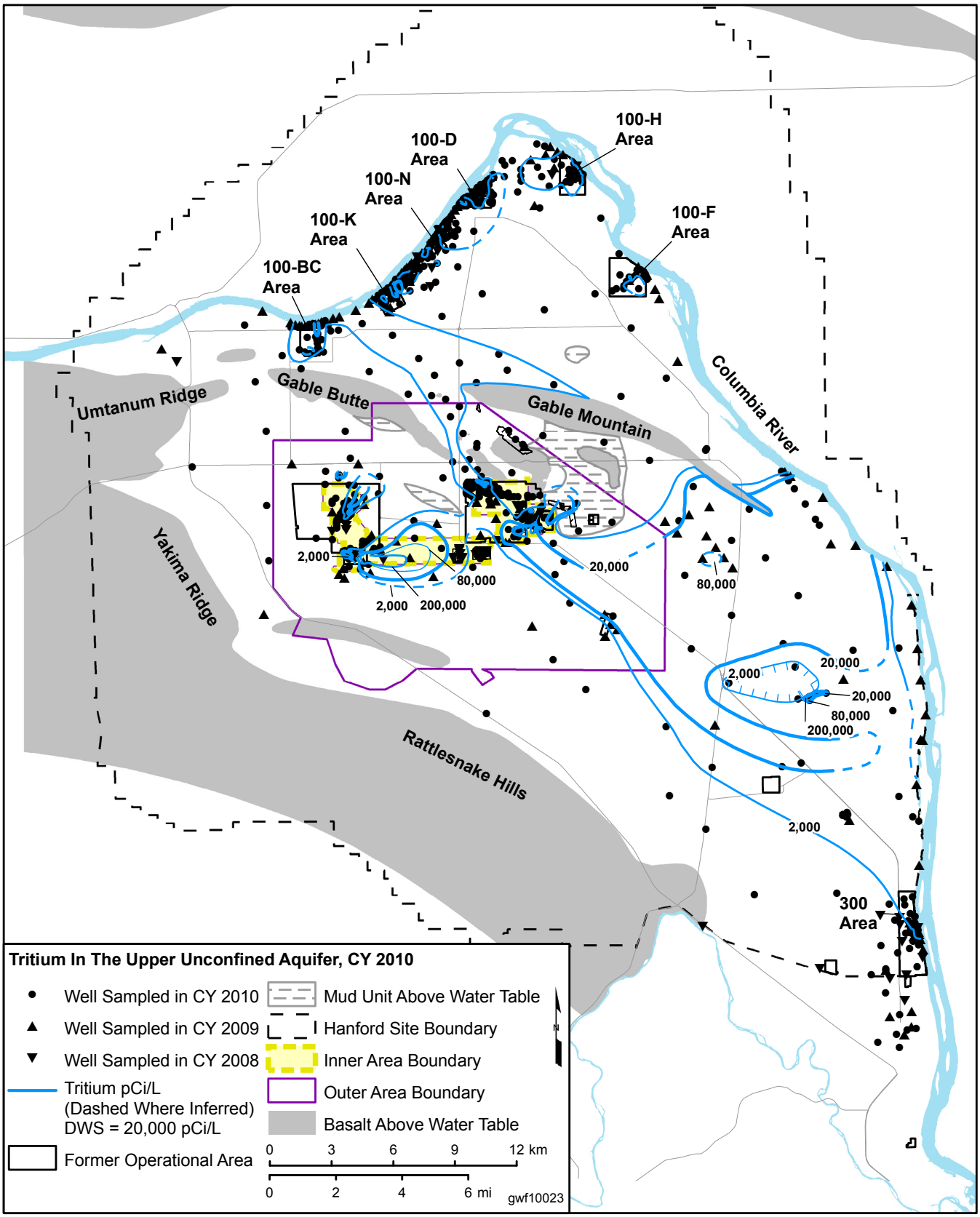
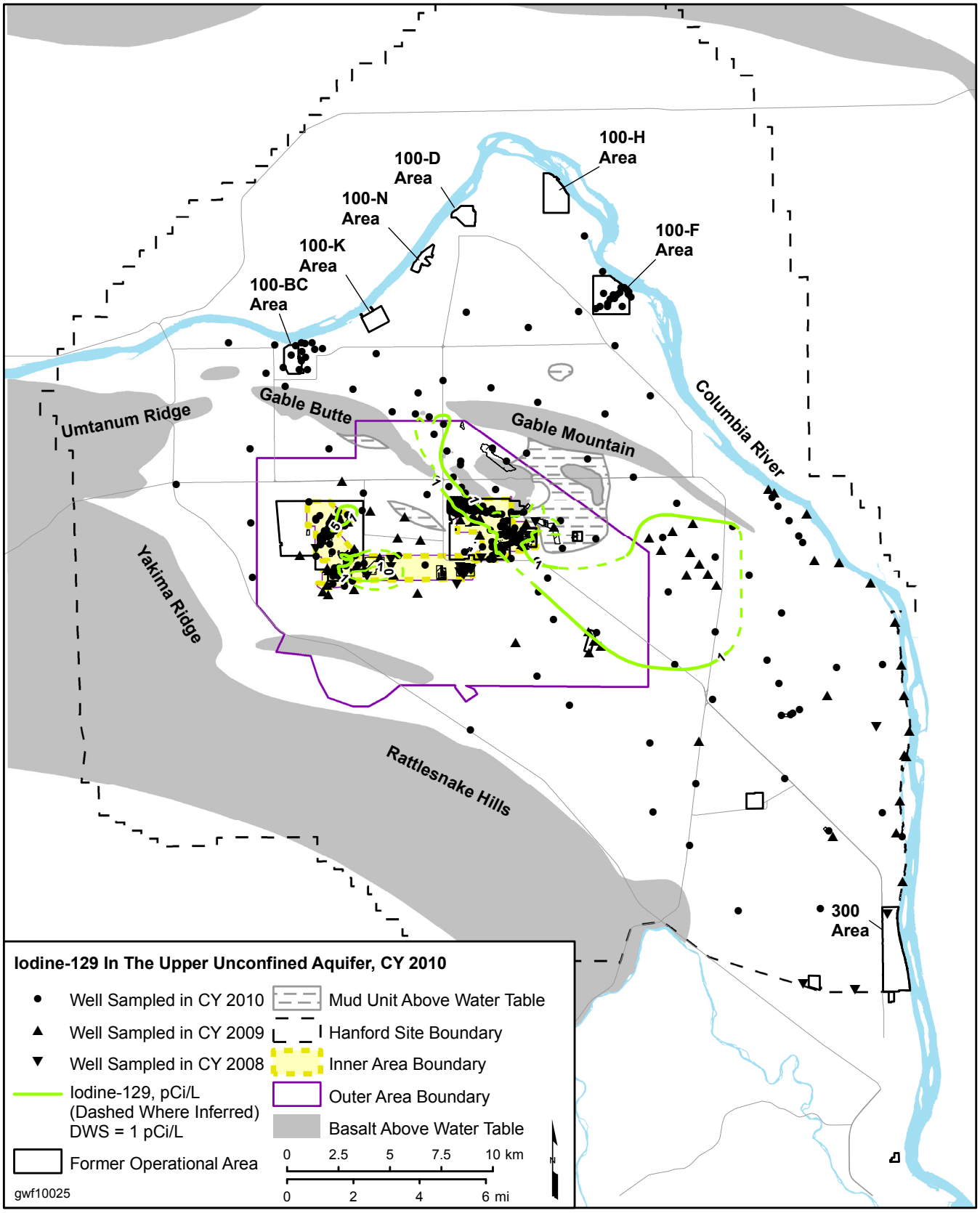


Figure 1-4. Average CY 2010 Iodine-129 Concentrations on the Hanford Site, Upper Portion of Unconfined Aquifer



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