DOE/RL-2015-07
Revision 0

Hanford Site Groundwater Monitoring Report for 2014

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2015-07
Revision 0

Hanford Site Groundwater Monitoring Report for 2014

Date Published
July 2015

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Ashley R Jenkins at 8:04 am, Jul 27, 2015

Release Approval | Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

Executive Summary

This document describes calendar year 2014 groundwater monitoring results for the U.S. Department of Energy (DOE) Hanford Site in Washington State. Groundwater is monitored for *Resource Conservation and Recovery Act of 1976* (RCRA) units; for *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) groundwater operable units (OUs); and for the *Atomic Energy Act of 1954* (AEA), as required by DOE orders. DOE publishes details on CERCLA remediation activities in separate reports that are summarized and referenced in this report.

The Hanford Site, part of the DOE nuclear weapons complex, encompasses approximately 1,500 km^2 (579 mi^2) along the Columbia River in southeastern Washington State. During World War II and the Cold War period, the government built and operated a total of nine nuclear reactors for the production of plutonium and other nuclear materials.

During reactor operations, chemical and radioactive waste was released into the environment and contaminated the soil and groundwater beneath portions of the Hanford Site, mostly in the 200 East Area, 200 West Area, 300 Area, 1100 Area, and the 100 Area, which includes reactor areas along the river (e.g., 100-BC and 100-K) (Figure ES-1). Since 1989, using its authority under CERCLA (42 U.S. Code 9601 et seq.), DOE has worked to remediate this contamination. As the U.S. Environmental Protection Agency (EPA) placed the Hanford Site on the CERCLA National Priorities List in 1989, and pursuant to CERCLA Section 120, DOE entered the Hanford Federal Facility Agreement and Consent Order (Ecology, EPA, and DOE, 1989), referred to as the Tri-Party Agreement, with EPA and the Washington State Department of Ecology (Ecology). The purpose of the Tri-Party Agreement is to provide a joint plan to address groundwater and vadose zone contamination and other aspects of remediating the radiological and chemical contamination of the Hanford Site. Key goals of this effort are (1) to protect the Columbia River and groundwater from further contamination, (2) to develop a cleanup decision process, and (3) to achieve final cleanup restoring groundwater to usable condition (e.g., restore groundwater to highest beneficial use).

Groundwater on the Hanford Site occurs in an unconfined aquifer within unconsolidated gravel and sand units. Groundwater in the unconfined aquifer generally flows from

upland areas in the west toward the regional discharge areas along the Columbia River (Figure ES-2).

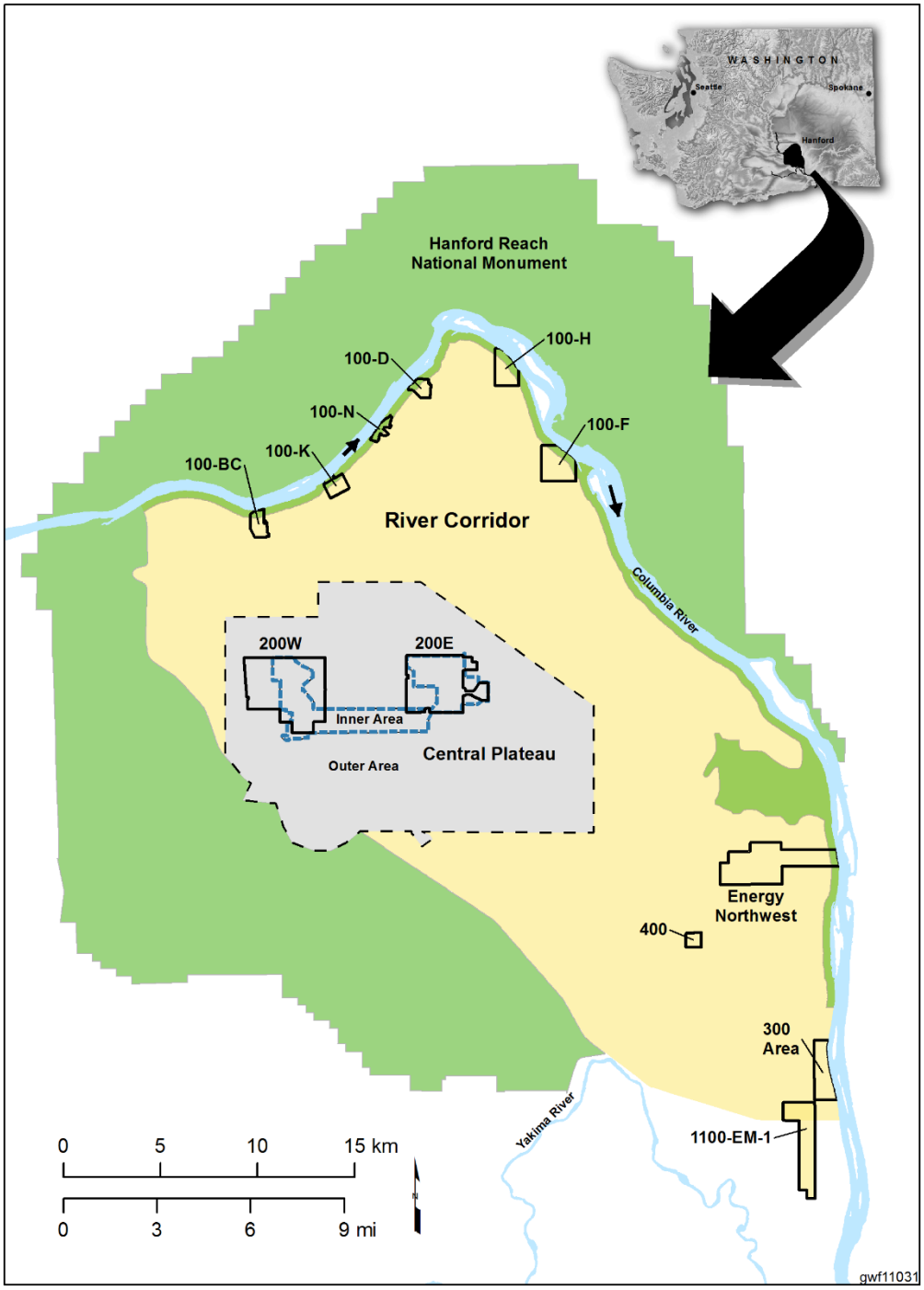


Figure ES-1. Regions of the Hanford Site

Hanford Site operations were primarily located in the 100 and 300 Areas of the River Corridor and the Inner Area of the Central Plateau. Most of the other portions of the site, including the Hanford Reach National Monument, are relatively undisturbed shrub steppe habitat.

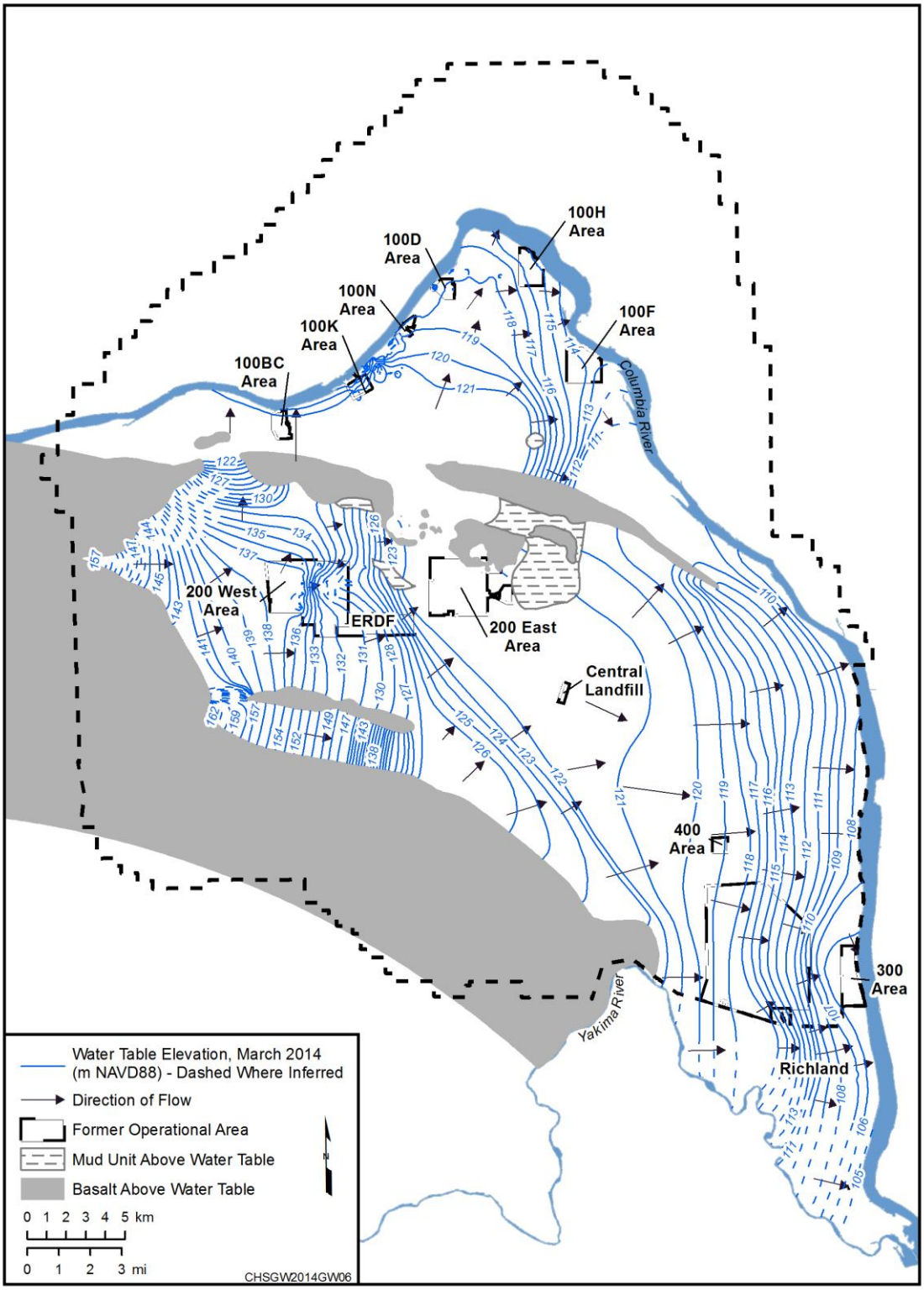


Figure ES-2. Hanford Site 2014 Water Table and Directions of Groundwater Flow

Groundwater flows from areas where the water table is high to where it is lower, and eventually discharges to the Columbia River.

The flow of water divides beneath the 200 East Area, with some water flowing toward the north and some flowing southeast. Maximum concentrations of key groundwater contaminants are presented in Tables ES-1 and ES-2.

Table ES-1. Overview of the River Corridor Groundwater Interest Areas Contaminant Concentrations

River Corridor Overview

Area	Primary Operations	Status of Waste Site Remediation[a]	Status of Ground-water ROD	Groundwater Contamination: Maximum Concentration and Plume Area						
				Carbon-14	Hexavalent Chromium	Nitrate	Strontium-90	Trichloro-ethene	Tritium	Uranium
100-BC	Reactor operations -- B Reactor 1944-69; C Reactor 1952-69	93% complete	None to date	N	63 µg/L	47 mg/L	43 pCi/L	2.43 µg/L	17,000 pCi/L	9 µg/L
100-K	Reactor operations -- KE Reactor 1955-71; KW Reactor 1955-70	59% complete	Interim action P&T	14,300 pCi/L	520 µg/L	74 mg/L	231	6.8 µg/L	414,000 pCi/L	7.7 µg/L
100-N	Reactor operations -- N Reactor 1963-87	92% complete	Interim action permeable reactive barrier	52 pCi/L	181 µg/L	186 mg/L	15,500 pCi/L	N	761,000 pCi/L	6.6 µg/L
100-D & 100-H	Reactor operations -- D Reactor 1944-67; DR Reactor 1950-64; H Reactor 1949-65	87% complete	Interim action P&T	N	3,440 µg/L	53 mg/L	36.4 pCi/L	N	20,400 pCi/L	52.1 µg/L
100-F	Reactor operations -- F Reactor 1945-65; Biological experiments until 1976	98% complete	Final action MNA	N	29 µg/L	146 mg/L	144 pCi/L	15.3 µg/L	5,500 pCi/L	21.1 µg/L
300	Nucelar fuel fabrication and research -- 1940s-1960s	91% complete	Final action enhanced attenuation, MNA	N	5.6 µg/L	(b)	1.9 pCi/L	83	994,000 pCi/L	358 µg/L
1100 and Offsite	Vehicle maintenance, 1954-85; solid waste landfill --1950s-1970	100% complete (final action ROD)	Final action MNA; goals met	N	N	(b)	N	0.71 µg/L	121 pCi/L	(b)
Standards[c]				2,000 pCi/L	10 µg/L	45 mg/L	8 pCi/L	5 µg/L	20,000 pCi/L	30 µg/L
Half-life (years)				5,730	N/A	N/A	28.8	N/A	12	>159,000
Mobility in subsurface				High	High to Moderate	High	Slight	Moderate	High	Moderate

Legend

Colors indicate maximum concentration in 2014

- ≥1,000 x standard
- ≥100 x standard and <1,000 x standard
- ≥10 x standard and <100 x standard
- ≥Standard and <10 x standard
- N Not detected or not analyzed

Height of bar indicates plume area above standard (km^2)

- >10
- >1 and ≤ 10
- >0.1 and ≤ 1
- >0, ≤0.1

NOTES

(a) Approximate percentage by number of waste sites classified as closed, interim closed, no action, rejected, or not accepted (end of 2014).

(b) Nitrate in 300-FF-5, and nitrate and uranium in 1100-EM-1, originates from offsite sources, so plume areas and maximum concentrations are not shown

(c) Drinking water standards for all but hexavalent chromium (aquatic standard)

ABBREVIATIONS

MNA Monitored natural attenuation N/A Not applicable ROD Record of decision

CHSGW2014GW04

Table ES-2. Overview of Central Plateau Groundwater Interest Areas Contaminant Concentrations

Central Plateau Overview

Area	Primary Operations	Status of Ground-water ROD	Groundwater Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area									
				Carbon Tetrachloride	Chromium	Cyanide	Iodine-129	Nitrate	Strontium-90	Trichloroethene	Technetium-99	Tritium	Uranium
200-ZP-1	T Plant (Pu separation) 1944-1956; Pu Finishing Plant: 1949-1989	Signed 2008 (final action)	Groundwater P&T and MNA: 1995-present. Soil vapor extraction 1991-2013	2,000 µg/L	186 µg/L	N	1.9 pCi/L	536 mg/L	N	8.6 µg/L	21,500	72,000 pCi/L	2.7 µg/L
200-UP-1	REDOX Plant (Pu separation) 1952-1967; U Plant (U recovery) 1952-1957	Signed 2012 (interim action)	U plant P&T: 1994-2011; S-SX P&T: 2012-present	See 200-ZP-1	497 µg/L	2.5 µg/L	11 pCi/L	2,270 mg/L	1.15 pCi/L	8.7 µg/L	86,500 pCi/L	280,000 pCi/L	734 µg/L
200-BP-5	B Plant Pu separation: 1945-1952; B Plant Sr and Cs recovery: 1967-1985	Expected 2016	Perched aquifer P&T test: 2011-2014	1.7 µg/L	172 µg/L	1,600 µg/L	6.05 pCi/L	1,480 mg/L	1,100 pCi/L	3.97 µg/L	42,000 pCi/L	37,000	4,030 µg/L
200-PO-1	PUREX Plant Pu separation: 1956-1972 and 1983-1989	Expected 2016	Vadose zone desiccation test: 2011	1.8 µg/L	167 µg/L	9.7 µg/L	6.49 pCi/L	156 mg/L	15 pCi/L	1.6 µg/L	1,840	510,000 pCi/L	57.8
Standards*				5 µg/L	48 µg/L	200 µg/L	1 pCi/L	45 mg/L	8 pCi/L	5 µg/L	900 pCi/L	20,000 pCi/L	30 µg/L
Half-life (years)				N/A	N/A	N/A	16,000,000	N/A	28.8	N/A	212,000	12	>159,000
Mobility in subsurface				Multi-phase	High to Moderate	Moderate	High	High	Slight	Moderate	High	High	Moderate

Legend

Colors indicate maximum concentration in 2014

- ≥100 x standard and <1,000 x standard
- ≥10 x standard and <100 x standard
- ≥Standard and <10 x standard
- N Not detected or not analyzed

*Drinking water standards for all but hexavalent chromium (MTCA standard)

Height of bar indicates plume area above standard (km^2)

- >10
- >1 and ≤10
- >0.1 and ≤ 1
- >0, ≤0.1

ABBREVIATIONS

N/A = Not applicable P&T = pump-and-treat ROD = record of decision MTCA = Model Toxics Control Act

CHSGW2014GW05

Figure ES-3 presents time series graphs of plume area over time for the largest plumes (tritium, iodine-129, nitrate, carbon tetrachloride, and chromium). The figure also illustrates the area of the combined plume footprint for all the plumes mapped for this report, which also include carbon-14, cyanide, strontium-90, technetium-99, trichloroethene, total petroleum hydrocarbons-diesel, and uranium.

DOE has taken the following actions to protect the Columbia River from contaminated groundwater:

- Ceasing discharge of all unpermitted liquids in the central Hanford Site
- Remediating waste sites in the 100 and 300 Areas

- Containing groundwater plumes and reducing the mass of primary contaminants through remedial actions such as pump and treat (P&T)

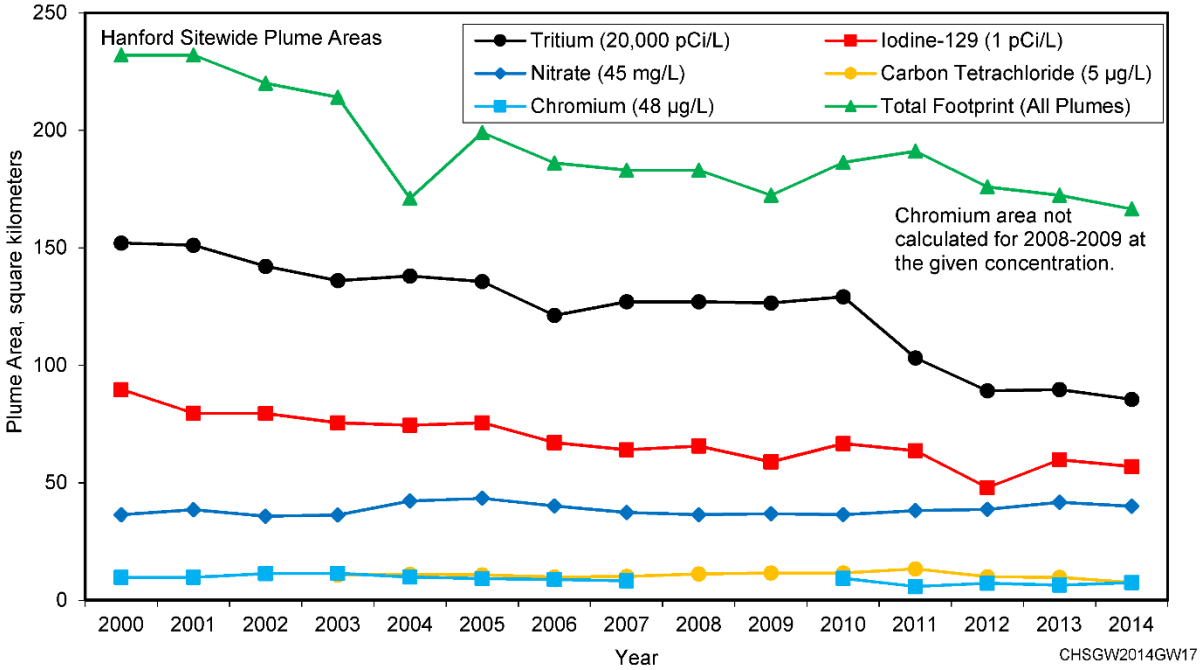


Figure ES-3. Hanford Sitewide Plume Areas in the Upper Part of the Unconfined Aquifer

This graph shows changes in plume areas, primarily based on data from wells screened near the top of the unconfined aquifer. Tritium and iodine-129 form the largest groundwater plumes on the Hanford Site. Their estimated areas have declined over time.

DOE operates an extensive groundwater monitoring program on the Hanford Site, collecting thousands of samples from hundreds of wells each year, and analyzing the samples for a variety of radionuclides and chemicals (Figures ES-4 and ES-5). In addition to monitoring wells, DOE monitors hundreds of sampling points near the Columbia River, known as aquifer sampling tubes, for general information about groundwater approaching the river. The percent useable groundwater monitoring data for 2014 is 96.7 percent, which exceeds the DOE groundwater monitoring requirement of 85 percent data usability. Figure ES-6 compares maximum concentrations of the major groundwater contaminants in various parts of the Site in 2014. These contaminants are discussed further in the remaining sections of this Executive Summary.

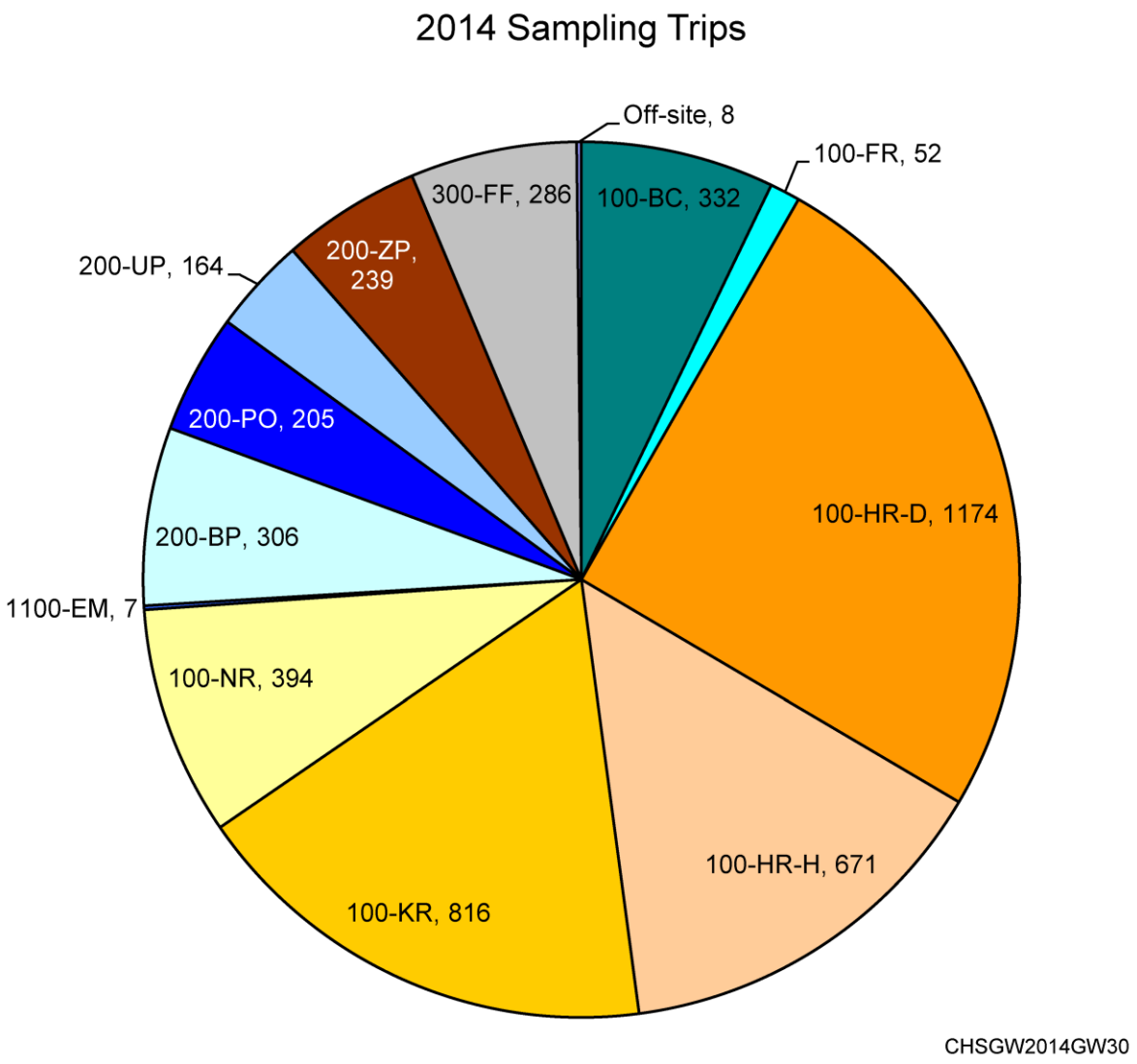


Figure ES-4. 2014 Sampling Events (Wells and Aquifer Tubes).

DOE sampled 977 monitoring and extraction wells, and 324 aquifer tubes in 2014. Many of them were sampled multiple times, for a total of 4,654 sampling events.

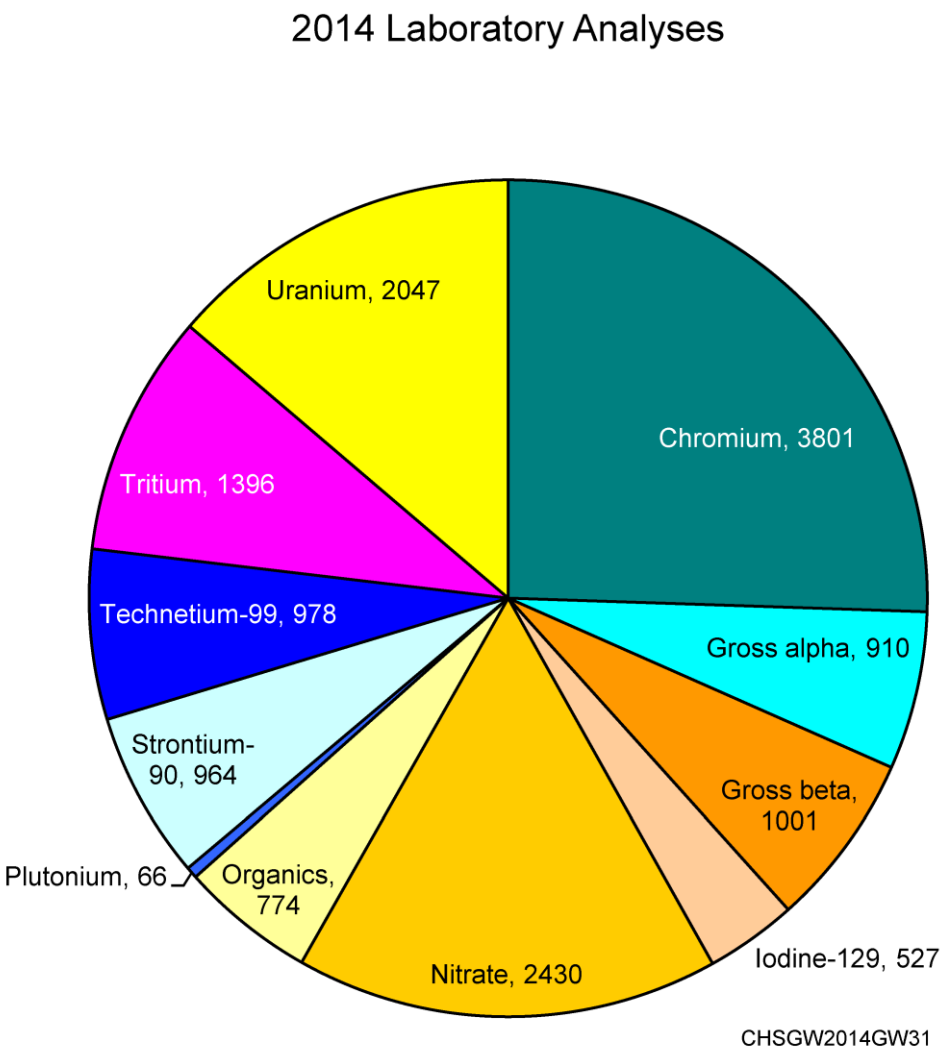


Figure ES-5. 2014 Laboratory Analyses of Groundwater Samples.

This chart shows the number of laboratory analyses run on Hanford Site groundwater samples for the most common constituents in 2014.

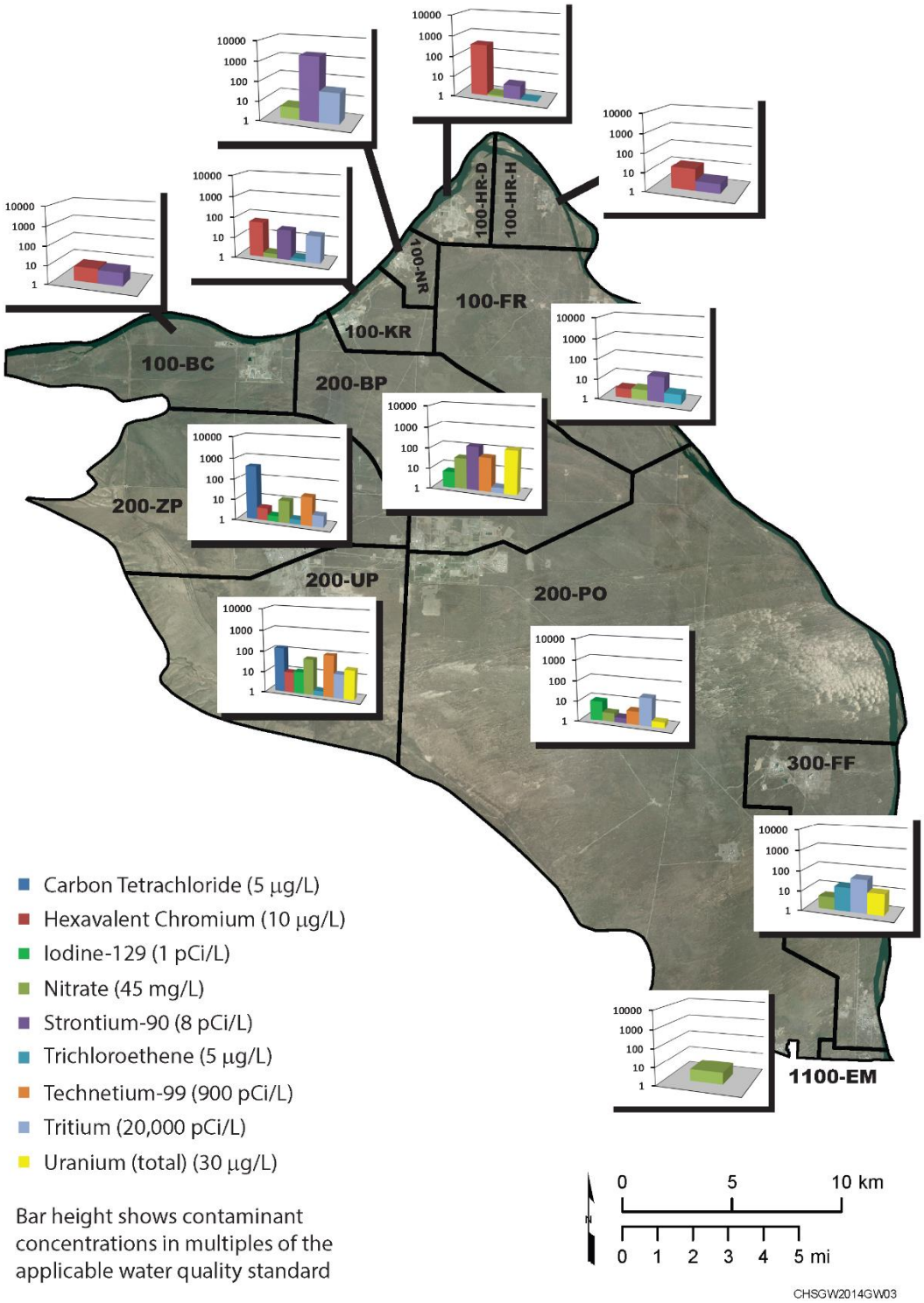


Figure ES-6. Exceedance Ratios of Groundwater Contaminants

This map shows the maximum concentrations of groundwater contaminants in each groundwater interest area in 2014. The heights of the bars represent multiples of the applicable water quality standards. For example in 100-FR, the maximum strontium-90 concentration was 144 pCi/L and the bar is 18 units high because the DWS is 8 pCi/L.

This summary is organized by geographic regions known as "groundwater interest areas" (Figure ES-6) that include the River Corridor and the Central Plateau.

River Corridor

Highlights:

- As of the end of 2014, 89 percent of the waste sites in the River Corridor had been remediated or were classified as not needing remediation under interim Records of Decision (RODs), as compared to 85 percent in 2013 and 74 percent in 2012. Cleanup of the remaining sites is underway.
- Based on remedy performance monitoring and the reduction in length of shoreline impacted by contaminant plumes, groundwater remediation systems in 100-HR, 100-KR, and 100-NR are reducing the amount of contamination entering the Columbia River.

Table ES-1 provides a summary of the River Corridor groundwater interest areas and associated contamination plumes. In the 100 Area, groundwater contamination is related to past disposal of waste associated with water-cooled nuclear reactors. The primary groundwater contaminants of concern (COCs) in the 100 Area are chromium (hexavalent and total), strontium-90, nitrate, trichloroethene, and tritium (Figure ES-7). Sources of hexavalent chromium contamination included the routine disposal of reactor cooling water, which contained the corrosion inhibitor sodium dichromate, and unplanned spills and leaks of the high-concentration sodium dichromate stock solution. In the 300 Area, the groundwater COCs are uranium, tritium, nitrate, gross alpha, trichloroethene and cis-1,2-dichloroethene.

Since the 1990s, DOE has been remediating waste sites and groundwater in the River Corridor under interim records of decision (RODs). Removal of contaminated soil has reduced the potential for exposure to contaminants, including future groundwater impacts.

Under interim action RODs, groundwater remediation systems in the 100-HR-3 and 100-KR-4 Operable Units are limiting the amount of contamination reaching the Columbia River and reducing the mass of contaminants. The primary contaminant addressed is hexavalent chromium. The comparison concentration for inland groundwater wells is 20 μg/L. Similar to other river corridor decisions (e.g., 100-FR-3),

the cleanup level for groundwater discharges to the river for the final action ROD for 100-HR-3 and 100-KR-4 is expected to be 10 µg/L, when they are completed.

EPA and DOE signed a final action ROD for 100-FR waste sites and groundwater in 2014. Final action RODs previously were signed for the 300-FF-5 and 1100-EM-1 OUs. Final action RODs for the other portions of the River Corridor are expected to be developed in the next few years.

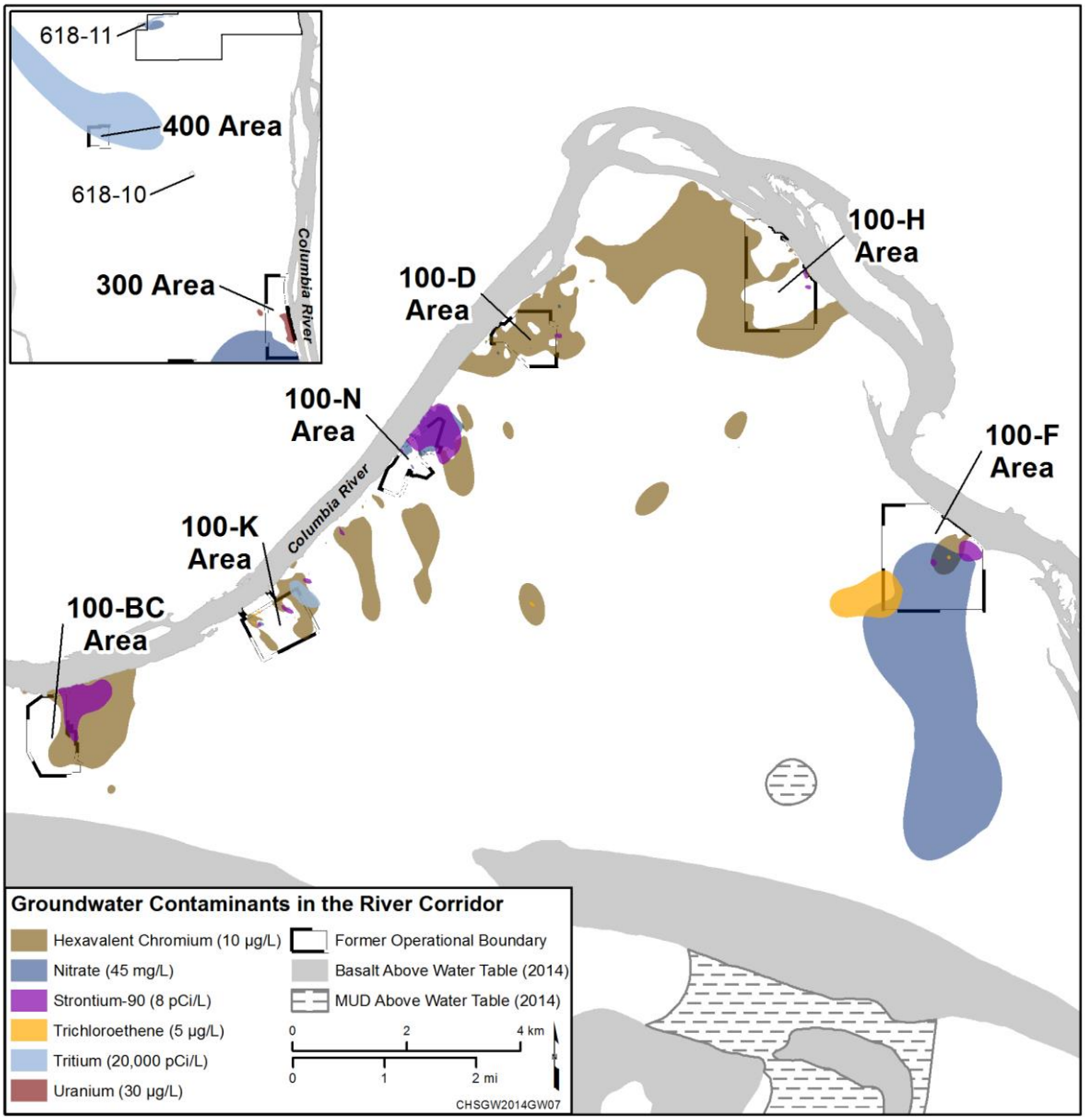


Figure ES-7. Groundwater Contaminants in the River Corridor

The largest contaminant plumes in the former reactor areas are hexavalent chromium and nitrate. Smaller plumes of strontium-90, tritium, and trichloroethene are also present. A uranium plume is present in 300 Area groundwater.

100-BC

Highlights:

- Remedial investigation (RI) studies continued in 100-BC in 2014, with additional sampling of wells and river shoreline sampling points installed in 2013. The studies, which are expected to conclude in 2016, will provide data to support remedy decisions for groundwater cleanup. This includes ongoing, intensive sampling of water in the shallow river bed to evaluate variable concentrations of hexavalent chromium, at the groundwater/surface water interface.

Groundwater contaminants in 100-BC include hexavalent chromium and strontium-90. Tritium concentrations remained below the drinking water standard (DWS) in 2014. Waste sites in 100-BC have been remediated under an interim action ROD, so contaminant levels in groundwater are expected to continue to decline.

DOE and EPA have agreed that additional RI studies are needed to reduce uncertainties relating to (1) the completion of waste site remediation; (2) short-term changes in groundwater contaminants related to waste site remediation; (3) modeling results predicting that the hexavalent chromium plume could persist for over 100 years; and (4) the level of risk associated with variable hexavalent chromium concentrations in Columbia River pore water.

100-KR

Highlights:

- Approximately 59 percent of the waste sites have been remediated or were determined not to require remediation under an interim action ROD.

- Three P&T systems continued to operate in 100-KR to remove hexavalent chromium from groundwater. In 2014, over 2.3 billion L (607.6 million gal) of groundwater was pumped from 41 extraction wells. A total of 797 kg of hexavalent chromium have been removed to date.

- The hexavalent chromium plume area (greater than 20 µg/L) was estimated to be 0.76 km^2 (0.29 mi^2) in 2014, a decrease from 2013. Since 2007, the plume area above 20 µg/L has decreased by approximately 70 percent, and the length of shoreline that the plume is interpreted to intersect (based on data from wells and

aquifer tubes) has decreased from 2,200 meters (7,200 feet) to 200 meters (660 feet) (Figure ES-8).

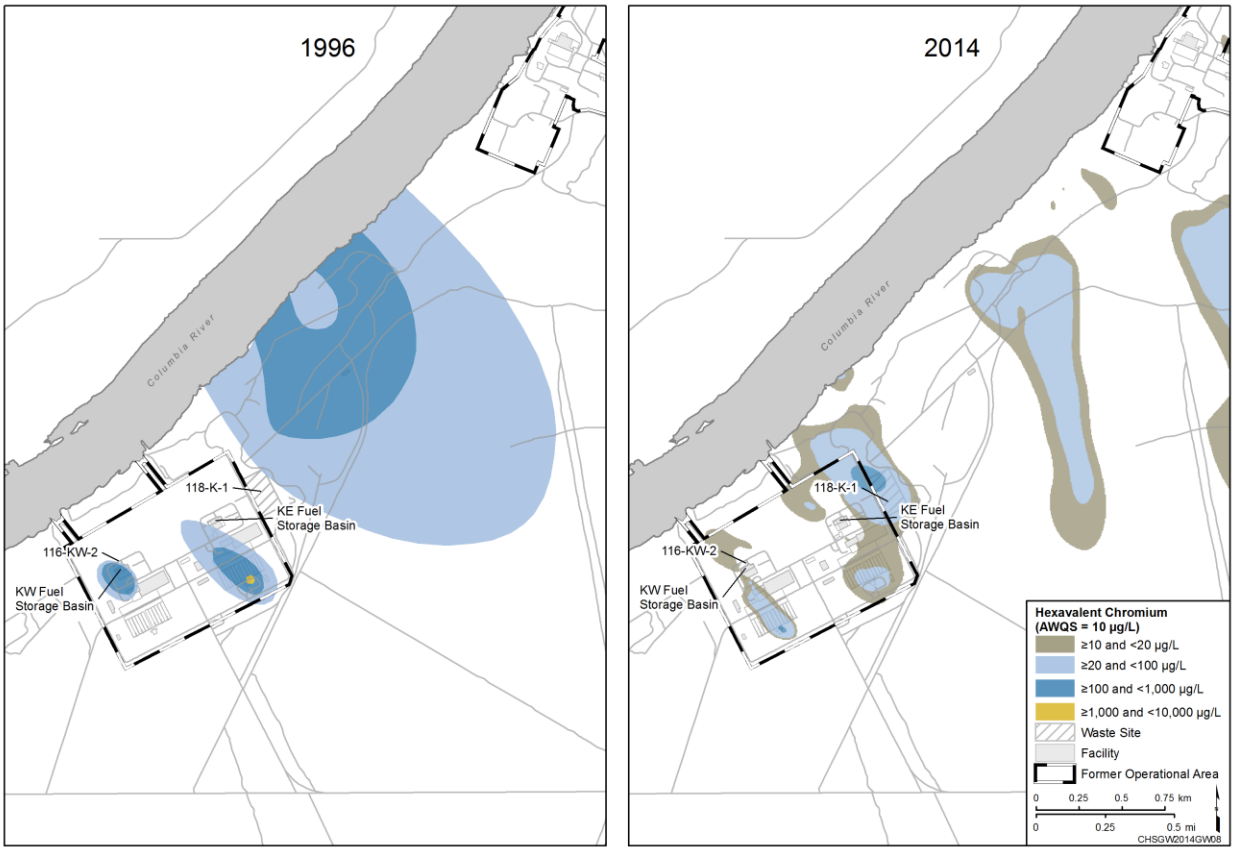


Figure ES-8. 100-KR Hexavalent Chromium Plume in 1996 (Before Interim Action) and 2014 (During Interim Action)

- *Three P&T systems reduce the amount of hexavalent chromium entering the Columbia River from 100-KR. The concentrations and size of the main plume have declined as a result of remediation, hydraulic control, and natural processes.*

Hexavalent chromium is the primary contaminant in 100-KR groundwater. Smaller plumes of carbon-14, tritium, strontium-90, nitrate, and trichloroethene also are present. Cleanup actions for these other contaminants will be defined in an upcoming ROD. DOE has proposed additional P&T for hexavalent chromium as part of a preferred alternative for groundwater remediation. The draft RI/Feasibility Study (FS) and Proposed Plan underwent review in 2012, and DOE will incorporate the results of supplemental source characterization activities that includes drilling boreholes near the KE Fuel Storage Basin and 116-KE-3 Crib and Reverse Well. These boreholes are expected to be drilled in 2015.

For AEA purposes, DOE monitors groundwater near the KW and former KE Fuel Storage Basins, which were integral parts of each reactor building. Until 2004, the concrete, water-filled basins were used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. The KE Basin was demolished. The KW Basin has been emptied of fuel rods, but remains a depository for contaminated sludge from the KE and KW Basins. Groundwater monitoring in 2014 did not show new groundwater impacts from the basins.

100-NR

Highlights:

- The major liquid waste disposal sites have been remediated, and excavation is continuing at remaining waste sites. Work is expected to be complete in 2015.
- Under an interim action ROD, a 900 ft (170 m) section of a permeable reactive barrier was placed along the shoreline, reducing the amount of strontium-90 migrating from groundwater into the river. Expansion of the barrier to its full 2500 ft (760 m) length is pending.
- Work continued in 2014 on revisions to the RI/FS report in response to Ecology comments.

Principal groundwater activities for 100-NR include RCRA monitoring and remediation of strontium-90 and total petroleum hydrocarbons. Other groundwater contaminants include nitrate and tritium. Hexavalent chromium from 100-KR has affected 100-NR groundwater in some locations.

Strontium-90, which originated at the 116-N-1 and 116-N-3 waste sites, is the primary contaminant. Strontium (including the strontium-90 isotope) substitutes for calcium in the sediment, reducing the mobility of this contaminant in the vadose zone and groundwater. As a result, the shape and size of the plume (Figure ES-9) has not changed significantly since 1996. P&T technology, which operated from 1995 to 2006, was found to be ineffective in cleaning up strontium-90, so DOE is now applying an in situ technology called strontium-90 sequestration, using an apatite chemical solution.

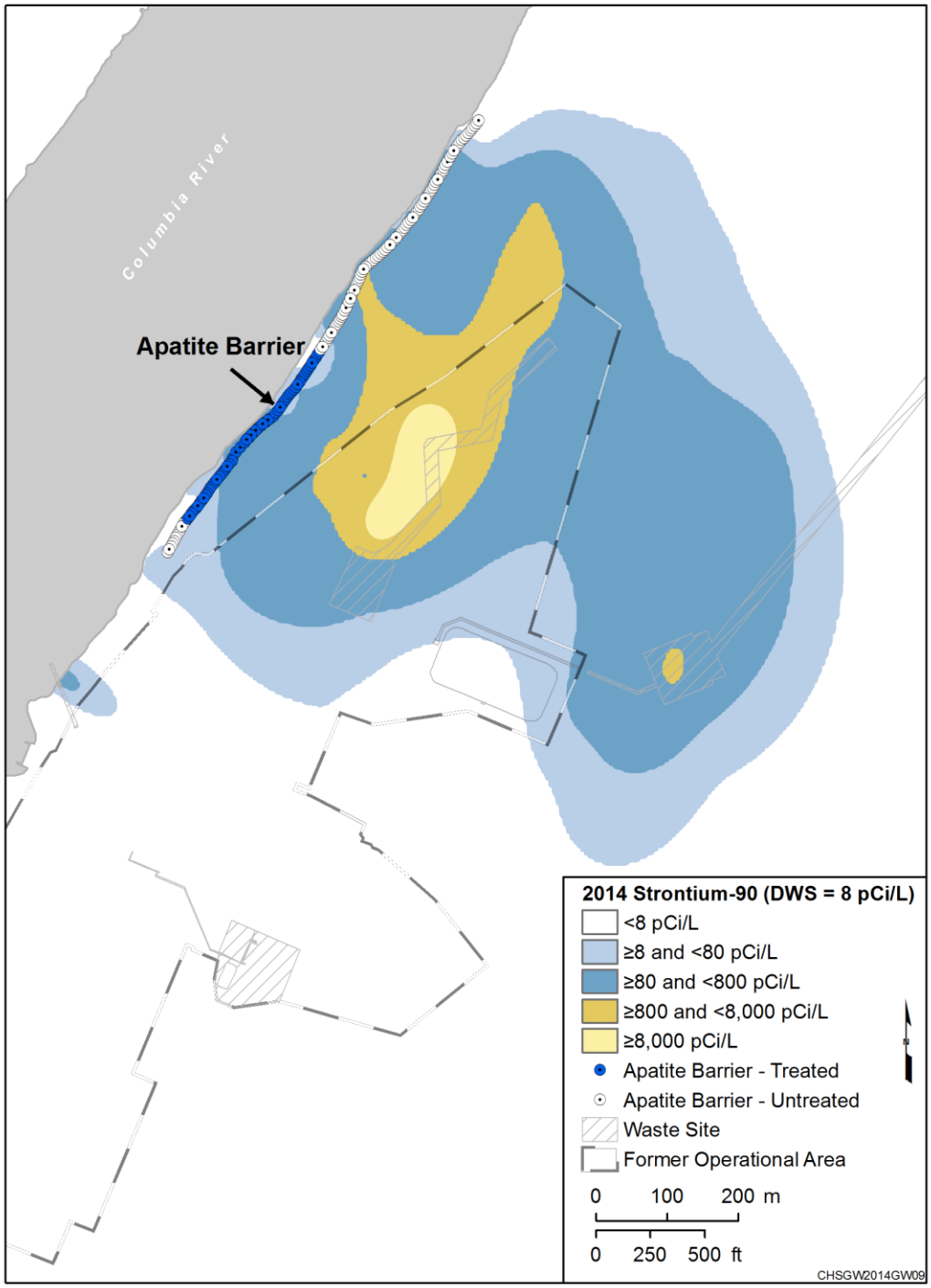


Figure ES-9. 100-NR 2014 Strontium-90 Plume and Apatite Barrier

To create the apatite barrier, DOE injected chemicals into a line of wells along the river shore, creating a treatment zone in the aquifer. As contaminated groundwater flows through this zone, much of the strontium-90 binds to the sediment grains before it can reach the river.

In 2014, RCRA monitoring continued under final status detection programs at the 1301-N, 1324-N/NA, and 1325-N facilities (waste sites 116-N-1, 120-N-1, 120-N-2, and 116-N-3). Results indicated no releases of dangerous waste constituents from the RCRA units.

DOE submitted a draft RI/FS report and proposed plan to Ecology for review in 2013. When finalized, these documents will be used to develop a ROD documenting remediation of waste sites and groundwater.

100-HR

Highlights:

- Approximately 87 percent of the former waste sites have been remediated or were determined not to require remediation under an interim action ROD. Remediation of waste sites continued in 2014, including 100-D-100, a major source of hexavalent chromium. Contaminated sediment was excavated down to the water table, and excavation into the top of the aquifer continues in 2015.
- Two P&T systems continued to operate under an interim action ROD, removing hexavalent chromium. In 2014, 2.4 billion L (634 million gal) of groundwater were pumped from 74 extraction wells. A total of 2,246 kg of hexavalent chromium have been removed to date. The plume area (greater than 20 µg/L) was estimated to be 3.5 km^2 (1.4 mi^2) in 2014, a decline from 2013. Since 2005 the plume has decreased in area by over 60 percent, and the length of shoreline intersected by the plume (above 20 µg/L) has been reduced from 2,550 m (8,200 ft) to 0 m (Figure ES-10). The changes are a result of contaminant removal, remediation of sources, hydraulic control, and natural processes.
- Ecology accepted the 100-HR-3 RI/FS Report in October 2014.

The 100-HR-3 Groundwater OU in the northern Hanford Site includes the 100-HR-D and 100-HR-H groundwater interest areas. Hexavalent chromium is the primary COC. Additional groundwater contaminants in 100-HR include strontium-90 and nitrate (Figure ES-7).

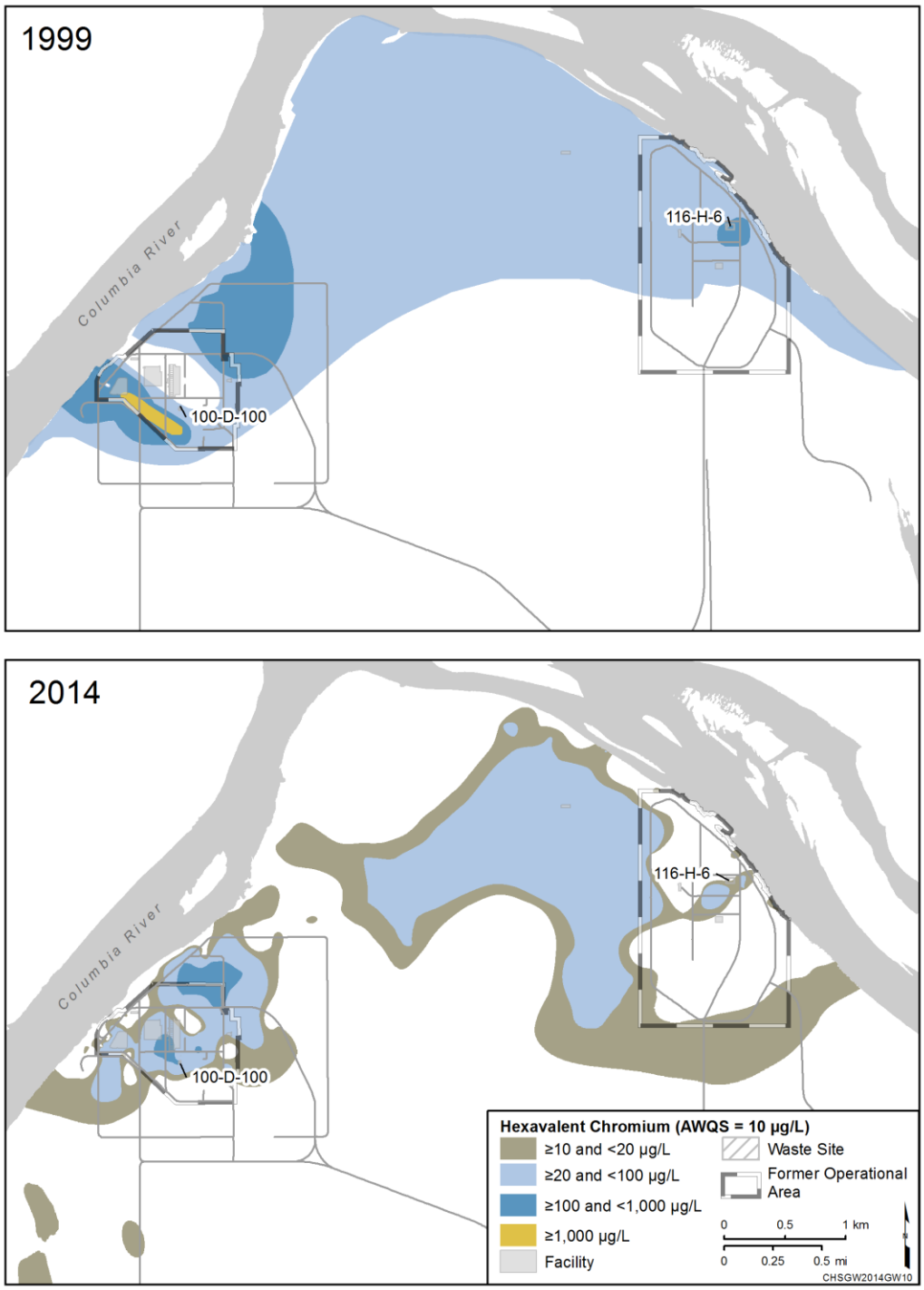


Figure ES-10. 100-HR Hexavalent Chromium Plume in 1999 (Early in Interim Action Period) and 2014 (During Interim Action)

Two P&T systems are remediating groundwater in the 100-HR-3 OU. The size and concentration of the plumes have declined since remediation began, especially in areas adjacent to the Columbia River.

Investigation of groundwater conditions at 100-HR greatly changed the understanding of the extent of chromium contamination since P&T began, primarily because many more wells were installed. In 1997, 110 wells and aquifer tubes were sampled, and in 2014, over 330 wells and aquifer tubes were sampled in 100-HR. The added wells and aquifer tubes identified areas of higher chromium concentrations at 100-D, in the Horn, and in the Ringold Formation upper mud unit (RUM). Even with areas of high levels of contamination being identified, the overall areal extent of the plume has decreased as a result of remediation (Figure ES-10).

The CERCLA process is underway to make final cleanup decisions for 100-HR. DOE submitted the Draft A RI/FS and Proposed Plan in 2012. In 2013 and 2014, DOE and Ecology worked through the comment resolution process, and Ecology accepted the RI/FS in 2014. The Proposed Plan is expected to be available for public comment in 2015 or 2016. A ROD will then be issued that identifies the final remedial alternatives. DOE has proposed ongoing P&T as the preferred alternative for remediating hexavalent chromium in groundwater.

The former 183-H Solar Evaporation Basins (waste site 116-H-6) constitute the only RCRA site in 100-HR. The site is monitored in accordance with RCRA corrective action requirements during the post-closure period to track contaminant trends during operation of the CERCLA interim action for hexavalent chromium.

100-FR

Highlights:

- Former 100-FR waste sites have been excavated and backfilled under an interim action ROD.
- In 2014, EPA and DOE signed a ROD that includes monitored natural attenuation (MNA) as the preferred alternative for 100-FR-3 groundwater remediation. Preparation of a work plan and sampling and analysis plan are underway.

Groundwater contamination in 100-FR originated from disposal of solid and liquid waste associated with operation of the water-cooled F Reactor and biological experiments. Nitrate concentrations in groundwater exceed the DWS beneath much of the 100-F Area and the plume extends southward approximately 5 km (3.1 mi). Smaller plumes of

hexavalent chromium, strontium-90, and trichloroethene are present (Figure ES-7). Contaminant concentrations are below cleanup standards near the river and are declining.

300-FF

Highlights:

- Approximately 91 percent of the waste sites have been remediated or classified as not requiring remediation. Remediation is continuing at the remaining sites.
- The remedial design report/remedial action work plan that implements the 2013 final action ROD is anticipated to be issued in 2015.
- DOE is conducting field and laboratory studies to understand and model the processes that control contaminant flux between groundwater and the Columbia River. In 2014, studies focused on seasonal water quality dynamics (including uranium and nitrate).

Three geographic regions comprise 300-FF: the 300 Area Industrial Complex; the 618-11 Burial Ground region; and a region including the 618-10 Burial Ground and 316-4 Cribs (Figure ES-7).

EPA and DOE signed a ROD in 2013. The remedial action for groundwater includes enhanced attenuation of uranium using sequestration by phosphate application. MNA is the selected remedy for other COCs: trichloroethene and cis-1,2-dichloroethene at the 300 Area Industrial Complex and tritium and nitrate at the 618-11 Burial Ground. Uranium concentrations remain above the cleanup level (30 µg/L) in groundwater in the 300 Area Industrial Complex and downgradient from the 618-7 Burial Ground (Figure ES-11). Contamination from 618-7 was mobilized by waste site remediation activities in recent years.

Trichloroethene concentrations exceeded the cleanup level (4 µg/L) in one 300-FF monitoring well and several aquifer tubes in 2014. Concentrations of nitrate above 45 mg/L are also present in groundwater beneath part of the 300 Area Industrial Complex, but these originated from sources off the Hanford Site; nitrate in the 300 Area Industrial Complex is not a COC for 300-FF.

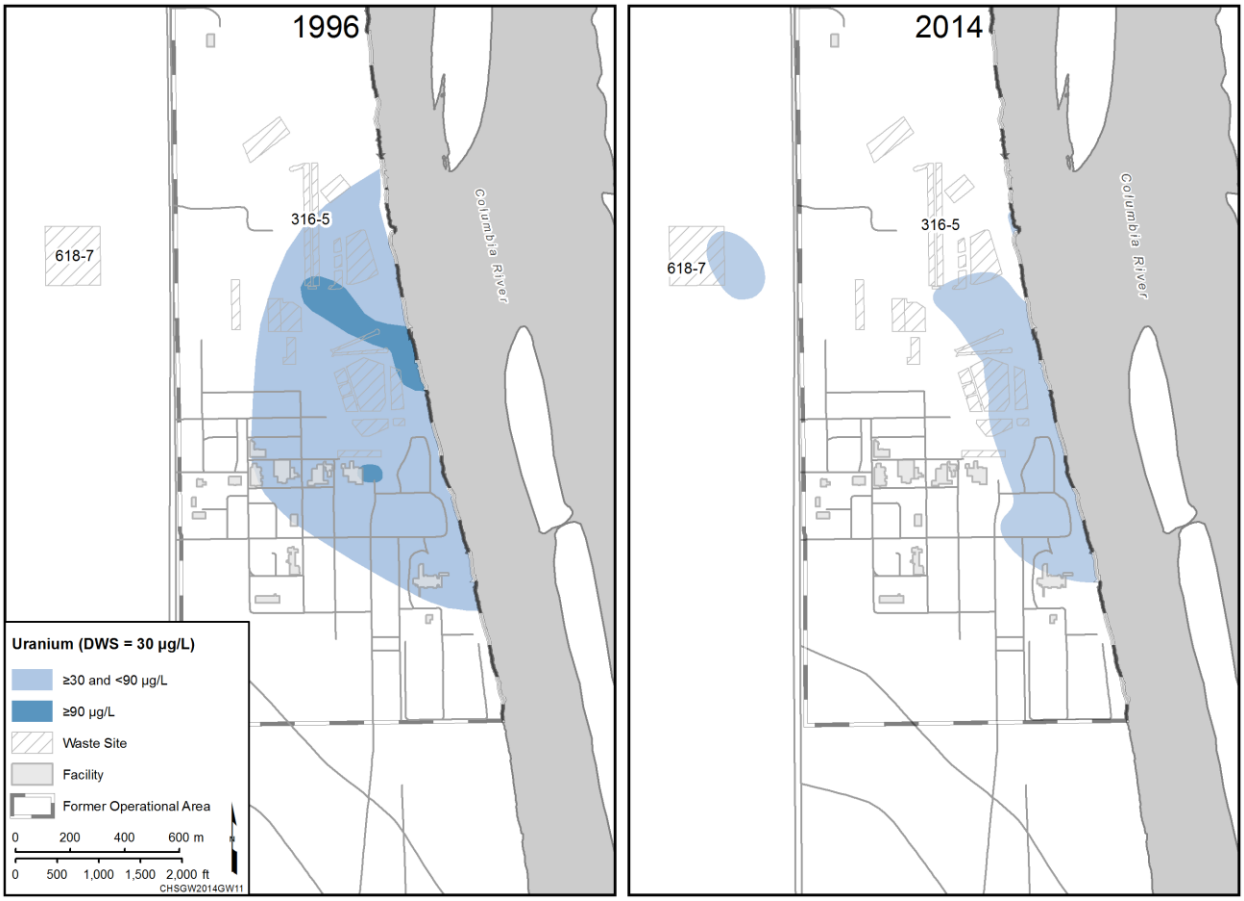


Figure ES-11. 300-FF Uranium Plume in 1996 and 2014

The uranium plume in the 300 Area is attenuating slowly. Groundwater remediation will include chemically sequestering contamination in the deep vadose zone and at the top of the aquifer beneath a former waste site, to decrease the amount of uranium feeding the groundwater plume.

Groundwater associated with the 618-11 Burial Ground, north of the 300 Area Industrial Complex, contains a high-concentration tritium plume originating from irradiated material in the burial ground. The waste site has not been remediated. Nitrate concentrations near the 618-11 Burial Ground also continued to exceed the cleanup level (45 mg/L).

RCRA groundwater monitoring continued at the 300 Area Process Trenches (waste site 316-5). The unit is monitored in accordance with post-closure corrective action requirements (WAC 173-303-645[11]). Uranium and cis-1,2-dichloroethene continued to exceed permit concentration limits in 2014. In accordance with the closure plan, groundwater corrective action will be addressed as part of the remediation for the CERCLA 300-FF-5 Groundwater OU.

1100-EM and Richland North

Highlights:

- Remediation of the former 1100-EM-1 OU is complete.
- DOE monitors wells in and near the north Richland well field, which is part of the municipal water supply system. Tritium concentrations are at background levels.

The 1100-EM-1 Groundwater OU was removed from the "National Priorities List" (40 CFR 300, Appendix B) in 1996. The selected remedy was MNA of volatile organic compounds, with institutional controls (ICs) on drilling of new water supply wells. Trichloroethene is the primary COC, but concentrations have remained below the cleanup level since 2001.

Uranium concentrations in Hanford Site wells in the vicinity of DOE's inactive Horn Rapids Landfill have increased gradually since 1996, exceeding the DWS in 2012 and dropping slightly below the standard in 2014. The presence of uranium at these locations is attributed to a plume moving northeast from an active offsite facility, AREVA NP, Inc. a nuclear fuel production facility.

Columbia River

Highlights:

- River water downstream of the Hanford Site meets water quality standards.

DOE samples Columbia River water, river sediment, and riverbank seeps to determine the extent of Hanford Site contaminants. Except for tritium and uranium isotopes, radionuclides were undetected in upstream and downstream samples. The average tritium concentration downstream of the Site, near the City of Richland, was 48 pCi/L, compared to 18 pCi/L upstream of the Site. The DWS for tritium is 20,000 pCi/L. The average concentration of uranium-238 downstream of the Site was 0.22 pCi/L, compared to 0.18 pCi/L upstream of the Site. The sum of uranium isotopes downstream of the Site equates to 0.72 µg/L total uranium, compared to the DWS of 30 µg/L. Chromium was undetected in upstream and downstream water samples.

Two DOE studies addressed the entire River Corridor in order to support the multiple River Corridor RI/FS documents. The 100 Area and 300 Area component of DOE's

River Corridor baseline risk assessment, published in 2011 and 2012 (DOE/RL-2007-21 and DOE/RL-2010-117) addresses post-remediation, residual contaminant concentrations in these areas, as well as the Hanford and White Bluffs town sites. The assessment also investigated the risks related to the potential transport of Hanford Site contaminants into Columbia River riparian and near-shore environments adjacent to the operational areas.

DOE completed an investigation of Hanford Site contaminant releases in the Columbia River in 2010 (DOE/RL-2010-117). Samples were collected of pore water (i.e., groundwater discharge into the river bottom sediment), river sediment, river water, fish, and island soil. Pore water in some samples from 100-BC, 100-K, 100-D, and 100-H had concentrations of hexavalent chromium above the aquatic standard, and strontium-90 exceeded the DWS in some 100-N Area samples. Tritium concentrations exceeded the DWS in some pore water samples near the former Hanford town site (location shown in Figure ES-17), and uranium exceeded the DWS in pore water near the 300 Area. The information obtained from this investigation is being used to help make final cleanup decisions for each of the River Corridor units.

Central Plateau

Highlights:

- An estimated 570,000 to 920,000 kg of liquid wastes with carbon tetrachloride was discharged to waste sites in 200-ZP-1. Remediation has reduced the size of the high-concentration core and the overall footprint of the carbon tetrachloride plume. Combined, the final action system, the interim action system, and a soil vapor extraction system have removed a total of 100,496 kg of carbon tetrachloride from the subsurface.
- A P&T system at Waste Management Area (WMA) S-SX in the 200-UP-1 OU, which began operating in July 2012, has removed 1.66 Ci of technetium-99, 16,280 kg of nitrate, 28.1 kg of chromium, and 250 kg of carbon tetrachloride from groundwater.
- The size of the regional tritium plume associated with 200-PO-1 has decreased in area by more than one-half (from 185 to 79 km^2) since 1980, primarily as a result of radioactive decay and dispersion.

When the Hanford Site was operating as a plutonium-production facility, irradiated fuel reprocessing, isotope recovery, and associated waste management activities occurred in the 200 East and 200 West Areas in the central portion of the Site. Ponds, cribs, and ditches used for disposal of liquid waste were primary sources of groundwater contamination. There are also seven single-shell tank WMAs in the 200 Area. Some of these tanks have leaked, contaminating the vadose zone and groundwater beneath the tanks.

Contamination is still present in many parts of the thick vadose zone, and may continue to drain into the groundwater. Remediation of the Central Plateau waste sites and vadose zone will accelerate after River Corridor remediation is complete. Meanwhile, DOE has been remediating groundwater and testing methods to remediate the deep vadose zone.

Groundwater contaminant plumes of tritium, nitrate, and iodine-129 formed when the waste discharged to ponds and cribs reached the aquifer. These contaminants form regional plumes originating on the Central Plateau. The plumes have decreased in area over the years as a result of dispersion and, in the case of tritium, radioactive decay. A large carbon tetrachloride plume originated in the Plutonium Finishing Plant (PFP) area of 200 West. Other groundwater contaminants in the Central Plateau include technetium-99, uranium, strontium-90, trichloroethene, hexavalent chromium, cyanide, and other dangerous waste constituents (Table ES-2 and Figure ES-12).

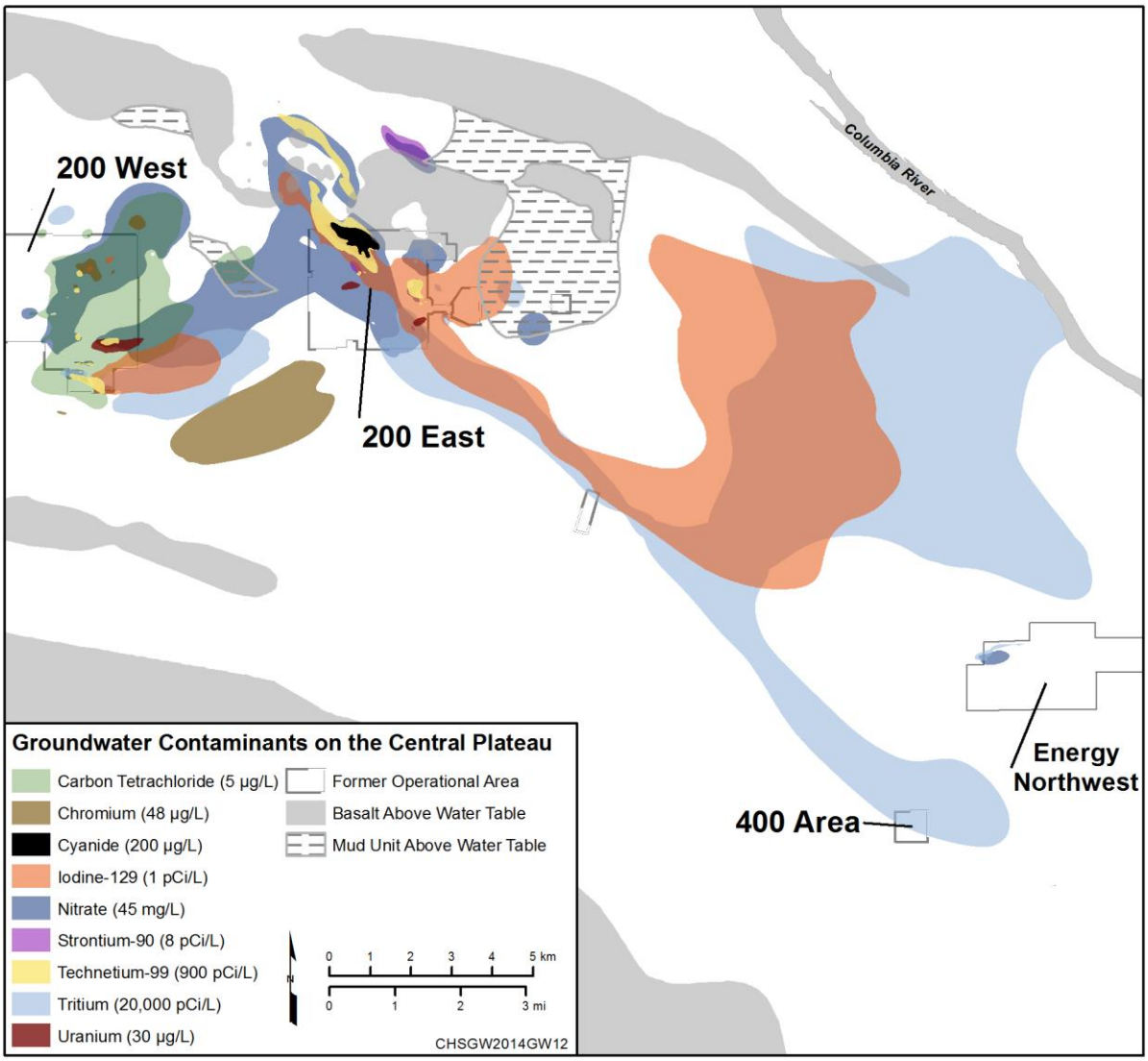


Figure ES-12. Groundwater Contaminants in the Central Plateau

Tritium and iodine-129 are mobile in groundwater and have formed extensive plumes that originated in the 200 Areas. Carbon tetrachloride forms a large plume beneath the 200 West Area. Other radionuclides and chemicals form smaller plumes beneath the Central Plateau.

200-ZP

Highlights:

- A P&T system has reduced the high-concentration core area of the carbon tetrachloride plume (Figure ES-13). The plume area above 5 µg/L was 13.1 km^2 (5.1 mi^2) in 2014, compared to 15.4 km^2 (5.9 mi^2) in 2013.
- In 2014, 20 extraction wells and 20 injection wells were in use and the treatment plant operated at a flow rate of 5,913 L/min (1,562 gpm) (71 percent of its design capacity). Additional wells were installed in 2014 that will be used to expand the extraction network. In 2014, the system processed 3.1 billion L (819 million gal) of groundwater and removed 2,796 kg of carbon tetrachloride, 234,616 kg of nitrate, and other contaminants from groundwater.
- Combined, the final action system, the interim action system, and a soil vapor extraction system have removed a total of 100,496 kg of carbon tetrachloride from the subsurface (Figure ES-14).

Contaminant sources in 200-ZP, located in the 200 West Area, included cribs, ponds, and single-shell storage tanks. A final action ROD for 200-ZP-1 OU groundwater identified carbon tetrachloride as the primary COC. Other COCs are trichloroethene, iodine-129, technetium-99, nitrate, chromium, and tritium.

Two Low-Level Waste Management Areas (LLWMA-3 and LLWMA-4) in 200-ZP are monitored under RCRA interim status, contaminant indicator parameter programs. Monitoring results showed no indication that either of these is contaminating groundwater.

RCRA assessment monitoring continued at WMA T and WMA TX-TY. Due to CERCLA remediation activities (operation of the 200 West P&T system) near WMA T, chromium concentrations are declining and the plume extents at both WMAs are shrinking.

The State-Approved Land Disposal Site (SALDS) receives treated water from the Hanford Site's Effluent Treatment Facility. It is regulated under a state waste discharge permit and has created a local tritium plume. All groundwater sampling results from the SALDS proximal wells were within permit compliance limits during 2014.

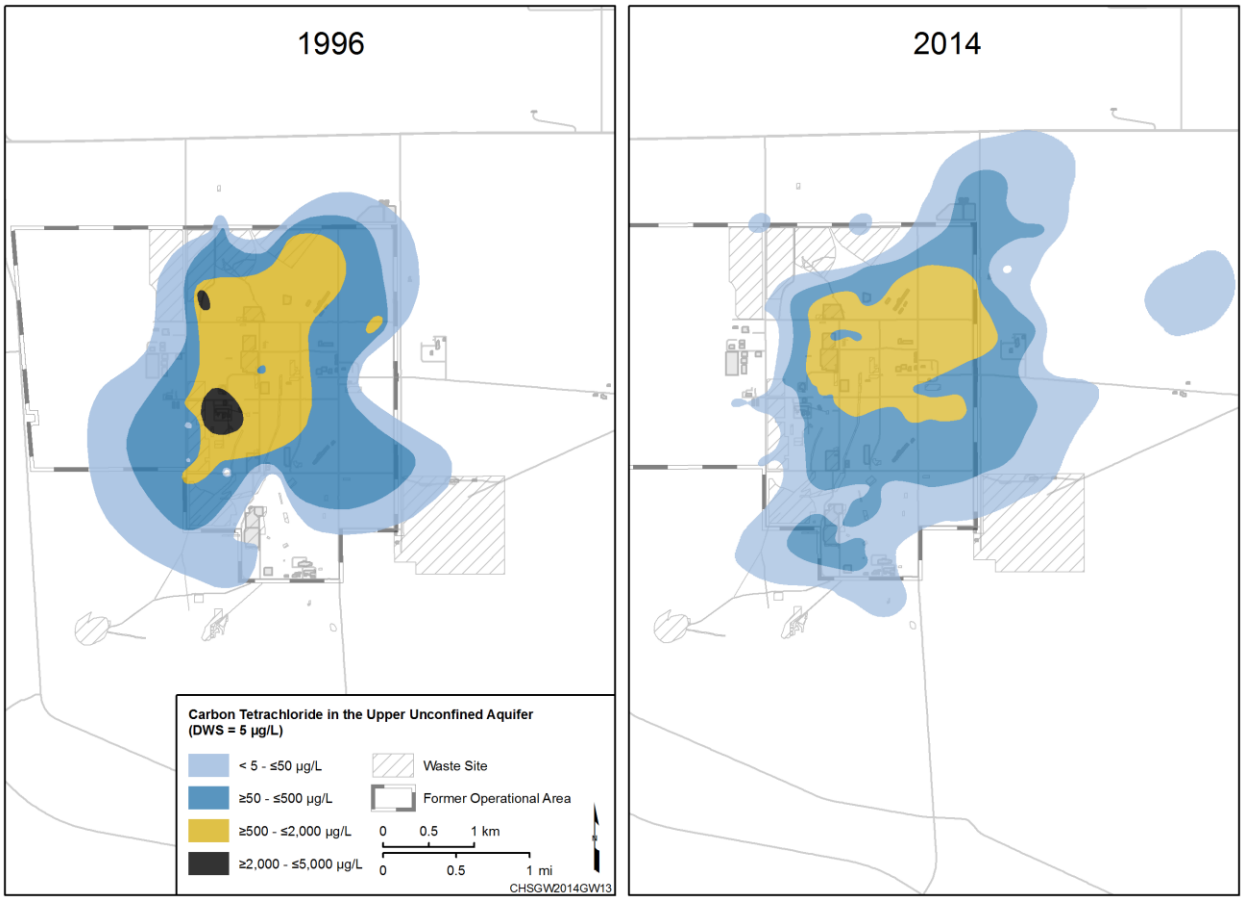


Figure ES-13. 200-West Carbon Tetrachloride Plume in 1996 (Upper Part of Unconfined Aquifer) and 2014 (Including Available Vertical Interval Data)

In 1996, little was known about the distribution of carbon tetrachloride in the deep part of the aquifer. Today, the plume is characterized throughout its full thickness, and the 2014 map includes data from various depths. An extensive P&T system is remediating the high-concentration portions of the plume.

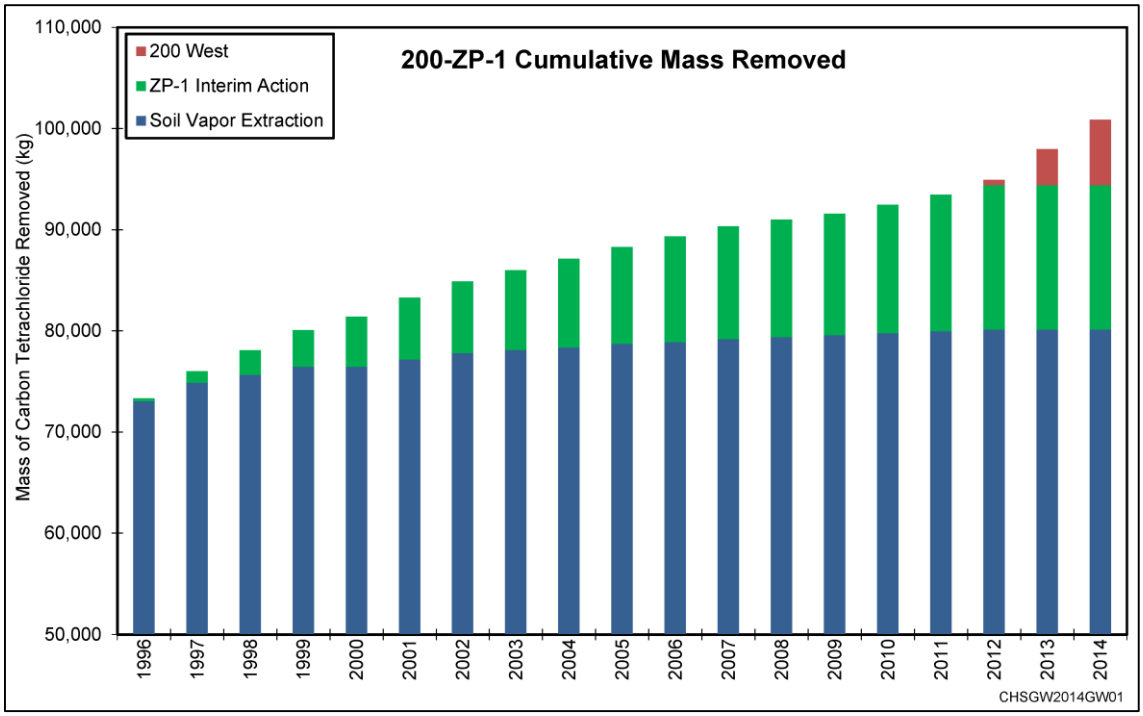


Figure ES-14. 200-ZP Carbon Tetrachloride Mass Removed by Final P&T, Interim P&T, and Soil Vapor Extraction

Since 1996 DOE has removed more than 100,000 kilograms of carbon tetrachloride from the vadose zone and groundwater in 200-ZP. The 200 West P&T system began to operate in 2012 under a final action ROD.

200-UP

Highlights:

- A P&T system at WMA S-SX began operating in July 2012. From 2012 to 2014 the system removed a 1.66 Ci of technetium-99, 16,280 kg of nitrate, 28.1 kg of chromium, and 250 kg of carbon tetrachloride from groundwater.
- Another part of groundwater remediation under the interim action ROD is a groundwater extraction system to remediate the uranium and technetium-99 plumes in the U Plant area. The system is currently being designed and will be constructed in 2015.

The southern portion of the 200 West Area and adjacent areas to the east and south comprise 200-UP. Contaminant sources included cribs, ponds, and single-shell tanks. Carbon tetrachloride, technetium-99, uranium, tritium, iodine-129, nitrate, and chromium plumes are present. Carbon tetrachloride in this region originated from sources

in 200-ZP. Wells near WMA S-SX monitor the highest technetium-99 concentrations on the Hanford Site, and the plume has grown in recent years (Figure ES-15).

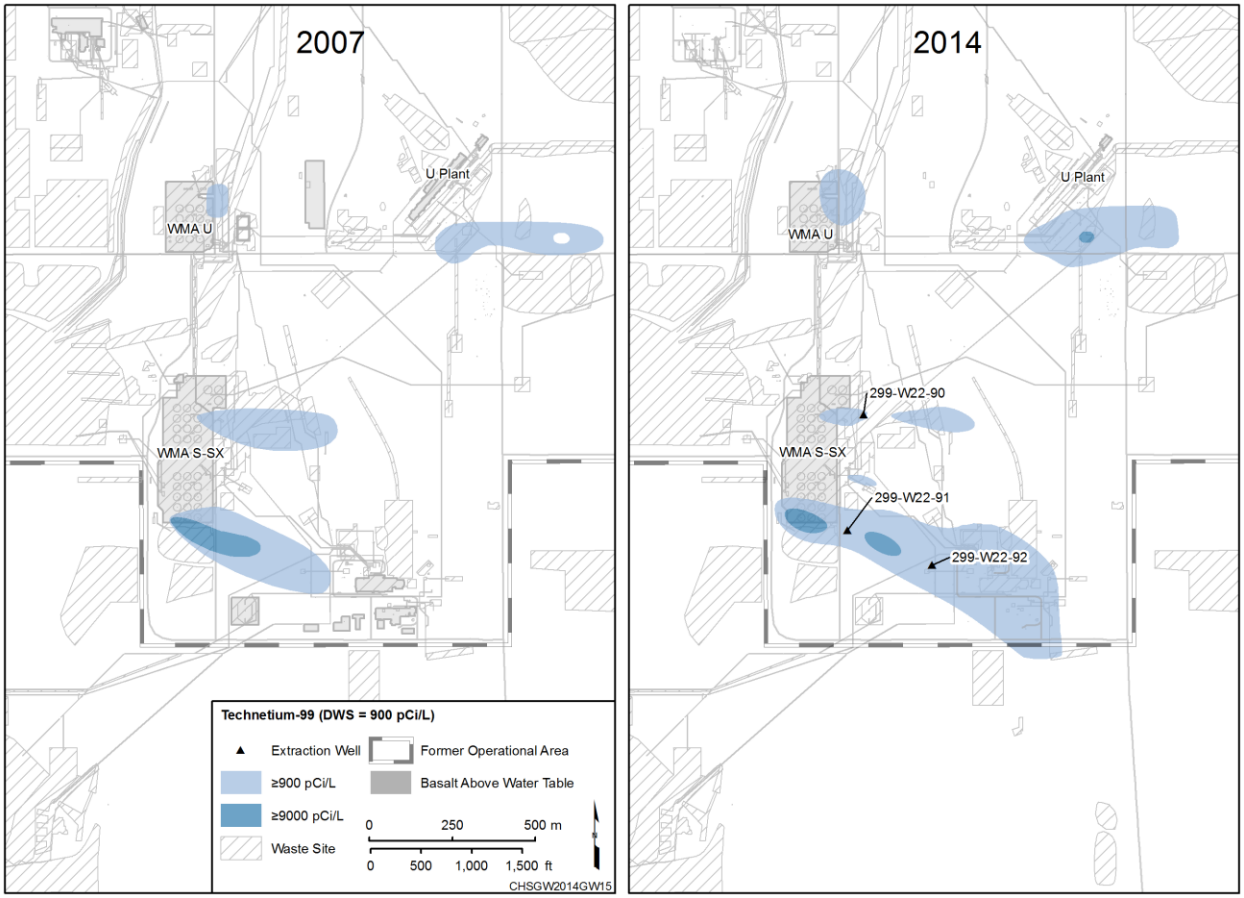


Figure ES-15. WMA S-SX Technetium-99 Plume in 2007 and 2014

A technetium-99 plume at the S and SX tank farms has expanded in recent years. Groundwater is now being extracted from the plume to remediate it.

An interim action ROD addressing all of the major contaminant plumes within the 200-UP-1 OU was published in 2012. The selected remedy in the ROD consists of a combination of P&T, MNA, hydraulic containment, and institutional controls.

RCRA monitoring in 200-UP includes interim status groundwater quality assessment monitoring at WMA S-SX and WMA U, and interim status indicator parameter evaluation monitoring at the 216-S-10 Pond and Ditch. WMA S-SX has contaminated groundwater with chromium, nitrate, and the non-RCRA constituent technetium-99. Water levels have declined at WMA S-SX due to groundwater extraction, causing some monitoring wells to go dry sooner than they would have otherwise. One new well was

installed in 2014 and four additional replacement wells are planned in 2015. Sources within WMA U have contaminated groundwater with nitrate and chromium. The groundwater beneath this tank farm is within the capture zone of a nearby extraction well. Indicator parameters did not exceed statistical comparison values at the 216-S-10 Pond and Ditch during 2014.

The Environmental Restoration Disposal Facility (ERDF) is a CERCLA disposal facility used for disposal of low-level radioactive mixed waste generated by remedial actions. The results of groundwater monitoring in 2014 continued to indicate that the facility has not impacted groundwater.

200-BP

Highlights:

- Wells in the northwestern part of 200-BP detect the highest concentrations of uranium in Hanford Site groundwater. Concentrations are even higher in a zone of perched water that lies above the water table. DOE, EPA, and Ecology signed an Action Memorandum in 2014 that directs continuing the extraction of contaminated perched water as a non-time-critical removal action under CERCLA. Approximately 53 kg of uranium were removed from the perched zone through the end of 2014.
- A draft RI report for the 200-BP-5 OU was prepared in 2014, describing the nature and extent of contamination and identifying contaminants of potential concern to support a future FS. In addition, work began on the FS in late 2014.

The 200-BP groundwater interest area includes the northern 200 East Area and the region to the northwest where mobile contaminants have migrated between Gable Mountain and Gable Butte. Most of the groundwater contamination is concentrated beneath WMA B-BX-BY and adjacent waste sites in the northwestern portion of the 200 East Area. Nitrate, iodine-129, and technetium-99 form the largest contaminant plumes. The high-concentration cores of these plumes have grown in size since 2007 due to continued drainage of contaminated water from the vadose zone into the aquifer (Figure ES-16). Smaller plumes of uranium, cyanide, strontium-90, and tritium also exceed their respective DWSs. Cesium-137 and plutonium-239/240 contamination is limited to one or two wells.

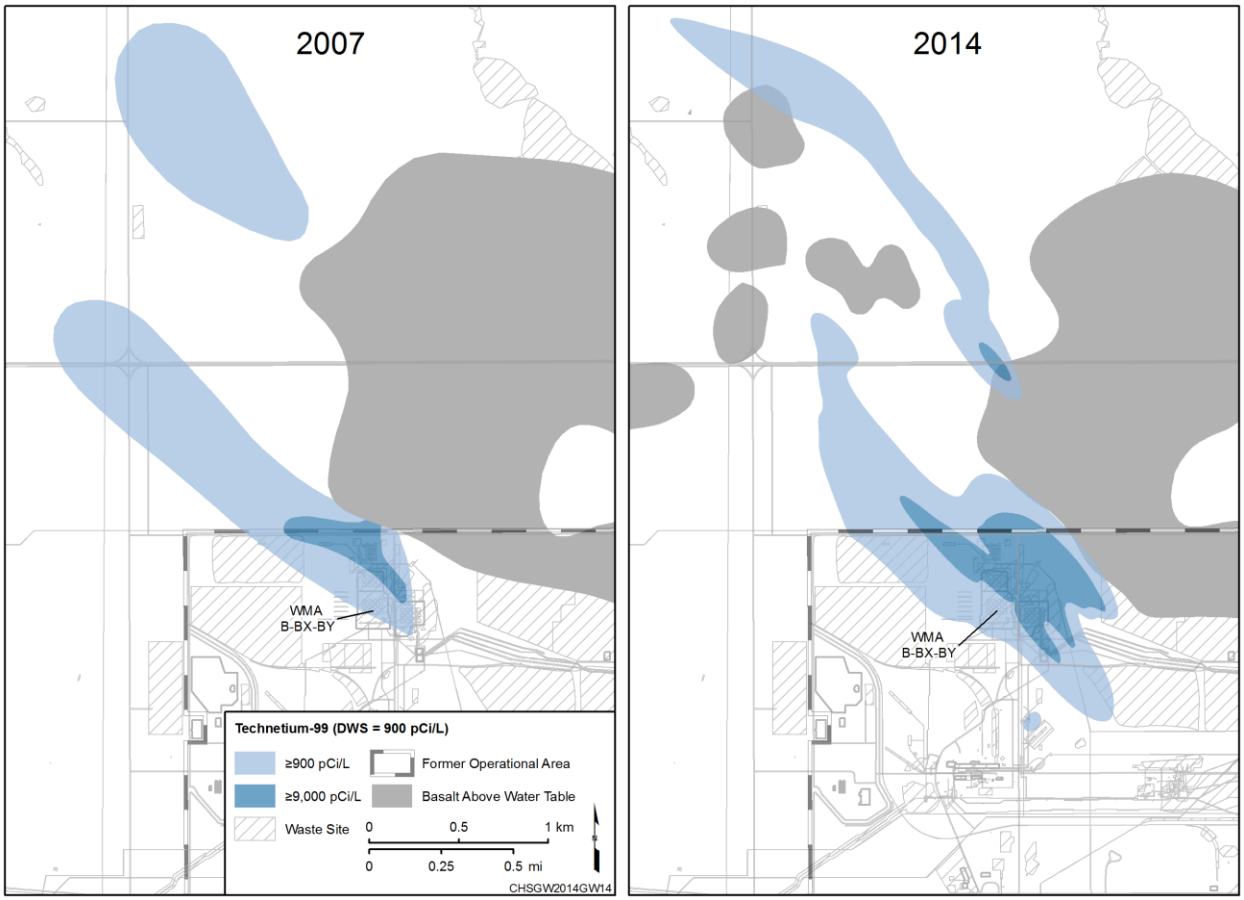


Figure ES-16. 200-BP Technetium-99 Plume in 2007 and 2014

The high-concentration cores of 200-BP contaminant plumes have grown in size since 2007 due to drainage of contaminated water from the vadose zone into the aquifer. DOE is pumping and treating perched water to lessen the amount that enters groundwater.

Six RCRA sites with groundwater monitoring requirements are located in 200-BP. RCRA groundwater quality assessment monitoring at WMA B-BX-BY and WMA C indicates that the dangerous waste constituent cyanide in groundwater originated in the WMAs. Because of the continued migration of this dangerous waste constituent an additional well was installed at WMA B-BX-BY in 2014. RCRA contamination indicator parameter monitoring continued at the 216-B-63 Trench, LLWMA-1, and LLWMA-2 in 2014. Results continued to show that these units have not impacted groundwater. DOE monitors the Liquid Effluent Retention Facility (LERF) under a RCRA final status detection program. Results showed no indication that the site has affected groundwater. A new groundwater monitoring plan for LERF was implemented in 2014.

200-PO

Highlights:

- The size of the regional tritium plume (Figure ES-17) from 200-PO has decreased in area by more than one-half since 1980 (from 185 to 79 km^2). The maximum concentration has declined from over 6 million pCi/L in the 1980s to 510,000 pCi/L in 2014.
- An RI addendum report for the 200-PO-1 OU is currently being prepared to update the risk assessment based on additional groundwater data collected since the RI was completed in 2008 and 2009. In addition, work began on the FS in late 2014.

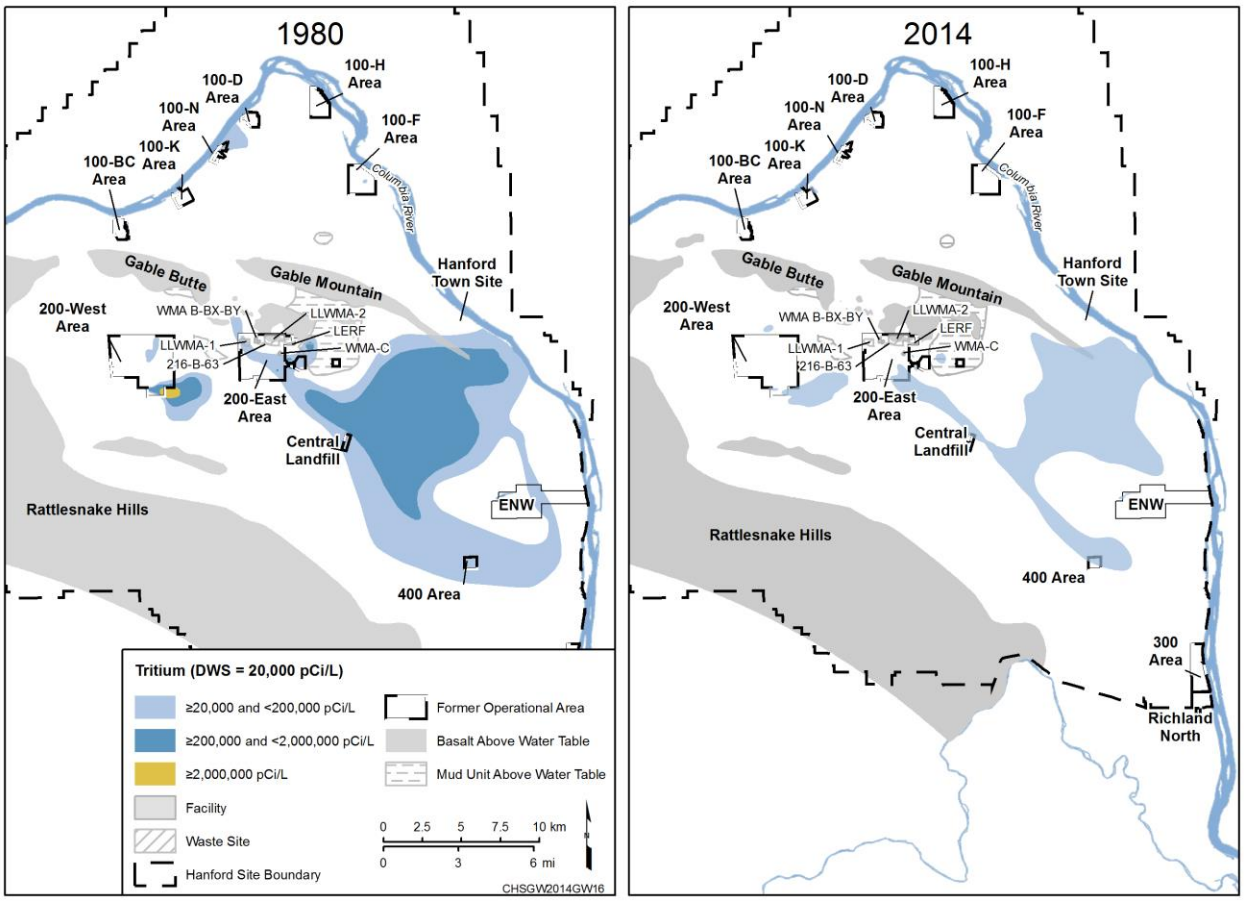


Figure ES-17. Hanford Site Tritium Plumes in 1980 and 2014

Hanford Site tritium plumes are shrinking as a result of radioactive decay, dispersion, and discharge to the Columbia River. Since 1980 the total area of the plumes has decreased by more than 50 percent and the maximum concentration has declined by 90 percent.

The southern portion of the 200 East Area and a large region of the Hanford Site to the east and southeast comprise 200-PO. Disposal of large volumes of liquid waste created regional groundwater plumes of tritium, iodine-129, and nitrate. The tritium plume had an estimated area of 79.2 km^2 (30.6 mi^2) in 2014, a 5 percent decrease from 2013. Concentrations of tritium are declining as the groundwater plume attenuates naturally as a result of radioactive decay and dispersion. The area of the iodine-129 plume above the 1 pCi/L contour has decreased slightly over the past decade, and maximum concentrations have declined as a result of dispersion. Radioactive decay has not decreased the level of iodine-129 contamination noticeably because this isotope has a half-life of 15.7 million years. The nitrate plume covers a large area, with concentrations above background, but mostly below the DWS. Other contaminants in 200-PO include strontium-90, technetium-99, and uranium in smaller areas near their discharge sources (Figure ES-12).

In 2014, RCRA assessment monitoring continued at WMA A-AX and interim status indicator parameter programs continued at the 216-A-36B Crib, 216-A-37-1 Crib, 216-A-29 Ditch, 216-B-3 Pond, and Nonradioactive Dangerous Waste Landfill (NRDWL). One monitoring well with casing corrosion associated with WMA A-AX was decommissioned in 2013. Drilling of a replacement well started in November 2014 and will be completed in early 2015. Monitoring results from the interim status sites provided no indication of releases from these facilities to groundwater.

The Integrated Disposal Facility is an expandable, double-lined landfill that is regulated under RCRA and the AEA. It is not yet in use, and current groundwater monitoring is directed at obtaining baseline data.

The Solid Waste Landfill is regulated under Washington State solid waste handling regulations. As in previous years, some of the monitoring wells showed higher concentrations of regulated constituents than the statistically calculated background threshold values. Background threshold values exceeded during 2014 included specific conductance, nitrite, sulfate, and total organic carbon.

Three on-site water supply wells provide drinking water and serve as an emergency water supply for the 400 Area, which is in the footprint of 200-PO. Because the 400 Area is in the path of the Hanford Sitewide tritium plume, DOE routinely monitors the wells for tritium.

Confined Aquifers

Although most Hanford Site groundwater contamination is found in the unconfined aquifer, DOE monitors wells in deeper aquifers because of potential downward movement of contamination.

One confined aquifer occurs within sand and gravel at the base of the Ringold Formation. Carbon tetrachloride, nitrate, and technetium-99 have contaminated this unit in a portion of the 200 West Area where the upper confining unit is absent. Newer wells have been installed to monitor and remediate this contamination. The Ringold confined aquifer is the uppermost aquifer in a region east of 200 East (within portions of 200-BP and 200-PO). Iodine-129 and tritium are detected in wells at this location, but the contamination has not migrated farther to the east or southeast.

In the northern Hanford Site, fine-grained sedimentary units, informally called the RUM, confine deeper sediments in the Ringold Formation. In some parts of 100-HR this unit is contaminated with hexavalent chromium at concentrations over 100 µg/L and is being remediated by a P&T system.

Groundwater within basalt fractures and joints, interflow contacts, and sedimentary interbeds make up the upper basalt-confined aquifer system.

Wells

Highlights:

- During 2014, DOE installed thirty new wells and six new aquifer tubes

Over the lifetime of the Hanford Site, DOE has installed thousands of wells to monitor and remediate groundwater and provide geologic data. Table ES-3 lists wells installed in 2014 and Figure ES-18 illustrates the number of wells installed during the past ten years.

DOE identifies wells, boreholes, or other subsurface installations for decommissioning when they are no longer needed. This involved sealing the wells in compliance with Washington State standards for construction and maintenance of wells (WAC 173-160). Four temporary wells in 100-D Area (199-D5-155, 199-D5-156, 199-D5-157, and 199-D5-158), were decommissioned in 2014.

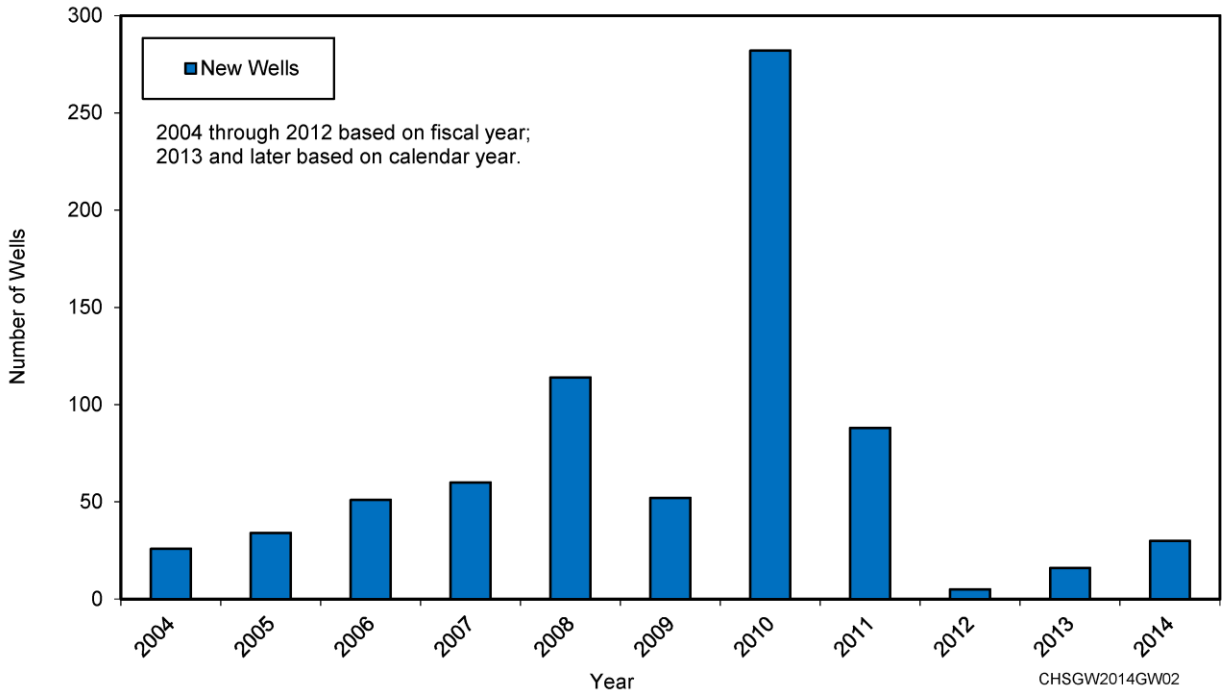


Figure ES-18. New Wells Installed on the Hanford Site, 2004 to 2014

New wells are installed to characterize, monitor, and remediate groundwater.

Table ES-3 New Wells and Aquifer Tubes Completed in 2014

Groundwater Interest Area	Wells	Aquifer Tubes
100-BC	8	6
100-HR-D	4	0
100-KR	6	0
200-BP	3	0
200-PO	3	0
200-UP	2	0
200-ZP	4	0
Total	**30**	**6**
Monitoring wells are constructed to WAC 173-160 specifications; aquifer tubes are not		

Additional Information

The monitoring data presented in this report, and information on monitoring well locations, construction details, and screened intervals, can be found through the DOE Environmental Dashboard Application at https://ehs.hanford.gov/eda/, in the interactive version of this document, or on the PHOENIX website at http://phoenix.pnnl.gov.

This page intentionally left blank.

Contents

Executive Summary ..... **iii**

Contents ..... **xxxvii**

Figures ..... **xliv**

Tables ..... **lvi**

Terms ..... **lix**

1 Introduction **1-1**

1.1 Purpose and Scope 1-3
1.2 Groundwater Monitoring 1-7
1.3 Conventions Used in this Report 1-8
1.4 River Corridor 1-12
1.4.1 Hydrogeology 1-16
1.4.2 Cleanup 1-19
1.4.3 Groundwater Monitoring Results 1-20
1.4.4 Shoreline Monitoring 1-24
1.4.5 River Corridor Baseline Risk Assessment and Columbia River Component Risk Assessment 1-29
1.5 Central Plateau 1-30
1.5.1 Hydrogeology 1-34
1.5.2 Cleanup 1-36
1.5.3 Groundwater Monitoring Results 1-36
1.6 CERCLA 5-Year Review 1-41
1.7 Quality Control Summary 1-41
1.8 Sources of Additional Information 1-41

2 100-BC **2-1**

2.1 Overview 2-1
2.2 CERCLA Activities 2-6
2.3 Hexavalent Chromium 2-7
2.4 Strontium-90 2-17
2.5 Tritium 2-19

3 100-FR **3-1**

3.1 Overview 3-1
3.2 CERCLA Activities 3-9
3.2.1 Groundwater Monitoring 3-9
3.2.2 Remedial Investigation/Feasibility Study 3-9
3.3 Nitrate 3-9

3.4 Trichloroethene 3-13
3.5 Hexavalent Chromium 3-15
3.6 Strontium-90 3-18
3.7 Uranium 3-20

4 100-HR 4-1

4.1 Overview 4-1
4.2 CERCLA Activities 4-10
4.2.1 Remedial Investigation/Feasibility Study 4-10
4.2.2 Interim Action Groundwater Remediation 4-11
4.3 100-HR-D Hexavalent Chromium 4-12
4.3.1 Southern Plume at 100-D 4-16
4.3.2 Northern Plume at 100-D 4-18
4.4 100-HR-H Hexavalent Chromium 4-20
4.4.1 Plume in the Horn and 100-H 4-20
4.4.2 Ringold Formation Upper Mud Unit 4-27
4.5 Nitrate 4-29
4.6 Strontium-90 4-32
4.7 Tritium 4-36
4.8 Uranium 4-38
4.9 Sulfate 4-40
4.10 Remedy Summary 4-41
4.10.1 Pump-and-Treat 4-42
4.10.2 In Situ Redox Manipulation Barrier 4-44
4.11 RCRA Monitoring 4-46

5 100-KR 5-1

5.1 Overview 5-1
5.2 CERCLA Activities 5-5
5.2.1 Remedial Investigation/Feasibility Study 5-7
5.3 Hexavalent Chromium – Low River Stage 5-7
5.3.1 116-K-2 Trench Associated Plume 5-11
5.3.2 K West Associated Plume 5-13
5.3.3 K East Associated Plume 5-15
5.4 Hexavalent Chromium – High River Stage 5-15
5.5 Tritium 5-20
5.6 Nitrate 5-23
5.7 Strontium-90 5-26
5.8 Carbon-14 5-30
5.9 Trichloroethene 5-32

5.10 100-KR-4 Remedy 5-35
5.10.1 Pump and Treat 5-35
5.11 Atomic Energy Act Monitoring 5-40

6 100-NR 6-1

6.1 Overview 6-1
6.2 CERCLA Activities 6-5
6.2.1 Groundwater Monitoring 6-5
6.2.2 Remedial Design/Remedial Action Work Plan 6-6
6.2.3 Remedial Investigation/Feasibility Study 6-6
6.2.4 Groundwater Remediation 6-6
6.3 Strontium-90 6-8
6.4 Tritium 6-12
6.5 Nitrate 6-13
6.6 Total Petroleum Hydrocarbons – Diesel 6-16
6.7 Hexavalent Chromium 6-19
6.8 100-NR-2 Remedies 6-20
6.8.1 Apatite Barrier 6-22
6.9 RCRA Monitoring 6-27
6.9.1 116-N-1 Crib and Trench 6-27
6.9.2 116-N-3 Crib and Trench 6-29
6.9.3 120-N-1 Percolation Pond and 120-N-2 Surface Impoundment 6-31

7 300-FF 7-1

7.1 Overview 7-1
7.2 CERCLA Activities 7-5
7.3 Uranium 7-8
7.3.1 Uranium at Low River Stage 7-8
7.3.2 Uranium at High River Stage 7-15
7.4 Tritium 7-18
7.5 Nitrate 7-20
7.5.1 618-11 Burial Ground 7-20
7.5.2 300 Area Industrial Complex 7-23
7.6 Trichloroethene and *cis*-1,2-Dichloroethene 7-23
7.7 RCRA – 316-5 Process Trenches 7-25

8 1100-EM 8-1

8.1 Overview 8-1
8.2 CERCLA Activities 8-5
8.3 Trichloroethene 8-6

8.4 Tritium....8-7
8.5 Nitrate....8-9
8.6 Uranium....8-11

9 200-BP....9-1

9.1 Overview....9-1
9.2 CERCLA Activities....9-10
9.3 Nitrate....9-15
9.3.1 BY Cribs....9-15
9.3.2 B Tank Farm....9-21
9.3.3 241-BX-102 Unplanned Release and 216-B-7A&B Cribs....9-22
9.3.4 216-B-12 Crib, B Plant, and 216-B-5 Injection Well....9-23
9.3.5 216-B-2 Ditches....9-23
9.3.6 Waste Management Area C....9-24
9.3.7 Gable Mountain Pond (216-A-25)....9-25
9.3.8 Gable Gap....9-25
9.4 Iodine-129....9-26
9.4.1 B Pond....9-26
9.4.2 Waste Management Area C....9-26
9.4.3 Low-Level Waste Management Area 2....9-26
9.4.4 216-B-5 Injection Well....9-26
9.4.5 216-B-2 Ditches....9-26
9.4.6 B Complex to Gable Gap....9-28
9.5 Technetium-99....9-29
9.5.1 BY Cribs....9-31
9.5.2 241-BX-102 Unplanned Release and 216-B-7A&B Cribs....9-36
9.5.3 B Tank Farm....9-38
9.5.4 Waste Management Area C....9-38
9.5.5 Gable Gap....9-39
9.6 Uranium....9-39
9.6.1 216-BX-102 Unplanned Release....9-39
9.6.2 216-B-12 Crib....9-42
9.7 Strontium-90....9-43
9.7.1 Gable Mountain Pond....9-43
9.7.2 216-B-5 Injection Well....9-43
9.8 Cyanide....9-46
9.8.1 BY Cribs....9-46
9.8.2 241-B Tank Farm....9-46
9.8.3 Gable Gap....9-46

9.9 Tritium 9-48
9.9.1 216-B-50 and 216-B-57 Cribs 9-48
9.9.2 216-BX-102 Unplanned Releas 9-50
9.9.3 216-B-12 Crib 9-50
9.9.4 216-B-3 Pond 9-50
9.10 RCRA Monitoring 9-50
9.10.1 Waste Management Area B-BX-BY 9-51
9.10.2 Waste Management Area C 9-53
9.10.3 216-B-63 Trench 9-57
9.10.4 Liquid Effluent Retention Facility 9-60
9.10.5 Low-Level Waste Management Area 1 9-63
9.10.6 Low-Level Waste Management Area 2 9-67

10 200-PO 10-1

10.1 Overview 10-1
10.2 200-PO and 200 East Area Hydraulic Gradient and Groundwater Flow Directions 10-5
10.3 CERCLA Activities 10-8
10.4 Tritium 10-10
10.5 Iodine-129 10-15
10.6 Nitrate 10-18
10.7 Strontium-90 10-22
10.8 Technetium-99 10-25
10.9 Uranium 10-28
10.10 Tetrachloroethene 10-30
10.11 Trichloroethene 10-30
10.12 AEA Monitoring 10-31
10.12.1 400 Area 10-31
10.12.2 Integrated Disposal Facility 10-33
10.13 RCRA Monitoring 10-33
10.13.1 Waste Management Area A-AX 10-34
10.13.2 216-A-36B Crib 10-36
10.13.3 216-A-37-1 Crib 10-39
10.13.4 216-A-29 Ditch 10-42
10.13.5 216-B-3 Pond 10-45
10.13.6 Integrated Disposal Facility 10-47
10.13.7 Nonradioactive Dangerous Waste Landfill 10-49
10.14 WAC Monitoring – Solid Waste Landfill 10-52
10.14.1 Sampling Results 10-54
10.14.2 Groundwater Monitoring Results 10-54

10.14.3 Water-Level and Well Network Evaluation 10-57

11 200-UP 11-1

11.1 Overview 11-1
11.2 CERCLA Activities 11-5
11.3 Technetium-99 11-7
11.3.1 Waste Management Area S-SX 11-7
11.3.2 216-U-1 and 216-U-2 Cribs 11-10
11.3.3 Waste Management Area U 11-12
11.4 Uranium 11-14
11.4.1 216-U-1 and 216-U-2 Cribs Plume 11-14
11.4.2 U Pond 11-16
11.5 Tritium 11-17
11.5.1 Eastern High-Concentration Area 11-17
11.5.2 216-S-25 Crib 11-17
11.5.3 216-S-21 Crib 11-17
11.6 Iodine-129 11-19
11.6.1 REDOX Waste Sites 11-19
11.6.2 SX Tank Farm 11-21
11.6.3 216-U-1 and 216-U-2 Cribs 11-21
11.7 Nitrate 11-22
11.7.1 U Plant Crib Sources 11-22
11.7.2 Waste Management Area U 11-22
11.7.3 Waste Management Area S-SX/216-S-25 Crib 11-25
11.8 Chromium 11-25
11.8.1 Waste Management Area S-SX 11-25
11.8.2 Southeast Plume 11-25
11.9 Carbon Tetrachloride 11-28
11.10 Trichloroethene 11-30
11.11 Environmental Restoration Disposal Facility 11-32
11.11.1 Leachate Monitoring 11-32
11.11.2 Groundwater Sampling 11-32
11.12 S-SX Pump-and-Treat 11-34
11.13 RCRA Monitoring 11-40
11.13.1 Waste Management Area S-SX 11-40
11.13.2 Waste Management Area U 11-44
11.13.3 216-S-10 Pond and Ditch 11-47

12 200-ZP 12-1

12.1 Overview 12-1

12.2 CERCLA Activities 12-7
12.3 Carbon Tetrachloride 12-7
12.4 Chromium 12-10
12.5 Iodine-129 12-13
12.6 Nitrate 12-15
12.7 Technetium-99 12-17
12.8 Trichloroethene 12-19
12.9 Tritium 12-21
12.10 200-ZP-1 Remedies 12-23
12.10.1 Pump and Treat 12-23
12.10.2 Soil Vapor Extraction 12-27
12.11 RCRA Monitoring 12-29
12.11.1 Waste Management Area T 12-30
12.11.2 Waste Management Area TX-TY 12-32
12.11.3 Low-Level Waste Management Area 3 12-34
12.11.4 Low-Level Waste Management Area 4 12-37
12.12 State-Approved Land Disposal Site — *Washington Administrative Code* Facility 12-39

13 References 13-1

Appendix A Supporting Information for CERCLA Operable Units ..... A-i
Appendix B Supporting Information for RCRA and Other Monitoring Facilities ..... B-i
Appendix C Supporting Information for Aquifer Sampling Tubes ..... C-i
Appendix D Confined Aquifers ..... D-i
Appendix E Well Installation, Maintenance, and Decommissioning ..... E-i
Appendix F Groundwater Monitoring Data Quality Assessment ..... F-i

Figures

Figure 1-1. DOE Hanford Site 1-2

Figure 1-2. Groundwater Interest Areas and Groundwater OUs 1-6

Figure 1-3. River Corridor Plumes and Remediation 1-15

Figure 1-4. River Corridor Geology 1-17

Figure 1-5. Hanford Site Water Table and Groundwater Flow, 2014 1-18

Figure 1-6. Relation of Lag Time to Distance from the Columbia River 1-25

Figure 1-7. Central Plateau Plumes and Remediation 1-33

Figure 1-8. Central Plateau Geology 1-35

Figure 2-1. 100-BC Sampling Locations, 2014 2-2

Figure 2-2. 100-BC Plume Areas 2-3

Figure 2-3. 100-BC Geology 2-4

Figure 2-4. 100-BC Water Table, 2014 2-5

Figure 2-5. 100-BC Hexavalent Chromium Plume, 2014 2-8

Figure 2-6. 100-BC Hexavalent Chromium and Water-Level Data in Wells 199-B4-14 and 199-B5-10 in Southern 100-BC 2-9

Figure 2-7. 100-BC Hexavalent Chromium Data for Wells 199-B3-1 and 199-B5-2 in Northern 100-BC 2-10

Figure 2-8. 100-BC Hexavalent Chromium Data in Wells 199-B4-4, 199-B4-7, and 199-B4-8 in Central 100-BC 2-10

Figure 2-9. 100-BC Hexavalent Chromium Data in Wells 199-B3-46, 199-B3-50, and 699-71-77 in Northeastern 100-BC 2-11

Figure 2-10. 100-BC Hexavalent Chromium Data in Wells Screened in Ringold Unit E 2-12

Figure 2-11. 100-BC Hexavalent Chromium in the Lower Part of the Unconfined Aquifer 2-13

Figure 2-12. 100-BC Cross Section Showing Hexavalent Chromium Distribution, South to North in Western 100-BC 2-14

Figure 2-13. 100-BC Cross Section Showing Hexavalent Chromium Distribution, Southwest to Northeast 2-15

Figure 2-14. 100-BC Hexavalent Chromium in 0.5 m Deep Hyporheic Sampling Points, October 2014 2-16

Figure 2-15. 100-BC Example of Monthly Hexavalent Chromium Concentrations in an HSP, in Relation to Daily Average River Stage Elevation below Priest Rapids Dam 2-17

Figure 2-16. 100-BC Strontium-90 Plume, 2014 2-18

Figure 2-17. 100-BC Strontium-90 Data in Wells 199-B3-1, 199-B3-46, and 199-B3-47 2-19

Figure 2-18. 100-BC Tritium Data for Well 199-B3-47 and Aquifer Tube 06-M in Northern 100-BC 2-20

Figure 3-1. 100-FR Sample Locations 3-3

Figure 3-2. 100-FR Sample Locations in Outlying Area 3-4

Figure 3-3. 100-FR-3 Plume Areas 3-5

Figure 3-4. 100-FR Water Table, March 2014 3-6

Figure 3-6. 100-FR Geology 3-8

Figure 3-7. 100-FR Nitrate Plume, 2014 3-10

Figure 3-8. 100-FR Nitrate Data for Wells 199-F5-4, 199-F5-47, and 199-F8-3 in Central 100-F Area 3-11

Figure 3-9. 100-FR Nitrate Data for Wells 199-F7-1, 199-F7-3, and 699-77-36 in Southwestern 100-F Area 3-12

Figure 3-10. 100-FR Nitrate Data for Wells in South Part of Plume 3-12

Figure 3-11. 100-FR TCE Plume and Extent of Ringold Unit E Above the Water Table, 2014 3-14

Figure 3-12. 100-FR TCE Data for Wells 199-F7-1, 199-F7-3, and 699-77-36 3-15

Figure 3-13. 100-FR Hexavalent Chromium Plume, 2014 3-16

Figure 3-15. 100-FR Dissolved Chromium Concentrations for Wells 199-F5-47 and 199-F5-56 in Central 100-F Area 3-18

Figure 3-16. 100-FR Strontium-90 Plume, 2014 3-19

Figure 3-17. 100-FR Strontium-90 Data and Water Levels for Well 199-F5-1 and 199-F5-55 3-20

Figure 4-1. 100-HR-D Wells and Aquifer Tubes 4-3

Figure 4-2. 100-HR-H Wells and Aquifer Tubes 4-4

Figure 4-3. 100-HR Geology 4-5

Figure 4-4. 100-HR-D Overview and March 2014 Water Table 4-7

Figure 4-5. 100-HR-H Overview and 2014 Water Table 4-8

Figure 4-6. Columbia River Stage at 100-D and 100-H Area in 2014 4-9

Figure 4-7. 100-HR Plume Areas 4-10

Figure 4-8. 100-HR-3 P&T Systems 4-11

Figure 4-9. 100-HR-D Hexavalent Chromium Plume, Fall 2014 (Low River Stage) 4-13

Figure 4-10. 100-HR-D Hexavalent Chromium Plume, Spring/Summer 2014 (High River Stage) 4-14

Figure 4-11. 100-HR Hexavalent Chromium Data for Well 199-D5-122 (Decommissioned) 4-15

Figure 4-12. 100-HR Hexavalent Chromium Data for Wells 199-D5-39 and 199-D5-104 4-15

Figure 4-13. 100-HR Hexavalent Chromium Data for Wells 199-D5-103 and 199-D5-34 4-17

Figure 4-14. 100-HR Hexavalent Chromium Data for Wells 199-D4-14, 199-D4-34, and 199-D4-39, Near ISRM Barrier 4-18

Figure 4-15. 100-HR Hexavalent Chromium Data for Wells 199-D5-132, 199-D8-4, and 199-D8-95, Northern Plume 4-19

Figure 4-16. 100-HR Hexavalent Chromium Data for Wells 199-D8-73, 199-D8-88, and 199-D8-95, Northern Plume 4-19

Figure 4-17. 100-HR-H Hexavalent Chromium Plume, Fall 2014 (Low River Stage) 4-22

Figure 4-18. 100-HR-H Hexavalent Chromium Plume, Spring/Summer 2014 (High River Stage) 4-23

Figure 4-19. Specific Conductance, 100-HR-D Low River Stage 4-25

Figure 4-20. Specific Conductance, 100-HR-H Low River Stage 4-26

Figure 4-21. 100-HR Hexavalent Chromium Concentrations in the RUM, during 2014 4-28

Figure 4-22. 100-HR-D Nitrate Plume, 2014 4-30

Figure 4-23. 100-HR-H 2014 Nitrate Plume, 2014 4-31

Figure 4-24. 100-HR Nitrate Data for RUM Wells 199-H3-9 and 199-H4-91 4-32

Figure 4-25. 100-HR-D Strontium-90 Plume, 2014 4-33

Figure 4-26. 100-HR-H 2014 Strontium-90 Plume, 2014 4-34

Figure 4-27. 100-HR Strontium-90 Data in Wells near 116-H-1 and 116-H-7 4-35

Figure 4-28. 100-HR-D Tritium, 2014 4-37

Figure 4-29. 100-HR-H Uranium, 2014 4-39

Figure 4-30. Uranium and Hexavalent Chromium in Well 199-H4-84. 4-40

Figure 4-31. 100-HR-3 Remedy Overview 4-41

Figure 4-32. 100-HR-3 Pump-and-Treat Mass Removal 4-43

Figure 4-33. 100-HR-3 IRSM Barrier 4-45

Figure 4-34. 100-HR RCRA Facility 183-H Monitoring Well Location 4-47

Figure 5-1. 100-KR Overview Map with 2014 Water Table 5-3

Figure 5-2. 100-KR Geology 5-4

Figure 5-3. Changes in Selected Plume Areas since 2003 at 100-KR-4 OU 5-5

Figure 5-4. 100-KR Sampling Locations, 2014 5-6

Figure 5-5. 100-KR Hexavalent Chromium Plume (Low River Stage), KE and KW Reactor Vicinity, 2014 5-8

Figure 5-6. 100-KR Hexavalent Chromium Plume (Low River Stage), 116-K-2 Trench and 100-N Area, 2014 5-9

Figure 5-7. Columbia River Stage at 100-K During 2014 5-10

Figure 5-8. 100-KR Hexavalent Chromium Data for Wells 199-K-130, 199-K-131, and 199-K-148 (Near-River Extraction Wells in Northern Portion 100-KR) 5-12

Figure 5-9. 100-KR Hexavalent Chromium Data for Wells 199-K-113A, 199-K-114A, and 199-K-146 (Near-River Extraction Wells in Northern Portion 100-KR) 5-12

Figure 5-10. 100-KR Hexavalent Chromium Data for Wells 199-K-132, 199-K-138, 199-K-196, and Aquifer Tube AT-K-1-D, Located Downgradient of KW Reactor 5-14

Figure 5-11. 100-KR Hexavalent Chromium Data for Wells 199-K-108A, 199-K-137, and 199-K-166, Located Just Upgradient of KW Reactor 5-14

Figure 5-12. 100-KR Hexavalent Chromium Plume (High River Stage), KE and KW Vicinity, 2014 5-17

Figure 5-13. 100-KR Hexavalent Chromium Plume (High River Stage), 116-K-2 Trench and 100-N Area, 2014 5-18

Figure 5-14. 100-KR Specific Conductance, Low River Stage 2014 5-19

Figure 5-15. 100-KR Hexavalent Chromium Data for Well 199-K-189, Located Downgradient of KE Reactor, Indicating Correlation to Transient Water Level 5-20

Figure 5-16. 100-KR Tritium Plume, 2014 5-22

Figure 5-17. 100-KR Tritium Data for Well 199-K-111A, Located Northeast of KE Reactor 5-23

Figure 5-18. 100-KR Nitrate Plume, 2014 5-24

Figure 5-19. 100-KR Nitrate Data for Wells 199-K-111 and 199-K-23, Located West of KE Reactor 5-25

Figure 5-20. 100-KR Nitrate Data for Wells 199-K-106A and 199-K-34, Located Near KW Reactor 5-26

Figure 5-21. 100-KR Strontium-90 Plume, 2014 5-28

Figure 5-22. 100-KR Strontium-90 Data for Well 199-K-200, Located in Former 116-K-2 Trench 5-29

Figure 5-23. 100-KR Strontium-90 Data for Wells 199-K-32A, 199-K-141, and 199-K-178, Located Downgradient of KE Reactor 5-29

Figure 5-24. 100-KR Carbon-14 Plume, 2014 5-31

Figure 5-25. 100-KR TCE Plume, 2014 5-33

Figure 5-26. 100-KR TCE Data for Wells 199-K-185 and 199-K-196, Located Downgradient of KW Reactor 5-34

Figure 5-27. 100-KR TCE Data for Wells 199-K-132 and 199-K-138, Located Downgradient of KW Reactor 5-34

Figure 5-28. 100-KR P&T Well Locations 5-36

Figure 5-29. 100-KR AEA Well Locations 5-41

Figure 6-1. 100-NR Overview Map with Groundwater Flow 6-2

Figure 6-2. 100-NR Plume Areas 6-4

Figure 6-3. 100-NR Geology 6-5

Figure 6-4. 100-NR Sample Locations, 2014 6-7

Figure 6-5. 100-NR Strontium-90 Plume, 2014 6-9

Figure 6-6. 100-NR Strontium-90 Data for Well 199-N-81 6-10

Figure 6-7. 100-NR Strontium-90 Data for Well 199-N-67 6-10

Figure 6-8. 100-NR Strontium-90 Data for Aquifer Tubes C7934, C7935, and C7936 6-11

Figure 6-9. 100-NR Tritium Data for Aquifer Tubes C7934, C7935, and C7936 6-12

Figure 6-10. 100-NR Nitrate Plume, 2014 6-14

Figure 6-11. 100-NR Nitrate Data for Wells 199-N-2 and 199-N-67 6-15

Figure 6-12. 100-NR Nitrate Data for Well 199-N-32 6-15

Figure 6-13. 100-NR Nitrate Data for Wells 199-N-59, 100-N-72, and 199-N-165 6-16

Figure 6-14. 100-NR TPH-Diesel Plume, 2014 6-17

Figure 6-15. 100-NR Chromium Data for Well 199-N-80 6-20

Figure 6-16. 100-NR Remedy Plumes 6-21

Figure 6-17. 100-NR Apatite Barrier 6-23

Figure 6-18. 100-NR Strontium-90 Data for Performance Monitoring Wells along the Central Segment of the Apatite PRB 6-26

Figure 6-19. RCRA 116-N-1 Monitoring Well Locations 6-28

Figure 6-20. RCRA 116-N-3 Monitoring Well Locations 6-30

Figure 6-21. RCRA 120-N-1 and 120-N-2 Monitoring Well Locations 6-32

Figure 7-1. 300-FF Overview Map with Groundwater Flow 7-2

Figure 7-2. 300-FF Geology 7-4

Figure 7-3. 300-FF-5 Plume Areas 7-5

Figure 7-4. 300-FF Sample Locations, 2014 7-7

Figure 7-5. 300-FF 2012 Uranium Plume, December 2014 (Low River Stage) 7-9

Figure 7-6. Uranium and Water-Level Data for Well 399-1-16A (Near River). 7-10

Figure 7-7. Uranium and Water-Level Data for Well 399-1-10A (Near River). 7-10

Figure 7-8. Uranium and Chromium Data for Wells 399-8-5A and 399-8-1, Downgradient of 618-7 Burial Ground. 7-11

Figure 7-9. 300-FF Uranium, July 2014 (High River Stage) 7-12

Figure 7-10. 300-FF Uranium in Aquifer Tube and Near-River Well Samples 7-13

Figure 7-11. 300-FF Aquifer Tube Sample Data 7-14

Figure 7-12. Uranium and Water-Level Data for Wells 699-S6-E4A, 699-S6-E4K, and 699-S6-E4L 7-15

Figure 7-13. Uranium and Water-Level Data for Well 399-1-17A (Inland) 7-16

Figure 7-14. Uranium and Water-Level Data for Well 399-1-23 (Inland) 7-16

Figure 7-15. Uranium and Water-Level Data for Well 399-1-55 (Inland) 7-17

Figure 7-16. Tritium near the 618-11 Burial Ground 7-19

Figure 7-17. 300-FF Tritium Data for Wells 699-12-2C, 699-13-0A, 699-13-1E, 699-13-2D, and 699-13-3A 7-20

Figure 7-18. Nitrate near the 618-11 Burial Ground 7-21

Figure 7-19. Nitrate Data for Well 699-13-3A 7-22

Figure 7-20. Nitrate Data for Well 699-13-1E 7-22

Figure 7-21. TCE in Aquifer Tube and Near-River Well Samples 7-24

Figure 7-22. 300-FF DCE, TCE, and PCE Data for Well 399-1-16B 7-25

Figure 7-23. 316-5 Process Trenches 7-27

Figure 8-1. 1100-EM Sampling Locations, 2014 8-2

Figure 8-2. 1100-EM Water Table, 2014 8-4

Figure 8-3. 1100-EM Lithology 8-5

Figure 8-4. TCE Data in 1100-EM-1 Compliance Wells 8-7

Figure 8-5. Tritium Concentrations in 1100-EM, Richland North, and the 300 Area, 2014 8-8

Figure 8-6. Nitrate Plume in 1100-EM, Richland North, and the 300 Area, 2014 8-10

Figure 8-7. 1100-EM Nitrate Data for Wells 699-S31-E10A and 699-S31-E10C 8-11

Figure 8-8. 1100-EM Uranium Data for Wells Downgradient of AREVA and Inactive Horn Rapids Landfill 8-12

Figure 9-1. 200-BP-5 Groundwater Interest Area and Geometry of Groundwater Contaminant Plumes 9-1

Figure 9-2. 200-BP-5 Plume Areas Over Time 9-3

Figure 9-3. Hanford Site General Stratigraphy, Including Lithologic, and Hydrostratigraphic Nomenclature 9-4

Figure 9-4. Three-Dimensional View of the Incising Ancestral Columbia River/Cataclysmic Glacial Flooding Paleochannel Entering the 200 East Area from the Northwest 9-5

Figure 9-5. Interpreted Low-Gradient Water Table Depiction for the Northwest Corner of the 200 East Area after the Groundwater Flow Direction Change in 2011 9-7

Figure 9-6. 200-BP-5 Overview with Interpreted Water Table Elevation 9-8

Figure 9-7. Interpreted Groundwater Flow Direction within the 200 East Area 9-9

Figure 9-8. 200-BP-5 Groundwater Sample Well Locations, 2014 9-12

Figure 9-9. Monthly Average 200 East Area Low Hydraulic Gradient Water Table Map, 2014 9-13

Figure 9-10. Location of 2014 Completed Well 699-46-91 at the Modular Storage Units Facility and Additional Well Location Options as Described in Subsection 3.3.1 of DOE/RL-2013-44 9-14

Figure 9-11. 200-BP Nitrate Plume, 2014 9-16

Figure 9-12. 200-BP Nitrate near BY Cribs, Summer 2011 9-17

Figure 9-13. 200-BP Nitrate near BY Cribs, Summer 2014 9-18

Figure 9-14. Trend Plot of Nitrate Concentrations at Wells 299-E33-3, 299-E33-16, and 299-E33-17 located within the Concentrated Portion of the BY Crib Plume Showing Recent Concentration Decreases 9-19

Figure 9-15. Trend Plot of Nitrate Concentrations at Wells 299-E28-23, 299-E28-24, and 299-E28-25 Located near the Former 216-B-5 Injection Well 9-21

Figure 9-16. Trend Plots of Nitrate Concentrations at Wells 299-E33-3, 299-E33-17, and 299-E33-47 Located within the B Complex for Comparison 9-22

Figure 9-17. Trend Plots of Nitrate Concentrations at Well 299-E33-344 Located within the B Complex Perch Water Horizon 9-23

Figure 9-18. 200-BP Iodine-129 Plume, 2014 9-27

Figure 9-19. Trend Plots of Iodine-129 at Gable Gap Wells 699-57-59, 699-59-58, and 699-60-60 9-28

Figure 9-20. Trend Plots of Iodine-129 within the Paleochannel between 200 East Area and Gable Gap at Wells 699-49-57A and 699-50-59 9-29

Figure 9-21. 200-BP Technetium-99 Plume, 2014 9-30

Figure 9-22. 200-BP Technetium-99 near BY Cribs, Summer 2011 9-31

Figure 9-23. 200-BP Technetium-99 near BY Cribs, Summer 2014 9-32

Figure 9-24. Trend Plot of Cyanide at Wells 299-E33-38, 299-E33-16, and 299-E33-20 Located Beneath the BY Cribs, 216-B-8 Crib, and Northwest Corner of the B Tank Farm, Respectively 9-32

Figure 9-25. Trend Plot of Technetium-99 at Well 299-E33-20 Located Beneath Northwest Corner of the B Tank Farm 9-33

Figure 9-26. Conceptual Site Model of the Cold Creek Unit Perching Zone within the B Complex 9-34

Figure 9-27. Trend Plot of Technetium-99 at Wells 299-E28-2, 299-E28-23, and 299-E28-24 Located near the Former 216-B-5 Injection Well 9-35

Figure 9-28. Trend Plot of Technetium-99 at Well 299-E33-12, Screened in the Rattlesnake Ridge Interbed near the BY Cribs 9-35

Figure 9-29. 200-BP Technetium-99 to Nitrate Ratio in Wells Associated with B Complex 9-36

Figure 9-30. Trend Plot of Technetium-99 at Wells 299-E33-337 and 299-E33-339 9-37

Figure 9-31. 200-BP Technetium-99 to Nitrate Ratio in Wells 299-E33-337 and 299-E33-339 9-37

Figure 9-32. 200-BP Technetium-99 Data for Wells Bounding WMA C 9-38

Figure 9-33. 200-BP Uranium Plume, 2014 9-40

Figure 9-34. Uranium Conceptual Site Model for 216-BX-102 Unplanned Release 9-41

Figure 9-35. 200-BP Uranium in Wells 299-E33-18, 299-E33-343, and 299-E33-345 9-41

Figure 9-36. 200-BP Uranium near WMA B-BX, Summer 2011 9-42

Figure 9-37. 200-BP Strontium-90 Plume, 2014 9-44

Figure 9-38. Trend Plots of Strontium-90 at Wells 699-53-47A, 699-53-47B, and 699-54-49 9-45

Figure 9-39. Trend Plots of Strontium-90 at Wells 299-E28-4, 299-E28-7, and 299-E28-24 9-45

Figure 9-40. 200-BP Cyanide Plume, 2014 9-47

Figure 9-41. 200-BP Trend Plots for Wells 299-E33-3, 299-E33-15, and 299-E33-16 9-48

Figure 9-42. 200-BP Tritium Plume, 2014 9-49

Figure 9-43. 200-BP WMA B-BX-BY Well Location Map 9-52

Figure 9-44. Low-Gradient Water-Level Network for the Northwest Quarter of the 200 East Area 9-54

Figure 9-45. 200-BP RCRA WMA C Monitoring Well Locations 9-56

Figure 9-46. Interpretation of the >Detection Limit (>1.67 µg/L) of Cyanide Isopleth in the Upper 4 m and Lower 4 m of the Aquifer at Waste Management Area C and Cyanide Trend Results at Select Waste Management Area C Wells 9-57

Figure 9-47. 200-BP RCRA 216-B-63 Monitoring Well Locations....9-59

Figure 9-48. 200-BP RCRA LERF Monitoring Well Locations....9-61

Figure 9-49. 200-BP Comparison of TOC at Wells 299-E26-10, 299-E27-10, and 299-E34-7....9-63

Figure 9-50. 200-BP RCRA LLWMA-1 Monitoring Well Locations....9-64

Figure 10-1. 200-PO Overview with Groundwater Flow....10-2

Figure 10-2. 200-PO Geology....10-4

Figure 10-3. Average 2013 Water Table, 200 East Area....10-6

Figure 10-4. Average 2014 Water Table, 200 East Area....10-7

Figure 10-5. 200-PO Sampling Locations, 2014....10-9

Figure 10-6. 200-PO Plume Areas, 2014....10-10

Figure 10-7. 200-PO Tritium Plume, 2014....10-11

Figure 10-8. 200-PO Tritium Data for Wells 299-E17-1, 299-E17-19, and 299-E17-14....10-12

Figure 10-9. 200-PO Tritium Data for Wells 699-31-31, 699-33-42, and 699-34-42....10-13

Figure 10-10. 200-PO Tritium Data for Wells 699-31-31, 699-26-33, and 699-28-40....10-13

Figure 10-11. 200-PO Tritium Data for Basalt-Confined Well 699-42-40C....10-14

Figure 10-12. 200-PO Iodine-129 Plume, 2014....10-16

Figure 10-13. 200-PO Iodine-129 Data for Wells 699-43-45, 299-E17-14, and 299-E17-19....10-17

Figure 10-14. 200-PO Iodine-129 Data for Wells 699-31-31 and 699-32-43....10-17

Figure 10-15. 200-PO Nitrate Plume, 2014....10-19

Figure 10-16. 200-PO Nitrate Data for Wells 299-E17-14 and 299-E17-19....10-20

Figure 10-17. 200-PO Nitrate Data for Wells 299-E25-17 and 699-37-47A....10-20

Figure 10-18. .200-PO Nitrate Data for Basalt-Confined Wells 699-S11-E12AP and 699-42-40C....10-21

Figure 10-19. 200-PO Strontium-90 Plume, 2014....10-23

Figure 10-20. 200-PO Strontium-90 Data for Wells 299-E17-14 and 299-E24-16....10-24

Figure 10-21. 200-PO Technetium-99 Plume, 2014....10-26

Figure 10-22. 200-PO Technetium-99 Data for Wells 299-E24-22, 299-E24-33, 299-E25-41, 299-E25-236 and 299-E25-93....10-27

Figure 10-23. 200-PO Uranium Plume, 2014....10-29

Figure 10-24. 200-PO Uranium Data for Wells 299-E17-14 and 299-E25-36....10-30

Figure 10-25. 200-PO AEA Monitoring and Water Supply Well Locations....10-32

Figure 10-26. 200-PO Tritium Data for Wells 499-S0-7, 499-S0-8, and 499-S1-8J and 400 Area Tap Water 10-33

Figure 10-27. 200-PO RCRA WMA A-AX Monitoring Well Locations 10-35

Figure 10-28. 200-PO RCRA 216-A-36B Monitoring Well Locations 10-37

Figure 10-29. 200-PO RCRA Facility 216-A-37-1 Monitoring Well Locations 10-40

Figure 10-30. 200-PO RCRA Facility 216-A-29 Monitoring Well Locations 10-43

Figure 10-31. 200-PO RCRA Facility 216-B-3 Monitoring Well Locations 10-46

Figure 10-32. 200-PO RCRA Facility IDF Monitoring Well Locations 10-48

Figure 10-33. 200-PO RCRA Facility NRDWL Monitoring Well Locations 10-50

Figure 11-1. Generalized Stratigraphy of the Hanford Site Central Plateau 11-3

Figure 11-2. 200-UP Water Table Map, March 2014 11-4

Figure 11-3. 200-UP Sampling Locations, 2014 11-6

Figure 11-4. 200-UP Plume Areas 11-7

Figure 11-5. 200-UP Technetium-99 Plume Map, 2014 11-8

Figure 11-6. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W23-19 at WMA S-SX 11-9

Figure 11-7. 200-UP Technetium-99 Data for Wells 299-W22-83 and 299-W23-86 East of WMA S-SX 11-9

Figure 11-8. 200-UP Technetium-99 Data for Wells 299-W19-36 and 299-W19-43 near U Plant 11-10

Figure 11-9. 200-UP Vertical Profile Sampling Results for Well 299-W19-113 near U Plant 11-11

Figure 11-10. 200-UP Vertical Profile Sampling Results for Well 299-W19-114 near U Plant 11-12

Figure 11-11. 200-UP Technetium-99 Data for Selected Wells at WMA U 11-13

Figure 11-12. 200-UP Vertical Profile Sampling Results for Well 299-W18-260 at WMA U 11-14

Figure 11-13. 200-UP 2014 Uranium Plume 11-15

Figure 11-14. 200-UP Uranium Data for Wells 299-W19-18, 299-W19-49, and 299-W19-43 near U Plant 11-16

Figure 11-15. 200-UP Tritium Plume, 2014 11-18

Figure 11-16. 200-UP Tritium Data for Well 299-W23-4 at the 216-S-21 Crib 11-19

Figure 11-17. 200-UP Iodine-129 Plume, 2014 11-20

Figure 11-18. 200-UP Iodine-129 Concentrations for Wells 299-W22-72, 699-36-66B, and 699-36-70A 11-21

Figure 11-19. 200-UP Nitrate Plume, 2014 11-23

Figure 11-20. 200-UP Nitrate Data for Wells 299-W19-36 and 299-W19-43 near U Plant 11-24

Figure 11-21. 200-UP Nitrate Data for Selected Wells at WMA U 11-24

Figure 11-22. 200-UP Chromium Plume, 2014 11-26

Figure 11-23. 200-UP Chromium Data for Wells 699-30-66 and 699-32-62 Southeast of the 200 West Area 11-27

Figure 11-24. 200-UP Chromium and Nitrate Data for Wells 299-W26-13 and 699-32-76 at the 216-S-10 Pond and Ditch 11-28

Figure 11-25. 200-UP Carbon Tetrachloride Plume, 2014 11-29

Figure 11-26. 200-UP Carbon Tetrachloride Data for Wells 299-W14-71 North of U Plant and 699-38-70B East of U Plant 11-30

Figure 11-27. 200-UP TCE Plume, 2013 11-31

Figure 11-28. 200-UP ERDF Monitoring Well Locations 11-33

Figure 11-29. 200-UP Remedy Locations 11-35

Figure 11-30. 200-UP Groundwater Capture Zones at WMA S-SX 11-37

Figure 11-31. 200-UP Chromium Data for WMA S-SX Extraction Wells 11-37

Figure 11-32. 200-UP Nitrate Data for WMA S-SX Extraction Wells 11-38

Figure 11-33. 200-UP Technetium-99 Data for WMA S-SX Extraction Wells 11-38

Figure 11-34. 200-UP Carbon Tetrachloride Data for WMA S-SX Extraction Wells 11-39

Figure 11-35. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W22-47 at WMA S-SX 11-40

Figure 11-36. 200-UP RCRA Facility WMA S-SX Monitoring Well Locations 11-42

Figure 11-37. 200-UP Chromium, Nitrate, and Technetium-99 Concentrations in Well 299-W22-86 Downgradient from WMA S-SX 11-44

Figure 11-38. 200-UP RCRA Facility WMA U Monitoring Well Locations 11-45

Figure 11-39. 200-UP RCRA Facility 216-S-10 Monitoring Well Locations 11-48

Figure 11-40. 200-UP Specific Conductance Data for Monitoring Wells at 216-S-10 11-50

Figure 12-1. 200-ZP Wells and Key Facilities 12-3

Figure 12-2. 200-ZP Plume Areas, 2014 12-5

Figure 12-3. Ringold Lower Mud Unit Extent 12-5

Figure 12-4. 200-ZP Overview with Groundwater Flow 12-6

Figure 12-5. 200-ZP Carbon Tetrachloride Plume, 2014 12-8

Figure 12-6. 200-ZP Carbon Tetrachloride Concentration Cross Section 12-9

Figure 12-7. Comparison of Carbon Tetrachloride Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-9

Figure 12-8. Comparison of Chromium Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-10

Figure 12-9. Comparison of Hexavalent Chromium Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-11

Figure 12-10. 200-ZP Chromium Plume, 2014 12-12

Figure 12-11. 200-ZP Iodine-129 Plume, 2014 12-14

Figure 12-12. Comparison of Iodine-129 Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-15

Figure 12-13. 200-ZP Nitrate Plume, 2014 12-16

Figure 12-14. Comparison of Nitrate Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-17

Figure 12-15. 200-ZP Technetium-99 Plume, 2014 12-18

Figure 12-16. Comparison of Technetium-99 Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-19

Figure 12-17. 200-ZP TCE Plume, 2014 12-20

Figure 12-18. Comparison of TCE Concentrations in Monitoring Wells During 2012, 2013, and 2014 12-21

Figure 12-19. 200-ZP Tritium Plume, 2014 12-22

Figure 12-20. 200-ZP Remedy Overview 12-24

Figure 12-21. 200-ZP-1 P&T System Hydraulic Capture Zone 12-25

Figure 12-22. 200 West P&T Facility 12-26

Figure 12-23. 200-PW-1 Soil Vapor Extraction Overview 12-28

Figure 12-24. 200-ZP Mass of Carbon Tetrachloride Removed from 200-PW-1 Vadose Zone 12-29

Figure 12-25. 200-ZP RCRA Facility WMA T Monitoring Well Locations 12-31

Figure 12-26. 200-ZP RCRA Facility WMA TX-TY Monitoring Well Locations 12-33

Figure 12-27. 200-ZP RCRA Facility LLWMA-3 Monitoring Well Locations 12-36

Figure 12-28. 200-ZP RCRA Facility LLWMA-4 Monitoring Well Locations 12-38

Figure 12-29. SALDS Facility Monitoring Well Network 12-41

Figure 12-30. 200-ZP Tritium Data for Wells Monitoring SALDS 12-43

Tables

Table 1-1. Reporting Requirements for Groundwater Monitoring 1-4

Table 1-2. Water Quality Criteria and Background for Hanford Site Groundwater Contaminants 1-10

Table 1-3. Derived Concentration Standards, 4 mrem Effective Dose Equivalent Concentrations, and Risk-Based Concentrations for Hanford Site Radionuclides 1-12

Table 1-4. River Corridor at a Glance 1-14

Table 1-5. Number of Wells and Well Sampling Trips in the River Corridor, 2014 1-20

Table 1-6. Maximum Concentrations of Selected Groundwater Constituents in River Corridor Interest Areas, 2014 1-21

Table 1-7. RCRA Monitoring Status for the River Corridor, 2014 1-24

Table 1-8. Hanford Site Contaminants in Columbia River Seeps, 2014 1-27

Table 1-9. Comparison of Contaminant Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site, 2013 1-29

Table 1-10. Central Plateau Groundwater and Source OUs 1-31

Table 1-11. Groundwater Sampling on the Central Plateau, 2014 1-37

Table 1-12. Maximum Concentrations of Selected Groundwater Constituents in Central Plateau Interest Areas, 2014 1-37

Table 1-13. RCRA Monitoring Status for the Central Plateau, 2014 1-40

Table 2-1. 100-BC at a Glance 2-1

Table 2-2. Hydraulic Gradient and Groundwater Flow Directions in 100-BC 2-6

Table 3-1. 100-FR at a Glance 3-2

Table 4-1. 100-HR at a Glance 4-2

Table 4-2. Summary of 2014 100-HR-3 P&T 4-42

Table 5-1. 100-KR at a Glance 5-2

Table 5-2. 100-KR-4 Interim Action P&T Systems, 2014 5-37

Table 5-3. Summary of Hexavalent Chromium Concentrations in 100-KR-4 OU Compliance and Performance Evaluation Wells for CY 2014 5-38

Table 6-1. 100-NR at a Glance 6-3

Table 6-2. 100-NR Hydrocarbon Product Removal from Well 199-N-18, 2003–2013 6-18

Table 6-3. Performance Monitoring at the Apatite PRB, 100-NR-2 OU 6-25

Table 7-1. 300-FF at a Glance 7-3

Table 8-1. 100-EM at a Glance 8-3

Table 9-1. 200-BP at a Glance **9-2**

Table 9-2. TEDF Discharge Volumes by Month Since January 2010 ..... **9-20**

Table 9-3. Comparison of Technetium-99 to Nitrogen in Nitrate at Wells 299-E27-14 and 299-E24-20 ..... **9-24**

Table 9-4. Comparison of Technetium-99 to Nitrogen in Nitrate at Wells 299-E24-22, 299-E27-21, 299-E27-23, and 299-E27-14 ..... **9-25**

Table 10-1. 200-PO at a Glance **10-3**

Table 11-1. 200-UP at a Glance **11-2**

Table 11-2. Depth Profile Sample Results for 299-W18-260 ..... **11-13**

Table 11-3. S-SX Tank Farms Groundwater Extraction System Summary **11-36**

Table 12-1. 200-ZP-1 at a Glance **12-4**

Table 12-2. 200 West P&T Performance for 2014 ..... **12-26**

Table 12-3. Soil Vapor Extraction Performance Since Startup **12-29**

This page intentionally left blank.

Terms

AEA	Atomic Energy Act of 1954
ASML	above mean sea level
AWLN	automated well level network
BTV	background threshold value
BER	DOE's Office of Science, Biological and Environmental Research
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CHPRC	CH2M Hill Plateau Remediation Company
COCs	contaminants of concern
COD	chemical oxygen demand
COI	contaminants of interest
COPCs	contaminants of potential concern
DCE	*cis*-1,2-dichloroethene
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
DWS	drinking water standards
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	Explanation of Significant Difference
ETF	Effluent Treatment Facility
FFTF	Fast Flux Test Facility
FS	feasibility study
FSB	Fuel Storage Basin
GC	gas chromatography
GEL	Geotechnical Engineering Laboratory
gpm	gallons per minute
HEIS	Hanford Environmental Information System
HGSM	Hanford South Geoframework Model
HSP	hyporheic sampling points
ICs	institutional controls
IDF	Integrated Disposal Facility
IFRC	Integrated Field Scale Research Challenge
ISRM	in situ redox manipulation
LERF	Liquid Effluent Retention Facility
LLBG	Low-Level Burial Ground
LLWMA	Low-Level Waste Management Area
LOQ	limit of quantitation
LWDF	Liquid Waste Disposal Facility

MDL	method detection limit
MNA	monitored natural attenuation
MS	mass spectrometry
MSA	Mission Support Alliance
MTCA	Model Toxic Control Act
NPL	National Priorities List
NRDWL	Nonradioactive Dangerous Waste Landfill
OU	operable unit
P&T	pump and treat
PCE	tetrachloroethene
PFP	Plutonium Finishing Plant
PRB	permeable reactive barrier
PQL	practical quantitation limit
PUREX	Plutonium-Uranium Extraction
QA	quality assurance
QC	quality control
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act of 1976
RDL	reported detection limit
RDR/RA WP	remedial design report/remedial action work plan
REDOX	Reduction Oxidation
RI	remedial investigation
RIR	remedial investigation report
ROA	remedial action objectives
ROD	Record of Decision
RUM	Ringold Formation upper mud unit
SALDS	State-Approved Land Disposal Site
SAP	sampling analysis plan
SFA	PNNL Scientific Focus Area
SST	single shell tank
SWL	Solid Waste Landfill
TASL	Test America St. Louis
TCE	trichloroethene
TEDF	Treated Effluent Disposal Facility
TOC	total organic carbon
TOX	total organic halides
TPA	Tri-Party Agreement
TPH	total petroleum hydrocarbons
TSD	treatment storage and/or disposal
VOA	volatile organic analysis

VOC	volatile organic compounds
WAC	Washington Administrative Code
WMA	Waste Management Area
WSCF	Waste Sampling and Characterization Facility

This page intentionally left blank.

1 Introduction

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

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

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

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

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

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

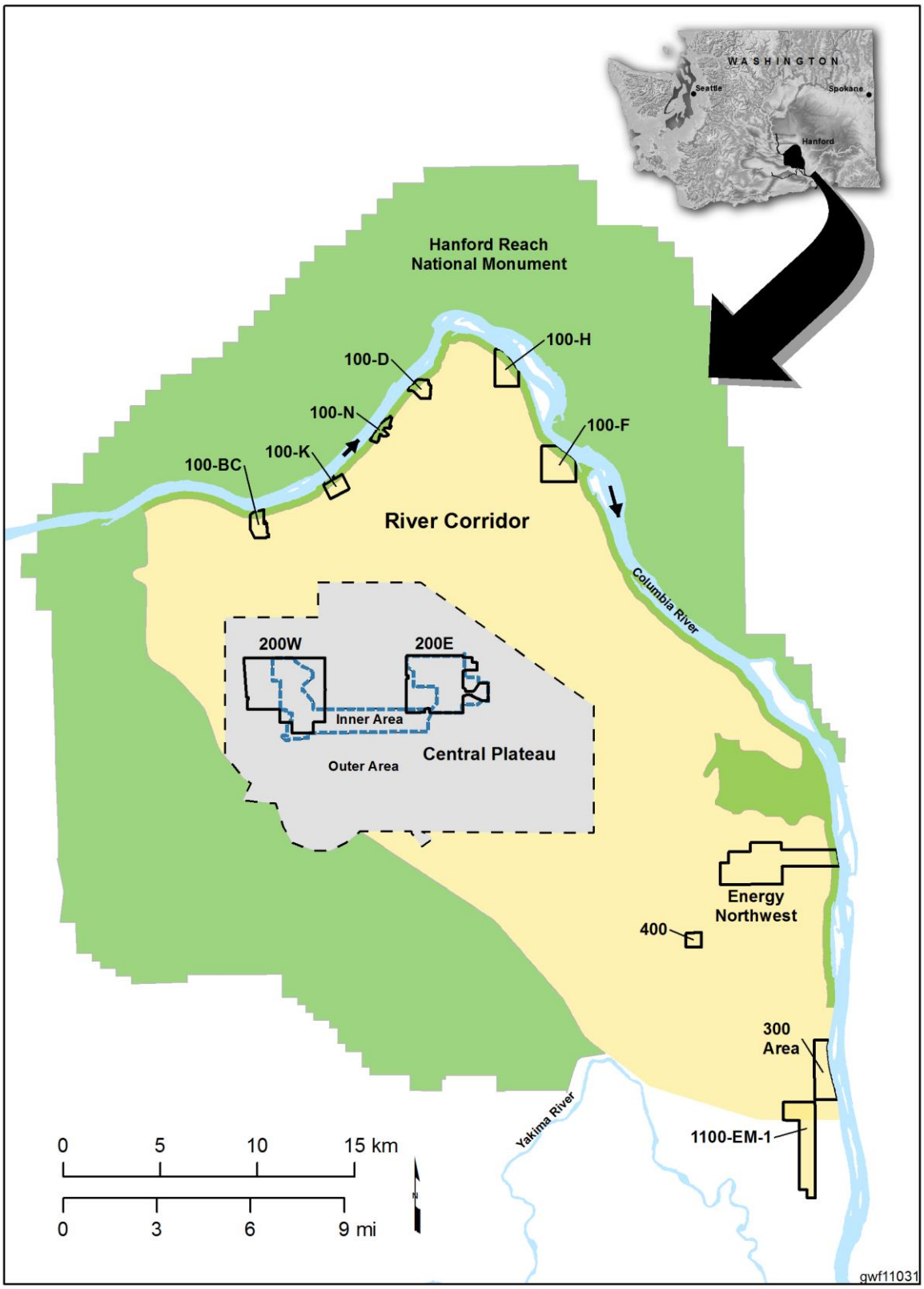


Figure 1-1. DOE Hanford Site

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

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

1.1 Purpose and Scope

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

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

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

Table 1-1. Reporting Requirements for Groundwater Monitoring

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

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

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

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

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

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

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

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

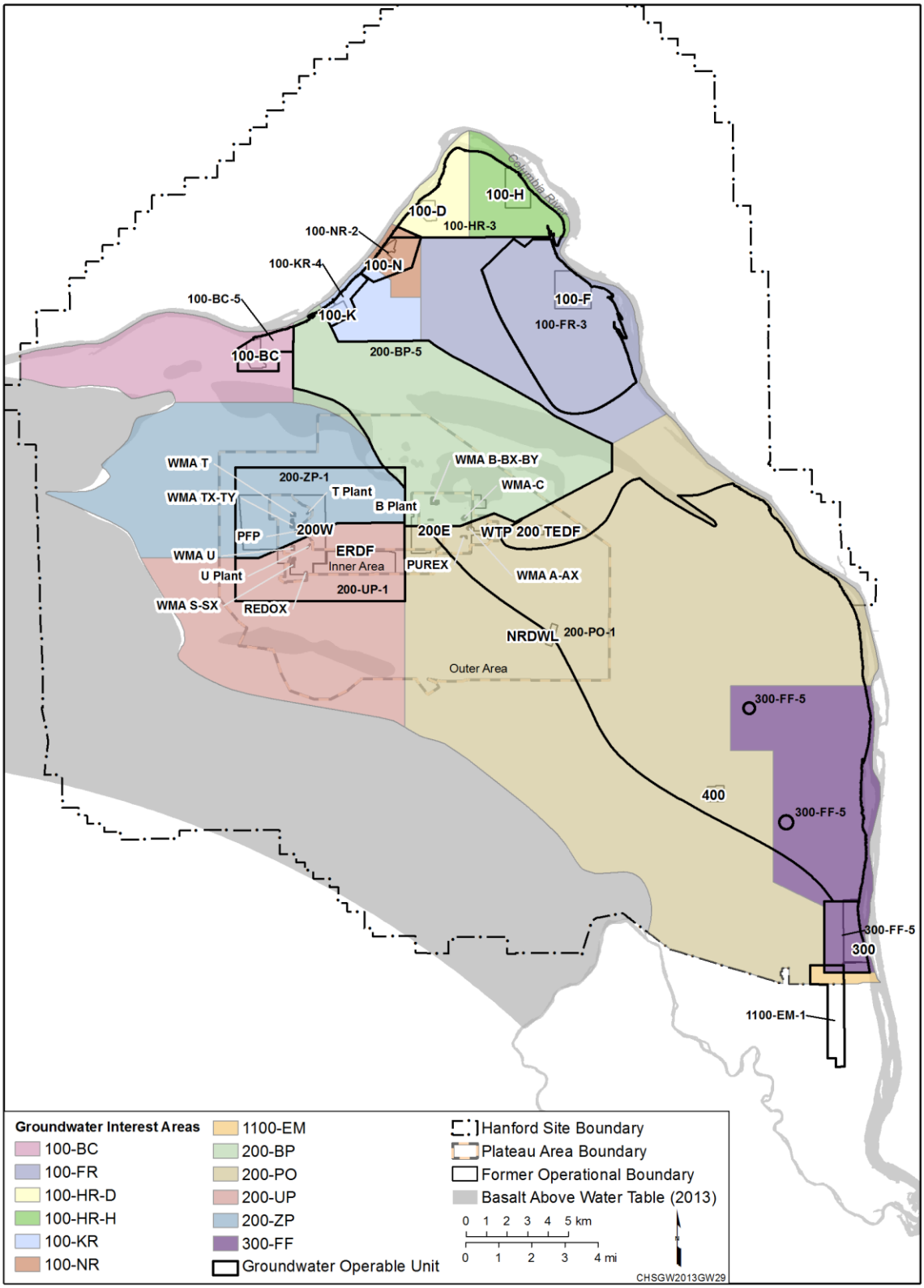


Figure 1-2. Groundwater Interest Areas and Groundwater OUs

1.2 Groundwater Monitoring

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

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

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

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

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

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

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

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

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

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

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

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

1.3 Conventions Used in this Report

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

e. Standard is for total trihalomethanes.

f. Total chromium.

g. Hexavalent chromium.

h. Action level.

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

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

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

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

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

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

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

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

d. See Table 1-2 for total uranium.

1.4 River Corridor

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

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

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

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

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

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

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

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

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

Table 1-4. River Corridor at a Glance

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

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

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

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

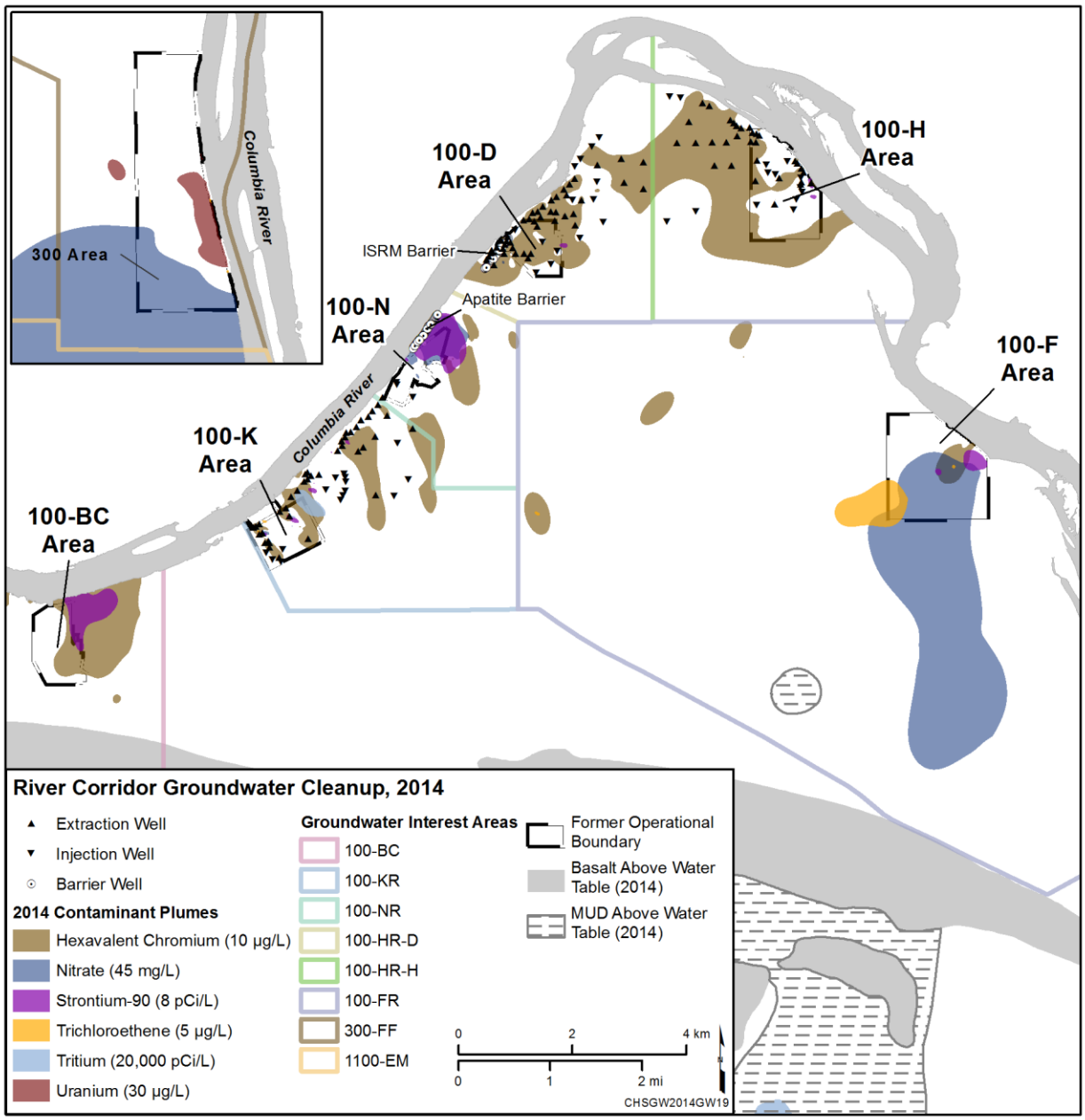


Figure 1-3. River Corridor Plumes and Remediation

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

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

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

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

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

1.4.1 Hydrogeology

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

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

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

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

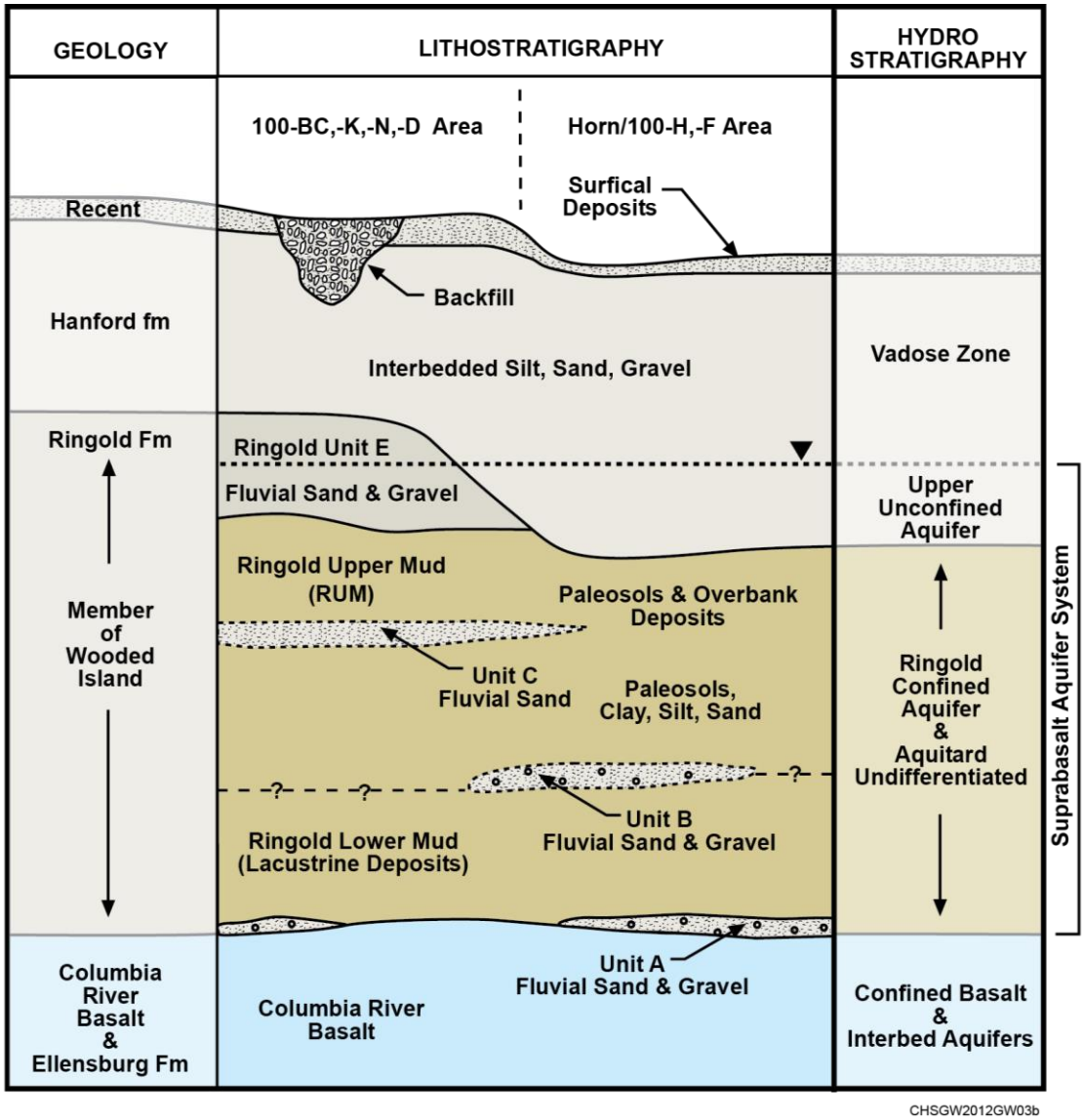


Figure 1-4. River Corridor Geology

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

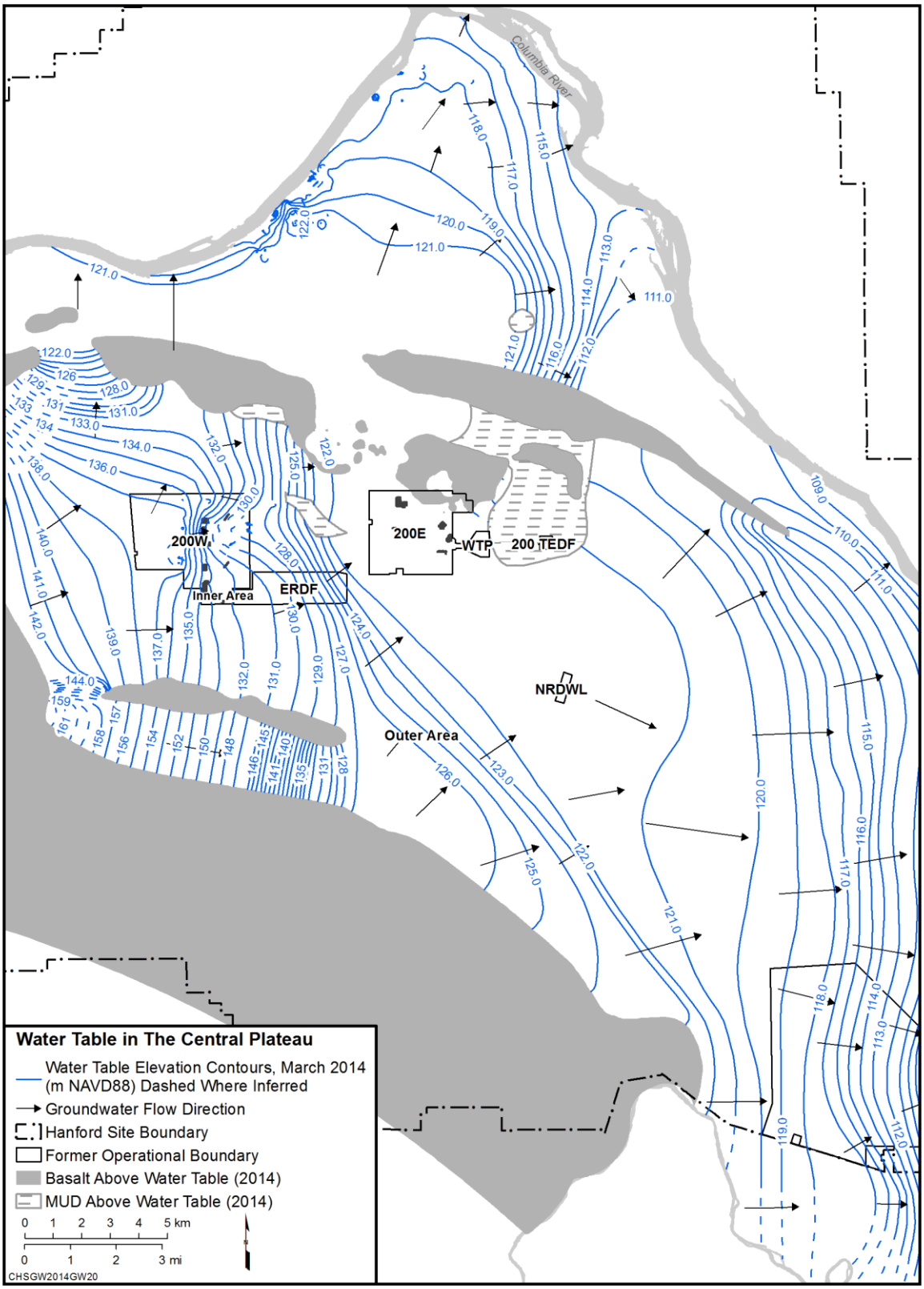


Figure 1-5. Hanford Site Water Table and Groundwater Flow, 2014

1.4.2 Cleanup

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

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

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

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

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

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

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

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

1.4.3 Groundwater Monitoring Results

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

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

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

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

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

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

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

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

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

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

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

Notes:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

LWDF = Liquid Waste Disposal Facility

1.4.4 Shoreline Monitoring

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

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

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

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

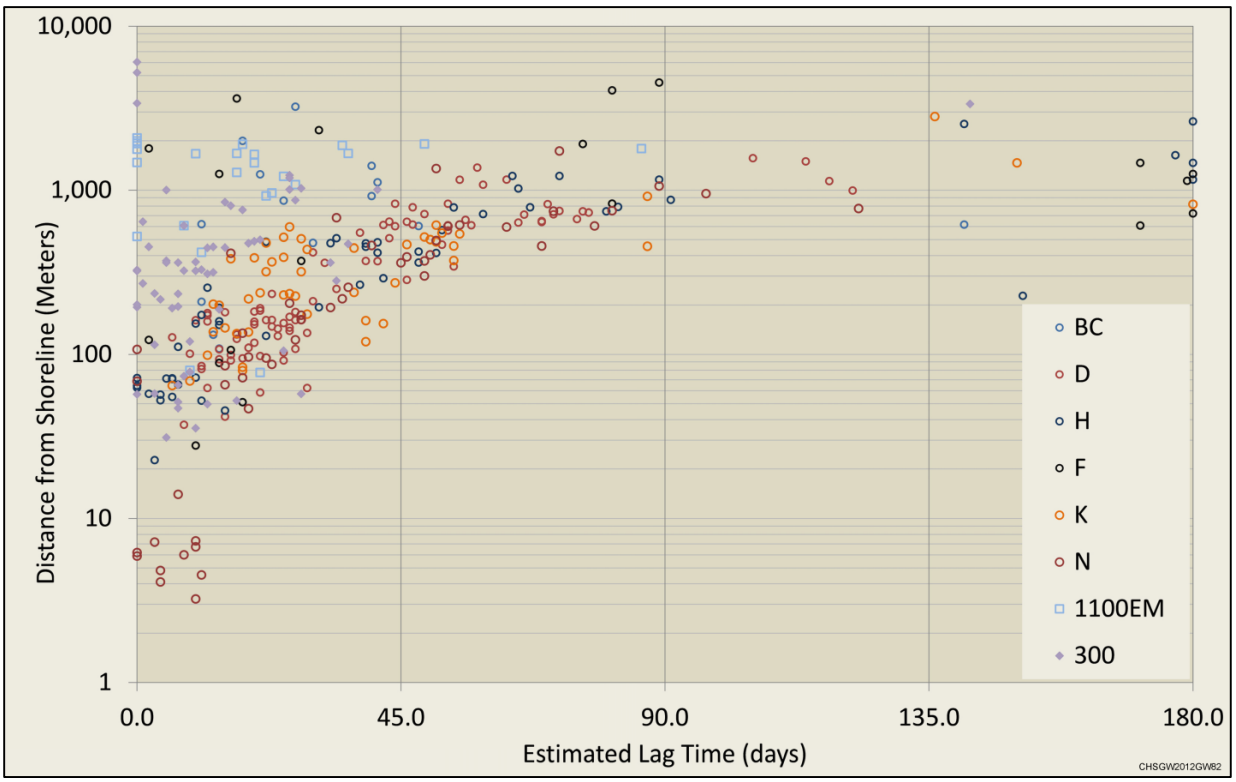


Figure 1-6. Relation of Lag Time to Distance from the Columbia River

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

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

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

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

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

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

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

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

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

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

Data qualifiers:

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

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

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

U = less than detection limit

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

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

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

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

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

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

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

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

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

Documents associated with these efforts include the following:

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

1.5 Central Plateau

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

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

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

Table 1-10. Central Plateau Groundwater and Source OUs

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

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

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

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

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

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

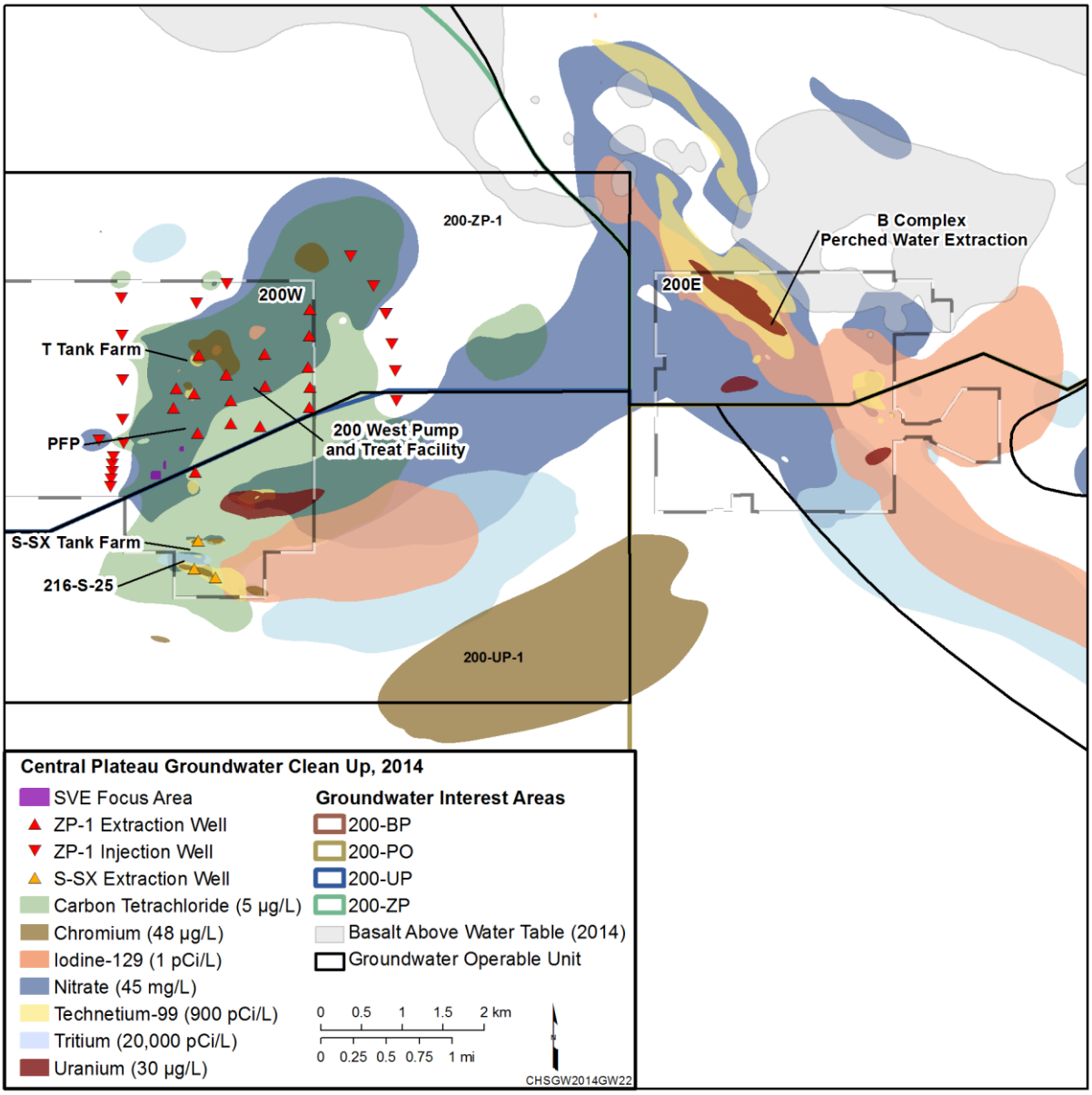


Figure 1-7. Central Plateau Plumes and Remediation

1.5.1 Hydrogeology

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

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

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

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

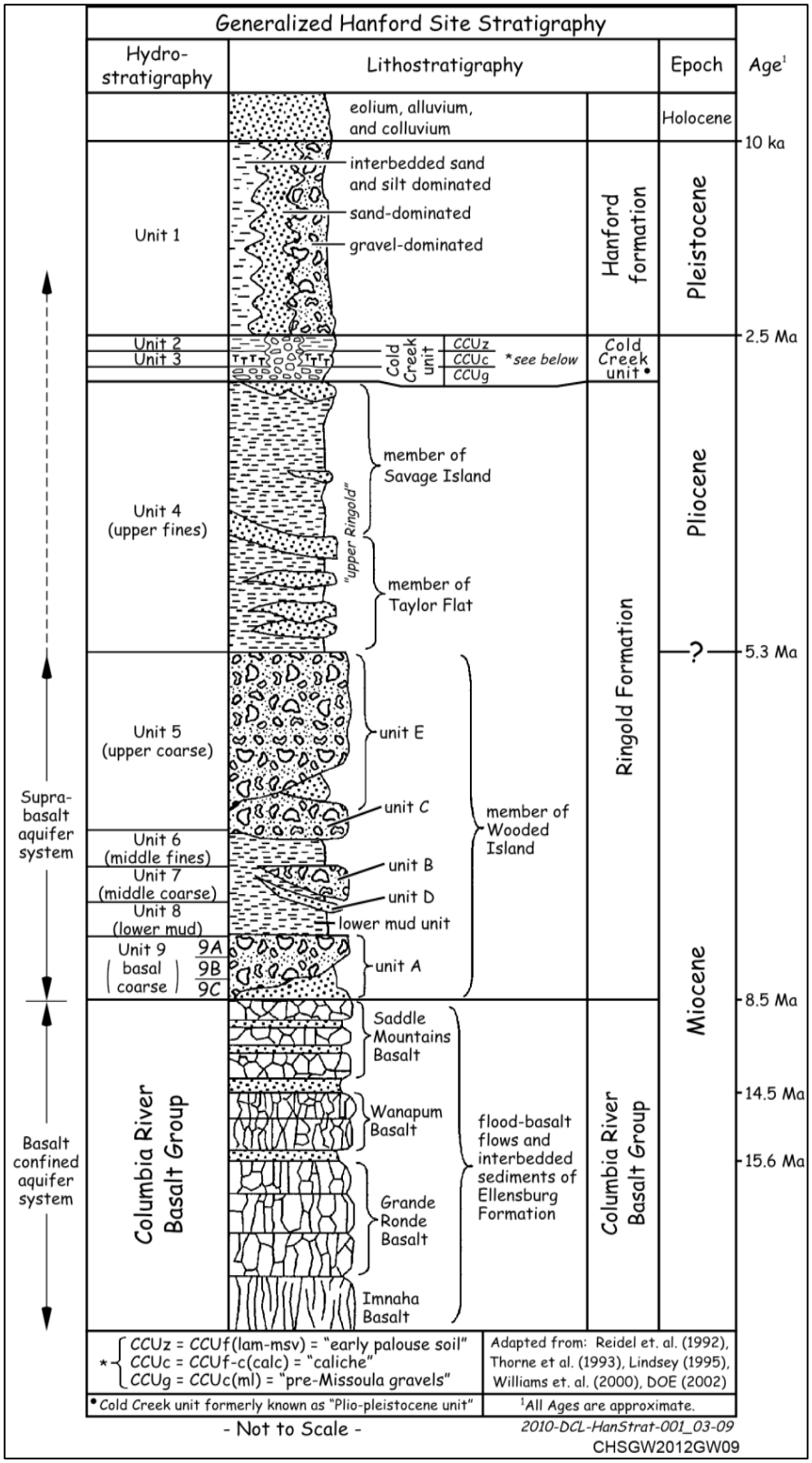


Figure 1-8. Central Plateau Geology

1.5.2 Cleanup

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

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

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

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

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

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

1.5.3 Groundwater Monitoring Results

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

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

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

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

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

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

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

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

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

Notes:

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

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

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

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

a. 4 mrem effective dose equivalent

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

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

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

e. Total trihalomethanes.

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

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

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

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

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

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

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

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

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

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

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

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

b. Primary RCRA constituents at this unit.

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

1.6 CERCLA 5-Year Review

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

1.7 Quality Control Summary

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

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

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

1.8 Sources of Additional Information

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

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

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

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

2 100-BC

2.1 Overview

The 100-BC groundwater interest area includes the 100-BC-5 OU and surrounding region. Two nuclear reactors formerly operated in 100-BC. The B Reactor was the first of its kind, and it operated from 1944 to 1968. The C Reactor operated from 1952 to 1969.

Groundwater contamination in 100-BC is mainly associated with waste produced by the reactors and related processes. Table 2-1 summarizes key facts about 100-BC. Additional details about 100-BC history and waste sites are provided in DOE/RL-2010-96. As of 2014, waste site remediation in 100-BC is 93 percent complete (Table 2-1). Figure 2-1 shows the locations of groundwater monitoring wells and aquifer sampling tubes. Section 1.3 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Table 2-1. 100-BC at a Glance

Reactor operations: B Reactor, 1944–1968; C Reactor: 1952–1969				
2014 Groundwater Monitoring				
Contaminant	**Water Quality Standard**	**Maximum Concentration**	**Plume Area[a] (km^2)**	**Shoreline Impact (m)**
Hexavalent chromium	48 µg/L[b]/ 10 µg/L[c]	63 µg/L (199-B3-47)	0.1[b]/2.0[c]	0[b]/1,800[c]
Strontium-90	8 pCi/L[d]	43 pCi/L (199-B3-46)	0.52	450
Tritium	20,000 pCi/L[d]	17,000 pCi/L (199-B8-9)	0	0
Remediation				
Waste sites (interim action): 93 percent complete[e] **Groundwater (interim action):** None Final ROD anticipated in 2017				

a. Estimated area at a concentration greater than the listed water quality standard.
b. 48 µg/L MTCA groundwater cleanup level.
c. 10 µg/L surface water standard.
d. Drinking water standard
e. Sites with status of closed, interim closed, no action, not accepted, or rejected.
COCs = contaminants of concern
MTCA = Model Toxic Control Act
ROD = Record of Decision

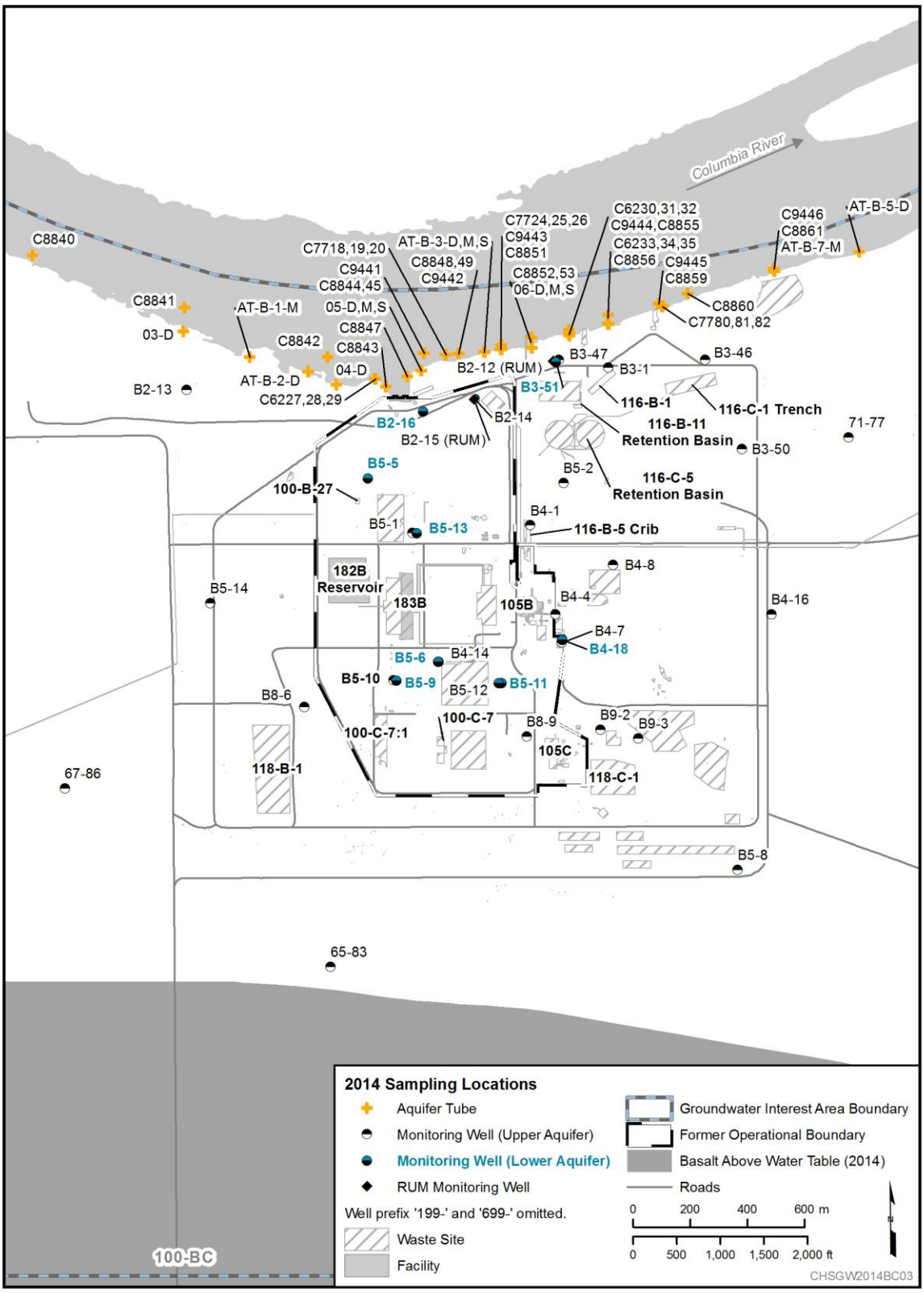


Figure 2-1. 100-BC Sampling Locations, 2014

DOE monitors 100-BC groundwater to meet CERCLA and AEA requirements. Groundwater contaminants of concern (COCs) are hexavalent chromium, strontium-90, and tritium (DOE/RL-2010-96). Previous assessments have not resulted in any interim remedial measures for groundwater. Figure 2-2 shows how estimated plume areas (in the upper part of the unconfined aquifer) have changed since 2003.

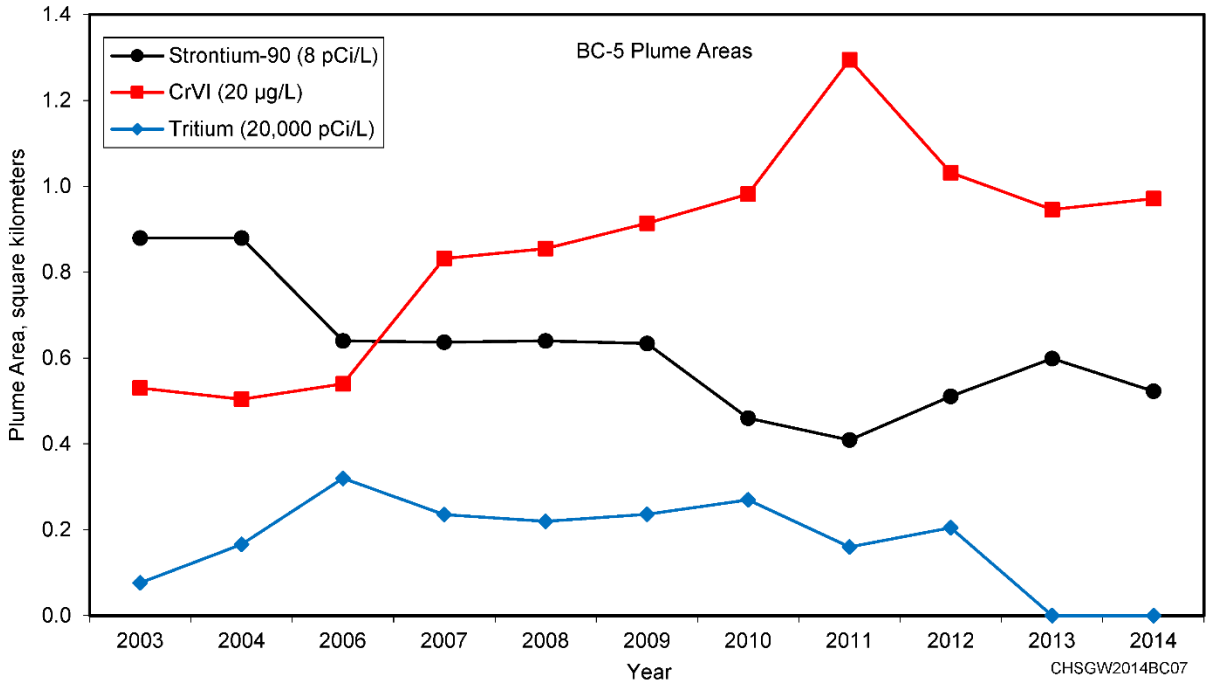


Figure 2-2. 100-BC Plume Areas

One of the last waste sites in 100-BC to undergo remediation under an interim action ROD (EPA/ROD/R10-95/126; EPA/ROD/R10-99/039; EPA/ROD/R10-00/121) was 100-C-7:1. This was the location of the former 183-C Head House, where unplanned releases of hexavalent chromium occurred. The contamination extended through the entire thickness of the vadose zone and the excavation reached the water table. After the completion of this remediation in 2013, there were no known remaining sources of significant contamination that could migrate to groundwater.

The vadose zone in 100-BC comprises Hanford formation sand and gravel (Figure 2-3). The water table is at a depth of approximately 18 to 24 m (59 to 79 ft). The upper portion of the unconfined aquifer beneath most of 100-BC is in the highly permeable sediments of the Hanford formation. The lower portion of the aquifer, and the entire aquifer near the Columbia River, is within the Ringold unit E sands and gravels. The unconfined aquifer is 32 to 48 m (105 to 158 ft) thick, and the base of the aquifer is a silt/clay-rich unit commonly called the RUM (DOE/RL-2010-96). SGW-58308 includes updated geologic maps of 100-BC.

Figure 2-4 illustrates water table contours based on data collected on February 28, 2014, when the river stage was low. The hydraulic gradient is steepest in the north near the Columbia River, where the water table is in Ringold unit E. The gradient is very low in southern 100-BC where the water table is in the highly permeable Hanford formation.

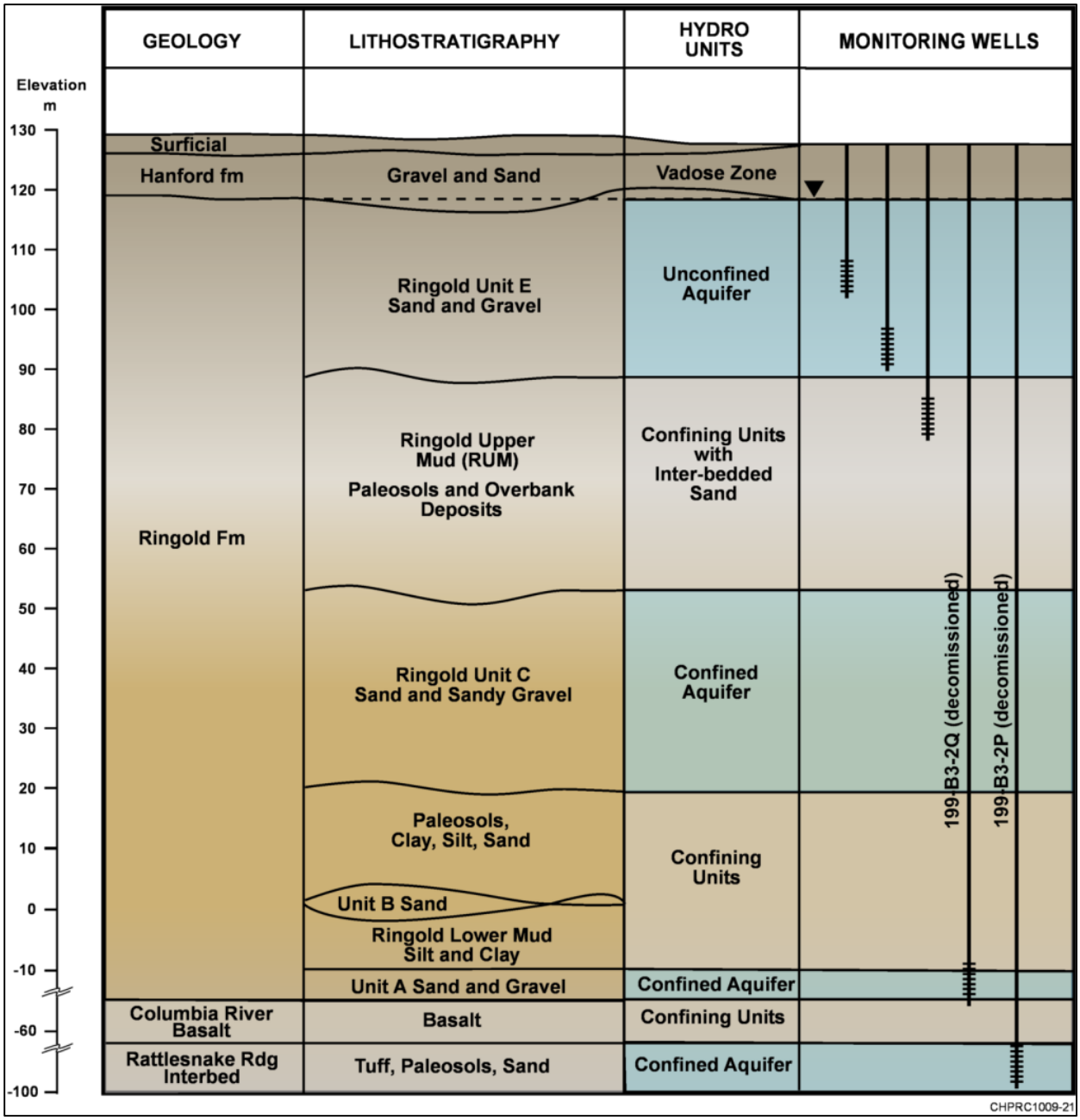


Figure 2-3. 100-BC Geology

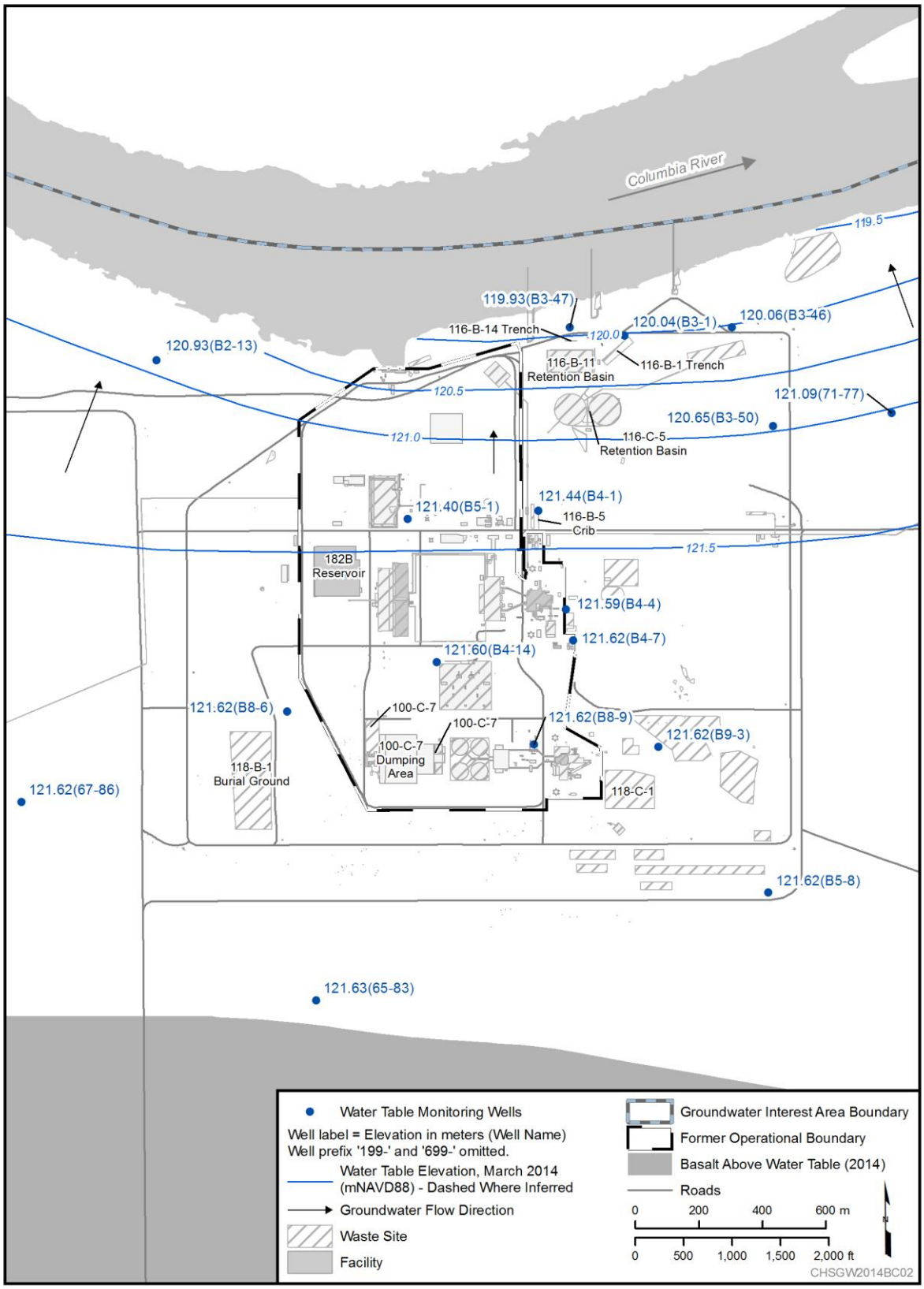


Figure 2-4. 100-BC Water Table, 2014

Table 2-2 summarizes the results of trend surface analysis of water-level data for three time periods in 2014. Three data sets are available for 2014: late February (low river stage), mid-June (high river stage) and mid-October (low river stage). The 100-BC Area is divided into two parts for gradient determination. In northern 100-BC, the gradient dipped consistently toward the north in 2014, ranging from 1.5×10^{-3} to 2.8×10^{-3} m/m. In southern 100-BC, the gradient is nearly flat. The average direction of groundwater flow is interpreted to be toward the northeast, based on water-level data and movement of the chromium plume. The magnitude and direction of the gradient vary seasonally. The gradient in February 2014 was approximately 2×10^{-5} m/m, dipping to the north. The largest gradient was in June at 2×10^{-4} m/m toward the northeast. In October 2014, calculated gradients varied from 10^{-5} to 10^{-4} m/m and estimated flow directions varied from northwest to northeast, depending on which set of wells were selected.

Table 2-2. Hydraulic Gradient and Groundwater Flow Directions in 100-BC

Date	Southern 100-BC		Northern 100-BC	
	Magnitude	Degrees East of North	Magnitude	Degrees East of North
February 28, 2014	1.8E-05*	0*	2.1E-03	9.3
Mid-June 2014	1.9E-04	47	1.5-03	5.6
Mid-October 2014	1.1E-04*	354*	2.8E-03	4.2

Source: SGW-58308.

* Results uncertain; little difference in water levels across region

Vertical hydraulic gradients in southern 100-BC generally are downward, particularly when the water table is dropping in late summer and fall. The vertical gradient in northern 100-BC is upward, indicative of a groundwater discharge area. The upward gradient is strongest in the fall when the water table and average river stage are low.

2.2 CERCLA Activities

In 2014, CERCLA activities in 100-BC included routine groundwater monitoring and RI studies.

Routine groundwater monitoring is described in the SAP for the OU (DOE/RL-2003-38 Rev. 1, as modified by TPA-CN-522). Groundwater monitoring wells in 100-BC are sampled at frequencies ranging from biennialy to monthly. The comprehensive annual sampling event was completed in October. Table A-1 of Appendix A lists the wells and constituents monitored. Aquifer tubes in 100-BC were sampled late August and September 2014 (Appendix C). River stage was low during this time and the head ends of the aquifer tubes were above the water level.

DOE is conducting additional studies in 100-BC between 2013 and 2015 to reduce uncertainties relating to (1) the completion of waste site remediation, (2) short-term changes in groundwater contaminants related to waste site remediation, (3) modeling results predicting that the hexavalent chromium plume could persist for over 100 years, and (4) the level of risk associated with variable contaminant concentrations in Columbia River pore water. To address these uncertainties, a change was initiated in Tri-Party Agreement Milestone M-015-74, and the RI/ FS work plan and SAP were amended (TPA-CN-558, TPA-CN-559, TPA-CN-592, TPA-CN-593, and TPA-CN-602).

In 2014, workers continued to sample a series of shallow aquifer tubes called hyporheic sampling points (HSP) to monitor Columbia River pore water. Their locations are shown on Figure 2-1. The HSPs are being monitored for hexavalent chromium monthly for 2 years to identify seasonal changes and characterize the level of risk to aquatic receptors.

The revised work plan also includes groundwater monitoring, including eight wells installed in 2013 and early 2014. The new wells and older wells will be monitored for 2 years to evaluate (1) the nature and extent of hexavalent chromium and co-contaminants, (2) groundwater model input parameters, and (3) which natural attenuation processes are occurring. Monitoring frequency is quarterly for the new wells and older wells with rapid changes in chromium concentration, and semiannually or annually for wells with less variability.

A recent report describes results of the RI studies from fall 2013 through December 2014 in detail (SGW-58308). The sections below summarize results for 2014.

2.3 Hexavalent Chromium

Sources of hexavalent chromium included cribs near the reactor buildings, trenches and retention basins near the Columbia River, and pipelines from the reactor buildings to the near-river facilities. Other chromium sources were the 100-C-7 and 100-C-7:1 sites in southern 100-BC and the 100-B-27 sodium dichromate spill site in the northwest.

Movement of chromium in 100-BC groundwater is influenced by differences in permeability in the Hanford formation and the underlying Ringold unit E. In most of 100-BC, the top of the aquifer includes 1 to 12 m (3 to 39 ft) of the Hanford formation. The chromium plume moves rapidly through these highly permeable sediments. In northern 100-BC, the Hanford formation is unsaturated and the aquifer is entirely within Ringold unit E. Chromium concentrations in the upper aquifer in this location are more stable than in the upper aquifer of southern 100-BC.

The hexavalent chromium plume with concentrations greater than 10 µg/L covers a large area at relatively low concentrations (Figure 2-5). The plume map illustrates distribution in the upper part of the aquifer, based on data collected in fall 2014. The following changes are evident when comparing the 2013 and 2014 plume maps:

- The 48 µg/L contour that originated in southern 100-BC (with former sources at 100- C-7:1 and 100-C-7) continued to migrate downgradient. The portion of the plume with concentrations greater than 48 µg/L formerly seen in the south has merged with the greater than 48 µg/L portion near the Columbia River.
- The 10 and 20 µg/L contours on the east side of the plume have migrated eastward.
- Chromium concentrations increased to levels above 10 µg/L in 199-B2-13 and some aquifer tubes west (upstream) of the main chromium plume (Figure 2-5).

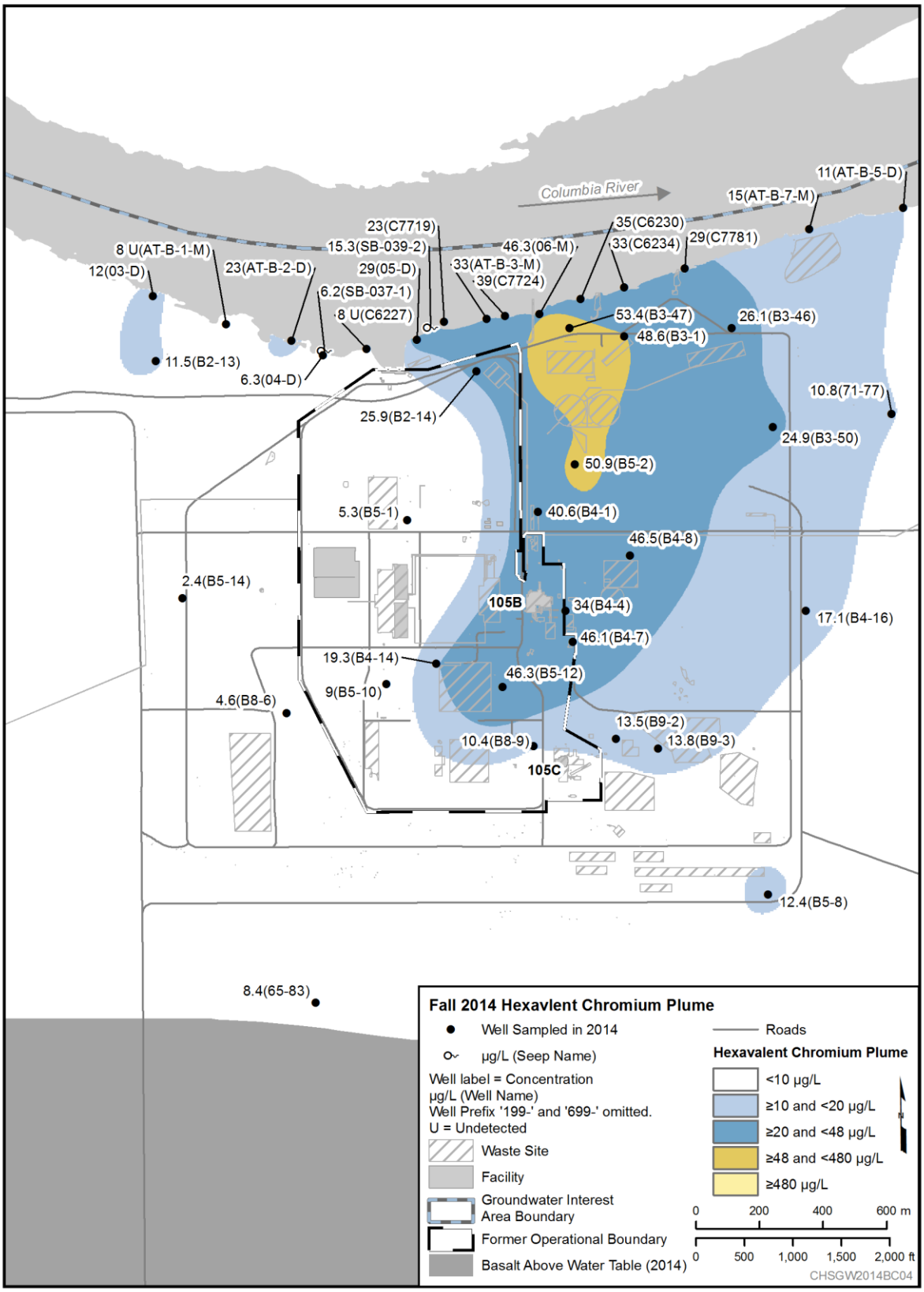


Figure 2-5. 100-BC Hexavalent Chromium Plume, 2014

Concentrations are variable in wells near the former hexavalent chromium sources at the 100-C-7 and 100-C-7:1 sites, which were remediated in 2011 and 2012 (Figure 2-6). The large peak seen in 199-B4-14 in 2012 was caused by activities related to waste site remediation. The subsequent, lower peaks are related to seasonal variations in groundwater flow direction. Well 199-B5-10 is located closer to the former source; its concentrations declined from 24 µg/L when the well was first sampled in January 2014 to 9 µg/L in October.

As the 100-C-7:1 contamination migrated to the northeast, concentrations in wells in northern 100-BC increased (Figure 2-7). The peak concentrations appear to have passed wells in central 100-BC (199-B4-4, 199-B4-7, and 199-B4-8; Figure 2-8).

The eastern boundary of the chromium plume at 10 and 20 µg/L is farther east than it was in 2013. The southern plume appears to have migrated downgradient (northeast), and then moved north toward the river. Concentrations have increased in 199-B3-46, 199-B3-50, and 699-71-77 (Figure 2-9) and in nearby aquifer tubes (AT-B-7-M and AT-B-5-D). Concentrations have also increased in the next well to the east, 699-72-73, but the average concentration in fall 2014 was slightly less than 10 µg/L.

Chromium concentrations increased in one well and two aquifer tubes located upstream of the main plume in 2014. The highest concentration was 23 µg/L in AT-B-2-D, a four-fold increase from the previous year. Analytical problems with hexavalent chromium analyses in 2014 created some uncertainty in unfiltered samples. However, during a data review, several samples were filtered and reanalyzed and results were consistent with the initial results. There is no known source of chromium in this region.

In recent years, chromium concentrations have declined in water table wells in western 100-BC, such as 199-B5-1 and 199-B8-6. This change indicates clean groundwater moving into 100-BC from the west and south. The low concentrations in these wells persisted in 2014.

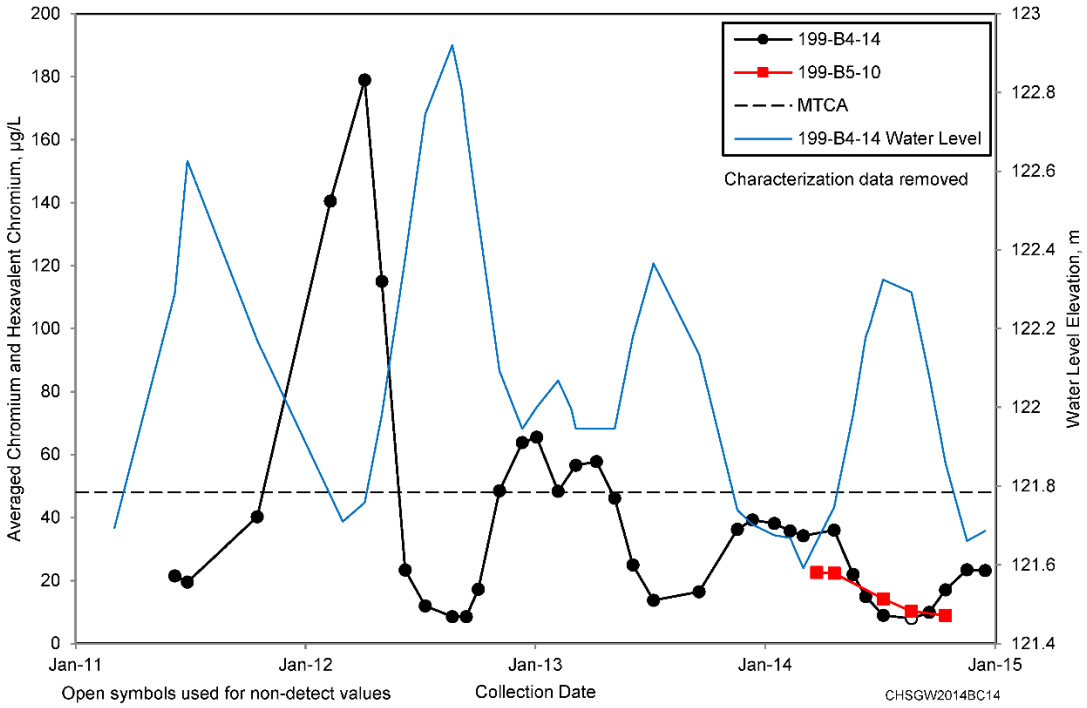


Figure 2-6. 100-BC Hexavalent Chromium and Water-Level Data in Wells 199-B4-14 and 199-B5-10 in Southern 100-BC

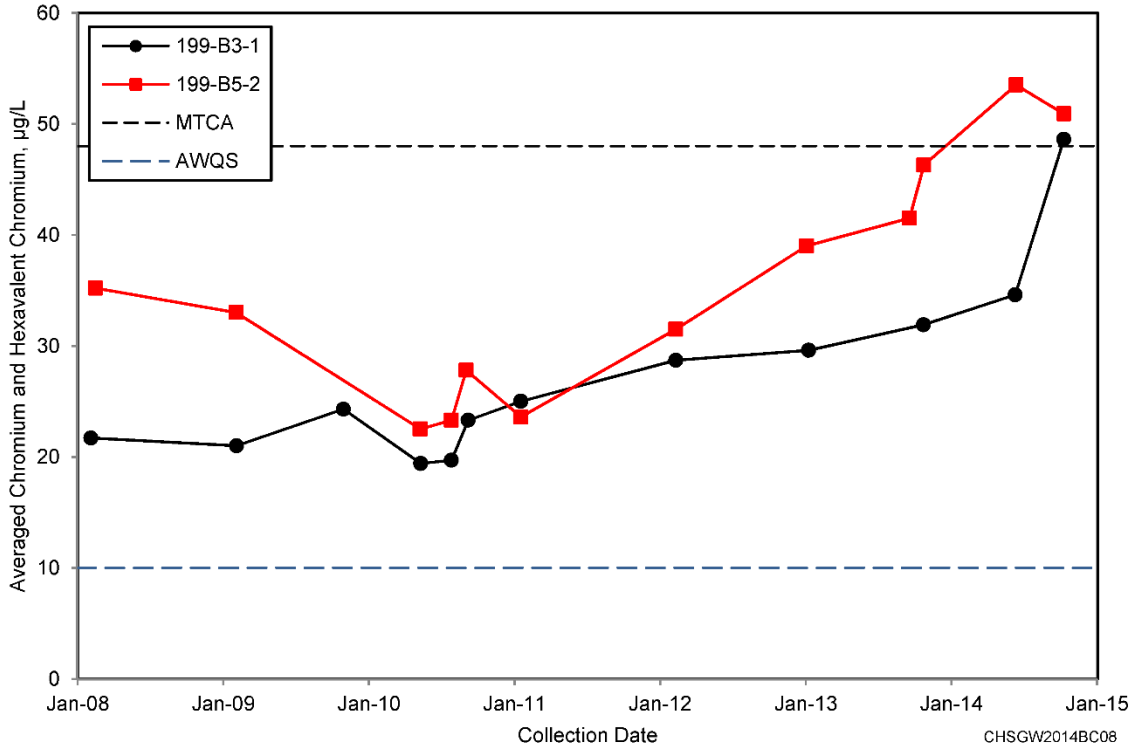


Figure 2-7. 100-BC Hexavalent Chromium Data for Wells 199-B3-1 and 199-B5-2 in Northern 100-BC

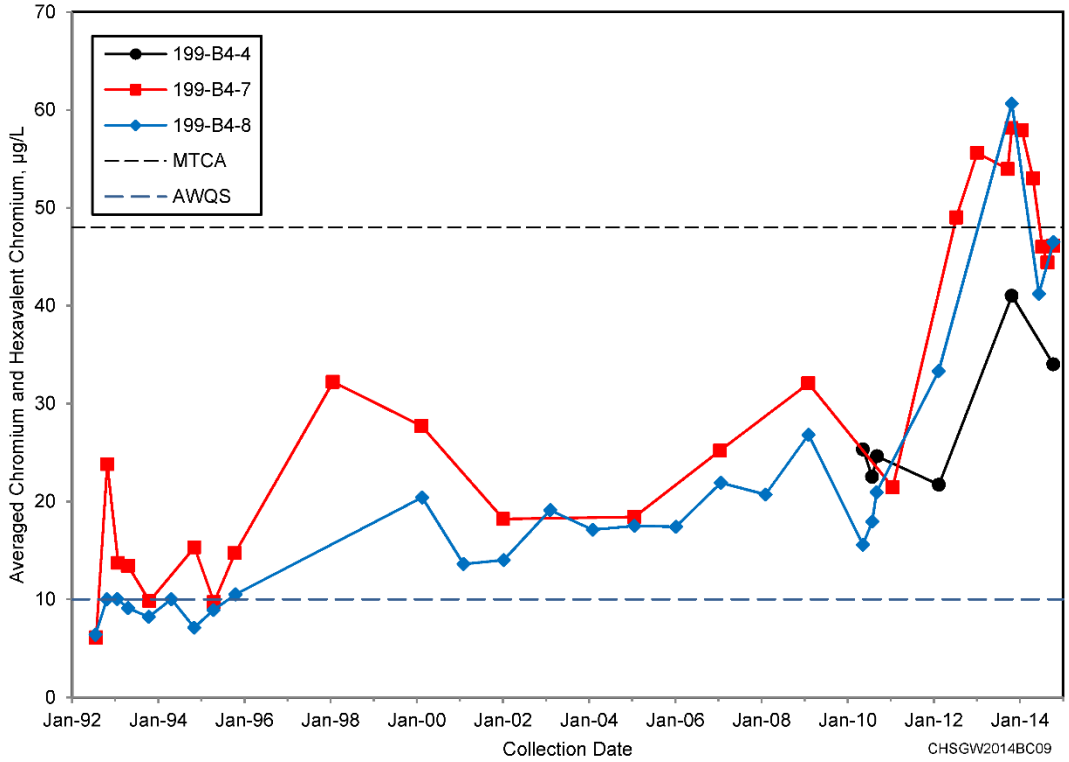


Figure 2-8. 100-BC Hexavalent Chromium Data in Wells 199-B4-4, 199-B4-7, and 199-B4-8 in Central 100-BC

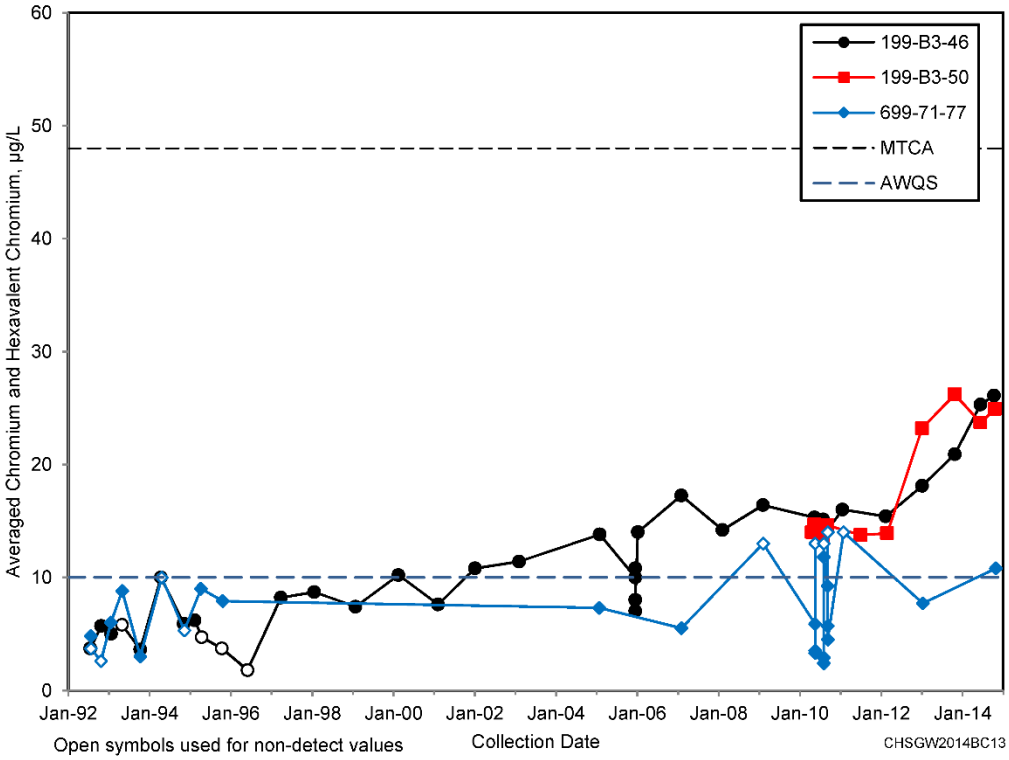


Figure 2-9. 100-BC Hexavalent Chromium Data in Wells 199-B3-46, 199-B3-50, and 699-71-77 in Northeastern 100-BC

Chromium concentrations are relatively stable in wells screened in Ringold unit E, which is less permeable than the Hanford formation. Figure 2-10 illustrates chromium trends in 199-B5-5 and 199-B5-6, which are screened in the lower part of Ringold unit E, and 199-B3-47, which is screened at the top of the aquifer where the water table is in the Ringold Formation. Ringold unit E is not as permeable as the Hanford formation in 100-BC, so groundwater moves more slowly.

Figure 2-11 shows chromium distribution in the lower part of the unconfined aquifer in fall 2014. Between 2009 and 2014, eight wells were installed and screened in the lower part of the aquifer. Deep contamination is present in southern and western 100-BC. No deep contamination is found in northeastern 100-BC (199-B3-51). The bimodal distribution of contamination in western 100-BC is attributed to contaminant releases of different ages. Older releases at a time when there was a strong, downward hydraulic gradient drove contamination into the lower part of the aquifer, which is less transmissive than the upper sediments.

Figures 2-12 and 2-13 are cross sections showing vertical distribution of hexavalent chromium in fall 2014. The interpretation is based on monitoring data wells screened at different depths, and supplemented by characterization data collected during drilling that were presented in the 2013 annual report (DOE/RL-2014-32). Deep contamination is now present in 199-B5-9, 199-B5-13 (Figure 2-12), and 199-B4-18 (Figure 2-13), which were previously thought to be uncontaminated based on characterization data. Note that early data from some of the newest deep wells may have been biased low because of residual effects of drilling, which create a locally reductive environment. This effect dissipates over time.

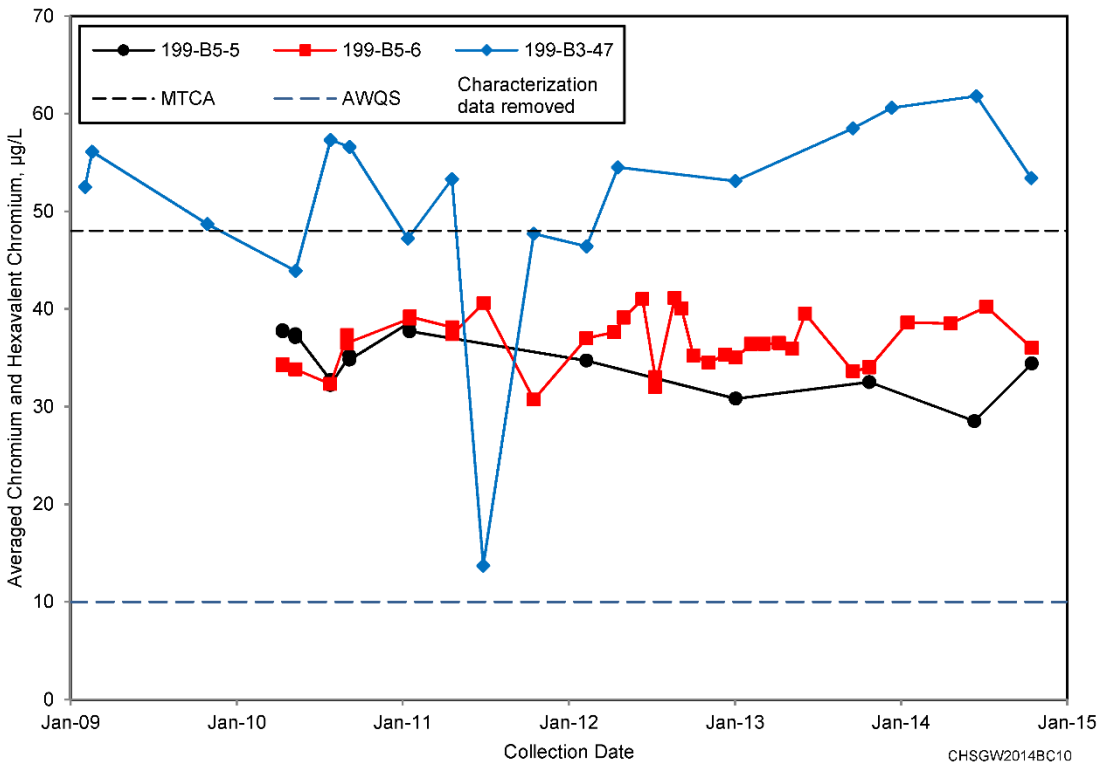


Figure 2-10. 100-BC Hexavalent Chromium Data in Wells Screened in Ringold Unit E

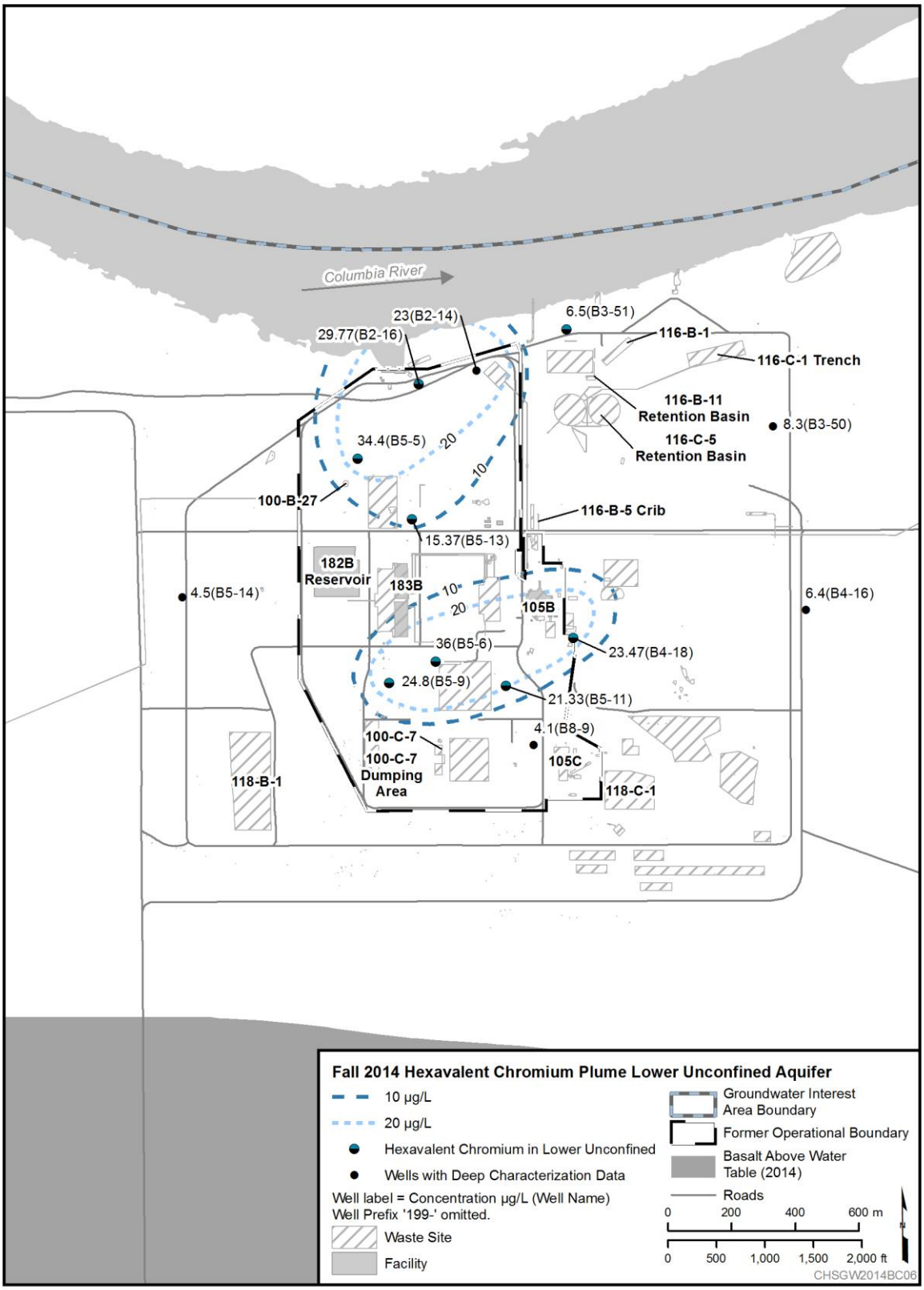


Figure 2-11. 100-BC Hexavalent Chromium in the Lower Part of the Unconfined Aquifer

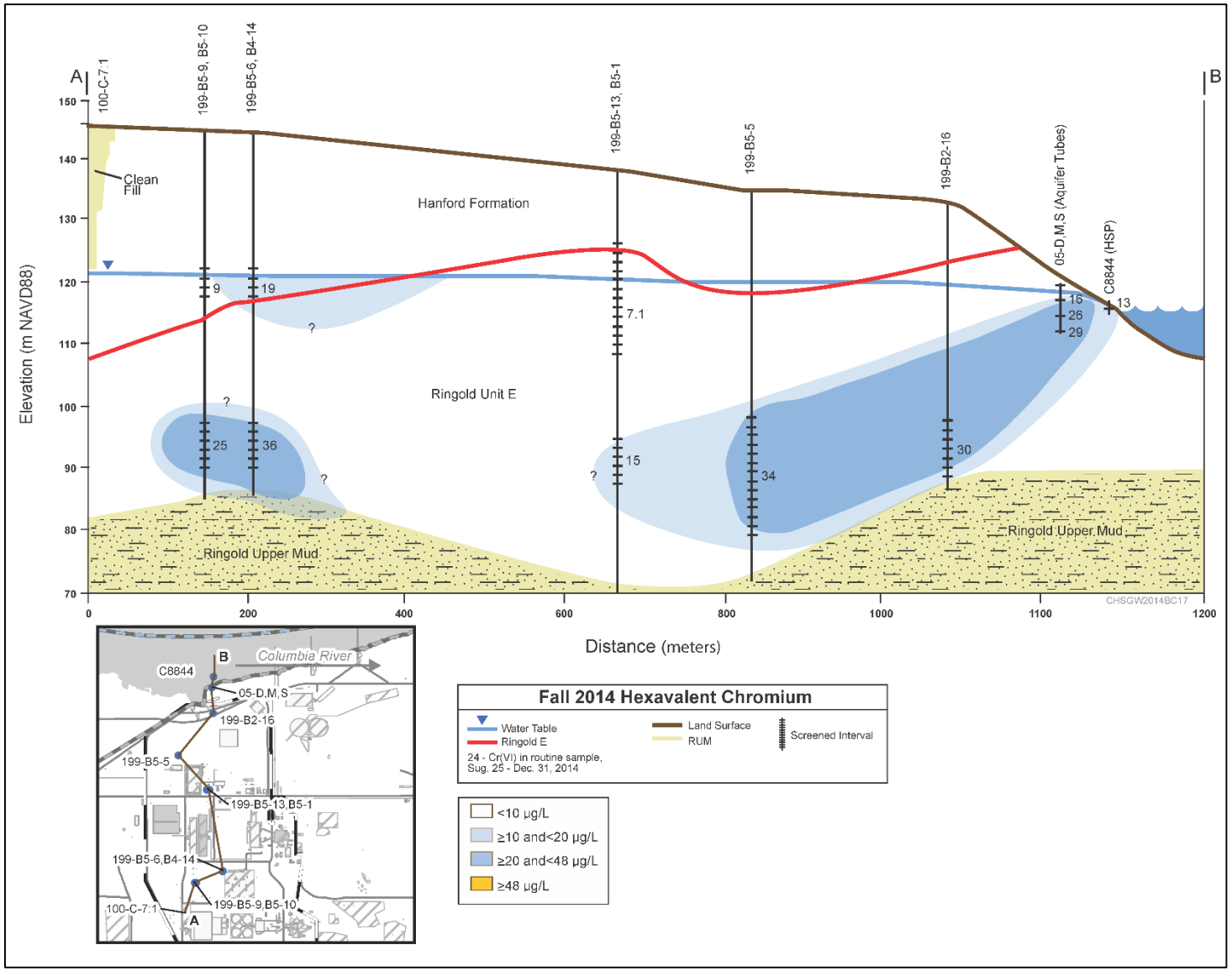


Figure 2-12. 100-BC Cross Section Showing Hexavalent Chromium Distribution, South to North in Western 100-BC

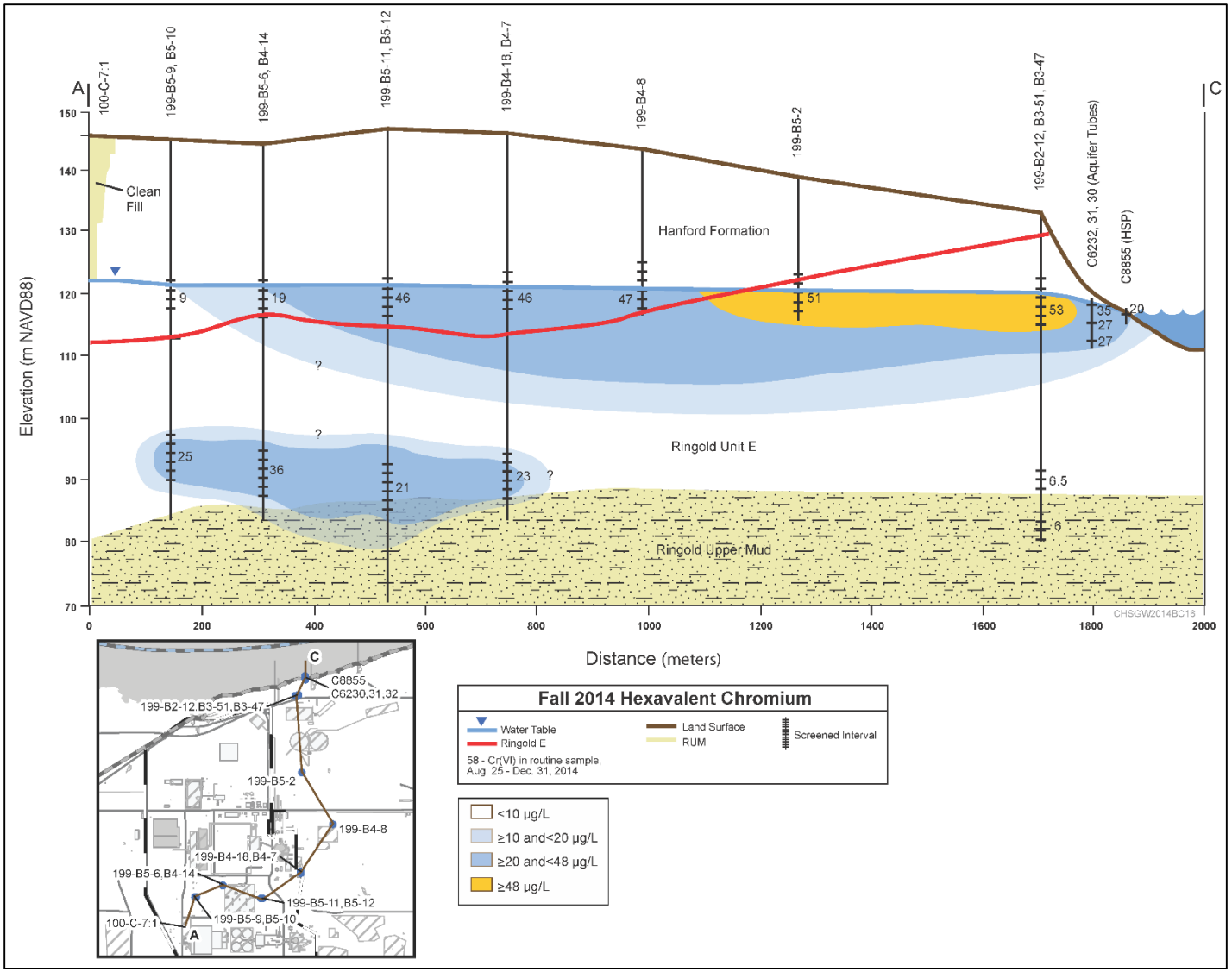


Figure 2-13. 100-BC Cross Section Showing Hexavalent Chromium Distribution, Southwest to Northeast

Aquifer Tubes and Hyporheic Sampling Points (HSPs). Thirty-five aquifer sampling tubes in 100-BC are monitored annually (Appendix C). These aquifer tubes range from 2 to 8 m (6.6 to 26.2 ft) in depth and provide an indication of groundwater quality approaching its point of discharge to the Columbia River. The heads of these tubes are on the shoreline above the low water mark, and they are sampled from the shore. The plume map of hexavalent chromium (Figure 2-5) includes the maximum concentration in each cluster sampled in fall 2014.

The RI project installed 23 shallower sampling points in 2013 and 2014 that are more indicative of concentrations in the accessible river environment. These range in depth from 15 cm (5.9 in.) to 1 m (3.3 ft). They are submerged even at low river stage and are sampled from a boat. Results of these studies are described in detail in SGW-58308.

Figure 2-14 shows results of October 2014 grab samples collected from 14 HSPs screened at 0.5 m (1.6 ft) depth. Concentrations ranged from below detection levels (upstream HSPs) to 22 µg/L adjacent to the contaminant plume. These samples were collected during a period when average river stage was low and groundwater was discharging to the river.

During periods of sustained high river stage, hexavalent chromium concentrations tended to be lower in HSP samples (Figure 2-15). Higher head pushes river water into the hyporheic zone where it mixes with or displaces groundwater.

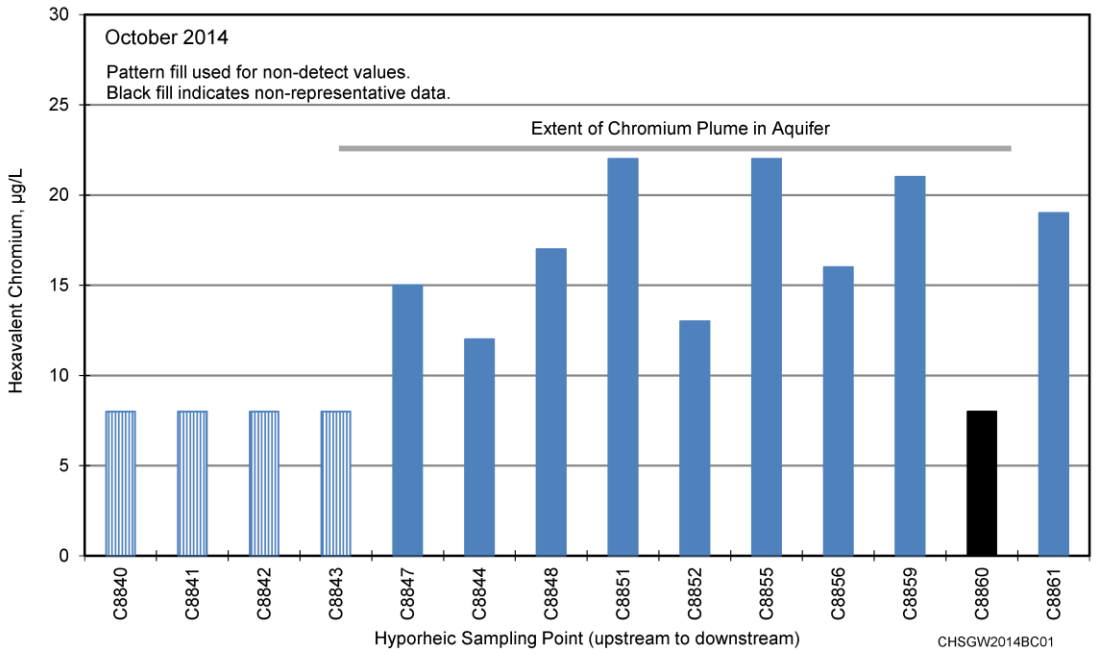


Figure 2-14. 100-BC Hexavalent Chromium in 0.5 m Deep Hyporheic Sampling Points, October 2014

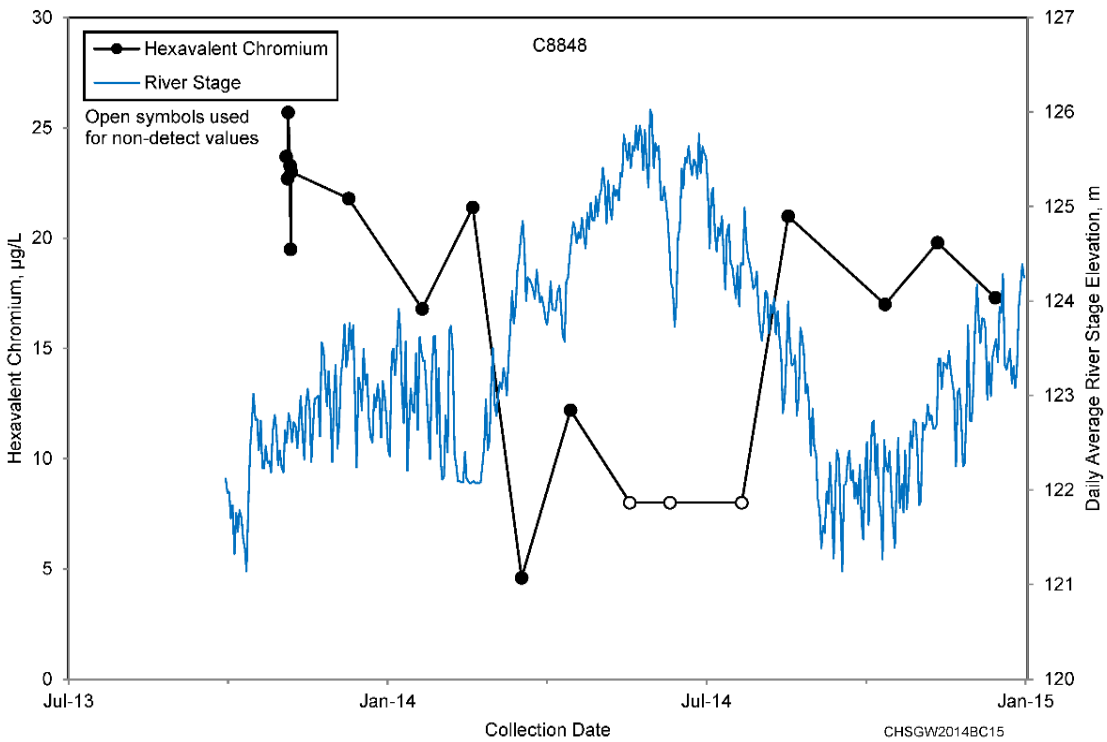


Figure 2-15. 100-BC Example of Monthly Hexavalent Chromium Concentrations in an HSP, in Relation to Daily Average River Stage Elevation below Priest Rapids Dam

Samplers collected river water from approximately 15 cm (5.9 in.) above the bottom at seven of the HSP sites during December 2014. Hexavalent chromium concentrations were near or below detection limits (maximum 3.2 µg/L). These results confirmed previous studies that showed chromium concentrations in the river at 100-BC were below the aquatic standard (WCH-380, Rev. 1).

DOE will continue to sample the HSPs monthly in 2015 to study the effects of seasonal river stage changes and plume migration.

2.4 Strontium-90

Liquid effluent containing strontium-90 was disposed to cribs near the reactor buildings and to cribs, trenches, and retention basins in northeastern 100-BC. Figure 2-16 shows an interpretation of the plume based on 2014 data. Concentrations ranged from below detection limits to 43 pCi/L, similar to previous years.

Figure 2-17 shows the strontium-90 trends in northern 100-BC near some of the former contaminant sources: 199-B3-47 near the 116-B-11 Retention Basin and 116-B-14 Trench, 199-B3-1 near the 116-B Trench, and 199-B3-46 near the 116-C-1 Trench. These sites have been remediated. The concentrations in groundwater have declined since the 1990s.

Groundwater samples indicate that strontium-90 contamination in 100-BC groundwater is limited to the upper portion of the unconfined aquifer. Strontium-90 concentrations in 199-B3-51, screened at the bottom of the aquifer, are below detection limits, while the adjacent (199-B3-47), screened at the water table, has concentrations above the DWS.

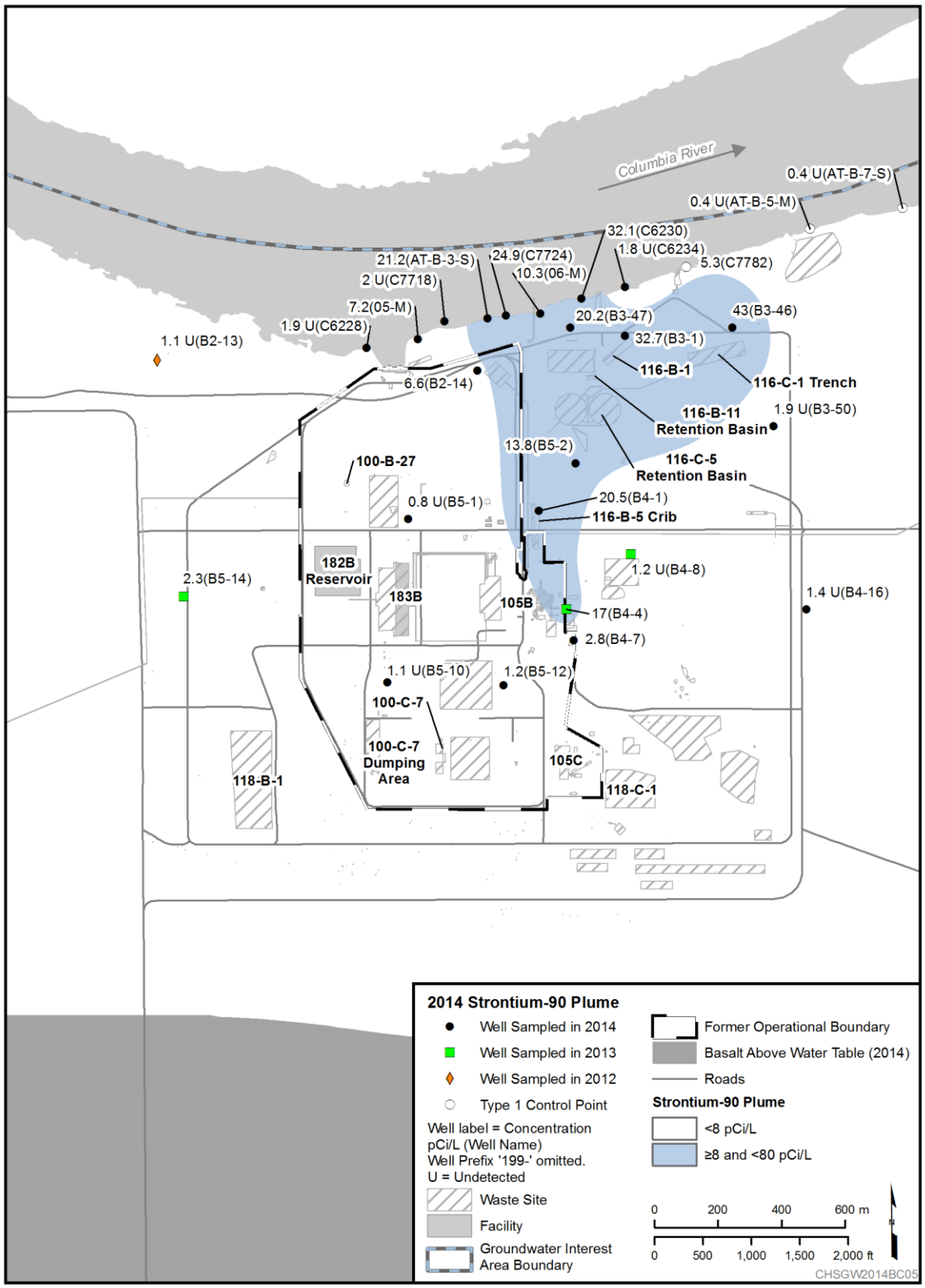


Figure 2-16. 100-BC Strontium-90 Plume, 2014

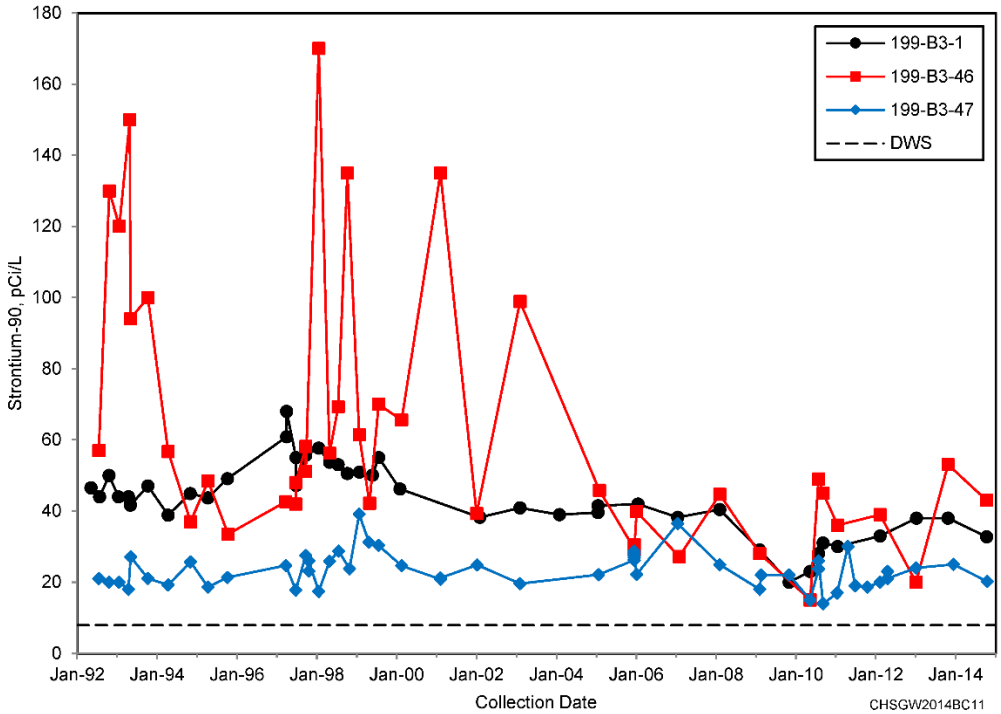


Figure 2-17. 100-BC Strontium-90 Data in Wells 199-B3-1, 199-B3-46, and 199-B3-47

Strontium-90 concentrations in several 100-BC aquifer tubes continued to exceed the DWS in 2014. The highest concentrations are in the shallow or mid-depth tubes, reflecting the distribution in the aquifer. Strontium-90 was not analyzed in HSPs in 2014 because they must be sampled at such low flow rates that it makes collecting large-volume samples like strontium-90 impractical. Five HSP samples were analyzed for strontium-90 in 2013, and the only detection was at 3.9 pCi/L in HSP C8847.

2.5 Tritium

Tritium was present in effluent discharged to former cribs near the B Reactor and near the Columbia River. The former 118-B-1 Burial Ground in southwestern 100-BC was another source of contamination. All of these waste sites have been remediated.

In 2014, as in 2013, no tritium concentrations exceeded the DWS in 100-BC monitoring wells or aquifer tubes. In 2012, two portions of 100-BC had tritium concentrations slightly above the DWS: one in northern 100-BC, and one in southern 100-BC. Concentrations continued to decline in 2014 (Figure 2-18).

Vertical characterization data from wells drilled in 2009, 2010, and 2013 indicated that tritium concentrations are generally highest near the top or middle of the aquifer, and lower at the bottom of the aquifer.

In the past, tritium contamination that originated in the 200 Areas migrated between Gable Butte and Gable Mountain to the region between 100-BC and 100-KR. The concentration peaked at 21,300 pCi/L in 699-72-73 in 2000 and subsequently declined to 2,580 pCi/L in 2014. In 2014, the maximum tritium concentration between 100-BC and 100-KR was 5,830 pCi/L in an aquifer tube (14-D). With the decline of the water table in the 200 Areas, there is little potential for continued migration of contamination through Gable Gap.

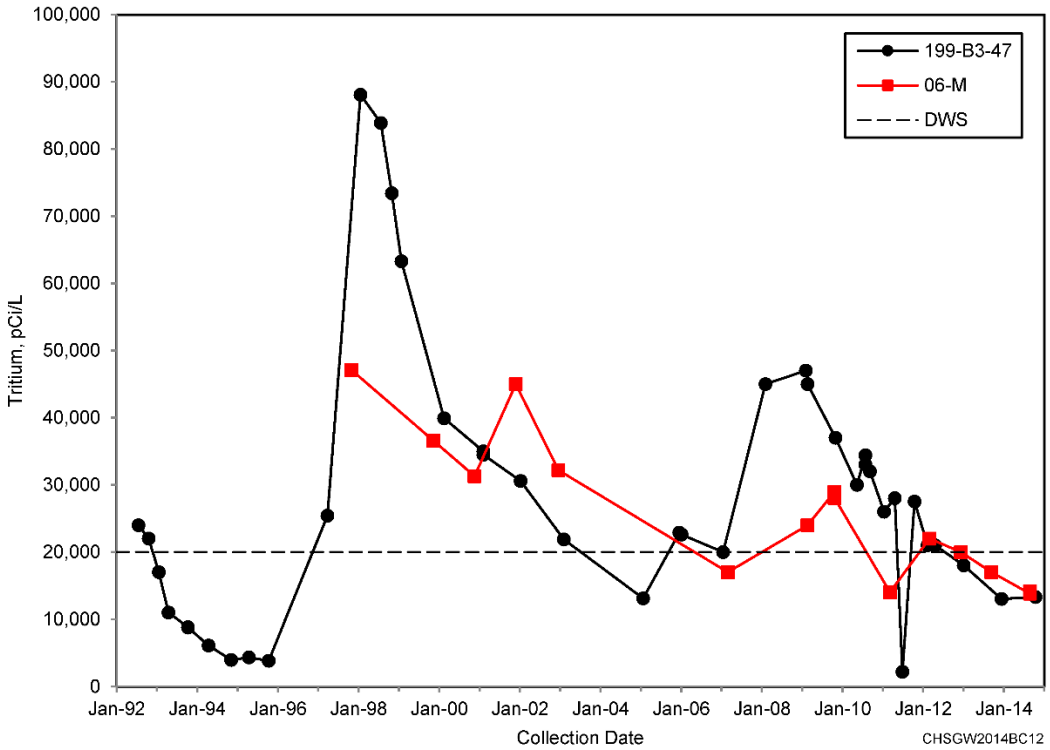


Figure 2-18. 100-BC Tritium Data for Well 199-B3-47 and Aquifer Tube 06-M in Northern 100-BC

3 100-FR

3.1 Overview

The 100-FR groundwater interest area includes the 100-FR-3 OU and surrounding region. One nuclear reactor operated at 100-FR between 1945 and 1965. Groundwater contamination originated from waste sources related to reactor operations and biological experiments that continued until 1976. Table 3-1 summarizes key facts about 100-FR and additional details about 100-FR history and waste sites are provided in DOE/RL-2010-98. As of 2014, waste site remediation in 100-FR is 100 percent complete (Table 3-1).

DOE monitors 100-FR groundwater to meet CERCLA and AEA requirements. Groundwater COCs are nitrate, TCE, hexavalent chromium, and strontium-90 (DOE/RL-2010-98). Figures 3-1 and 3-2 show the locations of groundwater monitoring wells and aquifer sampling tubes. Figure 3-3 shows how plume areas have changed over the years. Section 1.3 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Previous assessments have not resulted in any interim remedial measures for groundwater in 100-FR. EPA signed a final CERCLA ROD in September 2014 (*Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6 Operable Units* [EPA et al., 2014]).

Table 3-1. 100-FR at a Glance

F Reactor operations: 1945–1965 **Biological experiments:** 1945–1976				
2014 Groundwater Monitoring				
Contaminant	**Cleanup Level[a]**	**Maximum Concentration**	**Plume Area[b] (km^2)**	**Shoreline Impact (m)**
Nitrate	45 mg/L[c]	146 mg/L (199-F5-56)	7.9	0
Hexavalent chromium	48 µg/L[d]/ 10 µg/[d]	29 µg/L (199-F5-46)	0/0.58[e]	0
Strontium-90	8 pCi/L	144 pCi/L (199-F5-55)	0.13	0
Trichloroethene	4 µg/L	15.3 µg/L (199-F7-1)	1.0	0
Remediation				
Waste sites in 100-FR-1 and 100-FR-2 OU (interim action): 100 percent complete[f] Final ROD signed in 2014 MNA for groundwater				

a. Cleanup levels from EPA et al. (2014)

b. Estimated area at a concentration greater than the listed level.

c. 45 mg/L as NO_3 is equivalent to the drinking water standard of 10 mg/L as N.

d. 48 µg/L in upland groundwater and 10 µg/L where groundwater discharges to surface water.

e. Plume area >10 µg/L in 100-F Area is 0.58 km^2. Wells in western part of interest area not included because the 10 µg/L standard does not apply to inland areas.

f. Sites with status of closed, interim closed, no action, not accepted, or rejected. Two sites not covered by interim action are proposed as "no further action," and a third site, the reactor, is considered separately.

COCs = contaminants of concern
DWS = drinking water standard
MNA = monitored natural attenuation
OU = Operable Unit
ROD = Record of Decision

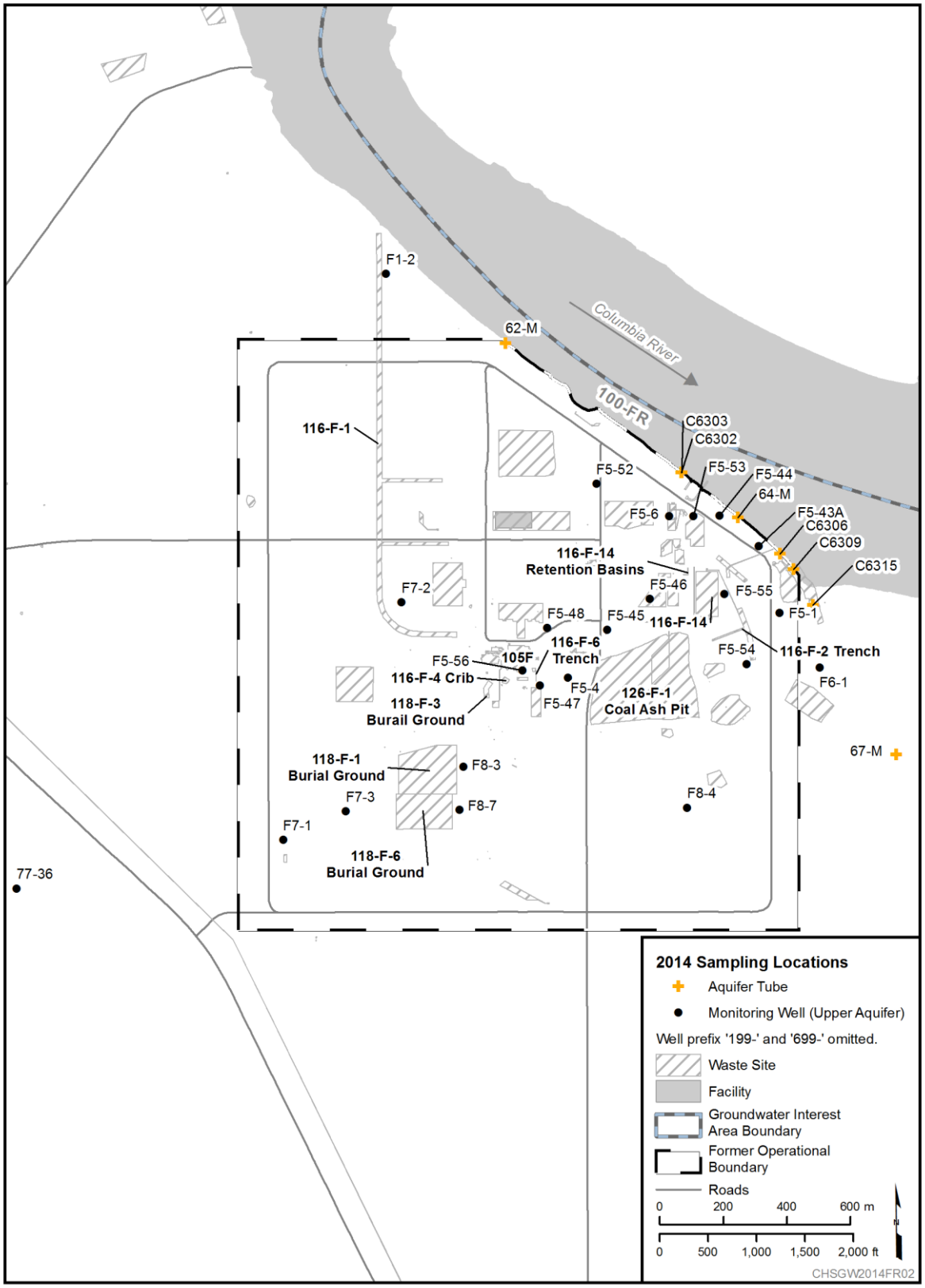


Figure 3-1. 100-FR Sample Locations

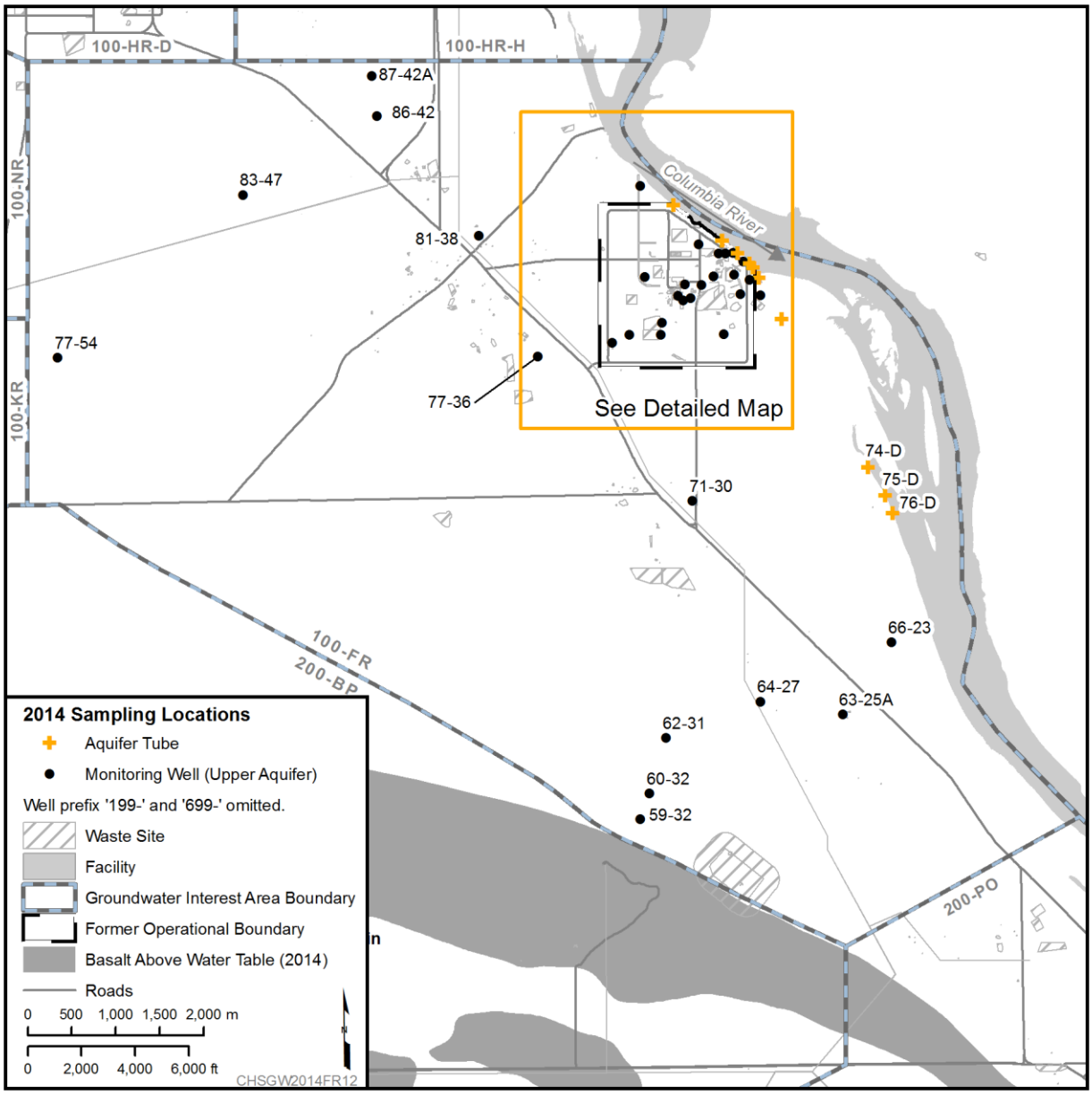


Figure 3-2. 100-FR Sample Locations in Outlying Area

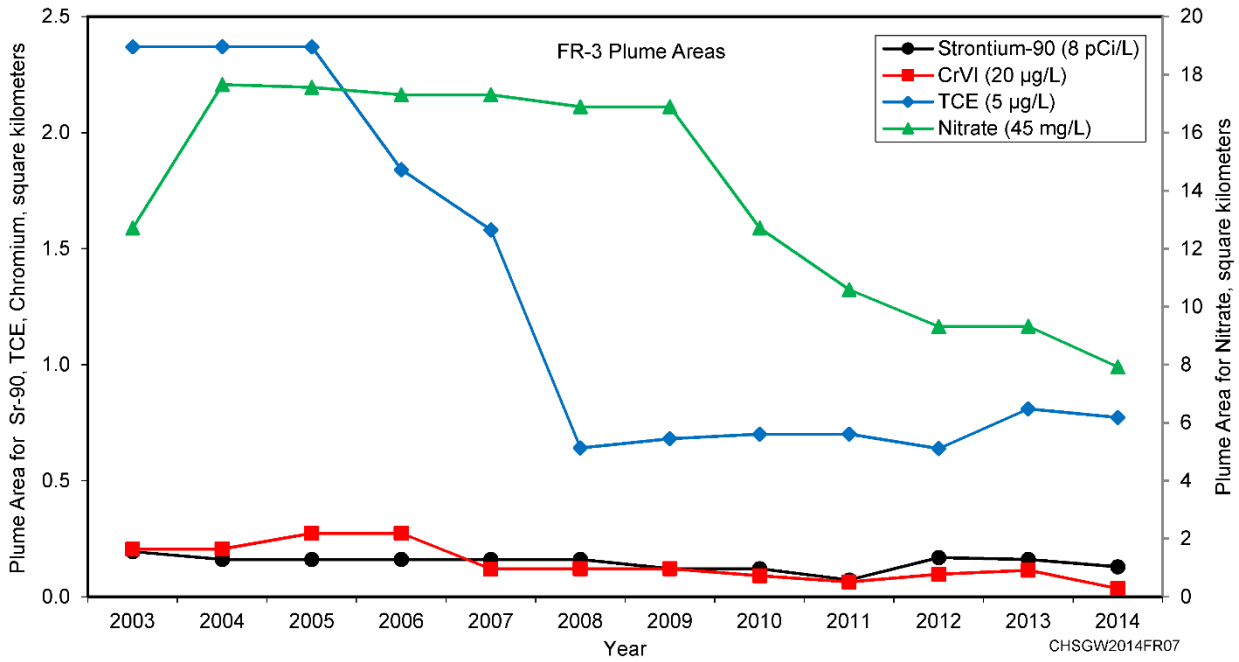


Figure 3-3. 100-FR-3 Plume Areas

Figure 3-4 includes water table contours based on data collected in March 2014. In the northern portion of the 100-F Area, groundwater flow is to the northeast, toward the river. In the southern 100-F Area, groundwater flows primarily to the east and then curves to the southeast. Southeast of the 100-F Area, the water table slopes very gently at elevations ranging from 110 to 112 m (361 to 368 ft). This is approximately the same elevation as the Columbia River at this location. Consequently, the average direction of groundwater flow is approximately parallel to the river. The shoreline topography in this area is low and flat, and the shore is submerged during the high river stage (spring and early summer). Normal seasonal variability in the water table in the 100-F Area is more than 3 m (10 ft) in wells near the river and decreases farther inland.

During seasonal periods of high river stage, the hydraulic gradient reverses near the river and surface water can flow into the aquifer. Figure 3-5 shows the water table in June 2014 when river stage had been high for several weeks. The measurements were made during a brief "dip" in river stage in mid-June, creating an extra bend in the water-table contours.

The vadose zone and the unconfined aquifer comprise Hanford formation sand and gravel (Figure 3-6). Ringold Formation unit E is largely absent in this region, but a remnant of Ringold unit E is interpreted to exist in the southwestern 100-F Area and smaller remnants in central and eastern 100-F Area. In two locations, Ringold unit E extends above the water table, comprising the entire aquifer thickness. Geologic maps were updated in 2014 for input to the 100 Areas groundwater model based on revised interpretations of geologic and geophysical logs. The updated maps will be presented in an upcoming SAP later in 2015.

The bottom of the aquifer is the RUM. The thickness of the aquifer ranges from 1 m (3 ft) in the southern 100-F Area to 8 m (26 ft) in the eastern 100-F Area. Most of the monitoring wells are screened across all, or nearly all, of the aquifer. Two wells are screened in water-bearing units of the RUM. No contamination has been detected in those wells.

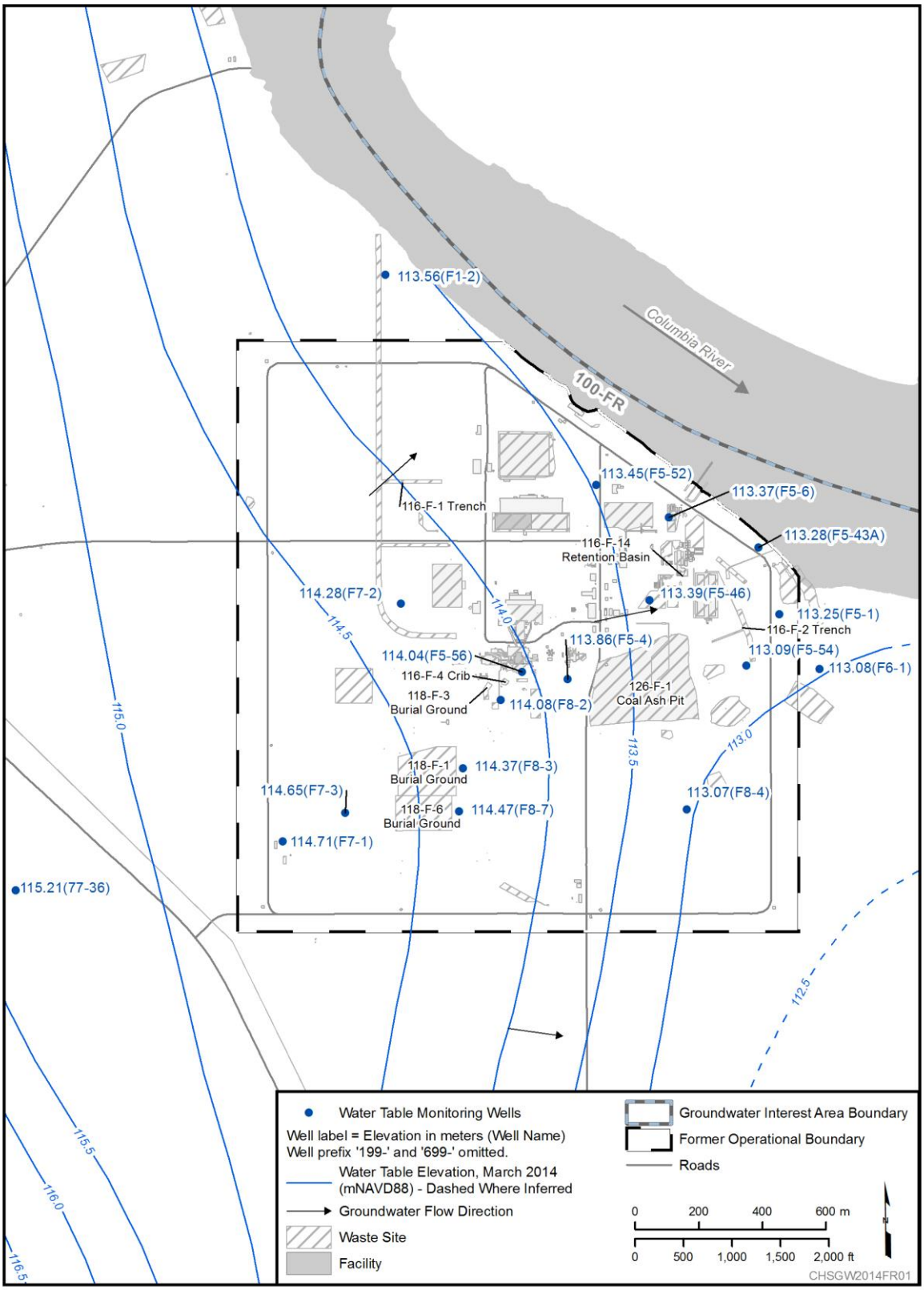


Figure 3-4. 100-FR Water Table, March 2014

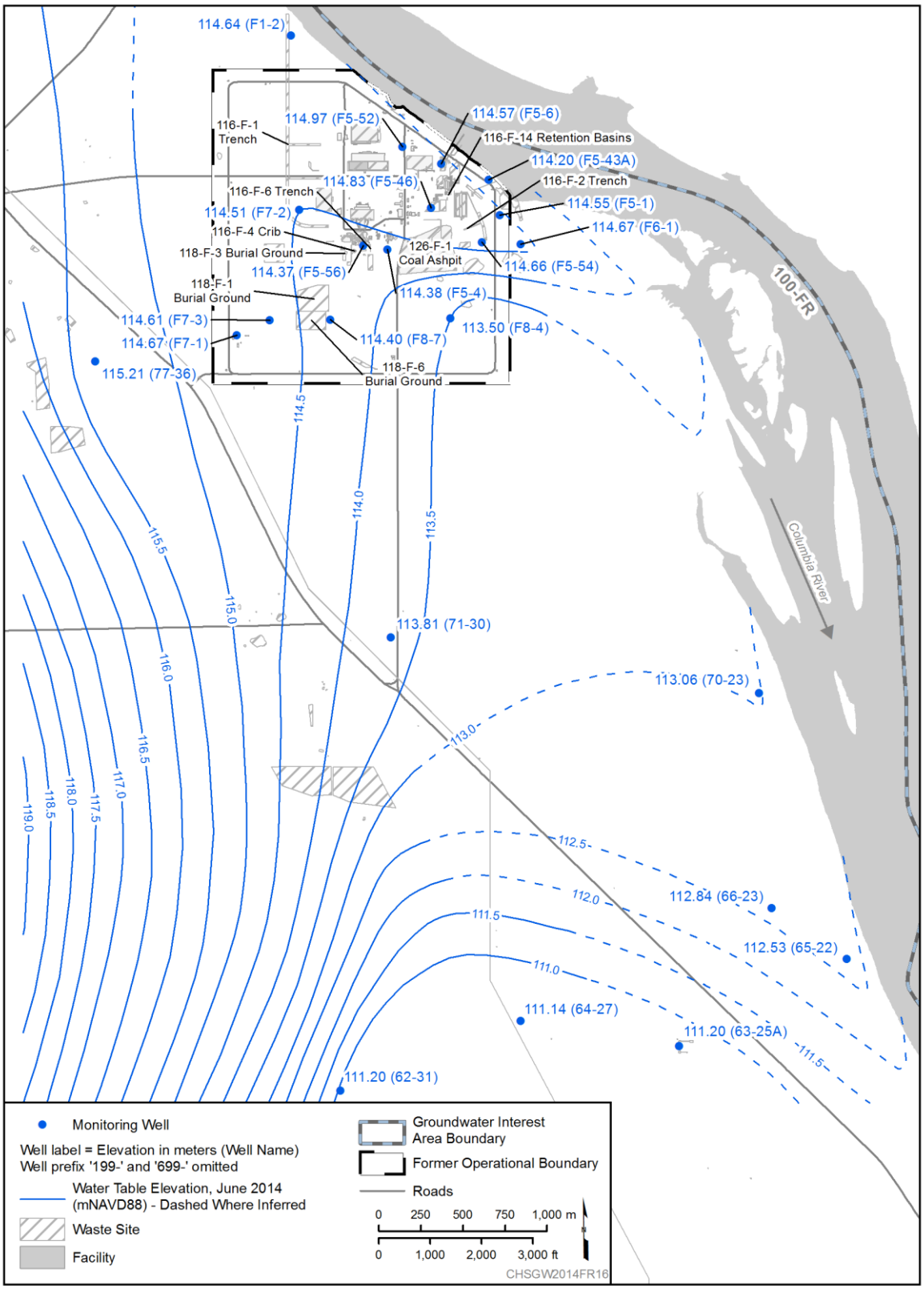


Figure 3-5. 100-FR Water Table, June 2014

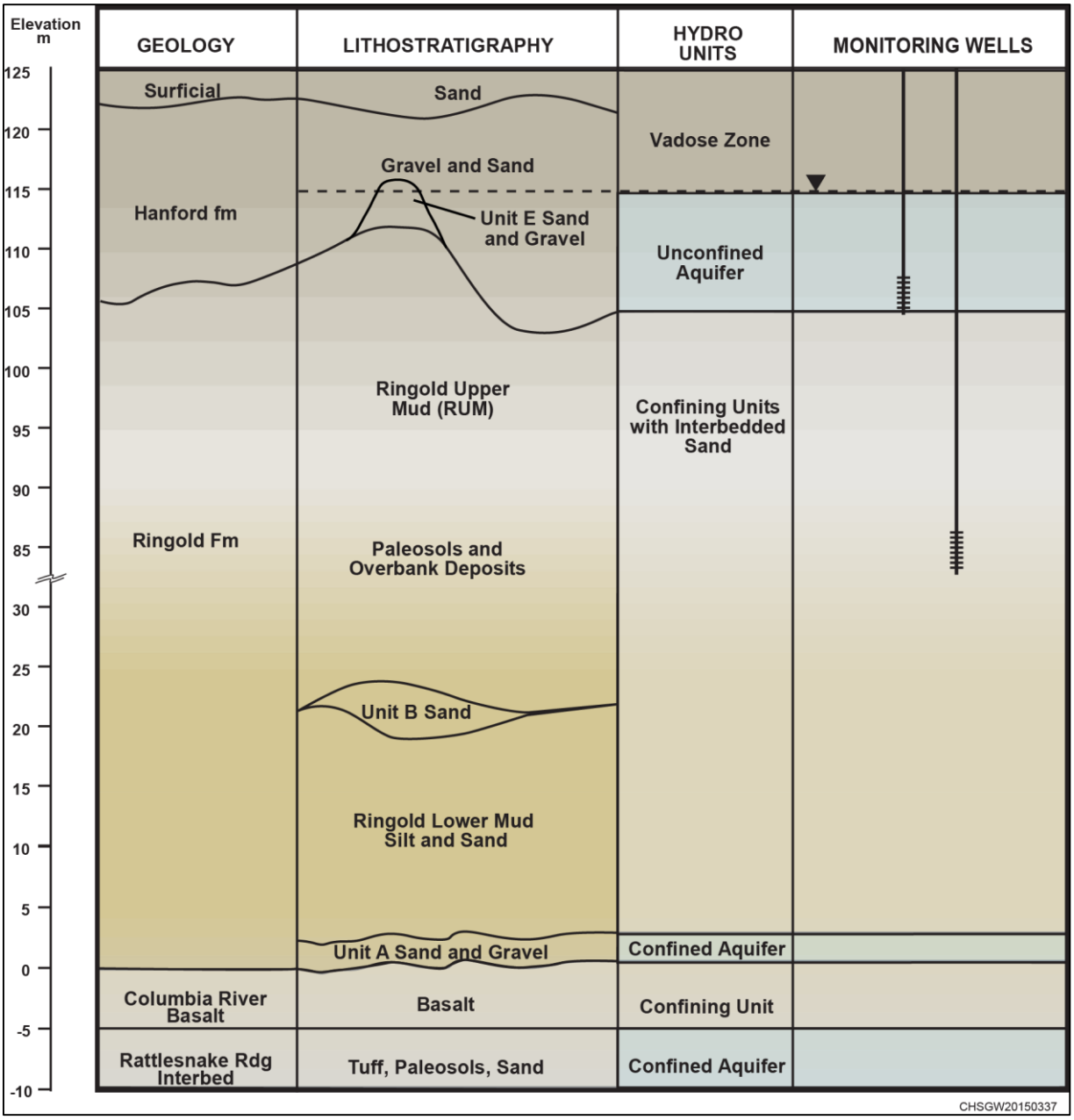


Figure 3-6. 100-FR Geology

3.2 CERCLA Activities

In 2014, CERCLA activities included routine groundwater monitoring, publication of a final RI/FS report and Proposed Plan, and a ROD.

3.2.1 Groundwater Monitoring

Routine groundwater sampling requirements were revised in 2014 under the groundwater SAP (DOE/RL-2003-49, Rev. 2). The comprehensive annual sampling event occurred in October; a few wells were also sampled in April. Table A-9 of Appendix A lists wells and constituents monitored in 2014. A subset of aquifer tubes was also scheduled for sampling in October 2014, but sampling was delayed until December due to resource limitations (Appendix C).

3.2.2 Remedial Investigation/Feasibility Study

In 2014, DOE released a final RI/FS report (DOE/RL-2010-98) and a Proposed Plan (DOE/RL-2012-41). In September 2014, EPA and DOE signed a ROD that includes MNA and ICs as the remedy for the 100-FR-3 Groundwater OU (EPA et al., 2014). MNA relies on natural processes within the aquifer to reduce the toxicity, mobility, volume, concentration, and/or bioavailability of the contaminants. Groundwater sampling and analysis, data evaluation, and reporting are an important component of this alternative to confirm that natural attenuation is occurring. ICs to protect human health and the environment will be maintained until cleanup levels are achieved.

To implement the remedial actions, DOE is preparing a remedial design/remedial action work plan for soil and groundwater. A groundwater addendum will include a SAP. These documents are planned for publication in 2015.

3.3 Nitrate

Past sources of nitrate contamination included the experimental animal farm (e.g., 116-F-9 Animal Leach Trench and 118-F-6 Burial Ground) and various septic tanks and leach fields located throughout the 100-F Area. These sites have been remediated. Pre-Hanford Site agriculture is another potential source of nitrate contamination.

A large nitrate plume with concentrations above 45 mg/L extends from the 100-F Area approximately 5 km (3.1 mi) to the south (Figure 3-7). The highest concentrations (greater than 120 mg/L) are in the central 100-F Area. Wells near the Columbia River (199-F5-43A, 199-F5-44, 199-F5-1, and 199-F6-1) have low nitrate concentrations. The water in these wells has low specific conductance (160 to 250 µS/cm), indicating the influence of inflowing river water even during periods of low river stage. Thus, the highest nitrate concentrations do not flow directly into the Columbia River adjacent to the 100-F Area.

The fact that the nitrate plume migrated southward is explained by the location of some of the nitrate sources in the southern 100-F Area, where groundwater flow is toward the south and south-southeast. Because there are relatively few monitoring wells to define the western portion of the plume, the western extent of the nitrate contamination above 45 mg/L is uncertain. Under the groundwater remediation alternative, MNA, additional monitoring wells will be installed to monitor the performance of the remedy.

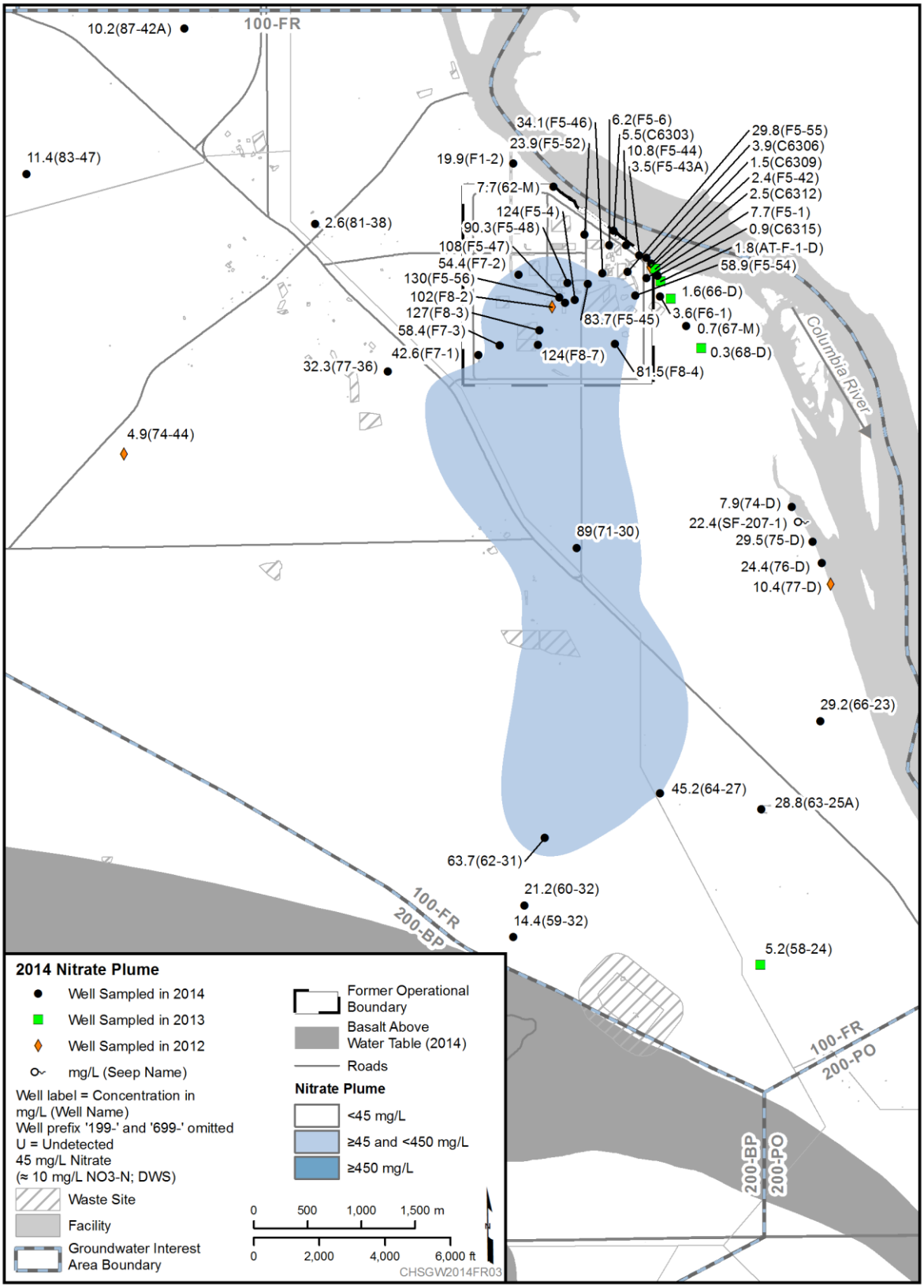


Figure 3-7. 100-FR Nitrate Plume, 2014

Between 2002 and 2014, nitrate concentrations declined in 17 of 30 wells, were stable in 7 wells, and increased in 6 wells. The median concentration decreased from 69 mg/L in 2002 to 45 mg/L in 2014. Concentrations in several wells in the high-concentration heart of the plume increased between 2002 and present (Figure 3-8), but 2014 data suggest the trend may be reversing.

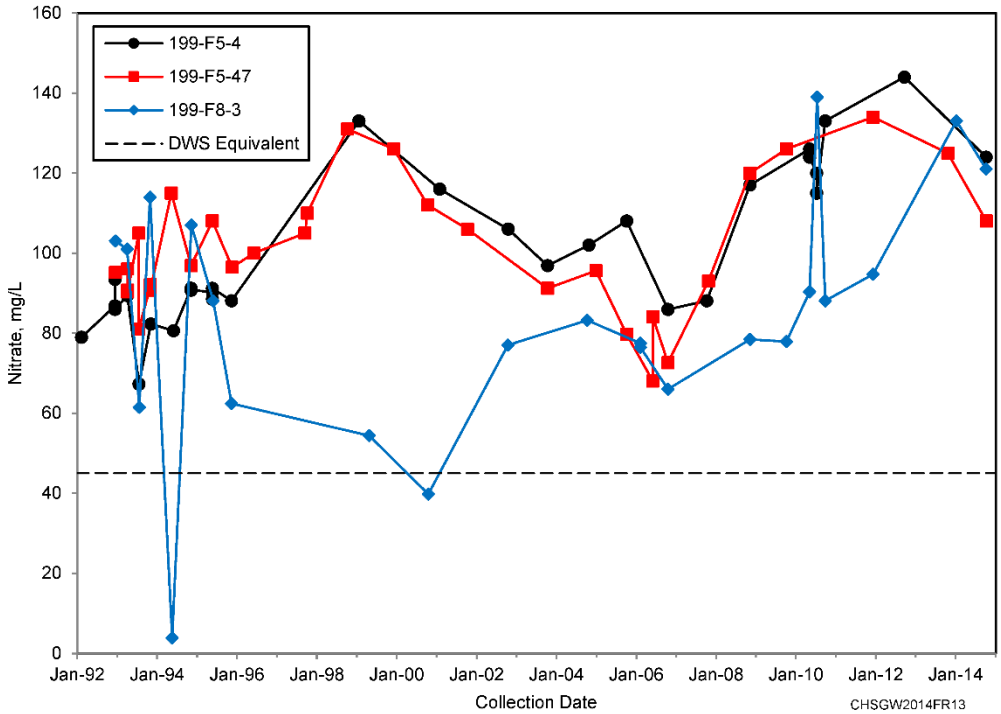


Figure 3-8. 100-FR Nitrate Data for Wells 199-F5-4, 199-F5-47, and 199-F8-3 in Central 100-F Area

Nitrate concentrations continued to decline in wells in the southwestern 100-F Area, dropping below the DWS for the first time in 199-F7-1 (Figure 3-9). Concentrations also are declining or stable in wells in the southern part of the plume (Figure 3-10).

The highest nitrate concentrations in aquifer tubes have historically been detected in 75-D (approximately 2 km [1.2 mi] downstream), exceeding 45 mg/L in 1999 and 2004. Concentrations have declined in this aquifer tube in recent years (25.7 mg/L in December 2014).

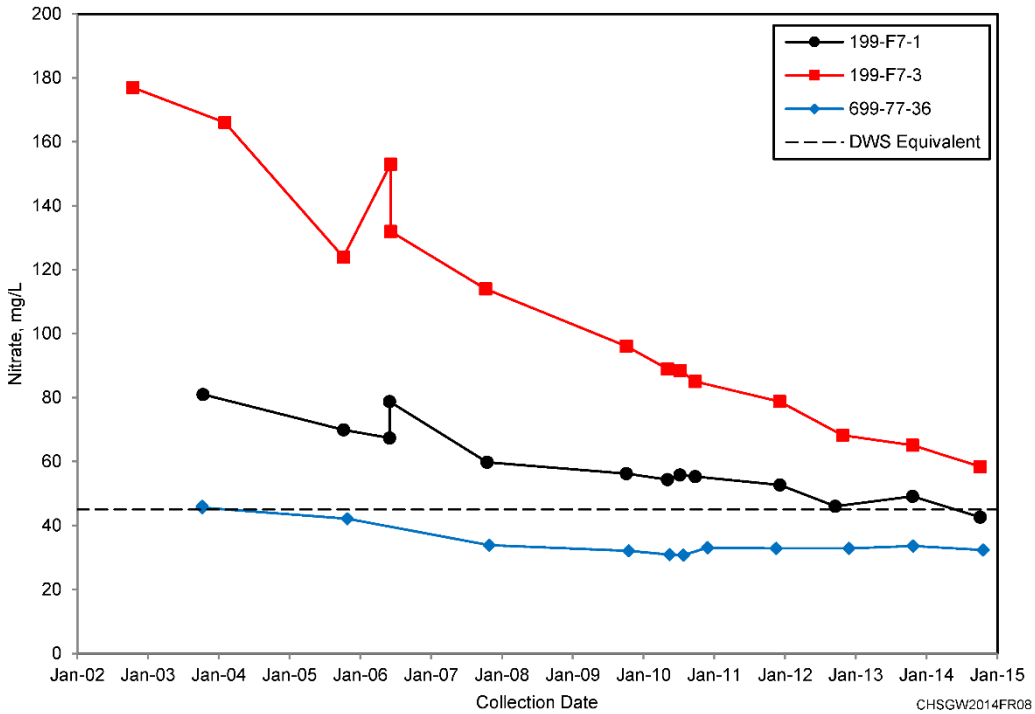


Figure 3-9. 100-FR Nitrate Data for Wells 199-F7-1, 199-F7-3, and 699-77-36 in Southwestern 100-F Area

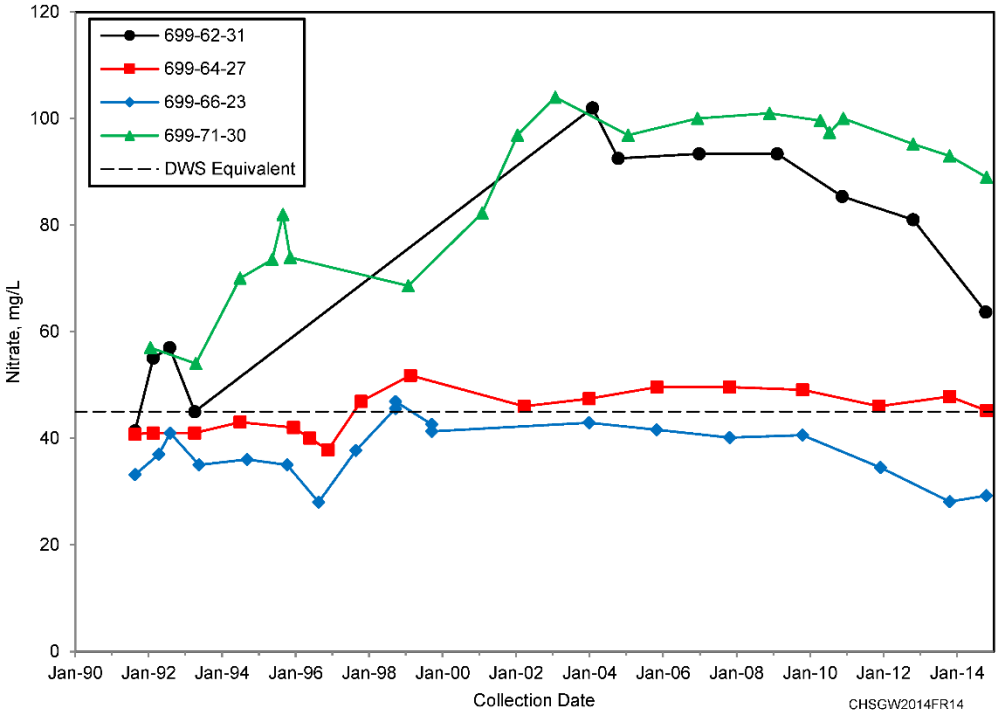


Figure 3-10. 100-FR Nitrate Data for Wells in South Part of Plume

3.4 Trichloroethene

TCE concentrations exceed the 4 µg/L cleanup level specified in the ROD in three wells in the southwestern 100-F Area and sporadically in wells in the central 100-F Area (Figure 3-11). Process knowledge of the former 600-127 waste site, located just west of the 100-F Area, suggests that it may have contributed to the TCE plume. This site was recently remediated. The lack of wells to the south creates uncertainty in the interpretation, and the plume may extend farther south than can be interpreted based on available data. Well 699-71-30, approximately 2 km (1.2 mi) to the south, detected traces of TCE in 2010 and 2014 (maximum 1.7 µg/L). Under the groundwater remediation alternative of MNA, an additional monitoring well will be installed south of the TCE plume.

TCE concentrations have declined since 1992 in 699-77-36 and 199-F7-1 in the southwestern 100-F Area (Figure 3-12). The trend in 199-F7-3 shows the arrival of the plume in the late 1990s and a declining trend since 2002. The monitoring wells in this location are screened across the entire aquifer thickness, which is less than 3 m (10 ft). Wells in other portions of the 100-F Area also detect TCE at concentrations that fluctuate around the cleanup level.

Recently updated interpretations of geologic logs indicate that the aquifer in the southwestern 100-F Area is within a remnant of Ringold unit E rather than in the Hanford formation, as is most of the 100-F aquifer. The presence of less transmissive sediments may explain the persistence of TCE in this region (Figure 3-11). A smaller remnant of Ringold unit E is present in the central 100-F Area where other traces of TCE are found.

Well 699-77-54, located approximately 6 km (3.7 mi) west of the 100-F Area, consistently has TCE concentrations above 5 µg/L, with a 2014 result of 11.8 µg/L. The well, which is located in the western part of the 100-FR groundwater interest area near the 100-KR-4 OU, also has elevated concentrations of chromium (24 µg/L in 2014).

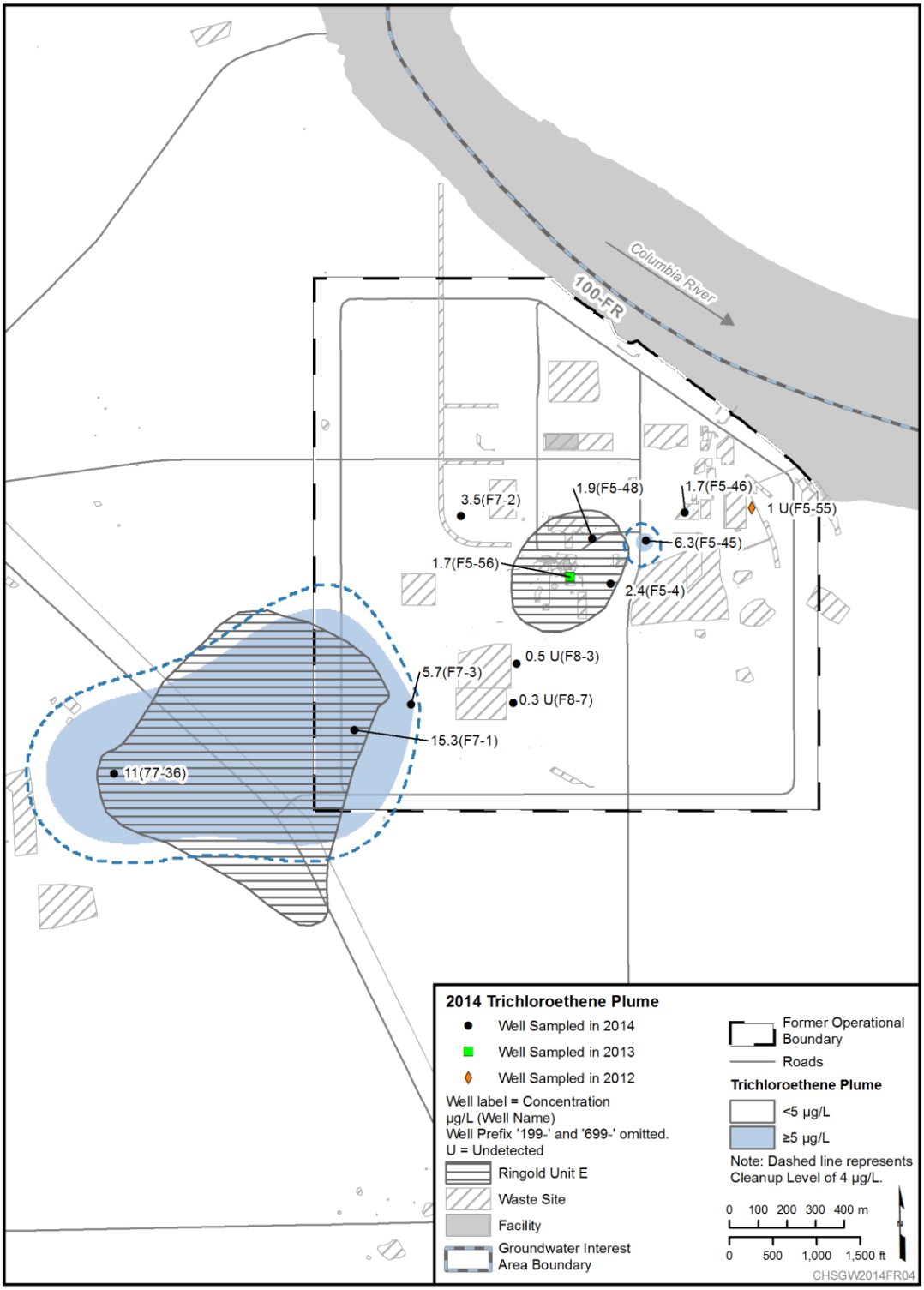


Figure 3-11. 100-FR TCE Plume and Extent of Ringold Unit E Above the Water Table, 2014

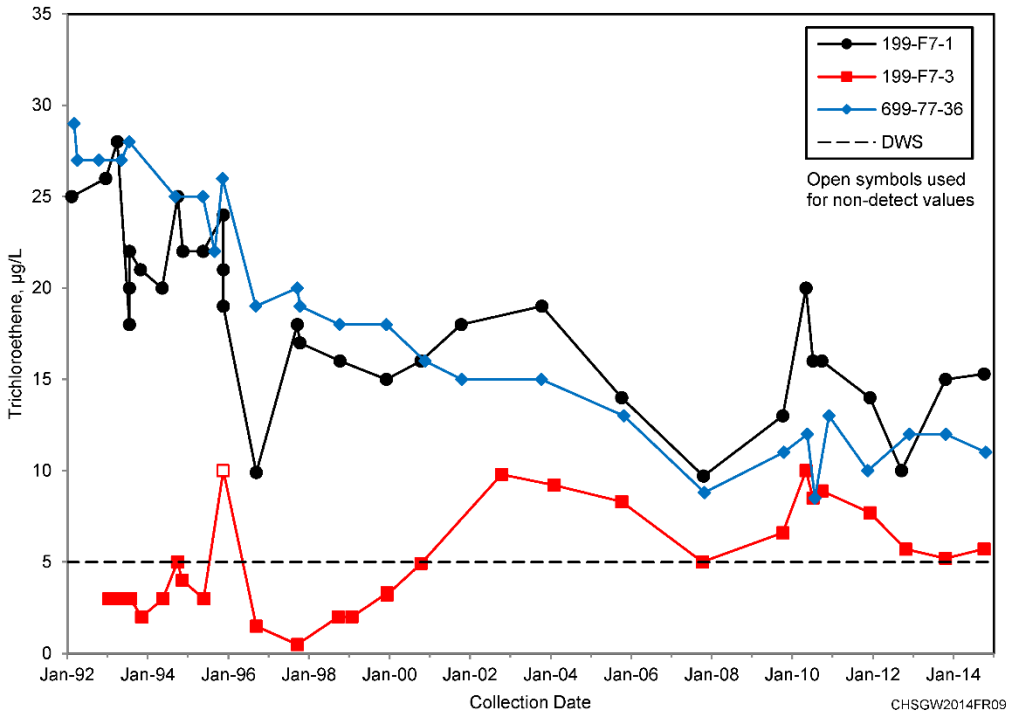


Figure 3-12. 100-FR TCE Data for Wells 199-F7-1, 199-F7-3, and 699-77-36

3.5 Hexavalent Chromium

Former sources of hexavalent chromium in 100-FR included facilities near the reactor building, trenches and retention basins near the Columbia River, and pipelines from the reactor building to these near-river facilities, primarily in the northern and eastern 100-F Area. The waste sites have been remediated, and concentrations in groundwater are expected to continue to decline with time.

Hexavalent chromium in 100-FR is present in a relatively small, low-concentration plume with all concentrations below the 48 µg/L cleanup level (Figure 3-13). Historically, the highest concentrations were in 199-F5-46, where levels have declined from greater than 300 µg/L in the early 1990s to 29 µg/L in 2014 (Figure 3-14). The plume extends toward the river where the concentration in 199-F5-44 continued to exceed the 10 µg/L aquatic standard in 2014. The concentration in 199-F5-6 was 8 µg/L, dropping below the standard for the first time since 1995. Concentrations in aquifer tubes in this region also were below the aquatic standard except C6303, which had a concentration of 10.3 µg/L in December 2014. Filtered total chromium was 6.6 µg/L.

Two wells in the central 100-F Area, 199-F5-47 and 199-F5-56, had increasing concentrations of chromium, 20 to 22 µg/L in 2014 (Figure 3-15). The trends may be related to waste site remediation in the area several years ago, and concentrations are expected to decline in the future. The wells are sampled annually.

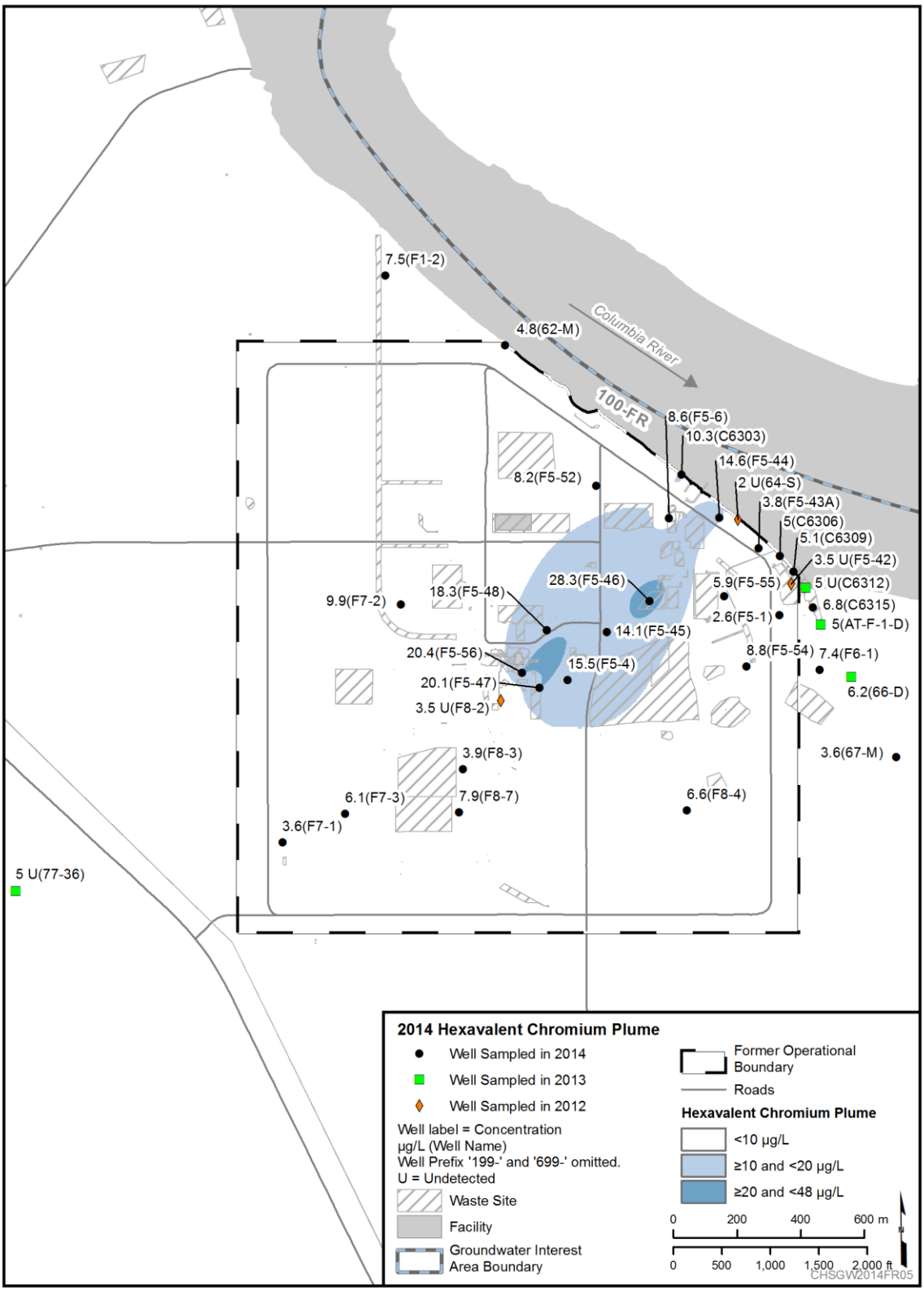


Figure 3-13. 100-FR Hexavalent Chromium Plume, 2014

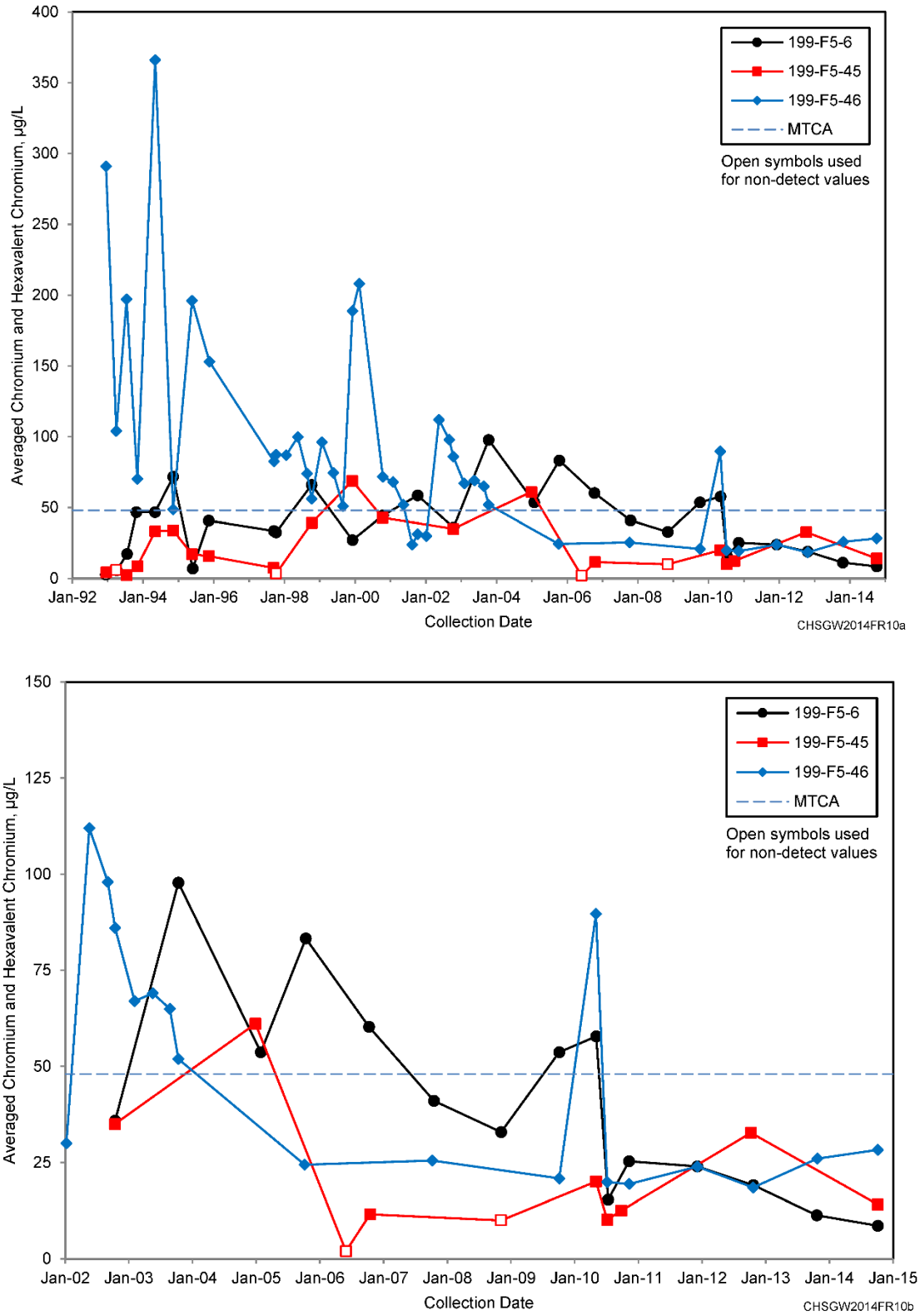


Figure 3-14. 100-FR Hexavalent Chromium Data for Wells 199-F5-6, 199-F5-45, and 199-F5-46 for 1992 to Present (top panel) and 2002 to Present (bottom panel)

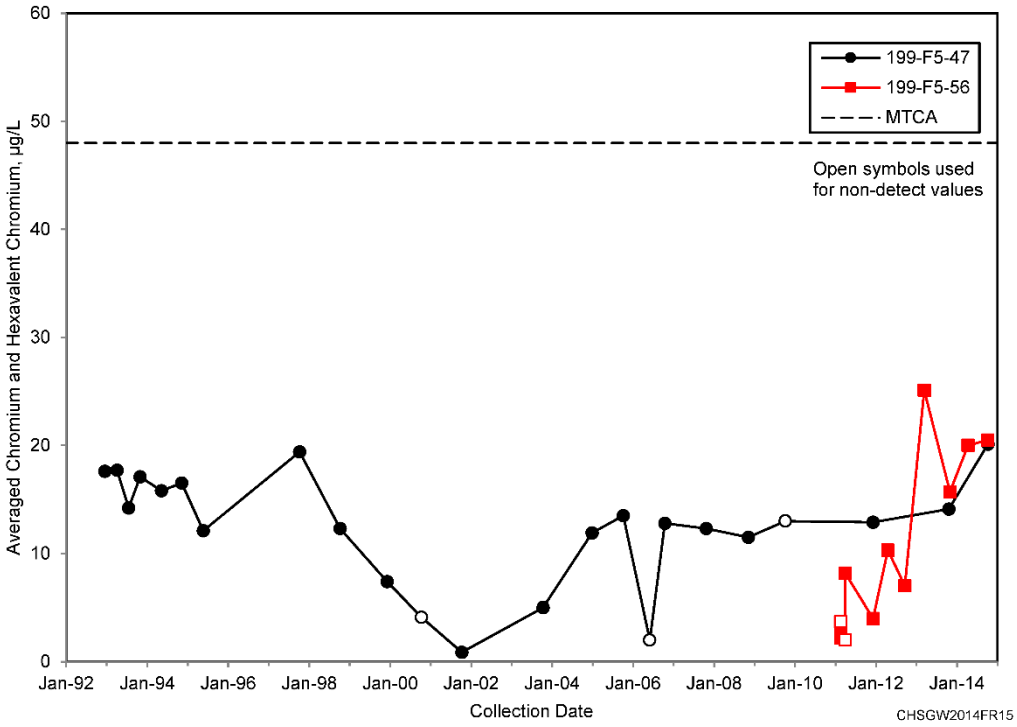


Figure 3-15. 100-FR Dissolved Chromium Concentrations for Wells 199-F5-47 and 199-F5-56 in Central 100-F Area

3.6 Strontium-90

Primary sources of strontium-90 included the 116-F-14 Retention Basins and 116-F-2 Trench in the eastern 100-F Area. Additional sources of strontium-90 were present near the reactor building and burial grounds.

In the eastern 100-F Area, two wells (199-F5-55 and 199-F5-1) continued to have strontium-90 concentrations above the 8 pCi/L DWS in 2014 (Figure 3-16). Well 199-F5-55 had the highest strontium-90 concentrations in 2014, with a maximum of 144 pCi/L (Figure 3-17). This borehole was installed in the former 116-F-14 Retention Basin to characterize the vadose zone and was completed as a monitoring well to obtain representative groundwater samples. Strontium-90 concentrations have declined since 2011 and are inversely related to water levels. This inverse correlation indicates that there is not a vadose zone source of strontium-90 in the vicinity of the well that is mobilized by a higher water table. The contamination is localized and the next nearest downgradient well (199-F5-1) has much lower concentrations.

Strontium-90 concentrations in Well 199-F5-56, near the F Reactor building, also exceeded the DWS with a maximum of 28 pCi/L in 2014, a decline from 2013. This borehole was drilled to characterize a waste site and completed as a well to obtain representative groundwater samples. It was the only well in the central 100-F Area with detectable strontium-90.

Strontium-90 concentrations in aquifer tubes have been below the DWS except in a single sample collected in 2012 from C6306 at 9.6 (±2.55) pCi/L. Concentrations were lower in 2013 (2.7 [±0.95] pCi/L) and 2014 (1.86 [±1.04] pCi/L). Previous studies indicate that strontium-90 concentrations in Columbia River pore water are below the DWS (DOE/RL-2010-98).

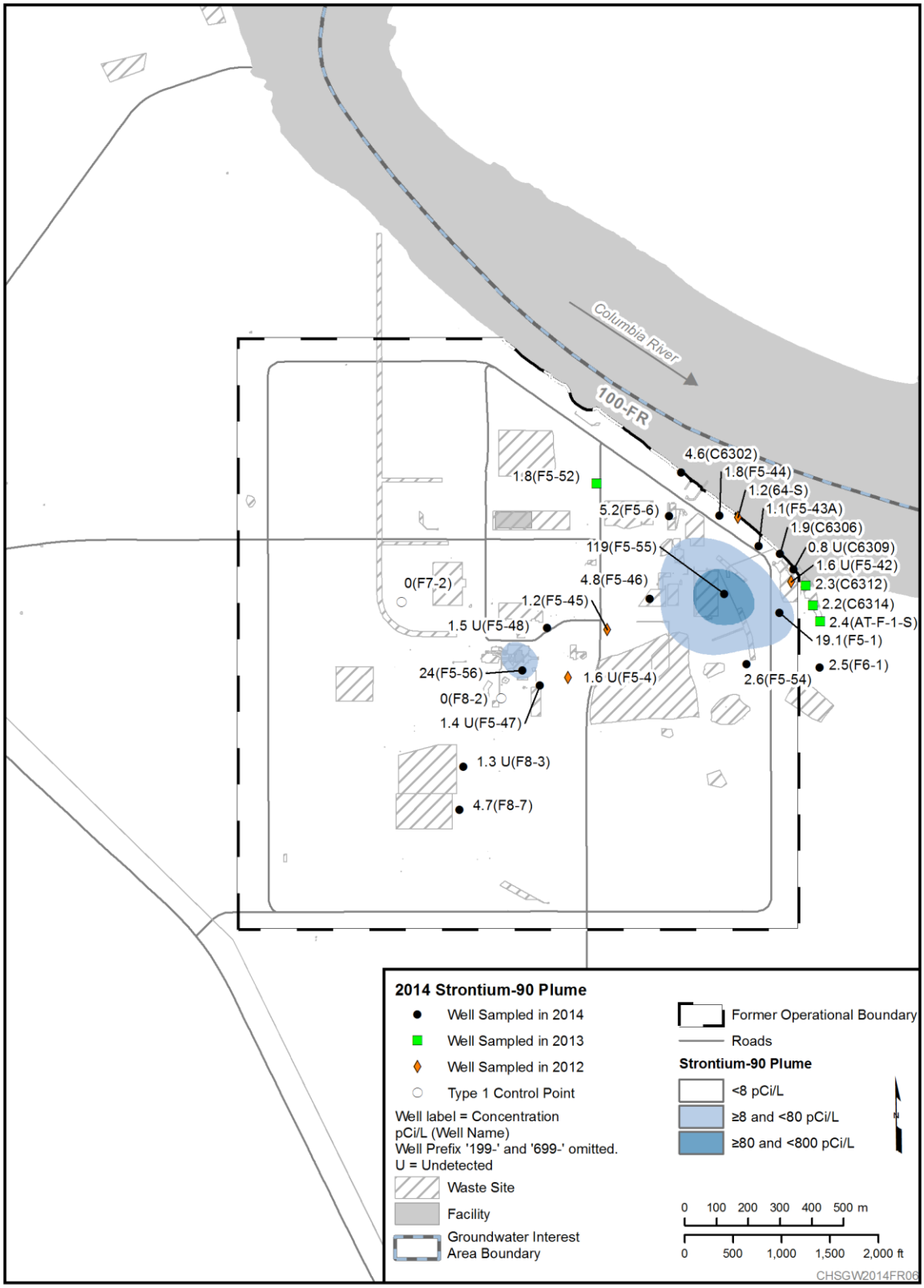


Figure 3-16. 100-FR Strontium-90 Plume, 2014

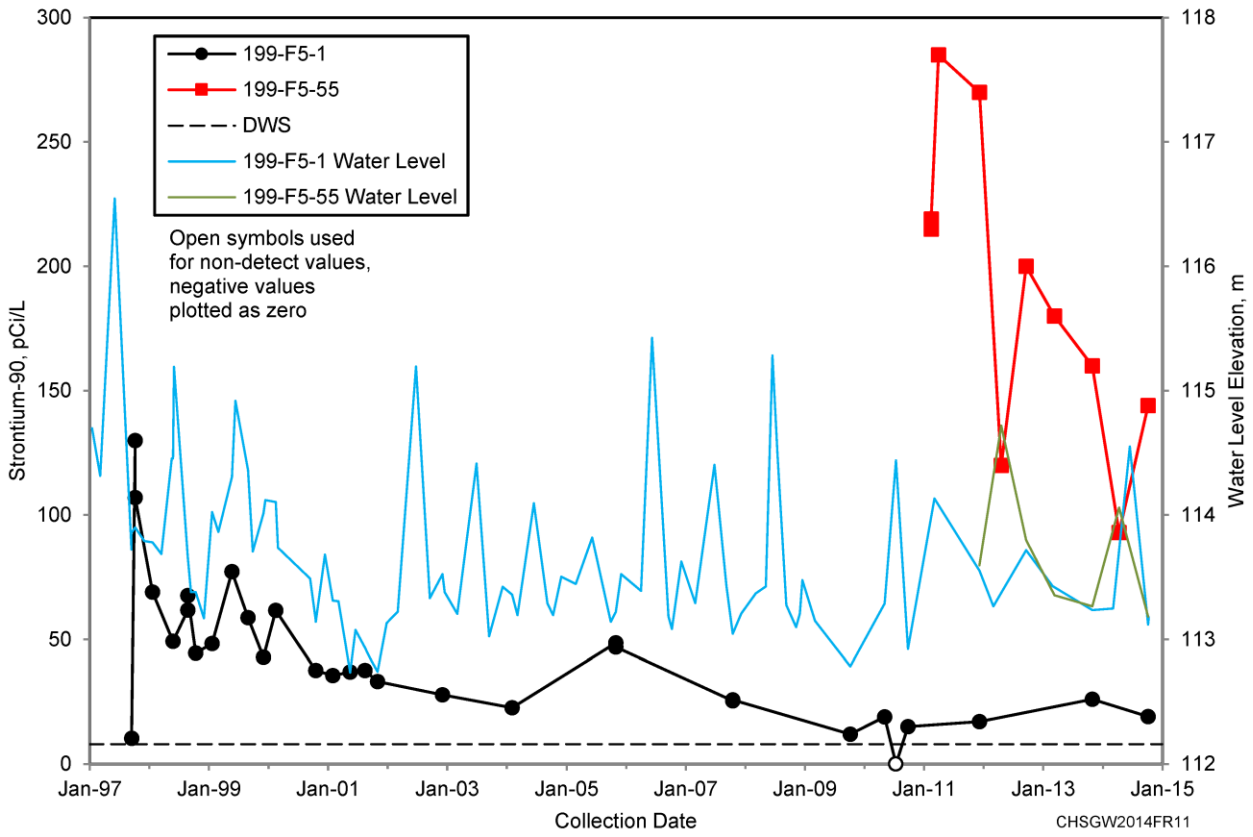


Figure 3-17. 100-FR Strontium-90 Data and Water Levels for Well 199-F5-1 and 199-F5-55

3.7 Uranium

Uranium is not a COC for 100-FR groundwater (DOE/RL-2010-98). However, it is monitored in one well under the routine groundwater SAP (DOE/RL-2003-49) because of one previous detection above the 30 µg/L DWS in 199-F5-56 (34.7 µg/L in 2011). The highest concentration in this well in 2014 was 18.1 µg/L.

4 100-HR

4.1 Overview

The 100-HR-3 Groundwater OU, in the northern Hanford Site, is within the 100-HR-D and 100-HR-H groundwater interest areas (Figure 1-2). Groundwater in this area was contaminated by waste releases associated with past operation of the D, DR, and H Reactors and associated support facilities. At the end of 2014, approximately 87 percent of the waste sites were classified as closed, interim closed, no action, not accepted, or rejected. That does not include the 100-D-100 waste site, which was excavated to the water table in 2013 and into the aquifer starting in December 2014. Hexavalent chromium was identified at 100-D-100 as a vadose zone source within the aquifer material, bound within a chromate-substituted calcite mineral precipitate (SGW-58416, *Persistent Source Investigation at 100-D Area*).

Table 4-1 lists key facts about 100-HR. Additional details about 100-HR-3 history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the 100-D/H RI/FS (DOE/RL-2010-95, Rev. 0). The location of monitoring, extraction and injection wells, and aquifer tubes are shown on Figures 4-1 and 4-2. Data from monitoring seeps and springs are shown on each of the plume figures presented, but were not used for plume development due to their transient nature. Plume mapping details, including descriptions of terms (e.g., Type 1 Control Point) in figure legends, are provided in Section 1.3.

Vadose zone thickness, which also represents the depth to groundwater, ranges from 0 to 27 m (89 ft), with an average thickness of 20 m (66 ft) in 100-D and an average thickness of 11.3 m (37.1 ft) in 100-H. Thickness of the unconfined aquifer ranges from less than 1 m (3.3 ft) in areas at 100-H to 12 m (39 ft) at 100-D, with the aquifer generally thinning from west to east. Average aquifer thickness varies from about 6 to 9 m (20 to 30 ft) beneath 100-D, and from 2 to 5 m (7 to 16 ft) beneath 100-H. The thickness of the unconfined aquifer mimics the topography of the RUM (DOE/RL-2008-42). The uneven surface of the silt and clay-rich RUM forms the base of the unconfined aquifer. Water-bearing units are found within the RUM, forming confined or semiconfined aquifers across 100-HR. It is unclear if the water-bearing units within the RUM are connected across the site, or are small isolated areas, since there are only a few wells completed in these water-bearing units.

Table 4-1. 100-HR at a Glance

Reactor operations: D: 1944–1967; DR: 1950–1964; H: 1949–1965				
2014 Groundwater Monitoring				
Contaminant	**Water Quality Standard**	**Maximum Concentration**	**Plume Area[a] (km^2)**	**Shoreline Impact (m)**
Hexavalent chromium	10 µg/L[b]	3,616 (199-D5-104)[c]	7.0[d]	0[d]
Nitrate	45 mg/L[e]	53.1 mg/L (199-D4-20)	0	0
Strontium-90	8 pCi/L[f]	36.4 pCi/L (199-D5-132)	0.02	25
Tritium [g]	20,000 pCi/L[f]	20,400 pCi/L (199-D4-20)	—	—
Remediation				
Waste sites (interim action): 87 percent complete[h] Groundwater (interim action for hexavalent chromium): • HR-3 P&T: 1997-2011, removed 406 kg • DR-5 P&T: 2004-2011, removed 338 kg • DX P&T: 2010-2014, removed 1,403 kg • HX P&T: 2011-2014, removed 93 kg • ISRM: 1997-2012 Final ROD anticipated in 2015/2016.				

a. Estimated area at a concentration greater than the listed water quality standard.

b. The applicable standard is the 10 µg/L surface water quality criterion. A 20 µg/L groundwater interim action cleanup target for inland groundwater was identified in RD/RA Work Plan (DOE/RL-96-84) for interim remedial action based on an assumed 1:1 dilution of groundwater entering the river. The interim remedial action objective remains to protect the Columbia River against releases that would cause exceedance of the 10 µg/L surface water quality criterion

c. Table lists maximum value from a sample collected during 2014 that is not flagged as suspect data.

d. This area is for the plume within the 100-HR-3 interest area during low river stage conditions.

e. 45 mg/L as NO3 is equivalent to the drinking water standard of 10 mg/L as N

f. Drinking water standard

g. Tritium was detected in a single well above the DWS of 20,000 pCi/L. No plume area was calculated.

h. Sites with closed, interim closed, no action, not accepted, or rejected status as of 12/31/2014.

ISRM = In Situ Redox Manipulation

P&T = pump and treat

ROD = Record of Decision

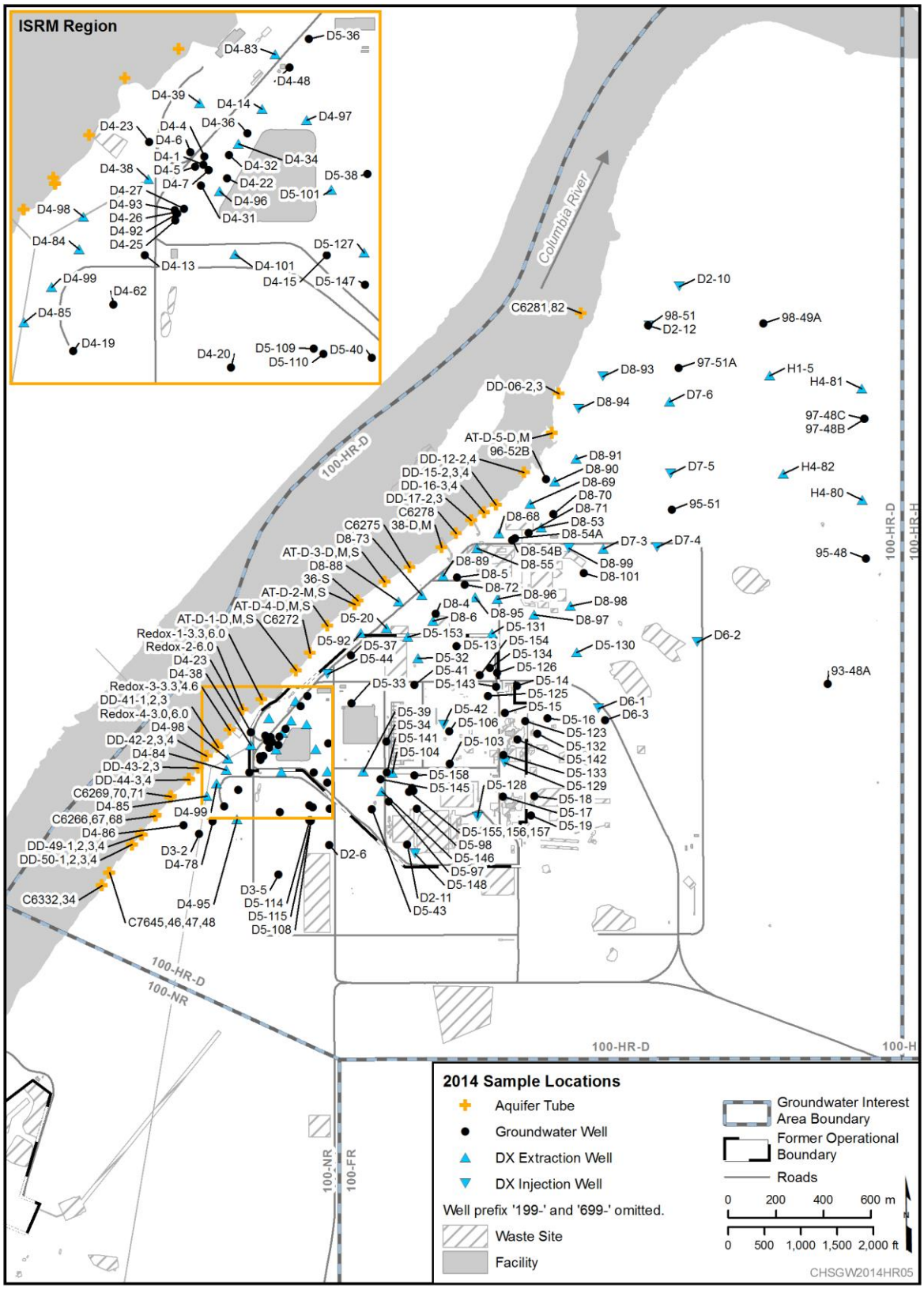


Figure 4-1. 100-HR-D Wells and Aquifer Tubes

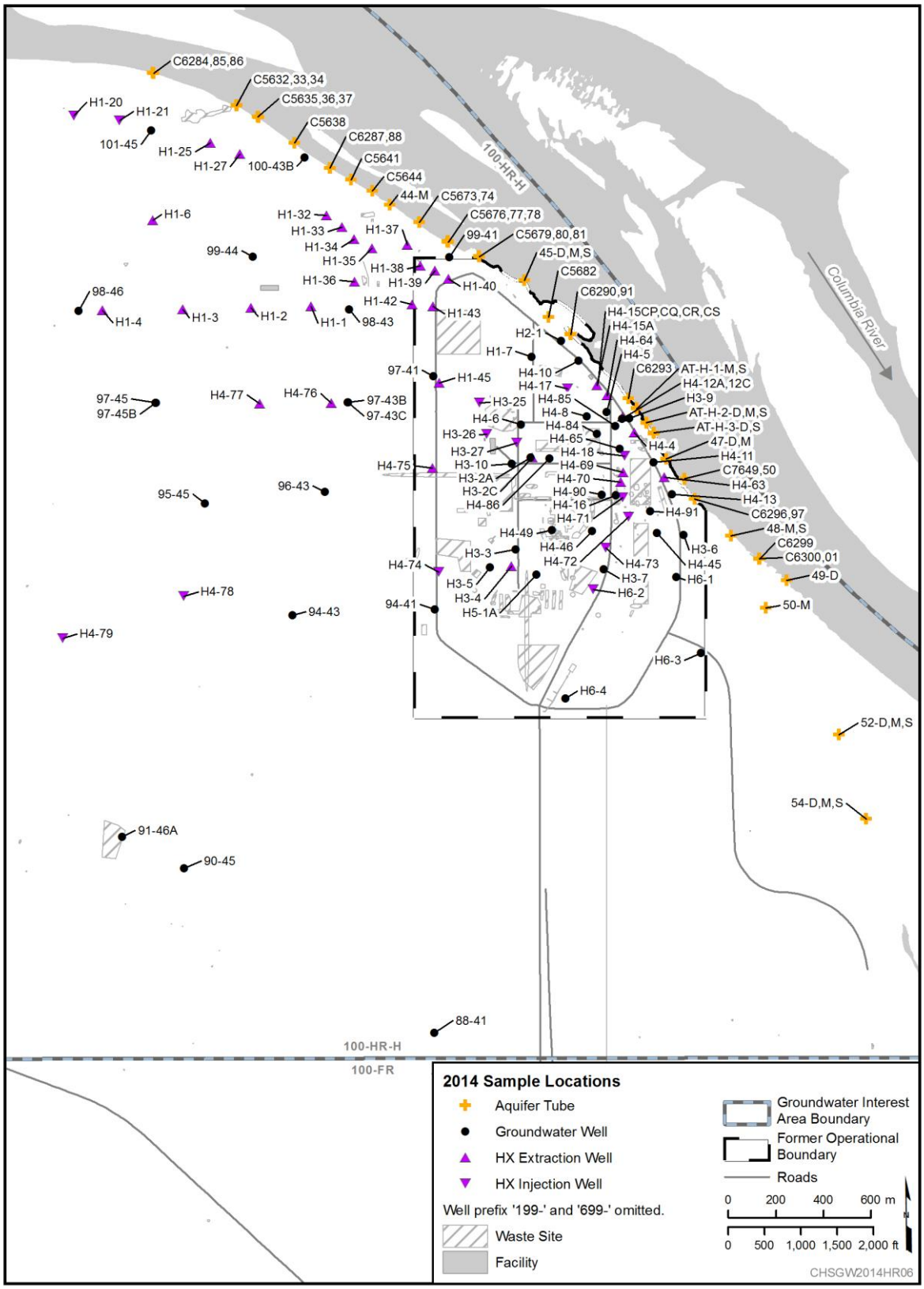


Figure 4-2. 100-HR-H Wells and Aquifer Tubes

The unconfined aquifer is primarily present in the Ringold Formation unit E sands and gravels in 100-D, and in the Hanford formation gravels in 100-H (Figure 4-3). Across the Horn, the geology is transitional, changing from predominantly Ringold unit E (closer to 100-D) to Hanford formation farther east. Pockets of Ringold unit E are found as remnants in various locations. In the areas across the Horn where Ringold unit E is absent, channels formed, resulting in preferential groundwater flow pathways. This complicated geology is discussed in detail in Chapter 3 of DOE/RL-2010-95.

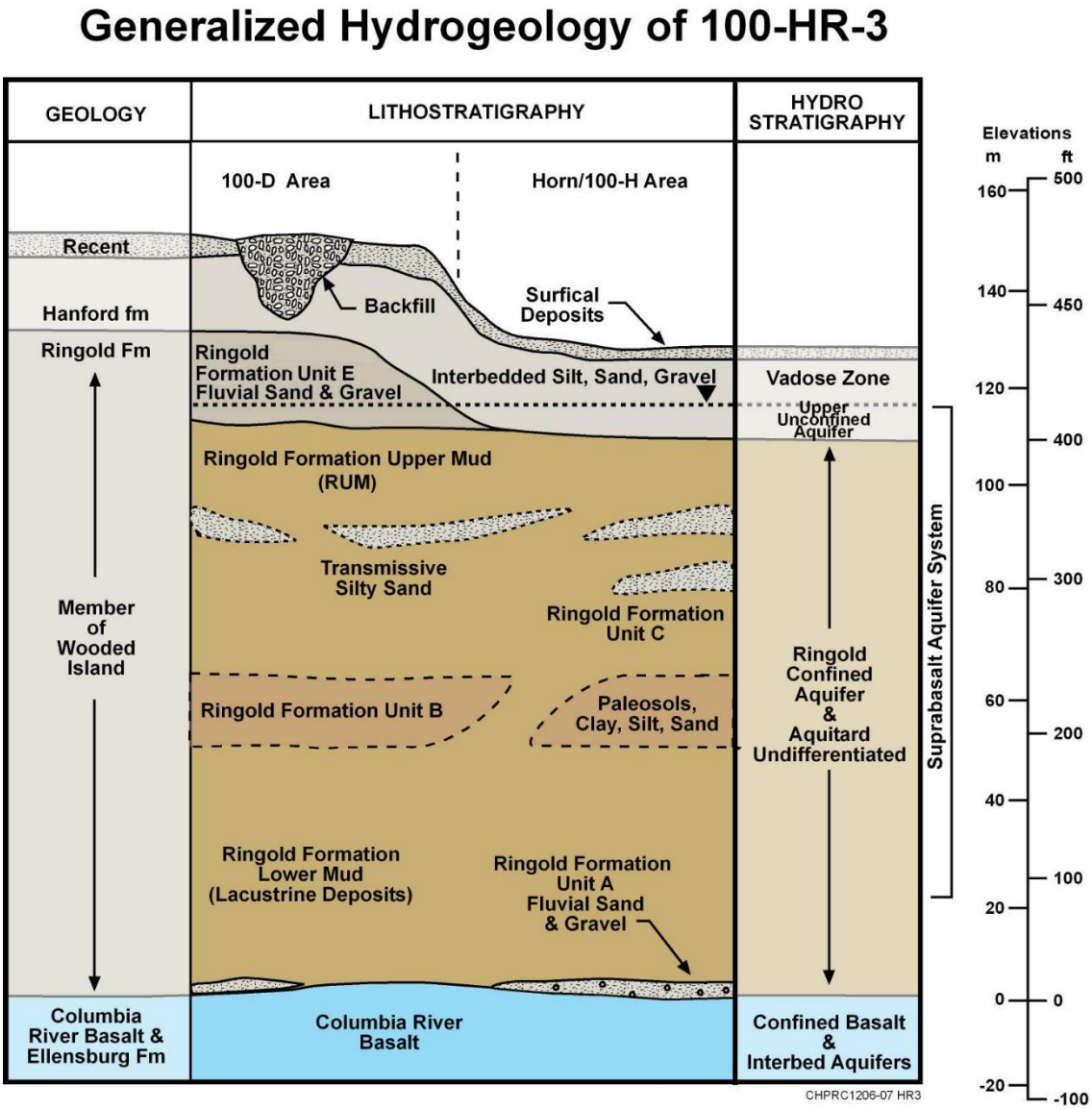


Figure 4-3. 100-HR Geology

Groundwater in 100-HR flows generally to the east-northeast direction, from 100-D across the Horn, toward 100-H. Flow in 100-H is to the east and northeast, generally towards the river. In the southern and central portions of 100-D, groundwater flows to the northwest, towards the Columbia River.

The hydraulic gradients are generally flatter during high river stage (ranging from approximately 0.0014 to 00023) when compared to low river conditions (ranging from approximately 0.0017 to 0.0031). Operation of P&T systems has created changes in groundwater flow direction and velocity throughout 100-HR-3. These changes are expressed as depressions and mounds in the water table, often very

localized, affecting the local flow direction and gradient. The March 2014 water table (Figures 4-4 and 4-5) shows the overall flow for the area. However, the flow directions and gradients experienced during low and high river stage have a greater effect on contaminant transport in the River Corridor than is represented by the March water table map. The water table contours for high and low river stage are included on the plume maps for hexavalent chromium.

Daily and seasonal fluctuations in the river stage (Figure 4-6) affect groundwater flow in 100-HR. As would be expected, longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. The high and low river stages, which typically last a period of a few months, affect the groundwater flow near the river and extend some distance inland depending mostly on geology. The 2014 water level was more typical than the last several years, which had high flows in 2011 and 2012, and fluctuating flows during high river stage in 2013. The high flow periods in 2011 and 2012 resulted in a pronounced groundwater flow reversal during the high river stage. In 2013, this effect was muted and groundwater flow was towards the river during most of the year. As a result of the more typical river stage in 2014, some groundwater flow reversal was exhibited during high river stage, although not as extreme as in 2011 and 2012.

COPCs in the 100-HR unconfined aquifer were identified in the interim ROD (Tables 1 and 2 of EPA/ROD/R10-96/134) and include hexavalent chromium, total chromium, nitrate, technetium-99, strontium-90, tritium, and several others. Within the unconfined aquifer, vertical stratification of hexavalent chromium has been identified in areas where highly concentrated sodium dichromate was handled. However, the stratification is not well defined or consistent within the aquifer. Measurements and observations continue to indicate the presence of hexavalent chromium in the first water-bearing sand unit within the RUM.

The 183-H Solar Evaporation Basin site is monitored under the Hanford Facility RCRA Permit and the *183-H Solar Evaporation Basins Postclosure Plan* (DOE/RL-97-48). Monitoring of the 183-H waste site includes total chromium, hexavalent chromium, nitrate, uranium, technetium-99, and fluoride. Of the contaminants monitored under the RCRA Permit, only hexavalent chromium, nitrate and uranium have periodic exceedances of the DWS and/or Permit levels (discussed later in this chapter).

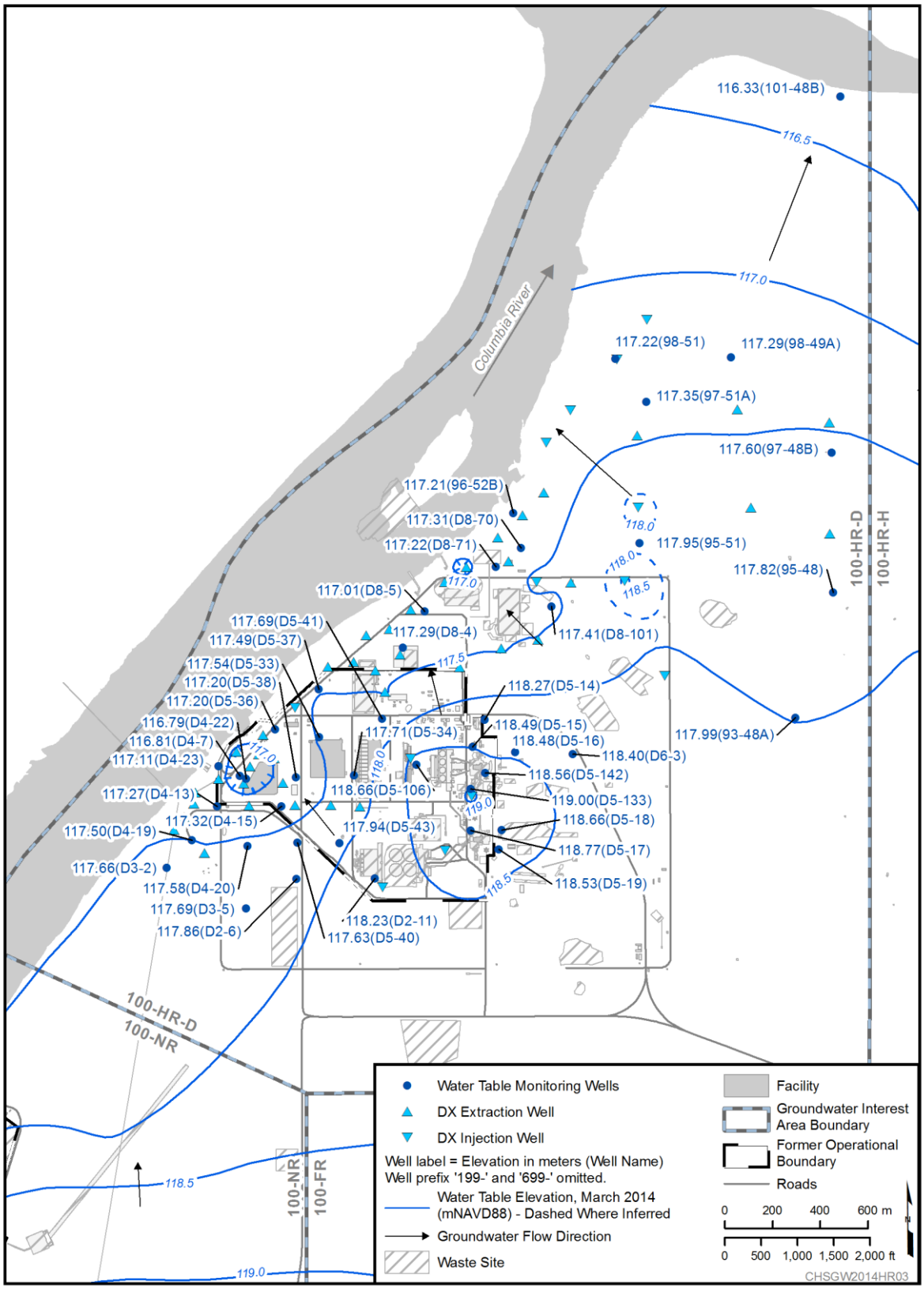


Figure 4-4. 100-HR-D Overview and March 2014 Water Table

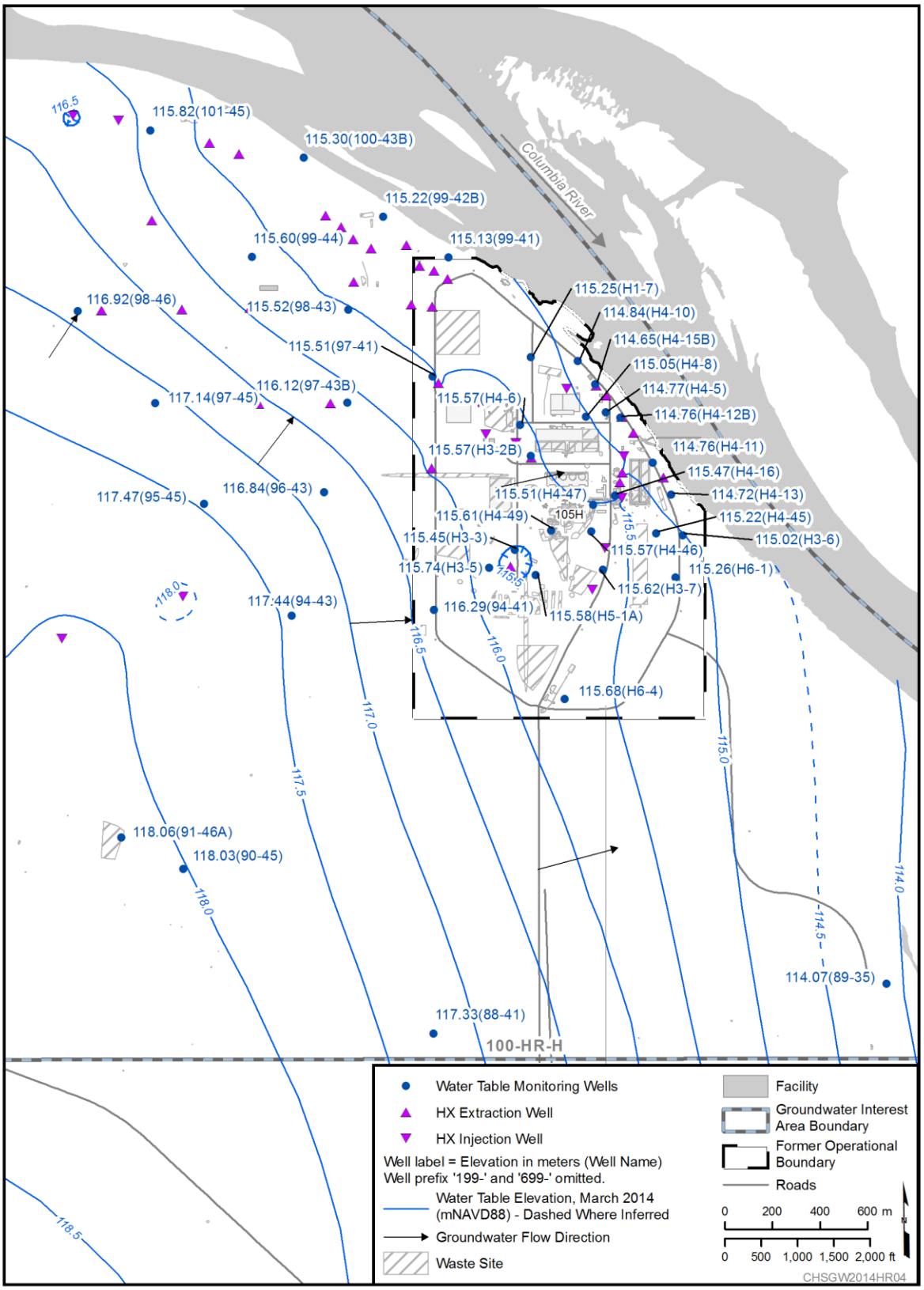


Figure 4-5. 100-HR-H Overview and 2014 Water Table

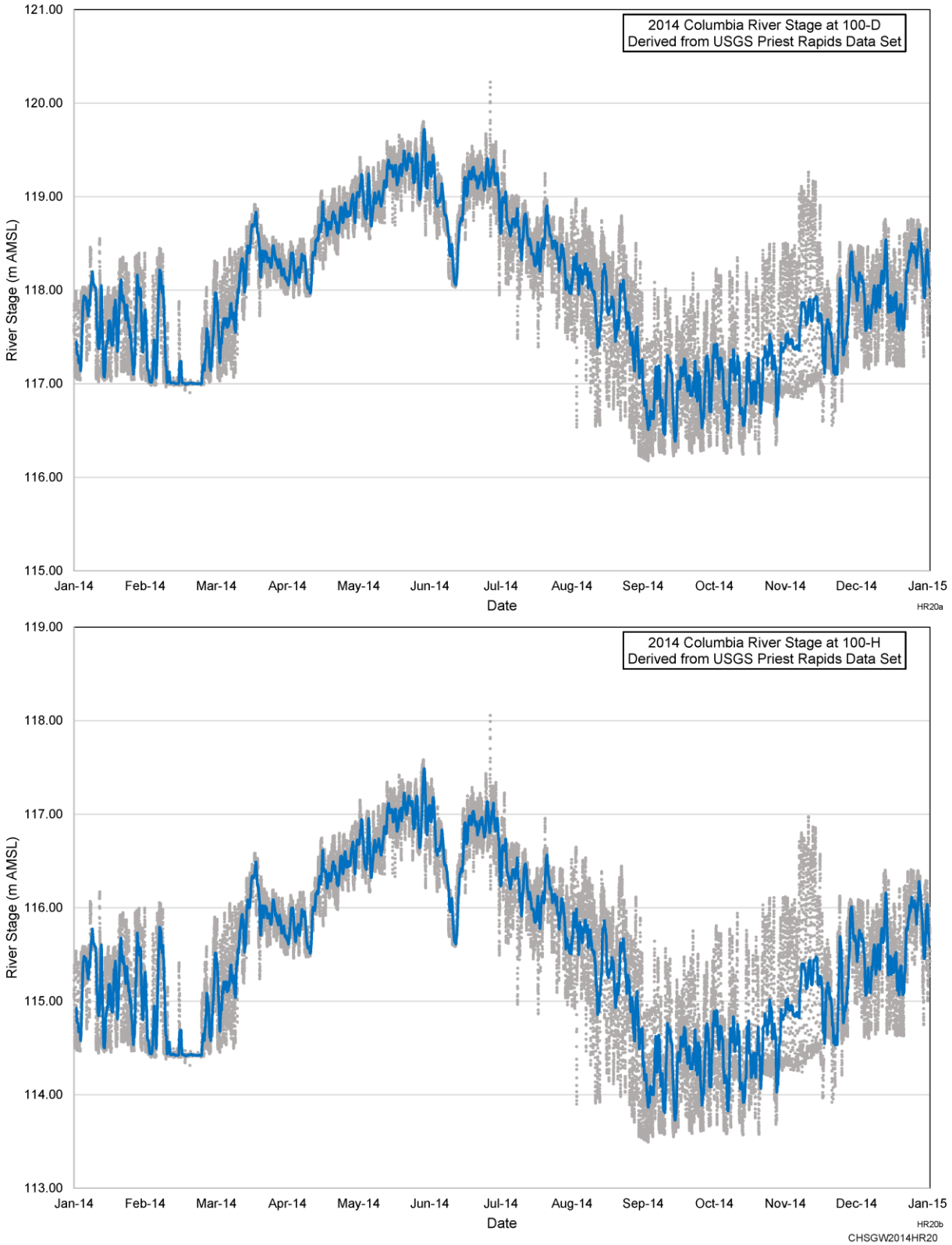


Figure 4-6. Columbia River Stage at 100-D and 100-H Area in 2014

4.2 CERCLA Activities

CERCLA groundwater activities in 100-HR-3 included groundwater monitoring; operation and optimization of interim remediation systems for hexavalent chromium (including adding new wells and realigning existing wells); and finalizing the RI/FS document. CERCLA groundwater sampling includes monitoring the effectiveness of interim remedial actions and monitoring wells throughout 100-HR to track plumes, plume areas (Figure 4-7; Table 4-1), and concentration trends. Wells sampled during 2014 are shown on Figures 1-1 and 1-2 and are listed in Appendix A, Table A-7. Appendix C lists aquifer tubes sampled in 2014.

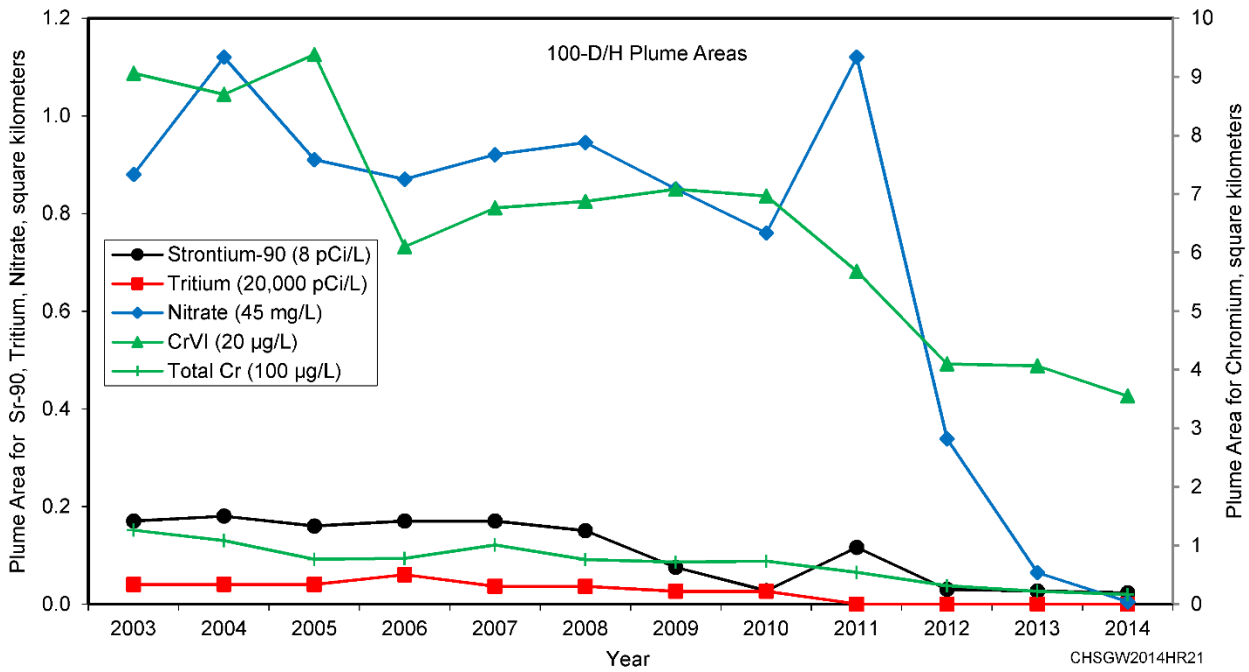


Figure 4-7. 100-HR Plume Areas

4.2.1 Remedial Investigation/Feasibility Study

In 2010 and 2011, the DOE conducted extensive field studies as described in an RI/FS work plan addendum (DOE/RL-2008-46-ADD1) and SAP (DOE/RL-2009-40). Changes to the SAP were documented in Tri-Party Agreement Change Notices (TPA-CN-460 and TPA-CN-368).

The RI/FS results were evaluated, and DOE submitted Draft A of the RI/FS and Proposed Plan for 100-D/H in late 2012 (DOE/RL-2010-95; DOE/RL-2011-111). The RI/FS was reviewed by Ecology, revised, and approved as Rev. 0 in October 2014. The RI/FS results support selection of final remedies under CERCLA, using an approach that integrates source and groundwater remedial actions, which is documented in the Proposed Plan. The Proposed Plan is currently being prepared and is expected to be available for public comment in 2015 or 2016. After public comments are received and incorporated, a ROD will be issued that identifies the final remedial alternatives.

Remedial action decisions will address the integrated cleanup of source waste sites and groundwater. The general objectives for all of these decisions is to protect human health and the environment, including restoring groundwater to beneficial use and protecting aquatic life in the Columbia River from exposure to site groundwater contaminants exceeding ambient water quality criteria.

4.2.2 Interim Action Groundwater Remediation

DOE has been operating a groundwater P&T system in the 100-HR-3 OU since 1997 under an interim remedial action ROD (EPA/ROD/R10-96/134), which was amended in 2000 (EPA/AMD/R10-00/122). Under the interim action, two P&T systems currently operate at 100-HR-3: DX and HX (Figure 4-8). Section 4.10 of this chapter includes more information.

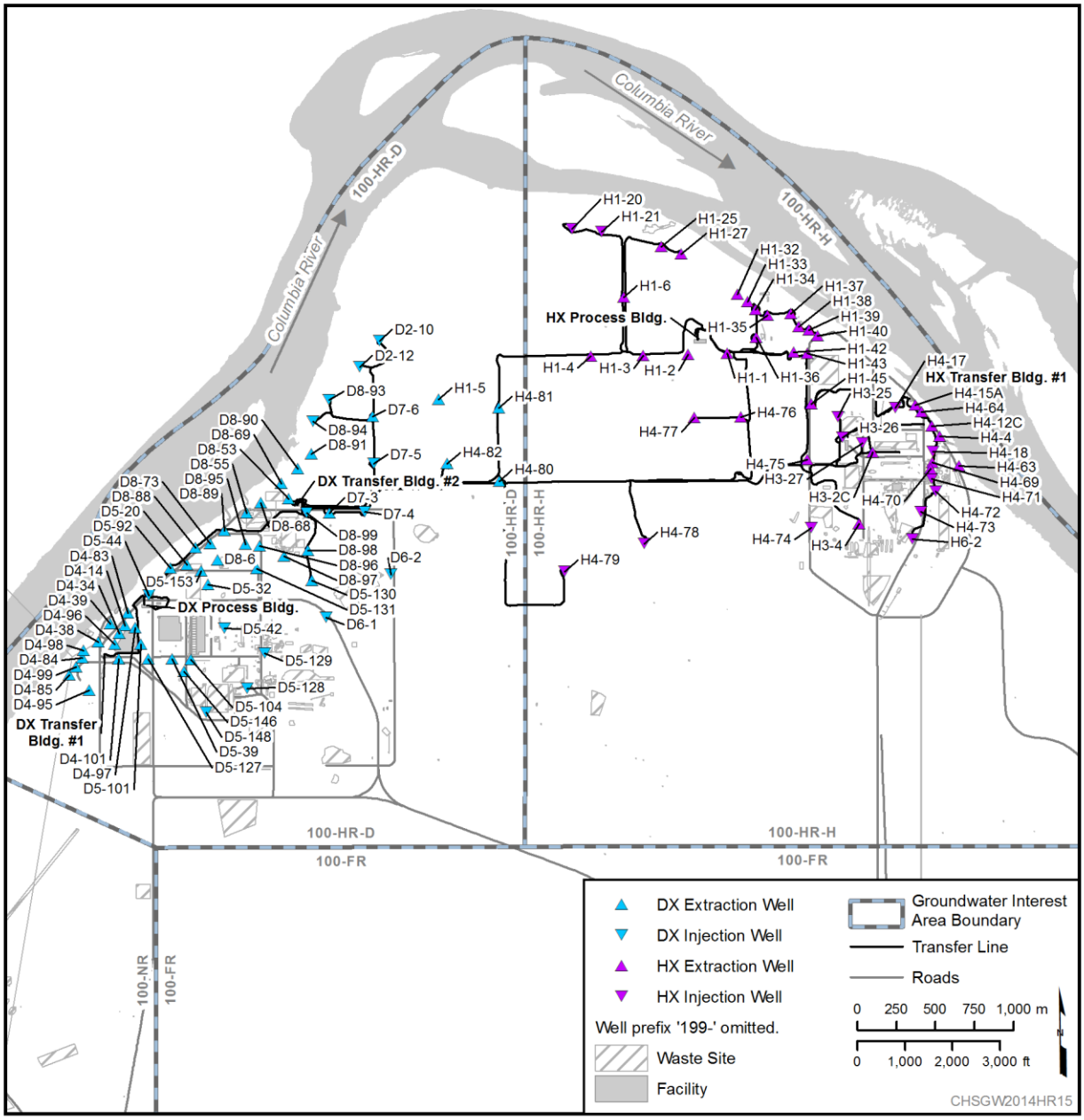


Figure 4-8. 100-HR-3 P&T Systems

4.3 100-HR-D Hexavalent Chromium

Hexavalent chromium is the primary contaminant, is present across the majority of 100-HR-3, and has the most expansive distribution of the contaminants. Its presence resulted from historic releases of two different types of wastewater contaminated with chromium. The first type of release included spills, leaks, and limited quantity intentional discharge of concentrated sodium dichromate solutions used as feed chemicals for conditioning reactor cooling water. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-DR-1&2 Trench during an infiltration test in 1967, which had high volumes of water with lower concentrations of sodium dichromate.

The conceptual site model for hexavalent chromium in the River Corridor has previously assumed that it moves readily through the vadose zone with the addition of water. Once reaching groundwater, it was thought to all be mobile, moving easily within the aquifer regardless of the sodium dichromate concentration of the source. This conceptual site model still appears to be accurate for areas where low concentrations of sodium dichromate were released to the environment, such as with cooling water discharged to the 116-DR-1&2 Trench. However, the aquifer investigation at the 100-D-100 waste site, which was the result of high-concentration sodium dichromate releases, indicates a different conceptual site model. At the 100-D-100 waste site, data indicate that chromium-substitute calcite was precipitated in the periodically rewetted zone and within the aquifer sediment. Most of the mass associated with the precipitate is found near the water table and in the upper portion of the aquifer material. The presence of chromium-substitute calcite provides a slow leaching source of hexavalent chromium to the aquifer, resulting in a long-term secondary source (SGW-58416). The discovery of this mineral led DOE to remove this source material from below the water table at 100-D-100. Removal of this type of secondary source material, where present, has the potential to greatly decrease the time frame and costs of groundwater remediation.

Within 100-D, the plume is separated into 100-D south and 100-D north (Figures 4-9 and 4-10). Due to ongoing waste site remediation and P&T operations, the high concentrations within the plume are decreasing rapidly. For example, Well 199-D5-122 (Figure 4-11) had a significant decline in concentrations after the startup of the DX system. In extraction Well 199-D5-104, which is directly downgradient from the 100-D-100 waste site that was remediated during 2014, hexavalent chromium concentrations dropped from 5,392 µg/L in April 2013 to 465 µg/L on December 29, 2014 (Figure 4-12). Throughout the 100-D Area, hexavalent chromium concentrations have declined by an order of magnitude and were below 500 µg/L by the end of 2014. More information on remediation of the hexavalent chromium plumes in the 100-HR-3 OU is available in *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05)

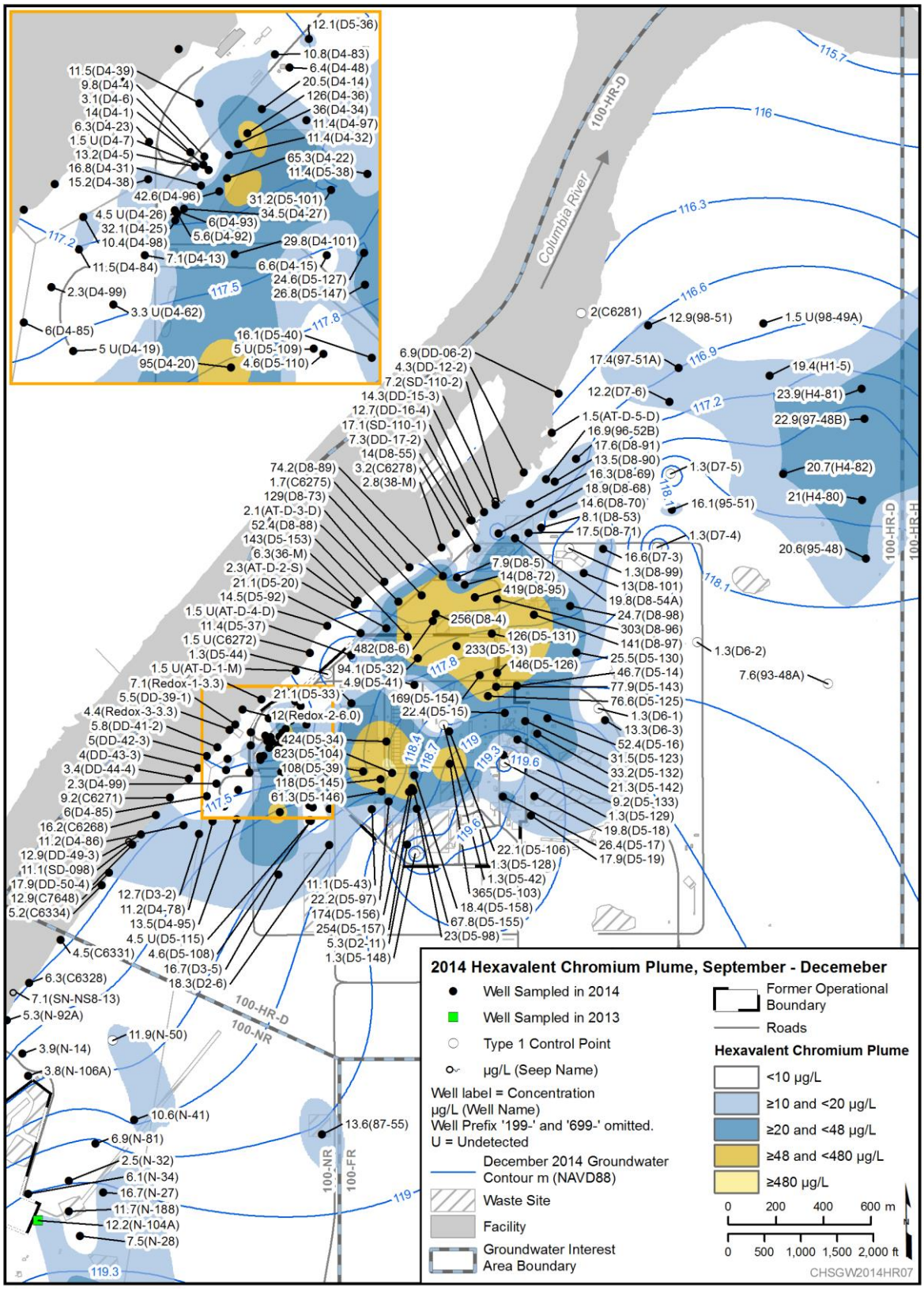


Figure 4-9. 100-HR-D Hexavalent Chromium Plume, Fall 2014 (Low River Stage)

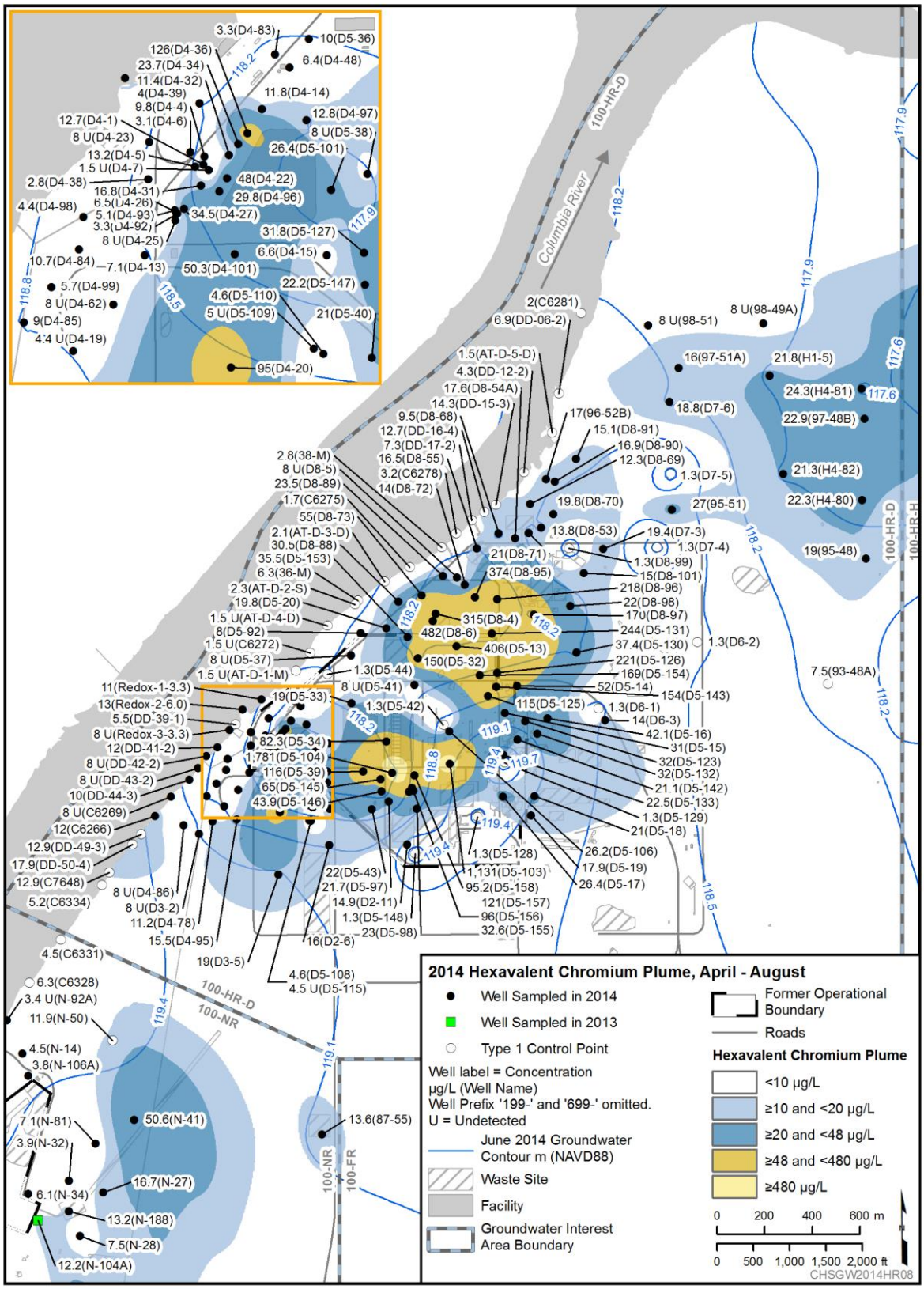


Figure 4-10. 100-HR-D Hexavalent Chromium Plume, Spring/Summer 2014 (High River Stage)

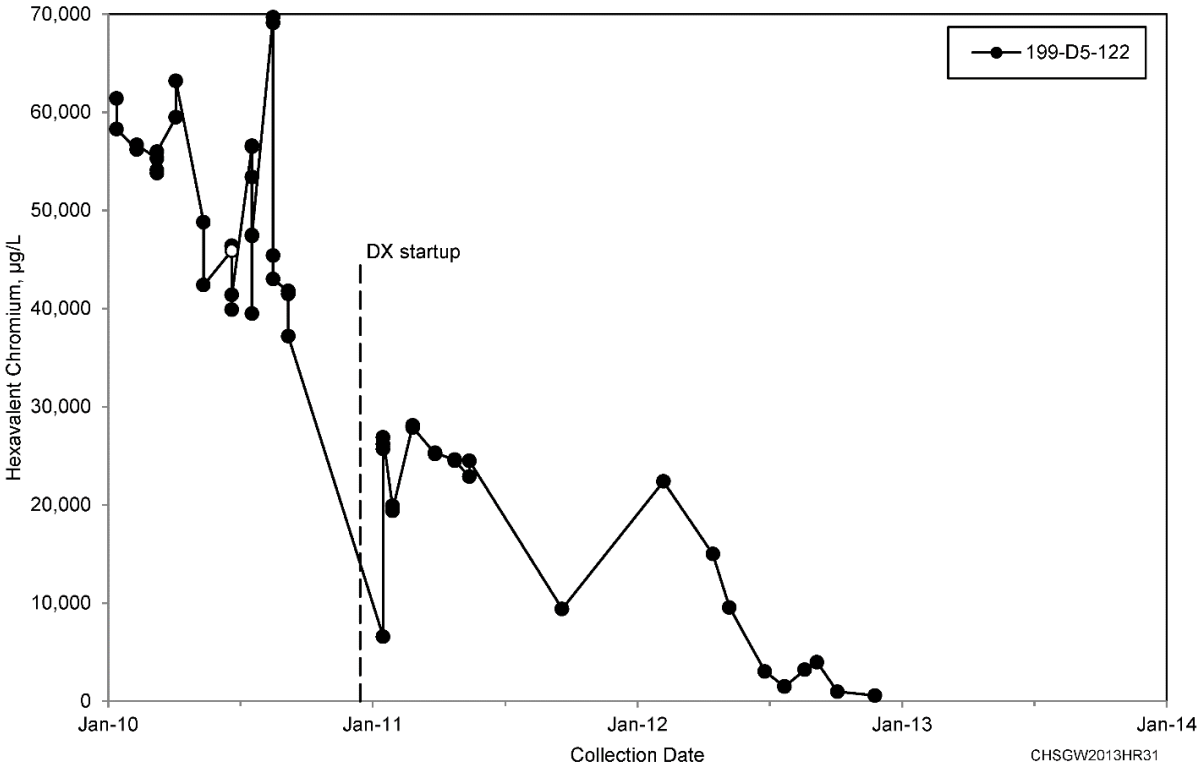


Figure 4-11. 100-HR Hexavalent Chromium Data for Well 199-D5-122 (Decommissioned)

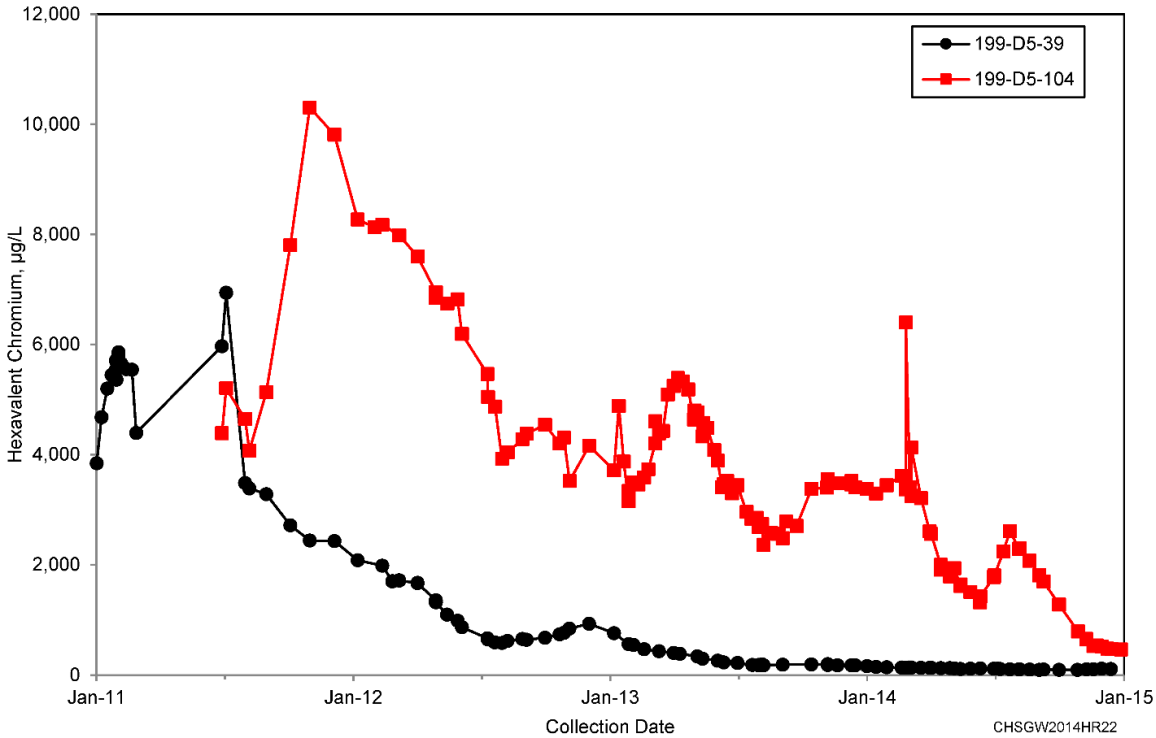


Figure 4-12. 100-HR Hexavalent Chromium Data for Wells 199-D5-39 and 199-D5-104

4.3.1 Southern Plume at 100-D

Hexavalent chromium concentrations continued to decline across the southern part of 100-D, with concentrations below 500 µg/L. As the areas of greatest concentration are reduced, small areas are being identified where hexavalent chromium levels remain stable or are slowly increasing. These areas were masked previously by the overall high levels of contamination but now can be addressed through modifications of the P&T system that realign wells for focused localized extraction and injection.

In the southern part of 100-D, remaining pockets of contamination have been identified:

- At the 100-D-100 waste site
- Near Well 199-D5-103
- Near Well 199-D4-20
- At the northern end of the in situ redox manipulation (ISRM) barrier

The highest concentrations in 100-D south continue to be found in extraction Well 199-D5-104, located downgradient from the 100-D-100 waste site. Near the 100-D-100 waste site, hexavalent chromium concentrations have dropped dramatically over the last few years as a result of the expanded P&T system and source area remediation. Hexavalent chromium concentrations in downgradient extraction Wells 199-D5-104 and 199-D5-39 have been declining overall, but the trend slowed as the remediation activity at 100-D-100 approached groundwater (Figure 4-12). The aquifer is expected to respond favorably with the additional excavation into the top 3 m (10 ft) of the aquifer, which will remove most of the remaining mass that is currently bound in a chromate-substitute calcite.

Hexavalent chromium concentrations in 199-D5-103 increased sharply during late 2011 and 2012 after the DX system became operational (Figure 4-13). This was in direct response to the increase in water levels of about 1 m (3.3 ft) due to nearby injection. Well 199-D5-103 is located between the 100-D-100 (southern plume) and 100-D-104/100-D-30 (northern plume) waste sites and also appeared to respond to excavation activities at those waste sites. Concentrations at 199-D5-103 increased during excavation activities, likely due to enhanced vertical migration of hexavalent chromium through the vadose zone during excavation (concurrent excavation took place at the waste sites during most of 2013). Hexavalent chromium concentration decreased in late 2013 when excavation activities concluded (Figure 4-13). Final soil remediation at 100-D-104/100-D-30 stopped in March 2014 and in January 2015 at 100-D-100. During 2014, the hexavalent chromium concentration increased again to a maximum of 1,370 µg/L before decreasing and ending the year at 307 µg/L in December 2014. This trend during 2014 likely resulted from increased local recharge with the excavations open to the water table and indicates the removal of chromium-contaminated soil and aquifer material resulting in the declining concentration late in 2014.

Well 199-D5-34, located farther downgradient, also exhibited an increase in hexavalent chromium concentration following startup of DX. Starting in mid-2013, the concentrations in this well exhibited a general increase to about 215 µg/L at the end of 2013 (Figure 4-13), which may also have been related to the excavation activities at the two upgradient waste sites. The hexavalent chromium concentration transient curve for Well 199-D5-34 exhibits a similar nature to that exhibited by Well 199-D5-103, with Well 199-D5-34 exhibiting lower peak concentrations and the timing of the transient peaks and lows lag several months behind those exhibited in Well 199-D5-103. This relationship suggests that these two wells are likely oriented along a groundwater flow path and are exhibiting responses to the same conditions, with responses at Well 199-D5-34 being diminished by distance. If this relationship holds true, the hexavalent chromium concentration in Well 199-D5-34 should decrease during 2015. Continued monitoring at these two locations will provide further understanding of the hexavalent chromium behavior in this area.

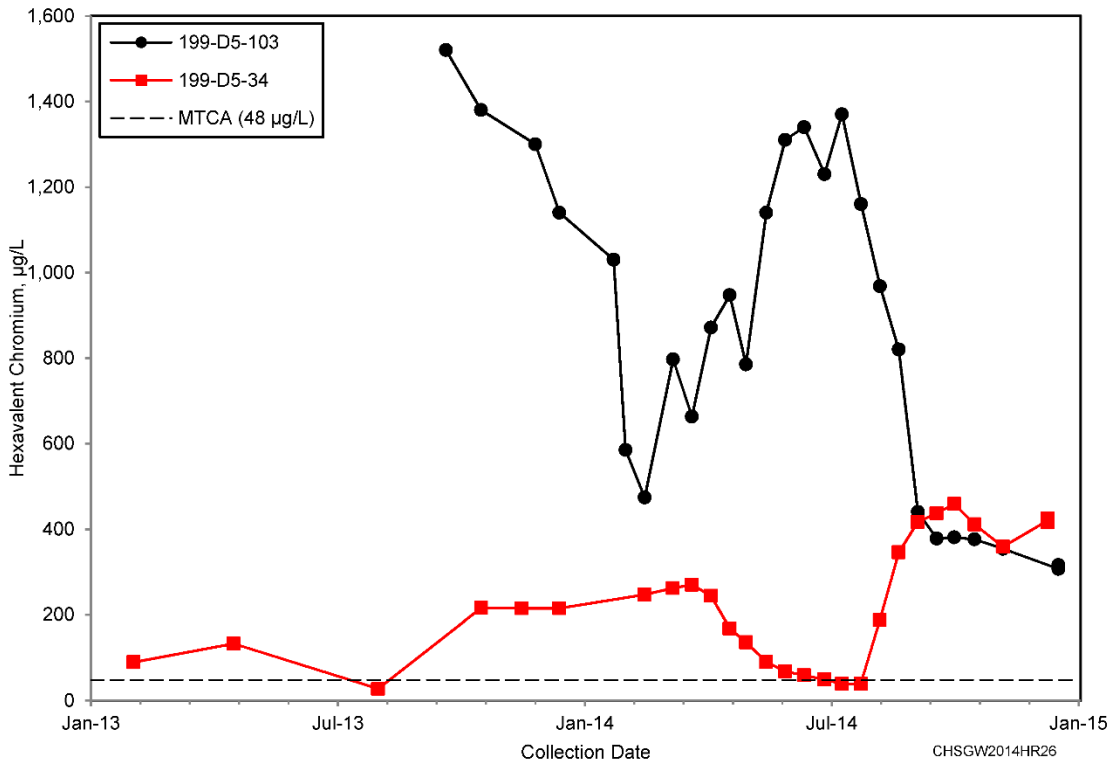


Figure 4-13. 100-HR Hexavalent Chromium Data for Wells 199-D5-103 and 199-D5-34

A third remaining area of elevated concentration in the southern plume is in the vicinity of Well 199-D4-20. Concentrations in this well were above 200 µg/L in 2005, and declined to 6.7 µg/L in August 2010. The hexavalent chromium concentration rose back up to 174 µg/L in September 2012. The most recent concentration at this well was is 87 µg/L (October 2014). A remaining source area near Well 199-D4-20 has not been definitively identified. The wells surrounding Well 199-D4-20 have concentrations ranging from below detection to around 30 µg/L; however, these wells are located in either a treatability test area (upgradient) or are within the ISRM barrier (downgradient). Based on examination of historical hexavalent chromium concentrations in Well 199-D4-20 and neighboring wells, it appears that the chromium observed in Well 199-D4-20 is likely a remnant of the former hexavalent chromium plume that was continuous throughout the area inland of the ISRM barrier wells. This plume has been dissected by operation of the pump and treat system, as well as by placement of the ISRM barrier and emplacement of the in situ bio-reduction test to the east of Well 199-D4-20.

In the northern portion of the ISRM barrier, hexavalent chromium concentrations have remained elevated for several years. As a result, the need for improved capture by the P&T system in this area was identified in 2012. In response to this need, two additional extraction wells were connected during 2013: Wells 199-D4-14 and 199-D4-34 (Figure 4-14). This system modification has resulted in concentrations declining in most of the ISRM wells and in downgradient extraction Well 199-D4-39 (Figure 4-14). The source of this contamination is presumed to be the 100-D-100 waste site. Figure 2-25 of DOE/RL-2015-05 shows the hydraulic containment achieved by the P&T system in 100-D Area.

Based on measurements in aquifer tubes south (i.e., upriver) of the ISRM barrier and in monitoring wells immediately inland, hexavalent chromium appears to continue to reach the shoreline of the Columbia River at low river stage (Figure 4-9). At the high river stage (Figure 4-10), the plume in this area is discontinuous, with inland wells 199-D3-2 and 199-D4-86 exhibiting no detectable hexavalent chromium.

Not all of the nearby aquifer tubes were sampled at the high river stage (some aquifer tubes are not accessible during high river stage). Aquifer tubes in the vicinity that were sampled during high river stage exhibited varying results, ranging from non-detectable to some locations exceeding 10 µg/L (e.g., aquifer tube C6268 at 19.2 µg/L). Based on these observations the hexavalent chromium plume in this vicinity is inferred to migrate to the river periodically.

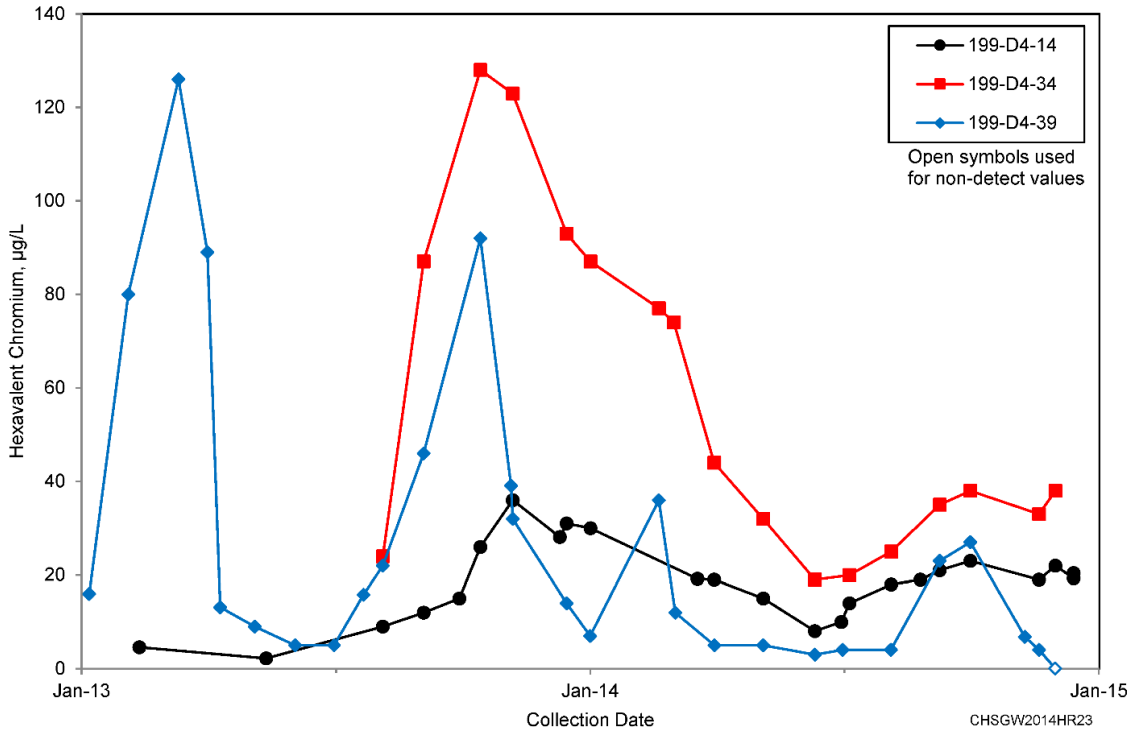


Figure 4-14. 100-HR Hexavalent Chromium Data for Wells 199-D4-14, 199-D4-34, and 199-D4-39, Near ISRM Barrier

4.3.2 Northern Plume at 100-D

The overall footprint of the 2014 hexavalent chromium northern plume (Figures 4-9 and 4-10) contour changed little compared to the 2013 plume at the 10 µg/L. As in the southern plume area, the areas of higher concentrations decreased in size. The plume area with concentrations greater than 480 µg/L was smaller, and concentrations declined to less than 480 µg/L by the end of 2014. It should be noted that Well 199-D8-6 was not sampled after March 2014, and concentrations had not yet declined. The plume above 48 µg/L was about the same size as in 2013 and is not interpreted to extend to the river. Most of the reductions in concentration were in response to active groundwater remediation, with source area removal at waste sites such as 100-D-104/100-D-30, contributing to the decline.

The areas of higher concentrations (greater than 100 µg/L) remaining within the northern 100-D plume are located in the vicinity of the 120-D-1, 100-D Ponds waste site, the 126-D-1 coal ash waste site, and in the area northeast of those waste sites near the 100-D-31 underground pipelines. In general, wells upgradient of those waste sites have decreasing concentrations. Those wells near the waste site (199-D8-95, 199-D5-153, 199-D5-32, and 199-D8-4) and downgradient (199-D8-73, 199-D8-88, and 199-D8-89) show the effects of seasonal variations but no pronounced downward trend (Figure 4-15 and 4-16). New extraction Well 199-D5-153 was not included in the trend plot as it had a short operational time frame.

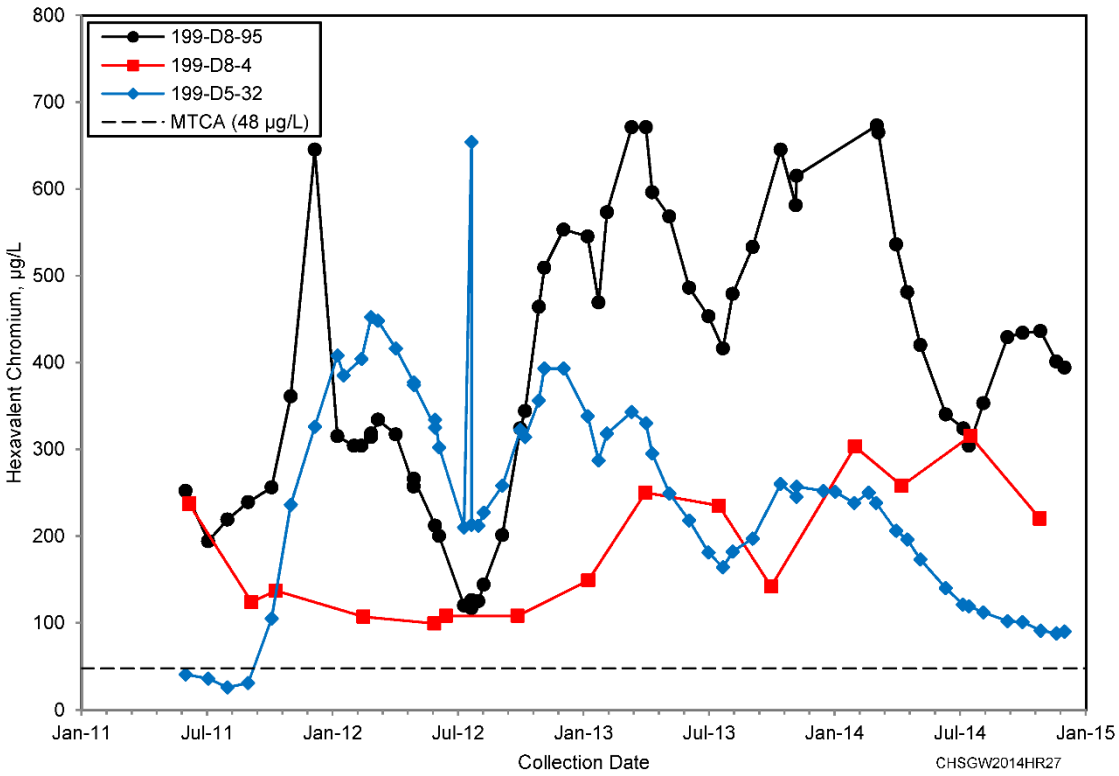


Figure 4-15. 100-HR Hexavalent Chromium Data for Wells 199-D5-132, 199-D8-4, and 199-D8-95, Northern Plume

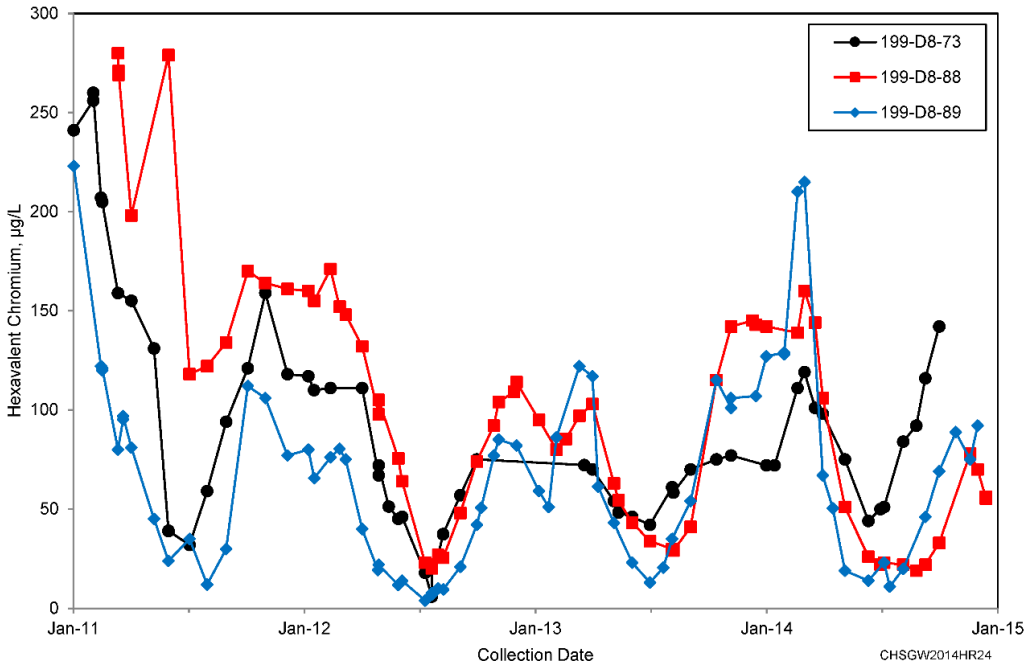


Figure 4-16. 100-HR Hexavalent Chromium Data for Wells 199-D8-73, 199-D8-88, and 199-D8-95, Northern Plume

Additional P&T capability was initiated in FYs 2013 and 2014 in response to elevated hexavalent chromium concentrations and impacts to the Columbia River near aquifer tube site AT-D-3 in 2013. This includes the addition of new extraction Well 199-D5-153, which is currently operational, and Well 199-D5-154, which is planned for startup in February 2015. Impacts from the operation of Well 199-D5-153 are already being realized, with concentrations in downgradient aquifer tubes declining. This increased mass removal in that area of the north plume, along with higher river stage, led to better capture and removal of hexavalent chromium, and lower concentrations in downgradient aquifer tubes. Figure 2-25 in DOE/RL-2015-05 illustrates the hydraulic containment of the hexavalent chromium plume in the 100-D Area.

Along the northern 100-D plume, hexavalent chromium continued to exceed 10 µg/L in aquifer tubes in fall 2014: DD-15-3 and DD-16-4, both located on the far north end. The capture in this area improved starting in 2013 as a result of system modifications. Changes included addition of new extraction wells, as noted above, and changes in water conveyance configuration that allowed increased pumping rates from selected extraction wells. The need for additional changes is being evaluated.

4.4 100-HR-H Hexavalent Chromium

4.4.1 Plume in the Horn and 100-H

Discharge to the 116-DR-1&2 Trenches during 1967 resulted in the hexavalent chromium plume that extends across the Horn from 100-D to 100-H (Figures 4-17 and 4-18; DOE/RL-2010-95, Rev. 0). This plume encompasses the largest area of 100-HR-3, but only a small area has concentrations greater than 48 µg/L. Ongoing remediation activities continue to reduce the contaminant levels; however the presence of a thin aquifer limits the effectiveness of the extraction wells. Across the Horn, the aquifer is less than 1 m (3.3 ft) in thickness in some locations during low river stage, which means that water cannot be withdrawn at a high rate of flow and removal of contaminants is minimized. Recent changes in extraction well design, including the use of larger well diameters, larger screen sizes and correspondingly larger filter packs, are expected to improve extraction performance in these areas of thin aquifer saturated thickness. Other alternative well construction techniques (e.g., the use of horizontal wells) are being evaluated for potential application in this area.

Currently, the highest concentrations in the unconfined aquifer in the Horn are found in extraction Wells 199-H4-75, 199-H4-76, and 199-H4-77; located just west of the 100-H Area. Concentrations in these extraction wells ranged from 41 to 60 µg/L in 2014, representing little change from 2013 levels. The slow decline in concentrations is likely related to the thin aquifer (less than 5 m [16 ft]), which results in extraction rates of less than 75.7 L/min (20 gpm) in these wells. Installation of new and/or replacement extraction wells that are better designed for operation in thin formations may improve performance in this area.

In the unconfined aquifer at H Reactor area, concentrations are typically less than 10 µg/L. Areas in 100-H with higher hexavalent chromium concentrations are found just north of H Reactor. One of these locations is at Well 199-H4-86, which is located just north of waste site 100-H-46. Well 199-H4-86, which was installed in 2013, had a high concentration of 85.5 µg/L in November 2014, during low river stage. Due to the consistent elevated concentrations during low river stage the well is planned for conversion to an extraction well in 2015.

The other areas with continuing hexavalent chromium are located at the 183-H Solar Evaporation Basin and the 116-H-7 Retention Basin, (Figures 4-17 and 4-18). Hexavalent chromium concentrations near the 183-H Solar Evaporation Basin were as high as 80 µg/L during 2014 (199-H4-84). Contaminant concentrations in this well are directly related to groundwater elevations, with the highest concentrations exhibited during high river stage as would be expected with a well located within a source area.

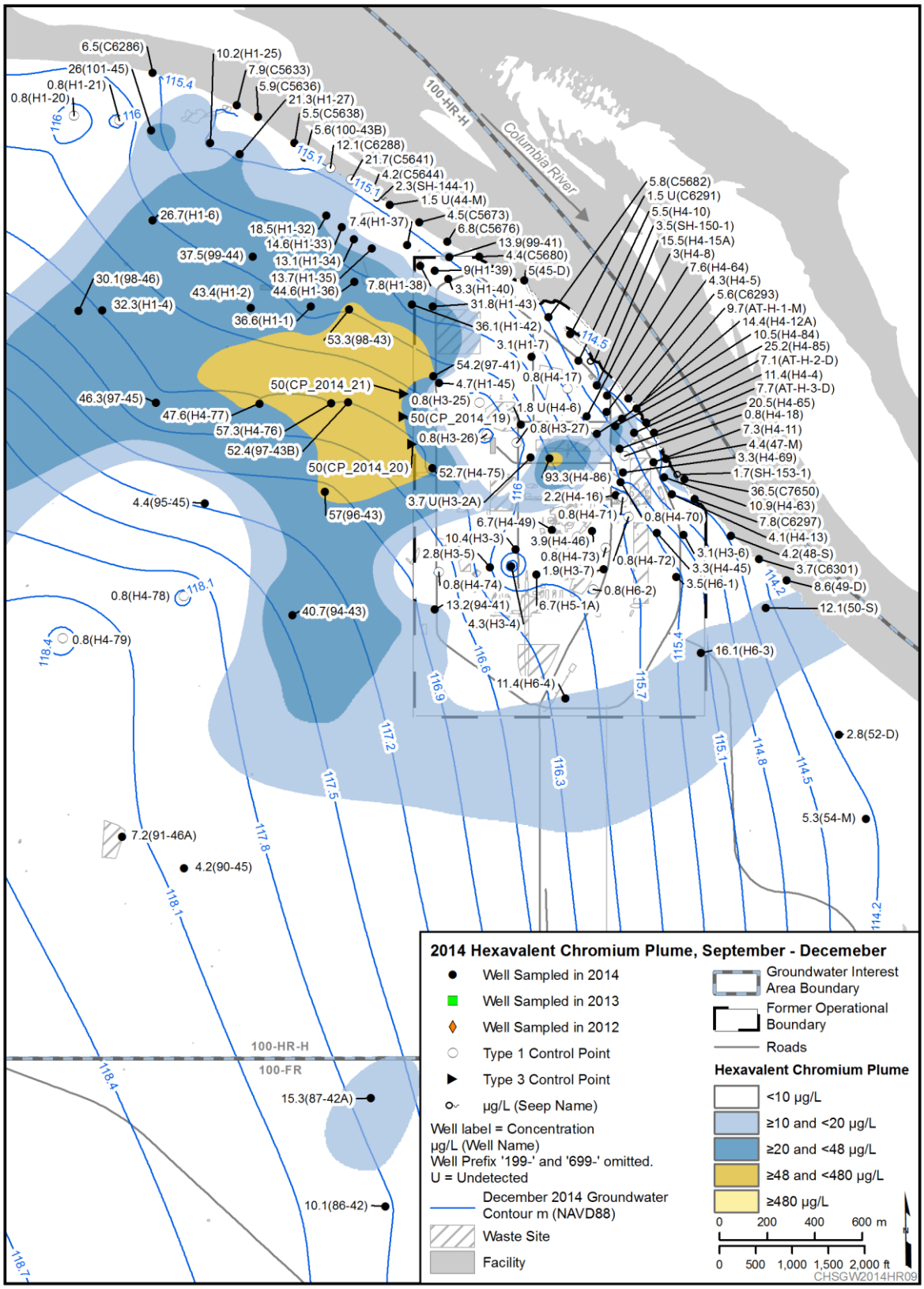


Figure 4-17. 100-HR-H Hexavalent Chromium Plume, Fall 2014 (Low River Stage)

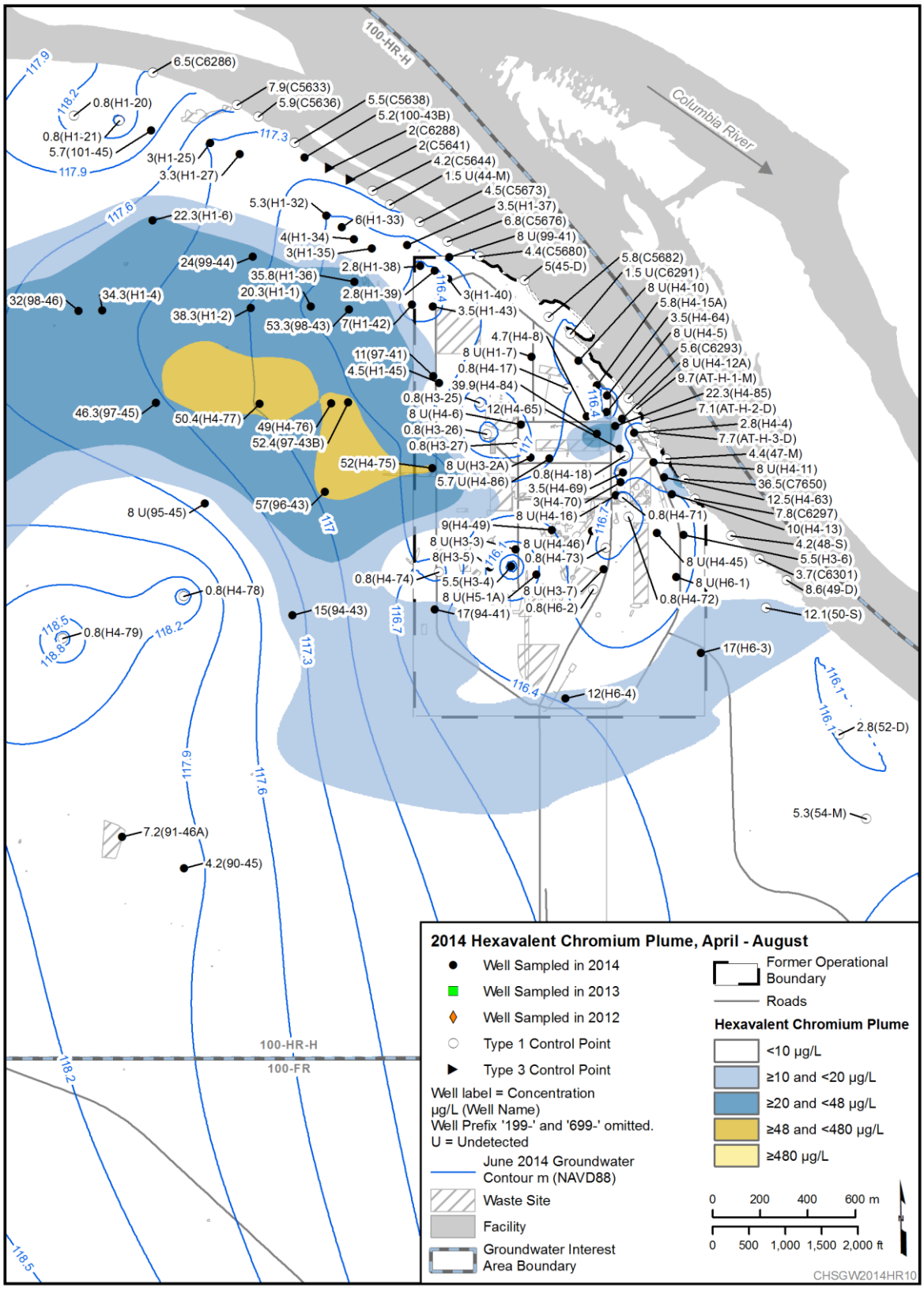


Figure 4-18. 100-HR-H Hexavalent Chromium Plume, Spring/Summer 2014 (High River Stage)

The southern edge of the 100-H Area (e.g. near Well 199-H6-3 and Aquifer Tube 50-S) continues to have fairly low levels of hexavalent chromium reaching the river, with the plume appearing to coincide roughly with an interpolated paleochannel. This apparent channel has a higher percentage of gravel material, and a slightly thicker aquifer, with groundwater flow rates that are much higher than in other areas in 100-H. Reconfiguration of the extraction and injection wells, along with installation of additional wells are planned in this area for 2015, which are designed to take advantage of the presence of the groundwater flow regime. Modifications to the P&T systems are discussed in the *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05).

North of 100-H, hexavalent chromium was identified above 10 µg/L in Aquifer Tubes C6288 and C5641 during low river stage. This is an area where capture is difficult during low river stage because the aquifer is very thin, which minimizes the amount of water that can be extracted by the current groundwater extraction well network configuration. Well reconfiguration in this area is planned for 2015 (DOE/RL-2015-05) to improve capture. During high river stage, those aquifer tubes were assumed to have concentration below detection limits for mapping purposes. This is based on the specific conductance of those wells indicating that river water is being pulled to the extraction wells, plume capture being obtained (as discussed in DOE/RL-2015-05), and the presence of low concentrations inland/upgradient of those aquifer tubes indicating that the plume was not present along that portion of shoreline. Figures 4-19 and 4-20 present the specific conductance at 100-HR-3.

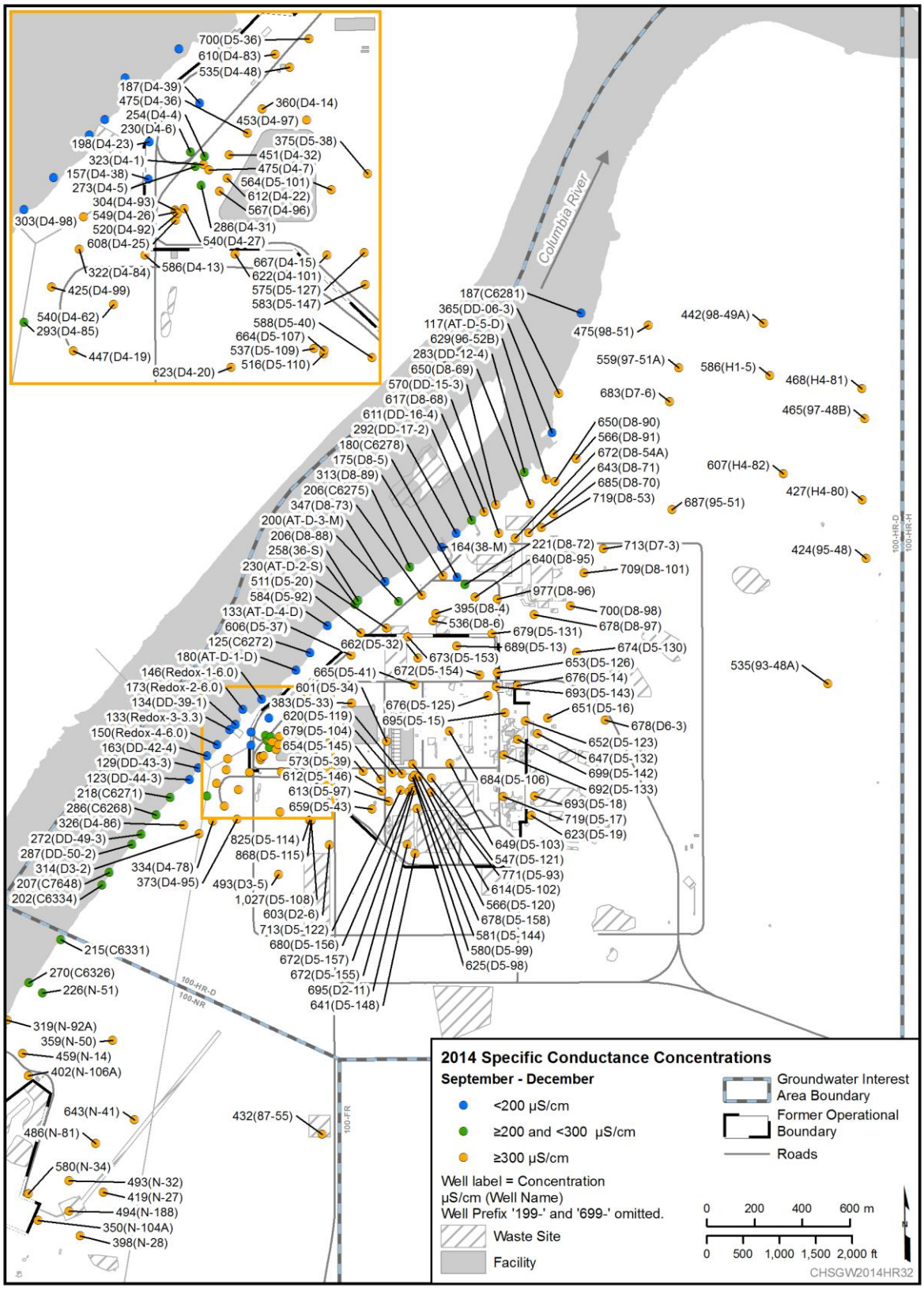


Figure 4-19. Specific Conductance, 100-HR-D Low River Stage

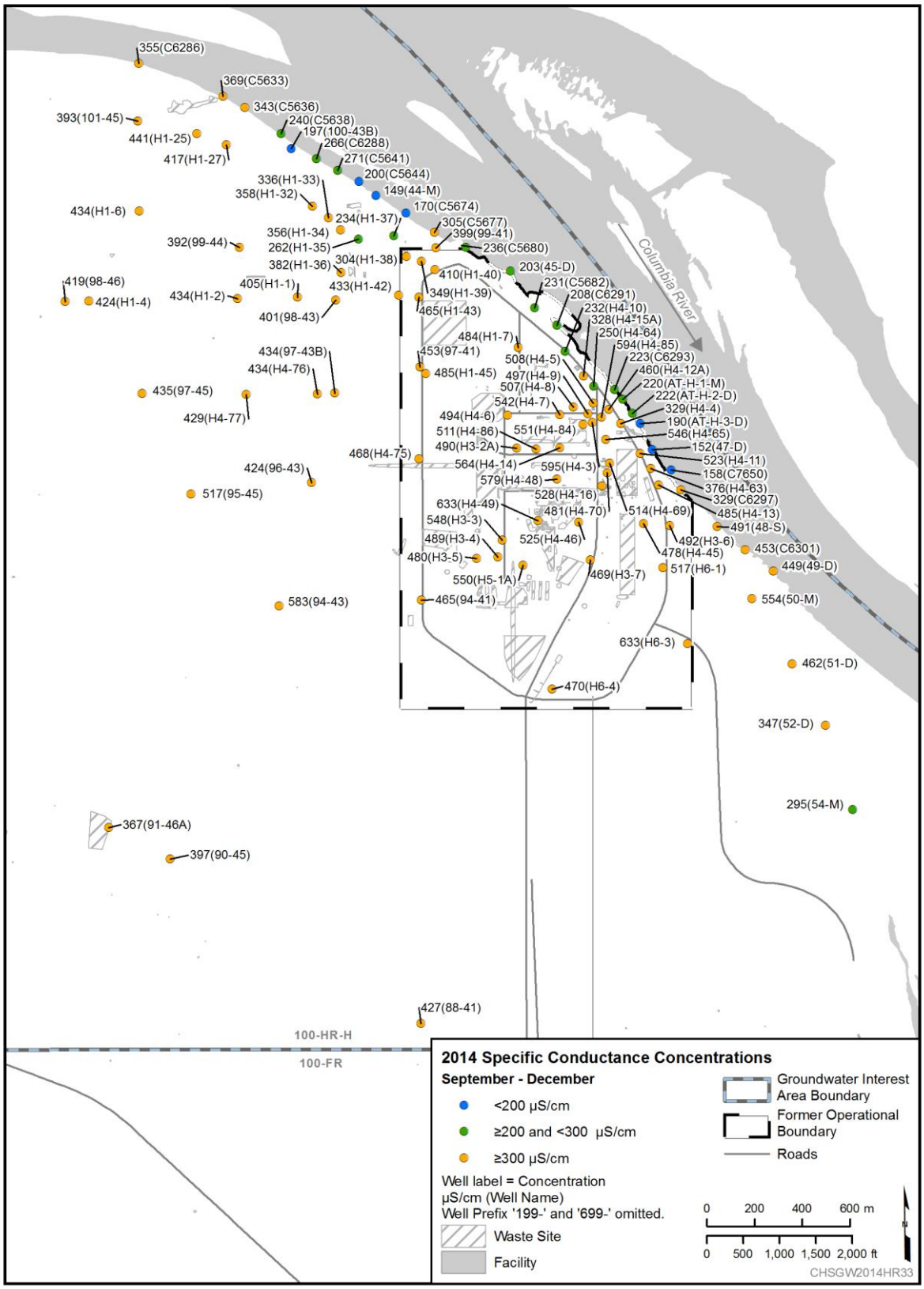


Figure 4-20. Specific Conductance, 100-HR-H Low River Stage

4.4.2 Ringold Formation Upper Mud Unit

Hexavalent chromium has been detected in the first water-bearing unit of the RUM in 100-H and the Horn for nearly 20 years. The water-bearing unit in the RUM consists generally of a silty sand unit about 3 to 5 m (10 to 15 ft) thick in the vicinity of 100-H. Concentrations in this unit near the river at 100-H ranged from below detection limits (199-H3-10 and 199-H2-1) to a high of 141 µg/L (199-H3-9) during 2014. This water-bearing unit is connected to the HX system through extraction Wells 199-H4-12C and 199-H3-2C, which started extraction operations in 2009. Concentrations in these wells remain fairly constant at 120 and 65 µg/L, respectively, with a slow decline over time. Near river RUM Well 199-H3-9 also has concentrations over 100 µg/L and is planned for connection to HX during 2015 to improve mass removal from the RUM.

The hexavalent chromium concentrations and distribution in the RUM are shown in Figure 4-21. A plume is not depicted because it has not yet been determined if the water-bearing units are connected. An aquifer pumping test plan is being prepared with the objective of determining if the water-bearing units within the RUM are connected at 100-H, or are small isolated areas. This will also be used to determine if the Columbia River is being impacted by the confined aquifer. This test is anticipated to be implemented during calendar year 2015.

Across the Horn, the highest hexavalent chromium concentrations in the RUM were detected in Well 699-97-48C, at 78.2 µg/L. This was a decline from 105 µg/L in 2013. Approximately 1,100 m (3,600 ft) to the east of Well 699-97-48C, however, the hexavalent chromium concentrations in RUM Well 699-97-45B increased from below detection to 7.40 µg/L. While this is a small increase, it is potentially significant, possibly indicating the front of the hexavalent chromium plume as it moves from west to east across the Horn in this discrete unit (Figure 4-21). This condition will continue to be monitored and additional monitoring wells are planned for installation in this area to provide additional information regarding the extent and range of concentration of hexavalent chromium within the RUM unit in the Horn.

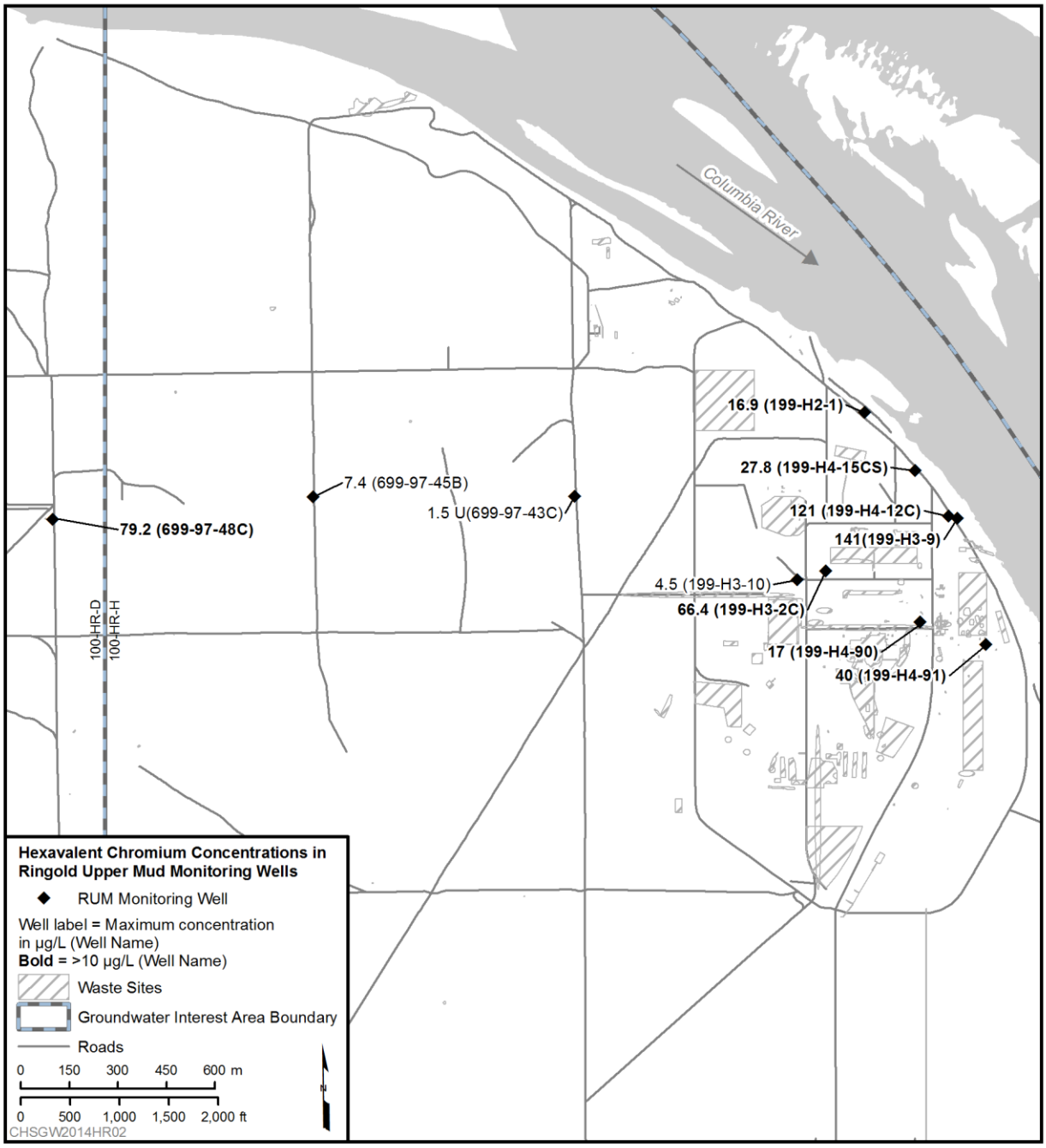


Figure 4-21. 100-HR Hexavalent Chromium Concentrations in the RUM, during 2014

4.5 Nitrate

Primary sources of nitrate in groundwater in 100-HR included gas condensate from the reactors, septic systems and sewer lines, former agricultural practices, and waste sites that received nitric acid. The nitrate plume is primarily co-located with chromium, and has a much smaller footprint at levels above the DWS, mostly within the 100-D Area. Nitrate concentrations continued to exceed the 45 mg/L DWS equivalent in 100-D groundwater in a small area (Figure 4-22). Historically, nitrate has been found above 45 mg/L in 100-H; however, concentrations were below that level throughout 100-H in 2013 and 2014 (Figure 4-23). Nitrate is not found above the DWS equivalent in the Horn. Overall, the combined area of the nitrate plumes continued to rapidly decrease (Figure 4-7), primarily because it is co-extracted with hexavalent chromium.

Nitrate contamination in 100-D was previously distributed in southern and northern plumes, similar to hexavalent chromium. As a result of ongoing groundwater remediation, nitrate concentrations have declined below the DWS in most wells. Only small pockets continue to have concentrations above 45 mg/L. Well 199-D5-155 is now decommissioned but was located within the 100-D-100 waste site excavation and had an average nitrate concentration of 52.3 mg/L. Well 199-D4-20, located upgradient of the ISRM barrier, had a nitrate concentration of 53.1 mg/L in 2014, a decrease from 70.4 mg/L in 2013. Wells with at least one sample result over the DWS for nitrate during 2014 are: 199-D2-6, 199-D4-20, 199-D5-142, 199-D5-155, and 199-D8-97.

Nitrate concentrations did not exceed 45 mg/L in 100-H or the Horn during 2014. The highest levels of nitrate at 100-H found during 2014 were in Well 199-H6-3, located south of the reactor area, at a maximum concentration of 41.2 mg/L (average of 40.9 mg/L). The nitrate concentrations in the remaining area of 100-H and the Horn were below 30 mg/L.

Nitrate concentrations in the RUM remain much lower than in the unconfined aquifer throughout 100-HR. Concentrations in 100-D remain near 2 mg/L (199-D5-134 and 199-D5-141), with concentrations in the Horn ranging from about 2 to 5 mg/L. Nitrate concentrations in 100-H increased in RUM Wells 199-H3-9 and 199-H4-91, with maximum concentrations at 23.5 and 17.1 mg/L, respectively (Figure 4-24). The source of the nitrate has not been evaluated since the concentrations remain well below the DWS and tend to fluctuate. A connection to the unconfined aquifer, however, may be suggested. Concentrations in the remaining RUM wells were generally stable at levels between 2 and 15 mg/L. While the concentrations remain well below 45 mg/L, the increasing trend will be monitored.

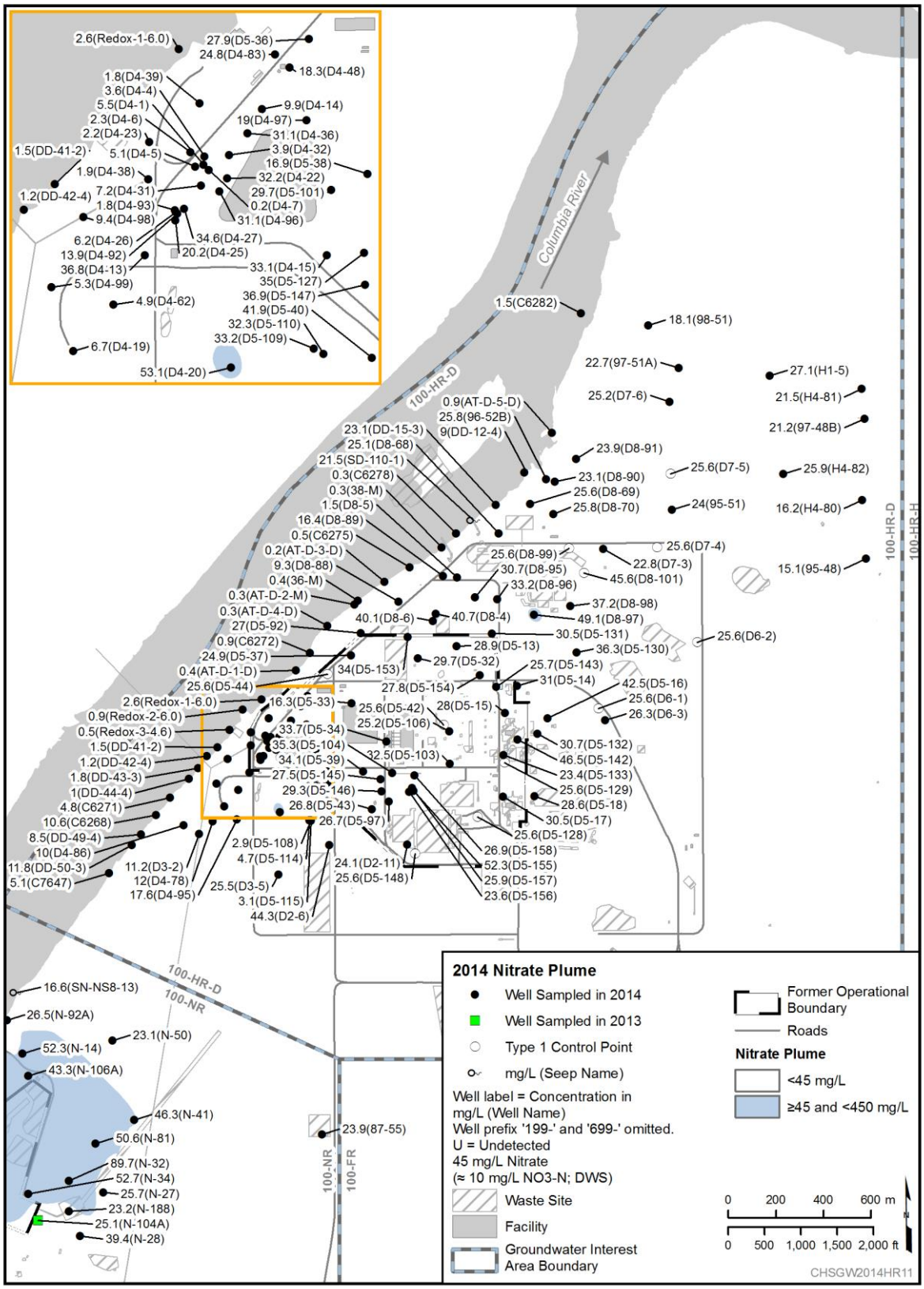


Figure 4-22. 100-HR-D Nitrate Plume, 2014

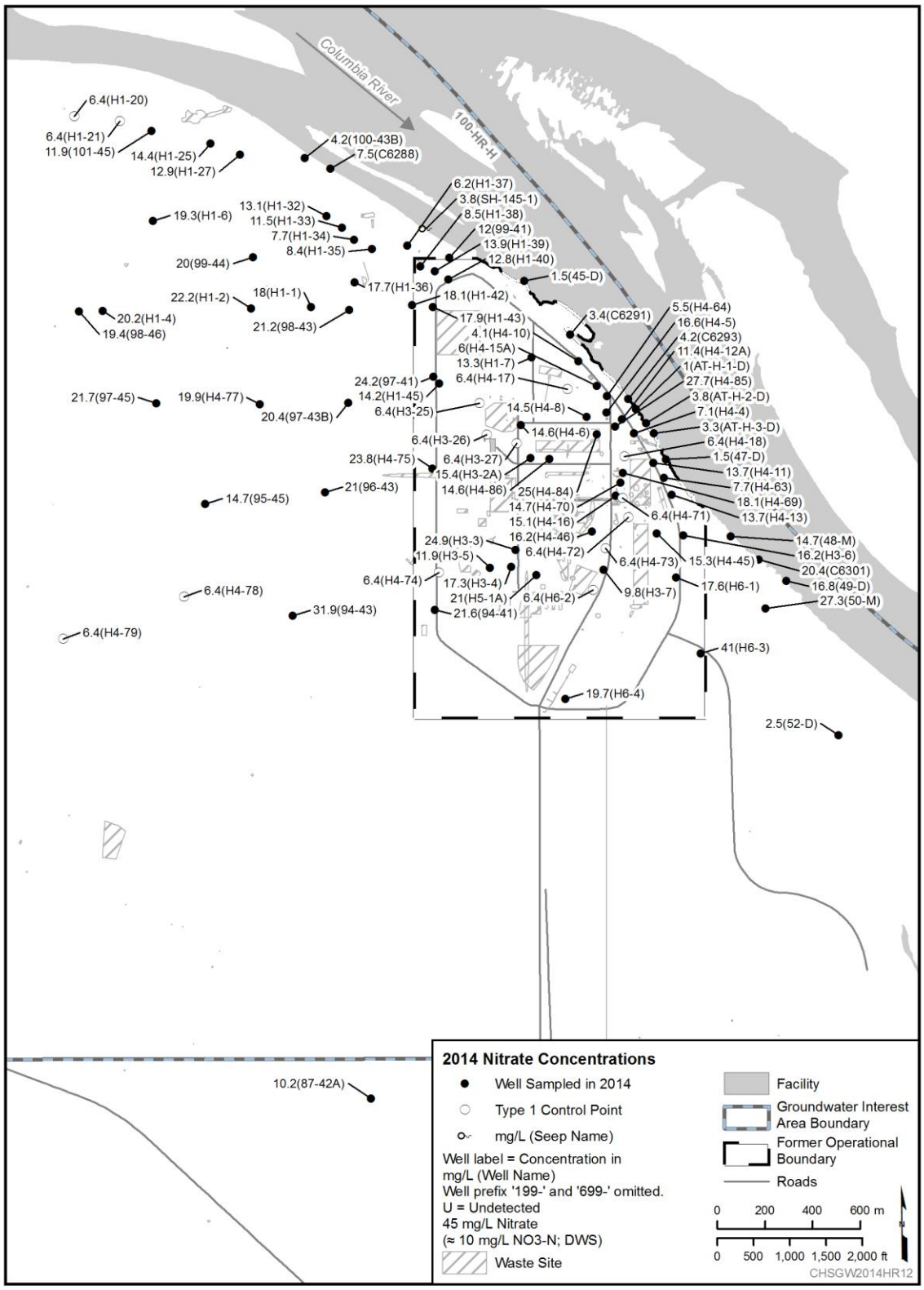


Figure 4-23. 100-HR-H 2014 Nitrate Plume, 2014

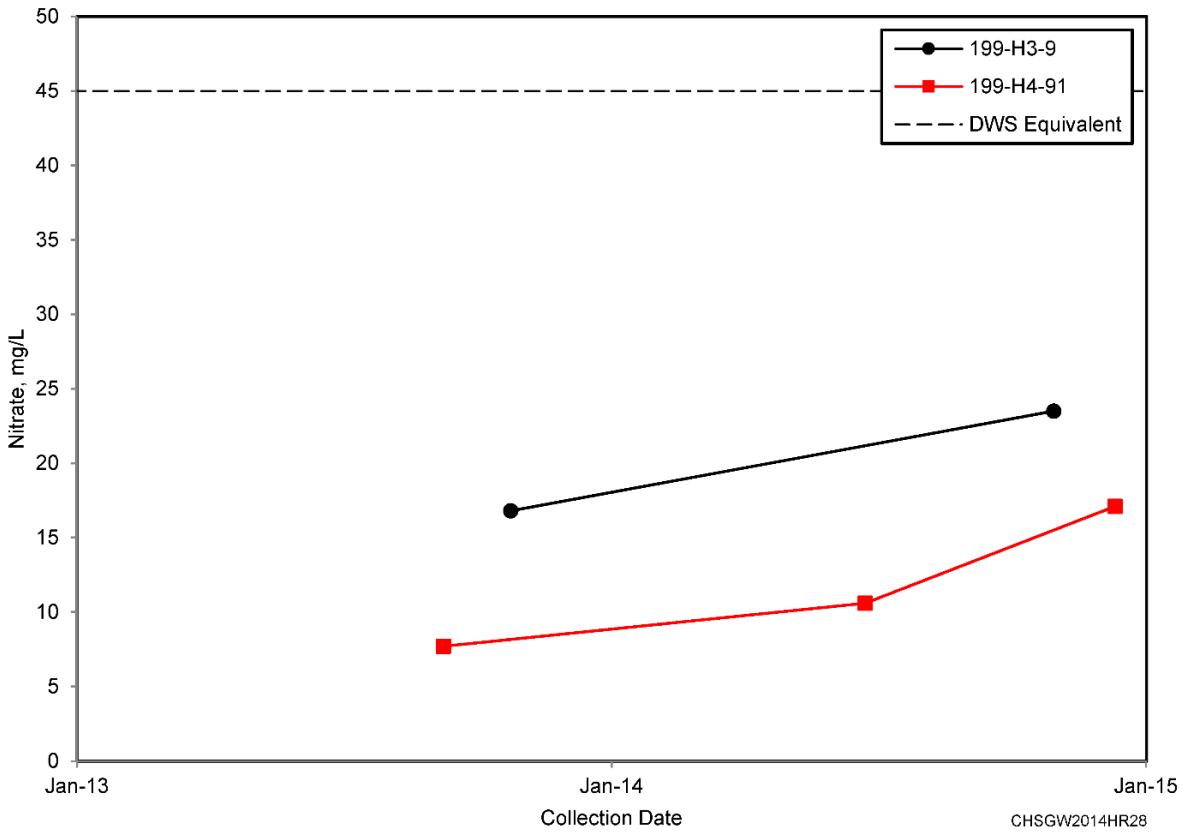


Figure 4-24. 100-HR Nitrate Data for RUM Wells 199-H3-9 and 199-H4-91

4.6 Strontium-90

Strontium-90 has been identified above the DWS in two isolated areas: one in 100-H, and one in 100-D. The concentrations and distribution of strontium-90 have shown little change. Strontium-90 was present in waste disposed of at both 100-D and 100-H. Elevated strontium-90 is associated with isolated source areas in both 100-H and 100-D in the vicinity of the reactors, and is not present in the Horn (Figures 4-25 and 4-26).

In 100-D, groundwater near the former fuel storage basin and waste water disposal trenches at the D Reactor has strontium-90 concentrations above the DWS of 8 pCi/L in two wells: 199-D5-132 and 199-D5-142. Well 199-D5-132 had the highest activity near the fuel storage basin, with a maximum reported value of 36.4 pCi/L in August 2014. Concentrations in this area remain relatively stable. Strontium-90 has not been detected above the DWS in the downgradient wells indicating that the contamination remains localized.

The area near the former retention basins in the northern 100-D Area historically had strontium-90 detections in groundwater. In that area, Well 199-D8-68 had the highest activity with a result of 6.23 pCi/L in December 2014, essentially no change from 2013 values. Strontium-90 values in Well 199-D8-54A were measured twice in 2014, with reported levels of 5.96 and 3.50 pCi/L during high and low water levels, respectively.

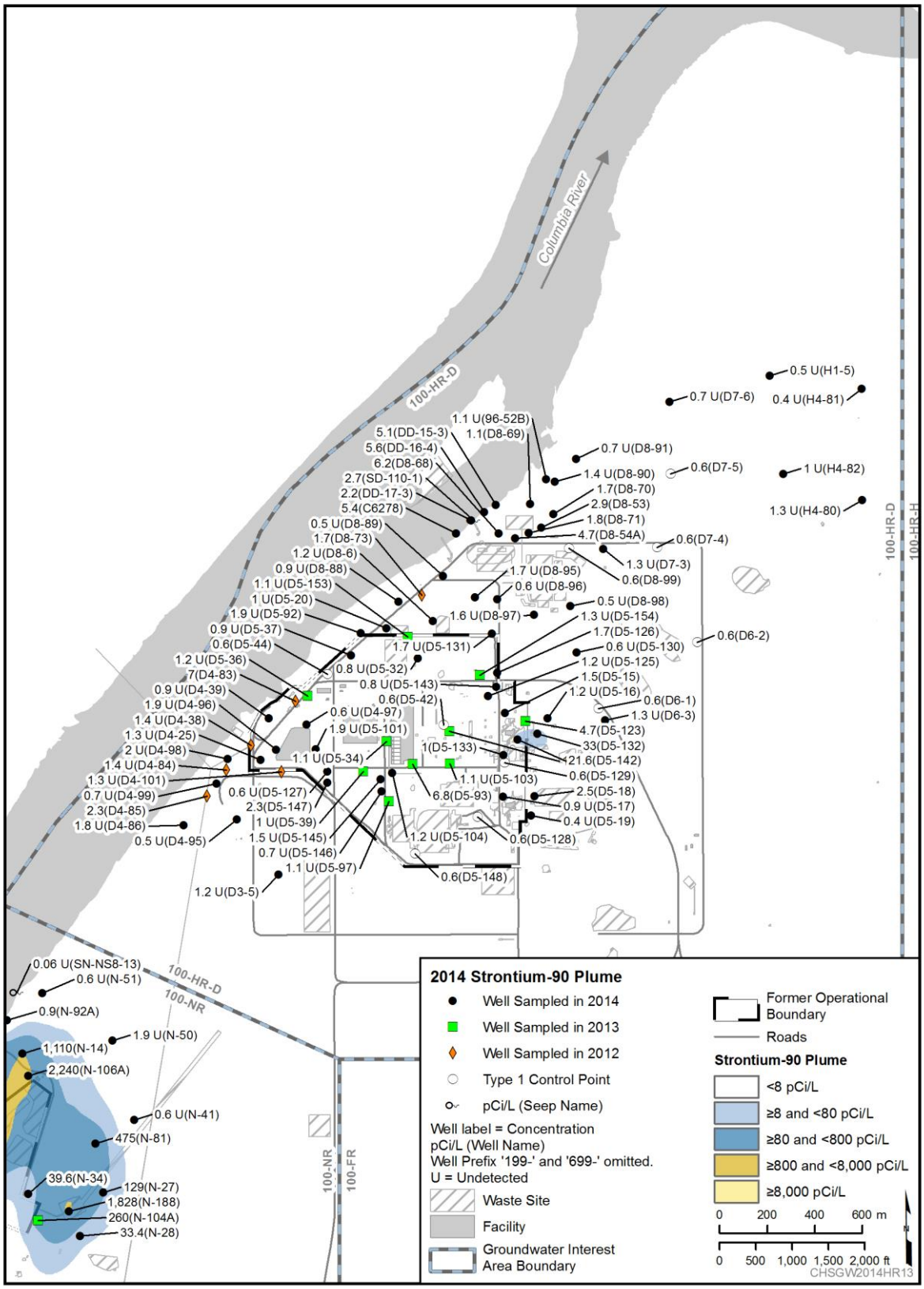


Figure 4-25. 100-HR-D Strontium-90 Plume, 2014

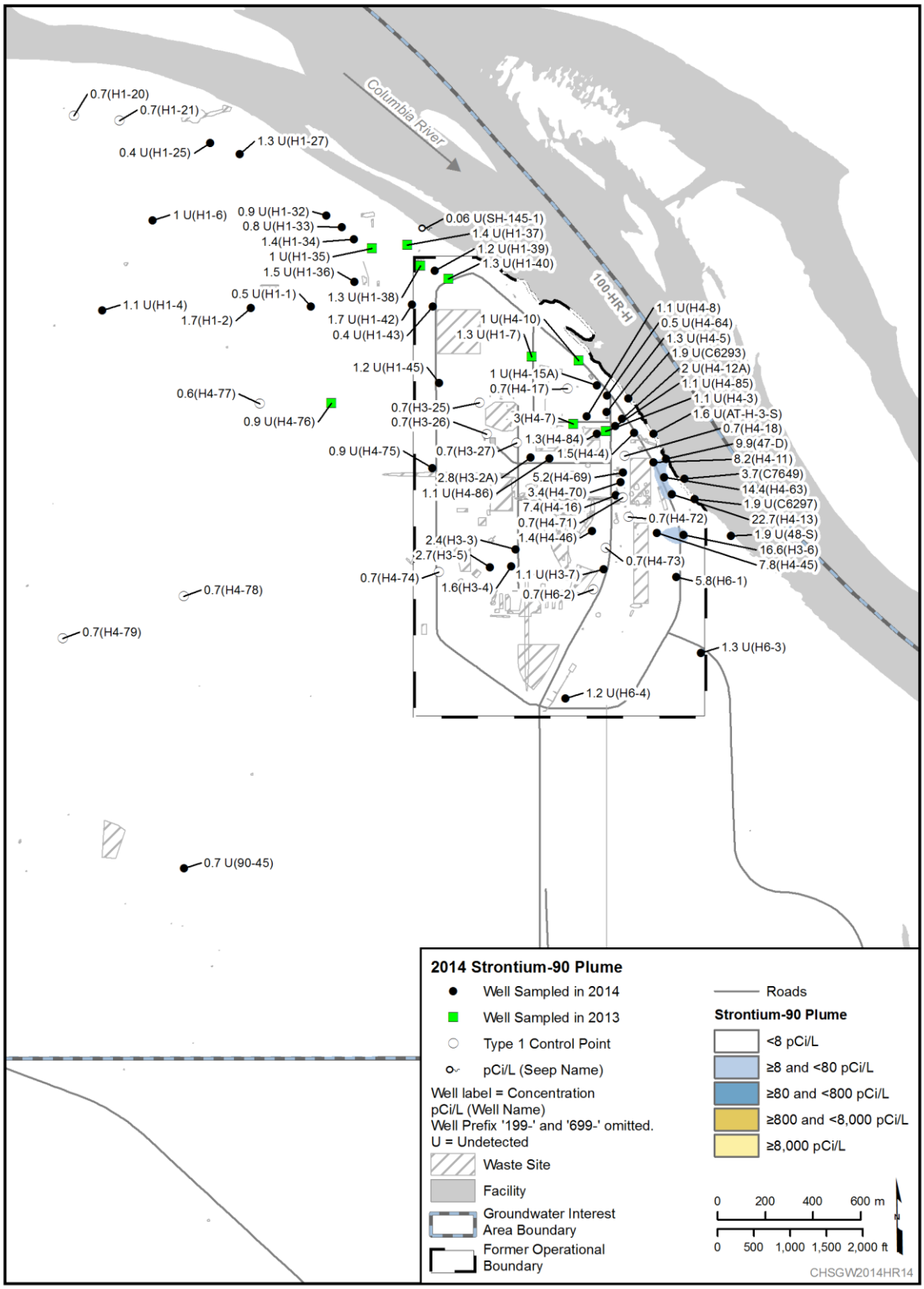


Figure 4-26. 100-HR-H 2014 Strontium-90 Plume, 2014

Historically, two wells to the northeast of D Reactor (199-D5-15 and 199-D5-143) exhibited strontium-90 in groundwater at concentrations less than 8 pCi/L. These observations suggest that strontium-90 in groundwater has been attenuated as the plume moves away from the source area(s) near the reactor.

Aquifer tube samples from the northern portion of 100-D near the 116-D-7 and 116-D-9 Retention Basins were also analyzed for strontium-90 in fall 2014. Strontium-90 was detected in most of the tubes near the basins. The highest detected activity was in DD-16-4, at 5.57 pCi/L. This is consistent with previous years.

Strontium-90 concentrations in 100-H groundwater continue to exceed the DWS near the former 116-H-7 Retention Basin and 116-H-1 Trench (Figure 4-27), located near the Columbia River to the east of H Reactor. Concentrations ranged from 5 to 17 pCi/L in 2014. This is the only area in 100-H with strontium-90 above the DWS, and concentrations remain fairly stable with some seasonal variation and a slight downward trend. Strontium-90 continues to be detected in aquifer tubes along the river shore, with aquifer tube 47-D exceeding the DWS with a concentration of 9.86 pCi/L in 2014. As compared to 2013, there was relatively little change in plume shape or concentrations. The highest strontium-90 concentration detected in 100-H during 2014 was 26 pCi/L in Well 199-H4-13 (March 2014). This monitoring location is close to the Columbia River (within 66 m [218 ft]); the nearest downgradient aquifer tube (C7650) exhibited strontium-90 at about 2 pCi/L in 2014, suggesting that some degree of attenuation of strontium-90 occurs in this vicinity.

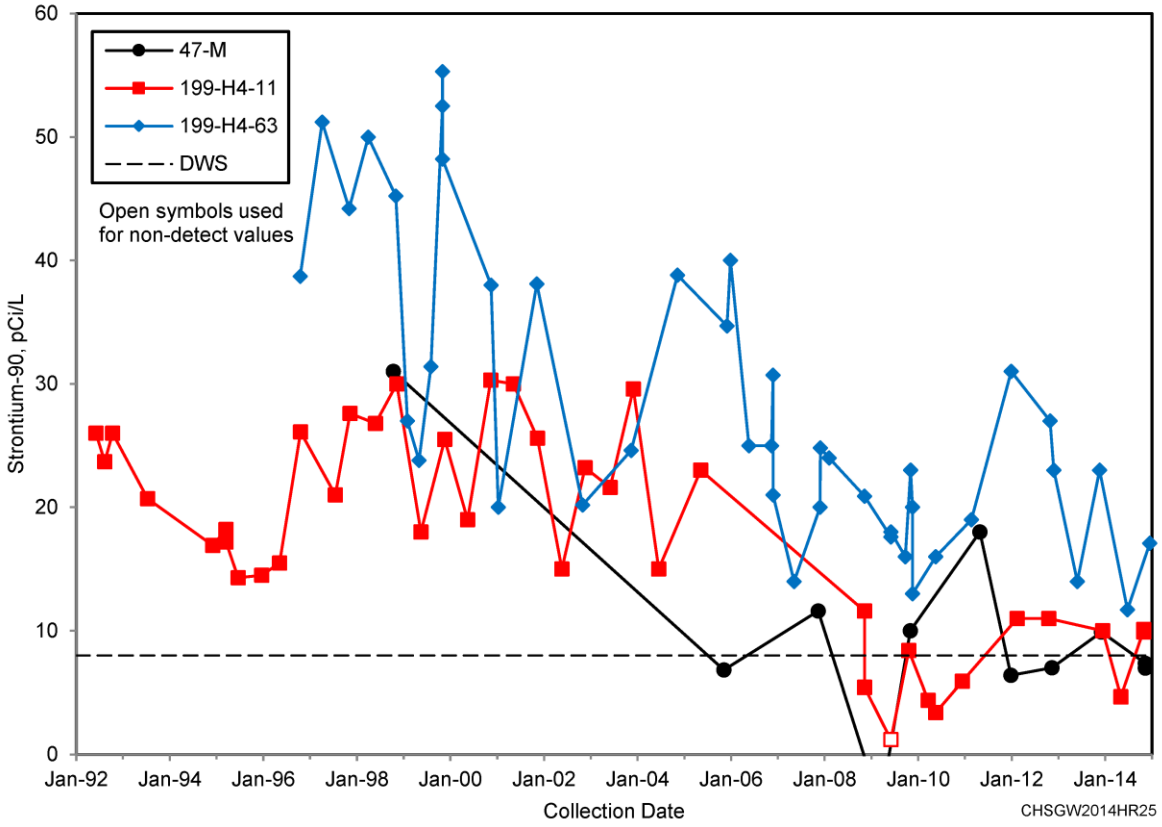


Figure 4-27. 100-HR Strontium-90 Data in Wells near 116-H-1 and 116-H-7

None of the RUM wells are located within the footprint of the 100-H or 100-D strontium-90 plume where concentrations are greater than 8 pCi/L (DWS). In addition, none of the RUM wells had strontium-90 reported above the minimum detectable activity during 2014. Unlike the 2013 results, which did show some low-level detections in 100-H, the 2014 results are consistent with historical data.

4.7 Tritium

Tritium has historically been detected at concentrations near or over the DWS of 20,000 pCi/L in the southern area of 100-D. Well 199-D4-20 had a tritium concentration of 20,400 pCi/L in 2014, which exceeds the DWS (20,000 pCi/L) and was the highest concentrations in 100-HR. This well is located in the area of historic detections. Concentrations of tritium in this well have been slowly increasing since 2007.

Tritium has been historically detected above 20,000 pCi/L near the ISRM barrier in the southern portion of 100-D and near the DR Reactor. Overall, concentrations had declined to below 20,000 pCi/L in 2011, and remained below the DWS during 2012. However, in 2013 tritium concentrations in Well 199-D4-20, upgradient from the ISRM barrier, were reported at 20,000 pCi/L. In 2014, the tritium concentrations in Well 199-D4-20 increased to 20,400 pCi/L, exceeding the DWS. Seven wells in 100-D had concentrations above 5,000 pCi/L during 2014, all located in the southern portion of 100-D. Only Wells 199-D4-20, 199-D4-15, and 199-D4-15 had concentrations above 10,000 pCi/L in 2014. Well 199-D4-101 had a concentration of 14,000 pCi/L in 2012 but was not sampled in 2013 or 2014. Tritium concentrations over the past 3 years at 100-D are presented in Figure 4-28.

The source of tritium observed in groundwater in the southern portion of 100-D Area has not been confirmed; several possible sources exist related to historical operations. The tritium may have originated from the 118-D-2 Burial Ground, which experienced a fire in 1958; large quantities of water were applied to extinguish the fire and could have leached contaminants, including tritium, into the underlying formation. During operation of D and DR Reactors, a large recharge mound formed beneath the cooling water retention basins and the emergency trench. This mound could have created a local flow regime beneath D Area that may have caused tritium released from the reactor areas, or the retention basin area, to migrate southward. The tritium concentration in groundwater at Well 199-D4-20 is consistent with concentrations observed over the past decade in wells near 105-DR Reactor (e.g., 199-D5-18 and 199-D5-17). One additional potential source of tritium in the southern 100-D Area is historical operations at 100-N Area. After the D and DR Reactors shut down, a northward groundwater gradient driven by the recharge mound beneath the radioactive waste water trenches at 100-N Area could also have contributed tritium to the southern portion of 100-D Area. Monitoring of tritium in groundwater at 100-D will continue. The tritium concentrations in 100-NR-2 were below 20,000 pCi/L by late 2008 (DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008)* indicating that it is an unlikely source area for this recent increase.

In the Horn and 100-H, the highest concentrations of tritium were in Well 699-94-43 at 3,500 pCi/L and in Well 199-H4-77 at 3,670 pCi/L. Both of these wells are located in the central Horn area, within the area having higher hexavalent chromium concentrations. The likely source of this tritium is from reactor operations at 100-D and discharge to the 116-DR-1&2 Trench in 1967.

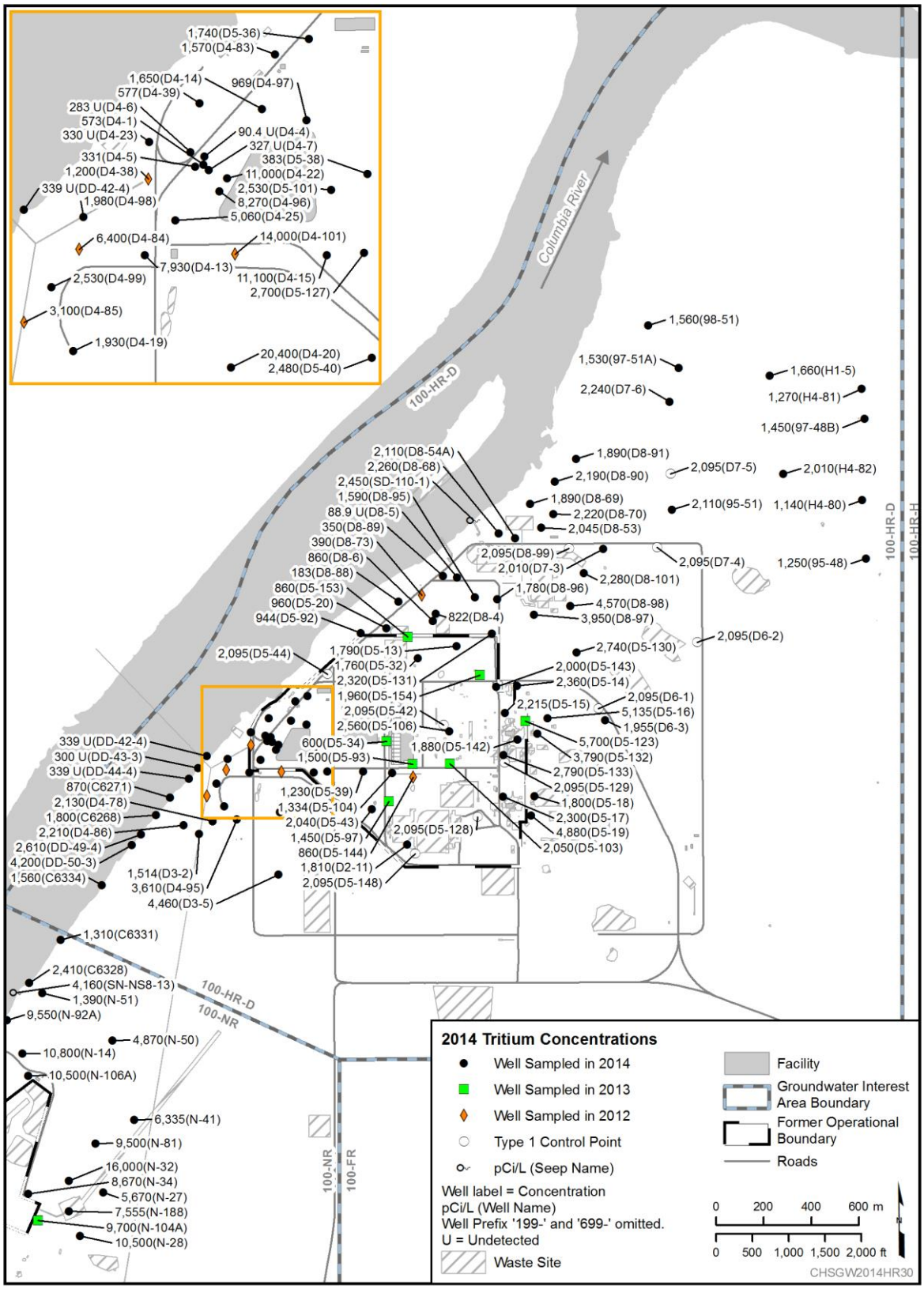


Figure 4-28. 100-HR-D Tritium, 2014

4.8 Uranium

Uranium is present in groundwater near the former 183-H Solar Evaporation Basins in 100-H (Figure 4-29 presents average uranium concentrations in 100-H Area for 2014). The overall 183-H RCRA facility is discussed in Section 4.11. Since 2012, uranium has been detected above 10 µg/L in four wells, all associated with the 183-H basins. Well 199-H4-85 had the highest annual average uranium concentration (13.9 µg/L), with little seasonal variability. Uranium has been detected above the DWS of 30 µg/L in the area of the 183-H basins in only one well since 2012. In 2014 uranium concentrations in Well 199-H4-84 ranged from about 3 µg/L in January to 52.1 µg/L in July. Like hexavalent chromium, uranium concentrations in this well increase with water levels, resulting in higher values during the summer months (Figure 4-30).

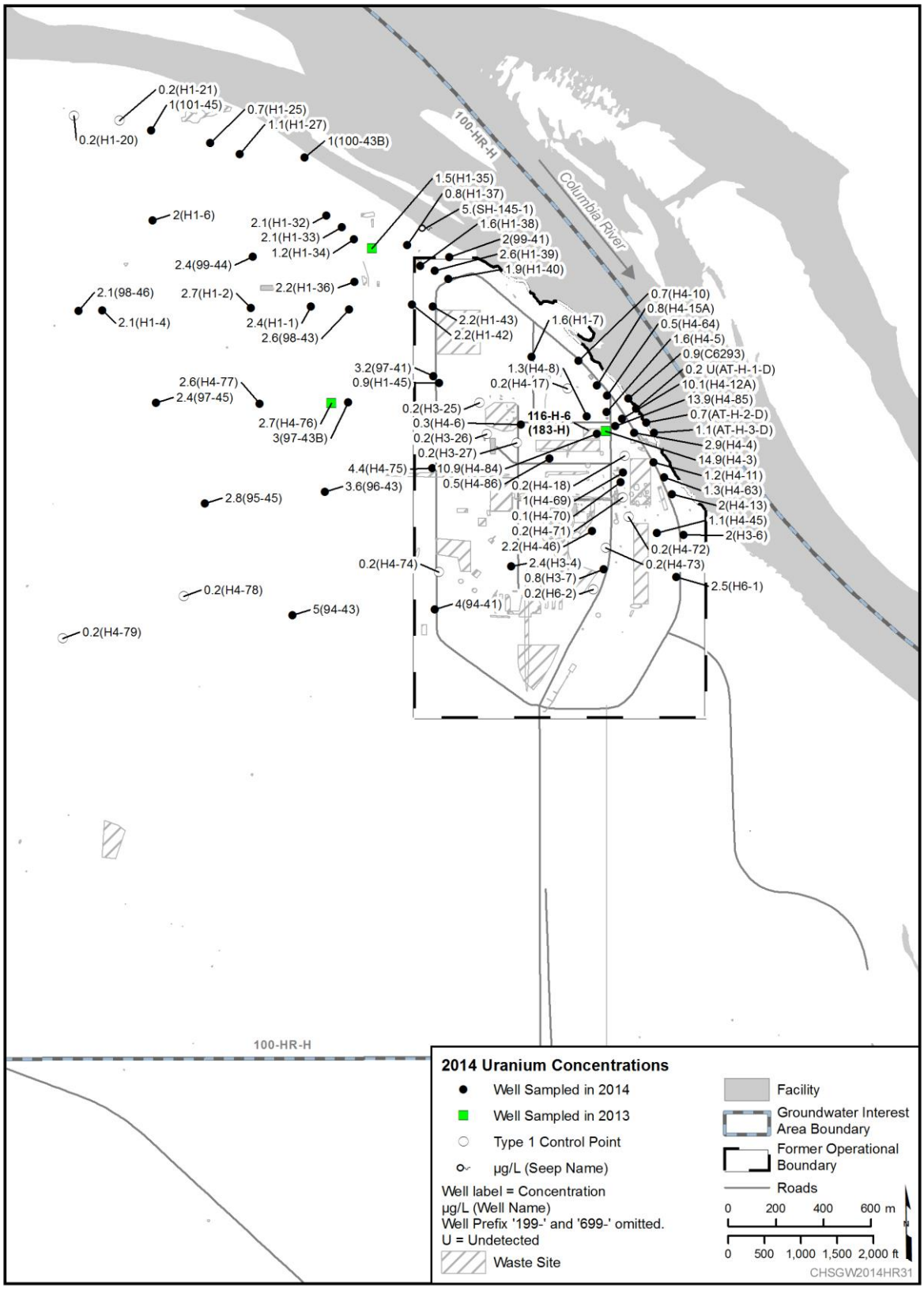


Figure 4-29. 100-HR-H Uranium, 2014

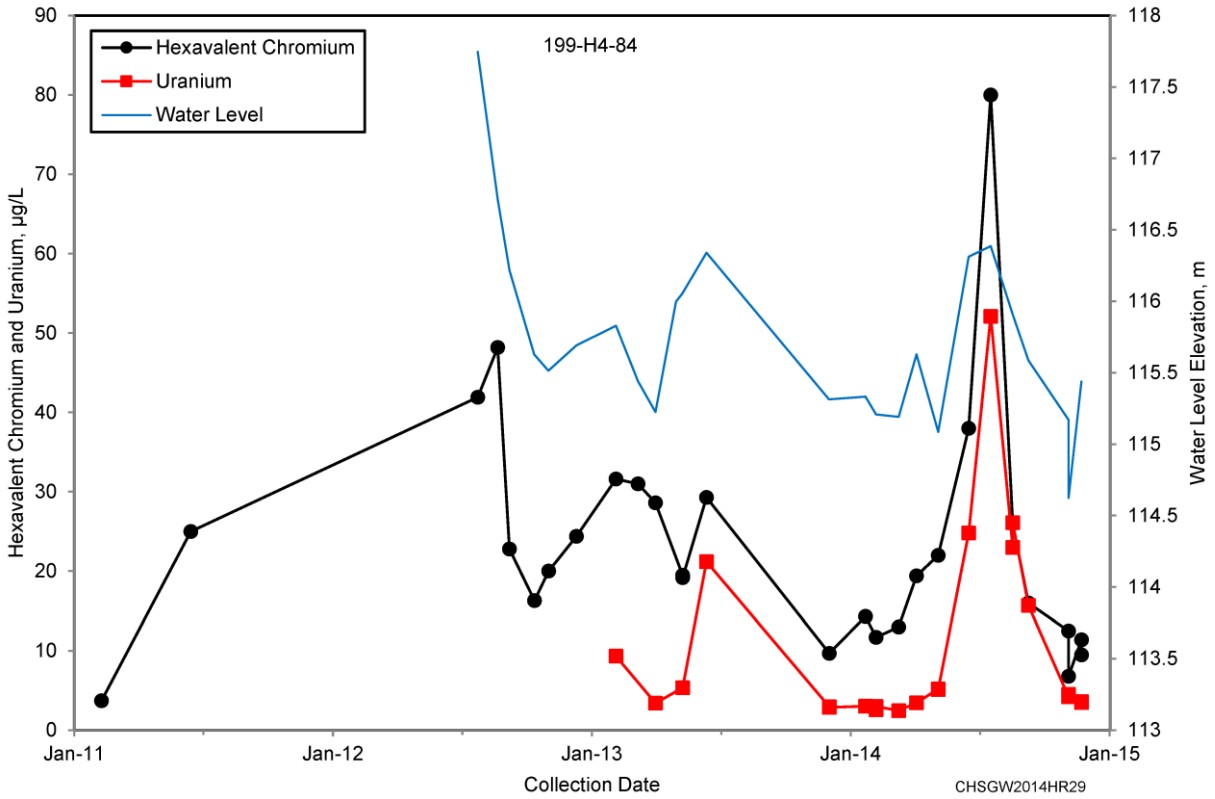


Figure 4-30. Uranium and Hexavalent Chromium in Well 199-H4-84.

4.9 Sulfate

The area around the ISRM barrier in 100-D has historically had elevated levels of hexavalent chromium and sulfate. Sulfate previously exceeded the 250 mg/L secondary DWS in wells within and downgradient of the ISRM barrier as a result of the sodium dithionite solution injections. There were no exceedances of the sulfate DWS at the ISRM barrier during 2014.

Sulfate is being detected at increasing levels in wells located near injection wells. Groundwater that has been treated in the DX P&T system is affected by the addition of sulfuric acid, changing the sulfate concentrations. The acid is used to lower the pH in the influent groundwater because the ResinTech® SIR-700 ion exchange resin treatment technology used to remediate hexavalent chromium is more efficient at a lower pH. Sodium hydroxide is added to the treated groundwater prior to re-injection into the aquifer to neutralize the acid and return to pH to near neutral; however, sulfate concentrations in the effluent are near the DWS, altering the sulfate concentration of the aquifer in the vicinity of the injection wells. The aquifer sulfate concentrations now appear to be stabilizing in areas near injection wells at levels above 200 mg/L, but below the secondary DWS of 250 mg/L.

During 2014, the highest concentrations of sulfate were in the four temporary wells installed at the base of the 100-D-100 waste site excavation (199-D5-155, 199-D5-156, 199-D5-157, and 199-D5-158). These wells are located downgradient from injection Well 199-D5-148. At least one sample from a port in these wells exceeded the sulfate DWS in 2014. The wells are now decommissioned and the waste site is being backfilled in early 2015. Other wells with high sulfate concentrations are also located near or downgradient from an injection well. Those wells with concentrations over 210 mg/L are: 199-D2-11, 199-D5-106, 199-D5-97, 199-D6-3, and 199-D8-101.

4.10 Remedy Summary

Both active (groundwater P&T; Figure 4-31) and passive (ISRM; Figure 4-33) interim remedial actions continued to address hexavalent chromium contamination within the 100-HR-3 OU. The ISRM barrier is monitored but no longer maintained. DOE has been operating a groundwater P&T system in the 100-HR-3 OU since 1997 under an interim remedial action ROD (EPA/ROD/R10-96/134), which was amended in 2000 (EPA/AMD/R10-00/122).

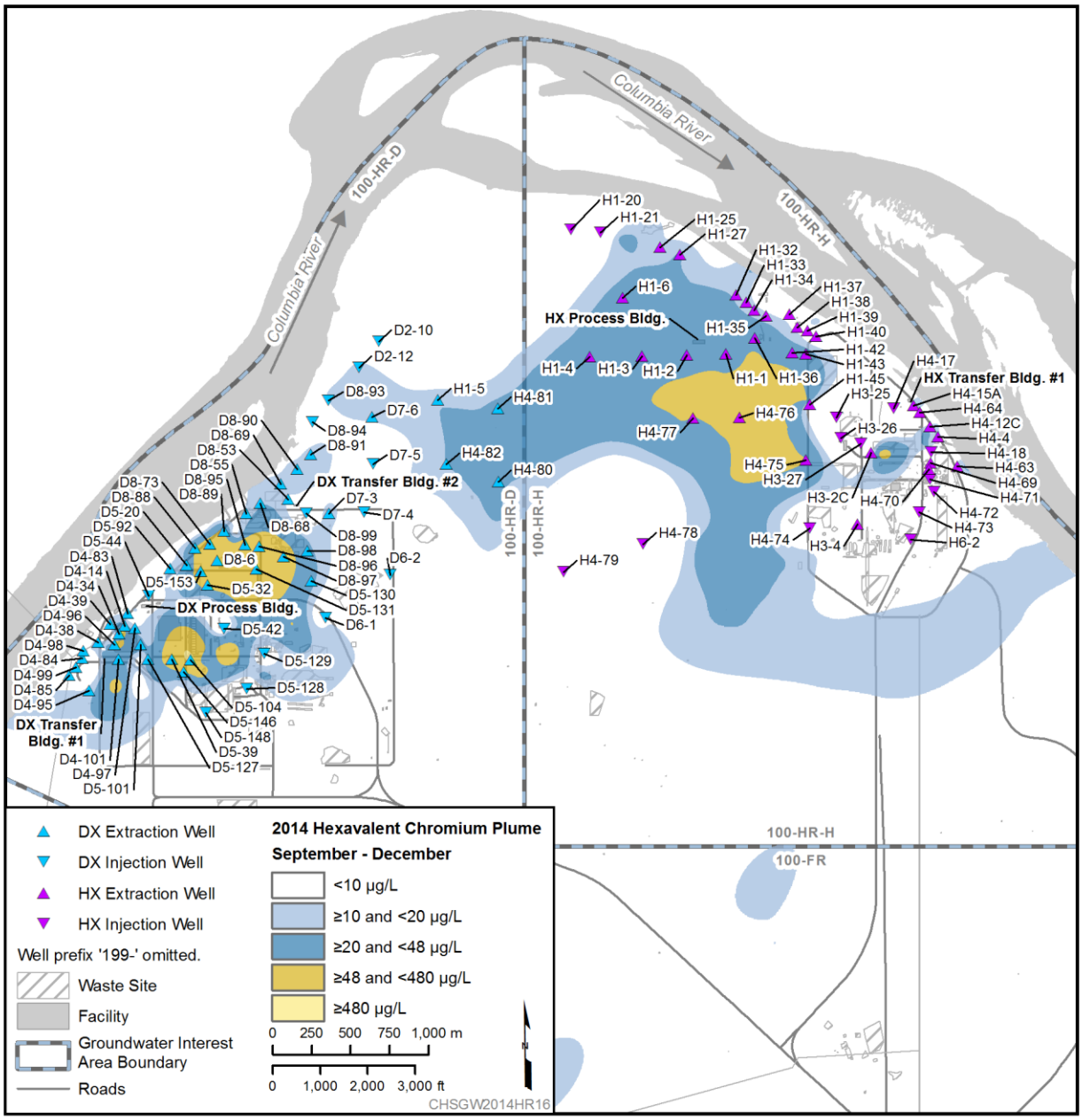


Figure 4-31. 100-HR-3 Remedy Overview

A summary of 2014 operations is provided in Table 4-2. Two P&T systems currently operate at 100-HR-3: DX and HX. These facilities were constructed in response to an explanation of significant difference (ESD) (EPA et al., 2009, Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington), which expanded the capacities of the P&T system and replaced the existing older DR-5 and HR-3 systems. These systems are described in previous P&T reports (e.g., DOE/RL-2010-11).

Table 4-2. Summary of 2014 100-HR-3 P&T

Groundwater Operable Unit	100-HR-3	
P&T System	**DX**	**HX**
Design capacity (L/min [gpm])	2,271 (600)	3,028 (800)
Extraction wells	44	31
Injection wells	10	14
Average flow rate (L/min [gpm])	2,230 (589)	2,237 (591)
Volume treated (million L [million gal])[a]	1,173 (309.8)	1,177 (310.9)
Hexavalent chromium mass removed (kg) [a]	178.7	22.8
Average hexavalent chromium influent concentration (µg/L)[b]	144.6	20.3
Average hexavalent chromium effluent concentration (µg/L)[b]	<2	<2

a. Total volume and mass of all systems since startup are: 2,240 kg from 12,927 million L (3,415 million gal).
b. Based on field and laboratory measurements

4.10.1 Pump-and-Treat

Due to continuing and effective remediation, the mass of chromium remaining in the aquifer is declining. As a result, the mass being removed from the groundwater each year continues to decline. Most of the hexavalent chromium mass removed from the DX and HX systems during 2014 originated in the interior of the plumes where concentrations are higher. The overall areal extent of the plumes, as defined by the 10 µg/L contour, did not change significantly in 2014; however, the 48 µg/L and 480 µg/L contours illustrate the plume response to remediation (Figures 4-9 and 4-10). Operation of remediation systems and groundwater monitoring results are described in *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05).

In 2014, the combined systems removed 202 kg of hexavalent chromium from 2,350 million liters (621 million gal) of groundwater. From 1997 through 2014, the combined 100-HR-3 P&T systems removed 2,240 kg of hexavalent chromium from the 12,927 million liters (3,415 million gal) of groundwater. Over one-half (63 percent) of this mass was removed by the DX system, which alone has removed 1,403 kg of hexavalent chromium since operations started in late 2010. Figure 4-32 presents the mass removed by system. Mass removal is slowing, however, as the high concentration areas are being remediated and the overall remaining concentrations have declined.

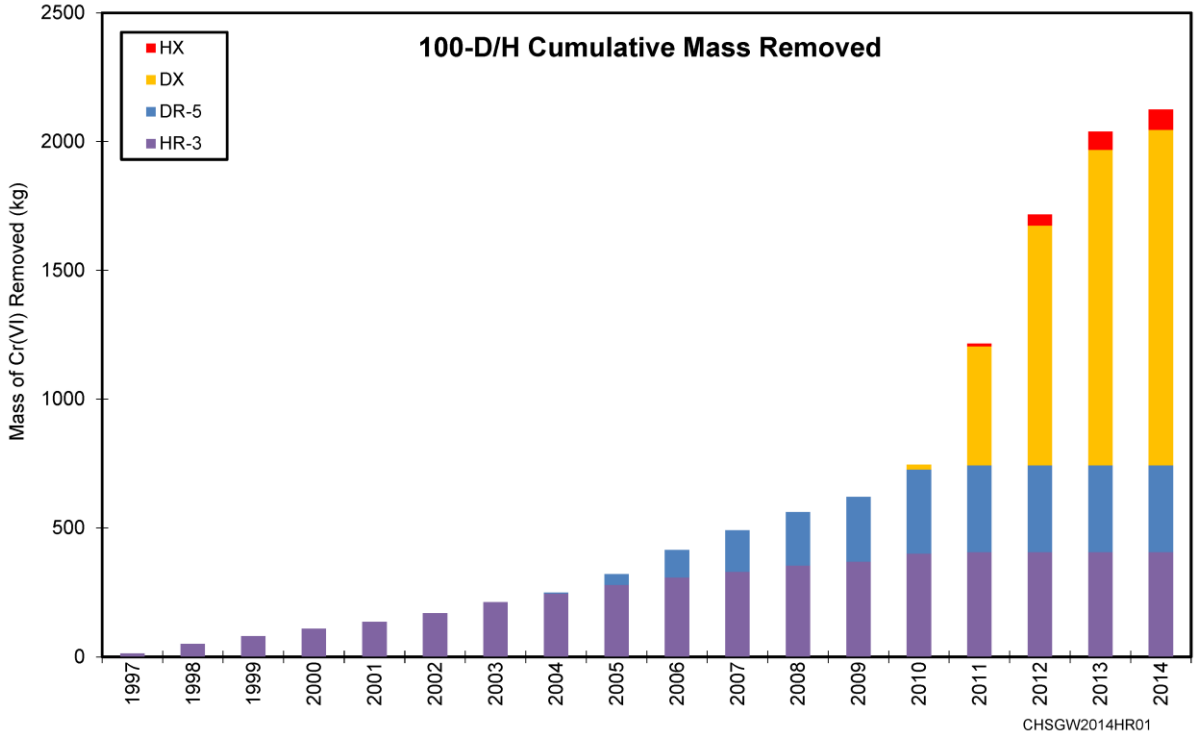


Figure 4-32. 100-HR-3 Pump-and-Treat Mass Removal

A total of 75 active extraction wells and 24 active injection wells operated during 2014, including those that were only operating a short time during the year. System realignments included turning off four previously used injection wells at DX due to poor performance. Those wells are still connected to the system. In addition, Well 199-D5-148 was added as an injection well, Wells 199-D5-146 and 199-D5-153 were added for extraction, and Well 199-D8-55 was converted from an injection well to an extraction well in 2014. Well 199-D5-153 was added to address an area of higher concentrations in the 100-D northern hexavalent chromium plume and to increase capture. Well 199-D8-55 was converted to increase capture along the river in the far north area of 100-D. Operation of remediation systems and groundwater monitoring results are described in DOE/RL-2015-05.

4.10.2 In Situ Redox Manipulation Barrier

In 2000, an in situ chemical treatment technology was added to the existing P&T remedy in the form of an ISRM barrier (Figure 4-33). Due to breakthrough of contaminants at the ISRM barrier, a notice of nonsignificant change to the ROD was issued in 2010, which indicated that the barrier would no longer be actively maintained (11-AMCP-0002). The notice of nonsignificant change shifted the groundwater remedy at the ISRM barrier to the P&T system. Groundwater at the ISRM site is still monitored, however, as part of CERCLA interim action monitoring, with hexavalent chromium as the target contaminant. In addition, where it is still slightly effective, the barrier treatment process reduces oxygen content in the aquifer; consequently, dissolved oxygen is also monitored.

The ISRM barrier continued to convert some hexavalent chromium to a nontoxic, immobile form (trivalent chromium) in the southern portion of the barrier during 2014 as suggested by the dissolved oxygen profile. The dissolved oxygen profile near the ISRM treatment zone is generally characterized by relatively high dissolved oxygen concentrations upgradient of the treatment zone, decreasing significantly through the treatment zone, and recovering to higher dissolved oxygen concentrations as groundwater flow approaches the river. Dissolved oxygen data indicate the barrier is becoming less effective; however the P&T system capture is improving in that area due to system modifications.

Groundwater samples collected from some wells in the ISRM barrier in 100-D contain concentrations of gross beta above 50 pCi/L, which is the level where additional monitoring is required. This gross beta activity is primarily caused by naturally present potassium-40 in the pH buffer that was used during injection of sodium dithionite (Section 2.5 of PNNL-13116). The highest gross beta concentration associated with the ISRM barrier in 2014 was 82 pCi/L in 199-D4-19, which is consistent with recent levels.

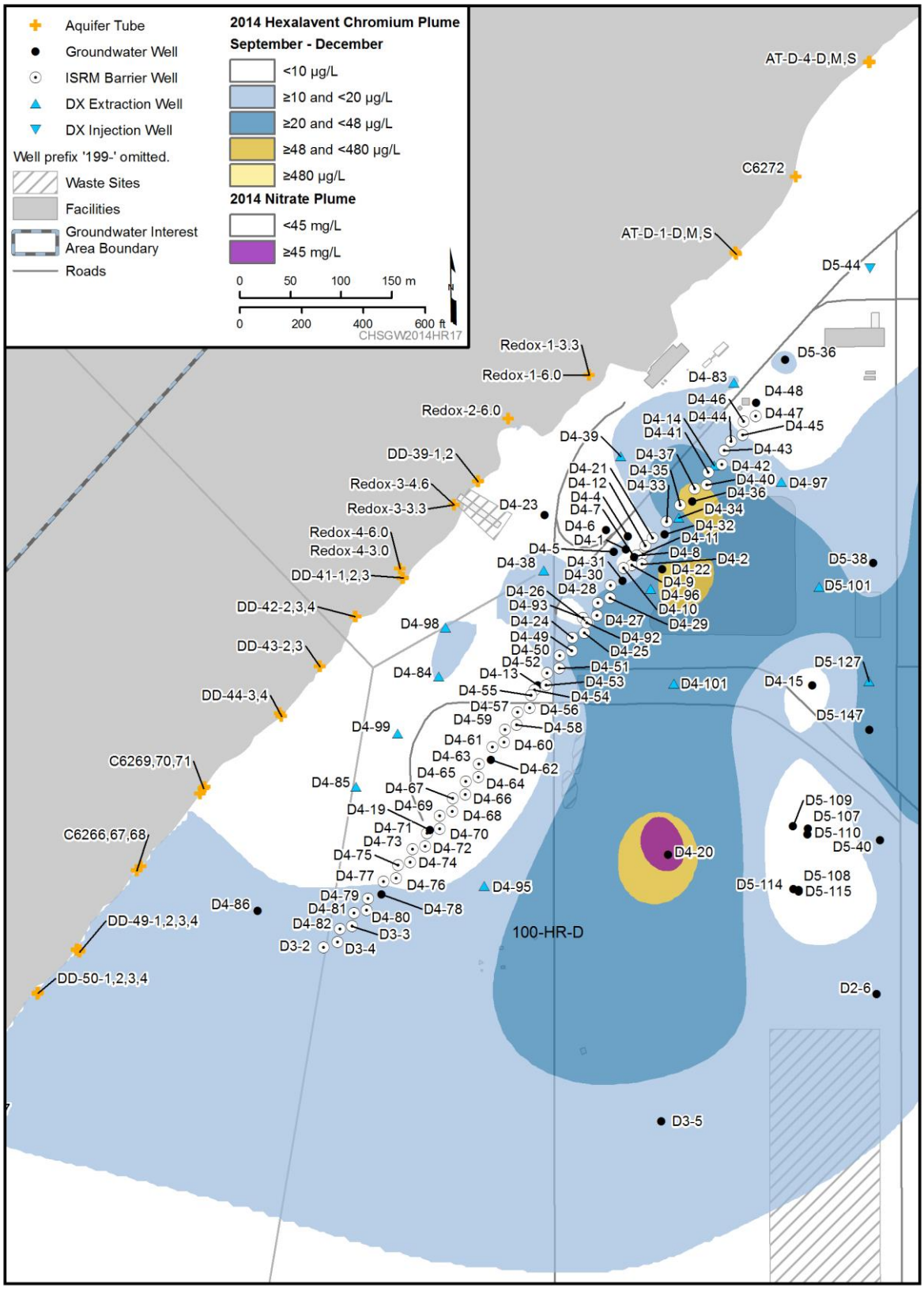


Figure 4-33. 100-HR-3 IRSM Barrier

4.11 RCRA Monitoring

The 183-H Solar Evaporation Basin (Figure 4-34) site is a RCRA TSD unit that consisted of four basins. The basins were originally part of the larger 183-H water treatment facility, which had 12 additional basins. Following decommissioning of the water treatment facility, the four remaining basins were used to evaporate various liquid waste streams, including neutralized, spent acid etch solutions from the 300 Area fuel fabrication facilities. The waste solutions contained various contaminants (e.g., chromium, nitrate, technetium-99, and uranium). The basins were used for waste evaporation from July 1973 until November 1985, demolished in 1995, and contaminated soil was removed from the surface to a depth of 7.6 m (25 ft) bgs beneath the site in 1996.

Groundwater protection was demonstrated through modeling and a modified RCRA closure (soil) was approved in 1997. Clean closure of the site has not been achieved because fluoride and nitrate levels in soil below the 4.6 m (15 ft) deep excavation exceed the "Model Toxics Control Act–Cleanup" (WAC 173-340) Method B cleanup levels for groundwater protection. Therefore, the unit was closed under the modified closure option, with specified measures for post-closure care.

The site is a post-closure unit in the Hanford Facility RCRA Permit (WA7890008967). Part VI, Chapter 3, Section 3.1.1.2 of the Permit, "WAC 173-303-645(5) Concentration Limits," identifies Permit limits for dangerous waste constituents (chromium and nitrate) and waste indicators (fluoride, technetium-99, and uranium) and requires annual groundwater monitoring of those constituents. Hexavalent chromium is also monitored, although not specifically required by the Permit. The RCRA wells were sampled as scheduled for the constituents of interest listed in the groundwater monitoring plan (PNNL-11573; Tables B-12 and B-14, Appendix B).

The groundwater gradient at the basin is 0.0039 m/m to the northeast, essentially perpendicular to the river. The extents of the chromium and nitrate plumes were discussed previously. Fluoride has not been detected above the Permit limit (1,400 µg/L) since 1999 (199-H4-3) and technetium-99 has not been detected above its DWS (900 pCi/L) since 2005 (199-H4-9).

The current RCRA monitoring wells are Wells 199-H4-8, 199-H4-12A, 199-H4-12C, and 199-H4-84. Uranium concentrations exceeded both the DWS (30 µg/L) and Permit limit (20 µg/L) in July 2014, with a result of 52.1 µg/L in Well 199-H4-84. The uranium concentrations were above 20 µg/L during both June and August but below the DWS, with results of 24.8 and 26.1 µg/L, respectively. Contaminant concentrations in Well 199-H4-84 are directly correlated with water levels with higher concentrations realized during high river stage. By September, both chromium and uranium concentrations had declined, with uranium concentrations down to 15.7 µg/L. Concentrations were below Permit limits for chromium (122 µg/L), nitrate (45 mg/L), and technetium-99 (900 pCi/L) in 2014.

DOE submitted two semiannual reports to Ecology, as required under RCRA corrective action monitoring for the 183-H Solar Evaporation Basins (SGW-58475; SGW-58600; *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins and the 300 Area Process Trenches: January – June 2014; July – December 2014*). The unit will remain in corrective action monitoring until the groundwater contamination is remediated under CERCLA.

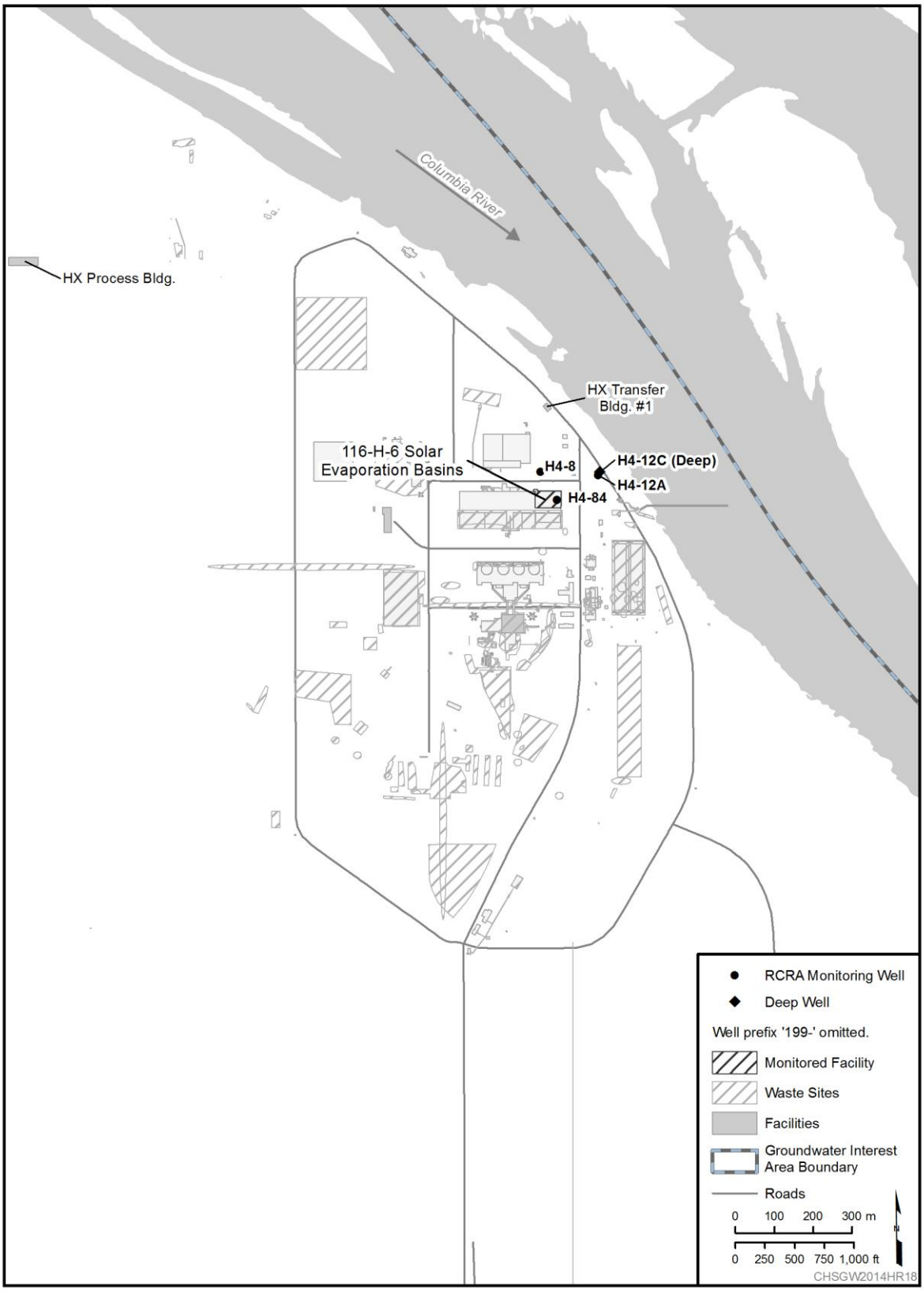


Figure 4-34. 100-HR RCRA Facility 183-H Monitoring Well Location

This page intentionally left blank.

5 100-KR

5.1 Overview

The 100-KR groundwater interest area includes the 100-KR-4 OU and an adjacent region to the east. Groundwater in 100-KR was contaminated by waste releases associated with past operations of the KE and KW Reactors and from associated support facilities. At the end of 2014, approximately 59 percent of the waste sites were classified as closed, interim closed, no action, or not accepted or rejected, with approximately 37 percent having undergone active remediation. Removing contaminants from the vadose zone eliminates secondary sources of contamination that could migrate to groundwater and reduces the risk of direct exposure at the surface.

Table 5-1 lists key facts about 100-KR. Additional details about 100-KR history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the RI/FS for the K Reactor area source and groundwater OUs (DOE/RL-2010-97, Draft A). Waste sites known or suspected to have contributed to observed groundwater contamination at 100-KR include 183-KE and 183-KW Head House tank farms, 116-KE-1 and 116-KW-1 Gas Condensate Cribs, 116-KE-3 and 116-KW-2 Fuel Storage Basin Cribs/Reverse Wells, 116-K-1 Crib, 116-K-2 Trench, and 118-K-1 Burial Ground. Figure 5-1 shows the locations of key features in 100-KR and the inferred groundwater elevation contours generated from the measurements collected in March 2014. Section 1.3 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

The unconfined aquifer in 100-KR ranges from 5.2 to more than 32 m (17.1 to 105 ft) thick. This aquifer is primarily present in the Ringold Formation unit E sand and gravel (Figure 5-2). This unit is overlain by the gravels and interbedded sand and silt of the Hanford formation, which comprise the bulk of the vadose zone. The vadose zone ranges from less than 1 m (3.3 ft) thick near the Columbia River to 32 m (105 ft) thick inland. The uneven surface of the silt- and clay-rich RUM forms the bottom of the unconfined aquifer. Contaminant concentrations are generally highest within the uppermost portion of the aquifer near the water table, however, mobile contaminants (e.g., hexavalent chromium) have been detected over the entire aquifer thickness, particularly near source areas.

Groundwater in 100-KR flows generally to the northwest toward the Columbia River, which forms a discharge boundary for the unconfined aquifer. Operation of P&T systems at 100-KR creates changes in groundwater flow direction and velocity. These changes are expressed as depressions and mounds in the water table, affecting the flow direction (Figure 5-1). Larger mounds, such as that produced by the combined discharges from the KR4 and KX systems near the middle of the 116-K-2 Trench, create conditions of radial flow away from the mound. This creates local diversion of groundwater flow direction away from the natural patterns. Groundwater further inland of the 100-K Area generally flows to the north and northeast toward the 100-N and 100-D Areas. The actual flow direction and apparent velocity in this inland area is somewhat uncertain due to sparse groundwater elevation measurements in the area.

Daily and seasonal fluctuations in the river stage also affect groundwater flow in 100-KR. As would be expected, longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. Intrusion of river water into the aquifer during high river stage can lower contaminant concentrations in aquifer tubes and in some near river wells. The highest river stage in 2014 was observed in the first week of June and the first week of July. Low river-stage periods for calendar year 2014 were observed from January through February and from late August through December. The peak river stage elevation observed in 2014 (i.e., about 121.2 m [397.6 ft] above mean sea level [amsl]) was similar to the peak observed in 2013.

Table 5-1. 100-KR at a Glance

Reactor operations: KE, 1955–1971; KW, 1955–1970				
2014 Groundwater Monitoring				
Contaminant	**Water Quality Standard[a]**	**Maximum Concentration**	**Plume Area[b] (km^2)**	**Shoreline Impact[c] (m)**
Hexavalent chromium	10 µg/L[d]	3,280 µg/L (199-K-205)[e]	2.1[f]	200
Tritium	20,000 pCi/L	414,000 pCi/L (199-K-207)	0.15	0
Nitrate	45 mg/L	74 mg/L (199-K-210)	0.01	0
Strontium-90	8 pCi/L	13,200 pCi/L[g]	0.03	0
Carbon-14	2,000 pCi/L	39,500 pCi/L[g]	0.04	0
TCE	5 µg/L	6.8 µg/L (199-K-185)	0.01	0
Remediation				
Waste sites (interim action): ~ 59 percent complete[h]				
Groundwater remediation (interim ROD for hexavalent chromium): • KR4 P&T: 1997–2014, removed 373 kg • KW P&T: 2007–2014, removed 224 kg • KX P&T: 2009–2014, removed 200 kg Final ROD anticipated after 2015.				

a. Drinking water standard for all but hexavalent chromium

b. Estimated area at a concentration greater than the listed water quality standard.

c. Length of shoreline at 100-KR that is not considered to be "protected" against potential for continuing release of hexavalent chromium to the river. Other contaminant plumes do not intersect the river at concentrations above standards, based on data from wells and aquifer tubes.

d. The applicable standard is the 10 µg/L surface water quality criterion. A 20 µg/L groundwater interim action cleanup target for inland groundwater was identified in RD/RA Work Plan (DOE/RL-96-84) for interim remedial action based on an assumed 1:1 dilution of groundwater entering the river. The interim remedial action objective remains to protect the Columbia River against releases that would cause exceedance of the 10 µg/L surface water quality criterion.

e. January 2014 sample collected during drilling of new well.

f. Based on a concentration greater than the 10 µg/L surface water quality criterion. This area includes the plume within the 100-KR interest area plus approximately 0.2 km^2 of additional chromium within the 100-NR and 100-FR interest areas that is apparently attributable to 100-KR historical operations is located within 100-NR interest area. The groundwater plume area exceeding the interim groundwater target concentration of 20 µg/L at 100-K is 0.76 km^2/0.29 $mi^{2.}$

g. Maximum based on estimated migration of historical plumes.

h. Sites with status of closed, interim closed, no action, not accepted, or rejected.

ROD = Record of Decision
TCE = Trichloroethene

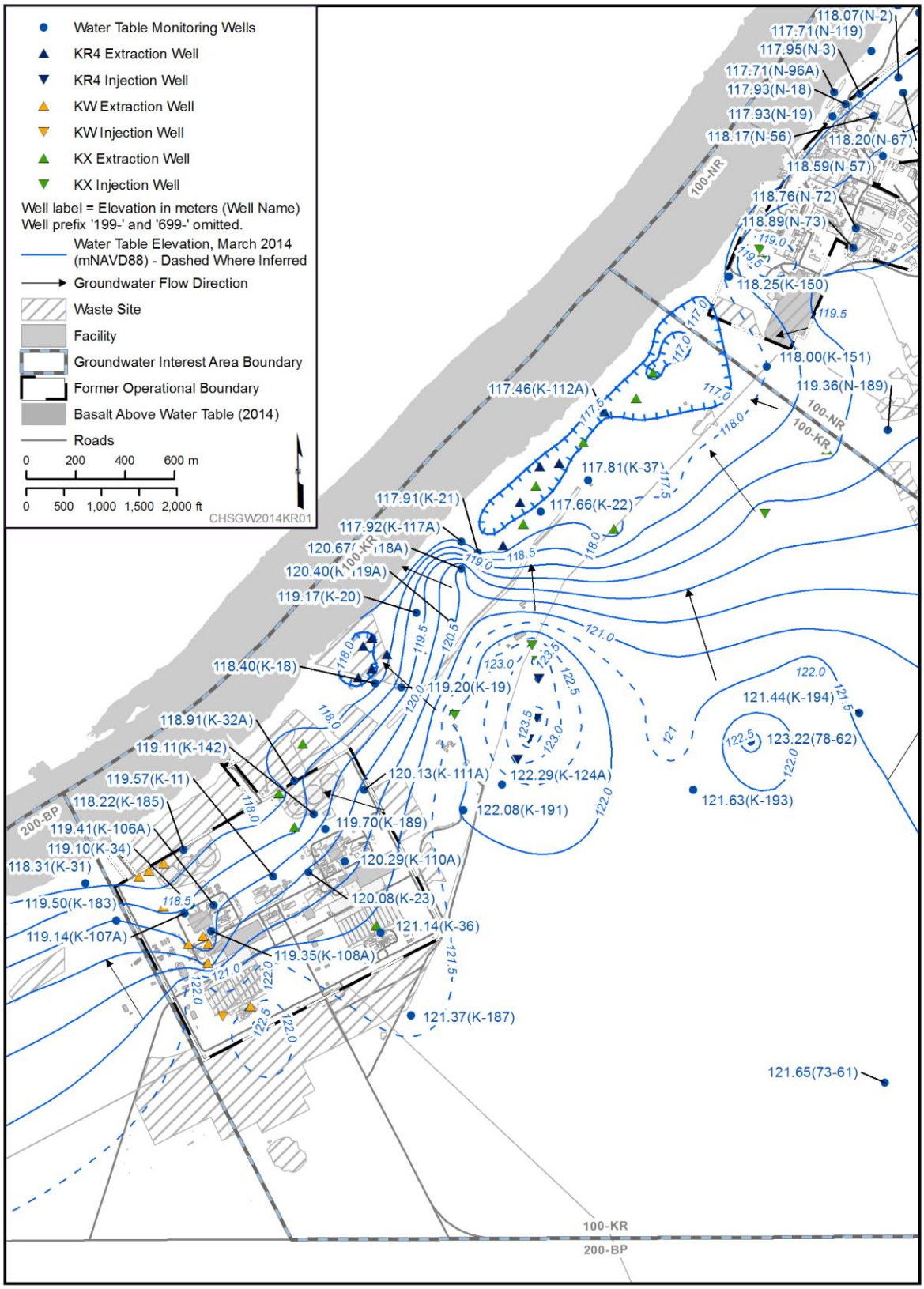


Figure 5-1. 100-KR Overview Map with 2014 Water Table

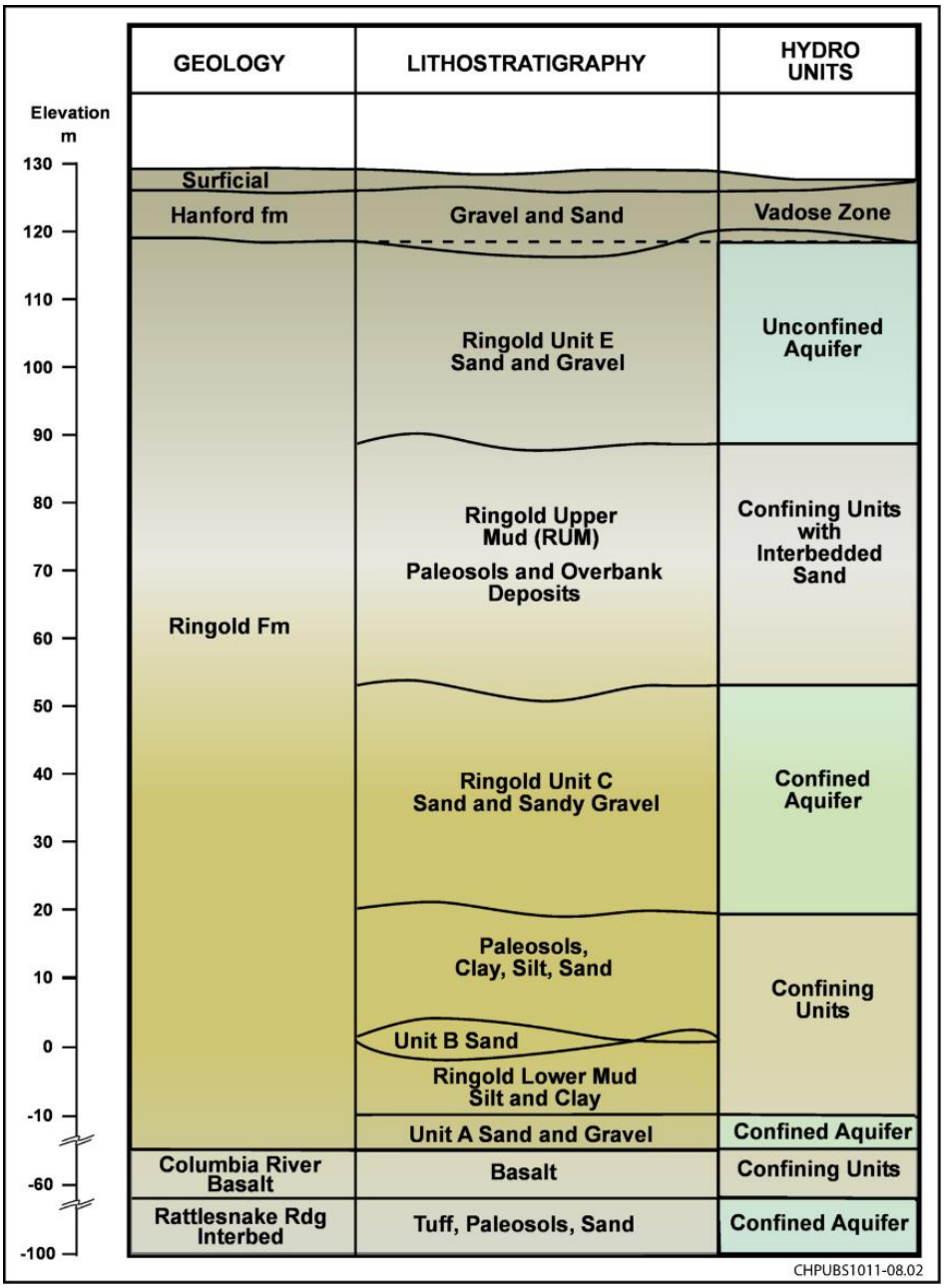


Figure 5-2. 100-KR Geology

Contaminants in the 100-KR unconfined aquifer were identified in the RI/FS and include chromium (total and hexavalent), tritium, nitrate, strontium-90, carbon-14, and TCE. Figure 5-3 shows how the plume areas have changed since 2003. Chromium in groundwater at some locations has historically been measured as total chromium (in filtered and/or unfiltered aliquots), instead of, or in addition to, hexavalent chromium. Anthropogenic chromium in groundwater at 100-KR is understood to be present as hexavalent chromium and so total chromium in filtered aliquots and hexavalent chromium are discussed as hexavalent chromium for purposes of this report.

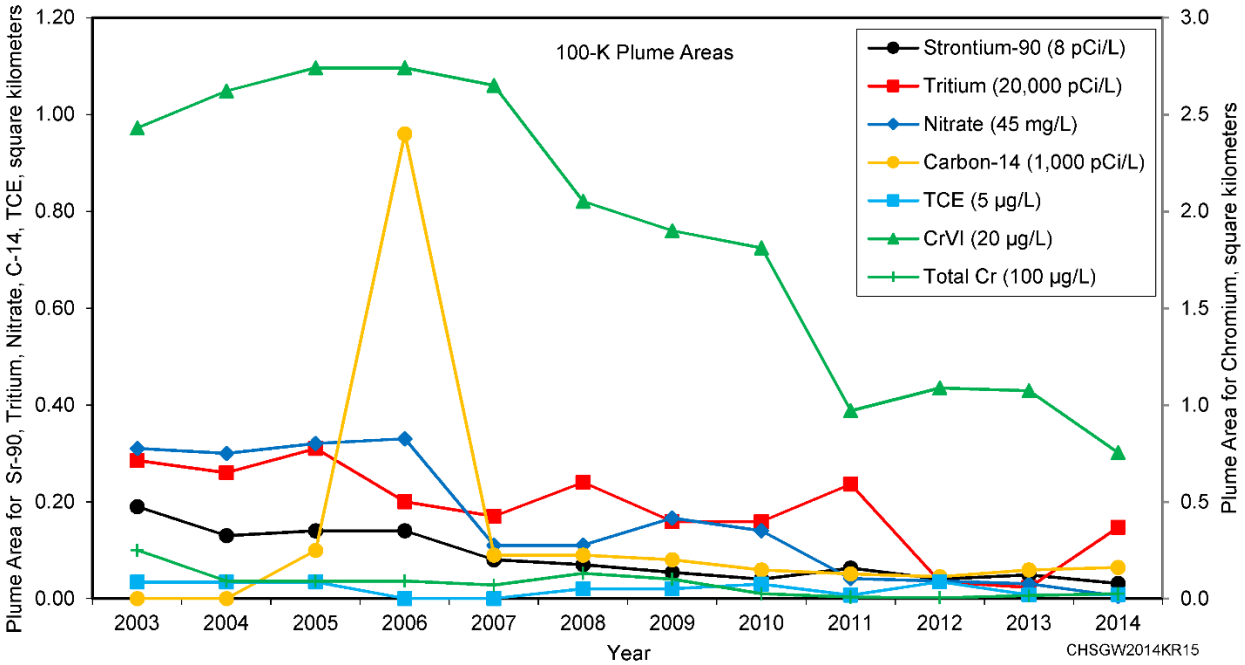


Figure 5-3. Changes in Selected Plume Areas since 2003 at 100-KR-4 OU

5.2 CERCLA Activities

CERCLA groundwater activities in 100-KR included groundwater sampling and analysis at monitoring well locations and operation of three interim groundwater remediation systems focusing on removal of hexavalent chromium (Figure 5-4; Table A-3 of Appendix A). CERCLA groundwater sampling includes monitoring interim remedial actions for effectiveness and monitoring wells throughout 100-KR to track contamination. Additional groundwater samples are collected and analyzed for identified co-contaminants of carbon-14, nitrate, strontium-90, TCE, and tritium, which are discussed separately. These constituents, which have been identified as groundwater COCs through the RI/FS process, may be captured and extracted incidentally by the interim remedial action system. They are not, however, treated by the interim action and are, therefore, considered to be co-contaminants of the hexavalent chromium, which is the primary target of the interim action. Another contaminant related to historical reactor operations at 100-KR is technetium-99. Technetium-99 is detected in groundwater within 100-KR at concentrations consistently less than 100 pCi/L, which is much less than the DWS equivalent concentration of 900 pCi/L. Technetium-99 has not been identified as a COC at 100-K.

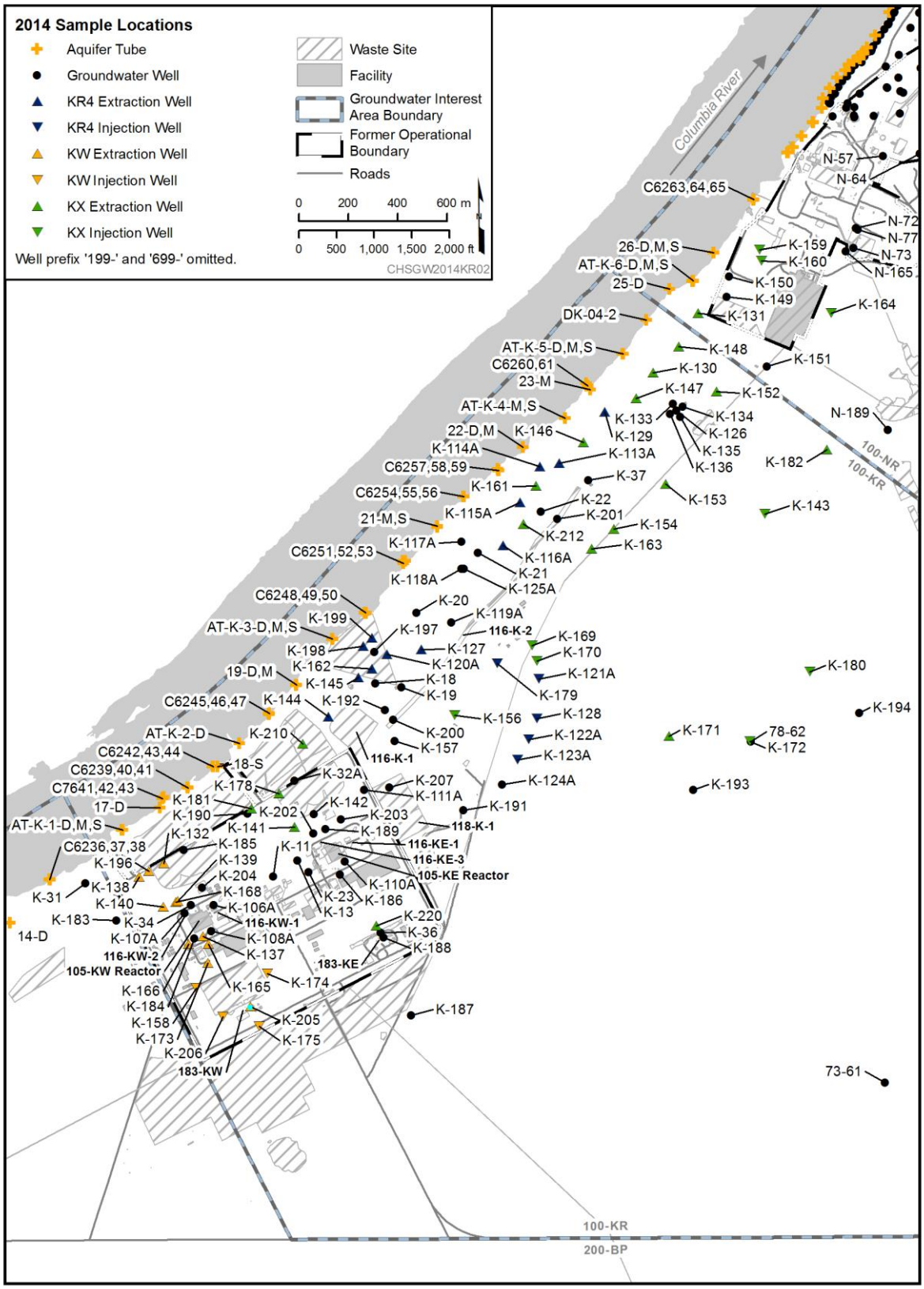


Figure 5-4. 100-KR Sampling Locations, 2014

Petroleum hydrocarbons (measured as total petroleum hydrocarbons, or TPH) have been encountered in the vadose zone during the drilling of Wells 199-K-167 (decommissioned), 199-K-173, and 199-K-186. Low levels of petroleum hydrocarbons (all less than 100 µg/L of diesel-range hydrocarbons) were detected in groundwater during 2014 at five locations. Detections of TPH were in one location in the vicinity of 105-KE and the other four were in the vicinity of 105-KW. All detections were downgradient of the reactor underground fuel oil storage tanks.

100-KR aquifer tubes are generally scheduled for annual sampling in the fall; this provides information about conditions near the river during the period of most rapid movement of groundwater toward the river. Aquifer tubes (described in Appendix C) provide samples of water from the near-river environment and hyporheic zone. Analysis of near-river samples provides information on conditions in potential exposure points for aquatic organisms. Seventy one samples were collected from 100-KR aquifer tubes during 2014.

As of December 2014, 41 extraction wells and 18 injection wells were in use for P&T groundwater remediation operations. Combined, the three systems are capable of treating more than 7.9 million L (2.1 million gal) of groundwater per day. The combined P&T systems in 100-KR removed 50 kg of hexavalent chromium from groundwater in 2014. Since 1997, the P&T systems have removed 797 kg of hexavalent chromium from the aquifer. Section 5.10 of this chapter provides additional information, and *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05) provides details.

5.2.1 Remedial Investigation/Feasibility Study

DOE submitted Draft A of an RI/FS (DOE/-RL-2010-97, Draft A) and Proposed Plan (DOE/RL-2011-82, Draft A) to EPA in 2011. EPA reviewed the documents in 2012, and DOE will incorporate the results of supplemental source characterization activities upon completion of additional investigation activities. The RI/FS report presents results of RI studies and evaluates alternatives for cleanup of the vadose zone and groundwater. Based on the observed efficacy of P&T systems at 100-KR-4 OU, it seems likely that the proposed plan for this OU will include P&T as a major element of a preferred alternative.

5.3 Hexavalent Chromium – Low River Stage

Hexavalent chromium is a mobile contaminant at 100-KR, and its presence resulted from historical releases of two different types of wastewater contaminated with chromium. The first type of release included spills, leaks, and limited intentional discharge of concentrated sodium dichromate dihydrate solutions used as feed chemicals for conditioning reactor cooling water. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-K-1 Crib and 116-K-2 Trench. The plumes from these sources are associated with three general areas: (1) a plume originating at, or near, the 183-KW Head House chemical storage tank farm and extending riverward; (2) a plume originating at, or near, the 183-KE Head House chemical storage tank farm and extending riverward; and (3) a plume originating at the 116-K-1 Crib and 116-K-2 Trench and extending radially away from those sites. These plumes have been reshaped and/or dissected by operation of the groundwater P&T systems at 100-K (Figures 5-5 and 5-6), which substantially reduced the observed groundwater hexavalent chromium concentrations since 1996. Based on aquifer tube sampling and near-river wells, the extent of hexavalent chromium at the river shore continues to decline.

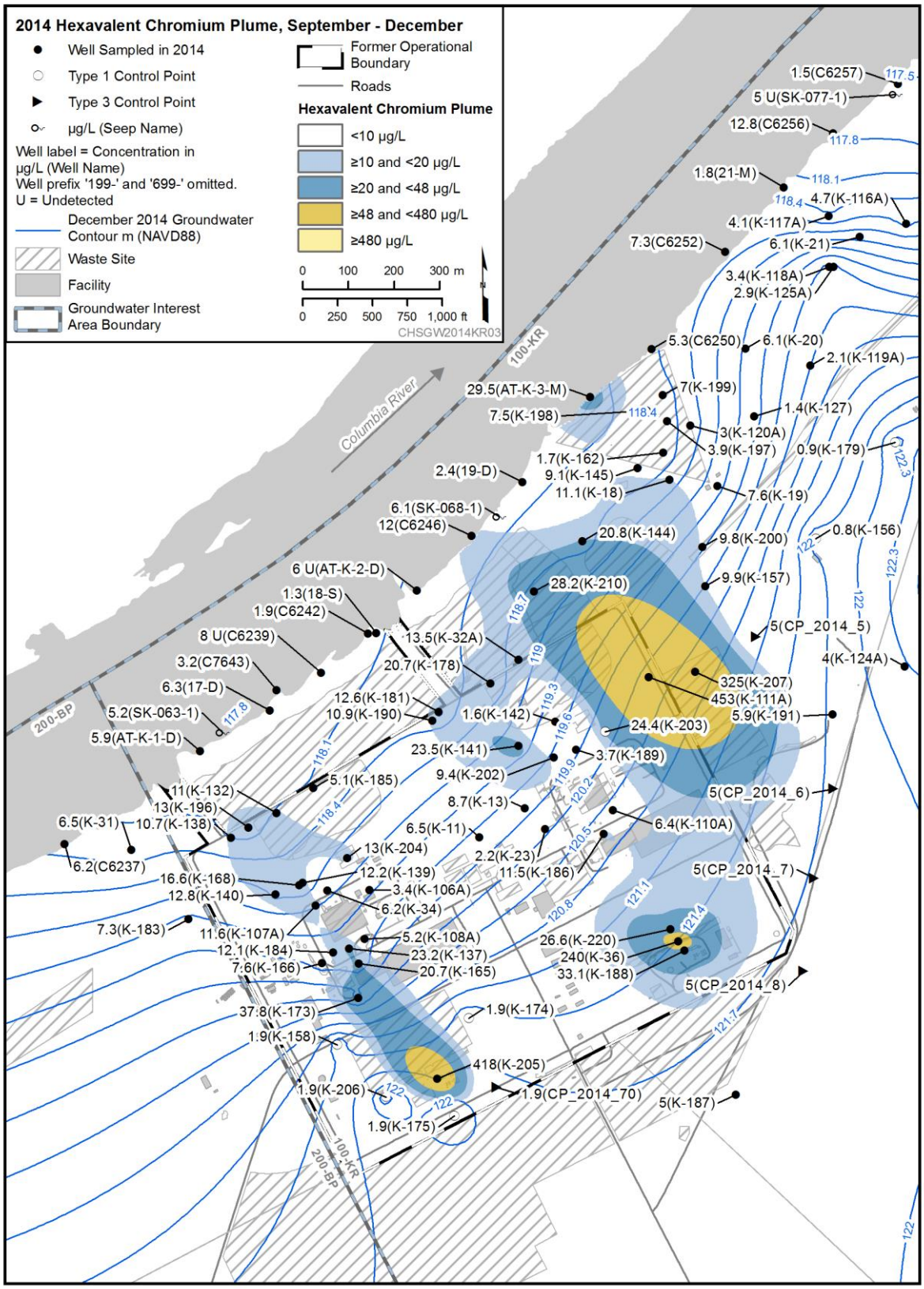


Figure 5-5. 100-KR Hexavalent Chromium Plume (Low River Stage), KE and KW Reactor Vicinity, 2014

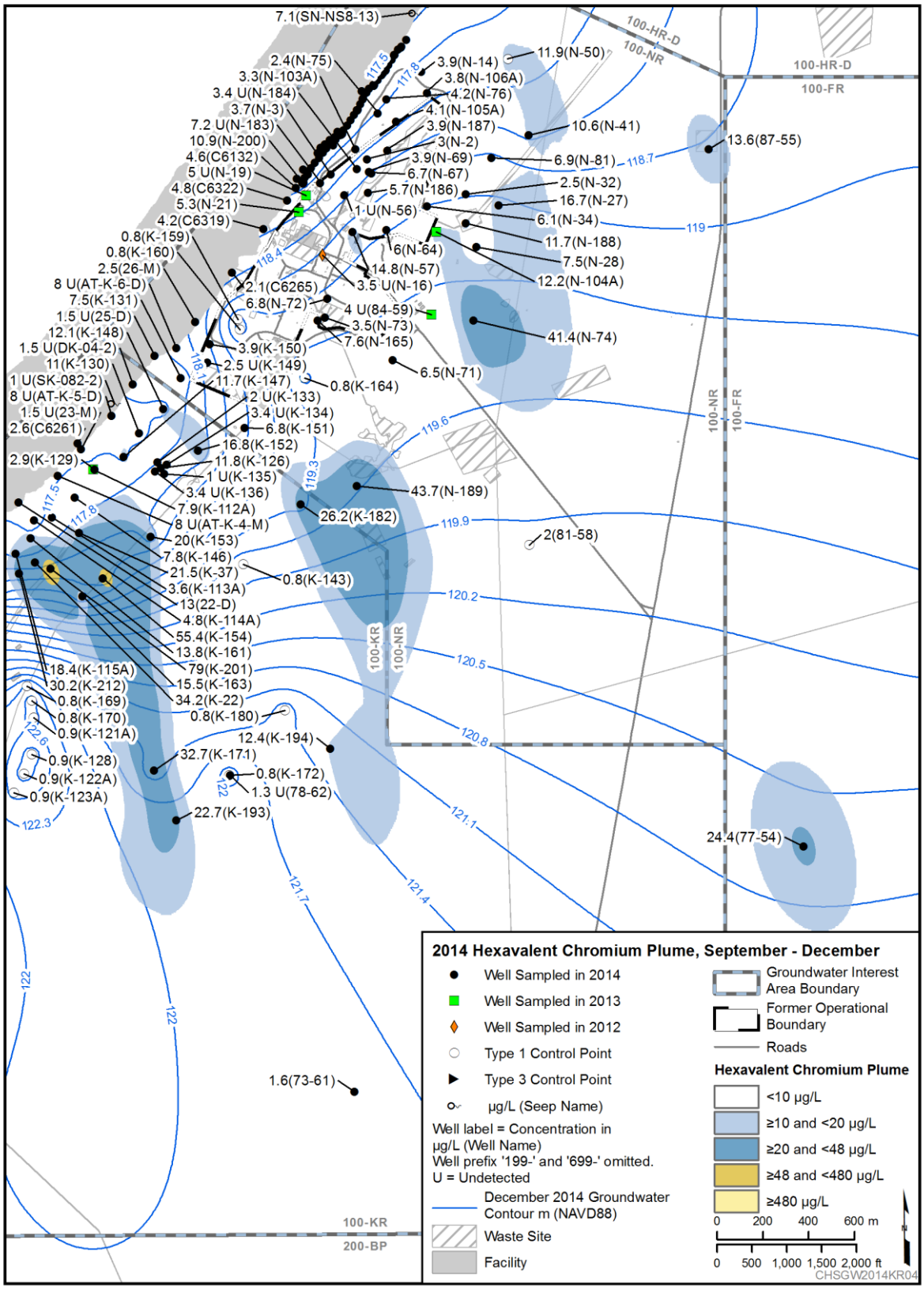


Figure 5-6. 100-KR Hexavalent Chromium Plume (Low River Stage), 116-K-2 Trench and 100-N Area, 2014

In addition to measurements collected from the near-river environment at aquifer tubes, river shore seeps at 100-KR Area were also sampled in 2014. The seeps are discrete areas of groundwater discharge to the ground surface near the river shore that appear during the low river stage and are most apparent during the falling limb of the river stage cycle. Seeps represent groundwater leaving the aquifer in areas where the groundwater elevation remains higher than the river elevation for some period of time. At the 100-KR Area, three seeps were sampled during 2014, all during September and October. The seep measurements provide useful information regarding near-shore surface water conditions, however, they do not technically represent groundwater. For information purposes, the 2014 seep sample results of hexavalent chromium measurements are posted on the hexavalent chromium plume maps for both low and high river stages in this report.

The Columbia River is a discharge boundary for groundwater beneath the 100-KR Area. When river stage is low (generally during the period from September through March [Figure 5-7]), groundwater flows readily toward the river and discharges into the river through areas of interaction in the hyporheic zone where the aquifer meets the surface water. The low river-stage period has been selected for collection of water samples from the aquifer tubes placed into the near-river environment at 100-KR. At this time, the chromium plume is most likely to be continuous between the inland aquifer and aquifer tube locations where hexavalent chromium is detected. During 2014, this condition occurred only at two locations. The inferred distribution of hexavalent chromium at 100-KR during the low river-stage period is shown in Figure 5-5 and 5-6.

Hexavalent chromium concentrations greater than 10 µg/L are observed in isolated wells east and northeast of 100-K Area: 699-87-55, 699-77-54 (Figure 5-6) and two wells farther east in the 100-FR groundwater interest area (Figure ES-7 in the Executive Summary). The origin of this contamination is unknown, but it may be related to historical sources in 100-K or 100-D Area.

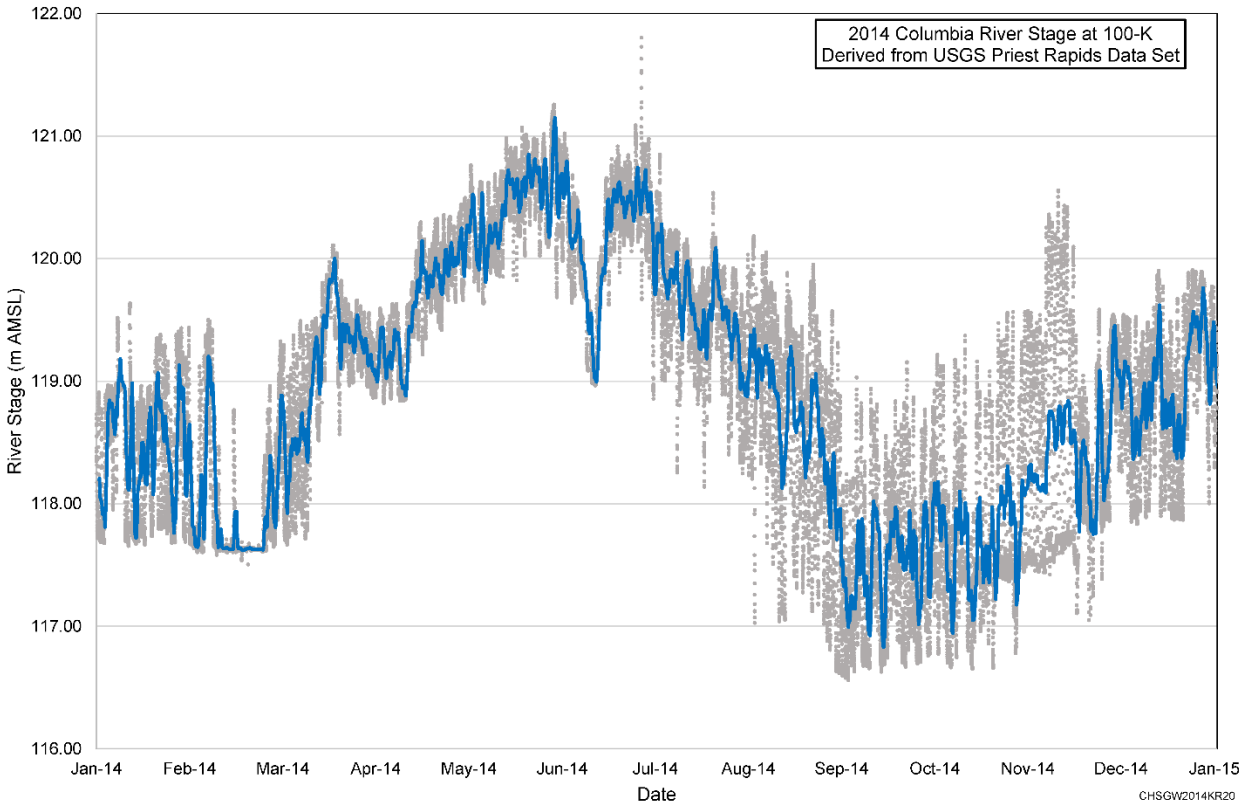


Figure 5-7. Columbia River Stage at 100-K During 2014

5.3.1 116-K-2 Trench Associated Plume

The current hexavalent chromium groundwater plume associated with the 116-K-2 Trench occurs in multiple, isolated plume segments at the 10 µg/L contour. This plume, which was initially inferred in the mid-1990s (see historical monitoring reports) as being continuous over the length of the 116-K-2 Trench, has been dissected by operation of the P&T systems. The northeastern portion of the 116-K-2 Trench plume extends northeast into the 100-NR-2 OU. Well 199-N-189, constructed in 2011, exhibited hexavalent chromium at 45 µg/L, similar to the range of 5 to 45 µg/L observed in Well 199-K-182, a 100-KX system extraction well. Well 199-N-74, which is located approximately 2 km (1.2 mi) from the end of the trench and farther north than Well 199-N-189, exhibited a hexavalent chromium concentration of about 45 µg/L in 2014. Hexavalent chromium concentrations near the river have been generally decreasing (Figures 5-8 and 5-9). Hexavalent chromium continues to be detected in wells further north within the footprint of 100-NR-2 OU. This includes a detection of 50.6 µg/L in a filtered aliquot collected in June 2014 in Well 199-N-41, located adjacent to the 116-N-3 Trench. This is the highest historical chromium concentration observed at this location. This single measurement expressed a substantial variation in the inferred hexavalent chromium plume distribution in the 100-N Area during the high river stage period (see Figure 5-6). The actual extent of the hexavalent chromium plume associated with Well 199-N-41 is highly uncertain due to the sparse quantity and frequency of measurements in nearby locations. The concentration at Well 199-N-41 was measured at 10.6 µg/L in the filtered aliquot in the September 2014 sample, which was more consistent with historical measurements.

A central plume segment, exhibiting concentrations greater than 10 µg/L extends from the vicinity of the 116-K-2 Trench inland to the vicinity of Well 199-K-193. Operation of injection wells of the KR4 and KX P&T systems has further dissected the hexavalent chromium plume in the central portion of the trench.

The hexavalent chromium plume associated with the proximal, or head end (southwest end) of the 116-K-2 Trench was previously inferred to be continuous with chromium originating at the 183-KE Head House area. The apparent source(s) of hexavalent chromium in groundwater in the vicinity of the 116-K-1 Crib include comingling of chromium from the crib and trench and likely chromium originating at the 183-KE Head House area. Concentrations of hexavalent chromium near the river have been generally decreasing in active extraction wells (Figure 5-8 and 5-9). The observation of a variable concentration of hexavalent chromium in Well 199-K-148 is consistent with active capture of chromium from upgradient (in the vicinity of Well 199-K-152). Hydraulic containment of the 100-KR plumes is illustrated in Figure 3-22 of DOE/RL-2015-05.

For 2014, as in 2013, the consistent groundwater flow vectors caused by the combination of forces related to recharge mounding from injection wells, and capture by extraction wells, were critically evaluated during plume distribution analysis. As illustrated in Figure 5-5, the hexavalent chromium plume in the vicinity of Well 199-K-111A is inferred to be continuous with groundwater to the east of that well location (i.e., in the vicinity of the 116-K-2 Trench and 118-K-1 Burial Ground). The inferred continuity of the 10 µg/L contour between the 183-KE Head House and 199-K-111A may be an artifact of sparse measurement data between these two vicinities. The dynamic conditions imparted on the aquifer by operation of the P&T systems are apparent as an east-to-west groundwater gradient in this area that segregates the hexavalent chromium plume into two distinct segments.

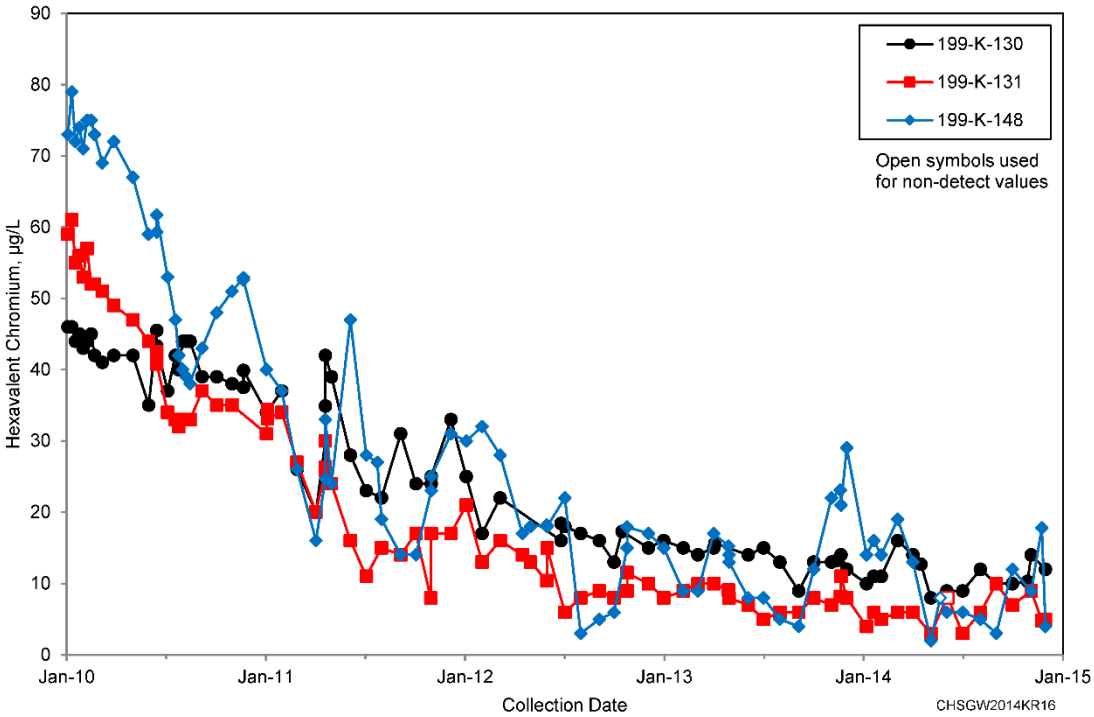


Figure 5-8. 100-KR Hexavalent Chromium Data for Wells 199-K-130, 199-K-131, and 199-K-148 (Near-River Extraction Wells in Northern Portion 100-KR)

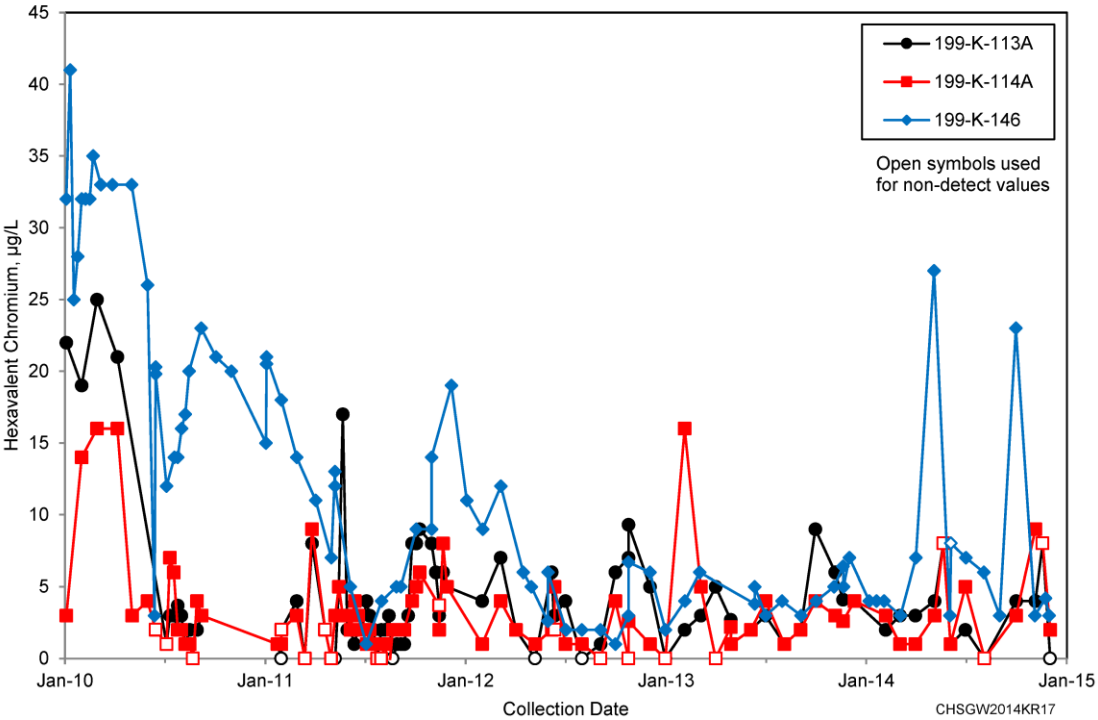


Figure 5-9. 100-KR Hexavalent Chromium Data for Wells 199-K-113A, 199-K-114A, and 199-K-146 (Near-River Extraction Wells in Northern Portion 100-KR)

5.3.2 K West Associated Plume

The K West hexavalent chromium plume is observed in a narrow band with relatively high concentrations starting near the head house and extending toward the river (Figure 5-5). The dimensions of this plume did not change substantially between 2011 and 2014. The highest hexavalent chromium concentrations in 100-KR in 2014 continued to be observed in wells upgradient from the KW Reactor building and extending to the 183-KW Head House vicinity.

With the decommissioning of Well 199-K-195, which previously exhibited the highest hexavalent chromium concentration of 3,340 µg/L (April 2011), in preparation for soil remedial activities, no wells remained in the vicinity of the KW Head House until construction of Well 199-K-205 in early 2014 as an additional extraction well for the 100-KW system. A maximum concentration of 3,280 µg/L was observed in January 2014 at this well. Elevated concentrations greater than 1,000 µg/L persisted until the well was brought online as an extraction well in September 2014. During extraction operations, Well 199-K-205 hexavalent chromium concentration has declined from 1,020 µg/L in September to about 200 µg/L in December 2014. The persistence of elevated hexavalent chromium concentration at this well, and the next downgradient well (199-K-173), indicates the likelihood of continuing contributions from secondary sources within the overlying vadose zone or periodically rewetted zone.

The next downgradient extraction well (199-K-173) continued to exhibit elevated, although decreasing, concentrations of hexavalent chromium during 2014. Hexavalent chromium, observed in that well at a high of 500 µg/L in late 2011, declined to about 30 µg/L at the end of 2014. The presence of injection Wells 199-K-175, 199-K-174, and 199-K-158 controls the upgradient edge of the plume. The plume does not extend inland past Well 199-K-175, which had concentrations below 10 µg/L when the well was sampled before conversion to an injection well for the KW P&T system.

At 2014 low river stage, Aquifer Tube AT-K-1-D exhibited less than 8.0 µg/L of hexavalent chromium; this is consistent with the 6.1 µg/L detected in 2013 and maintains the substantial decrease from the 32.7 µg/L observed at that location in 2012. The 100-KW system extraction Well 199-K-196 operated for all of 2014; this supplemented extraction by Wells 199-K-132 and 199-K-138 (Figure 5-10). This operation appears to be capturing contaminated groundwater from the KW plume inland of the river shore. Well 199-K-196 exhibited an increase in hexavalent chromium concentration to 32 µg/L shortly after being placed in service as an extraction well in 2013, and exhibited decreasing concentration to less than 20 µg/L by the end of 2014. Representative concentration trends for wells near the river and upgradient of the KW Reactor are shown in Figures 5-10 and 5-11. Of particular interest with respect to hexavalent chromium, Seep SK-063-1, located in the vicinity of the 100-KW chromium plume, exhibited a filtered total chromium concentration of 4.3 µg/ L in October 2014; this is a substantial decrease from the 24.6 µg/L in a sample collected in September 2013. This seep concentration is consistent with the less than 8 µg/L reported for nearby aquifer tube AT-K-1-D in September 2014. Continued operation of extraction Well 199-K-196 is anticipated to intercept the leading edge of the hexavalent chromium plume; monitoring activities at Aquifer Tube AT-K-1-D and Seep SK-063-1 will continue to support performance evaluation of the KW extraction system.

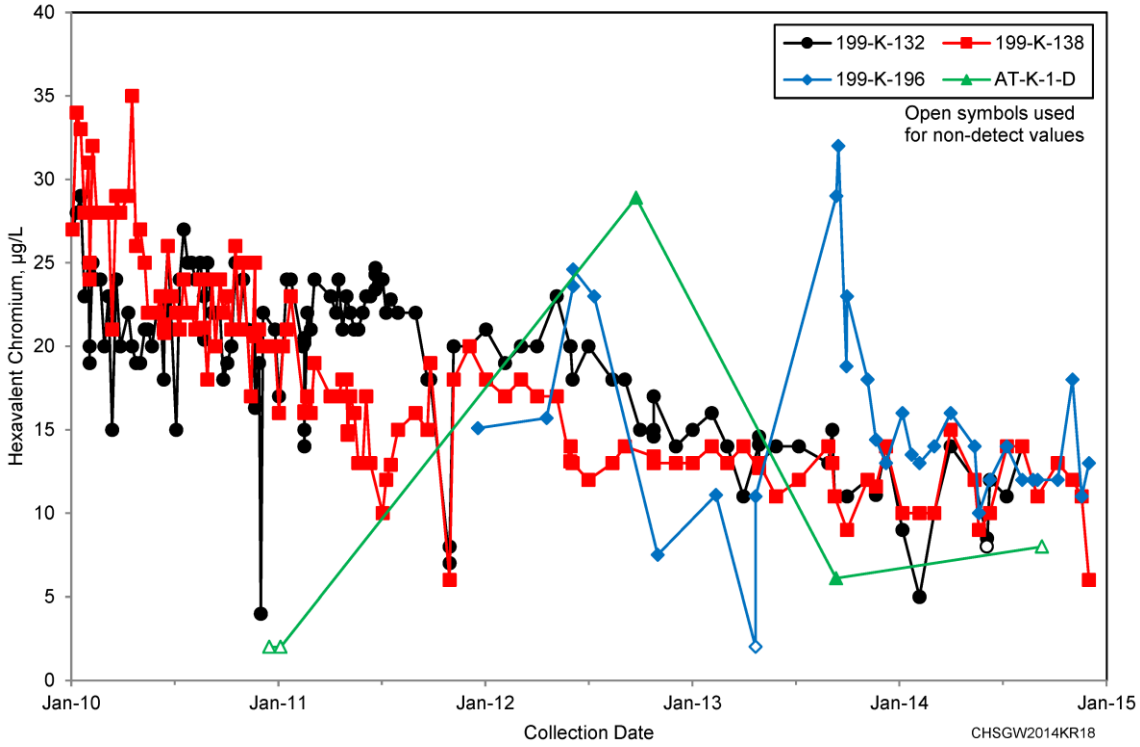


Figure 5-10. 100-KR Hexavalent Chromium Data for Wells 199-K-132, 199-K-138, 199-K-196, and Aquifer Tube AT-K-1-D, Located Downgradient of KW Reactor

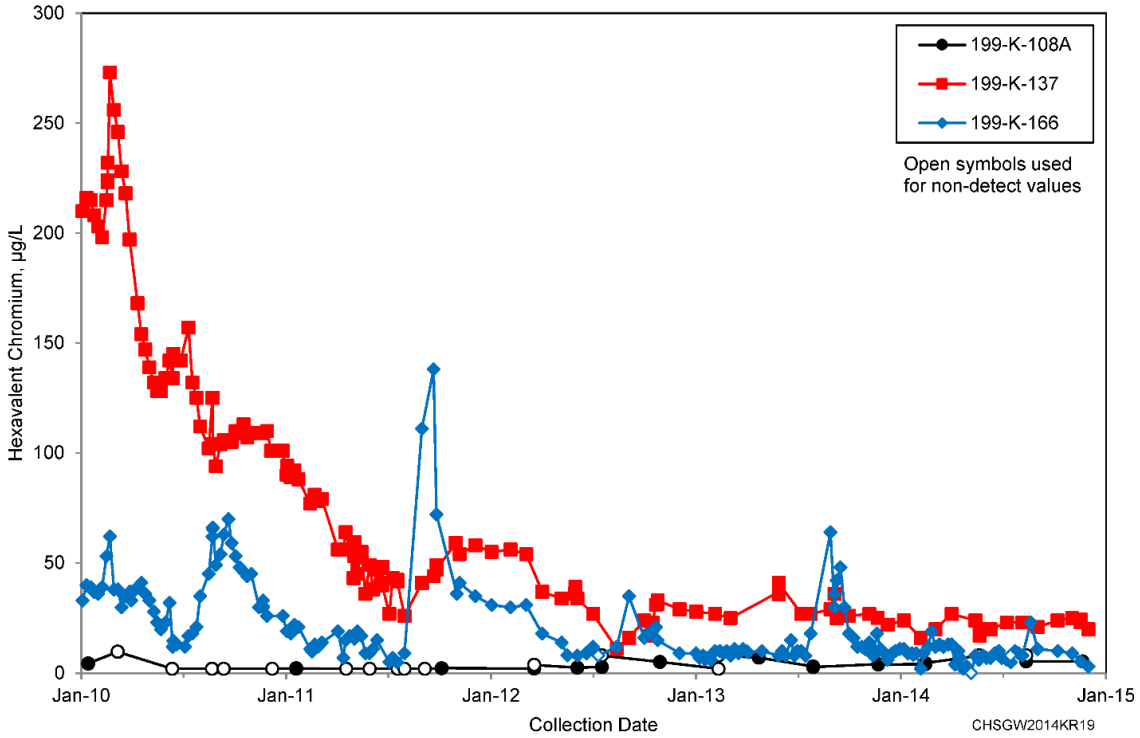


Figure 5-11. 100-KR Hexavalent Chromium Data for Wells 199-K-108A, 199-K-137, and 199-K-166, Located Just Upgradient of KW Reactor

5.3.3 K East Associated Plume

The K East plume is a relatively high concentration plume that extends from the vicinity of the 183-KE Head House in a northwest direction to the Columbia River (Figure 5-5). The apparent source is in the vicinity of the 183-KE Head House chemical storage tank farm, similar to the condition observed at KW. The existing monitoring well network does not clearly define the dimensions of the K East hexavalent chromium plume, but the plume definition has improved from previous years. Upgradient (inland) of the 183 KE Head House, Well 199-K-187 exhibited hexavalent chromium less than 8 µg/L in 2014. This location has consistently exhibited low hexavalent chromium concentration and appears to define the inland extent of elevated concentrations for this plume segment.

The plume extends from the 183-KE Head House (near Wells 199-K-36 and 199-K-188) toward the river. As described above for the plume related to the 116-K-2 Trench, evaluation of the dynamic groundwater gradients influenced by extraction and injection well operations produced an inferred hexavalent chromium plume distribution that differs from previous years. Chromium concentrations in Wells 199-K-36 (located at the former KE Head House) and 199-K-111A (located east of the KE Reactor and just west of the 118-K-1 Burial Ground) increased between 2010 and 2013, and declined in 2014. Examination of the concentration time series for co-contaminants, however, suggests that the chromium at these two wells likely originated from separate source areas. In Well 199-K-36 (at the head house), chromium and sulfate have increased in a parallel manner, while tritium has remained very low. At Well 199-K-111A (east of KE Reactor), chromium and tritium have increased in a parallel manner, while sulfate has remained relatively low. These relationships suggest that the chromium at Well 199-K-111A is likely related to a plume segment historically related to the 116-K-2 Trench moving westward coincidentally with tritium potentially originating from the burial ground. The westward flow at this location is apparently induced by the persistent recharge mound associated with the KR4 and KX injection wells located to the east. Elevated tritium was present in deep vadose zone soil beneath the 118-K-1 Burial Ground. A new monitoring well (199-K-207) was installed during 2014 to monitor conditions beneath the 118-K-1 Burial Ground. A sample collected during drilling exhibited 414,000 pCi/L tritium. This condition, located upgradient of Well 199-K-111A, is consistent with the tritium behavior in that well. The hexavalent chromium observed in Well 199-K-111A probably originated from historical discharges of reactor cooling water to the 116-K-2 Trench.

The increasing chromium observed at Well 199-K-36 (to a maximum concentration of 316 µg/L in 2014) is most likely related to continuing contribution from secondary sources in the vadose zone in the vicinity of the former head house chemical storage tank farm, migrating to groundwater coincidentally with sulfate residuals from historical release of other water treatment chemicals (e.g., alum or sulfuric acid) managed in the same tank farm area. Sulfate has exhibited a similar behavior in concentration time series to hexavalent chromium at Well 199-K-36. These separate source conditions are consistent with the current inferred plume distribution based on apparent groundwater flow gradients.

The K East plume is interpreted to reach the Columbia River at aquifer tube C6246. The hexavalent chromium concentration in this tube increased to 12 µg/L in 2014, having been below the 10 µg/L aquatic standard in 2012 and 2013.

5.4 Hexavalent Chromium – High River Stage

The observed stage in the Hanford Reach of the Columbia River varies daily with controlled release of water from the upstream Priest Rapids Dam and seasonally in response to annual snowmelt in the mountains of the drainage upstream. High river stage in the Hanford Reach of the Columbia River typically occurs in mid-summer at the peak of the annual freshet. A hydrograph of river stage at 100-K Area is shown in Figure 5-7. The high water stage was observed to begin in early March, and three

distinct peak responses were observed in 2014: one peak was observed in late March at about 120.1 m (394 ft) amsl, and two higher peaks in early June and early July at about 121.2 m (398 ft) amsl. The peak river stage elevations at 100-K Area in 2014 were similar in timing and magnitude to the corresponding peak stage elevations observed in 2013. The high river-stage period continued through the decline of the peak stage through August 2014. The low river-stage period was identified to have started in late August 2014.

Based on concentrations of hexavalent chromium in groundwater samples collected during the 2014 high river-stage period, the distribution of plumes within 100-KR at high river stage (Figures 5-12 and 5-13) are not dramatically different from those observed during the low river period. During the high river stage, river water may intrude into the aquifer, causing displacement and/or dilution of the aquifer water in the near-shore environment. During 2014, this bank storage condition may have occurred, based on evaluation of groundwater elevation maps. Due to increased pumping rates at groundwater extraction wells, particularly those riverward of the distal portion of the 116-K-2 Trench, groundwater gradient reversal near the river appears to have occurred at some locations. In particular, Wells 199-K-112A and 199-K-129 exhibited specific conductance measurements consistently below 200 µS/cm. This specific conductance is consistent with influence of mixing of groundwater with river water. The Columbia River water typically exhibits specific conductance of 130 to 140 µS/cm. A classified post map of measured groundwater specific conductance is shown in Figure 5-14. The measured hexavalent chromium concentrations in aquifer tubes collected during the low water period were, therefore, applied to those locations to prepare the high river stage plume maps. This was determined to be the most representative interpretation of the conditions observed during 2014. Inspection of the groundwater elevation contours for 2014 indicate that the P&T system imposed hydraulic capture of groundwater along the affected shoreline over most of the year (Figure 3-22 of DOE/RL-2015-05).

Some inland wells (e.g., wells more than 200 m [660 ft] away from the river shore) exhibit transient hexavalent chromium concentration effects during periods of seasonal high groundwater elevation. An example of this effect is shown at Well 199-K-189, located in the vicinity of the KE Reactor (Figure 5-15). This well has consistently exhibited seasonal concentration transients that appear to be directly proportional to changes in groundwater elevation (i.e., as groundwater elevation rises, hexavalent chromium concentration rises). The direct correlation indicates that this well may be located close to a secondary source within either the vadose zone or periodically rewetted zone.

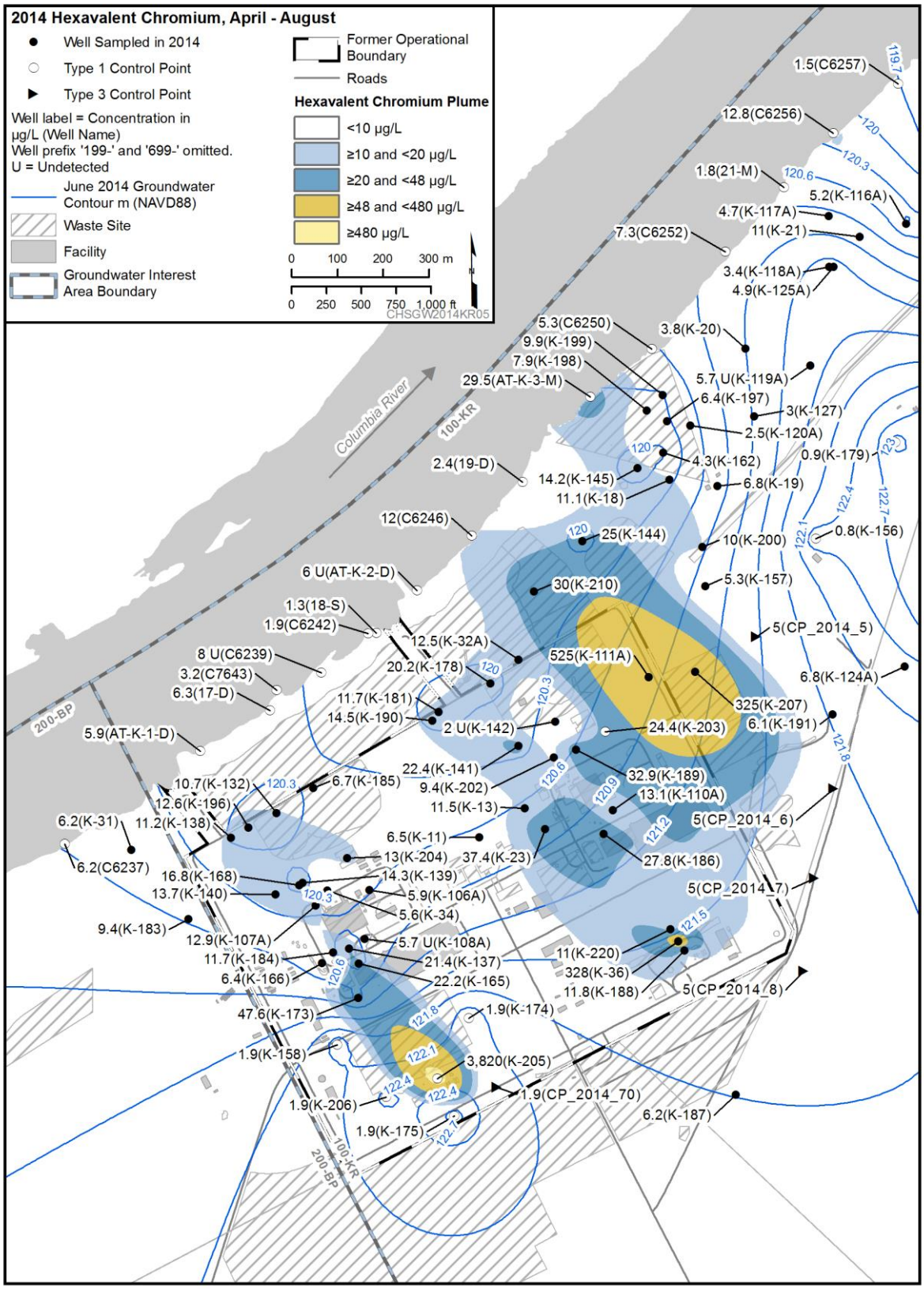


Figure 5-12. 100-KR Hexavalent Chromium Plume (High River Stage), KE and KW Vicinity, 2014

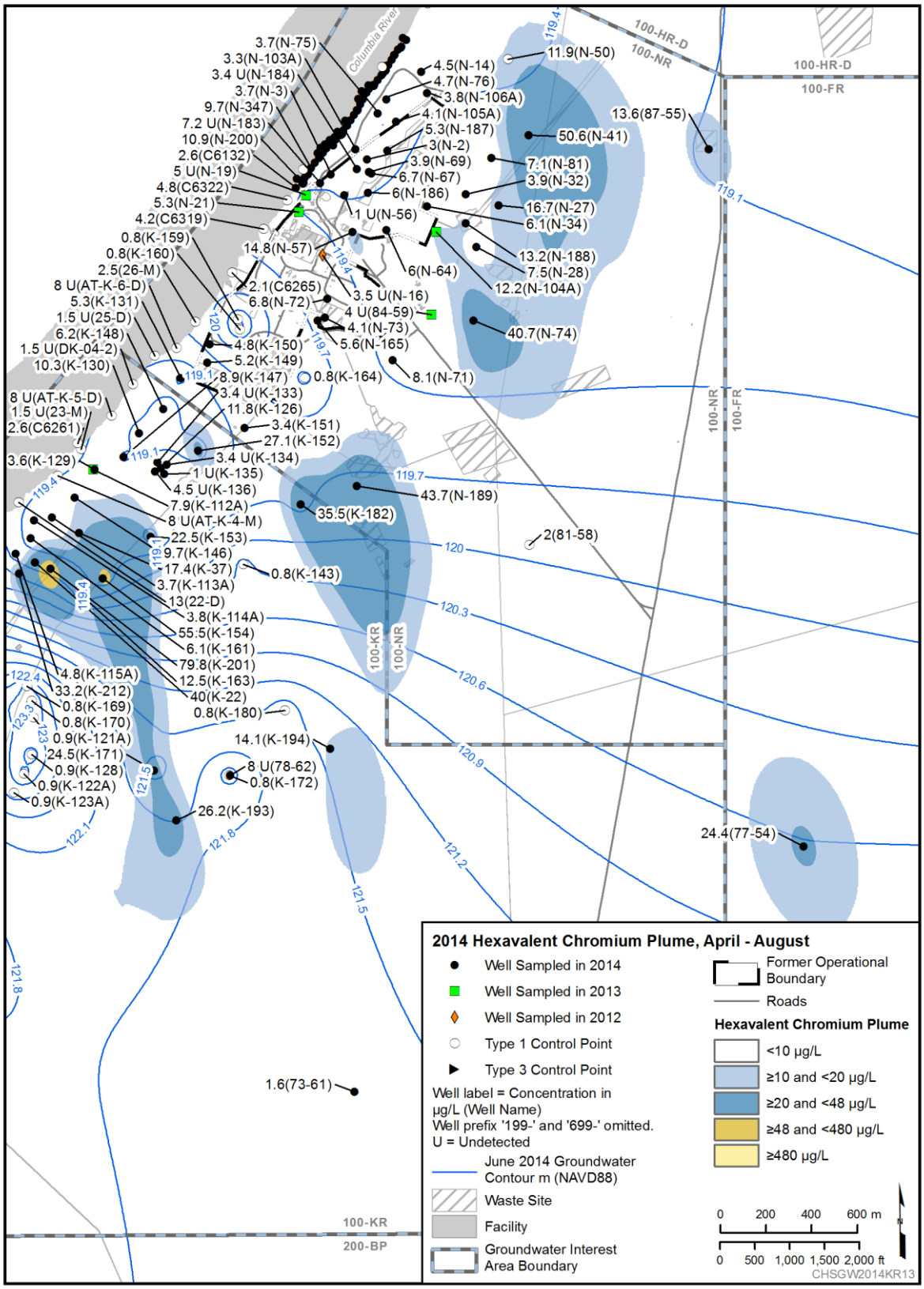


Figure 5-13. 100-KR Hexavalent Chromium Plume (High River Stage), 116-K-2 Trench and 100-N Area, 2014

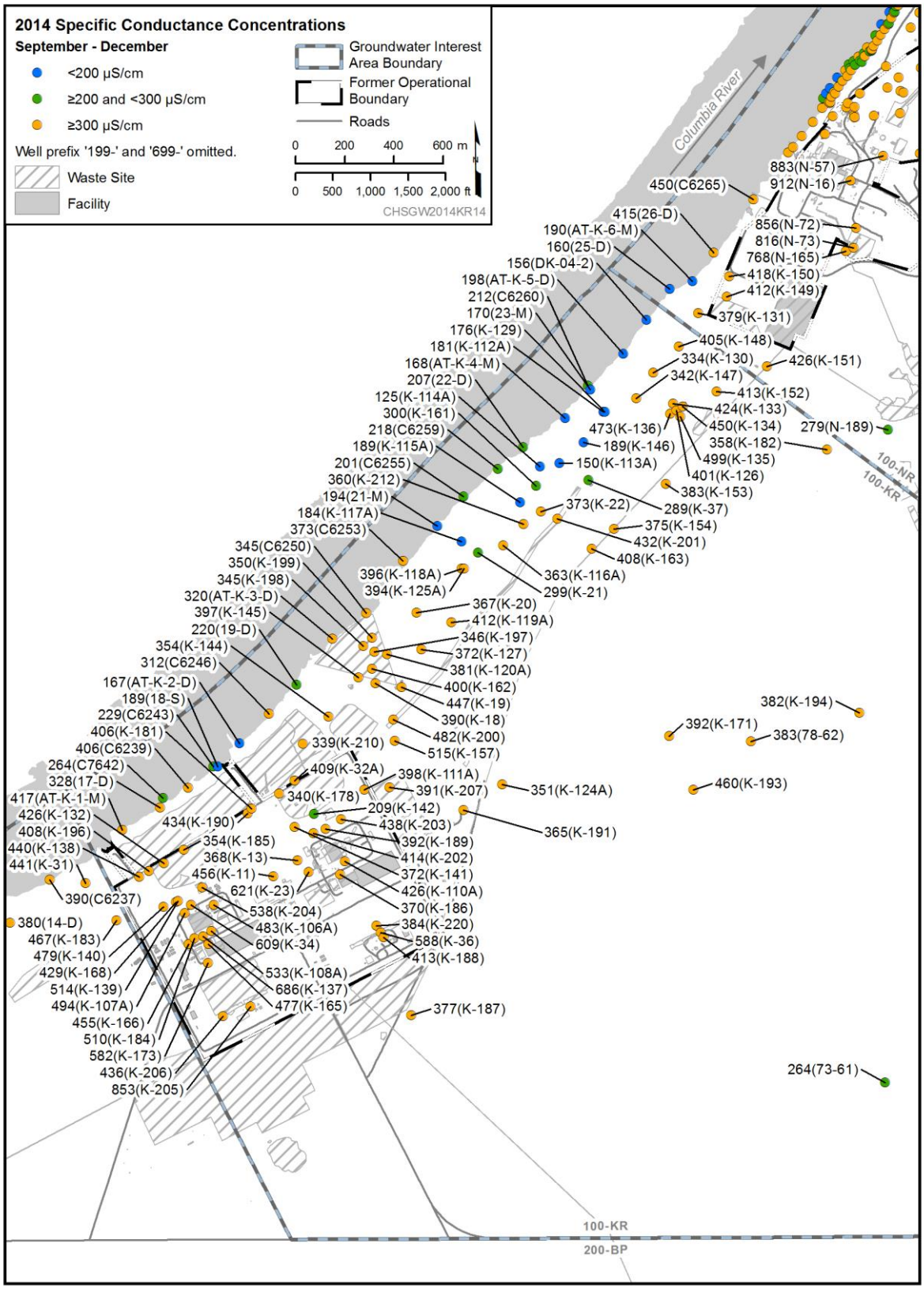


Figure 5-14. 100-KR Specific Conductance, Low River Stage 2014

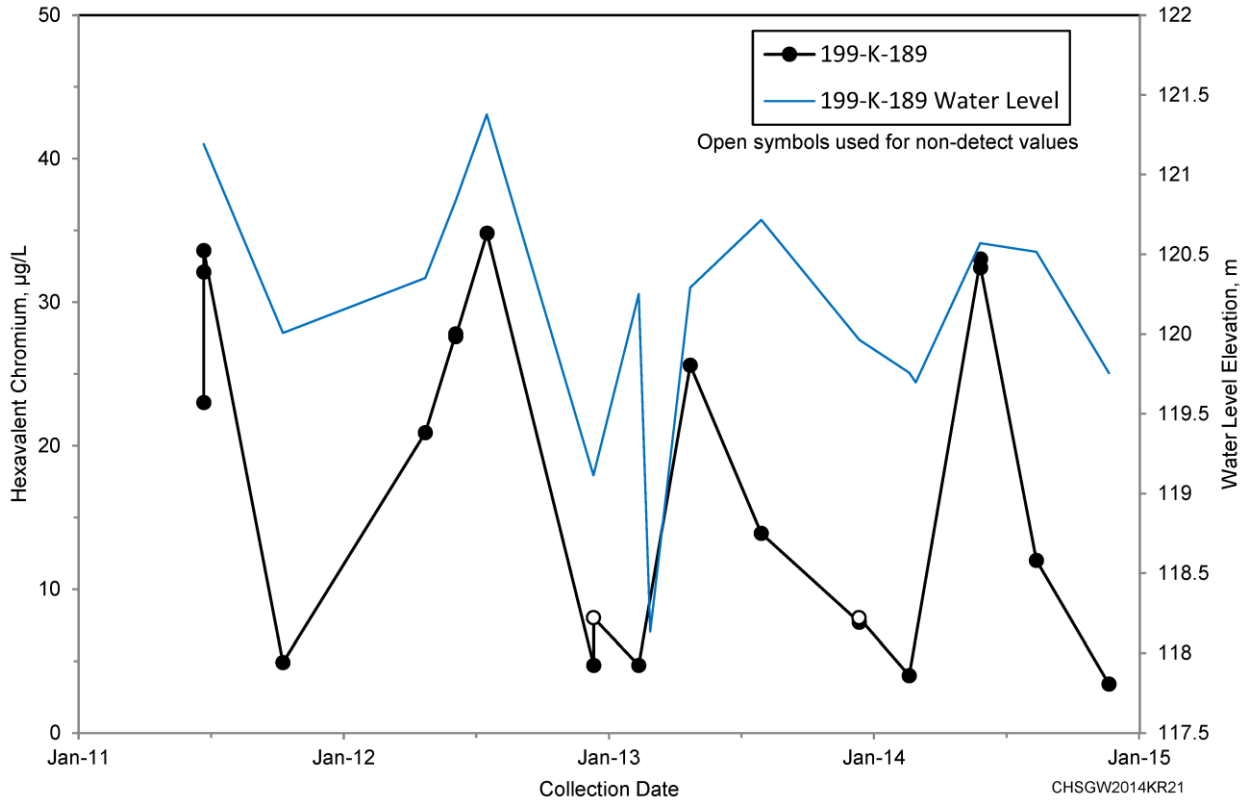


Figure 5-15. 100-KR Hexavalent Chromium Data for Well 199-K-189, Located Downgradient of KE Reactor, Indicating Correlation to Transient Water Level

5.5 Tritium

Tritium is a highly mobile contaminant in 100-KR groundwater and is present at levels above the 20,000 pCi/L DWS equivalent concentration. The major historical sources of tritium contamination included the following:

- Releases of reactor gas dryer condensate to the 116-KE-1 and 116-KW-1 Cribs (tritium activity concentrations up to 1×10^{10} pCi/L in the condensate, per HW-76258, *Reactor Gas Drier Condensate Waste – Decontamination Studies*)
- Release of fuel storage basin water to the 116-KE-3 and 116-KW-2 Cribs, and to UPR-100-K-1 (tritium activity concentrations up to 6×10^{9} pCi/L in the basin water, per WHC-EP-0877, *K Basin Corrosion Program Report*)
- Contaminated solid waste disposed at the 118-K-1 Burial Ground (tritium activity concentrations up to 13,400 pCi/g in deep vadose zone soil remaining after surface remediation, per CVP-2013-00002, Rev. 1)

Another source of tritium was the release of contaminated reactor cooling water to the retention basins, the 116-K-1 Crib, and the 116-K-2 Trench. The tritium distribution in groundwater in 2014 is shown in Figure 5-16.

As part of the active remediation of hexavalent chromium, extraction wells are also capturing tritium in this area. Because tritium is present primarily as tritiated water, it passes through the treatment system unaffected. Currently, the tritium-contaminated water within the aquifer is recirculated between affected

extraction wells and inland injection wells. Because of extraction and recirculation, tritium is now in groundwater at the active injection wells at 100-KR. Based on the design of the P&T system, much of this water will be recaptured by the downgradient extraction wells and the tritium will be recirculated and continue to decay. The plume is not presently reaching the river above the DWS, based on data from aquifer tubes. Tritium was detected in effluent water from the KW, KX, and KR4 P&T systems. The average effluent concentration of the KR4 system for 2014 was 6,835 pCi/L, which is below the DWS. Tritium concentration in the effluent from both KX and KW systems was less than 2,000 pCi/L during 2014, consistent with conditions observed in 2013.

The highest measured tritium value in groundwater during 2014 (414,000 pCi/L) was in a characterization sample from the new Well 199-K-207, located within the footprint of the former 118-K-1 Burial Ground. Tritium at this location is likely related to historical disposal of contaminated reactor hardware to the burial ground. Six monitoring wells at 100-K exhibited tritium concentrations exceeding 20,000 pCi/L in 2014 (199-K-18, 199-K-111A, 199-K-145, and 199-K-202 and the new Wells 199-K-207 and 199-K-208).

A portion of the tritium plume at K East appears to have originated at the 116-KE-1 Crib, with contribution from waste at the 118-K-1 Burial Ground (Figure 5-16). Concentrations in 2014 in Well 199-K-18 declined slightly in 2014, with one measurement below 20,000 pCi/L. Well 199-K-111A exhibited a declining trend in tritium concentration during 2014 after 2 years of rising concentration (Figure 5-17). This is inferred to result from westward migration of tritium-contaminated groundwater from the vicinity of the 118-K-1 Burial Ground. Tritium concentration in this well location is expected to increase with continued westward migration of contaminated groundwater. The new Well 199-K-207 was installed upgradient of Well 199-K-111A to provide information on conditions beneath the burial ground; this well exhibited 414,000 pCi/L tritium in a grab sample near the water table during drilling. In addition to the elevated tritium observed in Well 199-K-207, new extraction Well 199-K-208, located approximately 220 m (730 ft) northwest of Well 199-K-207, exhibited 271,000 pCi/L tritium in a shallow grab sample collected during drilling. Concentrations declined with depth in Wells 199-K-207 and 199-K-208. Tritium in Well 199-K-157 remained below 5,000 pCi/L during 2014 (Figure 5-16). This pattern is consistent with migration of contaminated groundwater from historical release points along inferred flow paths to locations where it is intercepted by extraction wells. The known historical release points (118-K-1 Burial Ground, 116-KE-1 Crib) may also be continuing secondary sources in the vadose zone and/or periodically-rewetted zone.

Tritium concentrations in K West in 2013 were consistently below the DWS. However, concentrations as high as 430,000 pCi/L were measured in Well 199-K-106A as recently as 2009 (with a historical maximum observed concentration of 2,240,000 pCi/L in 2005). Well 199-K-106A exhibited tritium at a maximum concentration of 2,370 pCi/L during 2014. It is unlikely that the plume has disappeared because the half-life of tritium is 12.3 years, but the plume has likely migrated downgradient to a location without monitoring wells. New Well 199-K-204 is located in this area of uncertainty to provide information on carbon-14 and tritium.

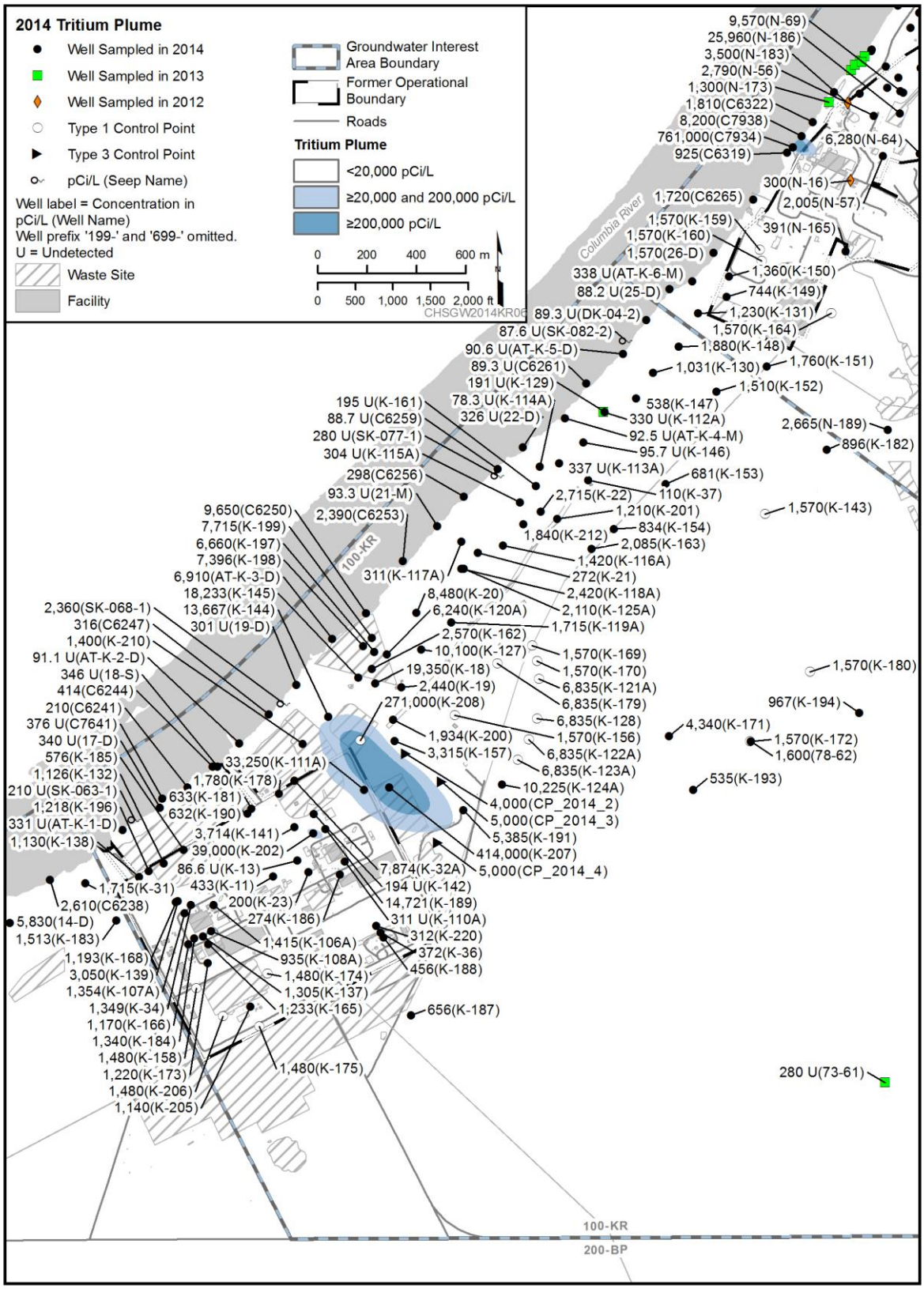


Figure 5-16. 100-KR Tritium Plume, 2014

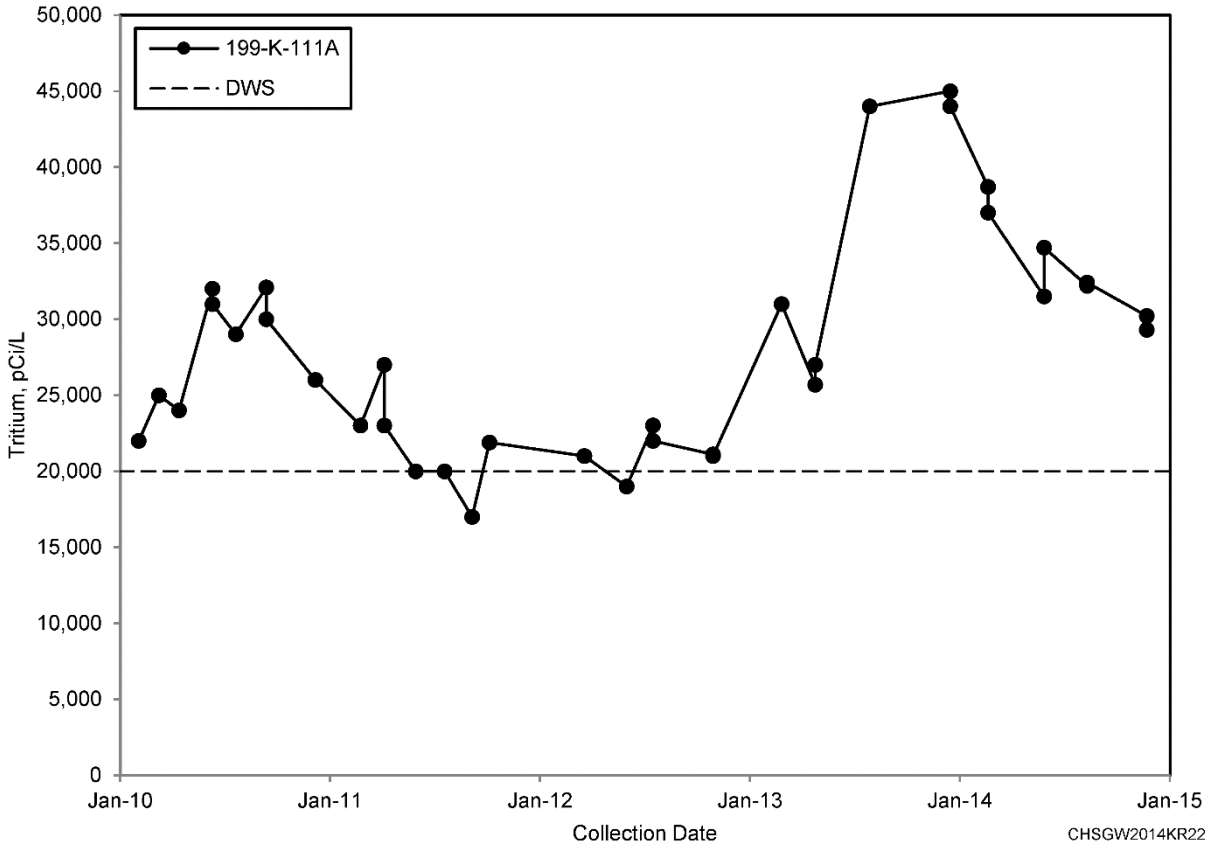


Figure 5-17. 100-KR Tritium Data for Well 199-K-111A, Located Northeast of KE Reactor

5.6 Nitrate

Nitrate concentrations continued to exceed 45 mg/L in several 100-KR wells in 2014. The nitrate observed in groundwater at 100-KR originated primarily from oxidation of high concentrations of ammonia in reactor gas dryer condensate (up to 36,000 mg/L) that was discharged to the 116-KE-1 and 116-KW-1 Cribs. Additional nitrate contributions to groundwater may have come from sanitary waste drain fields at various locations within the 100-KR Area. Nitrate distribution in groundwater in 2014 is shown in Figure 5-18. The size of the plume area exceeding the DWS decreased between 2011 and 2012, but remained fairly stable in 2013 (Figure 5-3).

In the K East region, only Well 199-K-23 exhibited a nitrate concentration above 45 mg/L in 2014, with a maximum observed concentration of 66.8 mg/L (Figure 5-19).

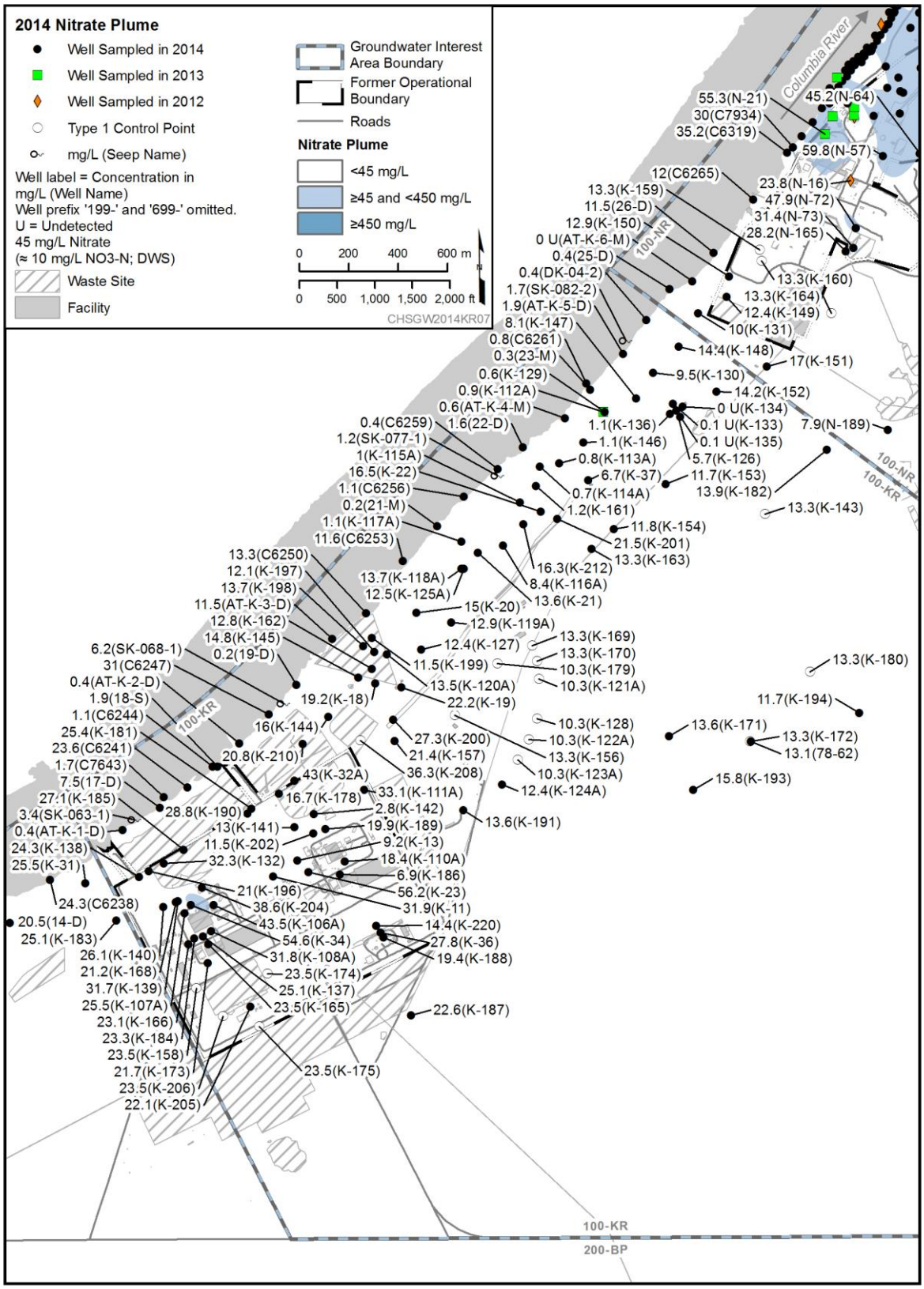


Figure 5-18. 100-KR Nitrate Plume, 2014

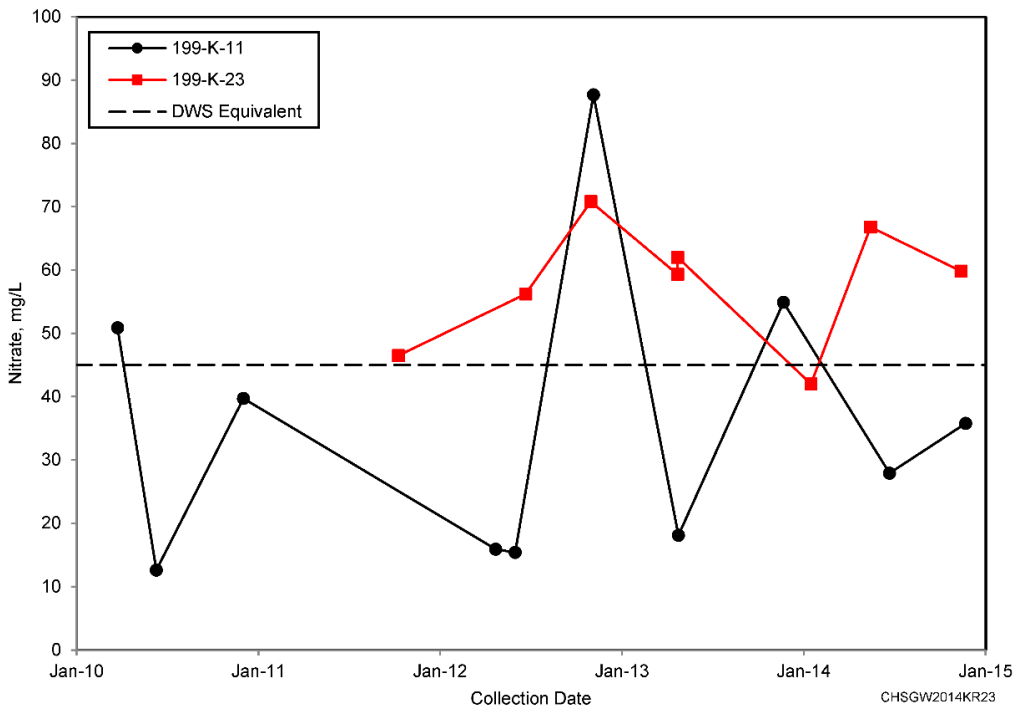


Figure 5-19. 100-KR Nitrate Data for Wells 199-K-111 and 199-K-23, Located West of KE Reactor

Two K West wells had nitrate levels above 45 mg/L in 2014 (199-K-34 and 199-K-106A) (Figure 5-20), although the nitrate concentration in Well 199-K-106A declined to about 39 mg/L by the end of the year. These are the two nearest wells to the 116-KW-1 Gas Condensate Crib, a known source of nitrate contamination. Two aquifer tubes downgradient from K West have historically exhibited nitrate concentrations above 45 mg/L (C6241 and 17-D), but have been below 45 mg/L since 2013 and 2011, respectively. Of particular interest with respect to nitrate, Seep SK-063-1, located in the vicinity of the 100-KW nitrate plume, exhibited a nitrate concentration of 3.4 mg/L in a sample collected on October 21, 2014. This is consistent with the nitrate concentrations measured in nearby Aquifer Tubes AT-K-1-D and 17-D (0.4 and 7.5 mg/L, respectively). This condition suggests that the KW P&T system is providing hydraulic capture of the plumes in the KW Reactor vicinity. It is notable that the concentration of nitrate in the treated effluent from 100-KW P&T system was 23 mg/L during 2014, consistent with 23 mg/L measured in 2013. This also indicates that the system is capturing the nitrate plume. Nitrate concentration in the effluent of 100-KR and 100-KX P&T systems was 10.3 and 13.3 mg/L, respectively.

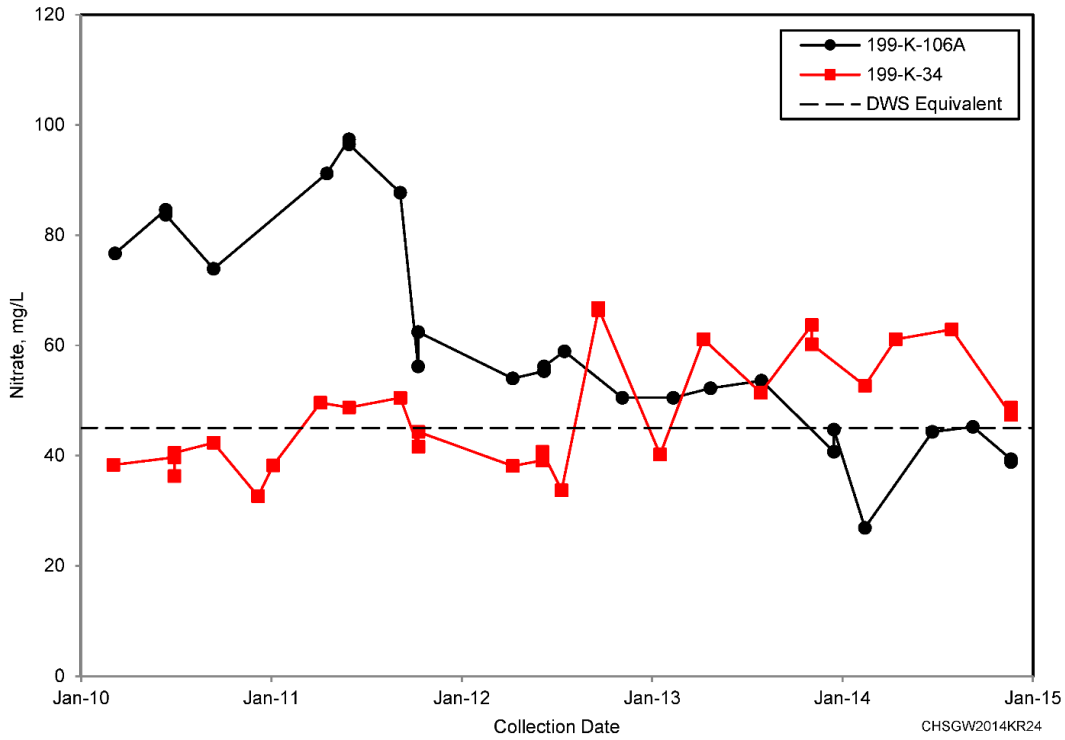


Figure 5-20. 100-KR Nitrate Data for Wells 199-K-106A and 199-K-34, Located Near KW Reactor

5.7 Strontium-90

Strontium-90 is a fission product generated within the reactor fuel during nuclear fission. Strontium-90 was historically released during fuel failure events and resulted in contamination of reactor cooling water. Contaminated cooling water, along with fragments of irradiated fuel, could be released to the 116-K-2 Trench under off-normal conditions as well as being released to the reactor fuel storage basins during discharge of irradiated fuel from the reactors. Cooling water contaminated by fuel rod failures was held in the 107-KE or 107-KW Retention Basins and subsequently discharged to the 116-K-2 Trench. Fission products, including strontium-90, contaminated the discharged water. The highest strontium-90 concentrations in groundwater are associated with historical releases from the fuel storage basins and their associated drainage systems. The fuel storage basins also contained cooling water contaminated with strontium-90. Releases from the fuel storage basins and discharges to the 116-K-2 Trench are the apparent sources of the strontium-90 contamination in 100-KR groundwater. Discharges to the 116-K-2 Trench resulted in strontium-90 distributed in groundwater at several locations along the length of the trench. Strontium-90 has also been released to groundwater via discharges to the 116-KW-2 and 116-KE-3 Fuel Storage Basin Cribs and reverse wells, or by direct leakage from the basins themselves (e.g., UPR-100-K-1 at the 105-KE Fuel Storage Basin). In 2013, DOE installed monitoring Well 199-K-202 downgradient of the KE Reactor to help delineate the strontium-90 plume in that area. Samples from this well exhibited no detectable strontium-90 during 2013 and 2014, indicating that this well location provides a bounding measurement for the high strontium-90 concentration plume historically defined by decommissioned Well 199-K-109A.

Strontium-90 contamination in 100-KR groundwater is found in four localized plumes at concentrations exceeding the DWS of 8 pCi/L (Figure 5-21). These plume areas are relatively small and approach, but do not reach, the Columbia River, except at the distal end (northeast end) of the 116-K-2 Trench, where aquifer tube 22-M exhibited a strontium-90 concentration of 7.2 pCi/L in 2014, slightly lower than the

8.8 pCi/L observed in 2013. This condition appears to represent downgradient migration of strontium-90 from the vicinity of the trench, where inland Wells 199-K-114A and 199-K-161 have both exhibited decreasing strontium-90 concentrations since 2000. The maximum 2014 strontium-90 concentrations in those wells were 3.3 and 11.8 pCi/L, respectively.

The historical area of the strontium-90 plume above the DWS is subject to substantial uncertainty because the plumes have not historically been delimited on the downgradient or cross gradient directions from either of the fuel storage basin cribs. The 2014 plumes were also interpreted to be smaller than in previous years as concentrations at wells located near the release points declined. The strontium-90 plume areas for 2014 are similar to 2013.

Many of the wells monitoring the 116-K-2 Trench have detectable strontium-90, but most concentrations are below or near the DWS of 8 pCi/L. The highest concentrations near the trench in 2014 were at Well 199-K-200 (Figure 5-22), which was drilled through the former trench near the head end (southwest). Concentrations in this well remained fairly stable in 2014 at about 200 pCi/L. Concentrations in other wells in the 116-K-2 Trench region were consistently less than 30 pCi/L. Strontium-90 has migrated away from the 116-K-2 Trench downgradient toward the Columbia River in at least two locations; downgradient Wells 199-K-19, 199-K-21, 199-K-22, and 199-K-161 all exhibited at least one measurement of strontium-90 exceeding the DWS during 2014. Aquifer tube 22-M, located along the Columbia River shore downgradient of the distal end of 116-K-2 Trench, exhibited a strontium-90 concentration during 2014 of 7.2 pCi/L (a slight decrease from the 8.8 pCi/L observed in 2013).

A high-concentration strontium-90 plume is present in the vicinity of KE Reactor. The highest concentration portion of the plume formerly was represented by Well 199-K-109A, which had a strontium-90 concentration of 1,120 pCi/L the last time the well was sampled in 2008, and a historical maximum concentration of 18,600 pCi/L. This well historically exhibited strontium-90 concentrations greater than 5,000 pCi/L from 1996 to 2000. This well was decommissioned to facilitate demolition activities. About 120 m (390 ft) directly downgradient from 199-K-109A, the measured strontium-90 concentration continued to rise in extraction Well 199-K-141 to 54 pCi/L by mid-2014 (Figure 5-23), with the increase beginning soon after starting groundwater extraction at that well. The increased concentration in extraction Well 199-K-141 indicates part of the leading edge of the K East strontium-90 plume continued migration downgradient in 2014. With the addition of nondetect strontium-90 measurements from new Well 199-K-202, it now appears that the strontium-90 plume in this area is migrating from the location of former Well 199-K-109A toward extraction Well 199-K-141. The conditions observed in 199-K-141 most likely represent the leading edge of the strontium-90 plume in this area. This direction of plume movement is consistent with the current interpretation of groundwater gradient in this area.

Two wells in the K West region continued to consistently exhibit strontium-90 concentrations above the DWS of 8 pCi/L (199-K-107A and 199-K-34) in 2014. The maximum concentration of 56 pCi/L reported in late 2014 (199-K-34) was consistent with conditions measured in 2013. The concentration continued to gradually decline in Well 199-K-107A to 12.7 pCi/L in 2014 versus 16 pCi/L in 2013. The plume is inferred to be similar in size for 2014 in this vicinity. Concentrations are near detection limits in wells farther downgradient. Strontium-90 was not detected in samples collected from seeps at 100-KR during 2014.

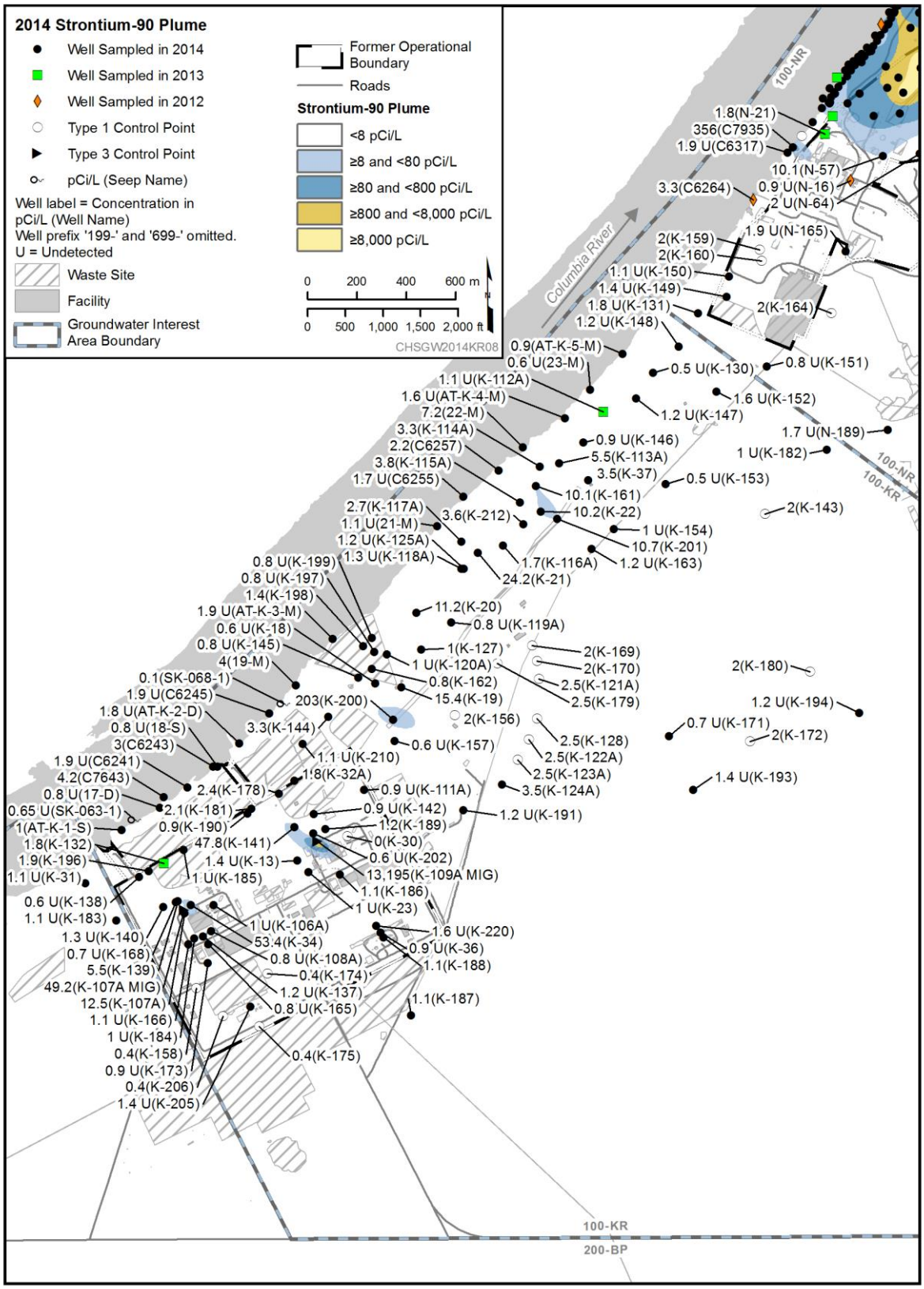


Figure 5-21. 100-KR Strontium-90 Plume, 2014

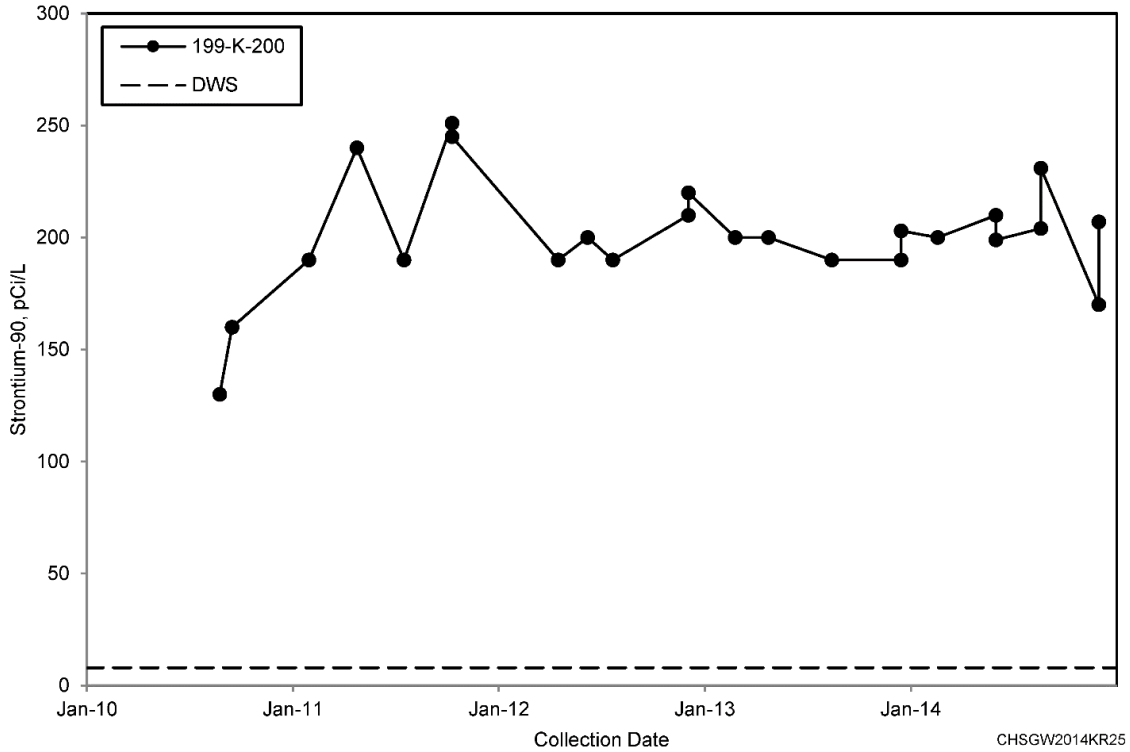


Figure 5-22. 100-KR Strontium-90 Data for Well 199-K-200, Located in Former 116-K-2 Trench

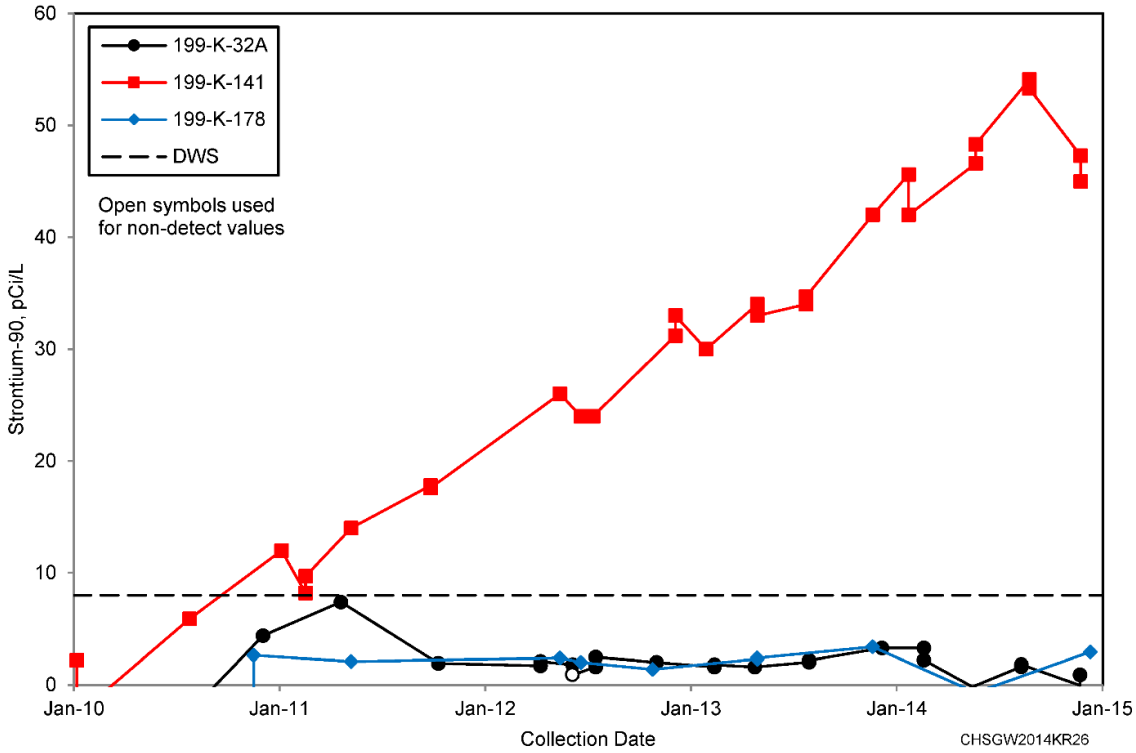


Figure 5-23. 100-KR Strontium-90 Data for Wells 199-K-32A, 199-K-141, and 199-K-178, Located Downgradient of KE Reactor

5.8 Carbon-14

Most of the carbon-14 in groundwater in 100-KR originated from historical discharges of reactor gas dryer regeneration condensate to the 116-KE-1 and 116-KW-1 Gas Condensate Cribs. Measurements of carbon-14 in gas dryer condensate collected at KE and KW Reactors during operation ranged from 2.9×10^8 pCi/L at KW Reactor to 1.04×10^9 pCi/L at KE Reactor. The gas condensate stream also contained tritium ranging from 3×10^9 pCi/L to 1×10^{10} pCi/L and ammonia ranging from 9,000 to 36,000 mg/L (HW-76258, *Reactor Gas Drier Condensate Waste – Decontamination Studies*).

To estimate the extent of carbon-14 groundwater contamination more accurately, extrapolations of historical carbon-14 concentrations from Wells 199-K-30 and 199-K-106A were evaluated. Plume migration was estimated in an area with no downgradient well. Values presented in the plume map (Figure 5-24) represent the extrapolated data. The highest residual carbon-14 concentrations in groundwater are associated with the KW Reactor, where the estimated maximum concentration derived from the extrapolation is approximately 39,500 pCi/L. The extrapolated concentrations associated with the KE Reactor are slightly lower, with the estimated maximum concentration of approximately 22,900 pCi/L. At both reactor areas, the resultant 2014 plume distribution exhibits an areal extent of concentrations exceeding the 2,000 pCi/L DWS that is similar to that inferred in 2013. Five wells in the K West region exhibited concentrations above 2,000 pCi/L in 2014 (199-K-106A, 199-K-34, 199-K-139, 199-K-132, and the new Well 199-K-204). These wells are located downgradient of the historical release site at the 116-KW-1 Crib and have exhibited the presence of elevated carbon-14 concentrations for most of the past 15 years. The carbon-14 concentration trends in these wells likely reflect migration of carbon-14 away from the inferred area of maximum concentration (greater than 30,000 pCi/L) immediately downgradient of the crib.

Monitoring results in 2014 from extraction Well 199-K-132 indicate that this well consistently exhibited carbon-14 concentration exceeding 2,000 pCi/L. Carbon-14 contamination in groundwater continued to be observed widely distributed over the KW Reactor vicinity at concentrations below 1,000 pCi/L.

A lower concentration carbon-14 plume exists in the K East region. The plume was formerly defined by Wells 199-K-29 and 199-K-30, which have been decommissioned. In 2010, Wells 199-K-29 and 199-K-30 had maximum concentrations of 3,120 and 6,900 pCi/L, respectively, which are above the DWS. These wells monitored conditions downgradient of the 116-KE-1 Crib waste site. As with conditions near the KW Reactor, the carbon-14 plume at the KE Reactor area appears to be migrating downgradient away from the source area. The extrapolated downgradient concentrations indicate that carbon-14 concentrations in groundwater, greater than 20,000 pCi/L, likely exist in the downgradient area where no effective monitoring currently exists. The carbon-14 plume at K East may not lie completely within the expected capture zone of the operating extraction wells of the KX P&T system.
Well 199-K-202 exhibited a carbon-14 concentration of 1,560 pCi/L in 2014. New Well 199-K-203, located riverward of the 116-KE-1 Crib, exhibited carbon-14 at 6,230 pCi/L in a sample collected just below the water table during drilling.

Well 199-K-189, located downgradient of KE Reactor, continued to exhibit an increasing trend in carbon-14 concentration, with a maximum measured value of 2,950 pCi/L during 2014. Similar to the conditions observed at KW Reactor area, carbon-14 continued to be detected at relatively low concentrations in aquifer tubes near the 105-KE vicinity (below 500 pCi/L).

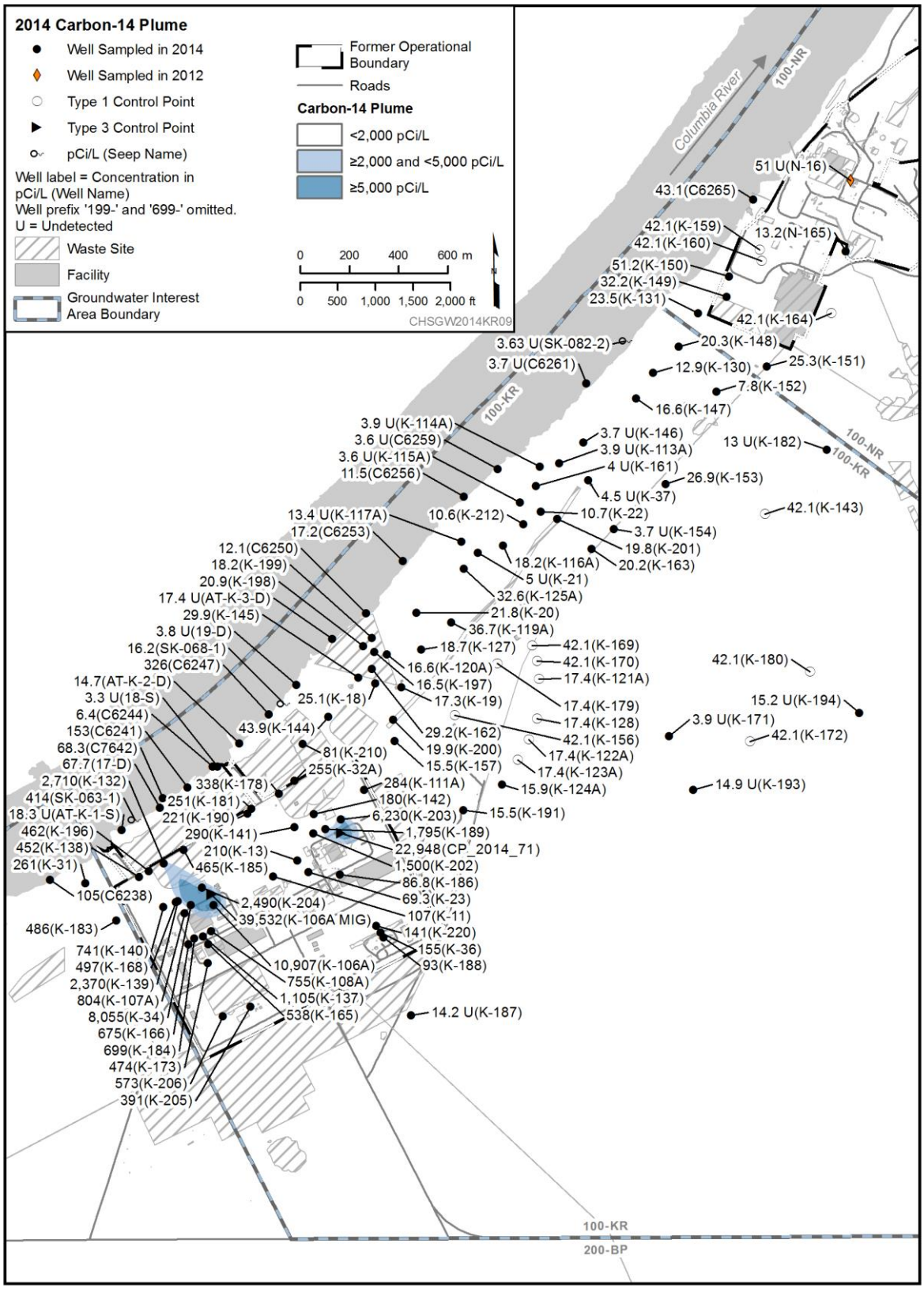


Figure 5-24. 100-KR Carbon-14 Plume, 2014

5.9 Trichloroethene

TCE continues to be detected in some 100-KR wells, primarily in the K West region (Figure 5-25). Seven wells in 100-K (199-K-132, 199-K-138, 199-K-139, 199-K-140, 199-K-168, 199-K-185, and 199-K-196) exhibited TCE at concentrations above the 5 µg/L DWS during at least one sampling event in 2014. The highest concentrations in routine samples in 2014 were 6.8 and 5.9 µg/L in Wells 199-K-185 (Figure 5-26) and 199-K-132 (Figure 5-27), respectively. The sources of TCE at 100-KR are not apparent but are likely related to the use of solvents during equipment maintenance activities; specific release points for TCE have not been identified at 100-KR. The TCE plume is poorly defined by the available measurements; there are relatively few wells in the general vicinity of the exceedance and this injects an element of uncertainty into interpolation of the plume contours. As with other contaminants at 100-KR Area, TCE is detected in effluent water at the KW P&T system. The annual average effluent concentration of 3.8 µg/L was assigned to the injection wells for the plume map interpretation. The relatively widespread occurrence of TCE in groundwater in the KW Reactor vicinity results in a dispersed plume in the KW vicinity that is slightly below the 5 µg/L DWS.

The primary source and release point(s) of TCE near the KW Reactor have not been identified, and historical maximum concentrations measured in monitoring wells were substantially larger than currently observed (e.g., 35 µg/L at Well 199-K-106A measured in 1995). The distribution of TCE in groundwater, as well as the actual maximum concentration, remains somewhat uncertain. At the near-river locations, TCE was detected in several aquifer tubes downgradient of the KW plume at less than 0.6 µg/L. Seep SK-063-1, located riverward of Well 199-K-132, exhibited TCE at concentrations below 1.0 µg/L during 2014; this is a decrease from the 2.38 µg/L measured in September 2013.

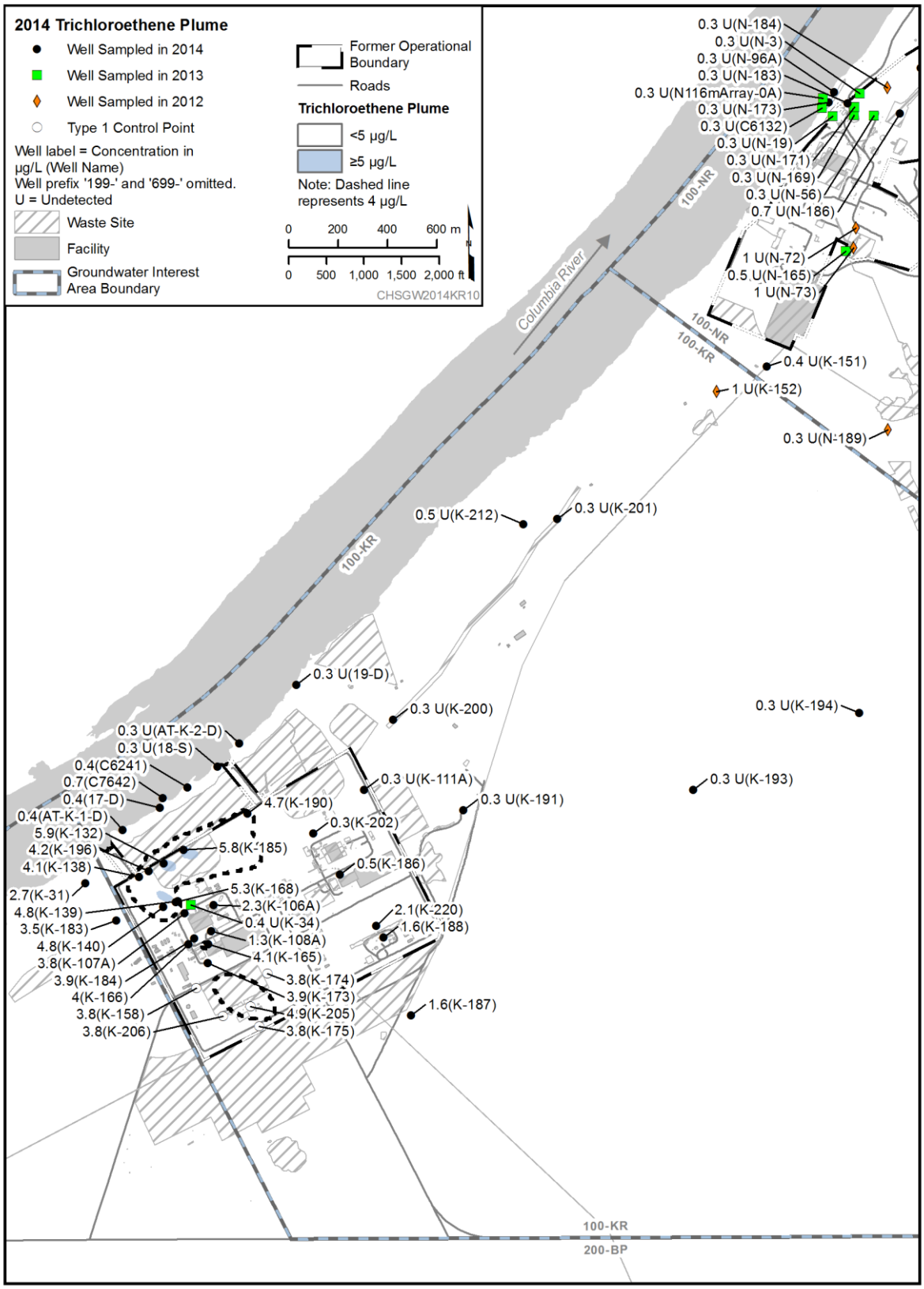


Figure 5-25. 100-KR TCE Plume, 2014

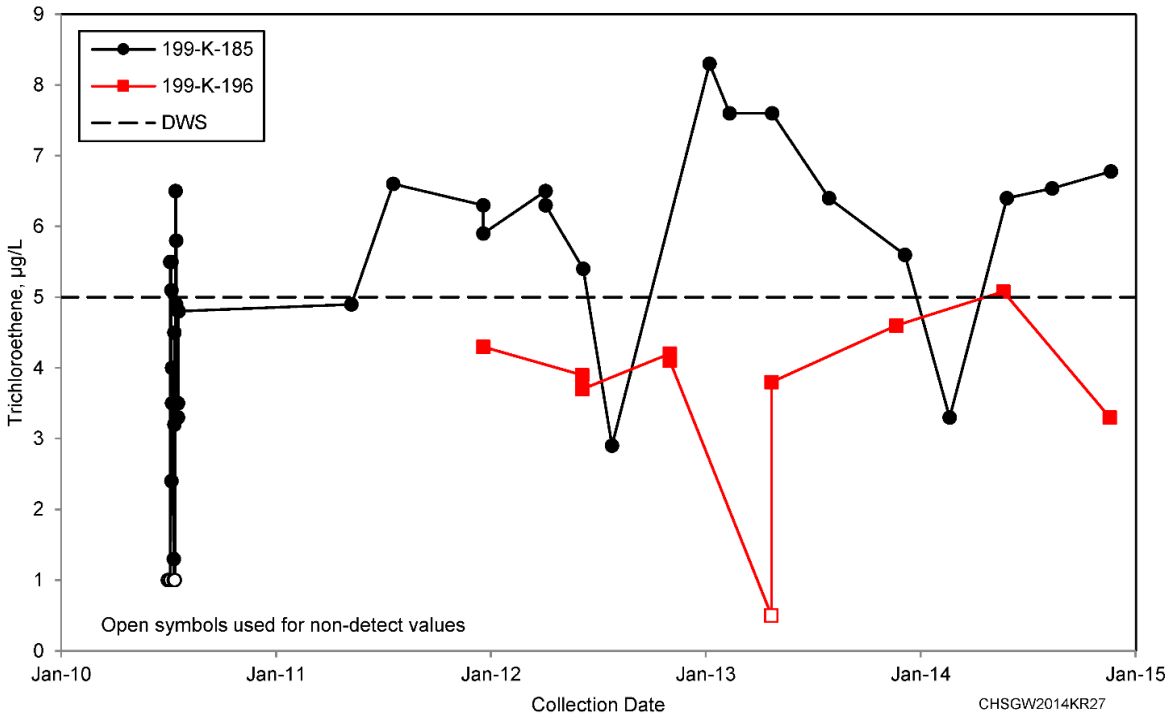


Figure 5-26. 100-KR TCE Data for Wells 199-K-185 and 199-K-196, Located Downgradient of KW Reactor

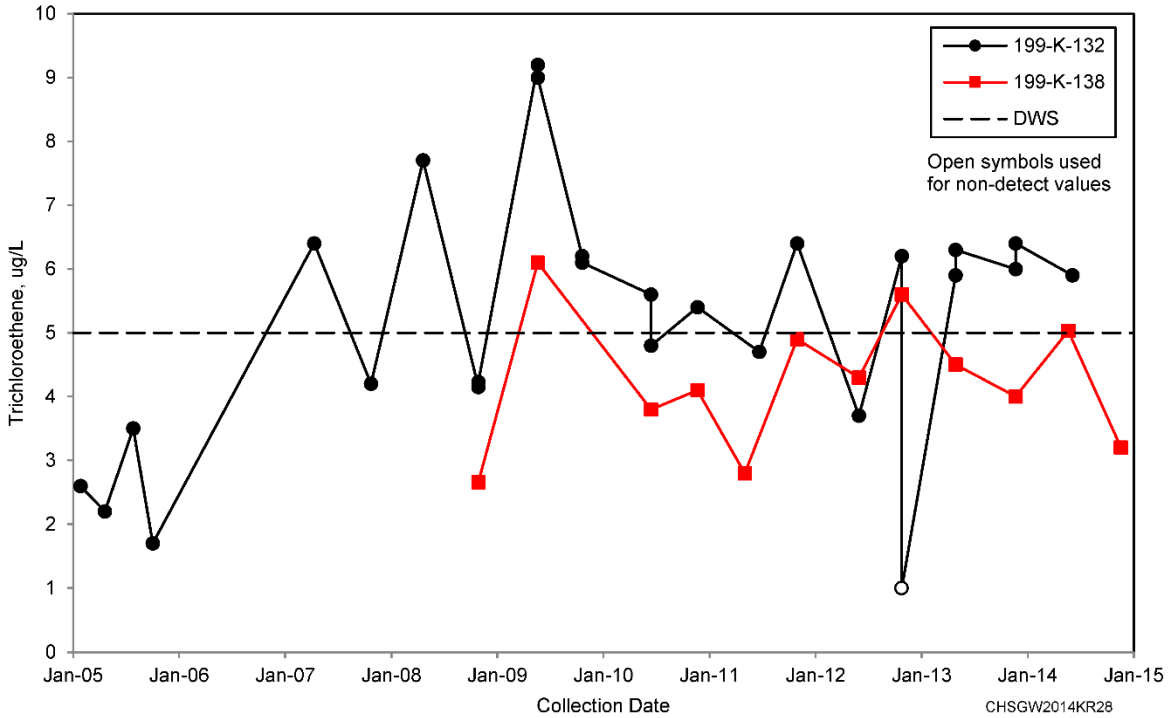


Figure 5-27. 100-KR TCE Data for Wells 199-K-132 and 199-K-138, Located Downgradient of KW Reactor

5.10 100-KR-4 Remedy

An interim action ROD for the 100-KR-4 OU was issued in April 1996 (EPA/ROD/R10-96/134). One of the RAOs identified in the interim action ROD is to protect aquatic receptors in the Columbia River from contaminants in groundwater. The interim action ROD included a preliminary estimated dilution factor of 1:1 for groundwater entering the Columbia River at 100-K, 100-D, and 100-H Areas under the assumption that dilution of groundwater with river water is expected before the groundwater would reach the aquatic receptor point of concern within the river substrate. This established and operational target for treatment system effluent at 20 µg/L for hexavalent chromium. For purposes of managing the interim remedial action, the working assumption is that groundwater at 20 µg/L at onshore, near-river monitoring locations will achieve the surface water standard of 10 µg/L at the point where groundwater discharges to the river (EPA et al., 2009).

Since the ROD was published, DOE has implemented three P&T systems to remediate hexavalent chromium contamination in 100-KR-4 OU groundwater and protect the Columbia River. All three systems, as listed below, operated in 2014 and are continuing to operate in 2015; 31 compliance and performance monitoring wells are identified for these systems:

- The original P&T system (KR-4), which began operating in 1997, focuses on contamination originating beneath the 116-K-2 Trench.
- The KX P&T system has two focus areas: one at the northeastern end of the 116-K-2 Trench, where the hexavalent chromium plume historically migrated toward 100-NR-2, and the other in the vicinity of KE Reactor facilities. The KX system began operating in 2009.
- The KW P&T system, which began operating in 2007, focuses on the hexavalent chromium plume at KW Reactor facilities.

Groundwater remedial action systems will continue to operate in the 100-KR-4 OU. These systems provide protection of the Columbia River from release of hexavalent chromium-contaminated groundwater that would cause an exceedance of the 10 µ/L surface water quality criterion and to maintain hydraulic containment of remaining hexavalent chromium plumes.

5.10.1 Pump and Treat

As of December 2014, 41 extraction wells and 18 injection wells were in service (Figure 5-28). Combined, the three systems are presently capable of treating about 8.2 million L (2.2 million gal) of groundwater per day. The combined P&T systems in 100-KR-4 removed 50 kg of hexavalent chromium from groundwater in 2014. Since 1997, the 100-KR-4 P&T systems have removed 797 kg of hexavalent chromium from the aquifer. *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operation, and 100-NR-2 Groundwater Remediation* (DOE/RL-2015-05) provides additional details.

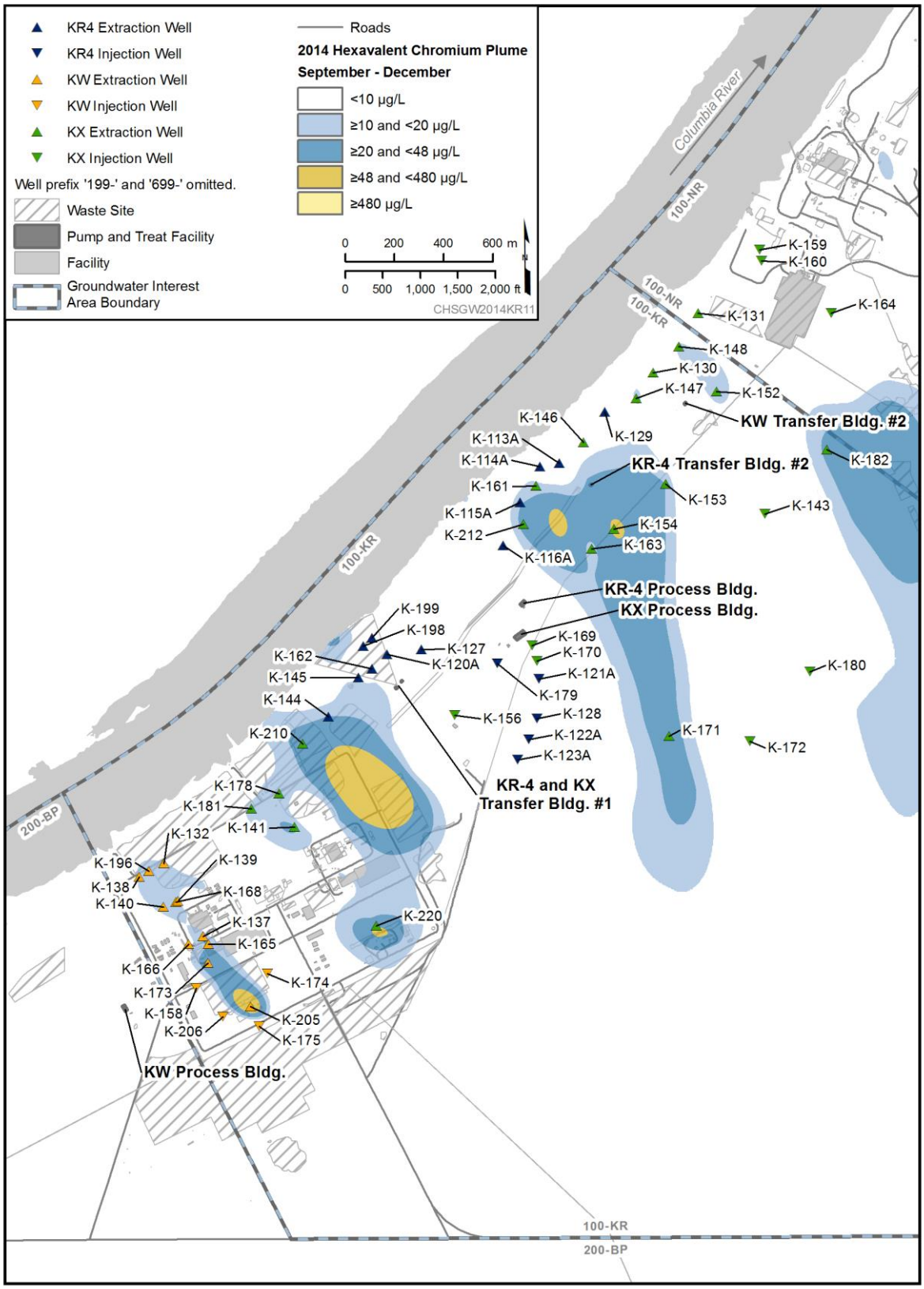


Figure 5-28. 100-KR P&T Well Locations

Under the current configuration, the 100-KR-4 P&T systems are demonstrating progress toward the interim RAOs (Table 5-2; Figure ES-5). Operation of the systems and containment of the plumes address the first and third RAOs defined by the ROD: (1) protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River, and (3) provide information that will lead to a final remedy. A summary of hexavalent chromium concentrations detected in compliance and performance evaluation wells during 2014 is provided in Table 5-3. Thirty-eight of fifty-eight wells identified in Table 5-3 exceed the 10 µg/L hexavalent chromium surface water quality criterion; twenty-four wells exceed 20 µg/L. Containment of the plume in combination with ICs also meets the second RAO: (2) protect human health by preventing exposure to contaminants in the groundwater. Operation and refinement of these remedial systems are also meeting the third RAO, which is to provide information that will lead to the final remedy. This included the addition of five extraction wells, one new injection well, and five new monitoring wells to the OU. Groundwater monitoring provides ongoing information regarding the nature, extent, and dynamic behavior of the groundwater plumes at 100-KR-4 OU.

Table 5-2. 100-KR-4 Interim Action P&T Systems, 2014

Performance	KR4		KX		KW		Total	
	2014	**1997–2014**	**2014**	**2009–2014**	**2014**	**2007–2014**	**2014**	**1997-2014**
Groundwater processed (million L/million gal)	527/139	7,280/1,925	1,198/316	5,773/1,524	579/153	2,916/771	2,304/609	15,969/4,221
Mass of hexavalent chromium removed (kg/lb)	5/11	373/833	26/57	200/497	19/43	224/537	50/111	797/1,868
Wells	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	
Number of extraction wells	12	11	18	14	11	11	41	N/A
Number of injection wells	5	5	9	9	4	4	18	N/A
Hexavalent Chromium Plume Area	**2014**				**Change from 2013**			
Greater than 10 µg/L	2.1 km^2/0.8 mi^2				+12%			
Greater than 20 µg/L	1 km^2/0.4 mi^2				0%			

Table 5-3. Summary of Hexavalent Chromium Concentrations in 100-KR-4 OU Compliance and Performance Evaluation Wells for CY 2014

Well Name	Treatment System	2014 Maximum Cr(VI) (µg/L)
199-K-106A	100-KW	4
199-K-107A	100-KW	13
199-K-111A	100-KR4/KX	520
199-K-113A	100-KR4/KX	4
199-K-114A	100-KR4/KX	9
199-K-115A	100-KR4/KX	47
199-K-116A	100-KR4/KX	6
199-K-117A	100-KR4/KX	2
199-K-118A	100-KR4/KX	3
199-K-119A	100-KR4/KX	2
199-K-120A	100-KR4/KX	6
199-K-124A	100-KR4/KX	4
199-K-125A	100-KR4/KX	3
199-K-126	100-KR4/KX	12
199-K-127	100-KR4/KX	3
199-K-129	100-KR4/KX	5
199-K-130	100-KR4/KX	16
199-K-131	100-KR4/KX	10
199-K-132	100-KW	14
199-K-137	100-KW	27
199-K-138	100-KW	15
199-K-139	100-KW	20
199-K-140	100-KW	19
199-K-141	100-KR4/KX	27
199-K-142	100-KR4/KX	1.6
199-K-144	100-KR4/KX	25
199-K-145	100-KR4/KX	21
199-K-146	100-KR4/KX	27
199-K-147	100-KR4/KX	15

Table 5-3. Summary of Hexavalent Chromium Concentrations in 100-KR-4 OU Compliance and Performance Evaluation Wells for CY 2014

Well Name	Treatment System	2014 Maximum Cr(VI) (µg/L)
199-K-148	100-KR4/KX	19
199-K-149	100-KR4/KX	4
199-K-150	100-KR4/KX	8
199-K-151	100-KR4/KX	6
199-K-152	100-KR4/KX	39
199-K-153	100-KR4/KX	30
199-K-154	100-KR4/KX	80
199-K-157	100-KR4/KX	11
199-K-161	100-KR4/KX	43
199-K-162	100-KR4/KX	5
199-K-163	100-KR4/KX	26
199-K-165	100-KW	32
199-K-166	100-KW	23
199-K-168	100-KW	24
199-K-171	100-KR4/KX	55
199-K-173	100-KW	71
199-K-178	100-KR4/KX	25
199-K-18	100-KR4/KX	11
199-K-181	100-KR4/KX	16
199-K-182	100-KR4/KX	46
199-K-19	100-KR4/KX	8
199-K-20	100-KR4/KX	9
199-K-21	100-KR4/KX	11
199-K-22	100-KR4/KX	40
199-K-32A	100-KR4/KX	14
199-K-36	100-KX	316
199-K-37	100-KR4/KX	21
199-K-205	100-KW	3,280
699-78-62	100-KR4/KX	2

5.11 Atomic Energy Act Monitoring

DOE requires monitoring of environmental conditions, including groundwater, to document and understand impacts to the environment and to ensure that site-related nuclear contaminants do not result in unacceptable exposures to human and ecological receptors. This monitoring, generically referred to as "AEA monitoring" (after the *Atomic Energy Act of 1954*, which invokes the requirements) is conducted at selected locations and typically at concurrent timing with other groundwater monitoring activities required by CERCLA within the 100-KR-4 Groundwater OU. AEA monitoring at 100-KR is conducted in the vicinity of the fuel storage basins under PNNL-14033. The SAP for AEA groundwater monitoring is presently under revision and is expected to be completed in calendar year 2015. Revision of the AEA SAP includes review and identification of affected facilities and specification of data needs and monitoring locations, including those related to facilities at 100-KR Area.

The fuel storage basins in the KW and KE Reactor buildings were used from 1955 to 1971 to store irradiated fuel generated at the K Reactors, and from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin held approximately 4.9 million L (1.3 million gal) of shielding water that became highly contaminated with fuel residues and fission products (e.g., strontium-90, cesium-137, and tritium). In addition, each basin was originally connected to a drain system that included a combined crib and reverse well (waste sites 116-KE-3 and 116-KW-2) designed to receive water from a sub-basin drain system. These waste sites, as well as leaks around the KE Basin, contaminated the adjacent vadose zone and groundwater. The KW Basin has no documented leaks.

Fuel rods and debris were removed from the K Basins by 2008. The KE Basin, substructure, and crib were demolished in 2009. The reverse well associated with the 116-KE-3 Crib remains in place. Contaminated soil around the basin and crib was removed; however, more contaminated vadose zone soil remains at these locations. Prior to building demolition and soil remediation, downgradient groundwater monitoring wells around the KE Basin were decommissioned. The KW Basin has been emptied of fuel rods but remains water-filled and continues to serve as a depository for contaminated sludge from the KE and KW Basins. The KW Basin and the 116-KW-2 Crib and reverse well are scheduled for removal following removal of the remaining contaminated materials from the basin.

Based on reported contamination in the basin shielding water, analytes that may affect groundwater include tritium, carbon-14, technetium-99, strontium-90, and cesium-137. Tritium and strontium-90 in groundwater are considered to be the primary indicators of water loss from the fuel storage basin and crib system.

PNNL-14033 specifies groundwater monitoring requirements. Although the KE Basin no longer exists, the KW Basin remains in service, and a continuing sampling program is being maintained (Figure 5-29; Table B-90 of Appendix B). Previous leakage at the KE Basin and the use of dust suppression water during basin and vadose zone remediation warrant continued monitoring at downgradient wells for the near future. The groundwater monitoring network has been modified to account for wells that have been decommissioned. There are currently no groundwater monitoring wells remaining immediately downgradient of the KE Basin. Monitoring of the area for strontium-90 will continue using the existing wells. One new well, 199-K-202, was installed downgradient of this area in 2013. During 2014, two more monitoring wells were installed in the vicinity downgradient of the reactors; 199-K-203 and 199-K-204 were installed downgradient of 116-KE-1 and 116-KE-3 Cribs, respectively. DOE plans to place two characterization borings in this area (one each at the location of 116-KE-3 Crib and the historical release site from 105-KE Fuel Storage Basin [UPR-100-K-1]). Current plans include completion of those borings as wells.

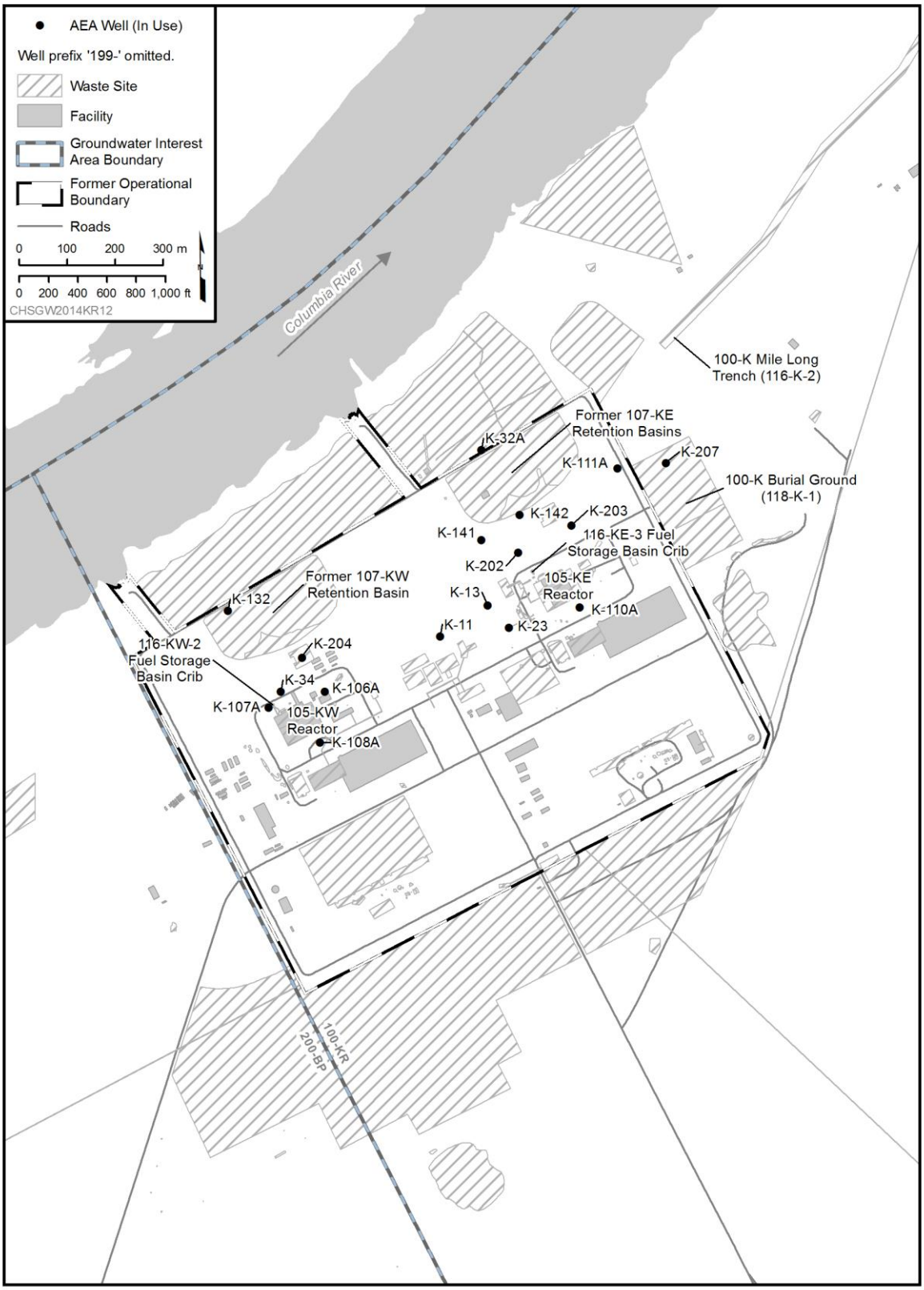


Figure 5-29. 100-KR AEA Well Locations

Tritium concentrations in wells downgradient from the KE Basins maintained previous trends in 2014, suggesting no new releases. Tritium was detected in a characterization sample from new Well 199-K-202 at 76,000 pCi/L. Well 199-K-111A exhibited an increasing trend since mid-2012; however, this tritium appears to originate in the vicinity of 118-K-1 Burial Ground, not the fuel storage basin, as indicated by the detection of elevated tritium in groundwater at new Well 199-K-207 (located within the burial ground footprint). Strontium-90 concentrations continued to increase in downgradient Well 199-K-141 (an extraction well for the chromium P&T system) in 2013. This contamination likely originated in the KE Basins or the adjacent 116-KE-3 Crib. In the past, higher levels of strontium-90 were detected in Well 199-K-109A, adjacent to the crib. Decreases in concentration at Well 199-K-109A between 1990 and 2008, when it was decommissioned, as well as the observed increase in Well 199-K-141, likely indicate downgradient movement of the plume. Strontium-90 was not detected in characterization samples collected from new Well 199-K-202. This indicates that the migrating strontium-90 plume is likely a narrow plume that lies between the location of the 116-K-3 Crib and 199-K-141. These conditions are consistent with migration of an existing plume and do not, of themselves, indicate any new release of contaminants to groundwater.

Tritium and strontium-90 concentrations in wells downgradient from the KW Fuel Storage Basin in 2014 were consistent with previous measurements and the expected migration of plumes downgradient, away from the source areas.

6 100-NR

6.1 Overview

The 100-NR groundwater interest area encompasses the 100-NR-2 OU and the surrounding area, located adjacent to the Columbia River (Figure 6-1). Among the Hanford Site plutonium-production reactors, the design of N Reactor was unique. The N Reactor, which operated in the 100-N Area from 1963 to 1987, was a dual-purpose reactor that produced plutonium for defense purposes and steam for commercial electrical power generation. Groundwater contamination in 100-NR is primarily associated with waste formerly produced by the reactor and associated processes. Approximately 92 percent of the waste sites in 100-NR have been remediated or classified as not requiring remediation under an interim action ROD. A summary of 100-NR, including key contaminants, is shown in Table 6-1. Additional details about 100-NR history and waste sites are provided in Section 1.3 of DOE/RL-2012-15, Draft A. Section 1.3 of this document provides details about plume mapping, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Strontium-90 is the principal groundwater contaminant. Other contaminants include nitrate, total petroleum hydrocarbon (TPH) diesel, hexavalent chromium, and tritium. Strontium-90 and TPH-diesel are being remediated under a CERCLA interim action ROD (EPA/ROD/R10-99/112, as amended). An apatite permeable reactive barrier (PRB) was installed between 2006 and 2011 to enhance attenuation of the strontium-90 in groundwater moving toward the Columbia River. TPH-diesel free product is being removed from groundwater in one well (199-N-18). A bioventing system began full-scale operations in 2012 to remediate TPH-diesel in the deep vadose zone. Groundwater is monitored at four waste sites to meet requirements of RCRA and WAC 173-303. Figure 6-2 illustrates how estimates of plume areas in the 100-NR groundwater interest area have changed since 2003.

The vadose zone in 100-NR is 0 to 23 m (76 ft) thick and is composed of gravels and sands of the Hanford formation and upper Ringold Formation unit E (Figure 6-3). The unconfined aquifer is approximately 6.5 to 14 m (21 to 46 ft) thick and primarily located within the Ringold Formation unit E. When the Columbia River stage is high, the water table can rise into the Hanford formation in wells near the shoreline. The RUM forms the base of the unconfined aquifer.

Groundwater in 100-NR generally flows northwest toward the Columbia River. As shown in Figure 6-1, the magnitude of the difference in groundwater hydraulic head across 100-NR in March 2014 was about 2 m (6.6 ft). Groundwater flow was influenced in 2014 by groundwater extraction and injection for the KX P&T remediation system located in the southwest portion of 100-NR. A groundwater mound approximately 1 m (3.3 ft) high surrounding KX injection Wells 199-K-159, 199-K-160, and 199-K-164 creates local radial flow (Figure 6-1).

In 2014, the high river stage lasted from mid-March through early August (Figure 5-7). Water levels in Well 199-N-146 near the river rose approximately 2 m (6.6 ft) between late February and mid-April. There is a lag time of a few days between the rise in water levels in wells near the river and in wells further inland (e.g., between 199-N-146 and 199-N-2, 170 m [560 ft] inland from the river) (DOE/RL-2014-32). Changing river stage can influence groundwater elevations over 1 km (0.6 mi) inland from the river (Section 3.6 of DOE/RL-2012-15).

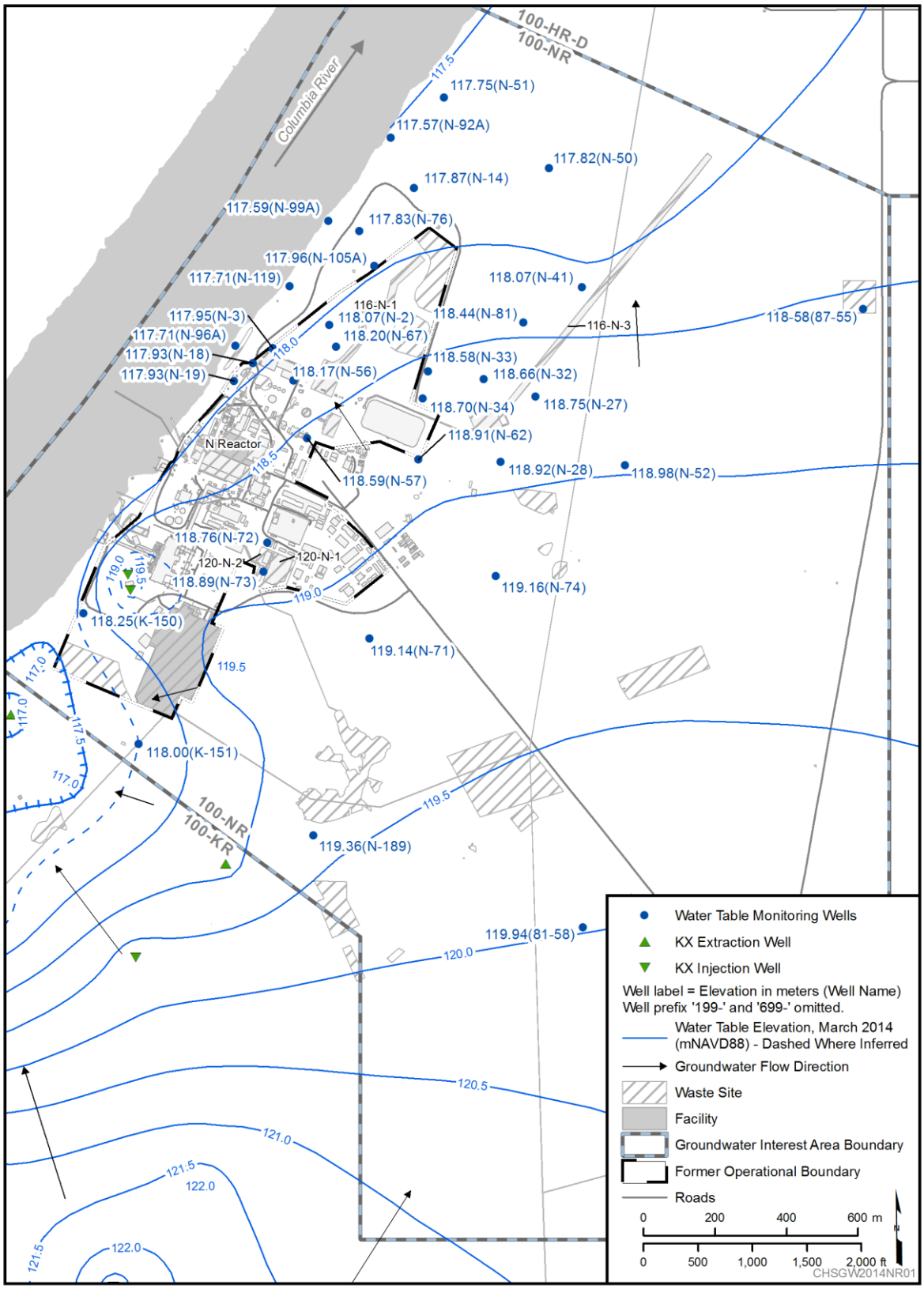


Figure 6-1. 100-NR Overview Map with Groundwater Flow

Table 6-1. 100-NR at a Glance

N Reactor operations: 1963–1987				
2014 Groundwater Monitoring				
Contaminants	**Water Quality Standard**	**Maximum Concentration**	**Plume Area[a]**	**Shoreline Impact (m)**
Strontium-90	8 pCi/L[b]	15,500 pCi/L (199-N-67)	0.61 km^2	600
Nitrate	45 mg/L[c]	186 mg/L (199-N-67)	0.53 km^2	100
Diesel (as total petroleum hydrocarbons)	0.5 mg/L[d]	18 mg/L (199-N-346)	0.01	60
Hexavalent Chromium	48 µg/L/ 10 µg/L[e]	193 µg/L (199-N-80)	0 / 0.81 km^2 [f]	0
Tritium	20,000 pCi/L[b]	761,000 (C7934)	NC[g]	NC[g]
Remediation				
Waste sites (interim action): 92 percent complete[h] Groundwater (interim action): • P&T: 1995-2006, 1.8 Ci strontium-90 removed • Apatite PRB: 2006-2014 Final ROD anticipated in 2015.				

a. Estimated area at a concentration greater than the listed water quality standard.

b. Drinking water standard

c. 45 mg/L as NO_3 is equivalent to the drinking water standard of 10 mg/L as N.

d. MTCA Method A for TPH-diesel range organics?

e. 48 µg/L MTCA standard, 10 µg/L surface water standard

f. Hexavalent chromium in 100-NR unconfined aquifer is believed to have origins in 100-KR

g. Plume area not calculated due to infrequent detection of tritium greater than 20,000 pCi/L. Shoreline impact not calculated since tritium only detected above 20,000 pCi/L in one aquifer tube cluster.

h. Sites with status of closed, interim closed, no action, not accepted, or rejected.

COCs = contaminants of concern
MTCA = Model Toxics Control Act
P&T = pump and treat
PRB = permeable reactive barrier
ROD = Record of Decision

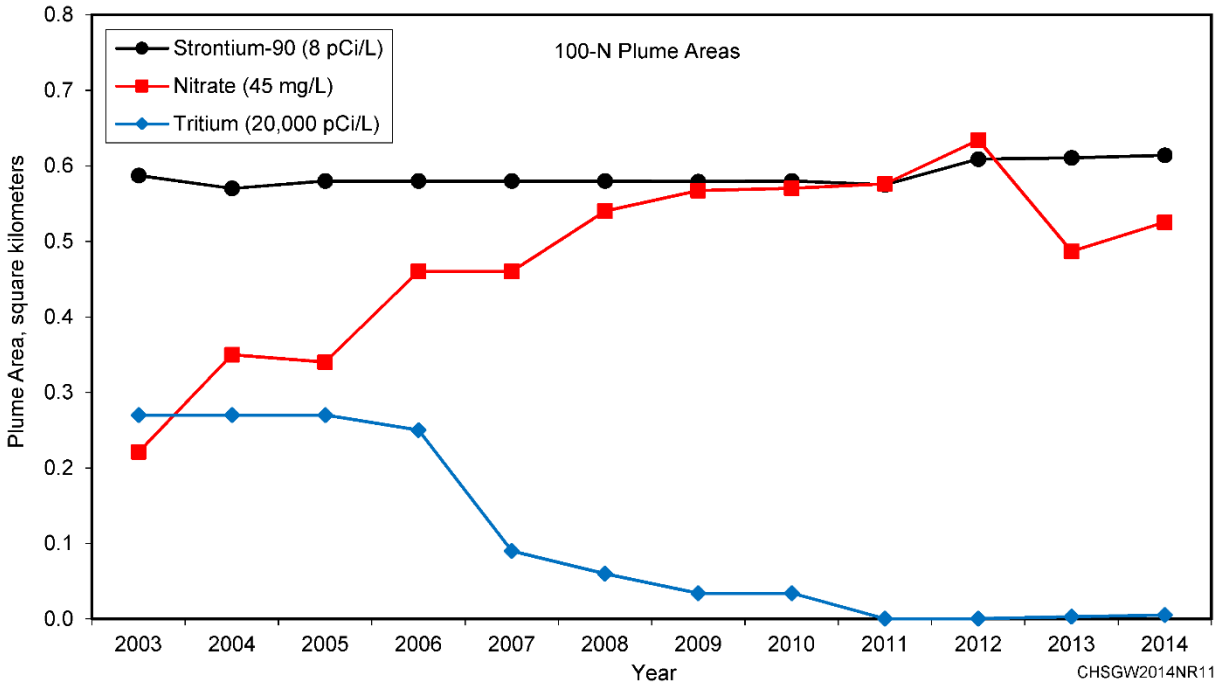


Figure 6-2. 100-NR Plume Areas

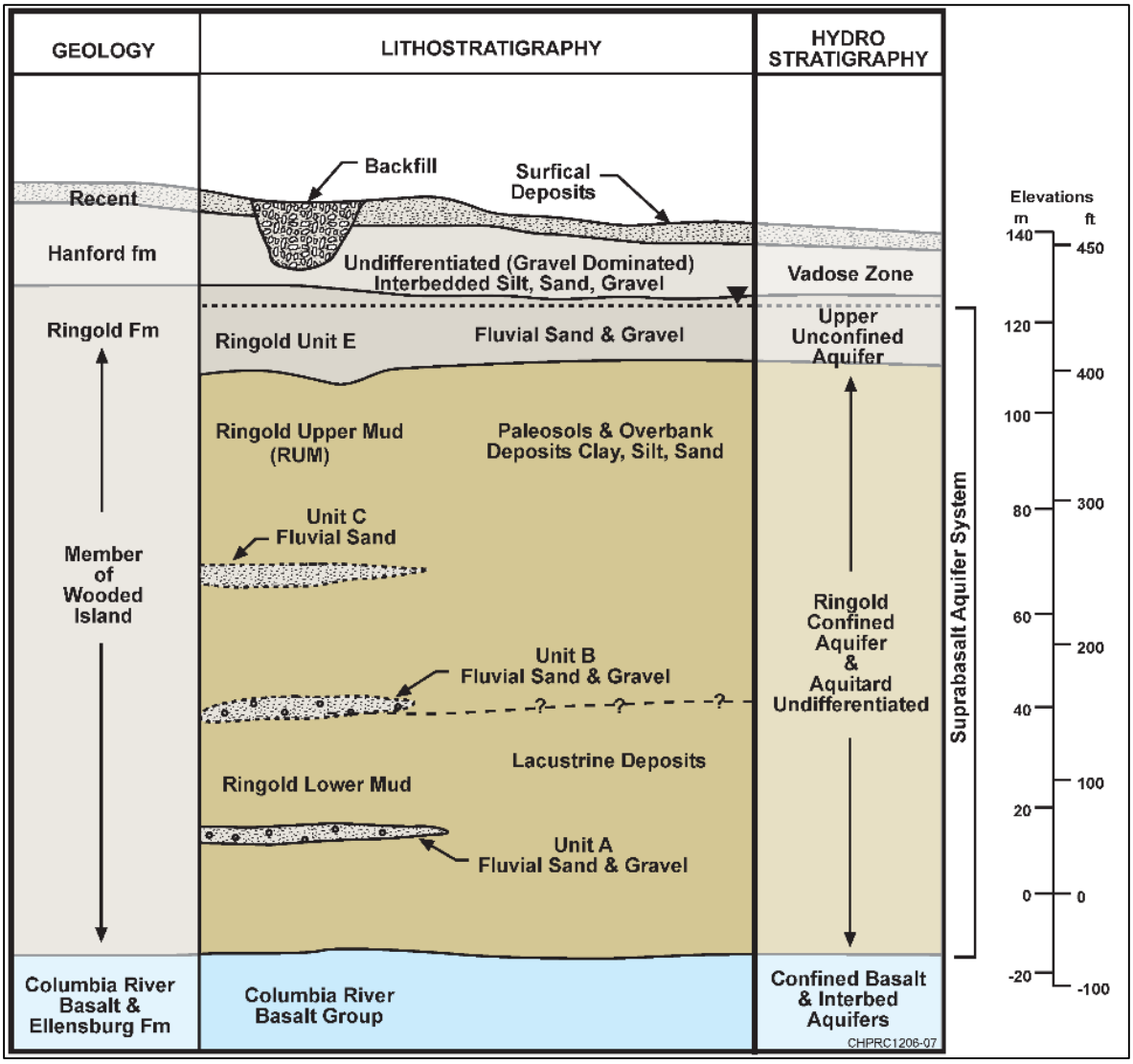


Figure 6-3. 100-NR Geology

6.2 CERCLA Activities

In 2014, CERCLA activities in 100-NR included routine groundwater monitoring, completion of the remedial design report/remedial action work plan (RD/RA WP; DOE/RL-2001-27, Rev. 1), beginning revision of Draft A of the RI/FS report (DOE/RL-2012-15) in response to comments, and continued interim remediation of strontium-90 and TPH-diesel contamination.

6.2.1 Groundwater Monitoring

Routine groundwater monitoring for October through December 2014 is described in the RDR/RA WP (DOE/RL-2001-27, Rev. 1), which was approved in September 2014. From January through September 2014, groundwater monitoring was described in the previous version of the work plan (DOE/RL-2001-27, Rev. 0, as modified by TPA-CN-256 and TPA-CN-569). From January through September 2014, groundwater sampling also was conducted in accordance with the RI/FS work plan (DOE/RL-2008-46 ADD5) and associated SAP (DOE/RL-2009-42, as modified by

TPA-CN-478). During CY 2014, aquifer tubes were monitored in accordance with the SAP for aquifer tubes (DOE/RL-2000-59, as modified by TPA-CN-353). The sampling locations for 100-NR are shown in Figure 6-4.

CERCLA sampling is conducted primarily in September, with selected wells also monitored in March. Table A-4 of Appendix A lists the wells and constituents monitored. Aquifer tubes in 100-NR were sampled in September 2014, and some were sampled more frequently (Appendix C).

One river shore seep at 100-NR was sampled in September 2014 during low river stage. Seeps occur when the groundwater elevation locally is higher than the river elevation causing groundwater to drain from the aquifer along the shoreline above the river. The results of the seep analyses for hexavalent chromium, nitrate, strontium-90, and tritium are shown as information on their respective plume maps but are not used during preparation of the plume configurations.

6.2.2 Remedial Design/Remedial Action Work Plan

The revised RDR/RA WP (DOE/RL-2001-27, Rev. 1) presents the approach for implementing the interim remedial actions selected for the 100-NR-2 Groundwater OU, as specified in the *Interim Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units* (EPA/ROD/R10-99/112). The RDR/RA WP includes the activities necessary to install and maintain an apatite PRB for the 100-NR-2 OU, as specified in the interim action ROD, as amended (EPA, 2010, *100-NR-1 and NR-2 Operable Units Hanford Site – 100 Area Benton County, Washington Amended Record of Decision, Decision Summary and Responsiveness Summary*). Appendix A of the RDR/RA WP is the SAP for interim remedial actions and routine groundwater monitoring. The revised RDR/RA WP was prepared to fulfill *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-015-60.

6.2.3 Remedial Investigation/Feasibility Study

Draft A of the RI/FS report (DOE/RL-2012-15) was submitted to Ecology, the lead regulatory agency for the 100-NR-1 and 100-NR-2 OUs, in June 2013 for review. The document was revised during 2014 in response to Ecology's comments. The RI/FS information will be used to make decisions for remediation of waste sites and groundwater. The ROD for these OUs, which will specify the remedies for cleanup of waste sites and groundwater, is anticipated in 2016.

6.2.4 Groundwater Remediation

Interim actions are being conducted for cleanup of strontium-90 and TPH-diesel contamination in 100-NR-2 OU groundwater. The activities and results for 2014 are summarized in Section 6.8. Additional details are available in DOE/RL-2015-05, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations, and 100-NR-2 Groundwater Remediation*.

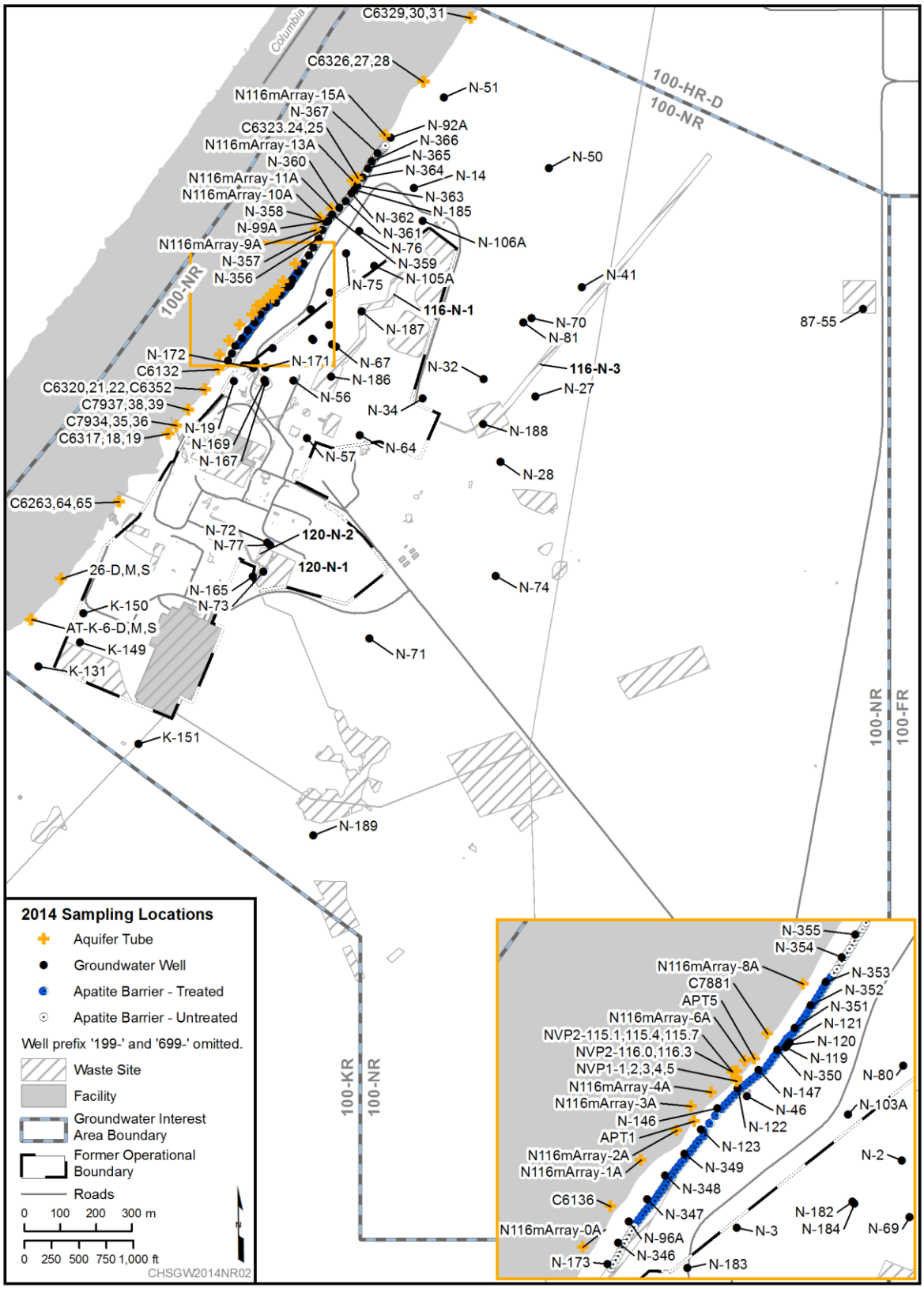


Figure 6-4. 100-NR Sample Locations, 2014

6.3 Strontium-90

The primary source of the strontium-90 contamination in 100-NR was liquid waste disposal to the 116-N-1 Crib and Trench and the 116-N-3 Crib and Trench. The size and shape of the strontium-90 plume changes very little from year to year, except near the apatite PRB (Figure 6-5). The low-mobility strontium-90 plume extends from beneath the 116-N-1 Crib and Trench and 116-N-3 Crib waste site sources to the Columbia River at concentrations exceeding the DWS (8 pCi/L). The highest concentration portion of the strontium-90 groundwater plume (i.e., the area with concentrations exceeding 800 pCi/L) is found beneath the 116-N-3 Crib and beneath and downgradient of the 116-N-1 Trench. The lateral distribution of the groundwater plume with concentrations between 8 and 80 pCi/L is found peripheral to the highest concentration area in a distribution consistent with historical radial flow away from the 116-N-1 and 116-N-3 Cribs and Trenches and elongated toward the river.

The highest strontium-90 groundwater concentration detected at 100-NR in 2014 was 15,500 pCi/L in a sample from Well 199-N-67, which is downgradient of the 116-N-1 Trench. Because of strontium-90's low mobility in groundwater, concentrations exceeding 100 pCi/L are limited to the very upper portion of the aquifer. Strontium-90 contamination is either not detected or is detected at very low concentrations in wells monitoring the base of the unconfined aquifer or the RUM. The highest strontium-90 concentration at the base of the aquifer in 2014 was 3.25 pCi/L at Well 199-N-69, adjacent to 199-N-67.

Water levels in the unconfined aquifer were significantly higher beneath the 116-N-1 and 116-N-3 waste sites when discharges were occurring. As the water level declined, strontium-90 remained sorbed to sediment in the lower vadose zone. When the current water table rises beneath these former waste sites, residual strontium-90 from the vadose zone may be temporarily remobilized, increasing the concentrations in groundwater. As the water table subsequently declines, strontium-90 sorbs back to the surrounding sediment. Strontium-90 concentrations in Well 199-N-81 downgradient of the 116-N-3 Trench have declined since the late 1990s. However, higher water levels in this well over the last 3 years correspond to a slight increase in the strontium-90 concentration that continues into the fall 2014 sample (Figure 6-6). Well 199-N-67 near the 116-N-1 Crib was sampled twice in 2014, with concentrations of 11,000 and 15,500 pCi/L in March and September, respectively. Strontium-90 concentrations in this well show no obvious long-term decline, but generally increase when the water level is elevated and decrease when it is lower (Figure 6-7). The positive variation of concentration with water level is more pronounced at this well near the 116-N-1 waste site, which received a much larger mass of strontium-90 than the 116-N-3 waste site and presumably has more residual strontium-90 in the lower vadose zone.

Strontium-90 concentrations in several wells within the untreated portion of the appatite barrier were also elevated. Wells 199-N-99A, 199-N-357, 199-N-280, and 199-N-281 had values that exceeded 800 pCi/L. This localized high concentration area has been interpreted to extend upgradient toward the 116-N-1 main portion of the high concentration plume (Figure 6-5).

Strontium-90 concentrations at the apatite PRB are discussed in Section 6.8. Strontium-90 concentrations in aquifer tubes are consistent with those seen in near-shore monitoring wells.

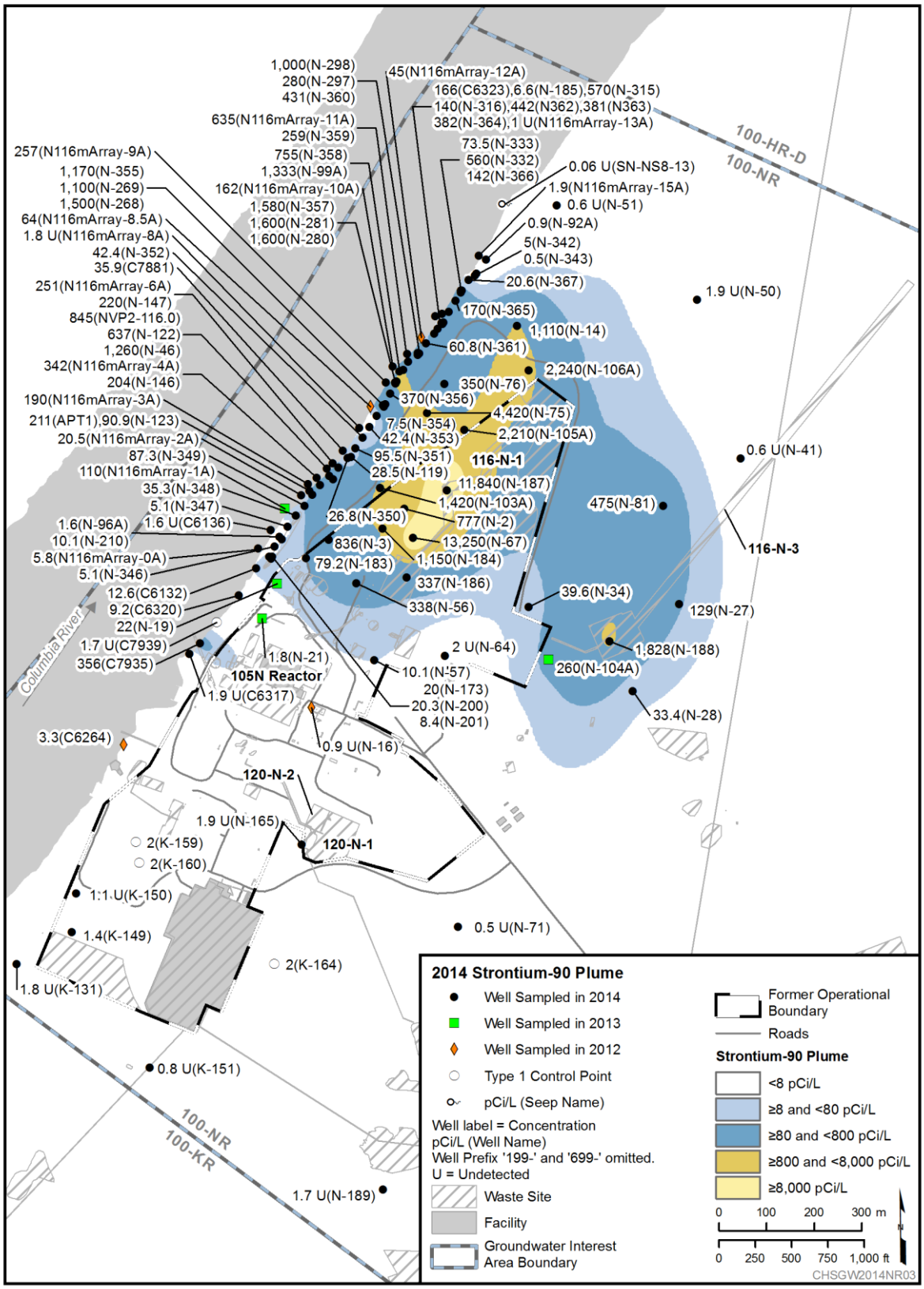


Figure 6-5. 100-NR Strontium-90 Plume, 2014

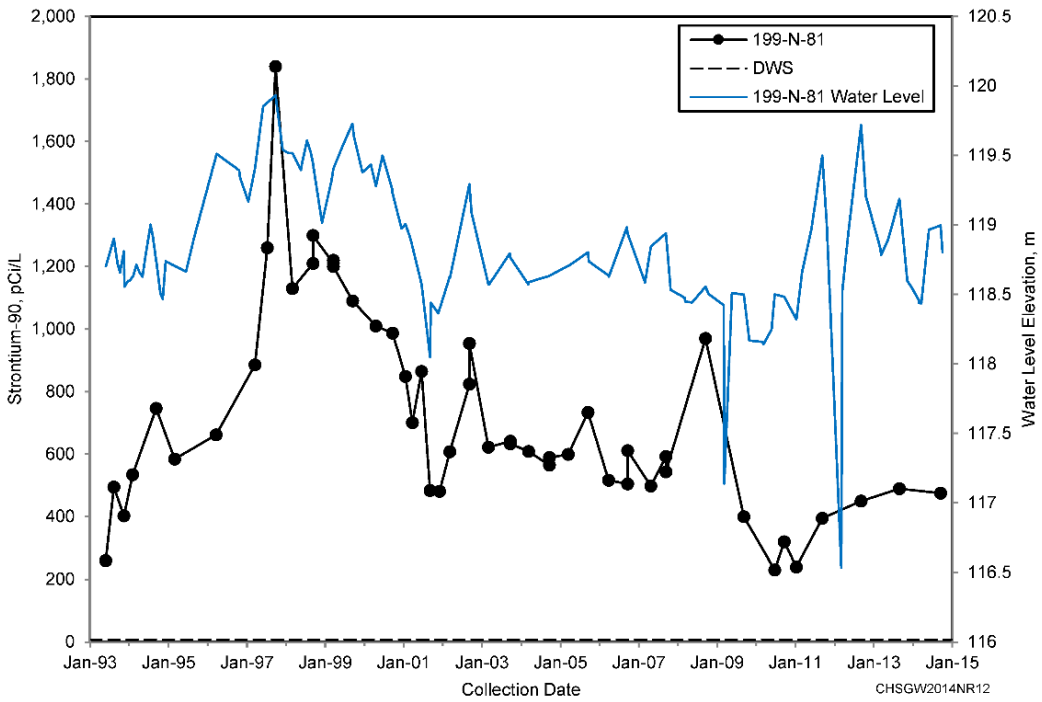


Figure 6-6. 100-NR Strontium-90 Data for Well 199-N-81

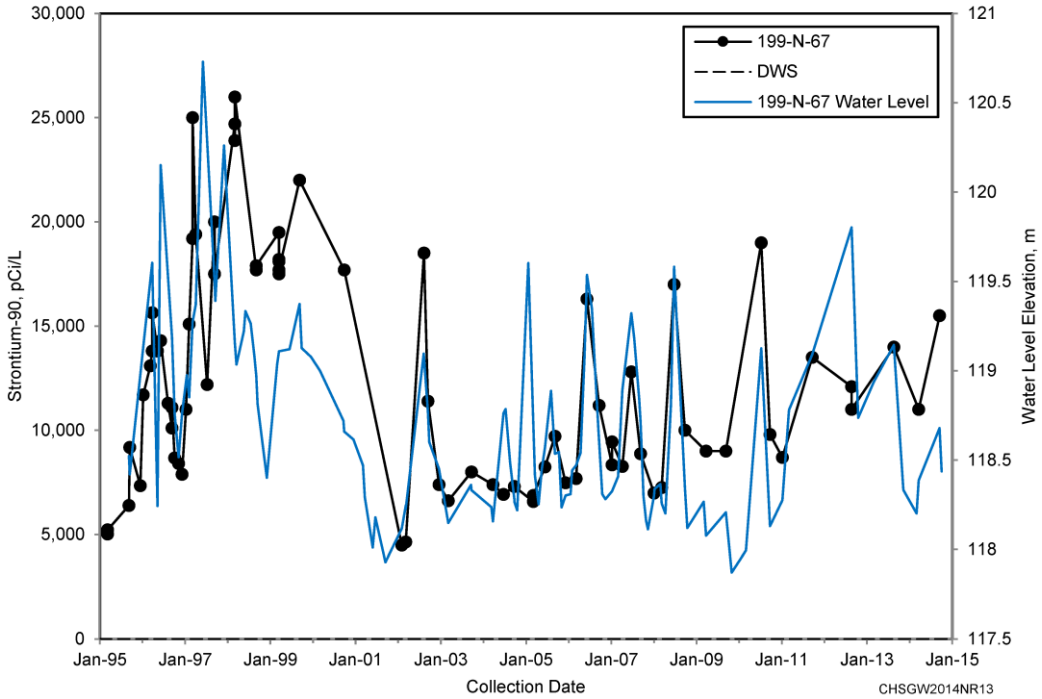


Figure 6-7. 100-NR Strontium-90 Data for Well 199-N-67

Strontium-90 is also detected in groundwater at aquifer tube cluster C7934/C7935/C7936 (Figure 6-8) located upriver from the main strontium-90 plume (Figure 6-5). When these aquifer tubes were first sampled in July 2010, strontium-90 concentrations were above the DWS. Strontium-90 concentrations have remained elevated but relatively stable through 2014, suggesting the presence of a small isolated area of low mobility strontium-90. These aquifer tubes are located close to the engineered fill around the 1908-N Outfall, which suggests that outfall construction created a preferential pathway in the fill for migration of contaminated groundwater to the river (Section 4.2 of SGW-49370). Leaks from the fuel storage basin and associated facilities and pipelines between the N Reactor and the river may be the source of the elevated strontium-90 concentrations at the aquifer tube cluster. Three new wells are planned to be drilled to evaluate the source.

Seep 100-N SPRING 8-13, on the river shore near aquifer tube 116mArray-16A, was sampled on September 24, 2014. The strontium-90 result (undetected) is posted on the strontium-90 plume map (Figure 6-5).

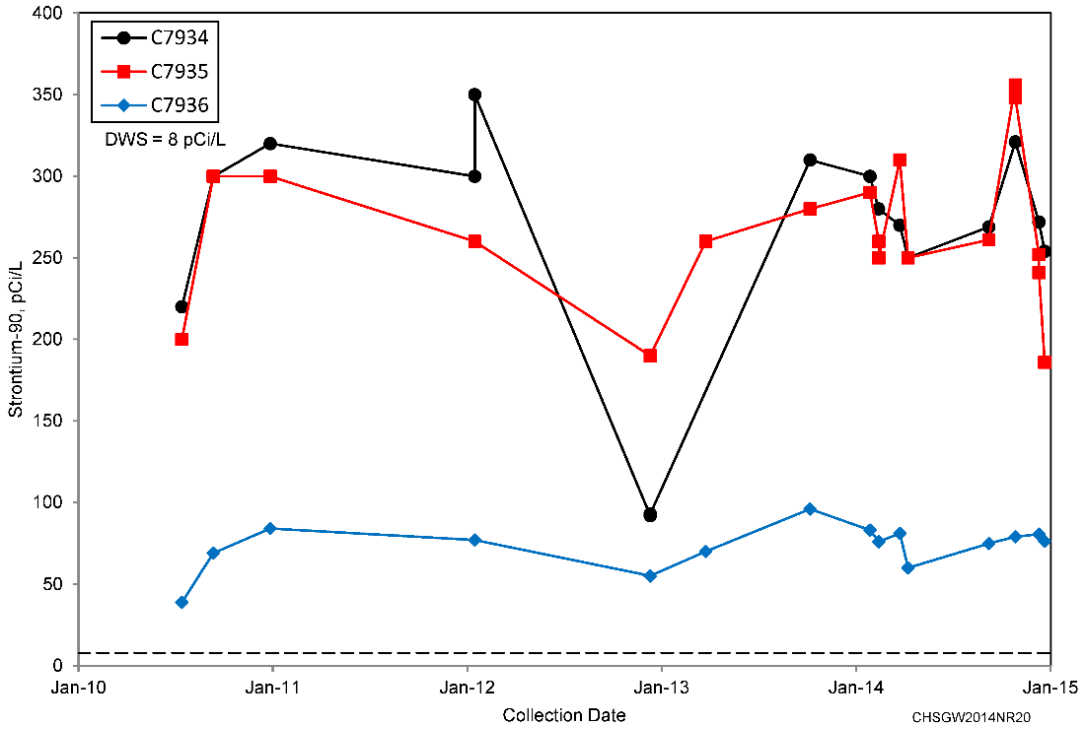


Figure 6-8. 100-NR Strontium-90 Data for Aquifer Tubes C7934, C7935, and C7936

6.4 Tritium

Tritium concentrations were elevated above the DWS in 2014 at aquifer tube cluster C7934/C7935/C7936 (Figure 6-9). Concentrations continued to increase in 2014, peaking at over 700,000 pCi/L. December 2014 results suggest that concentrations had begun to decline. The increasing tritium concentrations did not fluctuate with river stage, suggesting that a slug of tritium was moving through this area. Based on its high mobility, the tritium concentration increases are likely a result of the recent deep excavation and addition of dust suppression water at waste sites between the reactor and the river. The 1908-N Outfall construction likely created a preferential pathway in the fill for migration of contaminated groundwater to the river.

Tritium concentrations also exceeded the DWS (20,000 pCi/L) in Well 199-N-186 in 2014 (the maximum value was 35,100 pCi/L). The well was drilled through the 116-N-1 Crib in 2011. The 116-N-1 waste site was a source of tritium contamination in 100-NR groundwater. This was the only monitoring well in 100-NR with tritium concentrations above the DWS in 2014.

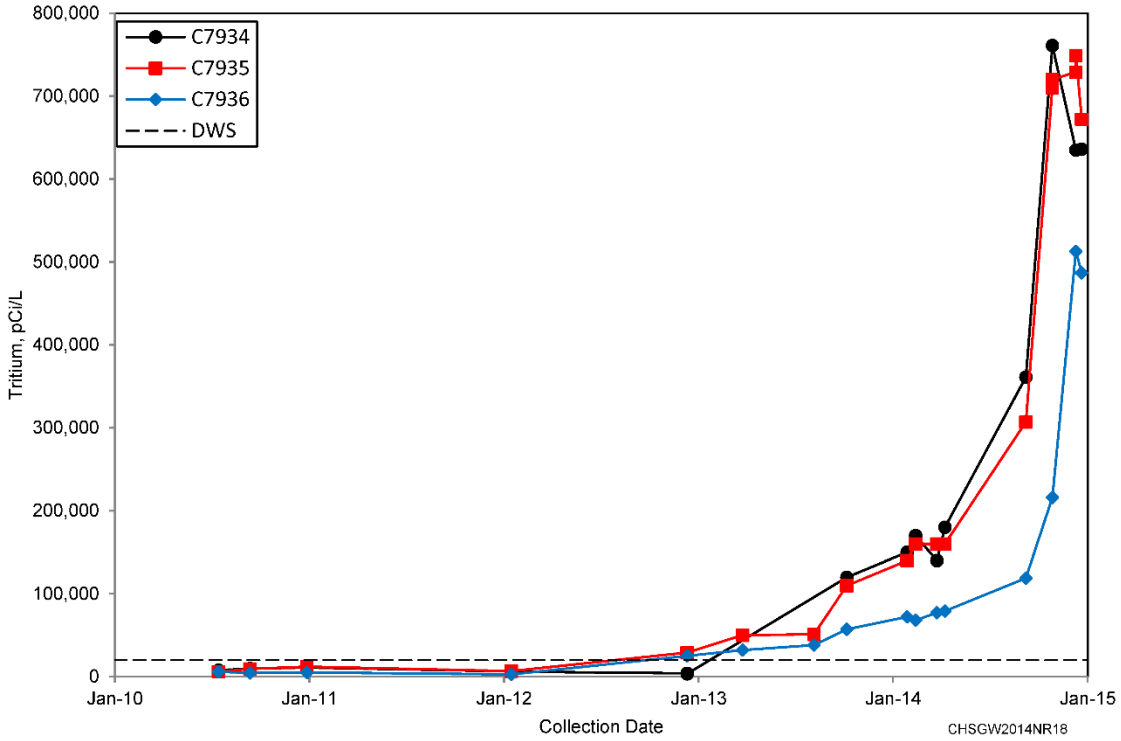


Figure 6-9. 100-NR Tritium Data for Aquifer Tubes C7934, C7935, and C7936

6.5 Nitrate

Nitrate exceeds 45 mg/L in groundwater beneath the 116-N-1 and 116-N-3 waste sites and the N Reactor area to the southwest (Figure 6-10). The highest concentration detected in 2014 was 186 mg/L in Well 199-N-67 downgradient of the 116-N-1 Crib. The 116-N-1 and 116-N-3 waste sites are implicated as the primary source of nitrate based on the persistent plume beneath them.

Nitrate concentrations were relatively low during disposal operations at the 116-N-1 and 116-N-3 waste sites (Figures 6-11 and 6-12). The highest nitrate concentrations were detected following remediation activities at these two sites from 2000 to 2006, which included excavation; application of dust suppression water and soil fixatives; and backfill. Increases in nitrate concentrations in 2014 may be due to delayed drainage from the deep vadose zone caused by additional surface water applied during waste site remediation several years ago.

Nitrate concentrations near the 120-N-1 waste site were very low when the waste site was in use but began to increase in the mid-1990s (Figure 6-13). Only low levels of nitrate (approximately 1 mg/L) were detected in the 120-N-1 effluent (Section 2.4.4 of DOE/RL-96-39). These factors suggest that the 120-N-1 waste site was not the source of the nitrate plume in the southwest region of 100-NR. The increase in nitrate concentrations since the mid-1990s may be a delayed or ongoing response to dust suppression water applied during past and ongoing waste site remediation activities in the area southwest of N Reactor. A new well is planned to be drilled in 2015 to evaluate the source.

The nitrate plume in 2011 through 2014 has a more limited extent to the southwest than in previous years because of the impact of treated water entering the aquifer through nearby 100-K injection wells.

Nitrate concentrations are anomalously low in wells in the area of the TPH-diesel groundwater plume (Figure 6-16). The lower concentrations are caused by the chemical reduction of nitrate during biodegradation of the TPH-diesel contamination. Low dissolved oxygen levels, lower pH, detectable nitrite, and elevated concentrations of iron and manganese support the interpretation of reducing conditions in this part of the aquifer.

Nitrate concentrations are highest in the upper part of the unconfined aquifer but are fairly well dispersed throughout the unconfined aquifer. Wells 199-N-69, 199-N-70, and 199-N-182, screened near the bottom of the aquifer, consistently have lower concentrations than the adjacent shallow wells. Concentrations have increased in deep Well 199-N-77 (maximum in 2014 was 35 mg/L), but remained lower than in nearby shallow Wells 199-N-72 and 199-N-73 (~50 mg/L).

Nitrate concentrations in several aquifer tubes in southwestern 100-NR exceeded the DWS in 2014 (Figure 6-10).

Seep 100-N SPRING 8-13, on the river shore near aquifer tube N116mArray-16A, was sampled on September 24, 2014. The nitrate result (16.6 mg/L) is posted on the nitrate plume map (Figure 6-10).

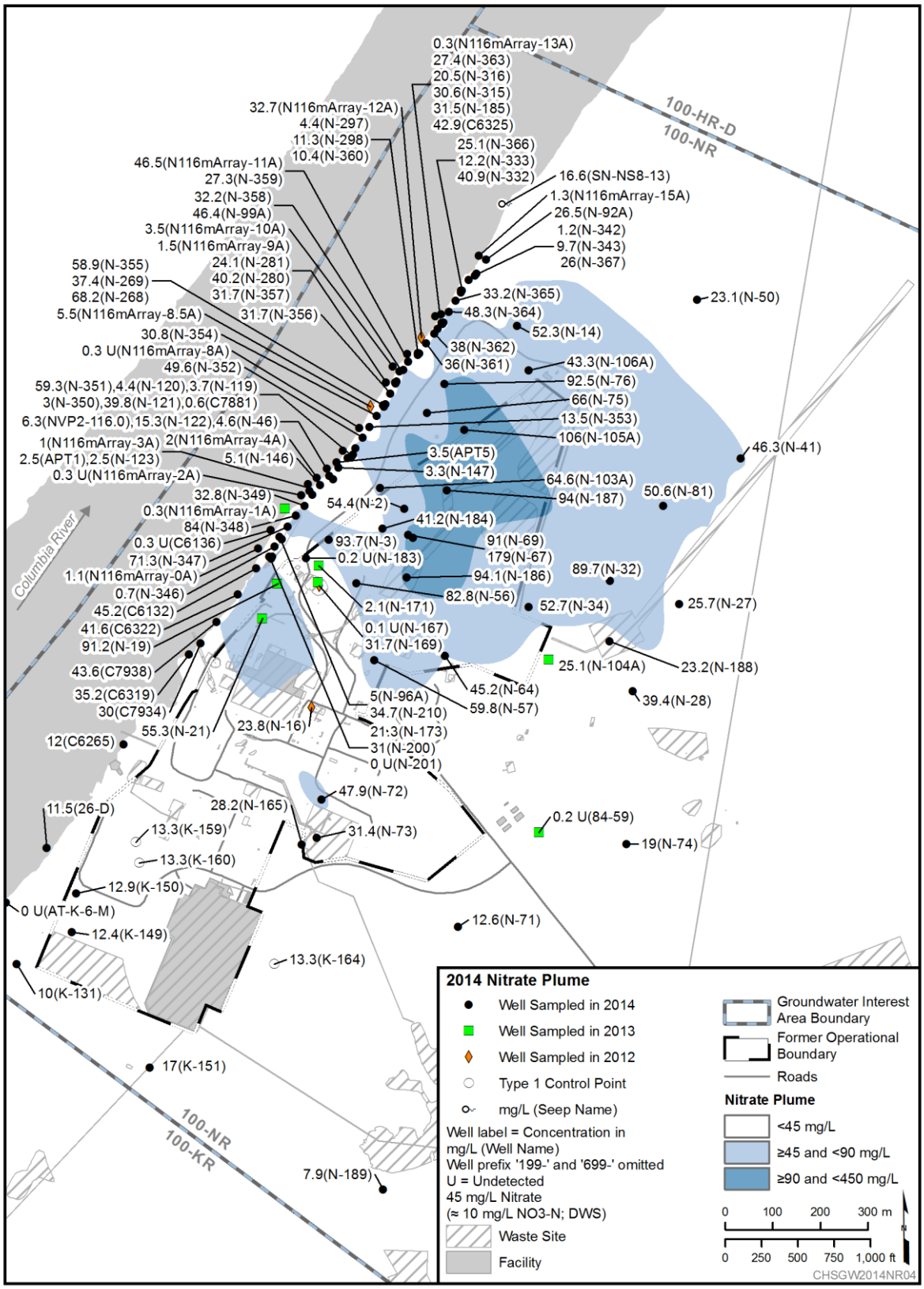


Figure 6-10. 100-NR Nitrate Plume, 2014

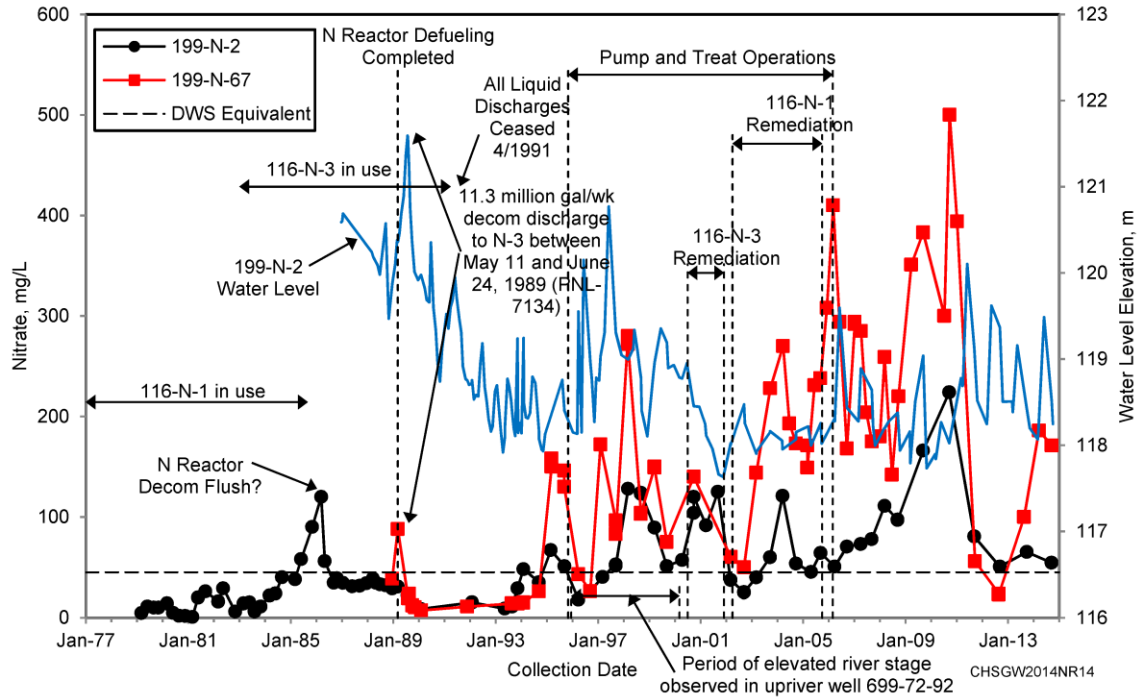


Figure 6-11. 100-NR Nitrate Data for Wells 199-N-2 and 199-N-67

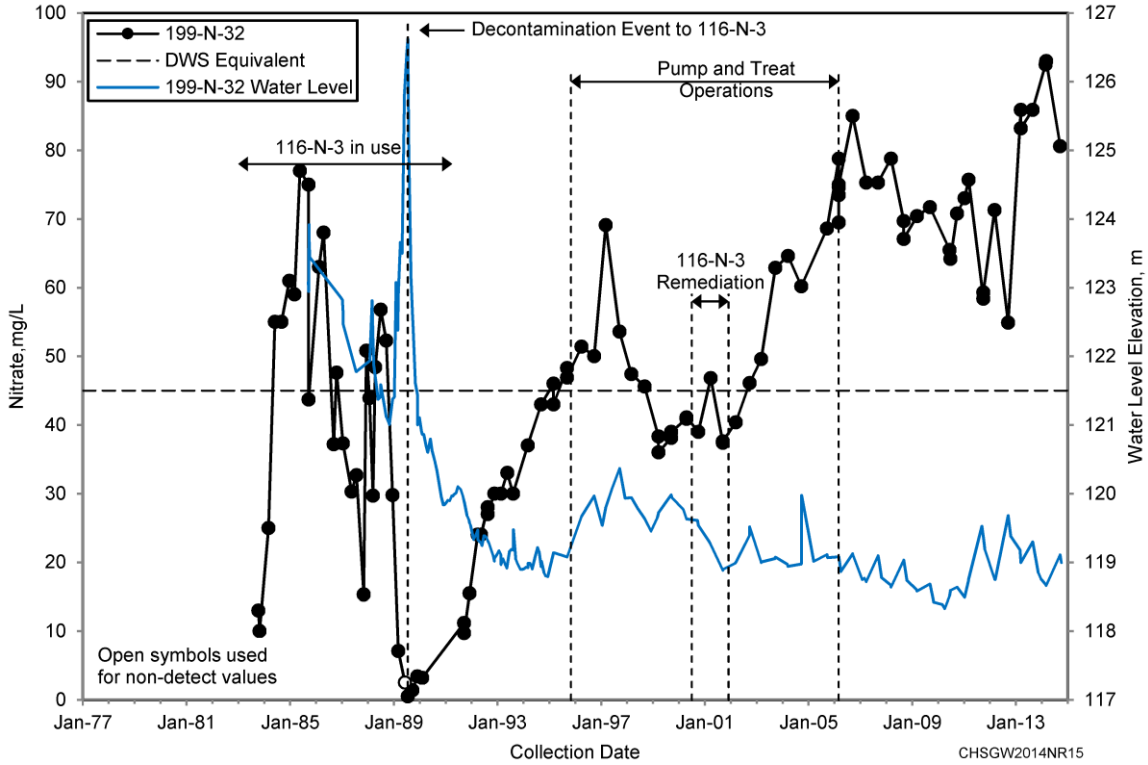


Figure 6-12. 100-NR Nitrate Data for Well 199-N-32

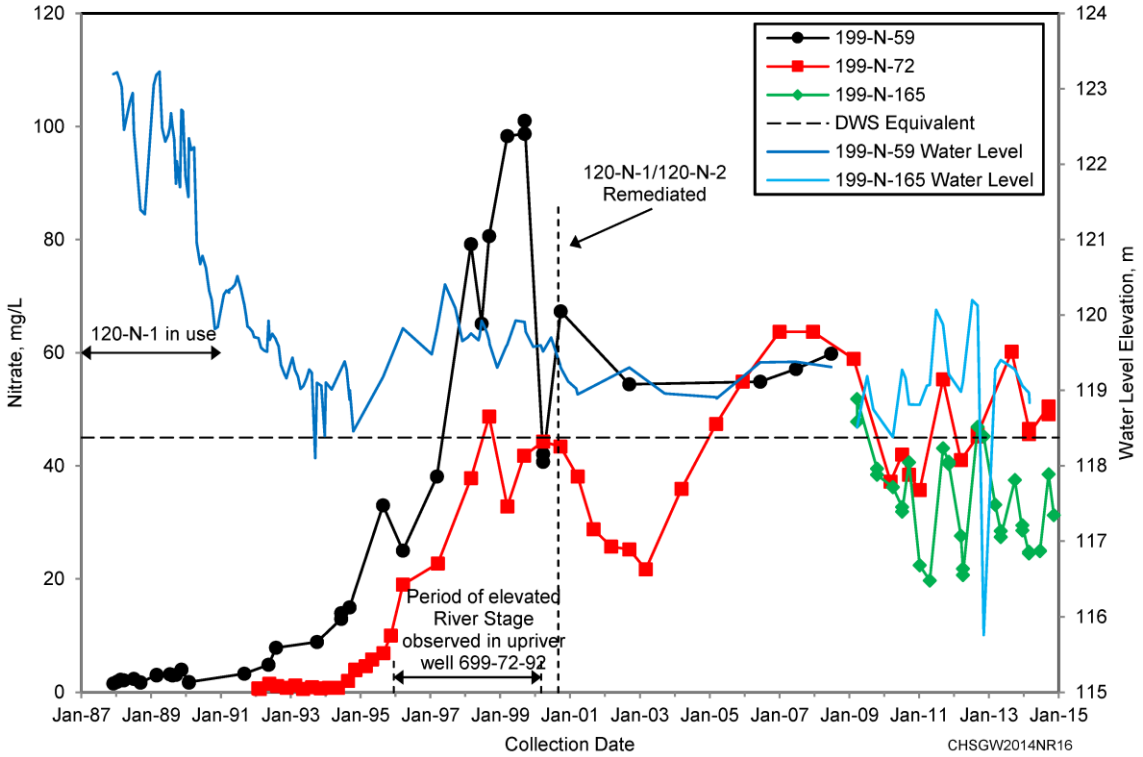


Figure 6-13. 100-NR Nitrate Data for Wells 199-N-59, 100-N-72, and 199-N-165

6.6 Total Petroleum Hydrocarbons – Diesel

The primary source of the TPH-diesel groundwater contamination is a 1966 diesel fuel spill (UPR-100-N-17). A small, relatively narrow groundwater plume extends downgradient from the spill location to the river (Figure 6-14). The highest groundwater concentration in 2014 was 18,000 µg/L (199-N-346), which was a substantial decrease from the 2011 and 2010 maximum concentrations of 48,000 and 420,000 µg/L, respectively (199-N-18), but an increase from the 2013 maximum concentration (199-N-171) of 9,450 µg/L. The overall plume reduction in concentration in 2012 through 2014 is attributed primarily to the bioventing conducted during that time for remediation of diesel in the deep vadose zone at UPR-100-N-17 (WCH-600).

In-situ bioventing introduces oxygen to promote in situ aerobic biodegradation of the TPH-diesel in the deep vadose zone to carbon dioxide and water. The data from the bioventing pilot test (2010–2011) were used to support the design of a full-scale bioventing system. Full-scale bioventing system operations began at UPR-100-N-17 in December 2012 using two vadose zone injection wells (199-N-167 and 199-N-172) and two vadose zone gas monitoring wells (199-N-169 and 199-N-171). Groundwater is monitored in eight monitoring wells (199-N-3, 199-N-19, 199-N-56, 199-N-96A, 199-N-169, 199-N-171, 199-N-173, and 199-N-183) (Appendix H of DOE/RL-2005-93).

Some natural biodegradation of diesel occurs in groundwater, as shown by the anomalously low nitrate groundwater concentrations in this area (discussed in Section 6.5).

In 2014, the two aquifer tubes near the intersection of the groundwater plume and the Columbia River showed detections of TPH-diesel (C6132 and N116mArray-0A [Figure 6-14]). A third aquifer tube (C6135) sampled in previous years was broken and could not be sampled in 2013 or 2014; a replacement is planned.

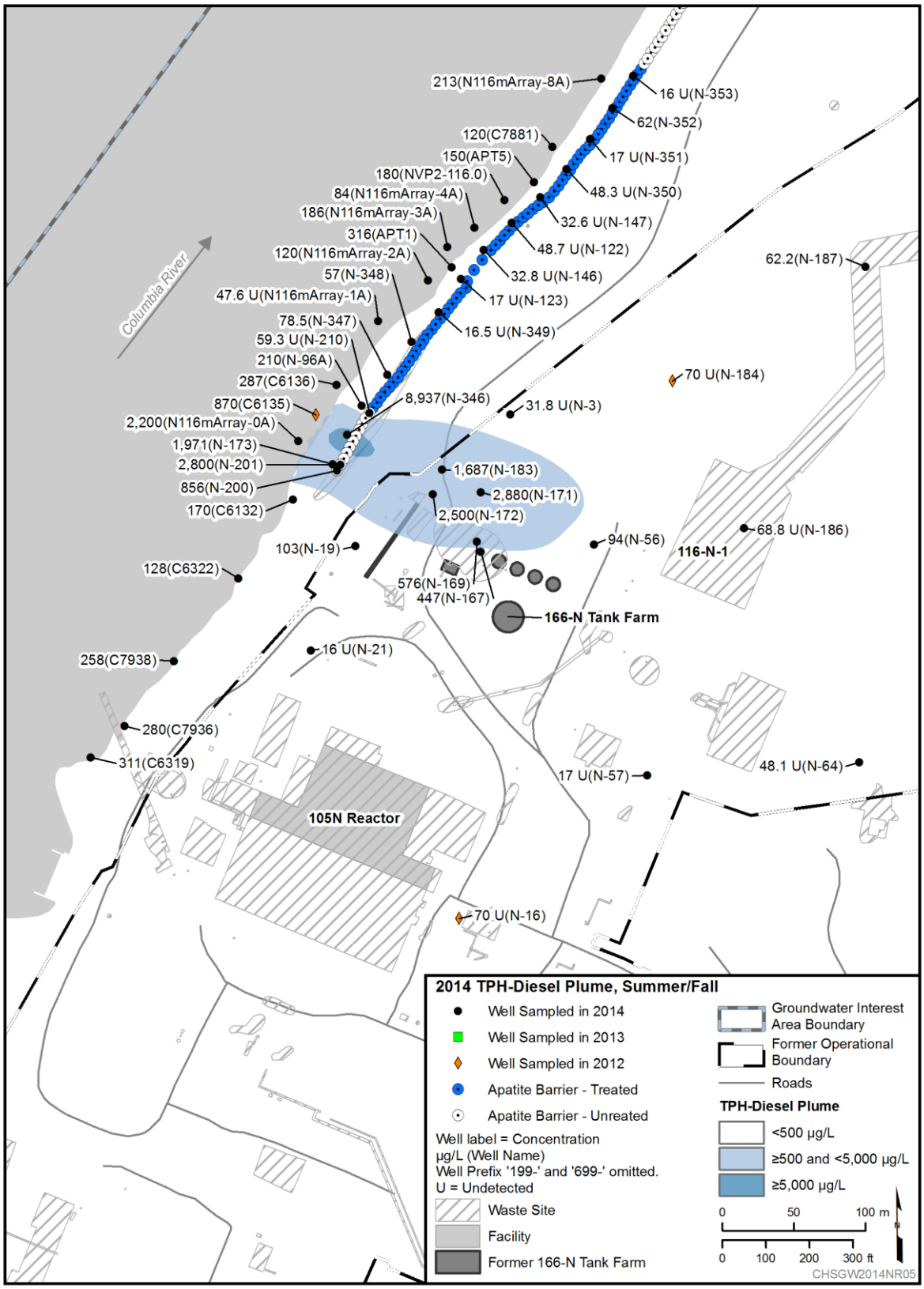


Figure 6-14. 100-NR TPH-Diesel Plume, 2014

If present as a nonaqueous phase (free product), the TPH-diesel in groundwater is found in the shallowest portion of the aquifer or floating on top of the water table (Section 4.4 of DOE/RL-2011-25). Removal of free product from Well 199-N-18 continued in 2014 in accordance with the interim action ROD (EPA/ROD/R10-99/112). The diesel is removed using a polymer "smart sponge" that selectively absorbs petroleum products from the surface of the water within the well. Approximately every 2 months, two sponges are lowered to the surface of the aquifer in Well 199-N-18 and left to soak up the diesel. The sponges are weighed prior to placement in the well and again after removal. The weight difference between the two measurements is the amount of diesel fuel removed from the well. In 2014, 550 g of diesel were removed from Well 199-N-18 (Table 6-2). Removal of petroleum product from Well 199-N-18 will continue in 2015.

Table 6-2. 100-NR Hydrocarbon Product Removal from Well 199-N-18, 2003–2013

Year	Product Removed (gram)	Notes
2003[a]	~1,200[b]	Estimate provided per information given in table note; data records lost when original work package was lost in the field
2004	3,475	Changed out twice per month
2005	780	Changed approximately every 2 months
2006	1,370	Changed every 2 months
2007	1,294	Changed every 2 months
2008	920	Changed every 2 months
2009	1,380	Changed approximately every 2 months
2010	225.5	Changed only twice prior to June 2010; smart sponge broke apart in well; no removal for second half of 2010
2011	500	Changed every 2 months
2012	600	Changed in January, April, June, and August 2012
2013	750	Changed in January, March, May, July, September, and November 2013
2014	550	Changed in February, April, June, August, and October 2014
	Total	**13,044.5 grams (approximately 13 kg) removed through end of 2014**

a. DOE/RL-2004-21, *Calendar Year 2003 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit (OU) Pump & Treat Operations*, reports that product removal started in October 2003.

b. DOE/RL-2005-18, *Calendar Year 2004 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operations*, states that the average mass removal for fiscal year 2004 (October 2003 through October 2004) was approximately 0.4 kg/month; therefore, an estimate is provided for the 3 months missing in 2003.

6.7 Hexavalent Chromium

Sodium dichromate was only used in N Reactor operations from 1964 to 1972 and in lesser amounts than in the other 100 Area reactors because of the design of the N Reactor cooling system and the use of corrosion resistant metals (e.g., zircaloy) in the fuel and facility (Section 1.3.2 of DOE/RL-2012-15). Although chromium was present in the effluent discharged to the 116-N-1 waste site, it was never detected in samples of the effluent (Section 3.1.1.4 of DOE/RL-90-22). Hexavalent chromium is mobile in solution and while chromium was being delivered to the 116-N-1 waste site, discharge rates and effluent temperatures were high. Liquid discharges to 116-N-1 continued for another 10 years after use of sodium dichromate had ceased. Because of these factors, the mobile portion of chromium was thoroughly flushed from the vadose zone and into the unconfined aquifer. Because a groundwater mound was present, the diluted effluent spread radially, with some portion going into the Columbia River by the end of the N Reactor's operational period (Section 4.8.1.4 of DOE/RL-2012-15). Dissolved chromium in Hanford Site groundwater is present in hexavalent form.

The maximum dissolved chromium concentration in 100-NR in 2014 was in Well 199-N-80, located downgradient from the 116-N-1 Trench and screened in a thin, confined, water-bearing zone in the upper portion of the RUM. The well was not sampled for hexavalent chromium,but the concentration of total chromium in a filtered sample was 193 µg/L, consistent with previous results and relatively unchanged since monitoring began (Figure 6-15). This water-bearing zone has not been detected in surrounding wells and boreholes and is not believed to be laterally continuous (Section 4.4.3 of DOE/RL-2012-15).

The chromium detected in Well 199-N-80 is likely the result of high-volume past disposal of chromium-bearing liquid waste into the nearby 116-N-1 waste site that was driven into this relatively shallow confined interval during extremely high unconfined aquifer heads and today remains trapped and relatively stagnant in this locally confined interval (Section 4.8.1.4 of DOE/RL-2012-15). Well maintenance activities in 2001 confirmed stainless-steel well screen corrosion was occurring, which could also release chromium into this well. However, other components of stainless steel (nickel, manganese, and iron) are present only at low or undetectable concentrations.

In 2014, hexavalent chromium continued to be detected below the 48 µg/L MTCA standard in wells approximately 750 m (2,500 ft) inland from the N Reactor and northeast around the upgradient portion of the 116-N-3 waste site. These chromium detections are not believed to be associated with a 100-NR waste site (Figure 5-6). This chromium contamination migrated inland while the 116-K-2 Trench was in use and a groundwater mound was present. A portion of this 100-KR chromium plume has migrated northward into 100-NR near Wells 199-N-74 and 199-N-189.

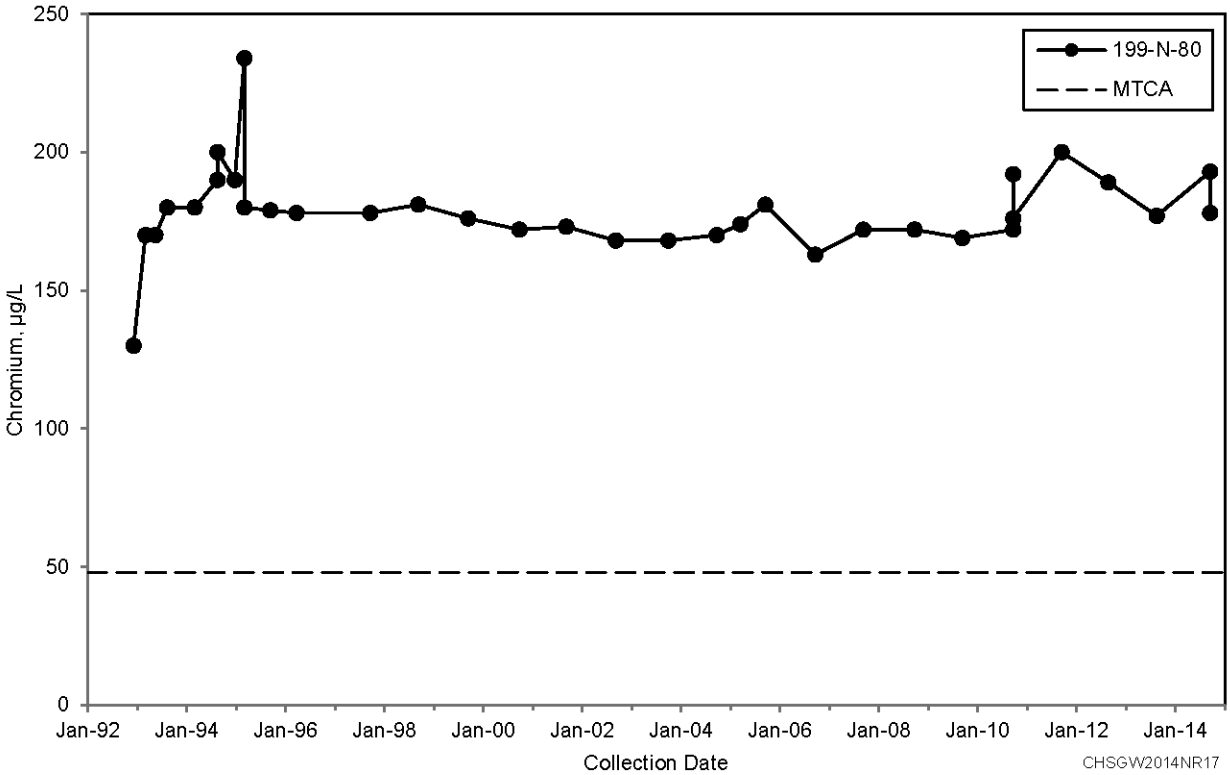


Figure 6-15. 100-NR Chromium Data for Well 199-N-80

The 2014 plume maps (Figures 5-5 and 5-6) suggest another area of chromium contamination within NR-2 may exist surrounding Well 199-N-41 and upgradient of the 116-N-3 waste site. Well 199-N-41 had a filtered chromium detection of 51 µg/L in June 2014 (Figure 5-13). However this result was 4 to 5 times higher than previous or subsequent results (including September 2014) and was flagged as a suspected error. Sparse and limited historical chromium concentration data, recent chromium increases, and limited well control in this region limit the ability to confidently map the chromium extent. None of these inland wells detected hexavalent chromium above the 48 µg/L MTCA standard, but several have had detections above the 10 µg/L ambient water quality standard. Future groundwater monitoring, as defined in the 100-NR-2 and 100-KR-4 OU groundwater SAPs, will provide additional data from an expanded list of monitoring wells. These results will be used to assess the presence and extent of hexavalent chromium contamination in this region of 100-NR and farther upgradient.

Hexavalent chromium concentrations were near or below detection limits in 100-NR aquifer tube samples in 2014. All were below the 10 µg/L ambient water quality standard.

Seep 100-N SPRING 8-13, on the river shore near aquifer tube 116mArray-16A, was sampled on September 24, 2014, with a hexavalent chromium result of 7.06 µg/L.

6.8 100-NR-2 Remedies

Interim actions are being conducted for cleanup of strontium-90 and TPH-diesel contamination in the 100-NR-2 OU (Figure 6-16). The activities and results for 2014 are summarized in this section. Additional details are available in DOE/RL-2015-05, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations, and 100-NR-2 Groundwater Remediation*.

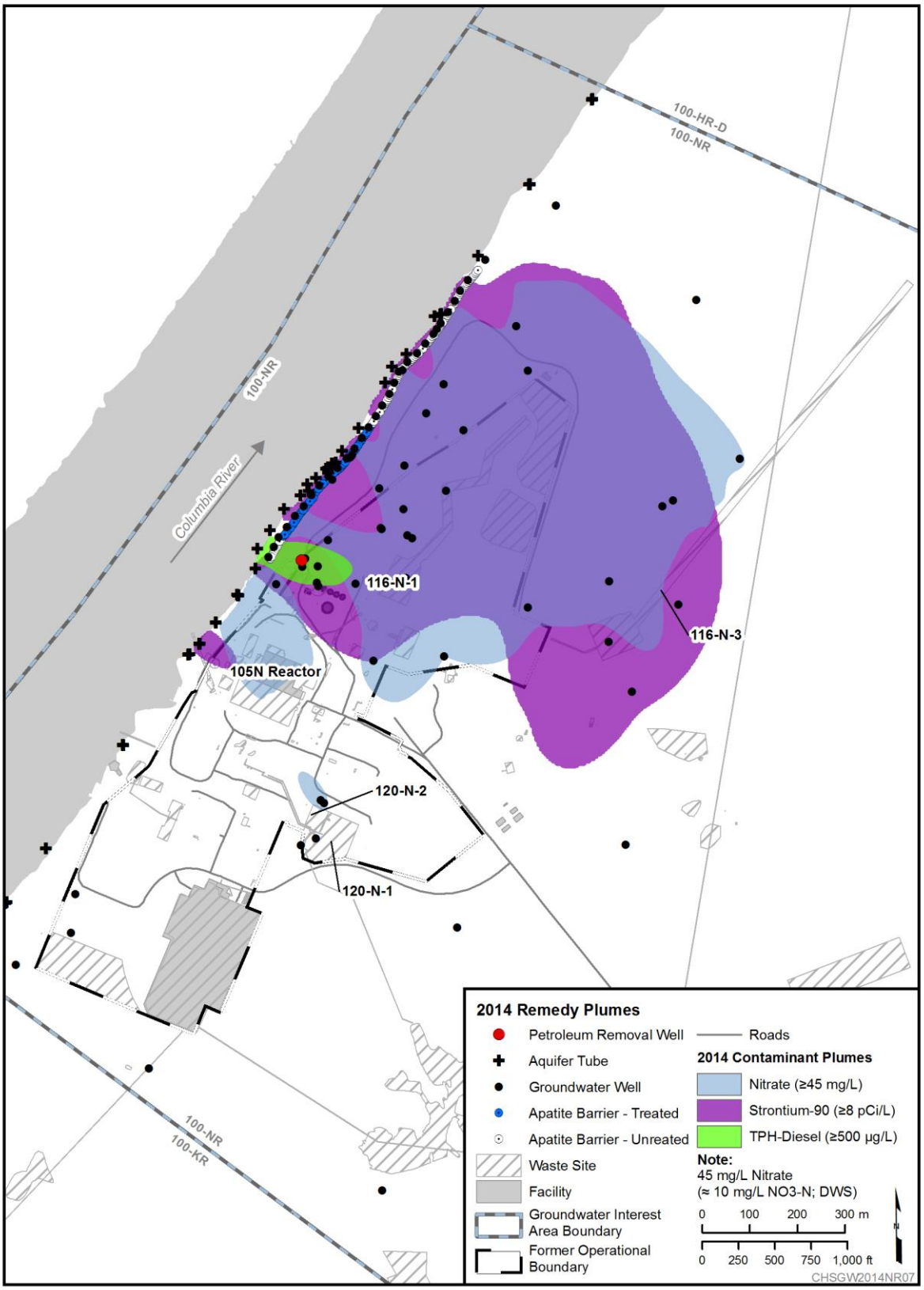


Figure 6-16. 100-NR Remedy Plumes

The CERCLA remediation of strontium-90 in groundwater is identified in the interim action ROD (EPA/ROD/R10-99/112). When the interim action ROD was issued in 1995, the interim action for remediation of strontium-90 in groundwater was P&T. The 100-NR-2 groundwater P&T system operated from 1995 until 2006. The system removed approximately 1.8 Ci of strontium-90 from the aquifer, which was less than the amount removed by radioactive decay during the same period. Because strontium-90 binds strongly to the sediment, the P&T system was not effective in the cleanup of strontium-90 from the aquifer.

One of the requirements of the interim action ROD was to evaluate alternative technologies for groundwater cleanup. Therefore, in 2006, Ecology, EPA, and DOE approved placing the P&T system in cold standby status and constructing a PRB. A 90 m (300 ft) long apatite PRB was completed as a treatability test in accordance with DOE/RL-2005-96. Based on the treatability test results (PNNL-17429; PNNL-SA-70033), the apatite technology showed promise as a remediation option. As a result, the interim action ROD was amended in 2010 to allow for expansion of the apatite barrier and permanent decommissioning of the 100-NR-2 P&T system.

The CERCLA interim action for remediation of TPH-diesel in groundwater is identified in the interim action ROD (EPA/ROD/R10-99/112). The interim action ROD specifies that petroleum hydrocarbons (free product) will be removed if observed in a monitoring well. The removal of the TPH-diesel is discussed in Section 6.6.

6.8.1 Apatite Barrier

The original, 90 m (300 ft) long apatite PRB was created by injection of apatite-forming solutions into 16 wells from 2006 through 2008 (PNNL-19572). The expanded apatite PRB well network was installed between late 2009 and early 2010, extending the original barrier well network upriver and downriver for a total length of 760 m (2,500 ft) (Figure 6-17). In September 2011, two segments of the extended well network, one upriver and one downriver of the original barrier, were injected with apatite-forming solution to extend the length of the apatite PRB to approximately 300 m (1,000 ft). The barrier was expanded in accordance with the design optimization study (DOE/RL-2010-29), which had seven objectives for evaluating barrier implementation and effectiveness. Data from the injections and subsequent performance monitoring are used to evaluate these objectives.

6.8.1.1 Apatite Permeable Reactive Barrier Technology

The apatite PRB is formed by injecting a calcium citrate phosphate solution into the aquifer through a network of vertical wells (i.e., the barrier well network). After the solution is injected, biodegradation of the citrate releases the calcium, which results in formation of apatite (a calcium phosphate mineral [$Ca_{10}(PO_4)_6(F, Cl, OH)_2$]). Strontium ions (including strontium-90) in groundwater substitute for calcium ions in the apatite via cation exchange and eventually become trapped as part of the mineral matrix during apatite crystallization (Section 1.3 of PNNL-16891). The strontium-90 in groundwater is sequestered within the apatite PRB as contaminated groundwater flows through the barrier. The PRB design assumes an average groundwater flow rate of 0.3 m/day. Based on data collected from batch laboratory tests, the calculated average incorporation rate for the PRB design apatite content of 0.96 mg apatite/g of sediment is 2 to 200 times greater than the estimated strontium flux through the barrier (PNNL-23367). At the design apatite content, strontium and strontium-90 would be incorporated into apatite more rapidly than the average groundwater flow rate and most high-flow events. The sequestered strontium-90 continues to decay in place within the barrier.

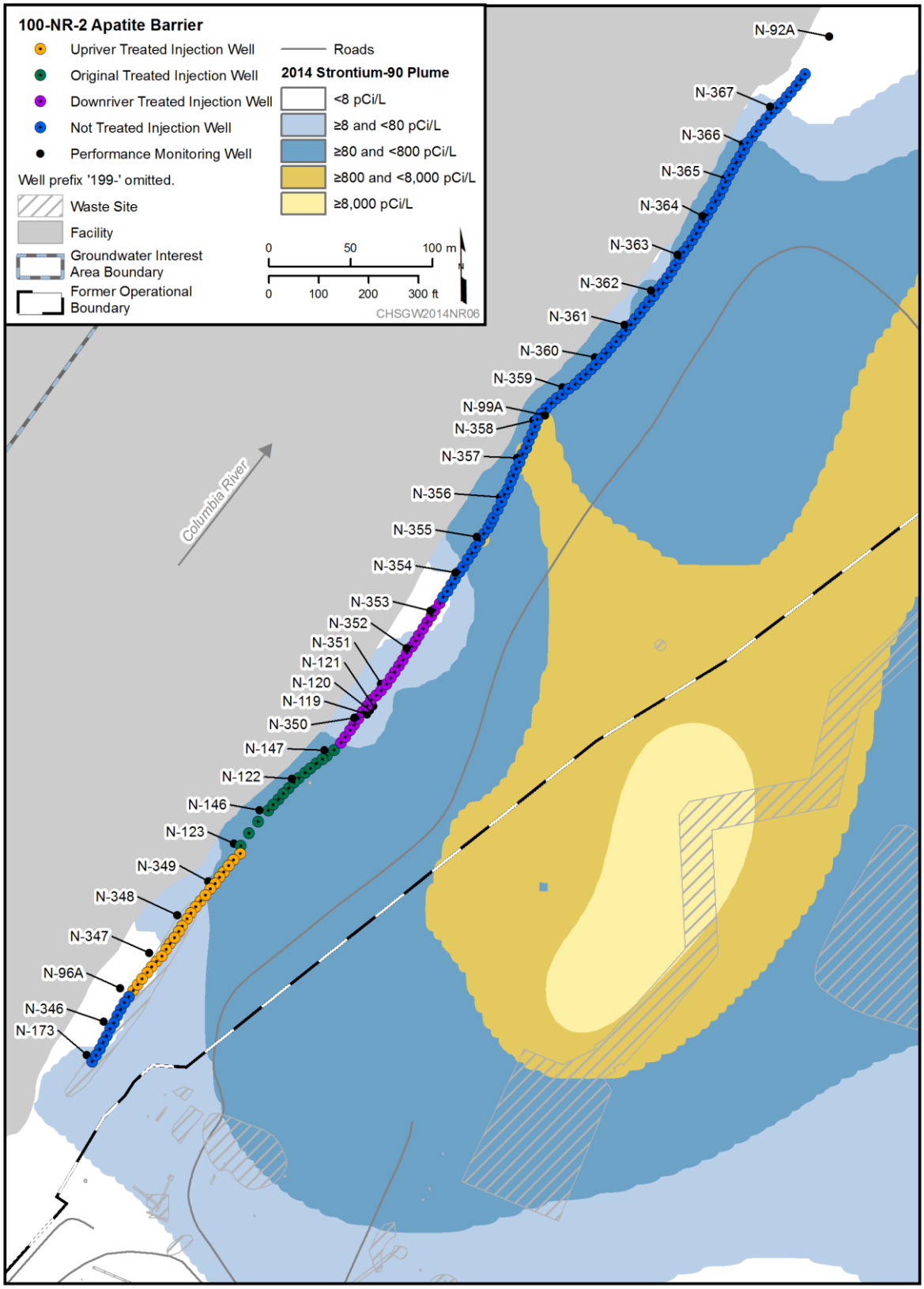


Figure 6-17. 100-NR Apatite Barrier

6.8.1.2 Apatite Permeable Reactive Barrier Performance Monitoring

Performance monitoring at the apatite barrier was conducted twice in 2014. Groundwater samples were collected from performance monitoring wells and aquifer tubes during high river stage in June and during low river stage in September. A comparison of 2014 data to baseline conditions is shown in Table 6-3. Semiannual performance monitoring (high and low river stages) will continue for the apatite PRB in 2015.

Following the apatite injections in 2008 in wells in the central (original) segment of the barrier, strontium-90 concentrations declined in the performance monitoring wells (Figure 6-18). The wells showed temporary, higher strontium-90 concentrations immediately following the injections of the apatite solution, which had a higher ionic strength than groundwater and temporarily mobilized cations and anions, causing their concentrations in groundwater to increase. Strontium-90 concentrations in Wells 199-N-122 and 199-N-123, which are near the upriver and downriver ends of the central barrier segment, temporarily increased following injections into the nearby barrier extension wells in 2011.

As of fall 2014, the strontium-90 concentrations were still considerably lower in the wells monitored along the central segment of the barrier than before the injections started in 2006. The treatability test plan objective was a 90 percent reduction in strontium-90 concentrations in the performance monitoring wells (Section 4.4.3 of DOE/RL-2005-96). The 2014 data indicate that the strontium-90 concentrations in groundwater have been reduced by approximately 90 percent in three of the four performance monitoring wells (Table 6-3). The percent reduction in strontium-90 concentrations ranged from 74 percent (199-N-146) to 90 percent (199-N-123) in spring 2014 and 85 percent (199-N-146) to 95 percent (199-N-123) in fall 2014.

In the performance monitoring wells along the upriver barrier extension, the percent reduction in strontium-90 concentrations in September 2014 (3 years following the injections) ranged from 10 percent (199-N-347) to 98 percent (199-N-96A). The relatively low percent reduction in Well 199-N-347 reflects comparison to the low baseline strontium-90 concentration. Both the baseline and the September 2014 sample concentrations were below the DWS (8 pCi/L). Strontium-90 concentration at Well 199-N-349 have trended up since the initial reduction following the 2011 injections. The reduction from baseline strontium-90 concentrations were 80 percent and 44 percent in spring and fall 2014 samples, respectively.

In the performance monitoring wells along the downriver barrier extension, the percent reduction in strontium-90 concentrations in September 2014 ranged from 54 percent (199-N-351) to 95 percent (199-N-353). Stronium-90 concentrations measured in samples collected in the spring from Well 199-N-351 do not indicate an increasing trend since injections in 2011. The strontium-90 concentration reduction from baseline values at Well 199-N-351 was 91 percent from the spring 2014 sample. Ongoing monitoring will allow the determination of the continued effectiveness of the apatite barrier and support decisions regarding additional future apatite treatments.

Table 6-3. Performance Monitoring at the Apatite PRB, 100-NR-2 OU

Well Name	Baseline Sample					2014 results			
	Sample Dates	Number of Samples	Number of Nondetects	Minimum Sr-90 (pCi/L)	Max imum Sr-90 (pCi/L)	June 4-5 Sr-90 (pCi/L)	Sept. 10-11 Sr-90 (pCi/L)	% Reduction June [a]	% Reduction Sept. [a]
Upriver Apatite PRB									
199-N-96A	1995-2007[a]	56	8	1.54[b]	37.9[b]	1.1	0.8	97	98
199-N-347	4/6/2010[b]	1	1	7[c]	7[c]	3.9	6.3	44	10
199-N-348	4/6/2010	1	0	1,800	1,800	10	60	99	97
199-N-349	4/6/2010	2	0	220	230	45.5	129	80	44
Central (Original) Apatite PRB									
199-N-122	2005-2007[d, e]	10	0	657	4,630	388	886	92	81
199-N-123	2005-2006[d, e]	6	0	689	1,180	61.7	120	95	90
199-N-146	2006-2007[d, e]	4	0	318	985	151	256	85	74
199-N-147	2006[d, e]	3	0	522	1,842	231	209	87	89
Downriver Apatite PRB									
199-N-350	7/29/2010	1	0	240	240	13.2	40.3	95	83
199-N-351	7/28/2010	1	0	350	350	30.9	160	91	54
199-N-352	7/28/2010	1	0	580	580	21.6	63.2	96	89
199-N-353	7/28/2010	1	0	83	83	3.8	4.3	95	95

a. The percent reduction in strontium-90 concentration is calculated as:

(([maximum baseline value] – [2014 value])/[baseline value]) × 100.

b. Between 1995 and 2011, the maximum baseline was measured on 12/06/1995; the minimum detected baseline was measured on 06/13/2006 and 06/22/2007.

c. Strontium-90 estimated from gross beta. Gross beta concentrations are approximately two times the strontium-90 concentrations. The strontium-90 concentration was 1.1 U pCi/L. The gross beta concentration, 14 pCi/L, was divided by two to approximate the strontium-90 concentration of 7 pCi/L.

d. From Table 8.1 in PNNL-17429.

e. From Table 4.1 in PNNL-19572,

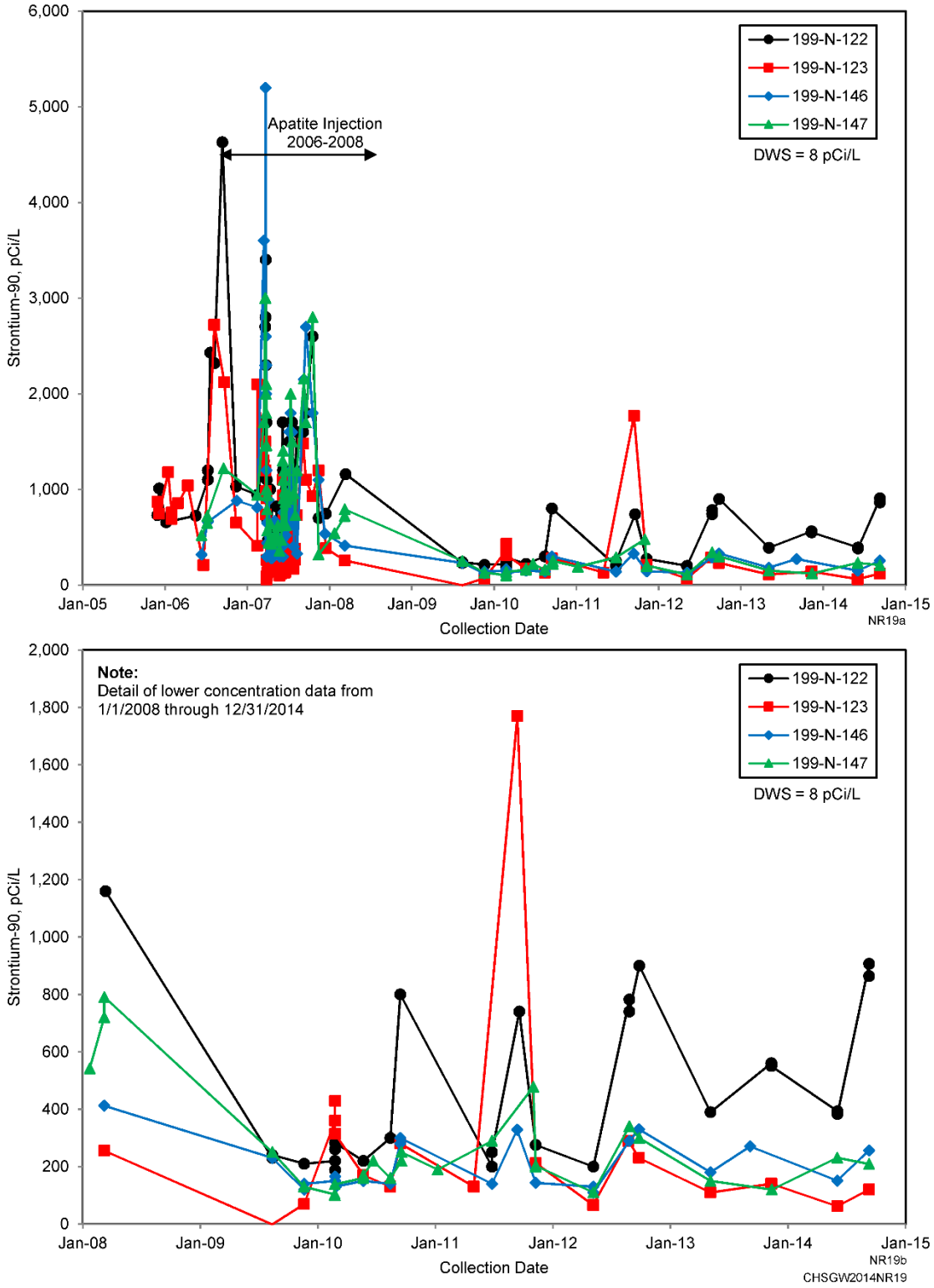


Figure 6-18. 100-NR Strontium-90 Data for Performance Monitoring Wells along the Central Segment of the Apatite PRB

6.9 RCRA Monitoring

This section describes the monitoring results for the following four RCRA facilities in 100-NR: the 116-N-1 Crib and Trench, the 116-N-3 Crib and Trench, the 120-N-1 Percolation Pond, and the 120-N-2 Surface Impoundment (Figure 6-1). Groundwater is monitored at these facilities to meet the requirements of RCRA and WAC-173-303 for dangerous waste constituents. Groundwater data for these facilities are available in the HEIS database and in the data files accompanying this report. Appendix B includes well and constituent lists, flow rates, and statistical tables for the four RCRA units in 100-NR.

6.9.1 116-N-1 Crib and Trench

The 116-N-1 waste site (Figure 6-19) was an unlined crib and trench used for disposal of liquid effluent from the 1960s through 1985. The effluent contained small quantities of dangerous waste in addition to the large volume of radioactive waste. The waste site excavation varied from 4.6 to 6.1 m (15 to 20 ft) below ground surface depending on location to remove shallow vadose zone sediment (where most of the radionuclide contamination resided) and was backfilled with clean fill.

The direction of groundwater flow beneath the 116-N-1 site in 2014 remained the same as in 2013; the area is not likely affected by the influence of groundwater injection in 100-KR-4 to the south (Figure 6-1). On February 28, 2014, the water table gradient beneath the 116-N-1 site was to the north at 1.9×10^{-3} m/m, and estimates of the groundwater flow rate ranged from 0.04 to 0.69 m/d (0.13 to 2.3 ft/d) (Table B-1, Appendix B).

Two upgradient wells (199-N-34 and 199-N-57) and three downgradient wells (199-N-2, 199-N-3, and 199-N-105A) monitor the 116-N-1 waste site (Table B-2, Appendix B). No changes to the monitoring network were made in 2014.

The 116-N-1 facility is included in the Hanford Facility RCRA Permit (WA7890008967), which 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 indicator evaluation program (40 CFR 265.93[b]), as referenced by WAC-173-303-400.

Upgradient and downgradient wells are scheduled for sampling twice each year for RCRA contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and turbidity, and once for groundwater quality and supporting parameters (chloride, iron, manganese, sodium, sulfate, and alkalinity). The wells were sampled as scheduled during 2014, and there were no critical mean exceedances (Table B-4, Appendix B).

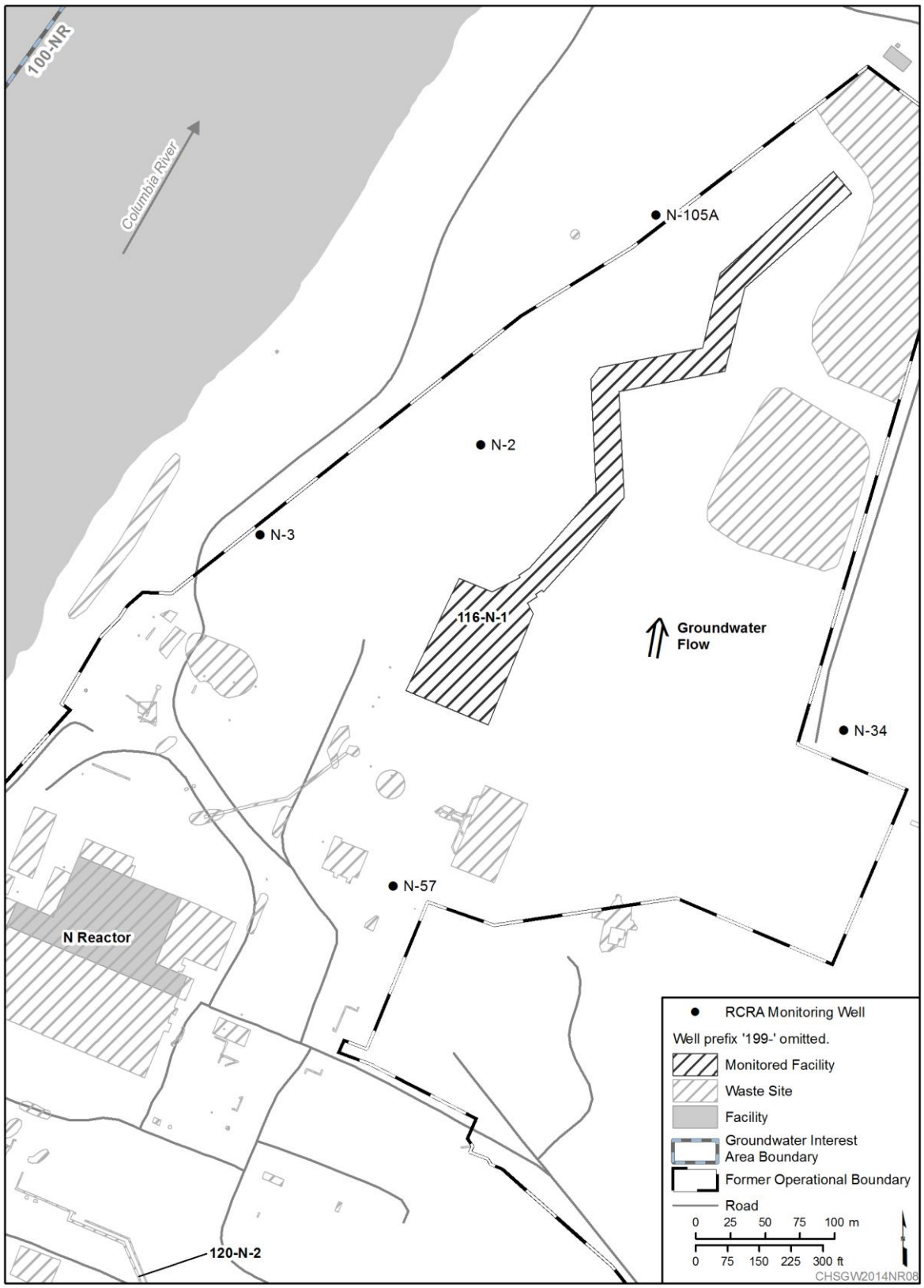


Figure 6-19. RCRA 116-N-1 Monitoring Well Locations

6.9.2 116-N-3 Crib and Trench

The 116-N-3 waste site (Figure 6-20) was an unlined crib and trench used to dispose of liquid effluent from 1983 through 1991. N Reactor was on cold standby beginning in 1987, but effluent was generated and disposed at a reduced rate until 1991. The effluent contained small quantities of dangerous waste in addition to the large volume of radioactive waste. The waste site was excavated to 1.5 m (5 ft) below the engineered structure to remove vadose zone material (which contained the highest concentrations of radionuclides) and was backfilled.

Groundwater flows to the north beneath the 116-N-3 site, turns to the northwest, and discharges to the Columbia River. The hydraulic gradient in February 2014 was to the north at 1.3×10^{-3} m/m with the groundwater flow rate estimated from 0.03 to 0.47 m/d (0.10 to 1.5 ft/d) (Table B-1, Appendix B).

The 116-N-3 facility is included in the Hanford Facility RCRA Permit (WA7890008967), which states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. BHI-00725 and a supplemental plan (PNNL-13914) are similar to an interim status indicator evaluation program (40 CFR 265.93[b], as referenced by WAC-173-303-400).

Upgradient Well 199-N-74 and downgradient Wells 199-N-32, 199-N-41, and 199-N-81 monitor the 116-N-3 waste site. Well 199-N-28 is monitored for supporting information; it previously reflected potential impacts of treated groundwater injected into a nearby well during operation of the 100-N P&T. Data from Well 199-N-28 are not evaluated statistically. No changes to the monitoring network were made in 2014.

All five wells in the RCRA network were sampled twice for RCRA contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and turbidity, and once for groundwater quality and supporting parameters (chloride, iron, manganese, sodium, sulfate, and alkalinity) in 2014. All five wells were sampled successfully as planned in 2014.

Average specific conductance values in all three of the downgradient wells (199-N-41, 199-N-81, and 199-N-32) and upgradient Well 199-N-74 exceeded the 2014 critical mean of 465 µS/cm (Table B-10, Appendix B). This is a continuation of previous exceedances noted from 1999 through 2013.
The assessment report for the original 1999 exceedance (at Well 199-N-41) concluded that the exceedance was caused by past discharges of nonregulated contaminants (sulfate and sodium) to the 120-N-1 site (00-GWVZ-054). During operation of the 120-N-1 percolation pond, a groundwater mound was present, pushing groundwater inland from the site. Recent data indicate that the conclusion of the 1999 assessment report (00-GWVZ-054) remains valid and the site remains in interim status monitoring.

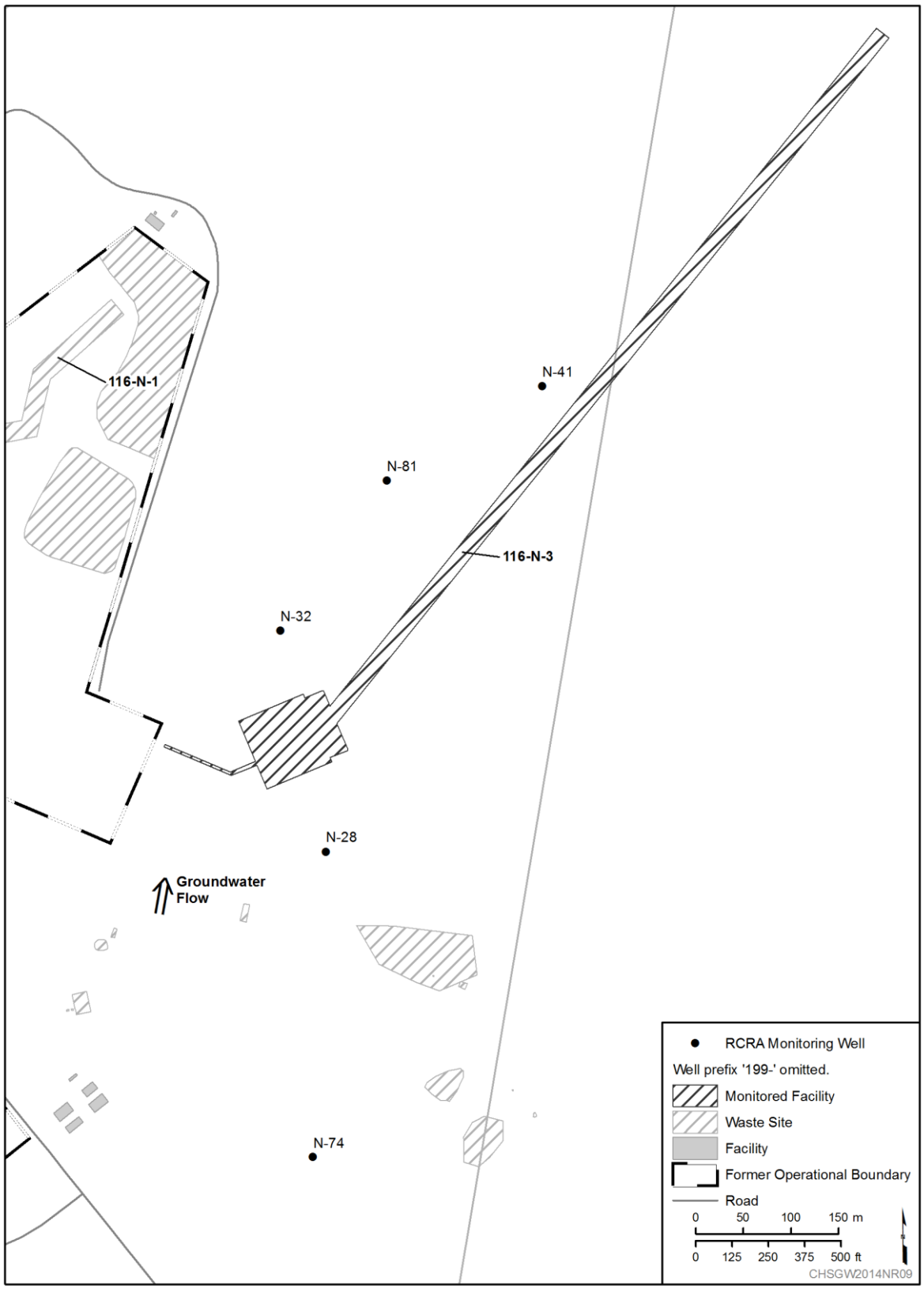


Figure 6-20. RCRA 116-N-3 Monitoring Well Locations

6.9.3 120-N-1 Percolation Pond and 120-N-2 Surface Impoundment

The 120-N-1 waste site and the 120-N-2 waste site were used to treat and dispose of corrosive, nonradioactive waste from 1977 to 1990. Both facilities have been remediated and backfilled. The remediation consisted of the removal and disposal of the miscellaneous site structures, including the 120-N-2 liner system, a small sampling shed, fencing, and other miscellaneous debris.

The 120-N-1 and 120-N-2 facilities (Figure 6-21) are included in the Hanford Facility RCRA Permit (WA7890008967), which states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. BHI-00725 and a supplemental plan (PNNL-13914) are similar to an interim status indicator evaluation program (40 CFR 265.93[b], as referenced by WAC 173-303-400). The two units are monitored as a single site (WMA) because of their proximity and similar waste types.

Upgradient Well 199-N-71 and downgradient Wells 199-N-72, 199-N-73, 199-N-77, and 199-N-165 monitor the 120-N-1 and 120-N-2 waste sites. Well 199-N-77 is screened at the base of the unconfined aquifer, and statistical comparisons are not performed on data from this well. No changes to the monitoring network were made in 2014.

All five of the monitoring wells for these sites were sampled as planned during 2014, twice for RCRA contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and turbidity, and once for groundwater quality and supporting parameters (chloride, iron, manganese, sodium, sulfate, and alkalinity) (Table B-2, Appendix B).

The 100-KR-4 injection wells south and west of the 120-N-1 and 120-N-2 sites have raised the water table and continued to affect groundwater flow in 2014 (Figure 6-1). Due to the injection mound, the water table slopes to the north-northwest. The hydraulic gradient was estimated to be 9.6×10^{-4} m/m in February 2014, and flow rates ranged from 0.02 to 0.36 m/d (0.07 to 1.2 ft/d) (Table B-1, Appendix B). The direction of flow has varied from north-northeast to north-northwest over the past three years.

Average specific conductance values in downgradient wells continued to exceed the critical mean value of 596 µS/cm in 2014. A previous groundwater quality assessment indicated that the high specific conductance is caused by the nonregulated constituents, sulfate and sodium (WHC-SD-EN-EV-003). These constituents, along with calcium, nitrate, other ions, and the indicator specific conductance, increased during the time of unusually high water levels in the aquifer in 2011 and 2012.
The concentrations dropped coincident with lower water table levels in 2013 and 2014. These data suggest that residual contamination of the constituents identified above may be present in the lower vadose zone near the water table beneath 120-N-1 and 120-N-2 and is released into the aquifer during unusually high water levels that saturated the normally unsaturated lower vadose zone. Recent data indicate that this conclusion in the 1992 assessment report (WHC-SD-EN-EV-003) remains valid and the site remains in interim status monitoring.

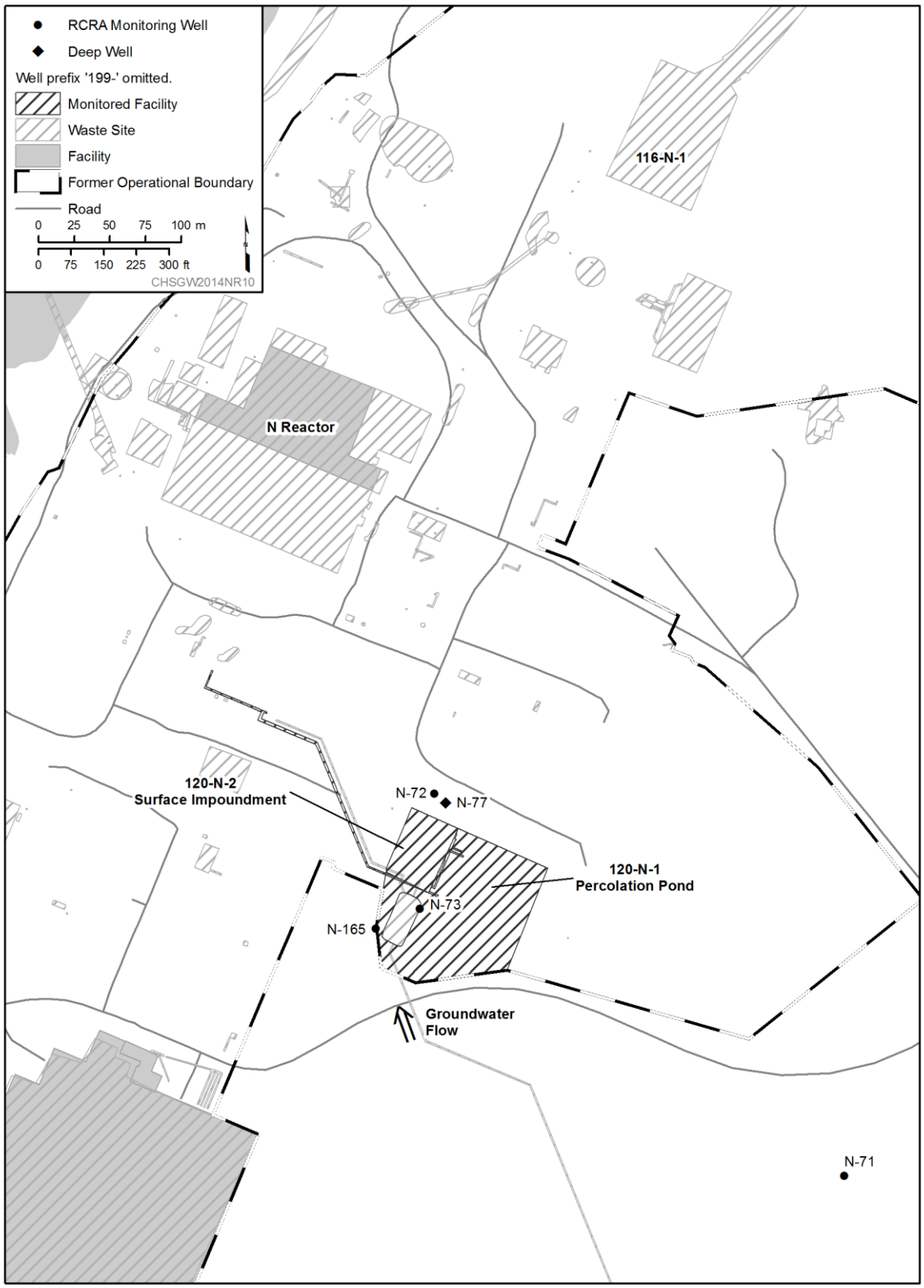


Figure 6-21. RCRA 120-N-1 and 120-N-2 Monitoring Well Locations

7 300-FF

7.1 Overview

The 300-FF groundwater interest area is located in the southeastern Hanford Site. It includes the 300-FF-5 OU, where groundwater was contaminated by releases at the 300 Area Industrial Complex, the 618-10 Burial Ground/316-4 Crib, and the 618-11 Burial Ground (Figure 7-1). Table 7-1 summarizes key facts about 300-FF. Section 1.3 provides details about plume mapping, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

300-FF groundwater contamination originated primarily from historical routine disposal of liquid effluent associated with fabrication of nuclear fuel assemblies and research involving the processing of irradiated fuel. Because principal liquid waste disposal facilities have been out of service for decades and most have been remediated by removing contaminated soil (Section 4.0 of DOE/RL-2004-74), the contamination remaining in the underlying vadose zone and aquifer is residual.

The groundwater in 300-FF is monitored under CERCLA, the AEA, and RCRA (DOE/RL-95-73; WHC-SD-EN-AP-185). The CERCLA contaminants in the groundwater are uranium, gross alpha, TCE, *cis*-1,2-dichloroethene (DCE), tritium, and nitrate. The former 300 Area Process Trenches (316-5) are an inactive TSD regulated under RCRA and undergoing post-closure monitoring.

Groundwater in the unconfined aquifer beneath the southeastern portion of the Hanford Site flows east or southeast toward the Columbia River (Figure 7-1). This flow direction is induced by regional groundwater flow that converges from the northwest, west, and southwest. Flow patterns throughout the region are complicated by the variable permeability of sediment in the upper portion of the unconfined aquifer. Near the Columbia River, groundwater flow is also influenced by river stage fluctuations. In 2014, groundwater underlying the 300 Area Industrial Complex flowed southward during low river stage (based on measurements made in March) and southwest during high river stage (based on measurements made in June).

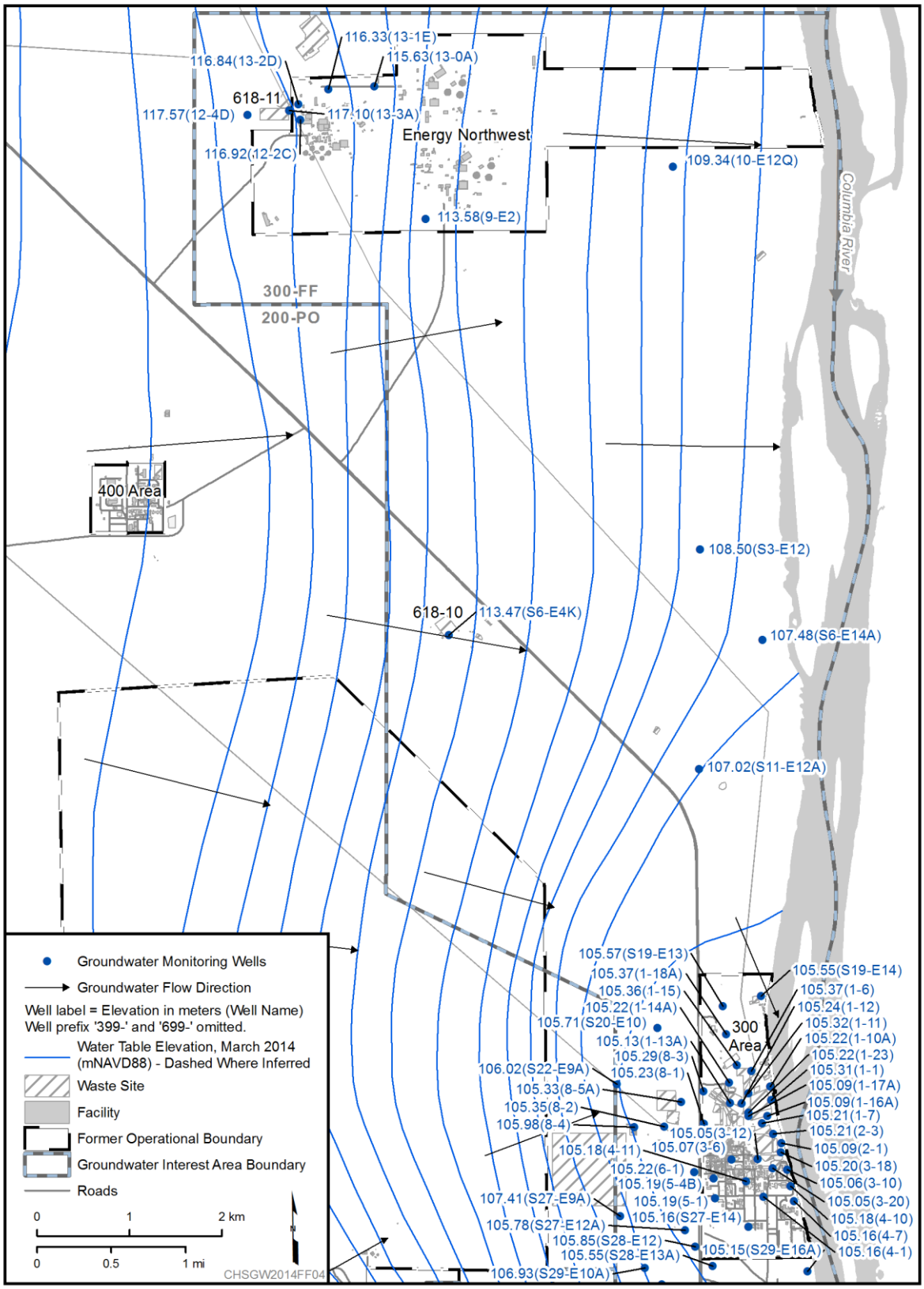


Figure 7-1. 300-FF Overview Map with Groundwater Flow

Table 7-1. 300-FF at a Glance

Fabrication of nuclear fuel assemblies: 1943–1987 Research in irradiated fuel processing: 1950s–1960s 300-FF includes 300 Area Industrial Complex, 618-10 Burial Ground/316-4 Crib, and 618-11 Burial Ground				
2014 Groundwater Monitoring				
Contaminant	**Cleanup Level[a]**	**Maximum Concentration**	**Plume Area[b] (km^2)**	**Shoreline Impact (m)**
Uranium (300 Area Industrial Complex)	30 µg/L	358 µg/L (399-1-62)	0.37	1,150
cis-1,2-Dichloroethene (DCE) (300 Area Industrial Complex)	16 µg/L	207 µg/L (399-1-16B)	Undefined[c]	Undefined[c]
Trichloroethene (TCE) (300 Area Industrial Complex)	4 µg/L	83 µg/L (AT-3-7-D)	Undefined[c]	Undefined[c]
Tritium (618-11)	20,000 pCi/L	994,000 pCi/L (699-13-3A)	0.12[e]	None[e]
Nitrate (618-11)	45 mg/L[d]	83.2 mg/L (699-12-2C)	0.19[e]	None
Remediation				
Waste sites (interim action): In progress 2014; 91 percent complete[f]. Groundwater (interim action): MNA and ICs on the use of groundwater. ROD for final remedial action issued in November 2013; implementation anticipated in 2015.				

a. *Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1, Hanford Site 300 Area* (EPA et al., 2013).

b. Estimated area at a concentration greater than the cleanup standard.

c. Organics are locally present in deeper sediments. Plumes cannot be defined by current data.

d. 45 mg/L nitrate ~ 10 mg/L NO_3-N; DWS.

e. Excludes tritium and nitrate in plume associated with 200-PO and nitrate from offsite.

f. Sites with status of closed, interim closed, no action, not accepted, or rejected.

COCs = contaminants of concern
ICs = institutional controls
MNA = monitored natural attenuation
ROD = Record of Decision

Contamination is generally found in the upper portion of the unconfined aquifer (i.e., the interval of Hanford formation gravelly sediment that lies below the water table) (Figure 7-2). The thickness of the contaminated portion of the unconfined aquifer is variable because of the undulating contact between the Hanford formation and the underlying Ringold Formation unit E. In addition, significant seasonal fluctuations in water table elevation (Section 3.0 of PNNL-17034) affect the thickness of the contaminated zone.

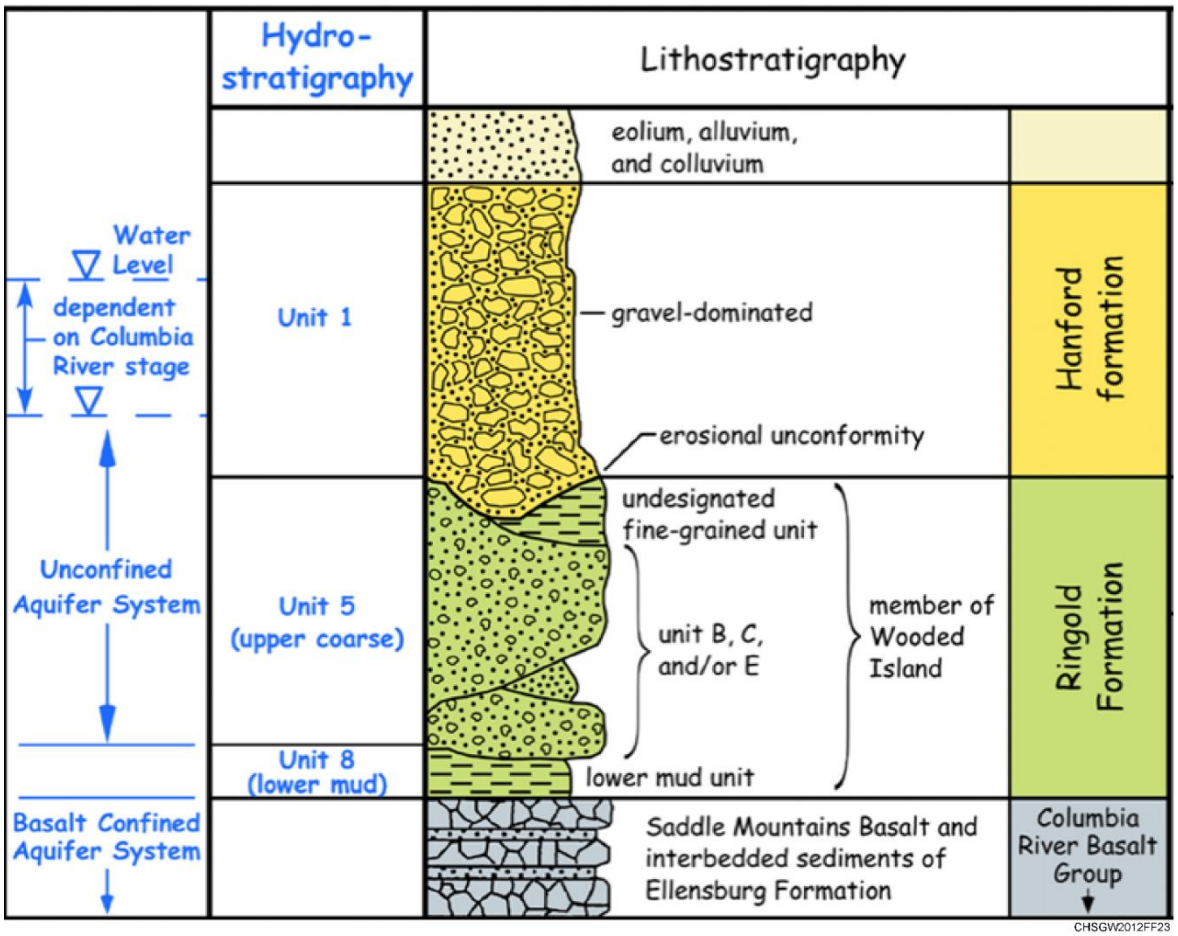


Figure 7-2. 300-FF Geology

Beneath the 300 Area Industrial Complex, paleochannels act as preferential pathways for groundwater flow (Figure 4-89 in DOE/RL-2010-99). In the 300 Area, contaminant discharge to the river occurs via riverbank springs that flow across the beach region (riparian zone) during periods of low river stage and by upward movement through the riverbed.

The rate of contaminant discharge to the river is influenced by daily and seasonal river stage fluctuations (Section 3.1 of PNNL-17708; Section 2.4.1 of PNNL-22048). The highest seasonal river elevations typically occur from May through June, and the lowest seasonal river elevations typically occur from September through mid-November (Section 4.4.2 of DOE/RL-2010-99). Effects of high river elevations include temporary reversal of flow direction, dilution of contamination in groundwater near the river by

the intrusion of clean river water, and possible influences on contaminant mobility caused by changes in the geochemical environment. Changes in the geochemical environment are most pronounced where river water intrudes into the aquifer. River water is lower in alkalinity (lower in bicarbonate content) and lower in specific conductance than groundwater (Section 3.6.1.4 of DOE/RL-2010-99).

Figure 7-3 illustrates how estimates of plume areas in the 300-FF groundwater interest area have changed since 2003.

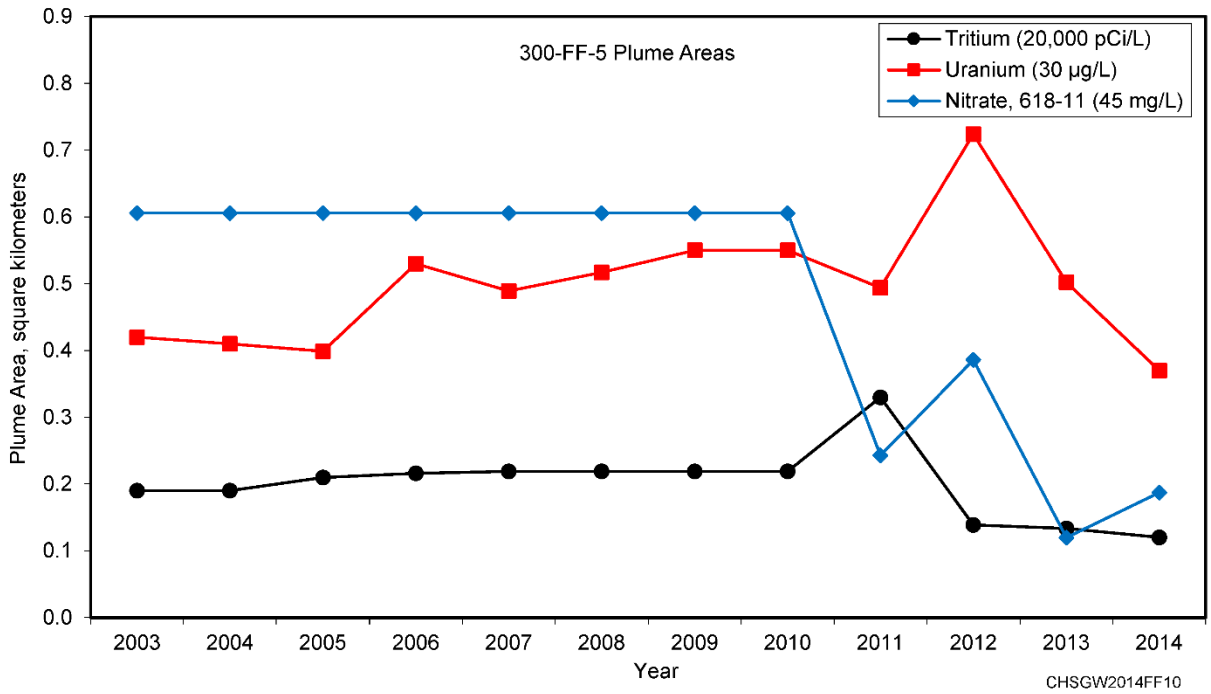


Figure 7-3. 300-FF-5 Plume Areas

7.2 CERCLA Activities

The RI/FS (DOE/RL-2010-99; DOE/RL-2010-99-ADD1) and the Proposed Plan (DOE/RL-2011-47) for the 300-FF-5 OU were issued in early July 2013, and the ROD (EPA et al., 2013) was signed by EPA and DOE on November 25, 2013. The COCs for groundwater are uranium, gross alpha, TCE, and DCE at the 300 Area Industrial Complex; and tritium and nitrate at the 618-11 Burial Ground.

The RAOs identified in the ROD for 300-FF-5 OU are as follows:

- Prevent human exposure to groundwater containing concentrations of COCs above cleanup levels.
- Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above cleanup levels for protection of groundwater, and of surface water concentrations above cleanup levels for the protection of surface water at locations where groundwater discharges to surface water.
- Restore groundwater impacted by Hanford Site releases to cleanup levels which include DWSs, within a time frame that is reasonable given the particular circumstances of the site.

Cleanup actions for the 300-FF-5 OU will consist of four remedy components: (1) MNA for nitrate, tritium, TCE, and DCE; (2) groundwater monitoring for uranium, gross alpha, nitrate, tritium, TCE, and DCE; (3) enhanced attenuation of uranium using sequestration by phosphate application in the vadose zone and at the top of aquifer; and (4) ICs.

In accordance with the 2013 ROD, the in-progress interim action will use the cleanup levels in the ROD immediately upon issuance of the ROD. All other aspects of the interim action will continue to be performed in accordance with the existing documents for the interim action. The RDR/RA WP that implements the 2013 ROD is anticipated to be issued in 2015. When the new RDR/RA WP is approved, it will direct future remedial actions and will replace all interim action ROD work plan requirements.

The remedy selected for the 300-FF-5 OU in the 1996 interim action ROD (EPA/ROD/R10-96/134) was MNA and ICs. Groundwater monitoring required under the 1996 interim action ROD is implemented through a SAP (DOE/RL-2002-11, Rev. 2). Comprehensive sampling events occur semiannually. Most monitoring wells have screens positioned to monitor the upper portion of the unconfined aquifer. Several wells are screened in the lower portion of the unconfined aquifer and a few wells are screened in the uppermost confined aquifer.

Wells and aquifer tubes were sampled as planned during 2014, with the following exception. For one well and all of the aquifer tubes, the sampling scheduled for December 2014 was conducted in early January 2015 due to resource constraints. At two aquifer tubes, samples could not be collected because of no yield. Other minor exceptions to planned monitoring occurred because of maintenance issues and scheduling constraints. Appendix A lists the sampling frequencies, types of laboratory analyses, and sample status for 2014 for the 300-FF-5 OU monitoring wells. Appendix C lists the aquifer tubes. Figure 7-4 shows locations of wells and aquifer tubes sampled in 2014.

DOE's Office of Science, Biological, and Environmental Research, is supporting integrated laboratory and field research through the PNNL Scientific Focus Area to understand and model the multi-scale hydrobiogeochemical functioning of the groundwater-surface water interaction zone along the Hanford Reach of the Columbia River. The overall goal is to understand linked hydrologic, climatic, geochemical, and microbiologic processes that control contaminant and nutrient fluxes between groundwater and the Columbia River at scales ranging from local (50 to 500 m [164 to 1,640.4 ft]) to the reach (about 75 km [46.6 mi]). Recent studies have focused on seasonal water quality dynamics (including uranium and nitrate) driven by Columbia River stage changes using geophysical monitoring and high-density sampling and analysis of subsurface waters in an east-west transect from the Integrated Field Scale Research Challenge well field in the historic South Process Pond of the 300 Area, through a coarse-textured subsurface paleochannel and associated hyporheic zone, to discharge in the Columbia River. The Scientific Focus Area continues active publication in the peer reviewed literature as the primary mode of results dissemination with a new web-site (http://www.pnnl.gov/biology/sfa) containing a project description, key highlights, and all publications. Recent publications have addressed hydrologic exchange, microbiology, and reactive transport process of carbon, nitrate, and uranium in the hyporheic zone and near-shore aquifer of the 300 Area.

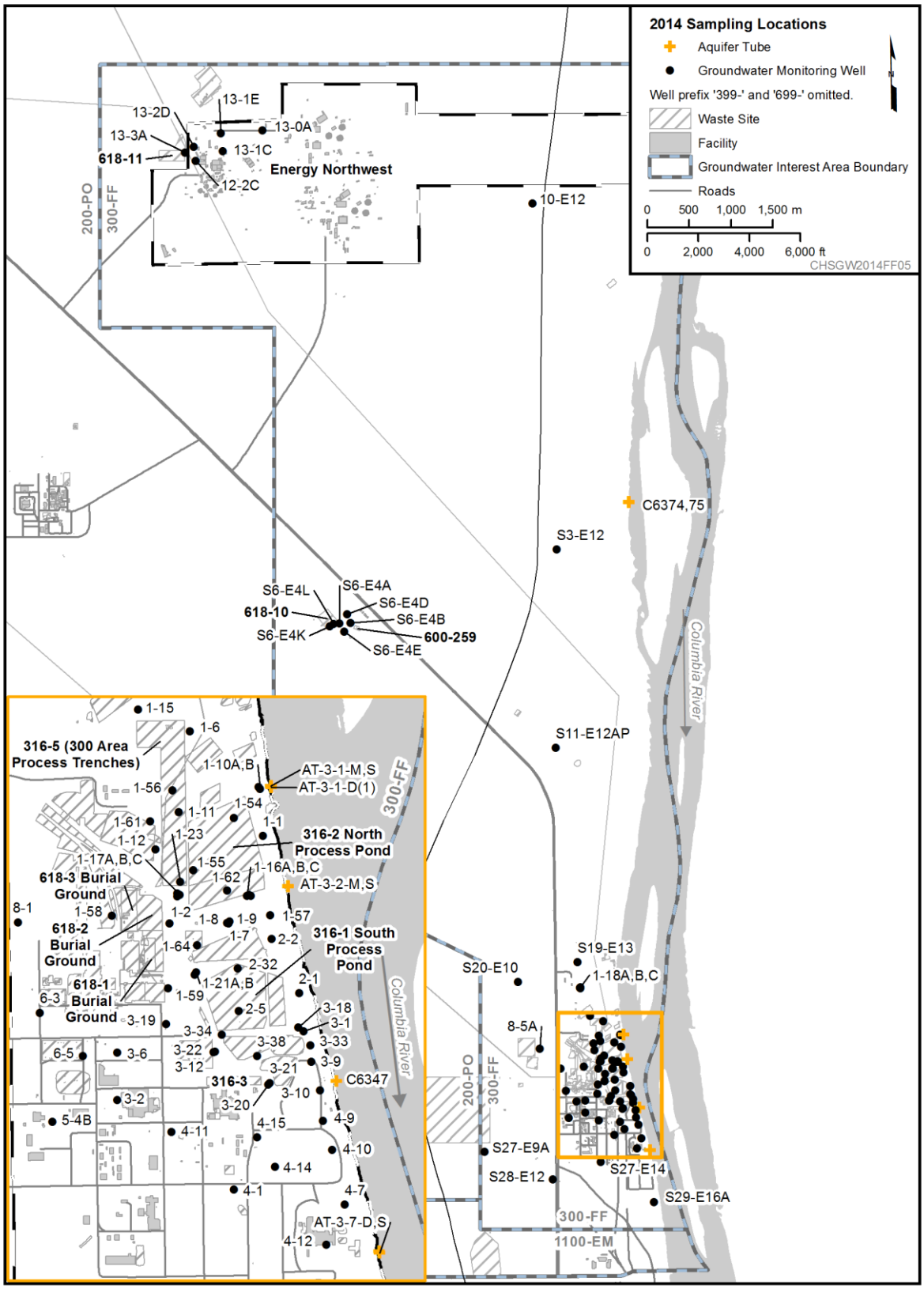


Figure 7-4. 300-FF Sample Locations, 2014

7.3 Uranium

Large volumes of liquid waste containing uranium were discharged to the former South Process Pond (316-1) (1943 to 1975), North Process Pond (316-2) (1948 to 1975), and 300 Area Process Trenches (316-5) (1975 to 1987). Discharge of cooling water with small quantities of nonhazardous maintenance and process waste continued at the 300 Area Process Trenches until December 1994 (Section 2.1 of PNNL-13645). Contaminated soil was removed from the 300 Area Process Trenches in 1991; additional excavation of contaminated soil occurred at this site and at other major liquid waste disposal sites in the 300 Area Industrial Complex from 1997 through 2000.

The areal extent of uranium contaminated groundwater that exceeds the cleanup level (30 µg/L, DWS) is estimated to be 0.4 km^2 (0.2 mi^2) beneath the 300 Area Industrial Complex. The persistence of the plume is attributed to resupply of mobile uranium from sources in the vadose zone and the periodically rewetted zone (the deepest part of the vadose zone through which the water table rises during high river stage) (Section 4.4.4.3 of DOE/RL-2010-99).

7.3.1 Uranium at Low River Stage

During seasonal low water table conditions, the highest uranium concentrations are often observed near the river, where uranium introduced inland during the preceding period of high water table conditions (due to groundwater contact with residual uranium in the lower vadose zone) has migrated downgradient to the shoreline, and intrusion of river water into the zone beneath the shoreline is lessened because of the lower river stage (Section 3.3 of PNNL-17034). The plume map (Figure 7-5) shows the uranium concentrations for the seasonal low water table conditions in December 2014. Figures 7-6 and 7-7 show the uranium concentration trends at locations representative of near-river conditions.

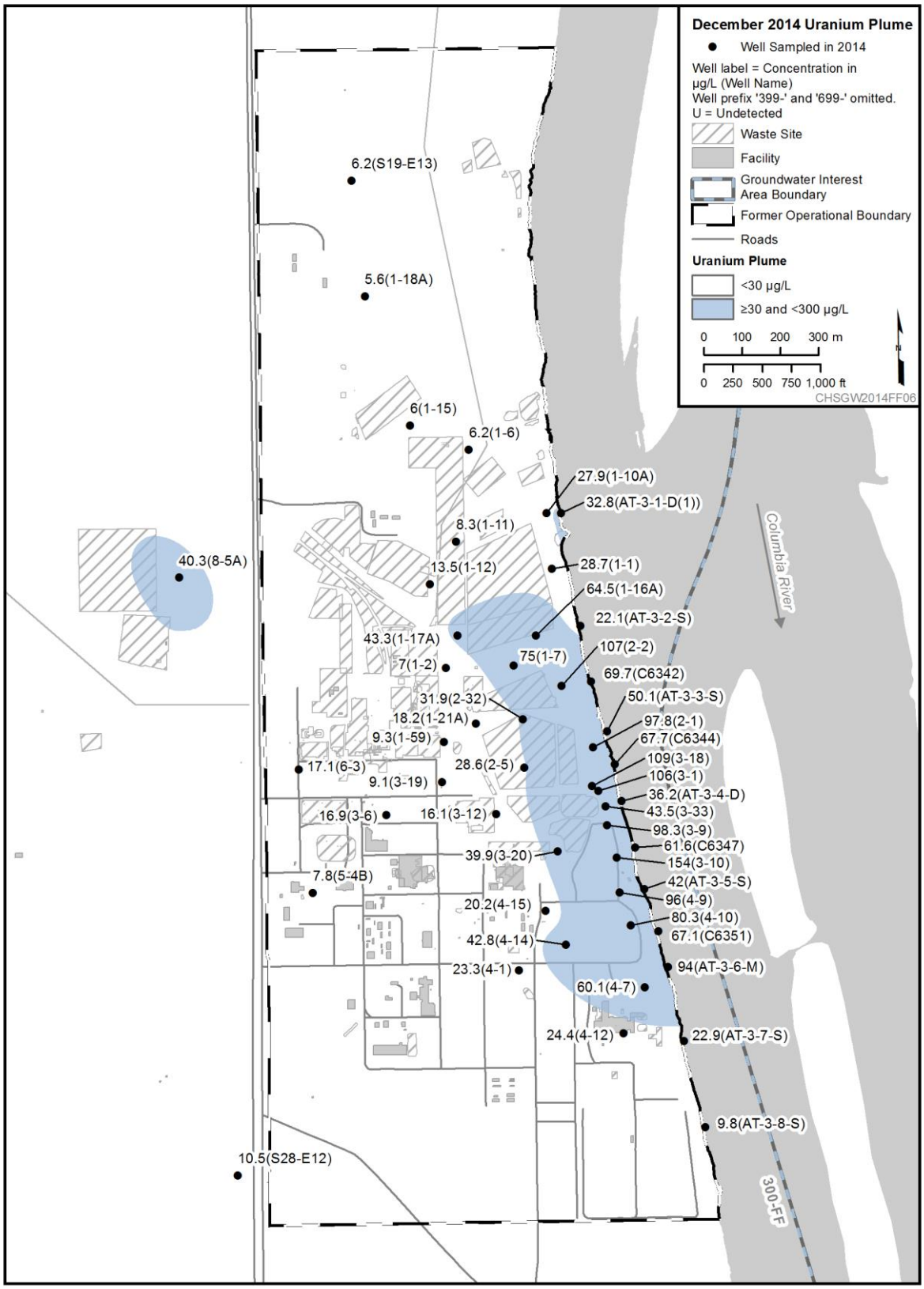


Figure 7-5. 300-FF 2012 Uranium Plume, December 2014 (Low River Stage)

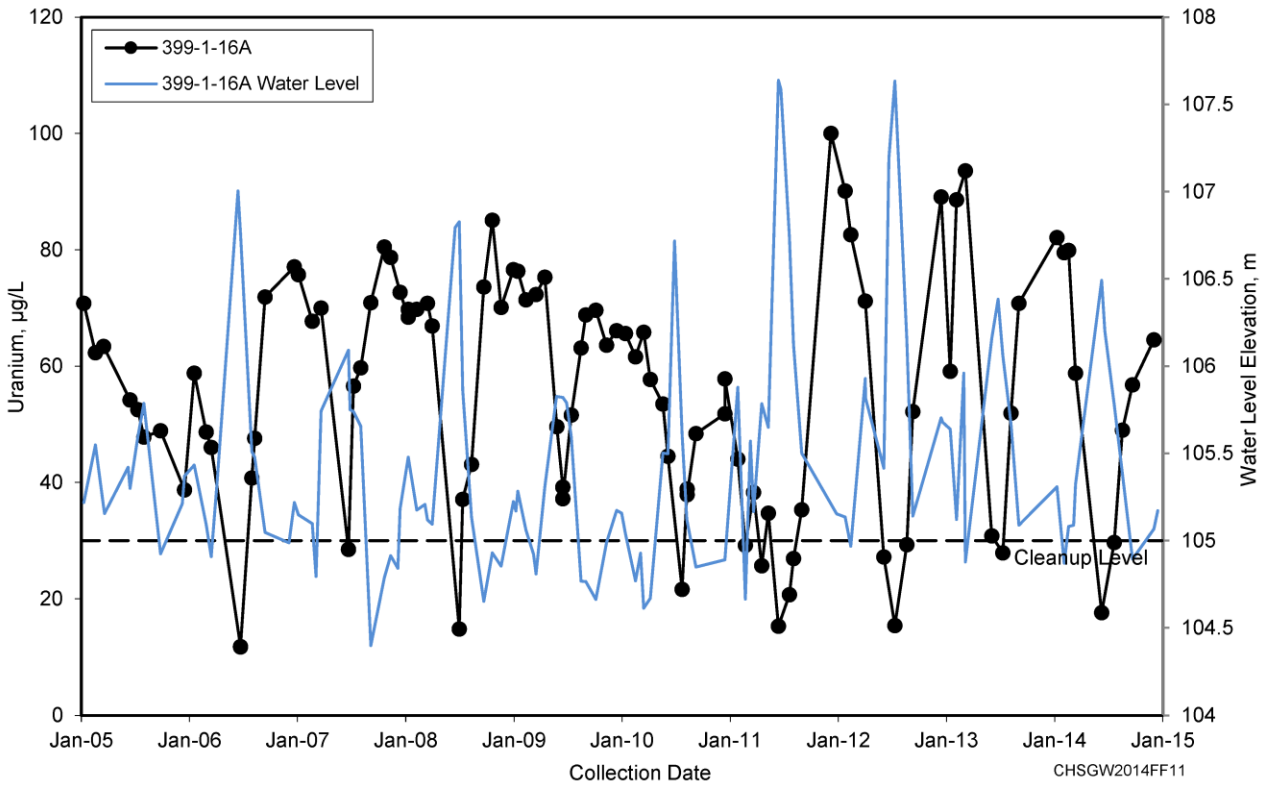


Figure 7-6. Uranium and Water-Level Data for Well 399-1-16A (Near River).

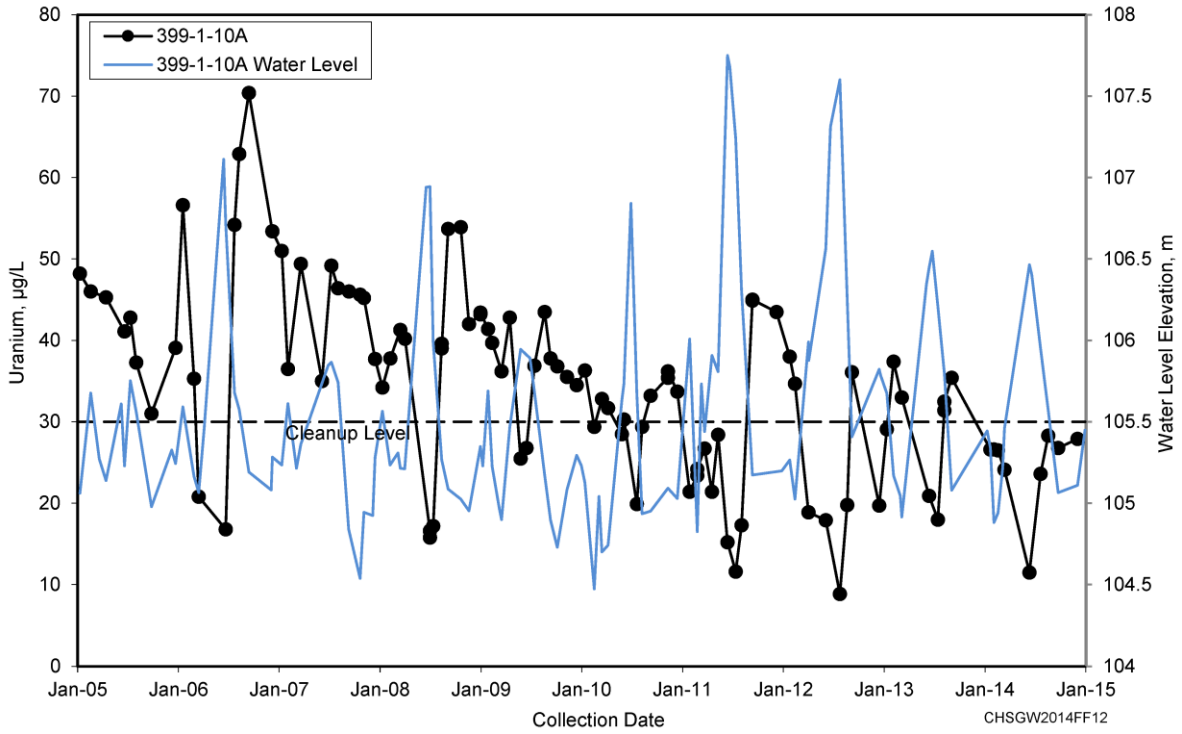


Figure 7-7. Uranium and Water-Level Data for Well 399-1-10A (Near River).

An area of uranium groundwater contamination developed in 2008 downgradient from the former 618-7 Burial Ground. The contaminant plume resulted from the infiltration of dust control water and soil fixatives used during remediation activities conducted at this site during 2007 and 2008. In addition to uranium, increases in the concentrations of chromium and constituents associated with soil fixatives (e.g., calcium and chloride) also occurred at Well 399-8-5A, which is adjacent to the waste site. By the end of 2010, concentrations at nearby downgradient Wells 399-8-5A and 399-8-1 continued to decrease, indicating passage of the contaminant plume (Figure 7-8). However, uranium concentrations increased again in samples collected after the seasonal high water table conditions in 2011 (August), in 2012 (August and November), and in 2013 (August), suggesting that mobile uranium remains in the lower portion of the vadose zone near Well 399-8-5A. The uranium plume appears to be recognizable along its projected migration path. Increases in uranium concentrations above the DWS were measured in January 2014 during low water conditions at the nearest downgradient well (399-8-1, approximately 340 m [1,100 ft] to the southeast) (Figure 7-5) and concentrations just below the DWS were measured during the following high water conditions at Well 399-1-59 (approximately 810 m [2,700 ft] to the southeast) (Figure 7-9).

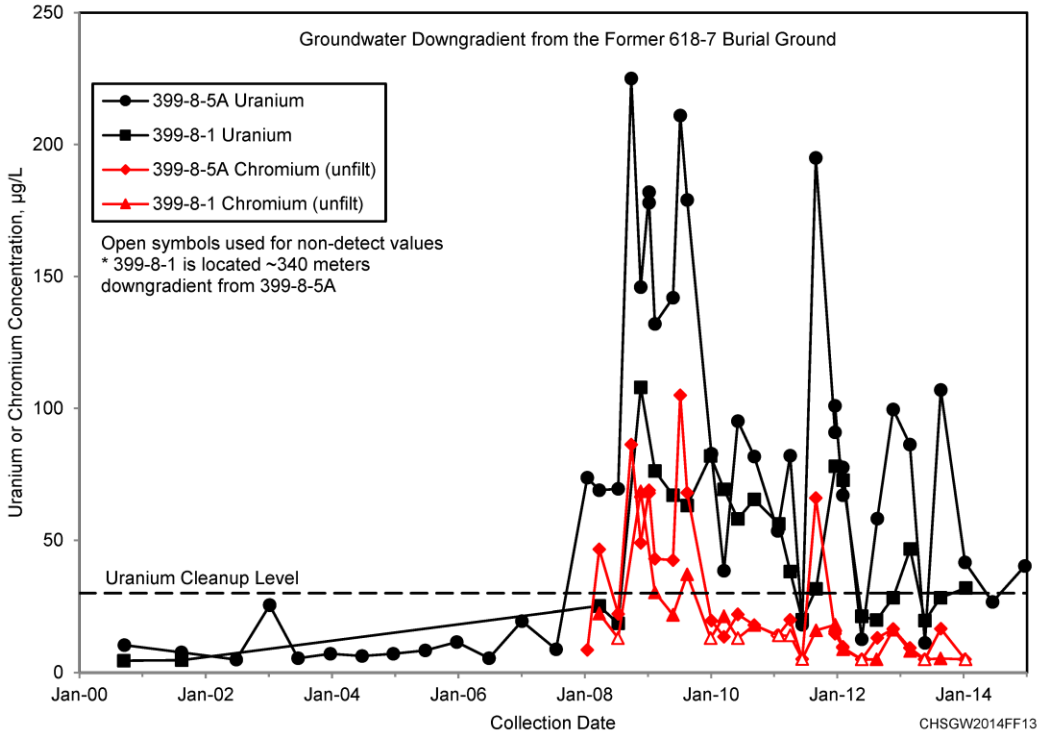


Figure 7-8. Uranium and Chromium Data for Wells 399-8-5A and 399-8-1, Downgradient of 618-7 Burial Ground.

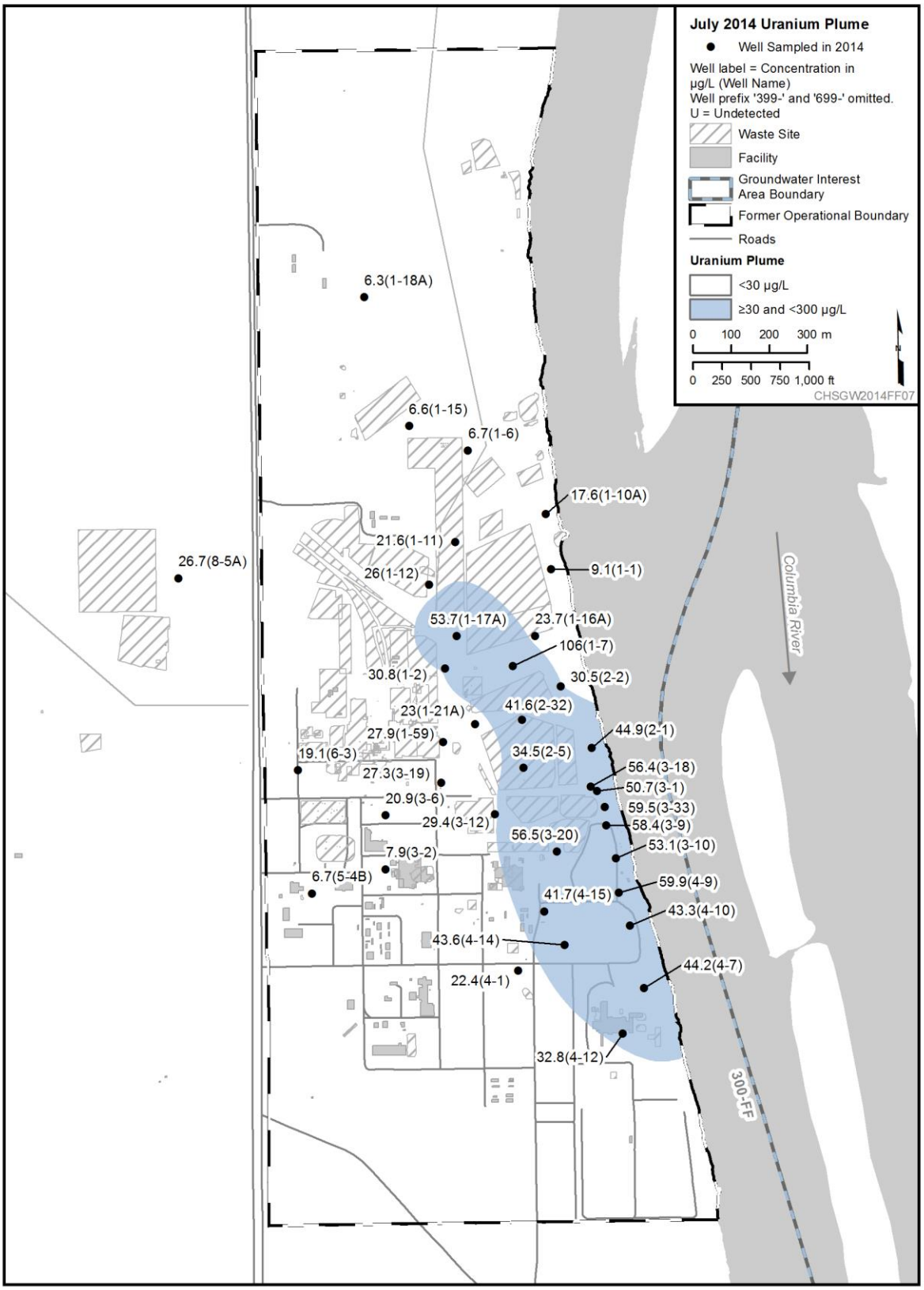


Figure 7-9. 300-FF Uranium, July 2014 (High River Stage)

Figure 7-10 shows the uranium concentrations observed in samples collected in December 2014 through January 2015 from aquifer tubes and near river monitoring wells. The lateral distribution of uranium, as indicated by the aquifer tube sample results, is consistent with the groundwater plume map for seasonal lower river stage conditions (Figure 7-5). The maximum uranium concentration in an aquifer tube was 127 µg/L (C6347) collected January 2014. Figure 7-11 illustrates the ranges of uranium concentrations detected over the period of aquifer tube monitoring in 300-FF. The concentrations in January 2015 in some of the downstream aquifer tubes were higher than those detected previously.

The contaminant concentrations measured in samples from aquifer tubes are lower than those in the approaching groundwater because river water intrudes into the unconfined aquifer beneath the shoreline, diluting the concentrations. A lowering of concentrations may also occur because of changes in geochemical conditions caused by the intrusion of river water, which could promote adsorption of dissolved uranium onto sediment near the river. The lower bicarbonate content of river water compared to groundwater enhances the tendency for adsorption, although the significance of this process with regard to influencing concentrations as observed in monitoring results is not known (Section 5.4 of PNNL-17031; Section 5.2 of Yabusaki et al., 2008; Section 5.1 of PNNL-22048).

Two river shore seeps at 300-FF were sampled in 2014 during low river stage. Seeps occur when groundwater drains from the aquifer, and the groundwater elevation locally is higher than the river elevation. The seep, which is exposed on the ground surface, is considered surface water rather than groundwater. The results of the seep analyses for uranium are shown as information on the plume map for that contaminant but were not used during preparation of the plume configuration.

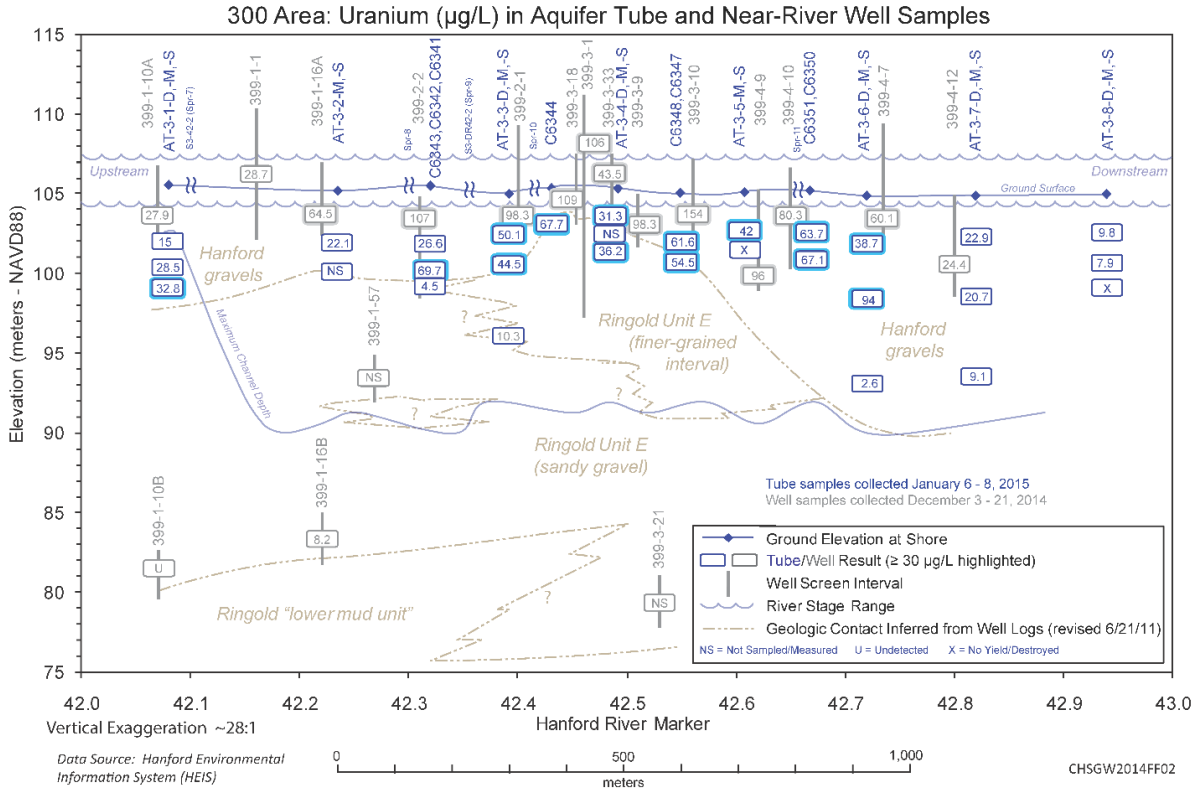


Figure 7-10. 300-FF Uranium in Aquifer Tube and Near-River Well Samples

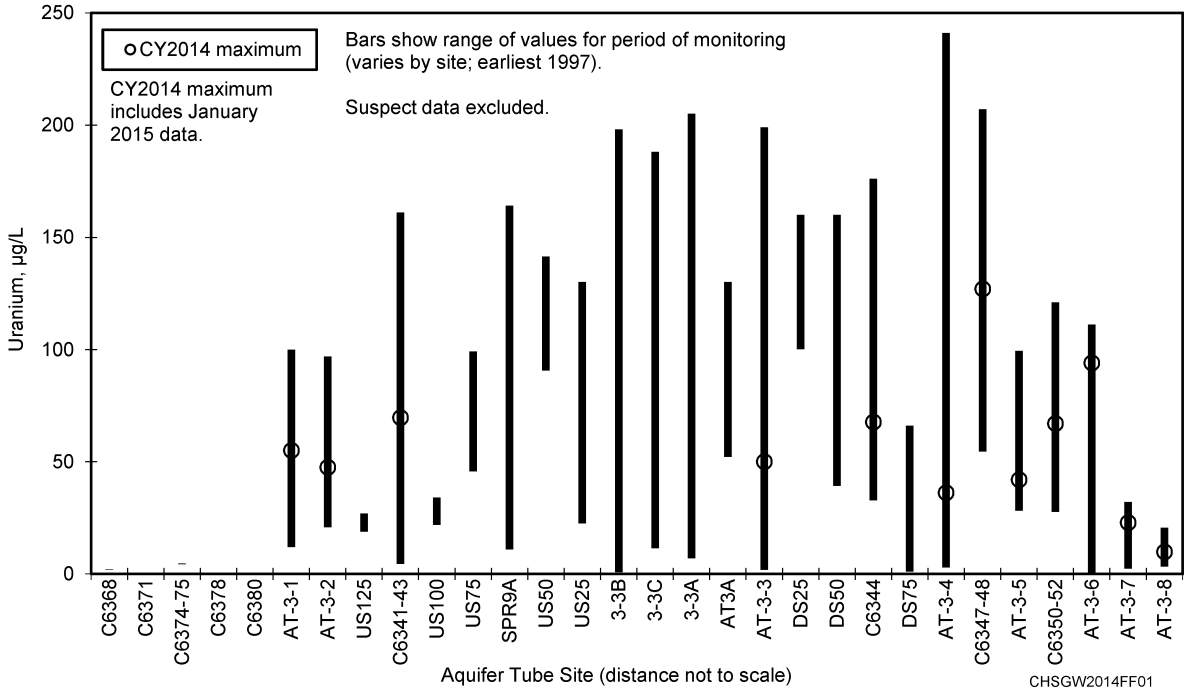


Figure 7-11. 300-FF Aquifer Tube Sample Data

Seep number "300 Area Spr DR 42-2," on the river shore downgradient from the 316-1 South Process Pond, was sampled on September 25, 2014. The uranium result was approximately 75.1 µg/L, based on the sum of uranium isotopic results. The uranium concentration in nearby Aquifer Tube C6341 was 26.6 µg/L in a sample collected on January 15, 2015. The uranium concentration in upgradient Well 399-2-2 was 107 µg/L in a sample collected on December 21, 2014.

Seep number "300 Area Spring 42-2," on the river shore downgradient from the 316-5 Process Trenches and 316-2 North Process Pond, was sampled on September 23, 2014. The uranium result was approximately 19.5 µg/L, based on the sum of uranium isotopic results. The uranium concentrations in nearby Aquifer Tubes AT-3-1-D, AT-3-1-M, and AT-3-1-S were 32.8 µg/L, 28.5 µg/L, and 15 µg/L, respectively, in samples collected in January 2015. The uranium concentration in upgradient Well 399-1-10A was 27.9 µg/L in December 2014.

Uranium concentrations also are detected in groundwater near the 618-10 Burial Ground/316-4 Crib, located northwest of the 300 Area Industrial Complex (Figure 7-4). From 1948 to 1956, uranium contaminated organic solvents were disposed to the 316-4 Crib, which is adjacent to the easternmost corner of the 618-10 Burial Ground (Section 3.6.33 of BHI-00012, *300-FF-3 Operable Unit Technical Baseline Report*). The crib and some of the contaminated adjacent soil were removed in 2003 and 2004, and the site was partially backfilled. However, some uranium contamination was known to remain in the soil beneath the excavated site (Sections 3.4.1.4 and 3.4.2.1 of DOE/RL-2006-20; EPA/ESD/R10-00/524).

Uranium concentrations increased above the DWS in 2004 in Wells 699-S6-E4A and 699-S6-E4L near the southeastern fence line of the 618-10 Burial Ground and the 316-4 Crib. This increase was caused by infiltration of dust control water applied during the 316-4 Crib excavation and backfilling. Concentrations were elevated again in Well 699-S6-E4L in 2012 and 2013 and still above the DWS in 2014 (2014 maximum was 47.7 µg/L) (Figure 7-12). The 2012 and 2013 increases are attributed to infiltration of dust

control water during removal actions that started in 2011 at the 618-10 Burial Ground. Because the water table elevation in this area has steadily declined by 1 m (3.3 ft) since 1998, the increase in uranium is not attributed to rewetting of the vadose zone by seasonal changes in the water table.

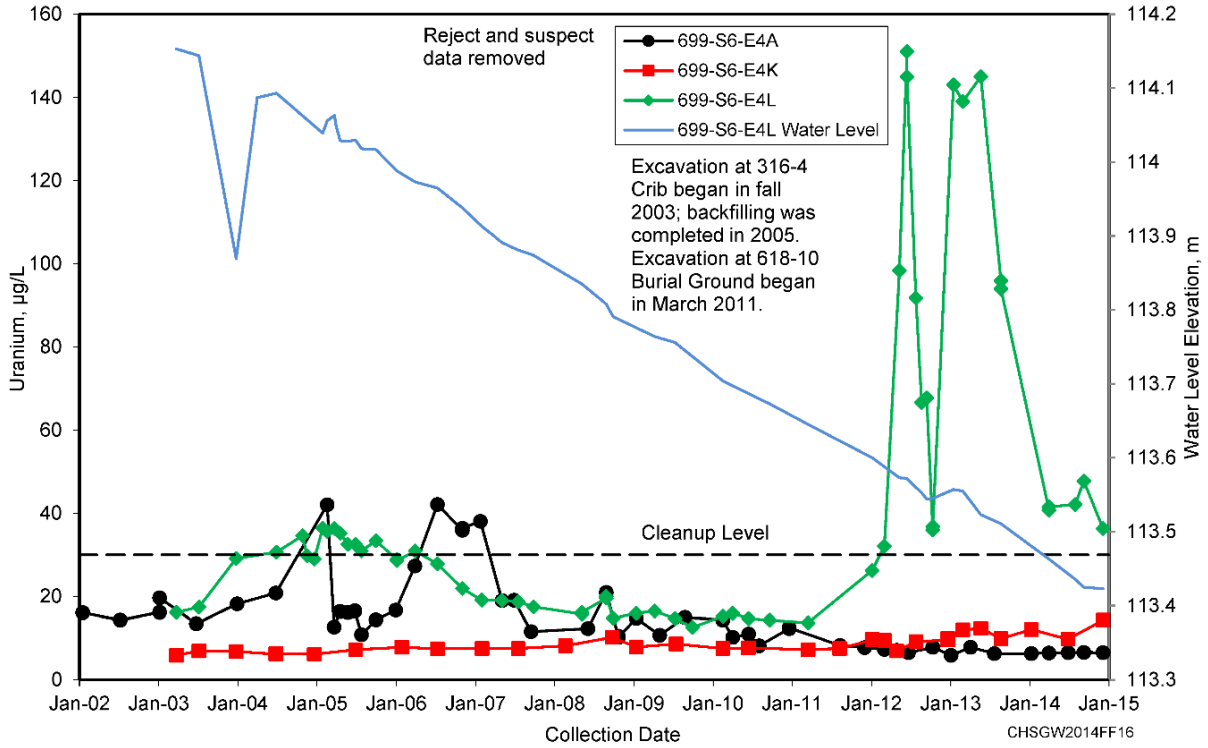


Figure 7-12. Uranium and Water-Level Data for Wells 699-S6-E4A, 699-S6-E4K, and 699-S6-E4L

7.3.2 Uranium at High River Stage

Uranium concentrations for the seasonal high water table conditions in June 2014 are shown on Figure 7-9. Groundwater elevations were high during April through August 2014. The water table was elevated sufficiently to rewet a portion of the vadose zone where residual amounts of mobile uranium remain at some locations. The rewetting of the vadose zone mobilized uranium into the groundwater causing higher concentrations in several wells adjacent to the former 300 Area Process Trenches (316-5) and the North Process Pond (316-2) (Figures 7-13, 7-14, and 7-15). The positive correlation between water table elevation and uranium concentration suggests that at or near these locations, uranium remains in the lower portion of the vadose zone and is available to be remobilized during periods of high water table conditions. During low water conditions, these high concentrations declined to more typical seasonal values. Elevated uranium concentrations measured in the downgradient wells the following winter likely reflect the migration of the elevated uranium concentrations measured farther inland in the summer.

Typical characteristics of the plume during seasonal high water table conditions include lowered concentrations along portions of the Columbia River shoreline and increased concentrations farther inland near source areas. The reduction in concentrations near the shoreline is caused by dilution from intrusion of river water into the aquifer, as evidenced by lower specific conductance measured in wells near the shoreline during high river stage. The increase in concentrations near source areas is caused by mobilization of residual contamination resulting from temporary elevation of the water table.

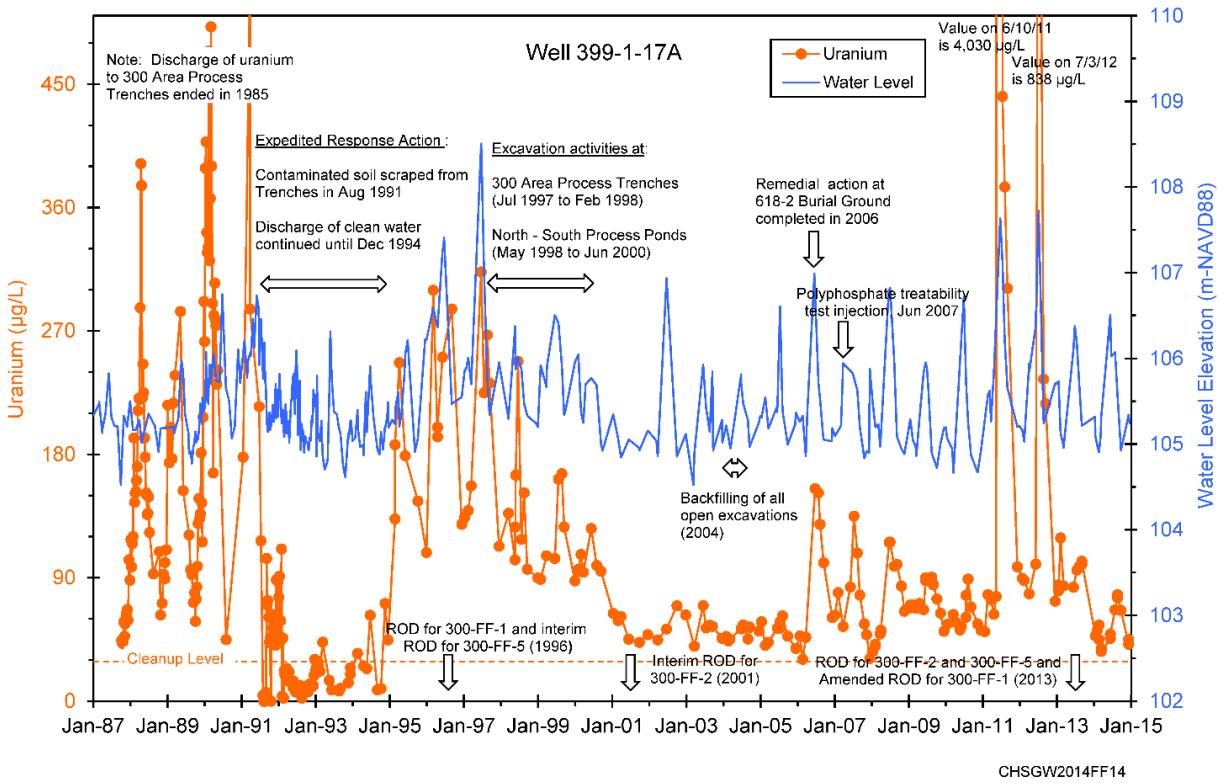


Figure 7-13. Uranium and Water-Level Data for Well 399-1-17A (Inland)

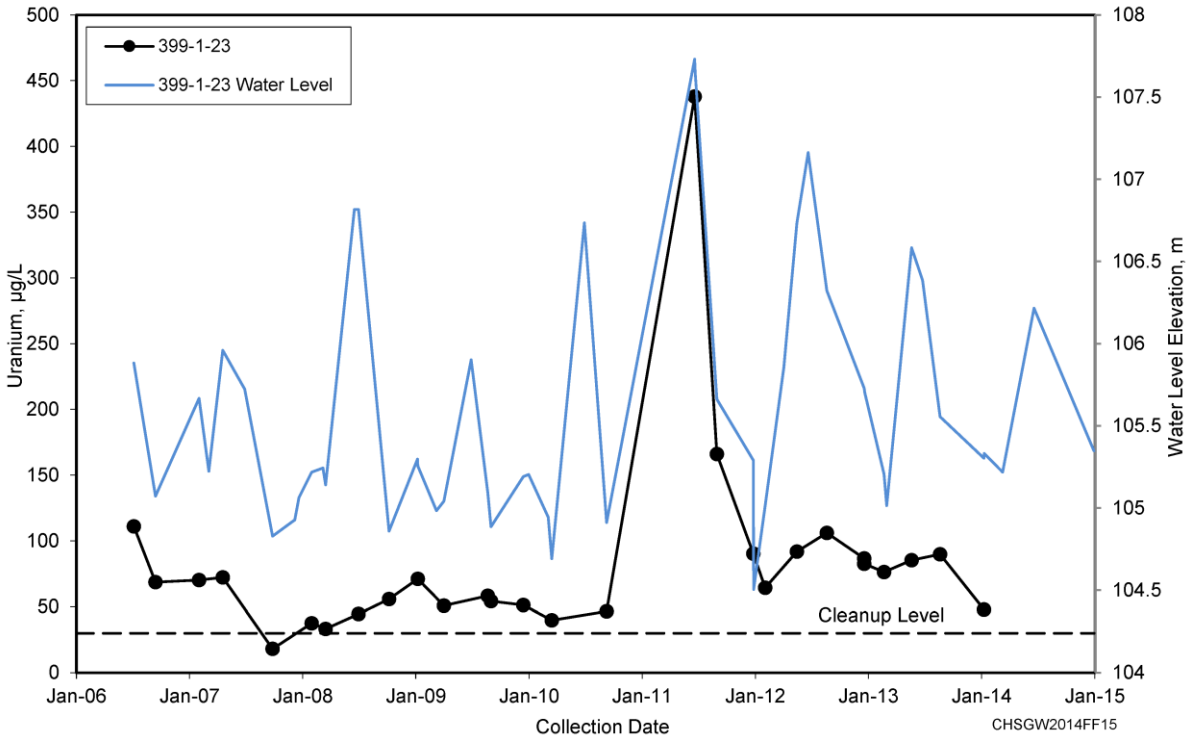


Figure 7-14. Uranium and Water-Level Data for Well 399-1-23 (Inland)

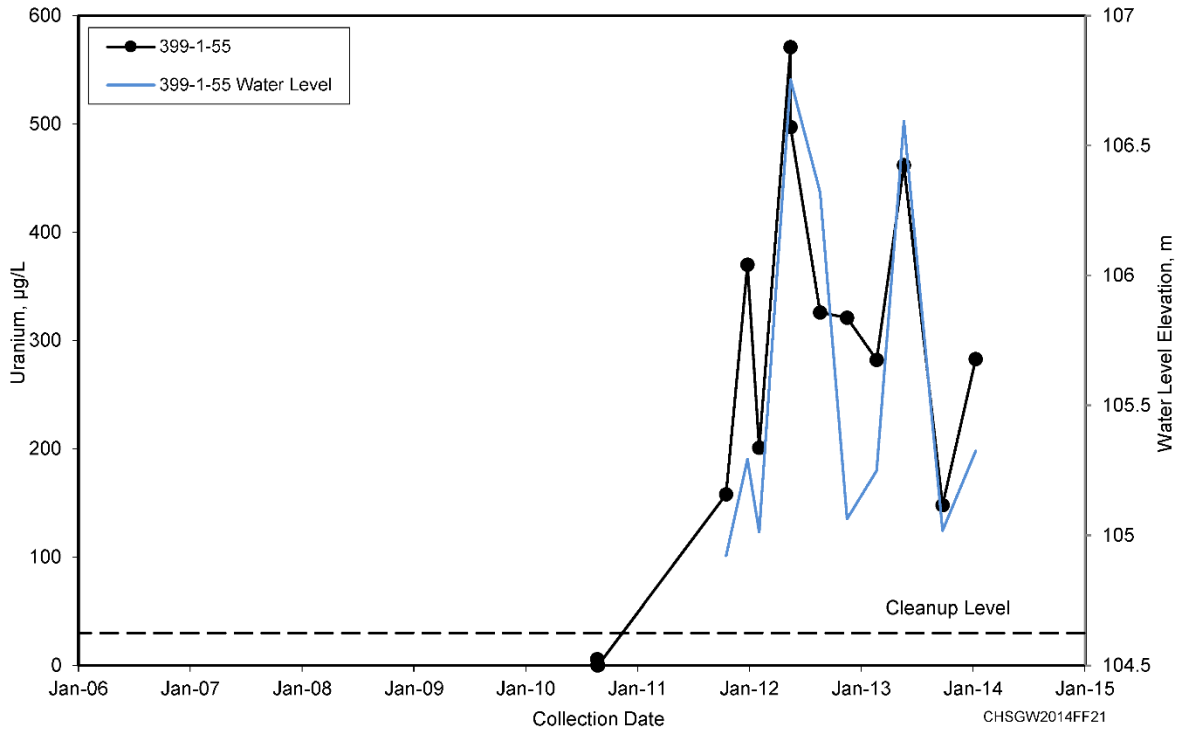


Figure 7-15. Uranium and Water-Level Data for Well 399-1-55 (Inland)

Uranium concentrations in wells that monitor the lower portion of the unconfined aquifer in the 300 Area Industrial Complex are typical of natural background levels (estimated to range between 0.5 and 12.8 µg/L [Table ES-1 of DOE/RL-96-61]), indicating little or no downward migration of contaminant uranium below the saturated Hanford formation sediment. Hydrographs for wells screened in saturated Hanford formation sediment or underlying Ringold Formation unit E sediment are virtually identical, indicating no significant vertical gradients.

Contamination has not been detected in the few wells that monitor the uppermost confined aquifer, which is a low to moderately permeable interval within the Ringold Formation lower mud unit. Hydrographs for two of these confined wells (399-1-16C and 399-1-17C) show a distinct upward hydraulic gradient, with hydraulic heads approximately 8 to 9 m (26 to 30 ft) higher than in adjacent water-table wells. These two deep wells are screened across the basalt/Ringold lower mud contact and show confined basalt aquifer conditions. The hydrograph for a third well identified as a confined well (399-1-18C) shows very little head difference compared to the adjacent water-table well. Because Well 399-1-18C is responding similarly to the unconfined and confined Ringold aquifers, it was completed in the lowest Ringold sediment rather than in the basalt-confined aquifer.

Gross alpha activity in 300-FF is attributed to uranium and exceeded the cleanup level (15 pCi/L, DWS) at numerous wells in the 300 Area Industrial Complex groundwater where uranium concentrations were also elevated during the high water table conditions in 2013. Uranium and gross alpha activity also exceeded the DWS at the 618-10 Burial Ground and the 316-4 Crib. However, the ROD (EPA et al., 2013) does not name those constituents as COCs at that location.

7.4 Tritium

Tritium is found in groundwater associated with the 618-11 Burial Ground at concentrations exceeding the cleanup level (20,000 pCi/L, DWS). The source of the plume is tritium gas released from buried radiological solid wastes in a series of caissons located along the north side of the burial ground (PNNL-13675). The narrow tritium plume extends for approximately 1.2 km (0.7 mi) to the east of (downgradient from) the 618-11 Burial Ground. The plume passes just to the north of the Energy Northwest Columbia Generating Station (Figure 7-16). The plume appears to be contained within the saturated Hanford formation gravels portion of the unconfined aquifer. The tritium concentrations attributed to the 618-11 Burial Ground lie within the larger, lower concentration tritium plume that is part of 200-PO (Section 4.4.5 of DOE/RL-2010-99).

Tritium concentrations near the 618-11 Burial Ground have declined from the maximum values observed in 1999 and 2000 (Figure 7-17). The trend in groundwater at Well 699-13-3A, adjacent to the eastern fence line of the burial ground, suggests that an episodic event of unknown nature caused a tritium release from buried materials to contaminate groundwater. The relatively constant tritium concentrations at Well 699-13-3A since 2006 suggest that buried materials are providing an ongoing source of tritium to groundwater. At wells farther downgradient from the 618-11 Burial Ground, such as Wells 699-13-2D and 699-12-2C, concentration trends reflect the plume's migration. The conceptual model for the plume, including a simulation of plume evolution over time, indicates that tritium concentrations will be below the cleanup level when the plume reaches the Columbia River (Section 5.1 of PNNL-15293). Groundwater wells monitored by Energy Northwest do not show evidence of this plume above the DWS, and tritium is not detected in Energy Northwest water supply wells (Mee, 2014).

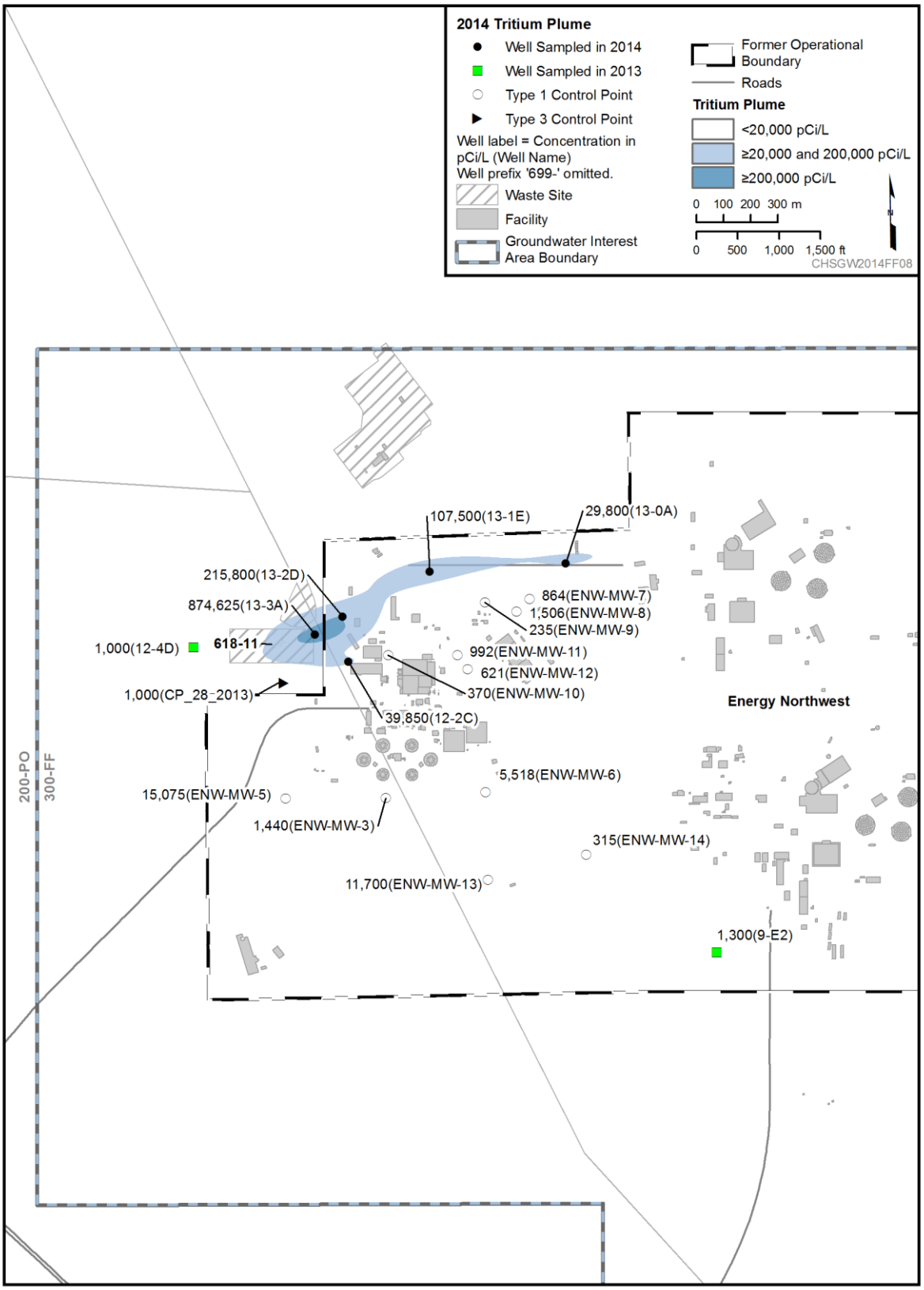


Figure 7-16. Tritium near the 618-11 Burial Ground

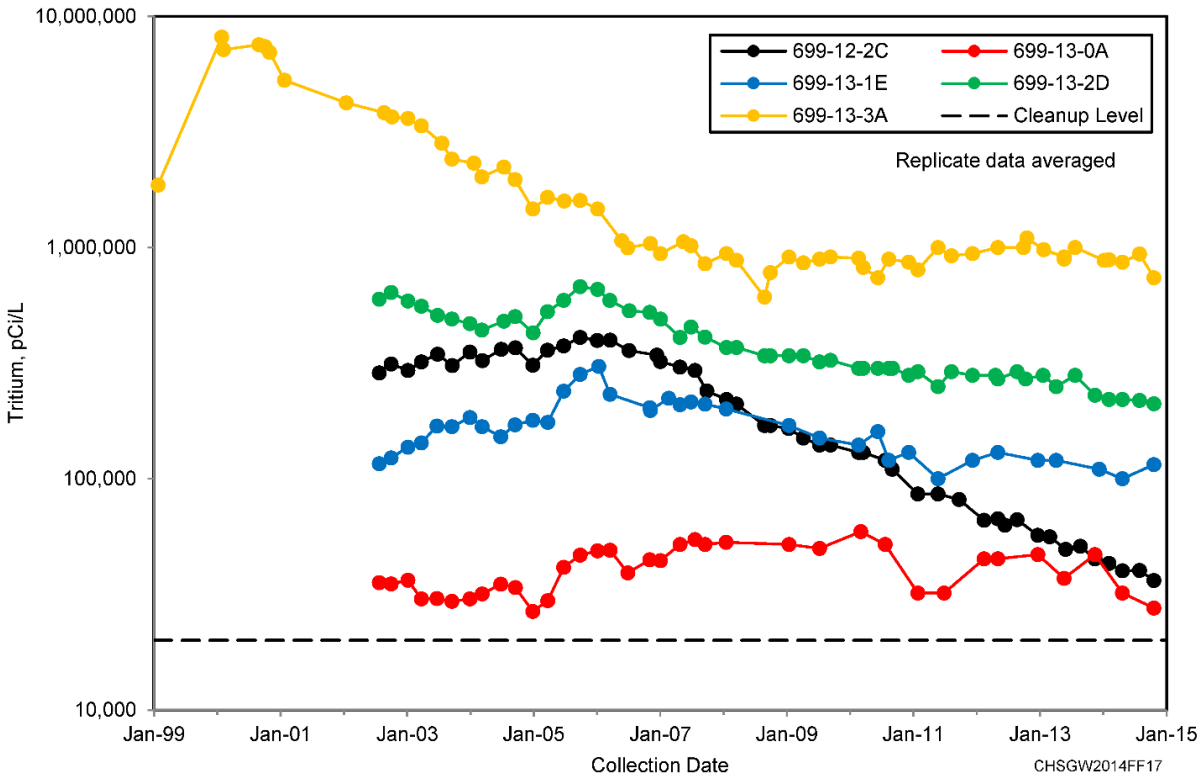


Figure 7-17. 300-FF Tritium Data for Wells 699-12-2C, 699-13-0A, 699-13-1E, 699-13-2D, and 699-13-3A

7.5 Nitrate

Nitrate concentrations exceeding the 45 mg/L cleanup level (DWS [10 mg/L measured as nitrogen in nitrate]) are found near the 618-11 Burial Ground (Figure 7-18). Nitrate exceeding 45 mg/L also is found in the southern portion of the 300 Area Industrial Complex. The principal sources of nitrate currently observed in 300 Area Industrial Complex groundwater are agricultural and industrial activities not associated with the Hanford Site. The nitrate in the southern portion of the 300 Area Industrial Complex is not part of the 300-FF-5 OU (EPA et al., 2013).

7.5.1 618-11 Burial Ground

Nitrate concentrations near the 618-11 Burial Ground continue to exceed the cleanup level (Figures 7-18, 7-19, and 7-20). Concentrations at Well 699-13-3A have generally decreased since 2010; the maximum concentration during 2014 was 83.2 mg/L (Figure 7-19). Historical records for materials sent to the 618-11 Burial Ground do not indicate significant quantities of nitrate-bearing wastes. Given that the elevated nitrate contamination in the groundwater corresponds to the elevated tritium contamination, which is attributed to the 618-11 Burial Ground, the nitrate contamination is also attributed to the 618-11 Burial Ground (Section 4.4.5 of DOE/RL-2010-99).

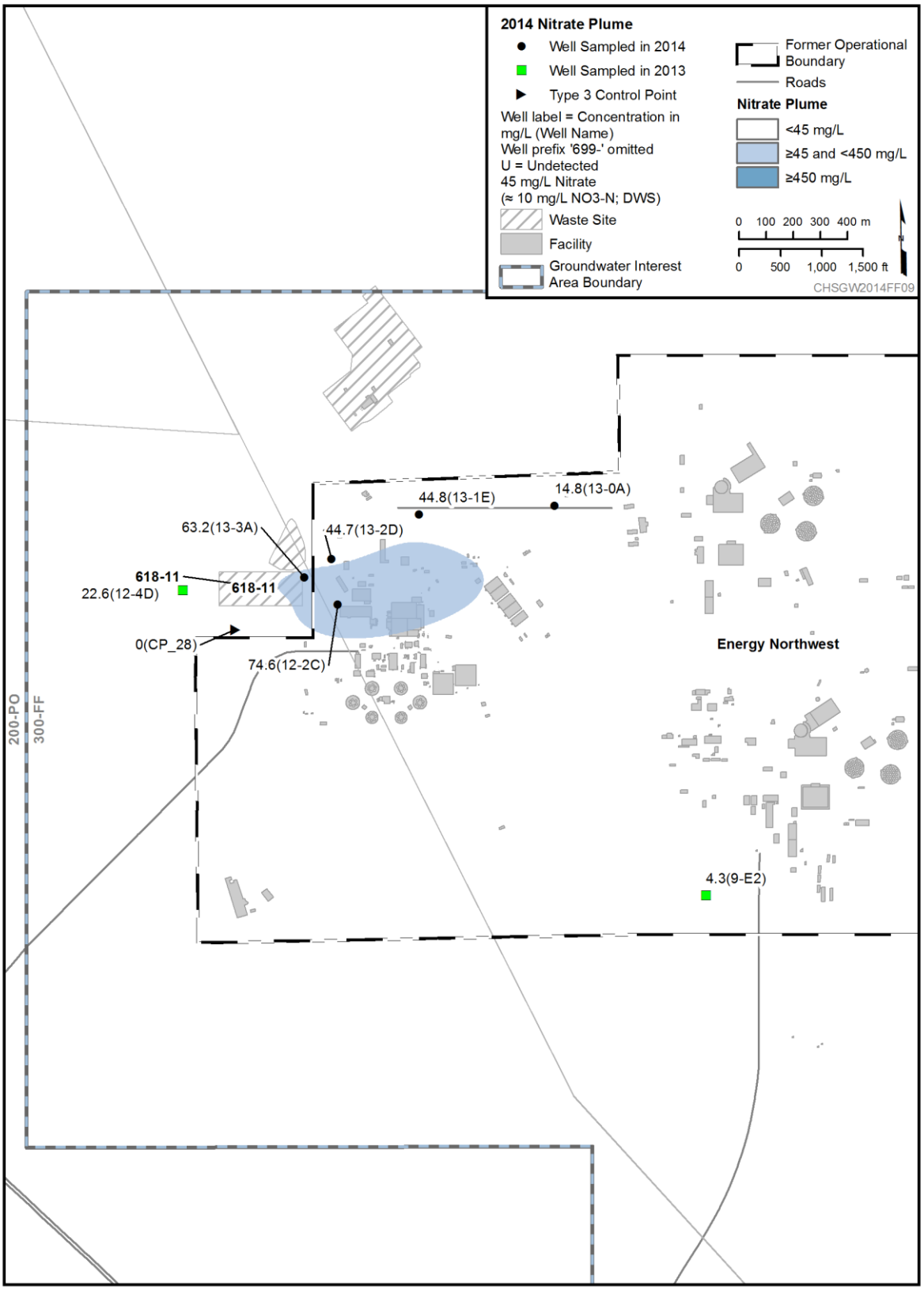


Figure 7-18. Nitrate near the 618-11 Burial Ground

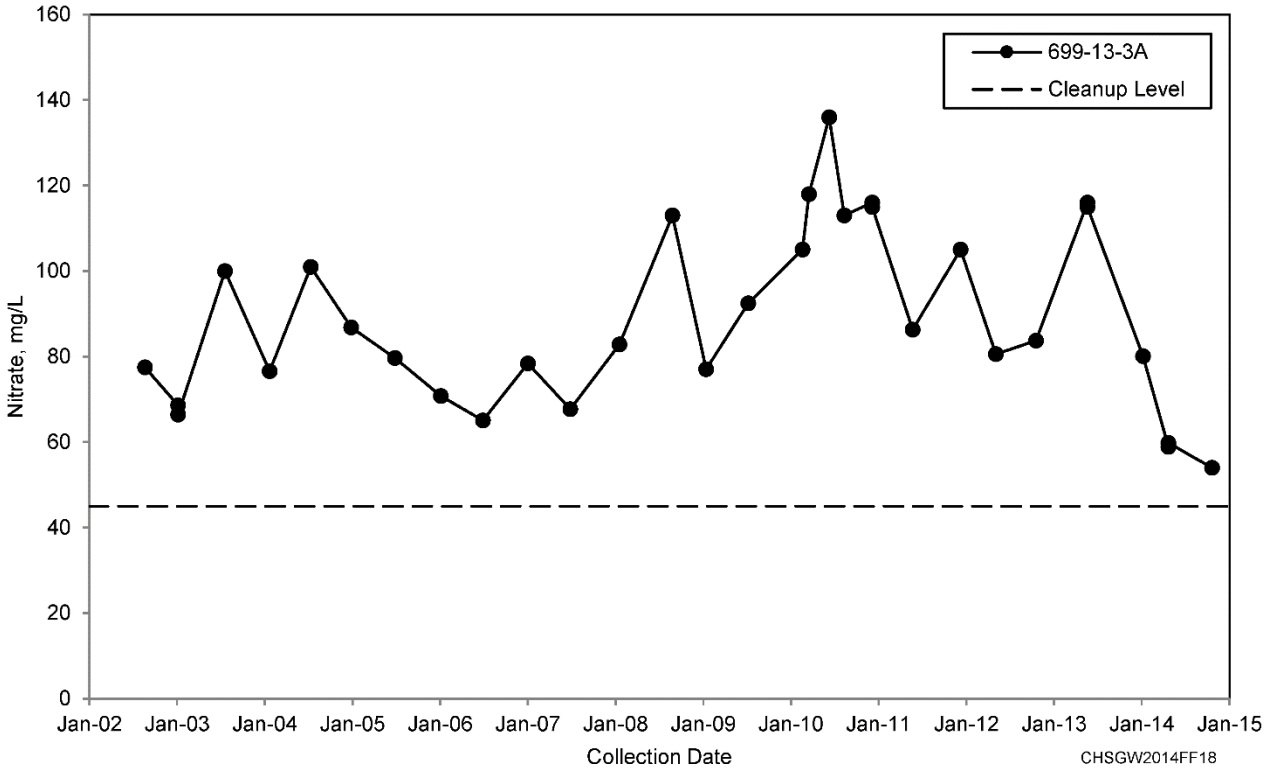


Figure 7-19. Nitrate Data for Well 699-13-3A

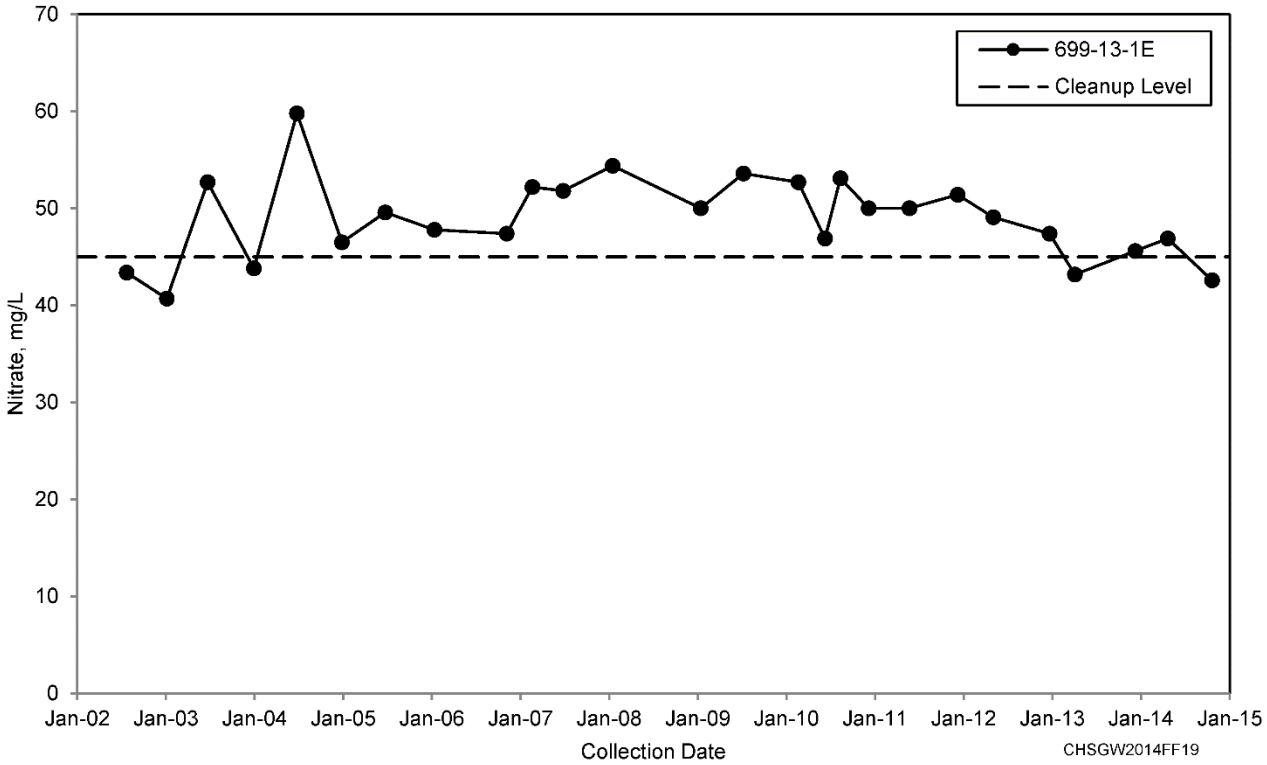


Figure 7-20. Nitrate Data for Well 699-13-1E

7.5.2 300 Area Industrial Complex

The nitrate concentrations exceeding the DWS in the southern portion of the 300 Area Industrial Complex reflect the migration of nitrate contaminated groundwater into the 300 Area Industrial Complex from sources to the southwest. For example, the maximum nitrate concentration near the southwestern corner of the 300 Area Industrial Complex (at Well 699-S28-E12 in the 1100-EM interest area) was 193 mg/L in April 2013, and the concentration at Well 699-S27-E14, approximately 616 m (2,021 ft) to the northeast, was 95.6 mg/L in April 2013. Nitrate also migrates into the 300 Area Industrial Complex from the northwest as part of the sitewide plume that originates in the 200 East Area, with concentrations typically ranging from 25 to 30 mg/L.

Seep number "300 Area Spr DR 42-2", on the river shore downgradient from the 316-1 South Process Pond, was sampled on September 3, 2013. The nitrate result was 21.9 mg/L. The nitrate concentration in upgradient Well 399-2-2 was 24.4 mg/L in January 2014.

Seep number "300 Area Spring 42-2", on the river shore downgradient from the 316-5 Process Trenches and 316-2 North Process Pond, was sampled on September 4, 2013 and had a nitrate concentration of 15.3 µg/L. The nitrate concentrations in nearby Aquifer Tube AT-3-1-M and in upgradient Well 399-1-10A were 14 and 25.5 mg/L, respectively, in January 2014.

7.6 Trichloroethene and *cis*-1,2-Dichloroethene

Two volatile organic compounds (VOCs), TCE and DCE, are found in localized areas in groundwater beneath the 300 Area Industrial Complex at concentrations exceeding their cleanup levels. DCE is a degradation product of TCE and tetrachloroethene (PCE). The original compounds degrade by dechlorination under conditions that include very low oxygen and the presence of certain types of microbes (Section 1.2 of PNNL-17666).

TCE and PCE were widely used in the 300 Area Industrial Complex in degreasing operations associated with the fuels fabrication process (Section 3.3.4 of BHI-00012, *300-FF-2 Operable Unit Technical Baseline Report*; Section 2.0 of EMO-1026; Section 1.0 of WHC-MR-0388). TCE was the primary degreaser used until the 1970s, followed by PCE in the 1970s and 1980s. TCE and PCE were discharged to the South Process Pond (316-1) and North Process Pond (316-2). PCE was evaluated in the RI/FS and was not found to be a COC in the 300 Area.

TCE concentrations exceeded the cleanup level (4 µg/L) in 2014 in one 300-FF well, 399-1-7 (5.8 µg/L).

During drilling in 2006, TCE (maximum concentration of 630 µg/L) was encountered in groundwater associated with an interval of relatively finer grained sediment within Ringold Formation unit E (Section 2.1 of PNNL-17666). Because this finer grained interval has a very low permeability and does not readily yield groundwater, monitoring wells have not been screened in this interval. This interval is incised by the river channel. Contamination slowly migrates within these sediments and into overlying or adjacent permeable Hanford formation sediment, as evidenced by periodic detections of TCE in aquifer tube samples that are collected from screens positioned near this contact (Section 4.8.4.4 of DOE/RL-2010-99).

TCE was detected in 2014 at concentrations exceeding the cleanup level at two aquifer tubes that are screened proximal to, or within, the finer grained interval of Ringold Formation sediment that is contaminated by TCE (Figure 7-21). Consistent with results from previous years, the highest concentrations (430 µg/L in December 2013 and 370 µg/L in January 2015) were observed at AT-3-3-D, which is the aquifer tube believed to be placed in the finer grained interval of Ringold Formation unit E sediment. Elevated concentrations are also consistently observed at AT-3-7-D, where the highest TCE

concentrations in January 2014 and January 2015 were 83 and 78.1 µg/L, respectively. The origin for the TCE in groundwater at this aquifer tube is not known, but is most likely associated with past disposal of TCE used in the manufacture of nuclear fuel.

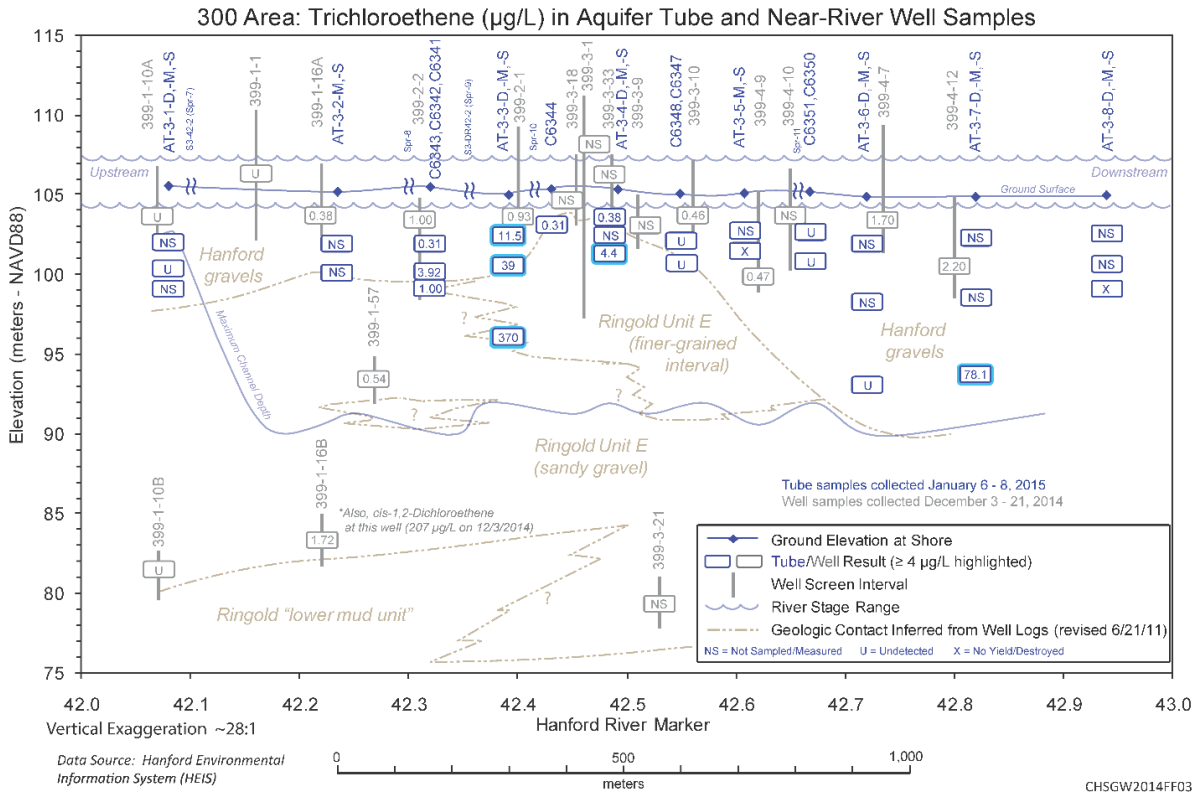


Figure 7-21. TCE in Aquifer Tube and Near-River Well Samples

Seep number "300 Area Spr DR 42-2," on the river shore downgradient from the 316-1 South Process Pond, was sampled on September 25, 2014, and had no detectable TCE. The TCE concentration in nearby Aquifer Tube C6341 was estimated at 0.31 µg/L in a sample collected on January 6, 2015. The TCE concentrations in upgradient Well 399-2-2 was 1.0 µg/L in December 2014.

Seep number "300 Area Spring 42-2," on the river shore downgradient from the 316-5 Process Trenches and 316-2 North Process Pond, was sampled on September 23, 2014, and had no detectable TCE. The TCE concentrations in nearby Aquifer Tube AT-3-1-M and in upgradient Well 399-1-10A were less than 0.3 µg/L in January 2015 and December 2014, respectively.

In the lower portion of the unconfined aquifer, DCE concentrations continue to exceed the cleanup level (16 µg/L) at one well (399-1-16B). The maximum concentration in 2014 was 207 µg/L (Figure 7-22). Well 399-1-16B is downgradient from the 300 Area Process Trenches (316-5) and North Process Pond (316-2). It is screened in Ringold Formation gravelly sediment. The elevation of the well's screen is approximately 7 m (23 ft) deeper than the elevation of the Columbia River's maximum channel depth (Section 4.4.4.5 of DOE/RL-2010-99). The origin for DCE is likely degradation of TCE and/or PCE disposed to the former North Process Pond (316-2) and/or 300 Area Process Trenches (316-5) (Sections 3.1 and 3.3 of PNNL-17666; Section 4.4.4.5 of DOE/RL-2010-99). The DCE concentration (62 µg/L) also exceeded the cleanup level in 2014 in a sample from Well 399-1-57, which is located 80 m (262.5 ft) to the southeast of 399-1-16B, and screened at mid-depth in the unconfined

aquifer in the Ringold Formation unit E sandy gravel; the lowest extent of the screen just enters the top of the finer grained interval within the Ringold unit E (p. 4-221 of DOE/RL-2010-99).

DCE concentrations did not exceed the cleanup level in 2014 in any 300-FF aquifer tubes. The maximum concentration (12.1 µg/L) was observed at AT-3-3-D in January 2015.

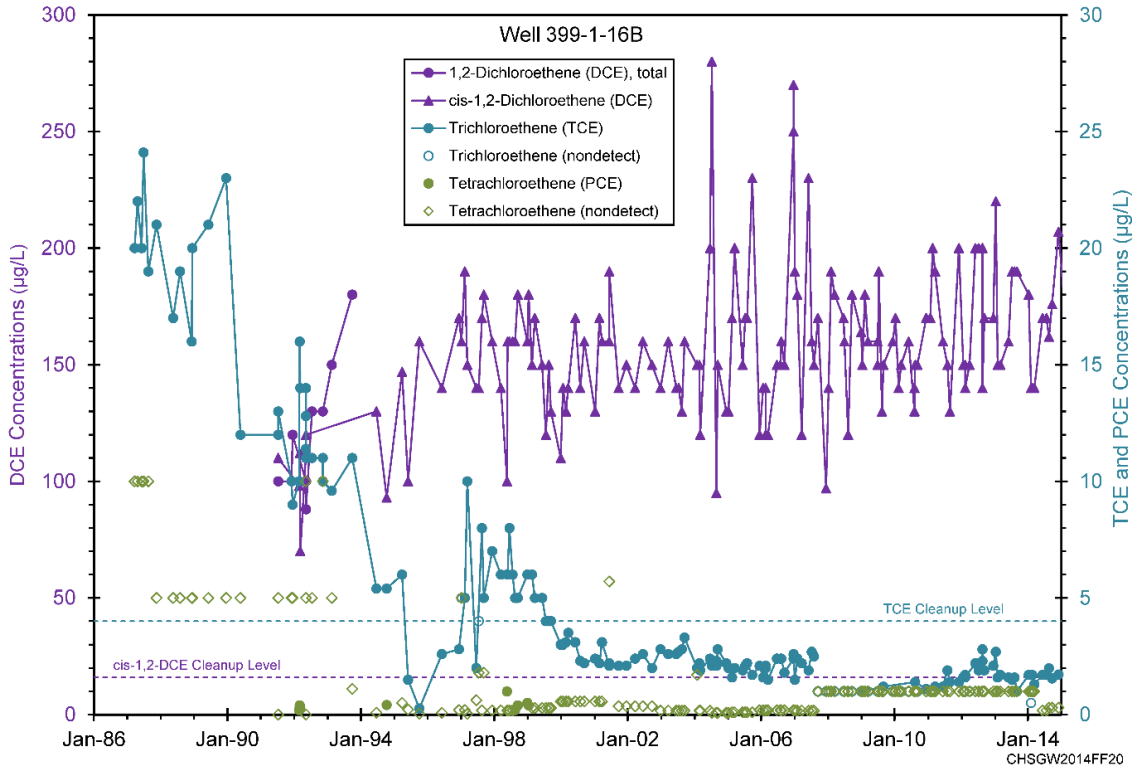


Figure 7-22. 300-FF DCE, TCE, and PCE Data for Well 399-1-16B

7.7 RCRA – 316-5 Process Trenches

One unit in the 300-FF interest area, the former 300 Area Process Trenches (316-5), is monitored per the Hanford Facility RCRA Permit WA7890008967. The 316-5 Process Trenches received effluent discharges of mixed waste from fuel fabrication and nuclear research laboratories in the 300 Area Industrial Complex from 1975 through 1987, followed by continued discharge of cooling water with small quantities of nonhazardous maintenance and process waste until December 1994. A comprehensive description of the facility and its history of operations is provided in Section 2.1 of PNNL-13645.

The trenches were remediated in 1991 under a CERCLA expedited response action by scraping contaminated soil to the north end of the facility (DOE/RL-92-32). Additional removal actions were performed in 1997 and 1998, followed by backfilling and surface restoration in 2004 (Section 3.0 of DOE/RL-2004-74). The modified closure plan (DOE/RL-93-73), which is incorporated into the Hanford Facility RCRA Permit WA7890008967, states that groundwater remediation is deferred to 300-FF-5 under CERCLA. The RDR/RA WP for 300-FF groundwater will describe the work elements and schedule for implementing the remedy selected in the 2013 CERCLA ROD (Section 7.2). The treatment area for uranium sequestration will be in the vicinity of the former 300 Area Process Trenches.

Groundwater monitoring to meet RCRA requirements is conducted in accordance with WHC-SD-EN-AP-185. The constituents monitored under this plan include chemical uranium, TCE,

and DCE. Uranium as a metal was included in the monitoring plan as an indicator and was incorporated by reference in the Hanford Facility RCRA Permit WA7890008967. The Permit concentration limits for TCE, and DCE are 5 µg/L and 70 µg/L, respectively; the DWS for uranium is 30 µg/L. Table B-39 in Appendix B summarizes data from 2014.

RCRA post-closure groundwater monitoring under the corrective action program of WAC 173-303-645 uses wells at four locations: one upgradient (northwest) and three downgradient (east, southeast, and south) of the former 300 Area Process Trenches (Figure 7-23). The most distant downgradient location is approximately 200 m (660 ft) to the southeast, along the dominant groundwater flow path from the trenches. Groundwater flows generally toward the south southeast beneath the former trenches. In March 2014, the gradient sloped to the south and the estimated groundwater flow rate was 17 m/d (56 ft/d) (Table B-1, Appendix B).

Two wells are at each of the four locations (Figure 7-23). The well with the well number ending in "A" is screened near the water table, and the well with the well number ending in "B" is screened in the lower portion of the unconfined aquifer (Table B-38, Appendix B). The sampling schedule for the eight wells is designed to accommodate two semiannual sampling events, with four time-independent samples collected during each period to provide data amenable to statistical analysis. As a result, the wells are sampled during 8 months of the year: the first sampling event covers December, January, February, and March; and the second sampling event covers June, July, August, and September. During 2014, sampling was performed as planned (Table B-37, Appendix B). Reports on the effectiveness of the corrective action monitoring program were prepared semiannually in accordance with WAC 173-303-645. The results for 2014 are provided in SGW-58475 and SGW-58600.Analytical results for TCE were all below the detection limit during 2014, with the exceptions of (1) eight samples from Well 399-1-16B, where the maximum concentration was estimated to be 1.99 µg/L; (2) three samples from Well 399-1-16A, where the maximum concentration was estimated to be 0.42 µg/L; and (3) two samples from Well 399-1-17A, where the maximum concentration was estimated to be 0.41 µg/L. Analytical results for DCE were all below the detection limit during 2014, with the exception of (1) all nine samples from Well 399-1-16B, where concentrations ranged from 140 to 207 µg/L (see Section 7.6); (2) three samples from Well 399-1-16A, where the maximum concentration was estimated to be 0.25 µg/L; and (3) eight samples from Well 399-1-17B, where the maximum concentration was estimated to be 4.45 µg/L.

Uranium was detected at six of the monitoring wells in 2014. In the three downgradient wells screened in the upper portion of the unconfined aquifer, maximum concentrations ranged from 28.3 to 82.1 µg/L (see Section 7.3). Concentrations at Wells 399-1-10A and 399-1-16A, which are near the Columbia River, declined in early summer when the river stage was high and increased in autumn with the arrival of uranium that had been remobilized upgradient. Concentrations at upgradient Well 399-1-18A are consistent with background levels for saturated Hanford formation sediment and ranged from 5.5 to 6.30 µg/L during 2014. Concentrations in the lower portion of the unconfined aquifer were typically below detection levels, with the exception of Well 399-1-16B, where the maximum concentration was 10.4 µg/L. Uranium is reported as total uranium in an unfiltered sample.

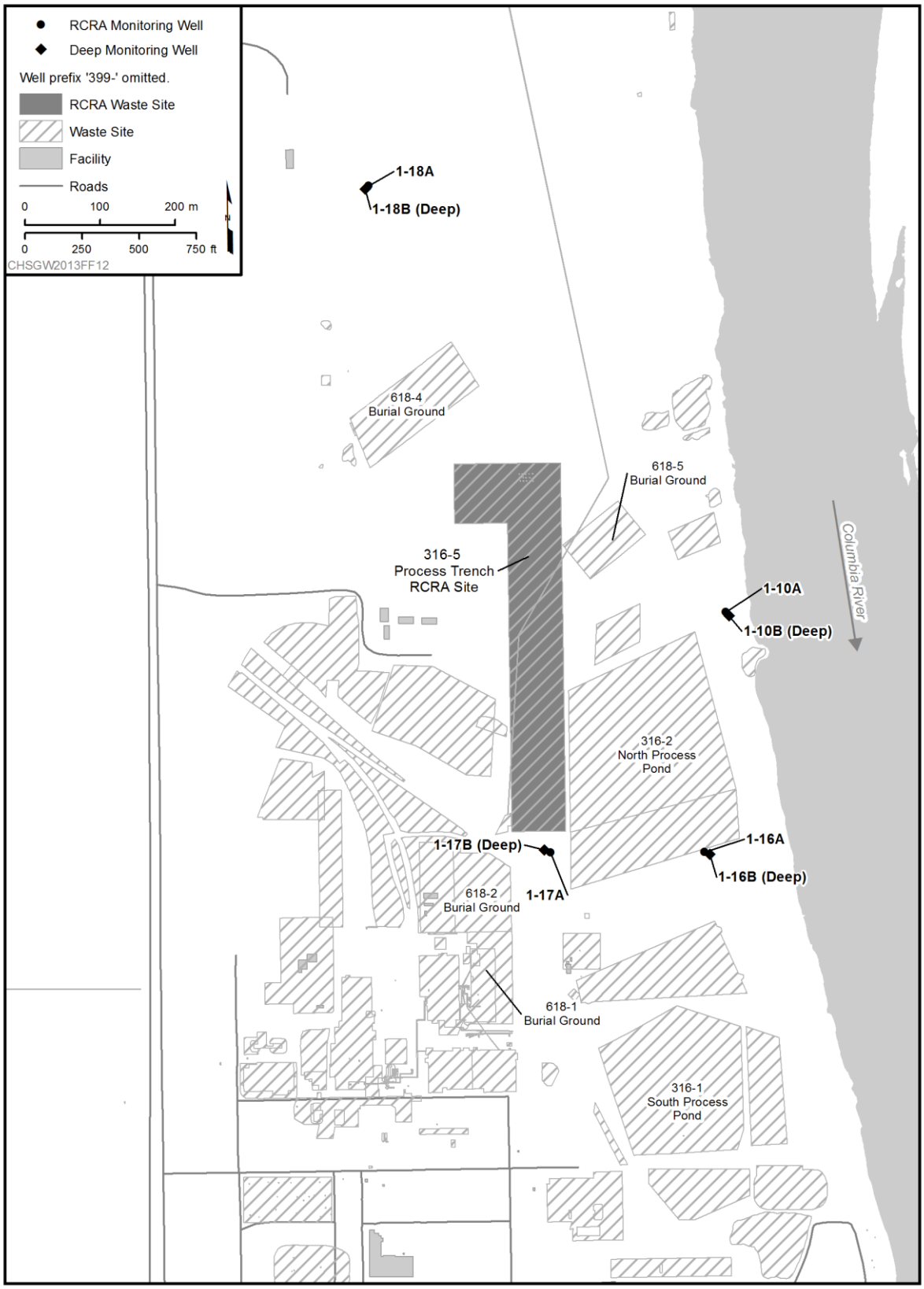


Figure 7-23. 316-5 Process Trenches

This page intentionally left blank.

8 1100-EM

8.1 Overview

This chapter describes groundwater monitoring in the 1100-EM groundwater interest area and the Richland North Area (Figure 8-1). Within this region, the former 1100-EM-1 OU includes the inactive DOE Horn Rapids Landfill, which was used from the late 1940s to the 1970s for disposal of office and construction waste, asbestos, sewage sludge, fly ash, and reportedly numerous drums of unidentified organic liquids (DOE/RL-90-18). Following cleanup of 1100-EM-1 and related source OUs, DOE transferred ownership of a portion of the property to the Port of Benton. Some key facts about 1100-EM are provided in Table 8-1. Groundwater monitoring is described in DOE/RL-2012-59, *Surveillance Groundwater Monitoring on the Hanford Site*. Section 1.3 provides details about plume mapping, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

The Richland North Area includes the City of Richland North Well Field and Recharge Ponds. The City of Richland pumps water from the Columbia River into the recharge ponds. The river water percolates to the groundwater, which is then pumped through surrounding wells for municipal use during peak demand periods (WHC-MR-0033). The Richland North Area also includes the AREVA NP, Inc. nuclear fuel production facility, which is southwest (upgradient) of the inactive DOE Horn Rapids Landfill.

Groundwater beneath 1100-EM and Richland North flows primarily west to east and discharges to the Columbia River (Figure 8-2). Groundwater flow from the west is diverted to the northeast and southeast around a recharge mound beneath Richland's recharge ponds. The unconfined aquifer is recharged by water from the Yakima River, by infiltration of agricultural irrigation, and by natural precipitation.

The thickness of the unconfined aquifer in this area is approximately 5.6 to 9 m (18 to 30 ft), with all but the upper few meters residing in the Ringold Formation unit E (Figure 8-3). A silt- and clay-dominated facies forms a local, laterally extensive upper aquitard up to 10 m (33 ft) thick.

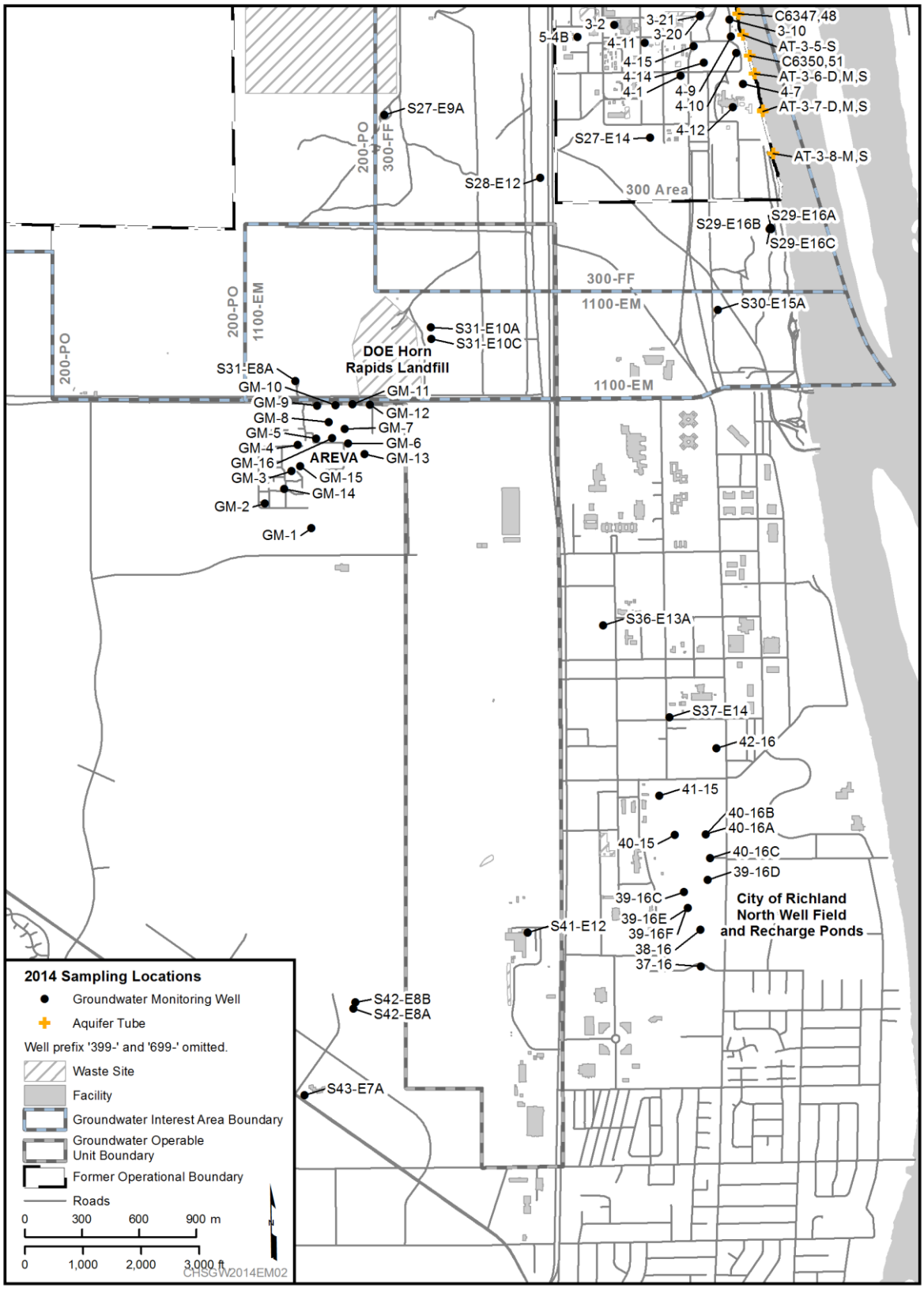


Figure 8-1. 1100-EM Sampling Locations, 2014

Table 8-1. 100-EM at a Glance

Operations included industrial and automotive activities (1954–1985), and a landfill (1950s–1970)			
2014 Groundwater Monitoring			
Contaminant	**Water Quality Criteria**	**Maximum Concentration**	**Plume Area[a] (km^2)**
Trichloroethene	5 µg/L[b]	0.71 µg/L (699-S31-E10A)	0
Nitrate	45 mg/L[c]	205 mg/L (699-S31-E10C)	Not calculated[d]
Uranium	30 µg/L[e]	28.4 µg/L (699-S31-E10A)	Not calculated[d]
Remediation			
Waste sites (final action): 100 percent complete[f] Groundwater (final action): MNA Final ROD: 1993			

a. Estimated area at a concentration greater than the DWS.

b. Cleanup level in ROD.

c. 45 mg/L as NO_3 is equivalent to the DWS of 10 mg/L as N.

d. Nitrate and uranium in 1100-EM are from offsite sources.

e. Drinking water standard

f. Sites with status of closed, interim closed, no action, not accepted, or rejected.

COCs = contaminants of concern

DWS = drinking water standard

MNA = monitored natural attenuation

ROD = Record of Decision

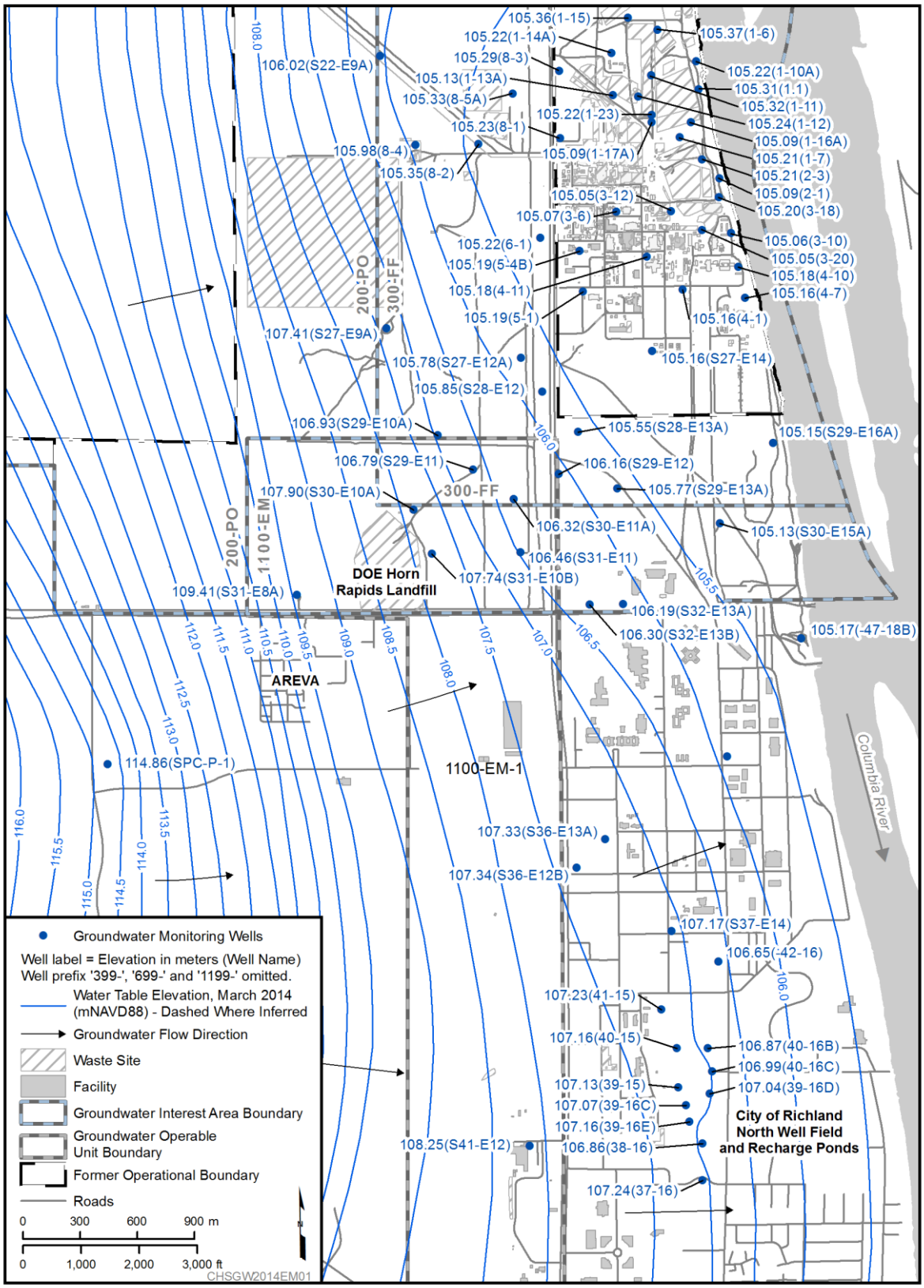


Figure 8-2. 1100-EM Water Table, 2014

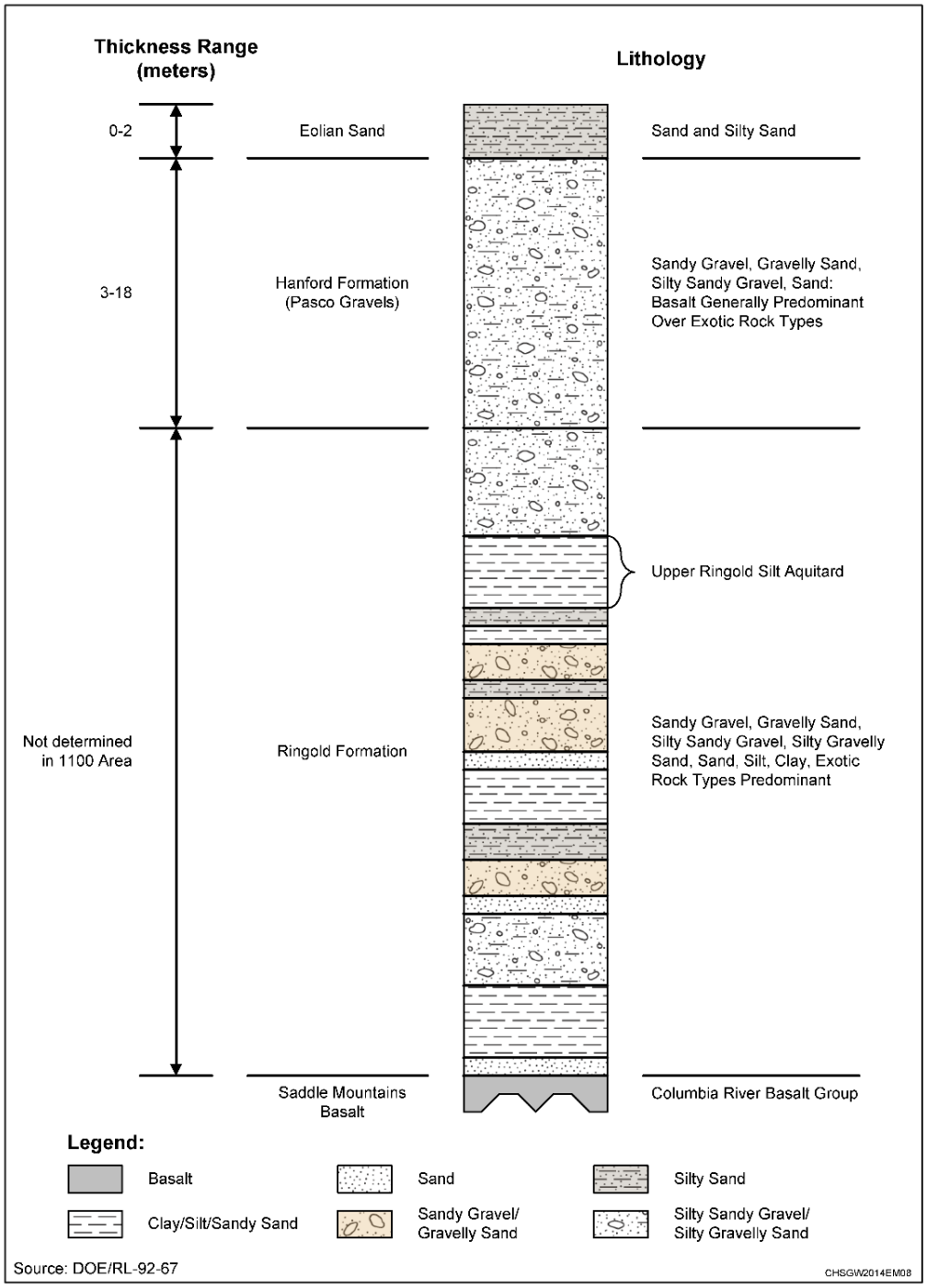


Figure 8-3. 1100-EM Lithology

8.2 CERCLA Activities

In 1993, EPA, Ecology, and DOE signed a ROD for the 1100 Area, which included the 1100-EM-1 Groundwater OU and two source OUs (1100-EM-2 and 1100-EM-3) (EPA/ROD/R10-93/063). The ROD had a groundwater component that relied on MNA for TCE, with a cleanup level of 5 µg/L.

In 2006, the second CERCLA 5-year review (DOE/RL-2006-20) concluded that remedies selected for the 1100-EM-1 OU had been completed. The RAOs established in the ROD had been achieved and are protective of human health and the environment. As a result, the 1100 Area was removed from the National Priorities List and DOE, EPA, and Ecology agreed to a change (reduction) in groundwater monitoring. Groundwater monitoring, described in TPA-CN-163, included the following to provide assurance that the remedial action goals had been achieved:

- Wells 699-S28-E12, 699-S31-E10A, and 699-S31-E10C
- Annual sampling for TCE, vinyl chloride, and 1,1-dichloroethene

Note that TPA-CN-163 also states that monitoring of nitrate and uranium near the DOE Horn Rapids Landfill would continue under the environmental monitoring activities performed to meet the AEA objectives, and monitoring associated with the 300-FF-5 OU will continue to evaluate TCE concentrations northeast of 1100-EM-1 near the river. Currently, monitoring of nitrate and uranium near the landfill, as well as tritium near the City of Richland's water supply wells, is described in DOE/RL-2012-59.

The third 5-year review (DOE/RL-2011-56) stated that the remedy remains protective of human health and the environment.

All three monitoring wells were sampled in January 2014 for the previous year, as discussed in last year's annual report. Two of the monitoring wells (699-S28-E12 and 699-S31-E10A) in the 1100-EM-1 network were sampled as scheduled in December 2014 (Table A-12 of Appendix A). The other well (699-S31-E10C) was delayed until February 2015 because of a broken pump.

8.3 Trichloroethene

Historically, TCE-contaminated groundwater was found upgradient and downgradient of the inactive DOE Horn Rapids Landfill. A review of available information indicated that TCE contamination moved into the Hanford Site's 1100 Area via groundwater. AREVA, a facility adjacent to the landfill, has investigated soil and groundwater contamination as an independent action in accordance with WAC 173-340, "Model Toxics Control Act—Cleanup." The past use of organic solvents at the AREVA lagoon area was the only documented record of TCE occurrence or use near the contaminant plume identified during the 1100-EM-1 RI/FS (DOE/RL-92-67). TCE was used to bond overlapping liner sections together during the installation, repair, and cleaning of lagoon liners at various times from 1978 through 1988. While the DOE Horn Rapids Landfill is thought to have received drummed waste solvents (DOE/RL-90-18), no evidence of a TCE source was revealed by soil vapor surveys, geophysical investigations, and trenching activities during the RI/FS (DOE/RL-92-67).

TCE concentrations in the three 1100-EM-1 CERCLA network wells continued to be near or below detection limits, with a maximum of 0.81 µg/L in December 2014. Concentrations have declined since the 1990s (Figure 8-4). Potential breakdown products of TCE (1,1-dichloroethene and vinyl chloride) remained below detection limits.

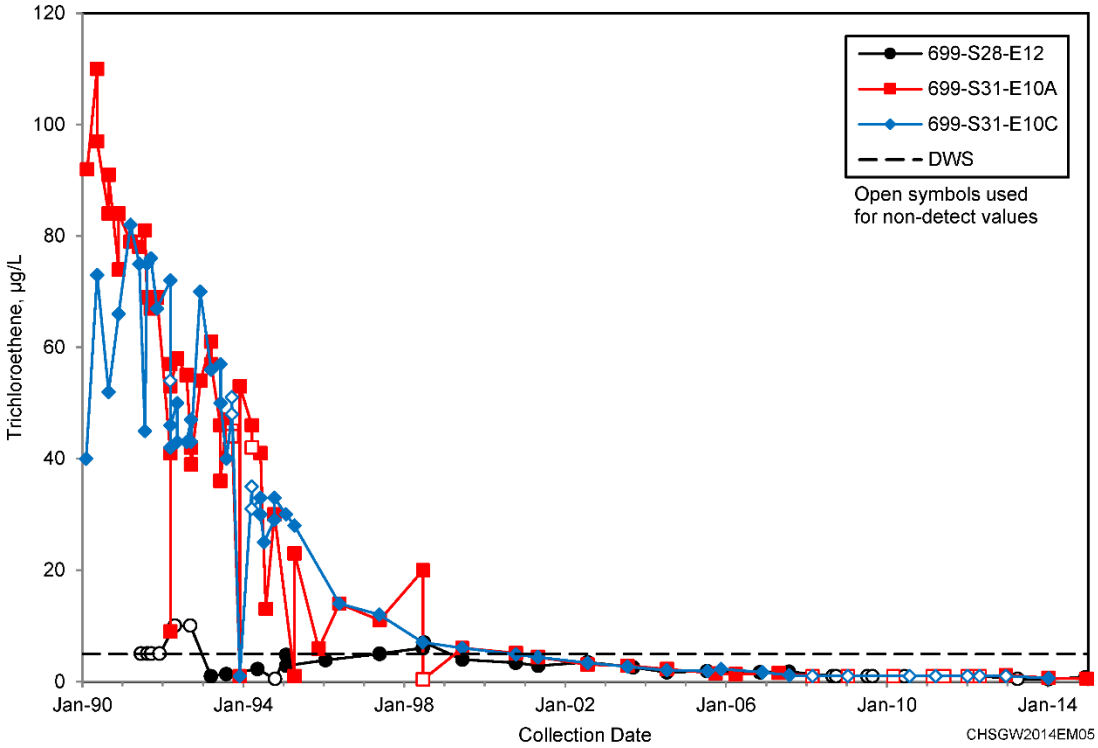


Figure 8-4. TCE Data in 1100-EM-1 Compliance Wells

The City of Richland monitors groundwater quarterly for chemical constituents in the upper portion of the unconfined aquifer at the Horn Rapids Sanitary Landfill (formerly the Richland Landfill), approximately 1 km (0.62 mi) south of the Hanford Site boundary. Maximum concentrations of the following chlorinated hydrocarbons exceeded the DWS in some of the city's monitoring wells in 2013, according to the most recent annual report (City of Richland, 2014, *Horn Rapids Landfill Environmental Monitoring Report Calendar Year 2013*).

- PCE: maximum 46 µg/L
- TCE: maximum 23 µg/L
- Vinyl chloride: maximum 8.3 µg/L

8.4 Tritium

The Hanford Site tritium plume that originated in the 200 Areas extends southeast through the 600 Area and into the 300 Area at levels below the 20,000 pCi/L DWS. The leading edge of the sitewide tritium plume, at concentrations far below the DWS, is monitored annually because of its proximity to the City of Richland's North Well Field (Figure 8-5). A representative background level of tritium in Hanford Site groundwater is 142 pCi/L (95th percentile) (DOE/RL-96-61). The maximum tritium concentration in 2014 was 125 pCi/L in Well 699-S41-E12.

Elevated tritium concentrations are found to the north of 1100-EM in the 300-FF groundwater interest area. Because groundwater flow in the 1100-EM and 300-FF groundwater interest areas is generally west to east, the tritium plume found to the north of 300 Area does not migrate southward toward 1100-EM.

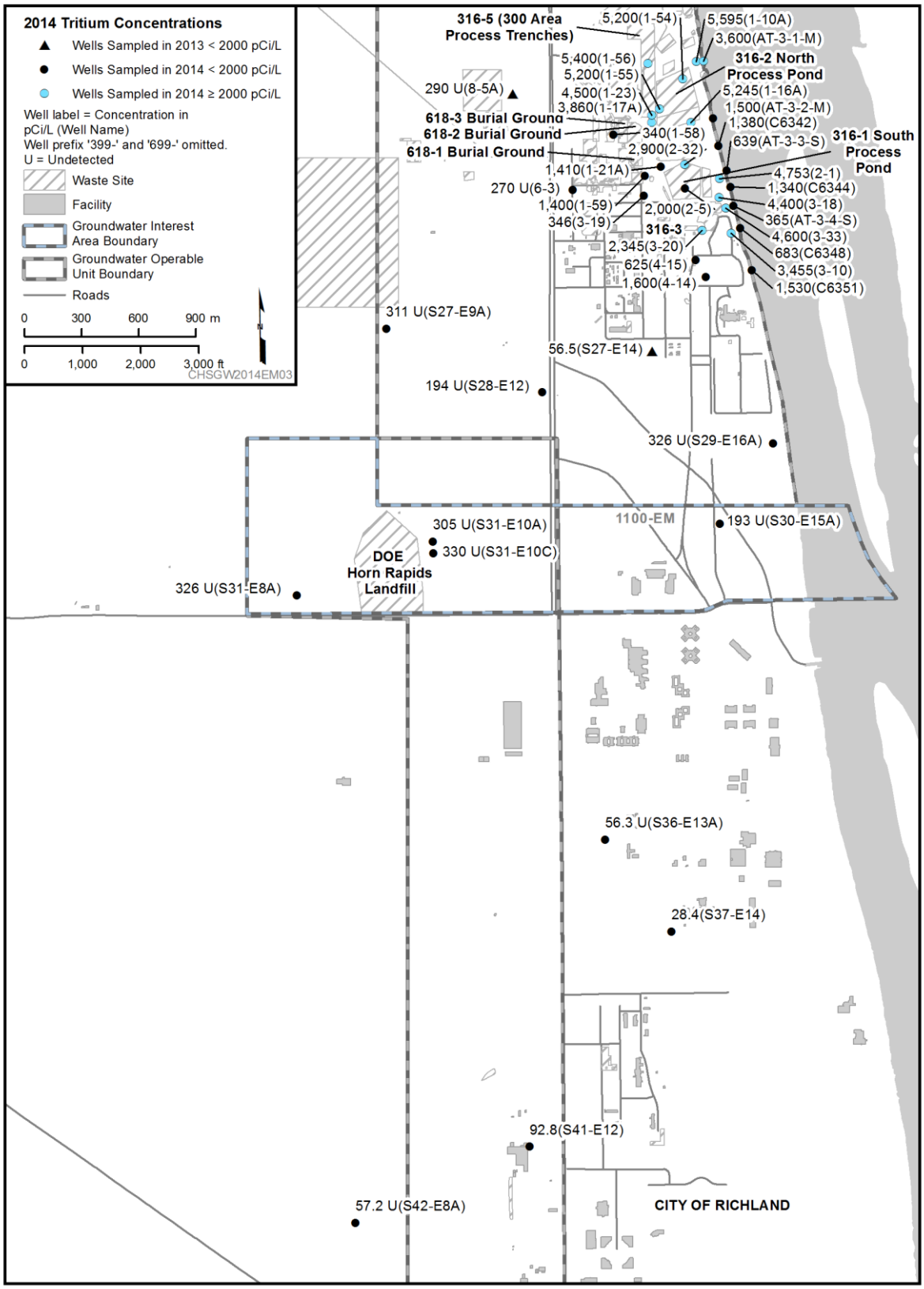


Figure 8-5. Tritium Concentrations in 1100-EM, Richland North, and the 300 Area, 2014

8.5 Nitrate

Nitrate concentrations are above 45 mg/L throughout much of 1100-EM and Richland North (Figure 8-6). Distribution, trends, the direction of groundwater flow, and location of offsite sources indicate that nitrate contamination in this area has likely resulted from industrial and agricultural uses off the Hanford Site. Agricultural uses include fertilizer applications to the irrigated fields west of 1100-EM. The highest concentration in an 1100-EM well on the Hanford Site in 2014 was 205 mg/L in Well 699-S31-E10C. Concentrations have been declining since 2010 (Figure 8-7). The wells are located downgradient of AREVA and the inactive DOE Horn Rapids Landfill.

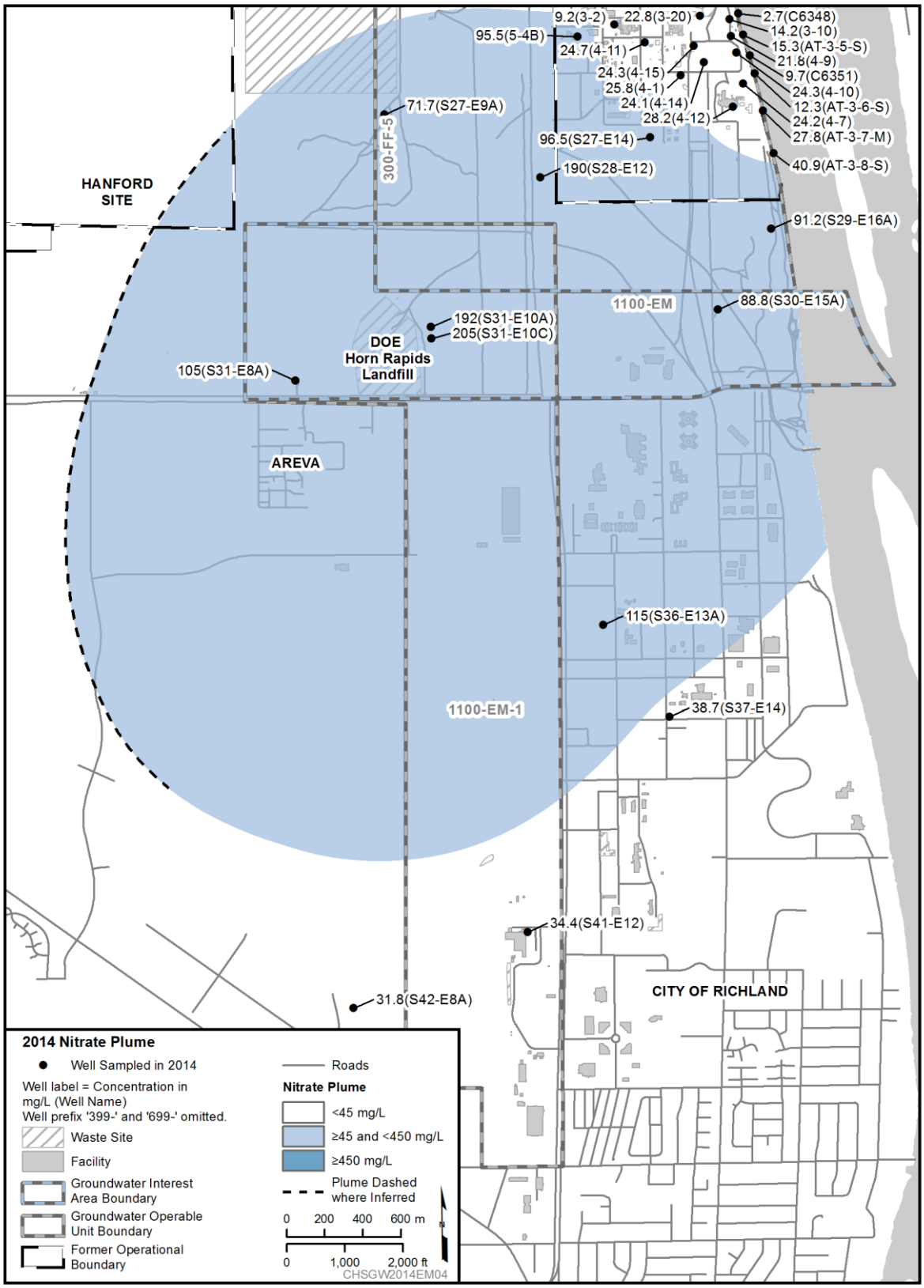


Figure 8-6. Nitrate Plume in 1100-EM, Richland North, and the 300 Area, 2014

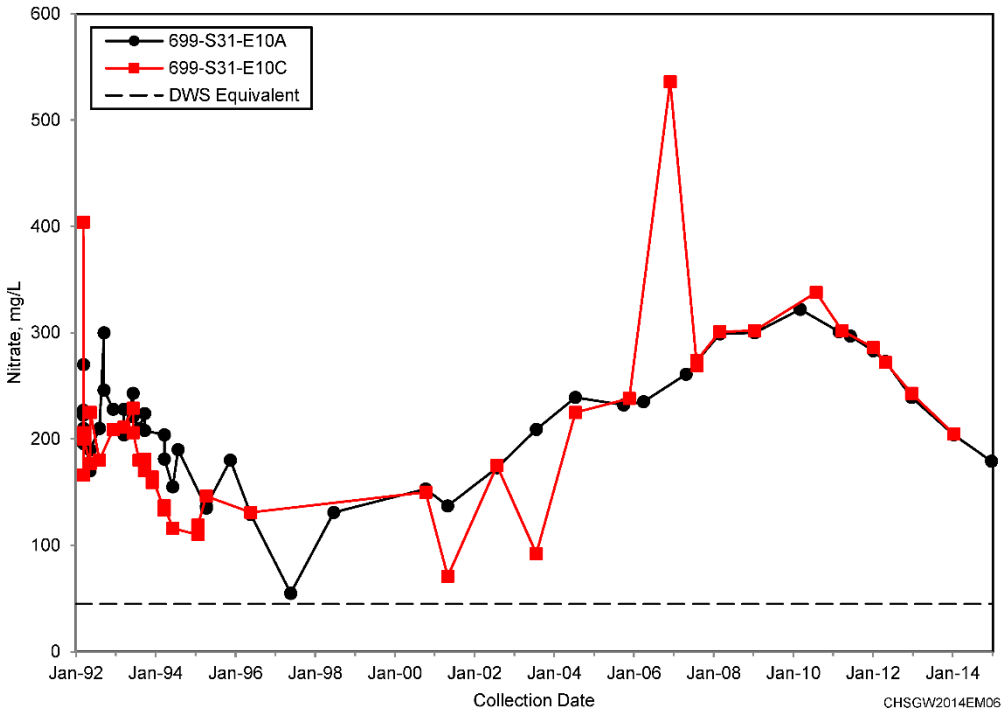


Figure 8-7. 1100-EM Nitrate Data for Wells 699-S31-E10A and 699-S31-E10C

8.6 Uranium

Elevated concentrations of uranium occur downgradient of the AREVA facility. The maximum uranium concentration in an AREVA well in 2013 was 36.5 µg/L (E06-09-006, 2013 *Annual Groundwater Report* AREVA, Richland, Washington).

Uranium concentrations in Hanford Site wells downgradient from AREVA were slightly below the DWS in 2014 (Figure 8-8).

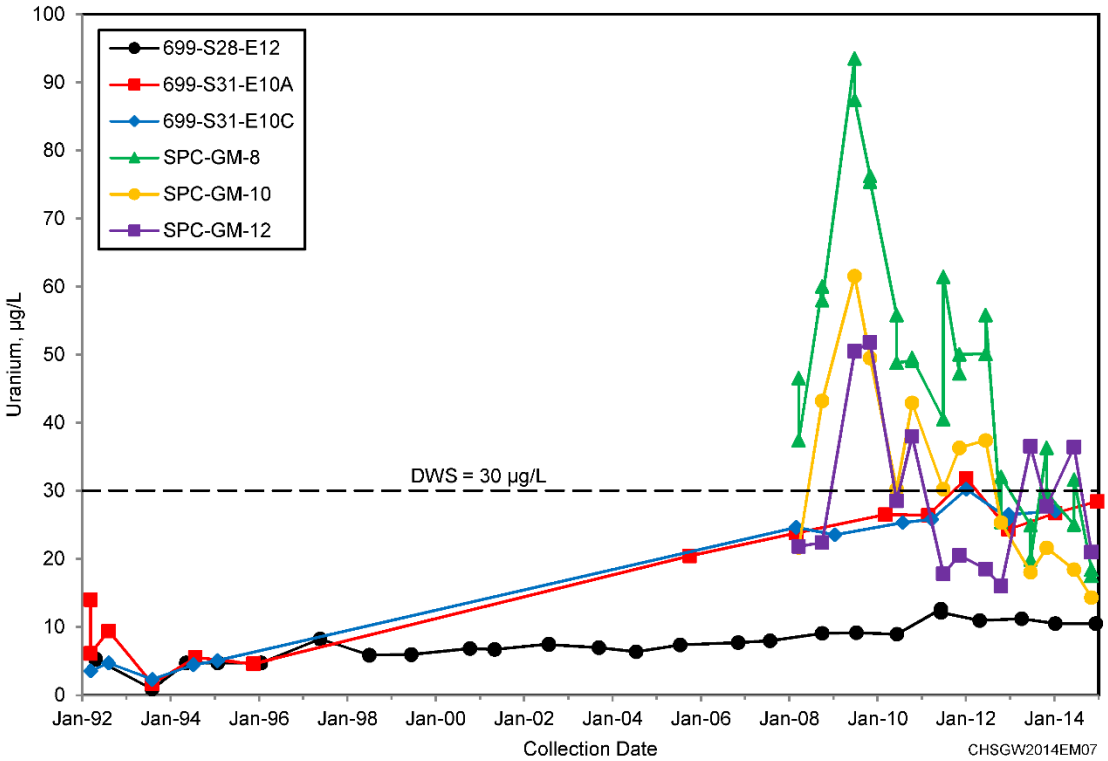


Figure 8-8. 1100-EM Uranium Data for Wells Downgradient of AREVA and Inactive Horn Rapids Landfill

9 200-BP

9.1 Overview

The 200-BP groundwater interest area includes groundwater and the associated contaminant plumes beneath the northern half of the 200 East Area and adjacent portions of the surrounding 600 Area (Figure 9-1). The 200-BP interest area, which includes the 200-BP-5 Groundwater OU and six RCRA sites, extends to the northwest to the Columbia River shoreline. The main process separation facilities overlying the OU were in 200 East Area, B Plant and Semiworks; however, liquid waste from the other process separation facilities at Hanford were also stored or released at sites overlying 200-BP. Waste sites that have affected or are currently affecting groundwater include various liquid waste disposal sites (cribs, ditches, and ponds), the 216-B-5 Injection Well, and leaking underground storage tanks (WMA B-BX-BY and WMA C).

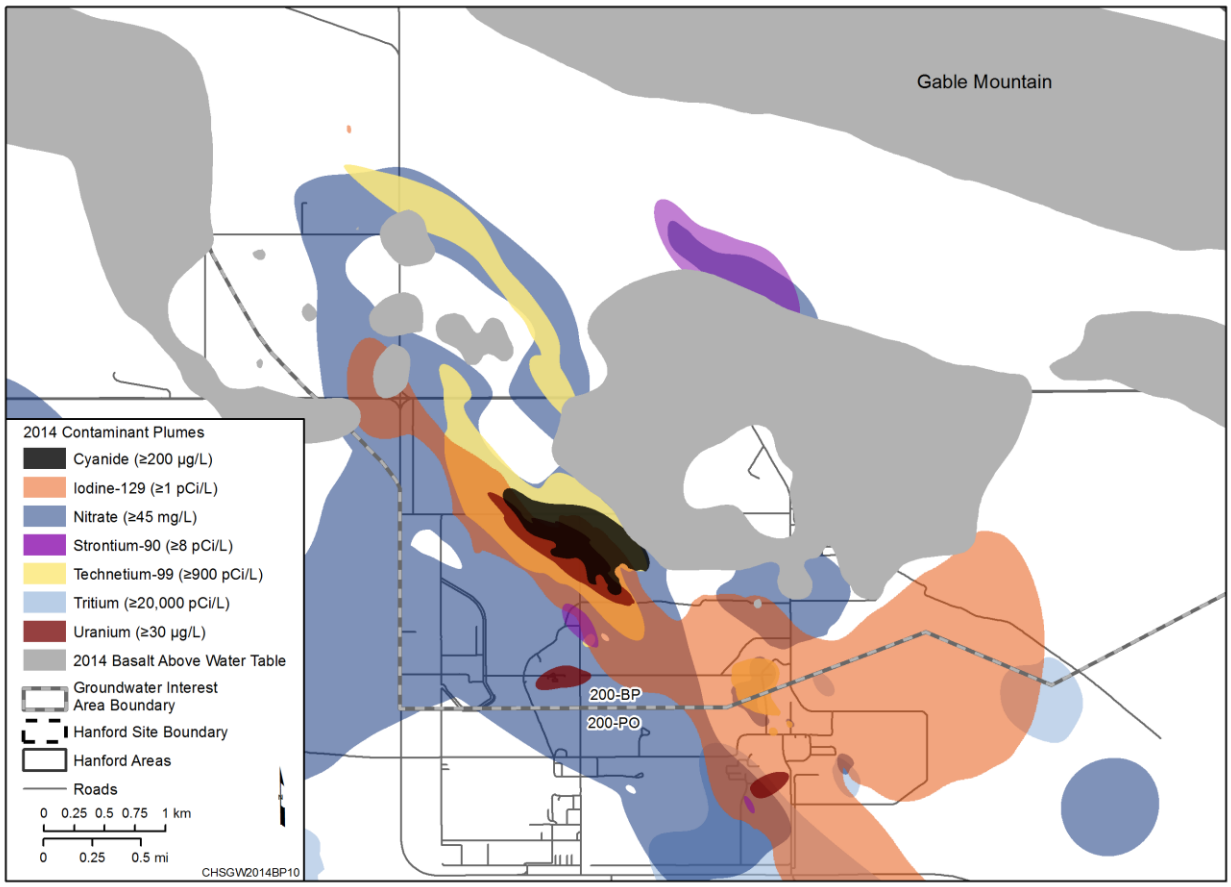


Figure 9-1. 200-BP-5 Groundwater Interest Area and Geometry of Groundwater Contaminant Plumes

Nitrate, iodine-129, technetium-99, and uranium are the most extensive groundwater plumes in 200-BP. These contaminants emanate mainly from local sources, except for iodine-129, which predominantly migrated into 200-BP from 200-PO in the late 1980s and early 1990s. Other contaminants with smaller areal extent within 200-BP include arsenic, cesium-137, cyanide, fluoride, plutonium-239/240, strontium-90, and tritium. Cesium-137, fluoride, and plutonium-239/240 are associated with a single monitoring well (299-E28-24), which is located next to the decommissioned 216-B-5 Injection Well. Arsenic, detected beneath the 216-B-8 Crib at Well 299-E33-16, is associated with acetic and

hydrochloric acid discharges to this site before it was retired in the early 1950s. Two other contaminants of interest, hexavalent chromium and cobalt-60, were below the DWS in 2014. Table 9-1 lists plume areas and other pertinent facts about 200-BP. Figure 9-2 shows changes in plume areas over time with 200-BP. Section 1.3 provides details about plume mapping, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Table 9-1. 200-BP at a Glance

B Plant operations: 1945 to 1952 (plutonium separation) 1967 to 1985 (strontium and cesium recovery)			
2014 Groundwater Monitoring			
Contaminant	**Drinking Water Standard**	**Maximum Concentration[a]**	**Plume Area[b] (km^2)**
Nitrate	45 mg/L	1,480 mg/L (299-E33-47)	8.7
Iodine-129	1 pCi/L	6.1 pCi/L (299-E27-13)	4.3
Technetium-99	900 pCi/L	42,000 pCi/L (299-E33-345)	2.1
Uranium	30 µg/L	4,030 µg/L (299-E33-345)	0.3
Strontium-90	8 pCi/L	1,100 pCi/L (299-E28-23)	0.6
Cyanide	200 µg/L	1,600 µg/L (299-E33-47)	0.4
Tritium	20,000 µg/L	37,000 pCi/L (699-42-40A)	0.1
Remediation			
B Complex perched aquifer (treatability test): • Being performed by the 200-DV-1 OU • Test successful; ~ 284,583 liters pumped in 2014 RI/FS being prepared.			

a. Maximum concentration within the regional unconfined aquifer (i.e., excludes the perched water beneath the B Complex) detected in 2014.

b. Estimated area above the drinking water standard.

COCs = contaminant of concern
OU = operable unit
P&T = pump and treat
RI/FS = remedial investigation/feasibility study

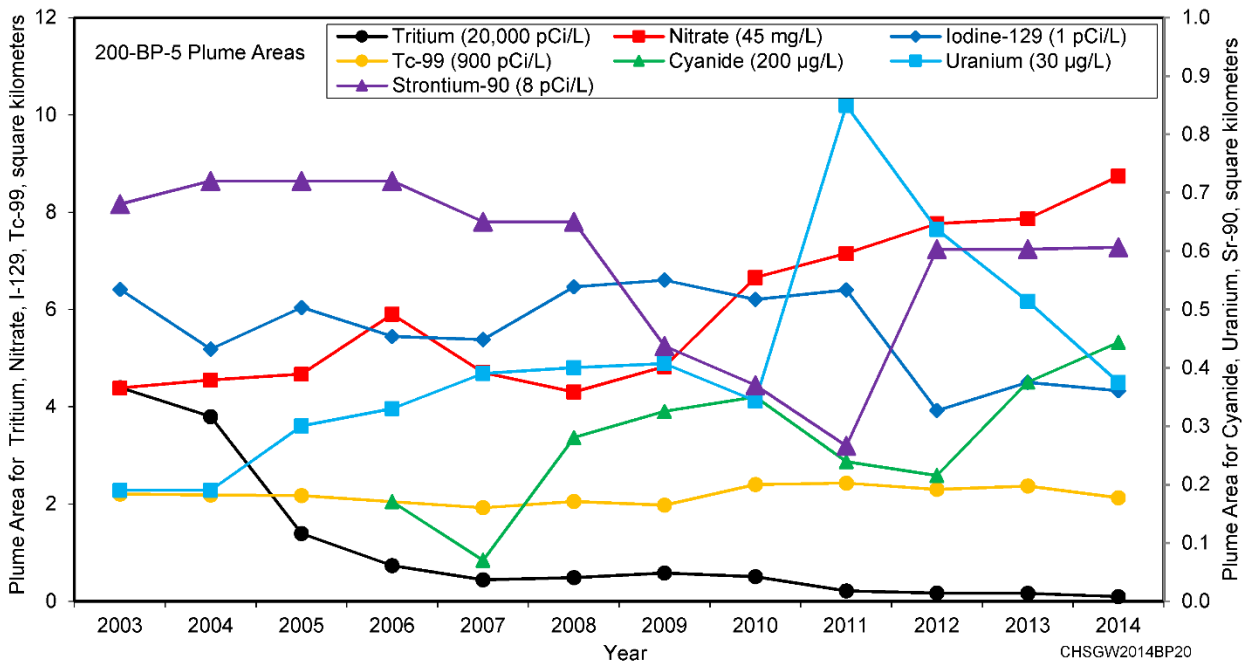


Figure 9-2. 200-BP-5 Plume Areas Over Time

The DOE conducts groundwater monitoring in 200-BP under the AEA, CERCLA, and RCRA requirements. AEA monitoring requirements are defined at the 218-E-10 and 218-E-12B Burial Grounds by DOE/RL-2000-72 and at WMA C by *Tri-Party Agreement Change Notice Form Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit*, TPA-CN-578. DOE performs CERCLA monitoring via DOE/RL-2001-49 to define the changing geometry of waste constituents in the groundwater. Finally, six RCRA sites (WMA B-BX-BY, WMA C, 216-B-63 Trench, LLWMA-1, LLWMA-2, and LERF) are monitored under different RCRA plans as discussed later in this chapter.

Groundwater conditions in 200-BP include unconfined, semiconfined, and confined. The unconfined aquifer within the 200 East Area boundary is the primary aquifer impacted by past waste disposal operations and is associated with the suprabasalt sediment of the Ringold Formation, Cold Creek unit, and Hanford formation (Figure 9-3). Depths from land surface to the water table in 200-BP range from less than 1 m (3 ft) near the Columbia River to 105 m (340 ft), with the greatest thickness occurring in the south portion of the OU (e.g., 200 East Area). The unconfined aquifer saturated thickness varies from less than 1 m (3 ft) north of the 200 East Area to more than 40 m (130 ft) in Gable Gap. Within and south of Gable Gap, the aquifer is mainly composed of unconsolidated to semiconsolidated gravels of the Hanford formation and Cold Creek lithostratigraphic facies. Because of erosion of the Elephant Mountain and Pomona basalt other minor unconfined saturated sediments within the Gable Gap include the Rattlesnake Ridge and Selah interbeds, as described in PNNL-19702. Within the northern portion of the 200 East Area, lower cohesive-fluvial-lacustrine units of the Wooded Island members of the Ringold Formation underlie or have been incised by the Hanford and Cold Creek sediments. The base of the aquifer south of Gable Gap is the Elephant Mountain Basalt. At some locations (Figure 9-1), the top of basalt is present above the water table. At these locations the basalt is inferred to impede contaminant migration because the hydraulic conductivity of the basalt is substantially lower than the unconsolidated aquifer.

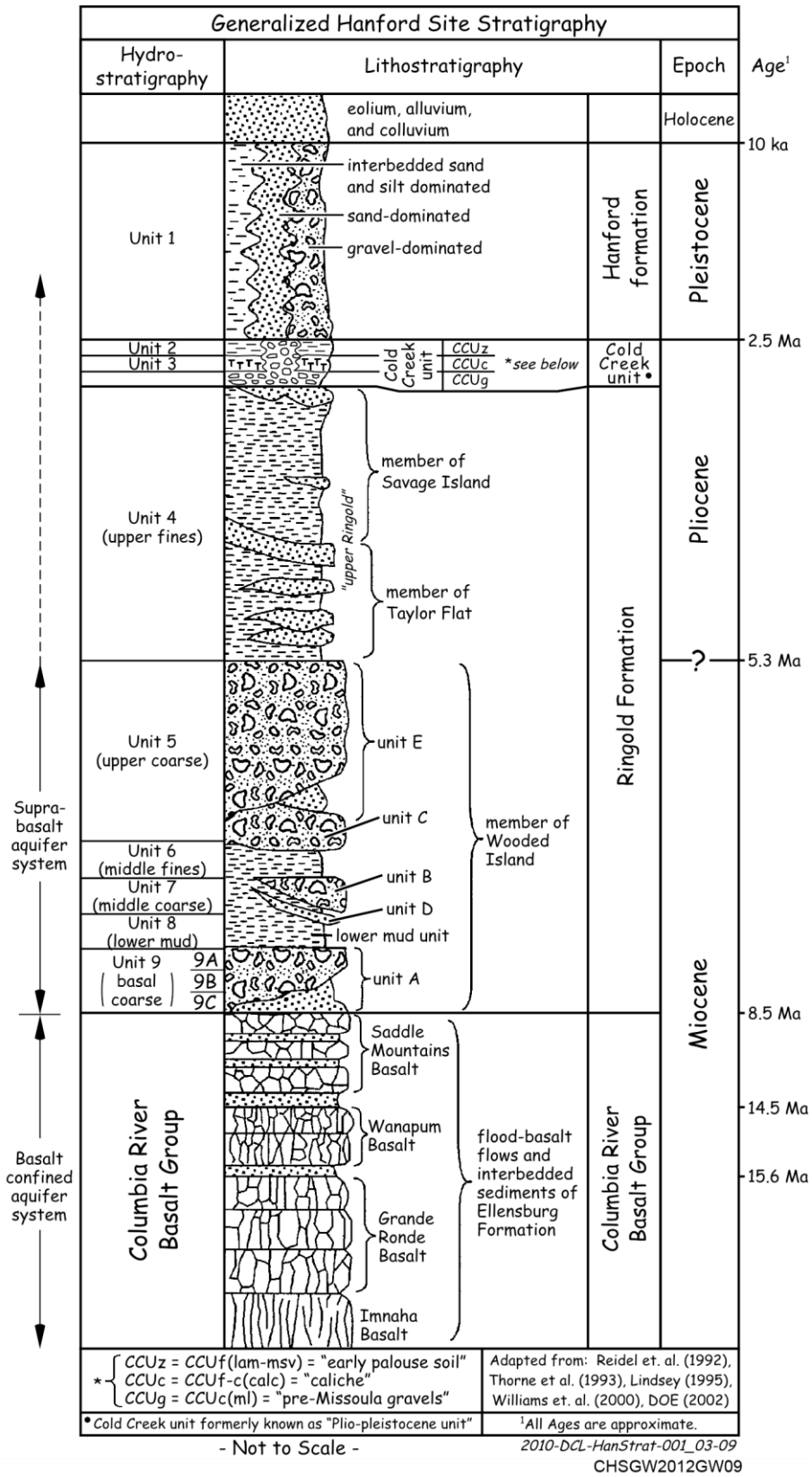
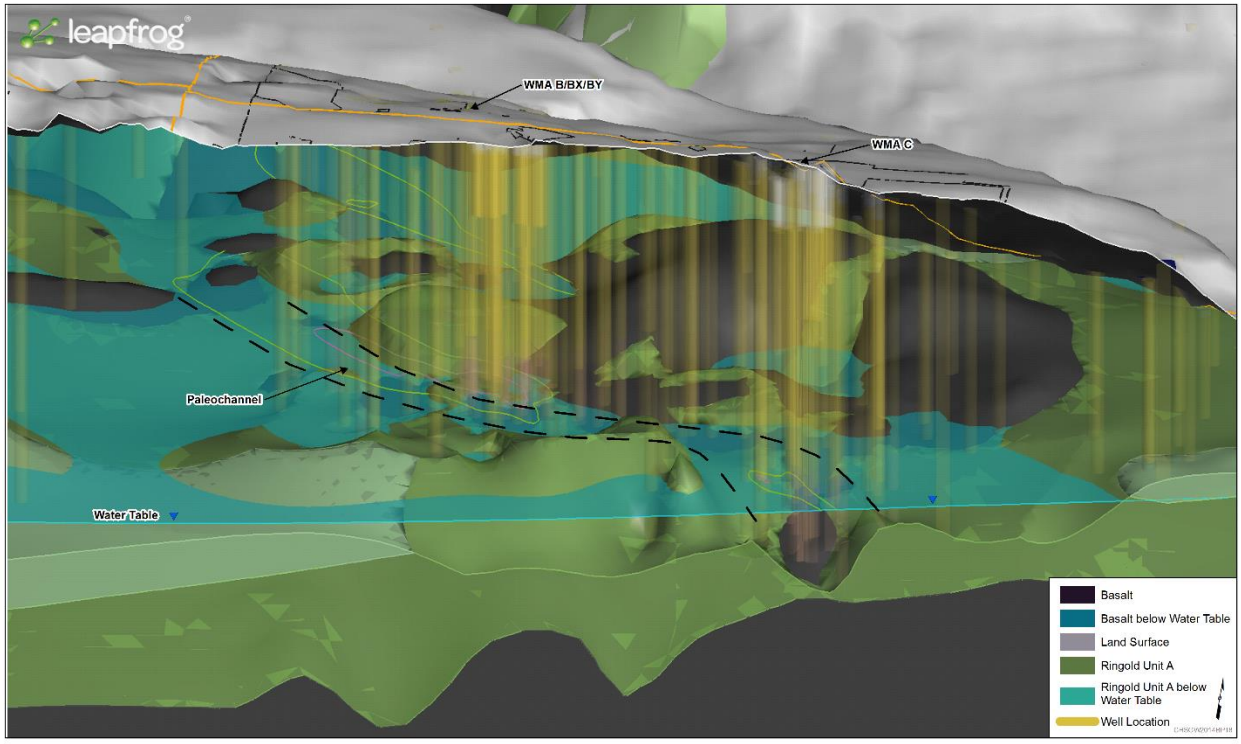


Figure 9-3. Hanford Site General Stratigraphy, Including Lithologic, and Hydrostratigraphic Nomenclature

The greatest levels of contamination for nitrate, technetium-99, and uranium in 200-BP are within the northwest portion of the 200 East Area, also referred to as the B Complex (e.g., WMA B-BX-BY and adjacent liquid waste sites). These plumes extend from the B Complex, both to the northwest and southeast within an ancestral Columbia River paleochannel that incised semiconsolidated gravels and cohesive fluvial-lacustrine Ringold deposits (Figure 9-4). Figure 9-4 provides the latest interpretation of the incising ancestral Columbia River/cataclysmic glacial flooding paleochannel entering the 200 East Area from the northwest. Figure 9-4 does not include the Cold Creek and Hanford sediments in order to depict the paleochannel. The channel was later filled with unconsolidated gravels and fluvial overbank/eolian sediments (PNNL-19702). A portion of the Cold Creek deposits and Ringold deposits were later incised by glacial fluvial cataclysmic flooding followed by Hanford sediment deposition (PNNL-19702).



Note: Plumes are depicted from 2011 annual report.

Figure 9-4. Three-Dimensional View of the Incising Ancestral Columbia River/Cataclysmic Glacial Flooding Paleochannel Entering the 200 East Area from the Northwest

Semiconfined aquifers are present in the Ringold Formation east and west of the higher permeability paleochannel. More specifically, the semiconfined aquifers in these areas are where hydrostratigraphic unit 9B overlies unit 9C. Contaminants in the semiconfined area along the west side of the 200 East Area are limited to nitrate, tritium, and uranium, thought to be associated with the 216-B-12 Crib. However, tritium near the bottom of the semiconfined aquifer may be associated with PUREX Cribs from 200-PO. Contaminants in the semiconfined area east of the 200 East Area are associated with the former B Pond and are limited to iodine-129 and tritium.

Within the Rattlesnake Ridge interbed, uppermost basalt confined aquifer, contamination exceeding the DWS is limited to technetium-99 at Well 299-E33-12 (beneath the B Complex area). The contamination was associated with one of the adjacent liquid waste cribs (BY Cribs), which released liquid scavenged waste to the soil column in the early 1950s. This contaminant waste had a high density, promoting downward migration into the confined aquifer before Well 299-E33-12 was properly sealed in 1979. The impact is limited to the immediate vicinity of this well; nearby wells that also monitor the basalt confined aquiferhave not shown contamination (see Appendix D).

Groundwater within the unconfined aquifer in the south part of 200-BP, south of Gable Mountain, flows to the south-southeast from the south part of the Gable Gap into the northwest quarter of the 200 East Area (Figure 9-5). Before 2011, groundwater flow was toward the north. The flow direction completed a 180-degree flow direction change in July 2011 because of ongoing water table declines in the 200 East Area and the temporal Columbia River stages. Groundwater from the west and east merge with the current south-southeast flow, as portrayed in the Hanford Site water table map (Figure 9-6) and more specifically with the 200 East groundwater flow map (Figure 9-7).

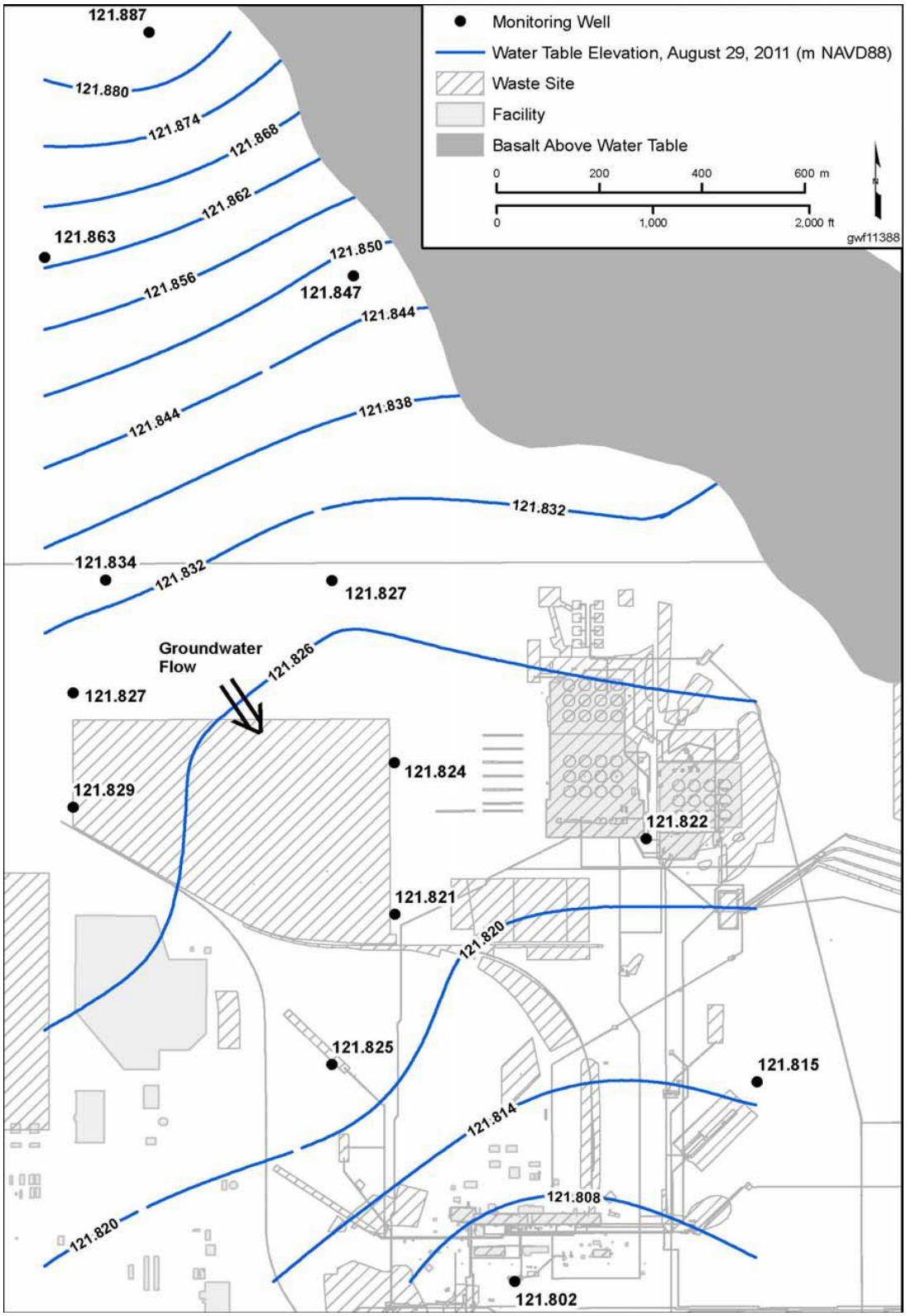


Figure 9-5. Interpreted Low-Gradient Water Table Depiction for the Northwest Corner of the 200 East Area after the Groundwater Flow Direction Change in 2011

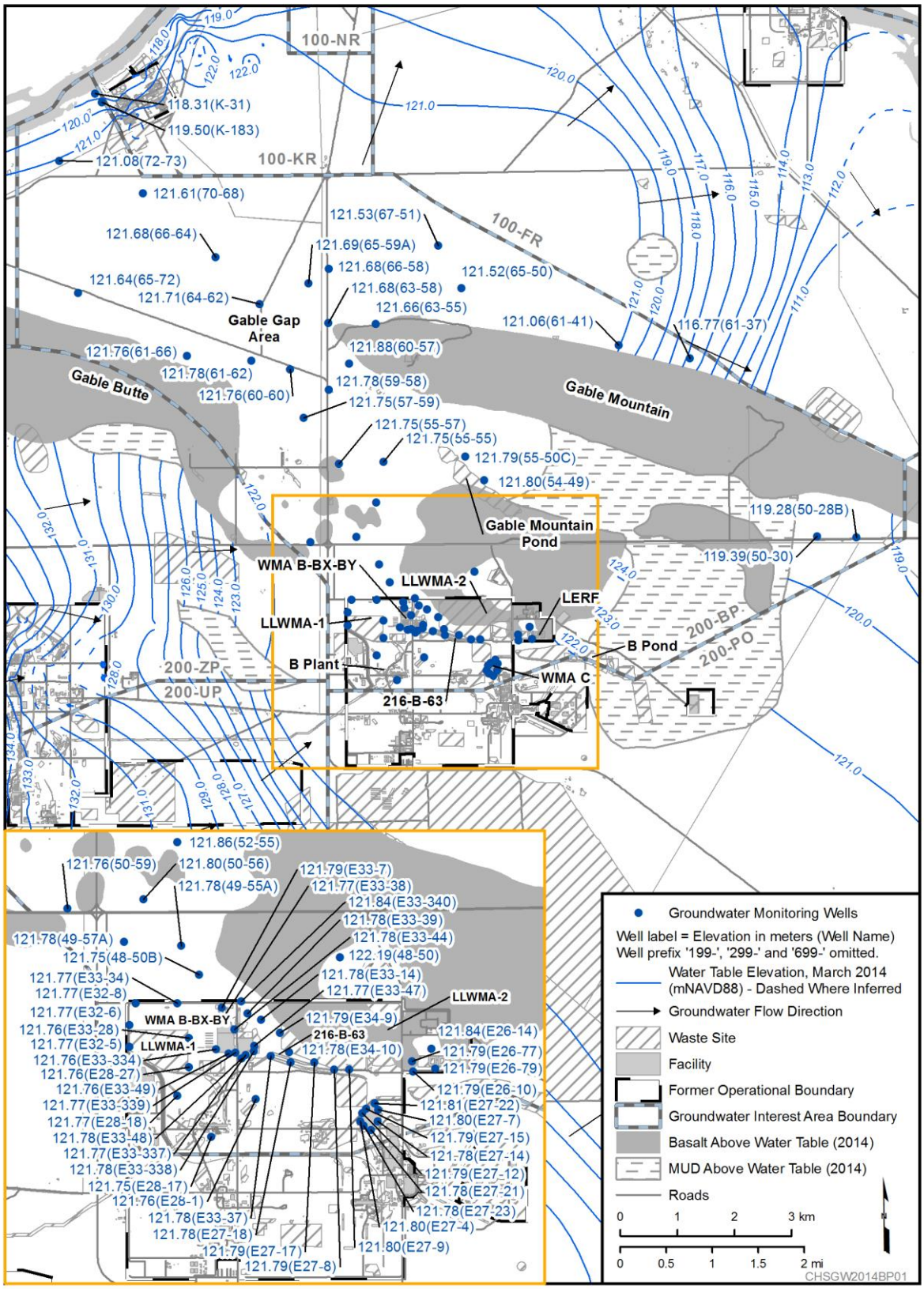


Figure 9-6. 200-BP-5 Overview with Interpreted Water Table Elevation

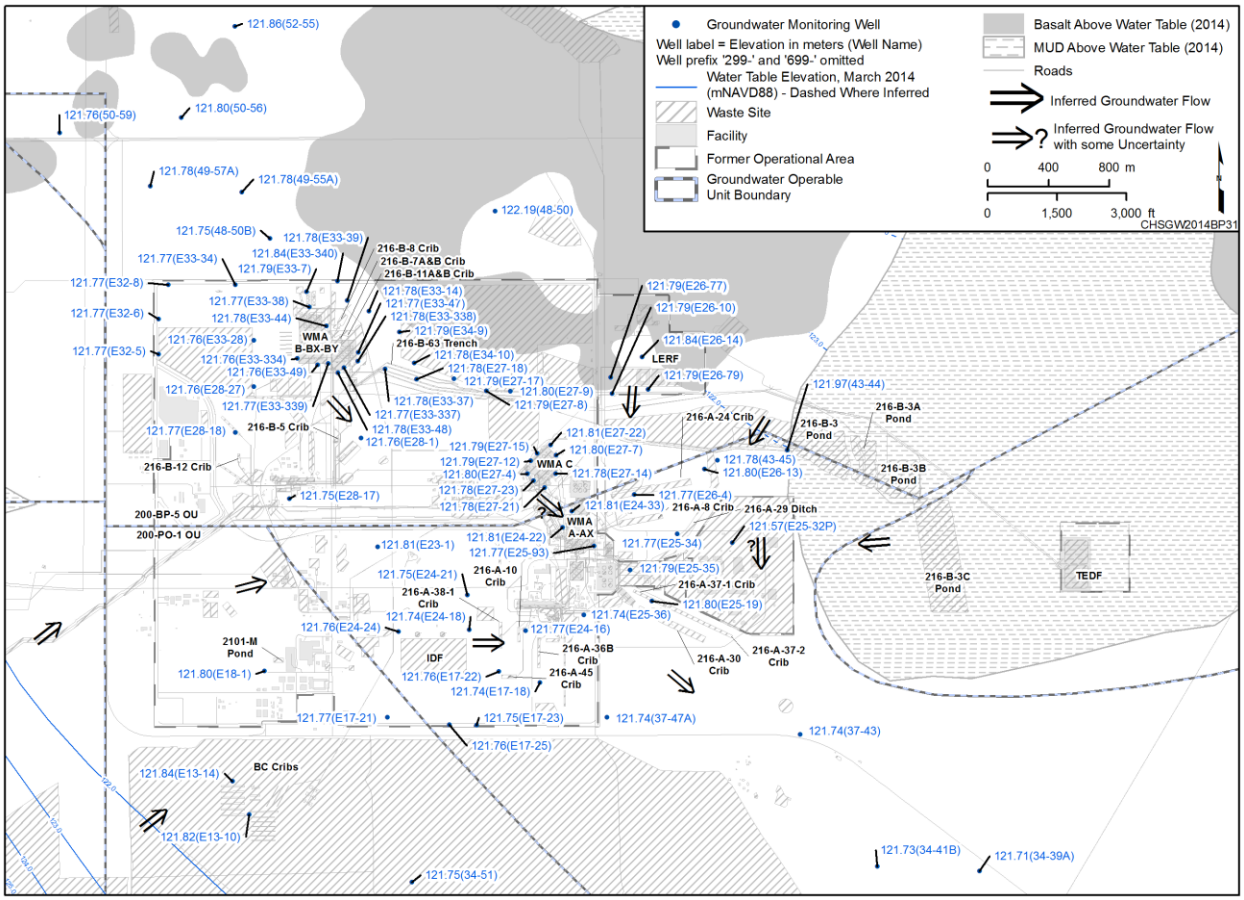


Figure 9-7. Interpreted Groundwater Flow Direction within the 200 East Area

9.2 CERCLA Activities

A draft RI report was prepared in 2014, describing the nature and extent of contamination and identifying contaminants of potential concern (COPCs) to support a future FS. DOE and regulatory reviews are planned in calendar year 2015. In addition, work began on an FS in late 2014, that will be combined with the 200-PO-1 OU.

Other ongoing CERCLA activities performed in 2014 and summarized below included: monitoring groundwater; draft revision of the SAP; expansion of the low-gradient water-level network across the 200 East Area; completion of two additional draft perched water documents related to removal of contaminants near WMA B-BX-BY; drilling and associated characterization sampling; removal of contaminated perched water near WMA B-BX-BY; and approval of *The Modular Storage Units Groundwater Monitoring Plan* (DOE/RL-2013-44). The 200-BP drilling in 2014 included two multipurpose wells near WMA B-BX-BY and one test well near the Modular Storage Unit Facility. Drilling plans for 2015 include four new aquifer monitoring wells.

Groundwater monitoring in 2014 continued under CERCLA, as described in DOE/RL-2001-49, Rev. 1. This SAP identifies requirements for monitoring 10 COPCs: nitrate, iodine-129, technetium-99, uranium, cyanide, strontium-90, tritium, cesium-137, plutonium-239/240, and cobalt-60. The integrated groundwater monitoring network within the 200-BP-5 OU is shown in Figure 9-8. Table A-15 of Appendix A lists wells, constituents, and 2014 sampling status. The plume areas have changed significantly between 2012 and 2014 within the northwest portion of the 200 East Area and within the ancestral Columbia River/cataclysmic glacial flooded paleochannel entering the 200 East Area from the northwest. The overall areal interpretation and calculated plume sizes for the major contaminants are shown in Figure 9-2 and Table 9-1, respectively. Specific discussions of the major changes in plume configurations are discussed in the contaminant sections below. Because of the changing plume geometries, a new SAP was drafted in 2014, *Groundwater Sampling and Analysis Plan for the 200-BP-5 Groundwater Operable Unit* (DOE/RL-2014-33, Draft A). The document is expected to be reviewed by the regulatory agencies in 2015, and, when approved, will replace DOE/RL-2001-49.

Also in 2014, the expanded 200 East Area low hydraulic gradient water-level network, defined in 2013, was used to collect monthly water levels for support of flow direction determination (SGW-54165). The 56 well network was used to complete 2014 monthly water table mapping and to prepare a composite low-gradient map (Figure 9-9). The results of this low-gradient flow map were consistent with local low-gradient monitoring results used to support northern 200 East Area RCRA facility monitoring.

A 2013 document supporting evaluation of contaminant impacts to perched water, SGW-53604, Rev. 1, recommended two proposed wells for further characterization of the contamination in the deep vadose zone perching horizon near WMA B-BX-BY. The two wells, 299-E33-350 and 299-E33-351, were drilled in early 2014 as discussed in the 2014 report, SGW-58147, *Annual Performance Report for the 200-DV-1 Operable Unit Perched Water Extraction, Fiscal Year 2014*. In addition, a perched water sample was collected during drilling of Well 299-E33-360 and associated analytical results are also provided in SGW-58147. SGW-58147 also provided recommendations to continue perched water extraction and consider evaluation of enhanced vacuum extraction system removal capacity. The following two documents were completed in 2014 for transition of the perched water treatability test to a non-time-critical removal action:

- DOE/RL-2013-37, *Engineering Evaluation/Cost Analysis for Perched Water Pumping/Pore Water Extraction*

- DOE/RL-2014-34, *Action Memorandum for 200-DV-1 operable Unit Perched Water Pumping/Pore Water Extraction*

The ongoing perched water treatability test at WMA B-BX-BY removed 284,583 L (75,187 gal) of water containing approximately 135 kg of nitrate, 0.01 Ci of technetium-99, and 21 kg of uranium in 2014.

At the Modular Storage Units Facility a monitoring network was approved to be installed based on the 2014 approval of DOE/RL-2014-34. One well, 699-46-91, was installed in 2014 to the southeast of the Modular Storage Units Facility (Figure 9-10). Monitoring will begin upon completion of the monitoring network. Three additional well installations have been planned per DOE/RL-2013-44 and will be installed based on priority and mutual Tri-Party agreement. Currently, there have been no significant releases at the Modular Storage Unit Facility.

Well drilling for 200-BP in 2014 included two multipurpose wells located near WMA B-BX-BY (Figure 9-10). Well 299-E33-360, located north of the B Tank Farm, was installed as a replacement well for decommissioned Well 299-E33-18 and as a potential future extraction well. Well 299-E33-361, located to the southeast of WMA B-BX-BY, was installed to track contaminant migration extending to the southeast of the B Complex and as a potential extraction well. Both wells were constructed as 20.3 cm (8 in.) diameter wells for potential conversion as extraction wells. Also both wells were included in DOE/RL-2014-33 to support CERCLA routine monitoring.

Finally, *Sampling Instruction for the FY2015 M-24 200 East Groundwater Monitoring Well Drilling and Installations* (SGW-58328) was completed for installation of two CERCLA wells, 299-E28-31 and 299-E28-32, near B Plant (Figure 9-10). These wells are being installed to delineate the nitrate, tritium, and uranium plumes that are assumed to have been related to 216-B-12 Crib past releases. These wells will be screened across the aquifer where elevated nitrate is observed from depth-discrete samples collected during drilling. Once the wells are completed they will be added to DOE/RL-2014-33. Two additional wells are also planned in 2015 for the RCRA facilities of LERF and WMA C (Figure 9-10).

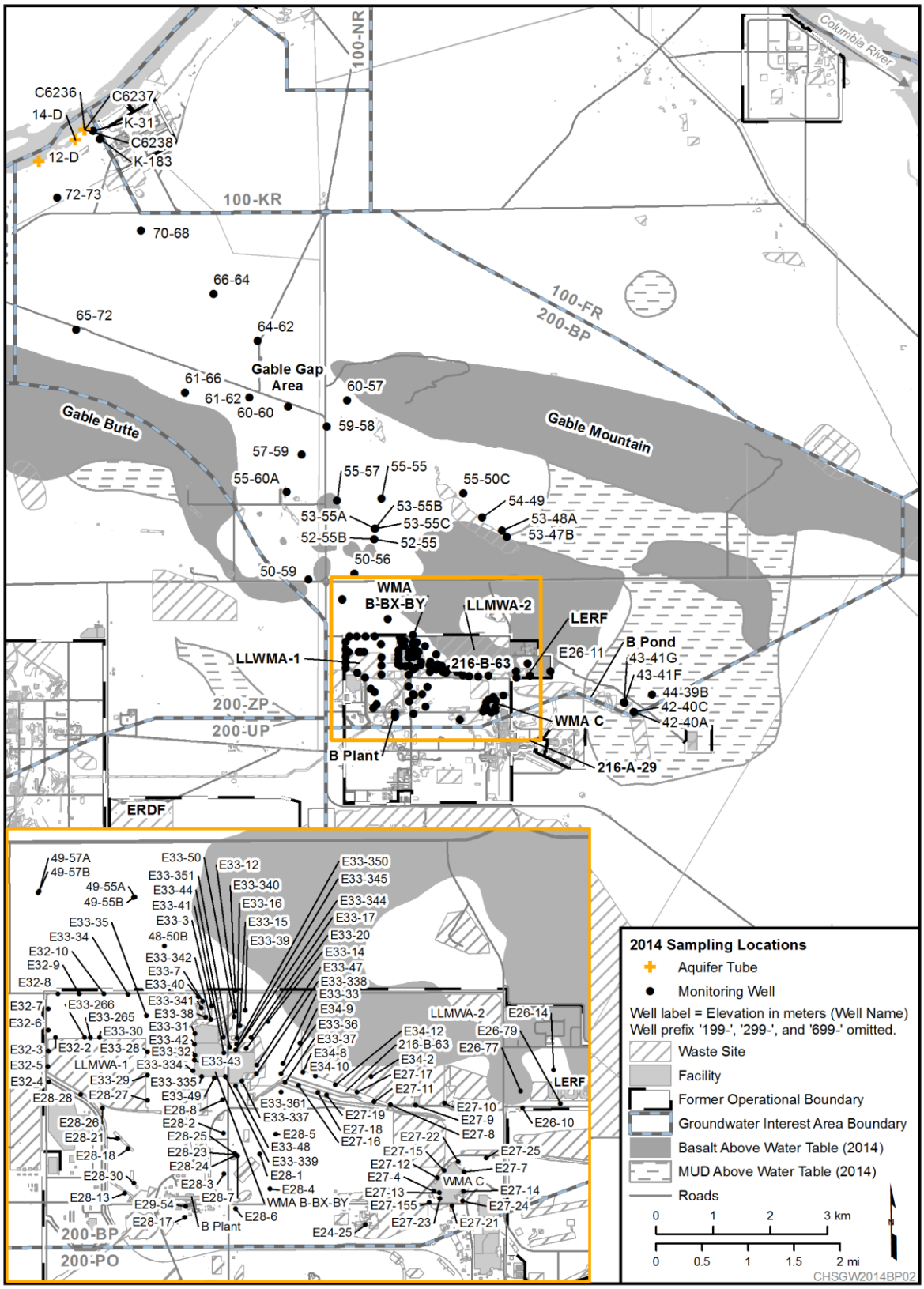


Figure 9-8. 200-BP-5 Groundwater Sample Well Locations, 2014

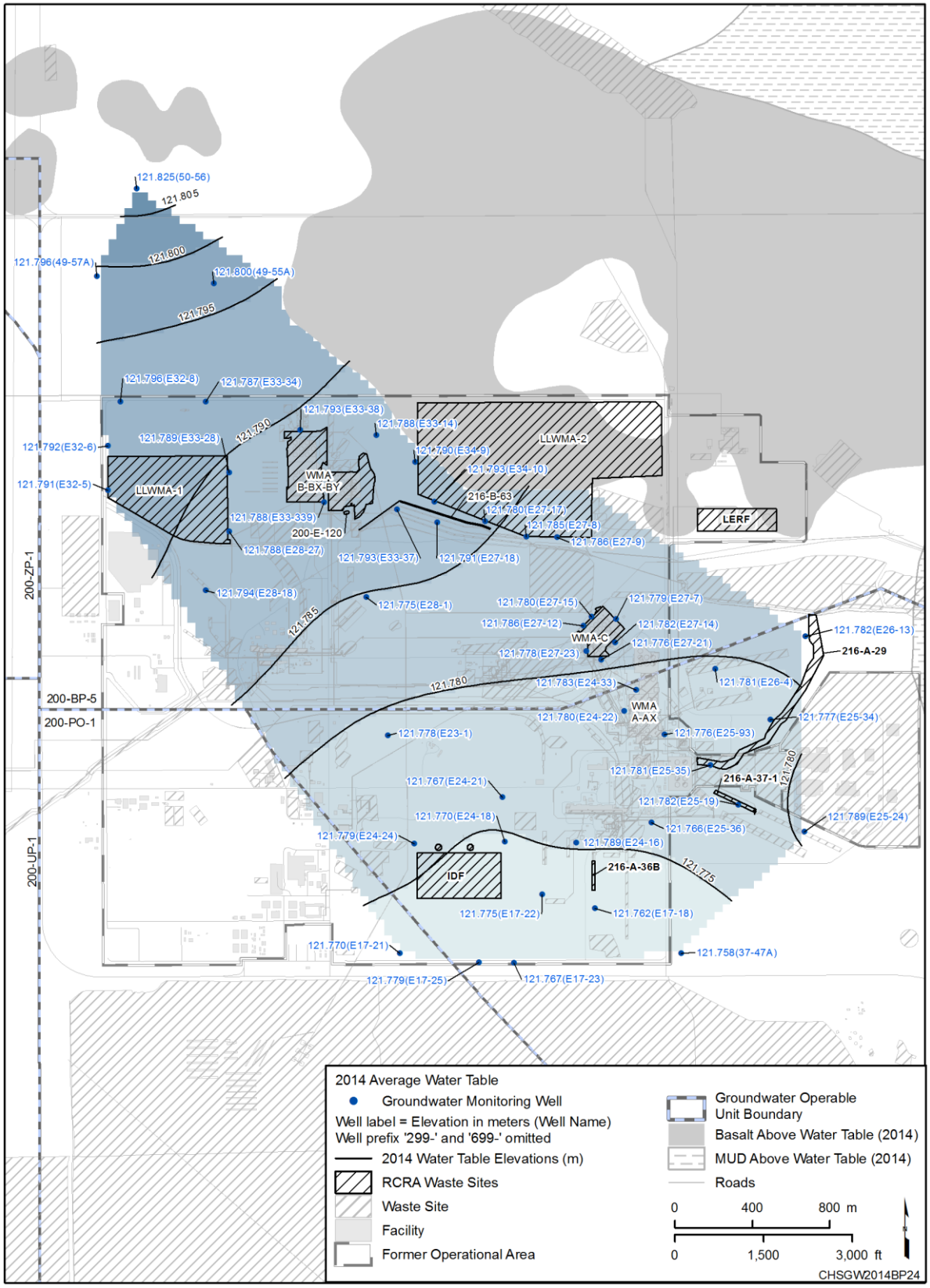


Figure 9-9. Monthly Average 200 East Area Low Hydraulic Gradient Water Table Map, 2014

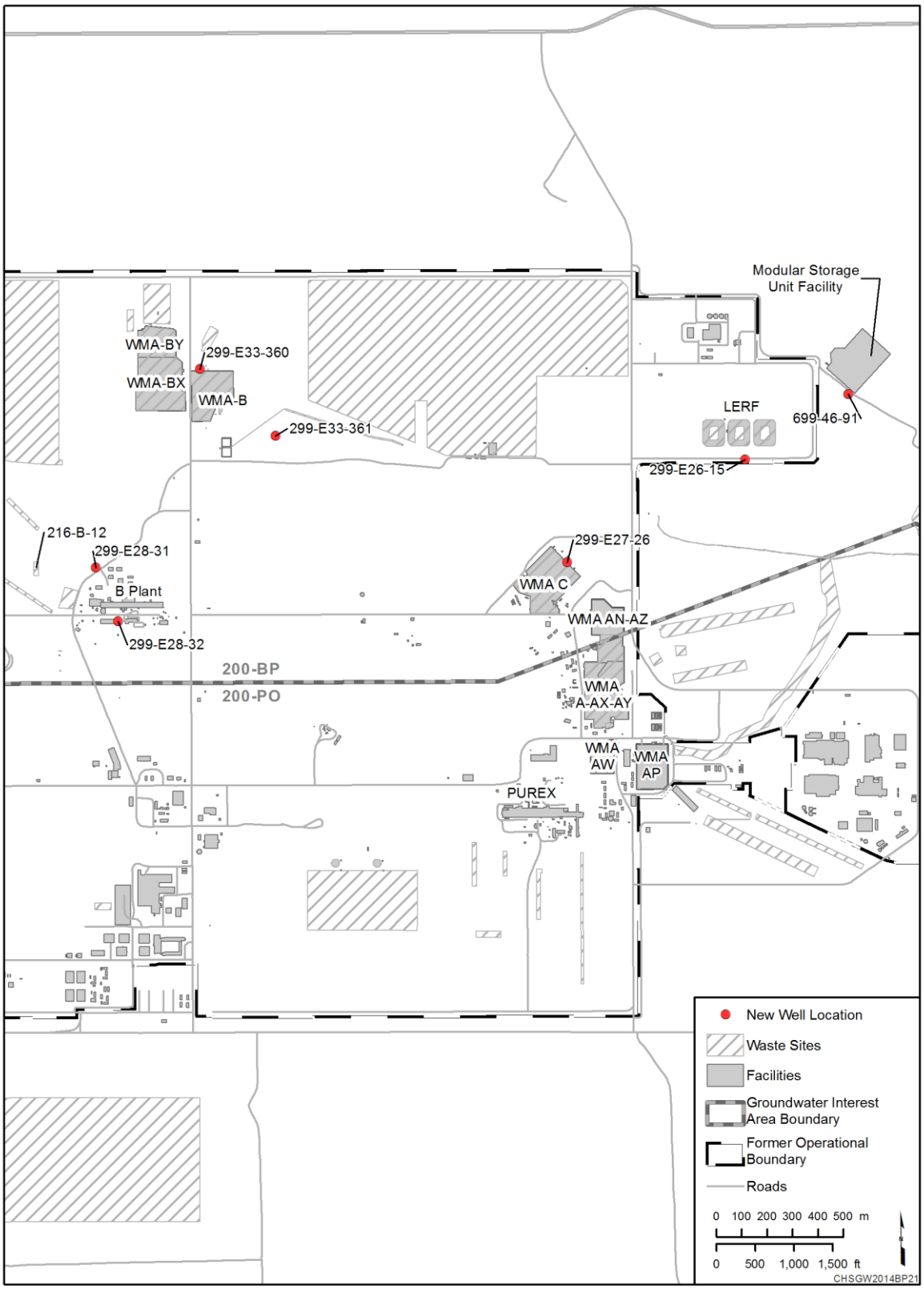


Figure 9-10. Location of 2014 Completed Well 699-46-91 at the Modular Storage Units Facility and Additional Well Location Options as Described in Subsection 3.3.1 of DOE/RL-2013-44

9.3 Nitrate

The most extensive plume in 2014 within 200-BP continues to be nitrate (Figure 9-11). Nitrate sources have been identified as the BY Cribs, 216-B-7A&B Cribs, 216-B-8 Crib, 241-BX-102 Unplanned Release, releases with B Tank Farm (part of WMA B-BX-BY), 216-B-12 Crib, 216-B-5 Injection Well, 216-B-2 2 Ditch, WMA C, and Gable Mountain Pond (Figure 9-6).

9.3.1 BY Cribs

Liquid waste contaminated with nitrate received at the BY Cribs in the past continues to migrate through approximately 70 m (230 ft) of vadose zone to groundwater. Prior to the 2011, groundwater flow reversal, nitrate concentrations were centered beneath this site ranging between 1,350 to 1,700 mg/L (Figure 9-12). The concentrated plume in Figure 9-11 was the result of minimal groundwater flow between 2006 and 2011 and continuous nitrate infiltration into the aquifer at an average concentration of approximately 200,000 mg/L based on the Hanford Soil Inventory Model, RPP-26744, *Hanford Soil Inventory Model Rev. 1*. Since 2011, this concentrated nitrate plume has expanded to the southeast due to migration as shown in Figures 9-13. There are now six wells engulfed by the concentrated portion of the BY Crib plume (concentrations exceeding 1,000 mg/L). It appears as the concentrated BY Crib plume reaches the north boundary of the B Tank Farm, the plume is diverted to the east or infiltration from the perched horizon dilutes the concentrated BY Crib plume to levels below 1,000 mg/L. Although the concentrated portion of the plume has continued to expand, the concentrations within the plume declined between 2012 and 2014, as shown in Figure 9-14.

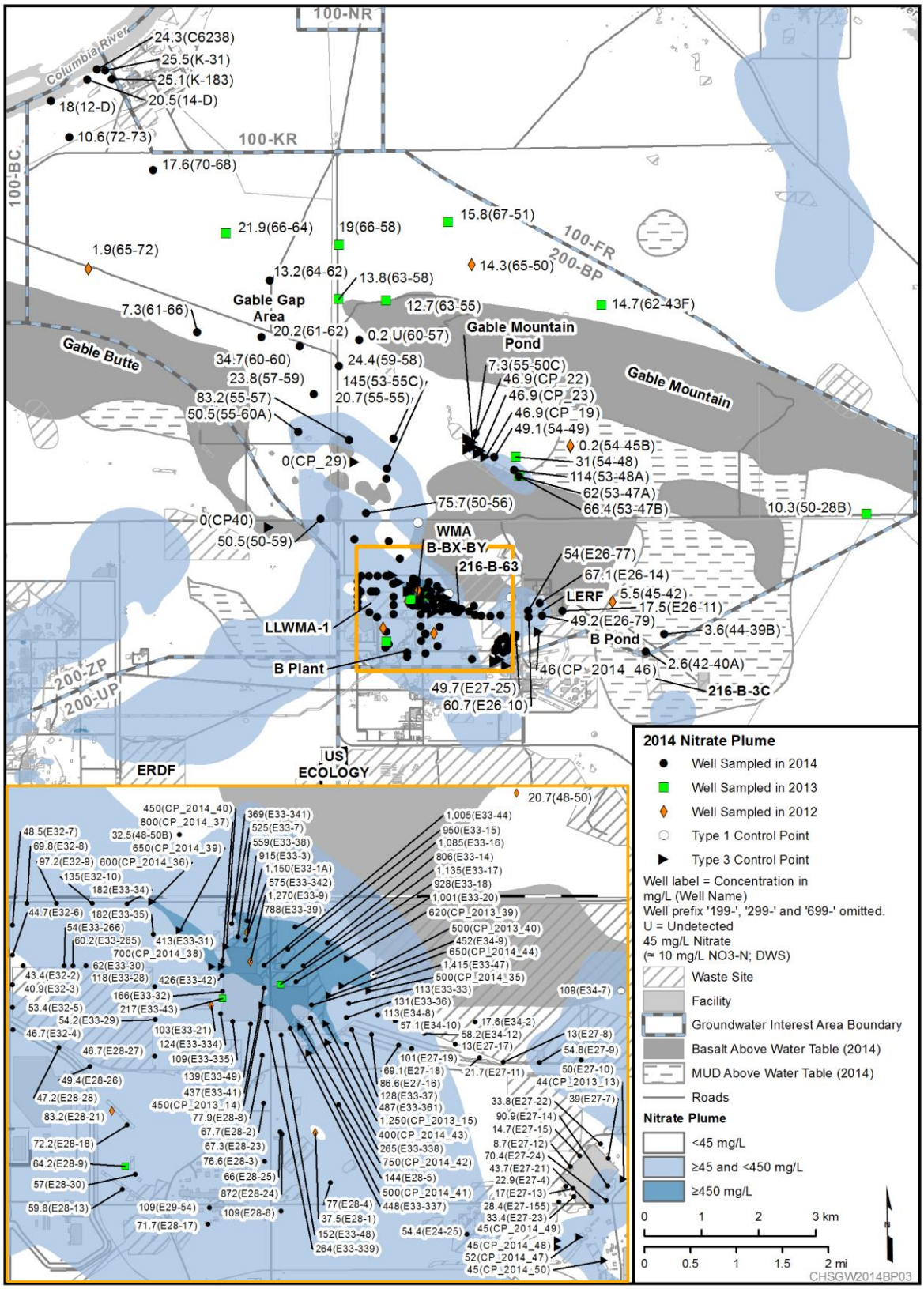


Figure 9-11. 200-BP Nitrate Plume, 2014

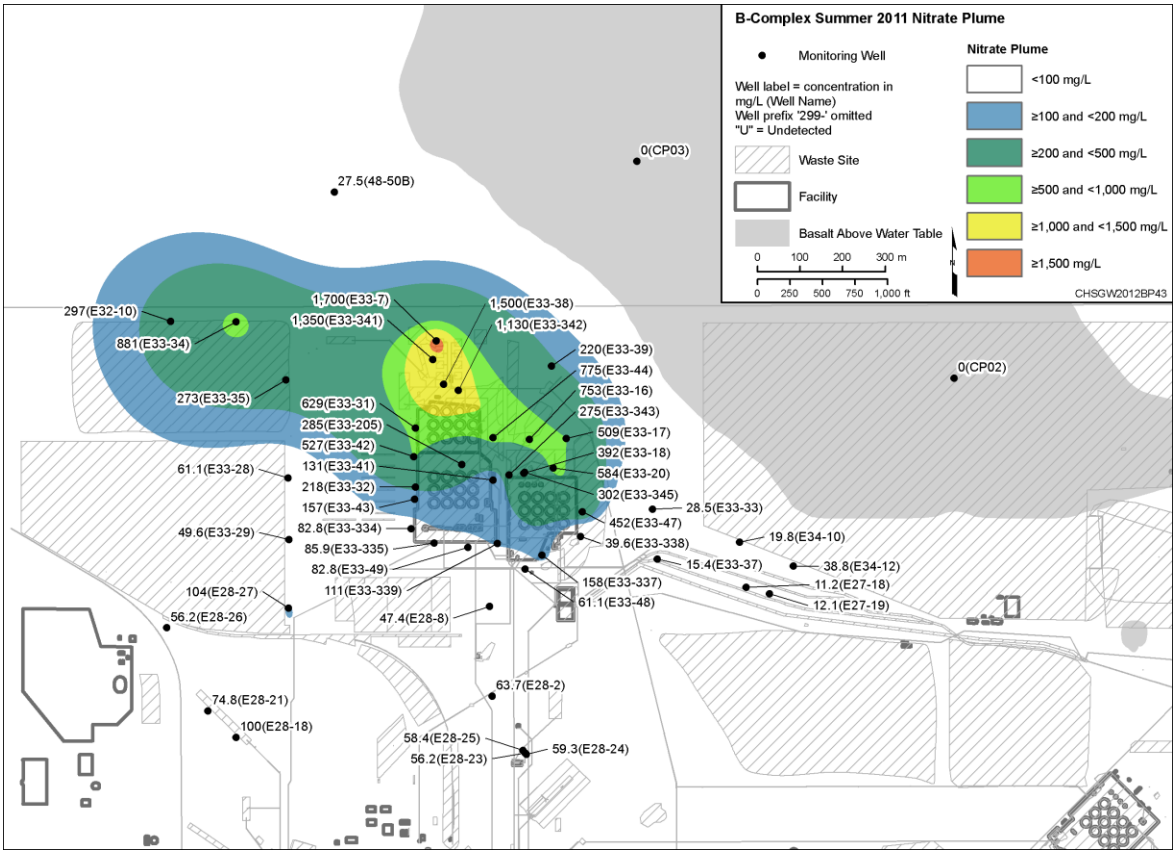


Figure 9-12. 200-BP Nitrate near BY Cribs, Summer 2011

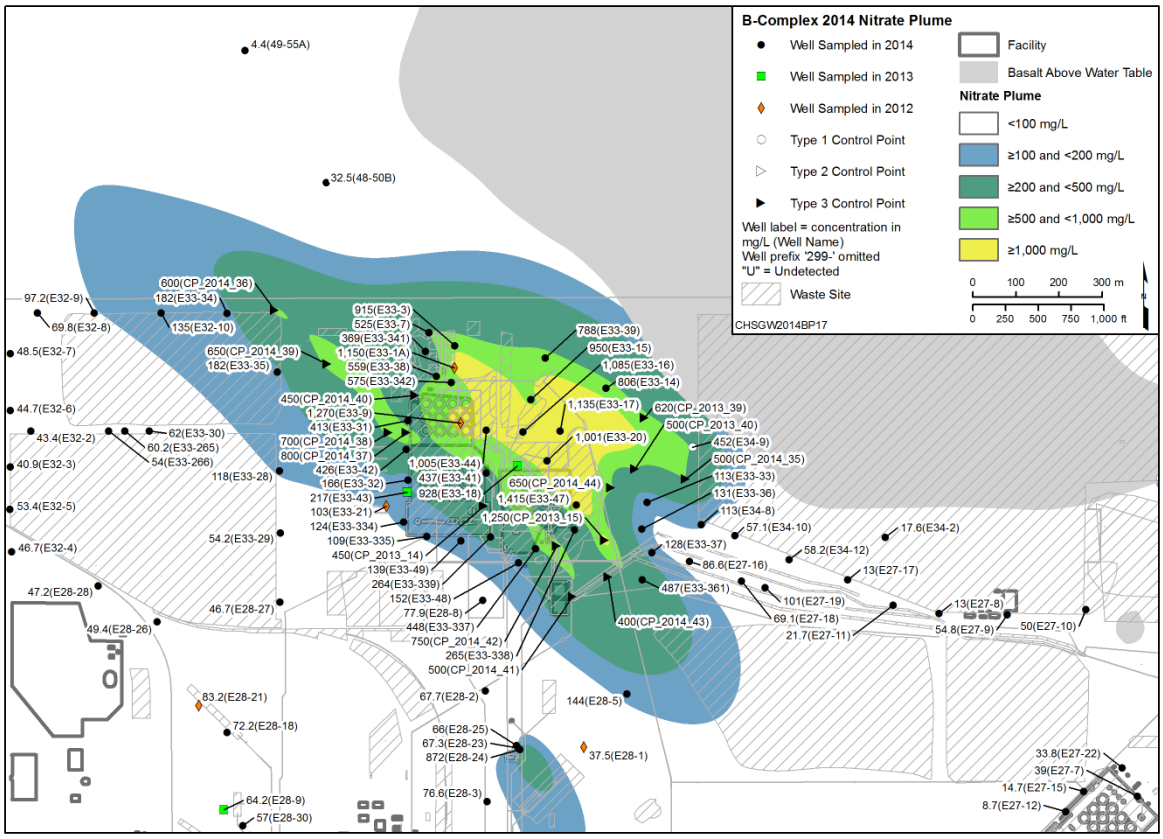


Figure 9-13. 200-BP Nitrate near BY Cribs, Summer 2014

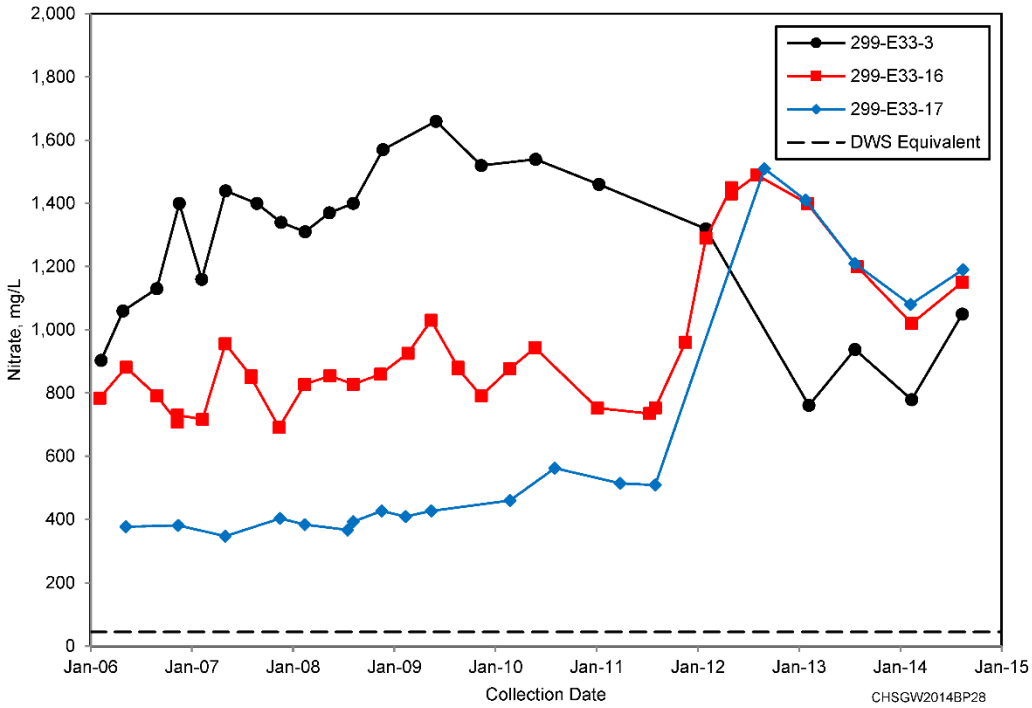


Figure 9-14. Trend Plot of Nitrate Concentrations at Wells 299-E33-3, 299-E33-16, and 299-E33-17 located within the Concentrated Portion of the BY Crib Plume Showing Recent Concentration Decreases

Increased liquid discharges to TEDF, located east of 200 East Area, can affect the hydraulic gradient in 200-BP (DOE/RL-2011-01). Prior to 2014, TEDF discharges were generally 10 million L/month (2.6 million gal/month). In 2014, occasional increased cooling water discharges from the 242-A Evaporator caused TEDF discharges to increase to 1 billion L/month (over 264 million gal/month). The last significant discharges, prior to 2014, were 2010 (Table 9-2). These large discharges can depress the water table gradient magnitude and result in slower groundwater flow. During these events, areas of ongoing contaminant infiltration into the aquifer can show temporary contaminant concentration increases. This may explain the late 2014 increase of nitrate beneath the BY Cribs at Well 299-E33-3 and beneath the 216-B-8 Crib at 299-E33-16 and Well 299-E33-17 (Figure 9-14).

Table 9-2. TEDF Discharge Volumes by Month Since January 2010

Year	Month	Flow Volume (L)		Year	Month	Flow Volume (L)
2010	January	6.08E+06		2012	July	9.80E+06
2010	February	7.48E+06		2012	August	8.28E+06
2010	March	7.60E+06		2012	September	6.70E+06
2010	April	2.06E+08		2012	October	8.83E+06
2010	May	2.18E+08		2012	November	7.03E+06
2010	June	6.87E+06		2012	December	6.70E+06
2010	July	2.30E+07		2013	January	5.74E+06
2010	August	1.39E+08		2013	February	5.04E+06
2010	September	4.33E+08		2013	March	7.43E+06
2010	October	1.12E+08		2013	April	6.38E+06
2010	November	6.70E+06		2013	May	7.60E+06
2010	December	6.25E+06		2013	June	9.97E+06
2011	January	3.38E+06		2013	July	9.63E+06
2011	February	4.58E+06		2013	August	1.15E+07
2011	March	3.89E+06		2013	September	1.28E+07
2011	April	3.92E+06		2013	October	9.61E+06
2011	May	6..67E+06		2013	November	1.02E+07
2011	June	6.38E+06		2013	December	9.38E+06
2011	July	4.06E+06		2014	January	7.29E+06
2011	August	5.74E+06		2014	February	1.72E+08
2011	September	3.92E+06		2014	March	1.99E+08
2011	October	3.89E+06		2014	April	8.36E+06
2011	November	3.76E+06		2014	May	7.53E+06
2011	December	3.55E+06		2014	June	7.20E+06
2012	January	4.22E+06		2014	July	2.56E+08
2012	February	2.37E+06		2014	August	6.90E+06
2012	March	3.72E+06		2014	September	4.00E+08
2012	April	6.38E+06		2014	October	2.81E+08
2012	May	8.62E+06		2014	November	6.21E+06
2012	June	9.16E+06		2014	December	6.46E+06

During 2013 and 2014, nitrate concentrations rose significantly (881 mg/L in 2014) at Well 299-E28-24, near the former 216-B-5 Injection Well (Figure 9-15). The presence of cyanide and technetium-99 indicate that the plume is derived from liquid scavenged waste. It is uncertain if the source is the BY Cribs, 216-BX-42 Trench, the unplanned release at the B Tank Farm, or an unknown unplanned release near B Plant. However, the elevated nitrate is not detected in other wells in this area that are screened across the upper part of the aquifer (Figure 9-15). Well 299-E28-24 is unique as it is perforated approximately 7.6 to 9.1 m (25 to 30 ft) below the water table. This elevation in the aquifer is where a similar concentrated plume of nitrate was detected at Well 299-E28-30 near the 216-B-12 Crib in 2010. However, no cyanide or technetium-99 were present in Well 299-E28-30. Two wells are scheduled to be drilled and screened deeper in the aquifer in 2015 near B Plant as discussed further in Section 9.3.4.

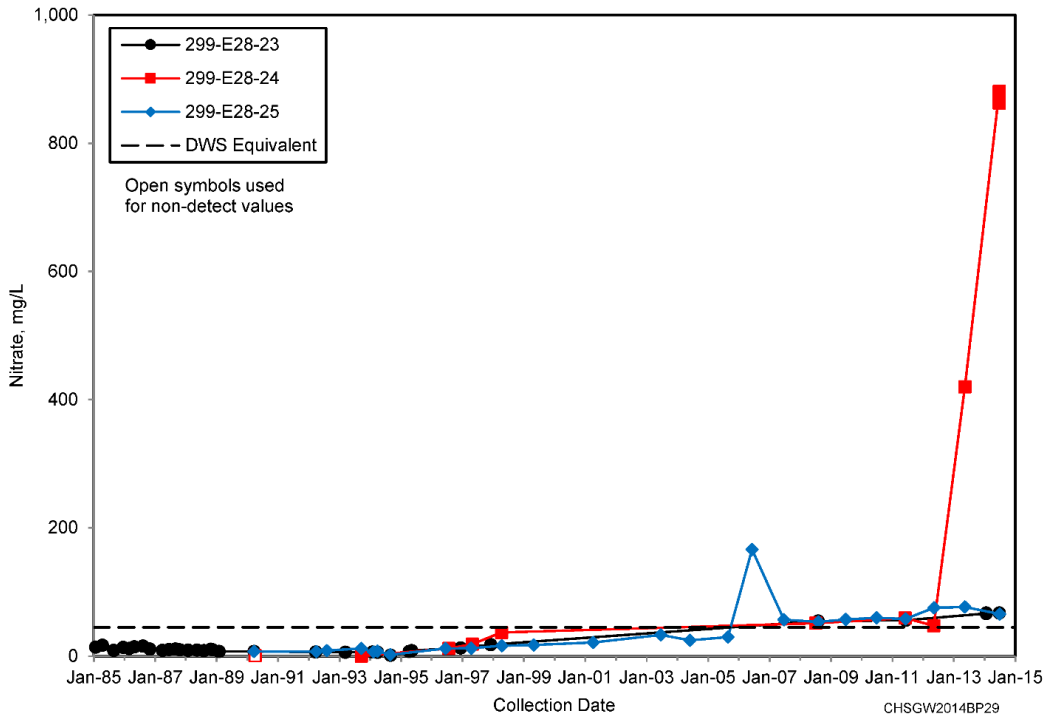


Figure 9-15. Trend Plot of Nitrate Concentrations at Wells 299-E28-23, 299-E28-24, and 299-E28-25 Located near the Former 216-B-5 Injection Well

9.3.2 B Tank Farm

The highest 2014 nitrate concentration (1,480 mg/L) in 200-BP and the B Complex area (e.g., WMA B-BX-BY and nearby waste sites) was at Well 299-E33-47 (Figure 9-16). The source of nitrate at this well was determined to be associated with an unplanned release within the B Tank Farm, as discussed in DOE/RL-2012-53. The plume growth at this location is shown by comparing Figures 9-12 and 9-13. Because this plume was expanding beyond the existing monitoring well network, a new well, 299-E33-361, was drilled and sampled in 2014 to help define the plume extent (Figure 9-12). Concentrations in samples collected during drilling ranged from 200 to 487 mg/L. An additional downgradient well is planned for FY 2016.

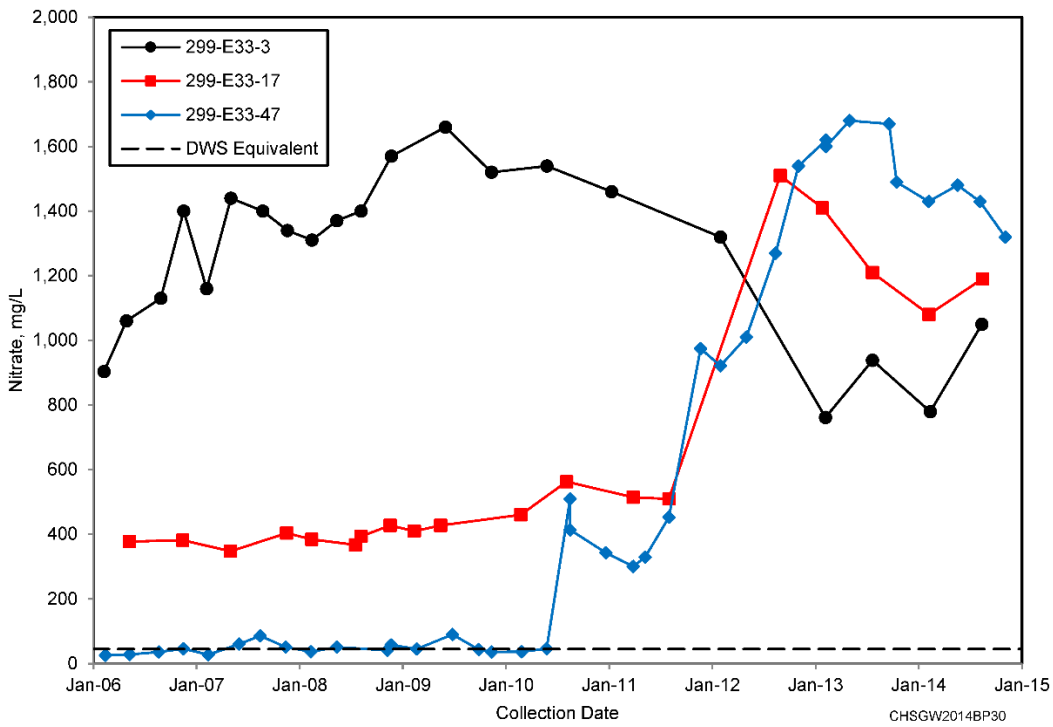


Figure 9-16. Trend Plots of Nitrate Concentrations at Wells 299-E33-3, 299-E33-17, and 299-E33-47 Located within the B Complex for Comparison

9.3.3 241-BX-102 Unplanned Release and 216-B-7A&B Cribs

Contaminated pore water within a perched water horizon, located approximately 3 m (10 ft) above the unconfined aquifer, is sourced from both the 241-BX-102 Unplanned Release and 216-B-7A&B Cribs. The contaminated water is monitored and removed by Well 299-E33-344. Nitrate at Well 299-E33-344 has ranged between 316 to 810 mg/L since installation in 2007 (Figure 9-17). The total estimated nitrate removed by extraction at Well 299-E33-344 is 495 kg, dating from August 2011 through December 2014. Continued pumping at this well is planned for the foreseeable future. Two additional perched water wells were installed in 2014, 299-E33-350 and 299-E33-351, and are planned to be connected as additional extraction wells upon approval of the action memorandum and connection to the 200 West P&T Facility. Concentrations in the new wells ranged up to 5,930 mg/L. Although nitrate is infiltrating from the perched water horizon into the aquifer near groundwater Wells 299-E33-16, 299-E33-44, and 299-E33-345, the concentrations from the perching horizon is less concentrated than the BY Cribs and the B Tank Farm release and tends to dilute the groundwater concentrations in this area.

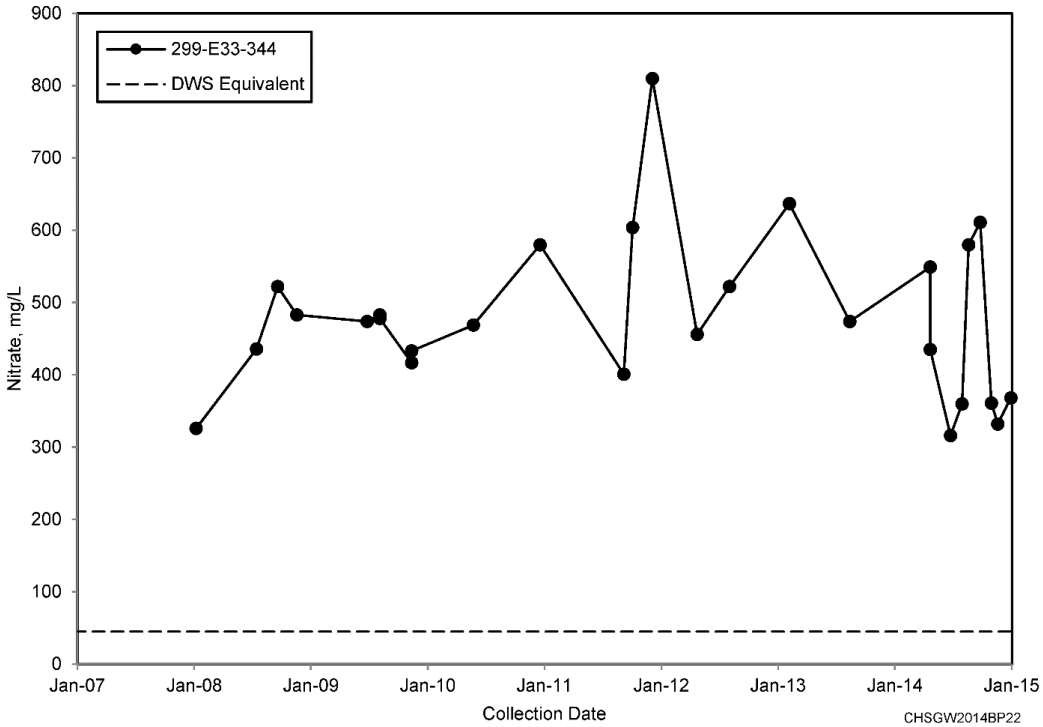


Figure 9-17. Trend Plots of Nitrate Concentrations at Well 299-E33-344 Located within the B Complex Perch Water Horizon

9.3.4 216-B-12 Crib, B Plant, and 216-B-5 Injection Well

South of the 216-B-12 Crib, nitrate concentrations remained relatively stable at Well 299-E28-30, ranging from 55.3 to 60.2 mg/L since installation in 2010. However, to the east at Well 299-E29-54 concentrations increased from 65.1 to 126 mg/L between 2012 and 2013, and in 2014 have remained above 100 mg/L (Figure 9-11). Nitrate also increased from 58.9 mg/L in 2011 to 109 mg/L in 2014 at Well 299-E28-6 (Figure 9-11). The nitrate concentration increases at Wells 299-E29-54 and 299-E28-6 may be associated with a concentrated nitrate plume found in the lower part of the aquifer during the 2010 RI drilling at Wells 299-E28-30 and 299-E29-54 as discussed in DOE/RL-2011-01. Concentrations at approximately 8 m (26 ft) below the water table at Well 299-E28-30 were nearly 900 mg/L. To better assess the horizontal and vertical extent of the plume in this area, two additional wells are planned in 2015 (Figure 9-10). Depth-discrete samples will be collected and analyzed for nitrate during drilling of these wells for defining well screen placement. These wells may be added to DOE/RL-2014-33 once the wells are accepted for monitoring. Nitrate as well as other contaminants of interest (e.g., tritium, technetium-99, and uranium) will be monitored at these new wells.

9.3.5 216-B-2 Ditches

The nitrate concentrations near the eastern portion of the 216-B-2 Ditches, in 299-E27-10, declined from 66.4 mg/L in February 2010 to 48.3 mg/L in October 2013. In 2014, the nitrate concentrations at Well 299-E27-10 did not change significantly. Nitrate concentrations to the east, south, and west of Well 299-E27-10 have similar concentrations, not exceeding at 61.1 mg/L in 2014. Based on the plume geometry and relatively stable concentrations within the plume, the plume has not moved significantly between 2012 and 2014. The lack of significant plume movement may be attributed to one or both of the following explanations: (1) nitrate concentrations attenuate below the DWS at the current boundary

because of increased aquifer thickness, and/or (2) the groundwater is moving much slower in this area than in other parts of the 200 East Area.

9.3.6 Waste Management Area C

Nitrate concentrations at three WMA C wells exceeded 45 mg/L in 2014. Two of the three wells, 299-E27-14 and 299-E27-24, are downgradient of WMA C. The other well (299-E27-25) is cross gradient of WMA C and is affected by migrating contaminant plumes to the north. The greatest nitrate concentration (99.2 mg/L) was at Well 299-E27-14, located on the southeast side of WMA C. Based on concentrations at Well 299-E27-24, which was installed in the lower portion of the unconfined aquifer approximately 66 m (216.5 ft) south of Well 299-E27-14 in 2010, the plume extends throughout the 15.5 m (50.9 ft) thick aquifer. The nitrate concentrations in Well 299-E27-24 have been stable, ranging between 65.5 and 73.5 mg/L since sample collection began in 2010. The nitrate plume shown in Figure 9-11 reflects a past southwest flow direction which has recently shifted to the south and southeast. Based on technetium-99 to nitrate ratios, it appears the 1990s plume at Well 299-E27-14 is now encroaching upon Well 299-E24-20 at WMA A-AX. The evidence for linking past affected groundwater at Well 299-E27-14 with recent contamination at Well 299-E24-20 is based on the lower technetium-99 to nitrate ratios compared to other wells displaying elevated technetium-99 and nitrate (Table 9-3). For example, Well 299-E27-23, which was installed at WMA C in 2003, has been determined to have been affected by PUREX-derived waste, which exhibits much greater technetium-99 to nitrate ratios (Table 9-4). At the height of contamination at Well 299-E27-23 the ratio was an order of magnitude higher than in Wells 299-E27-14 and 299-E27-24. After a flow change in 2011, Well 299-E27-21 was similarly affected as seen by the ratio increase (Table 9-4). The higher ratio for PUREX waste is based on the recycling of nitrate that occurred at PUREX. Prior to recycling at PUREX, technetium-99 to nitrate ratios resembled the ratios shown for Well 299-E27-14. This is also reflected in RPP-26744, where average scavenged waste technetium-99 to nitrate ratios are approximately 100, while PUREX-derived technetium-99 to nitrate ratios is on the order of 10^5. It appears that Well 299-E24-22 reflects the leading edge of the PUREX-derived waste released at WMA C because of the increased technetium-99.

Table 9-3. Comparison of Technetium-99 to Nitrogen in Nitrate at Wells 299-E27-14 and 299-E24-20

Sample Date	299-E27-14		Sample Date	299-E24-20
07/23/91	19.3		12/15/03	2.4
05/15/92	26.4		12/01/04	1.9
06/15/93	8.5		01/05/06	4.9
03/14/94	11.3		01/10/07	9.7
02/13/95	7.7		01/03/08	24.8
02/15/96	9.0		03/30/09	11.8
02/13/97	59.0		01/06/10	15.6
06/04/98	153.1		03/08/11	14.9
06/03/99	156.9		03/01/12	20.6
06/02/00	195.8		03/07/13	21.7
07/16/01	177.6		03/05/14	34.8

Note: Technetium-99 to nitrogen in nitrate ratios shown in pCi/mg.

Table 9-4. Comparison of Technetium-99 to Nitrogen in Nitrate at Wells 299-E24-22, 299-E27-21, 299-E27-23, and 299-E27-14

Sample Date	299-E24-22	299-E27-21	200-E27-23	299-E27-14
Winter 2003/2004	—	170.5	304.2	244.1
Winter 2004/2005	44.6	104.8	294.8	—
Winter 2005/2006	43.3	76.9	336.1	208.8
Winter 2006/2007	45.1	101.9	744.6	163.2
Winter 2007/2008	52.3	159.5	1146.6	153.8
Winter 2008/2009	40.5	200	1362.9	132.3
Winter 2009/2010	43.2	382.6	2143.8	104.0
Winter 2010/2011	40.8	431	2059.5	94.4
Winter 2011/2012	110.3	496.9	2500	92.8
Spring 2013	165.2	1363.6	1093.9	520.2
Winter 2013/2014	235.7	2079.2	563.4	178.3
Winter 2014/2015	301.1	2394.4	508.1	294.4

Note: Technetium-99 to nitrogen in nitrate ratios shown in pCi/mg.

9.3.7 Gable Mountain Pond (216-A-25)

The highest nitrate concentration in 2014 at the former Gable Mountain Pond was 114 mg/L at Well 699-53-48A. Over the previous 7 years, concentrations at this well have decreased from 210 mg/L. The aquifer at this well is approximately 2 m (6.6 ft) thick as defined by the underlying basalt. Concentrations in other wells in this area are approximately half or less than the concentration at Well 699-53-48A because the aquifer thickens to the west. The areal extent of nitrate exceeding DWS closely outlines the area of the former pond, with concentrations diminishing to the west as the aquifer increases in thickness.

9.3.8 Gable Gap

Prior to termination of discharges to Gable Mountain Pond, nitrate from the BY Cribs migrated north toward Well 699-50-53A, creating a significant plume as depicted in Figure 1-5 of DOE/RL-95-59. Since the termination of discharges to Gable Mountain Pond, nitrate migrated north-northwest as depicted in Figure 5-30 of DOE/RL-95-59 and Figure 9-11. Since 2007, concentrations at Well 699-53-55C have been stable, with a slight decrease since 2010. Concentrations have also been stable at Well 699-55-57; however, concentrations declined significantly at 699-57-59 and have risen in the short term at Well 699-55-60A. Thus, the nitrate plume geometry has changed from being directed toward Well 699-57-59 to nearly connecting with Well 699-55-60A, as portrayed in Figure 9-11.

9.4 Iodine-129

Three sources in the southeastern 200 East Area (216-A-10 Crib vicinity, 216-A-29 Ditch, and B Pond) were contributors to the widespread distribution of iodine-129 within the 200 East Area and Gable Gap (Figure 9-18).

The plume area remained relatively stable within the northern portion of the 200 East Area, but the plume appears to be dispersing in the Gable Gap area, based on declining activity levels in several wells (Figure 9-19).

Overall iodine-129 activity at most wells in 200-BP decreased in 2014, especially along the plume boundaries. The highest activity, 6.05 pCi/L, was at WMA C Well 299-E27-13.

9.4.1 B Pond

Three 200-BP wells (699-43-41F, 699-43-41G, and 699-45-42) were sampled and analyzed for iodine-129 near 216-B-3B Pond lobe in 2014. Results at two of the wells exceeded the DWS: 699-43-41F (2.74 pCi/L) and 699-43-41G (2.04 pCi/L). Well 699-43-41F is screened in the Ringold hydrostratigraphic unit 9B, which can be a confining layer for the underlying 9C. The other well (699-45-42) exceeding the DWS is screened in unit 9C. These wells are in close proximity to one another and appear to indicate downward migration of contamination. The head differences also suggest downward migration as the head in Well 699-43-41F is 123.3 m (404.5 ft), while the head in Well 699-43-41G is 123.01 m (403.6 ft). The highest iodine-129 activity near B Pond was at Well 699-43-45 (6.4 pCi/L) near the head end of the original 216-B-3 Pond in 200-PO.

9.4.2 Waste Management Area C

All 12 wells at WMA C had iodine-129 levels exceeding DWS and are associated with past migration of greater iodine-129 activity to the east/southeast. The levels at WMA C ranged from 2.4 to 6.05 pCi/L. Iodine-129 levels detected near WMA C have been relatively consistent over the past two decades.

9.4.3 Low-Level Waste Management Area 2

Elevated iodine-129 has been detected in the wells along the south side of LLWMA-2 since monitoring began in the early 1990s. The greatest activity was in Well 299-E27-10 when sampling began, but has continued to decline and is currently near DWS. Three east LLWMA-2 wells (299-E27-8, 299-E27-9, and 299-E27-10) and the southwest corner Well 299-E34-8 continue to have activity levels greater than the DWS. These wells define the northern extent of iodine-129 in this area.

9.4.4 216-B-5 Injection Well

The spatial distribution of iodine-129 at wells near the 216-B-5 Injection Well indicates a source to the east of the site. The 1 pCi/L DWS contour extends south of this waste site, between Wells 299-E28-3 and 299-E28-25.

9.4.5 216-B-2 Ditches

Elevated iodine-129 levels were detected in wells beneath the 216-B-2 Ditches as early as the 1990s. Past activity levels were greatest in Well 299-E33-36, located north of the head end of the ditches. Iodine-129 in this well has remained fairly high (3.53 pCi/L in 2013; not sampled in 2014), greater than to the east or south, likely representing the central portion of the plume that migrated to the northwest in the past.

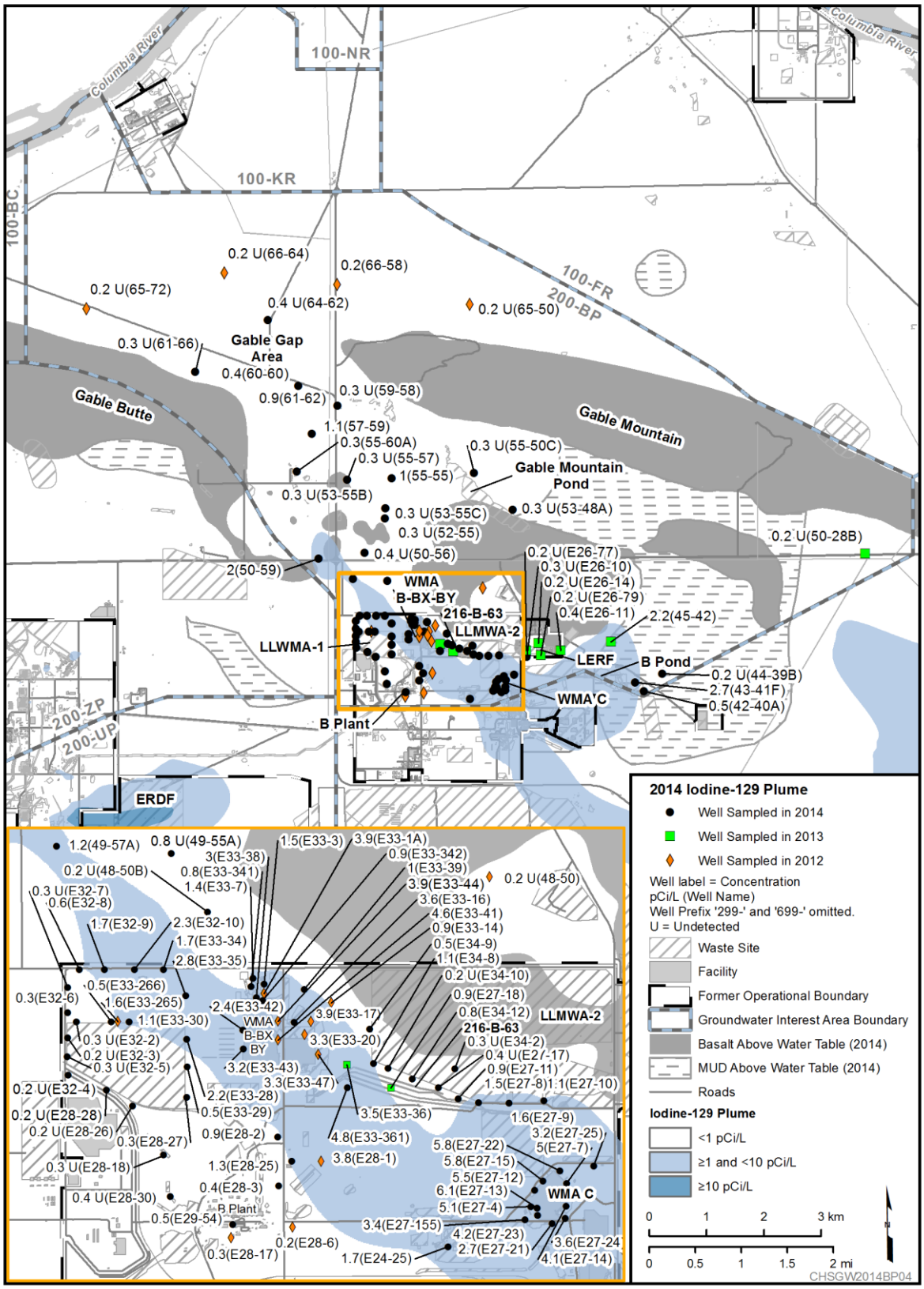


Figure 9-18. 200-BP Iodine-129 Plume, 2014

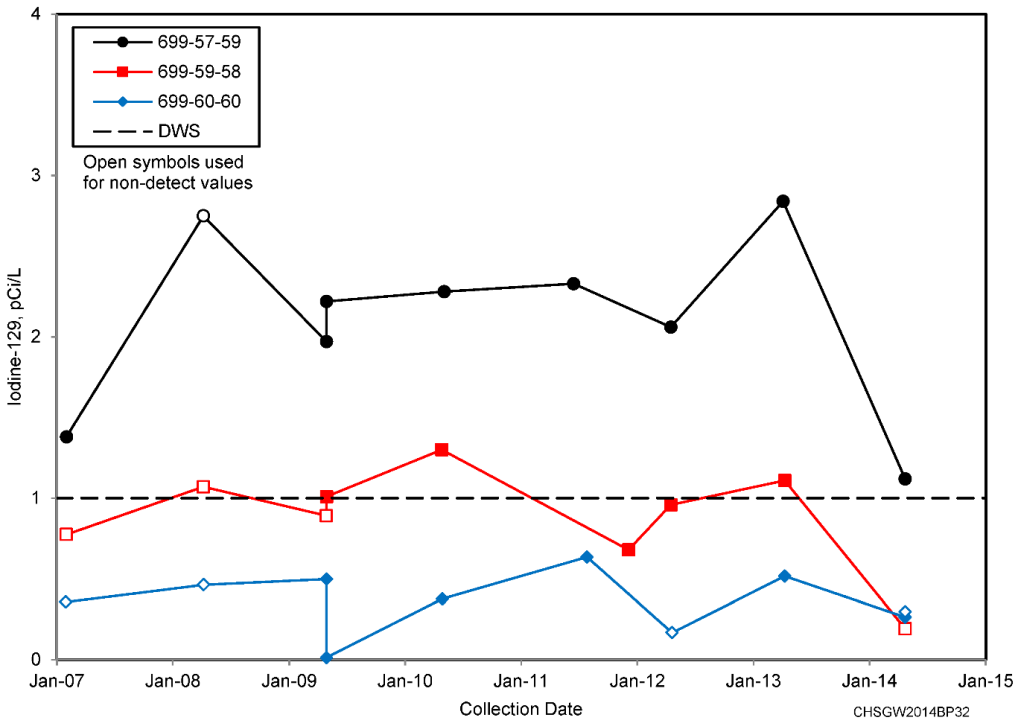


Figure 9-19. Trend Plots of Iodine-129 at Gable Gap Wells 699-57-59, 699-59-58, and 699-60-60

9.4.6 B Complex to Gable Gap

Iodine-129 activity in Wells 699-49-57A and 699-50-59 rose back above the DWS in 2014, causing the plume interpretation to extend farther to the northwest than in 2013. It is uncertain whether the contaminant geometry is continuous between wells or if the data reflects smaller, discrete plumes. For conservative measures the extent has been defined as a continuous plume. Recent results at these two wells have been variable (Figure 9-20). As mentioned in the introduction to this section, the plumes in the Gable Gap are considered to be dispersing because of the decreases seen in several of the wells and the thick aquifer in this area.

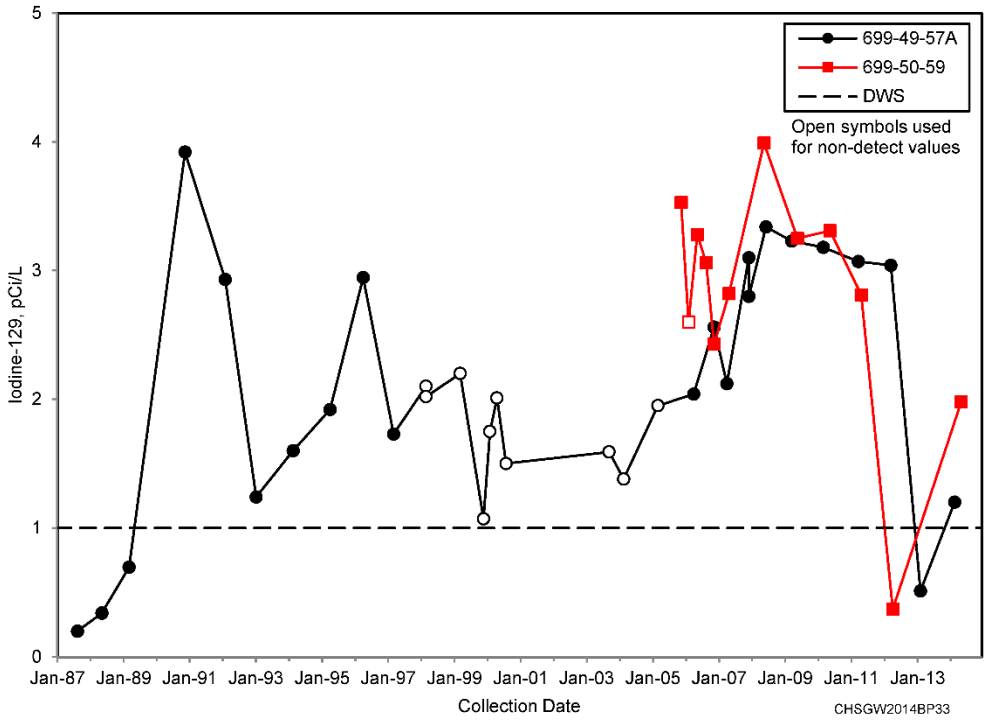


Figure 9-20. Trend Plots of Iodine-129 within the Paleochannel between 200 East Area and Gable Gap at Wells 699-49-57A and 699-50-59

9.5 Technetium-99

Technetium-99 sources overlying 200-BP have been identified as the BY Cribs, 216-B-7A&B Cribs, 216-B-8 Crib, 241-BX-102 Unplanned Release, releases with B Tank Farm (WMA B-BX-BY), and WMA C. Estimated plume distribution is shown in Figure 9-21. Four general plume areas are present within 200-BP: one area north of 200 East, one near WMA B-BX-BY, one near WMA C, and one well near the former 216-B-5 Injection Well. The largest of the four plumes is near WMA B-BX-BY and sources include the BY Cribs, 216-B-7A&B Cribs, 216-B-8 Crib, 241-BX-102 Unplanned Release, and releases associated with the B Tank Farm.

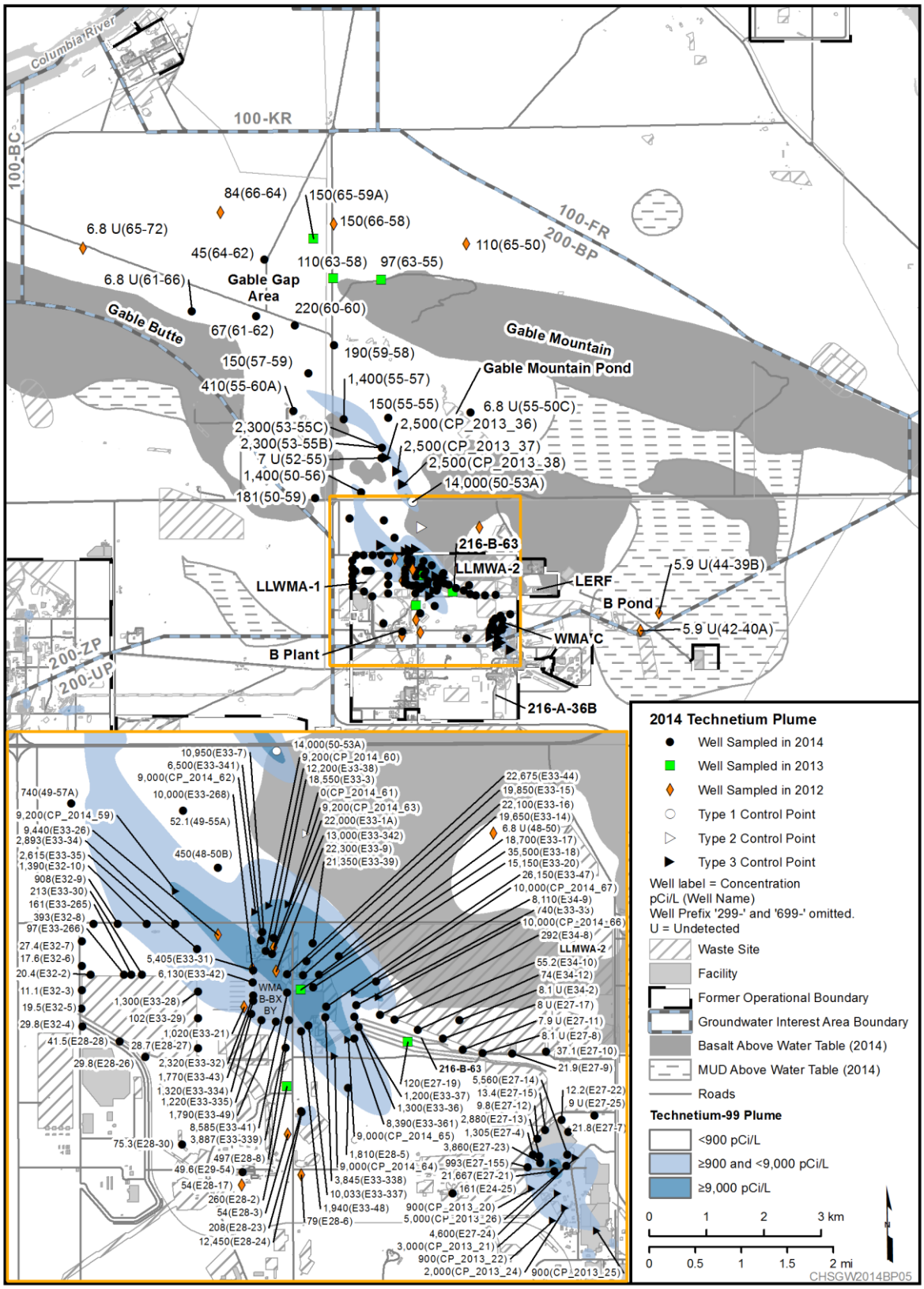


Figure 9-21. 200-BP Technetium-99 Plume, 2014

9.5.1 BY Cribs

Technetium-99 in 200-BP groundwater is primarily from liquid waste associated with the BY Cribs, which received a mean inventory of 128.6 Ci of technetium-99 (Appendix C of RPP-26744). Prior to the 2011 groundwater flow reversal, technetium-99 activity beneath the BY Cribs exceeded 30,000 pCi/L in all three wells located beneath the BY Cribs footprint (Figure 9-22). The increased activity was the result of minimal groundwater flow between 2006 and 2011 and continuous technetium-99 infiltration into the aquifer at an average activity of approximately 3.8 µCi/L based on RPP-26744. Since 2011, this concentrated technetium-99 plume has migrated and expanded to the southeast, as shown in Figure 9-23. Cyanide, technetium-99, and nitrate together define the signature of BY Crib scavenged waste contamination. Figure 9-24 shows a progression of peaks results of cyanide with time as a result of southeast migration. A peak cyanide concentration in 2009 beneath the BY Cribs at Well 299-E33-38 reached Well 299-E33-16 by early 2012 and Well 299-E33-20 by early 2014. However, technetium-99 is still increasing at Well 299-E33-20 (16,300 pCi/L) (Figure 9-25). The continued increase appears to be associated with contributions from the perched water horizon located approximately 3 m (9.8 ft) above the water table, as depicted in Figure 9-26. More discussion is provided in the Section 9.5.2.

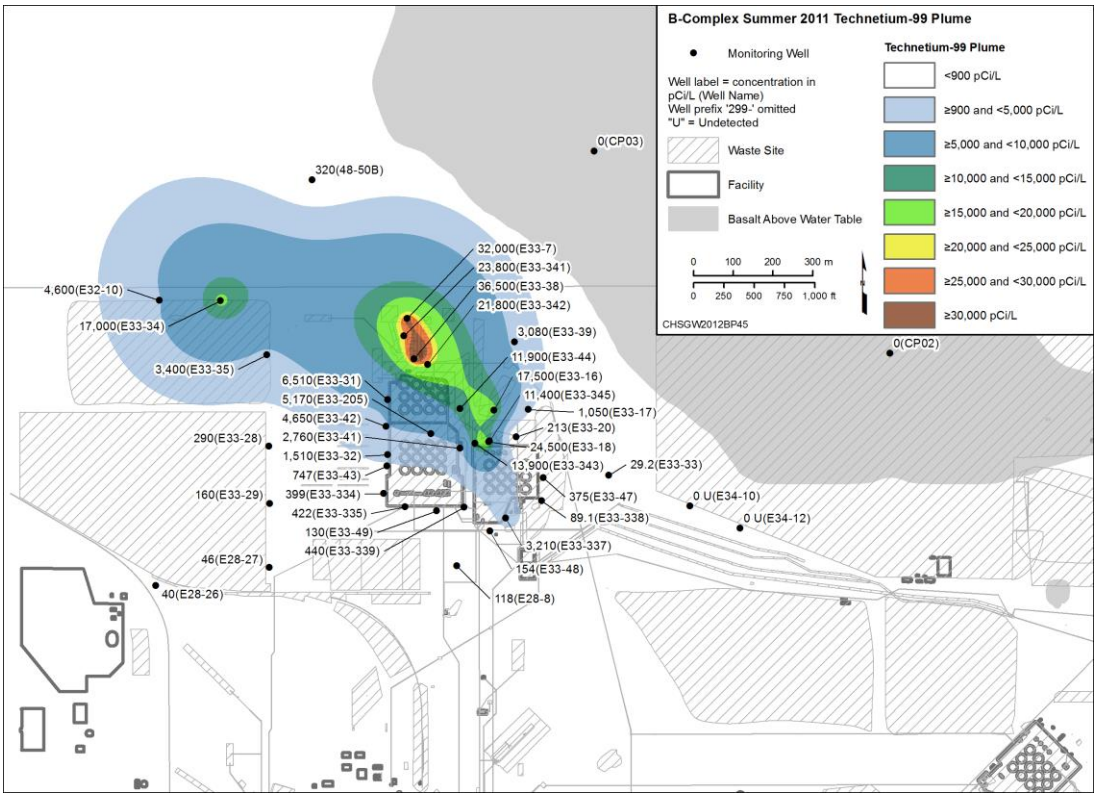


Figure 9-22. 200-BP Technetium-99 near BY Cribs, Summer 2011

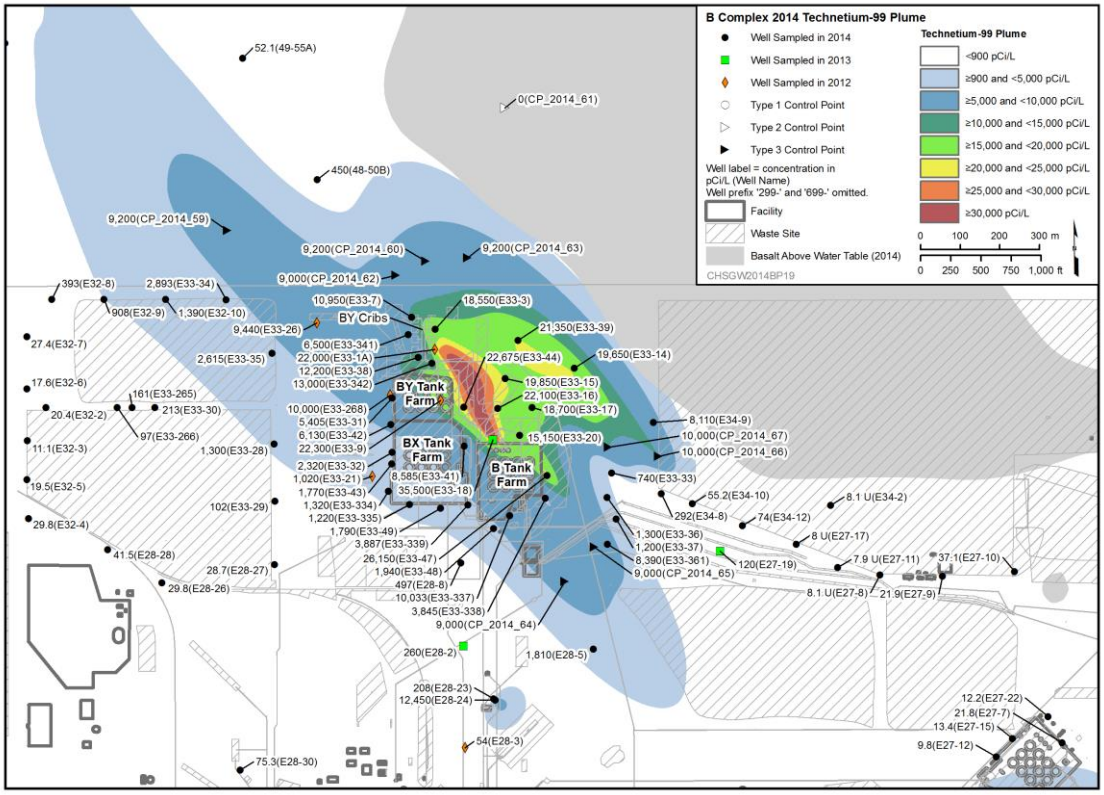


Figure 9-23. 200-BP Technetium-99 near BY Cribs, Summer 2014

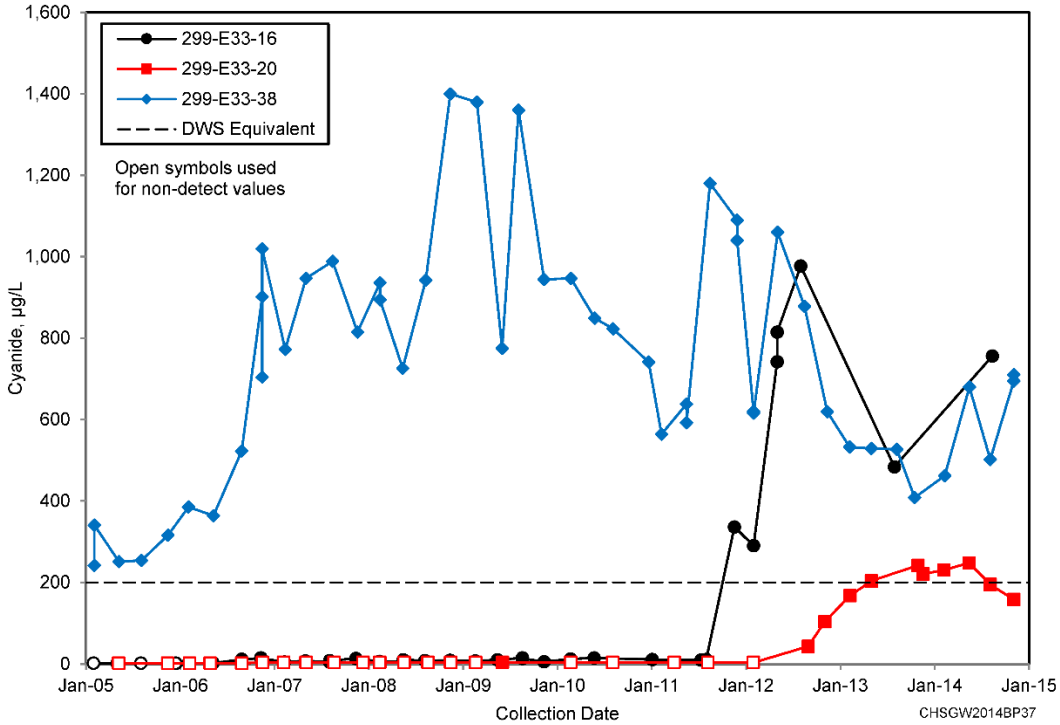


Figure 9-24. Trend Plot of Cyanide at Wells 299-E33-38, 299-E33-16, and 299-E33-20 Located Beneath the BY Cribs, 216-B-8 Crib, and Northwest Corner of the B Tank Farm, Respectively

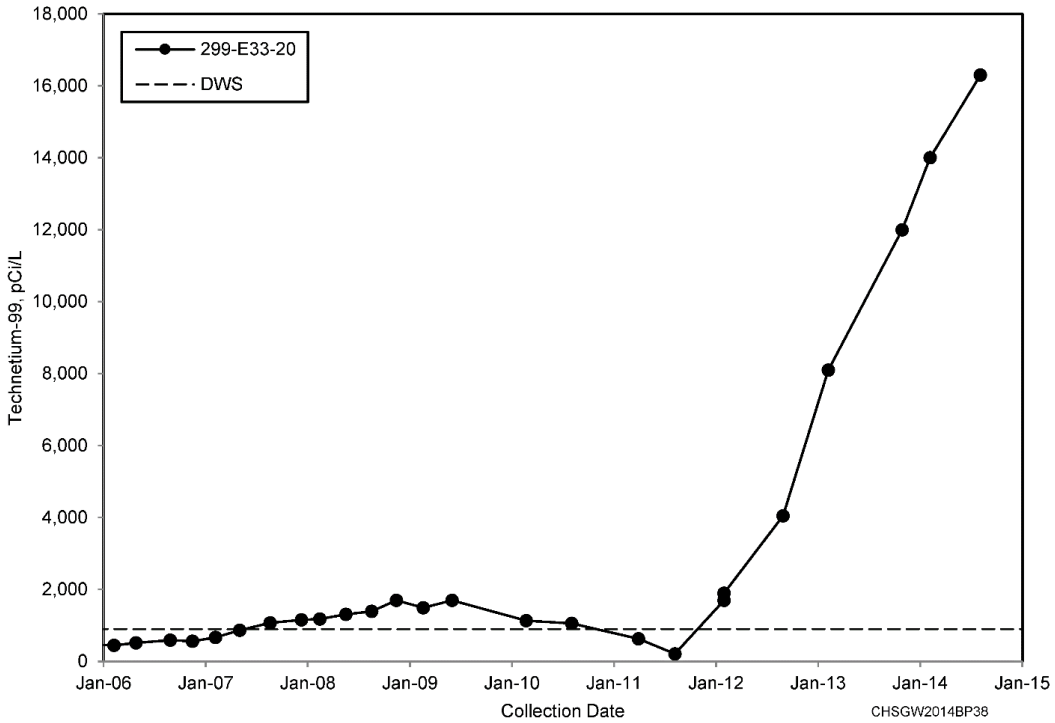


Figure 9-25. Trend Plot of Technetium-99 at Well 299-E33-20 Located Beneath Northwest Corner of the B Tank Farm

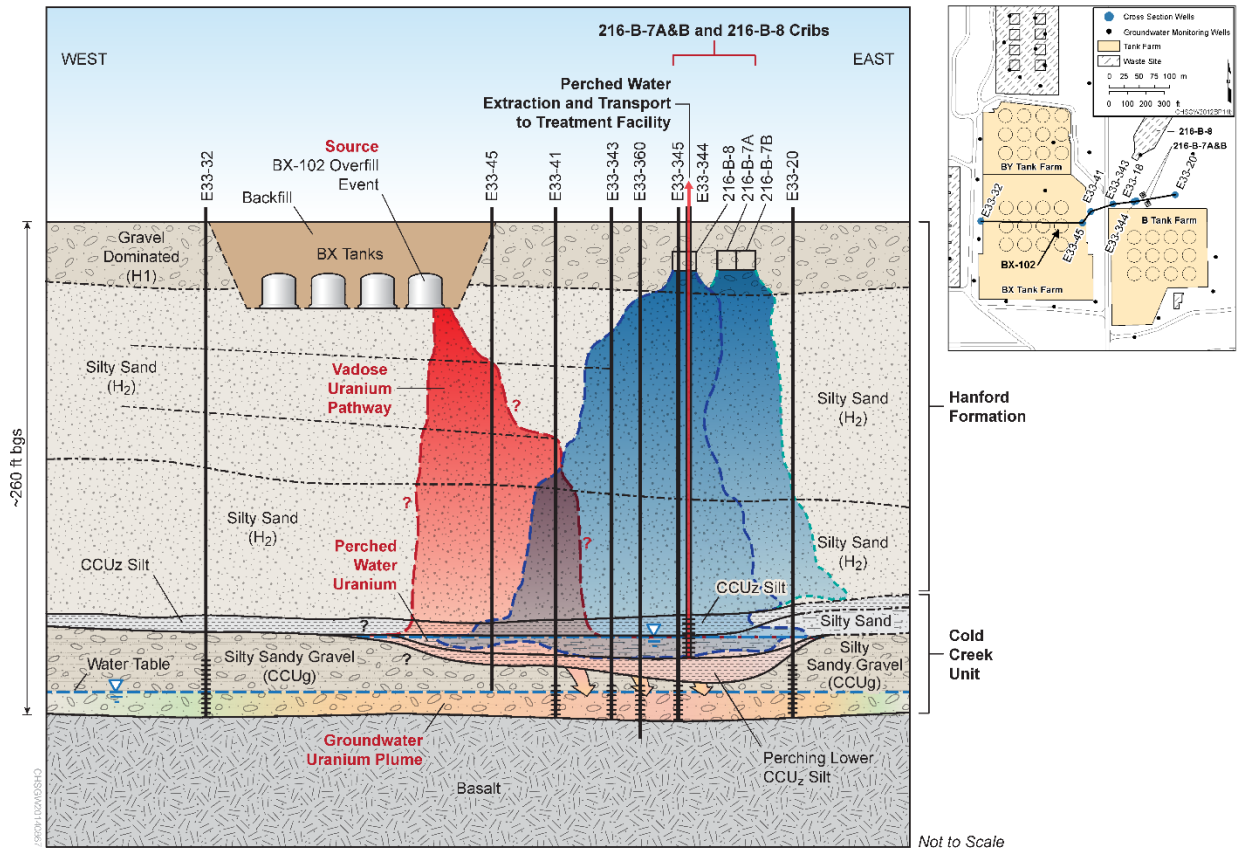


Figure 9-26. Conceptual Site Model of the Cold Creek Unit Perching Zone within the B Complex

During 2013 and 2014, technetium-99 rose significantly (to 12,500 pCi/L in 2014) at 299-E28-24, near the past 216-B-5 Injection Well (Figure 9-27). The presence of cyanide and nitrate indicate the plume is derived from liquid scavenged waste. It is uncertain if the source was the BY Cribs, 216-BX-42 Trench, the unplanned release at the B Tank Farm, or an unknown unplanned release near B Plant. The elevated technetium-99 is not detected in other wells in the area that are screened across the upper part of the aquifer (Figure 9-27). Well 299-E28-24 is unique, as it is perforated approximately 7.6 to 9.1 m (25 to 30 ft) below the water table. This suggests the plume may be density driven and the aquifer sediments may become less permeable below, creating a barrier to further downward migration. The 2014 sample results during drilling at Well 299-E33-361 found more concentrated contaminants near the basalt interface within the aquifer than higher up in the aquifer, and several of the contaminants were associated with liquid scavenged waste. Additional evidence of density associated with liquid scavenged waste is the elevated technetium-99 that migrated into the upper basalt-confined aquifer, the Rattlesnake Ridge interbed, in the past. This appears to have occurred in the 1950s at basalt-confined Well 299-E33-12 despite the presence of an upward hydraulic gradient. Technetium-99 is the only contaminant still exceeding the DWS in the confined well, with a 2014 activity of 1,000 pCi/L. However, technetium-99 is only 54 pCi/L at basalt-confined Well 299-E33-50, located 34 m (111.5 ft) to the south, and is less than detection at Well 299-E33-340, located 134 m (439.6 ft) to the north. Well 299-E33-12 was properly sealed in 1979, and technetium-99 results have trended down since (Figure 9-28).

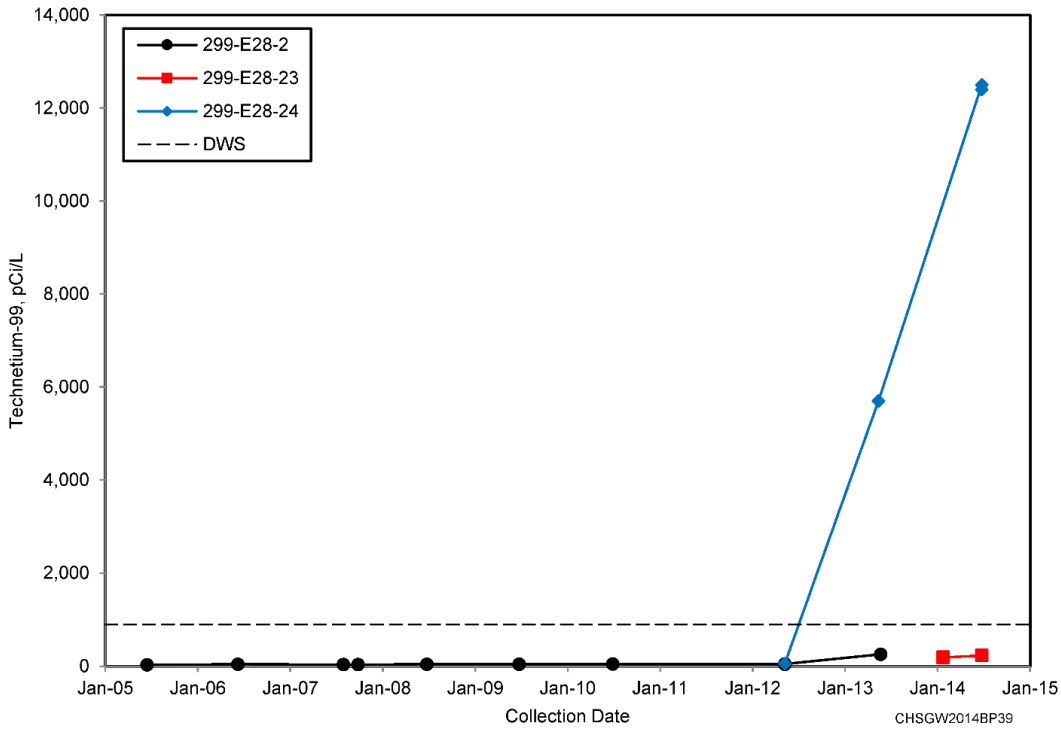


Figure 9-27. Trend Plot of Technetium-99 at Wells 299-E28-2, 299-E28-23, and 299-E28-24 Located near the Former 216-B-5 Injection Well

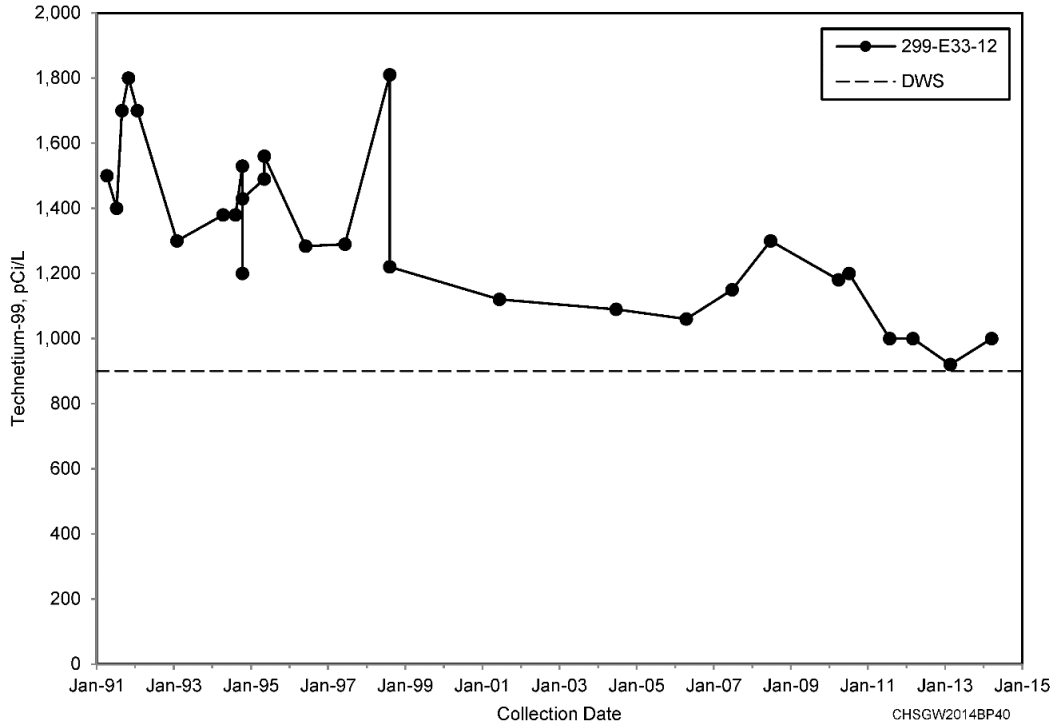


Figure 9-28. Trend Plot of Technetium-99 at Well 299-E33-12, Screened in the Rattlesnake Ridge Interbed near the BY Cribs

9.5.2 241-BX-102 Unplanned Release and 216-B-7A&B Cribs

The greatest 2014 technetium-99 activity in 200-BP groundwater occurred at Well 299-E33-345, with a maximum activity of 42,000 pCi/L. The ratio of technetium-99 to nitrate in groundwater is potentially useful for evaluating source contributions. The technetium-99 to nitrate ratio associated with this area indicates a potentially different source than the other high activity wells in this area, due to the greater technetium-99 activity and lower nitrate concentration (Figure 9-29). This is consistent with the type of waste released; metal waste from the 241-BX-102 Tank, which has a technetium-99 to nitrate ratio of approximately 600. By comparison, the technetium-99 to nitrate ratio in perched Well 299-E33-344 is lower than pure metal waste because of mixing with 216-B-7A&B waste, which had a technetium-99 to nitrate ratio below one until 1967, when the ratio was approximately 33. In addition, the technetium-99 to nitrate ratio at Wells 299-E33-18 and 299-E33-345 have generally been lower than Well 299-E33-344 since active pumping in the perched horizon began in 2011. However, the technetium-99 to nitrate ratio at Wells 299-E33-18 and 299-E33-345 continue to be higher than the other wells to the north and east, which reflect a scavenged waste signature of approximately 19. Some mixing of scavenged waste at Wells 299-E33-18 and 299-E33-345 is evident because of the cyanide presence.

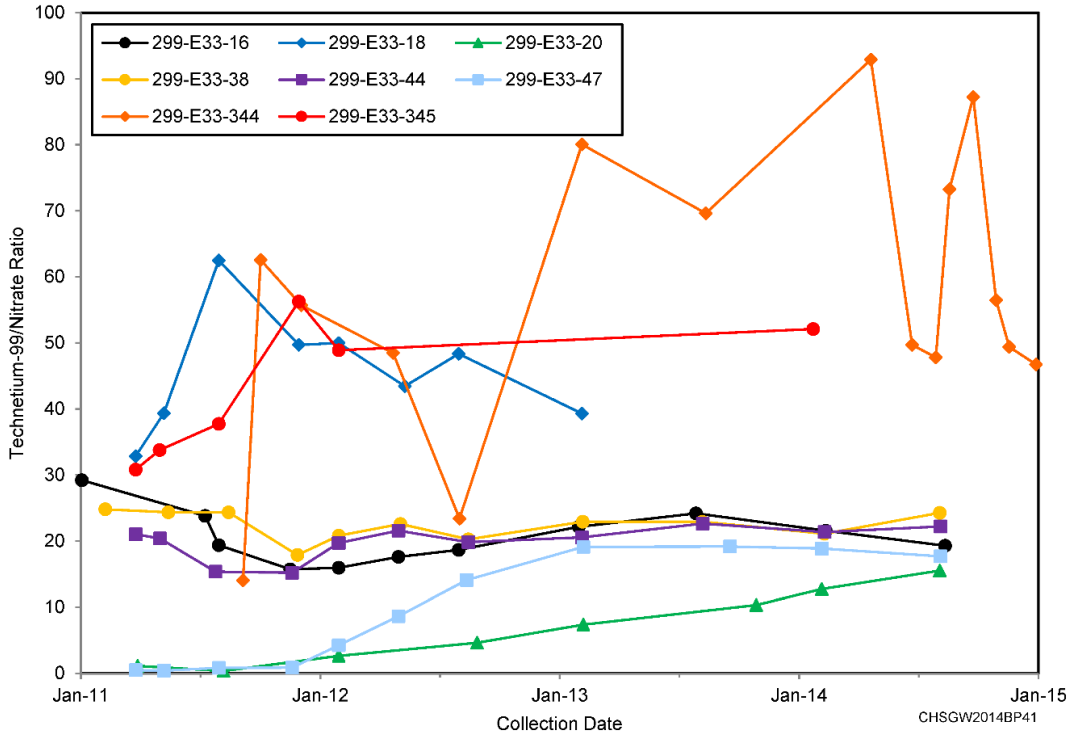


Figure 9-29. 200-BP Technetium-99 to Nitrate Ratio in Wells Associated with B Complex

In 2014, the total estimated technetium-99 removed from the perched horizon through extraction at Well 299-E33-344 was 0.01 Ci. The total removed dating from August 2011 through December 2014 was 0.03 Ci of technetium-99.

Technetium-99 levels continue to increase at Well 299-E33-337 on the south side of the B Tank Farm while they are leveling off at Well 299-E33-339 on the west side of the B Tank Farm (Figure 9-30). The technetium-99 to nitrate ratio at these wells also appears to diverge in 2014, where the ratio at Well 299-E33-337 is reflecting more of a perched horizon signature (Figure 9-31). Cyanide is also decreasing in Well 299-E33-339 compared to Well 299-E33-337 and appears to suggest a narrowing of the plume geometry.

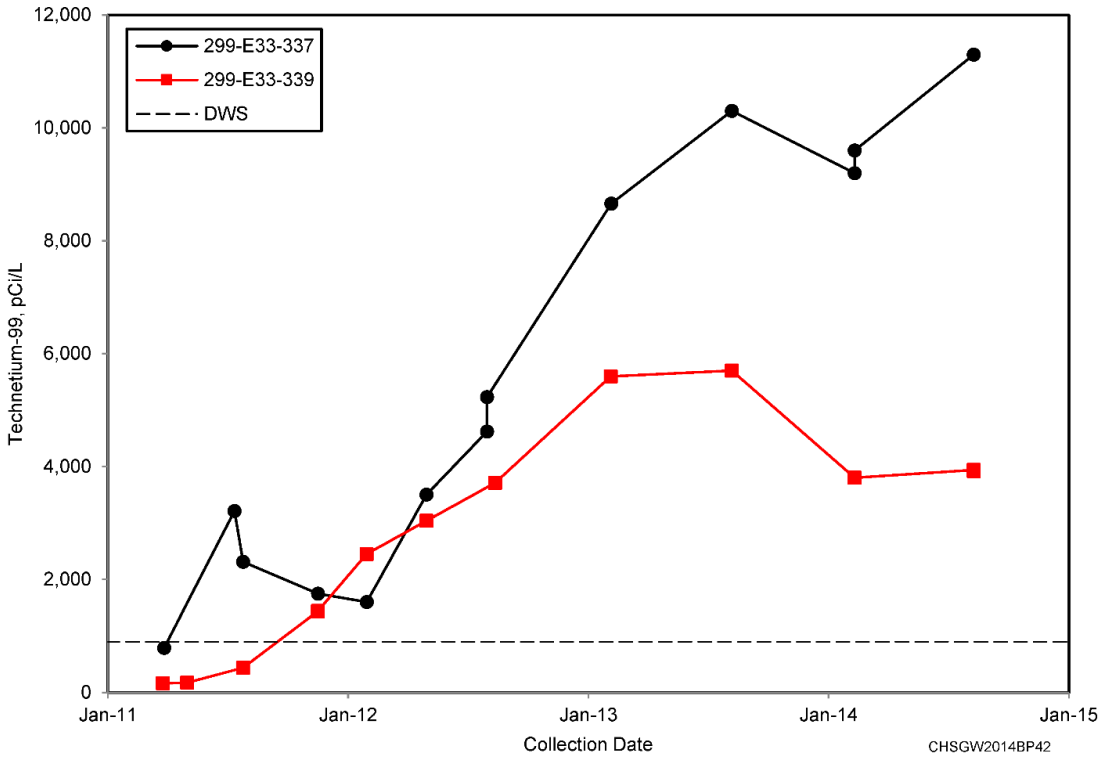


Figure 9-30. Trend Plot of Technetium-99 at Wells 299-E33-337 and 299-E33-339

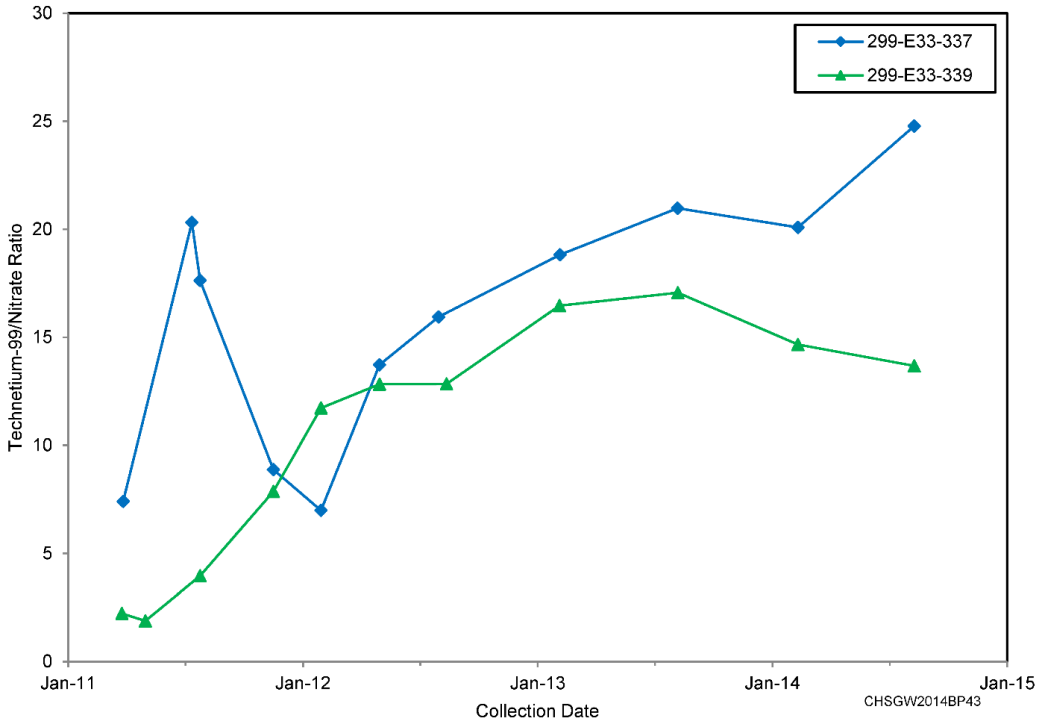


Figure 9-31. 200-BP Technetium-99 to Nitrate Ratio in Wells 299-E33-337 and 299-E33-339

9.5.3 B Tank Farm

A new contaminant source was identified in 2012 at the B Tank Farm, affecting two groundwater wells, 299-E33-47 and 299-E33-338 (Figure 9-23). Two observations at Well 299-E33-47 differentiate this plume from the upgradient 241-BX-102 Unplanned Release: (1) the technetium-99 to nitrate ratio, and (2) the increased presence of cyanide. The source is considered to be associated with a tributyl phosphate/scavenged waste release as discussed in DOE/RL-2012-53. Because this plume has expanded beyond the existing monitoring well network, Well 299-E33-361 was installed in 2014 to monitor the extent of contamination. An additional well further to the southeast is planned in 2016.

9.5.4 Waste Management Area C

In 2014, the same seven WMA C monitoring wells as in 2012 and 2013 exceeded the 900 pCi/L DWS for technetium-99 (Figure 9-32). However, activity is trending down in Well 299-E27-23, which had the greatest activity of all WMA C wells for 6 years; 2006 through 2012. Contrastingly, the technetium-99 activity at Well 299-E27-21 continues to increase reaching a peak concentration in December 2014 at 23,800 pCi/L. This is currently the highest technetium-99 activity recorded at WMA C. Just east of Well 299-E27-21 the activity level at Well 299-E27-14 is decreasing and, as of December 2014, was 4,590 pCi/L. A similar value, 4,810 pCi/L, is reported near the bottom of the aquifer at Well 299-E27-24. The technetium-99 to nitrate ratio in Wells 299-E27-21 and 299-E27-23 indicate a different source than in Wells 299-E27-14 and 299-E27-24. Further discussion of the contamination in these wells is provided in *WMA C October through December 2013 Quarterly Groundwater Monitoring Report*, SGW-56777.

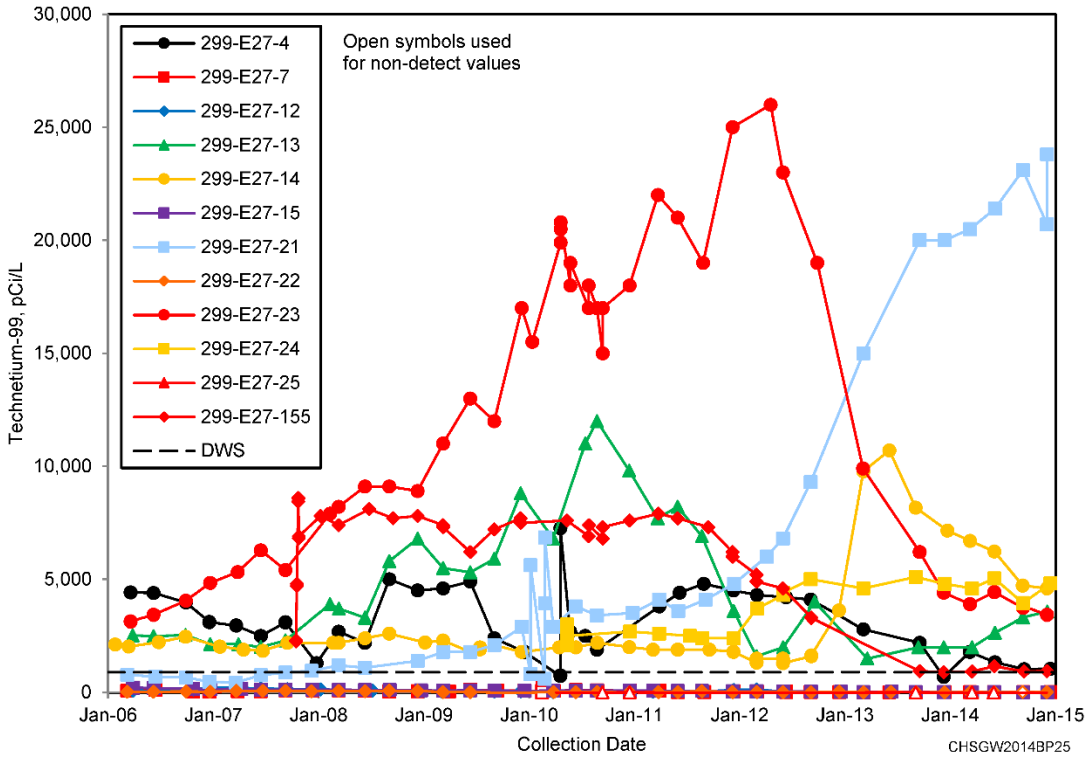


Figure 9-32. 200-BP Technetium-99 Data for Wells Bounding WMA C

9.5.5 Gable Gap

Prior to termination of discharges to Gable Mountain Pond, technetium-99 from the BY Cribs migrated north toward Well 699-50-53A creating a significant plume as depicted in Figure 1.3 of DOE/RL-95-59. Since the termination of discharges to Gable Mountain Pond, technetium-99 migrated north-northwest as depicted in Figure 5-30 of DOE/RL-95-59. Since 2010, activity at Well 699-53-55C has decreased. Activity has also decreased slowly at Well 699-55-57 since monitoring began in 1991. Activity has been relative unchanged at Well 699-57-59 since 2009; however, activity has risen at Well 699-55-60A. Thus, the nose of the technetium-99 plume geometry is portrayed to be contracting to the northwest and migrating westward from Wells 699-55-57 to 699-55-60A in this area.

9.6 Uranium

Uranium found in 200-BP groundwater primarily originated from large disposal inventories to the 216-B-12 Crib and the 241-BX-102 Unplanned Release (Figure 9-33). The uranium inventory disposed to these sites exceeded 10,000 kg, which is at least an order of magnitude greater than other waste sites overlying 200-BP.

9.6.1 216-BX-102 Unplanned Release

Rough order of magnitude calculations indicated that 1,050 kg of water extractable uranium may reside in the Cold Creek silt-dominated unit approximately 3 m (10 ft) above the aquifer (Figure 9-34). The estimate was based on sample results from three boreholes in an east west orientation within the perched water zone. To address the groundwater impact associated with contaminant migration from the perching horizon, DOE initiated a perched water treatability test in August 2011. Approximately 53 kg of uranium has been removed within this horizon through December 2014.

Well 299-E33-345 had the greatest uranium concentration in the unconfined aquifer in 2014 (4,030 µg/L) in 200-BP, part of a steeply increasing trend (Figure 9-35). This well is located 39 m (128 ft) east of Well 299-E33-343, which had the greatest groundwater uranium results from 2008 to 2011 (Figure 9-35). The maximum result at Well 299-E33-343 was 5,500 µg/L in June 2009. The migration of the high-concentration portion of this plume is attributed to the groundwater flow direction change from the northwest to the southeast. The results of this flow change are seen by comparing the spatial distribution of the uranium plume from summer 2011 (Figure 9-36), when the flow change was initiated, and 2014 plume (Figure 9-33). Continued southeast migration of the uranium plume beneath the B and BX Tank Farms has extended beyond existing monitoring wells as seen in Figure 9-33. As a result, a new well (299-E33-361) was drilled in 2014 to monitor the extent of uranium. An additional well further to the southeast is planned in 2016.

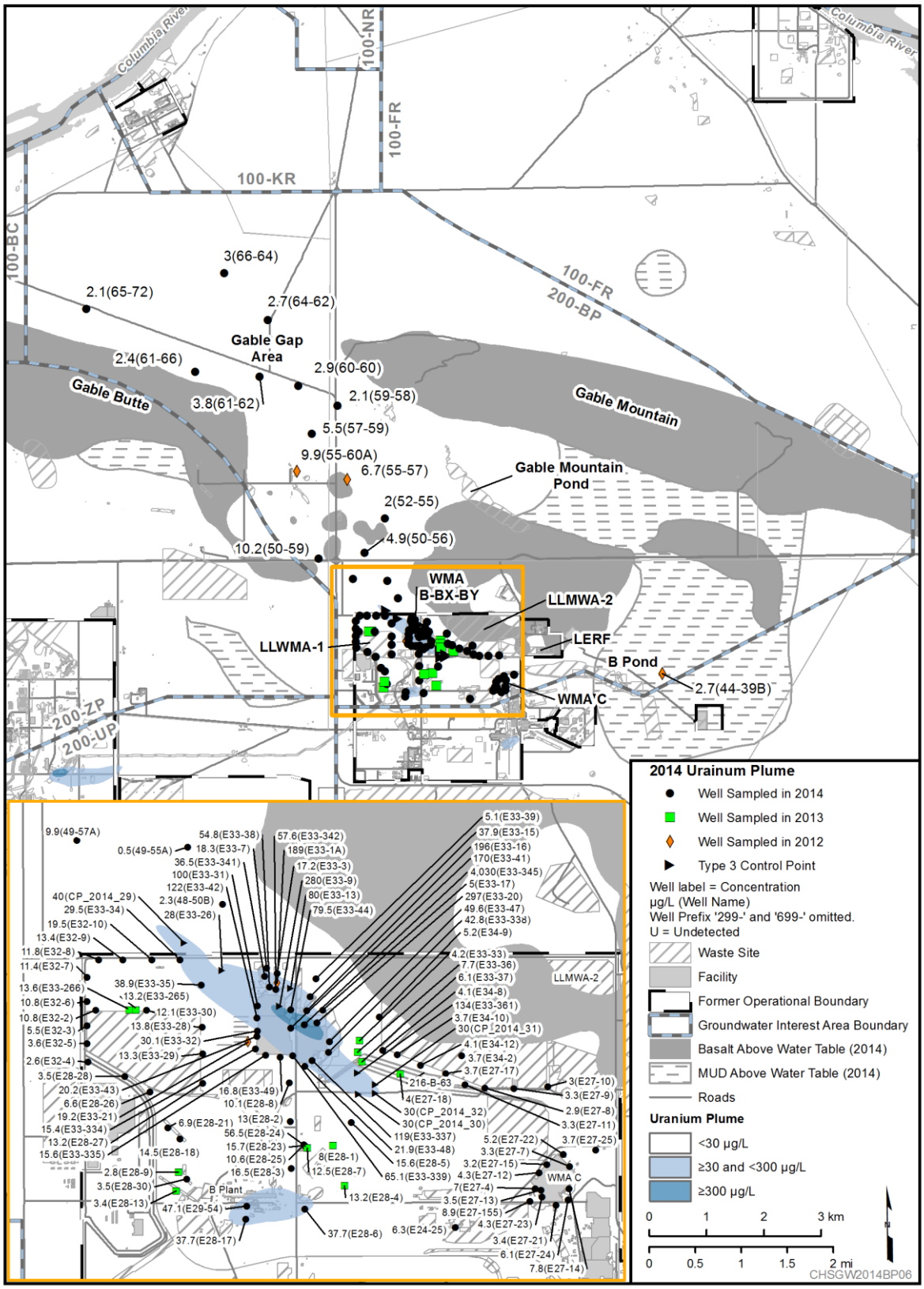


Figure 9-33. 200-BP Uranium Plume, 2014

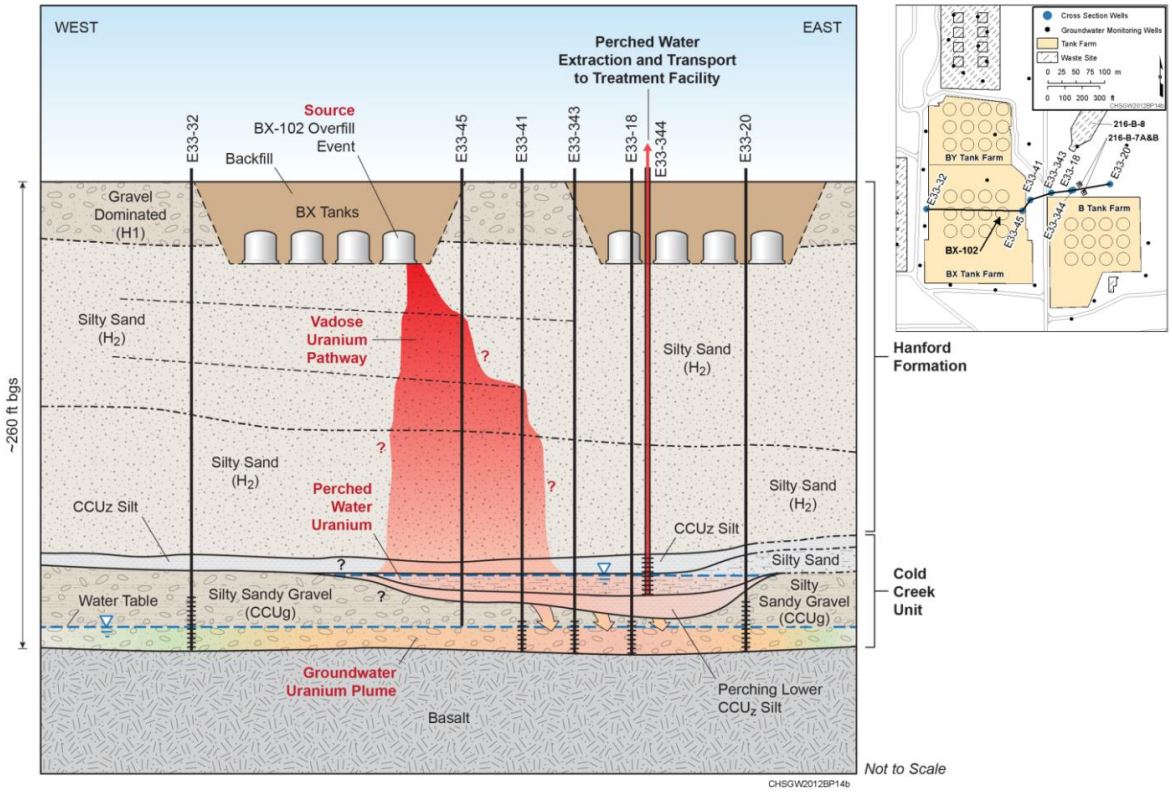


Figure 9-34. Uranium Conceptual Site Model for 216-BX-102 Unplanned Release

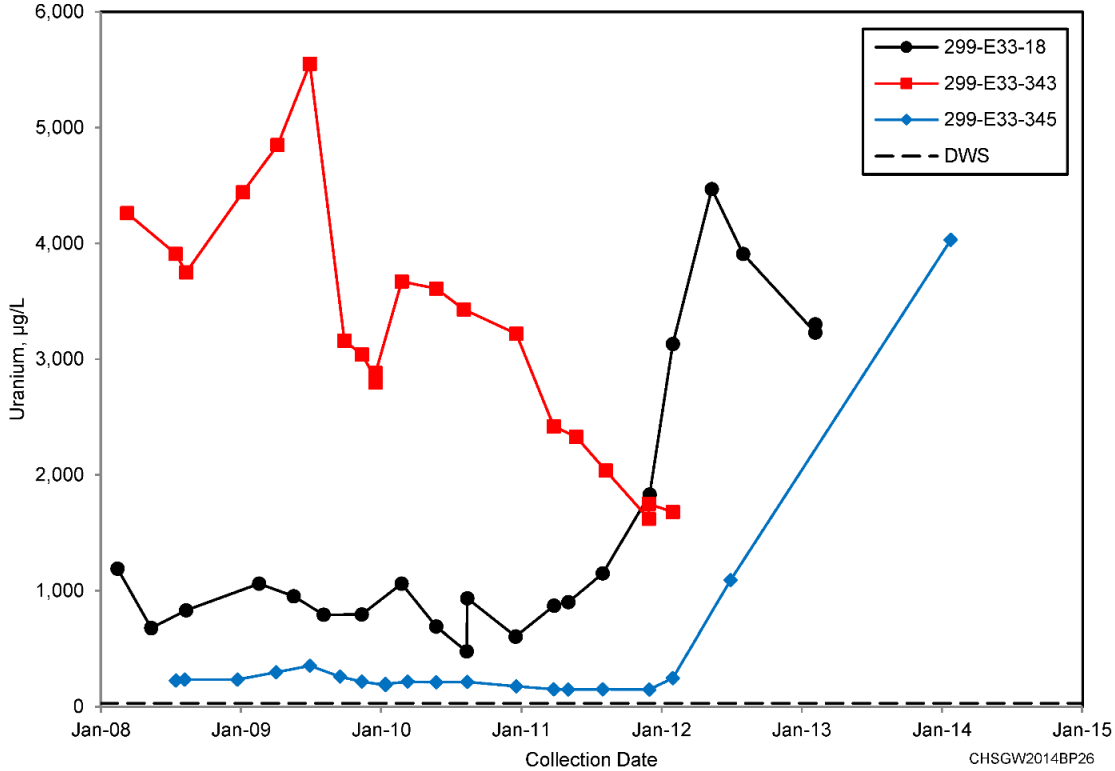


Figure 9-35. 200-BP Uranium in Wells 299-E33-18, 299-E33-343, and 299-E33-345

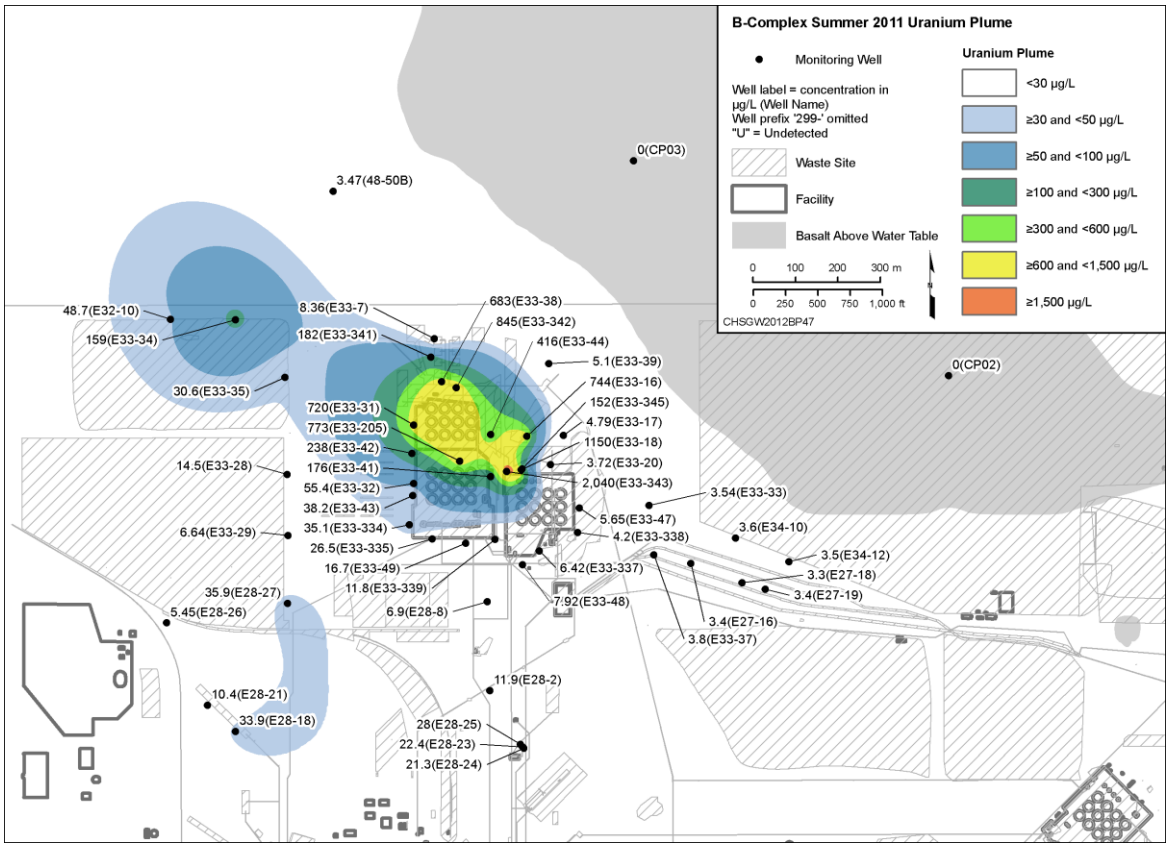


Figure 9-36. 200-BP Uranium near WMA B-BX, Summer 2011

9.6.2 216-B-12 Crib

A southern uranium plume defined by Wells 299-E28-6, 299-E28-17, and 299-E29-54 is considered to be sourced by the 216-B-12 Crib. The 216-B-12 Crib source is also considered to be associated with past elevated uranium near Well 299-E28-18, as discussed further in DOE/RL-2011-01. The extent of the uranium plume is uncertain due to the relatively low number of wells in this area, but is believed to be defined to the east by Wells 299-E28-2, 299-E28-3, and 299-E28-24 (Figure 9-33). Uranium near the 216-B-12 Crib has been detected deeper in the unconfined aquifer. During drilling of Wells 299-E28-30, the highest concentration of uranium was detected approximately 8 m (26 ft) below the water table. The current monitoring wells in the vicinity of the 216-B-12 Crib are screened above a depth of 8 m (26 ft) below the water table, or only partially screened in the interval where the highest concentrations were detected. Therefore, to better assess the horizontal and vertical extent of the deeper unconfined uranium concentrations, two wells are planned for drilling in 2015 (Figure 9-10). The well screens will be set based on the highest nitrate concentrations from samples collected during drilling, which are expected to be at the same intervals as the previous RI nitrate results associated with Well 299-E28-30.

9.7 Strontium-90

Strontium-90 exceeding the DWS is only found at two locations in 200-BP, the former Gable Mountain Pond (inactive and dry since the mid- to late 1980s) and the 216-B-5 Injection Well (Figure 9-37). Strontium-90 tends to bind to vadose zone sediments, so it only reached groundwater at locations where the vadose zone is relatively thin (e.g., at Gable Mountain Pond where the vadose zone thickness is less than 12 m [39 ft] thick), or where waste was injected into the aquifer (216-B-5 Injection Well).

9.7.1 Gable Mountain Pond

The areal extent of strontium-90 activity exceeding DWS closely outlines the area of the former pond, with activity diminishing to the west as the aquifer increases in thickness. The greatest historical strontium-90 activity reported at Gable Mountain Pond has been at Well 699-53-47A (beneath the southeastern portion of the once active pond). The activity at this well has steadily decreased from 1,320 pCi/L in 1997 to 200 pCi/L in 2013. Well 699-53-47A is perforated at the top of the aquifer. Because of decreasing water levels, difficulty collecting the 2013 sample, and confirmation of the conditions in the well via video survey, Well 699-53-47A was declared sample dry and was not scheduled for sampling in 2014. However, Well 699-53-47B, located adjacent to Well 699-53-47A, is perforated across the 2 m (6.6 ft) thick aquifer and was sampled in 2014 as a replacement for Well 699-53-47A. The results at Well 699-53-47B have also decreased over time, but less dramatically over the last decade than in Well 699-53-47A (Figure 9-38). Three other wells (699-53-48A, 699-54-49, and 699-55-50C) were sampled in 2014 at Gable Mountain Pond. Results at two of these wells (699-53-48A and 699-55-50C) were on trend with historical results; however, activity at Well 699-54-49 decreased dramatically and does not agree with the gross beta result. The sample result for Well 699-54-49 is a suspected error and the well will be resampled in 2015. The 2014 result was excluded from the plume map (Figure 9-37). As with past results, Well 699-55-50C located to northwest of Gable Mountain Pond, contains no detectable strontium-90.

9.7.2 216-B-5 Injection Well

Strontium-90 has relatively low mobility in the subsurface and does not migrate significant distances within the aquifer. Based on comparisons between Figure 1.4 of DOE/RL-95-59 and Map BP.7 in DOE/RL-2013-22, the plume exceeding DWS grew to the northwest from the mid-1990s to 2012. Wells northwest of Well 299-E28-2 had few strontium-90 detections over the past two decades. Out of 210 samples collected between 1986 and 2012, strontium-90 was detected only 11 times. The detection results ranged between 0.372 and 2.2 pCi/L, which are below the 8 pCi/L DWS. The relatively small number of detections and low activities detected indicates that the strontium-90 has not migrated significant distances from the 216-B Injection Well to the northwest and is less mobile than modeled in DOE/RL-95-59.

Since the 2011 flow reversal, strontium-90 activity had increased at Well 299-E28-24, located 5 m (16.4 ft) southeast of the 216-B-5 Injection Well, from 180 pCi/L in 2012 to 880 pCi/L in 2013 (Figure 9-39). In 2014, strontium-90 at Well 299-E28-24 decreased to 786 pCi/L. Two additional wells were added to evaluate the extent of strontium-90 southeast migration (299-E28-4 and 299-E28-7). Well 299-E28-7, located 12 m (39 ft) southeast of Well 299-E28-24, was analyzed with 540 pCi/L of strontium-90 in 2013 and 527 pCi/L in 2014 (Figure 9-39). No strontium-90 was detected at other wells to the east and southeast (e.g., 299-E28-1 and 299-E28-4, respectively). Conversely, strontium-90 levels at wells to the northwest (299-E28-2 and 299-E28-25) have decreased since the flow reversal. The highest concentration of strontium-90 detected in 2014 within 200-BP was at a concentration of 1,100 pCi/L in Well 299-E28-23 (Figure 9-37). Concentrations of strontium-90 have been descreasing in this well since 2001.

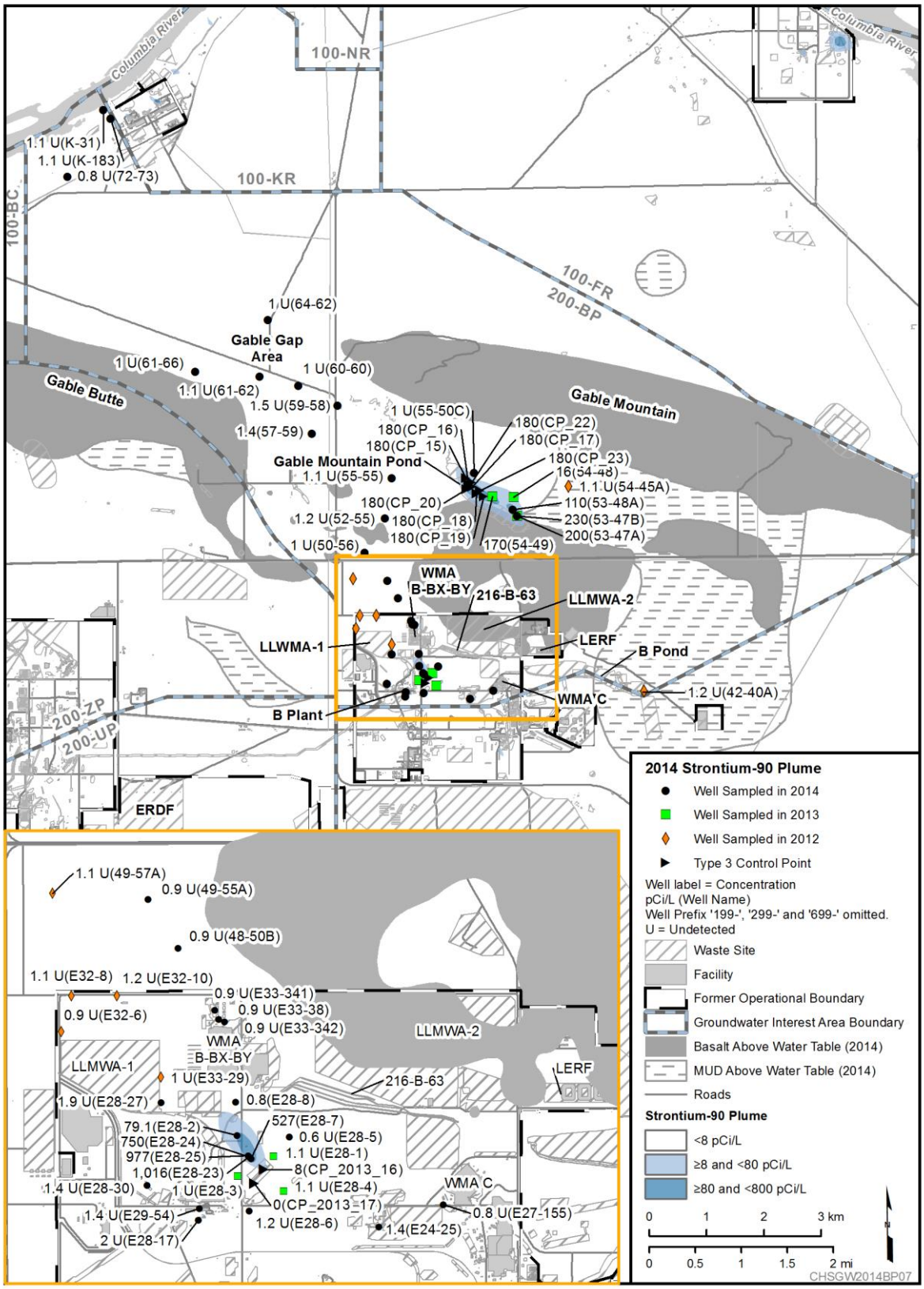


Figure 9-37. 200-BP Strontium-90 Plume, 2014

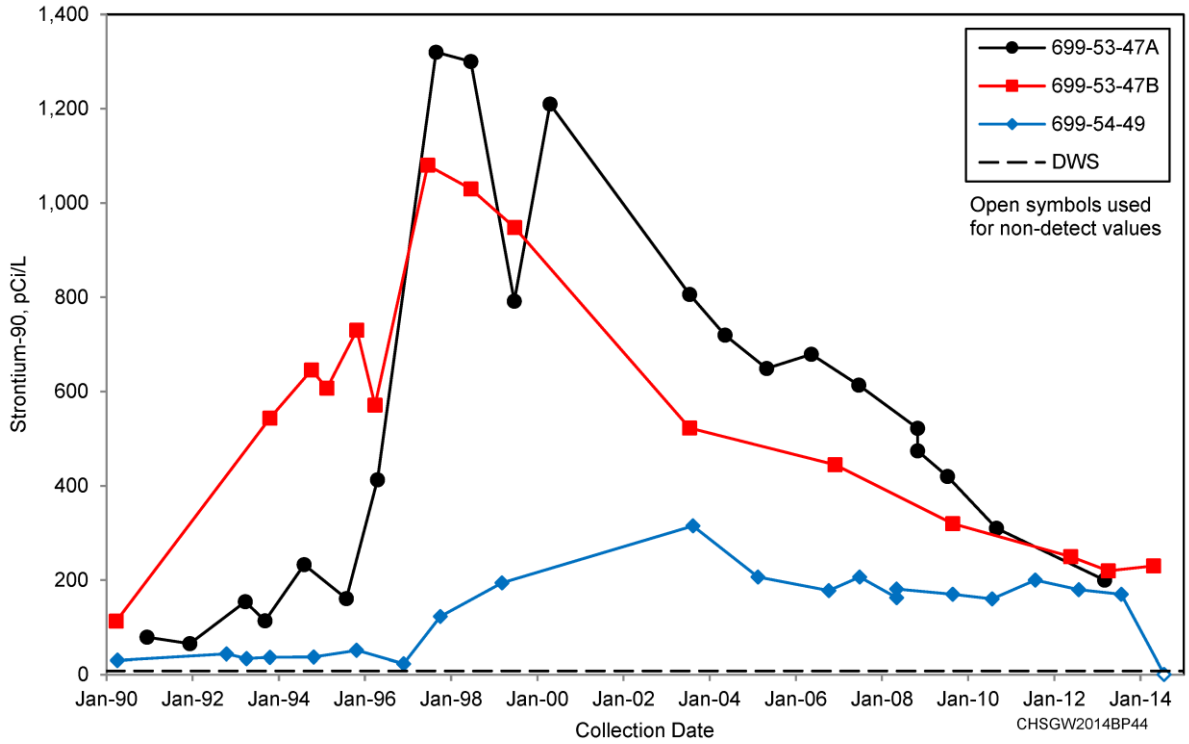


Figure 9-38. Trend Plots of Strontium-90 at Wells 699-53-47A, 699-53-47B, and 699-54-49

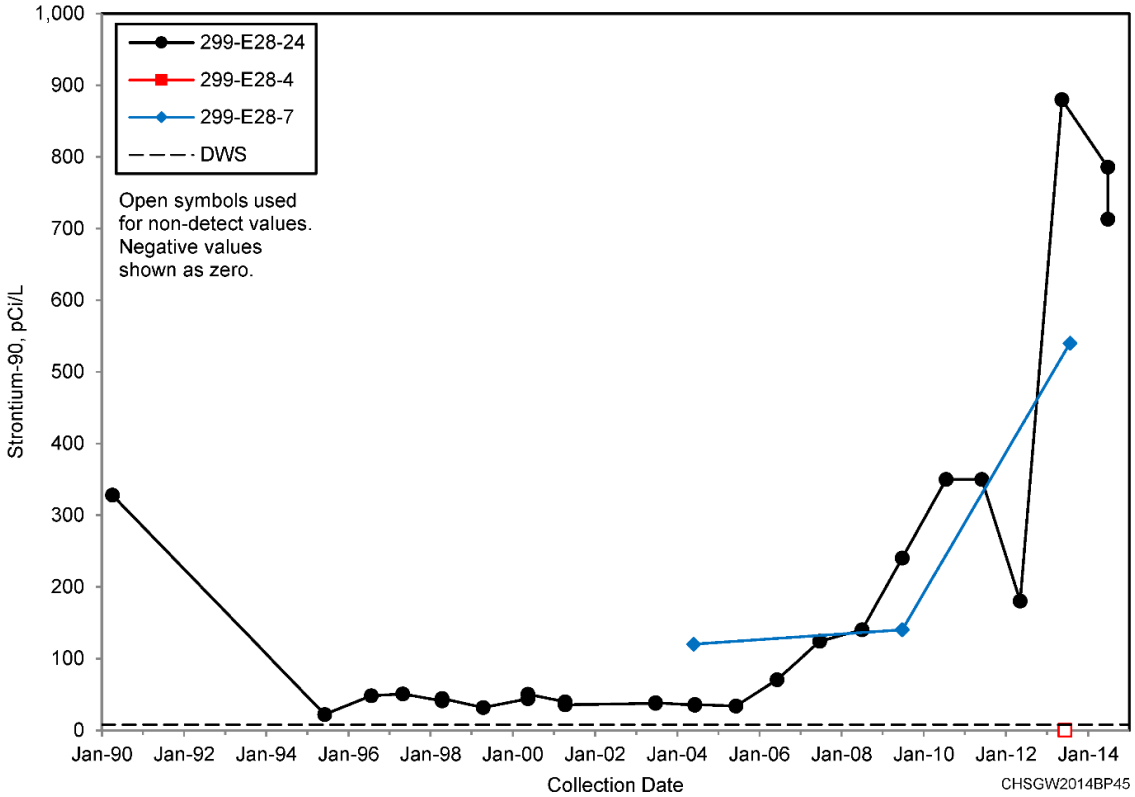


Figure 9-39. Trend Plots of Strontium-90 at Wells 299-E28-4, 299-E28-7, and 299-E28-24

9.8 Cyanide

Cyanide found in 200-BP groundwater originated from disposal of tributyl phosphate wastes scavenged for cesium-137. After scavenging was completed, the tank supernatant, including the remaining dissolved ferrocyanide compounds, was discharged to the BY Cribs. In the late 1990s, cyanide concentrations began to increase in the groundwater beneath the BY Cribs, along with nitrate and technetium-99. In addition, low concentrations of cyanide detected in the vicinity of WMA C are attributed to historical releases of ferrocyanide-containing waste at that facility, discussed further in Section 9.10.2.

9.8.1 BY Cribs

The distribution of cyanide above the 200 µg/L DWS extends both northwest and southeast from the BY Cribs (Figure 9-40). The plume configuration has contracted from the northwest and expanded to the southeast since the groundwater flow reversed from northwest to the southeast in 2011, as seen with the other co-contaminants (e.g., nitrate and technetium-99) in the same area.

The maximum 2014 cyanide concentration from the BY Crib source was at Well 299-E33-3 (1,470 µg/L), located beneath the northeast part of the BY Cribs (Figures 9-40 and 9-41). The cyanide concentration in this well appears to have increased in response to slowing of the groundwater flow rate and continued infiltration from the vadose zone. The flow rate change has been attributed to TEDF discharges as described in DOE/RL-2011-01 and most recently in SGW-58561, *WMA C October through December 2014 Quarterly Groundwater Monitoring Report*. Other wells to the southeast of the BY Cribs (299-E33-15 and 299-E33-16) showed an increase in August 2014, but most likely the increase was associated with migration of secondary peak slug as displayed in the July 2013 trend plot for Well 299-E33-3 (Figure 9-41).

Cyanide, a co-contaminant with the technetium-99 and nitrate and together defines the signature of BY Crib scavenged waste contamination, appears to have peaked in May 2014 at Well 299-E33-20 (Figure 9-24). The cyanide trend plots in Figure 9-24 depict peak contamination beneath the BY Cribs in 2008 and 2009, the initial peak arrival at Well 299-E33-16 in 2012 and the initial peak arrival at Well 299-E33-20 in May 2014. The lower cyanide concentrations in wells to the west of Well 299-E33-20 indicated diluting affects from the perched water horizon located approximately 3 m (10 ft) above the water table, which is currently without cyanide.

9.8.2 241-B Tank Farm

One other well (299-E33-47) located in the B Complex has also had very high cyanide concentrations. The maximum 2014 concentration in this well (1,600 µg/L) was greater than any other well in 200-BP. As discussed in DOE/RL-2012-53, this high-concentration area is associated with a release in the B Tank Farm. Continued southeast migration of this cyanide plume was extending beyond existing monitoring wells; therefore, Well 299-E33-361 was installed in 2014 to monitor the expanding extent (Figure 9-10). Results from this well during drilling (91.4 and 280 µg/L) were higher near the basalt interface than higher in the aquifer. The higher result was used to depict the extent of cyanide in this area (Figure 9-40).

9.8.3 Gable Gap

Cyanide concentrations to the north, near Gable Gap, have decreased in recent years. The greatest cyanide concentration associated with this plume is at Well 699-53-55C. Concentrations have decreased at this well from 195 µg/L in 2009 to 137 µg/L in 2013, and increased slightly to 146 µg/L in 2014. Concentrations in nearby wells have also been trending down but saw slight increases in 2014. None of the wells have exceeded the DWS in this area, and it is recommended that monitoring be reduced to just Well 699-53-55C.

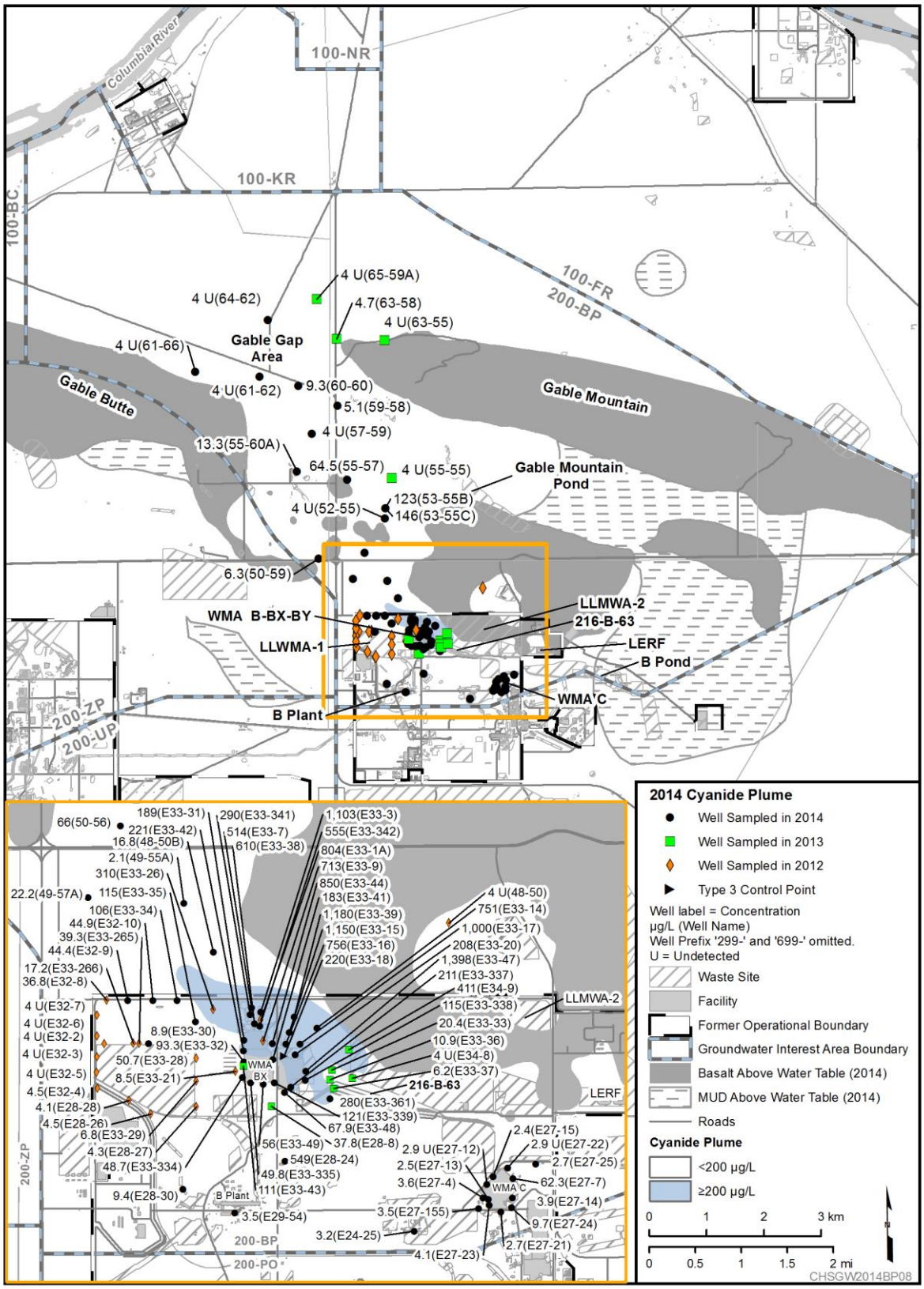


Figure 9-40. 200-BP Cyanide Plume, 2014

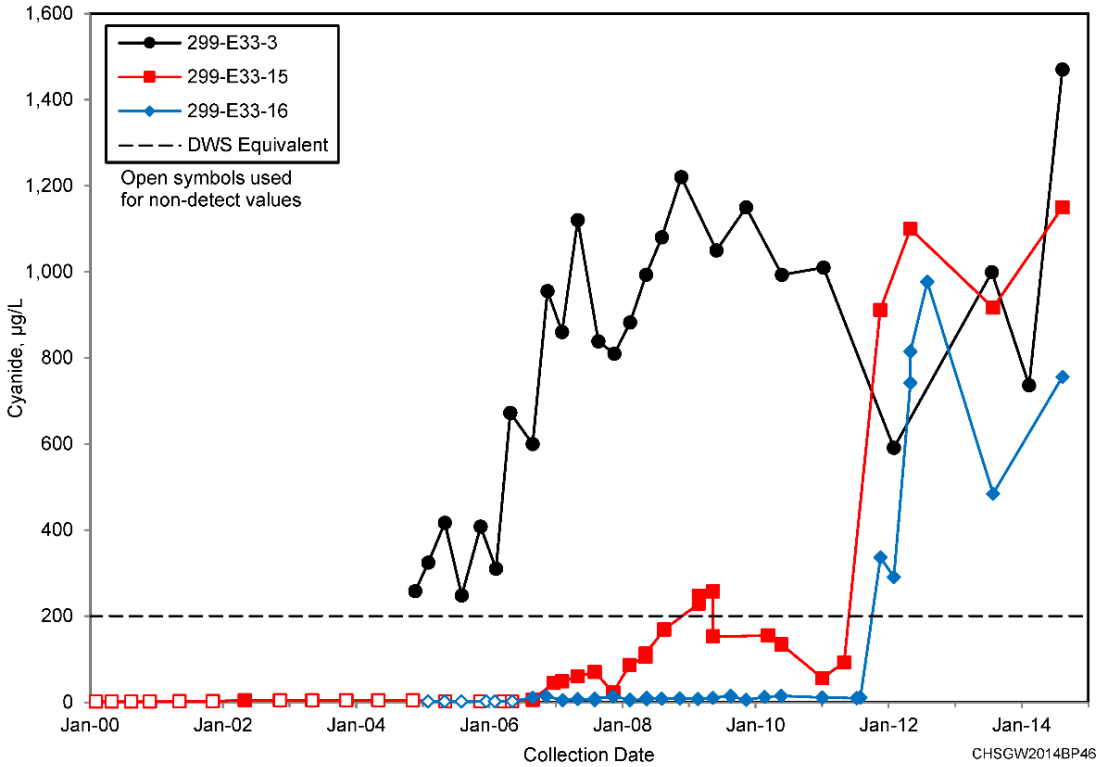


Figure 9-41. 200-BP Trend Plots for Wells 299-E33-3, 299-E33-15, and 299-E33-16

9.9 Tritium

The size of the tritium plume in the upper part of the unconfined aquifer within 200-BP has decreased since 2003. The decline is attributed with radioactive decay, dispersion, and possibly diminishing levels of drainage from the vadose zone at certain locations. In 2014, tritium results exceeding DWS were detected at four locations: beneath the 216-B-50 and 216-B-57 Cribs (located in the B Complex), beneath the B Tank Farm, and beneath the former 216-B-3 Pond (Figure 9-42). The greatest activity measured in 2014 was beneath the former 216-B-3 Pond. Another location which exhibited greater activity during depth discrete sampling in 2010 is near the 216-B-12 Crib and B Plant. This location is discussed although not portrayed in Figure 9-42 because current wells do not extend to depth to record the elevated activity at these locations. Two new wells are being drilled in this area in 2015 to depict the extent of the tritium at depth (Figure 9-10).

9.9.1 216-B-50 and 216-B-57 Cribs

Past tritium found in B Complex above DWS originated primarily from large inventories disposed to the 216-B-50 and 216-B-57 Cribs from the mid- to late 1960s to the early to mid-1970s. The 216-B-50 Crib received approximately 126.3 Ci and 216-B-57 Crib received approximately 194.6 Ci. The inventories received by the 216-B-50 and 216-B-57 Cribs was over 100 Ci of tritium more than most of the other site inventories in this area (RPP-26744). These sources are considered to be continuing to drain into the aquifer today. Due to the groundwater flow reversal in this area and wells not being sampled in the tank farms, only one well exceeded DWS in 2014 near these sites (299-E33-3) at 22,500 pCi/L (Figure 9-42). Overall, the tritium plume near the 216-B-50 and 216-B-57 Cribs continues to decrease in size and activity levels. It is recommended that the monitoring at these sites be reduced.

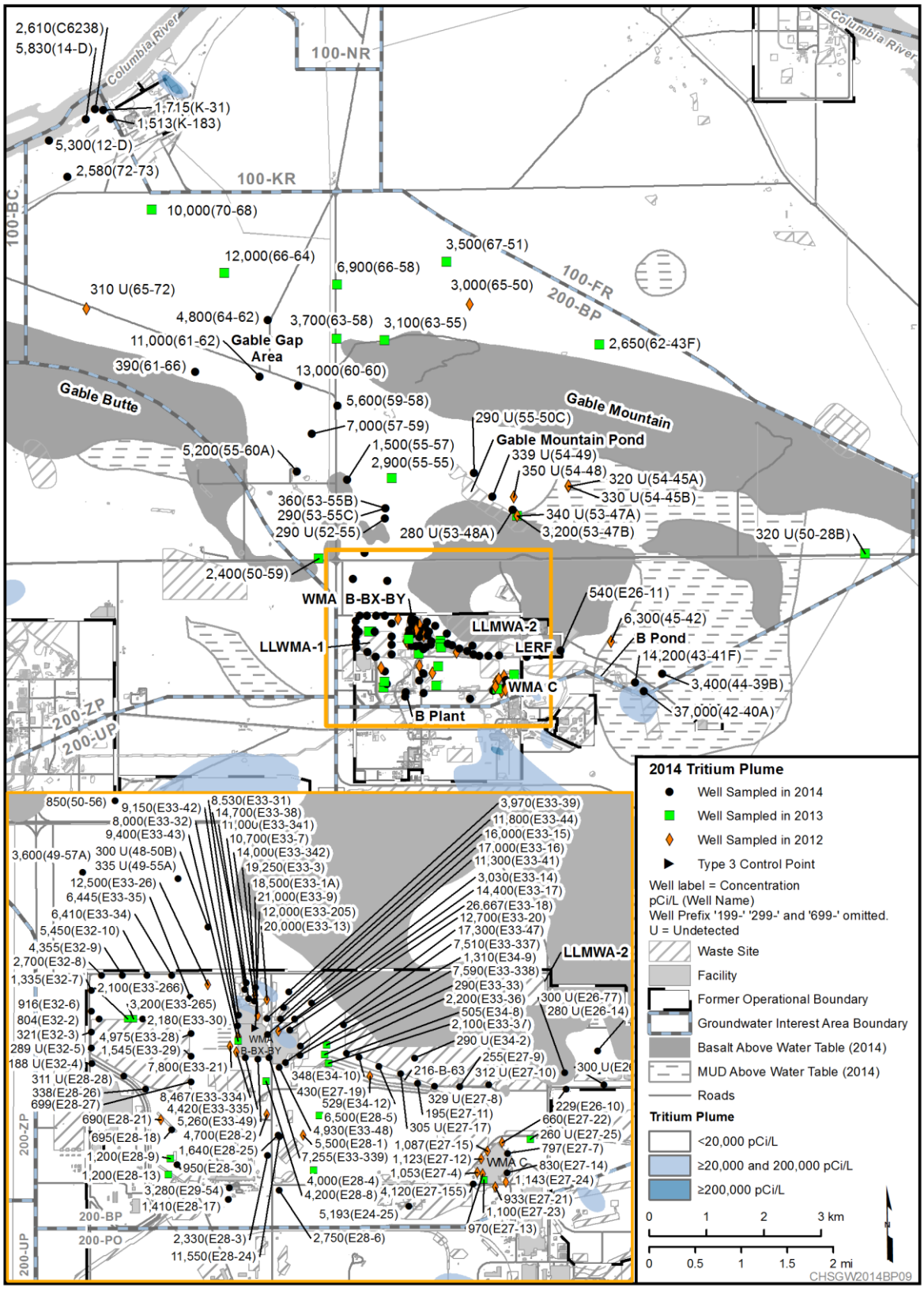


Figure 9-42. 200-BP Tritium Plume, 2014

9.9.2 216-BX-102 Unplanned Releas

The tritium activity from Tank 241-BX-102 was monitored in 2014 at Wells 299-E33-41, 299-E33-47, 299-E33-337, 299-E33-338, 299-E33-339, and 299-E33-345 (Figure 9-42). Several of these wells are screened within the unconfined aquifer, which is 3 m (10 ft) beneath a contaminated perched water horizon. The highest tritium activity was at Well 299-E33-345 (25,000 pCi/L). This was the only well with activity levels above the DWS. The remainder of the wells ranged between 7,500 and 17,300 pCi/L in 2014. Tritium concentrations in Well 299-E33-344, screened within the perched horizon near Well 299-E33-345, have ranged from 1,600 to 43,500 pCi/L since the well was installed in 2008. This well has been used to remove perched water and associated contamination over the past 4 years. As of the end of December 2014, approximately 1.87×10^{-2} Ci of tritium has been removed. Since the perching horizon is considered to leach contamination to the unconfined aquifer below, the interpretation of the tritium plume in this area was extended from Well 299-E33-345 to Well 299-E33-47, where 2014 tritium levels were reported at 17,300 pCi/L.

9.9.3 216-B-12 Crib

A deep zone of elevated tritium, not shown in Figure 9-42, was discovered in 2010 during RI drilling of Wells 299-E28-30 and 299-E29-54. Greater levels of tritium were found within the hydrostratigraphic units of 9A, 9B, and 9C. At approximately 8 m (26.2 ft) below the water table the tritium level was 94,000 pCi/L. The source is likely associated with the large inventory of tritium disposed to the 216-B-12 Crib in the 1950s when the crib received contaminated process condensate from U Plant operations. Alternatively, it may be from 200-PO sources. The two wells were completed at the water table and routine samples do not represent the deeper portion of the aquifer. Three additional wells were added to the Hanford well drilling priority list in 2013 to further define the extent of the deeper contamination. Two of these wells are planned to be screened at the discrete depth where elevated nitrate, tritium, and uranium were found in the aquifer (approximately 8 m [26 ft] below the water table) (Figure 9-10). Note that near the bottom of the aquifer at Well 299-E29-54, tritium activity of 150,000 pCi/L was observed. The 2014 wells will be screened at the shallower depth as that is where the highest nitrate and uranium concentrations were found. A later well may be installed to monitor the deeper tritium level.

9.9.4 216-B-3 Pond

East of the 200 East Area, significant inventories of tritium were discharged to the 216-B-3 Pond. Based on the 2014 tritium results, the highest tritium activity was at Well 699-42-40A at 37,000 pCi/L. Concentrations in this well have been relatively stable since 2007. Contamination appears to extend to the southwest toward Well 699-41-42, within 200-PO.

9.10 RCRA Monitoring

This section describes the results of monitoring at individual treatment, storage, and disposal units. These units are monitored under RCRA requirements for dangerous waste/dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials. Data from unit-specific monitoring are also integrated into CERCLA groundwater investigations. Dangerous constituents and radionuclides are occasionally discussed jointly in this section to provide comprehensive interpretations of groundwater contamination. As previously discussed and 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 may be 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.

The 200-BP groundwater interest area contains six RCRA sites with groundwater monitoring requirements: WMA B-BX-BY, WMA C, 216-B-63 Trench, LERF, LLWMA-1, and LLWMA-2 (Figure 9-6). The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for this reporting period. Groundwater data are available in the HEIS database and in the data files accompanying this report. Appendix B provides additional information (including well and constituent lists, and statistical tables).

9.10.1 Waste Management Area B-BX-BY

The WMA B-BX-BY is located in the north-northwest part of the 200 East Area (Figure 9-6). This dangerous waste management unit was constructed in stages with the B Tank Farm being constructed between 1943 and 1944, BX Tank Farm constructed between 1946 and 1947, and the BY Tank Farm constructed between 1948 and 1949 (Figure 9-43). All three farms provided interim storage of radioactive mixed waste, primarily from the bismuth phosphate, PUREX, and uranium extraction processes. However, none of the self-boiling wastes from the PUREX or REDOX Plants were sent to the B-BX-BY Tank Farms prior to removal of high-heat generating fission products. Each of the 24 tanks within the B and BX Tank Farms were built to store a maximum capacity of 2.0 million L (530,000 gal) of radioactive mixed waste or high-level radioactive liquid wastes. Each of the 12 tanks in the BY Tank Farm had a 2.9 million L (770,000 gal) maximum capacity. Within the B Tank Farm there were four additional tanks, with a maximum capacity of 208,000 L 55,000 gal) each. Ancillary equipment at WMA B-BX-BY includes 13 diversion boxes, the 244-BXR Waste Transfer Vault, five catch tanks, and several connecting underground lines. Twenty of the 40 tanks were defined as confirmed or assumed to have leaked. Additional sources of unplanned releases within WMA B-BX-BY include waste loss from spare inlet nozzles or cascade lines, pipeline leaks, and surface releases.

The nonradioactive constituents of the liquid wastes conveyed and stored within WMA B-BX-BY are regulated under RCRA and its implementing requirements (WAC 173-303-400). As a result, DOE monitors the groundwater under an interim status assessment program in accordance with 40 CFR 265.93(d)(4), as defined in Rev. 0 of DOE/RL-2012-53. This revised groundwater assessment (which included an expanded number of groundwater analytes) at WMA B-BX-BY was initiated in November 2012 and was targeted at determining those dangerous wastes/dangerous waste constituents that may be in the groundwater associated with releases at the WMA B-BX-BY in accordance with Section 3.1 of DOE/RL-2012-53. As of 2014, only one dangerous waste/dangerous waste constituent, cyanide, has been determined to be associated with releases associated with WMA B-BX-BY. Per 40 CFR 265.93, a first determination report is planned to be completed providing a list of the dangerous waste/dangerous waste constituents in groundwater associated with WMA B-BX-BY and will direct future groundwater monitoring requirements. Because of the continued migration of the dangerous waste constituent cyanide an additional well (299-E33-361) was installed in 2014 to provide control of monitoring the extent as required in 40 CFR 265.93(d)(4) (Figure 9-10). The replacement Well 299-E33-361 has been added to the revised *Groundwater Sampling and Analysis Plan for the 200-BP-5 Groundwater Operable Unit*, DOE/RL-2014-33.The dangerous waste/dangerous waste constituent cyanide extends from Well 299-E33-47 to beyond the new Well 299-E33-361 as shown in Figure 9-40.

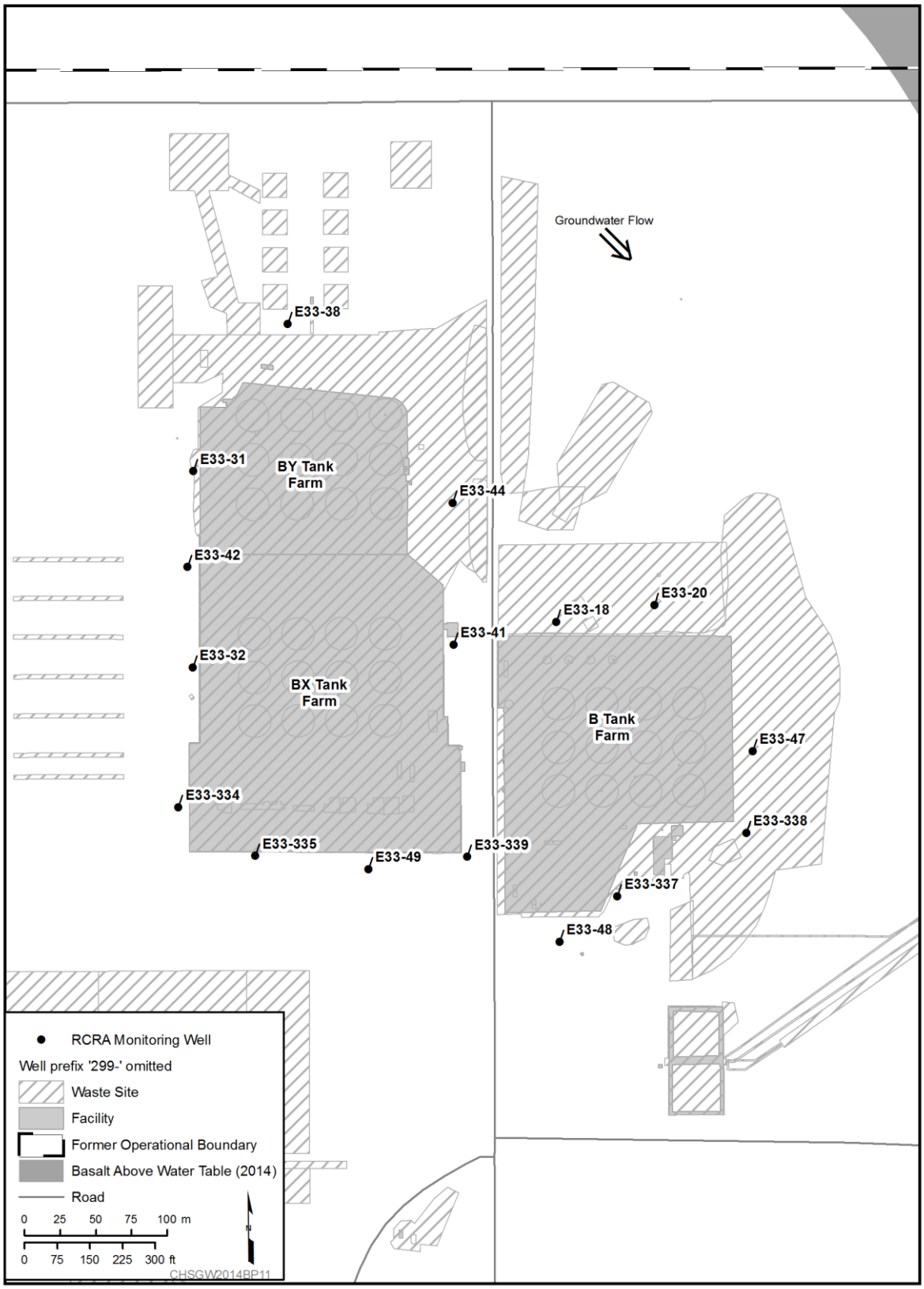


Figure 9-43. 200-BP WMA B-BX-BY Well Location Map

All of the wells were sampled quarterly, as required, during the reporting period, except Well 299-E33-18 (Table B-73, Appendix B). Noncompliant Well 299-E33-18 was decommissioned in 2013 as a potential conduit for contaminant migration from the contaminated perch water horizon to the unconfined aquifer. It was noncompliant because there was no outer seal to inhibit downward migration of perched water along the carbon steel casing. A replacement well, 299-E33-360, was installed in late 2014 and has been added to DOE/RL-2014-33 (Figure 9-10).

Estimations of groundwater flow rates are required by 40 CFR 265.94(d)(4), "Recordkeeping and Reporting," because of the presence of the dangerous waste constituent cyanide. The water-level measurements defining the gradient magnitude and flow direction for WMA B-BX-BY were collected monthly, which meets the quarterly requirement of 40 CFR 265.94(d)(7)(i). Because the water table is so flat in the 200 East Area, a select network of monitoring wells has been established to reduce errors and uncertainty in the data and improve the accuracy of measurements (Figure 9-44). Data are corrected for borehole deviation from vertical, barometric changes, and each well has been precision surveyed.

Since 2011, the continued decline of the water table in the 200 East Area and seasonally high Columbia River spring stage have resulted in a southeast groundwater flow direction into the northwest corner of the 200 East Area (Figure 9-5). The temporal fluctuations of the Columbia River stages result in an increasing gradient until October/November, followed by a decreasing gradient until the next June. The gradient decreased from 8.27×10^{-6} in January 2014 to 5.86×10^{-6} in June 2014. Some wells were not measured in July, so no results were derived. Between June and September 2014, the gradient increased to 2.1×10^{-5}. Significant TEDF discharges in July, September, and October appeared to depress the gradient magnitude in October (1.21×10^{-5}) and November ($1.51 \times 10_{-5}$) (Table 9-2). In December, the gradient (1.4×10^{-5}) began to decrease again. Thus, the lowest gradient in 2014 was in June and the highest gradient was in September. The average gradient magnitude for 2014 was 1.047×10^{-5}. The 2014 groundwater flow direction varied between 98 degrees from north (nearly east) to 216 degrees from north (southwest). The average flow direction was 159 degrees from north (southeast). This flow direction is consistent with plume migration as discussed in previous contaminant sections. Using an average gradient magnitude of 1.047×10^{-5} for 2014, the groundwater flow rate at WMA B-BX-BY was estimated to be 0.19 m/d (0.6 ft/d) or 68 m/yr [224 ft/yr] (Table B-1, Appendix B). This average flow rate agrees with the nitrate and technetium-99 plume movement in 2014.

The remaining water column across the perforated or screen portion of the well for the WMA B-BX-BY monitoring network ranges from 0.99 to 6.12 m (3.2 to 21.3 ft) (Table B-74, Appendix B). The least amount of water available for sampling is at Well 299-E33-20. There have not been any previous issues with groundwater collection in this well. However, this well is not WAC compliant and it was put on the well replacement priority list.

9.10.2 Waste Management Area C

The WMA C is located in the east central part of the 200 East Area (Figure 9-6). This dangerous waste management unit was constructed in 1943 and 1944 and provided interim storage of radioactive mixed waste, primarily from the bismuth phosphate, PUREX, and uranium extraction processes. The high-level liquid wastes from these processes were stored in 12 tanks, each with an approximate capacity of 1.9 million L (502,000 gal). Four additional tanks with an approximate capacity of 208,000 L (55,000 gal) each were also used to store high-level liquid waste. Ancillary equipment at WMA C includes seven diversion boxes, the 244-CR Vault with four permitted tanks, the 241-C-301 Catch Tank, one French drain, two dry wells, and several connecting underground lines. Seven of the 16 underground tanks were confirmed or assumed to have leaked and retrieval processes have been employed since 1998 to remove the liquid waste from these tanks. Additional sources of unplanned releases include waste loss from spare inlet nozzles or cascade lines, pipeline leaks, and surface releases.

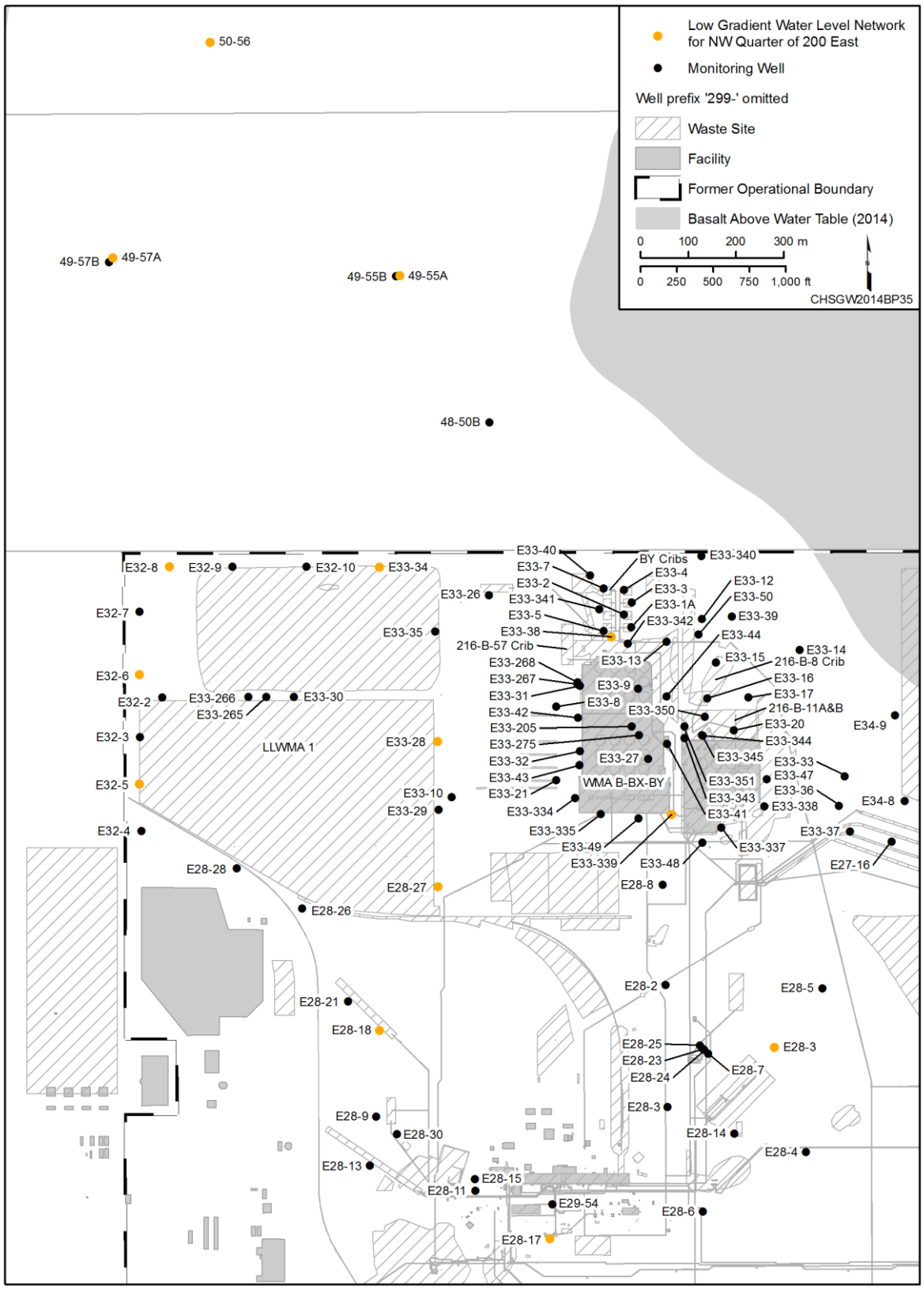


Figure 9-44. Low-Gradient Water-Level Network for the Northwest Quarter of the 200 East Area

The liquid waste is regulated under RCRA and its implementing requirements (WAC 173-303-400). As a result, DOE monitors the groundwater under an interim status assessment program in accordance with 40 CFR 265.93(d)(4), as defined in Rev. 0 of DOE/RL-2009-77 (Figure 9-45). As of 2014, cyanide is the only dangerous waste constituent determined as impacting groundwater from the C Tank Farm. Cyanide was continuously detected in Wells 299-E27-14 and 299-E27-23 each quarter in 2014, with concentrations ranging from 2.78 to 5.56 µg/L. The highest concentration of cyanide at WMA C in 2014 (13.9 µg/L) was at Well 299-E27-24. However, cyanide concentrations at this well declined to below detection by December 2014. The nondetect result in December appears to be out of trend and may be the result of laboratory error. Other wells with two quarterly values above detection limits in 2014 included Wells 299-E27-4 and 299-E27-7. The June 2014 result at Well 299-E27-7 (357 µg/L) was considered a laboratory error because the duplicate value was 5.1 µg/L. In addition, the duplicate was flagged because the QC sample was detected with cyanide. Four other wells (299-E27-12, 299-E27-15, 299-E27-21, and 299-E27-25) detected with cyanide in June 2014 were also flagged because the QC sample was detected with cyanide. Cyanide has not previously been detected in these four wells, further indicating laboratory issue with the June 2014 sample analyses. Figure 9-46 provides the estimated extent and trend results at select WMA C wells of the cyanide plume as required by 40 CFR 265.93(d)(4). In addition, all of the wells were sampled quarterly, as required, during the reporting period (Table B-75, Appendix B).

Estimations of groundwater flow rates are required by 40 CFR 265.94(d)(4) because of the presence of the dangerous waste constituent cyanide. The water-level measurements defining the gradient magnitude and flow direction at WMA C were collected quarterly, as required by 40 CFR 265.94(d)(7)(i), from two different water-level networks in the 200 East Area during 2014. Detailed reasoning for using the two networks is provided in SGW-54508. Thus, the flow rate beneath WMA C ranged between 0.006 and 0.33 m/d (0.021 and 1.1 ft/d), or 2.3 to 121 m/yr (7.5 to 398 ft/yr) (based on the parameters in Table B-1, Appendix B). The average groundwater flow direction in 2014 at WMA C was 129 degrees from north or southeast (with a range during the year of 117 to 145 degrees from north). Details of the flow direction for each quarter are provided in the quarterly reports provided below:

- SGW-58242, *WMA C January Through March 2014 Quarterly Groundwater Monitoring Report*
- SGW-58483, *WMA C April Through June 2014 Quarterly Groundwater Monitoring Report*
- SGW-58542, *WMA C July Through September 2014 Quarterly Groundwater Monitoring Report*
- SGW-58561, *WMA C October Through December 2014 Quarterly Groundwater Monitoring Report*

In addition to RCRA monitoring, WMA C is also monitored by AEA requirements in accordance with "Agreement on Content of Tank Waste Retrieval Work Plans" (04-TPD-083). Under this agreement gross beta, low-level gamma scans, technetium-99, and total uranium are monitored quarterly at each well location in accordance with TPA-CN-578 and DOE/RL-2001-49, Rev. 1.

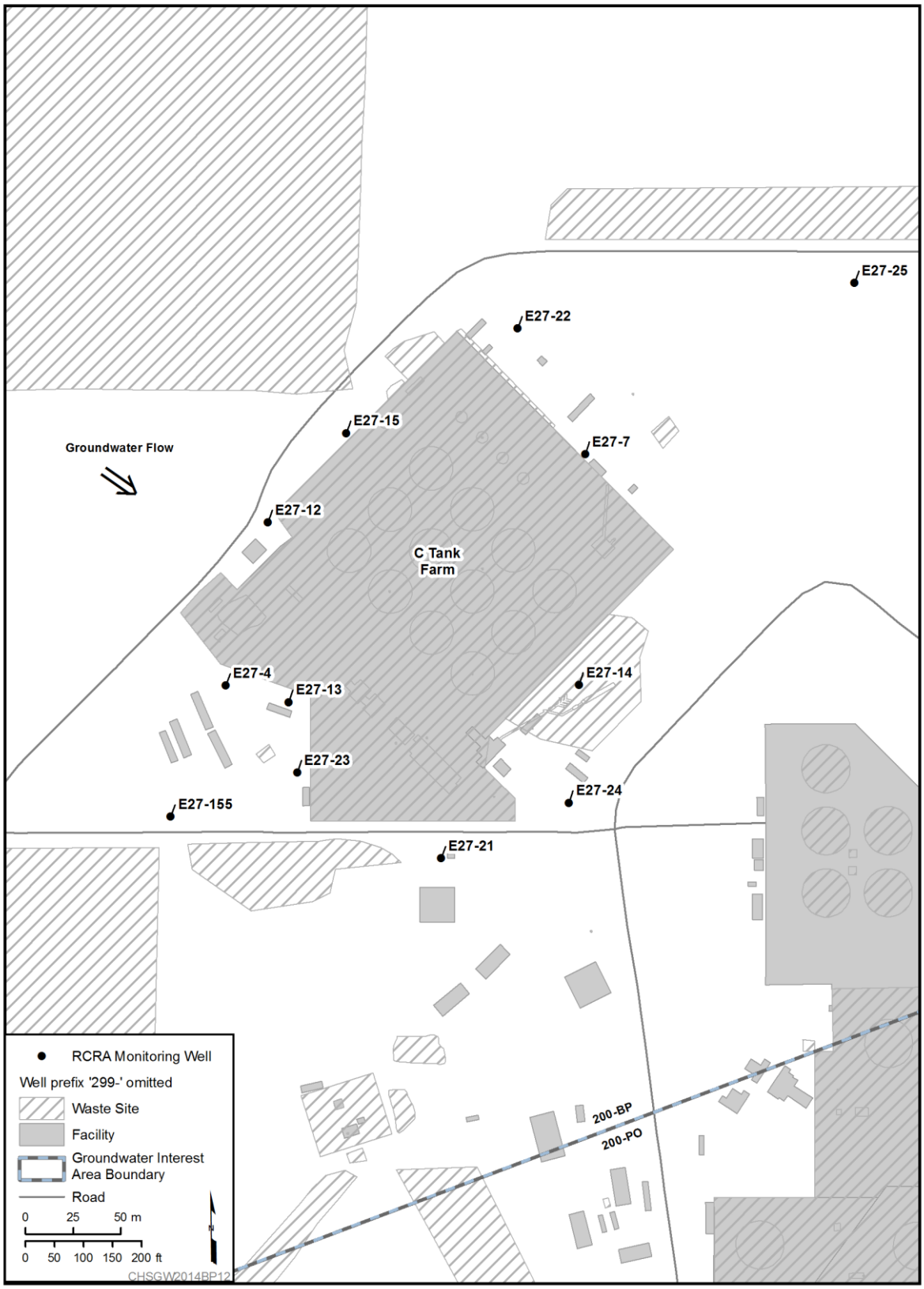


Figure 9-45. 200-BP RCRA WMA C Monitoring Well Locations

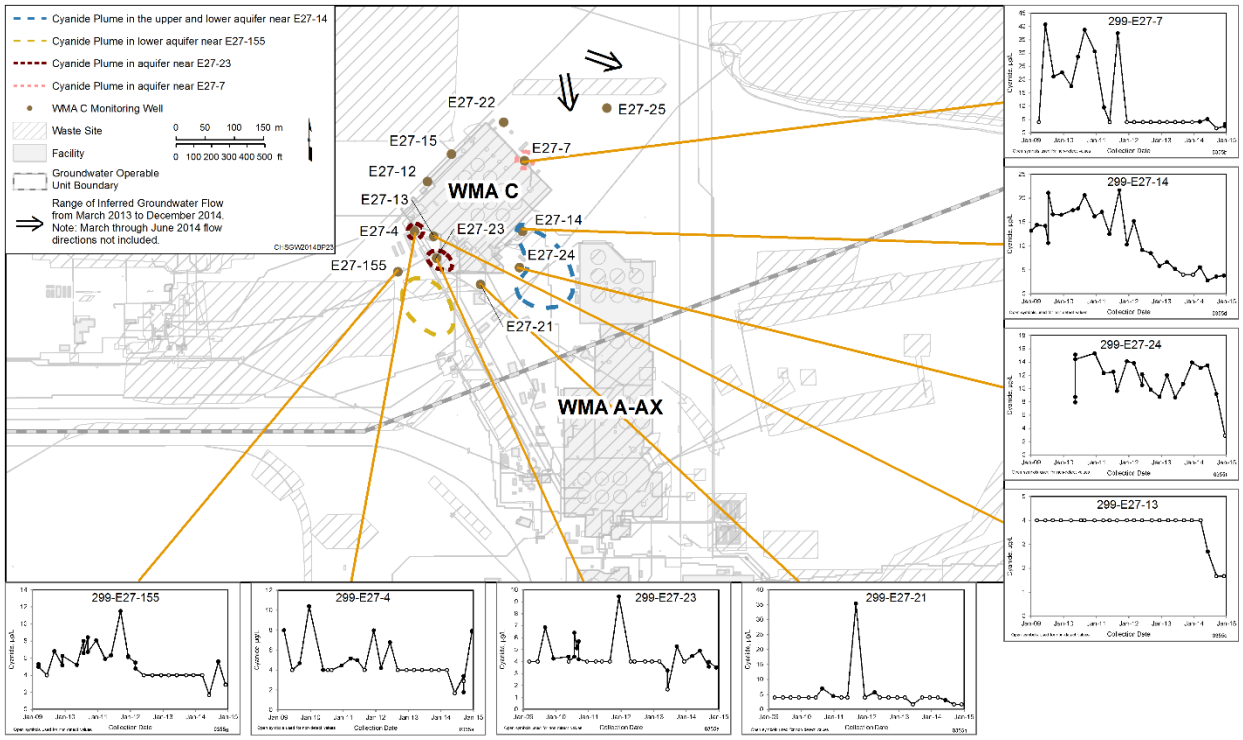


Figure 9-46. Interpretation of the >Detection Limit (>1.67 µg/L) of Cyanide Isopleth in the Upper 4 m and Lower 4 m of the Aquifer at Waste Management Area C and Cyanide Trend Results at Select Waste Management Area C Wells

In 2014, the low-level gamma results were less than detection limits, except for one false-positive result for beryllium-7. The beryllium-7 result was initially reported at Well 299-E27-22, but the reanalysis of the original sample was less than the detection limit.

The gross beta and technetium-99 results correlate, indicating only the presence of technetium-99. See Section 9.5 for a discussion of technetium-99 results.

Uranium concentrations in 2014 exceeded regional background levels of 4 µg/L (DOE/RL-96-61) at six wells: 299-E27-4, 299-E27-14, 299-E27-22, 299-E27-23, 299-E27-24, and 299-E27-155. The detected uranium concentrations were all below the 30 µg/L DWS. Four of the six wells (299-E27-4, 299-E27-14, 299-E27-22, and 299-E27-24), which had high concentrations in September 2014, were also flagged because the QC sample was out of limit. The other results in 2014 for these four wells, and Well 299-E27-23, were near background levels. The greatest non-flagged uranium concentration was 9.8 µg/L at Well 299-E27-155.

The remaining water column across the perforated or screen portion of the well for the WMA C monitoring network ranges from 1.61 to 13.47 m (3.2 to 21.3 ft) (Table B-76, Appendix B). These wells all have adequate water columns in the screened interval for sampling through the next decade or more.

9.10.3 216-B-63 Trench

The 216-B-63 Trench is located in the north central portion of the 200 East Area (Figure 9-6). The trench was constructed by 1970 as an emergency percolation trench for radioactively contaminated cooling water from B Plant. Through 1985, acidic and caustic treatments were completed to neutralize the waste. The actual corrosive portion from the demineralizers was less than 1,900 L/d (500 gal/d), while the

remainder of the 378,000 to 1,408,000 L/d (100,000 to 370,000 gal/d) was a combination of chemical sewer and cooling water. Discharges to this trench ceased in 1992. The corrosive waste discharges were regulated under RCRA and its implementing requirements WAC 173-303-400. DOE monitors the groundwater under an interim status indicator evaluation (detection) program in accordance with 40 CFR 265.93(b), as defined in Rev. 1 of DOE/RL-2008-60 (Figure 9-47). The revision was completed in 2012 to realign the upgradient and downgradient monitoring network to the new southeast groundwater flow condition. Previously, there has been no evidence of contaminant effects from the 216-B-63 Trench site within the groundwater. All of the wells were sampled semiannually, as required, during the reporting period (Table B-31, Appendix B).

As required by 40 CFR 265.94(a)(2)(ii), there were no indicator parameters that exceeded the critical mean in 2014. The results and comparison values are provided in Table B-32, Appendix B. Also provided in Table B-34, Appendix B is a summary of the groundwater quality parameters results as required by 40 CFR 265.92(b)(2).

Determining the groundwater gradient magnitude and flow direction from water-level data is not possible at this time with the 216-B-63 monitoring network due to the flat water table and minimal spatial geometry of the monitoring network. However, the 14-well low-gradient monitoring network, which encompasses wells just west of the 216-B-63 Trench, was used to estimate flow conditions at the 216-B-63 Trench (Figure 9-44). Based on the 2014 monthly average of the 14-well low-gradient water levels, a gradient magnitude of 1.047×10^{-5} with a flow direction of 159 degrees of north (southeast) was derived (Table B-1, Appendix B). Using the hydraulic parameters provided in Table B-1 of Appendix B, an estimated average flow rate of 0.021 m/d (0.07 ft/d) or 7.7 m/yr [25 ft/yr] was derived. This average flow rate agrees with the minimal cyanide, nitrate, and technetium-99 plume movement beneath the 216-B-63 Trench between 2013 and 2014. It appears that the more concentrated cyanide, nitrate, and technetium-99 plumes to the west of the 216-B-63 Trench are migrating almost directly south rather than beneath the trench. It also appears that the plumes to the north of the 216-B-63 Trench are migrating east rather than beneath the trench. This appears to be associated with lower hydraulic properties of the sediments beneath the 216-B-63 Trench as discussed in Appendix A of SGW-44329.

The depth of the water column in network wells ranges from 1.32 to 3.18 m (4.3 to 10.4 ft) (Table B-33, Appendix B). Most of the well screens extend to within 1.5 m (5 ft) of the underlying basalt surface, as discussed in Table B-33, Appendix B. These groundwater wells all have adequate water columns in the screened interval available for sampling for the next decade or more.

While the alignment of the revised well network allows for statistical measures for determining whether the 216-B-63 Trench is impacting groundwater under stationary conditions over time, contaminant plumes migrating towards this site from the northwest are anticipated to affect both the upgradient and downgradient wells in 2015 and beyond. An increasing trend in specific conductance is expected and may require the background comparison values to be recalculated as recommended in the unified guidance (EPA 530-R-09-007) and 40 CFR 265.91(a)(1). The unified guidance stance on trending background concentrations is that it violates the assumption of stationary concentrations over time, which is a key assumption for the statistical interim Student t-test approach used to derive background levels in accordance with 40 CFR 265.93(b). Furthermore, 40 CFR 265.91(a)(1) requires upgradient wells that are representative of background groundwater quality; thus, background levels will be recalculated as necessary to ensure representative comparisons with the changing background groundwater quality.

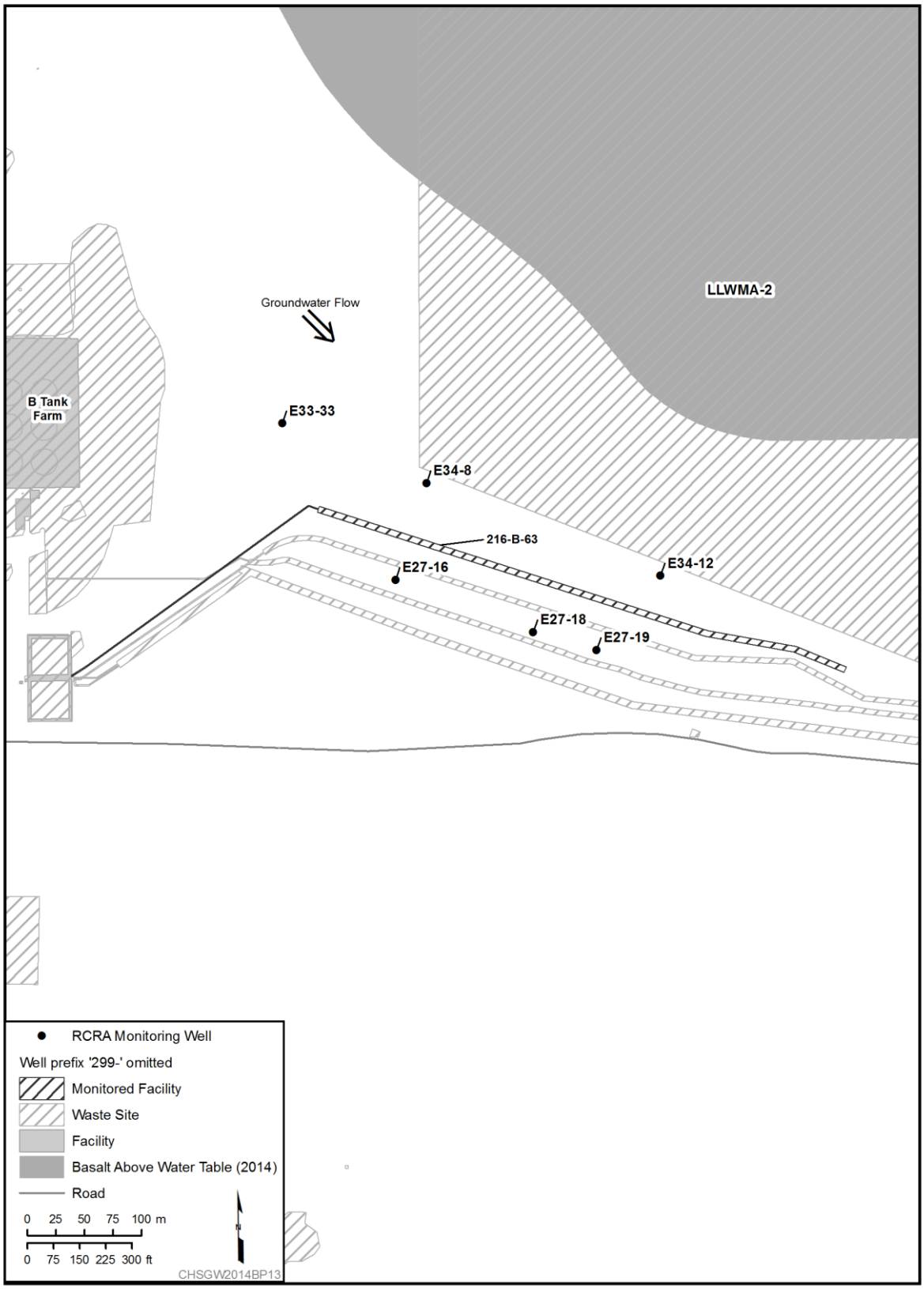


Figure 9-47. 200-BP RCRA 216-B-63 Monitoring Well Locations

9.10.4 Liquid Effluent Retention Facility

Located on the eastern boundary of the 200 East Area, the LERF consists of three lined surface impoundment basins (Basins 42, 43, and 44) (Figures 9-6 and 9-48). Construction of the complex was completed in 1991, utilizing a dual confinement barrier concept (i.e., dual basin liners and pipe-in-a-pipe transfer piping system) to minimize human exposure and potential for accidental releases to the environment. A leachate detection, collection, and removal system and basin covers were also added to reduce possible environmental or personnel exposure. The basins are arranged side by side, with 18 m (60 ft) of separation between each basin. The dimensions of each basin (cell) are 100 m by 82 m (330 ft by 270 ft), with a maximum fluid depth of 6.7 m (22 ft).

The LERF was constructed for interim storage and treatment for aqueous waste streams prior to final treatment in the 200 Area ETF. Treatment at LERF consists of flow and pH equalization. The flow equalization allows for several smaller waste streams that are intermittently received at the LERF basins to accumulate for continuous higher volume campaign processing at ETF.

LERF has and continues to receive liquid waste from a number of onsite facilities, with the most prominent volumes being received from the 242-A Evaporator, ERDF leachate, and purgewater from groundwater monitoring. Several of the liquid wastes contain metals and organics, which are regulated under RCW 70.105 and are subject to groundwater monitoring requirements pursuant to WAC 173-303-645. LERF is a final status facility included in RCRA Permit WA78900008967.

In 2013, DOE prepared a Class 2 modification of the permit, including a new groundwater monitoring plan in accordance with WAC 173-303-645(9), as defined in DOE/RL-2013-46, *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility*. The new detection monitoring plan identifies the indicator parameters to be used for statistically based comparisons (Table B-46, Appendix B). In addition, the plan defines the wells to be sampled, the sampling frequency, and geochemical parameters to be monitored each year (Table B-45, Appendix B). In this plan the monitoring network was modified based on statistical evaluations of the water table gradient magnitude and flow direction. The flow direction provided in Figure 9-48 is the average of monthly statistical derived flow directions between December 2011 and January 2013 using deviation and barometrically corrected measurements from Wells 299-E26-10, 299-E26-14, 299-E26-77, and 299-E26-79. The average 2014 flow direction was nearly the same; 191 degrees from north. The plan also requires one new downgradient well to complete the detection monitoring network (299-E26-15). This well is scheduled to be drilled in 2015. This plan was implemented on April 29, 2014, after a public comment period in early 2014.

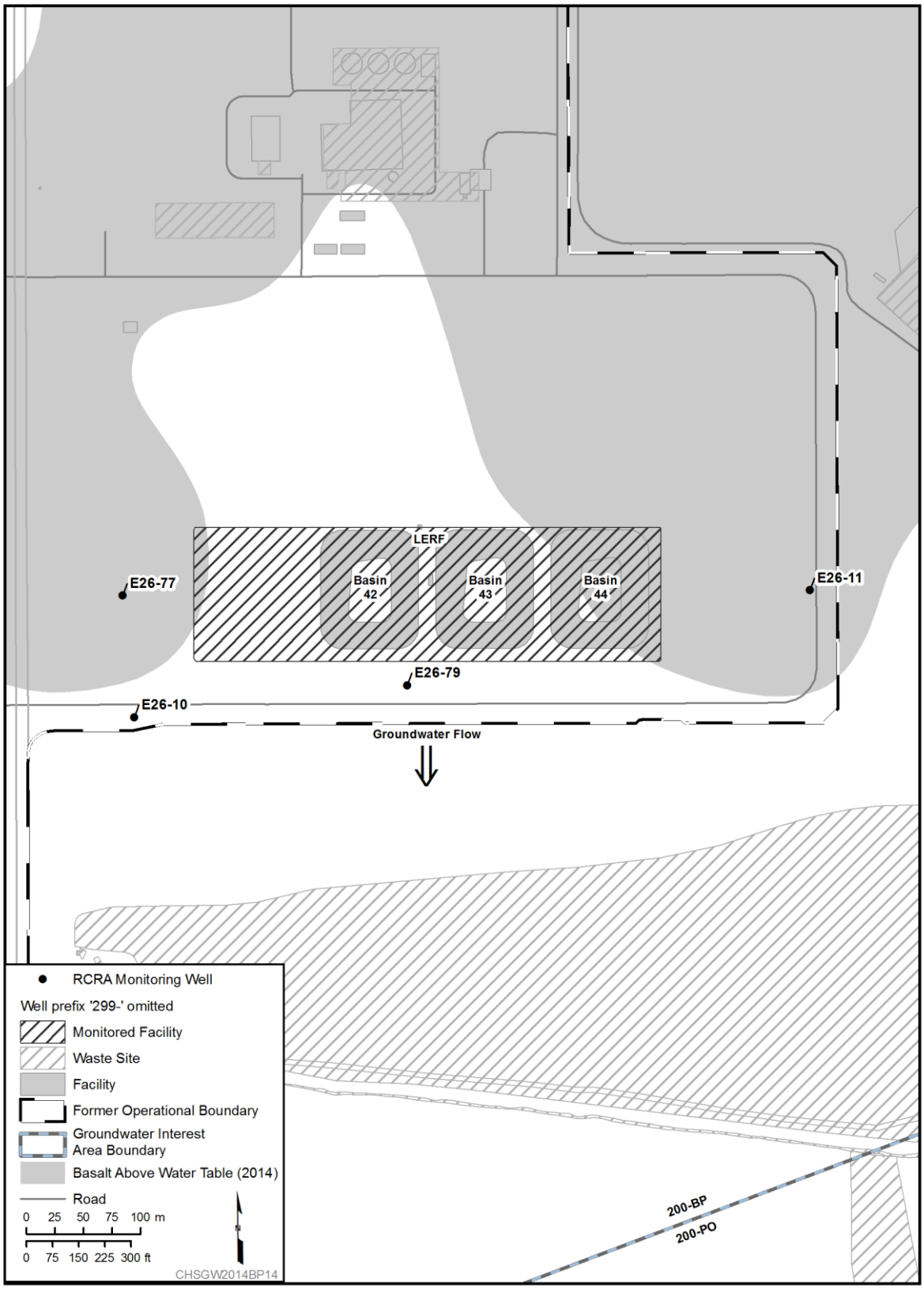


Figure 9-48. 200-BP RCRA LERF Monitoring Well Locations

Previously, there has been no evidence of contaminant effects from the LERF site within the groundwater; however, since 2001, interwell statistical evaluations of LERF groundwater monitoring data have not been performed. In July 2014, two wells (299-E26-14 [upgradient] and 299-E26-79 [downgradient]) were sampled for detection monitoring as required by DOE/RL-2013-46. Critical mean values were derived for four of the five indicator parameters identified in DOE/RL-2013-46 by ECF-Hanford-14-0043, *Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring* (Table B-46, Appendix B). The critical mean value is a concentration at the 0.01 level of significance, statistically derived for each of the indicator parameters from the upgradient monitoring well (299-E26-14) as directed by 40 CFR 265.93(b). The fifth indicator parameter, carbon tetrachloride, is triggered by any detectable concentration in the downgradient well because it is not a naturally occurring constituent in groundwater. A sixth potential indicator parameter, hexavalent chromium, is being monitored for background purposes. After four sampling events, the data will be evaluated to determine if statistical analysis would be acceptable for this constituent as an indicator parameter. As shown in Table B-46, Appendix B, no indicator parameter comparison values were exceeded in the July 2014 sampling event.

Geochemical constituents were also collected at Wells 299-E26-14, 299-E26-79, and 299-E26-77. These samples are evaluated to determine geochemical facies changes and whether groundwater flow directions are representative of current conditions. Samples collected for geochemical analyses included alkalinity, anions, and cations as required by Table D-6 in DOE/RL-2013-46. The anion and cation results balanced indicating the laboratory analyses were acceptable. Anion and cation results at each well indicate a calcium-sulfate facies. The facies is much stronger to the west than north or south of LERF. The calcium and sulfate concentrations from the July 2014 sampling event did not change significantly compared with the January 2014 sampling results. Thus, there is no reason to question the groundwater derived flow direction at this time.

It is noted that TOC values have risen significantly in the upgradient LERF Well 299-E26-14 (Figure 9-49). A similar occurrence was reported in the past at Well 299-E34-7. Past characterization at Well 299-E34-7, between 2000 and 2005, found no indication of dangerous waste/dangerous waste constituents (PNNL-15670, *Hanford site Groundwater Monitoring for Fiscal Year 2005*). A new characterization approach for quantifying elevated TOC was implemented in late 2014 for several northern 200 East Area wells that are showing persistent levels of elevated TOC. In 2015, the new characterization approach will be employed at Well 299-E26-14. The new approach utilizes three analytical methods: (1) direct gas chromatography (GC)/mass spectrometry (MS) injection to identify peaks that could represent the concentrated organic matter (used previously); (2) liquid chromatography/MS for evaluating concentrated organic material (new method employed for characterization at this site); and (3) direct electro-spray MS infusion of concentrated organic material (a new method employed for characterization at this site). It is hoped that the concentrating process of the TOC, along with the direct injection and new analytical methods being employed, will provide sufficient information to identify complex carbon molecules such as humic/fluvic acids or chelating agents, which may be causing the elevated TOC at Well 299-E26-14.

The depth of the water column in the LERF network wells ranges from 1.1 to 6.6 m (3.6 to 21.7 ft) (Table B-47, Appendix B). Three of the four well screens extend to the underlying basalt or within the basalt fracture zone. Well 299-E26-14 extends to within 0.9 m (approximately 3 ft) of the underlying basalt surface. All four of the groundwater wells have adequate water columns in the screened interval available for sampling for the next decade or more.

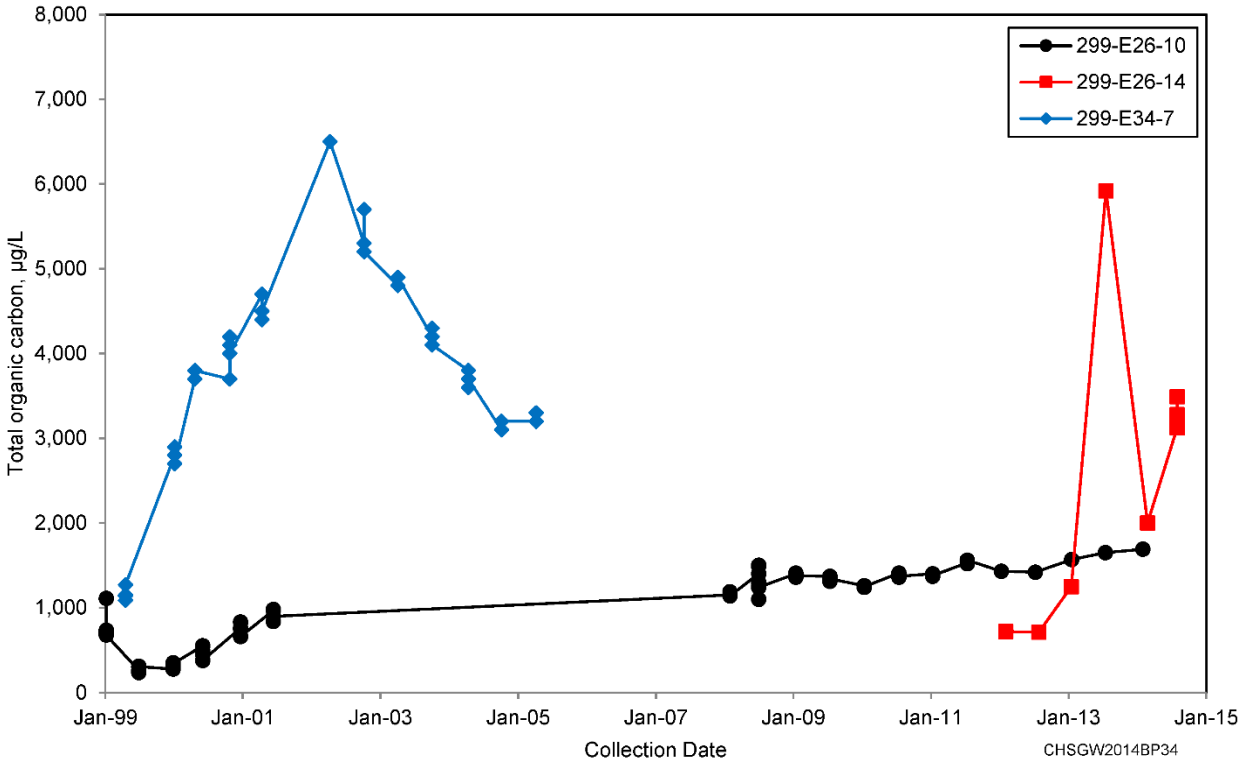


Figure 9-49. 200-BP Comparison of TOC at Wells 299-E26-10, 299-E27-10, and 299-E34-7

9.10.5 Low-Level Waste Management Area 1

The LLWMA-1 is located in the northwest corner of the 200 East Area (Figure 9-6). The LLWMA-1 monitoring network is designed for detection of dangerous waste/dangerous waste constituents affecting groundwater from the 218-E-10 Burial Ground, which consists of 14 unlined trenches (Figure 9-50). The 218-E-10 Burial Ground received low-level radiological waste and low-level mixed wastes beginning in 1955. The dangerous chemicals in the low-level mixed waste portions of the 218-E-10 Burial Ground are regulated under RCRA and its implementing requirements in WAC 173-303-400. DOE monitors the groundwater under an interim status indicator evaluation (detection) program in accordance with 40 CFR 265.93(b), as defined in DOE/RL-2009-75. The monitoring network currently consists of 18 wells (Figure 9-50). Previously, there has been no evidence of contaminant effects from the 218-E-10 Burial Ground site within the groundwater. All of the wells were sampled semiannually, as required, during the reporting period (Table B-48, Appendix B).

As required by 40 CFR 265.94(a)(2)(ii), the derived comparison value for a statistically significant increase was exceeded for TOC and TOX in 2014. The comparison values (critical means) were derived and reported in ECF-Hanford-14-0043. Table B-49, Appendix B summarizes the critical mean indicator comparison values, range of 2014 indicator parameter results, whether an exceedance occurred for an indicator parameter, and the wells associated with the exceedance. Discussions follow regarding the exceedance for TOC and TOX in 2014.

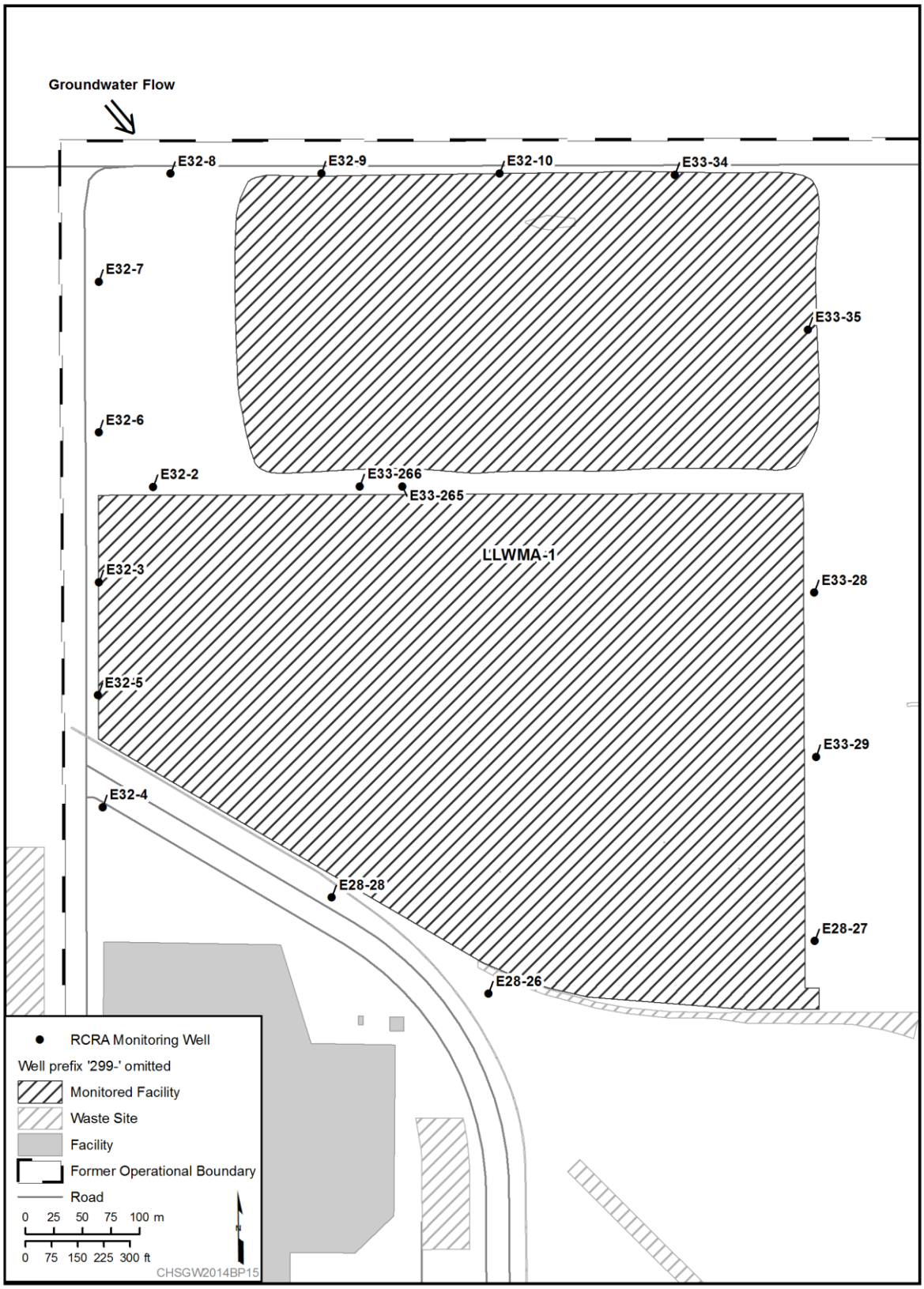


Figure 9-50. 200-BP RCRA LLWMA-1 Monitoring Well Locations

The TOC exceedance was only at Well 299-E33-265. Elevated TOC levels have persisted at this well since the groundwater flow reversal in 2011. After confirmation of the exceedance a draft of the *First Determination RCRA Groundwater Quality Assessment Plan For Low-Level Burial Grounds Low-Level Waste Management Area-1* (DOE/RL-2012-35) was submitted to Ecology in May 2012. Evaluation of the assessment results were reported in the *First Determination RCRA Groundwater Quality Assessment Report for Low-Level Burial Grounds Low-Level Waste Management Area-1*, DOE/RL-2013-25, which was submitted to the Administrative Record on May 10, 2013. The conclusion of the report was that no dangerous waste/dangerous waste constituents in groundwater were associated with the 218-E-10 Burial Ground; however, the TOC values remained elevated at Well 299-E33-265. The most likely reason for the elevated TOC is an upgradient source of natural organic material near the well. As discussed in Section 9.10.4, a new characterization approach for quantifying elevated TOC was implemented in late 2014. Currently, the LLWMA-1 site remains in interim detection monitoring, as recommended in DOE/RL-2013-25 and implemented through DOE/RL-2009-75. DOE has directed revision of several RCRA detection monitoring plans in 2015, which includes DOE/RL-2009-75.

The TOX exceedance occurred at 15 of the 18 LLWMA-1 wells scheduled for sampling in January 2014. The exceptions were those wells that were delayed in sampling until February (299-E28-26, 299-E28-27, and 299-E32-2). Because both the upgradient and downgradient wells were affected, the null hypothesis was maintained in that the background and downgradient wells share the same underlying distribution and that downgradient concentrations should be consistent with background in the absence of any contamination. Therefore the limit of quantitation (LOQ) associated with WSCF TOX results from October 1, 2012, through September 30, 2013; and from January 1, 2013, through December 31, 2013 were compared to the TOX results for each well. By comparison none of the well results exceeded either LOQ. A summary of the data is provided in Table B-49, Appendix B.

Evaluation of groundwater flow direction, as required by 40 CFR 265.94(a)(2)(iii), was based on water-level measurements from a select network of monitoring wells. The well network is shown in Figure 9-50. The network was established to define the gradient magnitude and flow direction for the nearly flat water table aquifer within the northwest corner of the 200 East Area. The network wells were precision surveyed, corrected for borehole deviation from vertical, and corrected for barometric changes to increase the precision for deriving the gradient magnitude and flow direction of the water table.

Since 2011, the continued decline of the water table in the 200 East Area and seasonally high Columbia River spring stage have resulted in a southeast groundwater flow direction into the northwest corner of the 200 East Area (Figure 9-5). The temporal fluctuations of the Columbia River stages result in an increasing gradient until October/November, followed by a decreasing gradient until the next June. The gradient decreased from 8.27×10^{-6} in January 2014 to 5.86×10^{-6} in June 2014. Some wells were not measured in July, so no results were derived. Between June and September 2014 the gradient increased to 2.1×10^{-5}. Significant TEDF discharges in July, September and October appeared to depress the gradient magnitude in October (1.21×10^{-5}) and November (1.51×10^{-5}) (Table 9-2). In December the gradient (1.4×10^{-5}) began to decrease again. Thus, the lowest gradient in 2014 was in June and the highest gradient was in September. The average gradient magnitude for 2014 was 1.047×10^{-5}. The 2014 groundwater flow direction varied between 98 degrees from north (nearly east) to 216 degrees from north (southwest). The average flow direction was 159 degrees from north (southeast). This flow direction is consistent with plume migration, as discussed in previous contaminant sections. Using an average gradient magnitude of 1.047×10^{-5} for 2014, the groundwater flow rate at LLWMA-1 was estimated to range between 0.19 m/d (0.6 ft/d) or 68 m/yr [224 ft/yr] near the northeast corner of the site, and 0.019 m/d (0.06 ft/d) or 6.8 m/yr [22.4 ft/yr] in the southwest part of the site (Table B-1, Appendix B). This average flow rate agrees with regional nitrate and technetium-99 plume movement in 2014. Based on this flow direction the following five downgradient wells (299-E28-26, 299-E28-27, 299-E28-28,

299-E33-28, and 299-E33-29) meet the requirements of 40 CFR 265.91(a)(2) and are sufficient for detecting a statistically significant amount of dangerous waste or dangerous waste constituents. In addition, 10 of the remaining 13 wells more than adequately represent upgradient groundwater background conditions Table B-48, Appendix B..

A summary of the groundwater quality parameters for LLWMA-1 is provided in Table B-51, Appendix B, as required by 40 CFR 265.92(b)(2). Overall the geochemistry of the groundwater portrays a calcium-carbonate facies, which grades into a calcium-carbonate-sulfate facies in the northeast part of the monitoring network. The incorporation of sulfate is associated with contaminant plumes from the BY Cribs and 241-BX-102 Unplanned Release.

The depth of the water column in monitoring wells ranges from 1.72 to 3.36 m (5.6 to 11.02 ft) into the aquifer (Table B-50, Appendix B). These groundwater wells all have adequate water columns in the screened interval available for sampling for the next decade or more.

Radionuclide performance assessment monitoring at LLWMA-1 (in accordance with AEA authority) is designed to complement RCRA detection monitoring and is specifically aimed at monitoring radionuclides not regulated under RCRA. The current monitoring plan (DOE/RL-2000-72) requires iodine-129, technetium-99, tritium, and uranium for assessing the groundwater. Based on observations at the LLWMA-1 wells and other 200-BP monitoring wells, the 218-E-10 Burial Ground have not impact the groundwater. Results for each of these constituents are discussed below and can be found on the site map in the respective sections above.

Elevated iodine-129 activities found predominantly in the northeast portion of LLWMA-1 are from sources to the east-southeast, as discussed in the Section 9.5. The highest level was in Well 299-E33-35 (3.4 pCi/L). Levels decrease across LLWMA-1 to the southwest.

Technetium-99 concentrations exceed DWS in wells monitoring the north and east portion of LLWMA-1. The elevated technetium-99 groundwater activity in the north and east wells (299-E32-9, 299-E32-10, 299-E33-28, 299-E33-34, and 299-E33-35) is primarily associated with the technetium-99 plume which migrated from the BY Cribs and the 241-BX-102 Unplanned Release in the past. These plumes are now migrating back from the northwest. Technetium-99 from the B Complex is discussed further in Section 9.5.

Tritium was not reported above the DWS in any LLWMA-1 monitoring well in 2014. The highest activity was in Well 299-E33-35, which is the result of migration from the 216-B-57 and 216-B-50 Cribs (see Section 9.9).

In 2014, uranium concentrations exceeded DWS in Wells 299-E33-34 and 299-E33-35, which monitor the northwest corner of LLWMA-1. The elevated concentrations are associated with the 241-BX-102 Unplanned Release. The highest concentration was in Well 299-E33-35 at 40.7 μg/L.

9.10.6 Low-Level Waste Management Area 2

The LLWMA-2 is located in the northeast corner of the 200 East Area (Figure 9-5). It includes the 218-E-12 Burial Ground, which consists of 40 unlined trenches (Figure 9-51). The 218-E-12 Burial Ground received low-level radiological waste and low-level mixed wastes beginning in 1967. The dangerous chemicals in the low-level mixed waste portions of LLWMA-2 are regulated under RCRA and its implementing requirements in WAC 173-303-400. DOE monitors the groundwater with an interim status indicator evaluation (detection) program in accordance with 40 CFR 265.93(b), as defined in DOE/RL-2009-76. To date, there has been no evidence of contaminant effects from the 218-E-12 Burial Ground within the groundwater. All of the wells were sampled semiannually, as required, during the reporting period (Table B-52, Appendix B).

As required by 40 CFR 265.94(a)(2)(ii), the derived comparison value for a statistically significant increase was exceeded for specific conductance in 2014. The comparison values (critical means) were derived and reported in ECF-Hanford-14-0043. Table B-53, Appendix B summarizes the critical mean indicator comparison values, range of 2014 indicator parameter results, whether an exceedance occurred for an indicator parameter, and the wells associated with the exceedance. Discussions follow regarding the exceedance for specific conductance in 2014.

The only indicator parameter that exceeded the critical mean in 2014 was specific conductance at Well 299-E34-9. The elevated specific conductance at this well was determined to be associated with nitrate migration in the groundwater primarily from the BY Cribs, as explained in Letter 13-AMRP-0192, sent to Ecology on May 28, 2013. The reason that the BY Cribs are now considered an upgradient source is because of the southeast flow direction change in 2011 in this area. DOE, Ecology, and CHPRC agreed that the 218-E-12B Burial Ground was not associated with the elevated specific conductance; therefore, the site remains in detection monitoring. DOE has directed revision of several RCRA detection monitoring plans in 2015, which includes DOE/RL-2009-76. It is recommended that the upgradient well network be reduced to Well 299-E34-2 and wells upgradient and downgradient of the unused portion of the facility be removed from the monitoring network during revision of the LLWMA-2 monitoring plan in 2015.

Determining the groundwater gradient magnitude and flow direction from the LLWMA-2 monitoring network based on water levels is not possible at this time due to the flat water table and geometry of the monitoring network. However, because of contaminant migration into the area, the flow along the west side of LLWMA-2 is considered southeast, while the flow direction along the east side is more southward. A 14-well low-gradient monitoring network, which encompasses wells just west of LLWMA-2, was also used to estimate flow conditions in 2014 for LLWMA-2 (Figure 9-51). Based on the 2014 monthly average of the 14-well low-gradient water levels, a gradient magnitude of 1.047×10^{-5} with a flow direction of 159 degrees of north (southeast) was derived (Table B-1, Appendix B). Using an average gradient magnitude of 1.047×10^{-5} for 2014, the groundwater flow rate at LLWMA-2 was estimated to be 0.12 m/d (0.38 ft/d) or 42 m/yr (138 ft/yr) (Table B-1, Appendix B). This average flow rate agrees with the minimal nitrate and technetium-99 plume movement beneath the west side of LLWMA-2 between 2013 and 2014. The estimated flow rate along the east side of LLWMA-2 is considered to be equivalent to the measurements completed for LERF (0.1 m/d [0.33 ft/d]).

A summary of the groundwater quality parameters for LLWMA-2 is provided in Table B-55, Appendix B, as required by 40 CFR 265.92(b)(2). Overall, the geochemistry of the groundwater portrays a calcium-sulfate facies to the east and west with a calcium-sulfate-carbonate facies in between. The incorporation of sulfate is associated with contaminant plumes from the BY Cribs to the west and possibly the 216-B-2-2 Ditch Unplanned Release along the east side of LLWMA-2.

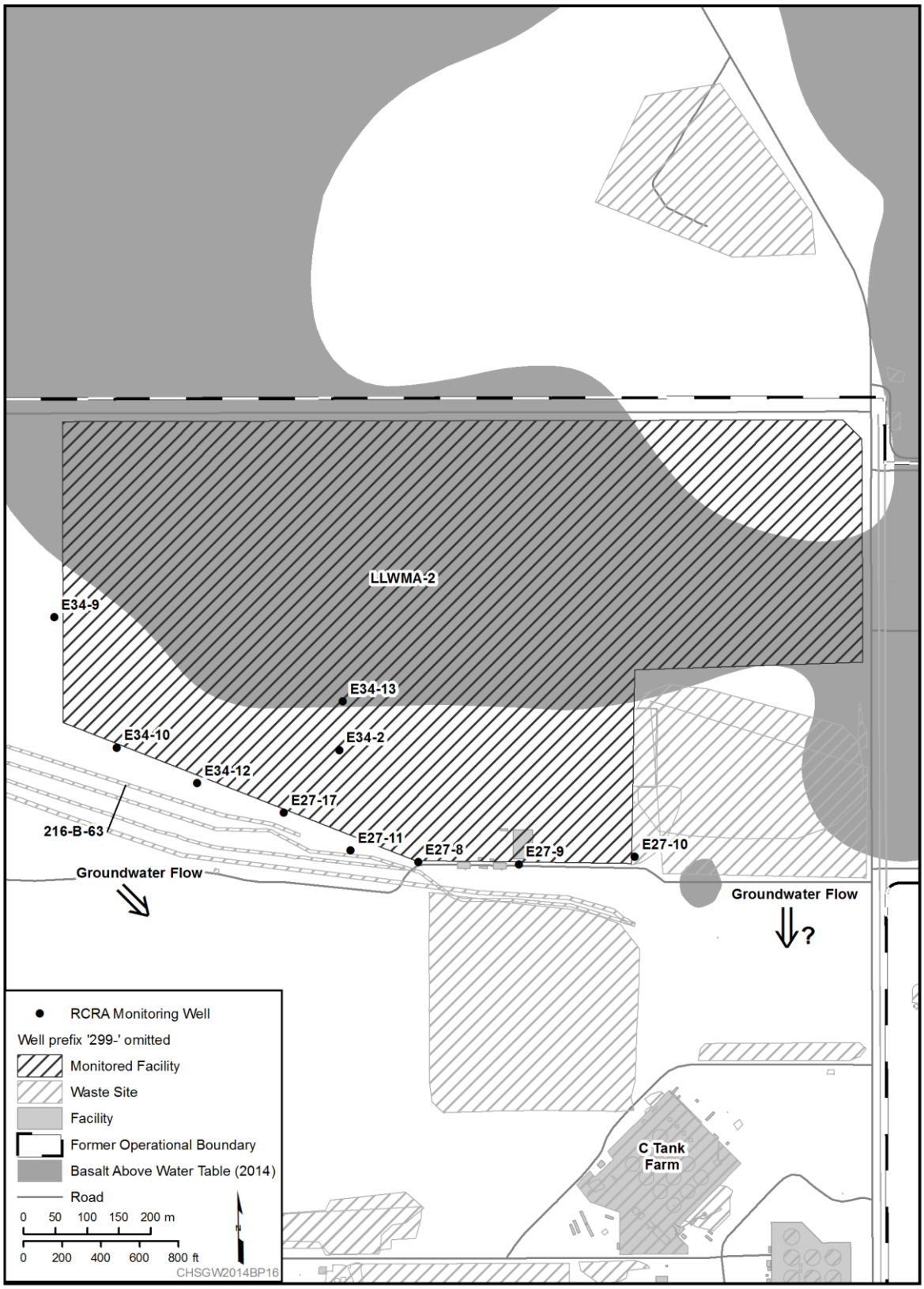


Figure 9-51. 200-BP RCRA LLWMA-2 Monitoring Well Locations

The depth of the water column in monitoring wells ranges from 1.24 to 2.78 m (4.1 to 9.12 ft) (Table B-54, Appendix B). These groundwater wells all have adequate water columns in the screened interval available for sampling for the next decade or more.

Radionuclide performance assessment monitoring at LLWMA-2 (in accordance with AEA authority) is designed to complement RCRA detection monitoring and specifically at monitoring radionuclides not regulated under RCRA. The current monitoring plan (DOE/RL-2000-72) requires groundwater be assessed for iodine-129, technetium-99, tritium, and uranium. Based on observations at the LLWMA-2 wells and other 200-BP monitoring wells, the 218-E-12 Burial Ground did not impact the groundwater. Results for each of these constituents are discussed below and can be found on the site map in their respective sections above.

9.10.6.1 Iodine-129

Elevated iodine-129 has been detected in the wells along the south side of LLWMA-2 since monitoring began in the early 1990s. The highest level was in Well 299-E27-10 when sampling began, but it has continued to decline, and by the end of 2014 was less than detection limits. At the end of 2014, only two wells (299-E27-8 and 299-E27-9) exceeded the DWS. Iodine-129 appears to have originally migrated into the area, occupied by these wells, after the termination of discharges to the Gable Mountain Pond from sources to the south and east. Since then, activity levels have been decreasing. Activity levels appear to be decreasing more rapidly over the past couple of years and appear to be associated with the groundwater flow direction change. The greatest activity in 2014 was at Well 299-E27-9 at 1.82 pCi/L.

9.10.6.2 Technetium-99

Technetium-99 activity beneath the west side of LLWMA-2 was increasing rapidly but has decreased since October 2013. The activity increase is associated with technetium-99 migration through the groundwater from the BY Cribs, similar to the nitrate discussed above. Currently, the only well exceeding the DWS is Well 299-E34-9, where the concentration increased from 1,900 pCi/L in October 2012 to 9,800 pCi/L in October 2013, and in October 2014 was 7,830 pCi/L. Activity levels beneath the east side of LLWMA-2 peaked at approximately 100 pCi/L in 2007 at Well 299-E27-10. Activity levels in this area have been declining, and the greatest activity level was 38 pCi/L at Well 299-E27-10 in 2014.

9.10.6.3 Tritium

Tritium activity beneath the west side of LLWMA-2 was increasing rapidly at Well 299-E34-9. The activity increase was associated with tritium migration through the groundwater from the 216-B-50 Crib, similar to the nitrate and technetium-99 discussed above from the BY Cribs. The activity level increased from 650 pCi/L, in October 2012, to 1,500 pCi/L, in October 2013, and in October 2014 was 1,430 pCi/L. Activity levels beneath the east side of LLWMA-2 peaked at approximately 12,000 pCi/L in 1991, shortly after the termination of discharges to the Gable Mountain Pond in 1987. Activity levels in this area have been less than detect since October 2012, except at Well 299-E27-9 where tritium was detected in October 2014 at 238 pCi/L.

9.10.6.4 Uranium

Uranium concentrations at LLWMA-2 were less than or equal to 4 µg/L, which is within regional background levels (DOE/RL-96-61); except at Well 299-E34-9. Concentrations at Well 299-E34-9 appear to be associated with the peripheral portion of the 241-BX-102 Unplanned Release as it migrates from the northwest to the southeast. The highest concentration at Well 299-E34-9 was 5.29 µg/L in October 2014.

This page intentionally left blank.

10 200-PO

10.1 Overview

This chapter summarizes groundwater sampling for the 200-PO groundwater interest area for calendar year 2014. Groundwater monitoring in 200-PO is performed to meet AEA, CERCLA, RCRA, and *Washington Administrative Code* requirements. The 200-PO interest area includes the CERCLA 200-PO-1 OU and adjacent region, seven RCRA units (216-A-29 Ditch, 216-A-36B Crib, 216-A-37-1 Crib, 216-B-3 Pond, Nonradioactive Dangerous Waste Landfill [NRDWL], Integrated Disposal Facility [IDF], and WMA A-AX (single-shell tanks), one state-regulated landfill (Solid Waste Landfill [SWL]), and the 400 Area. For purposes of CERCLA groundwater monitoring, the 200-PO-1 OU is informally divided into the near field area, which includes the former operational areas within and near the 200 East Area, and the far field area, which includes wells downgradient of the near field area, aquifer tubes along the Columbia River, and generally comprises areas where site operations did not occur (Figure 10-1). CERCLA sampling wells within the far field region have been grouped into several sub-areas including the BC Cribs, southeast transect, river transect, basalt confined aquifer, and the general far field (DOE/RL-2003-04, Rev. 1; TPA-CN-205). Table 10-1 summarizes some key facts about 200-PO. Section 1.3 provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Groundwater within the 200-PO interest area has been contaminated primarily by releases from cribs, ponds, single-shell tanks, and trenches associated with PUREX and B Plant operations. Groundwater sampling within the interest area is directed by the sampling and analysis plans, permits, Tri-Party Agreement (Ecology et al., 1989) change notices, and other documents that identify groundwater monitoring requirements. The CERCLA RI completed for the 200-PO-1 OU in 2008 identified tritium, iodine-129, nitrate, strontium-90, technetium-99, PCE, TCE, and uranium as final COPCs (DOE/RL-2009-85, Rev. 1). Active groundwater remediation is not currently being conducted within 200-PO.

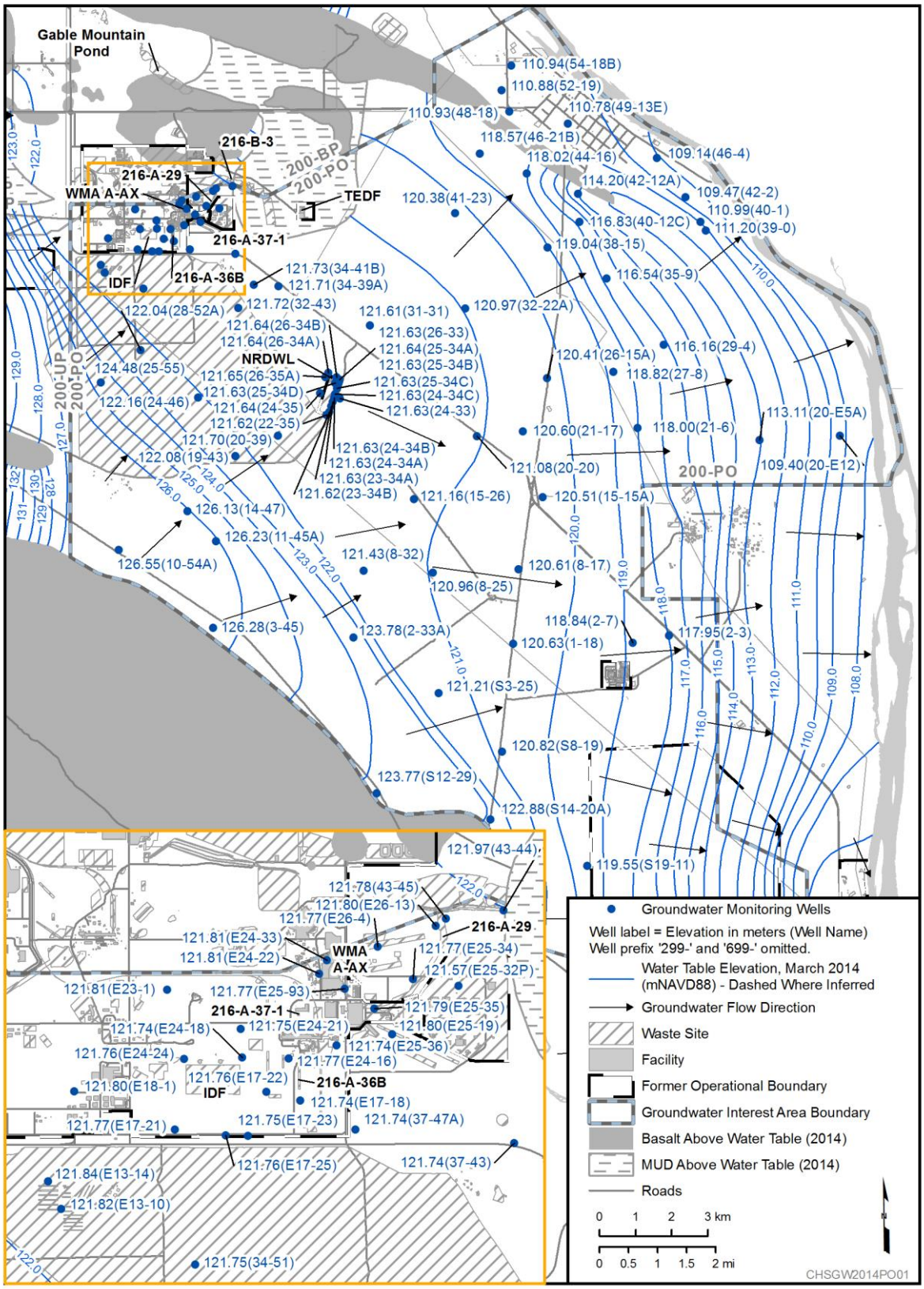


Figure 10-1. 200-PO Overview with Groundwater Flow

Table 10-1. 200-PO at a Glance

PUREX Plant operations:	1956 to 1972 (plutonium separation) 1983 to 1989 (plutonium separation)		
2014 Groundwater Monitoring			
Contaminant	**Drinking Water Standard**	**Maximum Concentration**	**Plume Area* (km^2)**
Tritium	20,000 pCi/L	510,000 µg/L (299-E17-19)	79.2
Iodine-129	1 pCi/L	6.49 pCi/L (699-43-45)	49.3
Nitrate	45 mg/L	156 mg/L (299-E17-19)	3.8
Strontium-90	8 pCi/L	15 pCi/L (299-E24-22)	0.01
Technetium-99	900 pCi/L	1,840 pCi/L (299-E25-93)	0.04
Uranium	30 µg/L	57.8 µg/L (299-E25-36)	0.05

* Estimated area at a concentration greater than the listed drinking water standard.

Groundwater beneath the interest area primarily occurs in an unconfined aquifer consisting of Hanford formation and Ringold Formation sands and gravels (Figure 10-2). However, due to the large extent and overall thickness of the aquifer (up to 215 m [705 ft]), it includes localized semiconfined and confined intervals within deeper portions of the aquifer system as well. The Ringold lower mud unit (hydrostratigraphic unit 8) confines the underlying unit 9. There are also finer-grained strata within unit 9 that confine underlying sediments. East of 200 East Area, there are no saturated sediments above unit 8 and the unconfined aquifer is absent. Detailed discussions of geology and hydrogeology within the 200-PO interest area are provided in DOE/RL-2009-85, DOE/RL-2011-118, and PNNL-12261.

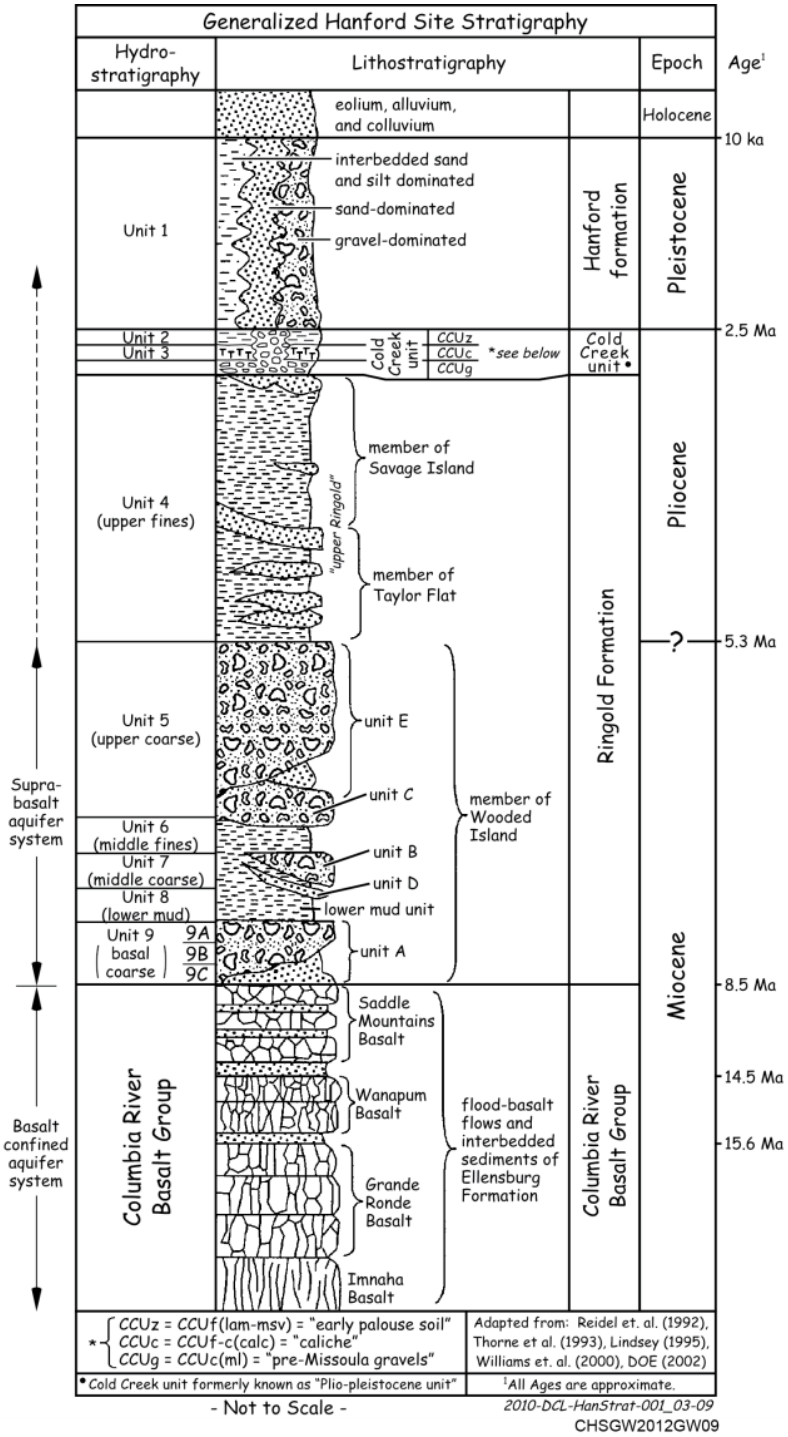


Figure 10-2. 200-PO Geology

10.2 200-PO and 200 East Area Hydraulic Gradient and Groundwater Flow Directions

The depth to the water table is more than 90 m (300 ft) near the southern boundary of the 200 East Area, and it varies in depth to near 0 m bgs at the Columbia River. The water table beneath 200 East Area and the region to the southeast is very flat (Figure 10-1), so special efforts are needed to determine the direction and magnitude of the hydraulic gradient. A network of wells used to evaluate the low-gradient region includes most of the 200 East Area. The network now consists of 56 wells extending from Well 699-50-56 north of LLWMA-1 to Well 699-37-47A just outside the southeast corner of the 200 East Area (SGW-54165). Geodetic casing elevation surveys and gyroscope surveys (for borehole verticality) have been performed in all wells. The collection of monthly water-level measurements from the expanded network began during May 2013. Contours representing the average water table across the low-gradient evaluation network, generated using the inverse distance gridding method, are shown in Figures 10-3 and 10-4 for 2013 and 2014, respectively. The maps generally show flow toward the southeast across the 200 East Area. The contours are more closely spaced in the northwest, indicating the magnitude of the hydraulic gradient is larger in the northwestern part of the 200 East Area compared to the southeast part. The aquifer thickness is smallest in the northwest causing the transmissivity to be lower, and lower transmissivity equates to higher hydraulic gradient magnitudes (when all other factors are equal).
The configuration of the 200 East Area water table at any given time results from the interaction of the river stage and stressors related to discharges to the Treated Effluent Disposal Facility (TEDF), located east of 200 East Area. Discharges to the TEDF are variable. The normal pattern of discharge is a low-volume background averaging 6.7 million L/month (1.8 million gal/month) (2011 through 2013), with occasional discharge volumes in excess of 100 million L/month (26 million gal/month) that occur when the 242-A Evaporator is operating. It is these larger discharges that affect the 200 East Area water table. The 242-A Evaporator began operating again during 2014, and high-volume discharges to the TEDF occurred during February, March, July, September, and October. The largest monthly discharge volume during 2014 was 40 million L (110 million gal) during September. The water table in 200 East Area also responds to Columbia River stage changes via the high-transmissivity paleochannel that originates to the north, near 100-BC Area (Figure 2-4 of SGW-54165). During the summers of 2013 and 2014 river stage was near its long-term average for the summer months, so this stressor was not as substantial as in 2011 and 2012. The combination of higher TEDF discharges to the east and lower river stages to the northwest resulted in a lower hydraulic gradient magnitude in the 200 East Area during 2014, as shown by the contours in Figure 10-4 being farther apart than in Figure 10-3. However, discharges to the TEDF were not substantial enough to cause the groundwater flow direction to change, and flow continued toward the southeast during most of 2014. The main effect of the TEDF discharges was to reduce the gradient toward the southeast. Section 10.13 describes groundwater flow directions beneath specific RCRA sites in 200-PO.

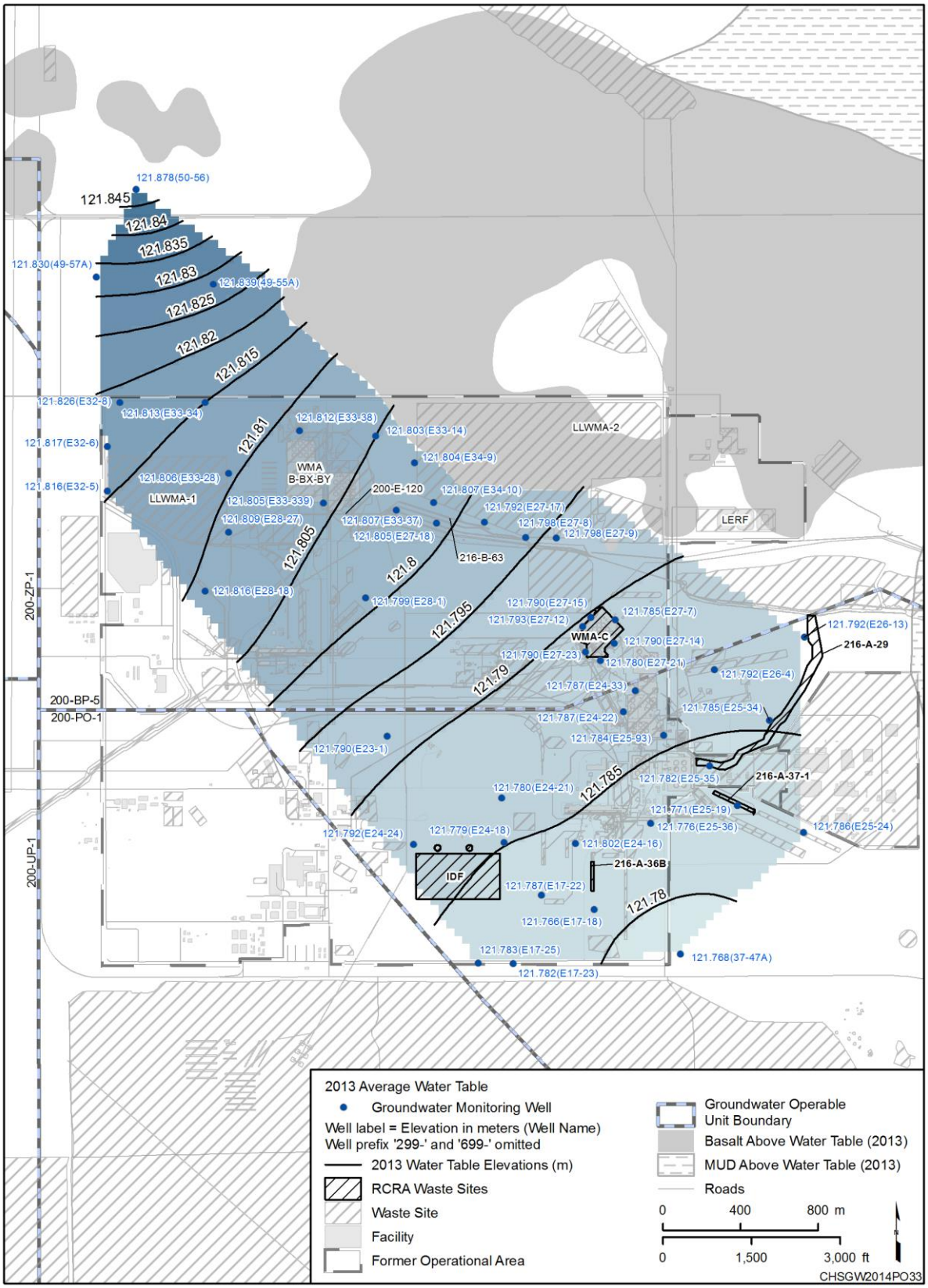


Figure 10-3. Average 2013 Water Table, 200 East Area

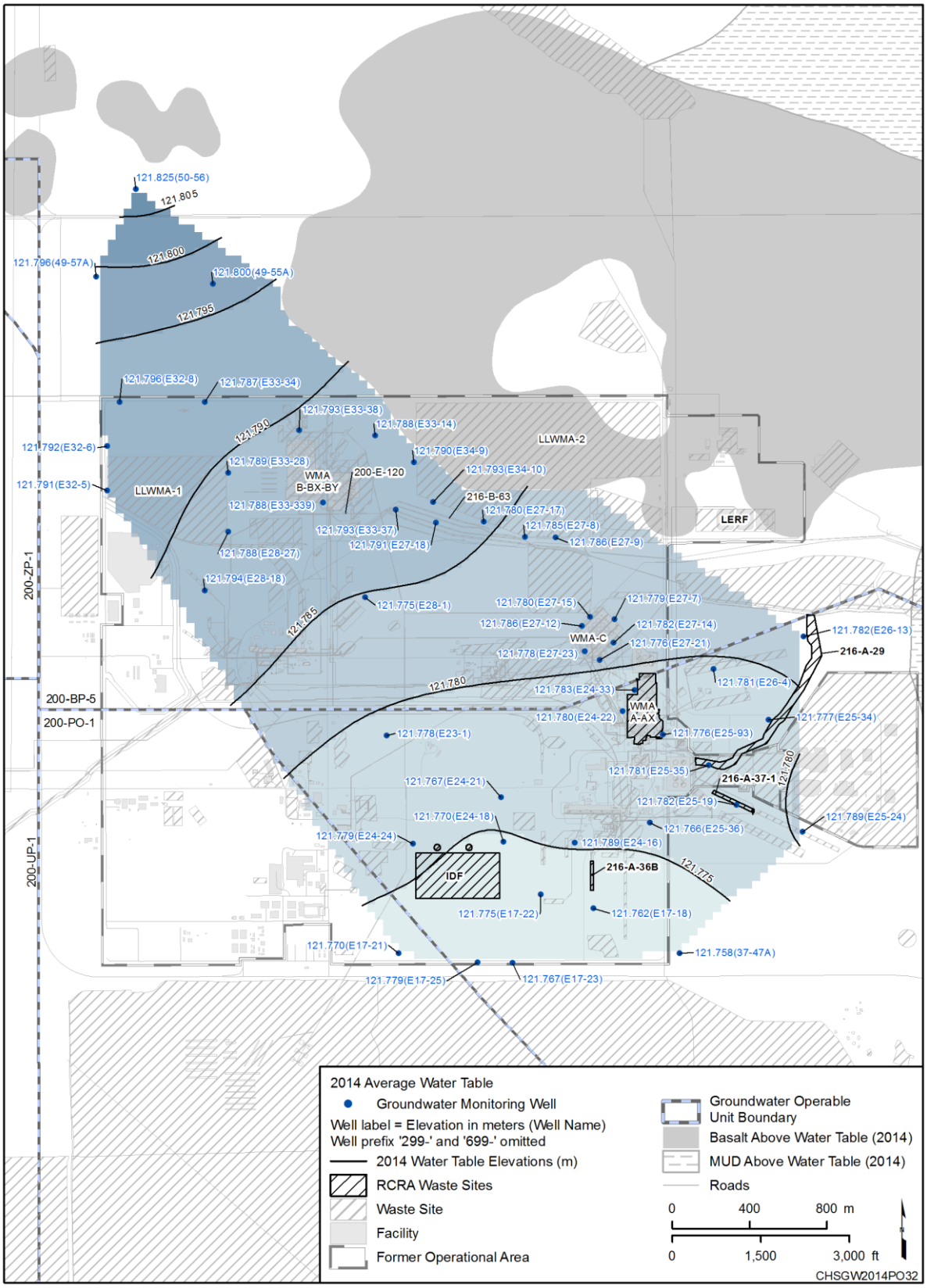


Figure 10-4. Average 2014 Water Table, 200 East Area

10.3 CERCLA Activities

Groundwater monitoring under CERCLA is described in the SAP (DOE/RL-2003-04, Rev. 1), as amended by TPA-CN-205; and DOE/RL-2007-31, Rev. 0, as amended by TPA-CN-2-253. Groundwater is monitored within the unconfined aquifer, Ringold confined aquifers, and the basalt-confined aquifer. Wells and aquifer tubes (Figure 10-5) are generally sampled annually or triennially (every 3 years). Additional aquifer tube sampling within 200-PO is also conducted as defined within the SAP for aquifer sampling tubes (DOE/RL-2000-59). Table A-17 of Appendix A lists monitoring wells, constituents, and sampling status for 2014. Table C-2 of Appendix C lists aquifer tubes sampled in 2014 and January 2015.

The results of the RI are provided in DOE/RL-2009-85, Rev. 1. The report recommended that the OU should advance to the next step in the CERCLA process, which is a FS to develop alternatives to remediate the groundwater contamination. The RI identified tritium, iodine-129, nitrate, strontium-90, technetium-99, PCE, TCE, and uranium as final COPCs. PCE and TCE were only detected at very low (laboratory estimated) concentrations (below the DWS) in far field region wells near the NRDWL and the SWL. Details regarding 2014 groundwater for each of these COPCs are described in the following sections of the report. An RI addendum is currently underway to update the risk assessment for the 200-PO-1 OU based on additional groundwater data collected since the RI was completed.

Plume areas measured from 2003 through 2014 for tritium, iodine-129, nitrate, uranium, and technetium-99 are presented on Figure 10-6. A change in calculated plume area occurred for some contaminants (e.g., nitrate) between 2011 and 2012 due to calculation of areas by interest area boundary starting in 2012, instead of calculation by source area prior to 2012. These COPCs, except technetium-99, are primarily associated with PUREX operations that discharged liquid effluents to the cribs and ditches in the southern part of the 200 East Area from 1956 to 1972, and 1983 to 1988. Technetium-99 within 200-PO has been detected above the DWS near WMA A-AX.

In 2013, one well was decommissioned (299-E25-236) due to casing corrosion issues and one well (699-S12-3) became sample dry. Drilling of a replacement well (299-E25-237) for Well 299-E25-236 was initiated in late 2014, with an early 2015 completion date. Well 699-S12-3 is now a candidate for decommissioning. In 2014, Well 699-25-34E was installed at the SWL as a replacement for Wells 699-25-34C and 699-24-34C, which had previously gone dry. New upgradient monitoring Wells 699-26-38 and 699-24-36 were installed for the NRDWL and the SWL, respectively (Table E-2, Appendix E).

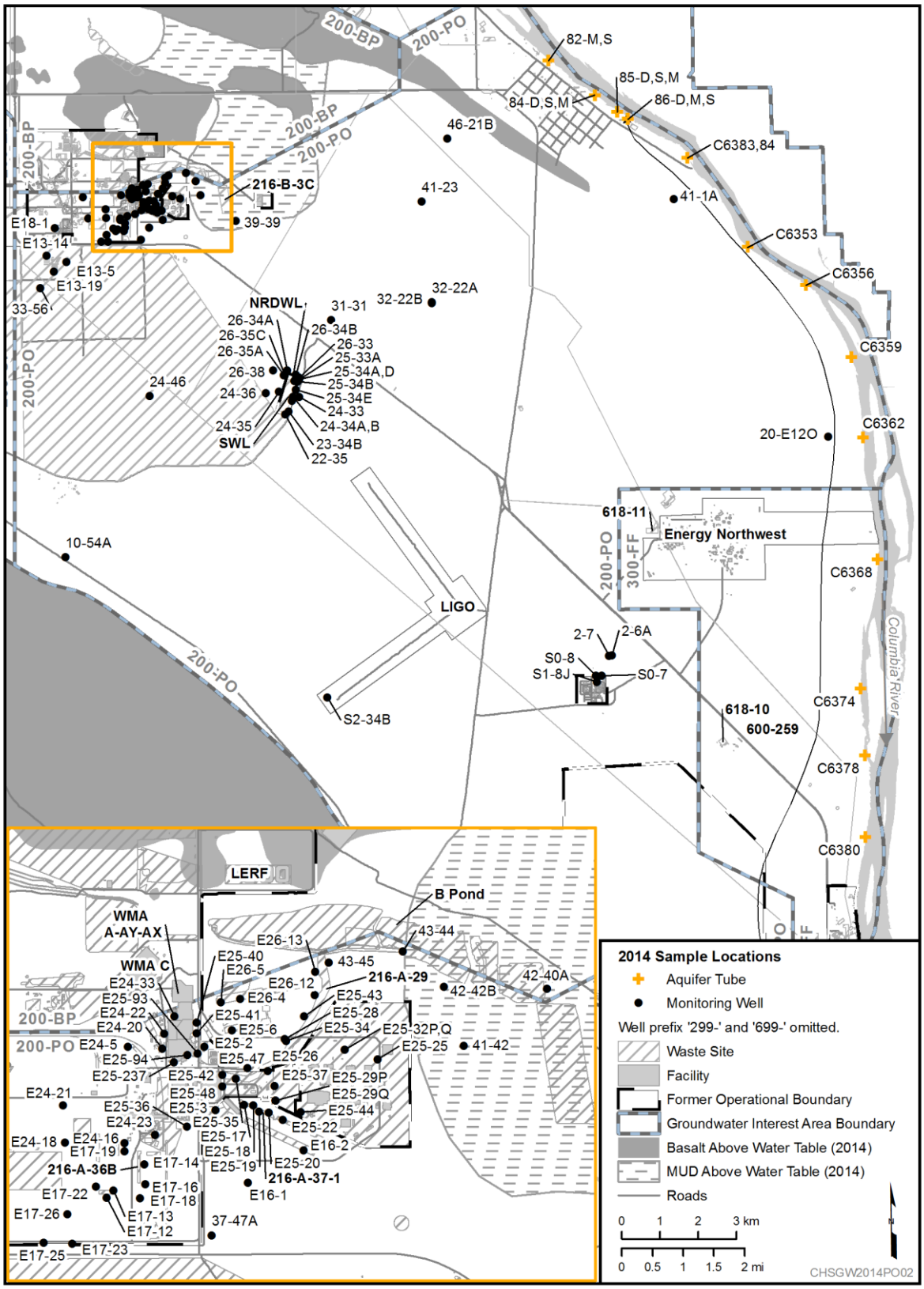


Figure 10-5. 200-PO Sampling Locations, 2014

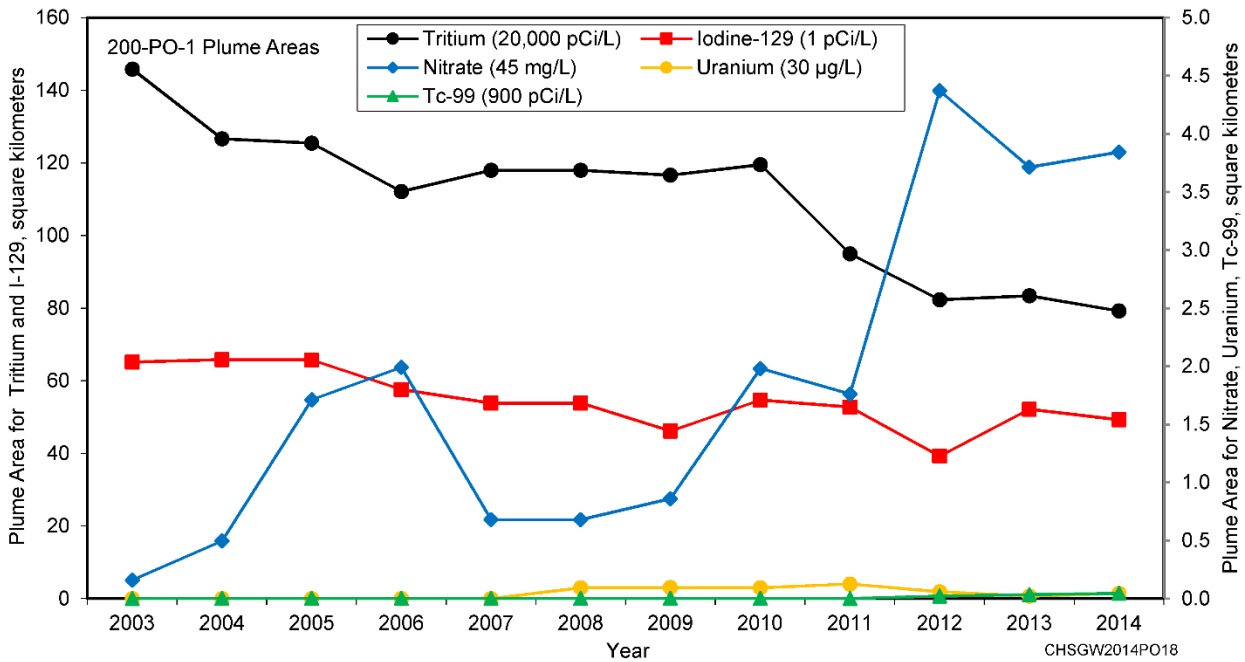


Figure 10-6. 200-PO Plume Areas, 2014

10.4 Tritium

For the 200-PO-1 OU, sampling for tritium in the near field is performed annually (Appendix A, Table A-16). For far field general wells, sampling is conducted primarily on a triennial frequency (Appendix A). Triennial sampling events were conducted in 2010 and 2013. Far field wells comprising the southeast transect and river transect are sampled annually (Appendix A, Table A-17).

Tritium contamination in groundwater is found at a concentration greater than the 20,000 pCi/L DWS in a large plume within 200-PO from the 200 East Area to the Columbia River (Figure 10-7). The highest current and historical concentrations have been detected near the PUREX Cribs and Trenches, which were the major sources of this contaminant. The tritium plume continues to be present the far field area with a portion of the plume discharging into the Columbia River to the east (Figure 10-7). Decreasing concentrations and attenuation of the plume in the far field region is due to dispersion and radioactive decay of tritium, but concentrations near the PUREX Cribs and Trenches remain up to 25 times the DWS of 20,000 pCi/L and have been relatively stable since 2000 indicating potential vadose zone sources. The interpolated portion of the tritium plume at a concentration above 20,000 pCi/L that discharges to the river has been reduced in 2014 in comparison to 2013 based on declines in levels observed in aquifer tubes and near-river wells. The highest tritium concentration detected at an aquifer tube sample location was 9,560 pCi/L at C6384 (Figure 10-7).

In 2014, the 20,000 pCi/L and 200,000 pCi/L interpolated plume intervals are generally consistent with the 2013 plume, with some localized reduction in extent (presented in DOE/RL-2014-32). The tritium plume has decreased in size by approximately 59 percent since 1996. For 2014, the highest concentrations of tritium in the near field area were 510,000 pCi/L in Well 299-E17-19 (near the 216-A-10 Crib), 400,000 pCi/L in Well 299-E17-14 (near the 216-A-36B Crib), and 172,000 pCi/L in Well 299-E24-16 (near the 216-A-10 Crib) (Figure 10-8). The highest concentration of tritium detected during 2014 from the far field was 739,000 pCi/L for a sample collected in October at Well 699-13-3A. The tritium in Well 699-13-3A originated at the 618-11 Burial Ground and is discussed in more detail in the 300-FF discussion (Chapter 7).

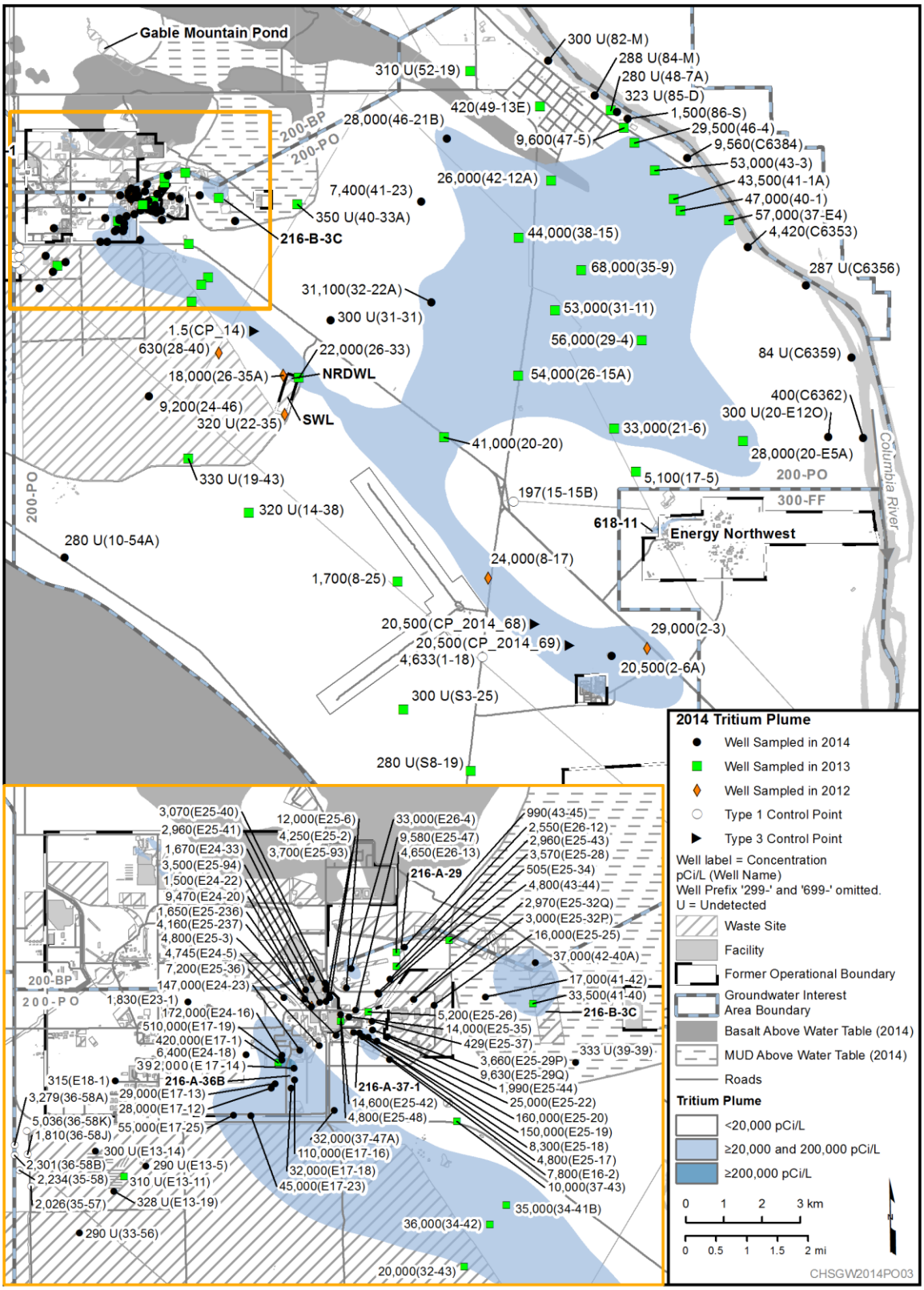


Figure 10-7. 200-PO Tritium Plume, 2014

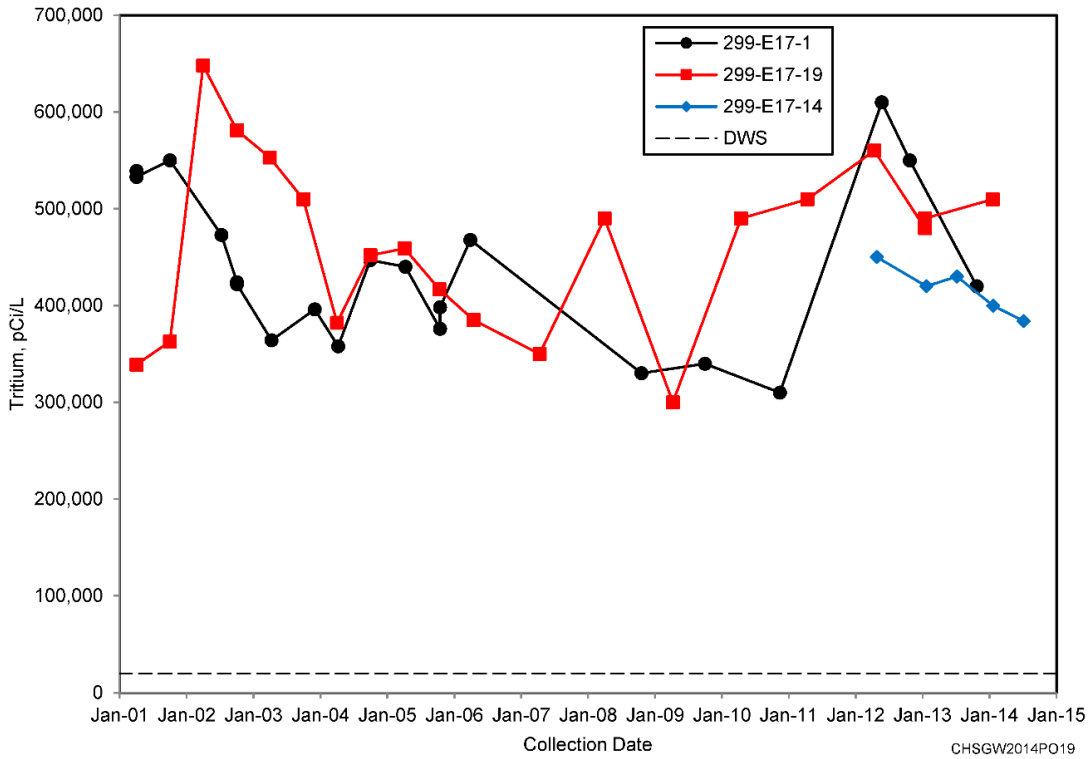


Figure 10-8. 200-PO Tritium Data for Wells 299-E17-1, 299-E17-19, and 299-E17-14

An area of lower tritium concentrations identified in the far field region near the Energy Northwest complex (Figure 10-7) is hypothesized to be due to a zone of lower hydraulic conductivity material in the unconfined aquifer, where the water table is within the upper portion of the Ringold Formation, which has a greater degree of local cementation. The zone of lower hydraulic conductivity has resulted in groundwater flow, and tritium contamination moving around this area.

Well 699-31-31 is one of the wells used to define the boundary of the tritium plume in the area where the plume narrows as it extends to the southeast between the 200 East Area and the distal far field (Figure 10-7). Well 699-31-31 and other wells in the vicinity of the plume in this region have been showing a decreasing concentration trend following peak levels that occurred when a high-concentration slug of tritium passed through the area between 1992 and 1994 (Figures 10-9 and 10-10). From 1992 to 2000, the tritium concentrations in this well usually exceeded the DWS. After 2000, concentrations of tritium detected in the well were approximately one order of magnitude lower than the concentration detected in 2000. The reason for the decrease in the tritium concentration in the well between 2000 and 2001 is not known. The concentration change could be related to a breach of one of the seals within this multi-level (nested) monitoring well or a distinct local groundwater concentration change. Since 2001, this well has had concentrations well below the DWS. In reviewing concentration trending for other wells in the area that are equal distance from the plume margin, current concentration trending for Well 699-31-31 is consistent with the regional pattern. Future utilization of Well 699-31-31 and the potential need to replace it will be further assessed as the FS for 200-PO-1 progresses and remedial alternatives are reviewed.

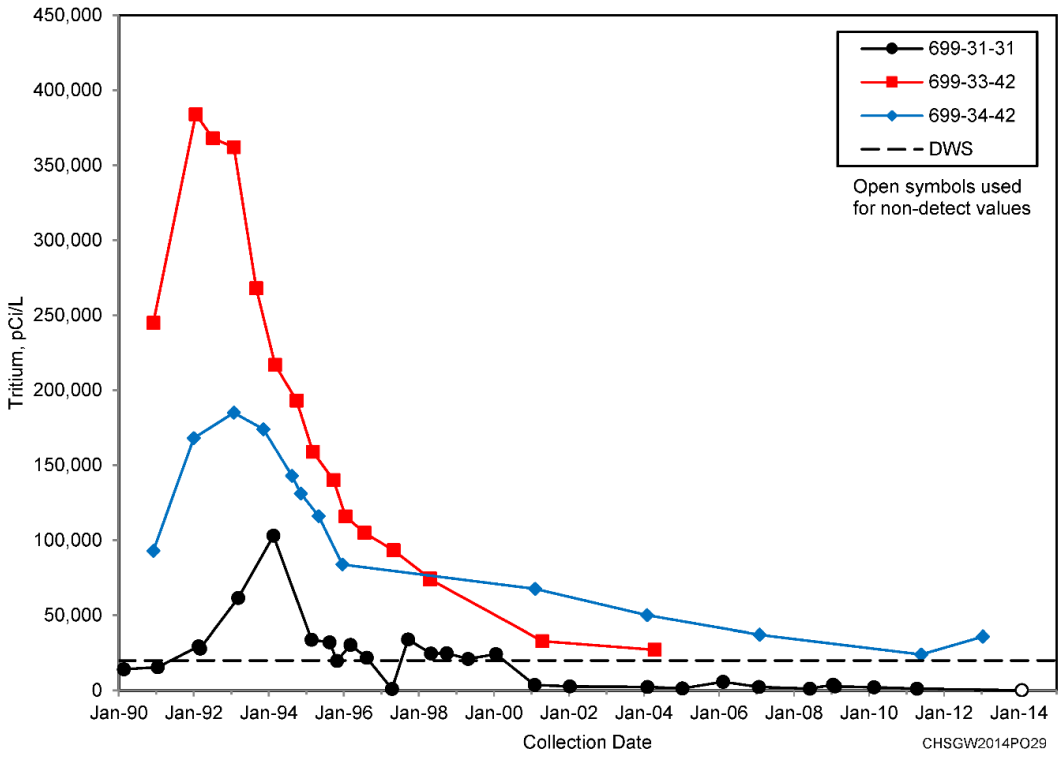


Figure 10-9. 200-PO Tritium Data for Wells 699-31-31, 699-33-42, and 699-34-42

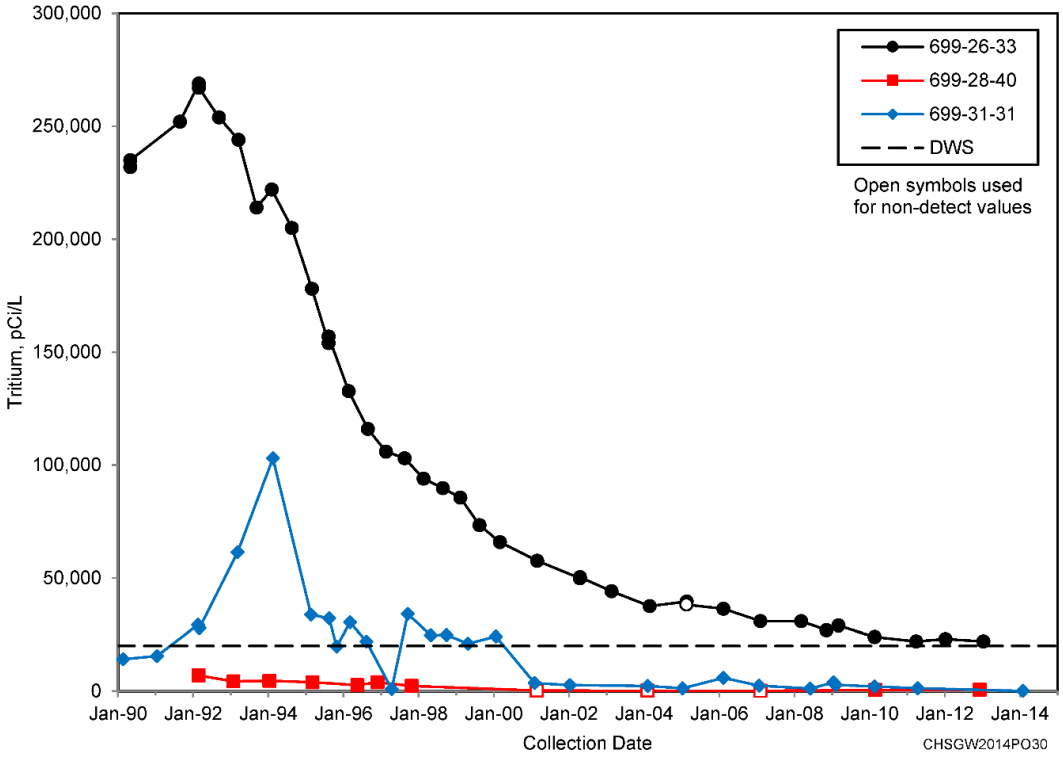


Figure 10-10. 200-PO Tritium Data for Wells 699-31-31, 699-26-33, and 699-28-40

Wells screened (or casings perforated) in the middle or lower portions of the unconfined aquifer had tritium results ranging from nondetect to 9,630 pCi/L (299-E25-29Q) in the near field region in 2014, and from nondetect to 57,000 pCi/L (near-river Well 699-37-E4) in the far field region in 2013. The 2013 concentration of tritium detected in Well 699-37-E4 was consistent with the level detected during the sampling of the well in 2010 (62,000 pCi/L). Similar concentrations in the upper part of the unconfined aquifer are detected near Well 699-37-E4. Tritium has been detected above the DWS in near-river Well 699-37-E4 since sampling for tritium began in the well in 1990. From 1990 to 1995, the concentration of tritium in Well 699-37-E4 increased. Since 1997, concentrations of tritium at this well have decreased.

In 2014, tritium concentrations in wells screened in the Ringold beneath the lower mud ranged from nondetect (699-39-39) to 37,000 pCi/L (699-42-40A). Both wells are located near B Pond (Figure 10-7). The concentration detected in 2013 in Ringold confined Well 699-41-40 (34,000 pCi/L) is consistent with the previous triennial sample which had a tritium concentration of 36,000 pCi/L in 2010. Tritium has been detected above the DWS in Well 699-41-40 since sampling began at this well in 1990. From 1990 to 2010, the tritium concentration in Well 699-41-40 has decreased from 226,000 pCi/L to 34,000 pCi/L. There is no unconfined aquifer at this well location.

Seven wells screened in basalt-confined aquifers are sampled triennially within 200-PO. Wells 299-E16-1 (screened in the Elephant Mountain interflow zone), 699-42-40C (Rattlesnake Ridge Interbed) and LIGO Well 699-S2-34B (with a completion depth of 591.6 m [1,941 ft] bgs is assumed to monitor a deeper confined aquifer) were sampled in 2014. The other four wells will be sampled in 2015. Tritium was not detected in Wells 299-E16-1 and 699-S2-34B in 2014. Tritium has been detected only intermittently at low concentrations below the DWS in samples collected from wells screened in basalt aquifers, with the exception of Well 699-42-40C located near the 216-B-3 Pond. Tritium in Well 699-42-40C has been detected since 1982 (Figure 10-11) up to a maximum concentration of 8,320 pCi/L in 1993. Since 1993 concentrations in Well 699-42-40C have decreased.

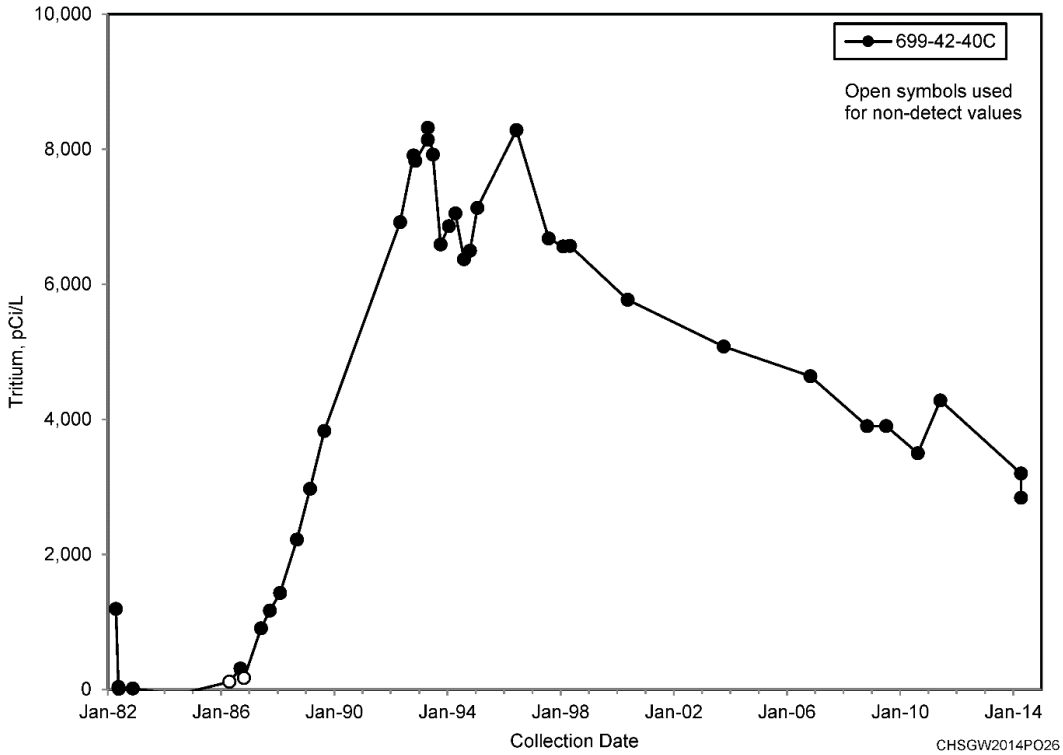


Figure 10-11. 200-PO Tritium Data for Basalt-Confined Well 699-42-40C

10.5 Iodine-129

Iodine-129 at a concentration greater than the 1 pCi/L DWS is found in a relatively dispersed plume that covers a large area within 200-PO (Figure 10-12). The highest historical concentrations have been detected near the PUREX Cribs and Trenches. The 2014 interpolated plume extent above the 1 pCi/L concentration is essentially the same as the 2013 plume presented in DOE/RL-2014-32, since the majority of the far field well sampling (triennial sampling) was completed in 2013.

Iodine-129 concentrations detected in near field wells in 2014 ranged from nondetect to 6.49 pCi/L. The highest concentrations in 2014 were detected near the PUREX Cribs and Trenches, 216-A-29 Ditch, 216-B-3 Pond, and WMA A-AX. None of the detected concentrations exceeded the DOE-derived concentration standard of 330 pCi/L (Table 5 of DOE-STD-1196-2011). In 2014, the highest concentrations of iodine-129 were detected in Wells 699-43-45 (6.49 pCi/L), 299-E25-2 (5.33 pCi/L), 299-E25-34 (5.19 pCi/L), 299-E17-14 (5.15 pCi/L),) and 299-E17-19 (5.15 pCi/L). Iodine-129 concentrations in Well 299-E17-19 near the PUREX Cribs has been relatively stable since sample collection started in 1992 (Figure 10-13) Concentrations in Well 699-43-45, located near 216-B-3 Pond and the north end of the 216-A-29 Ditch, showed an increasing trend between 2004 and 2011, but have decreased in the subsequent years (Figure 10-13). The highest concentrations of iodine-129 detected in 2014 sampling conducted in the far field occurred at Wells 699-32-22A (4.53 pCi/L) and 699-37-47A (3.32 pCi/L).

As with the tritium plume, Well 699-31-31 is one of the wells used to define the boundary of the iodine-129 plume in the area where the plume narrows as it extends to the southeast between the 200 East Area and the distal far field. Iodine-129 concentrations declined sharply between 1994 and 1995 (Figure 10-14). Concentration changes of that magnitude were not observed in wells farther downgradient. From 1991 to 1997, iodine-129 concentrations in Well 699-31-31 generally exceeded the DWS. Consistent with tritium peak levels, the peak iodine-129 concentration in this well occurred in 1994. Beginning in 1995, concentrations of iodine-129 decreased to between nondetect and relatively low detected values generally below the DWS (Figure 10-14). In reviewing concentration trending for other wells in the area that are equal distance from the plume margin, current iodine-129 concentration trending for this well is consistent with the regional pattern. Future utilization of Well 699-31-31 and the potential need to replace it will be further assessed as the FS for 200-PO-1 progresses and remedial alternatives are reviewed (see discussion of Well 699-31-31 in Section 10.4).

Iodine-129 was not detected in in aquifer tube sampling completed for 200-PO in 2014. Iodine-129 results for river transect Well 699-20-E12O did not detect iodine-129, which is consistent with all previous results since sampling was initiated in 1999.

Within the middle and lower part of the unconfined aquifer, iodine-129 was detected in three wells in the near field region at concentrations above the DWS: 3.43 pCi/L in Well 299-E25-28 located near the 216-A-29 Ditch; and 1.79 and 2.4 pCi/L in Wells 299-E25-29Q and 299-E25-32Q, respectively, located near the 216-A-30, 216-A-37-1, and 216-A-37-2 Cribs. Iodine-129 was detected during 2013 in one monitoring well (699-31-11) screened in the middle and lower part of the unconfined aquifer in the far field region at a concentration of 1.21 pCi/L (next scheduled for sampling in 2016) (Figure 10-12).

For 200-PO, the Ringold confined aquifer is monitored near the 216-B-3 Pond and the TEDF in 200-PO. In 2014, iodine-129 was detected at one well (699-42-42B) above the DWS (1.7 pCi/L) near the 216-B-3 Pond (Figure 10-12). Additional results for other Ringold confined wells are provided in Appendix D.

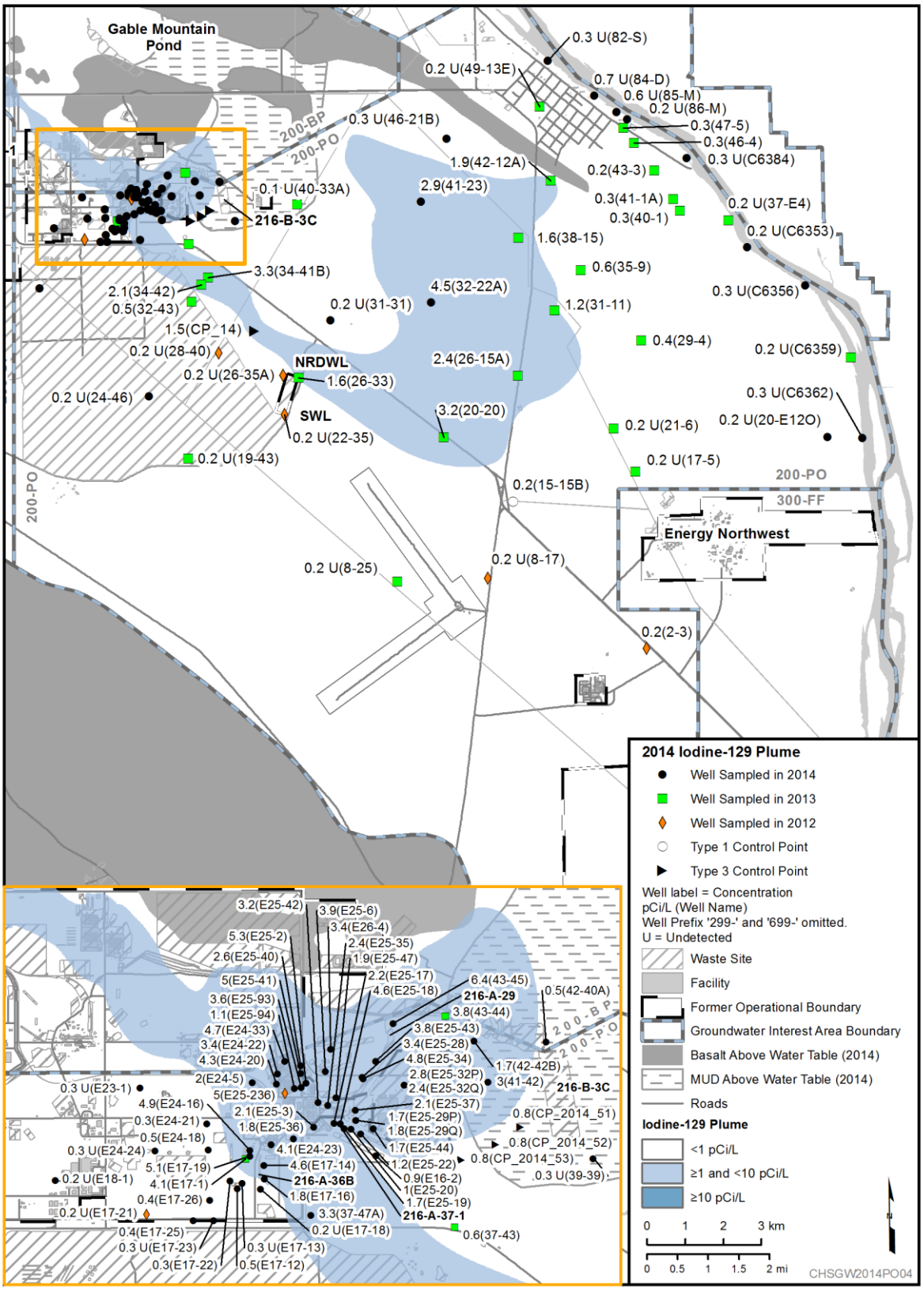


Figure 10-12. 200-PO Iodine-129 Plume, 2014

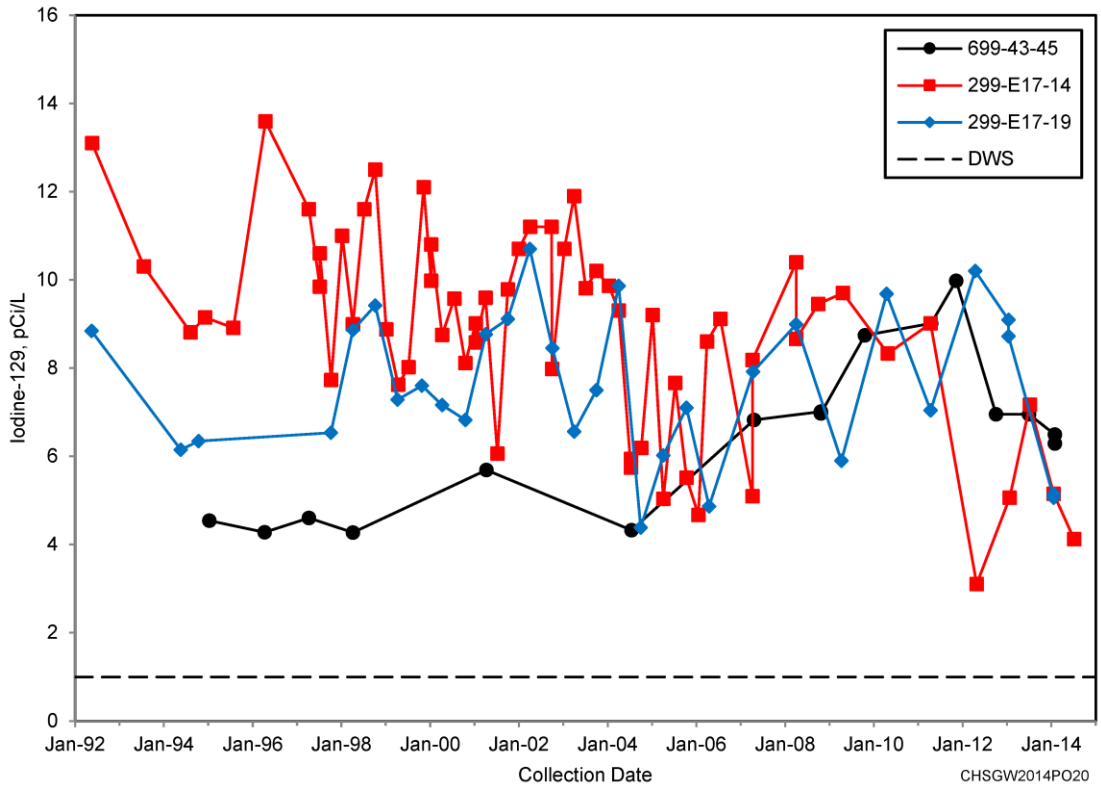


Figure 10-13. 200-PO Iodine-129 Data for Wells 699-43-45, 299-E17-14, and 299-E17-19

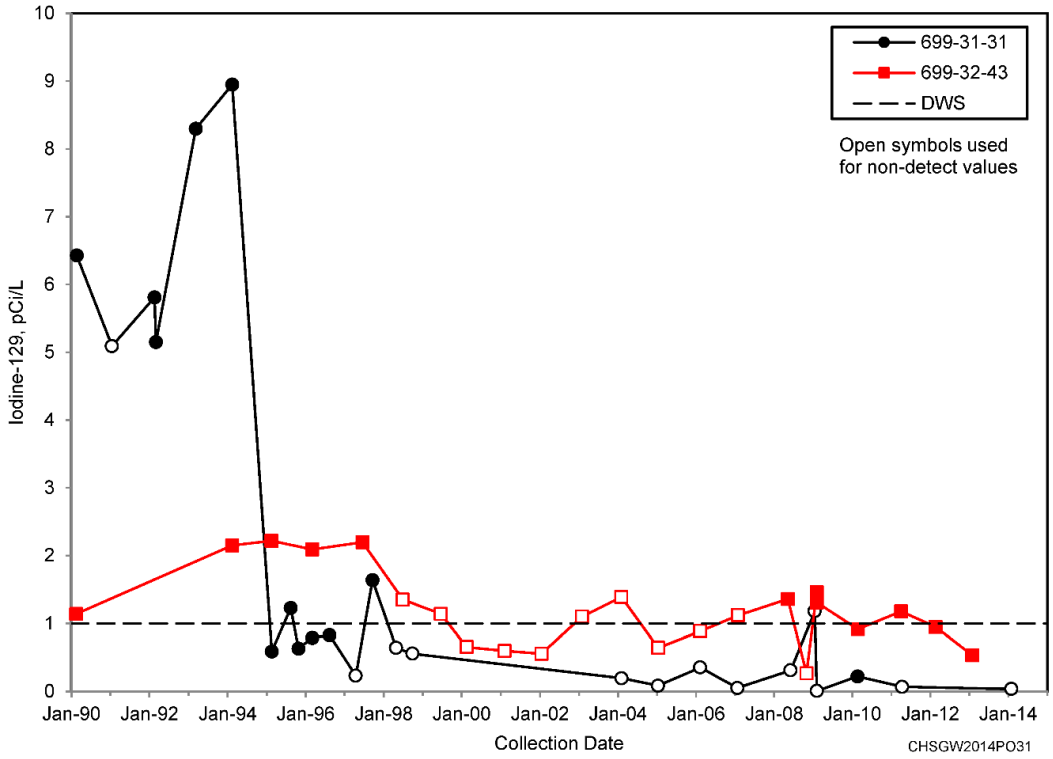


Figure 10-14. 200-PO Iodine-129 Data for Wells 699-31-31 and 699-32-43

Three wells screened in basalt-confined aquifers are sampled triennially within 200-PO for iodine-129. Wells 299-E16-1, 699-32-22B,B and 699-42-40C were sampled in 2014, and no iodine-129 was detected. Iodine-129 was only detected at very low concentrations from basalt wells in the early to mid-1990s, except in Well 699-42-40C located near the 216-B-3 Pond. Iodine-129 concentrations in Well 699-42-40C have been intermittently detected at low concentrations (below the 1 pCi/L DWS) since sampling began in 1988. The last detection was a concentration of 0.29 pCi/L in 2010. The highest concentration detected in the well was 0.36 pCi/L in 1996. Since 2000, the only detections of iodine-129 in the basalt-confined wells beneath 200-PO have been in 699-42-40C.

10.6 Nitrate

The highest historical concentrations of nitrate in 200-PO have been detected near the PUREX Cribs and Trenches. The extent of nitrate at concentrations greater than the 45 mg/L DWS is relatively small within the 200-PO interest area (Figure 10-15). Historically, the nitrate plume was relatively large, but concentrations within the far field region have decreased to below the 45 mg/L DWS equivalent, other than near the 618-10 Burial Ground (see 300-FF discussion in Chapter 7). The 2014 interpolated plume is generally consistent with the 2013 plume presented in DOE-RL-2014-32. Comparing the 2014 plume (Figure 10-15) to the 2013 plume reveals the following notable changes:

- The interpolated extent of the 45 mg/L concentrations are now farther south of the IDF in the 200 East Area. The 2014 interpolation is supported by concentrations greater than 45 mg/L in Wells 299-E17-23, 299-E17-25, and 299-E17-26 that were less than 45 mg/L in 2012. Sharply increasing concentration trends in these wells began in 2012.
- The nitrate plume now extends continuously from WMA C to Well 299-E24-20 along the eastern margin of WMA A-AX.

The highest nitrate concentrations in 200-PO from samples collected during 2014 were 156 mg/L at Well 299-E17-19, located downgradient of the 216-A-10 Crib, and 101 mg/L from Well 299-E17-14, located downgradient of the 216-A-36B Crib (Figure 10-16). Many of the wells near the PUREX Cribs, including Wells 299-E17-1, 299-E17-16, 299-E17-18, 299-E24-16, 299-E25-17, and 699-37-47A in the southeastern portion of the 200 East Area, have exhibited increasing nitrate concentrations since approximately 2002 (e.g., 299-E25-17 and 699-37-47A; Figure 10-17). Migration of the leading edge of nitrate plume to the south to southeast is indicated by the increasing concentrations in Wells 299-E17-25 and 299-E17-23 (Figure 10-17). The cause of the increase in nitrate concentrations in this portion of the 200 East Area may be related to a number of factors, including changing groundwater flow directions associated with cessation of wastewater discharges at B Pond, water table elevation decreases in the 200 East Area, and/or a vadose zone source(s) contribution associated with the PUREX Cribs.

For the wells screened (or casings perforated) in the middle to lower portions of the unconfined aquifer in the near field region (299-E25-29Q and 299-E25-32Q), nitrate did not exceed 45 mg/L in 2014, and concentrations above that level appear to occur within the upper 10 m (33 ft) of the aquifer. The most recent (2013) maximum nitrate concentration in the deeper portion of the aquifer was 33.6 mg/L in far field, near-river Well 699-37-E4. Nitrate levels have been stable in this well since approximately 1991. Within the near-field region, the highest nitrate concentration detected in 2014 in the deeper portion of the aquifer was 42.7 mg/L in Well 299-E25-29Q.

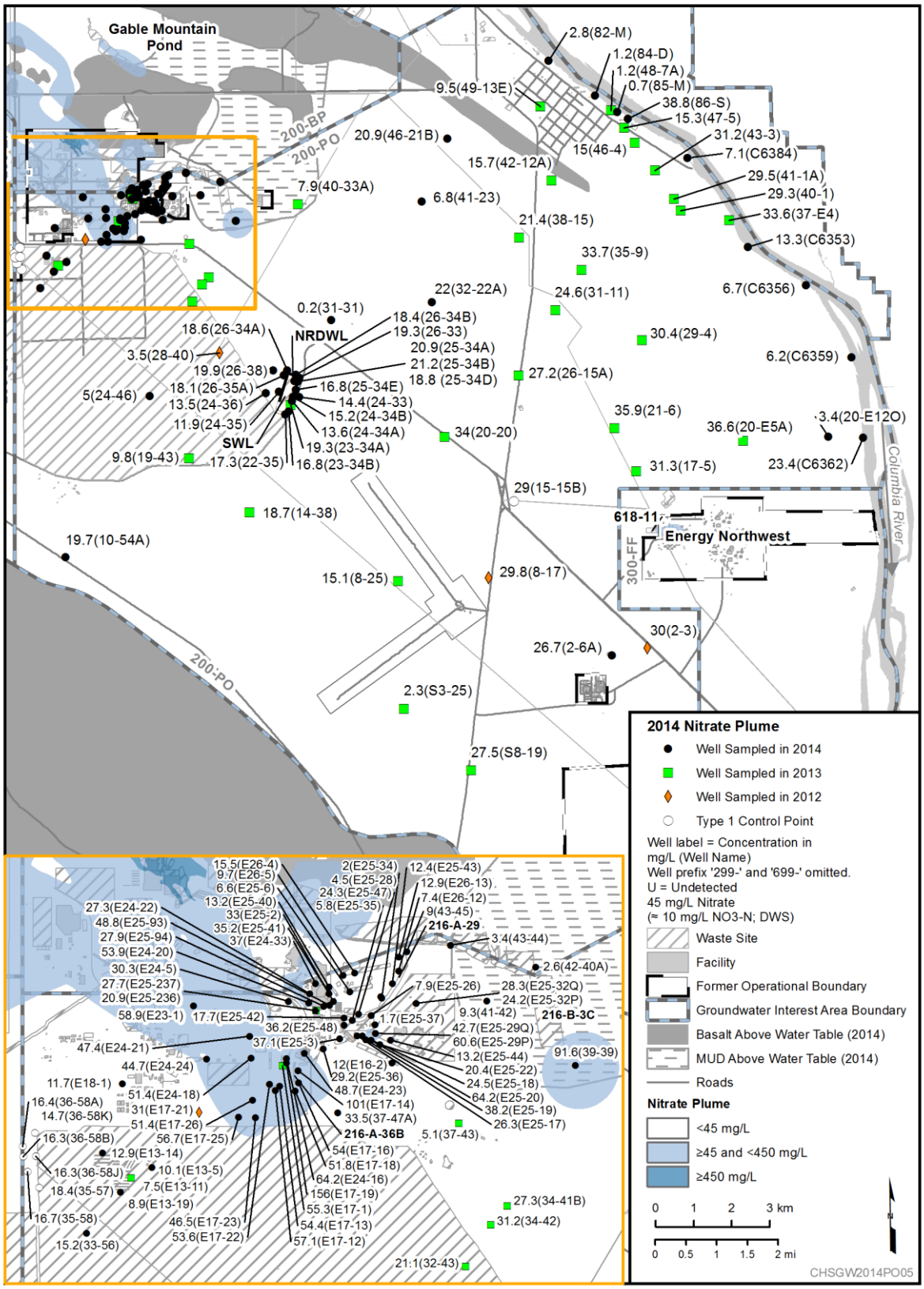


Figure 10-15. 200-PO Nitrate Plume, 2014

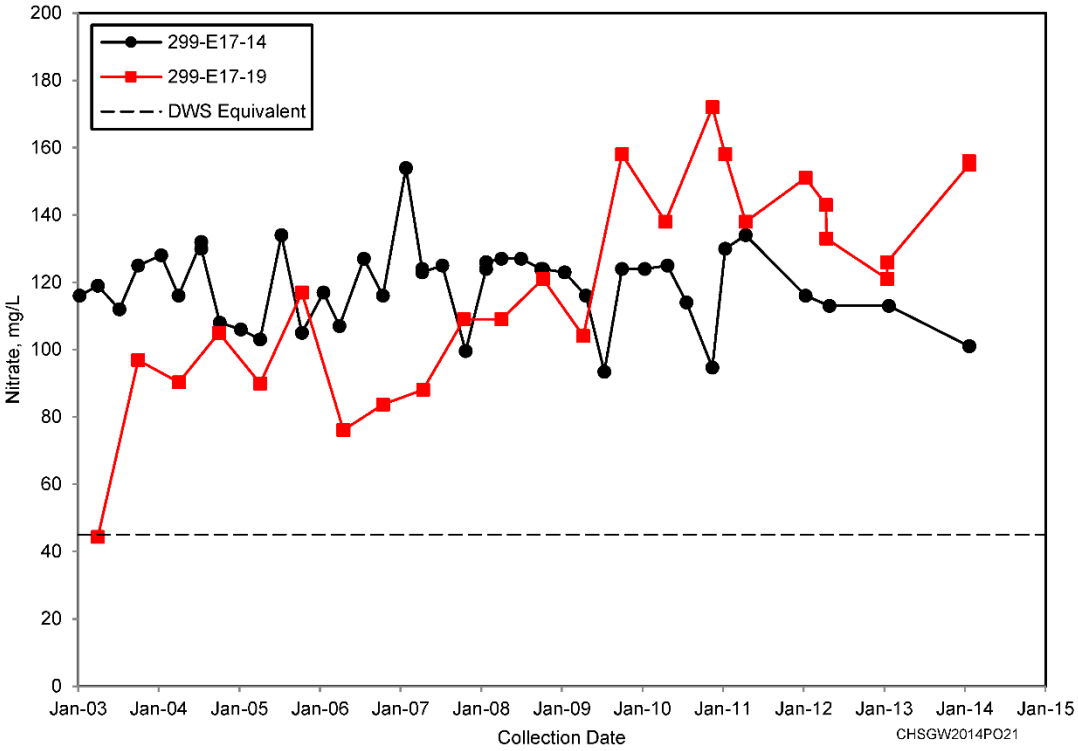


Figure 10-16. 200-PO Nitrate Data for Wells 299-E17-14 and 299-E17-19

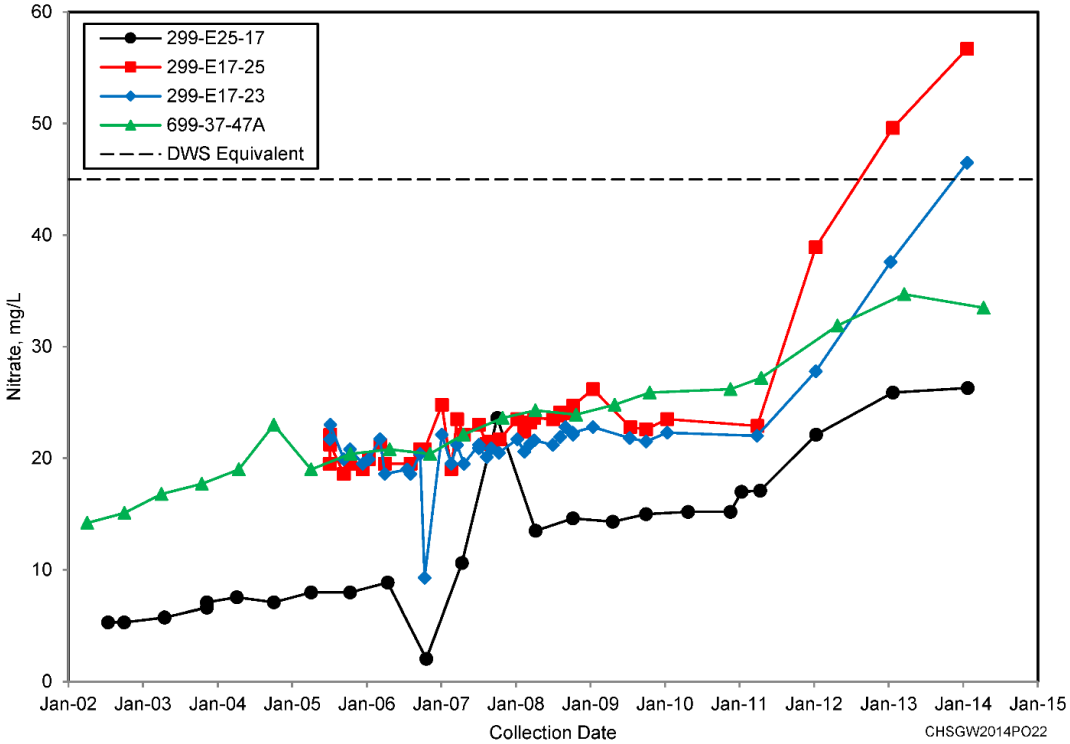


Figure 10-17. 200-PO Nitrate Data for Wells 299-E25-17 and 699-37-47A

Only one well in the far field region had a concentration above the 45 mg/L DWS in 2014. A maximum concentration of 80 mg/L was detected in Well 699-13-3A (see 300-FF discussion in Chapter 7). The source of the nitrate in this well is the 618-10 Burial Ground. Nitrate was near or below detection limits in the main water supply well for the 400 Area (499-S1-8J), which is screened in the deep portion of the unconfined aquifer.

Nitrate was detected in 2014 in one well within the Ringold Formation confined aquifer above 45 mg/L. A concentration of 91.6 mg/L was measured in Well 699-39-39. Nitrate concentrations began to increase substantially in this well starting in the late 1980s. Nitrate concentrations ranging between 85.4 and 94.7 mg/L have have been detected in the well since 2001. Nitrate was sampled from six wells screened in the basalt-confined aquifer beneath 200-PO in 2014 (Appendix A). Basalt-confined wells are sampled triennially, and the next scheduled sampling will occur in 2017. Nitrate concentrations in the basalt-confined aquifer, as indicated in Wells 699-42-40C and 699-S11-E12AP, which have been monitored since 1984, are lower than in the unconfined aquifer because the groundwater is less oxygenated (Figure 10-18).

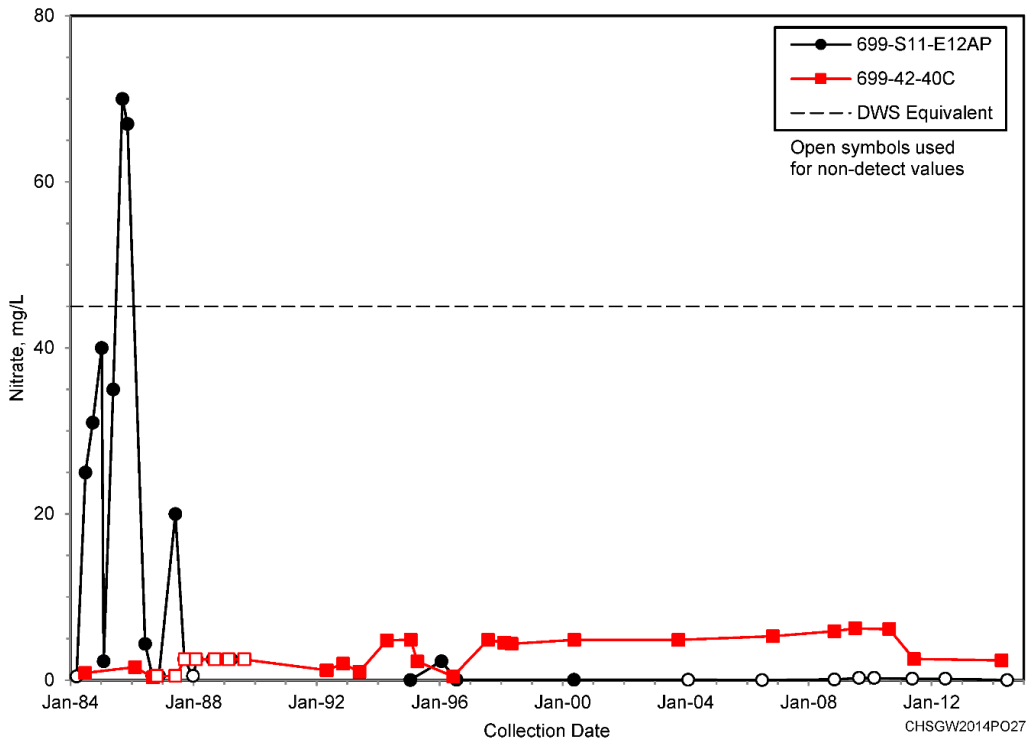


Figure 10-18. .200-PO Nitrate Data for Basalt-Confined Wells 699-S11-E12AP and 699-42-40C

10.7 Strontium-90

Strontium-90 has historically been detected in a relatively small area at concentrations greater than the DWS of 8 pCi/L near the 216-A-5, 216-A-10, and 216-A-36B Cribs. A small plume remains near the 216-A-36B Crib (Figure 10-19). Concentrations of strontium-90 near the 216-A-5 and 216-A-10 Cribs have only exceeded the 8 pCi/L DWS in one sampling event in one well (299-E24-16 at a concentration of 8.19 pCi/L in 2004). Concentrations in the well have historically ranged from 5.2 to 7.8 pCi/L (Figure 10-20).

Strontium-90 was detected above the DWS of 8 pCi/L during 2014 at Well 299-E17-14 near the 216-A-36B Crib. Since sampling was started for strontium-90 in this well in 1988, the general concentration trend has been relatively stable, ranging from 11 to 30 pCi/L (Figure 10-20), suggesting a potential for continuing contribution from the vadose zone. The 2014 result for Well 299-E17-14 was 15 pCi/L, the same as the 2013 and 2012 results.

In 2014, strontium-90 was detected in other wells near the PUREX Cribs and Trenches within the 200-PO near field region, but at concentrations below the DWS. These included 5.3 pCi/L in Well 299-E24-16 and 2.2 pCi/L in Wells 299-E17-19 near the 216-A-10 Crib; 2.2 pCi/L in Well 299-E17-16 near the 216-A-36B Crib; 2.1 pCi/L at Well 299-E25-18; and 1.1 pCi/L at Well 299-E25-17 near the 216-A-37-1 Crib. In 2013, strontium-90 was detected in one far field well (299-E13-11) located near the BC Cribs and Trenches, at a concentration of 2.4 pCi/L.

The middle or deep unconfined aquifer wells were not analyzed for strontium-90, with the exception of the three water supply wells in the 400 Area (499-S0-7, 499-S0-8, and 499-S1-8J). Strontium-90 was not detected in 2012 in samples collected from these wells, but a low-level concentration of 0.95(±0.93) pCi/L was measured in 2014 from Well 499-S0-7. The Ringold confined aquifer wells are not analyzed for strontium-90.

Strontium-90 is not currently required to be monitored in the seven basalt-confined aquifer wells (TPA-CN-205). Strontium-90 was sampled intermittently in the wells from 1988 to 2011. During that time, strontium-90 was detected in one sample from Well 699-42-40C (located near the 216-B-3 Pond), and one sample in Well 699-S11-E12AP (located southwest of the 400 Area). Both detections were reviewer qualified as suspect.

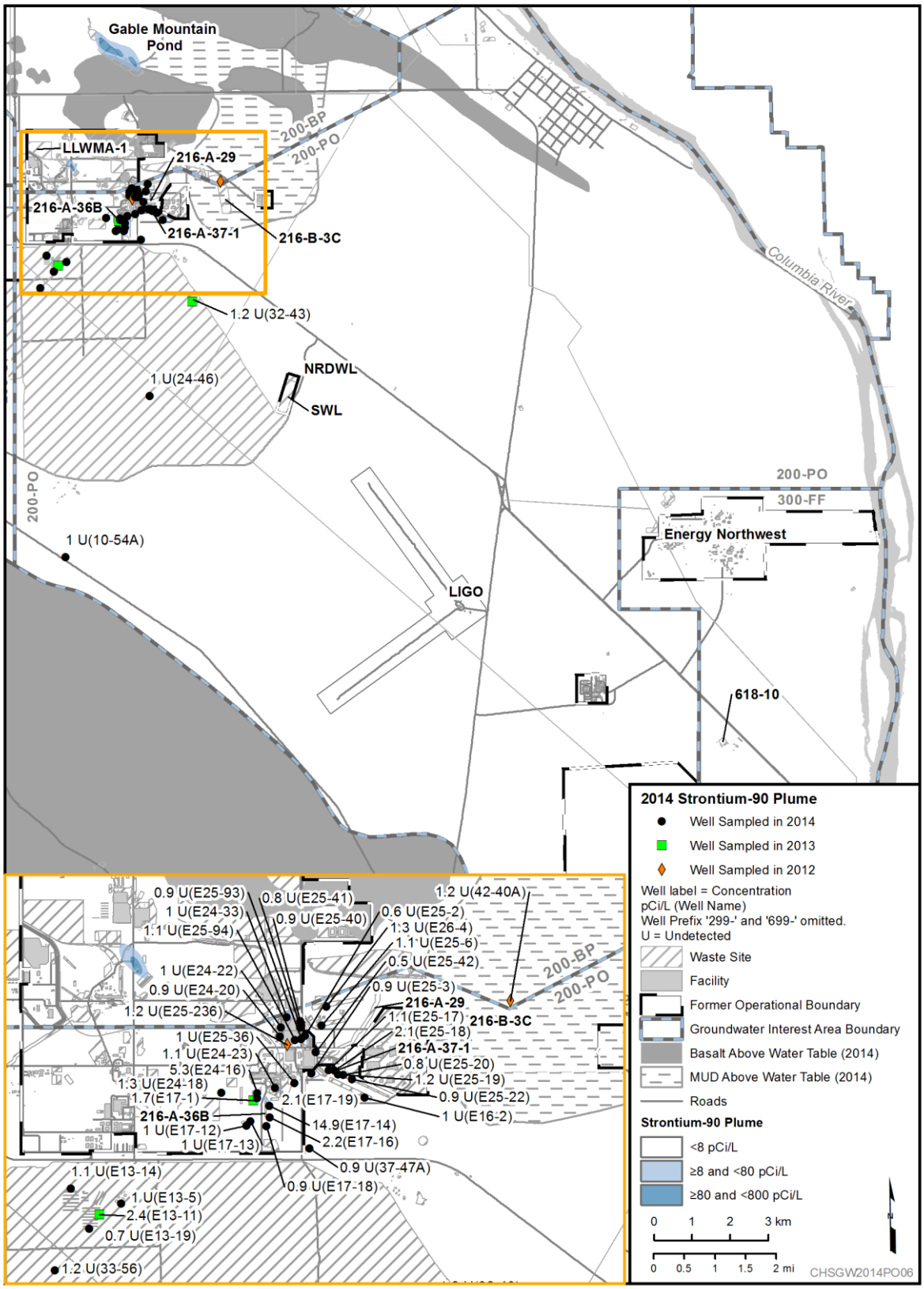


Figure 10-19. 200-PO Strontium-90 Plume, 2014

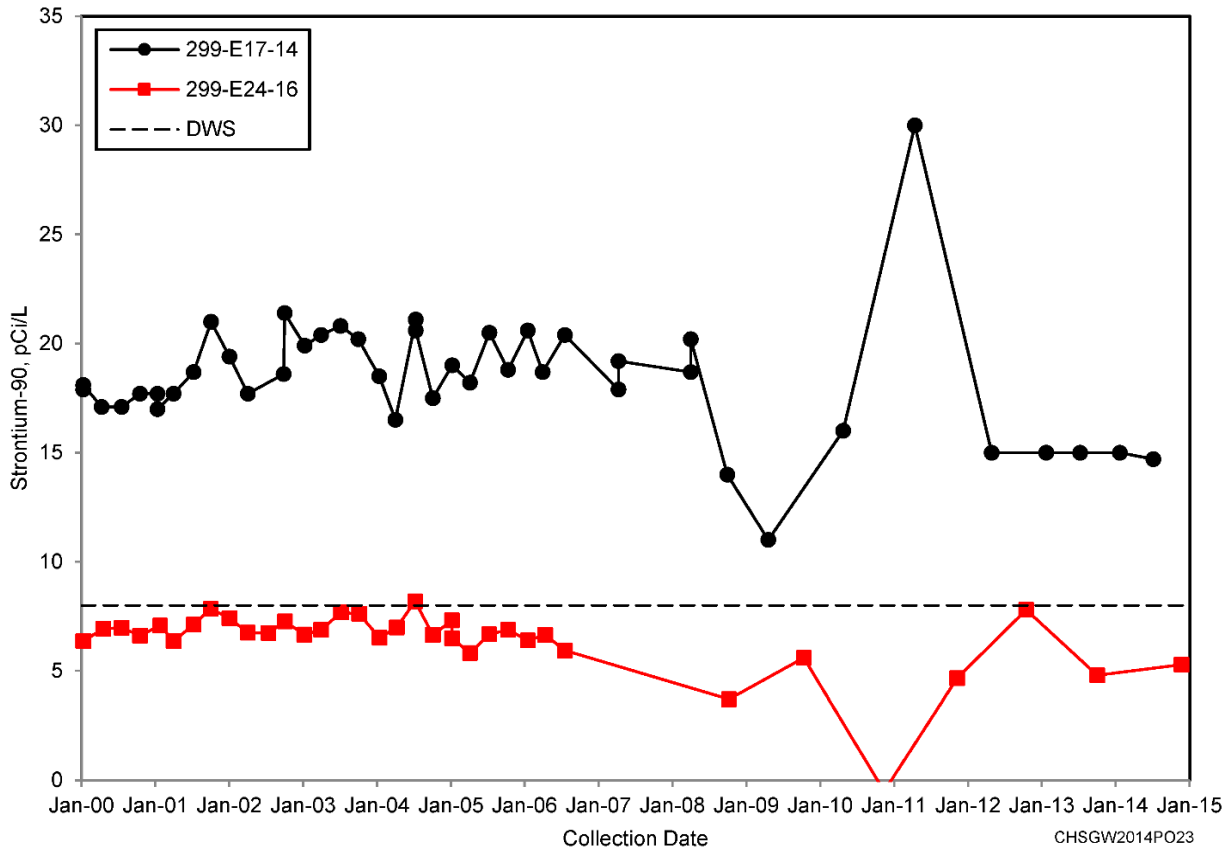


Figure 10-20. 200-PO Strontium-90 Data for Wells 299-E17-14 and 299-E24-16

10.8 Technetium-99

Technetium-99 has historically been detected in one relatively small area in the 200-PO near field region around WMA A-AX (Figure 10-21). This plume appears to have sources both in WMA C (in 200-BP) and in WMA A-AX (in 200-PO). WMA A-AX is hydraulically downgradient of WMA C. Concentrations greater than the 900 pCi/L DWS have been detected in groundwater near WMA A-AX since 2003. The 2014 interpolated plume extent above the 900 pCi/L concentration is consistent with the 2013 plume presented in DOE/RL-2014-32 and shows continued southeasterly migration and encroachment of higher concentrations of technetium-99 derived from WMA C. The interpolated 2014 boundary of the 900 pCi/L concentration extends from WMA C to the southeast toward the upgradient portion of WMA A-AX as defined by Well 299-E24-22. The leading edge of the technetium-99 plume migrating from WMA C is now projected as extending beneath the central portion of WMA A-AX. Well 299-E25-41, located along the northeast side of WMA A-AX, has been exhibiting an increasing concentration trend for technetium-99, which appears to represent a lower concentration portion of the technetium-99 plume migrating from WMA C and extending beneath WMA A-AX. The detections above the 900 pCi/L concentration southeast and downgradient of WMA A-AX (299-E25-93 and 299-E25-236) are inferred to be associated with WMA A-AX rather than WMA C. This interpretation is supported by differences in the historical technetium-99 concentration trends in upgradient Wells 299-E24-33 and 299-E24-22 in comparison to downgradient Wells 299-E25-93 and 299-E25-236 (Figure 10-21).

In 2014, technetium-99 was detected above a concentration of 900 pCi/L at three wells near WMA A-AX. Concentrations above the 900 pCi/L DWS occurred at Wells 299-E25-93 and 299-E25-41, located downgradient of WMA A-AX, and Well 299-E24-22, located upgradient of WMA A-AX and downgradient of WMA C. Until 2014, the highest concentrations were detected in Well 299-E25-93. Concentrations were elevated when the well was drilled in 2003 and have declined with time (Figure 10-22), with 2014 detections ranging from 1,000 to 1,700 pCi/L. Downgradient Well 299-E25-236 was decommissioned in July 2013 due to casing corrosion identified in 2012. Replacement Well 299-E25-237, located at the same location, was drilled in late 2014. The water table at the time drilling occurred was measured at 90.32 m (296.31 ft) bgs. Depth-discrete samples collected for technetium-99 during drilling showed concentrations of 1,110 pCi/L at 94.66 m (310.57 ft) bgs, 641 pCi/L at 99.39 m (326.08 ft) bgs, and nondetect at 112.43 m (368.85 ft) bgs. Final well construction should be completed in January 2015. Concentrations of technetium-99 in upgradient Well 299-E24-22 (Figure 10-22) have been increasing since 2011. Quarterly sampling concentrations detected in 2014 ranged from 1,420 to 1,840 pCi/L.

In the far field region to the east and southeast of the 200 East Area, technetium-99 was detected at concentrations ranging from nondetect to 32 pCi/L (699-13-3A). Well 699-13-3A is co-sampled with 300-FF and the well is associated with the 618-11 Burial Ground site. The technetium-99 concentration at this well decreased from the 2013 values. Technetium-99 continued to be detected at low levels in some aquifer tubes in 200-PO used to monitor groundwater adjacent to the Columbia River. In January 2015, a concentration of 19.2 pCi/L was detected in Aquifer Tube C6384 (a decrease from 51 pCi/L detection from 2013), and a concentration of 20.4 pCi/L was detected in C6374 (first data point).

In the Ringold confined aquifer, technetium-99 was monitored in one well (699-42-42B located near the 216-B-3 Pond) in 2011 and 2012. Technetium-99 was not detected and is no longer monitored at this well (TPA-CN-205). Basalt-confined aquifer wells are not currently required to be analyzed for technetium-99 (TPA-CN-205) beneath 200-PO. Basalt-confined wells were analyzed intermittently from 1988 to 2012, with only three very low-concentration detections (one in 1988 [13.2 pCi/L in 699-42-40C], one in 1994 [0.44 pCi/L in 699-S11-E12AP], and one in 1995 [0.32 pCi/L in 299-E16-1]).

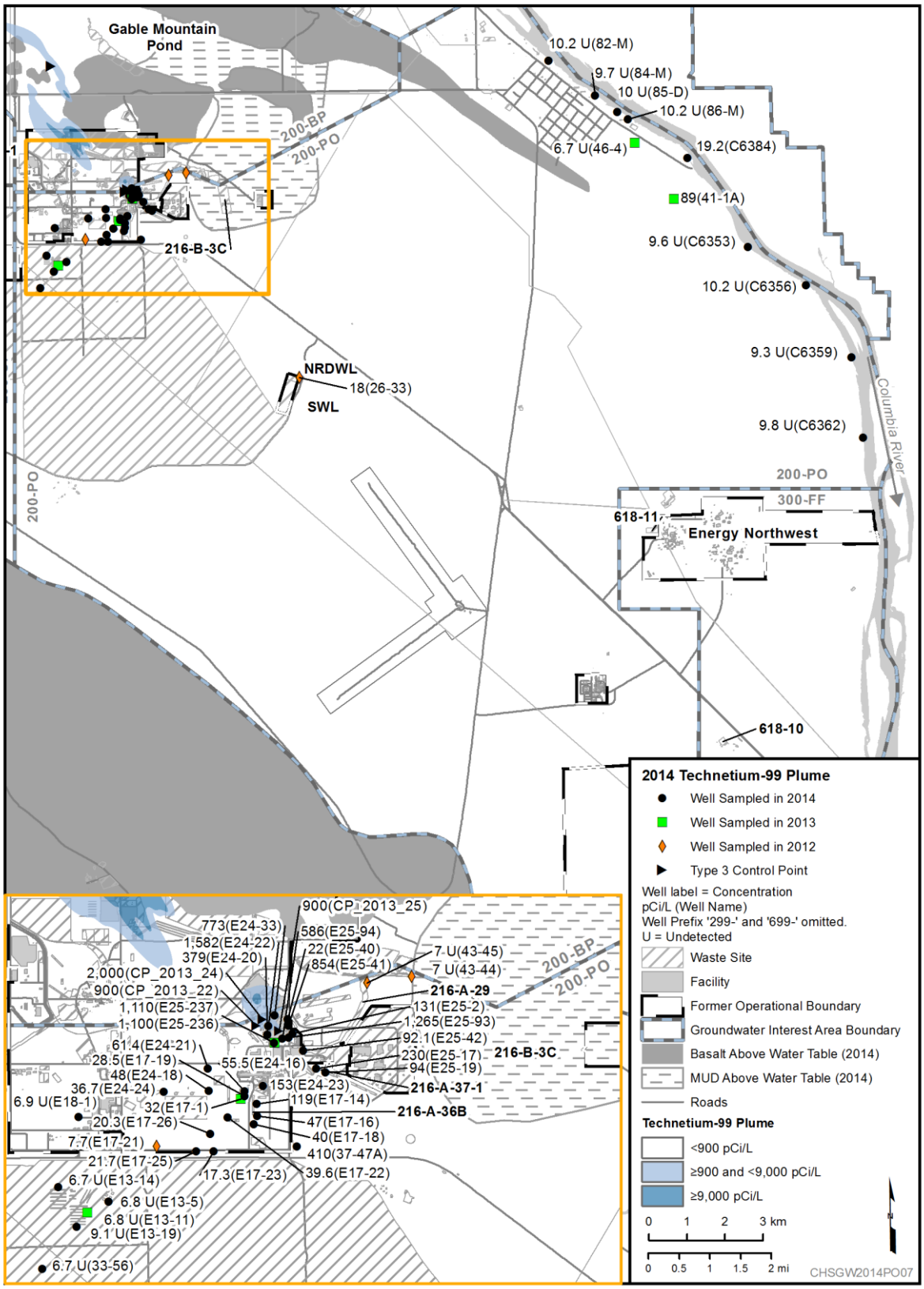


Figure 10-21. 200-PO Technetium-99 Plume, 2014

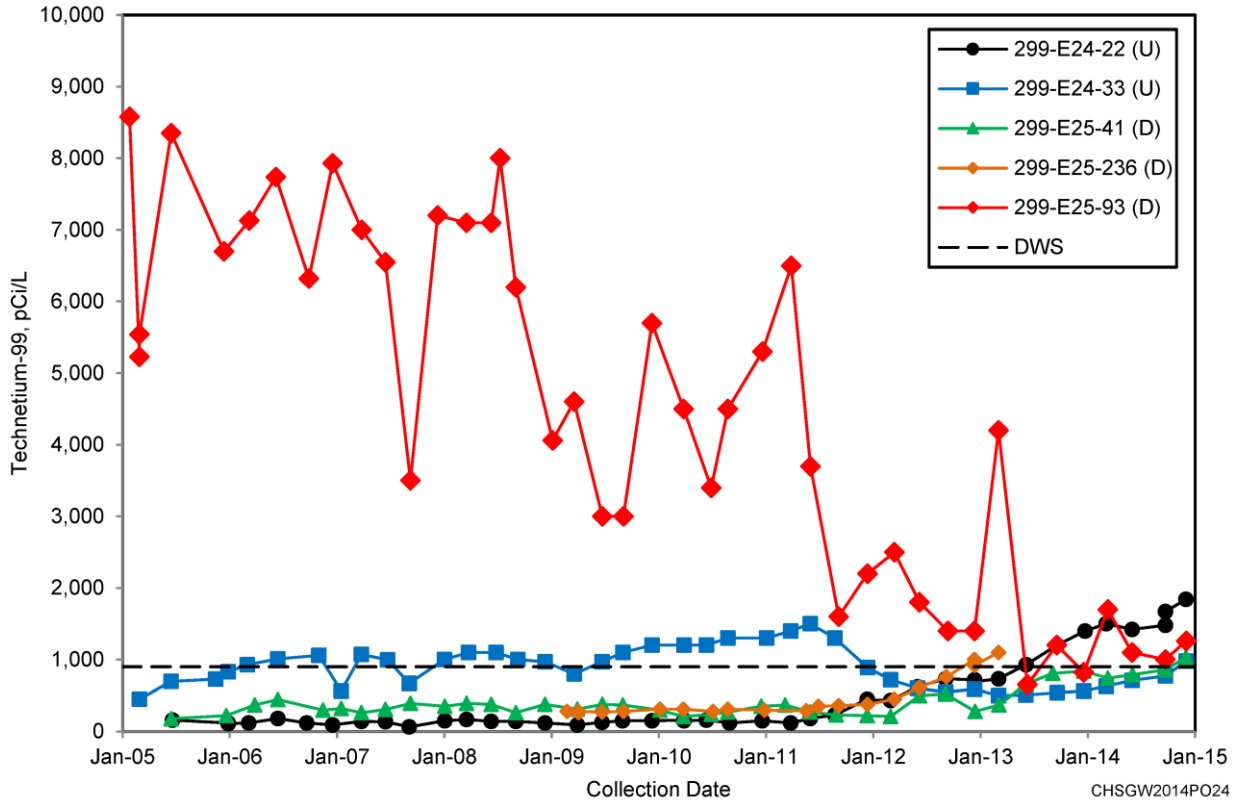


Figure 10-22. 200-PO Technetium-99 Data for Wells 299-E24-22, 299-E24-33, 299-E25-41, 299-E25-236 and 299-E25-93

10.9 Uranium

Uranium has been identified historically as a relatively small plume (Figure 10-23) near the PUREX Cribs and Trenches in the near field area and adjacent to the 618-10 Burial Ground (which is currently part of 300-FF) located in the far field area.

In 2014, concentrations of uranium above the 30 µg/L DWS were detected in three wells: Well 299-E25-36 at a concentration of 57.8 µg/L, compared to 58.5 µg/L in 2013; Well 299-E24-23 at a concentration of 39.5 µg/L, compared to 36.9 µg/L in 2012; and Well 299-E17-16 at a concentration of 34.8 µg/L, compared to a concentration of 17.0 µg/L in 2013. The value of 34.8 µg/L detected at Well 299-E17-16 is anomalous compared to all other measured uranium values at this well; the concentrations returned to normal in January 2015 (15 µg ug/L). These wells are located near the PUREX Cribs and Trenches in the near field region. Uranium concentrations at Well 299-E25-36 sharply increased between 1992 and 2007, but have been decreasing since 2010 (Figure 10-24). Uranium concentrations at Well 299-E17-14 are typically near or slightly above the DWS (Figure 10-24). Uranium remains somewhat mobile in groundwater at 200-PO, and the concentration changes observed are consistent with continued slow migration of uranium away from source areas.

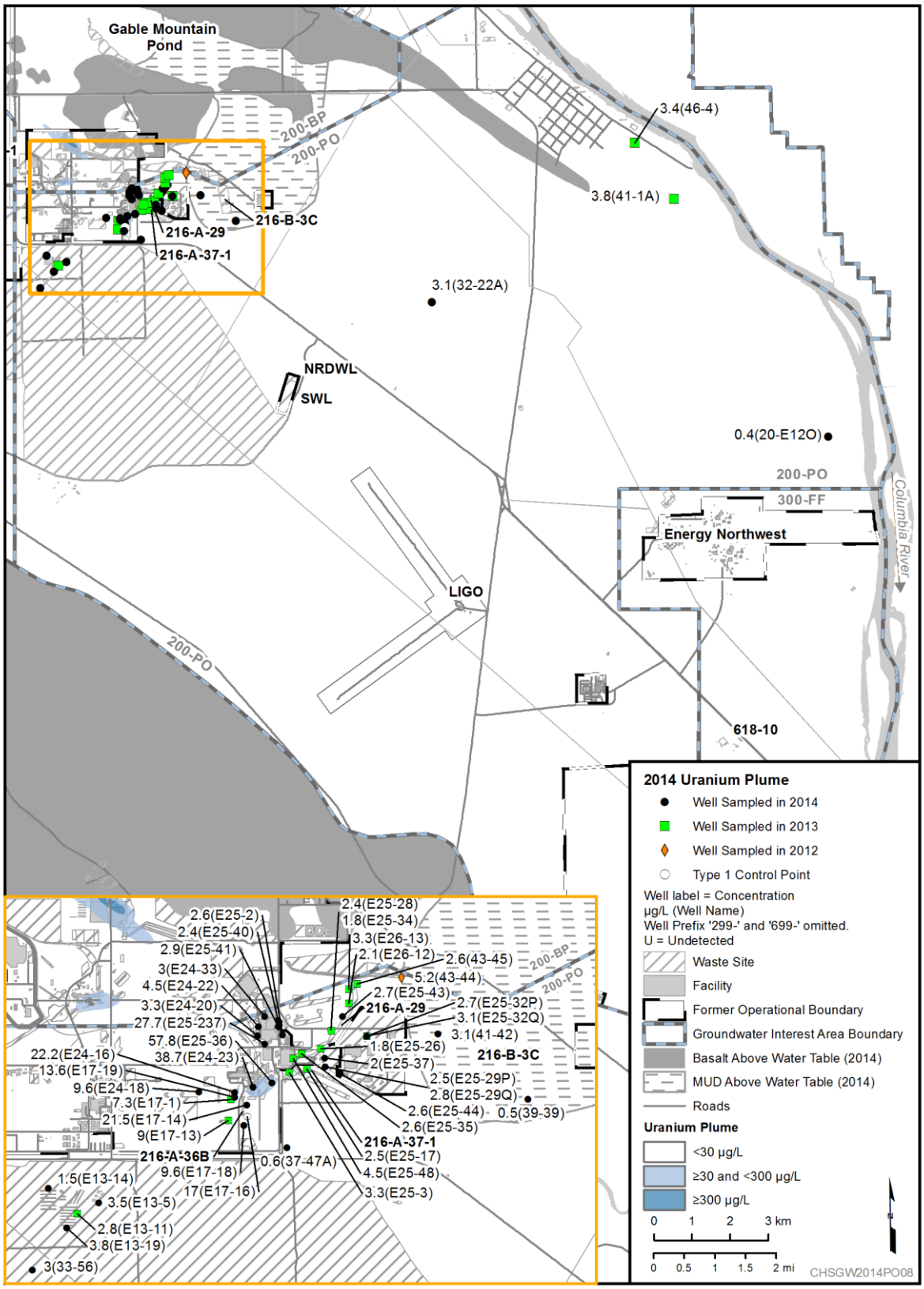


Figure 10-23. 200-PO Uranium Plume, 2014

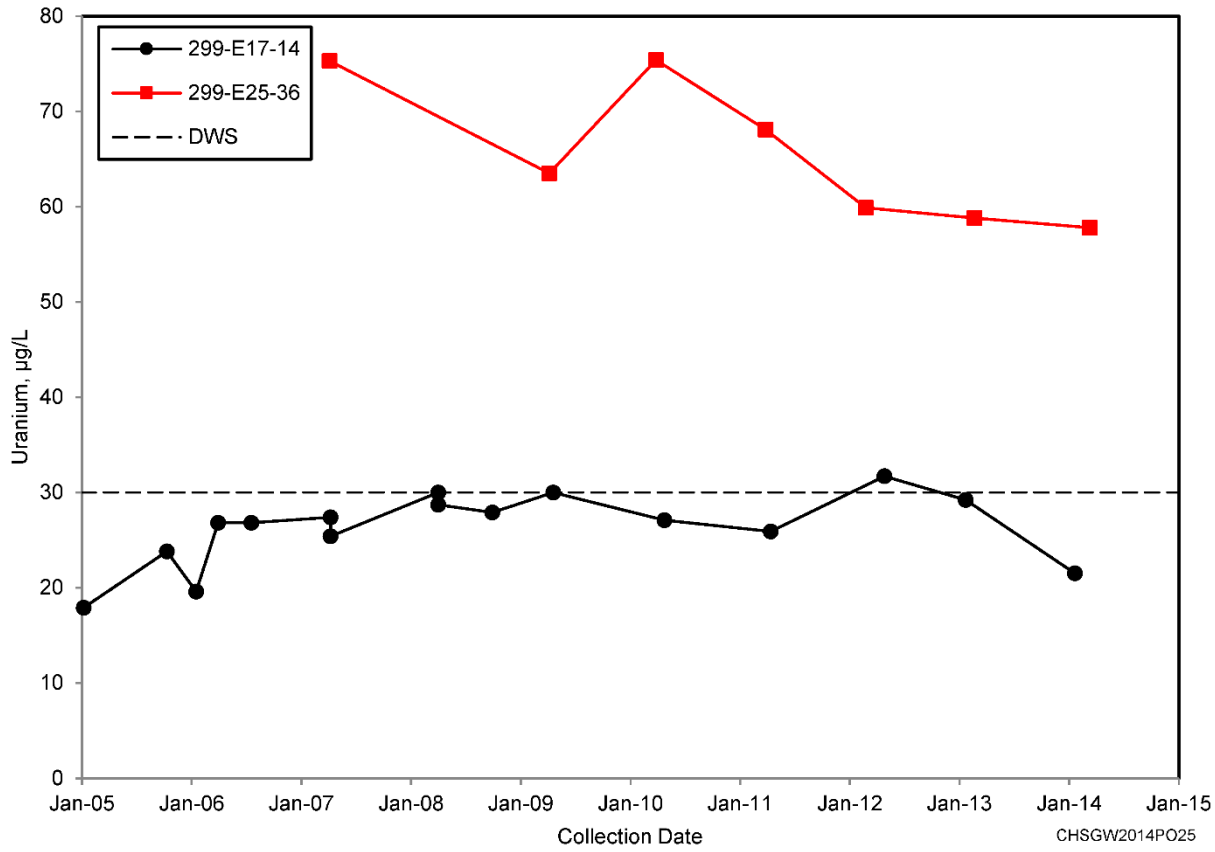


Figure 10-24. 200-PO Uranium Data for Wells 299-E17-14 and 299-E25-36

10.10 Tetrachloroethene

In 2014, PCE was detected in samples collected from monitoring Well 699-26-33 located downgradient of the NRDWL, at concentrations of 0.45 and 0.52 µg/L. The samples were "J" qualified by the laboratory. The laboratory "J" flag indicates that the value is estimated and the detection is uncertain, and the value reported is less than the practical quantitation limit but greater than or equal to the method detection limit. Low-level detections of PCE were common in a few wells near NRDWL and SWL before about 2007, but most results since then have been near or below detection limits. Results for PCE presented here are with respect to the CERCLA monitoring well network. Additional information concerning VOC results from wells utilized for RCRA monitoring are presented in Section 10.13.

10.11 Trichloroethene

TCE was detected within 200-PO in 2014 near the 216-A-36B Crib. TCE was detected in Well 299-E17-19 at concentrations ranging from 0.88 (J) µg/L to 1.53 µg/L and Well 299-E17-14 at a concentrations ranging from 1.3 to 1.47 µg/L. Monitoring for VOCs at the 216-A-36B Crib is part of the RCRA monitoring program. Additional discussion is provided in Section 10.13. CERCLA monitoring for VOCs is also performed in conjunction with RCRA monitoring at NRDWL and WAC monitoring at the SWL. TCE was not detected at the SWL in CERLCA network Well 699-25-33A. In 2014, TCE was not detected in 200-PO far field network wells, other than Well 699-S6-E4L, which is sampled as part of 300-FF in the vicinity of the 618-11 Burial Ground. In 2014, TCE concentrations at this well ranged from nondetect to 2.18 (J) µg/L.

10.12 AEA Monitoring

AEA monitoring for the 200-PO interest area is implemented through the CERCLA SAP (DOE/RL-2003-04, Rev. 1, as amended by TPA-CN-205). Additional AEA monitoring is described in RPP-PLAN-26534, *Integrated Disposal Facility Operational Monitoring Plan to Meet DOE Order 435.1*. Specific AEA monitoring that is part of the CERCLA SAP (DOE/RL-2003-04) includes monitoring of three water supply wells (499-S1-8J, 499-S0-7, and 499-S0-8) in the Hanford 400 Area. Well 49-S1-8J is the main water supply well, but occasionally Wells 499-S0-7 and 499-S0-8 are used for water supply. Wells selected for AEA monitoring are shown in Figure 10-25.

10.12.1 400 Area

The 400 Area is located 16.2 km (10.1 mi) southeast of the 200 East Area. The 400 Area includes the Fast Flux Test Facility (FFTF), ancillary facilities, and waste sites. Monitoring is conducted to provide information on the potential impact of site wide contamination (primarily tritium, nitrate, and iodine-129) on the water supply wells, which provide drinking water and emergency supply water for the 400 Area (Section 8.2.4 of DOE/RL-2011-119).

The wells have been sampled annually since 2009 for AEA monitoring including gamma scan, gross alpha, gross beta, iodine-129, strontium-90, technetium-99, and tritium, as well as additional analytes including ammonium, anions, metals (including uranium), and VOCs. Sampling of these three wells was conducted in February and October 2014.

Elevated levels of tritium associated with the groundwater plume originating in the 200 East Area were identified in the 400 Area water supply wells. Well 499-S1-8J has lower tritium levels because it is screened at a greater depth (top of screen 61 m [200 ft] below the water table) than the other two water supply Wells 499-S0-8 and 499-S0-7 (19 and 9 m [62 and 30 ft], respectively) (Figure 10-26). In 2014, tritium was measured at levels below the DWS (20,000 pCi/L) in all three water supply wells. A maximum tritium concentration of 11,400 pCi/L was detected in Well 499-S0-8 during October 2014. Tritium concentrations in Wells 499-S0-7 and 499-S0-8 have been stable and at similar levels from 2012 to 2014. Current levels are substantially lower than historical concentrations observed in these wells (e.g., greater than 80,000 pCi/L in the early to mid-1980s).

Other constituents detected in samples collected from the 2014 sampling event included several metals (e.g., uranium, chromium, nickel, arsenic, copper, and lead), gross alpha (499-S0-8), gross beta, nitrate, technetium-99, and tritium. These constituents, except for gross beta, nitrate, and tritium, were found in relatively low concentrations, and all below DWSs. The gross beta results ranged from 6.4 to 26 pCi/L (Well 499-S0-8), which is the highest value that has been detected in Well 499-S0-8. In 2012, gross beta was also elevated in this well with a concentration of 21 pCi/L. The next highest gross beta value detected in Well 499-S0-8 was 14.9 pCi/L in 1988. Technetium-99 levels increased in Well 499-S0-8 from 8.30 pCi/L in January 2012, to 21.20 pCi/L in September 2012, to 24.20 pCi/L in October 2014. Tritium also increased in this well from 2,700 pCi/L in 2011, to 12,000 pCi/L in 2012, and 11,400 pCi/L in 2014. In recent years, nitrate increased from 0.2 mg/L in 2012 to 19.4 mg/L in 2014. For 2014, Well 499-S0-8 often had the highest concentrations reported for the constituents detected among these three wells.

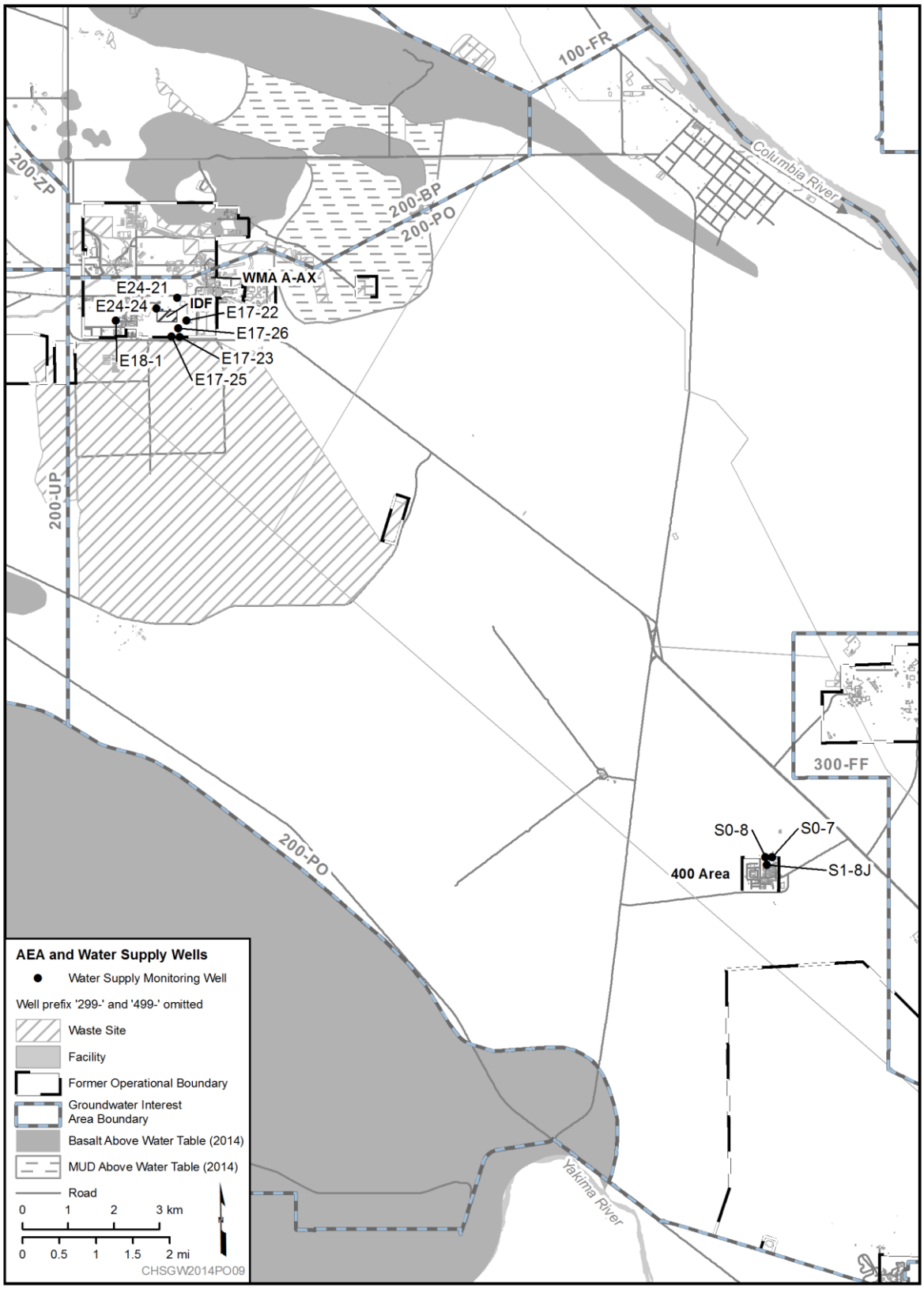


Figure 10-25. 200-PO AEA Monitoring and Water Supply Well Locations

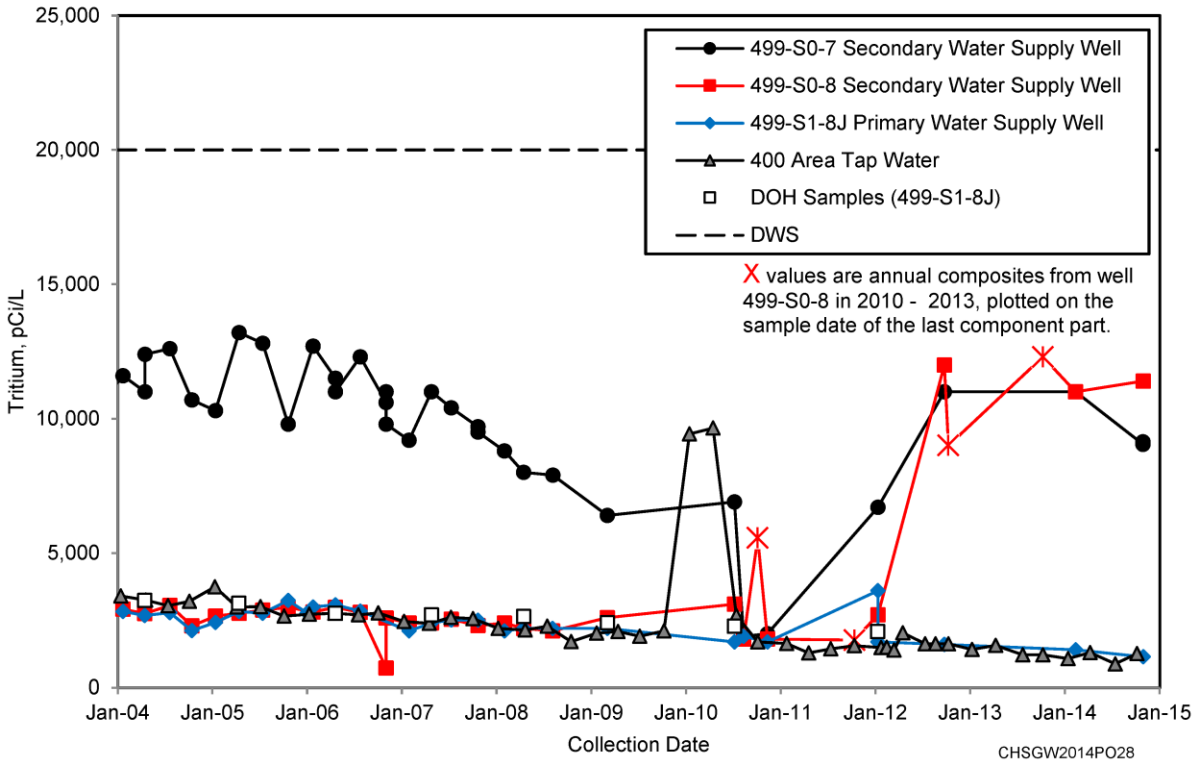


Figure 10-26. 200-PO Tritium Data for Wells 499-S0-7, 499-S0-8, and 499-S1-8J and 400 Area Tap Water

10.12.2 Integrated Disposal Facility

The IDF consists of an expandable, double-lined landfill with approximately 0.07 km^2 (0.027 mi^2) of liner. The landfill is divided into two distinct cells: (1) the east cell for the disposal of low-level radioactive waste, and (2) the west cell for the disposal of mixed waste. The landfill is not yet in use. It is a permitted RCRA facility and has additional groundwater sampling requirements under the AEA, as described in RPP-PLAN-26534. The plan describes sampling of two upgradient wells (299-E18-1 and 299-E24-24) and five downgradient wells (299-E17-22, 299-E17-23, 299-E17-25, 299-E17-26, and 299-E24-21) semiannually for gross alpha, gross beta, iodine-129, and technetium-99. Gross alpha was detected in wells (299-E17-22, 299-E17-23, 299-E17-26, and 299-E24-21) at concentrations ranging from 3.09 pCi/L (299-E17-26) to 11.1 pCi/L (299-E17-22), which is consistent with previous detections in these wells. Gross beta was detected in all of the wells at concentrations ranging from 6.96 pCi/L (299-E18-1) to 46 pCi/L (299-E24-21) and corresponds to changes in technetium-99 levels. The gross beta concentrations detected in 2014 were higher than the 2012 and 2013 values in most wells. Iodine-129 concentrations ranged from nondetect (299-E18-1) to 0.663 pCi/L (Well 299-E17-22). Technetium-99 concentrations ranged from nondetect (299-E18-1) to 69 pCi/L (299-E24-21).

10.13 RCRA Monitoring

The following describes the results of monitoring at seven individual waste management/disposal facilities within the 200-PO interest area, conducted in accordance with RCRA regulations: 216-A-29, 216-A-36B, 216-A-37-1, 216-B-3, IDF, NRDWL, and WMA A-AX (Figures 10-1 and 10-5). Interim status groundwater quality assessment monitoring is conducted at WMA A-AX (40 CFR 265.93[d], as referenced by WAC 173-303-400). Interim status detection monitoring for indicator parameter evaluation is conducted at five sites: 216-A-29, 216-A-36B, 216-A-37-1, 216-B-3, and NRDWL (40 CFR 265.92,

as referenced by WAC 173-303-400). The IDF is not operational but is monitored as incorporated into the Hanford Facility RCRA Permit (WA7890008967) to obtain baseline information.

10.13.1 Waste Management Area A-AX

The WMA A-AX is located in the southeast quarter of the 200 East Area (Figure 10-27), and consists of 10 underground storage tanks. Five of the 10 single-shell tanks are assumed or confirmed to have leaked. Significant uncertainty is associated with the extent of vadose zone contaminant migration from the tanks. Although none of the releases have been attributed with dangerous waste groundwater contamination, the site is in an interim status assessment program because an indicator parameter, specific conductance, exceeded the critical mean value in 2005.

The elevated specific conductance is associated with elevated nitrate at Well 299-E25-93. In 2014, nitrate continued to exceed the DWS in Well 299-E25-93 in 3 of 4 quarters sampled and remained above the DWS in Well 299-E24-20 during all of 2014. Nitrate in Well 299-E24-20 exceeded the DWS previously in 2004, 2005, 2008, 2010, and 2013. Nitrate levels in Well 299-E25-93 exceeded the DWS in 2004 and 2006 through 2013.

The well network was sampled quarterly to assess if dangerous waste/dangerous waste constituents are present in the groundwater and, if so, their extent and rate of migration. In 2014, the wells were monitored in accordance with PNNL-15315. All of the active network wells were sampled quarterly, as required, during 2014 (Table B-70, Appendix B). Appendix B (Table B-70) includes a list of WMA A-AX wells and constituents monitored, and it indicates if the wells were sampled as scheduled. Results for the assessment parameters are provided in Table B-72 of Appendix B.

Well 299-E25-236 was decommissioned in June 2013 as the result of accelerated casing corrosion and consequently was not sampled in 2014. Drilling of replacement Well 299-E25-237 was started in November 2014 and completed in January 2015. Three depth-discrete groundwater samples were collected during drilling at 94.7, 99.4, and 110.6 m (310.6, 326.1, and 363 ft) bgs for selected constituents. The water table at the time drilling occurred was measured at 90.32 m (296.31 ft) bgs. Nitrate concentrations detected were 27.7 mg/L at 94.7 m (310.6 ft) bgs, 24.8 mg/L at 99.4 m (326.1 ft) bgs, and 0.558 mg/L at 110.6 m (363 ft) bgs. Depth-discrete technetium-99 sampling results are provided in the technetium-99 plume section of this report. The WMA A-AX remained in assessment monitoring in accordance with 40 CFR 265.93[d], as referenced by WAC 173-303-400 during 2014. A revised assessment plan will be prepared in 2015 that will evaluate conditions that may have contributed to the casing degradation at Well 299-E25-236.

The groundwater flow direction in the unconfined aquifer near WMA A-AX is to the southeast, based on slightly higher hydraulic heads to the northwest (Figures 10-3 and 10-4), the orientation of a southeast trending paleochannel in the area (DOE/RL-2011-118, Appendix E), and the configuration and migration patterns of the nitrate and technetium-99 contamination plumes. Based on the 2014 low-gradient groundwater contour map that covers this area, the estimated hydraulic gradient is approximately 5×10^{-6}, with an estimated groundwater flow rate of approximately 0.1 m/d (0.33 ft/d). Additional gradient network evaluation near WMA A-AX is currently ongoing to provide greater certainty in calculations of groundwater flow in this area. The depth of the water column in monitoring wells ranges from 1.28 to 11.9 m (4.2 to 39.0 ft). These wells all have adequate water columns in the screened interval for continued sampling (Table B-71, Appendix B).

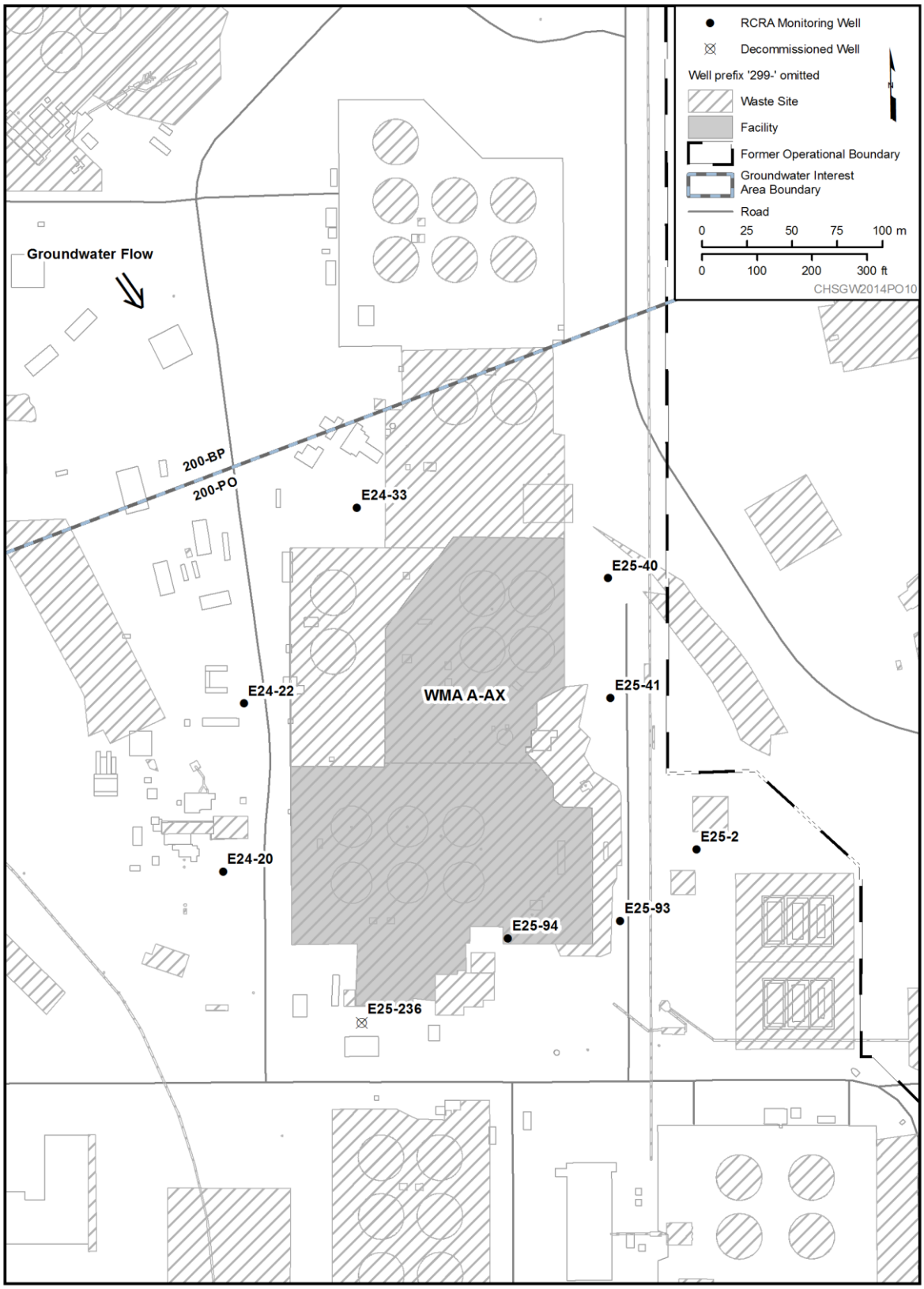


Figure 10-27. 200-PO RCRA WMA A-AX Monitoring Well Locations

10.13.2 216-A-36B Crib

The 216-A-36B Crib is located in the southeastern portion of the 200 East Area (Figure 10-28) and is 7 m (23 ft) deep, 150 m (490 ft) long, and 2.3 to 3.4 m (7.5 to 11.2 ft) wide at the base; the sides slope at 1:1.5. The crib was originally part of the 180 m (590 ft) long 216-A-36 Crib, which received PUREX effluent from September 1965 through March 1966. In March 1966, the northernmost 30 m (98 ft) of the crib were isolated and a grout barrier was established between it and the southern portion of the crib, now known as 216-A-36B. 216-A-36B was operational from March 1966 through October 1972, and it was reactivated in November 1982 for the PUREX Plant restart. The site received discharges of PUREX ammonia scrubber distillate totaling 290 million L (76.6 million gal). It was permanently removed from service in August 1987. After final receipt of waste, the crib was covered with 7 m (23 ft) of clean soil and revegetated. Additionally, in May 2010, 15 cm (6 in.) of clean gravel was added the 216-A-36B Crib as an interim stabilization measure.

Since January 2011, the 216-A-36B Crib has been monitored under interim status contamination indicator evaluation regulations to determine if dangerous waste constituents have impacted groundwater (DOE/RL-2010-93). Revision 1 of the plan was released in June 2011 to provide more detail pertaining to the constituent list and sampling frequency. Before 2011, the 216-A-36B Crib, along with two other PUREX Cribs (216-A-10 and 216-A-37-1), were monitored in a RCRA interim status groundwater quality assessment program. However, the 216-A-10 Crib was officially closed March 30, 2010, and was removed from Part A of the Hanford Facility Dangerous Waste Permit (WA7890008967). The two remaining cribs, 216-A-36B and 216-A-37-1, remain in RCRA interim status but were returned to indicator evaluation programs because groundwater constituents detected were not dangerous wastes or dangerous waste constituents. Other nearby cribs also received PUREX waste (e.g., 216-A-45 Crib); however, these other cribs are not regulated as RCRA treatment, storage, and disposal units, but are monitored under CERCLA through the 200-PO-1 OU instead.

The 216-A-36B Crib network groundwater wells were monitored in 2014 semiannually for the RCRA indicator parameters of TOC, TOX, pH, and specific conductance. Wells are also monitored annually for water quality parameters including alkalinity, anions (chloride, sulfate, and nitrate), metals (including calcium, magnesium, potassium, and sodium), phenols, temperature, and turbidity. Water level measurements are also collected semiannually. One upgradient well (299-E17-19) and three downgradient wells (299-E17-14, 299-E17-16, and 299-E17-18) are monitored for the site (Figure 10-28; Table B-19, Appendix B). Sampling details and site history are provided in DOE/RL-2010-93.

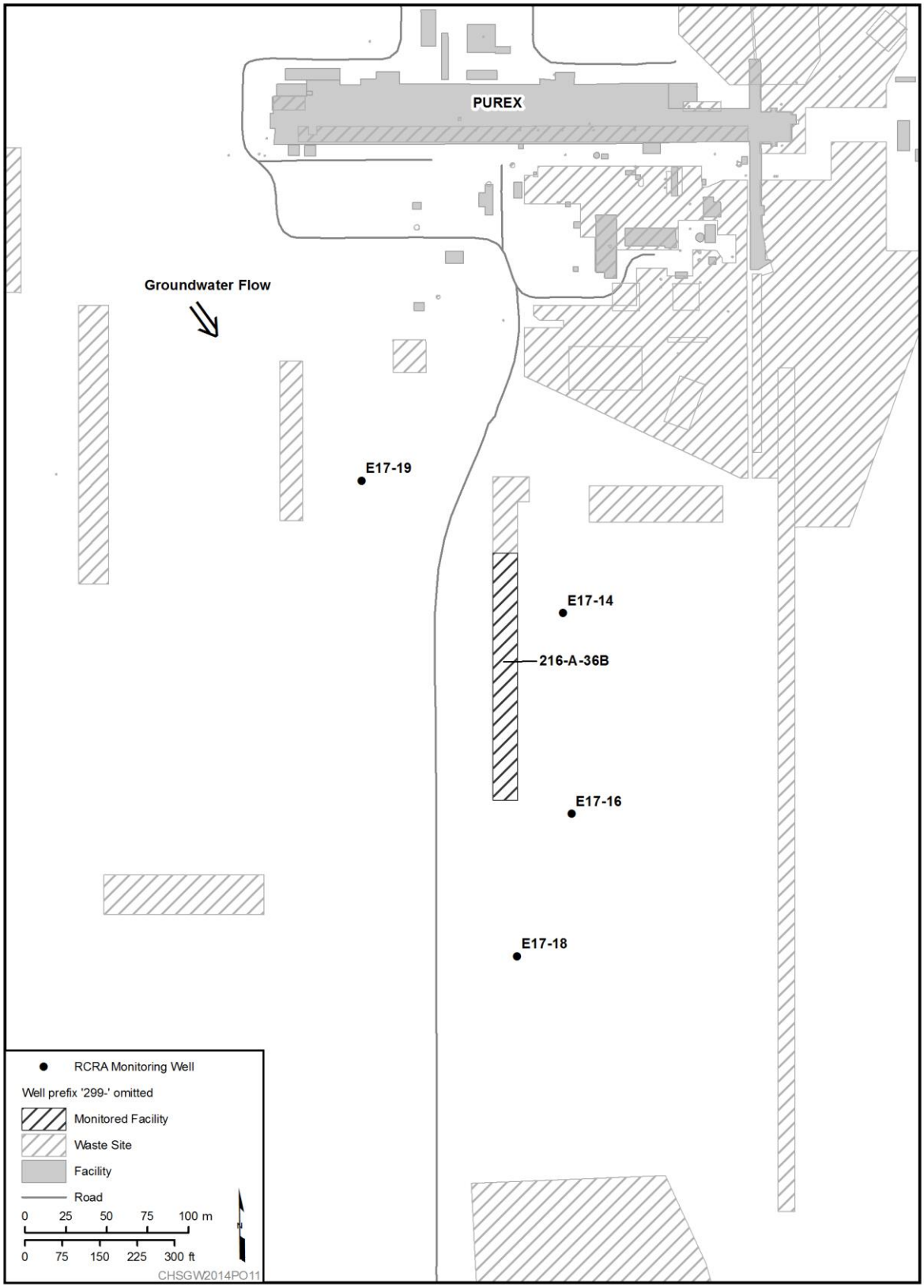


Figure 10-28. 200-PO RCRA 216-A-36B Monitoring Well Locations

10.13.2.1 Sampling Results

Sampling was conducted as planned in 2014. Several wells had initial analytical results exceeding critical mean values, but in all cases, verification sampling results were within critical mean ranges or did not exceed established values. During the first half the year, reported concentrations were compared to 2013 critical mean values. The 2014 critical mean values were established and utilized during the second half of the year. January samples from Wells 299-E17-14 and 299-E17-18 showed an initial exceedance for TOX in comparison with the 2013 critical mean value, but did not exceed the 2014 critical mean (Table B-21, Appendix B). January samples from Wells 299-E17-16 and 299-E17-18 had concentrations above the critical mean for TOC in comparison to both the 2013 and 2014 values (Table B-21, Appendix B). The January sample from Well 299-E27-14 had a value below the lower-bound 2013 pH critical mean, but was within the 2014 pH critical mean range. Details regarding calculation of the critical mean values are provided in ECF-Hanford-13-0013, Rev. 1, *Calculation of Critical Means for Calendar Year 2013 RCRA Groundwater Monitoring*, and ECF-Hanford-14-0043, Rev. 0, *Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring*.

Groundwater quality constituents monitored for the site include chloride, iron, manganese, nitrate, phenols, sodium, and sulfate. Samples for analyses of alkalinity, calcium, magnesium, and potassium are collected to support charge balance calculations for the calcium-bicarbonate type groundwater. A summary of water quality parameters is provided in Table B-22 of Appendix B. The primary constituent of interest at the 216-A-36B Crib is nitrate because it is a breakdown product of nitric acid, which was disposed to the nearby 216-A-10 Crib. Nitrate concentrations in all four wells continue to exceed the DWS, and these exceedances are associated with a relatively large Central Plateau nitrate plume (Figure 10-15). Concentrations of volatile organic compounds were monitored at 216-A-36B in 2014 to evaluate if previous historical intermittent low-level detections of TCE were still occurring at the site. During 2014, two network wells had detections. TCE was detected in upgradient Well 299-E17-19 at concentrations ranging from 0.88(J) to 1.53 µg/L. Downgradient Well 299-E17-14 detected TCE at a concentrations ranging from 1.3 to 1.47 µg/L.

10.13.2.2 Water-Level and Well Network Evaluation

Beginning in 2008, efforts have been undertaken to improve the accuracy of the water-level measurements and resultant estimates of groundwater gradient near the PUREX Plant and associated waste sites. The results of these efforts, which include vertical offset surveys of well casings and high-resolution water-level measurements, are provided in Section 3.2 of DOE/RL-2011-01. The well network for the trend surface analyses extends from the west side of IDF to east and southeast of the 216-A-36B Crib. Trend surface analysis of water-level measurements from June 16, 2008, through March 18, 2011, indicated an average hydraulic gradient magnitude of 2.2×10^{-5} ($\pm 0.3 \times 10^{-5}$) m/m with a northeast direction (64 [±12] degrees azimuth). Measurements between June 20, 2011, and December 31, 2012, showed an average hydraulic gradient magnitude of 2.4×10^{-5} ($\pm 0.2 \times 10^{-5}$) m/m with an eastward direction (95 [±5] degrees azimuth), indicating a change in flow from east northeast to east. Low-gradient groundwater contour maps constructed using 2013 and 2014 low- gradient well network data in the vicinity of the 216-A-36 Crib indicate a southeastward direction of flow (Figures 10-3 and 10-4). Data collection efforts continue to better define hydraulic gradients near the PUREX Cribs area. The groundwater flow rate is calculated to range between 0.0013 and 0.22 m/d (0.0043 to 0.72 ft/d) (Table B-1 in Appendix B).

Based on the current groundwater flow interpretations, the 216-A-36B Crib well network is capable of meeting the monitoring objective of determining if groundwater has been impacted with dangerous waste constituents. Table B-20 in Appendix B summarizes water-level information for the 216-A-36B monitoring network. An updated RCRA groundwater monitoring plan for the 216-A-36B Crib will be

developed in 2015. The new plan will incorporate the most current groundwater flow direction data obtained from the low-gradient monitoring network; present new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*); review and summarize historical monitoring results with the relationship to changing flow directions; and update the conceptual site model.

10.13.3 216-A-37-1 Crib

The 216-A-37-1 Crib is located east of the 200 East Area (Figure 10-29) and is 5.2 m (17.1 ft) deep, 213 m (699 ft) long, and 33 m (108 ft) wide at the base; the sides slope at 1:1. The crib was operational from March 1977 through April 1989 and was used for percolation of 242-A Evaporator process condensate to the soil column. The crib received spent halogenated and nonhalogenated solvents and ammonia. During its operational life, the 216-A-37-1 Crib received a total of 370 million L (98 million gal) of process condensate. Discharge of the evaporator process condensate to the 216-A-37-1 Crib continued through April 1989, when the crib was removed from service. In 1994, the bottom of the diversion box was filled with grout to physically preclude the potential for inadvertent discharges to the crib. In July of 2000, vent risers from the crib were sealed to prevent potential passive radioactive emissions.

Since January 2011, the 216-A-37-1 Crib has been monitored under interim status regulations to determine if dangerous waste constituents have impacted groundwater (DOE/RL-2010-92). Revision 1 of the plan was released in June 2011 to provide more detail pertaining to the constituent list and sampling frequency. Before 2011, the 216-A-37-1 Crib, along with two other PUREX Cribs (216-A-10 and 216-A-36B), were monitored in a RCRA interim status groundwater quality assessment program. However, the 216-A-10 Crib was officially closed March 30, 2010, and was removed from Part A of the Hanford Facility Dangerous Waste Permit (WA7890008967). The two remaining cribs, 216-A-36B and 216-A-37-1, remain in RCRA interim status but were returned to indicator evaluation programs because groundwater constituents detected were not dangerous wastes or dangerous waste constituents. Other nearby cribs also received PUREX waste (e.g., 216-A-45 Crib); however, these other cribs are not regulated as RCRA treatment, storage, and disposal units, but are monitored under CERCLA through the 200-PO-1 OU instead. An updated closure plan for the 216-A-37-1 Crib was submitted to Ecology in 2014 (*216-A-37-1 Ditch Closure Plan (D-2-10)*, DOE/RL-2005-88, Rev. 0) and is currently under review.

The 216-A-37-1 Crib network groundwater wells are monitored semiannually for RCRA indicator parameters of TOC, TOX, pH, and specific conductance, as well as temperature and turbidity. Wells are also monitored annually for water quality parameters including alkalinity, anions (chloride and sulfate), metals (including calcium, iron, manganese, magnesium, potassium, and sodium), and phenols. Water-level measurements are also collected semiannually. Sampling details and site history are described in DOE/RL-2010-92. One upgradient well (299-E25-47) and three downgradient wells (299-E25-17, 299-E25-19, and 299-E25-20) are monitored for the site (Figure 10-29; Table B-23, Appendix B).

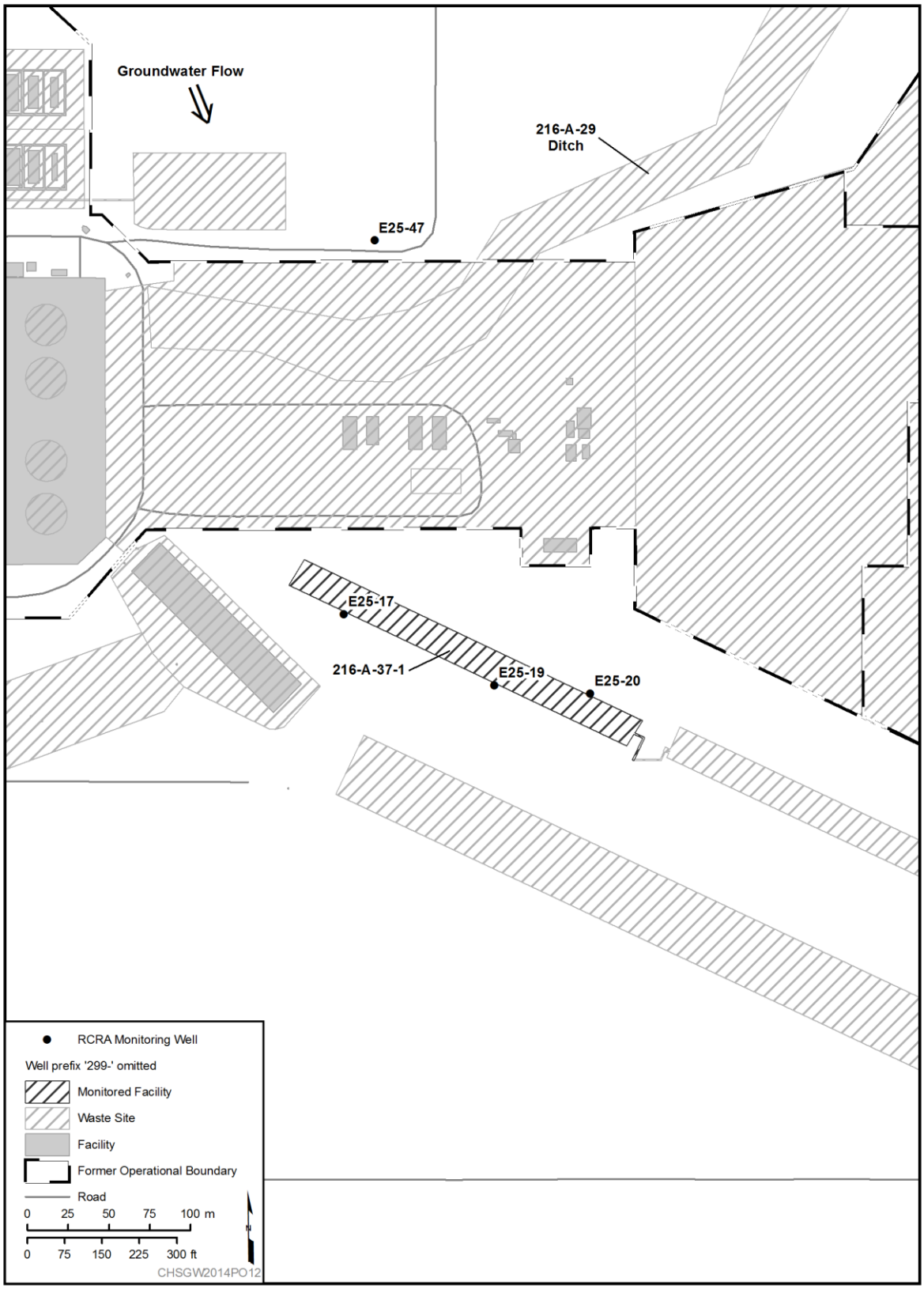


Figure 10-29. 200-PO RCRA Facility 216-A-37-1 Monitoring Well Locations

10.13.3.1 Sampling Results

Sampling events were delayed at two wells in 2014. Scheduled July sampling at Well 299-E25-17 did not occur until August due to an electrical issue with the pump. The annual sampling event for upgradient Well 299-E25-47 was missed in January due to inaccessibility of the sampling van. The semiannual event planned for July was completed as scheduled at this well.

The critical mean for TOC was exceeded in Well 299-E25-17 for the samples collected in July. This well had no previous history of elevated concentrations of TOC and had not been showing increasing levels. To determine if a laboratory analytical error was an issue, the laboratory reanalyzed the samples with results available in early November. High TOC concentrations were confirmed. Verification sampling was conducted at the well in late November, with two sets of quadruplicate samples sent to two laboratories. Both sets showed elevated TOC concentrations. Considering the anomalous nature of the elevated TOC values, the operational maintenance history at the well was reviewed. The increased TOC concentrations occurred following removal of the pump and connection piping required because of pump failure. It was suspected that some natural organic material may have been dislodged from the well inner casing wall during pump removal activities. In early December, as a precaution, the well screen was swabbed and brushed and the well was redeveloped with a new pump and connection piping. In mid-December the well was sampled again with two quadruplicate sample sets collected using a 7-day analytical turnaround, with separate analyses performed by two laboratories. Analytical results from both laboratories showed TOC concentrations below the critical mean.

All other indicator parameter analytical results for the 216-A-37-1 Crib network groundwater wells did not exceed the 2014 critical mean values for pH, specific conductance, TOC, and TOX; therefore, the site remains in interim status detection monitoring (Table B-25, Appendix B). Details regarding calculation of the critical mean values are provided in ECF-Hanford-14-0043, *Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring*.

Groundwater quality constituents monitored for the site include chloride, iron, manganese, phenols, sodium, nitrate, and sulfate (Table B-26 in Appendix B). Samples for analyses of alkalinity, calcium, magnesium, and potassium are collected to support charge balance calculations for the calcium-bicarbonate type groundwater. Nitrate continued the historical trend of being detected above the DWS of 45 mg/L at 299-E25-20. Manganese continues to intermittently exceed the secondary DWS in unfiltered samples from Wells 299-E25-19 and 299-E25-20. The secondary DWS for iron was exceeded in 2014 in unfiltered samples at Wells 299-E25-17, 299-E25-19, and 299-E25-20.

10.13.3.2 Water-Level and Well Network Evaluation

Near the 216-A-37-1 Crib, groundwater flow is estimated to be toward the southeast. Flow directions are influenced by a northwest-southeast trending paleochannel with high permeability Hanford formation sediments near the crib, the Ringold lower mud unit at the water table east of the 200 East Area, and the higher water table elevations to the west and north. These flow directions are supported mainly by the distribution of plumes emanating from near the crib and recent efforts to improve the accuracy of water level measurements in the southeastern portion of the 200 East Area (Section 10.13.2). The gradient magnitude is assumed to be similar to the 216-A-29 Ditch, which is 2.0×10^{-5} m/m. The groundwater flow rate is estimated to range between 0.0036 and 0.6 m/d (0.012 and 2.0 ft/d) (Table B-1 in Appendix B). Additional gradient network evaluation near 216-A-37-1 is currently being conducted to provide greater certainty in calculations of groundwater flow in this area. Table B-24 in Appendix B summarizes water-level data for the monitoring network.

Based on the current groundwater flow interpretations, the 216-A-37-1 Crib well network is capable of meeting the groundwater monitoring objectives to determine if groundwater has been impacted with

dangerous waste constituents. An updated RCRA groundwater monitoring plan for the 216-A-37-1 Crib will be developed in 2015. The new plan will incorporate the most current groundwater flow direction data obtained from the low-gradient monitoring network; present new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*); review and summarize historical monitoring results with the relationship to changing flow directions; and update the conceptual site model.

10.13.4 216-A-29 Ditch

The 216-A-29 Ditch is located just east of the 200 East area fence line (Figure 10-30) and is planned for closure. An updated closure plan was submitted to Ecology in 2014 (*216-A-29 Ditch Closure Plan (D-2-3)*, DOE/RL-2008-53, Rev. 1). The 216-A-29 Ditch is a regulated unit because it received nonradioactive dangerous waste regulated by 40 CFR 261, "Identification and Listing of Hazardous Waste," after November 19, 1980. The site is designated as a surface impoundment, as defined in WAC 173-303-400. The ditch was excavated to convey liquid effluent from the PUREX chemical sewer to the B Pond and was placed in service in November 1955. Flow from the chemical sewer (low-level contaminants) was continuous, with an average flow of 3,700 L/min (970 gpm). The 216-A-29 Ditch received continuous discharge of corrosive waste and potentially hazardous spilled chemical materials from the PUREX Plant. The most significant chemical discharges included acidic and caustic effluents associated with backwashing for the regeneration of demineralizer columns. The ditch also received spills from the PUREX Plant chemical sewer (low-level contamination). A complete, estimated inventory of materials discharged to the 216-A-29 Ditch is provided in WHC-SD-EN-AP-045, Appendix A.

The 216-A-29 Ditch is currently backfilled with material from the ditch sides and spoils piles in the bottom. The portion of the 216-A-29 Ditch inside the 200 East Area security fence was brought to grade with clean material. The portion of the ditch outside of the 200 East Area security fence was topped with clean material in a series of 11 terraces progressing down the length of the ditch. Both areas have been revegetated and appropriately signed (the 216-A-29 Ditch is an underground radioactive material area).

In accordance with WAC 173-303-400 and 40 CFR 265.92, the 216-A-29 Ditch network groundwater wells are monitored semiannually for RCRA indicator parameters of TOC, TOX, pH, and specific conductance. Wells are also monitored annually for water quality parameters including alkalinity, anions (chloride, fluoride, sulfate, nitrate, and nitrite), metals (including calcium, iron, manganese, magnesium, potassium, and sodium), oxidation/reduction potential, phenols, temperature, and turbidity. Water-level measurements are collected semiannually. Sampling details and site history are described in DOE/RL-2008-58. The current monitoring well network includes three upgradient wells (299-E26-12, 299-E26-13, 699-43-45) and six downgradient wells (299-E25-26, 299-E25-28, 299-E25-32P, 299-E25-34, 299-E25-35, and 299-E25-48) (Figure 10-30; Table B-15, Appendix B). Historically, Well 699-43-45 has served as an upgradient well for the 216-A-29 Ditch. With the continual shift in groundwater flow direction from the southwest to the southeast, this well is no longer upgradient of the unit. Wells 299-E26-12 and 299-E26-13, which have always been included in the network, became the new upgradient wells starting in 2011.

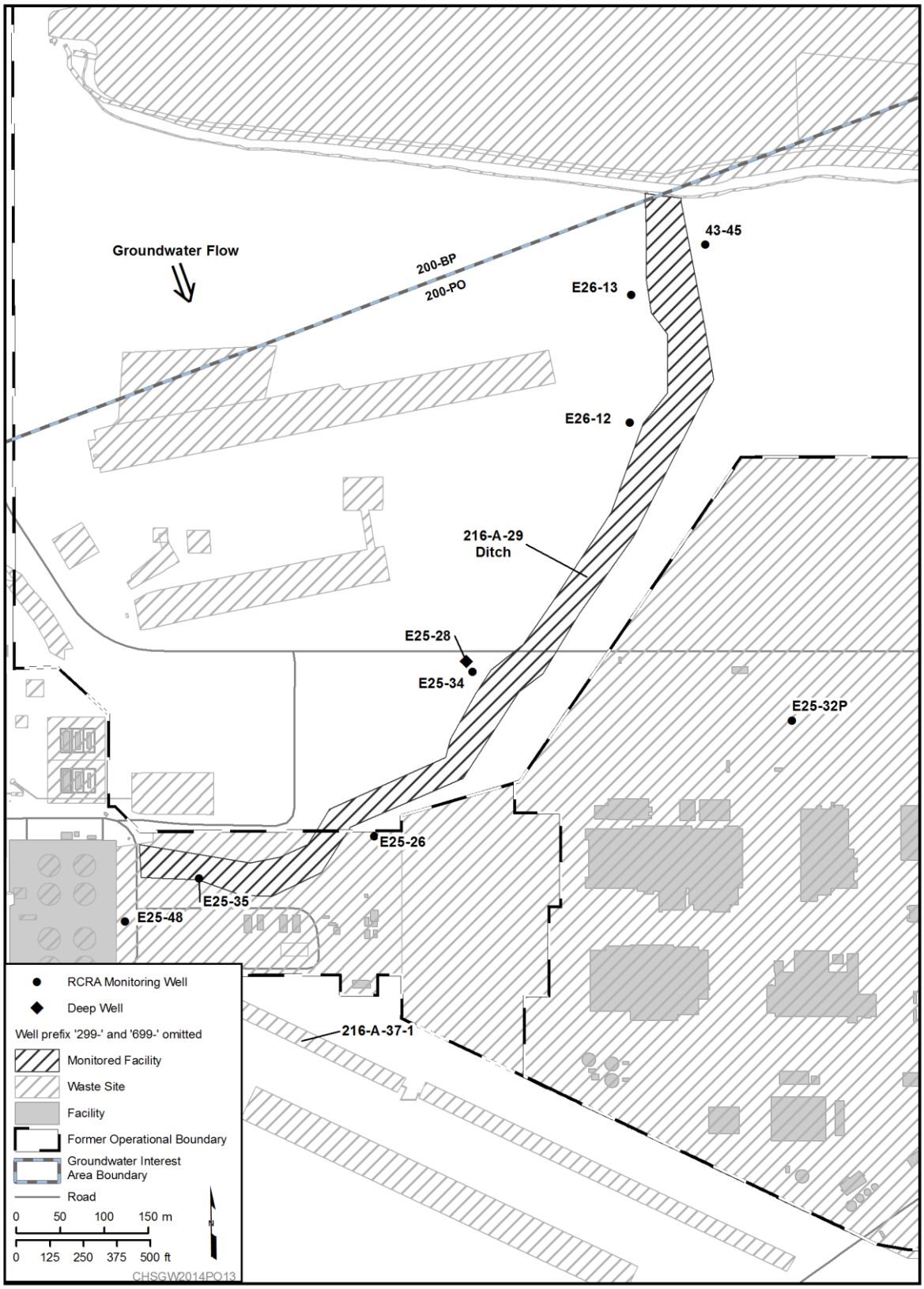


Figure 10-30. 200-PO RCRA Facility 216-A-29 Monitoring Well Locations

10.13.4.1 Sampling Results

The monitoring network was sampled as planned in 2014 with one exception. A software-generated paperwork error for the April-scheduled annual sampling event of network wells required the collection of annual samples for indicator parameters TOX and TOC at Well 299-E25-34 to be collected later, and was included with the subsequent semiannual sampling event conducted in October. As shown in Table B-17 of Appendix B, an exceedance of the critical mean for pH, specific conductance, and TOC occurred during 2014. The critical mean for specific conductance was exceeded in downgradient Wells 299-E25-35, 299-E25-48, and 299-E25-32P during each of the 2014 semiannual sampling events. The critical mean for specific conductance in Well 299-E25-35 has been exceeded since the early 1990s. A groundwater assessment for the specific conductance detected was performed in the early 1990s as described in WHC-SD-EN-EV-032, *Results of the Groundwater Quality Assessment Program at the 216-A-29 Ditch RCRA Facility*. The assessment concluded that the specific conductance exceedance at the site was caused by elevated calcium, sodium, and sulfate. These are nondangerous waste constituents, so the site remains in an indicator parameter program.

Due to the number of nondetects in upgradient wells, a 2014 critical mean was not calculated for the TOX. In lieu of a critical mean, sampling results were compared to the laboratory limit of quantitation (LOQ). Two new laboratories were utilized for groundwater analyses beginning in May 2014, requiring the determination of new LOQ values for TOC and TOX for each laboratory.

The mean of quadruplicate samples collected from Well 299-E25-26 for the October 2014 sampling event exceeded the 2014 critical mean that was established using upgradient data collected in 2012 and analyzed by WSCF. Until May 2014, WSCF had been utilized as the primary laboratory for groundwater analyses. The October TOC analytical result for Well 299-E25-26 was based on analyses performed by Test America St. Louis (TASL). The mean of quadruplicate samples from Well 299-E25-26 and the other downgradient wells were was less than the TASL LOQ for TOC.

Samples collected to support analysis of groundwater quality (chloride, iron, manganese, phenol, sodium, and sulfate) showed one exceedance in 2014 (Table B-18 in Appendix B). Iron has intermittently exceeded the secondary DWS in Well 299-E25-32P in unfiltered samples and in 2014 an exceedance occurred. The most recent exceedance in Well 299-E25-32P prior to 2012 was in 1995. Similarly, manganese has exceeded the secondary DWS intermittently in filtered and unfiltered samples from Well 299-E25-19, with the last exceedance in 1995. No exceedance of the manganese DWS occurred in 2014.

10.13.4.2 Water-Level and Well Network Evaluation

Near the north end of the ditch and immediately west and north of the 216-A-29 Ditch and the adjacent 216-B-3 Pond, flow in the unconfined aquifer is south to southwest (Figure 2-4 in DOE/RL-2008-59). Further east of the 216-A-29 Ditch, groundwater flow is more generally to the southeast. Trend surface analysis utilizing the low-gradient well network near the 216-A-29 Ditch indicates a water table gradient of 2.0×10^{-5} m/m with a south-southeast flow direction. Based on the current groundwater flow interpretation, the current monitoring network was capable of monitoring the 216-A-29 Ditch throughout 2014. The calculated average flow velocity is 0.0036 m/d (0.012 ft/d) (Table B-1, Appendix B). Similar to the 216-A-37-1 Crib and WMA A-AX, additional gradient network evaluation near 216-A-29 is currently ongoing to provide greater certainty in calculating groundwater flow direction in this area. Table B-16 of Appendix B summarizes water-level data for the monitoring network.

An updated RCRA groundwater monitoring plan for the 216-A-29 Ditch will be developed in 2015. The new plan will incorporate the most current groundwater flow direction data obtained from the low-gradient monitoring network; present new geologic cross sections derived from data incorporated in

the Hanford South Geoframework Model (ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*); review and summarize historical monitoring results with the relationship to changing flow directions; and update the conceptual site model.

10.13.5 216-B-3 Pond

The inactive 216-B-3 Pond was located east of the 200 East Area (Figure 10-31). The location was within a natural topographic depression. During operations, the pond covered approximately 16.2 ha (40 ac) with a depth of up to 6.1 m (20 ft). Total discharge to the pond since 1945 is estimated to have exceeded 10 billion L (260 billion gallons) (PNNL-15479). The B Pond is classified as a treatment, storage, and disposal unit because it received dangerous waste after implementation of dangerous waste regulations. The dangerous waste received came from three primary sources: corrosive and dangerous waste resulting from regeneration of demineralizer columns at PUREX, spills of dangerous or mixed waste from PUREX and other facilities, and off-specification chemical makeups at PUREX. The last known reportable discharge of chemical waste, sodium nitrite, occurred in 1987. The 216-B-3 Pond was decommissioned in 1994 by backfilling with coarse-grained material and then covering the pond with fine-grained material.

In accordance with WAC 173-303-400 and 40 CFR 265.92, the 216-B-3 Pond network groundwater wells are monitored semiannually for RCRA indicator parameters of TOC, TOX, pH, and specific conductance. Wells are also monitored annually for water quality parameters including chloride, iron (unfiltered), manganese (unfiltered), phenols, sodium, and sulfate. Water-level measurements are also collected semiannually. Sampling details and site history are described in DOE/RL-2008-59. The well network in 2014 consists of one upgradient (699-44-39B) and three downgradient wells (699-42-42B, 699-43-44, and 699-43-45) (Figure 10-31; Table B-27, Appendix B). The wells were sampled semiannually, as required, during 2014.

10.13.5.1 Sampling Results

As shown in Table B-29 in Appendix B, no exceedances of the critical mean for pH, specific conductance, or TOC were detected at the site in 2014. Due to the number of nondetects in the upgradient well, a 2014 critical mean was not calculated for TOX. In lieu of a critical mean, sampling results were compared to the laboratory LOQ. In addition to the use of WSCF for the first half of the year, two new laboratories were utilized for groundwater analyses beginning in May 2014, requiring the determination of new LOQ values for TOX from each laboratory. With respect to TOX, no exceedances of the laboratory LOQs occurred for the sampling events completed at the 216-B-3 Pond.

Groundwater quality constituents monitored for the site include chloride, iron (unfiltered), manganese (unfiltered), phenols, sodium (unfiltered), and sulfate (Table B-30 in Appendix B). No groundwater quality constituents exceeded the respective DWS in 2014. Additional contaminants of interest monitored for the site include arsenic (filtered and unfiltered), cadmium (filtered and unfiltered), and nitrate. Additional supporting constituents monitored for the site include dissolved oxygen, temperature, turbidity, alkalinity, anions, and metals (unfiltered).

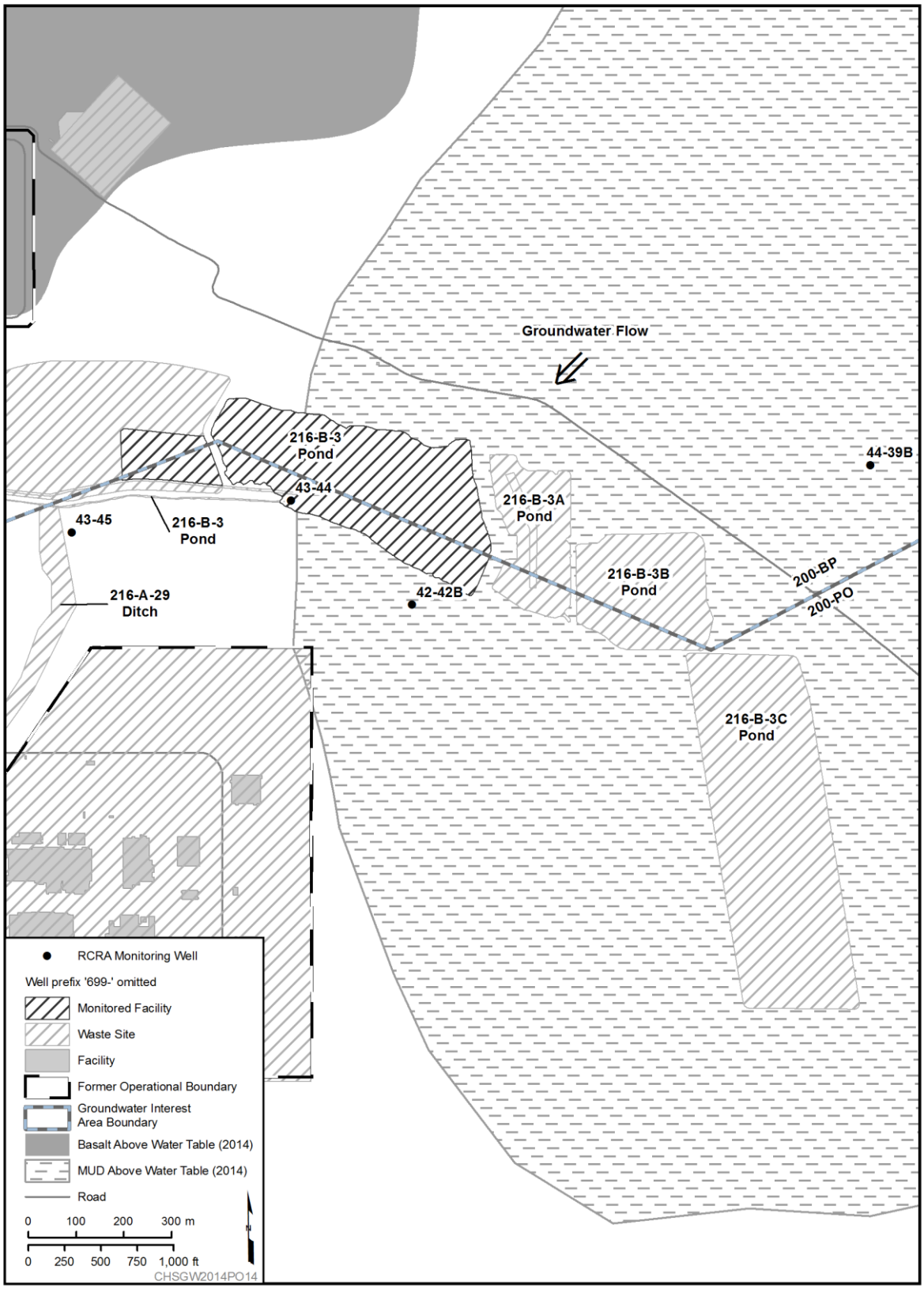


Figure 10-31. 200-PO RCRA Facility 216-B-3 Monitoring Well Locations

10.13.5.2 Water-Level and Well Network Evaluation

The monitoring network, as defined in DOE/RL-2008-59, consists of one upgradient and three downgradient wells, based on a groundwater flow direction to the west (see Section 2.4 of DOE/RL-2008-59). The 2014 flow rate is estimated to be 0.0056 m/d (0.018 ft/d) to the southwest. The network well screens range from 1.5 to 6.5 m (4.9 to 21 ft) into the aquifer. These current network wells have adequate water columns in the screened interval available for sampling (Table B-28 in Appendix B). An updated RCRA groundwater monitoring plan for the 216-B-3 Pond will be developed in 2015. The new plan will incorporate the most current groundwater flow direction data obtained from the low-gradient monitoring network; present new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*); review and summarize historical monitoring results with the relationship to changing flow directions; and update the conceptual site model.

10.13.6 Integrated Disposal Facility

The IDF consists of an expandable, double-lined landfill with approximately 0.07 km^2 (0.027 mi^2) of liner. The landfill is divided into two distinct cells: (1) the east cell for the disposal of low-level radioactive waste, and (2) the west cell for the disposal of mixed waste. The landfill is not yet in use.

Construction of the first phase for IDF was completed in April 2006 (Figure 10-32). DOE submitted a Part B RCRA Permit application to Ecology, which was incorporated into the Hanford Facility RCRA Permit (WA7890008967) on April 9, 2006. The start date for IDF operations has not been determined. IDF is currently monitored as part of a detection monitoring program as described in Section III.11.E.1.b of 10-EMD-0080. The wells are monitored annually for the following indicator parameters: chromium (filtered), pH, specific conductance, TOC, and TOX. In addition, groundwater is monitored for supplemental constituents of alkalinity, anions, metals, and turbidity. Based on the current southeasterly groundwater flow direction, the monitoring network consists of one upgradient well (299-E24-24) and two side-gradient wells (299-E18-1 and 299-E24-21), and four downgradient wells (299-E17-22, 299-E17-23, 299-E17-25, and 299-E17-26) (Figure 10-32; Table B-42, Appendix B). Since the facility is not yet operational, the current monitoring objective is to collect baseline groundwater information. All seven network wells were sampled as scheduled during 2014.

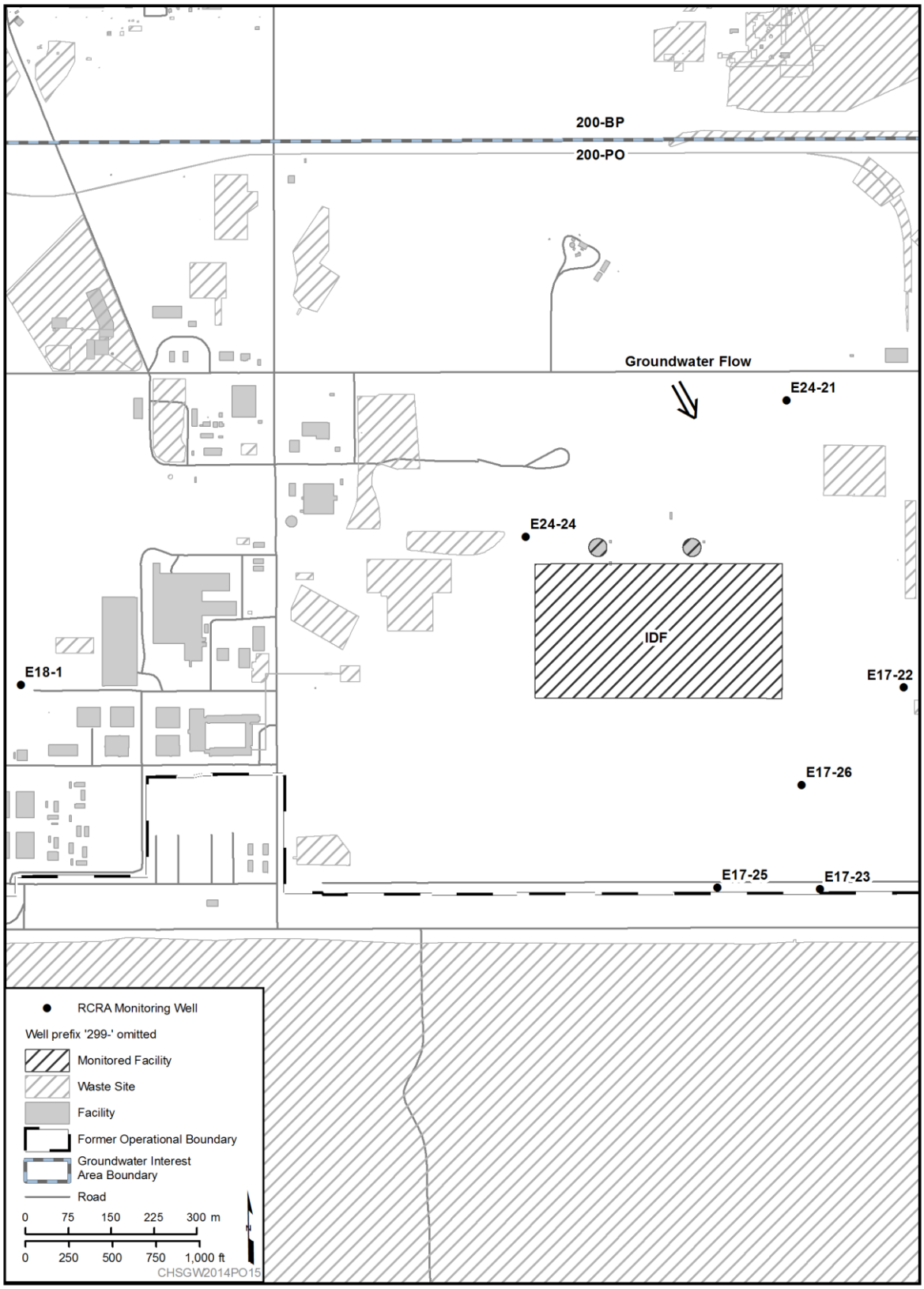


Figure 10-32. 200-PO RCRA Facility IDF Monitoring Well Locations

10.13.6.1 Sampling Results

A summary of the 2014 indicator parameter results is provided in Table B-44 of Appendix B. No upgradient/downgradient comparisons are required because the facility is not yet in use. With respect to the supplemental constituents, nitrate exceeded the DWS during 2014 in five wells at the IDF (299-E24-21, 299-E17-22, 299-E17-23, 299-E17-25, and 299-E17-26). Changes in the plume configuration and concentration trending shown at individual wells indicates that nitrate is migrating to the southeast in the vicinity of the IDF facility. The maximum nitrate concentration was 56.7 mg/L in Well 299-E17-25. This well is in the regional 200 East Area nitrate plume.

10.13.6.2 Water-Level and Well Network Evaluation

Groundwater modeling was conducted in 2000 (PNNL-13400) to support the assessment of flow and transport conductions during future utilization of IDF and to assist in positioning of wells to be installed as part of the facility's monitoring network. These early model results indicated a southeastward flow direction. Beginning in 2008, data collection efforts were started to improve the accuracy of the water-level measurements so that the groundwater flow direction beneath the PUREX Cribs and the nearby IDF could be evaluated in greater detail (Section 3.2 of DOE/RL-2011-01).

Trend surface analysis of water-level measurements from June 2008 through March 2011 indicated an average hydraulic gradient magnitude of 2.2×10^{-5} ($\pm 0.3 \times 10^{-5}$) m/m with an east-northeast direction (64 [±12] degrees azimuth). Measurements between June 2011 and December 2012, indicated an average hydraulic gradient magnitude of 2.4×10^{-5} ($\pm 0.2 \times 10^{-5}$) m/m with an eastern flow direction (95 [±5] degrees azimuth). The low-gradient network water-level data for 2013 and 2014 indicate a southeast flow direction in the vicinity of the IDF (Table B-1, Appendix B). The groundwater flow rate is estimated to range from 0.004 to 0.0045 m/d (0.013 to 0.015 ft/d) (Table B-1, Appendix B). The most recent assessment of flow direction completed utilizing 2013 and 2014 water-level data again indicates southeastward flow, as previously determined in 2000 (PNNL-13400). Based on current groundwater flow interpretations, the monitoring network is considered adequate. Work continues to better define groundwater flow in the area of IDF and the PUREX Cribs. Table B-43 in Appendix B summarizes water-level data for this facility.

10.13.7 Nonradioactive Dangerous Waste Landfill

The NRDWL is located southeast of the 200 East Area next to the SWL (Figure 10-33). The landfill has an area of 0.045 km^2 (0.017 mi^2) consisting of 19 parallel unlined trenches, each approximately 122 m (400 ft) long, 4.9 m (16 ft) wide at the base, and 4.6 m (15 ft) deep. The landfill received chemical waste, asbestos, and nonhazardous waste between 1975 and 1985.

The vadose zone beneath the NRDWL is approximately 40 m (131 ft) thick, composed of sand, silty-sandy gravel, and gravel of the Hanford formation. The uppermost aquifer consists of approximately 9 m (30 ft) of additional Hanford formation, 8 m (26.2 ft) of the Cold Creek unit (a pre-Missoula gravel deposit), and 6 m (20 ft) of undifferentiated Ringold Formation sandy gravel. The base of the aquifer is a low-permeability unit composed of silt and silty sand. Detailed geology of 200-PO is shown in Figure 10-2.

The objective of RCRA monitoring at the NRDWL is to determine if dangerous waste constituents from the landfill have contaminated groundwater (40 CFR 265.92, as referenced by WAC 173-303-400) through an interim status indicator evaluation monitoring program. The groundwater sampling well network and associated monitoring constituents are described in PNNL-12227 and associated PNNL interim change notice ICN-PNNL-12227, R0.1, *Interim Change Notice to the Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*.

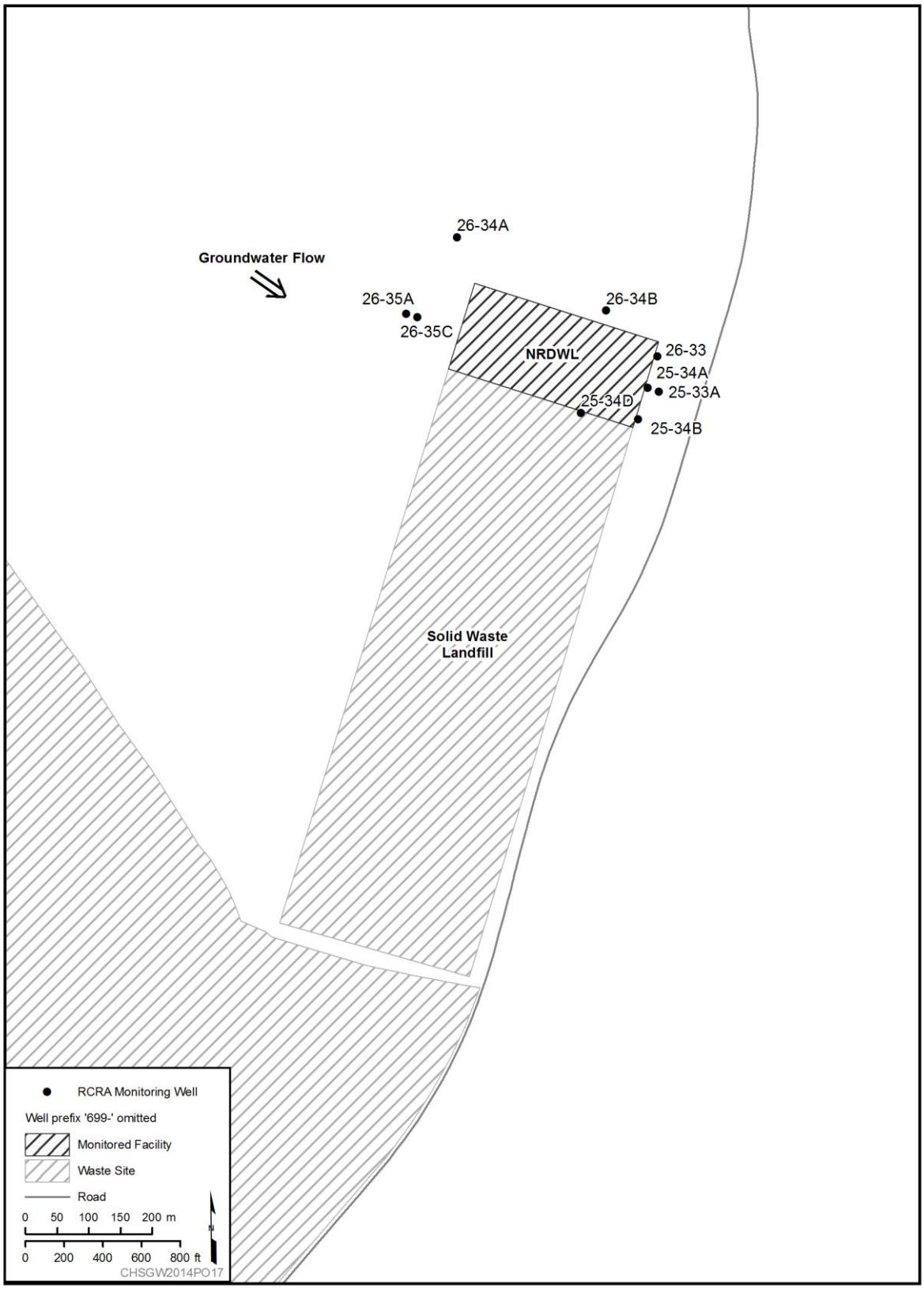


Figure 10-33. 200-PO RCRA Facility NRDWL Monitoring Well Locations

NRDWL is curently being monitored under PNNL-12227. During 2010, a new combination RCRA groundwater monitoring plan was released for NRDWL and SWL to combine the two units under one monitoring plan (DOE/RL-2010-28). The new monitoring plan was developed in association with the NRDWL/SWL closure/post-closure plan (DOE/RL-90-17, Rev. 2). The new monitoring plan specified phased changes to the existing well system, including the addition of two new far field upgradient wells during Phase 1 and one new far field downgradient well during Phase 2. Wells would be installed far enough away from the landfill to minimize the effects of VOCs from soil vapor in the vadose zone to groundwater. Monitoring under PNNL-12227 will continue until all three new wells are installed per DOE/RL-2010-28), and an associated Hanford Site RCRA Permit modification is approved.

New far field upgradient Wells 699-26-36 (upgradient of the solid waste landfill) and 699-24-38 (upgradient of the NRDWL) were completed in 2014 per DOE/RL-2010-28. New upgradient Well 699-26-38 will be integrated with the existing NRDWL monitoring network defined in PNNL-12227. Because a number of well network changes have occurred over the last several years, such as addition of a new upgradient well and anticipated loss of two downgradient wells that are going sample dry, a new monitoring plan will be prepared in 2015 to update PNNL-12227.

As defined in PNNL-12227, the monitoring well network (Figure 10-33; Table B-66, Appendix B) consists of two upgradient wells within the top of the unconfined aquifer (699-26-34A and 699-26-35A), four downgradient wells within the top of the unconfined aquifer (699-25-34A, 699-25-34B, 699-25-34D, and 699-26-33), one upgradient well directly above the low-permeability unit that forms the base of the unconfined aquifer (699-26-35C), one downgradient well directly above the low-permeability unit that forms the base of the unconfined aquifer (699-25-33A), and one side-gradient well (699-26-34B). Quadruplicate samples are not collected for Wells 699-25-33A and 699-26-35C, and results from these wells are not used for statistical comparisons with or calculations of critical mean values. The NRDWL groundwater wells are monitored semiannually for RCRA indicator parameters of TOC, TOX, pH, specific conductance, and site-specific parameters of VOCs and nitrate. Wells are monitored annually for the water quality parameters of chloride, iron, manganese, phenols, sodium, and sulfate. Wells 699-26-33 and 699-25-34A are planned to be replaced in 2015 in anticipation that there will be insufficient water within the screen interval for sample collection during future sampling events.

10.13.7.1 Sampling Results

Well 699-25-34D, which was not sampled as planned in January 2014 due to pump issues, was sampled successfully on March. Semiannual sampling of Wells 699-25-34A and 699-26-33 was not completed in January as planned because of a suspected pump issue, since no water could be retrieved. A camera survey was performed to inspect the well screens in April. The survey revealed 0.6 to 0.9 m (2 to 3 ft) of sediment fill in the bottom of the well, which was limiting the water available for sample collection. Removal of the sediment from the wells was completed and the wells were successfully sampled during the July event.

The mean of the quadruplicate specific conductance measurements in downgradient Wells 699-25-34A, 699-25-34B, and 699-25-34D from the July sampling event exceeded the critical mean (Table B-68 of Appendix B). A groundwater assessment performed in 2001 concluded elevated specific conductance at the site was due to the nondangerous waste constituents bicarbonate, sulfate, calcium, and magnesium. Between the late 1980s and about 2000, concentrations of common cations (e.g., calcium and magnesium) increased along with specific conductance in these three wells, and considering the results of the previous assessment, the site remains in interim status detection monitoring. Specific conductance measurements in 2014 were generally lower than those observed during the period from 2000 to 2013 in Wells 699-25-34D, 699-25-34A, and 699-24-34B. Over the last decade, specific conductance values have been showing an overall very gradual decline in these wells.

Low-level detections of several VOCs were noted in 2014 as the result of lower analytical method detection limits being available. All detected constituent concentrations were "J" qualified by the analytical laboratories. The laboratory "J" flag indicates that the value is estimated and the detection is uncertain, and the value reported is less than the practical quantitation limit, but greater than or equal to the method detection limit. The highest nitrate result was 23.5 mg/L in Well 699-25-34B, which is consistent with sitewide nitrate in the area. An elevated iron unfiltered concentration exceeding the secondary DWS occurred for a November sample collected from Well 699-25-34A.

10.13.7.2 Water-Level and Well Network Evaluation

From 2011 to March 2013, efforts were undertaken to improve the accuracy of the water-level measurements and resultant estimates of groundwater gradient near the NRDWL/SWL. The efforts included vertical offset surveys of well casings, high-resolution water-level measurements, and consideration of barometric effects. The results from the data collection and analysis yielded an average hydraulic gradient from January 2011 to March 2013 of 3.3×10^{-5} m/m and a flow direction of 101 degrees azimuth (southeast). Data compiled during 2014 and utilized for trend surface analysis indicate a flow direction of 125 degrees azimuth (southeast) and a hydraulic gradient of 2.4×10^{-5} m/m. This flow direction generally agrees with the southeastward flow direction inferred from historical plume migration in this area, and hydraulic head differences in the NRDWL/SWL area compared to the 200 East Area. For example, during 2012, the average water-level elevation near NRDWL/SWL (121.66 m [399.61 ft], NAVD88 for April 2012) was 0.14 m (0.46 ft) lower than the average elevation in the 200 East Area (121.80 m [399.61 ft], NAVD88 for April 2012), yielding a regional hydraulic gradient magnitude of 1.8×10^{-5} m/m. The wells continue to be located appropriately to accomplish the objectives of the interim status detection monitoring program.

An updated RCRA groundwater monitoring plan specifically for the NRDWL will be developed in 2015 to replace PNNL-12227. The new plan will incorporate the most current groundwater flow direction data obtained from the low-gradient monitoring network; present new geologic cross-sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*); review and summarize historical monitoring results with the relationship to changing flow directions; and update the conceptual site model.

10.14 WAC Monitoring – Solid Waste Landfill

The SWL is located south of and adjacent to the NRDWL (Figure 10-34). The landfill is regulated by Ecology in accordance with WAC 173-350, which requires monitoring of leachate, soil gas, and groundwater. Per the groundwater monitoring plan, PNNL-13014, and WAC 173-304, constituents and site-specific constituents (including selected VOCs and filtered arsenic) are analyzed in groundwater samples collected quarterly. Compliance is determined by comparing results from downgradient monitoring wells with statistically derived background threshold values (BTVs) from upgradient wells.

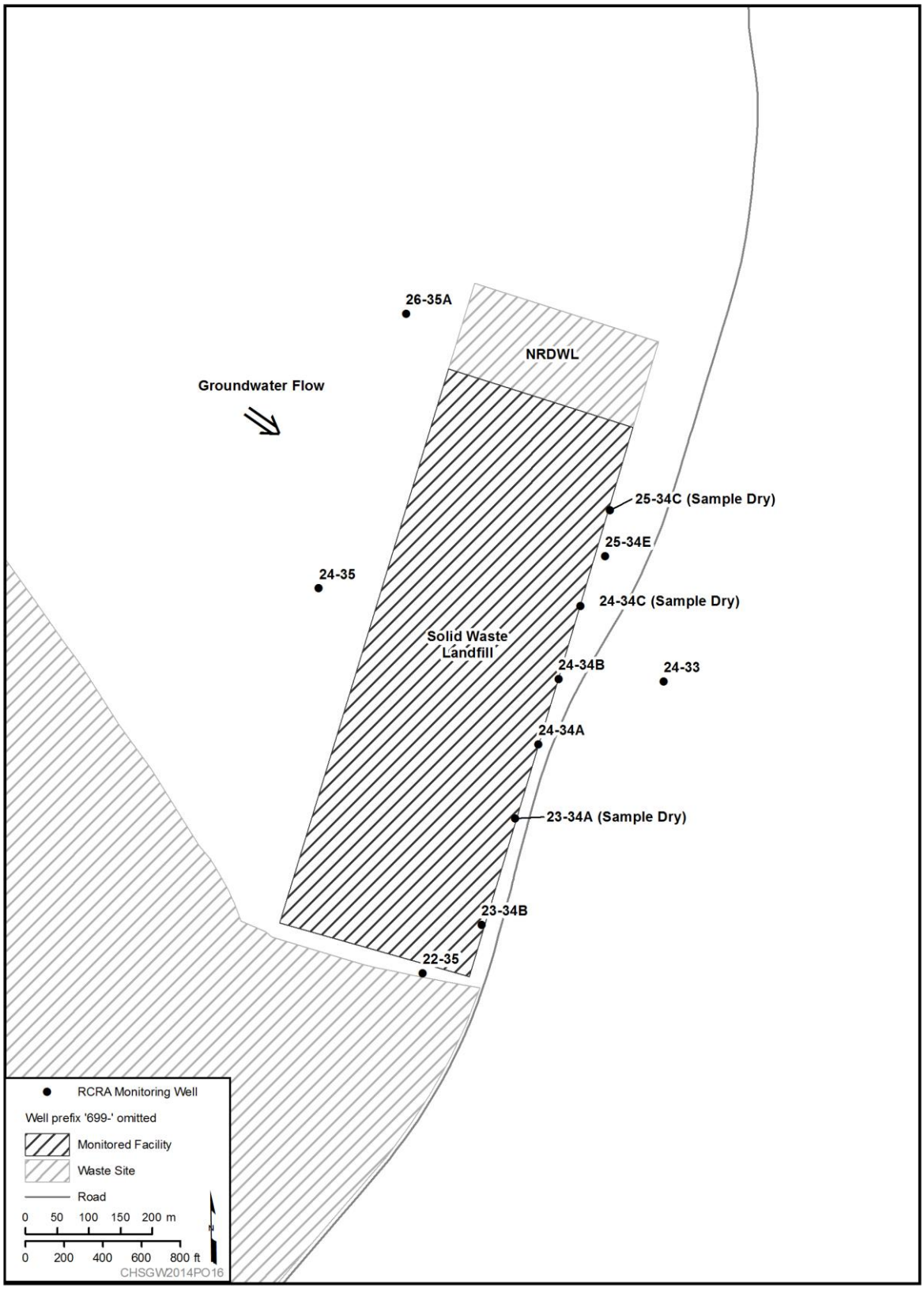


Figure 10-34. 200-PO WAC Facility SWL Monitoring Well Locations

In 2014, the monitoring well network consisted of two upgradient wells (699-24-35 and 699-26-35A) and six downgradient wells (699-22-35, 699-23-34B, 699-24-33, 699-24-34A, 699-24-34B, and 699-25-34E) (Table B-92 in Appendix B). Wells 699-24-34C and 699-25-34C that were part of the original network described in PNNL-13014 became sample dry prior to 2013 and can no longer be sampled. In addition, Well 699-23-34A became sample dry in October 2013 and can no longer be sampled. Replacement Well 699-25-34E was completed in 2014 and was sampled during the last quarterly event.

Per PNNL-13014, the wells are sampled quarterly for ammonium, chemical oxygen demand, chloride, iron (filtered), manganese (filtered), nitrate, nitrite, pH, specific conductance, sulfate, temperature, total coliform, TOC, and zinc (filtered) per WAC 173-304-490. The wells are also sampled for arsenic (filtered) and VOCs. Note that SWL is currently regulated by WAC 173-350; however, WAC 173-350 was not yet promulgated at the time that PNNL-13014 was written in 2000, so the plan was developed in accordance with WAC 173-304.

10.14.1 Sampling Results

The results of the leachate, soil gas, and groundwater monitoring are reported annually in a separate report prepared by MSA, (*Hanford Site Solid Waste Landfill Annual Monitoring Report, October 2013 through September 2014*). The following paragraphs provide a summary.

10.14.1.1 Leachate and Soil Vapor Monitoring

A leachate collection system (lysimeter) underlying one set of double trenches within SWL is sampled quarterly. Therefore, the results are not necessarily representative of total leachate volume or chemistry by all the trenches in the landfill.

Some of the inorganic analytes were detected, but the VOCs were generally not detected. Some of the leachate results, including dissolved iron, dissolved manganese, arsenic and total dissolved solids exceeded WAC 173-200 standards; however, the fact that contaminants are above compliance levels in the leachate does not necessarily mean they are present in the groundwater.

The soil gas monitoring network consists of eight shallow monitoring stations located around the perimeter of the SWL. In addition to the eight soil gas monitoring stations positioned around the SWL, an additional station is located between the SWL and NRDWL. Each monitoring station consists of two dedicated soil gas probes driven to depths of about 2.7 and 4.6 m (8.9 and 15 ft), respectively. The soil gas is monitored quarterly to determine concentrations of carbon dioxide and methane. The soil gas is also analyzed for several key VOCs: methylene chloride, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, carbon tetrachloride, TCE, 1,1,2-trichloroethane, and PCE. Soil gas at the SWL was analyzed in November 2013, February 2014, May 2014, and August 2014 (*Hanford Site Solid Waste Landfill Annual Monitoring Report, October 2013 through September 2014*). The concentrations for the VOCs, methane, and carbon dioxide continue to be consistent with results from previous monitoring. The concentrations for volatile organic constituents were at or below the detection limits. Methane concentrations remain low or are not detected. Carbon dioxide concentrations continue to be consistent with previous results.

10.14.2 Groundwater Monitoring Results

Groundwater monitoring results for the analytes listed in the sampling plan per WAC 173-304-490 are detailed in Table B-93 of Appendix B. The results are summarized below.

10.14.2.1 Ammonium

Ammonium did not exceed the BTV of 90 µg/L in 2014 with concentrations ranging from less than 6.44 µg/L (nondetect) to 64.9 µg/L. Historically, ammonium has been detected intermittently, and has only exceeded the BTV one time in Well 699-24-34A in 2009.

10.14.2.2 Chemical Oxygen Demand

In 2014, chemical oxygen demand (COD) ranged from less than 10 (nondetect) to 17.4 mg/L. COD exceeded the BTV of 10 mg/L in 2014 in downgradient Wells 699-24-34A, 699-24-34B, 699-23-34B, and 699-24-35 and upgradient Well 699-22-35.

10.14.2.3 Chloride

Chloride concentrations detected in 2014 ranged from 5.41 to 8.30 mg/L. Well 699-24-34E exceeded the BTV of 7.82 mg/L in the July sampling event. Since the current sampling plan was implemented at SWL in 2001, chloride has exceeded the BTV intermittently in all 10 of the network wells.

10.14.2.4 Coliform Bacteria

Coliform bacteria concentrations in 2014 ranged from less than 1 colony/100 mL (nondetect) to 12 colonies/100 mL. Coliform bacteria was detected above the BTV in Wells 699-24-34A, 699-24-34E, and 699-24-35. Well 699-24-34B had the maximum detected concentration in 2014 of 12 colonies/100 mL. Since sampling began per PNNL-13014 in January 2001, COD has exceeded the BTV intermittently in 9 of the 10 network wells, including both of the upgradient wells (699-24-35 and 699-26-35A).

10.14.2.5 Iron (Filtered)

In 2014, dissolved (filtered) iron concentrations ranged from less than 12.8 µg/L (nondetect) to 85.4 µg/L, which were all below the BTV of 160 µg/L. Only two iron results from Well 699-22-35 (at a concentration of 259 µg/L in 2011) and in Well 699-24-34A at a concentration of 211 µg/L in 2004, have exceeded the BTV.

10.14.2.6 Manganese (Filtered)

Dissolved (filtered) manganese concentrations ranged from less than 1 µg/L (nondetect) to 2.7 µg/L in the SWL wells. The reporting limit in 2014 was well below the BTV of 18 µg/L. Concentrations of dissolved manganese in the SWL wells have never been detected above the BTV since sampling was initiated under the current sampling plan in 2001. The maximum concentration detected was 17.9 µg/L in 2004 in Well 699-24-34A.

10.14.2.7 Nitrate

In 2014, nitrate concentrations were detected at concentrations ranging from 11.1 to 19.0 mg/L. Since 2001, the highest nitrate concentration detected in the SWL well network was 20.4 mg/L in Well 699-23-34A in 2011. The detected concentrations have been below the BTV of 29.0 mg/L. The SWL is near the southwestern extent of elevated nitrate concentrations that emanated from 200 East Area sources. Concentrations of nitrate detected in the SWL have been consistent with the regional interpretation of nitrate groundwater impacts.

10.14.2.8 Nitrite

All analyses for nitrite concentrations at the SWL in 2014 were nondetect. Detection limit values ranging from less than 131 to less than 9.85 µg/L were all below the BTV for nitrite of 266 µg/L. Since sampling

began per the current sampling plan in 2001, nitrite has exceeded the BTV intermittently in 8 of the 10 network wells, including both of the upgradient wells (699-2-35 and 699-26-35A).

10.14.2.9 pH Measurements

In 2014, pH measurements ranged from 6.55 to 7.04 in downgradient wells. The pH measurements did not exceed the upper bound BTV of 7.84. The pH measurements were less than the lower bound BTV of 6.68 in the January quarterly samples from Wells 699-24-34A, 699-24-34B, and 699-24-25-34E and in the July sampling event for Well 699-23-34B. Historically, pH measurements have exceeded the lower bound of the BTV intermittently in 6 of the 10 network wells, including upgradient Well 699-24-35, and have only been detected once above the upper-bound BTV in Well 699-25-34C in 2003.

10.14.2.10 Specific Conductance

In 2014, specific conductance was field measured at concentrations ranging from 627 to 808 µS/cm in downgradient wells. In 2014 as in 2013, all six downgradient wells had specific conductance that exceeded the BTV of 583 µS/cm. Three downgradient wells in 2014 had measurements above the 700 µS/cm limit of WAC 246-290-310. Specific conductance measurements in upgradient wells were below the BTV. Elevated specific conductance is principally caused by an increase of bicarbonate concentration in the groundwater at the SWL (Section 3.4 of DOE/RL-94-143). Since sampling began per the current sampling plan in 2001, specific conductance has exceeded the BTV intermittently in 6 of the 10 network wells, including upgradient Well 699-24-35.

10.14.2.11 Sulfate

Sulfate ranged in concentration from 38.8 to 47.8 mg/L during 2014. Sulfate exceeded the BTV of 47.2 mg/L in downgradient Well 699-23-34B during the July sampling events. Since 2000, sulfate has intermittently exceeded the BTV in 9 of 10 network wells.

10.14.2.12 Temperature

In 2014, only one temperature measurement in the third quarter (July) from Well 699-24-34A exceeded the BTV of 20.7°C (69.3°F). Excluding that one measurement, temperatures ranged from 17.7 to 20.3°C (63.9 to 68.5°F) in network wells. Since 2000, the temperature has been measured one time above the BTV in downgradient Wells 699-23-34A, 699-24-33, 699-24-34C, 699-24-34B, and 699-23-34B; two times in Well 699-24-34A; and three times in Well 699-22-35.

10.14.2.13 Total Organic Carbon

TOC concentrations ranged from less than 270 to 1,630 µg/L in 2014. TOC exceeded the BTV of 1,200 µg ug/L in downgradient Well 699-24-33 in April and October. Since 2000, TOC has been detected in all of the network wells ranging from 3 times in Well 699-24-34C (sample dry since 2001) to 22 times in Well 699-23-34B.

10.14.2.14 Zinc (Filtered)

In 2014, dissolved zinc concentrations ranged from less than 5 µg/L (not detected) to 33.6 µg/L, all below the BTV of 42.3 µg/L. Since 2000, dissolved (filtered) zinc has not been detected above the BTV of 42.3 µg/L.

10.14.2.15 Site-Specific Parameters

Additional site-specific parameters monitored for the SWL include filtered arsenic and VOCs. Filtered arsenic was detected in 2014 from well samples at concentrations ranging from 1.54 to 7.61 µg/L. In 2014, arsenic concentrations exceeded the MTCA Method A value of 5 µg/L in third quarter sampling at downgradient Well 699-24-34A, with a concentration of 7.61 µg/L. Since 2000, filtered arsenic has

been detected above the MTCA Method A value of 5 µg/L in three samples from three downgradient wells in 2012 (during second quarter sampling in Wells 699-24-35 and 699-23-34B; and third quarter sampling in Well 699-23-34A). The Hanford Site groundwater background value for arsenic is 11.8 µg/L (Table 1-2).

Five VOCs (PCE, TCE, chloroform, 1,1-dichloroethane, and 1,1,1-trichloroethane) were detected in samples at low concentrations that were "J" qualified by the laboratory. Concentrations ranged from 0.1 to 1.23 µg/L. Detections occurred at both upgradient and downgradient wells. The laboratory "J" flag indicates that the value is estimated and the detection is uncertain, and the value reported is less than the practical quantitation limit, but greater than or equal to the method detection limit.

Since 2000, a total of 20 VOCs have been detected in samples collected from the SWL monitoring network. Five of the VOCs (1,1,1-trichloroethane, 1,1-dichloroethane, chloroform, PCE, and TCE) have been detected most frequently. A large number of the detections were "J"-qualified values. These constituents have generally decreased in concentration since sampling began in 2000 (e.g., 1,1,1-trichloroethane)

10.14.3 Water-Level and Well Network Evaluation

From 2011 to March 2014, efforts were undertaken to improve the accuracy of the water-level measurements and resultant estimates of groundwater gradient near the NRDWL and SWL. The efforts included vertical offset surveys of well casings, high-resolution water-level measurements, and consideration of barometric effects. The results from the data collection and analysis yielded an average hydraulic gradient from January 2011 to March 2013 of 3.3×10^{-5} m/m and a flow direction of 101 degrees azimuth (southeast). Data compiled during 2014 and utilized for trend surface analysis indicate a flow direction of 125 degrees azimuth (southeast) and a hydraulic gradient of 2.4×10^{-5} m/m. This flow direction generally agrees with the southeastward flow direction inferred from historical plume migration in this area, and hydraulic head differences in the NRDWL/SWL area compared to the 200 East Area. For example, during 2012, the average water level elevation near NRDWL and SWL (121.66 m [399.15 ft], NAVD88 for April 2012) was 0.14 m (0.46 ft) lower than the average elevation in the 200 East Area (121.80 m [399.61 ft], NAVD88 for April 2012), yielding a regional hydraulic gradient magnitude of 1.8×10^{-5} m/m.

An updated WAC compliant groundwater monitoring plan for the SWL will be developed in 2015 to replace PNNL-13014. The new plan will incorporate the most current groundwater flow direction data obtained from the low-gradient monitoring network; present new geologic cross sections derived from data incorporated in the Hanford South Geoframework Model (ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*; review and summarize historical monitoring results with the relationship to changing flow directions, and update the conceptual site model.

This page intentionally left blank.

11 200-UP

11.1 Overview

The 200-UP groundwater interest area includes the 200-UP-1 Groundwater OU in the southern portion of the 200 West Area and adjacent portions of the surrounding 600 Area. With the exception of the ERDF, the facilities and waste sites within 200-UP are associated with early operation of the REDOX Plant (plutonium and uranium separation) and U Plant (uranium recovery). Currently there are no liquid waste disposal sites active within the OU. The only active solid waste disposal site is the ERDF which receives waste from surface remedial actions at the Hanford Site. The single-shell waste tanks in the OU have been interim stabilized in that all drainable liquid from each tank has been transferred to double-shell tanks.

DOE conducts groundwater monitoring in 200-UP under CERCLA for the 200-UP-1 OU and the ERDF; and under RCRA for WMA S-SX, WMA U, and the 216-S-10 Pond and Ditch. Monitoring of radionuclides is also performed to meet AEA requirements.

Groundwater monitoring within the 200-UP-1 OU is performed under a sampling schedule incorporated into the RD/RA work plan (DOE/RL-2013-07). Technetium-99, uranium, tritium, iodine-129, nitrate, chromium, and carbon tetrachloride form extensive groundwater plumes in the area. These contaminants originated from operations in this area except for carbon tetrachloride, which has mostly migrated into 200-UP from 200-ZP, although some carbon tetrachloride may have come from the U Pond. The contaminants chloroform, 1,4-dioxane, strontium-90, selenium-79, and TCE have been found in groundwater to a limited extent and are routinely sampled in selected wells. Table 11-1 lists key facts about 200-UP. Section 1.3 of the Introduction provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Within 200-UP, groundwater occurs as an unconfined aquifer and as confined aquifers beneath the Ringold lower mud unit and between the basalt flows. The unconfined aquifer is the aquifer directly impacted by past waste disposal operations within the OU. The unconfined aquifer occurs within Ringold unit E; its base is the fine-grained Ringold lower mud unit (Figure 11-1). There is some contamination (carbon tetrachloride) of the confined aquifer beneath the Ringold Lower Mud unit in the northern portion of the OU which originates from the 200-ZP-1 OU. Appendix A of DOE/RL-2013-07 contains a set of geologic cross sections with vertical contaminant distribution in 200-UP.

Depths from land surface to the water table range from 64 to 106 m (210 to 348 ft), with the largest depths occurring in the northeastern portion of the OU. The thickness of the unconfined aquifer varies from 70 m (230 ft) in the western portion of the OU to near zero north of the OU boundary where the top of the lower mud unit has been extrapolated to occur above the water table. The water table elevation in 200 West Area and resultant groundwater gradients have been historically affected by large-volume wastewater discharges (DOE/RL-2008-01; PNNL-13080).

Groundwater flow in the unconfined aquifer is toward the east within the southern 200 West Area and toward the east northeast in the eastern portion of the interest area (Figure 11-2).

Table 11-1. 200-UP at a Glance

REDOX Plant operations: 1952 to 1967 (plutonium separation) **U Plant operations:** 1952 to 1957 (uranium recovery)			
2014 Groundwater Monitoring			
Contaminant	**Cleanup Level[a]**	**Maximum Concentration**	**Plume Area[b] (km^2)**
Carbon tetrachloride	3.4 µg/L	680 µg/L (299-W14-71)	17.9[c]
Chromium	48[d]/100[e] µg/L	497 µg/L (299-W23-19)	4.7/0.4
Nitrate	45 mg/L	2,270 mg/L (288-W19-43)	5.8
Iodine-129	1 pCi/L	11.0 pCi/L (699-36-70A)	3.2
Technetium-99	900 pCi/L	86,500 pCi/L (299-W19-36)	0.3
Tritium	20,000 pCi/L	280,000 pCi/L (699-36-66B)	5.6
Uranium	30 µg/L	734 µg/L (299-W19-18)	0.3
Remediation			
U Plant P&T (interim action from 1994 to 2011): • Removed 220.5 kg uranium • Removed 2.17 Ci technetium-99 S-SX Tank Farms groundwater extraction system (interim action): • Began operating during July 2012 • Removed 1.66 Ci technetium-99 since startup • Removed 28.1 kg chromium since startup • Removed 16,280 kg nitrate since startup • Removed 250 kg carbon tetrachloride since startup Interim action record of decision approved in September 2012. Remedial Design/Remedial Action Work Plan released September 2013.			

a. From Table 14 in the interim ROD (EPA et al., 2012).

b. Estimated area above the cleanup level unless otherwise noted.

c. Represents the entire extent of the plume (includes the 200-ZP).

d. "Model Toxics Control Act—Cleanup" (WAC 173-340) Method B groundwater cleanup level for hexavalent chromium.

e. Federal drinking water standard for total chromium.

P&T - pump and treat

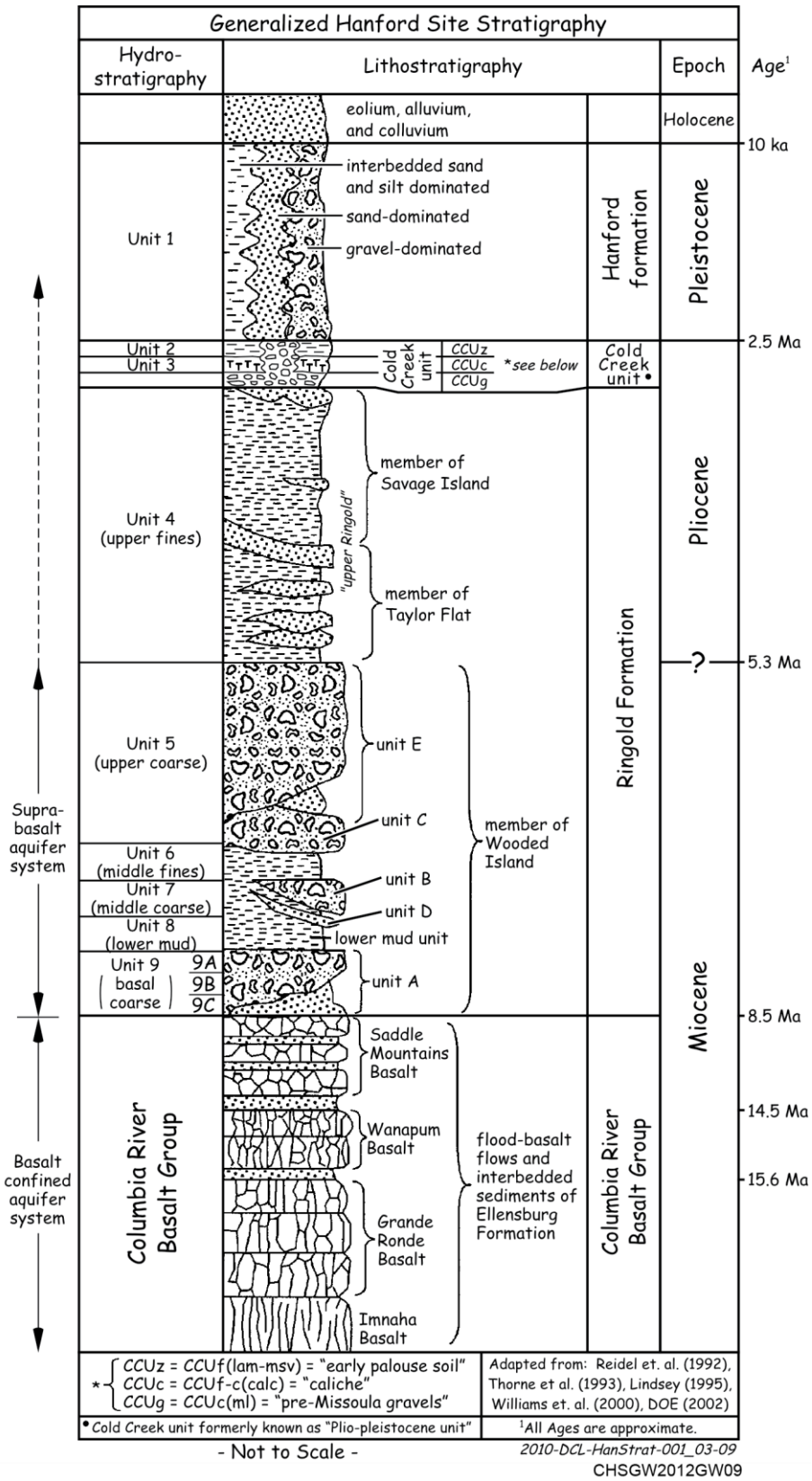


Figure 11-1. Generalized Stratigraphy of the Hanford Site Central Plateau

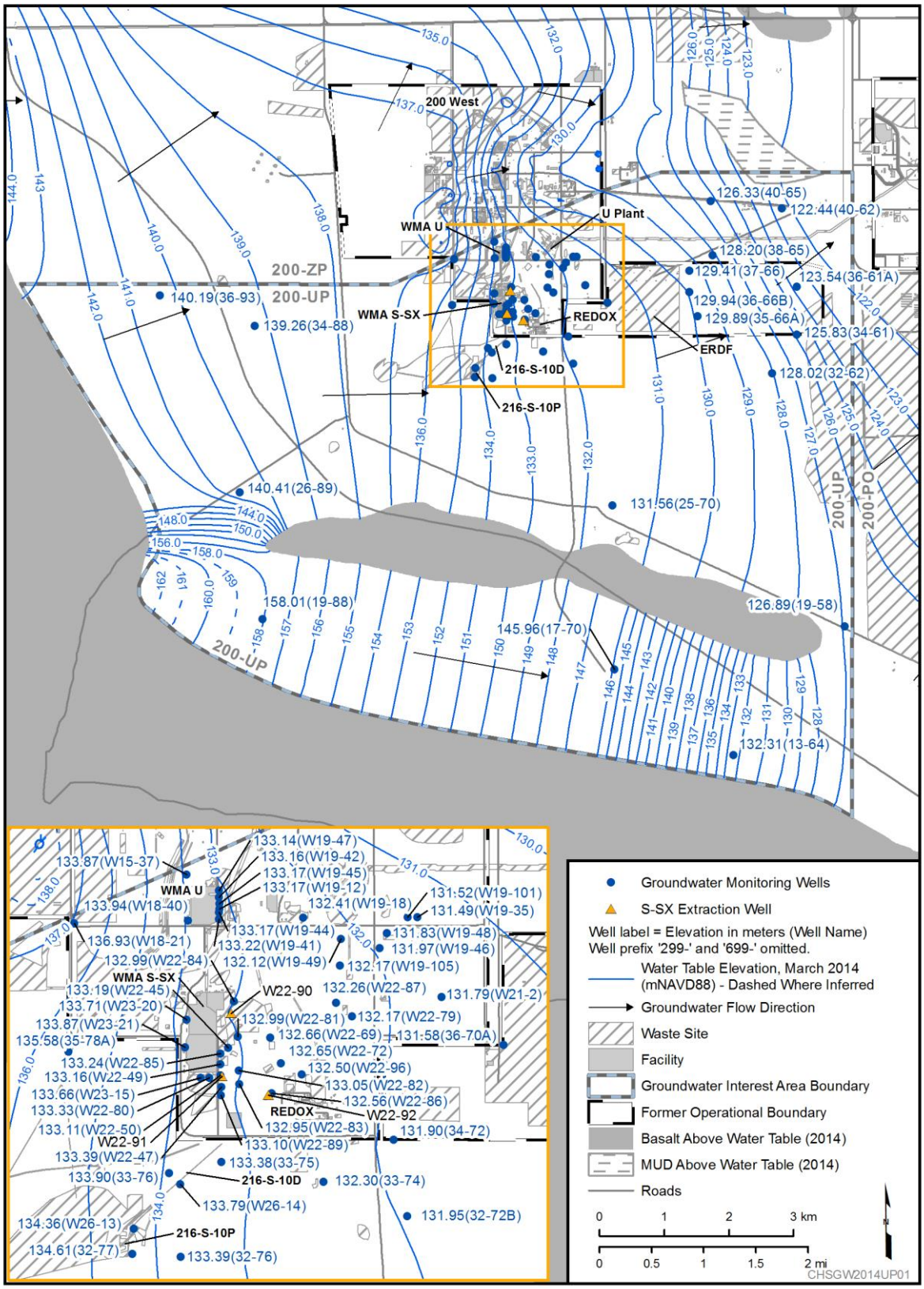


Figure 11-2. 200-UP Water Table Map, March 2014

11.2 CERCLA Activities

An interim action ROD addressing all of the major contaminant plumes within the 200-UP-1 OU was published during September 2012 (EPA et al., 2012). The selected remedy in the ROD consists of a combination of the following:

- Groundwater extraction and treatment for technetium-99, uranium, and chromium
- A combination of P&T and MNA for nitrate and carbon tetrachloride
- MNA for tritium
- Hydraulic containment for iodine-129 while treatment technologies are investigated
- Institutional Controls (ICs)

Implementation of the ROD is addressed by the *200-UP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2013-07). The plan addresses several topics, including the following:

- The approach to be used to design P&T systems for uranium and technetium-99 near U Plant, a P&T system for the chromium plume southeast of 200 West Area, and an injection well system for hydraulic control of the iodine-129 plume while treatment technologies are investigated
- Continued operation of the groundwater extraction system at the S-SX Tank Farms
- Modifications to the 200 West P&T in 200-ZP to accommodate the additional water and treatment needs for the 200-UP-1 remedies

Implementation of the RD/RA work plan began during 2014 with the following activities:

- A SAP was published to support drilling of two extraction wells for the uranium plume remedy near U Plant (DOE/RL-2014-27, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*)
- The 90 percent remedial design for the uranium plume remedy was completed
- Construction of the uranium plume remedy was initiated, including drilling of the two extraction wells (299-W19-113 and 299-W19-114); the wells will be completed in 2015
- Design of the iodine-129 hydraulic containment system was initiated, and locations for the injection wells were selected

Additional activities during 2014 included continued groundwater monitoring (sample locations shown in Figure 11-3) and continued operation of a groundwater extraction system downgradient from the S-SX Tank Farms.

Table A-14 in Appendix A lists the monitoring network and sampling status for 2014. The third CERCLA 5-year review (DOE/RL-2011-56) identified no issues pertaining to 200-UP-1. Changes in plume areas over time for major contaminant plumes within 200-UP are shown in Figure 11-4.

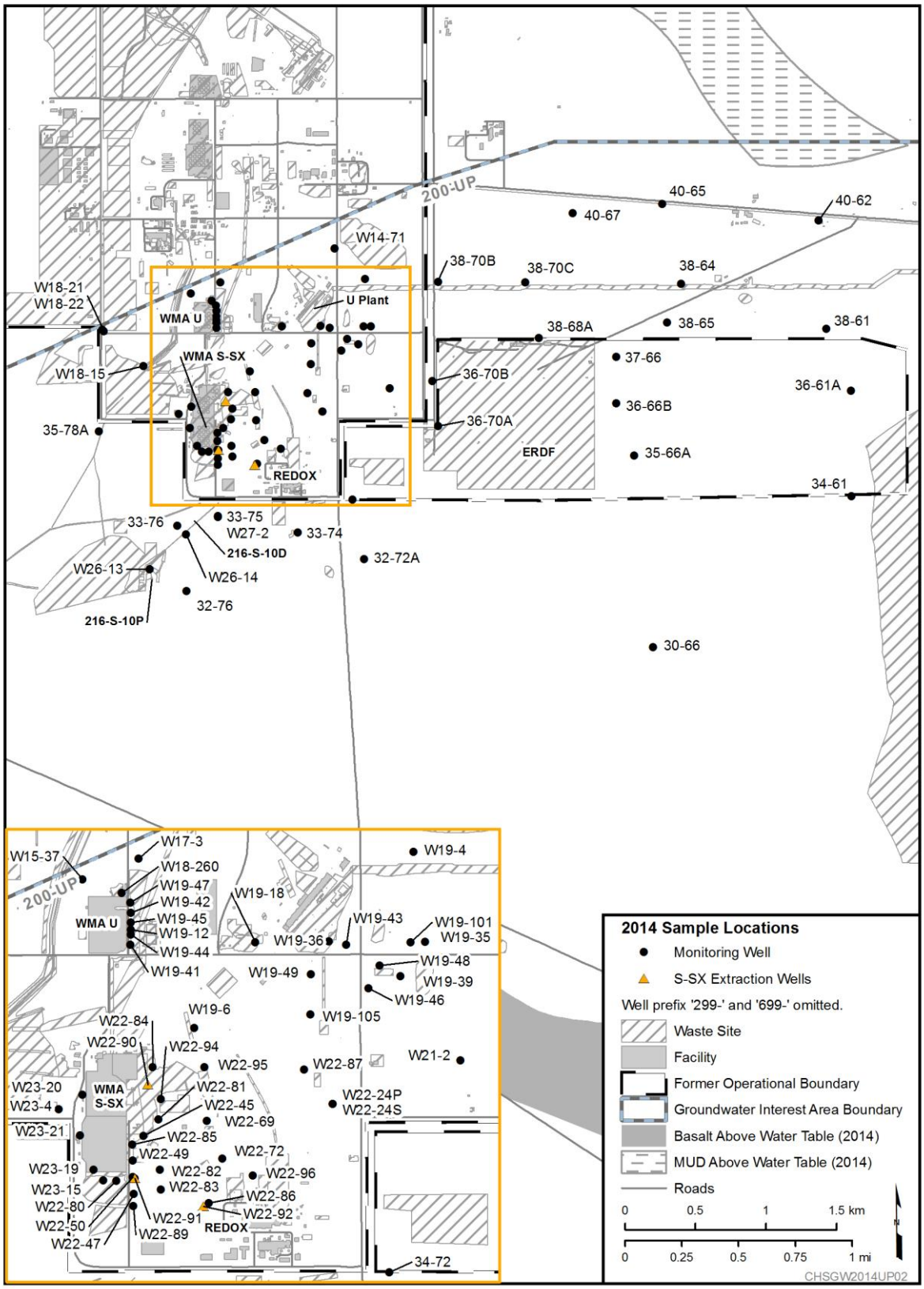


Figure 11-3. 200-UP Sampling Locations, 2014

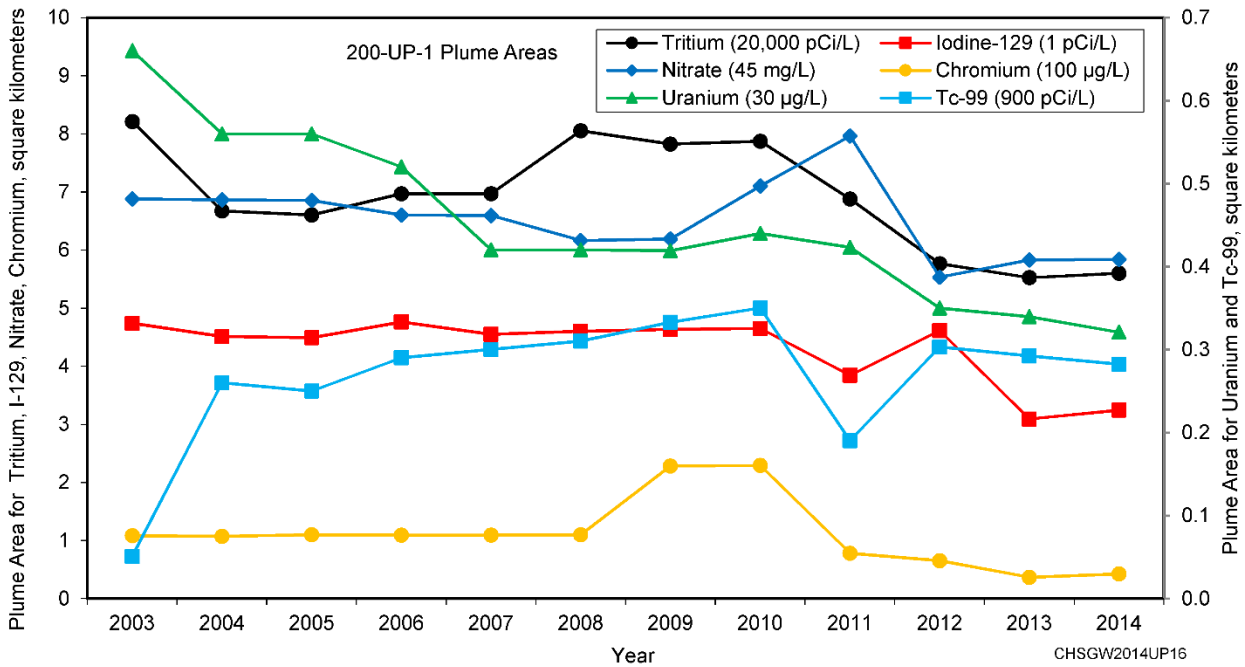


Figure 11-4. 200-UP Plume Areas

11.3 Technetium-99

Technetium-99 concentrations occur above the 900 pCi/L cleanup level downgradient of WMA S-SX, downgradient from the 216-U-1 and 216-U-2 Cribs (near U Plant), and downgradient of WMA U (Figure 11-5).

11.3.1 Waste Management Area S-SX

Technetium-99 plumes occur downgradient of both the S and SX Tank Farms. At Well 299-W23-19 (located next to Tank SX-115 inside the SX fence line), concentrations declined slightly during the year from 22,000 pCi/L in April to 16,600 pCi/L in December (Figure 11-6). These concentrations are substantially lower than the maximum during 2013 of 62,000 pCi/L. The decline is attributed to a groundwater extraction system which began operating during July 2012. The nearest extraction well, 299-W22-91, is located 155 m (509 ft) east-southeast of Well 299-W23-19 (Figure 11-3). Concentrations in many wells downgradient of the SX Tank Farm are declining due to operation of the groundwater extraction system (Figure 11-7). During the year, the technetium-99 concentration in Well 299-W22-47 declined to below the cleanup level. Concentrations are above the cleanup level in seven other monitoring wells within the plume. This plume is attributed primarily to a 190,000 L (51,000 gal) leak from Tank SX-115 that occurred during 1965 (Section 4.3 of RPP-ENV-39658). Depth-discrete sample results within this plume indicate it occurs within the upper 20 m (66 ft) of the aquifer at concentrations above the cleanup level (DOE/RL-2009-122).

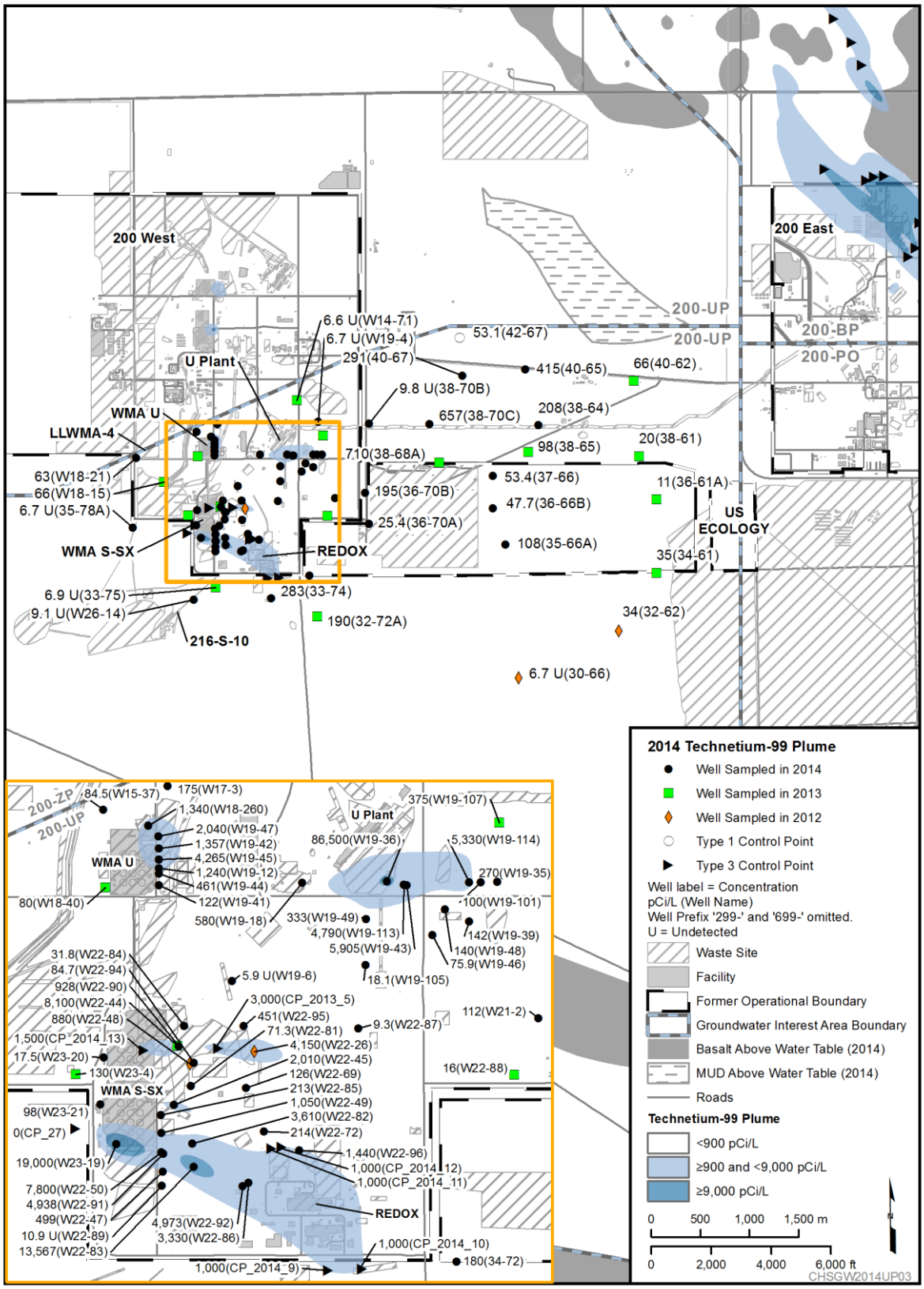


Figure 11-5. 200-UP Technetium-99 Plume Map, 2014

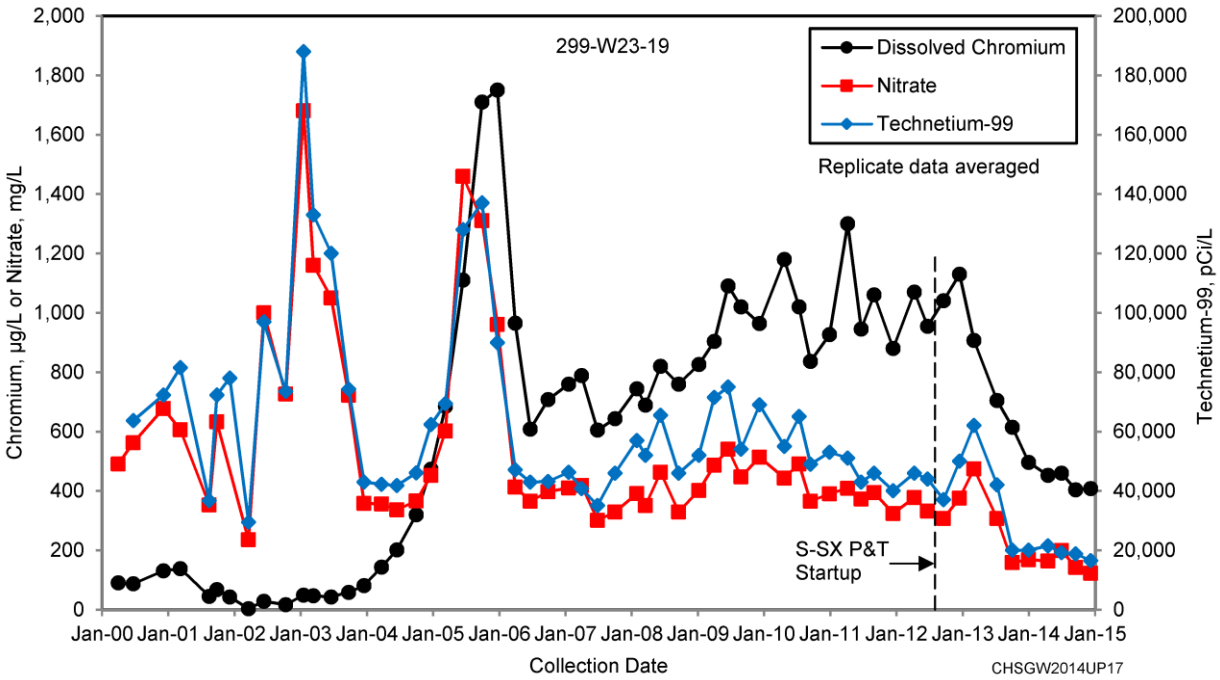


Figure 11-6. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W23-19 at WMA S-SX

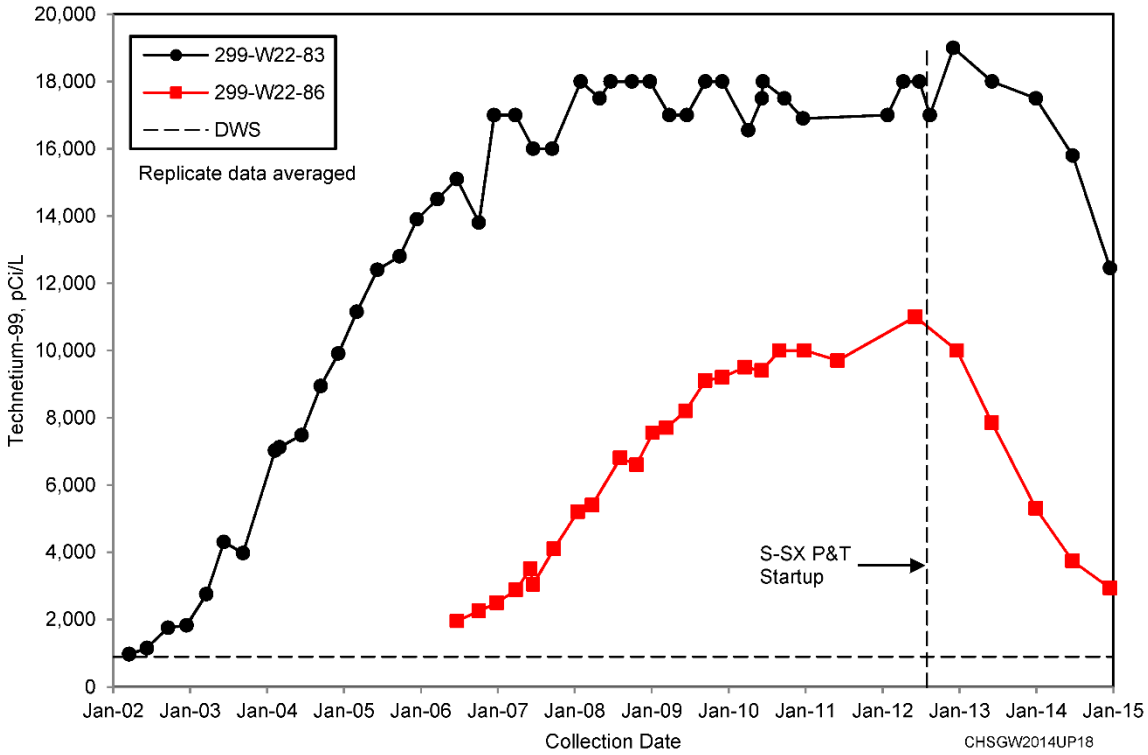


Figure 11-7. 200-UP Technetium-99 Data for Wells 299-W22-83 and 299-W23-86 East of WMA S-SX

Between 1966 and 1970, an estimated 91,000 L (24,000 gal) of waste were released from Tank S-104 (S Tank Farm) in an overfill event. A geophysical survey indicated the vadose zone plume has reached groundwater (Sections 3.7.2 and 4.6 in RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*). This is the source of the plume downgradient from the S Tank Farm. This plume has been defined by two wells, 299-W22-44 (the nearest downgradient well at S Tank Farm) and 299-W22-26 (located farther downgradient at the 216-S-9 Crib). Peak concentrations in these wells were 20,000 pCi/L in Well 299-W22-44 (January 2009) and 6,000 pCi/L in Well 299-W22-26 (December 2010). Both of these wells are now dry. Well 299-W22-95 was drilled during 2013 as a replacement for Well 299-W22-26. The new well is located north of Well 299-W22-26 because groundwater flow modeling indicates the flow direction will change in the future to be toward the northeast in response to operation of the large 200 West P&T system in 200-ZP. A replacement well for Well 299-W22-44 has not yet been drilled, but this well is located adjacent to extraction Well 299-W22-90 which is being sampled quarterly. The maximum concentration in the extraction well during 2014 was 976 pCi/L. Depth-discrete sample results during drilling of this well indicate the technetium-99 plume extends to a depth of 10 m (33 ft) below the water table at concentrations above the cleanup level (Section 3.3 of DOE/RL-2011-118).

11.3.2 216-U-1 and 216-U-2 Cribs

The technetium-99 plume near U Plant originated from these cribs, which were active in the 1950s and 1960s. A P&T system operated in this plume from 1994 until March 2011, and the system was effective at reducing technetium-99 concentrations in the aquifer. Recently, however, the technetium-99 concentration has rebounded at former extraction Well 299-W19-36. The concentration was 20,500 pCi/L in 2013, an increase from 6,300 pCi/L during 2010. The concentration increased still further during 2014 to 86,500 pCi/L (Figure 11-8). Concentrations have increased also at former extraction Well 299-W19-43 from 3,650 pCi/L during 2010 to 5,900 pCi/L during 2014 (Figure 11-8).

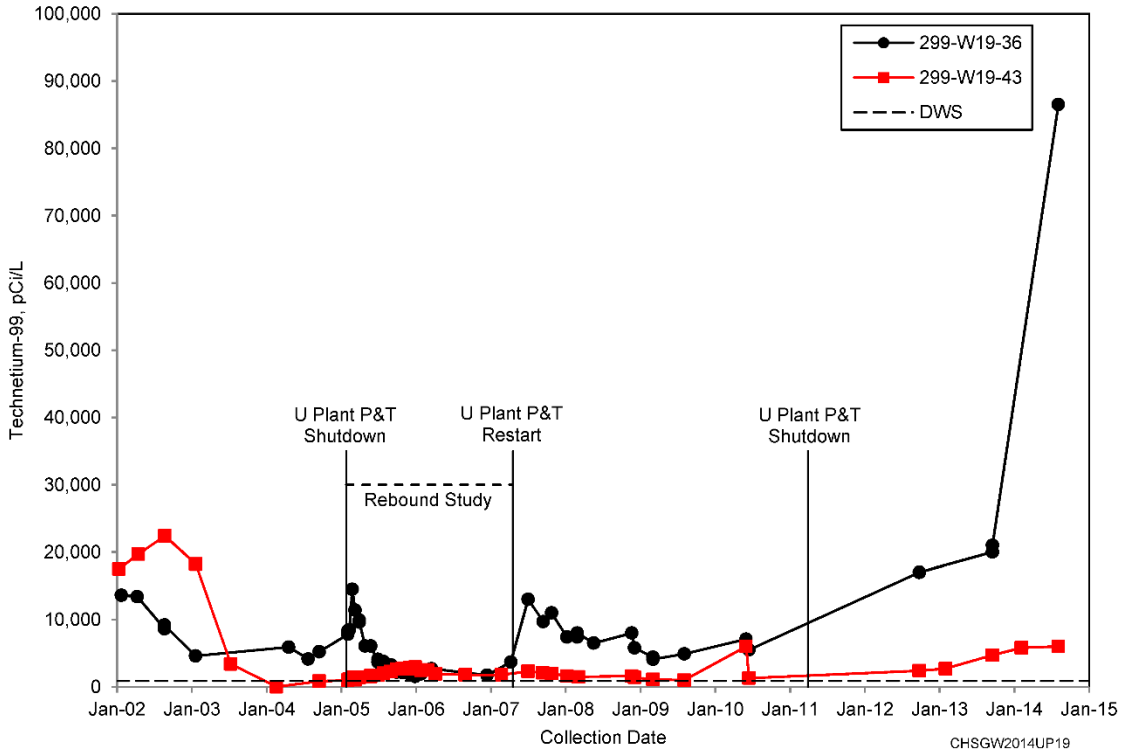


Figure 11-8. 200-UP Technetium-99 Data for Wells 299-W19-36 and 299-W19-43 near U Plant

Further remediation of this plume is addressed by the 2012 interim ROD (EPA et al., 2012) and a new groundwater extraction system is being installed. The system will consist of two extraction wells (299-W19-113 and 299-W19-114) (Figure 11-3) with treatment at the 200 West Groundwater Treatment Facility. Both wells were drilled to total depth during 2014 but due to a drilling problem; Well 299-W19-113 became partly filled in and had to be redrilled to total depth in early 2015. Vertical profile sampling was performed in the aquifer during drilling. The results show technetium-99 concentrations above the cleanup level from the water table to a depth of 10 m (33 ft) at Well 299-W19-113 (Figure 11-9). The plume is deeper at Well 299-W19-114, where concentrations were above the cleanup level between 9 and 27 m (28 and 89 ft) below the water table (Figure 11-10).

The groundwater flow direction in this area has changed due to operation of the 200 West P&T system. Formerly, the flow direction was toward the east, but the flow direction since 2013 has been toward the north-northeast (see Figure 11-2). This is causing the technetium-99 plume to move toward the north-northeast. This was demonstrated by the technetium-99 concentrations in Well 299-W19-107 to the north of the plume, which have increased from 91 pCi/L in June 2012 to 410 pCi/L in December 2013.

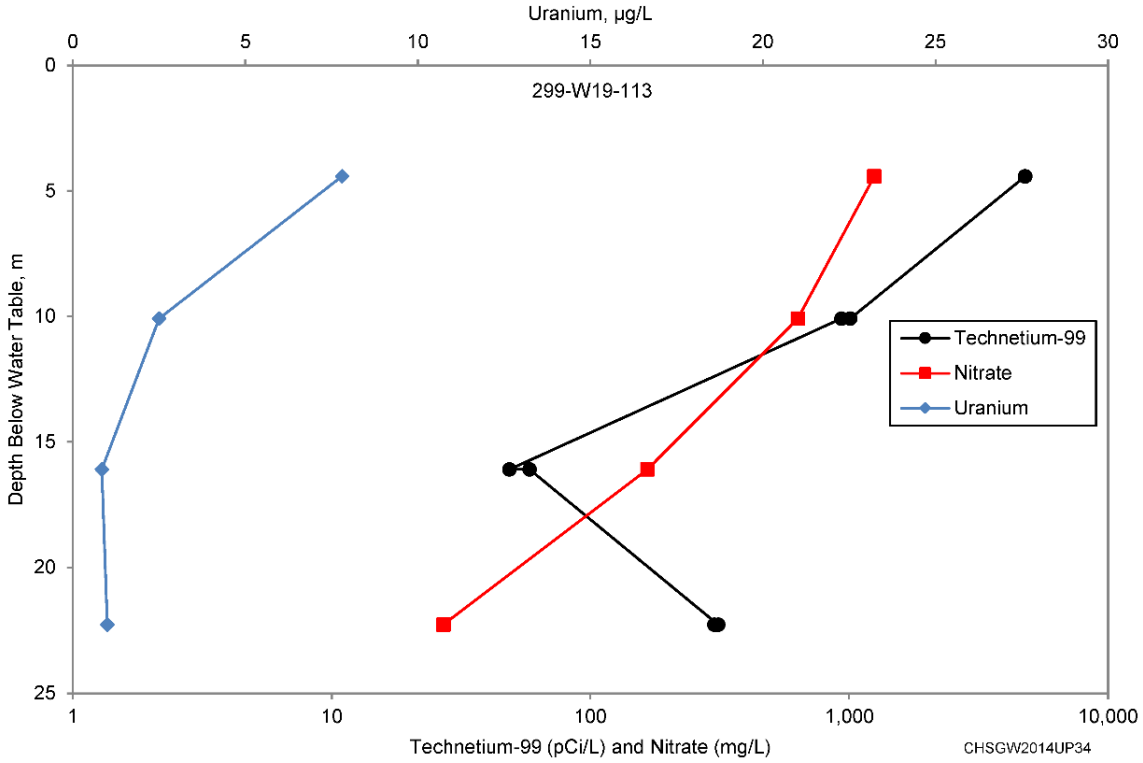


Figure 11-9. 200-UP Vertical Profile Sampling Results for Well 299-W19-113 near U Plant

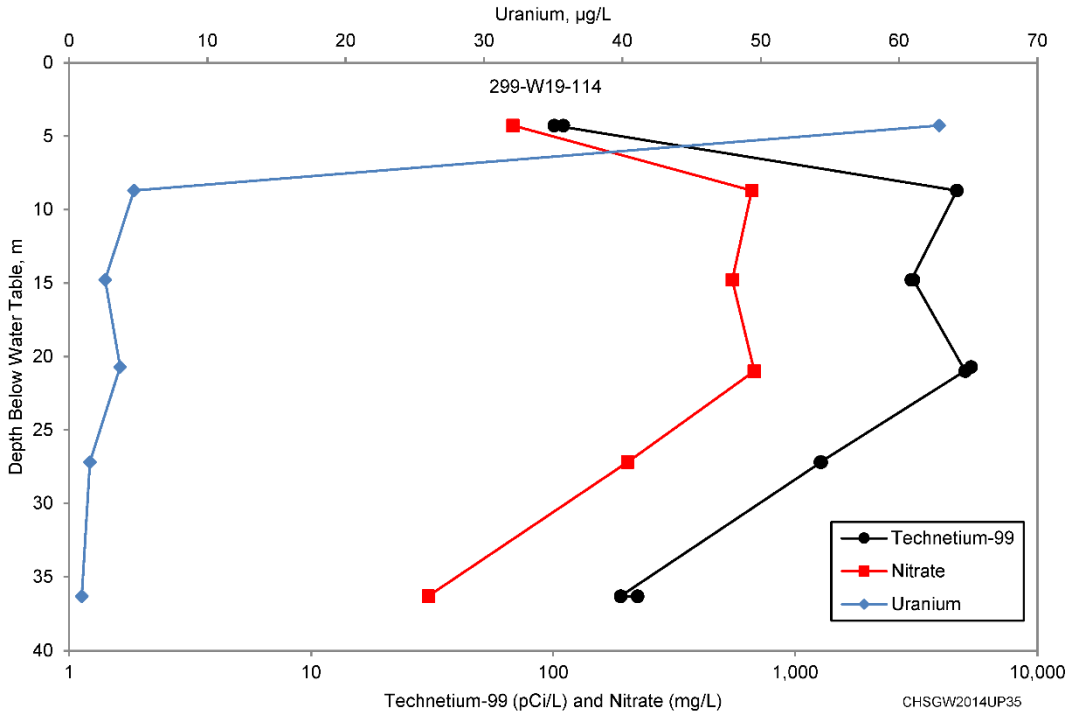


Figure 11-10. 200-UP Vertical Profile Sampling Results for Well 299-W19-114 near U Plant

11.3.3 Waste Management Area U

The WMA U area is a source of technetium-99 groundwater contamination (PNNL-13282). Concentrations in many of the downgradient wells are stable or slowly increasing, with the exception of Well 299-W19-45 in which concentrations have increased substantially since 2011 (Figure 11-11). Concentrations declined slightly in this well during 2014, from 5,400 pCi/L in July 2013 to 4,430 pCi/L in July 2014. Technetium-99 concentrations were also greater than the cleanup level in four other wells during 2014: 299-W19-12, 299-W19-42, 299-W19-47, and 299-W18-260. Well 299-W18-260 was drilled during 2014 as a replacement for dry Well 299-W18-30. Results of vertical profile sampling during drilling are shown in Table 11-2 and Figure 11-12. Technetium-99 occurs at concentrations above the cleanup level only in the upper part of the aquifer from the water table to a depth of 8 m (28 ft) below the water table. The groundwater contamination at WMA U is believed to result from multiple sources within the WMA (HNF-EP-0182). The contamination is within the capture zone of the 200 West P&T extraction well network (see Chapter 12, Figure 12-21).

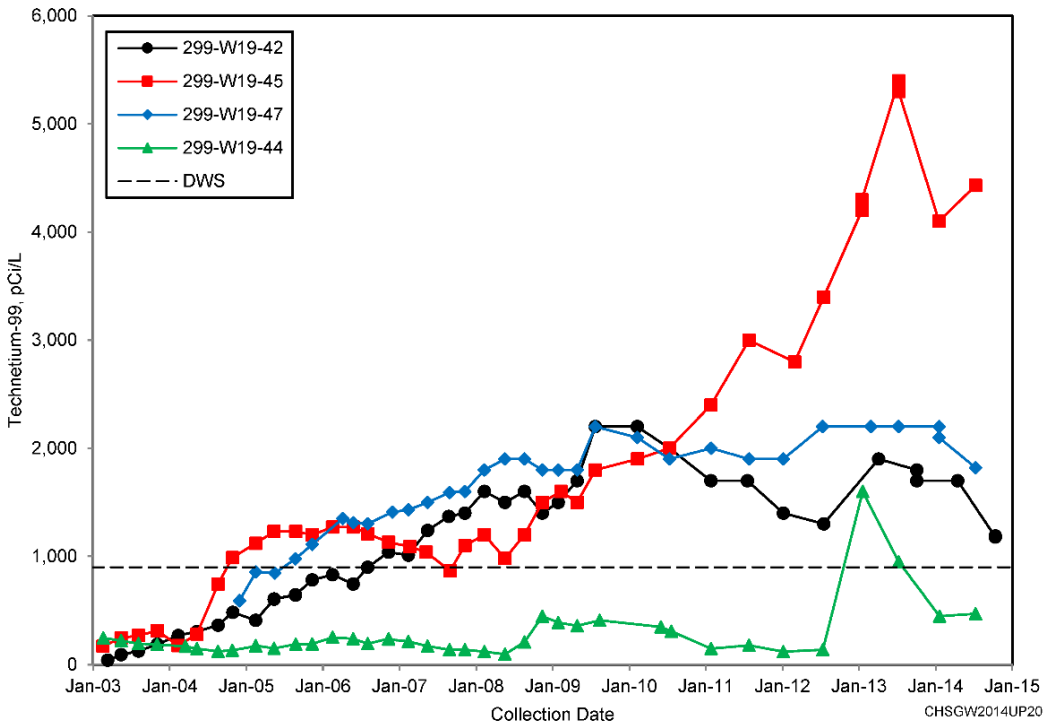


Figure 11-11. 200-UP Technetium-99 Data for Selected Wells at WMA U

Table 11-2. Depth Profile Sample Results for 299-W18-260

Depth (ft below water table)	Carbon Tetrachloride (µg/L)	Nitrate (mg/L)	Technetium-99 (pCi/L)
10	72.4	57.1	1,340
28	195	53.1	1,060
48	250	43.4	43.5
67	272	35.3	28.1
87	271	4.4	Not detected

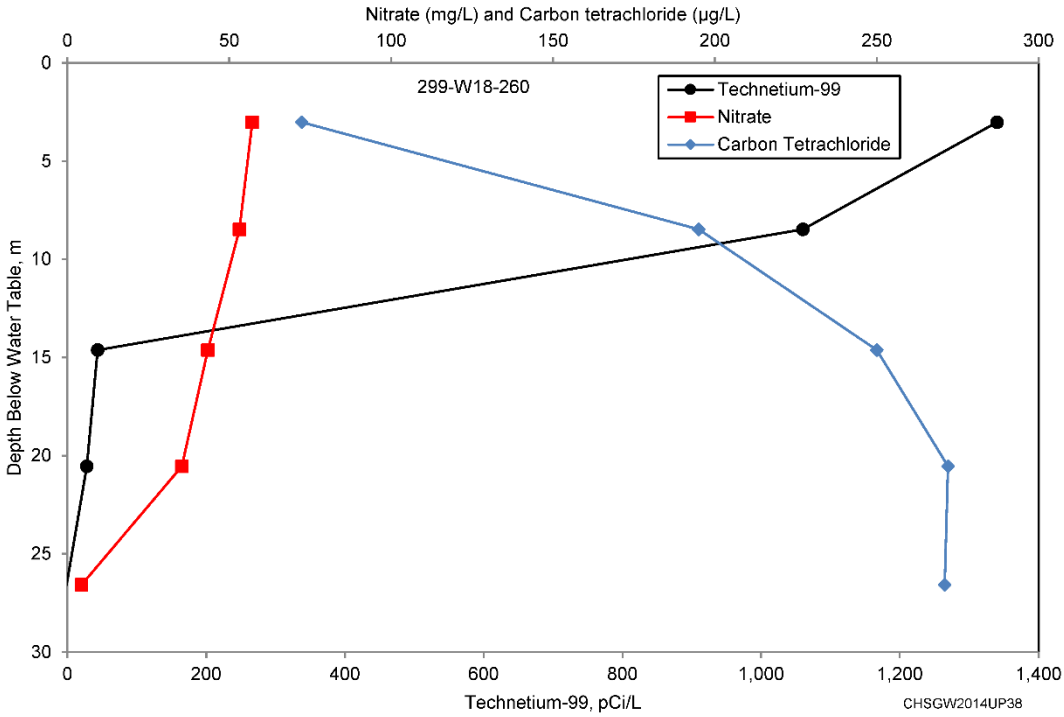


Figure 11-12. 200-UP Vertical Profile Sampling Results for Well 299-W18-260 at WMA U

11.4 Uranium

Uranium occurs at concentrations above the 30 µg/L cleanup level in two regions of 200-UP, downgradient of the 216-U-1 and 216-U-2 Cribs and near the 216-U-10 Pond (U Pond).

11.4.1 216-U-1 and 216-U-2 Cribs Plume

These cribs were the source of a uranium plume that is interpreted to extend 1.5 km (0.9 mi) to the east at levels above the 30 µg/L cleanup level (Figure 11-13). A P&T system operated in this plume from 1994 until March 2011. The system was effective at reducing uranium concentrations below the 300 µg/L former remedial action objective in the area targeted for remediation, but concentrations at most wells remained above the current cleanup level of 30 µg/L. This plume is limited to the upper 20 m (66 ft) of the aquifer (Figure 11-13 of DOE/RL-2011-01).

Further remediation of this plume is addressed by the 2012 interim ROD (EPA et al., 2012) and a new groundwater extraction system is being installed. The system will consist of two extraction wells (299-W19-113 and 299-W19-114) (Figure 11-2) with treatment at the 200 West Groundwater Treatment Facility. Both wells were drilled to total depth during 2014 but due to a drilling problem, Well 299-W19-113 became partly filled in and had to be redrilled to total depth in early 2015. Vertical profile sampling was performed in the aquifer during drilling. The uranium concentration at Well 299-W19-114 was 62.9 µg/L in the uppermost sample at 4 m (14 ft) below the water table, but was below the cleanup level for all deeper samples (Figure 11-10). Uranium was not detected above the cleanup level at Well 299-W19-113 (Figure 11-9). The maximum concentration was 7.8 µg/L at 4 m (14 ft) below the water table.

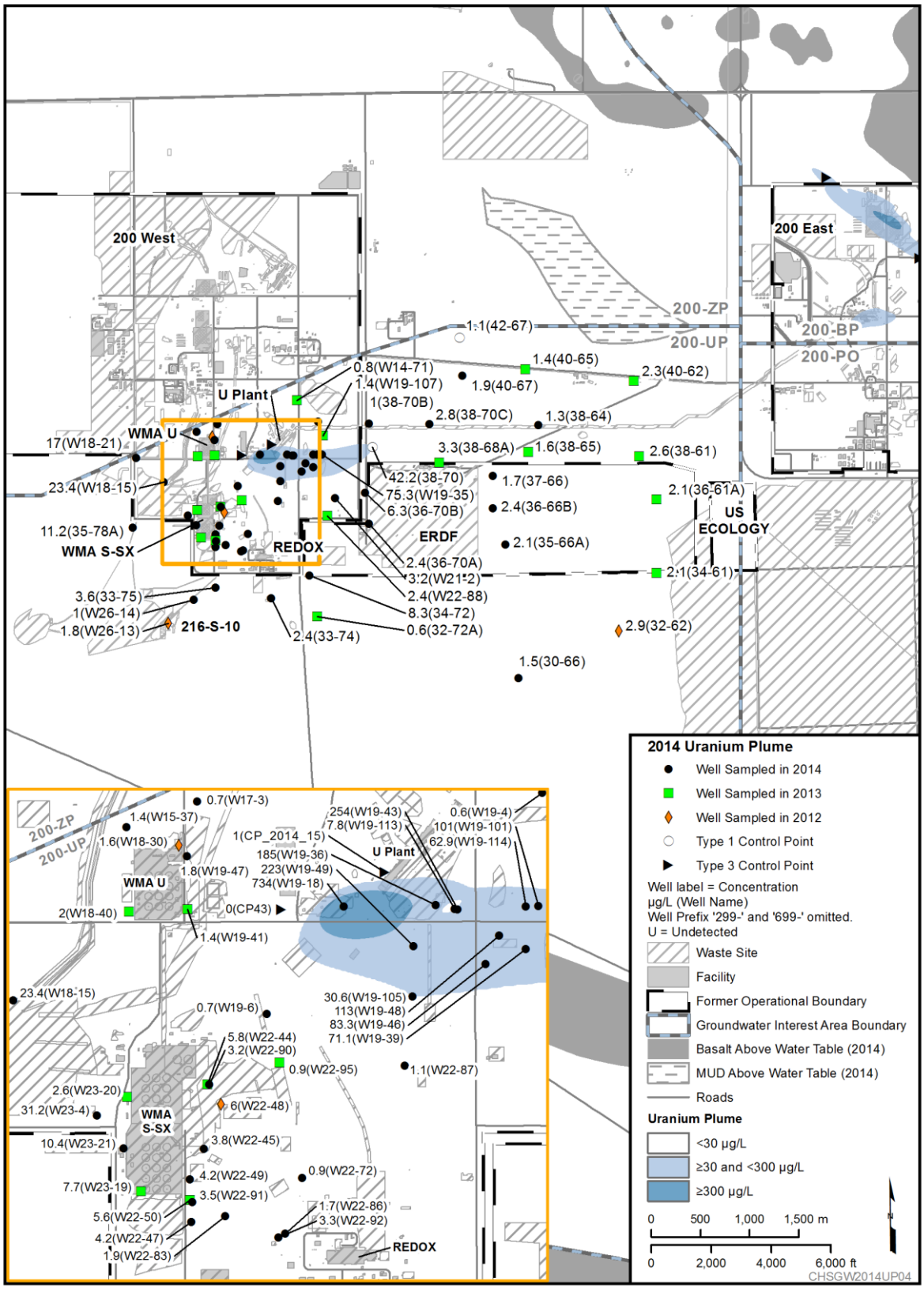


Figure 11-13. 200-UP 2014 Uranium Plume

The groundwater flow direction in this area has changed due to operation of the 200 West P&T system. Formerly, the flow direction was toward the east, but the direction since 2013 has been north-northeast toward the 200-ZP-1 extraction wells (Figure 11-2). The change in flow direction caused changes in the uranium concentration trends in some wells. The most notable change was in Well 299-W19-49 in which the uranium concentration increased from 56 to 264 µg/L between June 2012 and January 2013 (Figure 11-14). Concentrations in this well have declined slightly since then (218 µg/L in August 2014). The concentration declined in Well 299-W19-48 from 220 µg/L in January 2013 to 119 µg/L in August 2014.

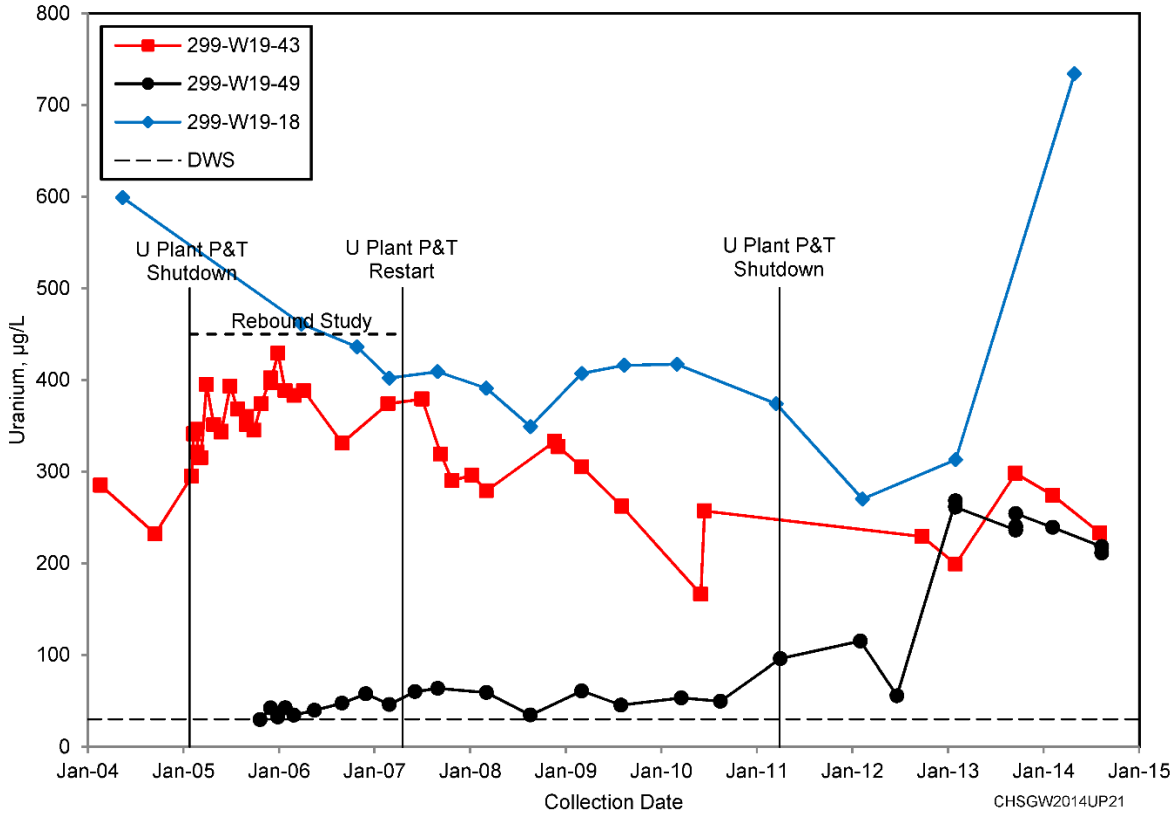


Figure 11-14. 200-UP Uranium Data for Wells 299-W19-18, 299-W19-49, and 299-W19-43 near U Plant

Near the cribs, uranium has remained elevated in Well 299-W19-18. The 2014 sample result was 734 µg/L, a substantial increase from 374 µg/L in 2011 (Figure 11-14). The persistence of elevated concentrations in this well may be caused by an ongoing source of uranium to the aquifer. Possible sources include continued leaching from the vadose zone beneath the cribs and/or desorption of uranium from aquifer sediment. However, the uranium concentration may also result from the slower migration of this constituent compared to technetium-99.

11.4.2 U Pond

Uranium concentrations exceed the cleanup level in one well near U Pond, Well 299-W23-4 (near the 216-S-21 Crib), which had a concentration of 31.2 µg/L during 2014. Concentrations have been increasing very slowly in this well since 2000. Two other wells in this area have had concentrations above the cleanup level: Wells 299-W18-21 (during the period between 2001 and 2004) and 299-W18-15 (before 2002 and in 2006). Uranium is interpreted to be leaching from the vadose zone beneath U Pond. The pond received an estimated 2,100 kg of uranium (Section 4.2.2 of DOE/RL-2009-122; Appendix C

of RPP-26744, *Hanford Soil Inventory Model, Rev. 1*, "SIM Production Output Files"). The wells installed around this area are older and were all completed to monitor the water table, therefore, no vertical groundwater profile data is available.

11.5 Tritium

Disposal facilities associated with the REDOX Plant, which operated from 1952 until 1967, were the primary sources of tritium in 200-UP. A large tritium plume from the REDOX Plant cribs extends 5 km (3.1 mi) toward the east and northeast at concentrations above the 20,000 pCi/L cleanup level (Figure 11-15).

11.5.1 Eastern High-Concentration Area

The highest concentration measured during 2014 within the tritium plume was 280,000 pCi/L in Well 699-36-66B, a decline from 310,000 pCi/L during 2013. High tritium concentrations historically occurred at now-dry Wells 699-35-70 and 299-W22-9. The concentration was 240,000 pCi/L in Well 699-35-70 when it was last sampled in 2008; the concentration was 1,020,000 pCi/L in Well 299-W22-9 when it was last sampled in 2005. Together, these three wells define a high-concentration portion of this plume (i.e., greater than 200,000 pCi/L) that extends 2.5 km (1.6 mi) east and northeast from the southern 200 West Area. Dry Wells 699-35-70 and 299-W22-9 are scheduled to be replaced and depth-discrete sampling will be performed during drilling to characterize the vertical extent of the tritium plume in this area (DOE/RL-2014-27, Rev. 1, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*). Concentration trends are declining in eight of the nine wells (not currently dry) within the 20,000 pCi/L contour (i.e., the cleanup level), consistent with attenuation of the plume by dispersion and radiological decay. At Well 299-W22-96, the tritium concentration has declined from 96,000 pCi/L in July 2012 to 17,000 pCi/L (below the cleanup level) in June 2014. This is consistent with the eastward migration of the high-concentration portion of this plume, although operation of extraction Well 299-W22-92 located 220 m (700 ft) southwest of Well 299-W22-96 may also be a factor.

11.5.2 216-S-25 Crib

Tritium occurs above the cleanup level in wells downgradient of the 216-S-25 Crib. The maximum tritium concentration in this area during 2014 was 69,400 pCi/L in Well 299-W22-49 located east of the SX Tank Farm and 260 m (850 ft) downgradient from the crib. Radioactive liquid effluent was discharged to the 216-S-25 Crib from 1973 through 1980, and effluent from a P&T system at the 216-U-1 and 216-U-2 Cribs was discharged to 216-S-25 for 6 months during 1985. The crib received an estimated 3,600 Ci of tritium (Appendix C in RPP-26744).

11.5.3 216-S-21 Crib

The tritium concentration in 299-W23-4 near the 216-S-21 Crib (west of WMA S-SX and north of the 216-S-25 Crib) had been increasing since 2003. The trend reversed during 2012 and the declining trend continued during 2014. The February sample result was 37,000 pCi/L, a decline from 63,000 pCi/L in January 2013 (Figure 11-16). The crib received an estimated 2,500 Ci of tritium between 1954 and 1969 (Appendix C in RPP-26744). To put the current contamination levels into perspective, the maximum tritium concentration in Well 299-W23-4 occurred in 1963 and 1964 at 110 million pCi/L.

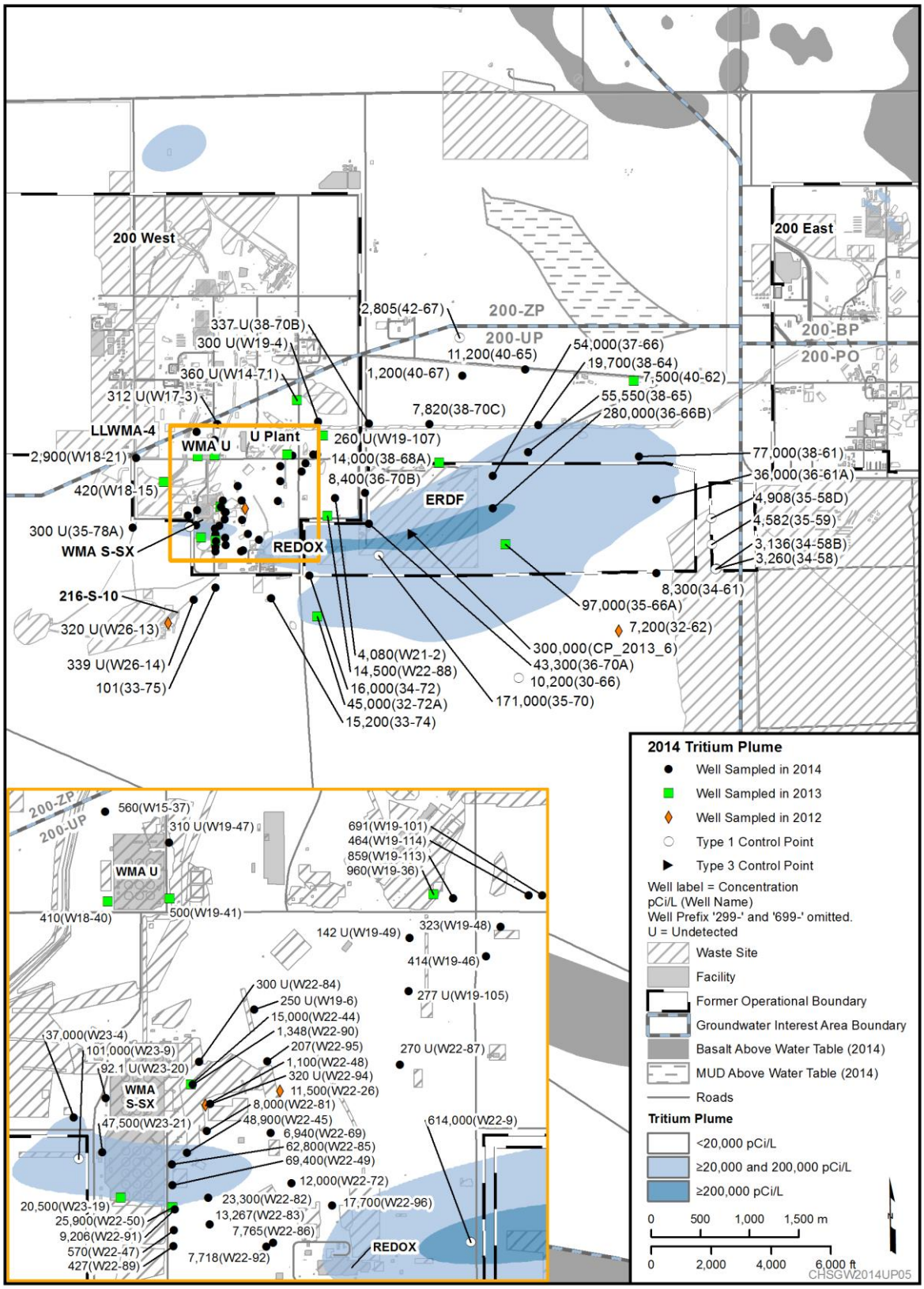


Figure 11-15. 200-UP Tritium Plume, 2014

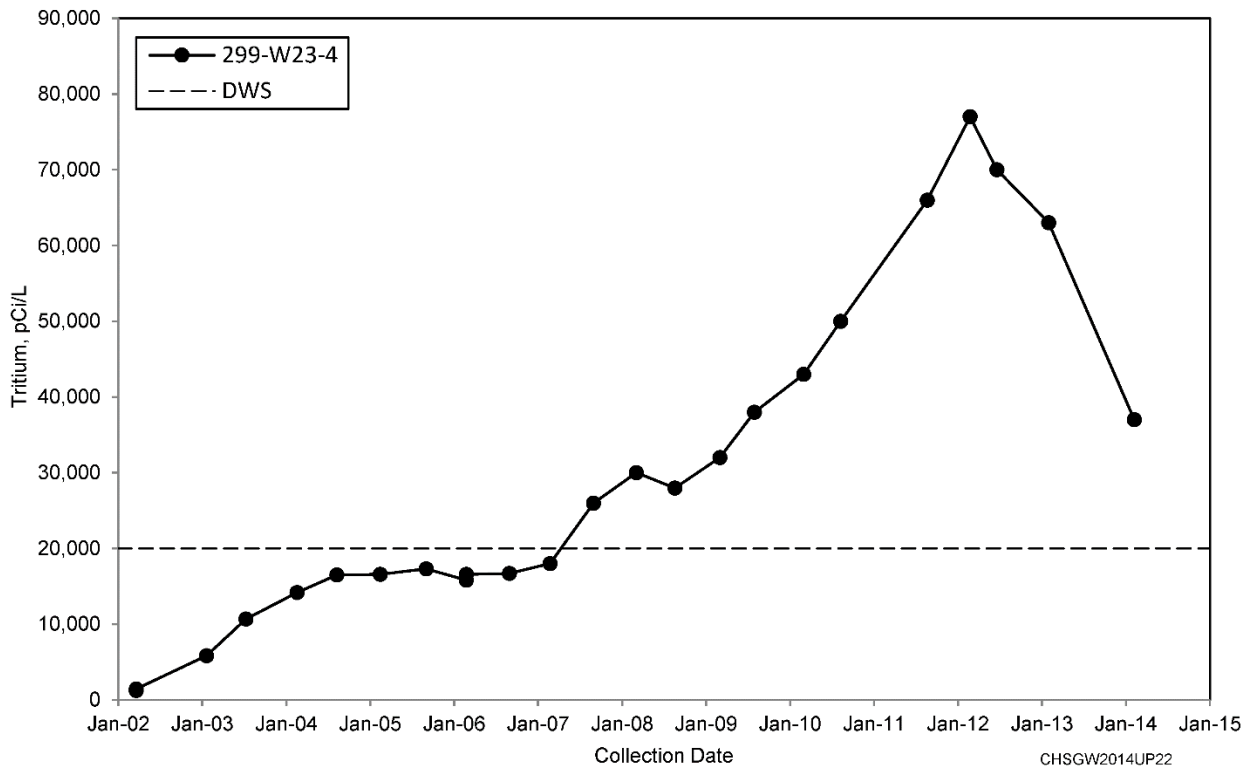


Figure 11-16. 200-UP Tritium Data for Well 299-W23-4 at the 216-S-21 Crib

11.6 Iodine-129

Iodine-129 plumes in 200-UP originated from U Plant and REDOX Plant waste sites, although the latter were the primary sources (Figure 11-17). Iodine-129 occurs as two plumes, one from the 216-U-1 and 216-U-2 Cribs near U Plant and a second from the REDOX Plant waste sites in the southern portion of the 200 West Area. East of the 200 West Area, these plumes have merged and become indistinguishable.

11.6.1 REDOX Waste Sites

The highest concentrations of iodine-129 within 200-UP, greater than 10 times the 1 pCi/L cleanup level, originate from the REDOX Plant waste sites and occur in a region extending 2.5 km (1.6 mi) east into the 600 Area from the southeastern 200 West Area (Figure 11-17). Although short-term variability in sample results can cause substantial concentration changes from year to year in some wells, long-term concentration trends in this plume tend to be stable to slightly declining (Figure 11-18). The maximum sample result during 2014 was 11 pCi/L in Well 699-36-70A. The highest concentrations recently in this plume occurred at Well 699-35-70, where the iodine-129 concentration was 37 pCi/L in March 2008. This well is now dry. High concentrations also occurred in Well 299-W22-9 located along the eastern boundary of the 200 West Area. This well became dry during 2006; the iodine-129 concentration was 30 pCi/L when this well was last sampled in 2005. Wells 699-35-70 and 299-W22-9 are scheduled to be replaced and depth-discrete sampling will be performed during drilling to characterize the vertical profile of the plume (DOE/RL-2014-27, Rev. 1).

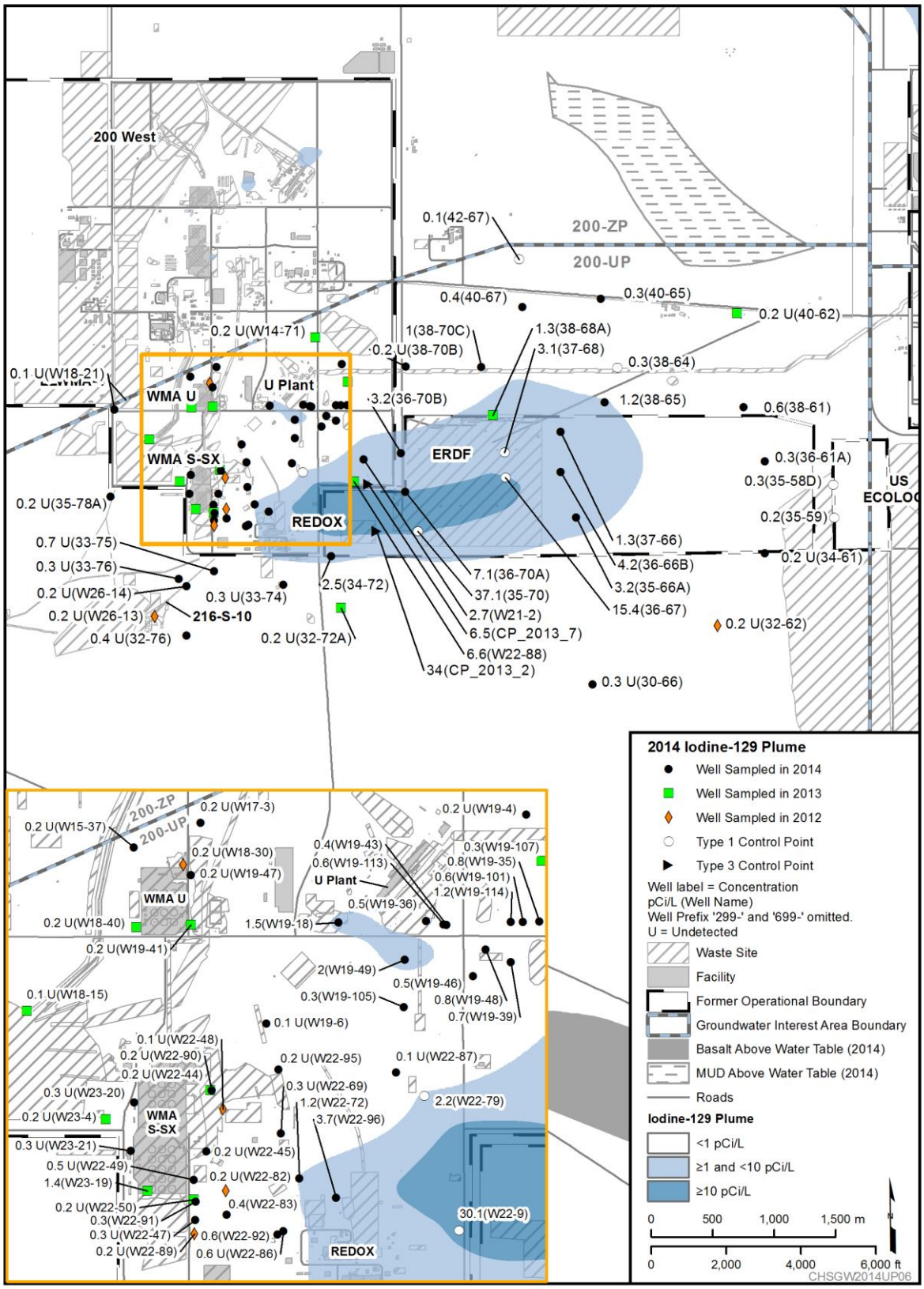


Figure 11-17. 200-UP Iodine-129 Plume, 2014

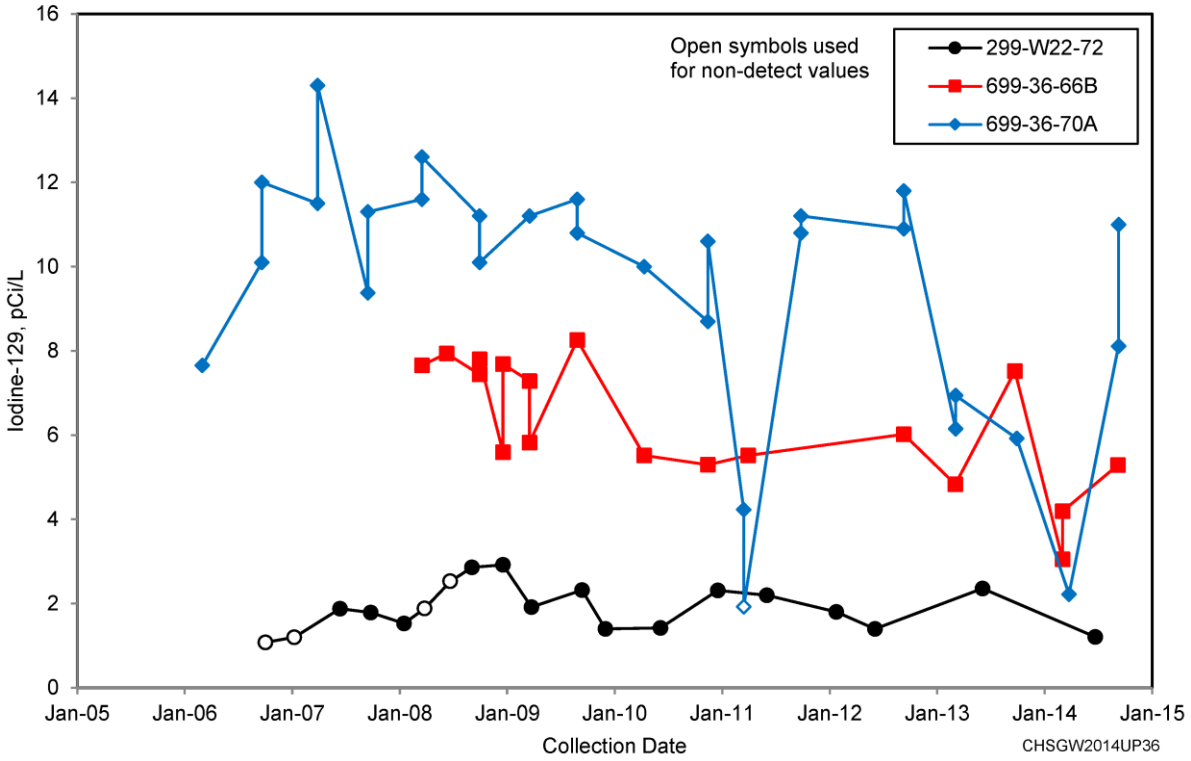


Figure 11-18. 200-UP Iodine-129 Concentrations for Wells 299-W22-72, 699-36-66B, and 699-36-70A

11.6.2 SX Tank Farm

Iodine-129 is interpreted to occur beneath the SX Tank Farm at concentrations slightly above the 1 pCi/L cleanup level (Figure 11-17). In a sample collected during December 2011 from Well 299-W23-19, located within the tank farm, the iodine-129 concentration was reported to be 2.0 pCi/L. Concentrations have declined since startup of groundwater extraction in the area during July 2012. In December 2013, the concentration was down to 1.0 pCi/L. Iodine-129 is not detected in upgradient Well 299-W23-21, so the SX Tank Farm is likely the source of this small plume. No other wells in the WMA S-SX vicinity have concentrations above the 1 pCi/L cleanup level. Iodine-129 was detected above the cleanup level at Well 299-W22-26 downgradient from the S Tank Farm before this well became dry (2.8 pCi/L in 2011), but the source is the 216-S-9 Crib.

11.6.3 216-U-1 and 216-U-2 Cribs

The maximum iodine-129 sample result downgradient from these cribs during 2014 was 2.8 pCi/L in Well 299-W19-49. Concentrations are low in this area. The only other well with concentrations above the 1 pCi/L cleanup level is Well 299-W19-18, which had a result of 1.53 pCi/L during April. This plume occurs at a shallow depth near the source, but deepens as the plume extends eastward. The plume is fully mixed vertically throughout the aquifer at Well 699-38-70C, located 1.8 km (1.1 mi) east of the cribs (see the plume cross section in DOE/RL-2011-01, Figure 11-16). Full mixing of the plume is attributed to vertical dispersion.

11.7 Nitrate

Nitrate plumes in 200-UP originated from U Plant and REDOX Plant disposal facilities, although U Plant sources were more substantial (Appendix C in RPP-26744, *Hanford Soil Inventory Model, Rev. 1*, "SIM Production Output Files") (Figure 11-19).

11.7.1 U Plant Crib Sources

In the U Plant area, nitrate concentrations have been highest in the two former extraction wells, 299-W19-36 and 299-W19-43. The 2014 sample result at Well 299-W19-36 was 1,010 mg/L, a substantial increase from 316 mg/L in 2013. The result from Well 299-W19-43 was 2,270 mg/L, a decline from 3,210 mg/L in 2013 (Figure 11-20). Because these concentrations are higher than historical nitrate concentrations in groundwater near the 216-U-1 and 216-U-2 Cribs (approximately 100 to 300 mg/L in the 1970s and 1980s), the nitrate at Wells 299-W19-36 and 299-W19-43 was thought to originate from a local source. However, efforts to identify a local source were not successful. The source is now interpreted to be the 216-U-1 and 216-U-2 Cribs which may have had effluent nitrate concentrations up to approximately 15,000 mg/L (based on the mean mass loading and effluent volumes reported in Appendix C of RPP-26744). The highest nitrate concentration in groundwater east of the 200 West Area during 2014 was 214 mg/L in Well 699-40-65.

Remediation of the region of high nitrate concentrations near former extraction Wells 299-W19-36 and 299-W19-43 is addressed by the 2012 interim ROD (EPA et al., 2012). A P&T system is being constructed and extraction Wells 299-W19-113 and 299-W19-114 were drilled to total depth in the U Plant area during 2014 but due to a drilling problem, Well 299-W19-113 became partly filled in and had to be redrilled to total depth in early 2015. Vertical profile sample results during drilling are shown in Figures 11-9 and 11-10. Nitrate concentrations were above the 45 mg/L cleanup level to a depth of 16 m (53 ft) below the water table in Well 299-W19-113 and to a depth of 29 m (89 ft) below the water table in Well 299-W19-114. The maximum concentrations were 1,250 mg/L in 299-W19-113 and 677 mg/L in Well 299-W19-114.

11.7.2 Waste Management Area U

Nitrate concentrations are greater than the 45 mg/L cleanup level in all of the monitoring wells at the U Tank Farm, except for the southernmost downgradient well, 299-W19-41. The concentration in the upgradient well, 299-W18-40, was 65.1 mg/L (December 2013). The upgradient source is interpreted to be the injection wells formerly used for the 200-ZP-1 interim action P&T system (Section 3.3.5 of DOE/RL-2011-118). Because concentrations in some of the downgradient wells are higher than in the upgradient well, it is likely that WMA U is also a source of nitrate to the groundwater. At downgradient Well 299-W19-44 the nitrate concentration increased rapidly during 2012 from 37 mg/L in April to 75 mg/L in October. The concentration peaked during January 2013 at 97 mg/L and has declined since to 68 mg/L in July 2014 (Figure 11-21). This trend change could be explained by a pulse of contamination entering the aquifer from beneath the tank farm. However, the trend change began shortly after startup of the nearby 200 West P&T system, which began operating during July 2012 and the perturbation of the groundwater flow system may also be the cause. The groundwater beneath this tank farm is within the capture zone of the nearby 200-ZP-1 remedy extraction Well 299-W17-3 (see Chapter 12, Figure 12-21).

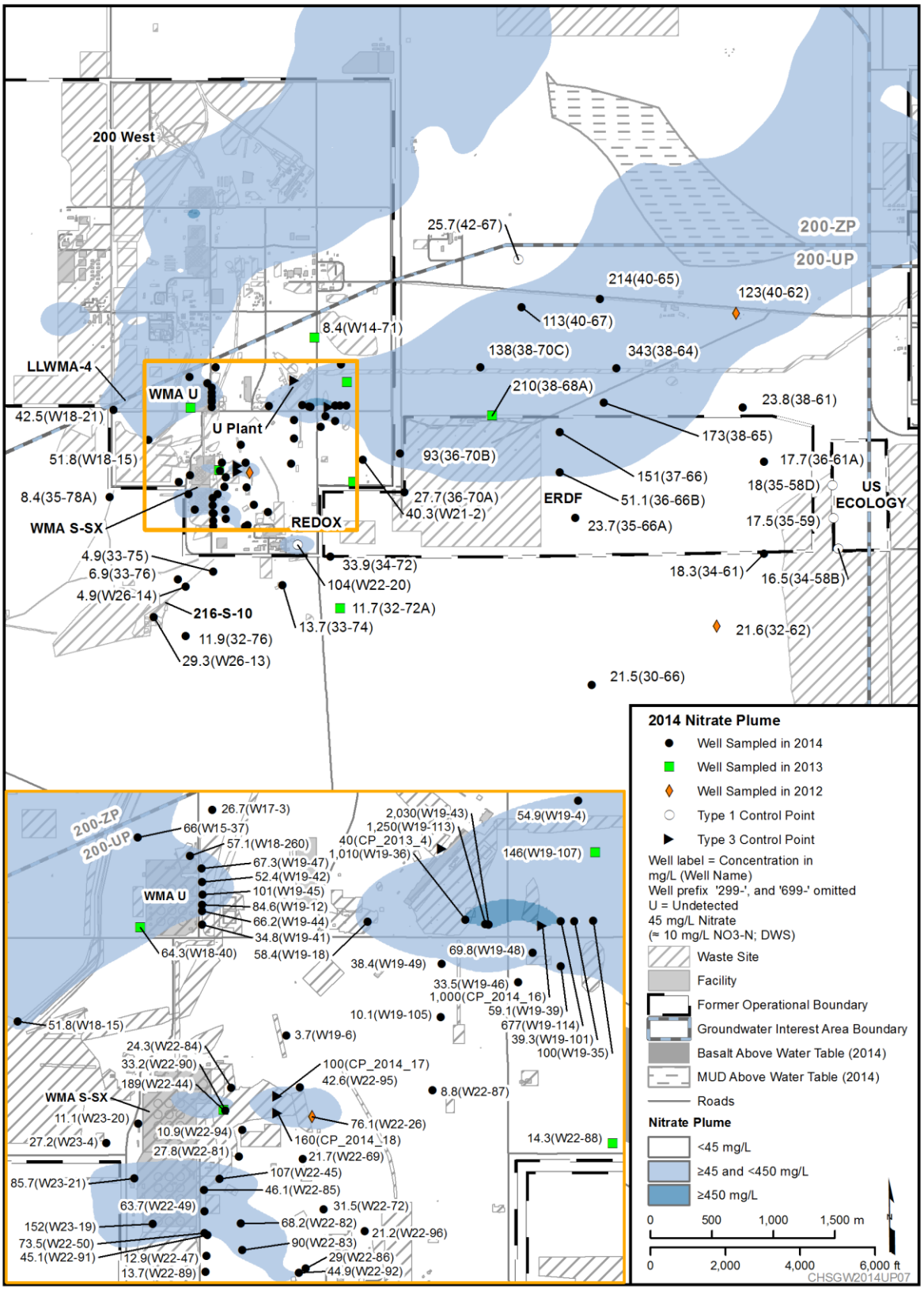


Figure 11-19. 200-UP Nitrate Plume, 2014

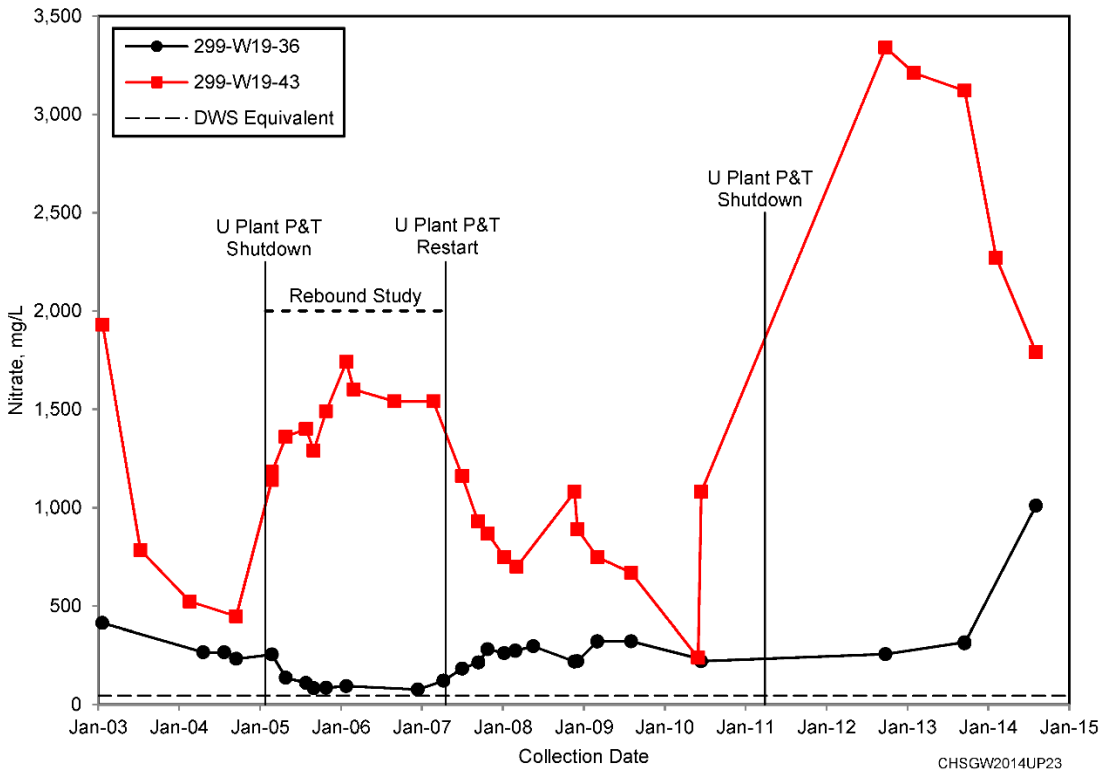


Figure 11-20. 200-UP Nitrate Data for Wells 299-W19-36 and 299-W19-43 near U Plant

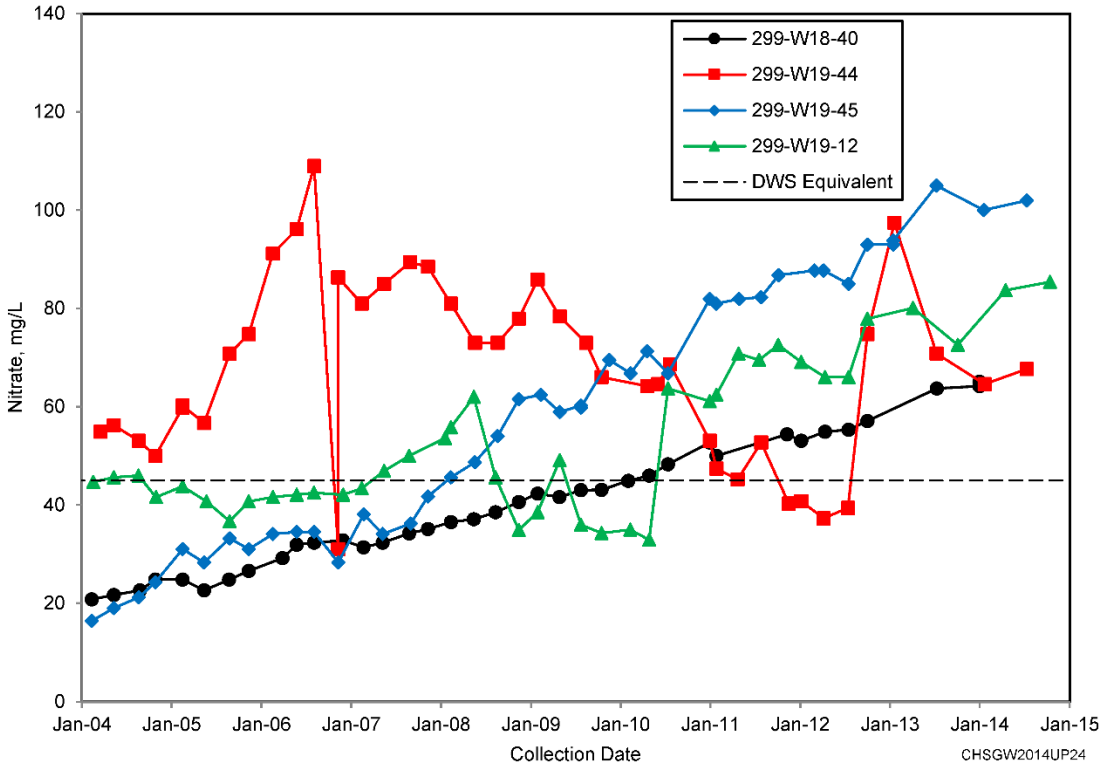


Figure 11-21. 200-UP Nitrate Data for Selected Wells at WMA U

11.7.3 Waste Management Area S-SX/216-S-25 Crib

A nitrate plume originates from the 216-S-25 Crib and merges with a nitrate plume from the SX Tank Farm. Nitrate concentrations are highest in Well 299-W23-19 within the SX Tank Farm. Concentrations in this well declined during 2014 from 170 mg/L in April to 121 mg/L in December (Figure 11-6). This decline is attributed to operation of the WMA S-SX groundwater extraction system. Nitrate from the WMA has been attributed primarily to a 190,000 L (51,000 gal) leak from Tank SX-115 that occurred during 1965 (Section 4.3 of RPP-ENV-39658). The contamination is gradually migrating into the unconfined aquifer.

A nitrate plume also originates from the S Tank Farm. The maximum concentration in this plume during 2013 was 193 mg/L measured at Well 299-W22-44. This well became dry during 2013 and a replacement well is scheduled for drilling. This plume originates from an overfill event at Tank S-104 between 1966 and 1970.

11.8 Chromium

Substantial chromium plumes are found in two regions of 200-UP: in two plumes at WMA S-SX and another, larger plume in the 600 Area east and southeast of the 200 West Area (Figure 11-22). Concentrations above the 48 µg/L cleanup level also occur near the 216-S-20 Crib and 216-S-10 Pond and Ditch, the sources of the 600 Area chromium plume.

11.8.1 Waste Management Area S-SX

Chromium concentrations in four wells at WMA S-SX exceeded the 48 µg/L cleanup level in at least one sample during 2014. The highest concentrations occurred at Well 299-W23-19, where sample results declined during the year from 497 µg/L in April to 413 µg/L in December (Figure 11-6). The decline is attributed to operation of the WMA S-SX groundwater extraction system. Concentrations in two wells declined to below the cleanup level during 2014, 299-W22-47 (near extraction Well 299-W22-91) and 299-W22-86 (near extraction Well 299-W22-92).

A second chromium plume occurs downgradient from the S Tank Farm. This plume originated from Tank S-104 (an overfill event from 1966 to 1970). At near field downgradient Well 299-W22-44, the chromium concentration was 404 µg/L in a filtered sample collected during March 2013 (the unfiltered result was 641 µg/L but was affected by high turbidity). This well is now dry, but a replacement well is scheduled for drilling. Concentrations at nearby extraction Well 299-W22-90 ranged between 58.5 and 78.7 µg/L during 2014. The extraction well captures the portion of the chromium plume near the source (Section 11.12).

11.8.2 Southeast Plume

Within the chromium plume east southeast of the 200 West Area, concentrations in Well 699-32-62 have slowly declined from 254 to 134 µg/L since this constituent was first measured in 1992 (Figure 11-23). The gradual reduction in concentration at this location likely results from the continued downgradient migration of the dissolved chromium plume. Chromium is also elevated at Well 699-30-66 (results between 117 and 127 µg/L during 2014), which is completed deep in the aquifer just above the Ringold lower mud unit (Figure 11-22). These data indicate chromium is present throughout the aquifer thickness in this region because of dispersion as the plume migrated east from the source sites (see the cross section on Figure 11-20 in DOE/RL-2011-01).

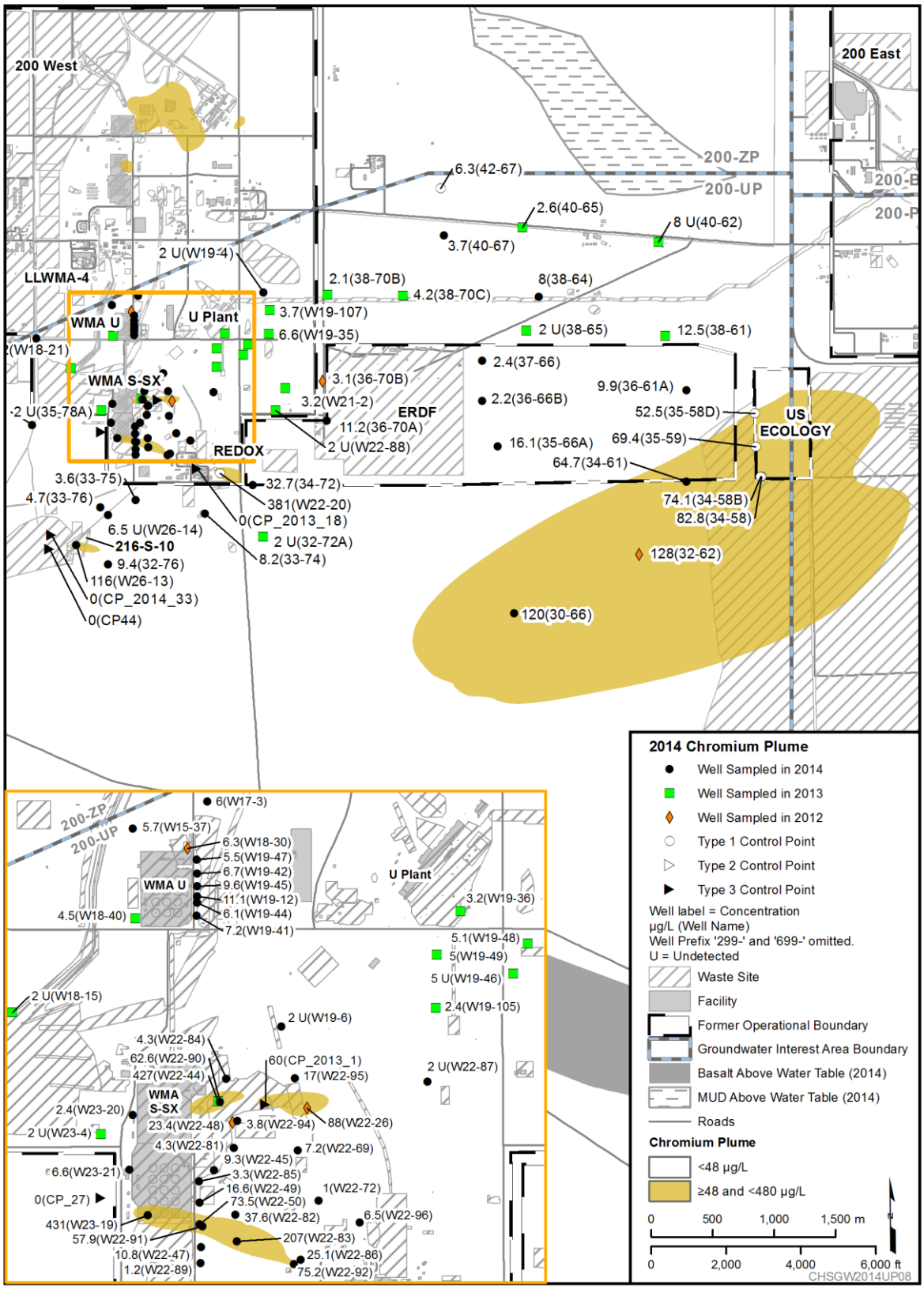


Figure 11-22. 200-UP Chromium Plume, 2014

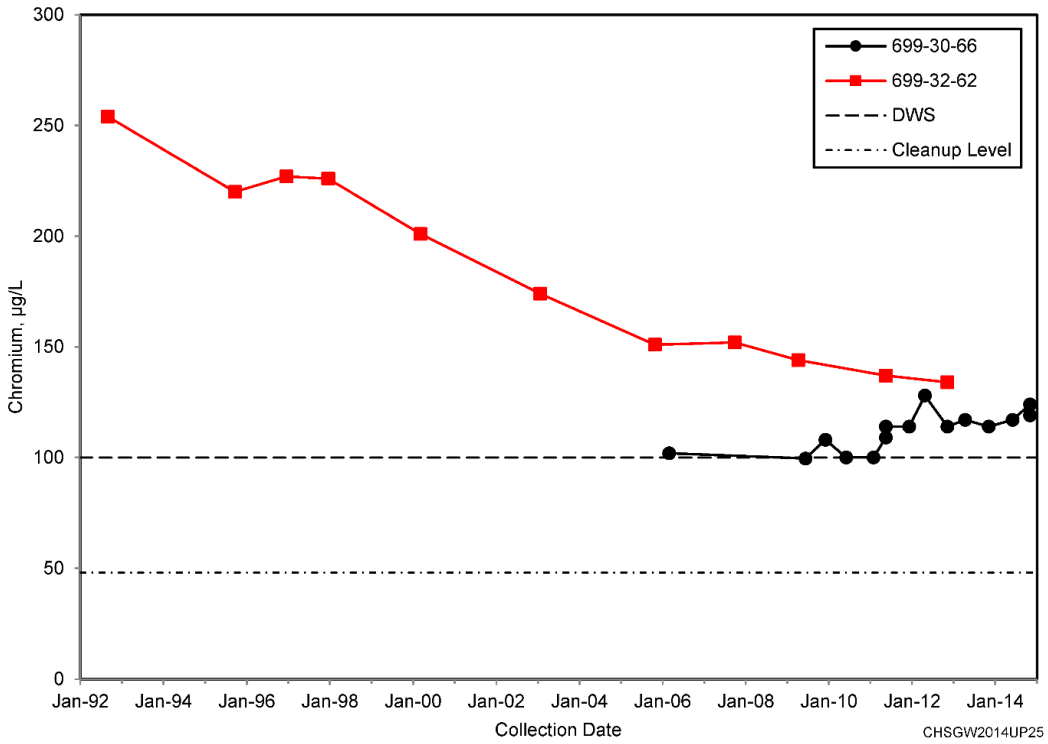


Figure 11-23. 200-UP Chromium Data for Wells 699-30-66 and 699-32-62 Southeast of the 200 West Area

This plume originated primarily from effluent disposal to the 216-S-20 Crib during the 1950s, although the REDOX Plant ponds and ditches south of the 200 West Area were also sources (Section 4.2.4 of DOE/RL-2009-122). An estimated 5,900 kg of chromium were disposed to the 216-S-20 Crib, and an estimated 3,000 kg were disposed to 216-S-10 Pond and Ditch (Appendix C in RPP-26744, *Hanford Soil Inventory Model, Rev. 1*, "SIM Production Output Files"). Chromium concentrations continue to be observed in groundwater near both of these source locations. In Well 699-34-72, downgradient from the 216-S-20 Crib, total chromium was detected at 33 µg/L in a filtered sample collected during February 2014 (42 µg/L in the unfiltered sample). In Well 299-W26-13 at the 216-S-10 Pond and Ditch, chromium averaged 116 µg/L during 2014 (hexavalent chromium and total chromium results combined) and the trend has been generally increasing (Figure 11-24). Chromium is also above background in Well 699-32-76, located 300 m (1,000 ft) farther downgradient (Figure 11-24).

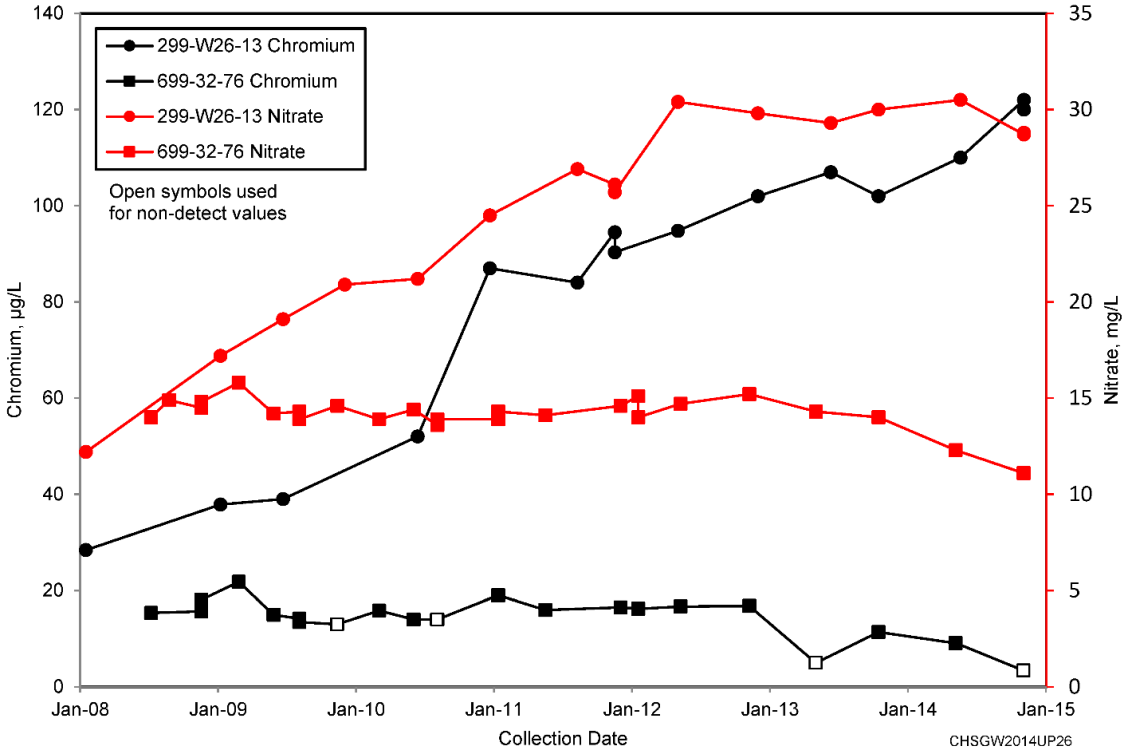


Figure 11-24. 200-UP Chromium and Nitrate Data for Wells 299-W26-13 and 699-32-76 at the 216-S-10 Pond and Ditch

The RD/RA work plan (DOE/RL-2013-07), released during September 2013, describes additional characterization activities to better define the vertical and horizontal extent of the southeast plume. The additional characterization will refine the geometry of the southeast regional chromium plume to focus and optimize the remedial design. Wells will be drilled and sampled in the area of the southeast chromium plume to collect the necessary data (DOE/RL-2014-27, Rev. 1).

11.9 Carbon Tetrachloride

The occurrence of carbon tetrachloride at concentrations above the 3.4 µg/L cleanup level is widespread within 200-UP. Concentrations were greater than 10 times the cleanup level in 27 wells during 2014. Concentrations were above the cleanup level in 48 of the 64 wells sampled for carbon tetrachloride within 200-UP in 2014. In the southern portion of the 200 West Area, the plume extends as much as 1.2 km (0.7 mi) east into the 600 Area (Figure 11-25). The plume originated from waste disposal sites associated with the PFP in 200-ZP. In the eastern portion of the plume, concentrations increase with depth (see the plume cross section in Figure 11-21 in DOE/RL-2011-01). For instance, the highest carbon tetrachloride concentration measured within 200-UP during 2014 was 680 µg/L at Well 299-W14-71 (Figure 11-26), which is screened at the bottom of the unconfined aquifer. The second highest concentrations occur in Well 699-38-70B (390 µg/L) which is also screened at the bottom of the unconfined aquifer. Also, concentrations at Well 299-W19-34A during 2013 averaged 101 µg/L, less than half the concentration of 220 µg/L in the adjacent Well 299-W19-34B, which is completed near the bottom of the aquifer. The 200-ZP section provides additional information regarding carbon tetrachloride in 200 West.

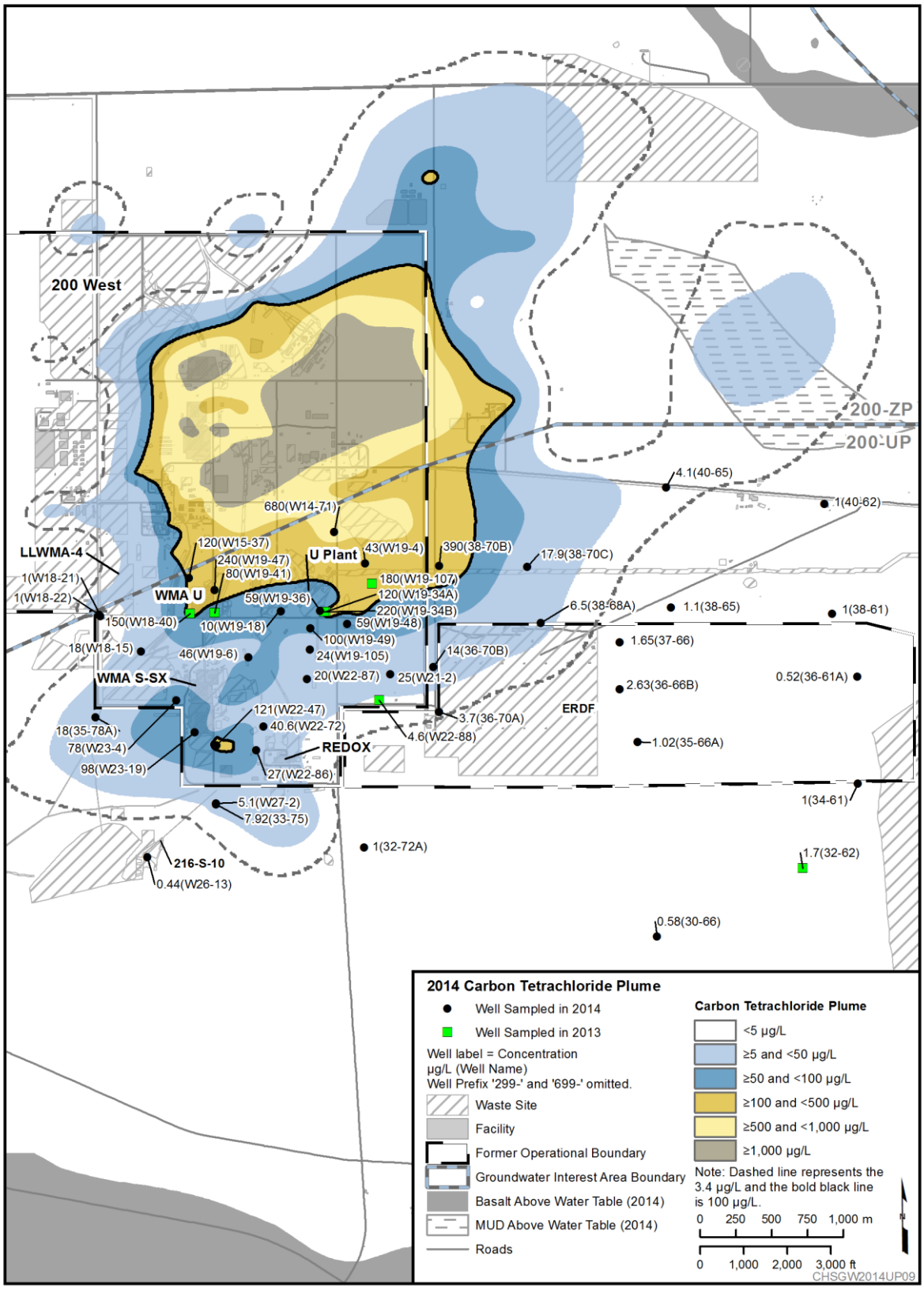


Figure 11-25. 200-UP Carbon Tetrachloride Plume, 2014

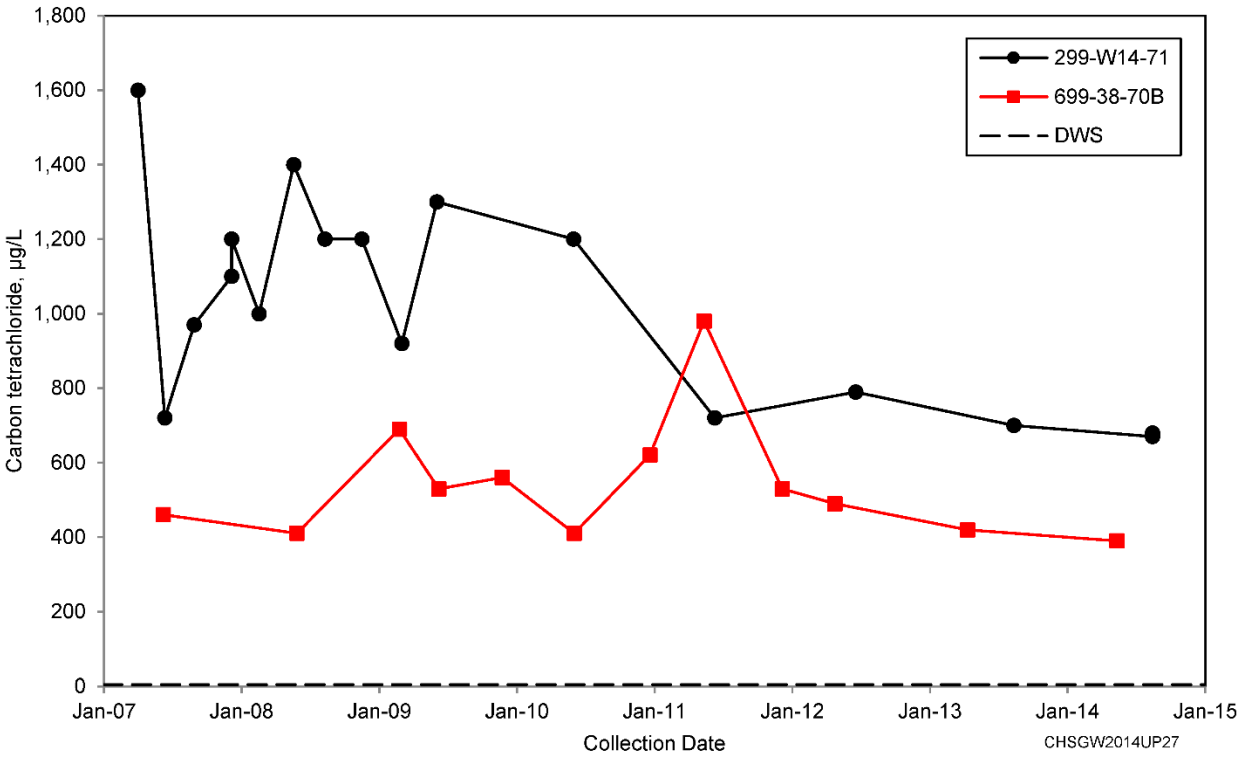


Figure 11-26. 200-UP Carbon Tetrachloride Data for Wells 299-W14-71 North of U Plant and 699-38-70B East of U Plant

Chloroform, a degradation product of carbon tetrachloride, tends to occur in the same wells as carbon tetrachloride. Thus, natural degradation of carbon tetrachloride is occurring, although chloroform was also introduced to the aquifer from the 2607-Z Tile Field (Section 3.2.8 in DOE/RL-2011-01). During 2014, 104 chloroform analyses were performed on samples from 63 wells within 200-UP; no exceedances of the DWS (80 µg/L for total trihalomethanes) were found. The maximum concentration was 10 µg/L in Well 299-W19-47. Depth-discrete sampling during new well installation indicates that chloroform concentrations tend to increase with depth, similar to carbon tetrachloride.

11.10 Trichloroethene

TCE is found in groundwater in the northern portion of 200-UP (Figure 11-27). Depth-discrete samples during well drilling show that TCE concentrations increase with depth, similar to carbon tetrachloride and chloroform. During 2014, 114 TCE analyses were performed on samples from 65 wells within 200-UP. TCE was detected in 14 wells, but the DWS (5 µg/L) was exceeded only at Well 299-W14-71 (8.7 µg/L) and in a single sample from Well 299-W19-114 collected during drilling (7.5 µg/L). Three of the four TCE degradation products, 1,1-dichloroethene, 1,2-dichloroethene (cis- and trans-), and chloroethene (i.e., vinyl chloride), were also analyzed for, but no detections occurred during 2014.

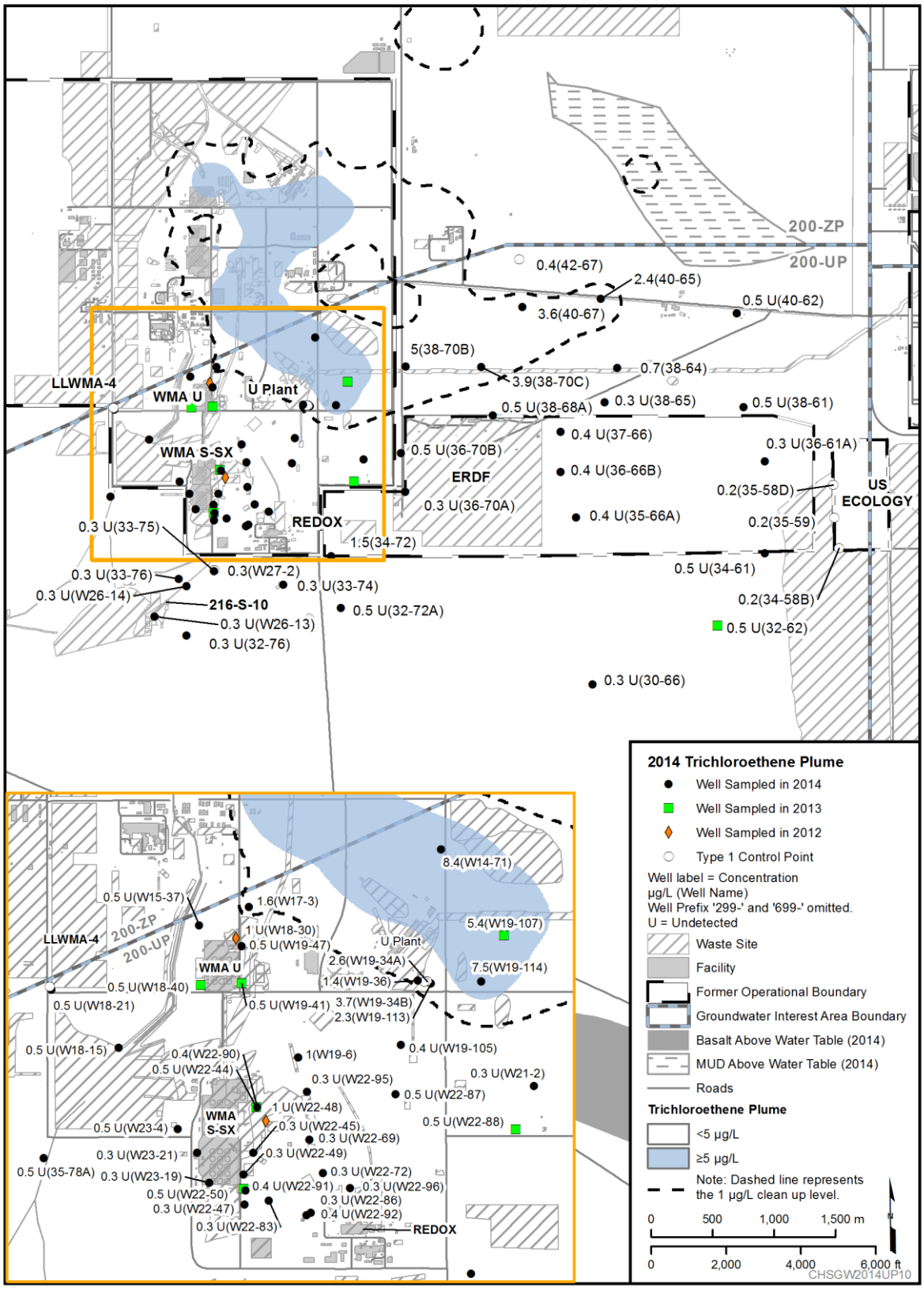


Figure 11-27. 200-UP TCE Plume, 2013

11.11 Environmental Restoration Disposal Facility

The ERDF is a low-level radioactive mixed waste facility used for disposal of waste from surface remedial actions on the Hanford Site. The facility consists of 10 disposal cells, 6 of which were active during 2014. Each disposal cell was constructed with a double liner system to collect leachate from natural precipitation and water added as a dust suppressant. Leachate collects in sumps beneath the cells and is pumped to two holding tanks before being sent to the Effluent Treatment Facility (ETF) for treatment. During 2014, 1,409,000 metric tons (1,553,000 tons) (9,400 Ci of radioactivity) of remediation waste were disposed of at the facility.

Groundwater monitoring at the ERDF is regulated under a CERCLA ROD (EPA/ROD/R10-95/100), which states that groundwater monitoring will be conducted in accordance with RCRA regulations. The site was designed to meet RCRA standards, although it is not actually permitted as a RCRA facility.

11.11.1 Leachate Monitoring

Periodic sampling and analyses of the ERDF leachate is performed to ensure the leachate meets the ETF waste acceptance criteria and to assess whether additional analytes should be added to the routine groundwater monitoring program. The ERDF leachate was delisted as a hazardous waste in 1999, allowing the leachate to be managed as a nonhazardous waste for transfer to the ETF for treatment. To maintain the delisting status, concentrations of certain constituents in the leachate must remain below the delisting levels. These constituents (all nonradionuclides), their delisting levels, and criteria to maintain delisting status are specified in WCH-173.

Samples are collected from the holding tanks and represent composite samples of all the leachate collected. Due to procedural and accessibility issues, the September 2013 sampling was delayed until February 2014. Leachate samples are normally collected during March and September of each year. Routine calendar year 2014 sampling of the leachate occurred on March 18, 2014, and November 11, 2014. The November sampling was for the biennial “long list” for over 300 chemical and radionuclide analytes. No exceedances of a delisting level occurred during this time frame. Seven organic compounds were reported as detected for the November sampling, all near analytical detection limits. The number of low-level organic detects was comparable to previous long list analyses. One organic, 1,2-diphenylhydrazine, was detected (0.25 µg/L) in one sample (replicate result was nondetected) just above the detection limit and just above 1/10th of the assigned delisting value (2.5 µg/L) The only other analyte detected at concentrations greater than 1/10th of the delisting value was nitrate. This compound will be monitored in the 2015 sampling for inclusion in the routine analysis list. All nitrate values to date have exceeded 1/10th of the delisting values. Nitrate values have continued to rebound from the near minimum values seen in 2012, but remained below historical averages. Results of the leachate sampling indicated that no analytes need to be added to the groundwater monitoring program.

11.11.2 Groundwater Sampling

Groundwater monitoring at the ERDF is performed in accordance with WCH-198. The groundwater flow direction beneath the ERDF is toward the east northeast. One upgradient well (699-36-70A) and three downgradient wells (699-37-66, 699-36-66B, and 699-35-66A) are sampled semiannually (Figure 11-28), typically in March and September. To detect impacts to groundwater quality, sample results are compared to baseline conditions established when monitoring began in 1996 using a tolerance interval approach (WCH-198). All monitoring wells were sampled successfully during 2014.

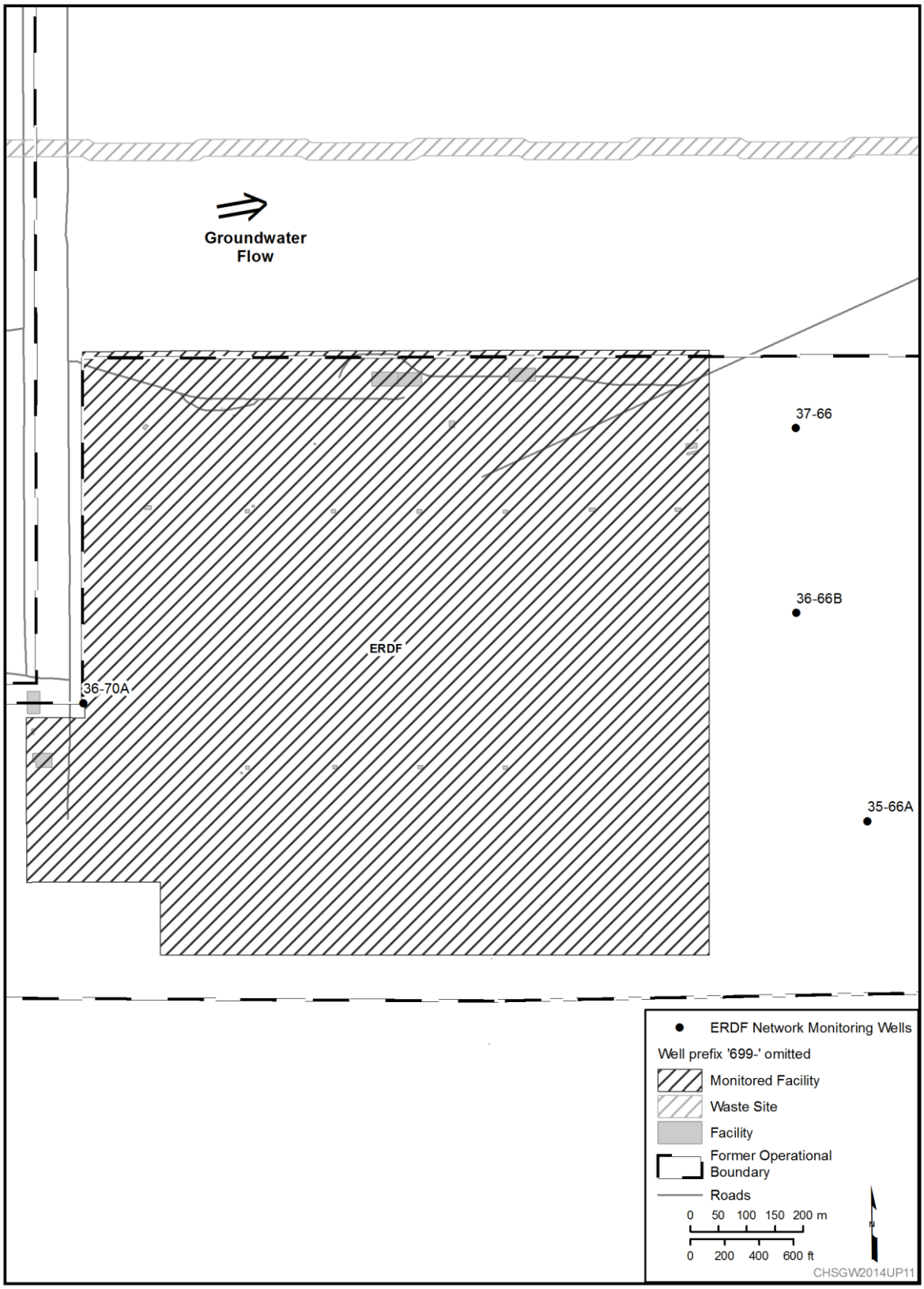


Figure 11-28. 200-UP ERDF Monitoring Well Locations

The results of groundwater monitoring at the ERDF continued to indicate that the facility has not affected groundwater quality. Several constituents (tritium, iodine-129, nitrate, and carbon tetrachloride) are present in the groundwater near or above the 200-UP-1 cleanup levels, but these constituents are elevated in both the upgradient and downgradient wells. These plumes originated in the 200 West Area and have migrated toward ERDF.

The uranium concentrations at all wells are consistent with Hanford Site background levels. Both technetium-99 and gross beta are trending downward in upgradient Well 699-36-70A and in downgradient Wells 699-37-66 and 699-36-66B. Technetium-99 and gross beta (affected by technetium-99) in downgradient Well 699-35-66A remained below the maximum seen in 2012 but have rebounded some from the 2013 results. Additional sampling will be needed to determine if these constituents are now trending downward similar to the other wells. The maximum technetium-99 results remain approximately 15 percent of the 200-UP-1 cleanup level.

Nitrate levels appear to be stabilizing in all wells with indications of a slight downward trend. Fluoride results for all wells appear to have stabilized near historical levels below the spikes noted in 2012. Fluoride concentrations in upgradient Well 699-36-70A remain slightly elevated from historical levels.

Vanadium results in all wells appear to be stabilizing at historical levels, down from the maximum seen in the March 2010 sampling. Chromium sample results appear to have stabilized in the downgradient wells. Upgradient Well 699-36-70A has elevated levels of chromium. While chromium is present as a contaminant in some areas of the Hanford Site, chromium has also been associated with corrosion of the stainless-steel well screens. Nickel and manganese (both components of 304/316 stainless steel) remain elevated at Well 699-36-70A, consistent with corrosion of the screen. Periodically, low levels of lead are detected, typically in all wells during a given sampling event. Lead detections were noted in both 2013 sampling events, with some values from September 2013 being the highest since 1999. Lead values for the 2014 sampling returned to nondetect levels. These specific items will continue to be monitored.

11.12 S-SX Pump-and-Treat

During 2014, one groundwater remediation measure operated within 200-UP: the WMA S-SX groundwater extraction system. This system began operating during July 2012. The implementation plan for the WMA S-SX groundwater extraction system is contained in DOE/RL-97-36, issued in 2010. The system operates under the interim action ROD issued in 2012 (EPA et al., 2012). This section provides a summary of this system for 2014. More details can be found in the 2014 annual P&T system report (DOE/RL-2015-06, in press).

The WMA S-SX groundwater extraction system consists of three extraction wells: 299-W22-90, 299-W22-91, and 299-W22-92 (Figure 11-29). Extracted water is pumped to the 200 West P&T. The extraction wells began operating during July 2012. During 2014, the combined flow rate from the extraction wells averaged 315 L/min (83 gpm). A total of 165.7 million L (43.8 million gal) were pumped during the year, and 0.63 Ci of technetium-99, 6,720 kg of nitrate, 10.2 kg of chromium, and 129 kg of carbon tetrachloride were removed from the aquifer (Table 11-3). Since startup, the system has extracted 327.3 million L (86.5 million gal) and removed 1.66 Ci of technetium-99, 16,280 kg of nitrate, 28.1 kg of chromium, and 250 kg of carbon tetrachloride.

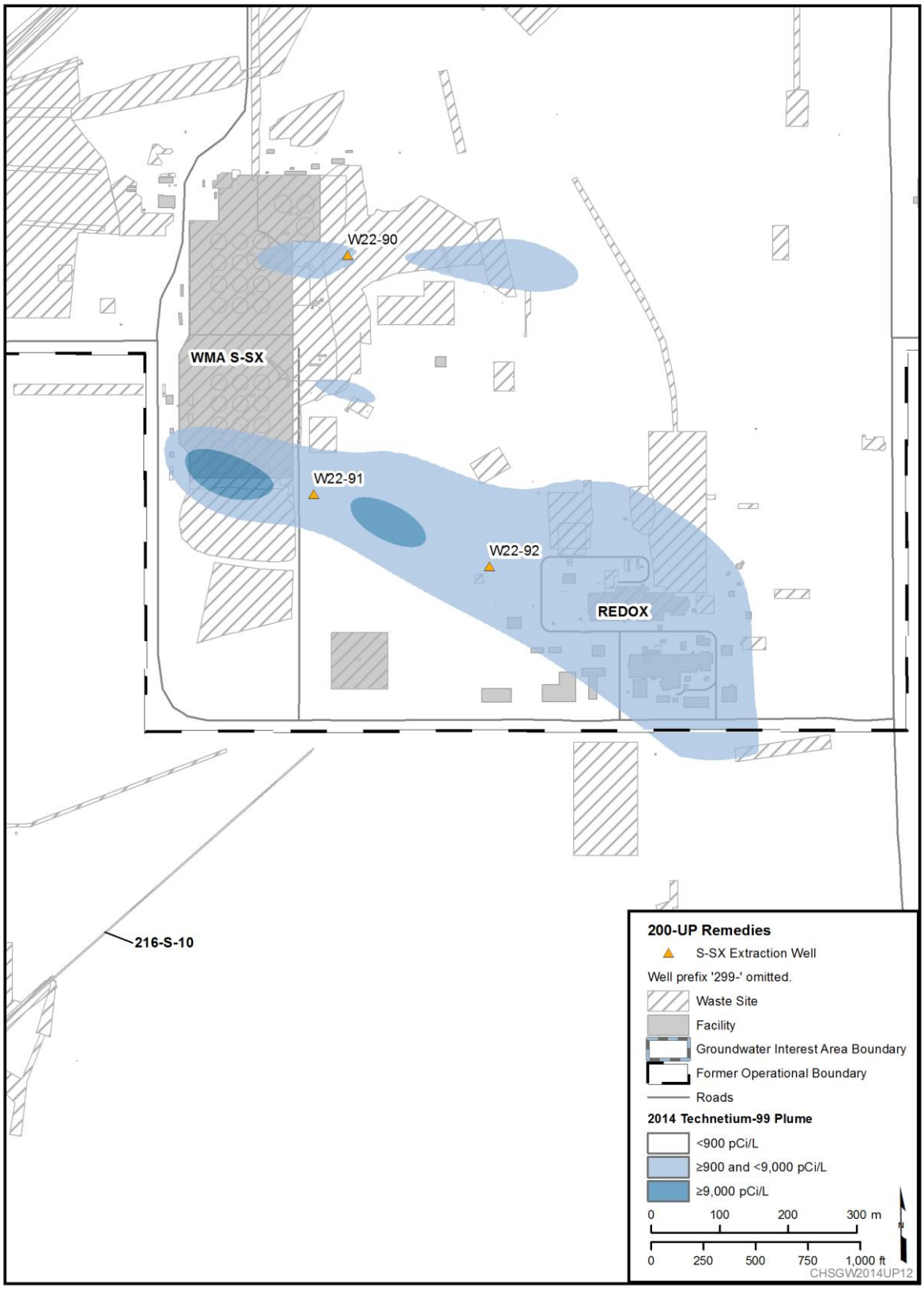


Figure 11-29. 200-UP Remedy Locations

Table 11-3. S-SX Tank Farms Groundwater Extraction System Summary

Parameter	2014	Since Startup
Total groundwater processed, millions of L	165.7	327.3
Mass of chromium removed, kg	10.2	28.1
Mass of nitrate removed, kg	6,720	16,280
Mass (activity) of technetium-99 removed, g (Ci)	37.2 (0.631)	98.0 (1.66)
Mass of carbon tetrachloride removed, kg	129	250
System availability during 2014	>90%	N/A

The system was specifically designed to capture the high-concentration portions of the technetium-99 plume. As shown by the hydraulic capture zones on Figure 11-30, it is expected that the extraction wells will capture almost all of the plume above 9,000 pCi/L near the sources in the S and SX Tank Farms. Previous analyses indicated that the capture zone at Well 299-W22-90 was substantially larger than the width of the technetium-99 plume. During 2014, the flow rate in this well was reduced from an average of 86 L/min (23 gpm) to 62 L/min (16 gpm) resulting in the smaller capture zone shown in Figure 11-30. The flow rate in Well 299-W22-92, where the technetium-99 plume has a larger width, was increased from 90 L/min (24 gpm) to 128 L/min (34 gpm) to increase the mass recovery at this location.

As expected, concentrations of chromium, nitrate, and technetium-99 in the extraction wells have exhibited generally declining trends since pumping began (Figures 11-31, 11-32, and 11-33). The declines are a combination of the removal of contaminant mass/activity from the aquifer and the growth of the capture zones either into portions of the plumes with different concentrations or outside of the plumes entirely (vertically and laterally). The chromium concentration at Well 299-W22-91 was below the 48 µg/L cleanup level during the April and July 2014 sample events but increased to above the cleanup level by October (Figure 11-29). By the end of the year, nitrate concentrations were below the 45 mg/L cleanup level in all three extraction wells. Concentrations of carbon tetrachloride are variable. Extraction Well 299-W22-90 has a generally increasing trend, but the other extraction wells show a slightly declining trend (Figure 11-34). The slow concentration change in these wells is consistent with the widespread occurrence of this constituent in the aquifer.

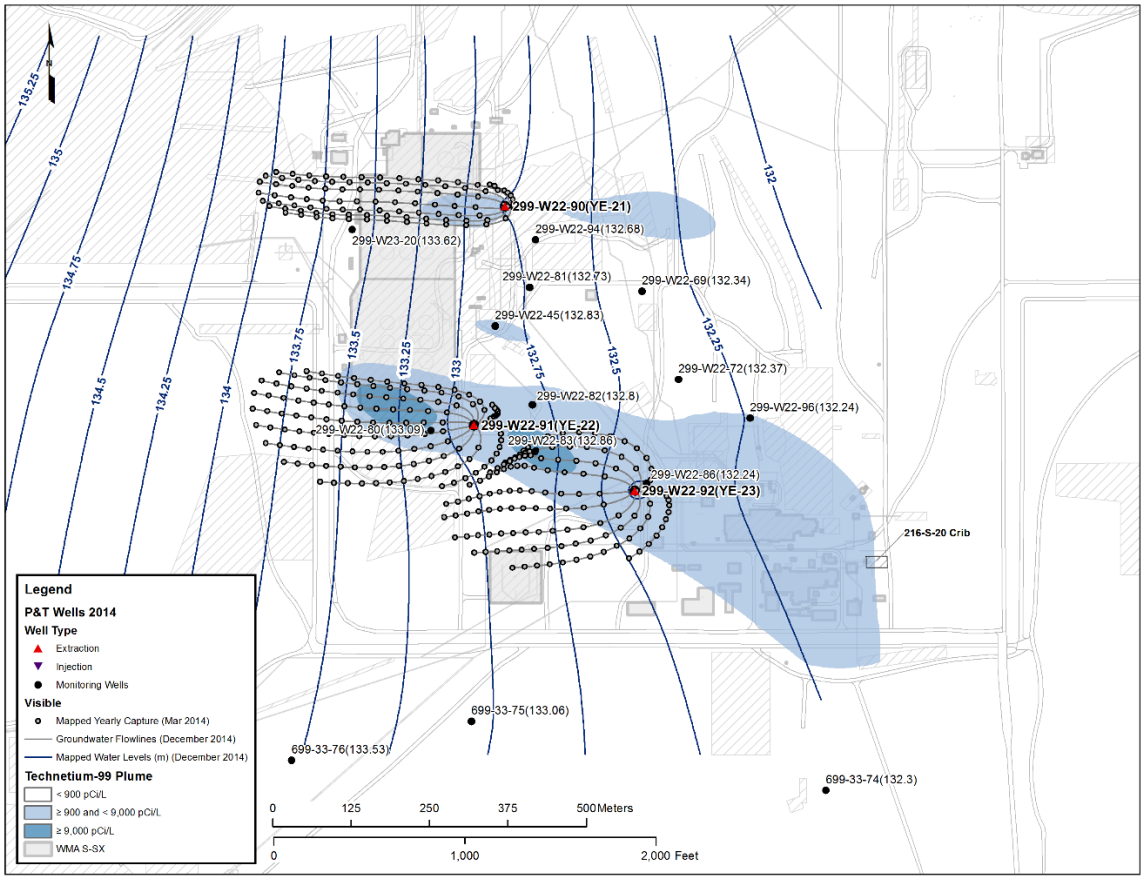


Figure 11-30. 200-UP Groundwater Capture Zones at WMA S-SX

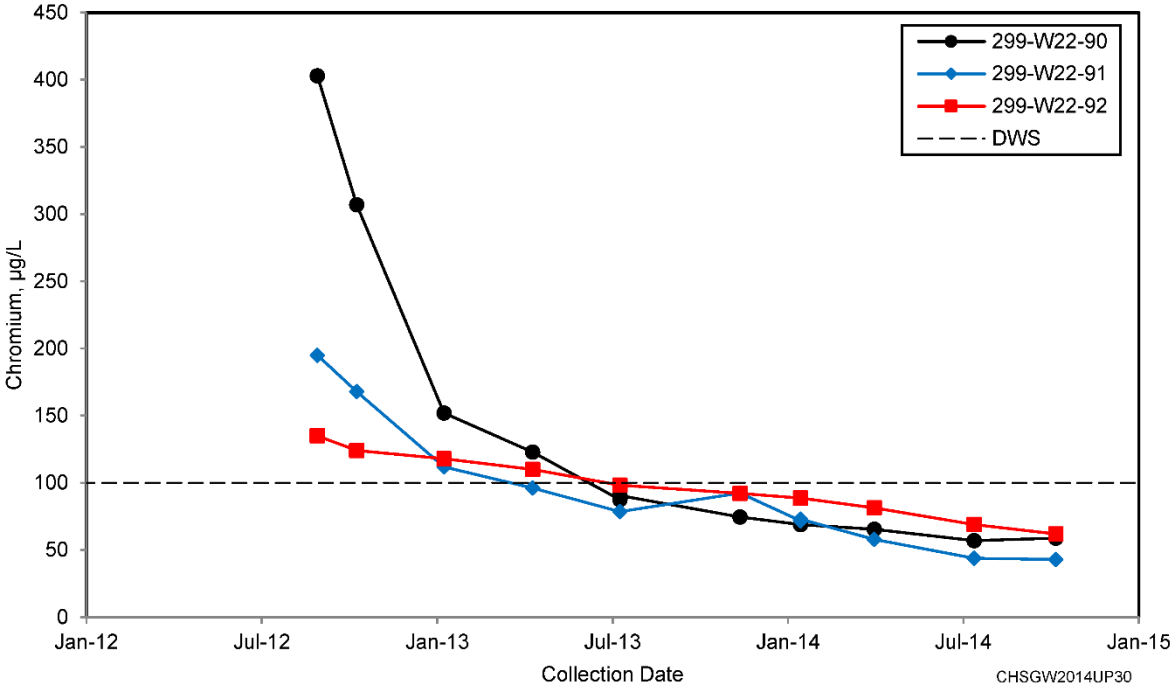


Figure 11-31. 200-UP Chromium Data for WMA S-SX Extraction Wells

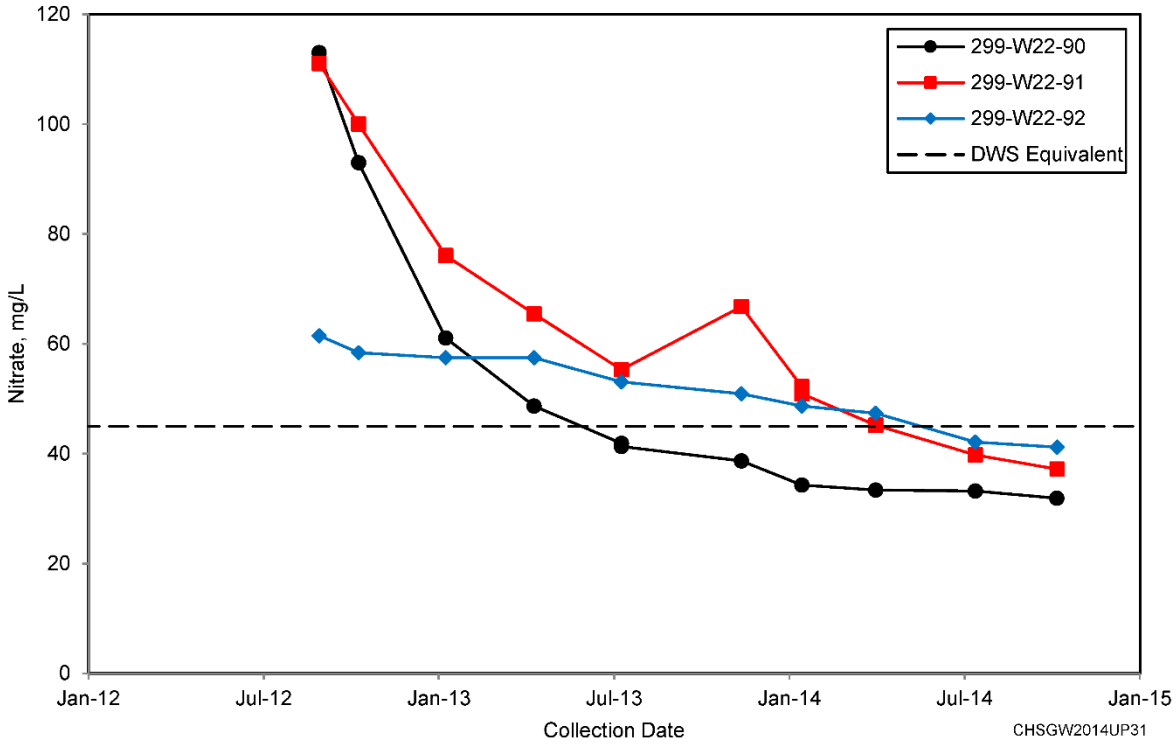


Figure 11-32. 200-UP Nitrate Data for WMA S-SX Extraction Wells

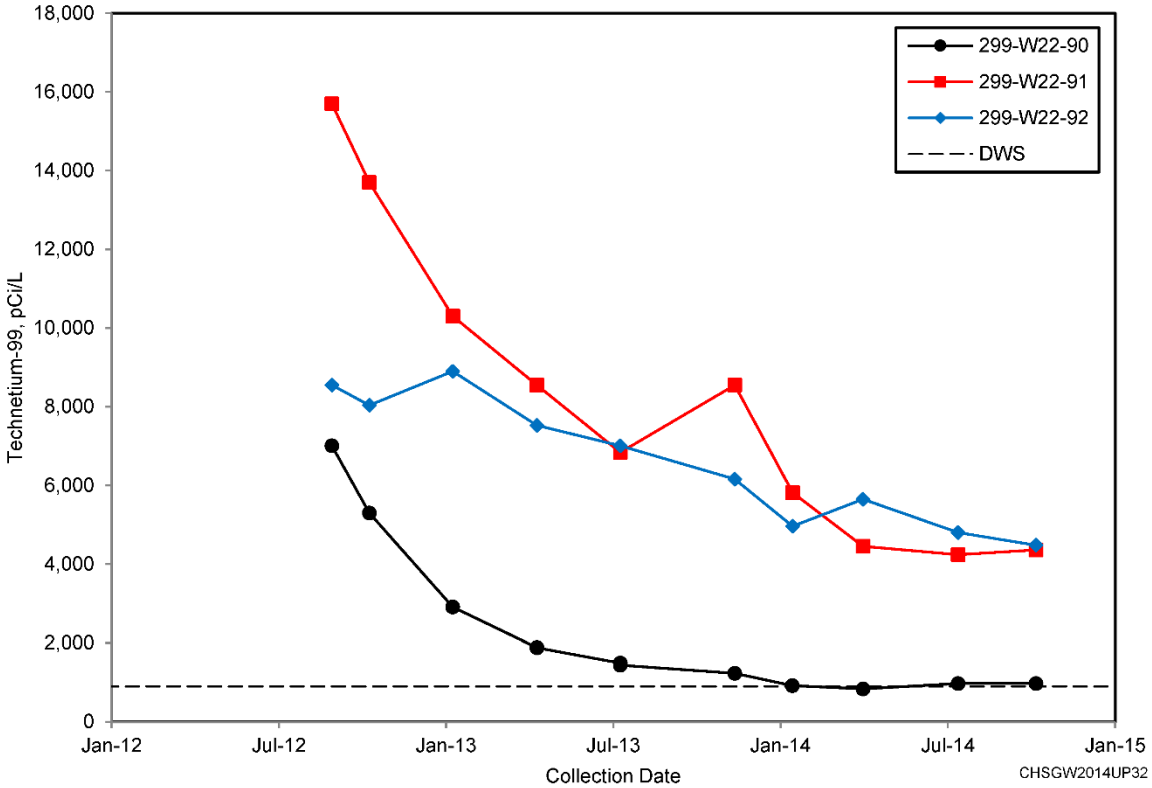


Figure 11-33. 200-UP Technetium-99 Data for WMA S-SX Extraction Wells

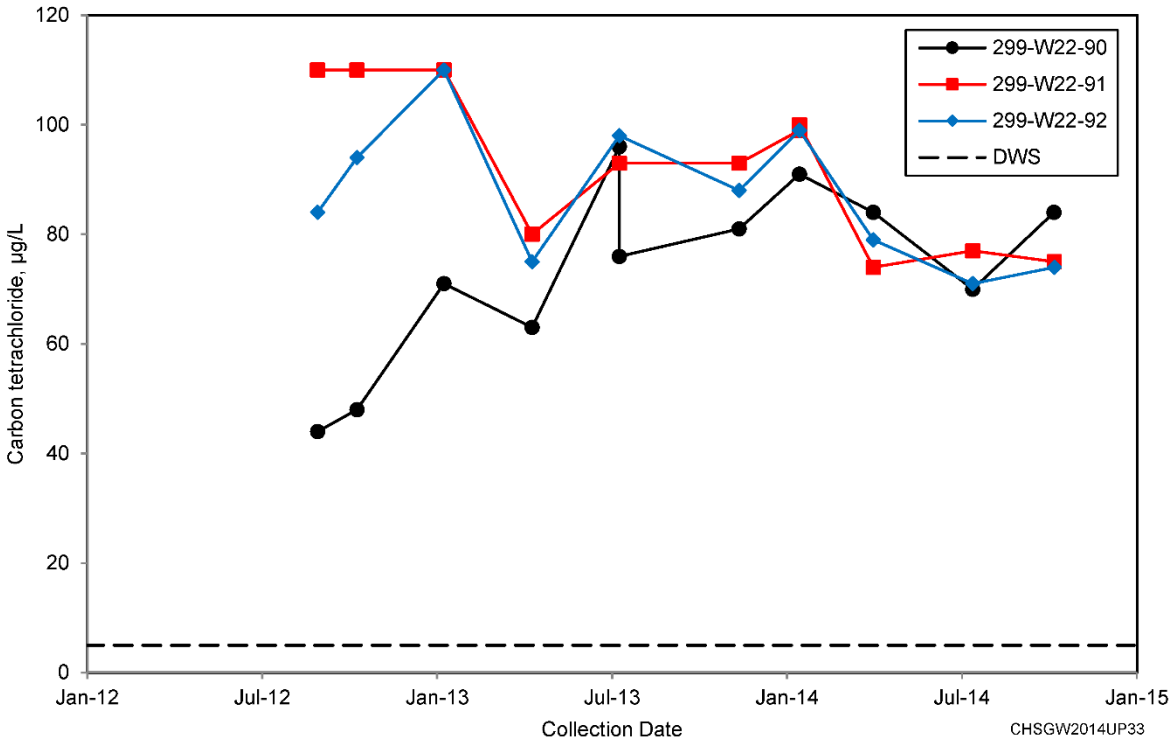


Figure 11-34. 200-UP Carbon Tetrachloride Data for WMA S-SX Extraction Wells

The groundwater extraction system has reduced the chromium, nitrate, and technetium-99 concentrations in many of the network monitoring wells. Considering those wells that had baseline concentrations above a cleanup level, chromium concentrations have declined in 3 of 6 wells, nitrate concentrations have declined in 7 of 11 wells, and technetium-99 concentrations have declined in 5 of 8 wells. The largest percentage declines have occurred in Well 299-W22-47 located south of extraction Well 299-W22-91. The chromium concentration in this well declined to 5.48 µg/L, a 97 percent reduction from the baseline of 183 µg/L. Nitrate has declined by 89 percent from 99.4 to 11.2 mg/L, and technetium-99 has declined by 99 percent from 15,000 to 139 pCi/L (Figure 11-35). During 2014, chromium and nitrate declined to below their cleanup levels in Well 299-W22-86, and nitrate declined to below its cleanup level in Well 299-W22-85.

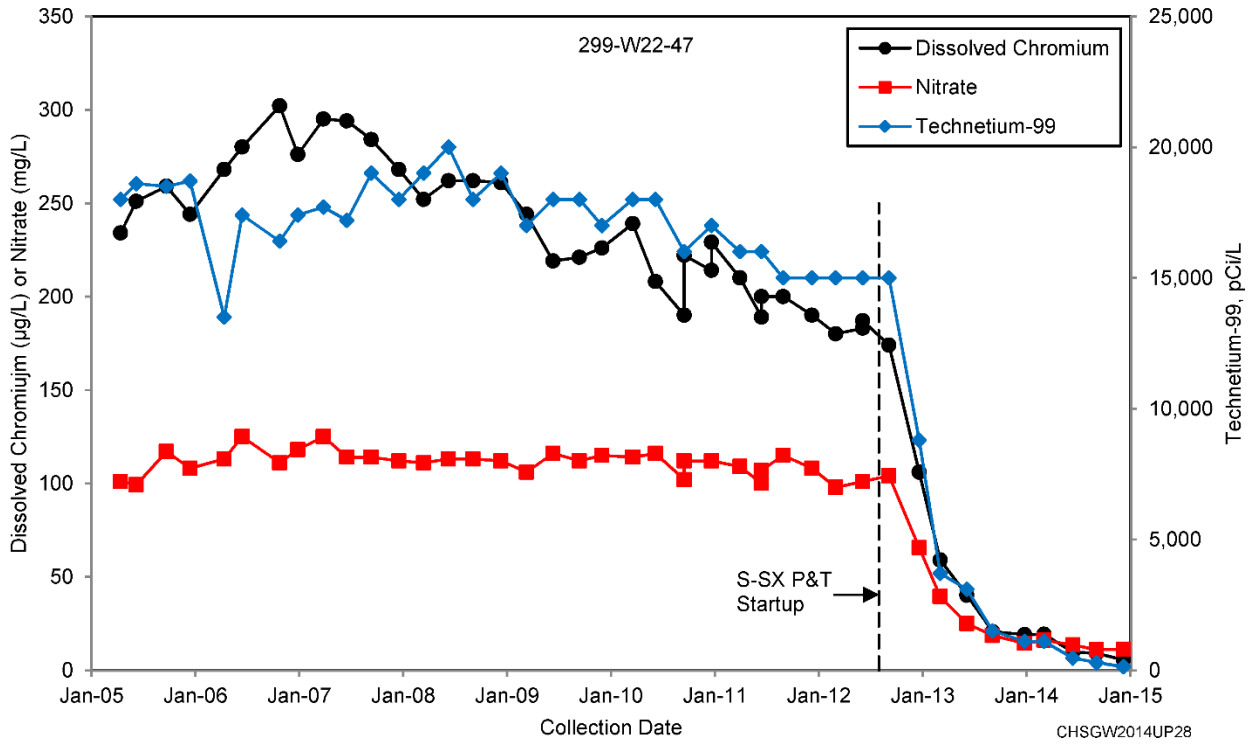


Figure 11-35. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W22-47 at WMA S-SX

11.13 RCRA Monitoring

The following sections describe the results of monitoring in accordance with RCRA regulations at three individual waste management/disposal facilities (WMA S-SX, WMA-U, and the 216-S-10 Pond and Ditch) within 200-UP. Interim status groundwater quality assessment monitoring is conducted at WMA S-SX and WMA U (40 CFR 265.93[d], as referenced by WAC 173-303-400). Interim status detection monitoring for indicator parameter evaluation is conducted at the 216-S-10 Pond and Ditch (40 CFR 265.92 and 40 CFR 265.93[b], as referenced by WAC 173-303-400). Locations of the RCRA sites within the 200-UP groundwater interest area are shown on Figure 11-3.

Groundwater data are available in the HEIS database, which is available at: https://ehs.hanford.gov/eda. Appendix B includes additional information (including well and constituent lists, groundwater flow rates, and statistical tables). Site analytical data can also be obtained from the PHOENIX system (http://phoenix.pnnl.gov/).

11.13.1 Waste Management Area S-SX

WMA S-SX consists of the S Tank Farm and the SX Tank Farm. The S Tank Farm contains 12 tanks, each with a capacity of 2.9 million L (758,000 gal). The SX Tank Farm contains 15 tanks, each with a capacity of 3.8 million L (1,000,000 gal) (Section 1.2 of RPP-7884). The WMA also includes ancillary equipment consisting of three catch tanks; one receiver tank; six diversion boxes; and associated piping, valve pits, and pumps (Section 1.2 of RPP-7884). Both tank farms received waste generated from REDOX Plant in the 1950s and 1960s. To minimize the probability and severity of future leaks, all drainable liquid in each tank has been removed and transferred to double-shell tanks. Monitoring wells are shown in Figure 11-36.

In 1996, at Ecology's direction, WMA S-SX was placed into assessment status because of elevated specific conductance in downgradient monitoring wells. The first determination assessment found that multiple sources within the WMA had affected groundwater quality with elevated concentrations of nitrate and chromium (Section 5.0 of PNNL-11810). Groundwater is currently monitored under DOE/RL-2009-73. The current objective of RCRA monitoring at WMA S-SX is to assess the extent and concentrations of dangerous waste constituents in the groundwater and determine their rate of movement. Table B-77 in Appendix B provides a list of the wells and constituents monitored for WMA S-SX. All required sampling was performed successfully during 2014, with the following exceptions:

- No attempts were made to sample Well 299-W22-44 during 2014 because this well became dry during June 2013. A location for a replacement well has been staked in the field, but the well has been a low priority for drilling because samples continue to be collected quarterly from the adjacent extraction well, 299-W22-90. Drilling of the replacement well is planned for 2015.
- Well 299-W22-50 was sampled successfully in March, but was found to be dry during June. Drilling of a replacement well has been a low priority because samples continue to be collected quarterly from the adjacent extraction well, 299-W22-91. Drilling of the replacement well is planned for 2015.
- Well 299-W22-113 is a replacement well completed late in 2014. It replaced Well 299-W22-49, which is nearly dry. Well 299-W22-49 was scheduled for sampling in June and December. It was removed from the sample schedule, and Well 299-W22-113 was added to the schedule in its place for the December sampling. No sampling event at this location was missed, but the December sampling of Well 299-W22-113 was delayed until early January 2015 for installation of the sample pump.
- The December sampling of Well 299-W22-95 was delayed until early January 2015 due to maintenance being performed on the well cap.

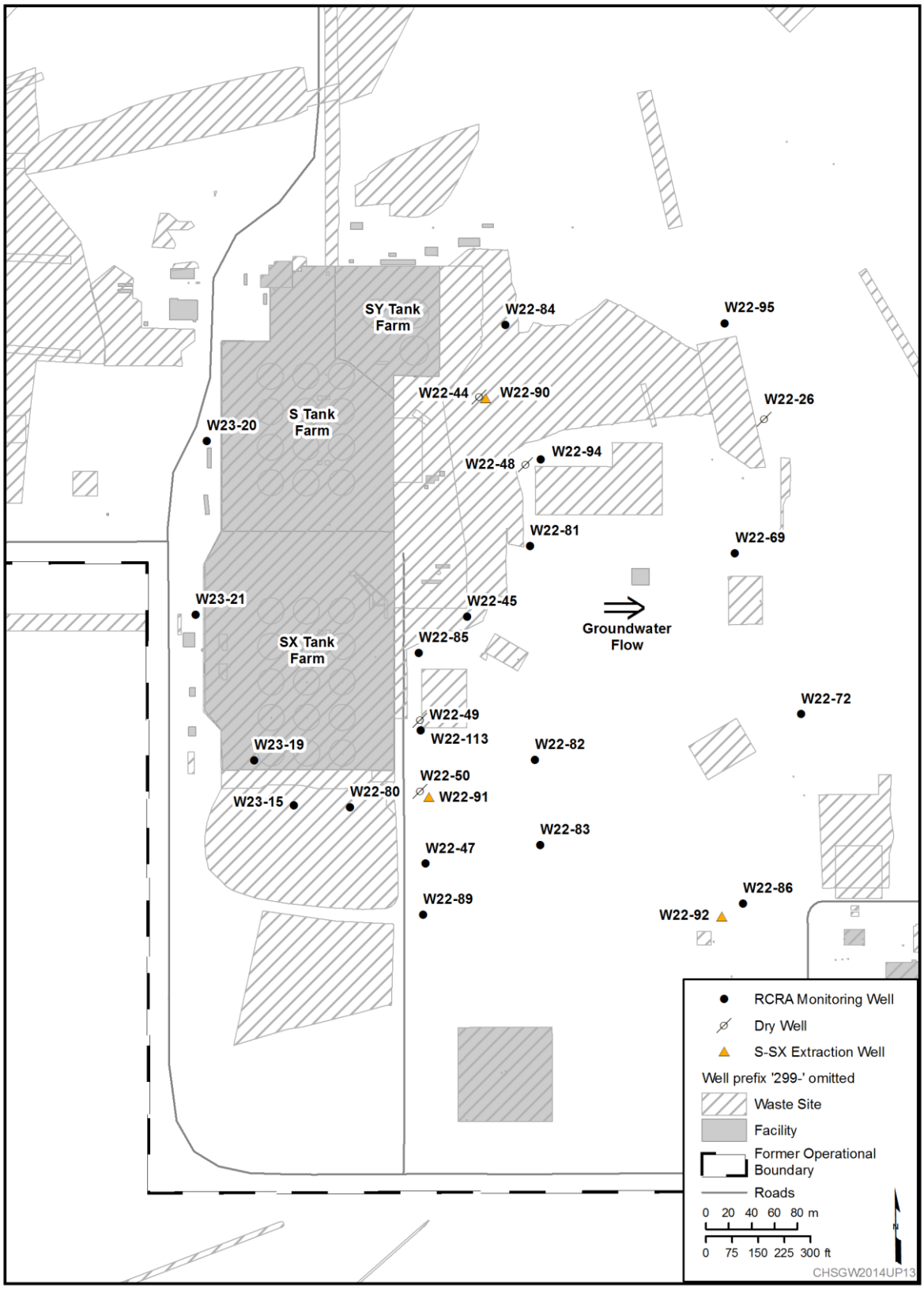


Figure 11-36. 200-UP RCRA Facility WMA S-SX Monitoring Well Locations

11.13.1.1 Water-Level and Well Network Evaluation

The water table elevation declined an average of 0.49 m (1.61 ft) in the monitoring wells between March 2013 and March 2014. This is larger than the long-term rate of decline between 2007 and 2011 of 0.25 m/yr (0.82 ft/yr). The larger decline is caused by the WMA S-SX groundwater extraction system, which began operating in 2012. Trend surface analyses were performed on four sets of water-level data collected during 2014. The average result was a hydraulic gradient of 2.8×10^{-3} m/m due east (90 degrees azimuth) and the groundwater flow rate (i.e., average linear velocity) ranged from 0.018 to 0.44 m/d (0.059 to 1.44 ft/d), depending on the hydraulic conductivity and effective porosity selected. Using values of 6.1 m/d (20 ft/d) for the hydraulic conductivity and 0.12 for the effective porosity (average values from multiple constant rate pumping tests in wells at the WMA [PNNL-13514; PNNL-14113; PNNL-14186]), the groundwater flow rate most representative for this site is 0.14 m/d (0.46 ft/d). This is slightly higher than the average for 2013 of 0.016 to 0.39 m/d (0.053 to 1.3 ft/d), with a best value of 0.12 m/d (0.39 ft/d). The higher average flow velocity for 2014 is caused by further drawdown of the water table near the extraction wells and the resulting increase in the average hydraulic gradient (for comparison, the average hydraulic gradient magnitude for 2013 was 2.4×10^{-3} m/m).

Based on the distribution of the monitoring wells compared to the extent of contamination, DOE believes the current well network is capable of monitoring the distribution of contamination at this WMA. The WMA S-SX will remain in interim status groundwater quality assessment monitoring for 2015.

11.13.1.2 Assessment Results

Groundwater beneath WMA S-SX is contaminated with the dangerous waste constituent chromium and supporting constituent nitrate. This contamination is attributed to two primary sources within the WMA: an overfill event of 91,000 L (24,000 gal) from Tank S-104 in the S Tank Farm (Sections 3.7.2 and 4.6 in RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*), and a 190,000 L (51,000 gal) leak from Tank SX-115 during 1965 in the SX Tank Farm (Section 4.3 of RPP-ENV-39658). Because chromium and nitrate are highly mobile in the aquifer, these constituents migrate at an average rate (toward the east) equal to the calculated average groundwater flow rate of 0.14 m/d (0.46 ft/d). The extent of the nitrate plume is shown on Figure 11-19 and the chromium plume extent is shown on Figure 11-22. Assessment data are summarized in Table B-79 of Appendix B.

Three groundwater extraction wells (299-W22-90, 299-W22-91, and 299-W22-92) located within the WMA S-SX plumes began pumping during July 2012. Operation of these wells has altered the migration of the chromium and nitrate plumes. Instead of continuing toward the east, some of the chromium and nitrate contamination is being drawn into the extraction wells. During 2014, 10.2 kg of chromium and 6,720 kg of nitrate were removed from the aquifer.

Operation of the groundwater extraction system has caused contaminant concentrations to decline in several of the network monitoring wells. In wells that had baseline chromium concentrations above the 48 µg/L cleanup level prior to operation of the groundwater extraction system, concentrations have decreased in four wells and are unchanged in four wells. In those wells with a baseline nitrate concentration above the 45 mg/L cleanup level, the concentration has decreased in seven wells, is unchanged in three wells, and has increased in one well. The nitrate concentration is trending upward in Well 299-W22-45, changing from 96.5 mg/L in December 2013 to 105 mg/L in December 2014. At Well 299-W23-19, located inside the SX Tank Farm, the chromium concentration declined from 484 µg/L in December 2013 to 413 µg/L in December 2014 (Figure 11-6). Nitrate also declined in this well from 168 mg/L in December 2013 to 122 mg/L in December 2014. This well has the maximum nitrate and chromium concentrations at the WMA because it is located in the source area. Both the chromium and nitrate concentrations declined to below their respective cleanup levels in Well 299-W22-86 (Figure 11-37) located near extraction Well 299-W22-92.

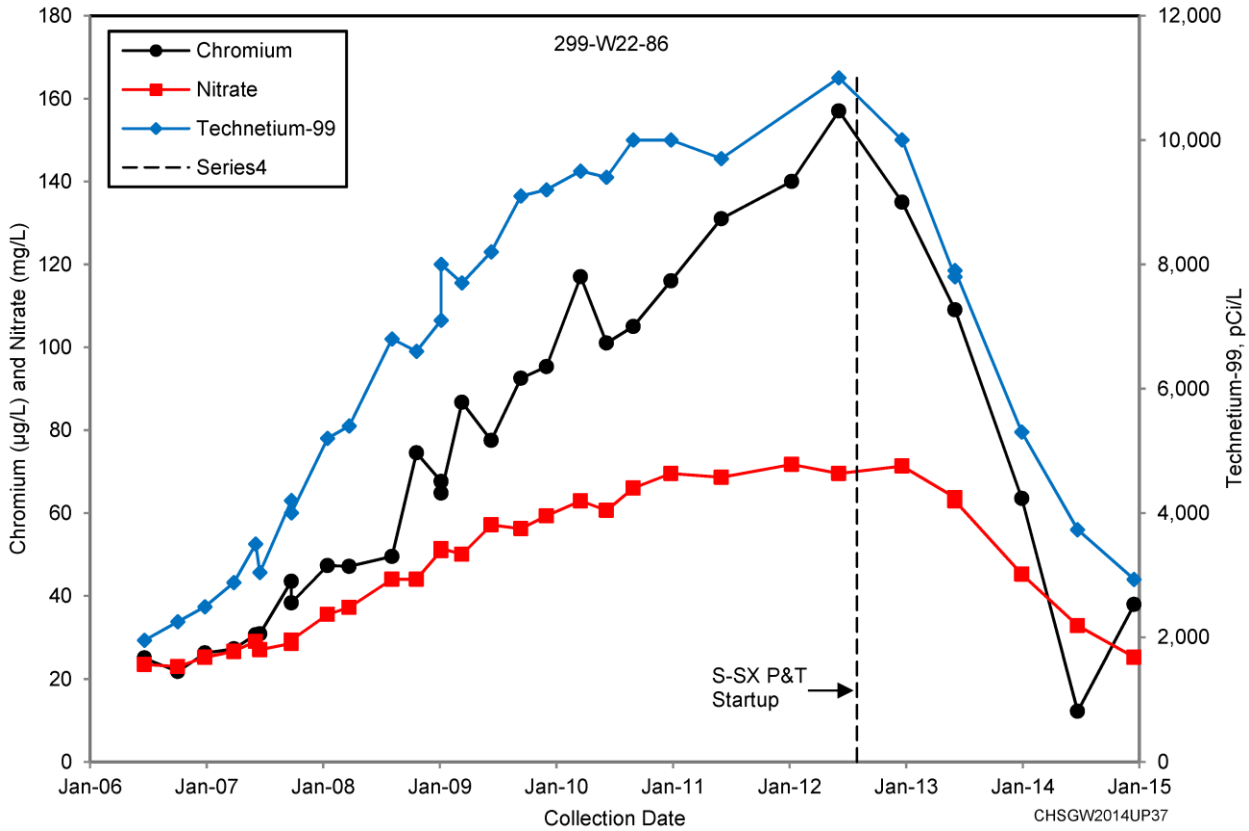


Figure 11-37. 200-UP Chromium, Nitrate, and Technetium-99 Concentrations in Well 299-W22-86 Downgradient from WMA S-SX

11.13.2 Waste Management Area U

The WMA U contains 16 underground single-shell tanks constructed between 1943 and 1944. Twelve of the single-shell tanks have capacities of 2 million L (535,000 gal) and four have capacities of 210,000 L (55,000 gal) (Section 1.2 of RP-35485, *Field Investigation Report for Waste Management Area U*). The WMA also contains a variety of ancillary equipment used to manage tank waste during operations, including six diversion boxes, the 271-UR Control House, the 244-UR Process Vault, the 244-U double-contained receiver tank, and waste transfer lines, pits, and junction boxes. Monitoring wells are shown in Figure 11-38.

The tank farm received waste from the bismuth phosphate process between 1946 and 1948, and from the REDOX process between 1954 and 1957 (WHC-MR-0132, *A History of the 200 Area Tank Farms*). In 1952, some waste was retrieved and pumped to the 242-T Evaporator and, between 1952 and 1957, the metal waste stored in nine of the 2 million L (535,000 gal) capacity tanks was transferred to U Plant for uranium recovery. To minimize the probability and severity of future leaks, all drainable liquid in each tank has been removed and transferred to double-shell tanks.

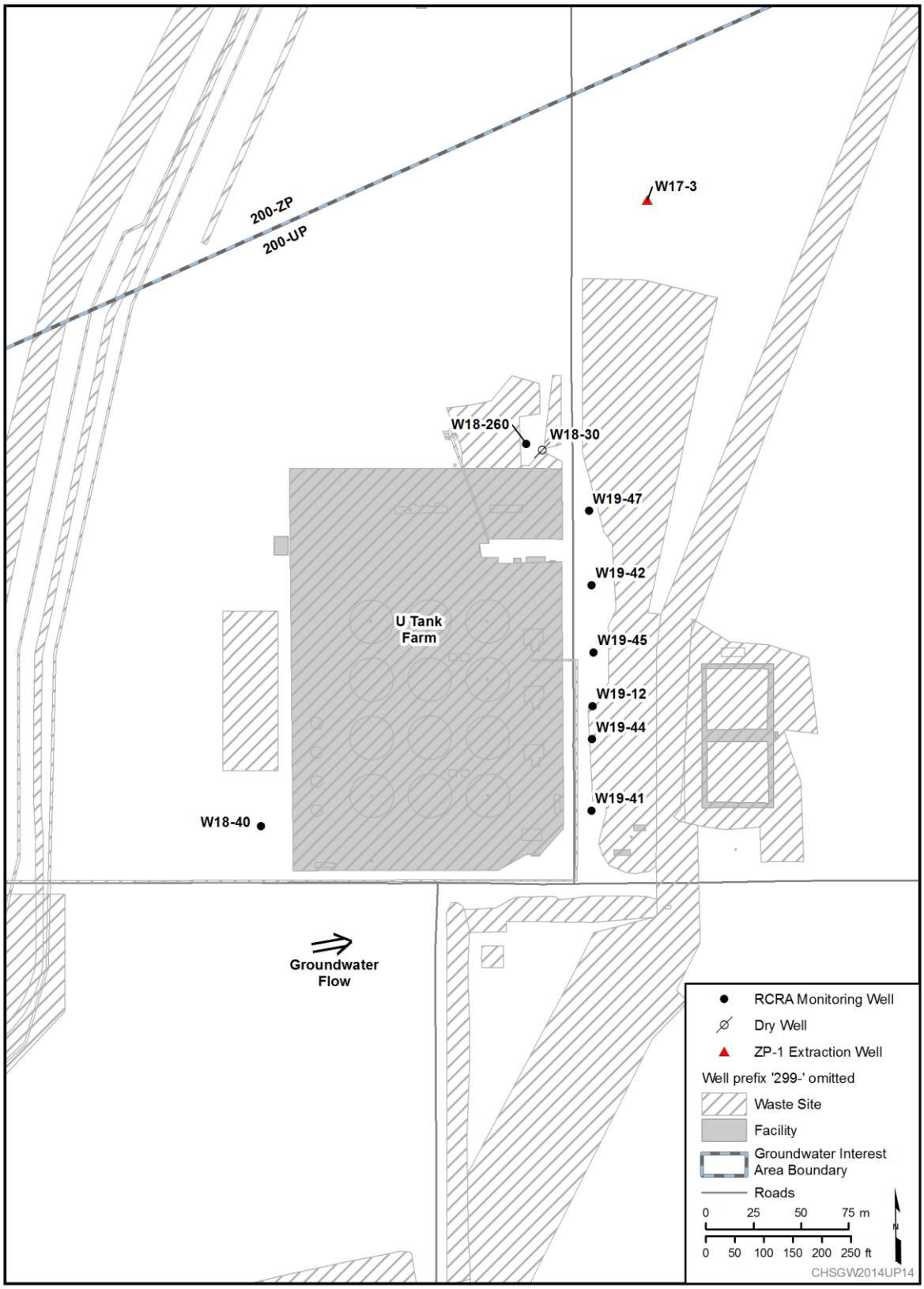


Figure 11-38. 200-UP RCRA Facility WMA U Monitoring Well Locations

WMA U was placed into assessment status in 2000 when specific conductance in groundwater monitoring wells downgradient of the WMA exceeded upgradient levels (Section 1.1 of PNNL-13185). An assessment of that finding determined that the WMA had affected groundwater quality, based on elevated concentrations of nitrate and possibly chromium in downgradient wells (Section 6.0 of PNNL-13282). Contaminant concentrations did not exceed their respective DWS, and the affected area was limited to the southeastern corner of the WMA at that time.

Groundwater at WMA U is currently monitored under DOE/RL-2009-74. The objective of RCRA monitoring at WMA U is to assess the extent and concentrations of dangerous waste constituents in the groundwater and determine their rate of movement. See RPP-35485 for a discussion of vadose zone conditions beneath the WMA, and see the 200-UP technetium-99 section of this report for a discussion of the technetium-99 plume. Table B-86 of Appendix B provides a list of wells and constituents monitored for WMA U. Well 299-W18-30 became dry during 2013, so it was not sampled during 2014. A replacement well, 299-W18-260, was drilled during 2014 and will be sampled beginning in 2015. All other required sampling was performed successfully during 2014.

11.13.2.1 Water-Level and Well Network Evaluation

Groundwater flow beneath WMA U is being affected by the 200 West P&T system. Trend surface analyses were performed on five sets of water-level measurements at WMA U during 2014, and the average hydraulic gradient magnitude was 4.1×10^{-3} m/m, an increase from the average of 3.6×10^{-3} m/m during 2013. An extraction well, 299-W17-3, is located 150 m (490 ft) north-northeast of the WMA (Figure 11-38). Drawdown around this well accounts for the increased gradient magnitude at WMA U. In response to pumping in this well, the groundwater flow direction beneath the WMA was expected to turn toward the northeast. However, the average direction during 2014 was similar to previous years: east-northeast at 82 degrees azimuth.

The average hydraulic gradient for 2014, 4.1×10^{-3} m/m, was used to estimate the flow rate beneath the WMA. The groundwater flow rate (i.e., average linear velocity) ranged from 0.035 to 0.39 m/d (0.11 to 1.3 ft/d), depending on the hydraulic conductivity and effective porosity selected. Using values believed to be most representative, 6.12 m/d (20.1 ft/d) for the hydraulic conductivity and 0.17 for the effective porosity from a constant rate pumping test conducted in Well 299-W19-42 (Section 7.4 of PNNL-13378), the groundwater flow rate most representative for this site is 0.15 m/d (0.49 ft/d). This is an increase from the estimated best value of 0.13 m/d (0.43 ft/d) for 2013.

Water levels in the monitoring wells declined an average of 0.54 m (1.77 ft) between March 2013 and March 2014. This is larger than the long-term average decline of 0.27 m (0.89 ft) between 2006 and 2011. The larger decline is due to drawdown associated with the 200 West P&T system, particularly operation of nearby extraction Well 299-W17-3 (which is operated for the 200-ZP-1 groundwater remedy).

Based on the distribution of wells at the WMA and the groundwater flow direction, DOE believes the well network is currently capable of monitoring the distribution of contamination from the WMA. Table B-87 in Appendix B summarizes water-level data for WMA U. The WMA U will remain in interim status groundwater quality assessment monitoring for 2015.

11.13.2.2 Assessment Results

WMA U has been identified as the source of groundwater contamination limited to the downgradient (east) side of the tank farm (Section 6.0 of PNNL-13282). The dangerous waste constituent chromium and supporting constituent nitrate are present in the groundwater (Table B-88 in Appendix B). During 2014, chromium was detected in several downgradient wells at concentrations ranging from 5.2 to 21 µg/L. Concentrations in upgradient Well 299-W18-40 averaged 4.2 µg/L. These concentrations

are below the 48 µg/L cleanup level for hexavalent chromium in 200-UP-1. While chromium is highly mobile in the aquifer, it can migrate more slowly than nitrate in the vadose zone beneath the tank farms, at least initially. This has been attributed to a reduction process where tank fluids dissolve divalent iron minerals in the sediment. The iron then reacts with the soluble hexavalent chromium, reducing it to trivalent chromium, which precipitates as an insoluble iron chromium hydroxide (Zachara et al., 2007, "Geochemical Processes Controlling Migration of Tank Wastes in Hanford's Vadose Zone"). This vadose zone reaction may explain the present low concentrations of chromium in the groundwater.

During 2014, nitrate concentrations were greater than the 45 mg/L cleanup level in six of the seven monitoring wells at the U Tank Farm, including the upgradient well, 299-W18-40. The source of the nitrate from upgradient was the former 200-ZP interim action P&T system injection wells (Section 3.3.5 of DOE/RL-2011-118). The maximum 2014 nitrate sample result was 102 mg/L in Well 299-W19-45 during July.

Chromium and nitrate are mobile in the aquifer; thus, their rate of migration (toward the east-northeast) is equal to the calculated groundwater flow rate of 0.15 m/d (0.49 ft/d).

Water samples were collected during drilling of replacement monitoring Well 299-W18-260. The results showed that the contamination is present in the upper part of the aquifer (Table 11-2; Figure 11-12). Nitrate concentrations were above the 45 mg/L cleanup level at the uppermost two sample depths (3 and 8.4 m [10 and 28 ft] below the water table), and were below the cleanup level at the deeper sample depths. The maximum concentration was 57.1 mg/L at 3 m (10 ft) below the water table.

11.13.3 216-S-10 Pond and Ditch

The 216-S-10 Pond and Ditch, located outside the southwestern corner of the 200 West Area , consisted of an unlined ditch, 1.2 m (3.9 ft) wide at its base and 686 m (2,250 ft) long, connected to a pond covering 0.02 km^2 (0.008 mi^2). The pond was shaped like a backwards "E" with an extra leg, where each leg was a separate leaching trench. The ditch was also connected to the 216-S-11 Pond, which was an overflow pond to accommodate excess discharges. During its active life from 1951 through 1991, the site received 6.6×10^9 L (1.7 billion gal) of effluent from the REDOX Plant chemical sewer. Monitoring wells are shown in Figure 11-39.

The groundwater beneath 216-S-10 is monitored under interim status regulations to determine whether dangerous waste constituents have affected groundwater (DOE/RL-2008-61). The monitoring well network consists of one upgradient well (699-33-76), four downgradient wells screened in the upper part of the aquifer at the water table (299-W26-13, 299-W26-14, 699-32-76, and 699-33-75), and one downgradient well screened 50 m (164 ft) below the water table (299-W27-2). Table B-35 of Appendix B includes a list of wells and constituents sampled for the 216-S-10 unit.

During 2014, all groundwater samples required by the monitoring plan (DOE/RL-2008-61) were collected as scheduled.

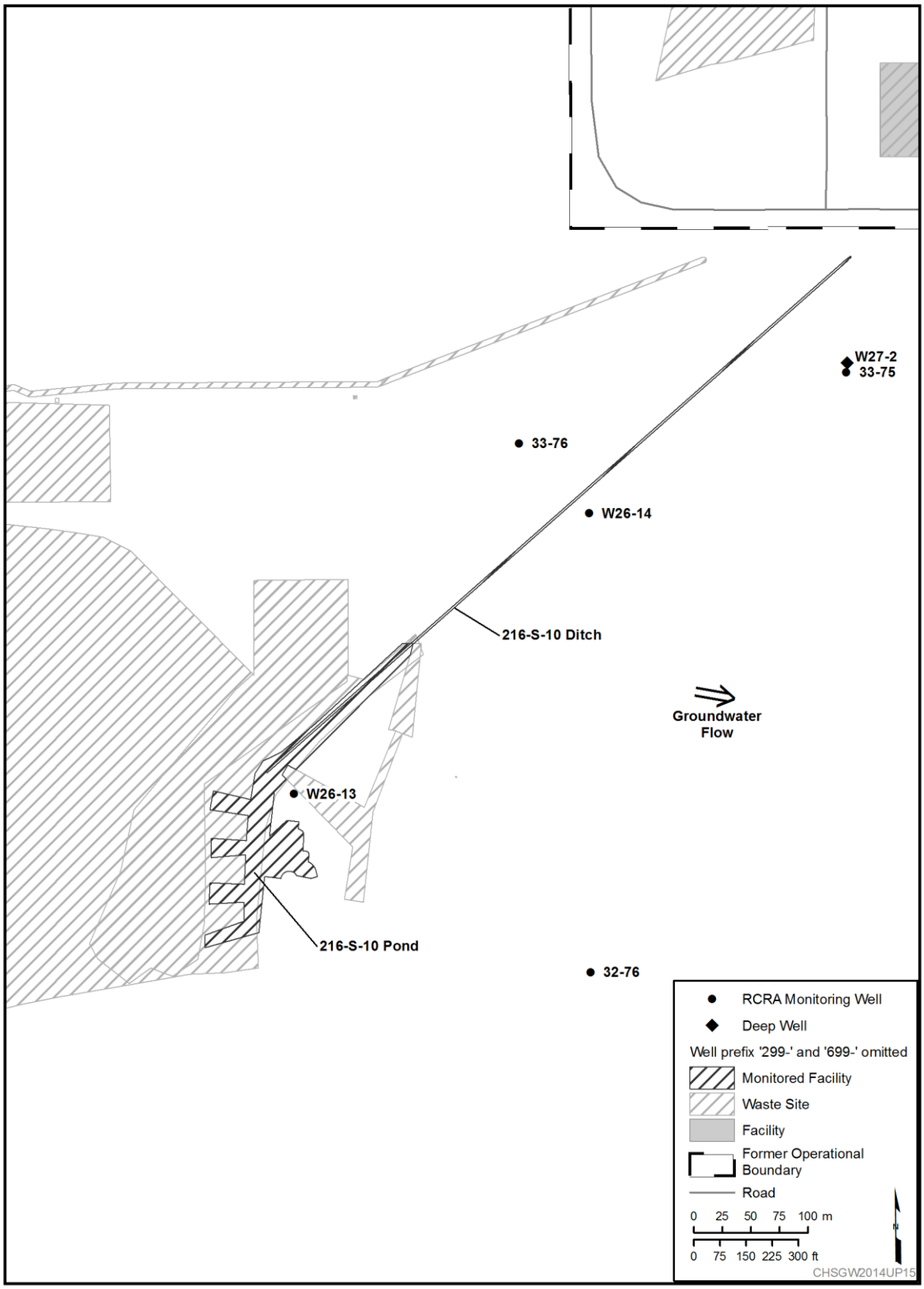


Figure 11-39. 200-UP RCRA Facility 216-S-10 Monitoring Well Locations

11.13.3.1 Water-Level and Well Network Evaluation

The hydraulic gradient beneath 216-S-10 was determined by trend surface analysis using water-level measurements collected during March and May 2014 from six wells: 299-W26-13, 299-W26-14, 699-32-76, 699-32-77 (March only), 699-33-75, and 699-33-76. The average direction of groundwater flow was calculated to be east southeast (104 degrees azimuth) with a hydraulic gradient magnitude of 2.9×10^{-3} m/m. Using a hydraulic conductivity range of 2 to 42.7 m/d (7 to 140 ft/d) (range of 14 hydraulic test results in the upper part of the aquifer at 216-S-10, excluding the high and low values) and an assumed effective porosity range of 0.1 to 0.2, the average linear velocity was estimated to range from 0.029 to 1.2 m/d (0.095 to 3.9 ft/d). Using a best hydraulic conductivity value of 10.4 m/d (34.1 ft/d) (constant rate discharge test at Well 299-W27-2 performed within a temporary open interval near the water table [WHC-SD-EN-DP-052]) and an assumed effective porosity of 0.15, the best estimate average linear velocity is 0.20 m/d (0.66 ft/d). Water levels in the network wells have been declining at a long term average rate of 0.23 m/yr (0.75 ft/yr) from 2010 to 2014.

Based on the calculated groundwater flow direction, DOE believes the monitoring well network remains capable of detecting constituents migrating from the 216-S-10 unit into the uppermost aquifer. Table B-37 in Appendix B summarizes water-level data for 2014.

11.13.3.2 Sampling Results

No exceedances of an indicator parameter critical mean occurred during 2014. Specific conductance is near the critical mean (363 µS/cm) in downgradient Well 699-32-76 (average value of 331 µS/cm during 2014), but the trend declined slightly during 2014 (Figure 11-40). Between 2007 and 2012, specific conductance generally trended upward in Well 299-W26-13 from annual average values of 270 to 310 µS/cm (Figure 11-40). The increasing trend correlated to increasing chromium and nitrate concentrations (Figure 11-24). From 2012 through 2014, specific conductance has been relatively stable, consistent with the nitrate trends. However, the chromium concentration has continued to increase and is above the 100 µg/L total chromium DWS (average value of 122 µg/L in November 2014). The 216-S-10 Pond and Ditch is probably the source of this chromium, because there are no other substantial chromium sources in the area (according to Appendix C of RPP-26744). Remediation of the groundwater is addressed by the 200-UP-1 ROD (EPA et al., 2012). The monitored natural attenuation component of the selected remedy is applicable to this plume. Table B-38 in Appendix B summarizes 2014 water quality parameters.

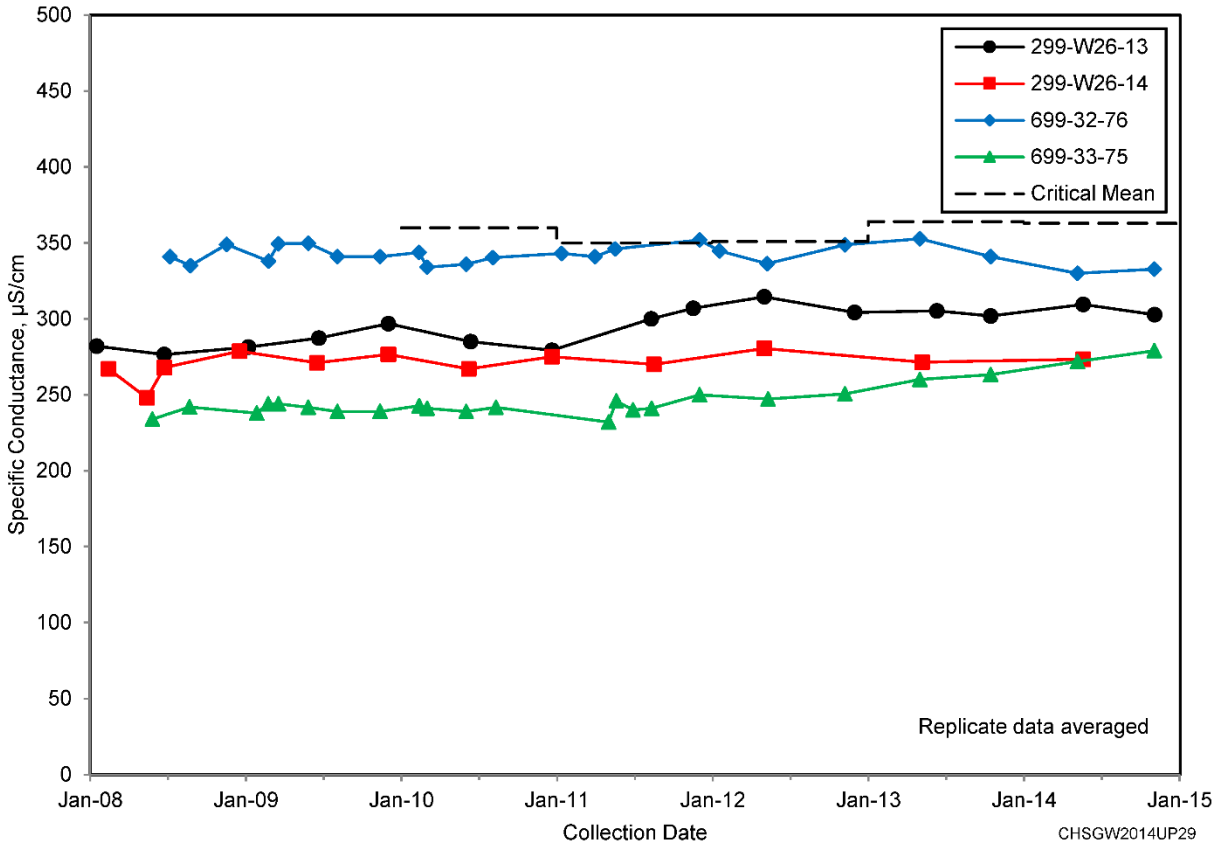


Figure 11-40. 200-UP Specific Conductance Data for Monitoring Wells at 216-S-10

Elevated levels of total organic halides formerly were detected in downgradient Well 699-33-75, but concentrations were near or below detection limits in 2014, far below the critical mean (49.82 µg/L). The average concentration was 4.7 µg/L during 2014, a decline from an average of 7.7 µg/L during 2013. Elevated total organic halides in this well was attributed to carbon tetrachloride, which has been detected in several wells within the 216-S-10 monitoring network. Well 699-33-75 has the highest concentrations in the network with an average of 7.2 µg/L during 2014. This is above the 3.4 µg/L cleanup level. Concentrations of carbon tetrachloride and total organic halides are trending downward in Well 699-33-75. Carbon tetrachloride is also detected in upgradient Well 699-33-76 (3.7 µg/L in 2014). This constituent does not originate from 216-S-10. It is widespread in the groundwater beneath and near the 200 West Area and originates from waste disposal sites at PFP.

Concentrations of chromium (unfiltered), iron (unfiltered), and nickel (filtered and unfiltered) continue to be elevated in Well 299-W27-2, which is screened 50 m (164 ft) below the water table. These constituents are stainless-steel corrosion products and this well is constructed of stainless-steel components. Corrosion of the well screen has been observed by a downhole camera survey confirming that the source of the elevated metals is corrosion.

12 200-ZP

12.1 Overview

The 200-ZP groundwater interest area is located in the northern and central portions of the 200 West Area and nearby portions of the 600 Area. It includes the 200-ZP-1 Groundwater OU, where activities focus on groundwater remediation, monitoring, and reporting. Figure 12-1 shows key facility areas and groundwater wells. Groundwater COCs include carbon tetrachloride, chromium (total and hexavalent), iodine-129, nitrate, technetium-99, TCE, and tritium (EPA et al., 2008). Table 12-1 lists some key facts about 200-ZP. Section 1.3 of the Introduction provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

Carbon tetrachloride is the main COC in groundwater, forming a plume greater than 13 km^2 (5 mi^2) in area extending north, south, and east from the source areas. The primary sources were associated with discharges of liquid waste from the PFP plutonium separation processes to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches. Except for nitrate, the remaining contaminant plumes within 200-ZP are located within the boundaries of the carbon tetrachloride plume. Figure 12-2 illustrates the change in plume area from 2003 to 2014 for each of the COCs.

Within 200-ZP, groundwater occurs in an unconfined aquifer and in confined aquifers beneath the Ringold lower mud unit and between the basalt flows. The unconfined aquifer is the aquifer directly impacted by past waste disposal operations. The unconfined aquifer occurs within Ringold unit E; its base is the fine-grained Ringold lower mud unit, where present, or the top of basalt, where the mud is absent in areas where the Ringold Formation sediments were eroded by Ice Age floods and subsequently filled with Hanford formation sediments (Figure 12-3). Depths from land surface to the water table range from 64 to 106 m (210 to 350 ft), with the largest depths occurring in the northeastern portion. The thickness of the unconfined aquifer within the interest area ranges from 8 to 68 m (26 to 220 ft) on the east and north sides, respectively (PNNL-13858). In those areas where the Ringold lower mud unit is missing in the stratigraphic sequence, carbon tetrachloride migrated below the mud unit and into Ringold Formation unit A. The contaminated groundwater then flows beneath the lower mud unit, contaminating the Ringold confined aquifer.

Groundwater in the 200 West Area generally flows east-northeast (Figure 12-4), but is influenced by the 200 West P&T and, to a lesser extent, effluent discharges to the State-Approved Land Disposal Site (SALDS). When 200 West facilities were active, disposal of liquid effluent raised the water table throughout the area and altered directions of groundwater flow. Cessation of effluent disposal in the 1990s caused the water table to drop. Since 2012, groundwater extraction wells for the 200 West P&T have created cones of depression that affect flow in a large part of the interest area. Injection of treated water west of the contaminant plumes has created groundwater mounds that create radial flow for a limited distance around the wells and steepen gradients toward the east. More injection wells located in the eastern part of the interest area help control migration of contaminant plumes in that direction. Section 12.11 discusses groundwater flow directions beneath the RCRA facilities in 200-ZP.

Groundwater flow rates range from 0.0001 m/d (0.0003 ft/d) in fine-textured, lower permeability Ringold sediments, to 0.6 m/d (2 ft/d) in coarse-textured, higher permeability Hanford sediments (SGW-38815). Detailed discussions of geology and hydrogeology within 200-ZP are provided in DOE/RL-2011-118, Rev. 0.

Groundwater in 200-ZP is monitored under CERCLA to assess the performance of the final remedy as documented in the ROD (EPA et al., 2008); under RCRA at WMA T, WMA TX-TY, Low-Level Waste Management Area (LLWMA)-3 Burial Ground, and LLWMA-4 Burial Ground; and under the

Washington Administrative Code at the SALDS. Radionuclide monitoring is performed in accordance with the AEA and CERCLA. Figure 12-1 shows wells sampled in 2014.

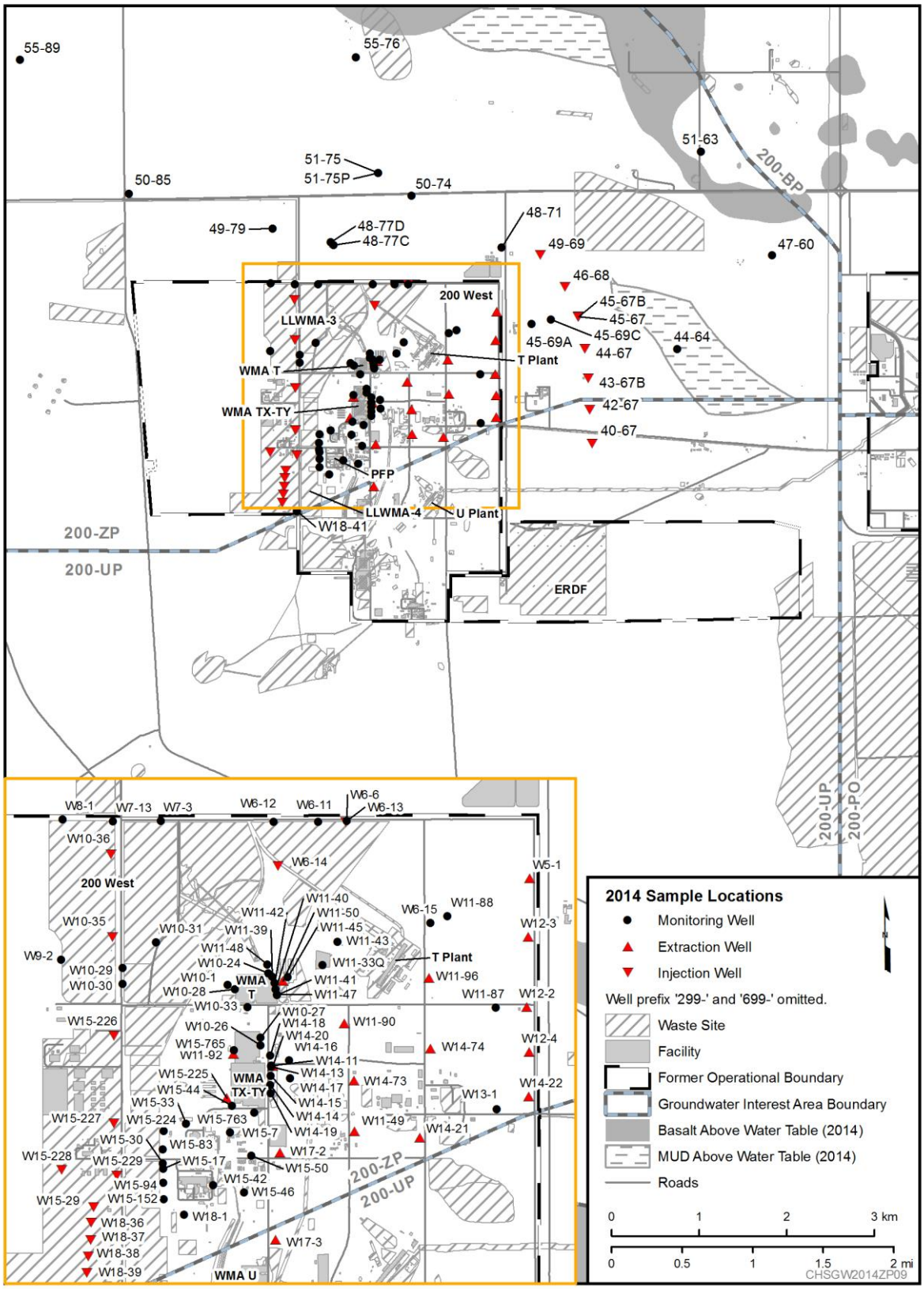


Figure 12-1. 200-ZP Wells and Key Facilities

Table 12-1. 200-ZP-1 at a Glance

T Plant operations: 1944 to 1956 (plutonium separation)
Plutonium Finishing Plant operations: 1949 to 1989

2014 Groundwater Monitoring				200 West Pump and Treat	
Contaminant	**Cleanup Level**	**Maximum Concentration**	**Plume Area[a] (km^2)**	**Mass or Activity Removed (2014)**	**Mass or Activity Removed (2012 to 2014)**
Carbon tetrachloride	3.4 µg/L	2,000 µg/L	17.9[b]	2,898 kg	6,478 kg
Chromium (Total and Hexavalent)	100/48 µg/L[c,d]	186/190 µg/L	0.33	75 kg	166 kg
Iodine-129	1 pCi/L	1.88 pCi/L	0.06	NA[e]	242,000,000 pCi
Nitrate	45[f] mg/L	536 mg/L	8.4	251,595 kg	495,682 kg
Technetium-99	900 pCi/L	21,500 pCi/L	0.03	1.31 Ci (77 g)	2.98 Ci (175 g)
Trichloroethene	1 µg/L	13 µg/L	3.25	10 kg	25.7 kg
Tritium	20,000 pCi/L	14,200 pCi/L	0.23	N/A	N/A
Uranium[g]	30 µg/L		N/A	0.77 kg	1.90 kg

a. Estimated area above listed cleanup level.
b. Area of full plume footprint (includes 200-UP-1 OU), all depths in unconfined aquifer.
c. 100 µg/L federal DWS for total chromium.
d. 48 µg/L groundwater cleanup standard for hexavalent chromium.
e. Iodine-129 concentrations were undetected in the influent and effluent in 2014.
f. Nitrate as nitrate; 10 mg/L nitrate as nitrogen.
g. Uranium is not a COC in 200-ZP-1; contaminant is extracted from wells in the 200-UP-1 OU.
COCs = contaminant of concern
DWS = drinking water standard

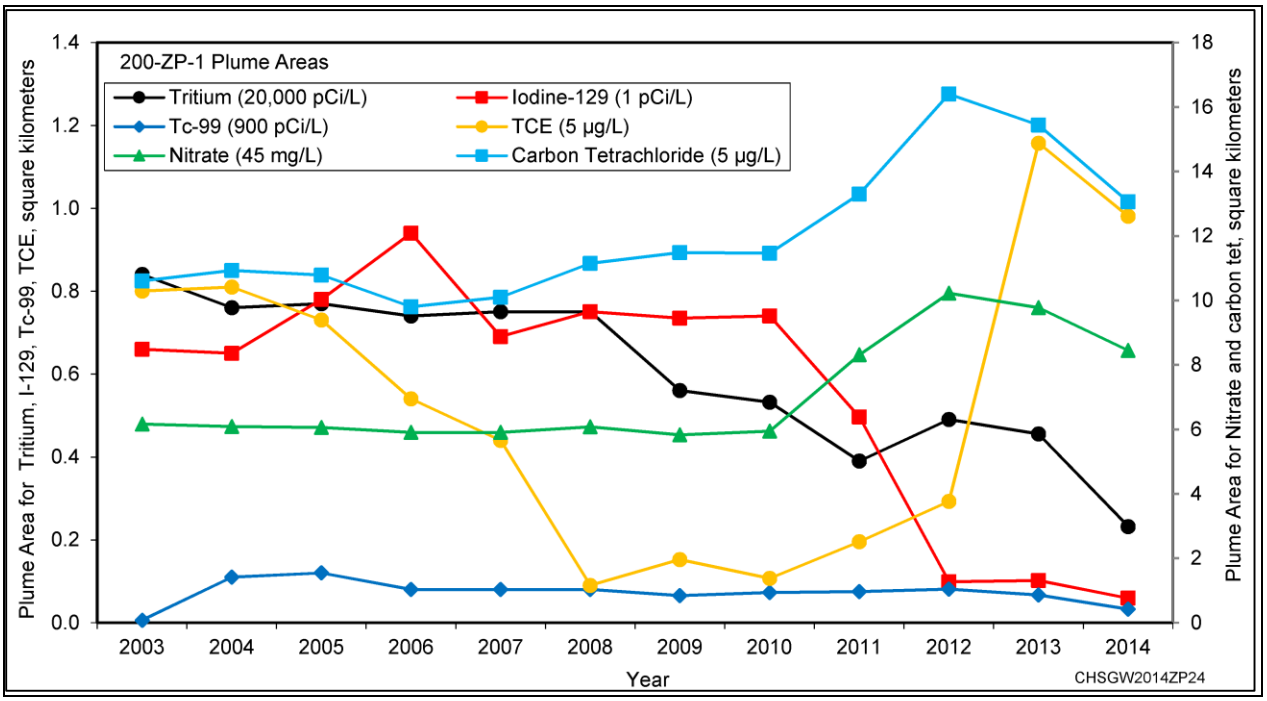


Figure 12-2. 200-ZP Plume Areas, 2014

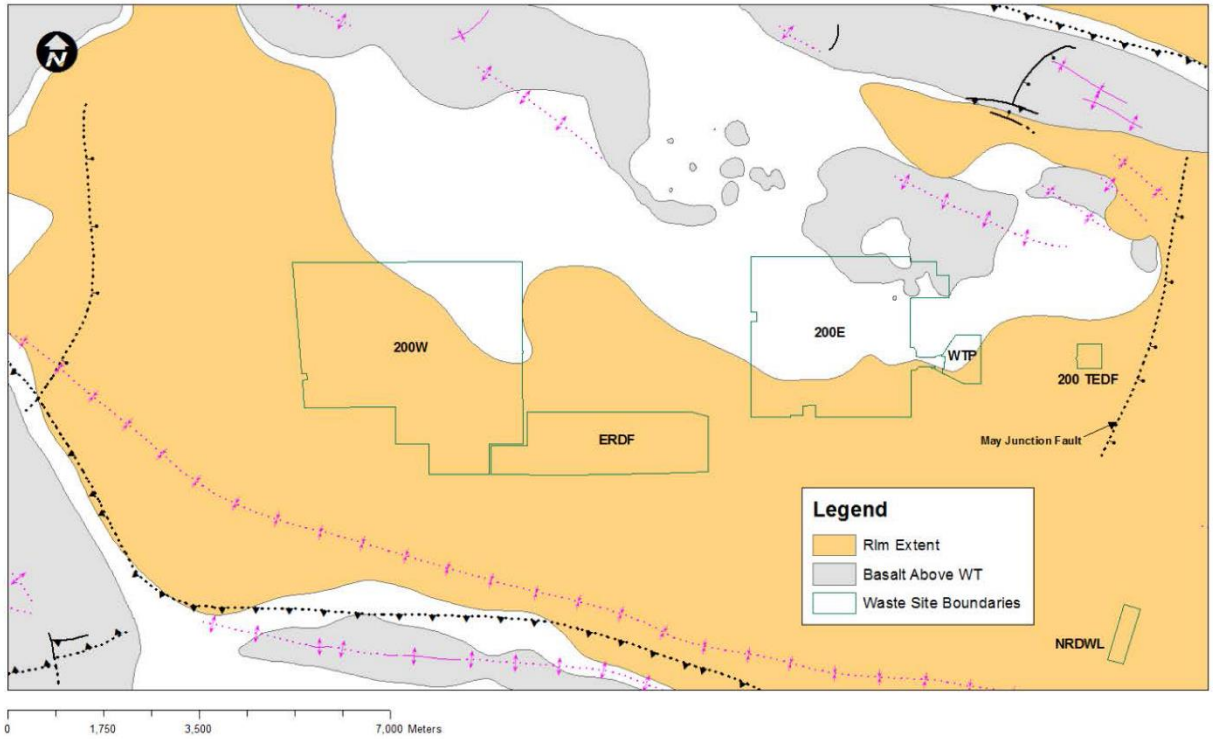


Figure 12-3. Ringold Lower Mud Unit Extent

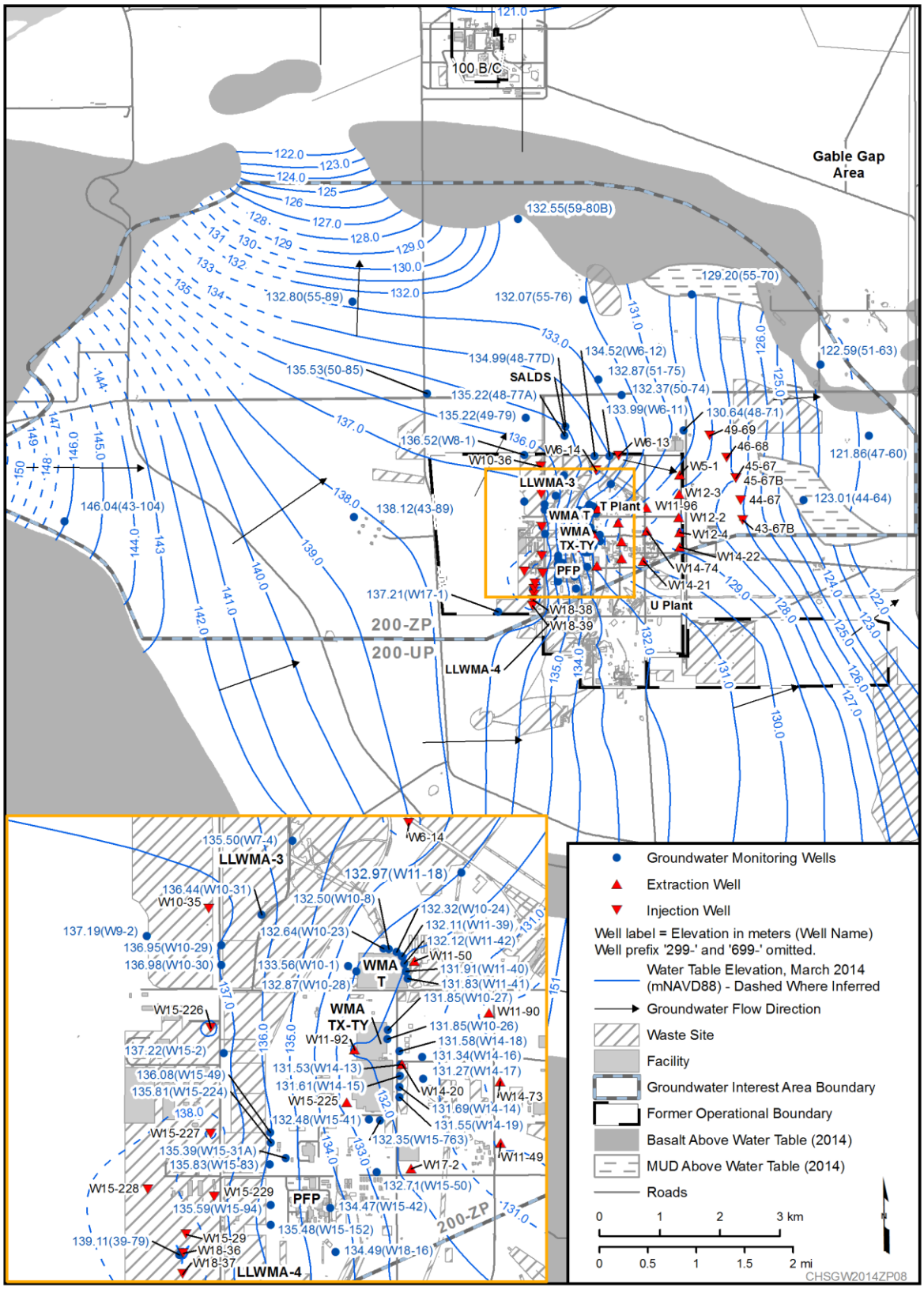


Figure 12-4. 200-ZP Overview with Groundwater Flow

12.2 CERCLA Activities

Groundwater contaminants in the 200-ZP-1 OU are being cleaned up under a CERCLA ROD (EPA et al., 2008).

The selected remedy in the ROD consists of a combination of the following remedy components: MNA, ICs, flow-path controls, and P&T of the contamination. The 200 West P&T began operations in 2012 and operated continuously in 2013 and 2014. Groundwater is monitored to assess the effectiveness of the remedy (DOE/RL-2009-115). Table A-13 of Appendix A lists the wells and constituents monitored under CERCLA.

Between 1996 and 2012, an interim remedial measure was active in 200-ZP-1. Both the 200-ZP-1 interim P&T system and WMA T P&T system were removed from service in 2012. Background information on the interim systems can be found in DOE/RL-2012-03. Description of the 200 West P&T facility is included in DOE/RL-2015-06. Additional information on the 200 West P&T, including 2014 activities, are found in the Section 12.10.

12.3 Carbon Tetrachloride

Carbon tetrachloride is found at concentrations greater than the final cleanup level (3.4 µg/L) and the DWS of 5 µg/L under most of the 200 West Area (Figure 12-5). Initially, carbon tetrachloride concentrations exceeding 2,000 µg/L were located beneath the PFP. After 16 years of interim P&T operations and 2.5 years of the final remedy, the areal extent of the 2,000 µg/L contour in the upper portion of the aquifer was reduced from 0.53 km^2 (0.20 mi^2) in 1996 to zero in 2014.

Continued investigations during drilling of groundwater monitoring, extraction, and injection wells revealed carbon tetrachloride concentrations greater than 1,000 µg/L throughout the entire thickness of the aquifer, not just the upper 15 m (50 ft). Figure 12-6 provides a visual cross-section through a three-dimensional conceptual model of the carbon tetrachloride plume. The data supporting this figure were derived from groundwater samples collected for all wells screened above the basalt within the unconfined aquifer.

As shown on the plume map (Figure 12-5), carbon tetrachloride extends to the east from the source areas. Prior to the start of 200-ZP-1 interim actions in 1996, concentrations of carbon tetrachloride in 17 extraction wells and 23 monitoring wells exceeded 2,000 µg/L, and 20 of those wells exceeded 4,000 µg/L. In 2014, sample results indicate no wells with carbon tetrachloride concentrations above 4,000 µg/L, and only two wells with maximum concentrations at 2,000 µg/L (monitoring Well 299-W11-87 and extraction Well 299-W11-90) (Figure 12-7). Extraction Wells 299-W17-2, 299-W11-50, and 299-W14-20 had the next highest concentrations at 1,800 µg/L, 1,600 µg/L, and 1,600 µg/L, respectively. The next highest concentrations in monitoring wells were 1,400 µg/L, 1,320 µg/L, and 1,200 µg/L in Well 299-W14-72, 299-W14-11, and 299-W10-1, respectively.

Concentrations of carbon tetrachloride are declining across 200-ZP as a result of capture by extraction wells and by natural attenuation processes (dispersion and degradation). The significant decline in both maximum carbon tetrachloride concentration (from 8,700 µg/L in 1990 to 2,000 µg/L in 2014) and in the number of wells exceeding 2,000 µg/L (from 40 wells to zero) demonstrates the effectiveness of the remedial actions in reducing carbon tetrachloride contamination. Concentrations continued to decline in most wells between 2012 and 2014 (Figure 12-7).

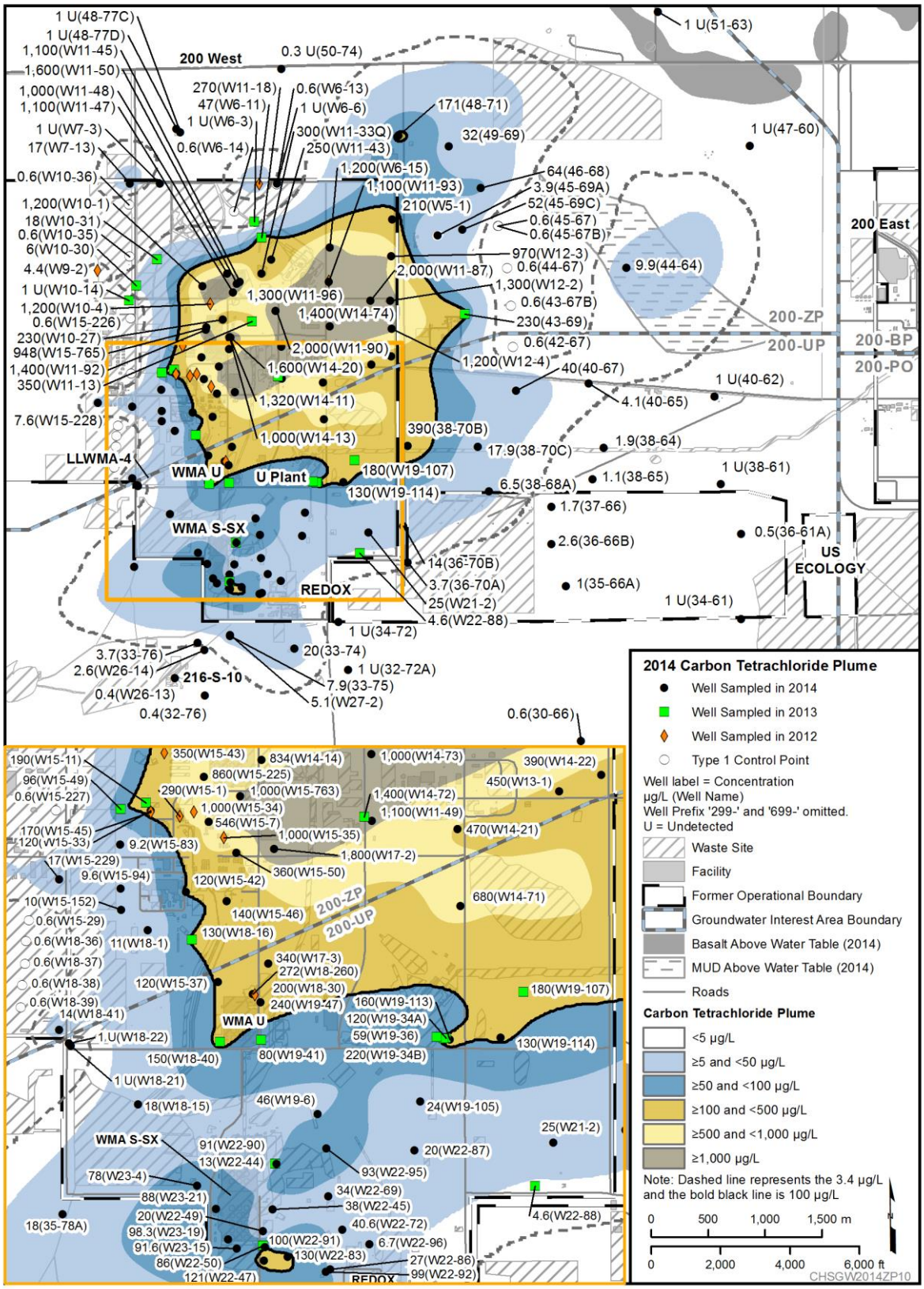


Figure 12-5. 200-ZP Carbon Tetrachloride Plume, 2014

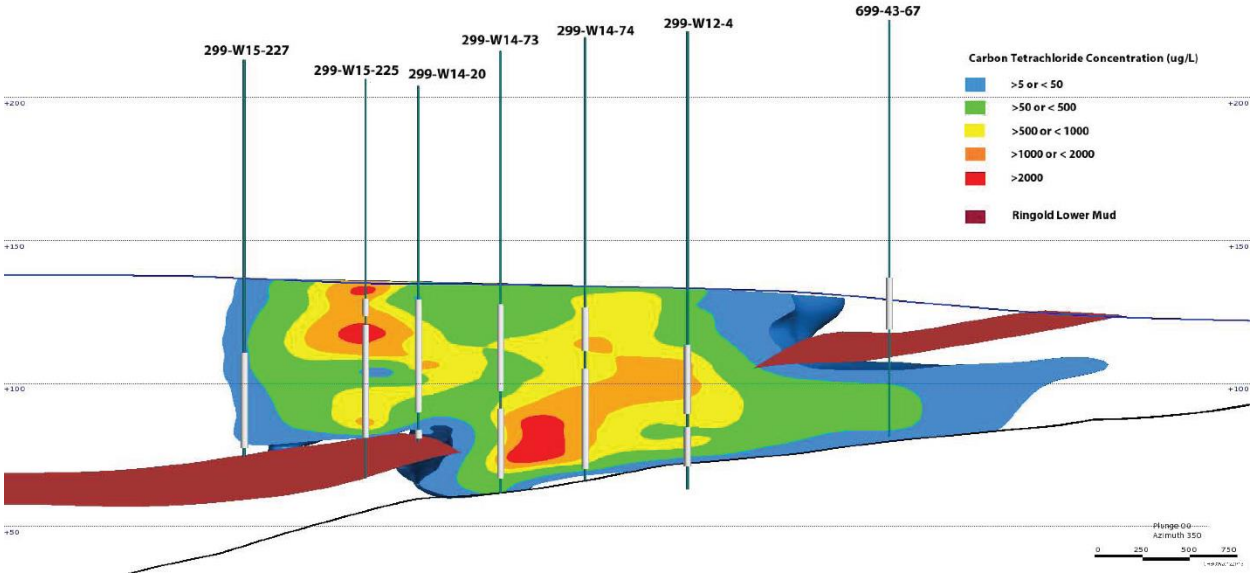


Figure 12-6. 200-ZP Carbon Tetrachloride Concentration Cross Section

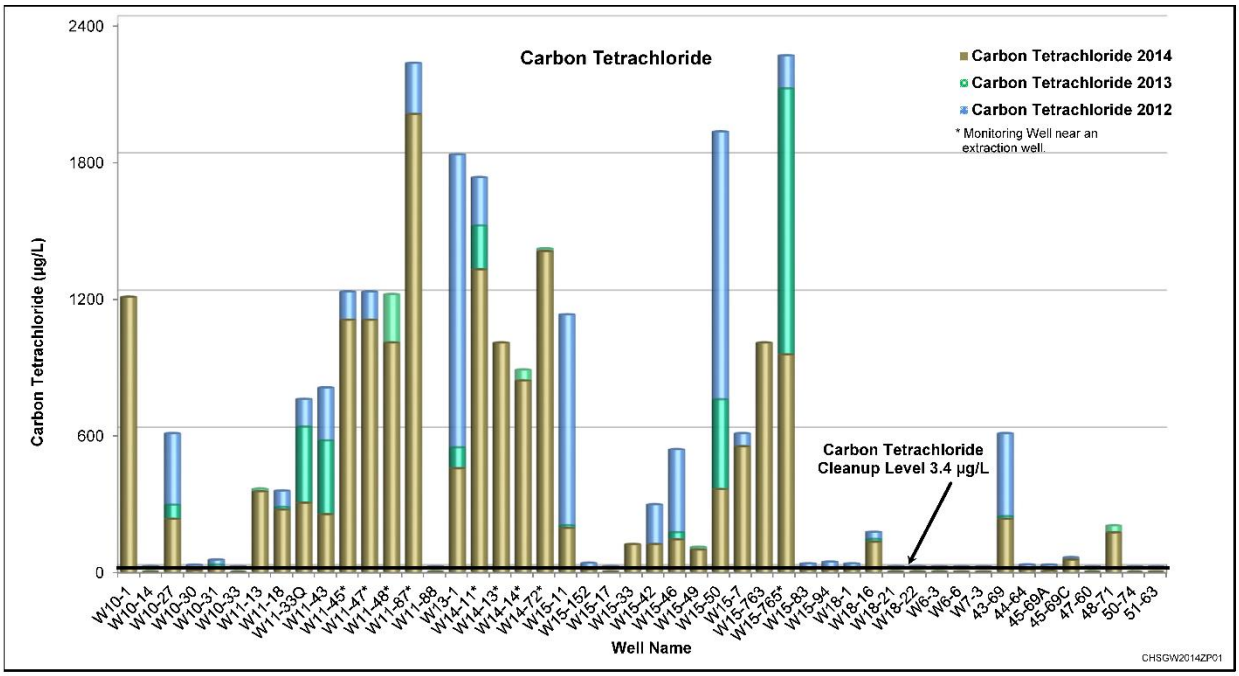


Figure 12-7. Comparison of Carbon Tetrachloride Concentrations in Monitoring Wells During 2012, 2013, and 2014

12.4 Chromium

Chromium contamination is found at concentrations above the final cleanup level (100 µg/L for total chromium and 48 µg/L for hexavalent chromium) beneath and downgradient of the single-shell tanks at WMA T and WMA TX-TY (Figures 12-8, 12-9, and 12-10; wells used for depiction of the 200-UP chromium plumes are shown in Figures 11-22). Sources of chromium contamination include past leaks from single-shell tanks containing metal and liquid waste from chemical processing of uranium-bearing, irradiated reactor fuel rods, the bismuth phosphate process, uranium-recovery process, and from REDOX and PUREX (located in the 200 East Area) plant operations (DOE/RL-2009-66; DOE/RL-2009-67).

In 2014, the maximum chromium concentration of 190 µg/L (hexavalent chromium) was found at Well 299-W11-43, located northeast of WMA T. This was an increase from 167 µg/L measured in this well in 2012. The increase in concentration is because the monitoring well is located near an extraction well, which is drawing groundwater from surrounding areas toward the extraction well. Monitoring Well 299-W15-763, south of WMA TX-TY, had an average chromium concentration of 285 µg/L in the unfiltered, total chromium samples, which is attributed to particulates and corrosion as the hexavalent chromium concentration averaged only 8.1 µg/L.

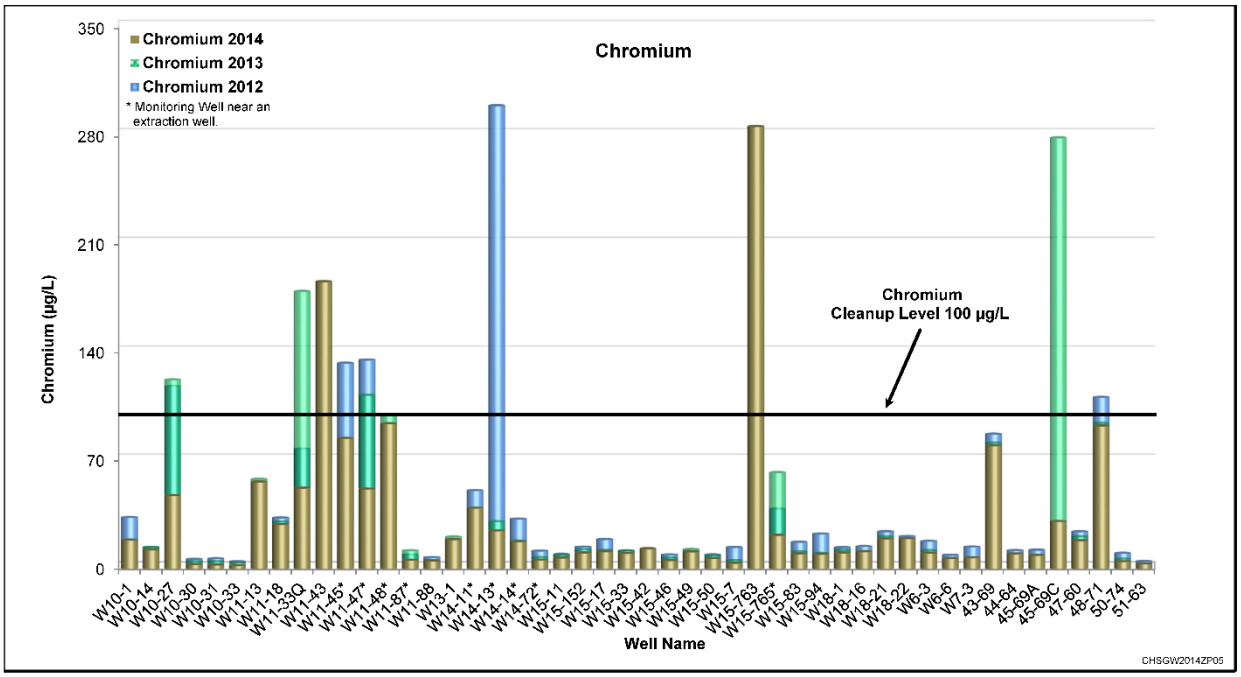


Figure 12-8. Comparison of Chromium Concentrations in Monitoring Wells During 2012, 2013, and 2014

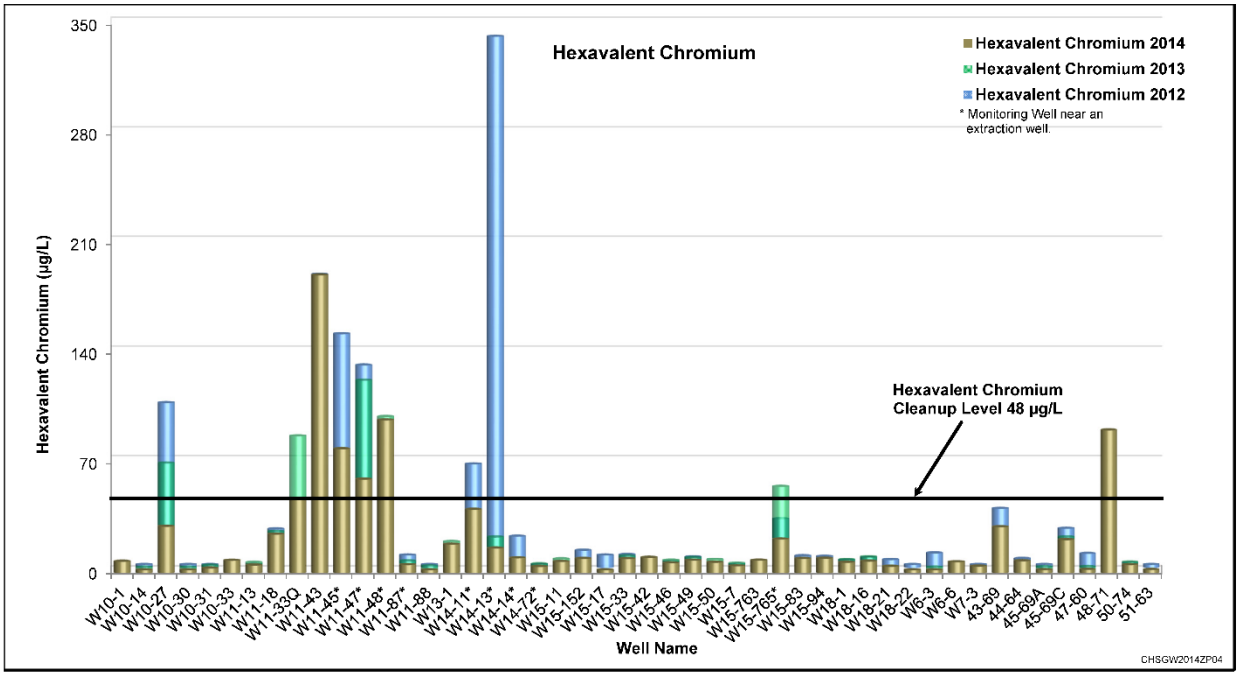


Figure 12-9. Comparison of Hexavalent Chromium Concentrations in Monitoring Wells During 2012, 2013, and 2014

Chromium concentrations in 699-48-71, located northeast of 200 West Area, have increased from 10 µg/L in 2000 (filtered, total chromium) to 93 µg ug/L (hexavalent chromium). The reason for the increase in unknown. This well will continue to be sampled under the 200-ZP-1 Performance Monitoring Plan (DOE/RL-2009-115).

The highest chromium concentration reported in 200 West extraction Well 299-W11-50 (located downgradient of WMA T Tank Farm) during 2014 was 89 µg/L. Chromium contamination in groundwater beneath WMA T is within the capture zone of the extraction well. Maximum chromium concentrations decreased in 200-ZP wells (Figure 12-8) as a result of the 200 West P&T remedial actions. The highest concentration reported in WMA TX-TY extraction Well 299-W14-20 during 2014 was 37 µg/L, a 53 percent reduction from the maximum chromium concentration of 79 µg/L in 2012. Chromium contamination in groundwater beneath WMA TX-TY is within the capture zone of the extraction well. Chromium concentrations are declining across 200-ZP; the areal extent of the chromium plume exceeding 48 µg/L decreased from 0.52 km^2 (0.20 mi^2) in 2012 to 0.33 km^2 (0.13 mi^2) in 2014 as a result of the 200 West P&T operations.

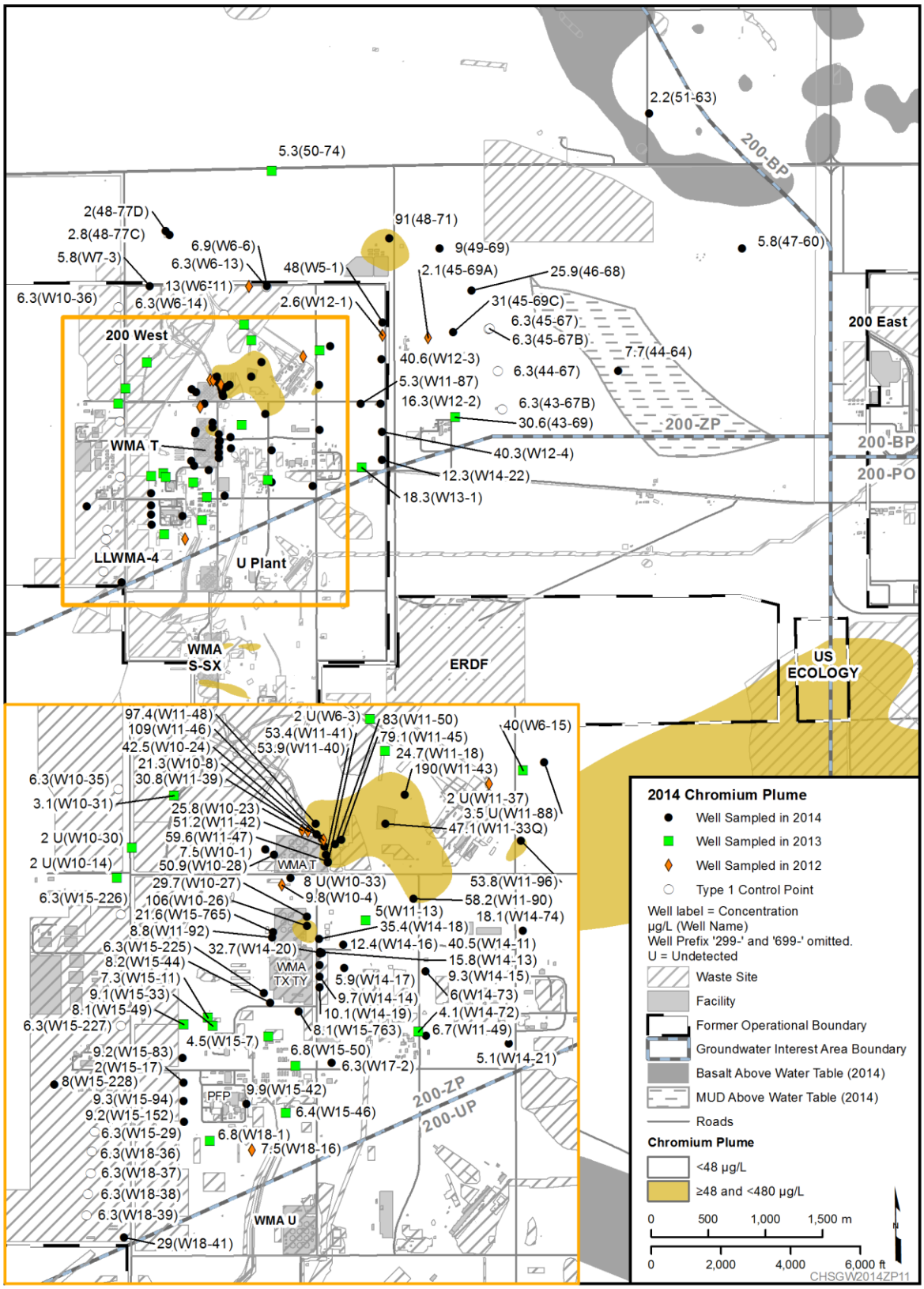


Figure 12-10. 200-ZP Chromium Plume, 2014

12.5 Iodine-129

In wells sampled in 2014, iodine-129 concentrations exceed the 1 pCi/L final cleanup level in only two wells east of WMA T: monitoring Well 299-W11-33Q at 1.88 pCi/L, and extraction Well 299-W6-15 at 1.22 pCi/L (Figure 12-11). Iodine-129 was detected above the 1 pCi/L final cleanup level in Well 299-W11-37 (1.50 pCi/L) located east of WMA T during the most recent sampling event in 2012, and in Well 299-W10-4 (1.35 pCi/L) located south of WMA T during the most recent sampling event in 2012. These wells could not be sampled in 2013 or 2014 because they were dry. Sources of iodine-129 include past leaks from single-shell tanks containing metal and liquid waste, and from chemical processing at T Plant. The plume map shows the extent and geometry of the iodine-129 plume at the 1 pCi/L final cleanup level. The detection limit for iodine-129 is approximately 0.2 pCi/L. Iodine-129 also exceeded the final cleanup level in Well 299-W14-15 (a RCRA monitoring well with 1.84 pCi/L), during the most recent sampling event in 2012.

The highest iodine-129 concentrations found in WMA T extraction Well 299-W11-50 and WMA TX-TY extraction Well 299-W14-20 measured 0.35 pCi/L and 0.26 pCi/L, respectively. Iodine-129 concentrations in 2014 declined compared to 2012 data, as did the areal extent of the iodine-129 plume, from 0.99 km^2 (0.038 mi^2) in 2012 to 0.059 km^2 (0.022 mi^2) in 2014. The greatest declines in iodine-129 concentrations occurred in monitoring wells located near extraction wells (Figure 12-12). For example, Well 299-W14-13 declined from 16 pCi/L in 2012 to less than 0.4 pCi/L in 2014 because the well is close to extraction Well 299-W14-20. Iodine-129 was detected in the influent to the radiological treatment system at low levels (less than 1 pCi/L) and was removed by the Purolite resin.

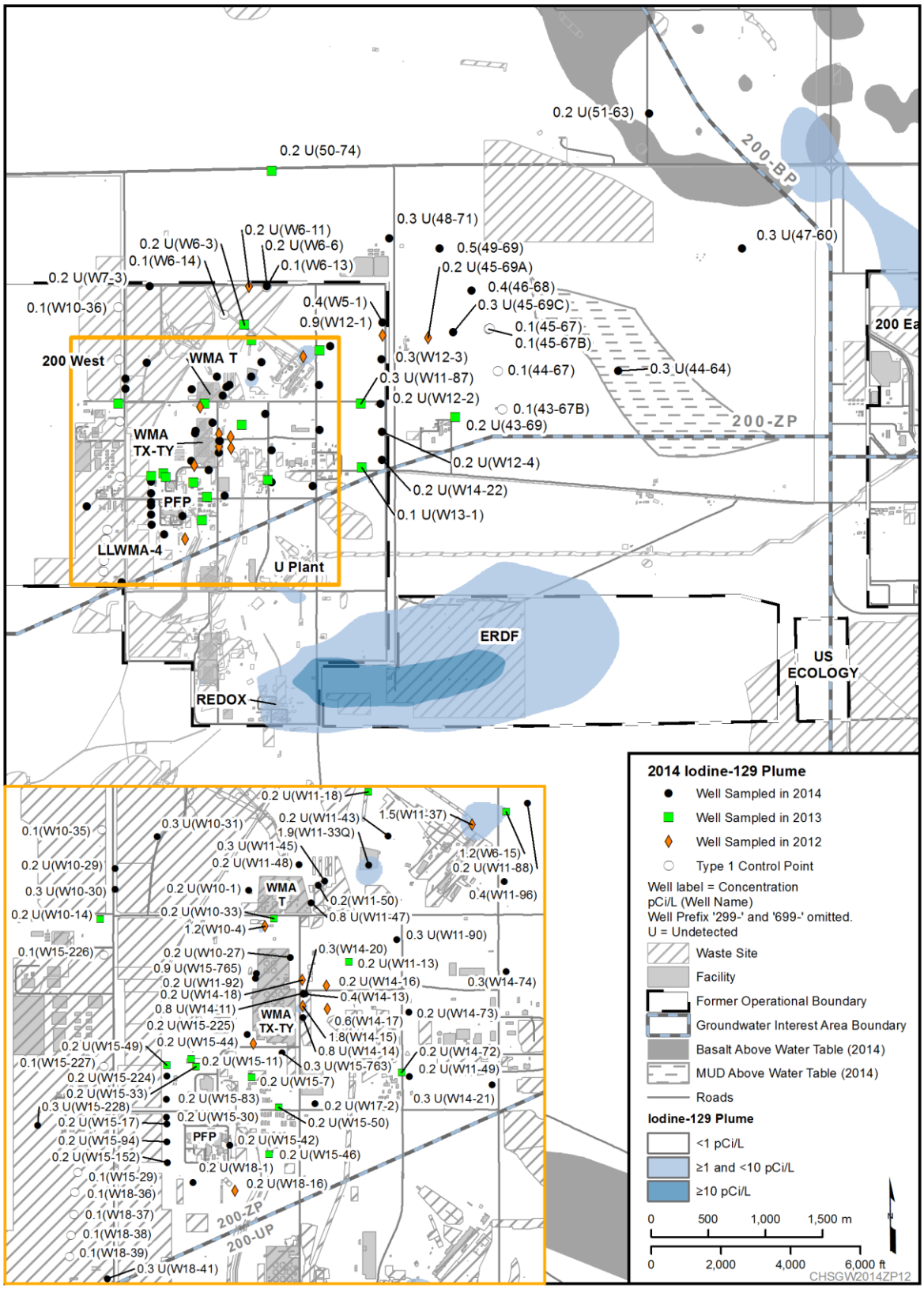


Figure 12-11. 200-ZP Iodine-129 Plume, 2014

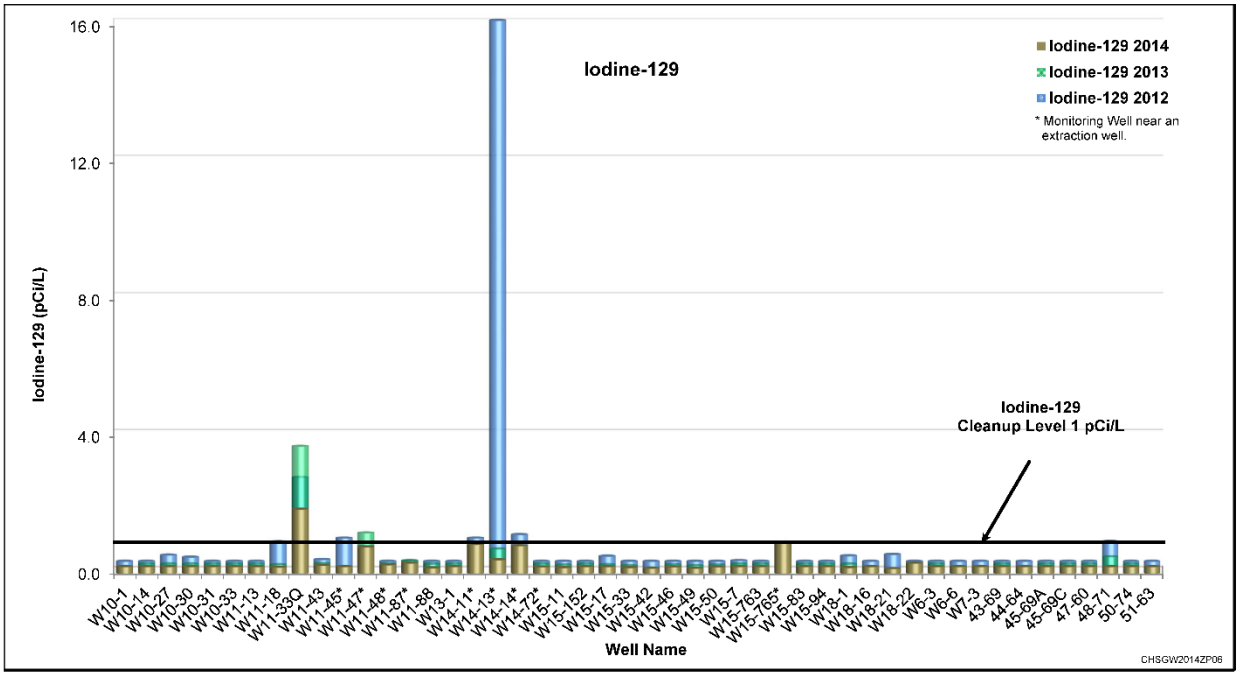


Figure 12-12. Comparison of Iodine-129 Concentrations in Monitoring Wells During 2012, 2013, and 2014

12.6 Nitrate

Nitrate concentrations greater than the final cleanup level (45 mg/L as nitrate) are present beneath much of 200-ZP (Figure 12-13). The size and concentration of contours in 2014 are less than those reported in 2013, from 11.1 km^2 (4.3 mi^2) in 2013 to 8.4 km^2 (3.2 mi^2) in 2014. Sources of nitrate included liquid waste disposal from PFP processes to the cribs near WMA T and the 216-Z Cribs and Trenches. Two discrete, high-concentration plumes are discernible: a plume located beneath WMA T and WMA TX-TY, and a plume observed at Well 299-W18-16 (near the 216-Z Cribs and Trenches). These plumes merge above the 45 mg/L contour extending from the 216-Z Cribs and Trenches to beyond the 200 West Area boundary to the northeast and the combined plume is distributed throughout the entire aquifer.

The high-concentration areas of the nitrate plume beneath WMA T and WMA TX-TY are located within the capture zones of 200 West P&T extraction Wells 299-W11-50 and 299-W14-20. The highest concentration at the 200-ZP wells for 2014 was 536 mg/L at Well 299-W14-13, an increase from previous years (Figure 12-13). The increase in nitrate concentration is likely because of the shifting of the regional nitrate plume and changes in groundwater flow in the area. Nitrate concentrations across 200-ZP are declining in most wells as a result of remedial efforts (Figure 12-14).

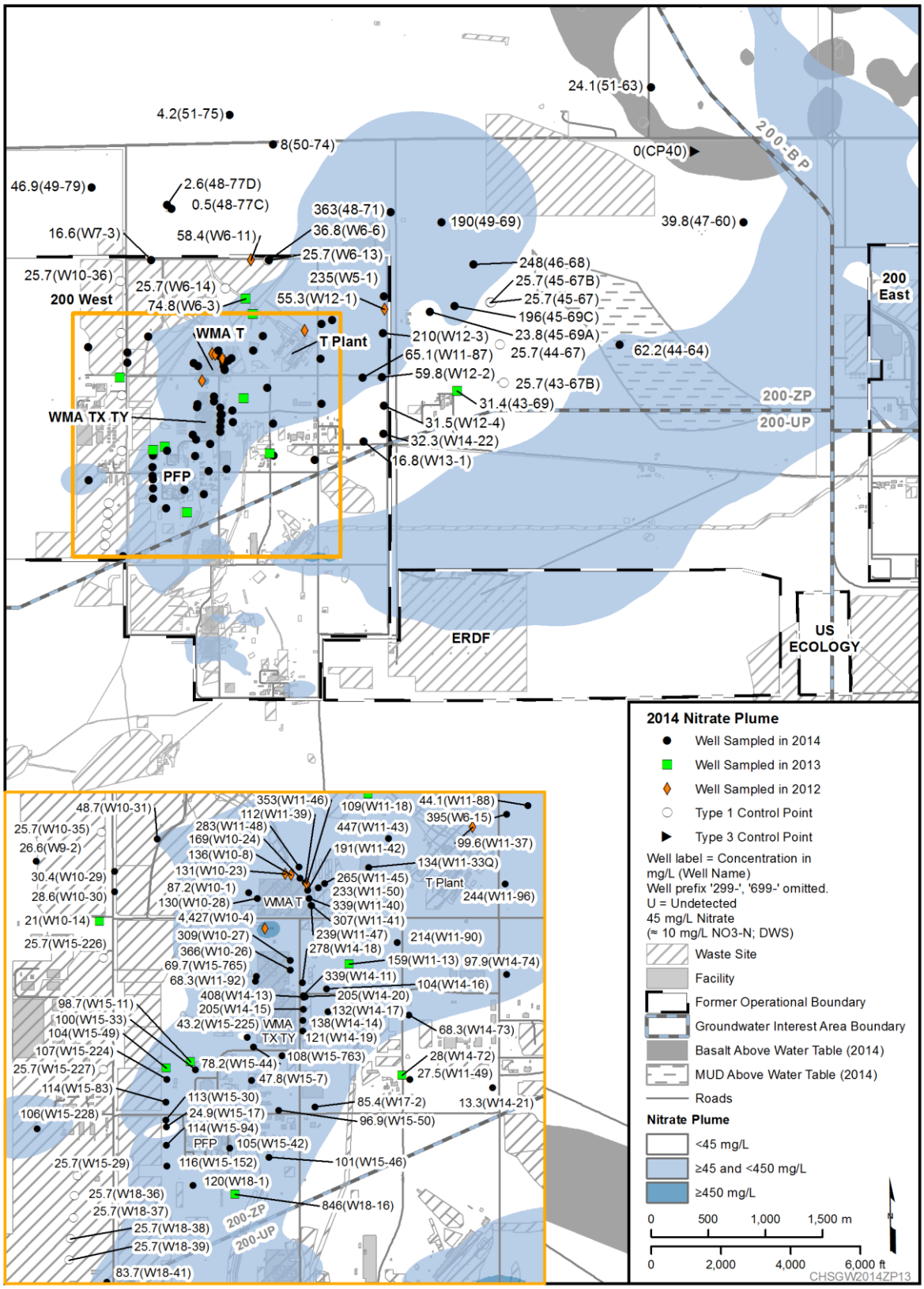


Figure 12-13. 200-ZP Nitrate Plume, 2014

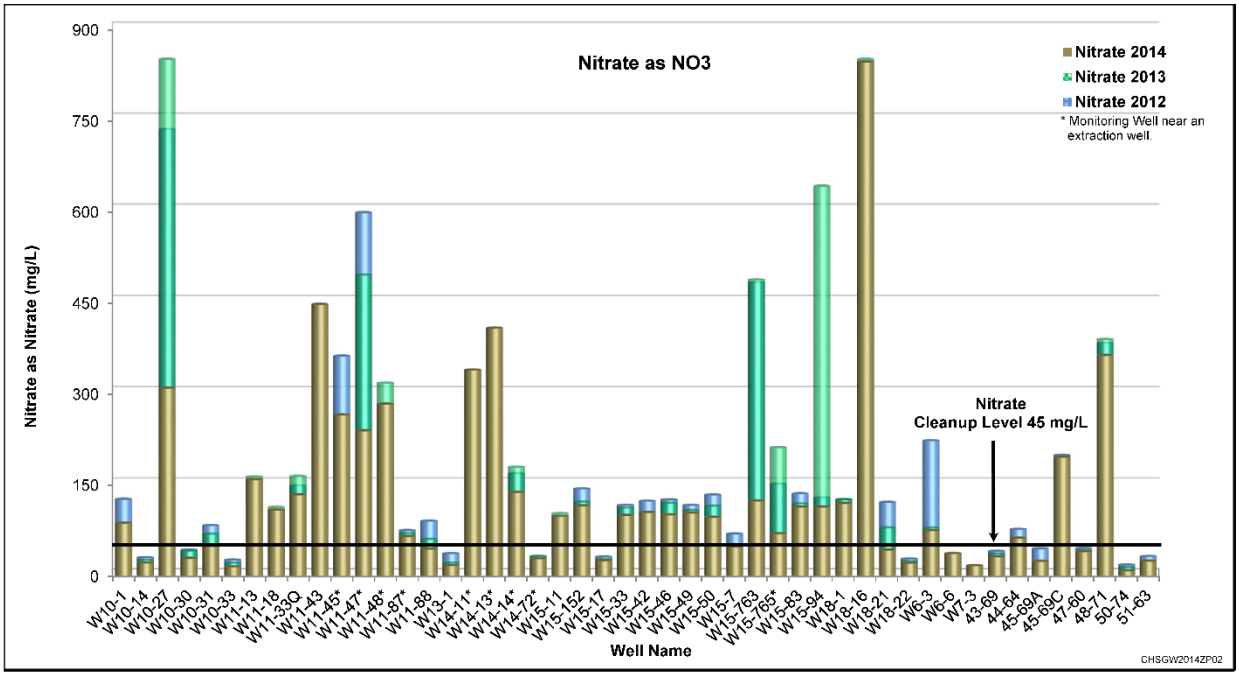


Figure 12-14. Comparison of Nitrate Concentrations in Monitoring Wells During 2012, 2013, and 2014

12.7 Technetium-99

Technetium-99 exceeded the 900 pCi/L final cleanup level at three monitoring wells in 2014 (Figure 12-15). Sources of technetium-99 contamination in 200-ZP were releases from past leaks in single-shell tanks and pipelines in WMA T and WMA TX-TY, and liquid waste disposal from plutonium-processing operations to cribs and trenches adjacent to the WMAs. Figure 12-15 shows two distinct technetium-99 plumes above the 900 pCi/L final cleanup level, centered at the north end of WMA TX-TY and beneath and east of WMA T. The highest concentration was 21,500 pCi/L in Well 299-W14-13, located east (downgradient) of WMA TX-TY. High technetium-99 concentrations also occurred in Well 299-W11-47 (11,800 pCi/L), 299-W14-11 (15,500 pCi/L), and in extraction Wells 299-W14-20 (2,110 pCi/L) and 299-W11-50 (1,510 pCi). The plumes assume the same eastward trend as other contaminant plumes in the OU. Technetium-99 contamination is found primarily in the upper 15 m (50 ft) of the unconfined aquifer.

Concentrations within the plume are declining. Before remediation activities began in 2007 at WMA T, 19 wells exceeded the DWS. During 2014, only five wells exceeded the cleanup level: three monitoring wells and two extraction wells (Figure 12-15 and 12-16). The three monitoring wells with increasing concentrations are located near extraction wells. Concentrations in these wells are increasing because the extraction wells are drawing groundwater in from surrounding areas. Plume size decreased from 0.11 km^2 (0.042 mi^2) in 2012 to 0.033 km^2 (0.013 mi^2) in 2014 as a result of remediation activities.

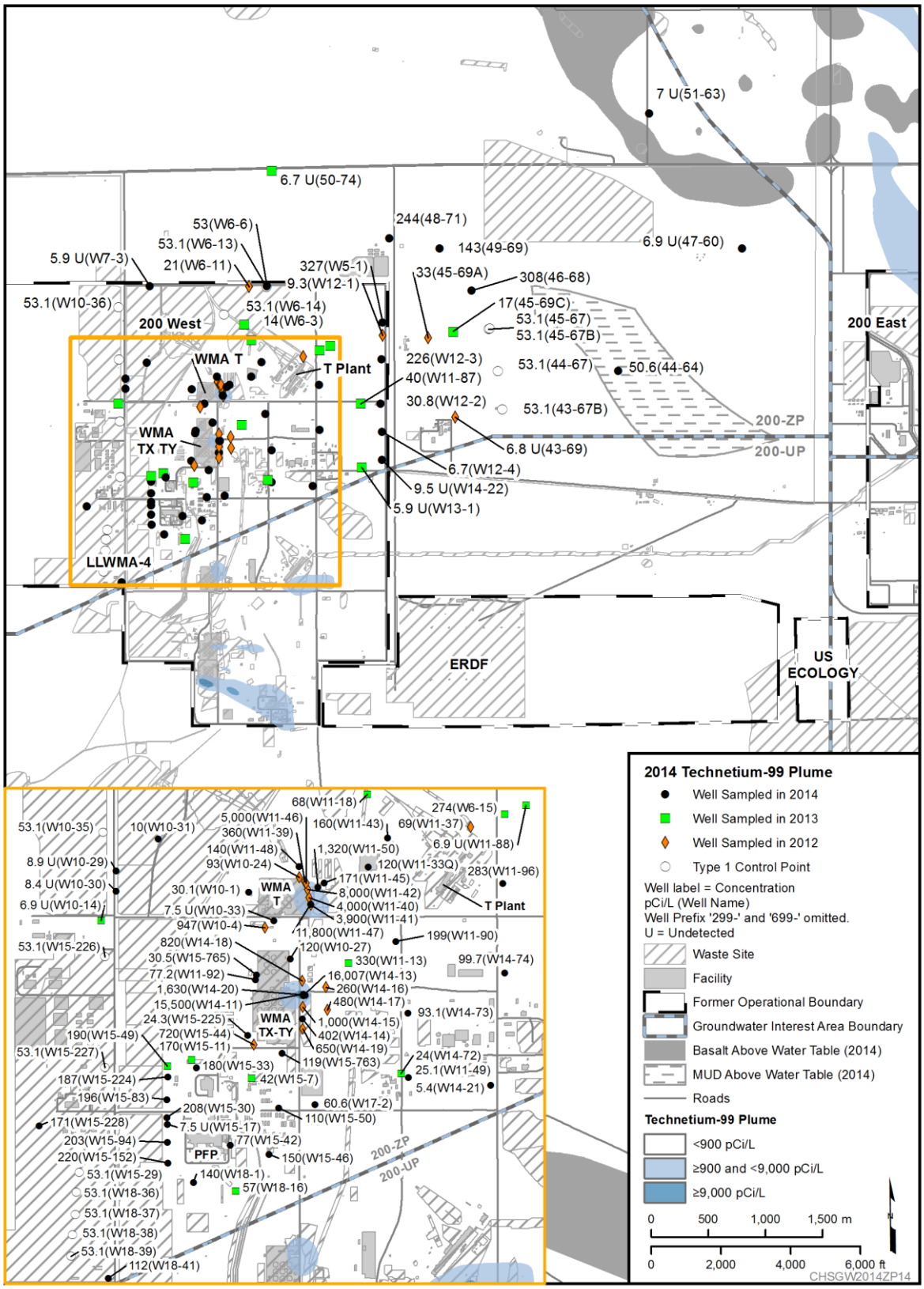


Figure 12-15. 200-ZP Technetium-99 Plume, 2014

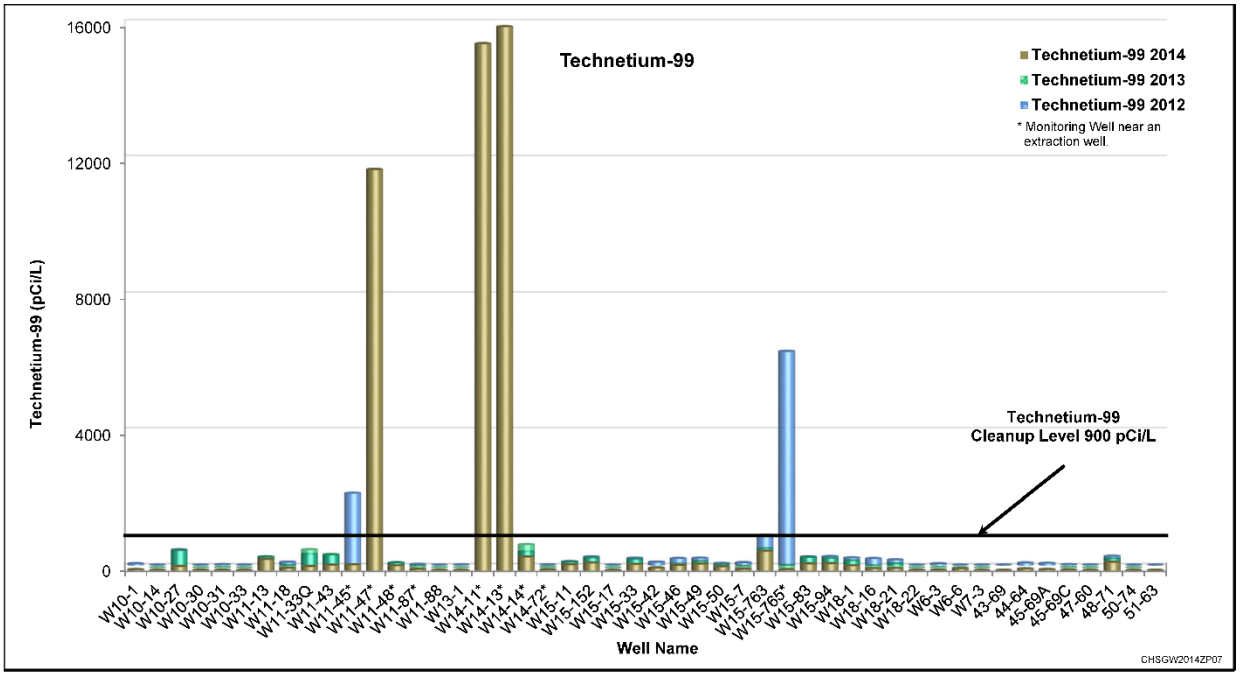


Figure 12-16. Comparison of Technetium-99 Concentrations in Monitoring Wells During 2012, 2013, and 2014

12.8 Trichloroethene

TCE is detected at levels above the final cleanup standard (1 µg/L) throughout much of 200-ZP (Figure 12-17). The TCE plume is co-located with the carbon tetrachloride plume and is found above the cleanup level from the water table to the bottom of the aquifer. The interpreted plume size increased between 2012 and 2014 because analytical sample data collected from varying depth intervals during drilling were used to better define the extent of the TCE plume. The detection limit for TCE is 0.5 µg/L.

The maximum TCE concentration reported during 2014 was 13 µg/L in extraction Well 299-W17-2. Concentrations declined in most wells with the exception of monitoring wells located near extraction wells (Figure 12-18). The increase in TCE concentration is caused by the influence on groundwater flow by nearby extraction wells. The high flow rate in extraction wells directs groundwater flow toward the extraction wells, effectively capturing contamination.

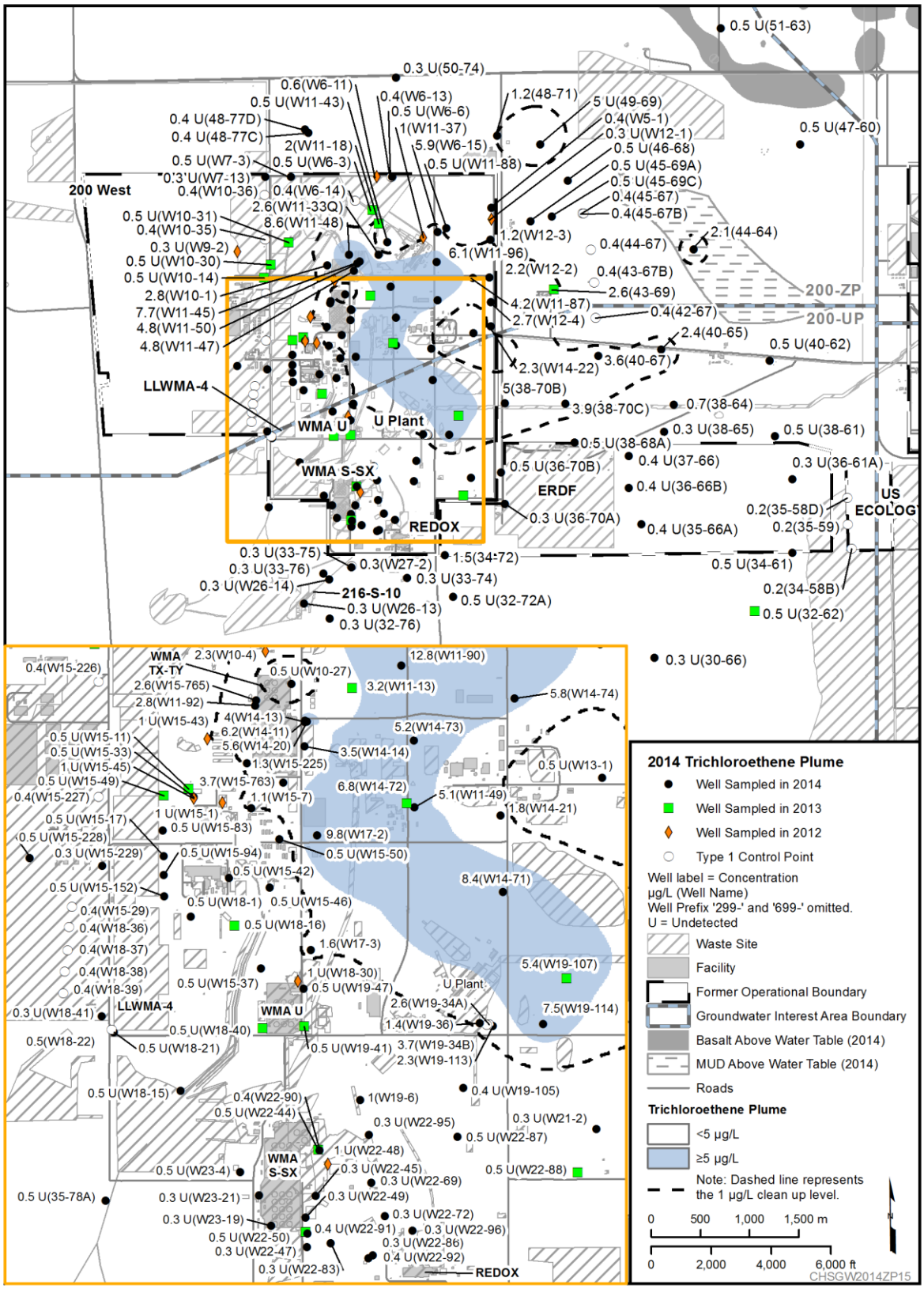


Figure 12-17. 200-ZP TCE Plume, 2014

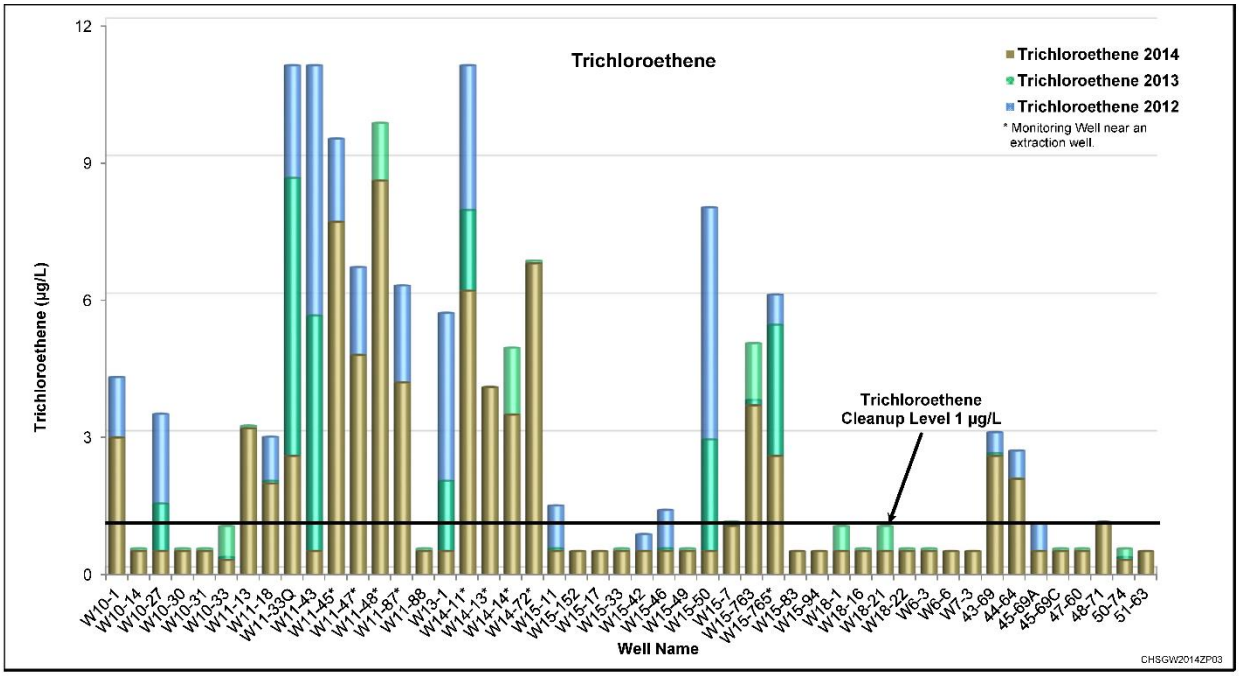


Figure 12-18. Comparison of TCE Concentrations in Monitoring Wells During 2012, 2013, and 2014

12.9 Tritium

Figure 12-19 shows the distribution of tritium in 200-ZP. Tritium concentrations did not exceed the final cleanup level of 20,000 pCi/L except in wells adjacent to the SALDS (699-48-77C and 699-48-77D) during 2014. Active permitted discharges at the SALDS are an ongoing source of tritium to groundwater in 200-ZP. Inactive sources of contamination are the liquid waste from plutonium processing to disposal facilities, including the 216-T-25 Trench, and past leaks from tanks and pipelines adjacent to WMA TX-TY. Tritium contamination is found primarily in the upper 15 m (50 ft) of the unconfined aquifer.

Outside the SALDS plume, tritium contaminant levels ranged from less than detection (<300 pCi/L) to 14,200 pCi/L in 200-ZP wells, with the highest concentration at extraction Well 299-W11-90 located east of WMA T. Tritium concentrations at wells near WMA T are declining (from a maximum tritium concentration of 2,940,000 pCi/L in 2000 to 14,200 pCi/L in 2014, which is a 99.5 percent decrease), suggesting that less contamination is moving from the vadose zone to groundwater.

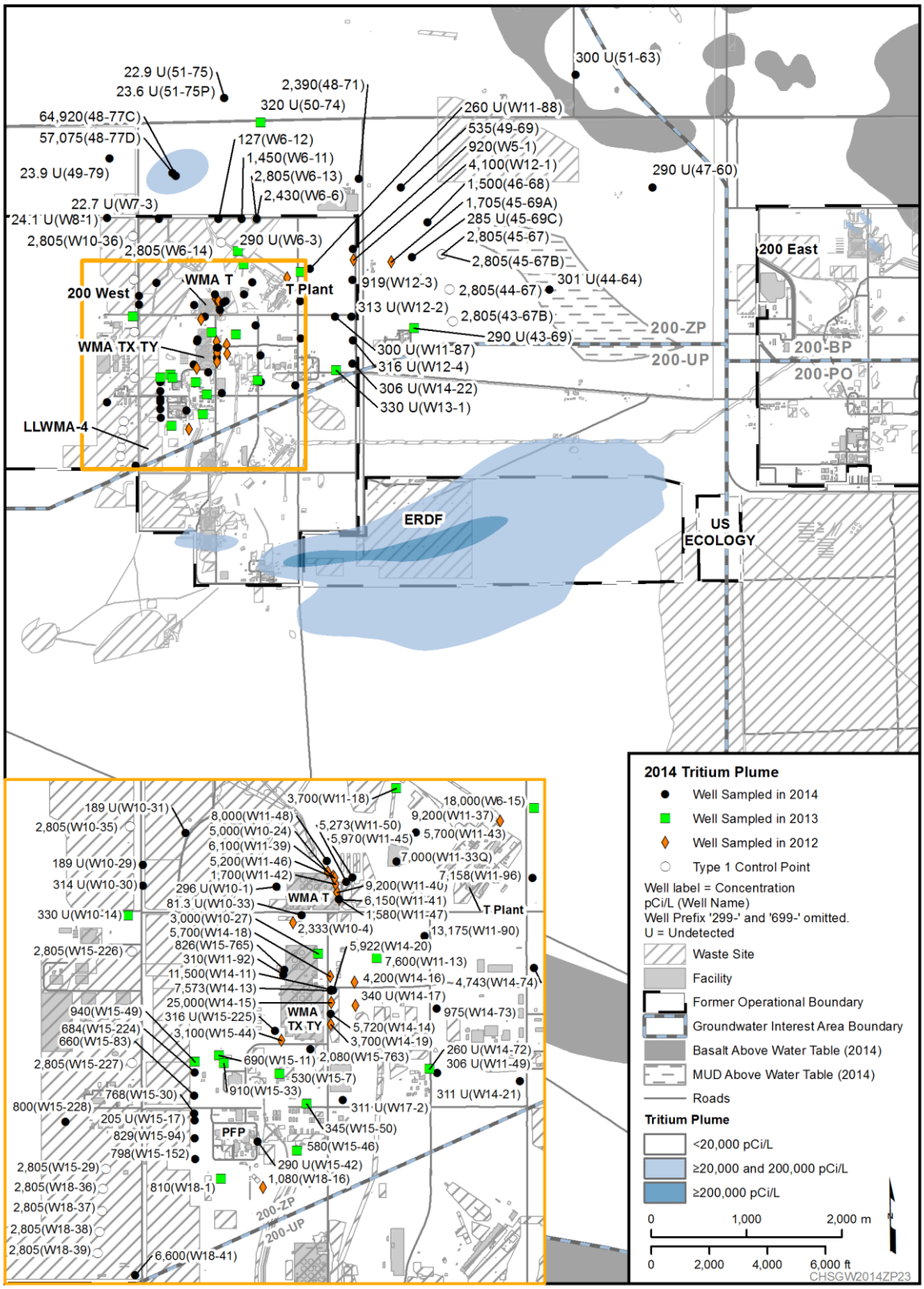


Figure 12-19. 200-ZP Tritium Plume, 2014

12.10 200-ZP-1 Remedies

Disposal of liquid wastes in the 200 West Area introduced an estimated 570,000 to 920,000 kg of carbon tetrachloride to the ground (DOE/RL-2006-58). As of December 2014, a final remedy P&T, a former interim remedy P&T, and vapor extraction systems have removed a total of 100,496 kg of carbon tetrachloride from the subsurface. Remediation also removes other contaminants including nitrate, chromium, and technetium-99.

12.10.1 Pump and Treat

CERCLA final remedial measures in operation at 200-ZP include groundwater P&T, soil vapor extraction, and MNA (Figure 12-20).

The 200 West P&T as a final remedy was implemented for the 200-ZP-1 OU beginning in 2012. The new system has a capacity of 9,500 L/min (2,500 gpm) and is designed to capture and treat contaminated groundwater and reduce the mass of COCs throughout the 200-ZP-1 OU by a minimum of 95 percent in 25 years. The 200 West P&T removes contaminants of concern (COCs) from groundwater using ion exchange, anoxic and aerobic bioreactors, and air stripping. Since there is no cost effective method of groundwater treatment for tritium, and because of its short half-life, natural radioactive decay will reduce tritium concentrations to below the cleanup level of 20,000 pCi/L within 125 years by 2137. The 200 West P&T has been implemented in combination with MNA (after completion of the P&T component) to achieve cleanup levels for all COCs in 125 years. At the end of 2014, 20 extraction wells and 21 injection wells were in use, and the treatment plant was operating at a flow rate of 5,913 L/min (1,562 gpm) (71 percent of its design capacity). Because the new 200 West P&T addresses all of the groundwater contamination in the northern 200 West Area, the two interim action P&T systems that had addressed carbon tetrachloride near the PFP and technetium-99 at the T Tank Farm were shut down during May 2012.

The 200 West P&T extraction and injection well network (Figure 12-20) is designed to capture and contain contamination within 200-ZP-1. The new extraction wells are 20 cm (8 in.) in diameter with long screens (greater than 30 m) placed to within 3 m (10 ft) of the bottom of each well. Aquifer testing was used to ensure that spacing of extraction wells would be sufficient to capture contamination throughout the aquifer (DOE/RL-2010-13). The estimate of hydraulic capture (Figure 12-21) is based on particle tracking using the water level surfaces and the techniques are detailed in SGW-42305.

In 2014, tasks performed to execute the final 200-ZP-1 ROD (EPA et al., 2008) RAOs included the completion of 4 injection wells to supplement the 33 wells completed between 2009 and 2013. In 2014, continuous operation of the 200 West P&T resulted in 3.12 billion L (8.24 million gal) of contaminated groundwater treated from 21 extraction wells. Table 12-2 lists the mass of contamination removed from groundwater in 2014. Initial mass estimates for each COC are provided in Table 7-1 of ECF-Hanford-14-0037, *Description of Groundwater Calculations and Assessments for the Calendar Year 2013 (CY2013) 200 Areas Pump-and-Treat Report*. Concentrations of COCs in the treated water sent to the 21 operational injection wells were at or below cleanup levels. More details on the 200 West P&T performance can be found in DOE/RL-2015-06. A photograph of the 200 West P&T process facility is shown in Figure 12-22.

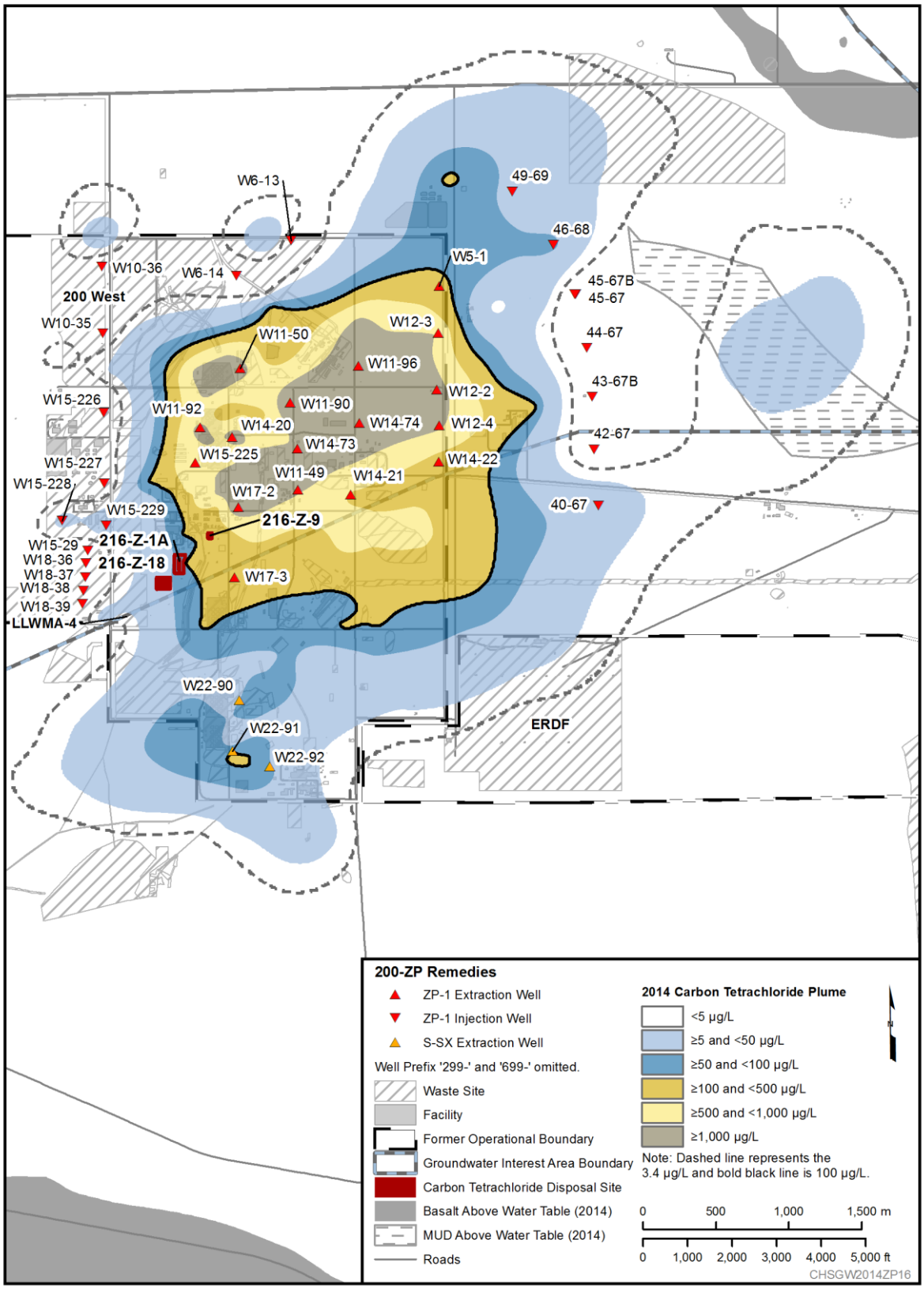


Figure 12-20. 200-ZP Remedy Overview

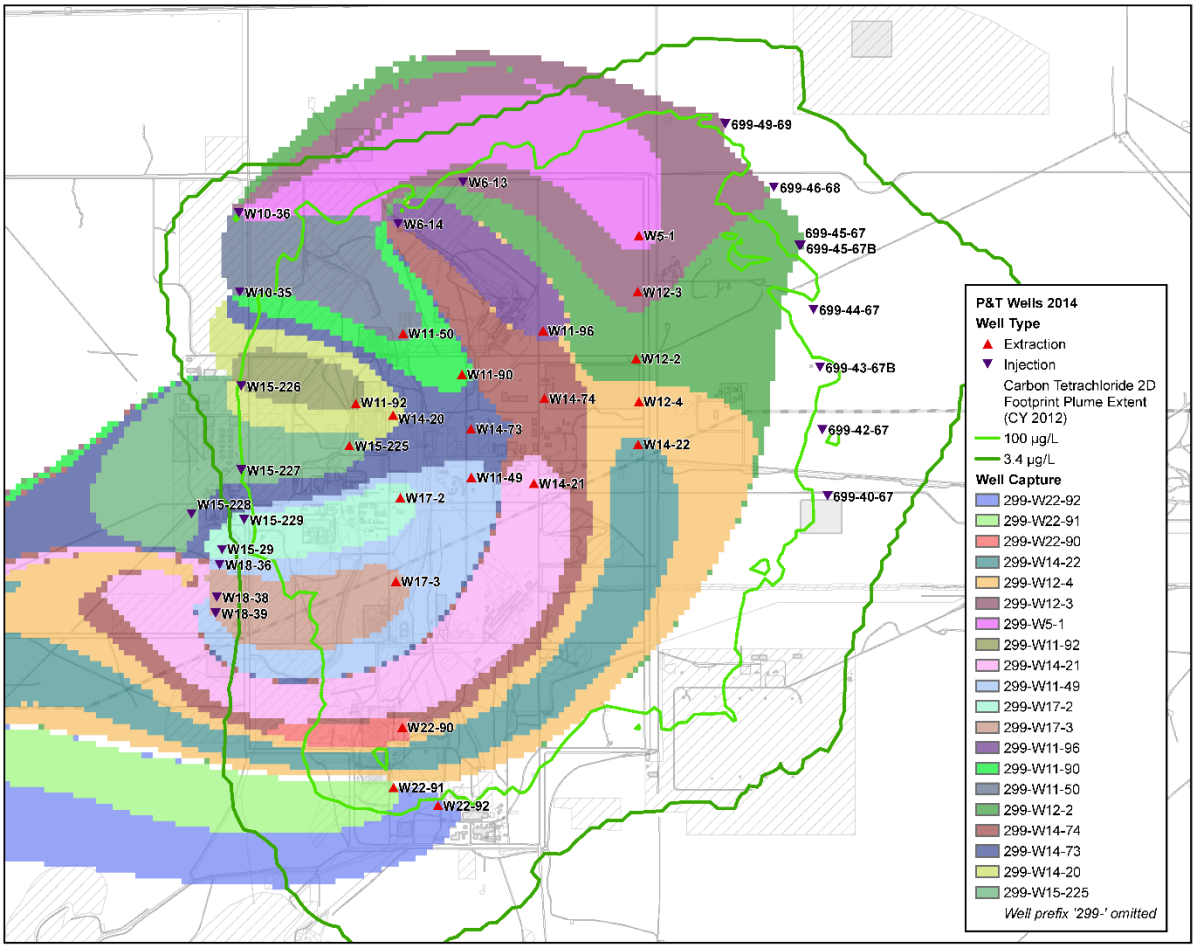


Figure 12-21. 200-ZP-1 P&T System Hydraulic Capture Zone

Table 12-2. 200 West P&T Performance for 2014

Performance	2014	Total Since Start of Final Remedy (2012)	Total Since Start of Interim Remedy (1996)
Total groundwater processed (L)	3,118,412,520	6,513,185,738	12,525,485,738
COCs	**Mass Removed**	**Total Since Start of Final Remedy (2012)**	**Total Since Start of Interim Remedy (1994)**
Carbon tetrachloride (kg)	2,898	6,478	20,389
Chromium (total and hexavalent) (kg)	75.17	166.37	181.54
Iodine-129 (p/Ci)	0[b]	242	242
Nitrate as nitrate (kg)	251,595	495,682	580,375
Technetium-99 (g)	76.96	174.99	256.99
Trichloroethene (kg)	10.24	25.73	26.73
Uranium[a] (kg)	0.77	1.85	1.85

a. Uranium is included to track 200-UP-1 groundwater treated.

b. Iodine-129 concentrations in the influent and effluent of the 200 West P&T in 2014 were less than the detection limit (0.2 pCi/L).

COCs = contaminant of concern

P&T = pump and treat

Figure 12-22. 200 West P&T Facility

12.10.2 Soil Vapor Extraction

Soil vapor extraction is being used to remove carbon tetrachloride from the vadose zone at the carbon tetrachloride site in 200-PW-1 overlying the 200-ZP-1 groundwater (Figure 12-23). Soil vapor extraction was implemented as an interim action in 1992. The purpose of the remediation using soil vapor extraction is to mitigate the threat to the environment caused by the migration of carbon tetrachloride vapors through the soil column and into the groundwater. The carbon tetrachloride site includes the three waste sites (216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib) used from 1955 through 1973 for disposal of waste liquids containing carbon tetrachloride. The purpose of the remediation using soil vapor extraction is to mitigate the threat to the environment caused by the migration of carbon tetrachloride vapors through the soil column and into the groundwater. Soil vapor extraction was implemented as an interim action in 1992 (Smith and Stanley, 1992). The CERCLA ROD for the 200-PW-1 OU was finalized in September 2011 (EPA et al., 2011). The ROD selected soil vapor extraction as the final remedial action for vadose zone carbon tetrachloride contamination at these OUs.

During soil vapor extraction operations, vapor-phase carbon tetrachloride is extracted through vadose zone wells and adsorbed onto granular activated carbon before the treated, clean vapor is released to the atmosphere. Design capacities ranging from 14 to 43 m^3/min (500 to 1,500 ft^3/min) were implemented with the interim systems. Between 2009 and 2012, two soil vapor extraction systems, each with a design capacity of 14 m^3/min (500 ft^3/min), were used from April through September of each year to remove carbon tetrachloride from the vadose zone. The systems were maintained in standby mode from October 2012 through April 2015 to allow time for carbon tetrachloride vapor concentrations to rebound. Since startup of soil vapor extraction operations in 1992, 80,107 kg of carbon tetrachloride have been removed from the vadose zone in 118 million m^3 (4.2 billion ft^3) of soil vapor (Figure 12-24; Table 12-3). Each soil vapor extraction system extracts simultaneously from multiple wells.

Passive soil vapor extraction systems formerly operated near the disposal sites associated with the PFP. Passive soil vapor extraction is a naturally occurring process driven by barometric pressure fluctuations. During its lifetime, the passive systems have removed approximately 110 kg of carbon tetrachloride. The passive soil vapor extraction wells were taken out of service permanently in March 2013.

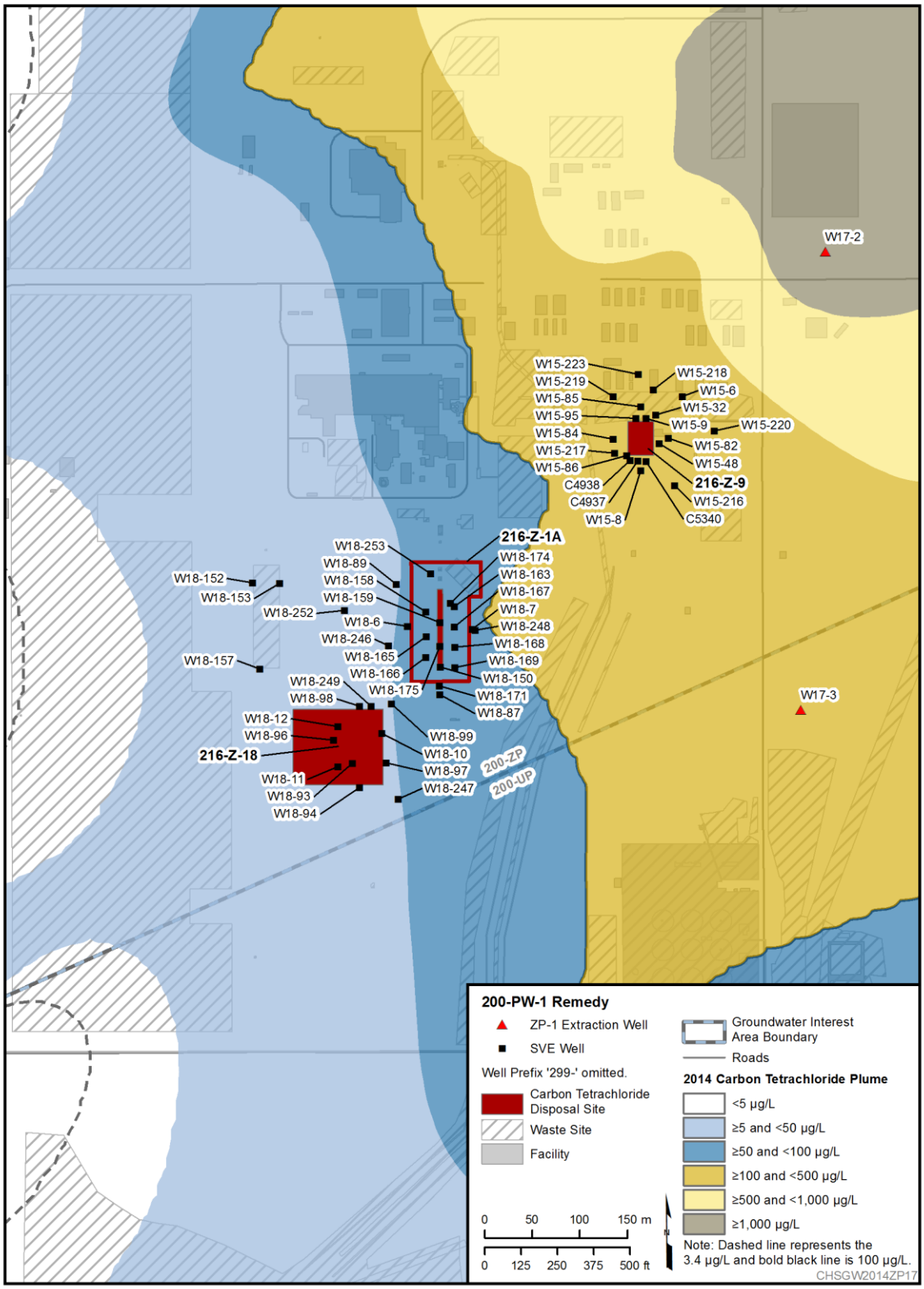


Figure 12-23. 200-PW-1 Soil Vapor Extraction Overview

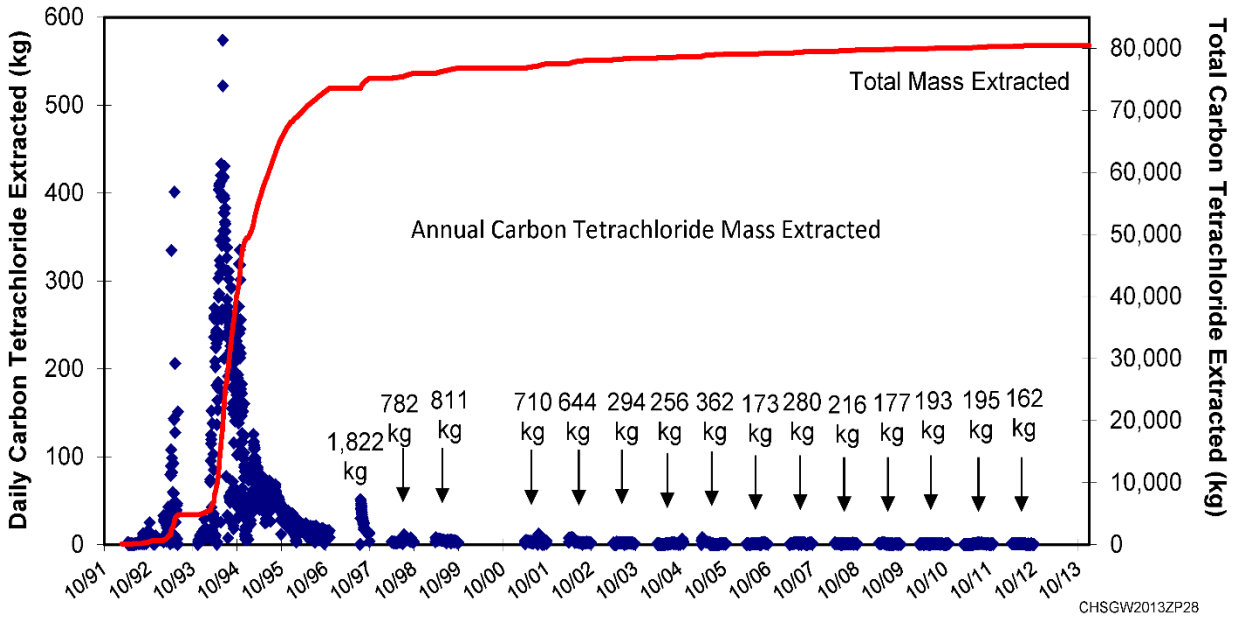


Figure 12-24. 200-ZP Mass of Carbon Tetrachloride Removed from 200-PW-1 Vadose Zone

Table 12-3. Soil Vapor Extraction Performance Since Startup

Performance	Since Startup (February 1992 to 2012[a, b])
Total soil vapor processed (m^3)	118,290,000
Total mass of carbon tetrachloride removed (kg)[c]	80,107

a. System did not operate in 2013 or 2014.

b. Includes the pilot test operations in April 1991.

c. Does not include the mass removed by the passive soil vapor extraction systems.

12.11 RCRA Monitoring

This section describes the results of monitoring at individual RCRA treatment, storage, and disposal units, including single-shell tank farms. Some of these units are monitored under RCRA requirements for dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials.

The 200-ZP interest area contains four RCRA sites with groundwater monitoring requirements: WMA T, WMA TX-TY, LLWMA-3, and LLWMA-4 (Figures 12-25, 12-26, 12-27, and 12-28). Interim status groundwater quality assessment monitoring was conducted at WMA T and WMA TX-TY (40 CFR 265.93[d], as referenced by WAC 173-303-400). Interim status indicator parameter evaluation monitoring was conducted at LLWMA-3 and LLWMA-4 (40 CFR 265.92 and 40 CFR 265.93[b], as referenced by WAC 173-303-400). The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for the reporting period. LLWMA-3 and LLWMA-4 also have AEA monitoring conducted under a performance assessment monitoring plan (DOE/RL-2000-72).

Groundwater data are available in the HEIS database and in the appendices accompanying this report. The database is available at http://environet.hanford.gov/eda/. Appendix B includes additional information (including well and constituent lists, flow rates, and statistical tables).

12.11.1 Waste Management Area T

WMA T (Figure 12-25), which includes the T Tank Farm, is located in the northern portion of the 200 West Area and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. The WMA T contains 16 underground single-shell tanks that were constructed in 1943 and 1944. Tanks T-101 through T-112 have capacities of 2,000,000 L (528,344 gal), and Tanks T-201 through T-204 have capacities of 208,000 L (55,000 gal). In addition to the tanks, six diversion boxes and ancillary pumps, valves, and pipes are included in the Dangerous Waste Permit Application Part A Form (WA7890008967) for the T Tank Farm single-shell tank system.

The tanks in WMA T began receiving waste in 1944 and were mostly in continual use until 1980, at which time all tanks in the WMA were removed from service. The single-shell tanks received predominantly high-level metal and first-cycle waste from chemical processing of uranium-bearing, irradiated reactor fuel rods. Lesser amounts of other waste also were stored in the tanks at WMA T. More detailed information on the WMA T can be found in DOE/RL-2009-66. All drainable liquid in each tank has been removed and the tanks have been interim stabilized.

In 2008, an interim corrective measure, consisting of surface barrier emplacement over a portion of the WMA, was designed and constructed to reduce infiltration and the subsequent migration of contaminants through the vadose zone to groundwater. Sections 12.5 and 12.7 discuss the distribution of these non-RCRA constituents near WMA T.

WMA T is monitored under an interim status assessment program because concentrations of the dangerous constituent chromium exceed the DWS (100 µg/L) in downgradient wells (Section 12.4). The well network was sampled quarterly in some wells and semiannually and annually in others for waste constituents and indicator parameters in the groundwater (DOE/RL-2009-66). Figure 12-25 shows well locations and Table B-80 of Appendix B includes a list of wells and constituents monitored.

The water table continues to decline beneath WMA T in response to extraction by the 200 West P&T. Extraction wells east of the WMA affect groundwater flow in this location. Groundwater flows to the east-southeast and estimates of groundwater/contaminant flow rates beneath WMA T (using the Darcy relationship) range from 0.34 to 0.54 m/d (1.1 to 1.8 ft/d). Table B-1 of Appendix B contains calculations of groundwater flow rates and gradients.

The WMA T monitoring well network consists of two upgradient, one assessment, one far-field, and six downgradient monitoring wells. The assessment well is not directly upgradient or downgradient and is used to help distinguish other contaminant plumes impinging on WMA T. The well network complies with RCRA groundwater monitoring requirements. Sampling of WMA T wells occurred as scheduled except for Well 299-W11-45, which required conversion to a monitoring well following the shutdown of the interim P&T system. Conversion to a monitoring well occurred in October 2014 and the well was sampled only once in 2014. The direction of groundwater flow is not expected to change with operation of the 200 West P&T. However, the magnitude and direction of groundwater flow will not be known until after a performance monitoring and assessment of the system, as defined in DOE/RL-2009-115, is completed.

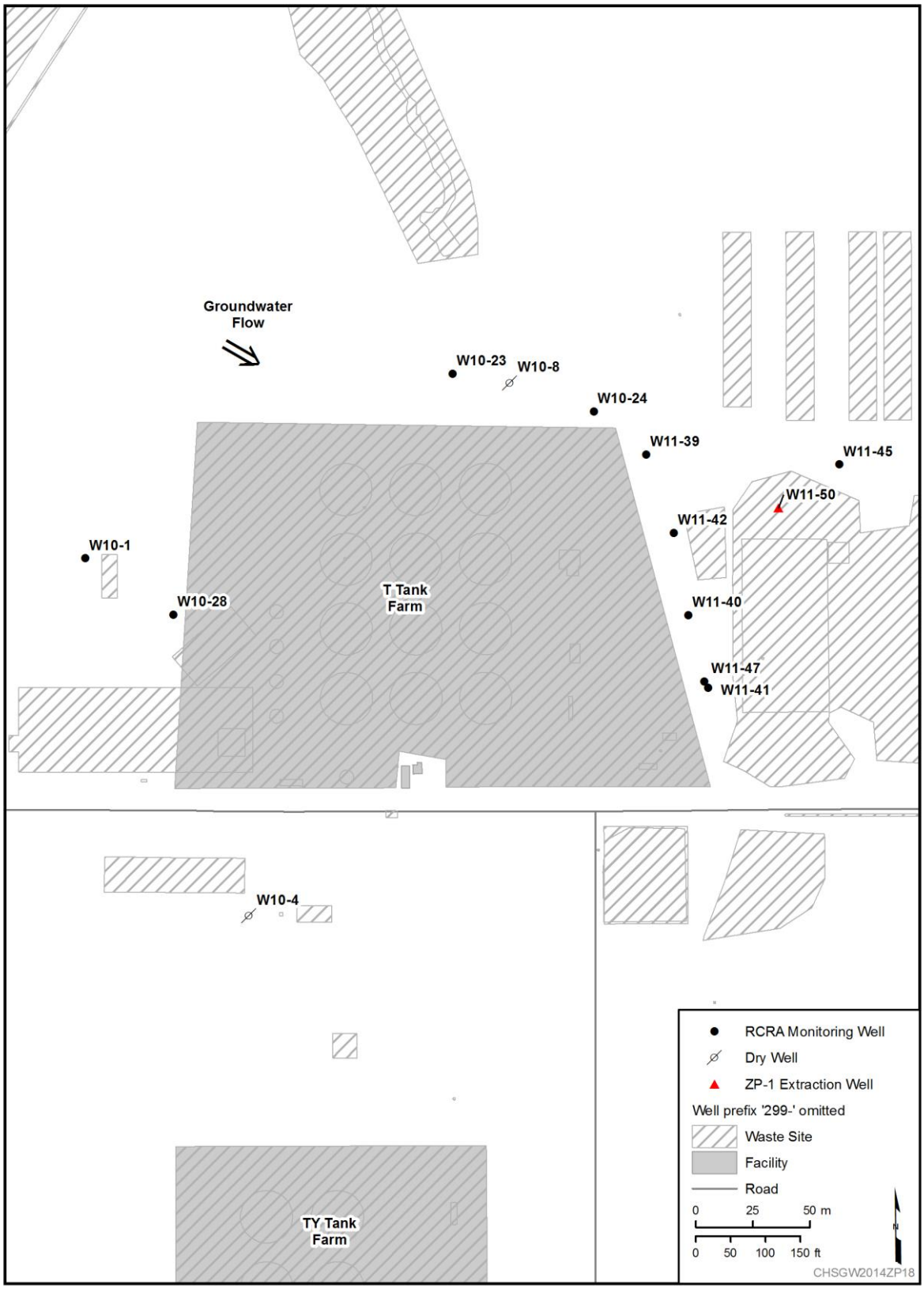


Figure 12-25. 200-ZP RCRA Facility WMA T Monitoring Well Locations

The primary dangerous waste constituents found beneath WMA T during the reporting period were chromium, carbon tetrachloride, and TCE. Carbon tetrachloride and TCE contamination is not related to WMA T but is associated with liquid disposal processes at the PFP (Section 12.3). These constituents are monitored as part of the 200-ZP-1 OU. Chromium is a dangerous constituent monitored under the RCRA assessment program. From 1944 to 1980, the WMA received metal and first-cycle waste from chemical processing, including the bismuth phosphate process, tributyl phosphate process, and REDOX process. Past leaks from single-shell tanks and waste pipelines within the WMA are the sources of the chromium contamination.

In 2014, the highest chromium concentration in the upper portion of the aquifer was in Well 299-W11-40 (109 µg/L), located east of the WMA. The highest chromium concentration found in wells screened deeper in the aquifer (above the Ringold lower mud unit) in WMA T was 67 µg/L in downgradient Well 299-W11-47 (screened between 7.5 and 17 m [25 to 56 ft] below the water table). The highest chromium concentration in adjacent downgradient Well 299-W11-39 (screened at the water table) was 31 µg/L. The high concentrations in the deeper screened wells show that the chromium plume extends relatively deep in the aquifer downgradient of WMA T and is present laterally at least 80 m (260 ft) downgradient (Figure 12-10). Because of groundwater remediation activities at WMA T, however, chromium concentrations are declining and the plume extent is shrinking. The groundwater beneath WMA T is within the capture zone of 200 West P&T extraction Well 299-W11-50.

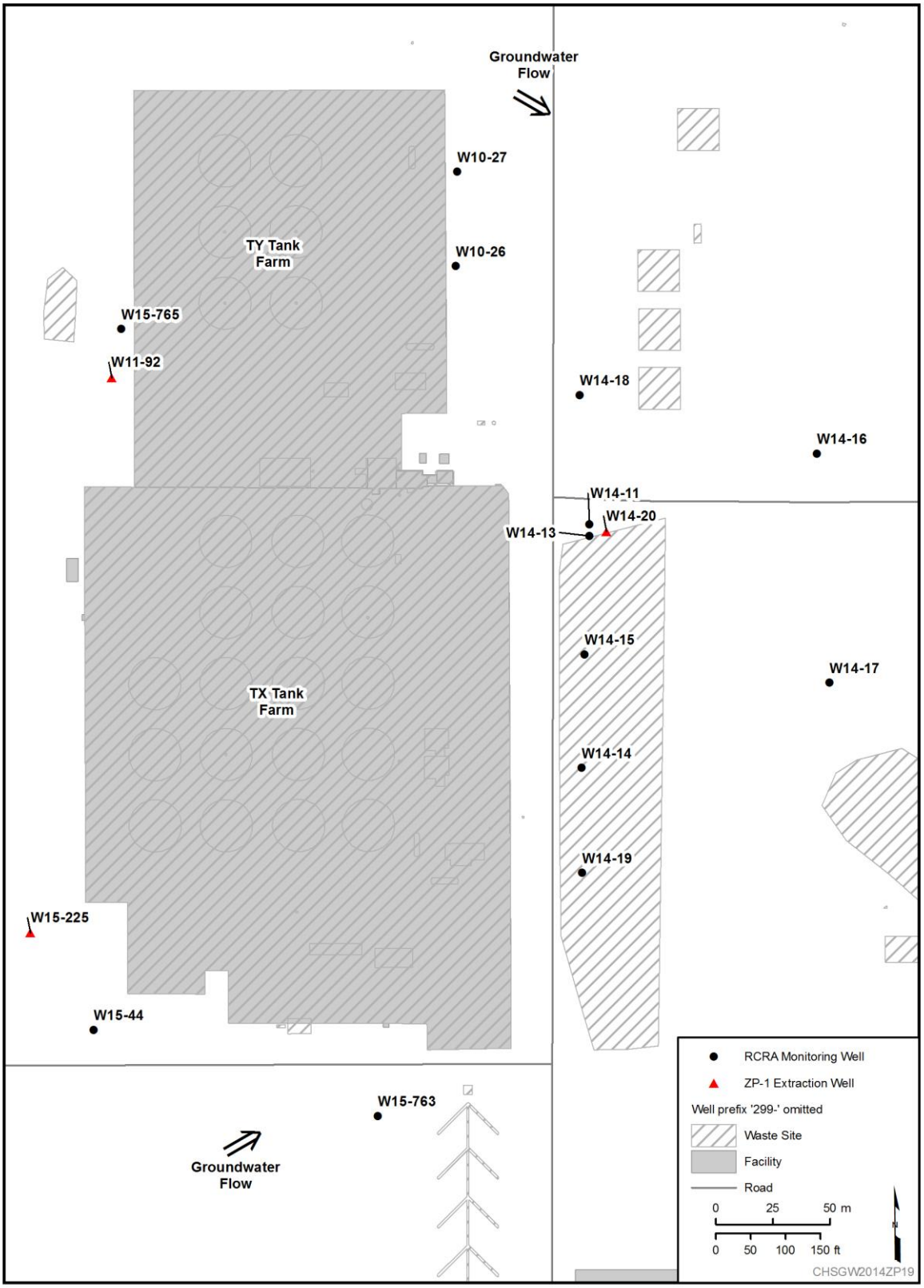
Nitrate is also found in the groundwater beneath the WMA from the same source as chromium. A nitrate plume beneath WMA T is located within the regional nitrate plume (Figure 12-13) and the plume configuration in 2014 was consistent with the configuration in 2013. During the reporting period, the highest nitrate concentrations (as nitrate) were in Well 299-W11-40 (456 mg/L) and 299-W11-41 (332 mg/L). The nitrate concentrations above the DWS in the remaining WMA T wells were between 77 and 26 mg/L. While WMA T is a source of nitrate, other upgradient sources are larger contributors.

12.11.2 Waste Management Area TX-TY

WMA TX-TY (Figure 12-26), which includes the TX and TY Tank Farms, is located in the northern portion of the 200 West Area and was used for interim storage of radioactive waste from chemical processing of reactor fuel for plutonium production. The WMA is regulated under RCRA and its implementing requirements in WAC 173-303-400. Sections 12.5 and 12.7 discuss the distribution of non-RCRA constituents iodine-129 and technetium-99 near WMA TX-TY.

The WMA contains 24 underground single-shell tanks, constructed in 1947 and 1948 for the TX Tank Farm and in 1951 and 1952 for the TY Tank Farm. Each tank has a capacity of 2.84 million L (750,000 gal). In addition to the tanks, six diversion boxes and ancillary pumps, valves, and pipes are included in the Dangerous Waste Permit Application Part A Form (WA7890008967) for the single-shell tanks in the TX-TY Tank Farms system.

The tanks in WMA TX-TY began receiving waste in 1949. The tanks in both the TX and TY Tank Farms were used to support the bismuth phosphate process and the uranium-recovery program. Some of the tanks in WMA TX-TY also received waste from REDOX Plant and PUREX Plant operations. Detailed information on the WMA TX-TY can be found in DOE/RL-2009-67. All drainable liquid in each tank has been removed and all tanks have been interim stabilized.



Note: Two flow direction arrows shown based on influence of P&T extraction wells.

Figure 12-26. 200-ZP RCRA Facility WMA TX-TY Monitoring Well Locations

The 200 West P&T extraction wells on the east, west, and south sides of the WMA alter the flow direction and hydraulic gradients. The water table continued to decline in 2014. Groundwater tends to flow to the east, although the extraction wells on the west side of the WMA disrupt the flow locally. Estimates of groundwater/contaminant flow rates beneath WMA TX-TY (using the Darcy relationship) range from 0.001 to 0.34 m/d (0.003 to 1.1 ft/d). Table B-1 of Appendix B contains calculations of groundwater flow rates and gradients. The magnitude and direction of changes in groundwater flow direction and rate will not be known until after the performance monitoring and assessment of the system is completed as defined in the Performance Monitoring Plan (DOE/RL-2009-115).

WMA TX-TY is monitored under an interim status assessment program because of elevated specific conductance in two downgradient wells in 1993. The well network currently consists of one upgradient, 2 far-field, and 10 downgradient monitoring wells (Figure 12-26). The well network complies with RCRA groundwater monitoring requirements. The WMA TX-TY well network was sampled quarterly, semiannually, and annually for contamination indicator parameters and supporting constituents (DOE/RL-2009-67). Table B-83 of Appendix B includes a list of wells and constituents monitored in 2014.

The dangerous waste constituent chromium was monitored under the RCRA assessment program in WMA TX-TY during the reporting period. Other dangerous waste constituents found at the WMA included carbon tetrachloride and TCE, which come from other sources associated with PFP operations. Nitrate is also found in the groundwater beneath the WMA.

In 2014, chromium was detected above the 100 µg/L DWS in two wells monitoring WMA TX-TY (Figure 12-10): Well 299-W10-26 and 299-W15-763. The highest chromium concentration in Well 299-W10-26 was 108 µg/L; a result of 144 µg/L was recorded in this well in 2013. The highest chromium concentration in Well 299-W15-763 was 447 µg/L in an unfiltered sample, but this is attributed to particulates and corrosion of the well; the highest hexavalent chromium concentration in this well was 10 µg ug/L. The source for the dissolved chromium was past leaks from tanks and pipelines at WMA TX-TY. The chromium plume is slightly larger in extent than depicted in 2013, from 0.25 km^2 (0.098 mi^2) to 0.33 km^2 (0.13 mi^2) in 2014 .

During 2014, nitrate concentrations exceeded the DWS in all wells in the monitoring network (Figure 12-13). Nitrate concentrations decreased in WMA TX-TY monitoring wells from the highest concentration found at 299-W14-11 during drilling in 2005 (3,600 mg/L) to the highest concentration found in 2014 at 299-W14-13 (536 mg/L). Nitrate concentrations in other WMA TX-TY wells ranged between 49.1 mg/L (299-W15-765) and 487 mg/L (299-W14-11). Most of the nitrate contamination is attributed to PFP operations, as well as past-practice disposal to cribs and trenches in the area.

12.11.3 Low-Level Waste Management Area 3

LLWMA-3 (Figure 12-27), located in the northwest corner of the 200 West Area, consists of the 218-W-3A Burial Ground, 218-W-3AE Burial Ground, and 218-W-5 Burial Ground. The 218-W-3A Burial Ground (0.204 km^2 [0.079 mi^2]) contains 57 unlined trenches operated between 1970 and 1998. The 218-W-3AE Burial Ground (0.200 km^2 [0.077 mi^2]) contains eight unlined trenches operated between 1981 and July 2004. The 218-W-5 Burial Ground (0.372 km^2 [0.144 mi^2]) contains 10 unlined trenches and 2 lined trenches. This burial ground began operating in 1986, and the two double-lined mixed waste trenches are the only trenches continuing to receive waste.

The LLWMA-3 is monitored under an interim status contamination indication (detection) program. Wells are sampled semiannually and annually from a network of four wells and samples are analyzed for

indicator parameters and supporting constituents (DOE/RL-2009-68). All the wells were sampled in 2014 (Table B-56 of Appendix B).

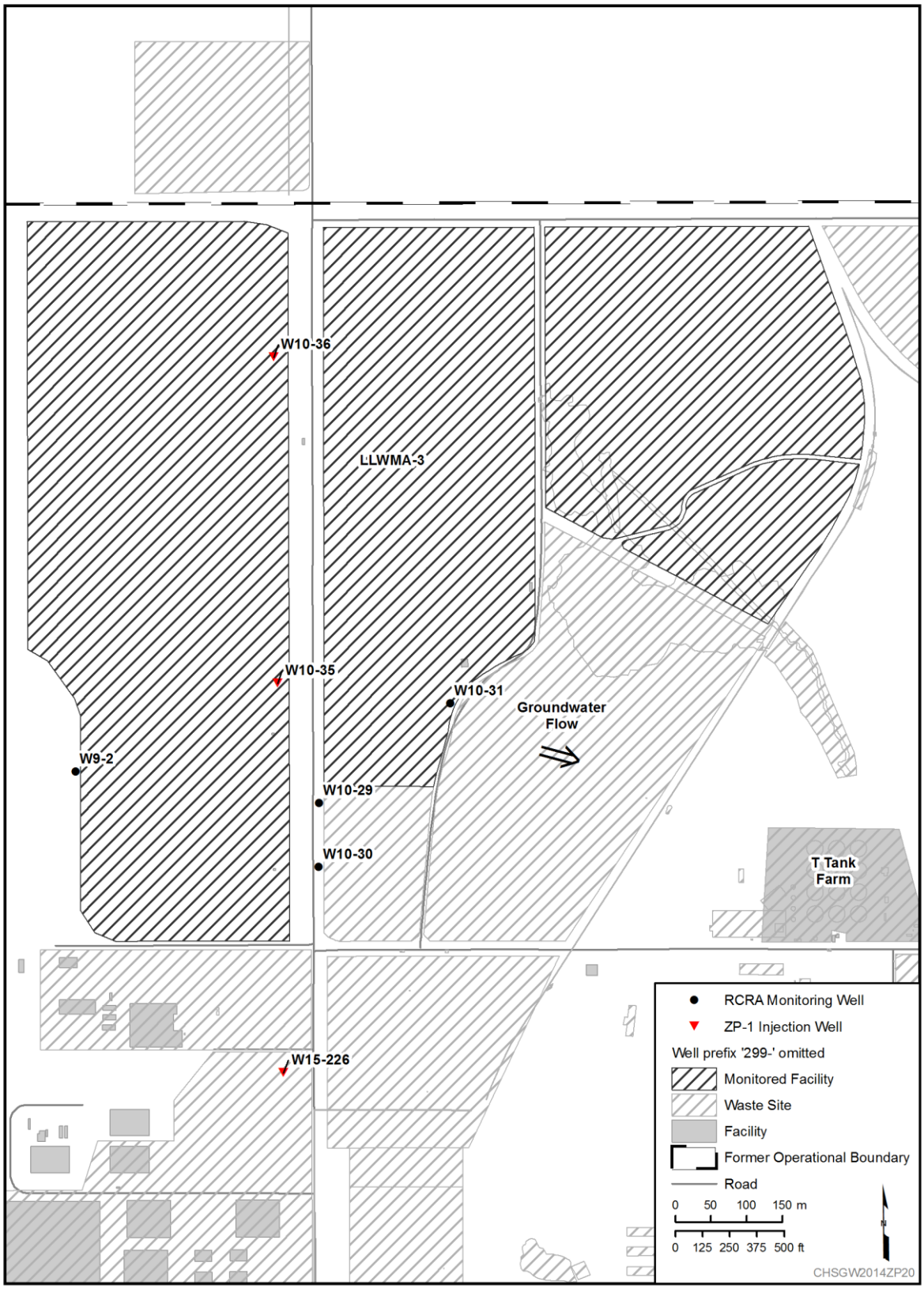


Figure 12-27. 200-ZP RCRA Facility LLWMA-3 Monitoring Well Locations

Water-level measurements are taken each time a groundwater sample is collected, and sitewide water-level measurements are collected annually, usually during March. The water table has risen in this region in 2012, 2013, and 2014 in response to groundwater injection. Two 200 West injection wells are within the boundaries of LLWMA-3. Another injection well is located east of the LLWMA. The groundwater flow direction across LLWMA-3 (east of injection Wells 299-W10-35 and 299-W10-36) is east to east-southeast at a calculated rate (using the Darcy relationship) of 0.16 to 0.63 m/d (0.52 to 2.1 ft/d). Groundwater may flow radially from the injection wells for some distance, but the head in upgradient Well 299-W9-2 remains higher than in the downgradient wells.

During the reporting period, all wells were sampled as scheduled for indicator parameters pH, specific conductance, total organic carbon (TOC), and total organic halides (TOX) (Table B-56, Appendix B). Concentrations of indicator parameters did not exceed their critical mean values except for specific conductance in Well 299-W10-31. Specific conductance measurements from 299-W10-31 exceeded the critical mean value of 448 µS/cm, with average values of 503 µS/cm and 473 µS/cm for the March 4, 2014, and September 5, 2014 samples. As reported in previous years' Hanford Site groundwater monitoring reports, the specific conductance trend at 299-W10-31 is presumed to be related to the increasing nitrate concentrations at this well, likely caused by movement of the regional nitrate plume. Indicator parameter averages in 2014 (Table B-58, Appendix B) were slightly higher than those in 2013.

In upgradient Well 299-W9-2, TOC decreased from a maximum of 12,200 µg/L in 2012 to an average of 304 µg/L in 2014. The 2012 elevated TOC in Well 299-W9-2 was attributed to the significant amount of vegetable grease used during well construction to lubricate casing connections. Because the vegetable grease was suspected to be the source of the elevated TOC, concentrations were expected to decrease with each sampling event to background levels. The decline in 2013 and 2014 sample results suggests vegetable grease was the source of the elevated TOC.

The high TOC values in 2012 resulted in an extremely high and potentially unprotective 2013 critical mean for downstream wells. For this reason, intrawell TOC critical means (Appendix B, Table B-58) were calculated for downgradient Wells 299-W10-30, 299-W10-29, and 299-W10-31 (ECF-Hanford-14-0043, *Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring*). These limits were calculated following procedures outlined in the Unified Guidance (EPA/530/R-09/007).

DOE monitors the LLWMAs for AEA radionuclides, as described in DOE/RL-2000-72. Iodine-129, technetium-99, and uranium are monitored semiannually in the three downgradient wells. Iodine-129 was undetected, and technetium-99 was at detection level in all three wells. Uranium was detected in all wells with a maximum concentration of 1.40 µg/L (background) in Well 299-W10-31. These results indicate the LLWMA-3 is not releasing radionuclides to groundwater.

12.11.4 Low-Level Waste Management Area 4

LLWMA-4 (Figure 12-28) consists of the 218-W-4B and 218-W-4C Burial Grounds, and contains 28 unlined trenches used for disposal of low-level radioactive wastes and low-level mixed wastes beginning in 1967. The 218-W-4B Burial Ground also contains 12 below-grade caissons at the southern end of the facility. The caissons in the 218-W-4B Burial Ground contain remote-handled, low-level waste and retrievable transuranic waste. The 218-W-4B Burial Ground was closed in 1990, and 218-W-4C was closed in 2004. The dangerous chemicals in the low-level mixed waste portions of LLWMA-4 are regulated under RCRA and its implementing requirements (WAC 173-303-400).

Figure 12-28. 200-ZP RCRA Facility LLWMA-4 Monitoring Well Locations

The LLWMA-4 well network was sampled semiannually for contamination indicator parameters and supporting constituents (DOE/RL-2009-69). Table B-62 of Appendix B includes a list of wells and the indicator parameters sampled in 2014.

Five 200 West injection wells located west (upgradient) of LLWMA-4 have caused the water table to rise and steepened the hydraulic gradient. The general direction of groundwater flow is east-northeast and the rate of flow (using the Darcy relationship) is estimated to be 0.16 to 0.64 m/d (0.52 to 2.1 ft/d) beneath this WMA (Table B-1 of Appendix B).

The monitoring network at LLWMA-4 includes six downgradient wells and one upgradient Well 299-W18-22 (Figure 12-28). Upgradient Well 299-W18-22 (screened at the bottom of the unconfined aquifer) is located at the southwestern corner of LLWMA-4. The well network complies with RCRA groundwater monitoring requirements. No new wells are expected at LLWMA-4 until the effects of the 200 West P&T are known.

Except for the upgradient well and downgradient, deep-screened Well 299-W15-17, all wells in the network are screened across the water table. These water table wells have adequate water columns in the screened interval (from 4 to 8 m [13 to 26 ft]) available for sampling. The well network was successfully sampled twice in 2014 for indicator and site-specific parameters including pH, specific conductance, TOC, and TOX.

Table B-63 of Appendix B includes a table with indicator parameter ranges for LLWMA-4 wells in 2014. Specific conductance, pH, TOC, and TOX in downgradient wells remained below their critical mean values for all wells except for TOX in Well 299-W15-224. The elevated TOX concentrations are consistent with observed levels of carbon tetrachloride from PFP operations. In 2014, TOX and TOC results increased compared to 2013 results. Indicator parameter averages for pH and specific conductance are similar to 2013.

DOE monitors the LLWMAs for AEA radionuclides, as described in DOE/RL-2000-72. Iodine-129, technetium-99, and uranium are monitored semiannually. Iodine-129 was undetected in all wells, technetium-99 was undetected in Wells 299-W15-17 and 299-W18-22 and detected at very low levels in the remaining five wells (maximum detected was 240 pCi/L in Well 299-W15-152), and uranium was detected in all wells, with a maximum of 2.13 µg/L in Well 299-W15-152. Detection of technetium-99 is consistent with observed levels in the aquifer and does not indicate contamination from LLWMA-4.

12.12 State-Approved Land Disposal Site — *Washington Administrative Code* Facility

The Effluent Treatment Facility (ETF) is regulated under WAC 173-216. The ETF processes aqueous wastes from various Hanford Site facilities. Treated water from the ETF is discharged to the SALDS (Figure 12-29), which is authorized to receive the effluent by State Waste Discharge Permit Number ST 4500 (Ecology, 2000; hereinafter referred to as the "Permit"). The Permit was issued in June 1995, and the site began operating in December 1995. The SALDS is located 400 m (1,300 ft) outside the northern boundary of the 200 West Area and consists of a 35 m by 61 m (115 ft by 200 ft) drain field. DOE has taken the position that its groundwater monitoring and provision of data to Ecology is a matter of intergovernmental comity and cooperation, and that the Permit has no jurisdiction over radionuclides, which are regulated by DOE under AEA authority, in the same way that permits for wastewater discharge to surface waters issued by the EPA under Section 402 of the *Clean Water Act* are preempted by the AEA from regulating radionuclides (40 CFR 122.2, Train v. Colorado Public Interest Research Group Inc.). A revised Permit was issued in December 2014 and is discussed at the end of this section.

During 2014, discharges to the SALDS occurred only during January. The volume released was 4.8 million L (1.3 million gal). The ETF has been shut down since February 2014 due to a major failure of the evaporator heat exchanger (reboiler). Replacement of the heat exchanger is expected to keep the facility shut down until late 2015. All of the water discharged in January was treated process condensate from the 242-A Evaporator.

Much of the effluent disposed of to the SALDS contains tritium because no cost-effective treatment technology is available to remove tritium from wastewater. The January 2014 release contained 2.26 Ci of tritium, a decrease from the 10.98 Ci released during 2013. Releases of tritium from the SALDS have resulted in a tritium plume in groundwater beneath the facility (Figure 12-19).

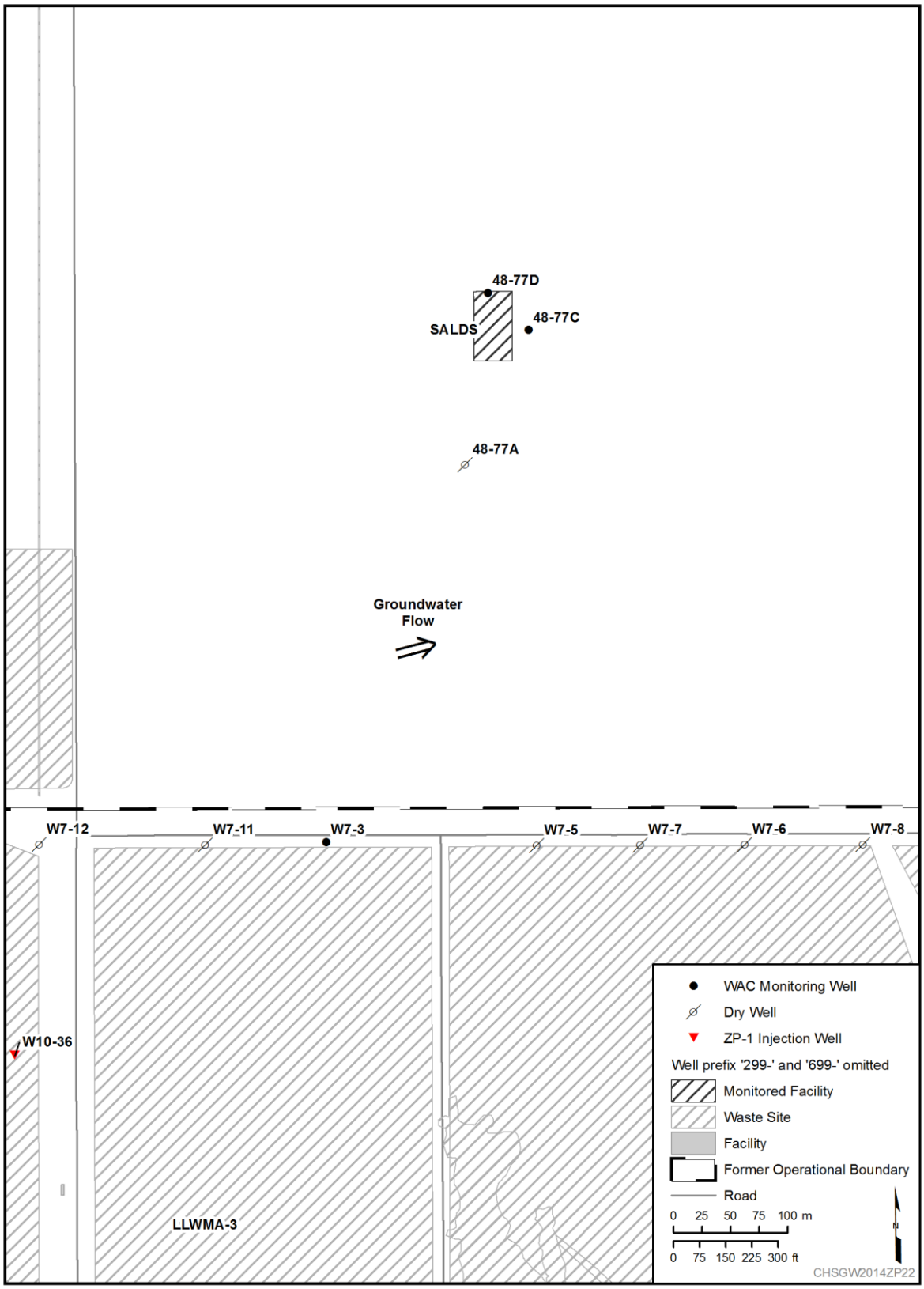


Figure 12-29. SALDS Facility Monitoring Well Network

DOE monitors groundwater in the SALDS vicinity to track the migration of the tritium plume and to compare concentrations of other constituents to Permit limits (prior to the revision of the Permit). Groundwater monitoring requirements are described in PNNL-13121. Quarterly sampling is required for two wells proximal to the SALDS facility, and both annual and semiannual sampling is required for a set of tritium-tracking wells located farther afield. Several wells are no longer sampled because they are dry. Table B-91 of Appendix B includes a list of wells and constituents sampled for the SALDS. All required sampling was completed during 2014, although some wells were sampled later than originally scheduled because of maintenance or access issues. Monitoring results for the SALDS are reported in annual reports (on a fiscal-year basis), most recently in *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2014* (SGW-58210). The Permit also specifies that periodic numerical modeling of the tritium plume be performed to predict future plume migration. The model was last updated during 2011; the results are summarized in SGW-58210.

Discharges from the SALDS form a small groundwater mound causing a localized area of radial flow beneath the facility. The center of the mound is offset from the facility to the south because the southward dip of the Cold Creek unit diverts the effluent while it infiltrates through the vadose zone. This mound was greatly diminished during 2014 because no discharges to the SALDS occurred after January (Figure 12-4). Water table mapping indicates that the regional groundwater flow direction in the SALDS vicinity is currently towards the east-northeast.

The water table beneath the SALDS responds to discharges from the facility, but it also responds to operation of the nearby 200-ZP-1 P&T system. Despite the low volume of discharges to the SALDS in 2014, the water table in the vicinity increased by an average of 0.26 m (0.85 ft) between March 2013 and March 2014 (SGW-58210). This was due to operation of nearby P&T system injection wells for the 200-ZP-1 OU and was predicted by groundwater modeling (SGW-56060, *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2013*; SGW-50907, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site*). Prior to startup of the P&T system in 2012, water table elevations exhibited a long-term declining trend due to the curtailment of wastewater discharges to the soil column between the mid-1980s and mid-1990s. This long-term decline has caused 11 of the 19 tritium-tracking wells listed in the monitoring plan (PNNL-13121) to become dry. One of the proximal wells, 699-48-77A, became dry during 2011. This issue is also affecting proximal Well 699-48-77D, which is expected to become dry within the next few years (Table 1 of SGW-50907). The third proximal well, 699-48-77C, is completed deeper in the unconfined aquifer and is not in danger of becoming dry.

During 2014, proximal Wells 699-48-77C and 699-48-77D were sampled for 17 constituents/parameters listed in the Permit. The Permit sets concentration limits for acetone, benzene, cadmium (total), chloroform, copper (total), lead (total), mercury (total), field pH, sulfate, tetrahydrofuran, and total dissolved solids. Gross alpha, gross beta, strontium-90, and tritium are also listed in the Permit, but these constituents are not assigned concentration limits. All groundwater sampling results from the SALDS proximal wells were within concentration limits during 2014.

Tritium concentrations in the proximal wells are affected by releases from the SALDS. Concentrations correlate with the activity of tritium released, although the concentration response in the deeper well, 699-48-77C, exhibits a time lag of several years. Recent trends in the proximal wells indicate declining tritium concentrations (Figure 12-30). Peak tritium concentrations during 2014 were 68,000 pCi/L in 699-48-77C and 60,500 pCi/L in 699-48-77D.

To date, tritium from the SALDS has not been detected in any of the tritium-tracking wells; this observation is consistent with numerical model predictions (SGW-58210). The low levels of tritium

observed in Well 299-W6-11, 699-W6-12, and 699-48-71 are interpreted to have originated from past wastewater releases from other 200 West Area sources to the south (Figure 12-19). Tritium was detected in tritium-tracking Well 299-W6-6 during 2014 at 2,430 pCi/L, but the source is a 200-ZP-1 injection well, 299-W6-13, located just 10 m (32.8 ft) away. Water extracted in the 200-ZP-1 OU contains tritium, but just like for the ETF, the 200 West P&T does not remove tritium from the water. Thus, the water injected into the aquifer at 299-W6-13 contains tritium, which is being detected in Well 299-W6-6.

The Permit was renewed effective January 1, 2015, for a 5-year period. The major change pertaining to groundwater monitoring is that sampling for comparison to the groundwater concentration limits will be performed at the ETF verification tank prior to discharge of effluent to the SALDS. If the discharged water has concentrations below Permit limits, then concentrations in the groundwater would also be below Permit limits. The only analyte listed for groundwater sampling in the new Permit is tritium.

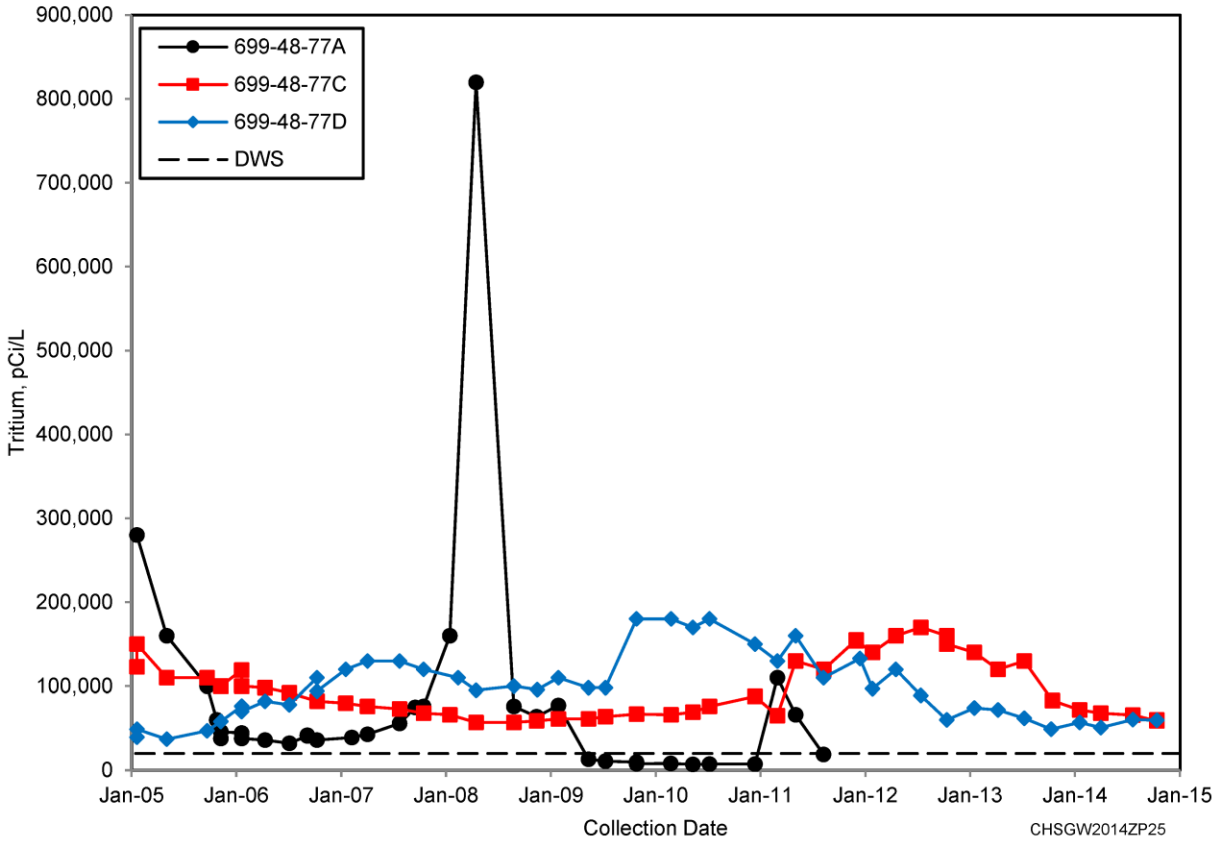


Figure 12-30. 200-ZP Tritium Data for Wells Monitoring SALDS

This page intentionally left blank.

13 References

00-GWVZ-054, 2000, *Results of Assessment at the 1325-N Facility* (letter to J. Hedges, Washington State Department of Ecology, from K.M. Thompson), U.S. Department of Energy, Richland Operations Office, Richland, Washington, dated July 11, 2000. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D2495687.

04-TPD-083 2004, *Agreement on Content of Tank Waste Retrieval Work Plans.* U.S. Department of Energy, Office of River Protection. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1212060215

10-EMD-0080, 2010, *Class 1 Modifications to the Hanford Facility Resource Conservation and Recovery Act Permit Quarter Ending June 30 2010*, U. S. Department of Energy. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1007220373.

11-AMCP-0002, 2010, *Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington. July 2010, Memo to File Regarding: Supplemental Actions for the In-Situ Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy*, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1011290677.

40 CFR 122, "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=1773726c1e724112ac989e047dafc02e&mc=true&node=pt40.22.122&rgn=div5.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=877d0a95450a18185e2bb887ded529c7&node=40:23.0.1.1.3&rgn=div5.

40 CFR 143, *"National Secondary Drinking Water Regulations," Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2002-title40-vol19/pdf/CFR-2002-title40-vol19-part143.pdf.

40 CFR 261, 2012, "Identification and Listing of Hazardous Waste", *Code of Federal Regulations.* Available at: http://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol27/xml/CFR-2012-title40-vol27-part261.xml.

40 CFR 265.91, 2010, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," "Ground-water monitoring system," *Code of Federal Regulations.* Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-sec265-91.xml.

40 CFR 265.92, 2010, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-sec265-92.xml.

40 CFR 265.93, 2010, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-sec265-93.xml.

40 CFR 265.94, 2010, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Recordkeeping and Reporting," *Code of Federal Regulations.* Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-sec265-94.xml.

40 CFR 300, 2010, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr300_main_02.tpl.

Atomic Energy Act of 1954, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: http://epw.senate.gov/atomic54.pdf.

BHI-00012, 1994, *300-FF-2 Operable Unit Technical Baseline Report*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

BHI-00725, 1996, *100-N Pilot Project: Proposed Consolidated Groundwater Monitoring Program*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197173616.

City of Richland, 2014, *Horn Rapids Landfill Environmental Monitoring Report Calendar Year 2013* p City of Richland, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

CVP-2013-00002, 2014, *Cleanup Verification Package for the 118-K-1 Burial Ground*, Rev. 1, prepared by Washington Closure Hanford, for the U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0086017.

DOE/RL-90-17, 2010, *Nonradioactive Dangerous Waste Landfill/Solid Waste Landfill Closure/ Postclosure Plan*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=1101200569.

DOE/RL-90-18, 1990, *Phase I Remedial Investigation Report for the Hanford Site 1100-EM-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199031271.

DOE/RL-90-22, 1996, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit, Hanford Site, Richland, Washington*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196119051.

DOE/RL-91-50, 2008, *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://nerp.pnnl.gov/docs/ecology/management/DOE-RL-91-50_Rev4.pdf.

DOE/RL-92-32, 1992, *Expedited Response Action Assessment for 316-5 Process Trenches*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/index.cfm?content=findpage&AKey=D196105947.

DOE/RL-92-67, 1993, *Draft Remedial Investigation/Feasibility Study for the 1100-EM-1 Operable Unit, Hanford*, Draft C, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA181107
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA181351
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA181534
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA181846
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA182181
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA182465
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA182894
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA183128

DOE/RL-93-73, 1995, *300 Area Process Trenches Modified Closure Postclosure Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000405.

DOE/RL-94-143, 1994, *Corrective Action Plan for the Hanford Site Solid Waste Landfill*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0039477.

DOE/RL-95-59, 1996, *200-BP-5 Operable Unit Treatability Test Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197189381.

DOE/RL-95-73, 2002, *Operation and Maintenance Plan for the 300-FF-5 Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0095180.

DOE/RL-96-39, 2002, *100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures Study/Closure Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D9039847. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D9039856. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D9039860.

DOE/RL-96-61, 1997, *Hanford Site Background: Part 3, Groundwater Background*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197226378.

DOE/RL-96-84, 2003, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Unit Interim Action*, Rev. 0-A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D1348764.

DOE/RL-97-36, 2010, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1003100445.

DOE/RL-97-48, 1997, *183-H Solar Evaporation Basins Postclosure Plan*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197226569.

DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D199153696.

DOE/RL-2000-41, 2000, *Interim Action Waste Management Plan for the 100-NR-2 Operable Unit*, Rev. 1, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8479569.

DOE/RL-2000-59, 2009, *Sampling and Analysis Plan for Aquifer Sampling Tubes*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091138.

DOE/RL-2000-72, 2006, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.osti.gov/bridge/servlets/purl/878238-LM8LvQ/.

DOE/RL-2001-49, 2004, *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D7379978.

DOE/RL-2001-27, 2011, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084005.

DOE/RL-2001-27, 2011, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, Rev. 1, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0093967.

DOE/RL-2001-49, 2004, Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D7005024.

DOE/RL-2002-11, 2008, *300-FF-5 Operable Unit Sampling and Analysis Plan*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0095179.

DOE/RL-2003-04, 2005, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA01974685.

DOE/RL-2003-38, 2004, *100-BC-5 Operable Unit Sampling and Analysis Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D6454831.

DOE/RL-2003-49, 2014. *100-FR-3 Operable Unit Sampling and Analysis Plan*, Rev. 2, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082941H.

DOE/RL-2004-21, 2004, *Calendar Year 2003 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-3 Operable Unit (OU) Pump & Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D4953894.

DOE/RL-2004-74, 2005, *300-FF-1 Operable Unit Remedial Action Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA01233219.

DOE/RL-2005-18, 2005, *Calendar Year 2004 Annual Summary Report for the 100-HR-3, 100-KR-4 and 100-NR-2 Operable Unit Pump-and-Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=DA088495.

DOE/RL-2005-88, 2014, *216-A-37-1 Crib Closure Plan (D-2-10)*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0085226.

DOE/RL-2005-93, 2006, *Remedial Design Report/Remedial Action Work Plan for the 100-N Area*, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04193451.

DOE/RL-2005-96, 2006, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit*, Rev. 0 REISSUE, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA02781523.

DOE/RL-2006-20, 2006, *The Second CERCLA Five-Year Review Report for the Hanford Site*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04570094.

DOE/RL-2006-58, 2007, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source Term Interim Characterization Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=DA04193109

DOE/RL-2007-21, 2012, *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment*, Volume 1, Parts 1 and 2, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
https://www.washingtonclosure.com/documents/mission_complete/RiskAsses/RCBRA_Vol_I_Rev_0_Part_1.pdf.
https://www.washingtonclosure.com/documents/mission_complete/RiskAsses/RCBRA_Vol_I_Rev_0_Part_2.pdf.

DOE/RL-2007-21, 2011, *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment*, Volume II, Parts 1 and 2, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.washingtonclosure.com/documents/mission_complete/RiskAsses/Vol%20II%20Part%201%20Rev.%200.pdf. https://www.washingtonclosure.com/documents/mission_complete/RiskAsses/Vol%20II%20Part%202%20Rev.%200.pdf.

DOE/RL-2007-31, 2008, *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA07159571.

DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/c.cfm/sgrp/GWRep07/start.htm.

DOE/RL-2008-11, 2008, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0810240394.

DOE/RL-2008-42, 2009, *Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0911161139.

DOE/RL-2008-46, 2010, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=1002260412.

DOE/RL-2008-46-ADD1, 2010, *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*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084374.

DOE/RL-2008-46-ADD5, 2010, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-NR-1 and 100-NR-2 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
Section 1: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031084.
Section 2: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031085.
Section 3: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031086.
Section 4: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031087.
Section 5: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031088.
Section 6: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031089.
Section 7: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031090.
Section 8: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031091.
Section 9: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031092.
Section 10: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031093.
Section 11: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031094.
Section 12: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031095.
Section 13: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031095.
Section 14: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031097.
Section 15: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105041220.
Section 16: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031099.
Section 17: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031100.
Section 18: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031101.
Section 19: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031102.
Section 20: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031103.

Section 21: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031104.
Section 22: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031105.
Section 23: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031106.
Section 24: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031107.
Section 25: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1105031108.

DOE/RL-2008-53, 2014, *216-A-29 Ditch Closure Plan (D-2-3)*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0085226.

DOE/RL-2008-58, 2010, *Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331.

DOE/RL-2008-59, 2010, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084215.

DOE/RL-2008-60, 2012, *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091409.

DOE/RL-2008-61, 2010, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331.

DOE/RL-2008-66, 2009, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/c.cfm/sgrp/GWRep08/start.htm.

DOE/RL-2009-10, 2010, *Hanford Site Cleanup Completion Framework*, Rev. 0, U.S. Department of Energy, Richland Operations Office and Office of River Protection, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1008190506.

DOE/RL-2009-30, 2009, *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units, Rev 0*, U.S. Department of Energy, Richland Operations Office and Office of River Protection, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0084339.

DOE/RL-2009-40, 2010, *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*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1008190506.

DOE/RL-2009-42, 2010, *Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084103.

DOE/RL-2009-66, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091408.

DOE/RL-2009-67, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091264.

DOE/RL-2009-68, 2011, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091262.

DOE/RL-2009-69, 2010, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091263.

DOE/RL-2009-73, 2011, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1103070707.

DOE/RL-2009-74, 2012, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091457,

DOE/RL-2009-75, 2009, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331.

DOE/RL-2009-76, 2010, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331.

DOE/RL-2009-77, 2010, *Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084330.

DOE/RL-2009-85, 2012, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091415.

DOE/RL-2009-115, 2010, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1007190651.

DOE/RL-2009-122, 2012, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0092247.

DOE/RL-2010-11, 2010, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084237.

DOE/RL-2010-13, 2010, *200 West Area Groundwater Pump-and-Treat Remedial Design Report*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084153.

DOE/RL-2010-28, 2010, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill, Rev. 1, U.S. Department of Energy, Richland Operations* Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1101200570.

DOE/RL-2010-29, 2010, *Design Optimization Study for Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1010051004.

DOE/RL-2010-92, 2011, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1106271470.

DOE/RL-2010-93, 2011, *Interim Status Groundwater Monitoring Plan for the 216-A-36B PUREX Plant Crib*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1108241345.

DOE/RL-2010-95, 2012, *Remedial Investigation/Feasibility Study for 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0090581.

DOE/RL-2010-95, 2014, *Remedial Investigation/Feasibility Study for 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0083383H.

DOE/RL-2010-96, 2013, *Remedial Investigation/Feasibility Study for 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0089052.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1308200693.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1308200694.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1308200695.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088925.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088924.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088923.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088922.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088921.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088920.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088919.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088918.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088917.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088916.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088915.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088914.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088913.

DOE/RL-2010-97, 2011, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR, and 100-KR-4 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093615.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093613.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093612.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093611.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093610.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093609.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093608.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093607.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093606.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093605.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093604.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093603.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093602.

DOE/RL-2010-98, 2012, *Remedial Investigation/Feasibility Study for 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0085352.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0085332.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0085351.

DOE/RL-2010-99, 2011, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093513.

DOE/RL-2010-99, 2013, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088359.

DOE/RL-2010-99 ADD 1, 2013, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units, Addendum*, Rev. 0, Prepared by CH2M HILL Plateau Remediation Company for the Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088361.

DOE/RL-2010-117, 2012, *Columbia River Component Risk Assessment, Volume I: Screening-Level Ecological Risk Assessment*, Volume I, Part 1, Rev. 0, Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://www.washingtonclosure.com/documents/mission_complete/ReleaseRA/2010-117_VI_R0_P1.pdf..

DOE/RL-2010-117, 2012, *Columbia River Component Risk Assessment, Volume II: Baseline Human Health Risk Assessment*, Volume II, Part 2, Rev. 0, Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0090730.

DOE/RL-2011-01, 2011, *Hanford Site Groundwater Monitoring Report for 2010*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/c.cfm/sgrp/GWRep10/html/start10.htm.

DOE/RL-2011-25, 2011, *Calendar Year 2010 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1108241346.

DOE/RL-2011-47, 2013, *Proposed Plan for the Remediation of 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088360.

DOE/RL-2011-56, 2012, *The Hanford Site Third CERCLA Five-Year Review Report*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/DOE-RL-2011-56_Rev 1__2-28-12_.pdf.

DOE/RL-2011-82, 2011, *Proposed Plan for Remediation of 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093614.

DOE/RL-2011-111, 2012, *Proposed Plan for Remediation of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0090582.

DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091795.

DOE/RL-2011-119, 2012, *Hanford Site Environmental Report for Calendar Year 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091455.

DOE/RL-2012-03, 2012, *Calendar Year 2011 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1207180240.

DOE/RL-2012-15, 2013, *Remedial Investigation/Feasibility Study for the 100-NR-1 and 100-NR-2 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088368.

DOE/RL-2012-35, 2012, *First Determination RCRA Groundwater Quality Assessment Plan for Low-Level Burial Grounds Low-Level Waste Management Area-1*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091456.

DOE/RL-2012-41, Rev. 0, 2014, *Proposed Plan for Remediation of the 100-FR-1,100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6Operable Units*. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0085353

DOE/RL-2012-53, 2012, *Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area B-BX-BY*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091056.

DOE/RL-2012-59, 2013, Surveillance Groundwater Monitoring on the Hanford Site, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081290H.

DOE/RL-2012-68, 2013, *Proposed Plan for Remediation of the 100-NR-1 and 100-NR-2 Operable Units*, CH2M HILL, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088369.

DOE/RL-2013-07, 2013, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0087671.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring Report for 2012*, Rev. 0, CH2M HILL, Richland, Washington. Available at: http://www.hanford.gov/c.cfm/sgrp/GWRep12/html/gw12_Start-PDF.htm.

DOE/RL-2013-25, 2013, *First Determination RCRA Groundwater Quality Assessment Report for Low-Level Burial Grounds Low-Level Waste Management Area-1*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088747.

DOE/RL-2013-37, 2014, *Engineering Evaluation/Cost Analysis for Perched Water Pumping/Pore Water Extraction*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0086598.

DOE/RL-2013-44, 2014, *The Modular Storage Units Groundwater Monitoring Plan*, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=1405060525.

DOE/RL-2013-46, 2013, *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/HDWP/USDOE/LERF-ETF/1-6-14/LERF-Groundwater-Monitoring-Plan-DOE-RL-2013-46-Rev.0.pdf.

DOE/RL-2013-47, 2014, *Hanford Site Environmental Report for Calendar Year 2013*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://msa.hanford.gov/files.cfm/2013_DOE-RL-2013-47_R0.pdf.

DOE/RL-2014-27, 2014, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0084907.

DOE/RL-2014-27, 2014, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081533H.

DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0084842.

DOE/RL-2014-33, 2015. Groundwater Sampling and Analysis Plan for the 200-BP-5 Groundwater Operable Unit, Draft A, Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081529H.

DOE/RL-2014-34, 2014, Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping / Pore Water Extraction, Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082284H.

DOE/RL-2015-05, In Press, *Calendar Year 2014 Annual Summary Report for the 100-HR-2 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:

DOE-STD-1196-2011, 2011, *Derived Concentration Technical Standard*, U.S. Department of Energy, Washington, D.C. Available at: http://energy.gov/sites/prod/files/2013/06/f1/DOE-STD-1196-2011.pdf.

E06-09-006, 2014, 2013 Annual Groundwater Report, AREVA, Inc., Richland, Washington.

ECF-100NPL-10-0462, 2013, *Calculation of Standard Method B Groundwater Cleanup Levels for Potable Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, Rev. 2, CH2M Hill Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0086687.

ECF-Hanford-12-0076, 2012, *Evaluation of the Relationship Between River Stage and Sampled Value for Several Analytes in the Hanford 100 Areas*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081272H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081271H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081270H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081269H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081268H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081267H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081266H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081265H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081264H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081263H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081262H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081261H
http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081260H.

ECF-Hanford-13-0013, 2014, *Calculation of Critical Means for Calendar Year 2013 RCRA Groundwater Monitoring*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-HANFORD-13-0029, *Geologic Framework Model to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at:

ECF-Hanford-14-0037, *Description of Groundwater Calculations and Assessments for the Calendar Year 2013 (CY2013) 200 Areas Pump-and-Treat Report*, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-Hanford-14-0043, 2014, Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082015H.

ECF-Hanford-14-0043, 2014, Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082015H.

ECF-Hanford-15-0003, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2014 (CY2014) Hanford Site Groundwater Monitoring Report*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

EPA, 2012, "Superfund Preliminary Remediation Goals for Radionuclides," U.S. Environmental Protection Agency website. Available at: http://epa-prgs.ornl.gov/radionuclides/.

EPA 530/R-09-007 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*, United States Environmental Protection Agency. Available at: http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/sitechar/gwstats/unified-guid.pdf.

EPA/AMD/R10-00/122, 2000, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/a1000122.pdf.

EPA/ESD/R10-00/524, 2000, *EPA Superfund Explanation of Significant Differences: Hanford 300-Area (USDOE)*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/e1000524.pdf.

EPA/ROD/R10-00/121, 2000, *Interim Remedial Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1000121.pdf.

EPA/ROD/R10-93/063, 1993, *Declaration of the Record of Decision for the USDOE Hanford 1100 Area*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1093063.pdf.

EPA/ROD/R10-95/100, 1995, *EPA Superfund Record of Decision: Hanford 200-Area (USDOE) Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1095100.pdf.

EPA/ROD/R10-95/126, 1995, *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units*, Hanford Site, Benton County, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1095126.pdf.

EPA/ROD/R10-96/134, 1996, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Interim Remedial Actions Benton County, Richland, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1096134.pdf.

EPA/ROD/R10-99/039, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1099039.pdf.

EPA/ROD/R10-99/112, 1999, *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Washington State Department of Ecology, and U.S. Department of Energy, Seattle, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1099112.pdf.

EPA, 2010, Amended Record of Decision, Decision Summary, and Responsiveness Summary for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site – 100 Area, U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0084198.

EPA, Ecology, and DOE, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r2008100003103.pdf.

EPA, Ecology, and DOE, 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0096029.

EPA, Ecology, and DOE, 2011, *Record of Decision for Decision—Hanford 200 Area Superfund Site: 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, United States Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/region10/pdf/sites/hanford/200/hanford_200_rod.pdf.

EPA, Ecology, and DOE, 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*, United States Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0091413.

EPA and DOE 2013, *Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*, Hanford Site 300 Area, U.S. Environmental Protection Agency, Region 10 U.S. Department of Energy, Richland Operations Office, November 2013. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0087180.

EPA et al., 2014. *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6 Operable Units*. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083577

HNF-EP-0182, 2013, *Waste Tank Summary Report for Month Ending December 31, 2012*, Rev. 297, Washington River Protection Solutions, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1302141456.

HW-76258, 1963, *Reactor Gas Drier Condensate Waste – Decontamination Studies*, Hanford Atomic Products Operation, Richland, Washington.

ICN-PNNL-12227, 1999, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1660026.

Mee, D., 2014, 2013 *2013 Annual Radiological Environmental Operating Report for the Columbia Generating Station*, Energy Northwest, Richland, Washington. Available at: http://pbadupws.nrc.gov/docs/ML1413/ML14135A376.pdf

Mission Support Alliance, 2015, *Hanford Site Solid Waste Landfill Annual Monitoring Report, October 2013 through September 2014*, Mission Support Alliance, Richland, Washington.

PNNL-11573, 1997, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D1659822.

PNNL-11810, 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D198175192.

PNNL-12220, 1999, *Sampling and Analysis Plan Update for Groundwater Monitoring – 100-EM-1 Operable Unit*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-12220.pdf.

PNNL-12227, 1999, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D1660026.

PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0906180659.

PNNL-13014, 2000, *Groundwater Monitoring Plan for the Solid Waste Landfill*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D1662904.

PNNL-13080, 2000, *Hanford Site Groundwater Monitoring: Setting, Sources and Methods*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D2760032.

PNNL-13121, 2000, *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D1665080.

PNNL-13116, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at:

Section 1: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2736610.
Section 2: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2736978.

PNNL-13185, 2000, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area U at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D1664858.

PNNL-13282, 2000, *Groundwater Quality Assessment for Waste Management Area U: First Determination*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D2760779.

PNNL-13378, 2001, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13378.PDF.

PNNL-13400, 2000, *Groundwater Flow and Transport Calculations Supporting the Immobilized Low-Activity Waste Disposal Facility Performance Assessment*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13400.pdf.

PNNL-13514, 2001, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13514.pdf.

PNNL-13645, 2001, *300 Area Process Trenches Groundwater Monitoring Plan*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D1664708.

PNNL-13674, 2001, *Hanford Site Groundwater and Adjacent Columbia River, Progress Report for the Groundwater/River Interface Task Science and Technology Groundwater/Vadose Zone Integration Project*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/pnnl-13674.pdf.

PNNL-13675, 2001, *Measurement of Helium-3/Helium-4 Ratios in Soil Gas at the 618-11 Burial Ground*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/pnnl-13675.pdf.

PNNL-13858, 2002, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site*, prepared for the U.S. Department of Energy under Contract DE-AC06-76RL01830, by Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13858.pdf.

PNNL-13914, 2002, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13914.pdf.

PNNL-14033, 2002, *Groundwater Monitoring and Assessment Plan for the 100-K Area Fuel Storage Basins*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14033.pdf.

PNNL-14113, 2002, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2001*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14113.pdf.

PNNL-14186, 2003, *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2002*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14186.pdf.

PNNL-15293, 2005, *Evaluation of the Fate and Transport of Tritium Contaminated Groundwater from the 618-11 Burial Ground*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15293.pdf.

PNNL-15315, 2006, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15315.pdf.

PNNL-15670, 2006, *Hanford Site Groundwater Monitoring for Fiscal Year 2005*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15670.pdf.

PNNL-15479, 2005, *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15479.pdf.

PNNL-16891, 2007, *Hanford 100-N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO4 Solution Injection and Sr-90 Immobilization in 100-N Sediments*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0084100.

PNNL-17031, 2007, *A Site-Wide Perspective on Uranium Geochemistry at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0911240713.

PNNL-17034, 2008, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093975.

PNNL-17429, 2008, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injections for In Situ Strontium-90 Immobilization*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0810240396.

PNNL-17666, 2008, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17666.pdf.

PNNL-17708, 2008, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington State*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17708.pdf.

PNNL-19052, 2009, *Water Quality Sampling Locations Along the Shoreline of the Columbia River, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19052.pdf.

PNNL-19572, 2010, *100-NR-2 Apatite Treatability Test: High-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19572.pdf.

PNNL-19702, 2010, *Hydrologic Model for the Gable Gap Area, Hanford Site*, prepared for the U.S. Department of Energy under Contract DE-AC06-76RL01830 by Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19702.pdf.

PNNL-23367, 2014, *Hanford Apatite Treatability Test Report Errata: Apatite Mass Loading Calculation*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23367.pdf

PNNL-22048, 2012, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22048.pdf.

PNNL-SA-70033, 2009, *100-NR-2 Apatite Treatability Test FY09 Status: High- Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization, Interim Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-SA-70033.pdf.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Pub. L. 94-580, 90 Stat. 2795. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington.* Available at: http://apps.leg.wa.gov/rcw/default.aspx?cite=70.105&full=true#.

RPP-7884, 2002, *Field Investigation Report for Waste Management Area S-SX*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at:
http://www5.hanford.gov/arpir/?content=findpage&AKey=D8974033.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D8974041.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D8974046.
http://www5.hanford.gov/arpir/?content=findpage&AKey=D8974049.

RPP-26744, 2005, *Hanford Soil Inventory Model, Rev. 1*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. No link on internet, in IDMS as RPP-26744 Rev 0

RPP-35485, 2007, Field Investigation Report for Waste Management Area U, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-ENV-39658, 2010, *Hanford SX-Farm Leak Assessments Report*, Rev. 0, CH2M HILL Plateau Remediation Company and Washington River Protection Solutions LLC, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/RPP-ENV-39658_Rev_0.pdf.

RPP-PLAN-26534, 2005, *Integrated Disposal Facility Operational Monitoring Plan to Meet DOE Order 435.1*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081138H.

RPP-RPT-48589, 2012, *Hanford 241-S Farm Leak Assessment Report*, Washington River Protection Solutions, LLC, Richland, Washington.

SGW-38815, 2009, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082378H.

SGW-42305, 2009, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1001210169.

SGW-49370, 2011, *Columbia River Pore Water Sampling in 100-N Area, December 2010*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-49575, 2011, *Columbia River Pore Water Sampling in 100-F Area, February 2011*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1107060718.

SGW-53543, 2012, *Automated Water Level Network Functional Requirements Document*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081288H.

SGW-53604, 2012, *Path Forward Recommendations Report for the Uranium Contamination in the B Area*, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088372.

SGW-54165, 2014, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/SGW-54165_-_Rev_00.pdf.

SGW-54508, 2013, *WMA C September 2012 Quarterly Groundwater Monitoring Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://www2.hanford.gov/ARPIR/?content=findpage&AKey=0089297.

SGW-56060, 2013, *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2013*, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-56777, 2014, *WMA C October Through December 2013 Quarterly Groundwater Monitoring Report*, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0085512.

SGW-58147, 2015, Annual Performance Report for the 200-DV-1 Operable Unit Perched Water Extraction, Fiscal Year 2014, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081530h.

SGW-58210, 2014, *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2014*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082942H.

SGW-58242, 2014, *WMA C Quarterly Report Through March 2014 Quarterly Groundwater Monitoring Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082917H.

SGW-58308, 2015, 100-BC-5 Remedial Investigation: 2014 Status Report, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0080814H

SGW-58328, 2014, *Sampling Instruction for the FY2015 M-24 200 East Groundwater Monitoring Well Drilling and Installations*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081285H.

SGW-58416, *Persistent Source Investigation at 100-D Area*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082018H.

SGW-58475, *Post-Closure Corrective Action Groundwater Monitoring Report for the 183H Solar Evaporation Basins and the 300 Area Process Trenches: January – June 2014*, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0082141H.

SGW-58542, 2015, *WMA C July through September 2014 Quarterly Groundwater Monitoring Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081461H.

SGW-58543, 2015, *Waste Management Area C Quarterly Groundwater Monitoring Report for April through June 2014*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081613HH.

SGW-58561, 2015, *WMA C Quarterly October through December 2014 Quarterly Groundwater Monitoring Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081467H.

SGW-58600, *Post-Closure Corrective Action Groundwater Monitoring Report for the 183H Solar Evaporation Basins and the 300 Area Process Trenches: July - December 2014*, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081627H.

Smith, Randall F. and Roger Stanley, 1992, "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (letter to Ronald D. Izatt, U.S. Department of Energy, Richland Operations Office, from Randall F. Smith, U.S. Environmental Protection Agency, Region 10, and Roger Stanley, Washington State Department of Ecology), correspondence incoming letter 9200423, Lacey, Washington, dated January 21. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196088487.

TPA-CN-163, 2007, *Change Notice for Modifying Approved Documents Work Plans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: PNNL-12220, "Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit"*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=DA05317392.

TPA-CN-205, 2008, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2003-4, Revision 1, Sampling and Analysis Plan for the 200-PO-1 Operable Unit*, dated June, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=0905200814.

TPA-CN-2-253, 2008, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2007-31 Rev 0, Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Operable Unit*, dated January 15, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0905200820.

TPA-CN-256, 2009, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2001-27, Rev 0, Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit and the Interim Action Waste Management Plan for the 100-NR-2 Operable Unit, DOE/RL-2000-41, Rev. 1*, dated February 12, Washington State Department of Ecology and U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0902180681.

TPA-CN-353, 2010, *Change Notice for Sampling and Analysis Plan for Aquifer Sampling Test Tubes, DOE/RL-2009-59, Rev.1*, dated May 4, U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=1006221269.

TPA-CN-368, 2010, *Tri Party Agreement TPA Change Notice Form: DOE/RL-2009-40 Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation Feasibility Study, Rev 0*, U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1009100198.

TPA-CN-460, 2011, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-40 Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study, Rev. 0*, dated May 9, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=1109060929.

TPA-CN-478, 2011, *Change Notice For Modifying Approved Documents/Workplans in Accordance with the TPA Action Plan Section 9.0 Documentation and Records DOE/RL-2009-42 Rev. 0 Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study, Rev. 0*, dated May 9, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0093668.

TPA-CN-522, 2012, *Change Notice for 100-BC-5 Operable Unit Sampling and Analysis Plan, DOE/RL-2003-38 Rev. 1 (as modified by TPA-CN-240, 12/8/2008 and TPA-CN-293, 10/6/2009)* dated May 25, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088994.

TPA-CN-558, 2013, *Tri-Party Agreement Change Notice Form: DOE/RL-2008-46-ADD3, Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units, Rev. 0*, dated January 28 (draft), U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=0089840.

TPA-CN-559, 2013, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-44, Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study, Rev. 0*, dated January 28 (draft), U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0081/0088651/TPA-CN-559_Final.pdf.

TPA-CN-569, *Change Notice For Modifying Approved Documents/Workplans in Accordance with the TPA Action Plan Section 9.0 Documentation and Records DOE/RL-2001-27 Rev. 0 Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, dated April 23, U.S. Department of Energy, Richland Operations Office and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=1305060797.

TPA-CN-578, 2013, *Tri Party Agreement TPA Change Notice Form Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit DOE/RL-2001-49 Rev 1*, dated August 13, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1310160532.

TPA-CN-592, 2013, *Tri-Party Agreement Change Notice Form: DOE/RL-2008-46 ADD3, Integrated 100 Area Remedial Investigation Feasibility Study Work Plan Addendum 3 100-BC-1 100-BC-2 and 100-BC-5 Operable Units Rev 0 as Modified By TPA-CN-558*, dated September 24, U.S. Department of Energy, Richland Operations Office and Washington State Department of Ecology, Richland, Washington. Available At: http://pdw.hanford.gov/arpir/pdf.cfm?accession=1310160530.

TPA-CN-593, 2013, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-44 Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study Rev 0 as Modified By TPA-CN-559*, dated September 24, U.S. Department of Energy, Richland Operations Office and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1310160531.

TPA-CN-602, 2013, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-44 Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study Rev 0 as Modified By TPA-CN-559 and TPA-CN-593*, dated September 24, U.S. Department of Energy, Richland Operations Office and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0087306.

Train v. Colorado Public Interest Research Group Inc., 1976, U.S. Supreme Court. Available at: https://supreme.justia.com/cases/federal/us/426/1/.

WA7890008967, 2007, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended, Washington State Department of Ecology, Richland, Washington.

WAC 173-200, "Water Quality Standards for Groundwaters of the State of Washington," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-200.

WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington," "Toxic Substances," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-240.

WAC 173-216, "State Waste Discharge Permit Program", *Washington Administrative Code*, Olympia, Washington. Available at: http://app.leg.wa.gov/WAC/default.aspx?cite=173-216.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-400.

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-645.

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-304.

WAC 173-304-490, "Minimum Functional Standards for Solid Waste Handling," "Ground Water Monitoring Requirements," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-304-490.

WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340.

WAC 173-350, "Solid Waste Handling Standards," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-350.

WAC 246-290-310, "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/wac/default.aspx?cite=246-290-310.

WCH-173, 2008, *Environmental Restoration Disposal Facility Leachate Sampling and Analysis Plan*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://www5.hanford.gov/pdw/fsd/ar/fsd0001/fsd0001/da05651180/1.pdf.

WCH-198, 2008, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0092667..

WCH-380, 2010, *Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington*, Rev. 1, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0093555.

WCH-600, 2014, Annual Operations and Monitoring Report for UPR-100-N-17: November 2012 – February 2014, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0085479.

WHC-EP-0877, 1995, *K Basin Corrosion Program Report*, A.B. Johnson, Jr. & S.P. Burke, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196008314.

WHC-MR-0033, 1989, *Recharge to the North Richland Well Field*, A.G. Law, Westinghouse Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=E0019009.

WHC-MR-0132, 1990, *A History of the 200 Area Tank Farms*, Rev. 0, J.D. Anderson, Westinghouse Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=D196015712. http://www5.hanford.gov/arpir/?content=findpage&AKey=D196015715.

WHC-MR-0388, 1992, *Past Practices Technical Characterization Study – 300 Area – Hanford Site*, M.S. Gerber, Westinghouse Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/pdw/fsd/AR/FSD0001/FSD0060/E0029700/0029700_-_[1010121436].pdf.

WHC-MR-0521, 1996, *The Plutonium Production Story at the Hanford Site: Processes and Facilities History*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0081287H.

WHC-SD-EN-AP-045 1991, *Groundwater Monitoring Plan for the 216-A-29 Ditch, Rev. 0*, Westinghouse Hanford Company, Richland, Washington. Available at:

WHC-SD-EN-AP-185, 1995, *Groundwater Monitoring Plan for the 300 Area Process Trenches*, Rev. 0, , Westinghouse Hanford Company, Richland, Washington. Available at: http://www2.hanford.gov/arpir/?content=findpage&AKey=D196020117.

WCH-SD-EN-DP-052, 1992, *Borehole Completion Package for 216-S-10 Facility CY 1992*, Geosciences, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196126388.

WCH-SD-EN-EV-003, 1992, *Results of Groundwater Quality Assessment Monitoring at the 1301-N and 1324-N/NA Facilities*, Rev. 1, Westinghouse Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=E0025405.

WHC-SD-EN-EV-032, 1995, *Results of Groundwater Quality Assessment Program at the 216-A-29 Ditch RCRA Facility*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://www5.hanford.gov/arpir/?content=findpage&AKey=E0042415.

WHC-SD-EN-TI-302, 1995, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=1201050287.

Zachara, J. M., Serne, J., Freshley, M., Mann, F., Anderson, F., Wood, M., et al. (2007). Geochemical Processes Controlling Migration of Tank Wastes in Hanford's Vadose Zone. *Vadose Zone Journal*, *6*(4), 985-1003. Avialable at: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1300&context=usdoepub&sei-redir=1&referer=http%3A%2F%2Fwww.bing.com%2Fsearch%3Fq%3DZachara%2C%2BJ.%2BM.%2C%2BSerne%2C%2BJ.%2C%2BFreshley%2C%2BM.%2C%2BMann%2C%2BF.%2C%2BAnderson%2C%2BF.%2C%2BWood%2C%2BM.%2C%2Bet%2Bal.%2B%282007%29.%2BGeochemical%2BProcesses%2BControlling%2BMigration%2Bof%2BTank%2BWastes%2Bin%2BHanford%27s%2BVadose%2BZone.%2BVadose%2BZone%2BJournal%2C%2B6%284%29%2C%2B985-1003.%26src%3Die9tr#search=%22Zachara%2C%20J.%20M.%2C%20Serne%2C%20J.%2C%20Freshley%2C%20M.%2C%20Mann%2C%20F.%2C%20Anderson%2C%20F.%2C%20Wood%2C%20M.%2C%20et%20al.%20%282007%29.%20Geochemical%20Processes%20Controlling%20Migration%20Tank%20Wastes%20Hanfords%20Vadose%20Zone.%20Vadose%20Zone%20Journal%2C%206%284%29%2C%20985-1003.%22.

Appendix A

Supporting Information for CERCLA Operable Units

This page intentionally left blank.

Tables

Table A-1. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit A-1
Table A-2. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit Remedial Investigation Studies A-3
Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4 ..... A-5
Table A-4. Monitoring Wells and Constituents for 100-NR-2 ..... A-11
Table A-5. Monitoring Wells and Constituents for the 100-NR-2 Apatite Permeable Reactive Barrier A-15
Table A-6. Monitoring Wells and Constituents for the 100-N (UPR-100-N-17) Bioremediation A-17
Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3 ..... A-18
Table A-8. Monitoring Wells and Constituents for the 100-FR-3 Operable Unit A-34
Table A-9. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 300 Area[a] A-36
Table A-10. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 618-10/316-4 Subregion[a] A-40
Table A.11. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 618-11 Subregion[a] . A-41
Table A-12. Monitoring Wells and Constituents for the Former 1100-EM-1 Operable Unit A-41
Table A-13. Monitoring Wells, Constituents, and Sampling Frequency for the 200-ZP-1 Operable Unit in 2014 ..... A-42
Table A-14. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit A-46
Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit A-51
Table A-16. Monitoring Wells and Constituents for 200-PO-1 Operable Unit Near-Field Wells A-60
Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells A-65

This page intentionally left blank.

A Supporting Information for CERCLA Operable Units

Under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), the contaminated groundwater beneath portions of the Hanford Site is divided into 11 groundwater operable units.

The tables provided in this chapter list the constituents, monitoring wells, and sampling frequency for each operable unit, as required by their respective sampling and analysis plans or other documentation. The tables also indicate whether the wells were sampled as scheduled during 2014. Aquifer tubes are also sampled at the Hanford Site as part of the CERCLA groundwater monitoring program. Details regarding aquifer tube sampling are provided in Appendix D.

In many cases, wells are sampled for additional constituents not strictly required by the plans. Those constituents are not listed in the tables of this appendix, but data files accompanying this report include all of the required and supplemental data.

Table A-1. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit

Well	Hydrologic Unit Monitored	Alkalinity	Gross Alpha/Beta	Anions	Hexavalent Chromium	Metals	Strontium-90	Tritium	Technetium-99	Volatile Organic Analytes	Sampled as Planned?
199-B2-12	RUM	BO	—	BO	BO	BO	BO	BO	—	—	Yes
199-B2-13	TU	BE	—	BE	BE	BE	BE	BE	—	—	Not scheduled*
199-B2-14	TU	—	—	—	A	—	A	A	—	—	Yes
199-B2-15	RUM	—	—	—	BE	—	BE	BE	—	—	Not scheduled
199-B2-16	BU	A	—	A	S	A	S	S	—	A	Yes
199-B3-1	TU	BE	—	BE	A	BE	A	A	—	—	Yes
199-B3-46	TU	BO	—	BO	A	BO	A	A	—	—	Yes
199-B3-47	TU	BE	—	BE	A	BE	A	A	—	—	Yes
199-B3-50	TU	—	—	—	A	—	A	A	—	—	Yes
199-B3-51	BU	BO	—	BO	BO	BO	BO	BO	—	—	Yes
199-B4-1	TU	BE	—	BE	A	BE	A	A	—	—	Yes
199-B4-4	TU	—	—	—	BE	—	BE	BE	—	—	Not scheduled*
199-B4-7	TU	A	—	A	S	A	A	S	—	—	Yes
199-B4-8	TU	BE	—	BE	BE	BE	BE	BE	—	—	Yes
199-B4-14	TU	A	—	A	M	A	M	M	—	—	Yes
199-B5-1	TU	A	—	A	S	A	A	S	—	—	Yes
199-B5-2	TU	—	—	—	A	—	A	A	—	—	Yes

Table A-1. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit

Well	Hydrologic Unit Monitored	Alkalinity	Gross Alpha/Beta	Anions	Hexavalent Chromium	Metals	Strontium-90	Tritium	Technetium-99	Volatile Organic Analytes	Sampled as Planned?
199-B5-5	BU	—	—	—	A	—	—	A	—	A	Yes
199-B5-6	BU	A	A	A	Q	A	—	Q	—	A	Yes
199-B5-8	TU	BE	BE	BE	BE	BE	—	BE	BE	BE	Not scheduled*
199-B8-6	TU	BO	BO	BO	A	BO	—	A	—	—	Yes
199-B8-9	TU	—	A	—	Q	—	—	Q	—	—	Yes
199-B9-2	TU	—	BE	—	BE	—	—	BE	—	—	Not scheduled*
199-B9-3	TU	BO	BO	BO	BO	BO	—	BO	—	—	Yes
699-63-90	U	BE	BE	BE	—	BE	—	BE	—	—	Not scheduled
699-65-83	U	—	—	—	—	—	—	BE	—	—	Not scheduled*
699-67-86	U	—	—	—	—	—	—	BO	—	—	Yes
699-68-105	U	BO	—	BO	—	BO	—	BO	—	—	Yes
699-71-77	U	BO	—	BO	—	BO	—	BO	BO	—	Yes
699-72-73	U	BE	—	BE	—	BE	—	BE	BE	—	Not scheduled*
699-72-92	U	BO	—	BO	—	BO	—	BO	—	—	Yes
Spring037-1	TU	—	A	—	A	—	—	A	—	—	Yes
Spring039-2	TU	—	A	—	A	—	—	A	—	—	Yes

Notes:

The sampling requirements are from DOE/RL-2003-38, *100-BC-5 Operable Unit Sampling and Analysis Plan*, as modified by TPA-CN-522, *Tri-Party Agreement Change Notice Form: 100-BC-5 Operable Unit Sampling and Analysis Plan, DOE/RL-2003-38, Rev. 1 (as modified by TPA-CN-240, 12/8/2008 and TPA-CN-293 (10/6/2009).*

Additional constituents sampled for include field parameters specific conductance, temperature, and turbidity.

* Not scheduled under the routine groundwater SAP. Sampled as required under a separate SAP.

A = to be sampled annually
BE = to be sampled biennially, even fiscal years
BO = to be sampled biennially, odd fiscal years
BU = bottom of unconfined aquifer
M = to be sampled monthly
Q = to be sampled quarterly
RUM = Ringold upper mud unit
TU = top of unconfined aquifer
U = unconfined aquifer (undifferentiated)

Table A-2. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit Remedial Investigation Studies

Well Name	Hydrologic Unit Monitored	Anions	Alkalinity	Cr(VI)	Metals	Sr-90	Tritium	DOC	Fe(II)	Isotopic Cr	Sulfide	Sampled as Planned in 2014?
199-B2-13	TU	A	A	A	A	—	—	A	—	—	—	Yes
199-B2-14	TU	A	A	S	S	A	A	S	S	S	S	No[a]
199-B2-16	BU	A	A	S	S	A	A	S	—	—	—	Yes
199-B3-1	TU	A	A	S	S	A	A	S	—	—	—	Yes
199-B3-46	TU	A	A	S	S	A	A	S	—	—	—	Yes
199-B3-47	TU	S	S	S	S	A	A	S	S	S	S	No[a]
199-B3-50	TU	A	A	S	S	A	A	S	—	—	—	Yes
199-B3-51	BU	A	A	A	A	A	A	A	—	—	—	Yes
199-B4-1	TU	A	A	S	S	A	A	S	S	S	S	No[a]
199-B4-4	TU	A	A	A	A	—	—	A	—	—	—	Yes
199-B4-7	TU	S	S	Q	Q	A	S	S	—	—	—	Yes
199-B4-8	TU	A	A	S	S	—	—	S	—	—	—	Yes
199-B4-14	TU	S	S	Q	Q	—	Q	S	S	S	S	No[a]
199-B4-16[c]	TU	Q	Q	Q	Q	—	Q	Q	—	—	—	Yes
199-B4-18[c]	BU	Q	Q	Q	Q	Q	Q	Q	—	—	—	No[b]
199-B5-1	TU	S	S	S	S	A	A	S	—	—	—	Yes
199-B5-2	TU	A	A	S	S	A	A	S	—	—	—	Yes
199-B5-5	BU	A	A	S	S	—	A	S	—	—	—	Yes
199-B5-6	BU	S	S	Q	Q	—	Q	S	—	—	—	Yes
199-B5-8	TU	A	A	A	A	—	A	A	—	—	—	Yes
199-B5-9[c]	BU	Q	Q	Q	Q	—	Q	Q	—	—	—	No[b]
199-B5-10[c]	TU	Q	Q	Q	Q	—	Q	Q	—	—	—	Yes
199-B5-11[c]	BU	Q	Q	Q	Q	—	Q	Q	—	—	—	No[b]
199-B5-12[c]	TU	Q	Q	Q	Q	—	Q	Q	—	—	—	Yes
199-B5-13[c]	BU	Q	Q	Q	Q	Q	Q	Q	—	—	—	No[b]
199-B5-14[c]	TU	Q	Q	Q	Q	—	Q	—	—	—	—	Yes
199-B8-6	TU	A	A	S	S	—	A	S	—	—	—	Yes

Table A-2. Monitoring Wells and Constituents for the 100-BC-5 Operable Unit Remedial Investigation Studies

Well Name	Hydrologic Unit Monitored	Anions	Alkalinity	Cr(VI)	Metals	Sr-90	Tritium	DOC	Fe(II)	Isotopic Cr	Sulfide	Sampled as Planned in 2014?
199-B8-9	TU	S	S	Q	Q	—	S	S	S	S	S	No[a]
199-B9-2	TU	A	A	A	A	—	—	A	—	—	—	Yes
199-B9-3	TU	A	A	S	S	—	—	S	—	—	—	Yes
699-65-83	U	A	A	A	A	—	—	A	—	—	—	Yes

Notes:

The sampling requirements are from DOE/RL-2009-44, *Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study*, as modified by TPA-CN-602, *Tri-Party Agreement Change Notice* Form, 1/5/2013.

Additional constituents sampled for include field parameters dissolved oxygen, pH, specific conductance, temperature, and turbidity.

a. Isotopic chromium analyses for June 2014 delayed too long; cancelled. Isotopic chromium analysis for October 2014 are pending. Earlier isotopic chromium data not yet in HEIS.

b. For the first two sample events in these new, deep wells, pumps were set at incorrect depths and wells were not purged sufficiently. Samples were judged to be non-representative. An extra sampling event was completed in the affected wells and their shallow counterparts.

c. New wells; first routine samples in March 2014. Quarterly sampling for first year; frequency may be reduced subsequently, with EPA and DOE concurrence.

A = to be sampled annually

BU = bottom of unconfined aquifer

Q = to be sampled quarterly

S = to be sampled semiannually

TU = top of unconfined aquifer

U = unconfined (undifferentiated)

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-11	6/23/2014	—
199-K-11	11/23/2014	—
199-K-13	5/9/2014	—
199-K-13	11/14/2014	—
199-K-18	2/6/2014	—
199-K-18	4/14/2014	—
199-K-18	7/17/2014	—
199-K-18	10/7/2014	—
199-K-19	5/16/2014	—
199-K-19	11/17/2014	—
199-K-20	2/6/2014	—
199-K-20	4/14/2014	—
199-K-20	7/17/2014	—
199-K-20	10/7/2014	—
199-K-21	4/18/2014	—
199-K-21	10/9/2014	—
199-K-22	5/16/2014	—
199-K-22	11/17/2014	—
199-K-23	1/16/2014	—
199-K-23	5/16/2014	—
199-K-23	11/14/2014	—
199-K-31	5/13/2014	—
199-K-31	11/14/2014	—
199-K-32A	2/19/2014	—
199-K-32A	5/16/2014	—
199-K-32A	8/11/2014	—
199-K-32A	11/23/2014	—
199-K-34	2/14/2014	—
199-K-34	4/14/2014	—

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-34	7/30/2014	—
199-K-34	11/21/2014	—
199-K-36	5/30/2014	—
199-K-36	11/21/2014	—
199-K-37	5/27/2014	—
199-K-37	11/17/2014	—
199-K-106A	2/14/2014	—
199-K-106A	6/23/2014	—
199-K-106A	9/9/2014	—
199-K-106A	11/21/2014	—
199-K-107A	2/14/2014	—
199-K-107A	5/21/2014	—
199-K-107A	9/9/2014	—
199-K-107A	11/21/2014	—
199-K-108A	2/14/2014	—
199-K-108A	5/21/2014	—
199-K-108A	8/13/2014	—
199-K-108A	11/21/2014	—
199-K-108A	11/24/2014	—
199-K-110A	5/9/2014	—
199-K-110A	11/23/2014	—
199-K-111A	2/20/2014	—
199-K-111A	5/28/2014	—
199-K-111A	8/11/2014	—
199-K-111A	11/23/2014	—
199-K-113A	5/22/2014	Extraction Well
199-K-113A	11/19/2014	Extraction Well
199-K-114A	5/22/2014	Extraction Well
199-K-114A	11/19/2014	Extraction Well

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-115A	5/22/2014	Extraction Well
199-K-115A	11/19/2014	Extraction Well
199-K-116A	5/22/2014	Extraction Well
199-K-116A	11/19/2014	Extraction Well
199-K-117A	2/6/2014	—
199-K-117A	4/14/2014	—
199-K-117A	7/17/2014	—
199-K-117A	10/9/2014	—
199-K-118A	11/17/2014	—
199-K-119A	5/9/2014	—
199-K-119A	11/17/2014	—
199-K-120A	11/19/2014	Extraction Well
199-K-121A	—	Injection Well
199-K-122A	—	Injection Well
199-K-123A	—	Injection Well
199-K-124A	5/27/2014	—
199-K-124A	12/2/2014	—
199-K-125A	5/28/2014	—
199-K-125A	11/23/2014	—
199-K-126	4/18/2014	—
199-K-127	11/19/2014	Extraction Well
199-K-128	—	Injection Well
199-K-129	5/22/2014	Extraction Well
199-K-129	11/19/2014	Extraction Well
199-K-130	4/17/2014	Extraction Well
199-K-130	10/29/2014	Extraction Well
199-K-131	6/5/2014	Extraction Well
199-K-131	11/24/2014	Extraction Well
199-K-132	6/5/2014	Extraction Well

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-133	5/27/2014	—
199-K-133	11/14/2014	—
199-K-134	11/14/2014	—
199-K-135	11/14/2014	—
199-K-136	5/27/2014	—
199-K-136	11/14/2014	—
199-K-137	5/22/2014	Extraction Well
199-K-137	11/18/2014	Extraction Well
199-K-138	5/22/2014	Extraction Well
199-K-138	11/19/2014	Extraction Well
199-K-138	11/20/2014	Extraction Well
199-K-139	5/22/2014	Extraction Well
199-K-139	11/19/2014	Extraction Well
199-K-140	1/23/2014	Extraction Well
199-K-140	5/22/2014	Extraction Well
199-K-140	8/25/2014	Extraction Well
199-K-140	11/19/2014	Extraction Well
199-K-141	1/23/2014	Extraction Well
199-K-141	5/22/2014	Extraction Well
199-K-141	8/25/2014	Extraction Well
199-K-141	11/24/2014	Extraction Well
199-K-142	5/30/2014	—
199-K-142	11/23/2014	—
199-K-143	—	Injection Well
199-K-144	1/16/2014	Extraction Well
199-K-144	5/22/2014	Extraction Well
199-K-144	12/16/2014	Extraction Well
199-K-145	5/22/2014	Extraction Well
199-K-145	11/19/2014	Extraction Well

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-146	6/5/2014	Extraction Well
199-K-146	11/24/2014	Extraction Well
199-K-147	5/22/2014	Extraction Well
199-K-147	11/24/2014	Extraction Well
199-K-148	5/22/2014	Extraction Well
199-K-148	11/24/2014	Extraction Well
199-K-149	5/28/2014	—
199-K-149	11/14/2014	—
199-K-150	1/16/2014	—
199-K-150	2/10/2014	—
199-K-150	3/3/2014	—
199-K-150	4/4/2014	—
199-K-150	5/9/2014	—
199-K-150	6/23/2014	—
199-K-150	7/17/2014	—
199-K-150	8/12/2014	—
199-K-150	9/9/2014	—
199-K-150	10/9/2014	—
199-K-150	11/18/2014	—
199-K-151	4/18/2014	—
199-K-151	10/13/2014	—
199-K-152	4/17/2014	Extraction Well
199-K-152	10/29/2014	Extraction Well
199-K-153	8/25/2014	Extraction Well
199-K-153	11/24/2014	Extraction Well
199-K-154	8/25/2014	Extraction Well
199-K-154	11/24/2014	Extraction Well
199-K-156	—	Injection Well
199-K-157	2/19/2014	—

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-157	5/30/2014	—
199-K-157	8/13/2014	—
199-K-157	11/23/2014	—
199-K-158	—	Injection Well
199-K-159	—	Injection Well
199-K-160	—	Injection Well
199-K-161	6/24/2014	Extraction Well
199-K-161	11/24/2014	Extraction Well
199-K-162	5/22/2014	Extraction Well
199-K-162	11/19/2014	Extraction Well
199-K-163	1/23/2014	Extraction Well
199-K-163	8/25/2014	Extraction Well
199-K-163	11/24/2014	Extraction Well
199-K-164	—	Injection Well
199-K-165	4/17/2014	Extraction Well
199-K-165	11/18/2014	Extraction Well
199-K-166	1/23/2014	Extraction Well
199-K-166	4/17/2014	Extraction Well
199-K-166	7/16/2014	Extraction Well
199-K-166	11/18/2014	Extraction Well
199-K-168	1/23/2014	Extraction Well
199-K-168	5/22/2014	Extraction Well
199-K-168	8/25/2014	Extraction Well
199-K-168	11/19/2014	Extraction Well
199-K-169	—	Injection Well
199-K-170	—	Injection Well
199-K-171	8/25/2014	Extraction Well
199-K-171	11/24/2014	Extraction Well
199-K-172	—	Injection Well

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-173	1/23/2014	Extraction Well
199-K-173	4/17/2014	Extraction Well
199-K-173	7/16/2014	Extraction Well
199-K-173	11/19/2014	Extraction Well
199-K-174	—	Injection Well
199-K-175	—	Injection Well
199-K-178	5/22/2014	Extraction Well
199-K-178	12/11/2014	Extraction Well
199-K-179	—	Injection Well
199-K-180	—	Injection Well
199-K-181	1/16/2014	Extraction Well
199-K-181	5/22/2014	Extraction Well
199-K-181	12/11/2014	Extraction Well
199-K-182	1/23/2014	Extraction Well
199-K-182	6/5/2014	Extraction Well
199-K-182	8/27/2014	Extraction Well
199-K-182	11/24/2014	Extraction Well
199-K-183	2/14/2014	—
199-K-183	5/13/2014	—
199-K-183	8/11/2014	—
199-K-183	11/18/2014	—
199-K-184	2/14/2014	—
199-K-184	5/21/2014	—
199-K-184	8/13/2014	—
199-K-184	11/21/2014	—
199-K-185	2/20/2014	—
199-K-185	5/28/2014	—
199-K-185	8/13/2014	—
199-K-185	11/21/2014	—

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-186	2/19/2014	—
199-K-186	5/27/2014	—
199-K-186	8/11/2014	—
199-K-186	11/23/2014	—
199-K-187	2/19/2014	—
199-K-187	5/13/2014	—
199-K-187	9/9/2014	—
199-K-187	11/18/2014	—
199-K-188	2/19/2014	—
199-K-188	5/30/2014	—
199-K-188	8/13/2014	—
199-K-188	11/21/2014	—
199-K-189	2/19/2014	—
199-K-189	5/28/2014	—
199-K-189	8/13/2014	—
199-K-189	11/21/2014	—
199-K-190	2/19/2014	—
199-K-190	5/9/2014	—
199-K-190	8/13/2014	—
199-K-190	11/23/2014	—
199-K-191	2/20/2014	—
199-K-191	5/27/2014	—
199-K-191	8/13/2014	—
199-K-191	11/18/2014	—
199-K-192	2/20/2014	—
199-K-192	6/2/2014	—
199-K-192	8/13/2014	—
199-K-192	11/23/2014	—
199-K-193	2/24/2014	—

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-193	5/28/2014	—
199-K-193	8/13/2014	—
199-K-193	12/2/2014	—
199-K-194	2/20/2014	—
199-K-194	6/23/2014	—
199-K-194	8/21/2014	—
199-K-194	11/21/2014	—
199-K-196	1/23/2014	Extraction Well
199-K-196	5/22/2014	Extraction Well
199-K-196	8/25/2014	Extraction Well
199-K-196	11/19/2014	Extraction Well
199-K-197	2/20/2014	—
199-K-197	6/2/2014	—
199-K-197	8/21/2014	—
199-K-197	11/21/2014	—
199-K-198	1/16/2014	Extraction Well
199-K-198	2/26/2014	Extraction Well
199-K-198	5/22/2014	Extraction Well
199-K-198	8/25/2014	Extraction Well
199-K-198	11/19/2014	Extraction Well
199-K-199	1/16/2014	Extraction Well
199-K-199	2/26/2014	Extraction Well
199-K-199	5/22/2014	Extraction Well
199-K-199	8/25/2014	Extraction Well
199-K-199	11/19/2014	Extraction Well
199-K-200	2/19/2014	—
199-K-200	6/2/2014	—
199-K-200	8/21/2014	—
199-K-200	12/2/2014	—

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-201	2/20/2014	—
199-K-201	5/9/2014	—
199-K-201	8/21/2014	—
199-K-202	10/13/2014	—
199-K-203	11/5/2014	—
199-K-203	11/12/2014	—
199-K-203	11/19/2014	—
199-K-204	9/2/2014	—
199-K-204	9/9/2014	—
199-K-204	9/18/2014	—
199-K-204	10/22/2014	—
199-K-205	2/3/2014	Extraction Well
199-K-205	2/3/2014	Extraction Well
199-K-205	2/4/2014	Extraction Well
199-K-205	9/30/2014	Extraction Well
199-K-205	12/11/2014	Extraction Well
199-K-206	3/31/2014	Injection Well
199-K-207	12/9/2014	—
199-K-207	12/9/2014	—
199-K-207	12/22/2014	—
199-K-207	12/23/2014	—
199-K-207	12/30/2014	—
199-K-210	3/13/2014	Extraction Well
199-K-210	3/20/2014	Extraction Well
199-K-210	3/25/2014	Extraction Well
199-K-210	4/1/2014	Extraction Well
199-K-210	6/3/2014	Extraction Well
199-K-210	11/24/2014	Extraction Well
199-K-212	3/24/2014	Extraction Well

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
199-K-212	3/25/2014	Extraction Well
199-K-212	3/26/2014	Extraction Well
199-K-212	3/31/2014	Extraction Well
199-K-212	5/20/2014	Extraction Well
199-K-212	11/24/2014	Extraction Well
199-K-220	4/8/2014	Extraction Well
199-K-220	4/14/2014	Extraction Well
199-K-220	4/17/2014	Extraction Well
199-K-220	6/9/2014	Extraction Well
199-K-220	12/11/2014	Extraction Well
199-N-71	2/24/2014	—
199-N-71	3/5/2014	—
199-N-71	6/19/2014	—
199-N-71	9/15/2014	—
199-N-71	11/12/2014	—
199-N-165	3/3/2014	—
199-N-165	6/19/2014	—
199-N-165	9/16/2014	—
199-N-165	11/12/2014	—
699-70-68	1/6/2014	—
699-70-68	10/27/2014	—
699-72-73	10/13/2014	—
699-73-61	1/6/2014	—
699-77-54	10/21/2014	—
699-78-62	2/20/2014	—
699-78-62	5/9/2014	—
699-78-62	8/22/2014	—
699-78-62	11/4/2014	—
Note:		

Table A-3. Extraction, Injection, and Monitoring Wells for 100-KR-4

Well Name	Sample Date	Comment
This table excludes sample dates associated with extraction wells that were taken at the plant on a monthly basis.		

Table A-4. Monitoring Wells and Constituents for 100-NR-2

Well Name	Field Parameters[c]	Alkalinity	Gross Alpha	Anions	Gross Beta	Gamma	Metals	Oil and Grease	PAH	Strontium-90	Total Petroleum Hydrocarbons	Tritium	VOC	SVOC	Sampled as Planned in 2014?	Comments
199-N-2[a]	A	—	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-3[a]	S	—	—	S	S	—	S	—	—	S	—	S	—	—	Yes	—
199-N-14[a]	S	—	—	S	S	—	S	—	—	S	—	S	—	—	Yes	—
199-N-16[a]	A	—	—	A	A	—	A	A	—	A	A	—	—	—	No	Decommissioned 2012
199-N-18[a]	A	—	—	—	—	—	—	A	—	—	A	—	—	—	No	Not sampled; used for removal of TPH free product
199-N-19	A	—	—	A	—	—	A	—	A	A	A	—	—	—	No	Sampled in January 2015; delayed by access restrictions
199-N-21[a]	A	—	—	A	—	—	A	—	—	—	—	—	—	—	No	Sampled in January 2015; delayed by access restrictions
199-N-27[a]	A	—	A	A	—	A	A	—	—	—	—	A	—	—	Yes	—
199-N-28	A	A	A	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-32[a]	S	—	—	S	S	S	S	—	—	S	—	S	—	—	Yes	—
199-N-34	A	A	—	A	—	—	A	—	—	A	—	A	—	—	Yes	—
199-N-41	A	A	—	A	—	—	A	—	—	A	—	A	—	—	Yes	—
199-N-46	S	S	S	S	S	S	S	—	—	S	—	—	—	—	Yes	—
199-N-50[a]	A	—	—	—	A	—	—	—	—	—	—	A	—	—	Yes	—

Table A-4. Monitoring Wells and Constituents for 100-NR-2

Well Name	Field Parameters[c]	Alkalinity	Gross Alpha	Anions	Gross Beta	Gamma	Metals	Oil and Grease	PAH	Strontium-90	Total Petroleum Hydrocarbons	Tritium	VOC	SVOC	Sampled as Planned in 2014?	Comments
199-N-51[a]	A	—	—	—	A	—	—	—	—	—	—	A	—	—	Yes	—
199-N-56	A	A	A	A	—	A	A	—	A	A	A	A	—	—	Yes	—
199-N-57	A	A	A	A	—	A	A	—	A	A	A	A	—	—	Yes	—
199-N-64[a]	A	—	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-67[a]	S	—	S	S	S	—	S	—	—	S	—	—	—	—	Yes	—
199-N-69	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-70[a]	A	—	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-71	A	A	—	A	—	—	A	—	—	—	—	—	—	—	Yes	—
199-N-73	A	A	—	A	—	—	A	—	—	—	—	—	—	—	Yes	—
199-N-74[a]	A	—	A	—	A	A	A	—	—	—	—	—	—	—	Yes	—
199-N-75[a]	S	—	—	S	S	—	S	—	—	S	—	S	—	—	Yes	—
199-N-76[a]	S	—	—	S	S	S	S	—	—	S	—	S	—	—	Yes	—
199-N-80[a]	A	—	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-81[a]	A	—	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-92A[a]	A	—	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-96A[a]	A	—	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—

Table A-4. Monitoring Wells and Constituents for 100-NR-2

Well Name	Field Parameters[c]	Alkalinity	Gross Alpha	Anions	Gross Beta	Gamma	Metals	Oil and Grease	PAH	Strontium-90	Total Petroleum Hydrocarbons	Tritium	VOC	SVOC	Sampled as Planned in 2014?	Comments
199-N-99A[a]	A	—	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-103A	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-105A	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-106A	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-119	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-120	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-121	A	A	A	A	A	A	A	—	—	A	—	A	—	—	Yes	—
199-N-173	A	A	—	A	A	—	A	—	A	A	A		A	—	Yes	
199-N-182	A	A	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-183	A	A	—	A	—	—	A	A	A	A	A	—	A	—	Yes	—
199-N-184	A	A	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-185	A	A	—	A	A	—	A	—	—	A	—	A	—	—	Yes	—
199-N-186[b]	Q	—	Q	Q	Q	Q	Q	—	Q	Q	Q	Q	Q	Q	Yes	Also sampled for an extended analyte list[d]
199-N-187[b]	Q	—	Q	Q	Q	Q	Q	—	Q	Q	Q	Q	Q	Q	Yes	Also sampled for an extended analyte list[d]

Table A-4. Monitoring Wells and Constituents for 100-NR-2

Well Name	Field Parameters[c]	Alkalinity	Gross Alpha	Anions	Gross Beta	Gamma	Metals	Oil and Grease	PAH	Strontium-90	Total Petroleum Hydrocarbons	Tritium	VOC	SVOC	Sampled as Planned in 2014?	Comments
199-N-188[b]	Q	—	Q	Q	Q	Q	Q	—	Q	Q	Q	Q	Q	Q	Yes	Also sampled for an extended analyte list[d]
199-N-189	A	A	—	A	A	—	A	—	—	A	—	A	—	—	Yes	

a. Monitoring requirements are from *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit* (DOE/RL-2001-27). TPA-CN-256, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2001-27, Rev. 0, Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit and the Interim Action Waste Management Plan for the 100-NR-2 Operable Unit, DOE/RL-2000-41, Rev. 1*, modified the monitoring requirements, including updating analyses and removing decommissioned wells.

b. Monitoring requirements are *Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study* (DOE/RL-2009-42). TPA-CN-478, *Tri-Party Agreement Change Notice Form: Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study, DOE/RL-2009-42, Rev. 0*, modified the monitoring requirements, adding quarterly sampling for wells 199-N-186, 199-N-187, and 199-N-188 for the list of constituents in Table 2-7 of DOE/RL-2009-42.

c. Field parameters include pH, temperature, conductivity, and turbidity; with dissolved oxygen and oxidation-reduction potential on some wells.

d. Wells 199-N-186, 199-N-187, and 199-N-188 also sampled for plutonium-238, plutonium-239/240, technetium-99, uranium-233/234, uranium-235, uranium-238, pesticides, cyanide, nonhalogenated hydrocarbons, polychlorinated biphenyls, hexavalent chromium, and mercury.

A = to be sampled annually
Q = to be sampled quarterly
S = to be sampled semiannually
SVOC = semivolatile organic compound
VOC = volatile organic compound

Table A-5. Monitoring Wells and Constituents for the 100-NR-2 Apatite Permeable Reactive Barrier

Well Name	Well Type	Field Parameters*	Anions	Gross Alpha/Beta	Metals	Strontium-90	TPH-Diesel	Sampled as Planned in 2014?
199-N-96A	Performance monitoring	S	S	S	S	S	S	Yes
199-N-122	Performance monitoring	S	S	S	S	S	S	Yes
199-N-123	Performance monitoring	S	S	S	S	S	S	Yes
199-N-146	Performance monitoring	S	S	S	S	S	S	Yes
199-N-147	Performance monitoring	S	S	S	S	S	S	Yes
199-N-347	Performance monitoring	S	S	S	S	S	S	Yes
199-N-348	Performance monitoring	S	S	S	S	S	S	Yes
199-N-349	Performance monitoring	S	S	S	S	S	S	Yes
199-N-350	Performance monitoring	S	S	S	S	S	S	Yes
199-N-351	Performance monitoring	S	S	S	S	S	S	Yes
199-N-352	Performance monitoring	S	S	S	S	S	S	Yes
199-N-353	Performance monitoring	S	S	S	S	S	S	Yes
APT1	Aquifer tube	S	S	S	S	S	S	Yes
APT5	Aquifer tube	S	S	S	S	S	S	Yes
C7881	Aquifer tube	S	S	S	S	S	S	Yes

Table A-5. Monitoring Wells and Constituents for the 100-NR-2 Apatite Permeable Reactive Barrier

Well Name	Well Type	Field Parameters*	Anions	Gross Alpha/Beta	Metals	Strontium-90	TPH-Diesel	Sampled as Planned in 2014?
N116mArray-1A	Aquifer tube	S	S	S	S	S	S	No; Tube missing. Repaired in fall, sampled once in December 2014. No metals, nitrate, or strontium-90.
N116mArray-2A	Aquifer tube	S	S	S	S	S	S	Yes
N116mArray-3A	Aquifer tube	S	S	S	S	S	S	Yes
N116mArray-4A	Aquifer tube	S	S	S	S	S	S	Yes
N116mArray-6A	Aquifer tube	S	S	S	S	S	S	Yes
N116mArray-8A	Aquifer tube	S	S	S	S	S	S	Yes
NVP2-116.0	Aquifer tube	S	S	S	S	S	S	Yes

Note: Sampling requirements are from *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit* (DOE/RL-2001-27). TPA-CN-569, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2001-27, Rev. 0, Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, added semiannual sampling at groundwater wells and aquifer tubes to monitor the performance of the 100-NR-2 apatite permeable reactive barrier.

* Field parameters: conductivity, pH, temperature, and turbidity.

S = sampled twice each year (at high and low river stages)

TPH = total petroleum hydrocarbon

Table A-6. Monitoring Wells and Constituents for the 100-N (UPR-100-N-17) Bioremediation

Well Name	Well Type	Field Parameters[a]	Alkalinity	Anions	Metals	Oil and Grease	PAHs	TPH[b]	VOCs	Sampled as Planned in 2014?
199-N-3	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-19	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-56	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-96A	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-167	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-169	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-171	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-172	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-173	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
199-N-183	Bioventing monitoring	S	S	S	S	S	S	S	S	No[c]
N116mArray-0A	Aquifer tube	S	S	S	S	S	S	S	S	No; O&G, PAH, VOA only once
C6132	Aquifer tube	S	S	S	S	S	S	S	S	No[c]
C6135	Aquifer tube	S	S	S	S	S	S	S	S	No; broken

Note: Sampling requirements are from *Remedial Design Report/Remedial Action Work Plan for the 100-N Area* (DOE/RL-2005-93), Appendix H, Table H-3.

a. Field parameters: conductivity, pH, temperature, turbidity, dissolved oxygen, oxidation-reduction potential, and sheen/odor.

b. TPH analyses: TPH-diesel, TPH-gasoline, and TPH-motor oil.

c. The scheduled October 2014 sampling was planned to be done concurrent with the fall bioventing respirometry test, which was delayed. Samples were collected in January 2015.

S = sampled twice each year (at high and low river stages)

PAH = polycyclic aromatic hydrocarbon

TPH = total petroleum hydrocarbon

VOC = volatile organic compound

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D2-6	5/29/2014	—
199-D2-6	11/14/2014	—
199-D2-10	—	Inactive injection
199-D2-11	1/31/2014	—
199-D2-11	2/7/2014	—
199-D2-11	3/7/2014	—
199-D2-11	3/21/2014	—
199-D2-11	4/4/2014	—
199-D2-11	4/18/2014	—
199-D2-11	4/30/2014	—
199-D2-11	5/15/2014	—
199-D2-11	5/29/2014	—
199-D2-11	6/15/2014	—
199-D2-11	6/27/2014	—
199-D2-11	7/10/2014	—
199-D2-11	7/24/2014	—
199-D2-11	8/7/2014	—
199-D2-11	8/21/2014	—
199-D2-11	9/4/2014	—
199-D2-11	11/14/2014	—
199-D2-12	—	Inactive injection
199-D3-2	1/8/2014	—
199-D3-2	3/21/2014	—
199-D3-2	6/20/2014	—
199-D3-2	9/19/2014	—
199-D3-2	12/9/2014	—
199-D3-5	2/11/2014	—
199-D3-5	6/11/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D3-5	8/5/2014	—
199-D3-5	11/7/2014	—
199-D4-1	1/8/2014	—
199-D4-1	12/9/2014	—
199-D4-4	12/9/2014	—
199-D4-5	11/21/2014	—
199-D4-6	12/19/2014	—
199-D4-7	12/12/2014	—
199-D4-13	11/21/2014	—
199-D4-14	3/20/2014	Extraction
199-D4-14	7/1/2014	Extraction
199-D4-14	8/27/2014	Extraction
199-D4-14	12/15/2014	Extraction
199-D4-15	11/21/2014	—
199-D4-19	1/24/2014	—
199-D4-19	4/8/2014	—
199-D4-19	8/18/2014	—
199-D4-19	10/14/2014	—
199-D4-20	10/15/2014	—
199-D4-22	3/21/2014	—
199-D4-22	6/20/2014	—
199-D4-22	9/26/2014	—
199-D4-22	12/9/2014	—
199-D4-23	3/21/2014	—
199-D4-23	6/20/2014	—
199-D4-23	9/19/2014	—
199-D4-23	12/30/2014	—
199-D4-25	3/21/2014	—
199-D4-25	7/10/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D4-25	9/19/2014	—
199-D4-25	12/19/2014	—
199-D4-26	1/24/2014	—
199-D4-26	4/18/2014	—
199-D4-26	7/10/2014	—
199-D4-26	10/14/2014	—
199-D4-27	12/19/2014	—
199-D4-31	12/12/2014	—
199-D4-32	12/19/2014	—
199-D4-34	—	Extraction
199-D4-36	12/17/2014	—
199-D4-38	3/20/2014	Extraction
199-D4-38	7/1/2014	Extraction
199-D4-38	8/27/2014	Extraction
199-D4-38	12/15/2014	Extraction
199-D4-39	1/30/2014	Extraction
199-D4-39	5/29/2014	Extraction
199-D4-39	8/7/2014	Extraction
199-D4-39	11/10/2014	Extraction
199-D4-48	12/19/2014	—
199-D4-62	3/21/2014	—
199-D4-62	6/20/2014	—
199-D4-62	9/19/2014	—
199-D4-62	12/19/2014	—
199-D4-78	11/21/2014	—
199-D4-83	11/10/2014	Extraction
199-D4-84	—	Extraction
199-D4-85	—	Extraction
199-D4-86	1/24/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D4-86	4/8/2014	—
199-D4-86	7/15/2014	—
199-D4-86	10/27/2014	—
199-D4-92	1/24/2014	—
199-D4-92	4/18/2014	—
199-D4-92	7/10/2014	—
199-D4-92	10/14/2014	—
199-D4-93	7/10/2014	—
199-D4-93	10/15/2014	—
199-D4-95	1/30/2014	Extraction
199-D4-95	4/17/2014	Extraction
199-D4-95	7/16/2014	Extraction
199-D4-95	12/11/2014	Extraction
199-D4-96	1/30/2014	Extraction
199-D4-96	4/17/2014	Extraction
199-D4-96	7/16/2014	Extraction
199-D4-96	10/29/2014	Extraction
199-D4-97	1/30/2014	Extraction
199-D4-97	4/17/2014	Extraction
199-D4-97	7/16/2014	Extraction
199-D4-97	10/29/2014	Extraction
199-D4-98	1/30/2014	Extraction
199-D4-98	4/17/2014	Extraction
199-D4-98	7/16/2014	Extraction
199-D4-98	10/29/2014	Extraction
199-D4-99	1/30/2014	Extraction
199-D4-99	4/17/2014	Extraction
199-D4-99	7/16/2014	Extraction
199-D4-99	11/10/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D4-101	—	Extraction
199-D5-13	2/6/2014	—
199-D5-13	4/8/2014	—
199-D5-13	7/9/2014	—
199-D5-13	11/4/2014	—
199-D5-13	1/31/2014	—
199-D5-13	4/8/2014	—
199-D5-13	7/9/2014	—
199-D5-13	10/24/2014	—
199-D5-15	3/20/2014	—
199-D5-15	6/20/2014	—
199-D5-15	9/5/2014	—
199-D5-15	12/12/2014	—
199-D5-16	4/18/2014	—
199-D5-16	6/20/2014	—
199-D5-16	9/19/2014	—
199-D5-16	12/12/2014	—
199-D5-17	6/6/2014	—
199-D5-17	10/24/2014	—
199-D5-18	6/6/2014	—
199-D5-18	11/7/2014	—
199-D5-19	6/20/2014	—
199-D5-19	10/24/2014	—
199-D5-20	1/30/2014	Extraction
199-D5-20	4/17/2014	Extraction
199-D5-20	7/16/2014	Extraction
199-D5-32	1/30/2014	Extraction
199-D5-32	4/17/2014	Extraction
199-D5-32	7/16/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-32	10/28/2014	Extraction
199-D5-33	1/31/2014	—
199-D5-33	4/8/2014	—
199-D5-33	7/9/2014	—
199-D5-33	10/27/2014	—
199-D5-34	2/14/2014	—
199-D5-34	3/7/2014	—
199-D5-34	3/21/2014	—
199-D5-34	4/4/2014	—
199-D5-34	4/18/2014	—
199-D5-34	4/30/2014	—
199-D5-34	5/15/2014	—
199-D5-34	5/29/2014	—
199-D5-34	6/12/2014	—
199-D5-34	6/27/2014	—
199-D5-34	7/10/2014	—
199-D5-34	7/24/2014	—
199-D5-34	8/7/2014	—
199-D5-34	8/21/2014	—
199-D5-34	9/4/2014	—
199-D5-34	9/18/2014	—
199-D5-34	10/1/2014	—
199-D5-34	10/16/2014	—
199-D5-34	11/6/2014	—
199-D5-34	12/9/2014	—
199-D5-36	1/31/2014	—
199-D5-36	4/8/2014	—
199-D5-36	7/30/2014	—
199-D5-36	10/27/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-37	1/31/2014	—
199-D5-37	4/9/2014	—
199-D5-37	7/15/2014	—
199-D5-37	11/4/2014	—
199-D5-38	3/21/2014	—
199-D5-38	6/20/2014	—
199-D5-38	9/26/2014	—
199-D5-38	12/17/2014	—
199-D5-39	1/15/2014	Extraction
199-D5-39	1/30/2014	Extraction
199-D5-39	2/26/2014	Extraction
199-D5-39	3/6/2014	Extraction
199-D5-39	3/20/2014	Extraction
199-D5-39	4/3/2014	Extraction
199-D5-39	4/17/2014	Extraction
199-D5-39	4/30/2014	Extraction
199-D5-39	5/15/2014	Extraction
199-D5-39	5/29/2014	Extraction
199-D5-39	6/12/2014	Extraction
199-D5-39	7/1/2014	Extraction
199-D5-39	7/10/2014	Extraction
199-D5-39	7/24/2014	Extraction
199-D5-39	8/7/2014	Extraction
199-D5-39	8/21/2014	Extraction
199-D5-39	9/4/2014	Extraction
199-D5-39	10/28/2014	Extraction
199-D5-39	11/10/2014	Extraction
199-D5-39	12/15/2014	Extraction
199-D5-40	3/25/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-40	6/17/2014	—
199-D5-40	8/5/2014	—
199-D5-40	11/7/2014	—
199-D5-41	6/11/2014	—
199-D5-41	12/19/2014	—
199-D5-42	—	Injection
199-D5-43	1/8/2014	—
199-D5-43	3/24/2014	—
199-D5-43	6/20/2014	—
199-D5-43	9/26/2014	—
199-D5-43	12/17/2014	—
199-D5-44	—	Injection
199-D5-92	1/30/2014	Extraction
199-D5-92	5/29/2014	Extraction
199-D5-92	8/7/2014	Extraction
199-D5-92	11/10/2014	Extraction
199-D5-97	1/22/2014	—
199-D5-97	1/31/2014	—
199-D5-97	2/14/2014	—
199-D5-97	3/7/2014	—
199-D5-97	3/21/2014	—
199-D5-97	4/4/2014	—
199-D5-97	4/18/2014	—
199-D5-97	4/30/2014	—
199-D5-97	5/15/2014	—
199-D5-97	5/29/2014	—
199-D5-97	6/15/2014	—
199-D5-97	6/27/2014	—
199-D5-97	7/10/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-97	7/24/2014	—
199-D5-97	8/7/2014	—
199-D5-97	8/21/2014	—
199-D5-97	9/4/2014	—
199-D5-97	9/18/2014	—
199-D5-97	10/1/2014	—
199-D5-97	10/16/2014	—
199-D5-97	11/6/2014	—
199-D5-97	12/17/2014	—
199-D5-101	1/30/2014	Extraction
199-D5-101	4/17/2014	Extraction
199-D5-101	7/16/2014	Extraction
199-D5-101	10/29/2014	Extraction
199-D5-103	1/22/2014	—
199-D5-103	1/31/2014	—
199-D5-103	2/14/2014	—
199-D5-103	3/7/2014	—
199-D5-103	3/21/2014	—
199-D5-103	4/4/2014	—
199-D5-103	4/18/2014	—
199-D5-103	4/30/2014	—
199-D5-103	5/15/2014	—
199-D5-103	5/29/2014	—
199-D5-103	6/12/2014	—
199-D5-103	6/27/2014	—
199-D5-103	7/10/2014	—
199-D5-103	7/24/2014	—
199-D5-103	8/7/2014	—
199-D5-103	8/21/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-103	9/4/2014	—
199-D5-103	9/18/2014	—
199-D5-103	10/1/2014	—
199-D5-103	10/16/2014	—
199-D5-103	11/6/2014	—
199-D5-103	12/17/2014	—
199-D5-104	1/15/2014	Extraction
199-D5-104	1/30/2014	Extraction
199-D5-104	2/26/2014	Extraction
199-D5-104	3/6/2014	Extraction
199-D5-104	3/20/2014	Extraction
199-D5-104	4/3/2014	Extraction
199-D5-104	4/17/2014	Extraction
199-D5-104	4/30/2014	Extraction
199-D5-104	5/15/2014	Extraction
199-D5-104	5/29/2014	Extraction
199-D5-104	6/12/2014	Extraction
199-D5-104	7/1/2014	Extraction
199-D5-104	7/15/2014	Extraction
199-D5-104	7/24/2014	Extraction
199-D5-104	8/7/2014	Extraction
199-D5-104	8/21/2014	Extraction
199-D5-104	9/4/2014	Extraction
199-D5-104	10/29/2014	Extraction
199-D5-104	11/10/2014	Extraction
199-D5-104	12/15/2014	Extraction
199-D5-106	1/22/2014	—
199-D5-106	2/14/2014	—
199-D5-106	3/7/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-106	4/11/2014	—
199-D5-106	6/11/2014	—
199-D5-106	6/20/2014	—
199-D5-106	7/15/2014	—
199-D5-106	8/5/2014	—
199-D5-106	9/5/2014	—
199-D5-106	10/27/2014	—
199-D5-106	11/7/2014	—
199-D5-106	12/17/2014	—
199-D5-108	10/14/2014	—
199-D5-109	10/15/2014	—
199-D5-110	10/15/2014	—
199-D5-114	10/15/2014	—
199-D5-115	10/15/2014	—
199-D5-127	—	Extraction
199-D5-128	—	Injection
199-D5-129	—	Injection
199-D5-130	—	Extraction
199-D5-123	3/24/2014	Extraction 6/14
199-D5-123	6/20/2014	Extraction 6/14
199-D5-123	9/5/2014	Extraction 6/14
199-D5-123	12/19/2014	Extraction 6/14
199-D5-125	3/24/2014	Extraction 6/14
199-D5-125	6/20/2014	—
199-D5-125	9/19/2014	—
199-D5-125	12/17/2014	—
199-D5-126	3/24/2014	—
199-D5-126	6/20/2014	—
199-D5-126	9/19/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-126	12/17/2014	—
199-D5-127	1/30/2014	Extraction
199-D5-127	3/6/2014	Extraction
199-D5-127	3/20/2014	Extraction
199-D5-127	4/3/2014	Extraction
199-D5-127	4/17/2014	Extraction
199-D5-127	4/30/2014	Extraction
199-D5-127	5/15/2014	Extraction
199-D5-127	5/29/2014	Extraction
199-D5-127	6/12/2014	Extraction
199-D5-127	7/1/2014	Extraction
199-D5-127	7/10/2014	Extraction
199-D5-127	7/24/2014	Extraction
199-D5-127	8/7/2014	Extraction
199-D5-127	8/21/2014	Extraction
199-D5-127	9/4/2014	Extraction
199-D5-127	10/29/2014	Extraction
199-D5-128	—	Injection
199-D5-129	—	Injection
199-D5-130	3/6/2014	Extraction
199-D5-130	4/17/2014	Extraction
199-D5-130	7/16/2014	Extraction
199-D5-130	10/28/2014	Extraction
199-D5-131	3/6/2014	Extraction
199-D5-131	4/17/2014	Extraction
199-D5-131	7/16/2014	Extraction
199-D5-131	11/10/2014	Extraction
199-D5-132	2/7/2014	—
199-D5-132	6/17/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-132	8/18/2014	—
199-D5-132	11/7/2014	—
199-D5-133	1/31/2014	—
199-D5-133	2/7/2014	—
199-D5-133	3/7/2014	—
199-D5-133	3/21/2014	—
199-D5-133	4/4/2014	—
199-D5-133	4/18/2014	—
199-D5-133	4/30/2014	—
199-D5-133	5/15/2014	—
199-D5-133	5/29/2014	—
199-D5-133	6/12/2014	—
199-D5-133	6/27/2014	—
199-D5-133	7/10/2014	—
199-D5-133	7/24/2014	—
199-D5-133	8/7/2014	—
199-D5-133	8/21/2014	—
199-D5-133	9/4/2014	—
199-D5-133	11/14/2014	—
199-D5-134	11/21/2014	—
199-D5-141	11/21/2014	—
199-D5-142	2/7/2014	—
199-D5-142	11/7/2014	—
199-D5-143	2/11/2014	—
199-D5-143	6/11/2014	—
199-D5-143	8/8/2014	—
199-D5-143	11/16/2014	—
199-D5-145	1/22/2014	—
199-D5-145	1/31/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-145	2/14/2014	—
199-D5-145	3/7/2014	—
199-D5-145	3/21/2014	—
199-D5-145	4/4/2014	—
199-D5-145	4/18/2014	—
199-D5-145	4/30/2014	—
199-D5-145	5/15/2014	—
199-D5-145	5/29/2014	—
199-D5-145	6/12/2014	—
199-D5-145	6/27/2014	—
199-D5-145	7/10/2014	—
199-D5-145	7/24/2014	—
199-D5-145	8/7/2014	—
199-D5-145	8/21/2014	—
199-D5-145	9/4/2014	—
199-D5-145	9/18/2014	—
199-D5-145	10/1/2014	—
199-D5-145	10/16/2014	—
199-D5-145	11/6/2014	—
199-D5-145	12/17/2014	—
199-D5-146	1/22/2014	Extraction 6/14
199-D5-146	1/31/2014	Extraction 6/14
199-D5-146	2/14/2014	Extraction 6/14
199-D5-146	3/7/2014	Extraction 6/14
199-D5-146	3/21/2014	Extraction 6/14
199-D5-146	4/4/2014	Extraction 6/14
199-D5-146	6/12/2014	Extraction 6/14
199-D5-146	7/1/2014	Extraction 6/14
199-D5-146	7/10/2014	Extraction 6/14

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-146	7/24/2014	Extraction 6/14
199-D5-146	8/7/2014	Extraction 6/14
199-D5-146	8/21/2014	Extraction 6/14
199-D5-146	9/4/2014	Extraction 6/14
199-D5-146	10/28/2014	Extraction 6/14
199-D5-146	11/10/2014	Extraction 6/14
199-D5-146	12/15/2014	Extraction 6/14
199-D5-147	3/7/2014	—
199-D5-147	6/17/2014	—
199-D5-147	8/5/2014	—
199-D5-147	11/16/2014	—
199-D5-148	1/31/2014	Injection 6/14
199-D5-148	2/11/2014	Injection 6/14
199-D5-148	3/7/2014	Injection 6/14
199-D5-148	3/21/2014	Injection 6/14
199-D5-148	4/4/2014	Injection 6/14
199-D5-153	4/3/2014	Extraction 6/14
199-D5-154	4/3/2014	—
199-D5-155	5/28/2014	Multiple ports
199-D5-155	6/26/2014	Multiple ports
199-D5-155	7/21/2014	Multiple ports
199-D5-155	8/6/2014	Multiple ports
199-D5-155	9/17/2014	Multiple ports
199-D5-155	10/1/2014	Multiple ports
199-D5-155	11/6/2014	Multiple ports
199-D5-155	11/20/2014	Multiple ports
199-D5-156	5/27/2014	Multiple ports
199-D5-156	6/26/2014	Multiple ports
199-D5-156	7/21/2014	Multiple ports

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D5-156	8/6/2014	Multiple ports
199-D5-156	9/17/2014	Multiple ports
199-D5-156	10/1/2014	Multiple ports
199-D5-156	11/6/2014	Multiple ports
199-D5-156	11/20/2014	Multiple ports
199-D5-157	5/27/2014	Multiple ports
199-D5-157	6/26/2014	Multiple ports
199-D5-157	7/21/2014	Multiple ports
199-D5-157	8/6/2014	Multiple ports
199-D5-157	9/17/2014	Multiple ports
199-D5-157	10/1/2014	Multiple ports
199-D5-157	11/6/2014	Multiple ports
199-D5-157	11/20/2014	Multiple ports
199-D5-158	5/21/2014	Multiple ports
199-D5-158	5/22/2014	Multiple ports
199-D5-158	6/26/2014	Multiple ports
199-D5-158	7/21/2014	Multiple ports
199-D5-158	8/6/2014	Multiple ports
199-D5-158	9/17/2014	Multiple ports
199-D5-158	10/1/2014	Multiple ports
199-D5-158	11/6/2014	Multiple ports
199-D5-158	11/20/2014	Multiple ports
199-D6-1	—	Injection
199-D6-2	—	Injection
199-D6-3	2/10/2014	—
199-D6-3	6/20/2014	—
199-D6-3	8/5/2014	—
199-D6-3	11/21/2014	—
199-D7-3	3/6/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D7-3	4/17/2014	Extraction
199-D7-3	7/16/2014	Extraction
199-D7-3	10/28/2014	Extraction
199-D7-4	—	Injection
199-D7-5	—	Injection
199-D7-6	3/6/2014	Extraction
199-D7-6	4/17/2014	Extraction
199-D7-6	7/16/2014	Extraction
199-D7-6	10/28/2014	Extraction
199-D8-4	1/31/2014	—
199-D8-4	4/9/2014	—
199-D8-4	7/18/2014	—
199-D8-4	10/27/2014	—
199-D8-5	3/24/2014	—
199-D8-5	6/20/2014	—
199-D8-5	9/5/2014	—
199-D8-5	12/17/2014	—
199-D8-6	1/15/2014	Extraction
199-D8-53	6/24/2014	Extraction 4/14
199-D8-53	12/15/2014	Extraction 4/14
199-D8-54A	8/8/2014	—
199-D8-54A	12/17/2014	—
199-D8-54B	6/24/2014	—
199-D8-54B	12/19/2014	—
199-D8-55	—	Extraction
199-D8-68	3/20/2014	Extraction
199-D8-68	6/24/2014	Extraction
199-D8-68	9/4/2014	Extraction
199-D8-68	12/15/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D8-69	3/20/2014	Extraction
199-D8-69	6/24/2014	Extraction
199-D8-69	9/4/2014	Extraction
199-D8-69	12/15/2014	Extraction
199-D8-70	2/14/2014	—
199-D8-70	3/24/2014	—
199-D8-70	6/24/2014	—
199-D8-70	9/19/2014	—
199-D8-70	12/19/2014	—
199-D8-71	2/11/2014	—
199-D8-71	6/11/2014	—
199-D8-71	8/8/2014	—
199-D8-71	11/14/2014	—
199-D8-72	6/24/2014	—
199-D8-73	1/15/2014	Extraction
199-D8-73	3/20/2014	Extraction
199-D8-73	7/1/2014	Extraction
199-D8-73	8/27/2014	—
199-D8-88	3/20/2014	Extraction
199-D8-88	7/1/2014	Extraction
199-D8-88	8/27/2014	Extraction
199-D8-88	12/15/2014	Extraction
199-D8-89	1/30/2014	Extraction
199-D8-89	4/17/2014	Extraction
199-D8-89	7/16/2014	Extraction
199-D8-89	10/28/2014	Extraction
199-D8-90	1/30/2014	Extraction
199-D8-90	4/17/2014	Extraction
199-D8-90	7/16/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-D8-90	10/28/2014	Extraction
199-D8-91	1/30/2014	Extraction
199-D8-91	4/17/2014	Extraction
199-D8-91	7/16/2014	Extraction
199-D8-91	10/28/2014	Extraction
199-D8-93	—	Inactive injection
199-D8-94	—	Inactive injection
199-D8-95	3/6/2014	Extraction
199-D8-95	4/17/2014	Extraction
199-D8-95	7/16/2014	Extraction
199-D8-95	10/28/2014	Extraction
199-D8-96	3/6/2014	Extraction
199-D8-96	4/17/2014	Extraction
199-D8-96	7/16/2014	Extraction
199-D8-96	10/28/2014	Extraction
199-D8-97	1/30/2014	Extraction
199-D8-97	4/17/2014	Extraction
199-D8-97	7/16/2014	Extraction
199-D8-97	10/28/2014	Extraction
199-D8-98	3/6/2014	Extraction
199-D8-98	4/17/2014	Extraction
199-D8-98	7/16/2014	Extraction
199-D8-98	10/28/2014	Extraction
199-D8-99	—	Injection
199-D8-101	2/6/2014	—
199-D8-101	4/9/2014	—
199-D8-101	7/24/2014	—
199-D8-101	10/27/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H1-1	3/19/2014	Extraction
199-H1-1	6/11/2014	Extraction
199-H1-1	8/26/2014	Extraction
199-H1-1	12/11/2014	Extraction
199-H1-2	3/19/2014	Extraction
199-H1-2	6/11/2014	Extraction
199-H1-2	8/26/2014	Extraction
199-H1-2	12/11/2014	Extraction
199-H1-3	6/5/2014	Extraction
199-H1-4	3/19/2014	Extraction
199-H1-4	6/11/2014	Extraction
199-H1-4	8/26/2014	Extraction
199-H1-5	3/20/2014	Extraction
199-H1-5	6/24/2014	Extraction
199-H1-5	10/28/2014	Extraction
199-H1-5	12/15/2014	Extraction
199-H1-6	3/19/2014	Extraction
199-H1-6	6/11/2014	Extraction
199-H1-6	8/26/2014	Extraction
199-H1-6	12/16/2014	Extraction
199-H1-7	2/25/2014	—
199-H1-7	5/5/2014	—
199-H1-7	8/1/2014	—
199-H1-7	10/31/2014	—
199-H1-20	—	Injection
199-H1-21	—	Injection
199-H1-25	3/19/2014	Extraction
199-H1-25	6/11/2014	Extraction
199-H1-25	8/26/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H1-25	12/16/2014	Extraction
199-H1-27	3/19/2014	Extraction
199-H1-27	6/11/2014	Extraction
199-H1-27	8/26/2014	Extraction
199-H1-27	12/16/2014	Extraction
199-H1-32	1/22/2014	Extraction
199-H1-32	1/29/2014	Extraction
199-H1-32	6/5/2014	Extraction
199-H1-32	8/14/2014	Extraction
199-H1-32	12/11/2014	Extraction
199-H1-33	1/15/2014	Extraction
199-H1-33	1/29/2014	Extraction
199-H1-33	6/5/2014	Extraction
199-H1-33	8/14/2014	Extraction
199-H1-33	12/11/2014	Extraction
199-H1-34	3/19/2014	Extraction
199-H1-34	6/11/2014	Extraction
199-H1-34	8/26/2014	Extraction
199-H1-34	12/16/2014	Extraction
199-H1-35	1/29/2014	Extraction
199-H1-35	6/5/2014	Extraction
199-H1-35	8/14/2014	Extraction
199-H1-35	11/10/2014	Extraction
199-H1-36	3/19/2014	Extraction
199-H1-36	6/11/2014	Extraction
199-H1-36	8/26/2014	Extraction
199-H1-36	12/16/2014	Extraction
199-H1-37	1/29/2014	Extraction
199-H1-37	6/5/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H1-37	8/14/2014	Extraction
199-H1-37	11/10/2014	Extraction
199-H1-38	1/29/2014	Extraction
199-H1-38	6/5/2014	Extraction
199-H1-38	8/14/2014	Extraction
199-H1-38	11/10/2014	Extraction
199-H1-39	1/15/2014	Extraction
199-H1-39	3/19/2014	Extraction
199-H1-39	6/11/2014	Extraction
199-H1-39	8/26/2014	Extraction
199-H1-40	1/29/2014	Extraction
199-H1-40	6/5/2014	Extraction
199-H1-40	8/14/2014	Extraction
199-H1-40	11/10/2014	Extraction
199-H1-42	3/19/2014	Extraction
199-H1-42	6/11/2014	Extraction
199-H1-42	8/26/2014	Extraction
199-H1-42	12/16/2014	Extraction
199-H1-43	3/19/2014	Extraction
199-H1-43	6/11/2014	Extraction
199-H1-43	10/29/2014	Extraction
199-H1-43	12/16/2014	Extraction
199-H1-45	3/19/2014	Extraction
199-H1-45	6/24/2014	Extraction
199-H1-45	8/27/2014	Extraction
199-H1-45	12/16/2014	Extraction
199-H2-1	2/25/2014	—
199-H2-1	5/15/2014	—
199-H2-1	8/1/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H2-1	10/31/2014	—
199-H3-2A	3/19/2014	—
199-H3-2A	6/20/2014	—
199-H3-2A	9/5/2014	—
199-H3-2A	12/12/2014	—
199-H3-2C	3/19/2014	Extraction
199-H3-2C	6/24/2014	Extraction
199-H3-2C	8/27/2014	Extraction
199-H3-2C	12/16/2014	Extraction
199-H3-3	2/21/2014	—
199-H3-3	5/5/2014	—
199-H3-3	8/1/2014	—
199-H3-3	10/31/2014	
199-H3-4	1/29/2014	Extraction
199-H3-4	6/5/2014	Extraction
199-H3-4	8/14/2014	Extraction
199-H3-4	11/10/2014	Extraction
199-H3-5	2/21/2014	—
199-H3-5	5/5/2014	—
199-H3-5	8/1/2014	—
199-H3-5	10/31/2014	—
199-H3-6	2/21/2014	—
199-H3-6	5/5/2014	—
199-H3-6	8/18/2014	—
199-H3-6	10/31/2014	—
199-H3-7	2/21/2014	—
199-H3-7	5/5/2014	—
199-H3-7	8/1/2014	—
199-H3-7	10/31/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H3-9	2/21/2014	—
199-H3-9	6/17/2014	—
199-H3-9	8/8/2014	—
199-H3-9	10/31/2014	—
199-H3-10	2/21/2014	—
199-H3-10	5/5/2014	—
199-H3-10	8/8/2014	—
199-H3-10	10/31/2014	—
199-H3-25	—	Injection
199-H3-26	—	Injection
199-H3-27	—	Injection
199-H4-4	1/29/2014	Extraction
199-H4-4	6/5/2014	Extraction
199-H4-4	8/14/2014	Extraction
199-H4-4	12/16/2014	Extraction
199-H4-5	3/19/2014	—
199-H4-5	6/20/2014	—
199-H4-5	9/5/2014	—
199-H4-5	12/12/2014	—
199-H4-6	1/22/2014	—
199-H4-6	4/11/2014	—
199-H4-6	7/24/2014	—
199-H4-6	10/24/2014	—
199-H4-8	3/10/2014	—
199-H4-8	11/5/2014	—
199-H4-10	3/19/2014	—
199-H4-10	6/20/2014	—
199-H4-10	9/5/2014	—
199-H4-10	12/12/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H4-11	2/21/2014	—
199-H4-11	5/5/2014	—
199-H4-11	8/1/2014	—
199-H4-11	10/31/2014	—
199-H4-12A	2/21/2014	—
199-H4-12A	5/5/2014	—
199-H4-12A	8/1/2014	—
199-H4-12A	11/5/2014	—
199-H4-12B	—	Extraction
199-H4-12C	1/29/2014	Extraction
199-H4-12C	6/5/2014	Extraction
199-H4-12C	7/23/2014	Extraction
199-H4-12C	8/14/2014	Extraction
199-H4-12C	11/10/2014	Extraction
199-H4-13	3/19/2014	—
199-H4-13	6/20/2014	—
199-H4-13	9/26/2014	—
199-H4-13	12/15/2014	—
199-H4-14	—	—
199-H4-15A	1/29/2014	Extraction
199-H4-15A	6/5/2014	Extraction
199-H4-15A	8/14/2014	Extraction
199-H4-15A	11/10/2014	Extraction
199-H4-15CP	11/23/2014	—
199-H4-15CQ	11/23/2014	—
199-H4-15CR	11/23/2014	—
199-H4-15CS	11/23/2014	—
199-H4-16	2/21/2014	—
199-H4-16	5/5/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H4-16	8/1/2014	—
199-H4-16	10/31/2014	—
199-H4-17	—	Injection
199-H4-18	—	Injection
199-H4-45	3/19/2014	—
199-H4-45	6/24/2014	—
199-H4-45	9/5/2014	—
199-H4-45	12/12/2014	—
199-H4-46	2/21/2014	—
199-H4-46	5/15/2014	—
199-H4-46	8/1/2014	—
199-H4-46	10/31/2014	—
199-H4-49	2/21/2014	—
199-H4-49	5/5/2014	—
199-H4-49	8/1/2014	—
199-H4-49	10/31/2014	—
199-H4-63	4/17/2014	Extraction
199-H4-63	6/24/2014	Extraction
199-H4-63	8/27/2014	Extraction
199-H4-63	12/16/2014	Extraction
199-H4-64	3/19/2014	Extraction
199-H4-64	6/24/2014	Extraction
199-H4-64	8/27/2014	Extraction
199-H4-64	12/16/2014	Extraction
199-H4-65	2/21/2014	—
199-H4-65	5/5/2014	—
199-H4-65	8/8/2014	—
199-H4-65	10/31/2014	—
199-H4-69	3/19/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H4-69	6/24/2014	Extraction
199-H4-69	8/27/2014	Extraction
199-H4-69	12/16/2014	Extraction
199-H4-70	3/19/2014	Extraction
199-H4-70	6/24/2014	Extraction
199-H4-70	8/27/2014	Extraction
199-H4-70	12/16/2014	Extraction
199-H4-71	—	Injection
199-H4-72	—	Injection
199-H4-73	—	Injection
199-H4-74	—	Injection
199-H4-75	3/19/2014	Extraction
199-H4-75	6/24/2014	Extraction
199-H4-75	8/27/2014	Extraction
199-H4-75	12/16/2014	Extraction
199-H4-76	6/5/2014	Extraction
199-H4-76	8/26/2014	Extraction
199-H4-77	3/19/2014	Extraction
199-H4-77	6/11/2014	Extraction
199-H4-77	10/29/2014	Extraction
199-H4-77	12/16/2014	Extraction
199-H4-78	—	Injection
199-H4-79	—	Injection
199-H4-80	3/20/2014	Extraction
199-H4-80	6/24/2014	Extraction
199-H4-80	10/28/2014	Extraction
199-H4-80	12/15/2014	Extraction
199-H4-81	3/20/2014	Extraction
199-H4-81	6/24/2014	Extraction

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H4-81	10/28/2014	Extraction
199-H4-81	12/12/2014	Extraction
199-H4-82	3/20/2014	Extraction
199-H4-82	6/24/2014	Extraction
199-H4-82	10/28/2014	Extraction
199-H4-82	12/15/2014	Extraction
199-H4-84	1/22/2014	—
199-H4-84	2/6/2014	—
199-H4-84	3/10/2014	—
199-H4-84	4/4/2014	—
199-H4-84	5/5/2014	—
199-H4-84	6/17/2014	—
199-H4-84	7/18/2014	—
199-H4-84	8/18/2014	—
199-H4-84	9/9/2014	—
199-H4-84	11/5/2014	—
199-H4-84	11/23/2014	—
199-H4-85	2/21/2014	—
199-H4-85	5/5/2014	—
199-H4-85	8/25/2014	—
199-H4-85	10/31/2014	—
199-H4-86	2/21/2014	—
199-H4-86	5/15/2014	—
199-H4-86	8/18/2014	—
199-H4-86	11/7/2014	—
199-H4-90	6/20/2014	—
199-H4-90	9/15/2014	—
199-H4-91	6/24/2014	—
199-H4-91	9/26/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
199-H4-91	12/12/2014	—
199-H5-1A	2/25/2014	—
199-H5-1A	5/5/2014	—
199-H5-1A	8/1/2014	—
199-H5-1A	11/7/2014	—
199-H6-1	5/5/2014	—
199-H6-1	11/5/2014	—
199-H6-2	—	Extraction
199-H6-3	5/12/2014	—
199-H6-3	11/5/2014	—
199-H6-4	5/12/2014	—
199-H6-4	11/7/2014	—
699-86-42	10/21/2014	—
699-87-42A	10/24/2014	—
699-87-55	10/24/2014	—
699-88-41	10/24/2014	—
699-90-45	10/24/2014	—
699-91-46A	10/24/2014	—
699-93-48A	2/27/2014	—
699-93-48A	6/2/2014	—
699-93-48A	8/15/2014	—
699-93-48A	11/3/2014	—
699-94-41	2/27/2014	—
699-94-41	6/2/2014	—
699-94-41	8/8/2014	—
699-94-41	11/3/2014	—
699-94-43	2/24/2014	—
699-94-43	6/2/2014	—
699-94-43	8/8/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
699-94-43	11/3/2014	—
699-95-45	2/24/2014	—
699-95-45	6/6/2014	—
699-95-45	8/15/2014	—
699-95-45	11/3/2014	—
699-95-48	2/27/2014	—
699-95-48	6/6/2014	—
699-95-48	8/15/2014	—
699-95-48	11/4/2014	—
699-95-51	2/14/2014	—
699-95-51	6/2/2014	—
699-95-51	8/15/2014	—
699-95-51	11/4/2014	—
699-96-43	11/21/2014	—
699-96-52B	2/25/2014	—
699-96-52B	6/6/2014	—
699-96-52B	8/22/2014	—
699-96-52B	12/19/2014	—
699-97-41	2/24/2014	—
699-97-41	6/6/2014	—
699-97-41	8/22/2014	—
699-97-41	12/19/2014	—
699-97-43B	10/24/2014	—
699-97-43C	10/24/2014	—
699-97-45	10/24/2014	—
699-97-45B	10/24/2014	—
699-97-48B	10/24/2014	—
699-97-48C	10/24/2014	—
699-97-51A	2/27/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
699-97-51A	6/2/2014	—
699-97-51A	8/15/2014	—
699-97-51A	11/3/2014	—
699-98-43	10/24/2014	—
699-98-46	2/25/2014	—
699-98-46	6/6/2014	—
699-98-46	8/25/2014	—
699-98-46	11/4/2014	—
699-98-49A	2/27/2014	—
699-98-49A	6/2/2014	—
699-98-49A	8/15/2014	—
699-98-49A	11/4/2014	—
699-98-51	2/25/2014	—
699-98-51	6/6/2014	—
699-98-51	8/25/2014	—
699-98-51	11/21/2014	—
699-99-41	2/25/2014	—
699-99-41	6/6/2014	—

Table A-7. Extraction, Injection, and Monitoring Wells for 100-HR-3

Well Name	Sample Date	Comment
699-99-41	8/25/2014	—
699-99-41	11/7/2014	—
699-99-44	3/3/2014	—
699-99-44	6/6/2014	—
699-99-44	8/25/2014	—
699-99-44	11/14/2014	—
699-100-43B	3/10/2014	—
699-100-43B	4/9/2014	—
699-100-43B	7/30/2014	—
699-100-43B	10/24/2014	—
699-101-45	1/31/2014	—
699-101-45	4/9/2014	—
699-101-45	7/18/2014	—
699-101-45	10/24/2014	—
199-D5-131	—	Extraction

Table A-8. Monitoring Wells and Constituents for the 100-FR-3 Operable Unit

Well	Field	Chromium (Hexavalent)	Nitrate (Anions)	Strontium-90	Trichloroethene (VOA)	Uranium (Total)	Trace Metals	Alkalinity	6010 Metals	Sampled as Planned in 2014?
199-F1-2	BO	—	BO	—	—	—	BO	—	—	Yes
199-F5-1	S	A	A	S	—	—	A	—	—	Yes
199-F5-4	A	A	A	—	A	—	A	—	—	Yes
199-F5-6	S	S	A	A	—	—	A	A	A	Yes
199-F5-43A	A	A	A	A	—	—	A	—	—	Yes
199-F5-44	A	A	A	A	—	—	A	—	—	Yes
199-F5-45	A	A	A	—	A	—	A	—	—	Yes
199-F5-46	S	A	A	S	A	—	A	—	—	Yes
199-F5-47	A	A	A	BO	—	—	A	—	—	Yes
199-F5-48	A	A	A	BO	A	—	A	—	—	Yes
199-F5-52	BO	BO	BO	—	—	—	BO	—	—	Yes
199-F5-53	BO	BO	BO	BO	—	—	BO	—	—	Yes
199-F5-54	BO	BO	BO	BO	—	—	BO	—	—	Yes
199-F5-55	S	A	A	S	—	—	A	—	—	Yes
199-F5-56	A	A	A	A	—	A	A	—	—	Yes
199-F6-1	A	A	A	A	—	—	A	—	—	Yes
199-F7-1	A	—	A	—	A	—	A	A	A	Yes
199-F7-2	BO	BO	BO	—	BO	—	BO	—	—	Yes
199-F7-3	A	—	A	—	A	—	A	—	—	Yes
199-F8-3	BO	BO	BO	—	—	—	BO	—	—	Yes
199-F8-4	BO	BO	BO	—	—	—	BO	BO	BO	Yes
199-F8-7	BO	—	BO	BO	BO	—	BO	—	—	Yes
699-60-32	BO	—	BO	—	—	—	—	—	—	Yes
699-62-31	BO	—	BO	—	—	—	—	—	—	Yes
699-63-25A	BO	—	BO	—	—	—	—	—	—	Yes
699-64-27	BO	—	BO	—	—	—	—	—	—	Yes
699-66-23	BO	—	BO	—	—	—	—	—	—	Yes

Table A-8. Monitoring Wells and Constituents for the 100-FR-3 Operable Unit

Well	Field	Chromium (Hexavalent)	Nitrate (Anions)	Strontium-90	Trichloroethene (VOA)	Uranium (Total)	Trace Metals	Alkalinity	6010 Metals	Sampled as Planned in 2014?
699-71-30	A	—	A	—	A	—	—	A	A	Yes
699-77-36	A	—	A	—	A	—	—	—	—	Yes
699-77-54	BO	BO	BO	—	BO	—	—	—	—	Yes
699-81-38	BO	BO	BO	—	BO	—	—	—	—	Yes
699-83-47	BO	BO	BO	—	BO	—	—	—	—	Yes
Aquifer Tubes[a]										
62-M	A	A	A	—	—	—	—	A	A	Yes
64-M	A	A	A	A	—	—	—	—	—	Yes
67-M	A	A	A	—	—	—	—	—	—	Yes
72-M	A	A	A	—	—	—	—	—	—	No access
74-D	A	A	A	—	—	—	—	—	—	Yes
75-D	A	A	A	—	—	—	—	A	A	Yes
76-D	A	A	A	—	—	—	—	—	—	Yes
77-D	A	A	A	—	—	—	—	—	—	No; damaged
C6302	A	A	A	A	—	—	—	—	—	Yes
C6303	A	A	A	—	—	—	—	—	—	Yes
C6306	A	A	A	A	—	—	—	A	A	Yes
C6309	A	A	A	A	—	—	—	—	—	Yes
C6315	A	A	A	—	—	—	—	—	—	Yes

Notes:

Sampling requirements are from *100-FR-3 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-49, Rev. 2)

All wells are screened in the unconfined aquifer, except 199-F5-53, which is screened in the Ringold Formation aquitard.

a. Aquifer tubes were incorporated into DOE/RL-2003-49, Rev. 2.

A = to be sampled annually

BO = to be sampled biennially, odd fiscal years (October 2014 for fiscal year 2015)

S = to be sampled semiannually

TCE = trichloroethene

VOA = volatile organic analyte

Table A-9. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 300 Area[a]

Well Name	Hydrologic Unit Monitored	cis-1,2-Dichloroethene	Trichloroethene	Uranium, Total (Unfiltered)	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals	Volatile Organic Compounds	Gross Alpha/Beta	Uranium, Isotopic	Sampled as Planned in 2014?
399-1-1	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-10A	TU	S	S	Q	S	—	A	Q	Q	Q	S	S	S	A	Yes
399-1-10B	LU	S	S	S	S	—	—	S	S	S	S	S	—	—	Yes
399-1-11	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-12	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-15	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-16A	TU	S	S	Q	S	—	A	Q	Q	Q	S	S	S	A	Yes
399-1-16B	LU	S	S	S	S	—	—	S	S	S	S	S	—	—	Yes
399-1-17A	TU	S	S	Q	S	—	A	Q	Q	Q	S	S	S	A	Yes
399-1-17B	LU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-18A	TU	—	—	S	—	—	S	S	S	S	S	—	—	—	Yes
399-1-18B	LU	—	—	S	—	—	S	S	S	S	S	—	—	—	Yes
399-1-2	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-21A	TU	S	S	Q	S	—	A	Q	Q	Q	S	S	S	A	Yes
399-1-21B	LU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-57	LU	S	S	—	S	—	—	—	—	—	—	S	—	—	Yes

Table A-9. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 300 Area[a]

Well Name	Hydrologic Unit Monitored	cis-1,2-Dichloroethene	Trichloroethene	Uranium, Total (Unfiltered)	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals	Volatile Organic Compounds	Gross Alpha/Beta	Uranium, Isotopic	Sampled as Planned in 2014?
399-1-59	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-1-6	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-7	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-1-8	LU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-2-1	TU	S	S	Q	S	—	A	Q	Q	Q	S	S	S	A	Yes
399-2-2	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-2-32	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-2-5	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-3-1	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-3-10	TU	S	S	Q	S	—	A	Q	Q	Q	S	S	S	A	Yes
399-3-12	TU	S	S	Q	S	Q	—	S	Q	S	S	S	—	—	Yes[b]
399-3-18	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-3-19	TU	S	S	Q	S	Q	A	Q	Q	Q	S	S	S	A	Yes[b]
399-3-2	TU	S	S	S	S	—	—	S	S	S	S	S	—	—	No[c]
399-3-20	TU	S	S	Q	S	Q	A	Q	Q	Q	S	S	S	A	Yes[b]
399-3-22	LU	—	—	Q	—	Q	—	—	Q	—	—	—	—	—	Yes[b]

Table A-9. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 300 Area[a]

Well Name	Hydrologic Unit Monitored	cis-1,2-Dichloroethene	Trichloroethene	Uranium, Total (Unfiltered)	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals	Volatile Organic Compounds	Gross Alpha/Beta	Uranium, Isotopic	Sampled as Planned in 2014?
399-3-33	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-3-34	TU	—	—	Q	—	Q	—	—	Q	—	—	—	—	—	Yes[b]
399-3-38	TU	—	—	Q	—	Q	—	—	Q	—	—	—	—	—	Yes[b]
399-3-6	TU	S	S	S	S	—	—	S	S	S	S	S	—	—	Yes
399-3-9	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-4-1	TU	S	S	S	S	—	—	S	S	S	S	S	—	—	Yes
399-4-10	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-4-12	TU	S	S	S	S	—	—	S	S	S	S	S	—	—	Yes
399-4-14	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-4-15	TU	—	—	Q	—	Q	—	—	Q	—	—	—	—	—	Yes[b]
399-4-7	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-4-9	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes
399-5-4B	TU	S	S	S	S	—	—	S	S	S	S	S	—	—	Yes
399-6-3	TU	—	—	S	—	—	—	—	—	—	—	—	—	—	Yes
399-8-5A	TU	S	S	S	S	—	—	S	S	S	S	S	S	—	Yes

Table A-9. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 300 Area[a]

Well Name	Hydrologic Unit Monitored	cis-1,2-Dichloroethene	Trichloroethene	Uranium, Total (Unfiltered)	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals	Volatile Organic Compounds	Gross Alpha/Beta	Uranium, Isotopic	Sampled as Planned in 2014?

Note: Per TPA-CN-609 and TPA-CN-610 (both dated February 11, 2014), no further groundwater sampling will be conducted under the *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2009-30) or the *300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2009-45).

a. Sampling requirements are from the *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2002-11) as modified by TPA-CN-611, *Tri-Party Agreement Change Notice 611* (February 11, 2014).

b. Per TPA-CN-611, well sampled quarterly for phosphate, strontium-90, cesium-137 (well 399-3-12 only), and uranium during calendar year 2014 to monitor potential impacts from remediation of the 340 Vault.

c. December 2014 sample delayed to January 2015.

A = to be sampled annually
LU = lower portion of unconfined aquifer
Q = to be sampled quarterly
S = to be sampled semiannually
TU = upper portion of unconfined aquifer, including water table

Table A-10. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 618-10/316-4 Subregion[a]

Well[b]	Uranium, Total	Tributyl Phosphate	Gross Alpha/Beta	Nitrate	Alkalinity	Metals	Volatile Organic Compounds	Tritium	Technetium-99	Uranium, Isotopic	Sampled as Planned in 2014?
699-S6-E4A	Q	S	Q	Q	S	S	S	S	S	A	Yes
699-S6-E4B	S	—	S	S	S	S	—	S	—	—	Yes[c]
699-S6-E4D	A	—	A	A	A	A	—	A	A	—	Yes
699-S6-E4E	S	—	S	S	S	S	—	S	—	—	Yes
699-S6-E4K	S	S	S	S	S	S	S	S	S	A	Yes
699-S6-E4L	Q[d]	S	Q[d]	Q[d]	S	S	S	S	S	A	Yes

a. Sampling requirements are from the *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2002-11) as modified by TPA-CN-611, *Tri-Party Agreement Change Notice 611* (February 11, 2014).

b. Wells are completed at the top of the unconfined aquifer.

c. June 2014 sample delayed until September 2014.

d. The samples collected in March 2014 fulfill the delayed December 2013 sample requirements as well as the first quarterly sample requirements for 2014.

A = to be sampled annually

Q = to be sampled quarterly

S = to be sampled semiannually

Table A.11. Monitoring Wells and Constituents for the 300-FF-5 Operable Unit, 618-11 Subregion[a]

Well[b]	Tritium	Gross Alpha/Beta	Uranium, Total (Unfiltered)	Technetium-99	Nitrate	Alkalinity	Anions	Metals	Sampled as Planned in 2014?
699-12-2C	Q	Q	S	S	S	S	S	S	Yes
699-13-0A	S	S	—	—	S	S	S	S	Yes
699-13-1E	S	S	—	—	S	S	S	S	Yes
699-13-2D	Q	Q	S	S	S	S	S	S	Yes
699-13-3A	Q	Q	S	S	S	S	S	S	Yes

a. Sampling requirements are from the *300-FF-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2002-11) as modified by TPA-CN-611, *Tri-Party Agreement Change Notice 611* (February 11, 2014).

b. Wells are completed at the top of the unconfined aquifer.

A = to be sampled annually

Q = to be sampled quarterly

S = to be sampled semiannually

Table A-12. Monitoring Wells and Constituents for the Former 1100-EM-1 Operable Unit

Well	1,1-Dichloroethene	Trichloroethene	Vinyl Chloride	Anions*	Sampled as Scheduled in 2014?
699-S28-E12	A	A	A	A	Yes
699-S31-E10A	A	A	A	A	Yes
699-S31-E10C	A	A	A	A	Delayed to 2015; broken pump

Note: Sampling requirements are from TPA-CN-163, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records*; PNNL-12220, *Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit*.

* Supplemental analyses.

A = to be sampled annually

Table A-13. Monitoring Wells, Constituents, and Sampling Frequency for the 200-ZP-1 Operable Unit in 2014

Well Name	Carbon Tetrachloride	Chromium	Hexavalent Chromium	Iodine-129	Nitrate	Techneitum-99	Trichloroethene	Tritium	Uranium	Sampled as Scheduled in 2014?
299-W10-1	A	A	A	5	A	5	A	5	5	Yes
299-W10-14	A	5	5	5	A	5	A	5	5	Yes
299-W10-27	A	A	A	A	A	A	A	5	5	Yes
299-W10-30	A	5	5	5	A	5	A	5	5	Yes
299-W10-31	A	5	5	5	A	5	A	5	5	Yes
299-W10-33	A	A	A	5	A	A	A	A	5	Yes
299-W11-13	A	A	A	A	A	A	A	A	5	Yes
299-W11-18	A	A	A	A	A	5	A	A	5	Yes
299-W11-33Q	A	A	A	A	A	A	A	A	5	Yes
299-W11-43	A	A	A	A	A	A	A	A	5	Yes
299-W11-45	A	A	A	A	A	A	A	A	5	Yes[a]
299-W11-47	A	A	A	A	A	A	A	A	5	Yes
299-W11-48	A	A	A	A	A	A	A	A	5	Yes
299-W11-87	A	A	A	5	A	5	A	A	5	Yes
299-W11-88	A	A	A	A	A	5	A	A	5	Yes
299-W13-1	A	5	5	5	A	5	A	5	5	Yes
299-W14-11	A	A	A	A	A	A	A	A	5	Yes
299-W14-13	A	A	A	A	A	A	A	A	5	Yes
299-W14-14	A	A	A	A	A	A	A	A	5	Yes
299-W14-71	A	—	—	—	—	—	A	—	—	Yes
299-W14-72	A	5	5	5	A	5	A	5	5	Yes
299-W15-11	A	5	5	5	A	A	A	5	5	Yes
299-W15-152	A	5	5	5	A	5	A	5	5	Yes
299-W15-17	A	5	5	5	A	5	A	5	5	Yes
299-W15-33	A	5	5	5	A	A	A	5	5	Yes
299-W15-37	A	—	—	—	—	—	A	—	—	Yes

Table A-13. Monitoring Wells, Constituents, and Sampling Frequency for the 200-ZP-1 Operable Unit in 2014

Well Name	Carbon Tetrachloride	Chromium	Hexavalent Chromium	Iodine-129	Nitrate	Techneitum-99	Trichloroethene	Tritium	Uranium	Sampled as Scheduled in 2014?
299-W15-42	A	5	5	A	A	A	A	5	5	Yes
299-W15-46	A	5	5	5	A	A	A	5	5	Yes
299-W15-49	A	5	5	5	A	A	A	5	5	Yes
299-W15-50	A	5	5	5	A	A	A	5	5	Yes
299-W15-7	A	5	5	5	A	5	A	5	5	Yes
299-W15-763	A	5	5	5	A	A	A	A	5	Yes
299-W15-765	A	A	A	5	A	A	A	A	5	Yes
299-W15-83	A	5	5	5	A	5	A	5	5	Yes
299-W15-94	A	5	5	5	A	5	A	5	5	Yes
299-W18-1	A	5	5	A	A	A	A	5	5	Yes
299-W18-15	A	—	—	—	—	—	A	—	—	Yes
299-W18-16	A	5	5	5	A	A	A	5	5	Yes
299-W18-21	A	—	—	—	—	—	A	—	—	Yes
299-W18-22	A	—	—	—	—	—	A	—	—	Yes
299-W18-40	A	—	—	—	—	—	A	—	—	Yes
299-W19-105	A	—	—	—	—	—	A	—	—	Yes
299-W19-107	A	—	—	—	—	—	A	—	—	Yes
299-W19-18	A	—	—	—	—	—	A	—	—	Yes
299-W19-34A	A	—	—	—	—	—	A	—	—	Yes
299-W19-34B	A	—	—	—	—	—	A	—	—	Yes
299-W19-36	A	—	—	—	—	—	A	—	—	Yes
299-W19-4	A	—	—	—	—	—	A	—	—	Yes
299-W19-41	A	—	—	—	—	—	A	—	—	Yes
299-W19-47	A	—	—	—	—	—	A	—	—	Yes
299-W19-48	A	—	—	—	—	—	A	—	—	Yes
299-W19-49	A	—	—	—	—	—	A	—	—	Yes

Table A-13. Monitoring Wells, Constituents, and Sampling Frequency for the 200-ZP-1 Operable Unit in 2014

Well Name	Carbon Tetrachloride	Chromium	Hexavalent Chromium	Iodine-129	Nitrate	Techneitum-99	Trichloroethene	Tritium	Uranium	Sampled as Scheduled in 2014?
299-W19-6	A	—	—	—	—	—	A	—	—	Yes
299-W21-2	A	—	—	—	—	—	A	—	—	Yes
299-W22-24S[b]	A	—	—	—	—	—	A	—	—	No
299-W22-47	A	—	—	—	—	—	A	—	—	Yes
299-W22-72	A	—	—	—	—	—	A	—	—	Yes
299-W22-86	A	—	—	—	—	—	A	—	—	Yes
299-W22-87	A	—	—	—	—	—	A	—	—	Yes
299-W22-88	A	—	—	—	—	—	A	—	—	Yes
299-W23-19	A	—	—	—	—	—	A	—	—	Yes
299-W23-4	A	—	—	—	—	—	A	—	—	Yes
299-W26-13	A	—	—	—	—	—	A	—	—	Yes
299-W27-2	A	—	—	—	—	—	A	—	—	Yes
299-W6-3	A	5	5	5	A	A	A	5	5	Yes
299-W6-6	A	5	5	5	A	A	A	5	5	Yes
299-W7-3	A	5	5	5	A	5	A	5	5	Yes
699-30-66	A	—	—	—	—	—	A	—	—	Yes
699-32-62	A	—	—	—	—	—	A	—	—	Yes
699-32-72A	A	—	—	—	—	—	A	—	—	Yes
699-33-75	A	—	—	—	—	—	A	—	—	Yes
699-34-61	A	—	—	—	—	—	A	—	—	Yes
699-35-66A	A	—	—	—	—	—	A	—	—	Yes
699-35-78A	A	—	—	—	—	—	A	—	—	Yes
699-36-61A	A	—	—	—	—	—	A	—	—	Yes
699-36-66B	A	—	—	—	—	—	A	—	—	Yes
699-36-70A	A	—	—	—	—	—	A	—	—	Yes
699-36-70B	A	—	—	—	—	—	A	—	—	Yes

Table A-13. Monitoring Wells, Constituents, and Sampling Frequency for the 200-ZP-1 Operable Unit in 2014

Well Name	Carbon Tetrachloride	Chromium	Hexavalent Chromium	Iodine-129	Nitrate	Techneitum-99	Trichloroethene	Tritium	Uranium	Sampled as Scheduled in 2014?
699-37-66	A	—	—	—	—	—	A	—	—	Yes
699-38-61	A	—	—	—	—	—	A	—	—	Yes
699-38-65	A	—	—	—	—	—	A	—	—	Yes
699-38-68A	A	—	—	—	—	—	A	—	—	Yes
699-38-70B	A	—	—	—	—	—	A	—	—	Yes
699-38-70C	A	—	—	—	—	—	A	—	—	Yes
699-40-62	A	—	—	—	—	—	A	—	—	Yes
699-40-65	A	—	—	—	—	—	A	—	—	Yes
699-43-69	A	A	A	5	A	5	A	5	5	Yes
699-44-64	A	5	5	5	A	A	A	5	5	Yes
699-45-69A	A	5	5	5	A	5	A	5	5	Yes
699-45-69C	A	5	5	5	A	5	A	5	5	Yes
699-47-60	A	5	5	5	A	5	A	5	5	Yes
699-48-71	A	A	A	A	A	A	A	A	5	Yes
699-50-74	A	5	5	5	A	5	A	5	5	Yes
699-51-63	A	5	5	5	A	5	A	5	5	Yes

Note: Requirements are from DOE/RL-2009-124, *200 West Area Pump-and-Treat Facility Operations and Maintenance Plan*, Rev. 3; and DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*, Rev. 1.

a. Former extraction well 299-W11-45 has been offline since February 2015 and was converted to a monitoring well in October 2014.

b. Wells 299-W22-24S cannot be sampled as currently configured and was removed from the sampling schedule in 2014.

A = annual sampling

5 = sampled every 5 years in preparation for the CERCLA 5-year review

Table A-14. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit

Well Name	Volatile Organic Analytes				Anions	Metals[a]	Radionuclides						Sampled as Scheduled in 2014?
	Carbon Tetrachloride	Chloroform	1,4-Dioxane	Trichloroethene	Nitrate	Chromium (Total)	Iodine-129	Selenium-79	Strontium-90	Technetium-99	Tritium	Uranium	
299-W15-37	A	A	—	A	A	—	—	—	—	—	—	A	Yes
299-W18-15	A	A	—	A	A	—	—	—	—	—	—	A	Yes
299-W18-21	A	—	—	A	A	—	—	—	—	A	—	A	Yes
299-W18-22	A	—	—	A	A	—	—	—	—	A	—	A	Yes
299-W19-101	A	—	—	A	A	—	A	—	—	A	A	A	Yes
299-W19-105	SA	—	—	—	SA	—	SA	—	—	SA	SA	SA	Yes
299-W19-107	A	—	—	A	A	—	A	—	—	A	—	A	Yes
299-W19-18	A	—	—	—	A	—	A	—	—	A	—	A	No; February event delayed until April; well nearly dry
299-W19-34A	A	A	—	A	A	—	A	—	—	A	—	A	Yes
299-W19-34B	BE	BE	—	BE	BE	—	BE	—	—	BE	—	BE	Yes
299-W19-35	SA	—	—	SA	SA	—	SA	—	—	SA	—	SA	No; August sample event cancelled; dry
299-W19-36	A	A	—	A	A	—	A	—	—	A	—	A	Yes
299-W19-39	SA	SA	—	SA	SA	—	SA	—	—	SA	—	SA	Yes
299-W19-4	BO	—	—	BO	BO	—	BO	—	—	BO	—	BO	Not scheduled
299-W19-43	SA	SA	—	SA	SA	—	SA	—	—	SA	—	SA	Yes

Table A-14. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit

Well Name	Volatile Organic Analytes				Anions	Metals[a]	Radionuclides						Sampled as Scheduled in 2014?
	Carbon Tetrachloride	Chloroform	1,4-Dioxane	Trichloroethene	Nitrate	Chromium (Total)	Iodine-129	Selenium-79	Strontium-90	Technetium-99	Tritium	Uranium	
299-W19-46	SA	SA	—	SA	SA	—	SA	—	—	SA	SA	SA	Yes
299-W19-48	SA	—	—	SA	SA	—	SA	—	—	SA	SA	SA	Yes
299-W19-49	SA	—	—	—	SA	—	SA	—	—	SA	SA	SA	Yes
299-W21-2	A	—	—	—	A	—	A	—	A	A	A	A	Yes
299-W22-45	A	—	—	A	A	—	A	—	A	—	A	A	No; June event delayed until July; access restricted due to tank vapors
299-W22-49	SA	—	—	SA	SA	—	SA	—	SA	SA	SA	SA	No; dry; replaced by 299-W22-113 for December sample event (delayed till Jan. 2015)
299-W22-69	A	—	—	—	A	—	A	—	—	A	A	—	Yes
299-W22-72	A	—	—	—	A	—	A	—	A	A	A	A	Yes
299-W22-83	SA	—	—	SA	SA	—	SA	SA	SA	SA	SA	SA	Yes
299-W22-86	SA	—	—	SA	SA	SA	SA	SA	—	SA	SA	—	Yes
299-W22-87	A	—	—	—	A	—	A	—	—	A	A	A	Yes
299-W22-88	—	—	—	—	A	—	A	—	—	A	A	A	Yes
299-W22-95[b]	Q/A[b]	—	—	—	Q/A[b]	Q/A[b]	Q/A[b]	—	—	Q/A[b]	Q/A[b]	—	Yes

Table A-14. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit

Well Name	Volatile Organic Analytes				Anions	Metals[a]	Radionuclides						Sampled as Scheduled in 2014?
	Carbon Tetrachloride	Chloroform	1,4-Dioxane	Trichloroethene	Nitrate	Chromium (Total)	Iodine-129	Selenium-79	Strontium-90	Technetium-99	Tritium	Uranium	
299-W22-96	A	—	—	—	A	A	A	—	—	A	A	—	Yes
299-W22-113	SA	—	—	SA	SA	—	SA	—	SA	SA	SA	SA	No; replacement for 299-W22-49; scheduled for December but not sample ready until January 2015
299-W23-15	A	A	—	—	A	—	—	—	—	A	A	A	No; June event delayed until August due to pump problem
299-W23-21	A	—	—	—	A	—	—	—	—	A	A	A	Yes
299-W23-4	A	A	—	A	A	—	—	—	—	—	A	A	Yes
299-W26-13	BO	—	—	BO	BO	—	BO	—	—	—	BO	BO	Not scheduled
299-W26-14	BE	—	—	BE	BE	—	BE	—	—	BE	BE	BE	Yes
699-30-66	SA	—	—	—	SA	SA	SA	—	—	—	SA	SA	Yes
699-32-62	—	—	—	—	BO	BO	BO	—	—	—	BO	—	Not scheduled
699-32-72A	—	—	—	BO	BO	—	BO	—	—	—	BO	—	Yes
699-32-76	BO	—	—	—	BO	BO	BO	—	—	—	—	—	Not scheduled
699-33-74	A	—	—	A	A	A	A	—	—	A	A	A	Yes
699-33-75	SA	—	—	SA	SA	SA	SA	—	—	—	SA	SA	Yes

Table A-14. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit

Well Name	Volatile Organic Analytes				Anions	Metals[a]	Radionuclides						Sampled as Scheduled in 2014?
	Carbon Tetrachloride	Chloroform	1,4-Dioxane	Trichloroethene	Nitrate	Chromium (Total)	Iodine-129	Selenium-79	Strontium-90	Technetium-99	Tritium	Uranium	
699-33-76	A	—	—	—	A	A	A	—	—	—	—	—	Yes
699-34-61	—	—	—	—	A	A	A	—	—	—	A	—	Yes
699-34-72	A	—	A	—	A	A	A	—	A	A	A	A	Yes
699-35-66A	BO	—	—	—	BO	BO	BO	—	—	—	BO	—	Not scheduled
699-35-78A	A	—	—	—	A	—	—	—	—	—	—	A	No; delayed until January 2014
699-36-61A	—	—	—	—	BE	BE	BE	—	—	—	BE	—	Yes
699-36-66B	—	—	—	—	A	—	A	—	—	—	A	—	Yes
699-36-70A	A	—	—	—	A	—	A	—	—	A	A	A	Yes
699-36-70B	A	—	—	A	A	—	A	—	—	A	A	A	Yes
699-37-66	—	—	—	—	A	—	A	—	—	—	A	—	Yes
699-38-61	—	—	—	—	A	—	A	—	—	—	A	—	Yes
699-38-65	—	—	—	—	A	—	A	—	—	—	A	—	Yes
699-38-68A	BO	—	—	BO	BO	—	BO	—	—	BO	BO	BO	Not scheduled
699-38-70B	A	—	—	A	A	—	A	—	—	A	A	A	Yes
699-38-70C	A	—	—	—	A	—	A	—	—	A	A	A	Yes
699-40-62	—	—	—	—	BO	—	BO	—	—	BO	BO	BO	Not scheduled

Table A-14. Monitoring Wells and Constituents for the 200-UP-1 Operable Unit

Well Name	Volatile Organic Analytes				Anions	Metals[a]	Radionuclides						Sampled as Scheduled in 2014?
	Carbon Tetrachloride	Chloroform	1,4-Dioxane	Trichloroethene	Nitrate	Chromium (Total)	Iodine-129	Selenium-79	Strontium-90	Technetium-99	Tritium	Uranium	
699-40-65	A	—	—	—	A	—	A	—	—	A	A	—	Yes

Note: Requirements are from Appendix B of *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan* (DOE/RL-2013-07).

a. Filtered and unfiltered analyses.

b. Sample quarterly for one year after drilling, then annually thereafter. Quarterly sampling began during December 2013.

A = to be sampled annually

BE = to be sampled every other year (biennially) in even fiscal years

BO = to be sampled every other year (biennially) in odd fiscal years

Q = to be sampled quarterly

SA = to be sampled semiannually

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
299-E24-8	3-16	3-16	—	3-16	3-16	—	—	—	3-16	—	—	3-16	—	3-16	—	—	—	Not required
299-E24-25*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
299-E26-10	—	—	—	A	A	—	—	—	A	—	—	—	—	—	—	—	—	Yes
299-E26-11	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	3-16	—	—	—	Not required, but sampled
299-E27-7	—	—	—	A	A	—	—	A	A	—	—	—	—	A	—	—	—	Yes
299-E27-10	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	3-16	—	—	—	Not required, but sampled
299-E27-14	—	—	—	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
299-E27-15	—	—	—	—	A	—	—	A	—	—	A	—	—	—	A	—	—	Yes
299-E27-17	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	3-16	—	—	—	Not required, but sampled
299-E27-18	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	3-16	—	—	—	Not required, but sampled
299-E27-155*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
299-E28-2	A	—	—	A	A	A	A	A	A	—	A	A	—	—	A		—	Yes, no Tc-99 or tritium analyzed

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
299-E28-5	A	—	—	3-16	3-16	A	A	—	3-16	A	—	3-16	—	3-16	—	—	—	Yes
299-E28-6	A	A	—	3-16	3-16	A	A	—	3-16	A	—	3-16	—	3-16	—	—	—	Yes
299-E28-8	A	—	—	—	—	A	A	A	—	A	—	—	—	—	—	—	—	Yes
299-E28-17	A	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	3 16	—	—	—	Not required, but sampled
299-E28-18	—	—	—	A	A	—	—	—	A	A	—	A	—	A	—	—	—	Yes
299-E28-21	—	—	—	—	—	—	—	—	—	A	—	—	—	—	—	—	—	Yes
299-E28-23	A	—	—	—	—	A	A	—	—	A	—	A	A	—	—	A	—	Yes
299-E28-24	A	—	—	—	—	A	A	—	A	A	—	A	A	—	—	A	—	Yes
299-E28-25	A	—	—	A	A	A	A	—	A	A	—	A	A	A	—	A	—	Yes
299-E28-26	—	—	—	3-16	A	—	—	A	3-16	A	—	—	—	3-16	—	—	—	Yes
299-E28-27	A	—	—	A	A	A	A	A	3-16	A	—	—	—	—	—	—	—	Yes
299-E28-28	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required, but sampled

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
299-E28-30*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		Yes
299-E29-54*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		Yes
299-E32-2	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
299-E32-4	—	—	—	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
299-E32-5	—	—	—	3-16	3-16	—	—	—	3-16	3-16	—	—	—	—	—	—	—	Not required, but sampled
299-E32-6	—	—	—	3-16	A	—	—	A	3-16	3-16	—	—	—	—	—	—	—	Yes
299-E32-7	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
299-E32-8	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
299-E32-9	—	—	3-16	A	A	—	—	—	3-16	—	—	—	—	—	—	—	—	Yes
299-E32-10	—	A	A	3-16	3-16	—	—	A	3-16	A	—	—	—	3-16	—	—	—	Yes
299-E33-7	A	A	A	A	A	—	—	A	A	A	—	A	—	—	—	—	—	Yes

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
299-E33-13	—	—	A	—	—	—	—	—	—	A	—	—	—	—	—	—	—	No, two unsuccessful attempts in 2014. Declared sample dry
299-E33-15	—	—	—	—	A	—	—	A	—	—	—	—	—	—	—	—	—	Yes
299-E33-16	—	—	A	A	A	—	—	A	—	A	—	—	—	—	—	—	—	Yes
299-E33-18	—	—	—	A	A	—	—	A	—	A	—	—	—	—	—	—	—	No, decommissioned 2013
299-E33-26	—	A	A	3-16	3-16	—	—	A	3-16	A	—	3-16	—	—	—	—	—	No, dry well
299-E33-28	—	—	—	—	A	—	—	A	—	—	—	—	—	—	—	—	—	Yes
299-E33-29	—	—	—	3-16	3-16	—	—	3-16	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
299-E33-30	—	—	—	—	A	—	—	A	—	—	—	—	—	—	—	—	—	Yes
299-E33-32	—	—	—	3-16	3-16	—	—	3-16	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
299-E33-33	—	—	—	3-16	3-16	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	Not required, but sampled
299-E33-34	—	A	A	A	A	—	—	A	A	A	—	—	—	—	—	—	—	Yes

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
299-E33-35	3-16	3-16	A	3-16	A	—	—	A	3-16	A	—	—	—	—	—	—	—	Yes
299-E33-37	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
299-E33-38	—	A	A	A	A	A	A	A	A	A	—	A	—	A	—	—	—	Yes
299-E33-39	—	—	A	A	A	—	—	A	A	A	—	—	—	—	—	—	—	Yes
299-E33-41	3-16	3-16	3-16	3-16	3-16	—	—	A	3-16	A	—	—	—	—	—	—	—	Yes
299-E33-42	—	—	—	A	—	—	—	A	—	A	—	—	—	—	—	—	—	Yes
299-E33-43	—	—	—	A	—	—	—	A	—	A	—	—	—	—	—	—	—	Yes
299-E33-44	—	A	—	—	—	—	—	A	—	A	—	—	—	—	—	—	—	Yes
299-E33-50*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
299-E33-205*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	No, access issue
299-E33-334	—	—	—	—	A	—	—	A	—	A	—	—	—	—	—	—	—	Yes
299-E33-335	—	—	—	—	—	A	—	A	—	—	—	—	—	—	—	—	—	Yes, no Pu-239/240 analyzed
299-E33-338	—	—	—	—	—	—	—	A	—	A	—	—	—	—	—	—	—	Yes
299-E33-340*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
299-E33-341*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
299-E33-342*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
299-E33-343*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Not accessible
299-E33-345*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
299-E34-2	—	—	—	A	A	—	—	—	A	—	—	—	—	—	—	—	—	Yes
299-E34-9	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
699-44-39B	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Yes
699-45-42	—	—	—	3-16	3-16	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required
699-47-60	—	—	—	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
699-48-50B*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
699-49-55A	A	A	A	A	A	A	A	A	A	A	—	A	—	—	—	—	—	Yes, no alpha/beta analyzed
699-49-57A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	—	—	—	Yes
699-49-57B	A	A	A	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
699-50-56*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
699-50-59	—	—	A	A	A	—	—	A	—	A	—	—	—	—	—	—	—	Yes
699-52-55*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
699-52-55B*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	—	Yes
699-53-47A	—	—	—	—	A	—	A	—	A	—	—	A	—	—	—	—	—	No, dry well
699-53-47B	—	—	—	—	3-15	—	3-15	—	—	—	—	—	—	—	—	—	—	Not required, but sampled
699-53-48A	—	—	—	A	A	—	A	—	A	—	—	A	—	—	A	—	—	Yes, no metals analyzed
699-53-55A	—	A	A	—	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
699-53-55B	—	A	A	—	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
699-53-55C	—	A	A	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
699-54-45A	—	—	—	—	3-15	—	—	—	—	—	—	—	—	—	—	—	—	Not required
699-54-45B	—	—	—	—	3-15	—	—	—	—	—	—	—	—	—	—	—	—	Not required
699-54-48	—	—	—	—	—	—	3-15	—	—	—	—	—	—	—	—	—	—	Not required

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
699-54-49	—	—	—	—	A	—	A	—	A	—	—	A	—	—	—	—	—	Yes
699-55-50C	—	—	—	A	A	—	A	A	A	—	—	—	—	—	—	—	—	Yes
699-55-57	—	A	A	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
699-55-60A	—	A	A	A	A	—	—	A	A	—	—	—	—	—	—	—	—	Yes
699-57-59	A	A	A	A	A	A	A	A	A	A	A	A	—	—	A	—	A	Yes
699-59-58	A	A	A	A	A	A	A	A	A	A	A	A	—	—	A	—	A	Yes
699-60-60	A	A	A	A	A	A	A	A	A	A	A	A	—	—	A	—	A	Yes
699-61-62	A	A	A	A	A	A	A	A	A	A	A	A	—	—	A	—	A	Yes
699-61-66	A	A	A	A	A	A	A	A	A	A	A	A	—	—	A	—	A	Yes
699-64-62	A	A	A	A	A	A	A	A	A	A	A	A	—	—	A	—	A	Yes
699-65-50	—	—	—	—	—	—	—	3-16	—	—	—	—	—	—	—	—	—	Not required
699-65-72	—	—	—	—	—	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required
699-66-58	—	—	—	—	—	—	—	3-16	3-16	—	—	—	—	—	—	—	—	Not required

Table A-15. Monitoring Wells and Constituents for the 200-BP-5 Operable Unit

Well	Contaminants of Concern										Supporting Constituents							Sampled as Scheduled in 2014?
	Cesium-137	Cobalt-60	Cyanide	Iodine-129	Nitrate	Plutonium-239/240	Strontium-90	Technetium-99	Tritium	Uranium	Alkalinity	Alpha/Beta	Americium-241	Arsenic	Metals (Filtered)	Neptunium-237	TOC/TOX	
699-66-64	—	—	—	—	—	—	—	3-16	3-16	—	—	—	—	—	—	—	—	Not required
699-70-68	—	—	—	—	—	—	—	3-16	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
699-72-73	—	—	—	—	3-16	—	—	3-16	3-16	—	—	—	—	—	—	—	—	Not required, but sampled
699-73-61	—	—	—	—	—	—	—	—	3-16	—	—	—	—	—	—	—	—	Not required

Note: Sampling requirements are from *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit* (DOE/RL-2001-49).

* Well was not listed in DOE/RL-2001-49 but was added to the sampling schedule per *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit* (DOE/RL-2007-18). Wells were also sampled and analyzed for volatile organic analytes and semivolatile organic analytes.

3-xx = to be sampled triennially (every 3 years); xx indicates the fiscal year of sampling for a specified analyte

A = to be sampled annually

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

LLWMA = low-level waste management area

TOC = total organic carbon

TOX = total organic halides

Table A-16. Monitoring Wells and Constituents for 200-PO-1 Operable Unit Near-Field Wells

Well Number	Contaminants of Concern					Supporting Constituents					Sampled as Planned in 2014?	Comments
	Field Parameters	Iodine-129	Strontium-90	Technetium-99	Tritium	Gross Alpha	Anions[a]	Gross Beta	Metals[b]	Uranium		
299-E16-2	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E17-1	A	A	A	A	A	A	A	A	A	A	No	Sampled Oct 2013, next sampling event February 2015
299-E17-15	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E17-13	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E17-14	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E17-16	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E17-18	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E17-19	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E17-23	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E17-25	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E18-1	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E23-1	A	A	—	—	A	A	A	A	A	—	No	Delayed 2013 sample collected Aug 2014

Table A-16. Monitoring Wells and Constituents for 200-PO-1 Operable Unit Near-Field Wells

Well Number	Contaminants of Concern					Supporting Constituents					Sampled as Planned in 2014?	Comments
	Field Parameters	Iodine-129	Strontium-90	Technetium-99	Tritium	Gross Alpha	Anions[a]	Gross Beta	Metals[b]	Uranium		
299-E24-16	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E24-18	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E24-20	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E24-22	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E24-23	A	A	A	A	A	A	A	A	A	A	Yes	—
299-E24-33	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E24-5	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-17	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-18	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E25-19	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-2	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-20	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E25-22	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E25-28	A	A	—	—	A	A	A	A	A	—	Yes	—

Table A-16. Monitoring Wells and Constituents for 200-PO-1 Operable Unit Near-Field Wells

Well Number	Contaminants of Concern					Supporting Constituents					Sampled as Planned in 2014?	Comments
	Field Parameters	Iodine-129	Strontium-90	Technetium-99	Tritium	Gross Alpha	Anions[a]	Gross Beta	Metals[b]	Uranium		
299-E25-29P	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-29Q	A	A	—	—	A	—	—	A	A	—	Yes	—
299-E25-236	A	A	A	A	A	A	A	A	A	—	No	Well decommissioned June 2013
299-E25-3	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E25-32P	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-32Q	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-34	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-35	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-36	A	A	A	—	A	A	A	A	A	A	Yes	—
299-E25-37	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-40	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-41	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-42	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-43	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-44	A	A	—	—	A	A	A	A	A	—	Yes	—

Table A-16. Monitoring Wells and Constituents for 200-PO-1 Operable Unit Near-Field Wells

Well Number	Contaminants of Concern					Supporting Constituents					Sampled as Planned in 2014?	Comments
	Field Parameters	Iodine-129	Strontium-90	Technetium-99	Tritium	Gross Alpha	Anions[a]	Gross Beta	Metals[b]	Uranium		
299-E25-47	A	A	—	—	A	A	A	A	A	—	Yes	—
299-E25-6	A	A	A	—	A	A	A	A	A	—	Yes	—
299-E25-93	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E25-94	A	A	A	A	A	A	A	A	A	—	Yes	—
299-E26-4	A	A	A	—	A	A	A	A	A	—	Yes	—
699-37-47A	A	A	A	A	A	A	A	A	A	A	Yes	—
699-39-39[c]	A	A	—	—	A	A	A	A	A	—	Yes	—
699-41-42	A	A	—	—	A	A	A	A	A	—	Yes	—
699-42-40A[c]	A	A	—	—	A	A	A	A	A	—	Yes	—
699-42-42B[c]	A	A	—	—	A	A	A	A	A	—	Yes	—
699-43-45	A	A	—	—	A	A	A	A	A	—	Yes	—
699-44-39B	A	A	—	—	A	A	A	A	A	—	Yes	—

Table A-16. Monitoring Wells and Constituents for 200-PO-1 Operable Unit Near-Field Wells

Well Number	Contaminants of Concern					Supporting Constituents					Sampled as Planned in 2014?	Comments
	Field Parameters	Iodine-129	Strontium-90	Technetium-99	Tritium	Gross Alpha	Anions[a]	Gross Beta	Metals[b]	Uranium		

Note: Sampling requirements are from *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2003-04), as amended by TPA-CN-205, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2003-04, Revision 1, Sampling and Analysis Plan for the 200-PO-1 Operable Unit*, and *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Operable Unit* (DOE/RL-2007-31), as amended by TPA-CN-2-253, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2007-31 Rev. 0, Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Operable Unit*.

a. Anions; analytes include, but are not limited to, chloride, nitrate, and sulfate.

b. Metals; analytes include, but are not limited to, chromium, manganese, and vanadium.

c. Ringold confined aquifer.

A = to be sampled annually

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
BC Cribs																		
299-E13-14	—	A	A	A	A	A	A	—	A	A	A	A	A	A	—	—	Yes	—
299-E13-5	—	A	A	A	A	A	A	—	A	A	A	A	A	A	—	—	Yes	—
299-E13-11	—	A	A	A	A	A	A	—	A	A	A	A	A	A	—	—	No	Access to well restricted
299-E13-19	—	A	A	A	A	A	A	—	A	A	A	A	A	A	—	—	Yes	—
Southeast Transect																		
699-10-54A	—	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-24-46	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-26-33	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	No	No; I-129, tritium, alpha, beta, gamma, or Sr-90
699-31-31	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-32-22A	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-32-43	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	No	Scheduled Jan 2014, collected January 2015
699-41-23	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-46-21B	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
River Transect																		
699-10-E12	—	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-20-E12O	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-41-1A	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	Sampled early; 12/31/2013
699-46-4	A	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	Sampled early; 12/31/2013
699-S3-E12	—	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
699-S19-E13	—	A	A	A	A	A	A	—	—	A	A	A	—	—	—	A	Yes	—
Basalt-Confined Aquifer																		
299-E16-1	T	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	Yes	—
699-13-1C	—	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	Yes	—
699-24-1P	—	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	NS	Last sampled in 2012
699-32-22B	T	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	Yes	—
699-42-40C	T	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	Yes	—
699-S2-34B	—	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	Yes	—

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
699-S11-E12AP	—	T	T	T	T	T	T	—	—	—	T	—	—	—	—	—	Yes	—
Far-Field General																		
499-S0-7	A	A	A	A	A	A	A	—	—	A	A	A	A	A	A	A	Yes	—
499-S0-8	A	A	A	A	A	A	A	—	—	A	A	A	A	A	A	A	Yes	—
499-S1-8J	A	A	A	A	A	A	A	—	—	A	A	A	A	A	A	A	Yes	—
699-15-4D	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-13-1A	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-13-3A	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-14-38	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-17-5	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-19-43	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-20-20	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-20-E12S	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-20-E5A	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-21-6	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
699-2-3	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-22-35	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-24-34C	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	No	Well is sample dry
699-25-33A	A	A	A	A	A	A	—	—	—	A	A	A	A	A	A	A	No	No gamma or ammonia
699-26-15A	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-26-35A	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-2-6A	—	A	A	A	—	A	—	—	—	—	—	—	—	—	—	—	Yes	—
699-2-7	—	A	A	A	—	A	—	—	—	—	—	—	—	—	—	—	Yes	—
699-28-40	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-29-4	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-31-11	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-33-56	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	Yes	—
699-34-41B	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-34-42	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-35-9	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
699-37-43	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-37-E4	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-38-15	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-40-1	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-40-33A	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-40-36[c]	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	Last sampled Oct 2012
699-41-40[c]	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-41-42	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	Yes	—
699-42-15A	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-42-39A	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-42-39B[c]	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-43-3	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-45-42[c]	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-47-5	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-48-7A	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
699-49-13E	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-50-28B	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-52-19	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-8-17	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-8-25	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-9-E2	T	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S12-3	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S19-E14	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S3-25	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S6-E14A	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S6-E4A	—	T	T	T	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S6-E4B	—	T	T	—	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
699-S8-19	—	T	T	—	—	T	—	—	—	—	—	—	—	—	—	—	NS	—
Aquifer Tubes[d]																		
82-M	A	A	A	A	A	—	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
82-S	A	A	A	A	A	—	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
83-D	A	A	A	A	A	—	A	A	—	—	—	—	A	—	—	—	No	Cannot be located
84-D	A	A	A	A	A	—	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
84-M	A	A	A	A	A	—	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
84-S	A	A	A	A	A	—	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
85-M	A	A	A	A	A	A	A	—	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
85-S	A	A	A	A	A	A	A	—	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
85-D	A	—	A	A	A	A	A	—	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
86-D	A	—	A	A	A	A	A	—	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
86-M	A	A	A	A	A	A	A	—	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
86-S	A	A	A	A	A	A	A	—	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6353	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6356	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6359	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6362	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		
C6365	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Cannot be located
C6368	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6371	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	No yield; cancelled
C6374	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—	No	Delayed until 01/2015
C6375	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Broken; cancelled
C6378	A	A	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6380	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015
C6383	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—	No	Delayed until 01/2015
C6384	A	—	A	A	A	A	A	A	—	—	—	—	A	—	—	—	No	Delayed until 01/2015

Table A-17. Monitoring Wells and Constituents for the 200-PO-1 Operable Unit Far-Field Wells

Well or Aquifer Tube Name	Contaminants of Concern			Field Parameters	Supporting Constituents												Sampled as Planned in 2014?	Comments
	Iodine-129	Nitrate	Tritium		Gross Alpha	Anions[a]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals[b]	Strontium-90	Technetium-99	Uranium	Ammonia	Volatile Organic Analytes		

Note: Sampling requirements for wells are from *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2003-04), and *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Operable Unit* (DOE/RL-2007-31), as amended by TPA-CN-2-253, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2007-31 Rev. 0, Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Operable Unit*.

a. Anions; analytes include, but are not limited to, chloride, nitrate, and sulfate.

b. Metals; analytes include, but are not limited to, chromium, manganese, and vanadium.

c. Ringold confined aquifer.

d. The following aquifer tubes were listed in DOE/RL-2003-04, but were not successfully installed in 2008: C6360, C6361, C6366, C6367, C6377, C6369, C6381, and C6382.

A = to be sampled annually

NS = not scheduled

T = to be sampled triennially

This page intentionally left blank.

Appendix B

Supporting Information for RCRA and Other Monitoring Facilities

This page intentionally left blank.

Tables

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities B-8
Table B-2. Monitoring Wells and Constituents for 100-N Area Units B-15
Table B-3. 116-N-1 (1301-N) Water Level Summary B-16
Table B-4. 116-N-1 (1301-N) Liquid Waste Disposal Facility Indicator Parameter Results B-17
Table B-5. 116-N-1 (1301-N) Liquid Waste Disposal Facility Water Quality Parameter Results B-17
Table B-6. 120-N-1 and 120-N-2 (1324-N/NA) Water Level Summary B-18
Table B-7. 120-N-1 and 120-N-2 Facilities (1324-N/NA) Indicator Parameter Results B-18
Table B-8. 120-N-1 and 120-N-2 (1324-N/NA) Facilities Water Quality Summary B-19
Table B-9. 116-N-3 Water Level Summary B-19
Table B-10. 116-N-3 (1325-N) Indicator Parameter Results B-20
Table B-11. 116-N-3 (1325-N) Water Quality Parameter Results B-20
Table B-12. Monitoring Wells and Constituents for 183-H (116-H-6) Evaporation Basins B-21
Table B-13. 183-H Water Level Summary B-22
Table B-14. 183-H Permit Required Consistuent Summary B-22
Table B-15. Monitoring Wells and Constituents for 216-A-29 Ditch B-23
Table B-16. 216-A-29 Water Level Summary B-24
Table B-17. 216-A-29 Ditch Indicator Parameter Results B-24
Table B-18. 216-A-29 Groundwater Quality Parameter Results B-25
Table B-19. Monitoring Wells and Constituents for 216-A-36B Crib B-26
Table B-20. 216-A-36B Water Level Summary B-27
Table B-21. 216-A-36B Crib Indicator Parameter Results B-27
Table B-22. 216-A-36B Groundwater Quality Parameter Summary B-28
Table B-23. Monitoring Wells and Constituents for 216-A-37-1 Crib B-29
Table B-24. 216-A-37-1 Water Level Summary B-30
Table B-25. 216-A-37-1 Crib Indicator Parameter Results B-30
Table B-26. 216-A-37-1 Crib Groundwater Quality Parameter Summar B-31
Table B-27. Monitoring Wells and Constituents for 216-B-3 Pond B-32
Table B-28. 216-B-3 Water Level Summary B-32
Table B-29. 216-B-3 Pond Indicator Parameter Results B-33
Table B-30. 216-B-3 Groundwater Quality Parameter Results B-34
Table B-31. Monitoring Wells and Constituents for 216-B-63 Trench B-35
Table B-32. 216-B-63 Trench Indicator Parameter Results B-36
Table B-33. 216-B-63 Water-Level Summary B-36
Table B-34. 216-B-63 Groundwater Quality Parameter Results B-37
Table B-35. Monitoring Wells and Constituents for 216-S-10 Pond and Ditch B-38
Table B-36. 216-S-10 Pond and Ditch Indicator Parameter Results B-39
Table B-37. 216-S-10 Pond and Ditch Water Level Summary B-39
Table B-38. 216-S-10 Pond and Ditch Water Quality and Other Monitored Parameters B-40

Table B-39. Monitoring Wells and Constituents for 316-5 Process Trenches B-41
Table B-40. 316-5 Process Trenches Water Level Summary B-42
Table B-41. 316-5 Process Trenches Post-Closure Corrective Action Monitoring Constituent Summary B-42
Table B-42. Monitoring Wells and Constituents for the Integrated Disposal Facility B-43
Table B-43. Integrated Disposal Facility Water Level Summary B-44
Table B-44. Integrated Disposal Facility RCRA Indicator Parameter Results B-44
Table B-45. Monitoring Wells and Constituents for Liquid Effluent Retention Facility B-45
Table B-46. Liquid Effluent Retention Facility Indicator Constituent Results B-45
Table B-47. Liquid Effluent Retention Facility Water Level Summary B-46
Table B-48. Semiannual Monitoring Wells and Constituents for Low-Level Waste Management Area 1 ..... B-47
Table B-49. Low-Level Waste Management Area 1 Indicator Parameter Results B-49
Table B-50. Low-Level Waste Management Area 1 Water Level Summary B-50
Table B-51. Low-Level Waste Management Area 1 Groundwater Quality Parameter Results B-51
Table B-52. Monitoring Wells and Constituents for Low-Level Waste Management Area 2 ..... B-52
Table B-53. Low-Level Waste Management Area 2 Indicator Parameter Results B-53
Table B-54. Low Level Waste Mangement Area 2 Water Level Summary B-53
Table B-55. Low-Level Waste Management Area 2 Groundwater Quality Parameter Results B-54
Table B-56. Monitoring Wells and Constituents for Low-Level Waste Management Area 3 ..... B-55
Table B-57. Low-Level Waste Management Area 3 Water Level Summary B-55
Table B-58. Low-Level Waste Management Area 3 Indicator Parameter Results B-56
Table B-59. Low-Level Waste Management Area 3 Intrawell Total Organic Carbon Indicator Parameter Results B-56
Table B-60. Average Concentration for Indicator Parameters in Low-Level Waste Management Area 3 Wells in 2014 ..... B-56
Table B-61. Low-Level Waste Management Area 3 Water Quality and Supporting Constituent Parameter Summary B-57
Table B-62. Monitoring Wells and Constituents for Low-Level Waste Management Area 4 ..... B-58
Table B-63. Low-Level Waste Management Area 4 Indicator Parameter Results B-59
Table B-64. Low-Level Waste Management Area 4 Water Level Summary B-59
Table B-65. Low-Level Waste Management Area 4 Groundwater Quality Parameter and Supporting Constituent Summary B-60
Table B-66. Monitoring Wells and Constituents for the Nonradioactive Dangerous Waste Landfill B-61
Table B-67. Nonradioactive Dangerous Waste Landfill Water Level Summary B-62
Table B-68. Nonradioactive Dangerous Waste Landfill Indicator Parameter Results B-63
Table B-69. Nonradioactive Dangerous Waste Landfill Water Quality and Site-Specific Parameter Results B-64
Table B-70. Monitoring Wells and Constituents for Waste Management Area A-AX B-65
Table B-71. Waste Management Area A-AX Water Levels B-66
Table B-72. Waste Management Area A-AX 2014 Assessment Parameter Summary B-66

Table B-73. Monitoring Wells and Constituents for Waste Management Area B-BX-BY B-67
Table B-74. Waste Management Area B-BX-BY Water Level Summary B-68
Table B-75. Monitoring Wells and Constituents for Waste Management Area C B-69
Table B-76. Waste Management Area C Water Level Summary B-70
Table B-77. Monitoring Wells and Constituents for Waste Management Area S-SX..... B-71
Table B-78. Waste Management Area S-SX Water Level Summary B-73
Table B-79. Waste Management Area S-SX Assessment Parameter Summary B-74
Table B-80. Monitoring Wells and Constituents for Waste Management Area T..... B-75
Table B-81. Waste Management Area T Water Level Summary B-76
Table B-82. Waste Management Area T Assessment Parameter Summary B-77
Table B-83. Monitoring Wells and Constituents for Waste Management Area TX-TY B-78
Table B-84. Waste Management Area TX-TY Water Level Summary..... B-79
Table B-85. Waste Management Area TX-TY Assessment Parameter Summmary B-80
Table B-86. Monitoring Wells and Constituents for Waste Management Area U B-81
Table B-87. Waste Management Area U Water Level Summary..... B-82
Table B-88. Waste Management Area U Assessment Parameter Summary..... B-82
Table B-89. Monitoring Wells and Constituents for Environmental Restoration Disposal Facility B-83
Table B-90. Monitoring Wells and Constituents for the KE and KW Basins B-84
Table B-91. Monitoring Wells, Constituents, and Enforcement Limits for State-Approved Land Disposal Site..... B-86
Table B-92. Monitoring Wells and Constituents for Solid Waste Landfill B-88
Table B-93. Analytical Results for Required Constituents at the Solid Waste Landfill, 2014..... B-90
Table B-94. Solid Waste Landfill Groundwater Monitoring Results B-94

This page intentionally left blank.

B Supporting Information for RCRA and Other Monitored Facilities

This chapter provides supplemental information for the *Resource Conservation and Recovery Act of 1976* (RCRA) and other regulated units on the Hanford Site that require groundwater monitoring, excluding *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) operable units (discussed in Appendix A). Site-specific information for each facility included in each chapter of the report, under the respective groundwater interest area in which the facility is located.

Groundwater monitoring under RCRA continued during the reporting period at 26 waste management areas. Estimates of groundwater velocity, hydrologic properties, and associated references are shown in Table B-1 for the RCRA sites.

To determine if a waste site has adversely affected groundwater quality under RCRA interim status regulations (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"; 40 CFR 265.93, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response"), concentrations of indicator parameters in downgradient wells are compared to statistically derived critical mean values. The indicator parameters under interim status are specific conductance, pH, total organic carbon (TOC), and total organic halides (TOX). The critical values to which the indicator parameters are compared represent 99 percent prediction limits, which are calculated for each facility based on samples from upgradient wells. The methodology used to calculate the critical value is the Student's t-test in accordance with 40 CFR 265.93(b). The formula and individual parameters for the test are provided in Section 7.1 of PNNL-13080, *Hanford Site Groundwater Monitoring: Setting, Sources and Methods*. The upper prediction limits (and lower limit in the case of pH) are also referred to as critical mean values.

Critical mean values are recalculated annually or if the number of analyses changes. Annual recalculation accounts for changing background conditions. Changes in the number of analyses are usually the result of changes in monitoring well networks (e.g., wells are added or deleted). If changes occur in a monitoring well network, critical mean values for that facility are recalculated for subsequent semiannual sampling events using the new well network. Details for the critical mean values for RCRA sites, and comparison values for other monitored facilities, are provided in ECF-Hanford-14-0043, Rev. 0, *Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring.*.

Tables B-3 through B-88 provide supporting information for the RCRA sites, including the comparison values (critical mean values and limits of quantitation) used during the reporting period.

This chapter also provides constituent lists, well network configurations, and other ancillary information for regulated facilities that fall outside of the RCRA program. Some network wells in these facilities are shared with RCRA facilities. Tables B-89 through B-94 list the constituents and/or the results summaries for these facilities.

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
116-N-1 LWDF	West-northwest	0.04 – 0.70	Darcy	6.1 – 37 (PNL-8335)	—	1.9×10^{-3}	Trend surface analysis.
120-N-1 and 120-N-2	West-northwest	0.02 – 0.36	Darcy	6.1 – 37 (PNL-8335)	—	9.6×10^{-4}	Trend surface analysis.
116-N-3 LWDF	North	0.03 – 0.48	Darcy	6.1 – 37 (PNL-8335)	—	1.3×10^{-3}	Trend surface analysis.
116-H-6 Evaporation Basins	North-northeast	0.20 – 5.5	Darcy	15 – 140 (PNL-6728)	—	3.9×10^{-3}	Trend surface analysis.
216-A-29 Ditch	South-southeast	0.0036	Darcy	18 (WHC-SD-EN-DP-047, *Borehole Completion Data Package for the 216-A-29 RCRA Facility*)	0.1	2.0×10^{-5}	Gradient and flow direction based on 2013 trend surface analysis. Low gradient well network (SGW-54165).
216-A-36B Crib	Southeast	0.0013 – 0.22	Darcy	18 – 3,000 (PNNL-11523)	0.1	7.4×10^{-6}	Gradient derived using 2013 low gradient groundwater contour map (Figure 10-3). Flow direction based on 2013 low gradient groundwater contour map and plume movement. Low gradient well network (SGW-54165).

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
216-A-37-1 Crib	South-southeast	0.0036 – 0.6	Darcy	18 – 3,000 (PNNL-11523)	—	2.0×10^{-5}	Gradient and flow direction based on 2013 trend surface analysis. Low gradient well network (SGW-54165).
216-B-3 Pond	Southwest	0.0056	Darcy	1.0 (WHC-SD-EN-EV-002 *Groundwater Quality Asessment for the 216-B-3 Pond*, PNL-10195)	0.25	0.00111	Gradient based on trend surface analysis using wells 699-42-42B, 699-43-44, 699-43-45, 699-44-39B, and 699-45-42. Trend surface derived by least squares regression of a plane to points in three-dimensional space (Davis, 2002, *Statistics and Data Analysis in Geology*).
216-B-63 Trench	Southeast	0.019 – 0.024	Darcy and plume movement	180 – 230, SGW-44329	0.1	1.047×10^{-5} 2014 average	Gradient (G) and flow direction based on monthly water level measurments corrected for barometric response between January and December 2014 at a 14 well low-gradient network as shown in Figure 9-45. Effective porosity (n_e) based on discussion in SGW-54508. Flow based on formula V=(K*G)/n_e (Driscoll, 1986, *Groundwater and Wells*). Flow rate correlates with nitrate and technetium-99 plume movement.

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
216-S-10 Pond and Ditch	East-southeast	0.20	Darcy	10.4 (WHC-SD-EN-DP-052)	0.15	2.9×10^{-3}	Trend surface analysis.
316-5 Process Trenches	South-southeast	17	Darcy	9,000 (ECF-300-FF-11-0151 Rev. 3 (Available in Appenix F of DOE/RL-2010-99)	0.17	3.3×10^{-4}	Trend surface analysis.
316-5 Process Trenches	Southwest	13				2.4×10^{-4} (June)	
IDF	Southeast	0.004 – 0.0045	Darcy	68 – 75 (PNNL-13652, PNNL-11957)	0.1	6×10^{-6}	Gradient derived using 2013 low gradient groundwater contour map (Figure 10-3). Flow direction based on 2013 low gradient groundwater contour map and plume movement. Low gradient well network (SGW-54165).
Liquid Effluent Retention Facility	South	0.1	Darcy	36.2 – 39.8 (PNNL-14804)	0.1	2.41×10^{-4} 2014 average	The groundwater flow direction based on January through December 2014 water-level measurements at wells 299-E26-10, 299-E26-14, 299-E26-77, and 299-E26-79 was 191 degrees from north in a clockwise direction. The groundwater gradient magnitude from the same well network produced 2.41×10^{-4}.

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
LLWMA-1	Southeast	Variable. Ranges from 0.19 near northeast corner to 0.019 near southwest corner.	Darcy	Variable. Ranges from 1,785 near northeast corner to 240 near southwest corner. (PNL-8337)	0.1	1.047×10^{-5} 2014 average	Gradient (G) and flow direction based on monthly water level measurments corrected for barometric response between January and December 2014 at a 14 well low-gradient network as shown in Figure 9-45. Effective porosity (n_e) based on discussion in SGW-54508. Flow based on formula V=(K*G)/n_e (Driscoll, 1986, *Groundwater and Wells*). Flow rate correlates with nitrate and technetium-99 plume movement.
LLWMA-2	Southeast to south	Variable. Ranges from 0.12 near west side of LLWMA-2 to 0.1 on east side.	Darcy and plume movement	1,100 – 2,100	0.1	Variable. Ranges from 1.047×10^{-5} on west side of LLWMA-2 to uncertain on east side as low-gradient network is not sufficient to derive a gradient.	Gradient (G) and flow direction on the west side of LLWMA-2 based on formula, V=(K*G)/n_e, mentioned for WMA B-BX-BY and plume movement at WMA B-BX-BY. East side of LLWMA-2 is uncertain because of lack of gradient and greater hydraulic conductivity found at well 299-E27-9 and -10 versus wells at LERF.

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
LLWMA-3	East	0.11 – 0.43	Darcy	2.5 – 10 (PNNL-14753)	0.1 (PNNL-14753)	4.3×10^{-3}	Trend surface analysis using data east of injection wells.
LLWMA-4	East-northeast	0.16 – 0.64	Darcy	2.5 – 10 (PNNL-14753)	0.1 (PNNL-14753)	6.4×10^{-3}	Trend surface analysis. General approximation from the groundwater mound west of LLWMA-4 to wells east of the LLWMA.
NRDWL/SWL	Southeast	0.12 – 0.37	Darcy	518 – 1,524 (WHC-EP-0021)	—	2.4×10^{-5}	Trend surface analysis.
WMA A-AX	Southeast	0.1	Darcy	1,981 (PNL-8337, WHC-SD-EN-TI-019)	0.1	5×10^{-6}	Gradient derived using 2014 low gradient groundwater contour map (Figure 10-4). Flow direction based on 2014 low gradient groundwater contour map and plume movement. Low gradient well network (SGW-54165)

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
WMA B-BX-BY	Southeast	0.19	Darcy and plume movement	1,785 (PNL-8337)	0.1	1.047×10^{-5} 2014 average	Gradient (G) and flow direction based on monthly water level measurments corrected for barometric response between January and December 2014 at a 14 well low-gradient network as shown in Figure 9-45. Effective porosity (n_e) based on discussion in SGW-54508. Flow based on formula V=(K*G)/n_e (Driscoll, 1986, *Groundwater and Wells*). Flow rate correlates with nitrate and technetium-99 plume movement.
WMA C	Southeast	0.006 – 0.33	See comment	100 – 2,100 based on SGW-54675	0.1	Range: 6.26×10^{-6} - 1.5×10^{-5} 2014 average 1.1×10^{-5}	Values based on information provided in quarterly reports: SGW-58242, SGW-58483, SGW-58542, and SGW-58561.
WMA S-SX	East	0.14	Darcy	6.1 (PNNL-13514, PNNL-14113, PNNL-14186)	0.12	2.8×10^{-3}	Trend surface analysis.
WMA T	East-southeast	0.34 – 0.54	Darcy	6.11 - 9.69 (PNNL-17732)	0.1	5.6×10^{-3}	Trend surface analysis.
WMA TX-TY	South	0.001 – 0.34	Darcy	0.07 - 19.9 (PNNL-18279)	0.18 (DOE/RL-2009-38)	3.1×10^{-3}	Trend surface analysis.

Table B-1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/day) (Source)	Effective Porosity[a]	Gradient[b]	Comments
WMA U	East-northeast	0.15	Darcy	6.12 (PNNL-13378)	0.17	4.1×10^{-3}	Trend surface analysis.

a. Effective porosity assumed to be between 0.1 and 0.3, a representative range for the unconfined aquifer system, unless otherwise noted.

b. February or March 2014, unless otherwise noted.

c. Flow direction is based on those determined on a regional basis.

IDF = Integrated Disposal Facility
LLWMA = low-level waste management area
LWDF = Liquid Waste Disposal Facility
NA = not applicable
NRDWL = Nonradioactive Dangerous Waste Landfill
RCRA = *Resource Conservation and Recovery Act of 1976*
WMA = waste management area

Table B-2. Monitoring Wells and Constituents for 100-N Area Units

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Parameters			Sampled as Scheduled in 2014?
			Specific Condition (Field)	pH (Field)	TOC	TOX	Alkalinity	Anions	Metals (Filtered)	
116-N-1 (1301-N) Liquid Waste Disposal Facility										
199-N-105A	—	C	S	S	S	S	A	A	A	Yes
199-N-2	—	P	S	S	S	S	A	A	A	Yes
199-N-3	—	P	S	S	S	S	A	A	A	Yes
199-N-34	—	P	S	S	S	S	A	A	A	Yes
199-N-57	—	C	S	S	S	S	A	A	A	Yes
120-N-1 and 120-N-2 (1324-N/NA) Facilities										
199-N-71	—	C	S	S	S	S	A	A	A	Yes
199-N-72	—	C	S	S	S	S	A	A	A	Yes
199-N-73	—	C	S	S	S	S	A	A	A	Yes
199-N-77	Bottom of aquifer; no statistics	C	S	S	S	S	A	A	A	Yes
199-N-165	—	C	S	S	S	S	A	A	A	Yes
116-N-3 (1325-N) Liquid Waste Disposal Facility										
199-N-28	Information only; no statistics	P	S	S	S	S	A	A	A	Yes
199-N-32	—	P	S	S	S	S	S	S	S	Yes
199-N-41	—	P	S	S	S	S	A	A	A	Yes
199-N-74	—	C	S	S	S	S	A	A	A	Yes
199-N-81	—	C	S	S	S	S	A	A	A	Yes

Notes: Requirements are from *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities* (PNNL-13914) and the Hanford Facility RCRA Permit modification (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italics*** indicates upgradient well.

b. Quadruplicate samples collected during each sampling event except at wells not included for statistical evaluation, as noted.

Table B-2. Monitoring Wells and Constituents for 100-N Area Units

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Parameters			Sampled as Scheduled in 2014?
			Specific Condition (Field)	pH (Field)	TOC	TOX	Alkalinity	Anions	Metals (Filtered)	

A = to be sample annually
C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"
P = constructed prior to WAC requirements
S = to be sampled semiannually
TOC = total organic carbon
TOX = total organic halides
WAC = *Washington Administrative Code*

Table B-3. 116-N-1 (1301-N) Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
199-N-105A	1995	70.8	10/3/2014	39	94	23.2	Downgradient
199-N-2	1964	75.2	10/3/2014	34	95	19.8	Downgradient
199-N-3	1964	75.7	10/3/2014	34	95	19.3	Downgradient
199-N-34	1983	73.0	10/3/2014	34	78	5.0	Upgradient
199-N-57	1987	71.5	10/3/2014	58	73	1.5	Upgradient

Table B-4. 116-N-1 (1301-N) Liquid Waste Disposal Facility Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	5.83 – 9.65	7.00 – 8.19	No	None
Specific conductance (µS/cm)	1,825	444 – 1029	No	None
Total organic carbon (µg/L)	2,584	306 – 1,062	No	None
Total organic halides (µg/L)	33.06	3.0 – 14.9	No	None

Table B-5. 116-N-1 (1301-N) Liquid Waste Disposal Facility Water Quality Parameter Results

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride (mg/L)	9.34 – 86.7	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<12.8 – 827	300	Secondary MCL	Yes	199-N-57 (upgradient)
Iron (unfiltered)	22.3 – 926	300	Secondary MCL	Yes	199-N-57 (upgradient)
Manganese (filtered) (µg/L)	1.0 – 110	50	Secondary MCL	Yes	199-N-3, 199-N-57 (upgradient)
Manganese (unfiltered)	<1.0 – 66.4	50	Secondary MCL	Yes	199-N-3, 199-N-57 (upgradient)
Sodium (filtered) (mg/L)	4.53 – 45.7	None	NA	—	None
Sodium (unfiltered)	4.53 – 42.9	None	NA	—	None
Sulfate (mg/L)	38.4 – 139.0	250	Secondary MCL	No	None

Table B-6. 120-N-1 and 120-N-2 (1324-N/NA) Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
199-N-165	2008	72.4	9/16/2014	67.89	82.89	10.49	Downgradient
199-N-71	1991	74.6	10/3/2014	63.8	84.5	9.9	Upgradient
199-N-72	1991	71.7	10/3/2014	61.22	82	10.3	Downgradient
199-N-73	1991	75.5	10/3/2014	65.6	86.1	10.6	Downgradient
199-N-77	1992	72.0	10/3/2014	84.36	94.3	22.3	Supporting information

Table B-7. 120-N-1 and 120-N-2 Facilities (1324-N/NA) Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.76 – 8.43	7.87 – 8.52	No[a]	None
Specific conductance (µS/cm)	596	378 – 860	Yes	199-N-72 199-N-73 199-N-165
Total organic carbon (µg/L)	1,257	276 – 885	No	None
Total organic halides (µg/L)	12.51 (LOQ = 18.3 1st quarter; NC[b] 2nd quarter; 17.5 3rd quarter, 14.7 4th quarter)	4.28 – 13.8	No[a]	None

a. Average of quadruplicates is below critical mean value.

b. Insufficient data to calculate an LOQ.

LOQ = limit of quantitation

NC = not calculated

Table B-8. 120-N-1 and 120-N-2 (1324-N/NA) Facilities Water Quality Summary

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride (mg/L)	13.8 – 23.5	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<30 – 101	300	Secondary MCL	No	None
Iron (unfiltered)	<30 – 149	300	Secondary MCL	No	None
Manganese (filtered) (µg/L)	0.7 – 5*	50	Secondary MCL	No	None
Manganese (unfiltered)	1.0 – 5	50	Secondary MCL	No	None
Sodium (filtered) (mg/L)	25.2 – 161	None	NA	—	None
Sodium (unfiltered)	25.0 – 165	None	NA	—	None
Sulfate	53 – 213	250	Secondary MCL	No	None

* Nondetects range from <1 µg/L to <5 µg/L.

Table B-9. 116-N-3 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
199-N-28	1983	77.0	10/3/2014	47	83	6.0	Supporting information
199-N-32	1983	75.6	10/3/2014	44	80	4.4	Downgradient
199-N-41	1984	73.4	10/3/2014	53	73	-0.4	Downgradient
199-N-74	1991	69.3	10/3/2014	59	79.3	10.0	Upgradient
199-N-81	1993	76.3	10/3/2014	69.7	89.5	13.2	Downgradient

Table B-10. 116-N-3 (1325-N) Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.65 – 8.56	7.65 – 8.32	No	None
Specific conductance (µS/cm)	465	398 – 668	Yes	199-N-32 199-N-41 199-N-74 (upgradient) 199-N-81
Total organic carbon (µg/L)	1,156	195 – 750	No	None
Total organic halides (µg/L)	9.54 (LOQ = 18.3 1st quarter; NC 2nd quarter; 17.5 3rd quarter; 14.7 4th quarter)	<3.33 – 8.9	No	None

LOQ = limit of quantitation
NC = not calculated because proportion non-detects is greater than 50%

Table B-11. 116-N-3 (1325-N) Water Quality Parameter Results

Constituent (units)	2013 Range	DWS	Standard Type	2013 Exceedance?	Wells Exceeded
Chloride (mg/L)	11.0 – 43.5	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<12.8 – 662	300	Secondary MCL	Yes	199-N-32
Iron (unfiltered)	33.5 – 737	300	Secondary MCL	Yes	199-N-32
Manganese (filtered) (µg/L)	<1 – 42.0	50	Secondary MCL	No	None
Manganese (unfiltered)	1.6 – 40.7	50	Secondary MCL	No	None
Sodium (filtered) (mg/L)	7.19 – 22.8	None	NA	—	None
Sodium (unfiltered)	7.36 – 16.1	None	NA	—	None
Sulfate (mg/L)	72.2 – 155	250	Secondary MCL	No	None

Table B-12. Monitoring Wells and Constituents for 183-H (116-H-6) Evaporation Basins

Well Name	Comment	WAC Compliant	Permit-Specified					Other Parameters			Sampled as Scheduled in 2014?
			Chromium (Filtered)	Nitrate	Technetium-99*	Fluoride	Uranium*	Alkalinity	Anions	Metals (Filtered)	
199-H4-12A	Monitoring well	C	A	A	A	A	A	A	A	A	Yes
199-H4-12C	Extraction well; Ringold formation upper mud	C	A	A	A	A	A	A	A	A	Yes
199-H4-84	Monitoring well	C	A	A	A	A	A	A	A	A	Yes
199-H4-8	—	C	A	A	A	A	A	A	A	A	Yes

Notes:

Requirements are from *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins* (PNNL-11573) and the 2008 Hanford Facility RCRA Permit modification (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

* Radionuclides are not typically subject to RCRA monitoring but are included in the current Hanford Facility RCRA Permit (WA7890008967) for this facility.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

WAC = *Washington Administrative Code*

Table B-13. 183-H Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
199-H4-8	1986	46.2	11/5/2014	38	48	1.8	Downgradient
199-H4-84	2011	43.5	11/23/2014	37.7	47.7	4.2	In waste site
199-H4-12A	1986	38.2	11/5/2014	33	48	9.8	Downgradient
199-H4-12C	1986	NA	Extraction well	72	82	NA	Downgradient

Table B-14. 183-H Permit Required Consistuent Summary

Constituent (units)	2014 Range	DWS	Permit Limit	Standard Type	2014 Exceedance?	Wells Exceeded Permit Limit
Hexavalent chromium (µg/L)	<1.5 – 121	100	122	Dangerous waste	No	None
Total chromium (µg/L)	2.8 – 120	100	122	Dangerous waste	No	None
Nitrate (mg/L)	1.64 – 34.7	45	45	Dangerous waste*	No	None
Fluoride (µg/L)	117 – 180	4,000	1,400	Waste indicator	No	None
Technetium-99 (pCi/L)	<6.5 – 32	900	900	Waste indicator	No	None
Uranium (µg/L)	0.72 – 52.1	30	20	Waste indicator	Yes	199-H4-84

* Nitrate is not considered a dangerous waste constituent under RCRA (WAC 173-303-9905, “Dangerous Waste Regulations,” “Dangerous Waste Constituents List”).

Table B-15. Monitoring Wells and Constituents for 216-A-29 Ditch

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Parameters				Sampled as Scheduled in 2014?
			Specific Conductance (Field)	pH (Field)	TOC	TOX	Alkalinity	Anions	Metals	Phenols	
299-E25-26	—	C	S	S	S	S	S	S	A	A	Yes
299-E25-28	Deep unconfined; no statistical evaluation	C	A	A	A	A	A	A	A	A	Yes
299-E25-32P	—	C	S	S	S	S	S	S	A	A	Yes
299-E25-34	—	C	A	A	A	A	A	A	A	A	No[c]
299-E25-35	—	C	S	S	S	S	S	S	A	A	Yes
299-E25-48	—	C	S	S	S	S	S	S	A	A	Yes
299-E26-12	—	C	A	A	A	A	A	A	A	A	Yes
299-E26-13	—	C	S	S	S	S	S	S	A	A	No[d]
699-43-45	—	C	S	S	S	S	S	S	A	A	Yes

Notes: Requirements are from *Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch* (DOE/RL-2008-58, Rev. 0).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. Upgradient well(s) are noted in ***bold italics***.

b. Quadruplicate samples were collected during each sampling event for contamination indicator parameters.

c. Sampling for April event delayed until October.

d. Sampling for October event delayed until November because well not accessable, road needed work.

A = to be sampled annually

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-16. 216-A-29 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E25-26	1985	272.6	10/03/2014	270	290	17.4	Downgradient
299-E25-28	1985	264.4	10/15/2014	320	340	20	Downgradient
299-E25-32P	1988	271.7	10/23/2014	259.4	279.4	7.7	Downgradient
299-E25-34	1988	264.8	12/22/2014	251.6	271.6	6.8	Downgradient
299-E25-35	1988	275.1	12/22/2014	260.5	281	5.9	Downgradient
299-E25-48	1992	283.5	10/3/2014	274.3	294.6	11.1	Downgradient
299-E26-12	1991	231.1	10/15/2014	217.6	238.6	7.5	Upgradient
299-E26-13	1991	205.5	12/22/2014	191.7	212.3	6.8	Upgradient
699-43-45	1989	198.3	10/23/2014	183	203.3	4.99	Downgradient

Table B-17. 216-A-29 Ditch Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.80 – 8.74	7.73 – 8.64	Yes	299-E26-13[a] (low)
Specific conductance (µS/cm)	388	223 – 596	Yes	299-E25-35 299-E25-48 299-E25-32P
Total organic carbon (µg/L)	949	132 – 1,200	Yes	299-E25-26[b]
Total organic halides (µg/L)	1st quarter: WSCF (LOQ = 18.3) 2nd quarter: TASL (insufficient data) GEL (insufficient data) 3rd quarter: TASL (LOQ = 17.5) GEL (insufficient data) 4th quarter: TASL (LOQ = 14.7) GEL (LOQ = 5.6)	<1.8 – 18.3	No	None

Table B-17. 216-A-29 Ditch Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded

a. Upgradient network well not subject to verification resampling.

b. Reported value was less than 3rd quarter TASL limit of quantitation (LOQ).

GEL = Geotechnical Engineering Laboratory

LOQ = limit of quanitation

NC = not calculated because proportion non-detects is greater than 50 percent

TASL = Test America St. Louis

WSCF = Waste Sampling and Characterization Facility

Table B-18. 216-A-29 Groundwater Quality Parameter Results

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride (mg/L)	3.1 – 22.7	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<30 – <40	300	Secondary MCL	No	None
Iron (unfiltered)	<40 – 353	300	Secondary MCL	Yes	299-E25-32P
Manganese (filtered) (µg/L)	<1 – <4	50	Secondary MCL	No	None
Manganese (unfiltered)	1.3 – 9.0	50	Secondary MCL	No	None
Phenol (µg/L)	<0.9	2,400	MTCA Method B	No	None
Sodium (filtered) (mg/L)	9.3 – 28.9	None	NA	—	None
Sodium (unfiltered)	9.1 – 28.8	None	NA	—	None
Sulfate (mg/L)	14.0 – 136	250	Secondary MCL	No	None

Table B-19. Monitoring Wells and Constituents for 216-A-36B Crib

Well Name[a]	WAC Compliant	Contamination Indicator Parameters[b]				Supporting Constituents				Sampled as Scheduled in 2014?
		pH (field)	Specific Conductance (field)	TOC	TOX	Anions[c]	Metals[c]	Alkalinity	Phenols	
299-E17-14	C	S	S	S	S	A	A	A	A	Yes
299-E17-16	P	S	S	S	S	A	A	A	A	Yes
299-E17-18	C	S	S	S	S	A	A	A	A	Yes
299-E17-19	C	S	S	S	S	A	A	A	A	Yes

Notes: Requirements for 216-A-36B Crib are from *Interim Status Groundwater Monitoring Plan for the 216-A-36B PUREX Plant Crib* (DOE/RL-2010-93, Rev. 1).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italic*** indicates upgradient well.

b. Quadruplicate replicates were collected during each sampling event for contamination indicator parameters.

c. Anions analysis includes, at a minimum, nitrate and the groundwater quality parameters chloride and sulfate. Metals analysis includes, at a minimum, calcium, magnesium, potassium, and sodium, as well as the groundwater quality parameters iron and manganese.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-20. 216-A-36B Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E17-14	1988	323.4	7/7/2014	309.5	331.5	8.1	Downgradient
299-E17-16	1988	322.3	7/7/2014	310	330	7.7	Downgradient
299-E17-18	1988	321.8	12/21/2014	308.7	331.5	9.7	Downgradient
299-E17-19	1988	321.3	7/7/2014	304	326.6	5.3	Upgradient

Table B-21. 216-A-36B Crib Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.31 – 8.44	7.58 – 8.01	No	None[a]
Specific conductance (µS/cm)	853	553 – 719	No	None
Total organic carbon (µg/L)	719	246 – 794	Yes	299-E17-16[b] 299-E17-18[b]
Total organic halides (µg/L)	31.5	2.2 – 24.6	No	None

a. Verification sample results for pH were within the 2013 or 2014 ranges.

b. Verification sampling results for TOC were less than the 2013 and 2014 critical mean values for TOC.

Table B-22. 216-A-36B Groundwater Quality Parameter Summary

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Alkalinity (µg/L)	110,000 – 130,000	None	NA	—	None
Calcium (µg/L)	61,600 – 72,800	None	NA	—	None
Chloride (mg/L)	13.0 – 17.6	250	Secondary MCL	No	None
Iron (µg/L)	<40 – 46.4	300	Secondary MCL	No	None
Magnesium (µg/L)	19,100 – 23,100	None	NA	—	None
Manganese (µg/L)	0.76 – <4	50	Secondary MCL	No	None
Nitrate (mg/L)*	51.8 – 156	45	MCL	Yes	299-E17-14 299-E17-16 299-E17-18 299-E17-19
Phenol (µg/L)	<0.9	2,400	MTCA Method B	No	None
Potassium (µg/L)	8,120 – 8,840	None	NA	—	None
Sodium (mg/L)	25.0 – 29.1	None	NA	NA	NA
Sulfate (mg/L)	78.4 – 93.2	250	Secondary MCL	No	None

Table B-23. Monitoring Wells and Constituents for 216-A-37-1 Crib

Well Name[a]	WAC Compliant	Contamination Indicator Parameters[b]				Supporting Constituents				Sampled as Scheduled in 2014?
		pH (field)	Specific Conductance (field)	TOC	TOX	Anions[c]	Metals[c]	Alkalinity	Phenols	
299-E25-17	P	S	S	S	S	A	A	A	A	No[d]
299-E25-19	P	S	S	S	S	A	A	A	A	Yes
299-E25-20	P	S	S	S	S	A	A	A	A	Yes
299-E25-47	C	S	S	S	S	A	A	A	A	No[e]

Notes: Requirements for 216-A-37-1 Crib are from *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib* (DOE/RL-2010-92 Rev. 1).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italic*** indicates upgradient well.

b. Quadruplicate samples were collected during each sampling event for contamination indicator parameters.

c. Anions analysis includes, at a minimum, the groundwater quality parameters chloride and sulfate. Metals analysis includes, at a minimum, calcium, magnesium, potassium, and sodium, as well as the groundwater quality parameters iron and manganese.

d. July sampling event delayed until August due to an electrical issue with the well pump.

e. January sampling event missed because well was not accessible to sampling van.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-24. 216-A-37-1 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E25-17*	1976	278.5	12/12/2014	273	295	16.5	Downgradient
299-E25-19*	1976	279.6	12/22/2014	270	295	15.4	Downgradient
299-E25-20*	1976	279.0	7/11/2014	269	294	14.96	Downgradient
299-E25-47	1992	274.3	7/7/2014	263	283.2	8.9	Upgradient

* Perforated well.

Table B-25. 216-A-37-1 Crib Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.53 – 8.43	7.65 – 8.37	No	None
Specific conductance (µS/cm)	937	362 – 531	No	None
Total organic carbon (µg/L)	1,267	<270 – 3,080	Yes	299-E25-17*
Total organic halides (µg/L)	14.93	<3.33 – 15.0	No	None

* Verification sampling results were less than the 2014 critical mean.

Table B-26. 216-A-37-1 Crib Groundwater Quality Parameter Summar

Constituent (units)	2013 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Alkalinity (µg/L)	83,000 – 87,000	NA	None	—	None
Calcium (µg/L)	34,200 – 47,600	NA	None	—	None
Chloride (mg/L)	5.2 – 12.8	250	Secondary MCL	No	none
Iron (µg/L)	221 – 1,330	300	Secondary MCL	Yes	299-E25-17 299-E25-19 299-E25-47
Magnesium (µg/L)	11,000 – 14,500	NA	None	—	None
Manganese (µg/L)	8.1 – 139	50	Secondary MCL	Yes	299-E25-19 299-E25-20
Nitrate (mg/L)	24.3 – 64.2	45	MCL	Yes	299-E25-20
Phenol (µg/L)	<0.9	2,400	MTCA Method B	No	None
Potassium (µg/L)	6,470 – 8,420	NA	None	—	None
Sodium (mg/L)	18.3 – 24.2	None	NA	NA	NA
Sulfate (mg/L)	40.7 – 105	250	Secondary MCL	No	None

Table B-27. Monitoring Wells and Constituents for 216-B-3 Pond

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Parameters						Sampled as Scheduled in 2014?
			Specific Conductance	pH (Field)	TOC	TOX	Alkalinity	Arsenic	Anions	Cadmium	Metals	Phenols	
699-42-42B	Bottom of aquifer	C	S	S	S	S	A	A	A	A	A	A	Yes
699-43-44	—	C	S	S	S	S	A	A	A	A	A	A	Yes
699-43-45	—	C	S	S	S	S	A	A	A	A	A	A	Yes
699-44-39B	—	C	S	S	S	S	A	A	A	A	A	A	No[c]

Notes: Requirements are from *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond* (DOE/RL-2008-59).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. Upgradient well is noted by ***bold italic***.

b. Quadruplicate samples were collected during each sampling event for contamination indicator parameters.

c. January sampling delayed until February because of equipment malfunction.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-28. 216-B-3 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
699-42-42B	1988	182.1	7/7/2014	183.5	203.5	21.4	Downgradient
699-43-44	1999	179.9	7/7/2014	171	191	11.7	Downgradient
699-43-45	1989	198.3	10/23/2014	183	203.3	5	Downgradient
699-44-39B	1992	107.7	7/7/2014	98.9	118.9	11.2	Upgradient

Table B-29. 216-B-3 Pond Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.50 – 8.61	7.90 – 8.55	No	None
Specific conductance (µS/cm)	356	254 – 309	No	None
Total organic carbon (µg/L)	499	143 – 326	No	None
Total organic halides (µg/L)	1st quarter: WSCF (LOQ = 18.3) 2nd quarter: TASL (insufficient data) GEL (insufficient data) 3rd quarter: TASL (LOQ = 17.5) GEL (insufficient data) 4th quarter: TASL (LOQ = 14.7) GEL (LOQ = 5.6)	2.3 – 5.93	No	None

GEL = Geotechnical Engineering Laboratory
LOQ = limit of quanitation
NC = not calculated because proportion non-detects is greater than 50 percent
TASL = Test America St. Louis
WSCF = Waste Sampling and Characterization Facility

Table B-30. 216-B-3 Groundwater Quality Parameter Results

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Arsenic (filtered) (µg/L)	4.2 – 9.5*	10	MCL	No	None
Arsenic (unfiltered) (µg/L)	4.1 – 8.8*	10	MCL	No	None
Cadmium (filtered) (µg/L)	<4	5	MCL	No	None
Cadmium (unfiltered) (µg/L)	<0.3 – <4	5	MCL	No	None
Chloride (mg/L)	3.0 – 5.2	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<40	300	Secondary MCL	No	None
Iron (unfiltered)	<40 – 48.4	300	Secondary MCL	No	None
Manganese (filtered) (µg/L)	<4	50	Secondary MCL	No	None
Manganese (unfiltered)	<1 – <4	50	Secondary MCL	No	None
Nitrate (mg/L)	3.4 – 9.9	45	MCL	No	None
Phenol (µg/L)	<0.9	2,400	MTCA Method B	No	None
Sodium (filtered) (mg/L)	9.8 – 20.1	None	NA	—	None
Sodium (unfiltered)	10.4 – 20.2	None	NA	—	None
Sulfate (mg/L)	15.9 – 27.9	250	Secondary MCL	No	None

* Samples analyzed per EPA Method6010 had a detection limit of 25 µg/L.

Table B-31. Monitoring Wells and Constituents for 216-B-63 Trench

Well Name[a]	WAC Compliant	Contamination Indicator Parameters[b]				Other Parameters				Sampled as Scheduled in 2014?
		Specific Conductance (Field)	pH (Field)	TOC	TOX	Alkalinity	Anions	Metals	Phenols	
299-E27-16	C	S4	S4	S4	S4	A	S	S	S	Yes
299-E27-18	C	S4	S4	S4	S4	A	S	S	S	Yes
299-E27-19	C	S4	S4	S4	S4	A	S	S	S	Yes
299-E33-33	C	S4	S4	S4	S4	A	S	S	S	Yes
299-E34-8	C	S4	S4	S4	S4	A	S	S	S	Yes
299-E34-12	C	S4	S4	S4	S4	A	S	S	S	Yes

Source: *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench* (DOE/RL-2008-60, Rev. 1).

Note: All wells screened from the water table to t the top of the unconfined aquifer.

a. ***Bold italics*** well names are upgradient wells.

b. Quadruplicate samples were collected during each sampling event (e.g., S4).

c. For anions, analytes include, but not limited to, chloride, nitrate, nitrite, and sulfate. For metals, analytes include, but are not limited to, calcium, magnesium, potassium, and sodium.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-32. 216-B-63 Trench Indicator Parameter Results

Constituent (units)	2014 Critical Mean Comparison Value[a]	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.62 – 8.66	7.86 – 8.29	No	None
Specific conductance (µS/cm)	703	528 – 668	No	None
Total organic carbon (µg/L)	547	230 – 452	No	None
Total organic halides (µg/L)	April – 28.5[b] October – NA[c]	9.15 – 15.2 <3.33 – 3.7	No	None

a. *Environmental Calculation File: Calculation of Critical Means for Calendar Year 2013 RCRA Groundwater Monitoring*, Table 9 (ECF-Hanford-13-0013).

b. LOQ value derived for comparison value based on WSCF blank sample results from 1/1/2013 through 12/31/2013.

c. LOQ value not able to be derived, as the laboratories providing analyses were recently contracted and there was insufficient data to statistically derive comparison value.

LOQ = limit of quantitation (used because insufficient results to derive critical mean comparison value from upgradient 216-B-63 Trench wells)

WSCF = Waste Sampling and Characterization Facility

Table B-33. 216-B-63 Water-Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)*	Remaining Water Column (ft)	Location
299-E27-16	1989	253.4	10/3/2014	238.7	259.7	6.3	Downgradient
299-E27-18	1992	251.0	11/25/2014	241.4	261.5	10.5	Downgradient
299-E27-19	1992	251.9	10/3/2014	242	262.1	10.2	Downgradient
299-E33-33	1990	241.3	10/3/2014	227.3	248.3	7.0	Upgradient
299-E34-8	1991	242.1	10/3/2014	227.9	247.9	5.8	Upgradient
299-E34-12	1991	239.9	10/22/2014	223.9	244.5	4.6	Upgradient

Source: *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench* (DOE/RL-2008-60, Rev. 1).

* None of the wells are screened to basalt, but 4 of the 6 well screens are within 10 feet of basalt. Well 299-E34-8 was drilled 12.1 ft beyond the bottom of the screen, but did not encounter basalt. Well 299-E27-19 was drilled to 4.7 ft below the well screen, but did not encounter basalt.

bgs = below ground surface

Table B-34. 216-B-63 Groundwater Quality Parameter Results

Constituent (units)	2014 Range (µg/L)	DWS (µg/L)	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride	18,900 – 28,200	250,000	Secondary MCL	No	None
Iron (unfiltered)	34.4 – 72.9	300	Secondary MCL	No	None
Manganese (unfiltered)	<1 – <4	50	Secondary MCL	No	None
Nitrate	51,800 – 118,000	45,000	Primary MCL	Yes	All
Phenol	<0.9 – <3.0	2,400	MTCA Method B	No	None
Sodium (unfiltered)	21,800 – 28,400	None	NA	NA	NA
Sulfate	78,600 – 103,000	250,000	Secondary MCL	No	None

DWS = drinking water standard
MCL = maximum contaminant level
MTCA = Model Toxic Control Act
NA = not applicable

Table B-35. Monitoring Wells and Constituents for 216-S-10 Pond and Ditch

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Parameters								Sampled as Scheduled During 2014?
			Specific Conductance (Field)	pH (Field)	TOC	TOX	Alkalinity	Anions	Metals	Hexavalent Chromium	Mercury	VOAs	PCBs	Phenols	
299-W26-13	—	C	S	S	S	S	S	S	S	S	S	A	A	A	Yes
299-W26-14	—	C	A	A	A	A	A	A	A	A	A	A	A	A	Yes
299-W27-2	Bottom of aquifer; no statistics	C	A	A	A	A	A	A	A	A	A	A	A	A	Yes
699-32-76	—	C	S	S	S	S	S	S	S	S	S	A	A	A	Yes
699-33-75	—	C	S	S	S	S	S	S	S	S	S	A	A	A	Yes
699-33-76	—	C	S	S	S	S	S	S	S	S	S	A	A	A	Yes

Notes: Requirements are from *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch* (DOE/RL-2008-61).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. Upgradient well is noted by ***bold italic***.

b. Quadruplicate samples were collected during each sampling event.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-36. 216-S-10 Pond and Ditch Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	4.19 – 11.30	7.79 – 7.99	No	None
Specific conductance (µS/cm)	363	272 – 333	No	None
Total organic carbon (µg/L)	852	273 – 439	No	None
Total organic halides (µg/L)	49.82	3.0 – 8.2	No	None

Table B-37. 216-S-10 Pond and Ditch Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-W26-13	1999	213.0	11/4/2014	202.2	237.3	24.3	Downgradient
299-W26-14	2003	233.1	5/20/2014	223.4	258.4	25.3	Downgradient
299-W27-2	1992	240.2	5/20/2014	406.1	416.6	176.4	Downgradient
699-32-76	2008	232.4	11/3/2014	227.0	262.0	29.6	Downgradient
699-33-75	2008	241.3	11/3/2014	235.0	270.0	28.7	Downgradient
699-33-76	2008	228.4	11/3/2014	222.0	257.0	28.6	Upgradient

Table B-38. 216-S-10 Pond and Ditch Water Quality and Other Monitored Parameters

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride (mg/L)	6.4 – 19.7	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<12.8 – <30	300	Secondary MCL	No	None
Iron (unfiltered) (µg/L)	<30 – 544*	300	Secondary MCL	No	299-W27-2*
Manganese (filtered) (µg/L)	<1 – <2	50	Secondary MCL	No	None
Manganese (unfiltered) (µg/L)	<1 – 11.2[a]	50	Secondary MCL	No	None
Phenol (µg/L)	<1.9 – <9.6	2,400	MTCA Method B	No	None
Sodium (filtered) (µg/L)	13,300 – 22,700	None	NA	—	None
Sodium (unfiltered) (µg/L)	12,400 – 22,700	None	NA	—	None
Sulfate (mg/L)	16.3 – 23.6	250	Secondary MCL	No	None
Chromium (total, filtered) (µg/L)	<1 – 122	48	MTCA Method B	Yes	299-W26-13
Chromium (total, unfiltered) (µg/L)	<1 – 127	48	MTCA Method B	Yes	299-W26-13 299-W27-2*
Hexavalent chromium (filtered) (µg/L)	<1.5 – 121	48	MTCA Method B	Yes	299-W26-13
Hexavalent chromium (unfiltered) (µg/L)	1.6 – 122	48	MTCA Method B	Yes	299-W26-13
Copper (filtered) (µg/L)	<2.1 – 3.6	1,000	Secondary MCL	No	None
Copper (unfiltered) (µg/L)	<2.1 – <3	1,000	Secondary MCL	No	None
Mercury (filtered) (µg/L)	<0.06 – 0.08	2	Primary MCL	No	None
Mercury (unfiltered) (µg/L)	<0.06 – 0.11	2	Primary MCL	No	None
Zinc (filtered) (µg/L)	<3.3 – 13.7	5,000	Secondary MCL	No	None
Zinc (unfiltered) (µg/L)	<3.3 – 18	5,000	Secondary MCL	No	None
Aroclor-1254 (µg/L)	<0.09 – <0.16	0.5	Primary MCL for PCBs	No	None

Table B-38. 216-S-10 Pond and Ditch Water Quality and Other Monitored Parameters

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Benzo(a)pyrene (µg/L)	All results <0.1	0.2	Primary MCL	No	None

* Results from well 299-W27-2 are affected by corrosion of the stainless-steel screen.

DWS = drinking water standard

MCL = maximum contaminant level

MTCA = Model Toxic Control Act

Table B-39. Monitoring Wells and Constituents for 316-5 Process Trenches

Well Name	Aquifer	WAC Compliant	cis-1,2-Dichloroethene	Trichloroethene	Uranium*	Sampled as Planned in 2014?
399-1-10A	Top unconfined	C	S	S	S	Yes
399-1-10B	Lower unconfined	C	S	S	S	Yes
399-1-16A	Top unconfined	C	S	S	S	Yes
399-1-16B	Lower unconfined	C	S	S	S	Yes
399-1-17A	Top unconfined	C	S	S	S	Yes
399-1-17B	Lower unconfined	C	S	S	S	Yes
399-1-18A	Top unconfined	C	S	S	S	Yes
399-1-18B	Lower unconfined	C	S	S	S	Yes

Notes: Requirements are from *Groundwater Monitoring Plan for the 300 Area Process Trenches* (WHC-SD-EN-AP-185) and the Hanford Facility RCRA Permit modification (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*).

* Radionuclides are not typically subject to RCRA monitoring but are included in the current Hanford Facility RCRA Permit (WA7890008967) for the 316-5 Process Trenches.

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled four times semiannually (8 months)

WAC = *Washington Administrative Code*

Table B-40. 316-5 Process Trenches Water Level Summary

Well Name	Year Installed	Water Depth (m bgs)	Water Depth (ft bgs)	Water Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
399-1-10A	1986	8.92	29.27	12/30/2014	24.5	39.5	10.23	Downgradient
399-1-10B	1991	9.44	30.98	12/03/2014	104.5	114.5	83.52	Downgradient
399-1-16A	1986	11.74	38.50	12/16/2014	32.5	47.5	9.00	Downgradient
399-1-16B	1987	11.64	38.18	12/16/2014	105.0	115.0	76.82	Downgradient
399-1-17A	1986	10.12	33.19	12/16/2014	25.0	40.0	6.81	Downgradient
399-1-17B	1986	10.20	33.47	12/16/2014	100.0	110.0	76.53	Downgradient
399-1-18A	1986	13.66	44.82	12/16/2014	39.0	54.0	9.18	Upgradient
399-1-18B	1987	13.45	44.12	12/16/2014	108.5	118.5	74.38	Upgradient

bgs = below ground surface

Table B-41. 316-5 Process Trenches Post-Closure Corrective Action Monitoring Constituent Summary

COC	Range Low (µg/L)	Range High (µg/L)	RCRA Concentration Limit* (µg/L)	Exceedance in 2014?
Trichloroethene	0.25 U	1.99 J	5	No
cis-1,2-Dichloroethene	0.09 U	207 D	70	Yes
Other Waste Constituent	**Range Low (µg/L)**	**Range High (µg/L)**	**Concentration Limit (µg/L)**	**Exceedance in 2014?**
Uranium (total; chemical analysis)	0.144 U	79.9 D	30	Yes

* Concentration limits are from *Groundwater Monitoring Plan for the 300 Area Process Trenches* (WHC-SD-EN-AP-185) and the Hanford Facility RCRA Permit modification (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste*).

D = analyte reported at a secondary dilution factor

COC = contaminant of concern

J = estimated value

U = undetected above the practical quantitative limit

Table B-42. Monitoring Wells and Constituents for the Integrated Disposal Facility

Well Name[a]	WAC Compliant	Indicator Parameters					Other Parameters								Sampled as Planned in 2014?
		Chromium (Filtered)	Specific Conductance (Field)	pH (Field)	TOC	TOX	Alkalinity	Turbidity (Field)	Anions	Metals	Alpha[b]	Beta[b]	Iodine-129[b]	Technetium-99[b]	
299-E17-22	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes
299-E17-23	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes
299-E17-25	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes
299-E17-26	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes
299-E18-1	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes
299-E24-21	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes
299-E24-24	C	A	A	A	A	A	A	A	A	A	S	S	S	S	Yes

Notes: Requirements are from *Hanford Facility Dangerous Waste Permit Application Integrated Disposal Facility* (WA890008967) and *Integrated Disposal Facility Operational Monitoring Plan to Meet DOE Order 435.1* (RPP-PLAN-26534). Per June 30, 2010 Class 1 Modification of RCRA Permit WA7890008967, *Part III Operating Units 11, Integrated Disposal Facility*, groundwater sampling under the permit will continue annually during the pre-active life of the facility.

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italics*** indicate upgradient well.

b. Operational parameters are monitored for DOE O 435.1, *Radioactive Waste Management*, and not for RCRA purposes.

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

TOC = total organic carbon

TOX = total organic halides

WAC = *Washington Administrative Code*

Table B-43. Integrated Disposal Facility Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E18-1	1988	320.7	7/11/2014	308.5	331.5	10.8	Upgradient
299-E24-21	2001	315.3	12/21/2014	312.2	332.2	16.9	Upgradient
299-E24-24	2005	323.9	12/21/2014	321.4	356.4	32.5	Upgradient
299-E17-22	2002	324.2	12/21/2014	321.6	356.7	32.5	Downgradient
299-E17-23	2002	334.9	12/21/2014	333	367.1	32.1	Downgradient
299-E17-25	2002	339.8	12/21/2014	336.6	371.6	31.8	Downgradient
299-E17-26	2005	340.6	7/11/2014	338.1	373.1	32.5	Downgradient

bgs = below ground surface

Table B-44. Integrated Disposal Facility RCRA Indicator Parameter Results

Constituent (units)	Historical Range	2014 Range	Standard	Standard Type	2014 Exceedance?
Chromium – filtered (µg/L)	<1.9 – 32.1	<5 – 7.2	48*	MTCA Method B	No
pH	6.90 – 8.80	7.46 – 8.74	—	—	—
Specific conductance (µS/cm)	316 – 812	379 – 612	—	—	—
Total organic carbon (µg/L)	<100 – 16,100	139 – 692	—	—	—
Total organic halides (mg/L)	<1 – 61.9	12.5 – 16.1	—	—	—

* Groundwater cleanup level is for hexavalent chromium. Filtered chromium was included in the permit list of constituents since hexavalent chromium is a mobile regulated metal expected to be disposed of at the Integrated Disposal Facility. Comparison to MTCA Method B value provided for informational purposes only.

MTCA = "Model Toxics Control Act—Cleanup" (WAC 173-340)

Table B-45. Monitoring Wells and Constituents for Liquid Effluent Retention Facility

Well Name[a]	WAC Compliant	Geochemical Parameters			Indicator Parameters[b]						Sampled as Scheduled in 2014?[c]
		Alkalinity	Anions	Metals	Hexavalent Chromium[c]	Carbon Tetrachloride	pH	Specific Conductance	Total Organic Caron	Organic Total Halides	
299-E26-14	C	S	S	S	S	S	S	S	S	S	Yes
299-E26-77	C	S	S	S	S	S	S	S	S	S	Yes
299-E26-79	C	S	S	S	S	S	S	S	S	S	Yes

Notes:

Requirements for the July 2014 sampling event were based on *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility*, DOE/RL-2013-46 which was approved and implemented in April 2014. Prior to the July sampling event, samples were collected in accordance with the *Liquid Effluent Retention Facility Final-Status Groundwater Monitoring Plan* (PNNL-11620).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italic*** indicates upgradient well.

b. Quadruplicate samples were collected during the July sampling event.

c. At least four sampling events must be completed prior to deriving a critical mean. Until that time the results are collected to derive a local background concentration.

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-46. Liquid Effluent Retention Facility Indicator Constituent Results

Constituent (units)	2014 Critical Mean Comparison Value*	2014 Concentration at Upgradient Well 299-E26-14	2014 Concentration at Downgradient Well 299-E26-79	2014 Exceedance?
pH measurement	7.42 – 8.15	7.88	7.96	No
Specific conductance (µS/cm)	1,005	771	699	No
Total organic carbon (µg/L)	3,376	3,280	741	No
Total organic halides (µg/L)	11.07	4.17	3.38	No
Carbon tetrachloride (µg/L)	> detection	<0.3	<0.3	No

* *Environmental Calculation File: Calculation of Critical Means for Calendar Year 2014 RCRA Groundwater Monitoring*, Table 7-10 (ECF-HANFORD-14-0043, Rev. 0).

Table B-47. Liquid Effluent Retention Facility Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Water Table Elevation (ft)	Screen Top (ft bgs)	Screen Bottom (ft bgs)*	Remaining Water Column (ft)	Location
299-E26-10	1990	202.51	4/24/2014	399.56	190.5	206.1	3.59	Crossgradient
299-E26-14	2011	198.93	4/24/2014	399.81	195.9	215.9	16.97	Upgradient
299-E26-77	2008	203.76	4/24/2014	399.61	200.85	225.6	21.84	Crossgradient
299-E26-79	2008	198.70	4/24/2014	399.58	195.2	220.2	21.50	Downgradient

Source: *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility* (DOE/RL-2013-46, Rev. 0).

* Three of the wells are screened to basalt or beyond the top of basalt. Well 299-E26-14 was screened approximately 3 ft above the basalt surface.

bgs = below ground surface

Table B-48. Semiannual Monitoring Wells and Constituents for Low-Level Waste Management Area 1

Well Name[a]	WAC Compliant	RCRA Required Constituents										Supporting Constituents				Sampled as Scheduled in 2014?
		Contaminant Indicator Parameters[b]				Groundwater Quality Parameters										
						Anions[c]			Metals, Unfiltered, Filtered[c]							
		pH	Specific Conductance	Total Organic Carbon	Total Organic Halides	Chloride	Sulfate	Phenols	Iron	Manganese	Sodium	Alkalinity	Dissolved Oxygen	Temperature	Turbidity	
299-E28-26	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	No[d]
299-E28-27	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	No[d]
299-E28-28	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-2	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	No[d]
299-E32-3	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-4[e]	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-5	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-6	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-7	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-8	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-9	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E32-10	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E33-28	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E33-29	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes

Table B-48. Semiannual Monitoring Wells and Constituents for Low-Level Waste Management Area 1

Well Name[a]	WAC Compliant	RCRA Required Constituents										Supporting Constituents				Sampled as Scheduled in 2014?
		Contaminant Indicator Parameters[b]				Groundwater Quality Parameters										
						Anions[c]			Metals, Unfiltered, Filtered[c]							
		pH	Specific Conductance	Total Organic Carbon	Total Organic Halides	Chloride	Sulfate	Phenols	Iron	Manganese	Sodium	Alkalinity	Dissolved Oxygen	Temperature	Turbidity	
299-E33-34[e]	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E33-35[e]	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E33-265	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E33-266	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes

Note: Requirements are from *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1* (DOE/RL-2009-75).

a. ***Bold italics*** indicates upgradient well. The upgradient wells identified reflects the flow direction change. The monitoring plan is being updated in 2015 to reflect the apparent permanent change.

b. Quadruplicate samples were collected during each sampling event.

c. For anions, analytes include chloride, fluoride, nitrate, nitrite, and sulfate. For metals, analytes include (but are not limited to) calcium, chromium, iron, manganese, potassium, and sodium.

d. January sampling delayed until first week of February, because of increased sampling requirements for 100-BC in November and December 2013 and lack of time for schedule recovery.

e. **Bold** indicates crossgradient well. The crossgradient wells identified reflects the flow direction change. The monitoring plan is being updated in 2015 to reflect the apparent permanent change.

A = to be sampled annually

C = well is constructed in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

RCRA = *Resource Conservation and Recovery Act of 1976*

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-49. Low-Level Waste Management Area 1 Indicator Parameter Results

Constituent (units)	2014 Critical Mean Comparison Value[a]	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.54 – 8.36	7.75 – 8.22	No	None
Specific conductance (µS/cm)	2,510	407 – 827	No	None
Total organic carbon (µg/L)	899	108 – 1,270	Yes[b]	299-E33-265
Total organic halides (µg/L)	11.4	<1.8 – 24.5	Yes[c]	All, except 299-E28-26, 299-E28-27, and 299-E32-2

a. *Environmental Calculation File: Calculation of Critical Means for Calendar Year 2013 RCRA Groundwater Monitoring*, Table 9 (ECF-Hanford-13-0013).

b. Previously assessed and concluded to most likely be associated with natural organic material.

c. Total organic halide critical mean was exceeded in January 2014 for 15 of 18 wells. However, all the results were less than the Limit of Quantitation (LOQ) for WSCF data for the periods 10/1/2012 through 9/30/2013 (LOQ = 29.1 µg/L) and 1/1/2013 through 12/31/2013 (LOQ = 28.5 µg/L). Total organic halide results from the July sampling event returned results all below the critical mean value.

LOQ = limit of quantitation

WSCF = Waste Sampling and Characterization Facility

Table B-50. Low-Level Waste Management Area 1 Water Level Summary

Well Name[a]	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E28-26	1987	289	7/22/2014	278.8	298.8	9.88	Downgradient
299-E28-27	1987	282.1	12/21/2014	269.8	289.8	7.7	Downgradient
299-E28-28	1990	287.9	7/21/2014	275	295	7.1	Downgradient
299-E32-10	1991	238.8	7/22/2014	225	245.3	6.5	Upgradient
299-E32-2	1987	272.1	7/8/2014	257.8	289.2	17.1	Upgradient
299-E32-3	1987	279.4	7/8/2014	266.2	286.2	6.8	Upgradient
299-E32-4	1987	289	7/22/2014	278.1	298.1	9.1	Crossgradient
299-E32-5	1989	283	12/21/2014	270.8	291.8	8.8	Upgradient
299-E32-6	1991	267.6	12/21/2014	254.5	275.5	7.9	Upgradient
299-E32-7	1991	258.7	7/14/2014	245.6	266.6	7.9	Upgradient
299-E32-8	1991	245.8	12/21/2014	234.7	255	9.2	Upgradient
299-E32-9	1991	243.8	7/22/2014	230.7	251.3	7.5	Upgradient
299-E33-28	1987	266.5	12/21/2014	255.7	275.7	9.2	Downgradient
299-E33-29	1987	275.7	7/9/2014	279.5	289.5	13.8	Downgradient
299-E33-34	1990	234.4	12/21/2014	219	239.3	4.9	Cross gradient
299-E33-35	1990	244.3	7/22/2014	228.3	249.3	5	Cross gradient
299-E33-265	2010	267.5	7/30/2014	260.9	281	13.5	Upgradient
299-E33-266	2010	268.8	7/30/2014	263.1	283.1	14.3	Upgradient

a. ***Bold italics*** indicates upgradient well. The upgradient wells identified reflects the flow direction change. The monitoring plan is being updated in 2015 to reflect the apparent permanent change.

b. **Bold** indicates crossgradient well. The crossgradient wells identified reflects the flow direction change. The monitoring plan is being updated in 2015 to reflect the apparent permanent change.

bgs = gelow ground surface

Table B-51. Low-Level Waste Management Area 1 Groundwater Quality Parameter Results

Constituent (units)	2014 Range (µg/L)	DWS (µg/L)	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride	10,800 – 20,900	250,000	Secondary MCL	No	None
Iron (unfiltered)	<12.8 – 220	300	Secondary MCL	No	None
Manganese (unfiltered)	<1 – 4.79	50	Secondary MCL	No	None
Nitrate	40,700 – 194,000	45,000	Primary MCL	Yes	All, except 299-E32-2 and 299-E32-3
Phenol	<0.9 – <3.0	2,400	MTCA Method B	No	None
Sodium (unfiltered)	20,900 – 60,300	None	NA	NA	NA
Sulfate	36,900 – 110,000	250,000	Secondary MCL	No	None

DWS = drinking water standard
MCL = maximum contaminant level
MTCA = Model Toxic Control Act
NA = not applicable

Table B-52. Monitoring Wells and Constituents for Low-Level Waste Management Area 2

Well Name[a]	WAC Compliant	RCRA Required Constituents										Supporting Constituents				Sampled as Scheduled in 2013?
		Contaminant Indicator Parameters[b]				Groundwater Quality Parameters										
						Anions[c]			Metals, Unfiltered, Filtered[c]							
		pH	Specific Conductance	TOC	TOX	Chloride	Sulfate	Phenols	Iron	Manganese	Sodium	Alkalinity	Dissolved Oxygen	Temperature	Turbidity	
299-E27-8	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E27-9	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E27-10[a]	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	No[d]
299-E27-11	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E27-17	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E34-2	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E34-9	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E34-10	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes
299-E34-12	C	S	S	S	S	S	S	A	S	S	S	S	S	S	S	Yes

Note: Requirements are from *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2* (DOE/RL-2009-76).

a. According to DOE/RL-2009-76, well 299-E27-10 is used as the upgradient well; however, based on the flow direction change a revised monitoring plan will be implemented in 2015 establishing a new upgradient well and network.

b. Quadruplicate samples were collected during each sampling event.

c. For anions, analytes include chloride, fluoride, nitrate, nitrite, and sulfate. For metals, analytes include, but are not limited to, calcium, chromium, iron, manganese, potassium, and sodium.

d. October 2014 sampling event was delayed until December for coordination with TOC characterization of groundwater at this well.

A = to be sampled annually

C = well is constructed in accordance with requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

RCRA = *Resource Conservation and Recovery Act of 1976*

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

Table B-53. Low-Level Waste Management Area 2 Indicator Parameter Results

Constituent (units)	2014 Critical Mean Comparison Value[a]	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	6.84 – 8.78	7.74 – 8.24	No	None
Specific conductance (µS/cm)	1,400	444 – 1,490	Yes	299-E34-9[b]
Total organic carbon (µg/L)	1,750	222 – 862	No	None
Total organic halides (µg/L)	16	<3.3 – 15.1	No	None

a. *Environmental Calculation File: Calculation of Critical Means for Calendar Year 2013 RCRA Groundwater Monitoring*, Table 9 (ECF-Hanford-13-0013).

b. Previously assessed and concluded the elevated specific conductance in this well is mainly associated with a migrating nitrate plume from the BY Cribs as explained in Letter 13-AMRP-0192.

Table B-54. Low Level Waste Mangement Area 2 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E27-10	1987	226.4	12/19/2014	212.1	232.4	6.0	Downgradient
299-E27-11	1993	244.5	10/20/2014	230.4	251.4	6.9	Cross gradient
299-E27-17	1991	235.5	12/22/2014	223.2	244.2	8.7	Cross gradient
299-E27-8	1987	238.6	12/22/2014	225.5	245.5	6.9	Downgradient
299-E27-9	1987	231.3	12/22/2014	219.8	239.1	7.8	Downgradient
299-E34-10	1991	240.7	12/22/2014	225.3	246.3	5.6	Cross gradient
299-E34-12	1991	239.9	10/22/2014	223.9	244.5	4.6	Cross gradient
299-E34-2	1987	233.0	10/22/2014	219.9	239.9	6.9	Upgradient
299-E34-9	1991	229.7	4/24/2014	212.6	233.4	3.7	Cross gradient

a. ***Bold italics*** indicates upgradient well. The upgradient wells identified reflects the flow direction change. The monitoring plan is being updated in 2015 to reflect the apparent permanent change.

bgs = below ground surface

Table B-55. Low-Level Waste Management Area 2 Groundwater Quality Parameter Results

Constituent (units)	2014 Range (µg/L)	DWS (µg/L)	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride	17,900 – 79,100	250,000	Secondary MCL	No	None
Iron (unfiltered)	38.5 – 357	300	Secondary MCL	Yes	299-E27-10[a]
Manganese (unfiltered)	<2 – 13.5	50	Secondary MCL	No	None
Nitrate	12,400 – 379,000	45,000	Primary MCL	Yes	299-E27-9[b], 299-E27-10[b], 299-E34-9[c], 299-E34-10[c], 299-E34-12[c]
Phenol	<0.94 – <4.72	2,400	MTCA Method B	No	None
Sodium (unfiltered)	16,000 – 50,200	None	NA	NA	NA
Sulfate	81,700 – 350,000	250,000	Secondary MCL	Yes	299-E27-10[b], 299-E34-9[c]

a. Appears to be associated with casing corrosion as this well has been video surveyed and shown corrosion on the screen.

b. Elevated nitrate and sulfate appears to be associated with past release at the 216-B-2 Ditches.

c. Elevated nitrate and sulfate are associated with southeast migration of nitrate plume from the BY Cribs.

DWS = drinking water standard

MCL = maximum contaminant level

MTCA = Model Toxic Control Act

NA = not applicable

Table B-56. Monitoring Wells and Constituents for Low-Level Waste Management Area 3

Well Name[a]	WAC Compliant	Contamination Indicator Parameters[b]				Other Chemical Parameters				Sampled as Scheduled in 2014?
		pH (Field)	Specific Conductance (Field)	TOC	TOX	Alkalinity	Anions[c]	Metals[c]	Phenols	
299-W9-2	C	S	S	S	S	A	A	A	A	Yes
299-W10-29	C	S	S	S	S	A	A	A	A	Yes
299-W10-30	C	S	S	S	S	A	A	A	A	Yes
299-W10-31	C	S	S	S	S	A	A	A	A	Yes

Notes: Requirements are from *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3* (DOE/RL-2009-68, Rev. 2).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. Upgradient well is noted in ***bold italic***.

b. Quadruplicate samples were collected during each sampling event.

c. For anions, analytes include chloride, fluoride, nitrate, nitrite, and sulfate. For metals, analytes include, but are not limited to, calcium, chromium, iron, manganese, potassium, and sodium.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

Table B-57. Low-Level Waste Management Area 3 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-W9-2	2011	284	11/18/2014	285	320	36	Upgradient
299-W10-29	2006	245	9/5/2014	245	280	35	Downgradient
299-W10-30	2006	242	9/5/2014	242	277	35	Downgradient
299-W10-31	2006	240	9/5/2014	240	275	35	Downgradient

bgs = below ground surface

Table B-58. Low-Level Waste Management Area 3 Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.52 – 8.48	7.52 – 8.02	No	None
Specific conductance (µS/cm)	448	379 – 503	Yes	299-W10-31
Total organic halides (µg/L)	11.36	3.33 – 21.3	Yes	299-W10-29 299-W10-30 299-W10-31

* Average of quadruplicate measurements below critical mean.

LOQ = limit of quantitation

Table B-59. Low-Level Waste Management Area 3 Intrawell Total Organic Carbon Indicator Parameter Results

Well Name	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?
299-W10-29	5,447	176 – 429	No
299-W10-30	10,339	350 – 830	No
299-W10-31	7,709	271 – 439	No

Table B-60. Average Concentration for Indicator Parameters in Low-Level Waste Management Area 3 Wells in 2014

Well Name	pH Measurement Critical Mean (7.52 – 8.48)	Specific Conductance Critical Mean (448)	TOX Critical Mean (11.4)	TOC Critical Mean (5447 – 10339)
299-W10-29	7.88	396	7.2	284
299-W10-30	7.75	407	11.9	525
299-W10-31	7.85	488	15.8	352
299-W9-2	7.94	392	6.2	304

TOC = total organic carbon

TOX = total organic halides

Table B-61. Low-Level Waste Management Area 3 Water Quality and Supporting Constituent Parameter Summary

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Alkalinity (mg/L)	110	NA	NA	No	None
Calcium (µg/L)	46,500 – 59,500	NA	NA	No	None
Chloride (mg/L)	15.4 – 29.4	250	Secondary MCL	No	None
Chromium (µg/L)	<5	100	Federal MCL	No	None
Dissolved oxygen (mg/L)	5.3 – 10.5	NA	NA	No	None
Fluoride (µg/L)	187 – 222	2,000	Secondary MCL	No	None
Hexavalent chromium (µg/L)	<2 – 3.1	48	Federal MCL	No	None
Iron – unfiltered (µg/L)	<20 – 69.5	300	Secondary MCL	No	None
Magnesium – unfiltered (µg/L)	14,300 – 18,800	NA	NA	No	None
Manganese – unfiltered (µg/L)	<4 – 7.5	50	Secondary MCL	No	None
Nitrate (as N mg/L)	6.0 – 11.0	10	Federal MCL	Yes	299-W10-31
Oxidation reduction (mV)	226 – 408	NA	NA	No	None
pH (unitless)	7.52 – 8.02	6.5 – 8.5	Secondary MCL	No	None
Phenol (µg/L)	<0.9	2,400	MTCA Method B	No	None
Potassium (µg/L)	4,050 – 4,370	NA	NA	No	None
Sodium (mg/L)	11.5 – 12.9	NA	NA	No	None
Specific conductance (µS/cm)	379 – 503	448	Critical mean	Yes	299-W10-31
Sulfate (mg/L)	37.4 – 64.6	250	Secondary MCL	No	None
Temperature	13.6 – 21.8	NA	NA	No	None
Turbidity (NTU)	0.62 – 4.58	NA	NA	No	None

DWS = drinking water standard
MCL = maximum contaminant level
MTCA = Model Toxic Control Act
NA = not applicable

Table B-62. Monitoring Wells and Constituents for Low-Level Waste Management Area 4

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Chemical Parameters				Sampled as Scheduled in 2014?
			pH (Field)	Specific Conductance (Field)	TOC	TOX	Alkalinity	Anions[c]	Metals[c]	Phenols	
299-W15-17	Deep unconfined; no statistics	C	S	S	S	S	S	A	A	A	Yes
299-W15-30	—	C	S	S	S	S	S	A	A	A	Yes
299-W15-83	—	C	S	S	S	S	S	A	A	A	Yes
299-W15-94	—	C	S	S	S	S	S	A	A	A	Yes
299-W15-152	—	C	S	S	S	S	S	A	A	A	Yes
299-W15-224	—	C	S	S	S	S	S	A	A	A	Yes
299-W18-21	—	C	A	A	A	A	A	A	A	A	Yes
299-W18-22	Deep unconfined; no statistics	C	S	S	S	S	S	A	A	A	Yes

Notes: Requirements are from *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4* (DOE/RL-2009-69, Rev. 2).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. Upgradient well is noted in ***bold italic***.

b. Quadruplicate samples were collected during each sampling event.

c. For anions, analytes include chloride, fluoride, nitrate, nitrite, and sulfate. For metals, analytes include (but are not limited to) calcium, chromium, iron, manganese, potassium, and sodium.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

Table B-63. Low-Level Waste Management Area 4 Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	7.18 – 8.37	7.77 – 8.22	No	None
Specific conductance (µS/cm)	671	365 – 575	No	None
Total organic carbon (µg/L)	1,585	<270 – 830	No	None
Total organic halides (µg/L)	48.89	<3.3 – 58.4	Yes	299-W15-224

Table B-64. Low-Level Waste Management Area 4 Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-W15-17	1987	243	11/14/2014	422	432	189	Downgradient
299-W15-30	1995	244	11/14/2014	218	258	14	Downgradient
299-W15-83	2005	241	7/9/2014	235	270	29	Downgradient
299-W15-94	2005	243	7/9/2014	236	271	28	Downgradient
299-W15-152	2005	250	7/22/2015	236	271	21	Downgradient
299-W15-224	2006	239	7/9/2014	236	271	32	Downgradient
299-W18-22	1987	227	11/18/2014	416	447	220	Upgradient

bgs = below ground surface

Table B-65. Low-Level Waste Management Area 4 Groundwater Quality Parameter and Supporting Constituent Summary

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Alkalinity (mg/L)	100 – 130	—	NA	—	None
Aluminum (µg/L)	<20	200	Secondary MCL	No	None
Calcium (mg/L)	39.2 – 62.2	—	NA	—	None
Chloride (mg/L)	10.7 – 35.7	250	Secondary MCL	No	None
Chromium (µg/L)	5.6 – 19.7	100	Federal MCL	No	None
Dissolved oxygen (mg/L)	6.8 – 9.4	—	NA	No	None
Fluoride (µg/L)	223 – 528	2,000	Secondary MCL	No	None
Hexavalent chromium (µg/L)	2 – 9.3	48	Federal MCL	—	—
Iron – unfiltered (µg/L)	<40 – 84.3	300	Secondary MCL	No	None
Magnesium – unfiltered (mg/L)	13.7 – 19.5	—	NA	—	None
Manganese – unfiltered (µg/L)	<4	50	Secondary MCL	No	None
Nitrate (as N mg/L)	4.7 – 25.9	10	Federal MCL	Yes	299-W15-30 299-W15-83 299-W15-94 299-W15-152 299-W15-224
Oxidation reduction (mV)	177 – 369	—	NA	No	None
pH (unitless)	7.77 – 8.22	6.5 – 8.5	Secondary MCL	No	None
Phenol (µg/L)	<1	2,400	MTCA Method B	No	None
Potassium (µg/L)	4,690 – 5,580	—	NA	—	None
Sodium (mg/L)	14.4 – 31.2	—	NA	—	None
Specific conductance (µS/cm)	365 – 575	671	Critical mean	No	None
Sulfate (mg/L)	23.7 – 68.7	250	Secondary MCL	No	None
Temperature	16.9 – 23.3	—	NA	—	None
Turbidity (NTU)	0.39 – 4.20	—	NA	—	None

DWS = drinking water standard
MCL = maximum contaminant level
MTCA = Model Toxic Control Act
NA = not applicable

Table B-66. Monitoring Wells and Constituents for the Nonradioactive Dangerous Waste Landfill

Well Name[a]	Comment	WAC Compliant	Contamination Indicator Parameters[b]				Other Chemical Parameters				Sampled as Scheduled in 2014?
			pH (Field)	Specific Conductance (Field)	TOC	TOX	Anions	Metals	Phenols	VOA	
699-25-33A	Top of LPU; no statistical evaluation	C	S	S	S	S	S	A	A	S	Yes
699-25-34A	—	C	S	S	S	S	S	A	A	S	No[c]
699-25-34B	—	C	S	S	S	S	S	A	A	S	Yes
699-25-34D	—	C	S	S	S	S	S	A	A	S	No[d]
699-26-33	—	C	S	S	S	S	S	A	A	S	No[c]
699-26-34A	—	C	S	S	S	S	S	A	A	S	Yes
699-26-34B	—	C	S	S	S	S	S	A	A	S	Yes
699-26-35A	—	C	S	S	S	S	S	A	A	S	Yes
699-26-35C	Top of LPU; no statistical evaluation	C	S	S	S	S	S	A	A	S	Yes

Notes: Requirements are from *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill* (PNNL-12227) and corresponding Interim Change Notice 1 (PNNL-12227-ICN-1).

Wells completed at the top of the unconfined aquifer unless otherwise specified.

a. ***Bold italics*** indicate upgradient wells.

b. Quadruplicate samples were collected during each sampling event for contamination indicator parameters except in LPU wells.

c. Well not sampled in January due to pump issues.

d. January sampling event delayed to March due to pump issues.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

LPU = low-permeability units (in upper portion of Ringold Formation within member of Taylor Flat)

S = to be sampled semiannually

TOC = total organic carbon

TOX = total organic halides

VOA = volatile organic analyte

Table B-67. Nonradioactive Dangerous Waste Landfill Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
699-25-33A	1987	130.9	10/28/2014	191.0	201.0	10.0	Downgradient
699-25-34A	1986	132.37	11/13/2014	117.9	137.9	5.5	Downgradient
699-25-34B	1986	131.2	10/14/2014	118.2	138.2	6.8	Downgradient
699-25-34D	1992	138.6	11/13/2014	126.8	161.3	22.8	Downgradient
699-26-33	1986	137.8	10/28/2014	123.5	143.5	5.7	Downgradient
699-26-34A	1986	130.5	10/28/2014	117.2	137.2	6.7	Upgradient
699-26-34B	1992	130.6	11/13/2014	118.4	153.3	22.7	Downgradient
699-26-35C	1987	134.7	10/28/2014	193.0	203.0	10.0	Downgradient
699-26-35A[d]	1986	134.5	10/28/2014	120.4	140.4	6	Upgradient

bgs = below ground surface

Table B-68. Nonradioactive Dangerous Waste Landfill Indicator Parameter Results

Constituent (units)	2014 Critical Mean	2014 Concentration Range	2014 Exceedance?	Wells Exceeded
pH	6.74 – 7.96	7.11 – 8.26	Yes (high)	699-25-33A*
Specific conductance (µS/cm)	583	317 – 615	Yes	699-25-34A 699-25-34B 699-25-34D
Total organic carbon (µg/L)	725	170 – 1,200	Yes (high)	699-26-35C*
Total organic halides (µg/L)	1st quarter: WSCF (LOQ = 18.3) 2nd quarter: TASL (insufficient data) GEL (insufficient data) 3rd quarter: TASL (LOQ = 17.5) GEL (insufficient data) 4th quarter: TASL (LOQ = 14.7) GEL (5.6)	<1.8 – 10.5	No	None

* Deep well not used in statistical evaluation.

GEL = Geotechnical Engineering Laboratory

LOQ = limit of quantitation

NC = not calculated because proportion non-detects is greater than 50 percent.

TASL = Test America St. Loius

Table B-69. Nonradioactive Dangerous Waste Landfill Water Quality and Site-Specific Parameter Results

Constituent (units)	2014 Range	DWS	Standard Type	2014 Exceedance?	Wells Exceeded
Chloride (mg/L)	6.07 – 8.50	250	Secondary MCL	No	None
Iron (filtered) (µg/L)	<12.8 – <40	300	Secondary MCL	No	None
Iron (unfiltered) (µg/L)	<12.8 – 922	300	Secondary MCL	Yes	699-25-34A
Manganese (filtered) (µg/L)	0.53 – <4	50	Secondary MCL	No	None
Manganese (unfiltered) (µg/L)	<1 – 10.8	50	Secondary MCL	No	None
Nitrate (mg/L)	5.8 – 23.5	45	MCL	No	None
Phenol (µg/L)	<0.9 – <2.9	2,400	MTCA Method B	No	None
Sodium (filtered) (mg/L)	19.8 – 25.2	None	NA	—	None
Sodium (unfiltered)	17.3 – 27.6	None	NA	—	None
Sulfate (mg/L)	26.0 – 50.1	250	Secondary MCL	No	None

DWS = drinking water standard
MCL = maximum contaminant level
MTCA = "Model Toxics Control Act—Cleanup" (WAC 173-340)
NA = not applicable

Table B-70. Monitoring Wells and Constituents for Waste Management Area A-AX

Well Name[a]	WAC Compliant	Site-Specific Constituents						Supporting Constituents					Sampled as Scheduled in 2013?
		Nitrate	Sodium	Sulfate	TOC	Chromium	Lead	Alkalinity	Anions[b]	Metals[b]	Technetium-99[c]	Field Parameters	
299-E24-20	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E24-22	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E24-33	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-2	P	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-40	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-41	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-93	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-94	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-236	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	No[d]

Notes: Requirements are from *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site* (PNNL-15315).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italics*** indicate upgradient wells.

b. For anions, analytes include, but are not limited to, nitrate and sulfate. For metals, analytes include, but are not limited to, chromium and sodium.

c. *Atomic Energy Act of 1954* parameter.

d. Well decommissioned in June 2013.

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

TOC = total organic carbon

Table B-71. Waste Management Area A-AX Water Levels

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E24-20	1991	289.7	12/2/2014	279.2	299.4	9.7	Upgradient
299-E24-22	2003	288.3	12/22/2014	286.2	321.3	33	Upgradient
299-E24-33	2004	276.5	12/22/2014	278.1	310.1	33.6	Upgradient
299-E25-2*	1955	277.0	12/2/2014	276.0	316.0	39	Downgradient
299-E25-40	1989	266.9	12/2/2014	252.0	273.0	6.1	Downgradient
299-E25-41	1989	272.1	12/2/2014	255.3	276.3	4.2	Downgradient
299-E25-93	2003	280.5	12/22/2014	278.2	313.3	32.8	Downgradient
299-E25-94	2004	294.6	12/3/2014	295.1	330.1	35.5	Downgradient
299-E25-236	Decommissioned		—	—	—	—	Downgradient

* Perforated well.

bgs = below ground surface

Table B-72. Waste Management Area A-AX 2014 Assessment Parameter Summary

Parameter	Range
Alkalinity	75,400 – 136,000 µg/L
Chromium (filtered)	<1 – 10.6 µg/L
Lead (filtered)	<0.05 – <0.5 µg/L
Nitrate	12,300 – 60,200 µg/L
pH Measurement	7.23 – 8.34
Sodium (filtered)	11,200 – 28,800 µg/L
Specific conductance	445 – 725 µS/cm
Sulfate	92,300 – 210,000 µg/L
Technetium-99	<11.8 – 1,840 pCi/L
Temperature	16.0 – 20.8°C
Total organic carbon	230 – 850 µg/L
Turbidity	0.14 – 53.3 NTU

Table B-73. Monitoring Wells and Constituents for Waste Management Area B-BX-BY

Well Name[a]	WAC Compliant	pH	Specific Conductance	TOC	Alkalinity	Anions[b]	Cyanide	Metals[c]	Water Level	Sampled as Scheduled in 2014?
299-E33-18	P	Q	Q	Q	Q	Q	Q	Q	Q	No[d]
299-E33-20	P	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-31	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-32	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-38	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-41	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-42	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-44	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-47	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-48	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-49	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-334	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-335	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-337	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-338	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E33-339	C	Q	Q	Q	Q	Q	Q	Q	Q	Yes

Source: *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY* (DOE/RL-2012-53).

Note: Wells generally screened acrossed entire unconfined aquifer. Aquifer thickness ranges from approximately 1 to 6 m.

a. ***Bold italic*** well names are upgradient wells due to flow direction change to southeast.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate.

c. Metals (filtered and unfiltered) include, but are not limited to, iron, manganese, and sodium .

d. Well decommissioned in June 2013.

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

WAC = *Washington Administrative Code*

Table B-74. Waste Management Area B-BX-BY Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E33-20[a]	1956	250.8	11/4/2014	239.0	254.0	3.2	Upgradient
299-E33-31	1989	248.1	11/4/2014	234.9	255.9	7.8	Upgradient
299-E33-32	1989	260.8	11/4/2014	246.4	267.4	6.6	Upgradient
299-E33-334[b]	2000	267.3	11/5/2014	257.7	282.7	15.4	Upgradient
299-E33-335	2000	267.8	11/5/2014	260.0	280.0	12.2	Downgradient
299-E33-337	2001	263.1	11/5/2014	255.4	280.4	17.3	Downgradient
299-E33-338	2001	257.4	11.5/2014	250.9	270.9	13.5	Downgradient
299-E33-339[b]	2001	264.1	12/21//2014	259.4	279.3	15.2	Downgradient
299-E33-38	1991	233.6	12/21/2014	218.6	239.6	6.0	Upgradient
299-E33-41	1991	255.3	11/4/2014	244.9	261.0	5.7	Downgradient
299-E33-42[b]	1991	254.6	11/4/2014	238.5	259.8	5.2	Upgradient
299-E33-44	1998	243.3	11/4/2014	238.0	253.0	9.7	Downgradient
299-E33-47	2004	242.8	11/4/2014	244.1	264.1	21.3	Downgradient
299-E33-48	2004	265.0	11/4/2014	260.2	285.2	20.2	Downgradient
299-E33-49	2004	266.9	11/4/2014	263.5	283.5	16.6	Downgradient

a. Well not constructed as a WAC 173-350 resource protection well.

b. Well not drilled to basalt.

bgs = below ground surface

Table B-75. Monitoring Wells and Constituents for Waste Management Area C

Well Name[a]	Well Construction Standard	pH	Specific Conductance	Alkalinity	Anion[b]	Cyanide	Metals[c], Unfiltered, Filtered	Sampled as Scheduled in 2014?
299-E27-4	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-7	P	Q	Q	Q	Q	Q	Q	Yes
299-E27-12	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-13	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-14	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-15	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-21	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-22	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-23	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-24	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-25	C	Q	Q	Q	Q	Q	Q	Yes
299-E27-155	C	Q	Q	Q	Q	Q	Q	Yes

Source: *Groundwater Quality Assessment Plan for the Single-Shell Waste Management Area C* (DOE/RL-2009-77).

Note: Ten wells screened from the water table to 1.5 to 12.2 m below the water table. Two wells, 299-E27-24 and 299-E27-155 , screened across the bottom 6.1 and 10.6 m of the aquifer, respectively.

a. ***Bold italics*** well names are upgradient wells.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate.

c. Metals (filtered and unfiltered) include, but are not limited to, iron, manganese, and sodium.

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P constructed before WAC requirements were applicable at the Hanford Site

Q = to be sampled quarterly

WAC = *Washington Administrative Code*

Table B-76. Waste Management Area C Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-E27-12	1989	261.5	11/25/2014	246.5	267.6	6.1	Upgradient
299-E27-13	1989	270.0	12/5/2014	253.6	274.7	4.7	Upgradient
299-E27-14	1989	259.2	12/4/2014	245.8	266.8	7.6	Downgradient
299-E27-15	1989	253.7	12/5/2014	238.0	259.0	5.3	Upgradient
299-E27-155	2007	282.0	12/4/2014	300.5	335.5	35	Cross gradient
299-E27-21	2003	272.9	3/25/2014	271.4	306.4	33.5	Downgradient
299-E27-22	2003	232.1	12/3/2014	228.1	268.0	35.9	Upgradient
299-E27-23	2003	275.0	12/4/2014	273.5	308.5	33.5	Downgradient
299-E27-24	2010	266.0	12/16/2014	294.6	314.6	20.0	Downgradient
299-E27-25	2010	214.4	12/3/2014	209.1	229.2	14.8	Cross gradient
299-E27-4	2003	271.8	12/16/2014	270.3	305.3	33.5	Upgradient
299-E27-7	1982	237.6	12/16/2014	241.0	281.0	40.0	Downgradient

bgs = below ground surface

Table B-77. Monitoring Wells and Constituents for Waste Management Area S-SX

Well Name[a]	WAC Compliant	RCRA		Supporting Constituents				Sampled as Scheduled in 2014?
		Chromium	Nitrate	Alkalinity	Anions[b]	Metals[b]	Field Parameters	
299-W22-44	C	Q	Q	Q	Q	Q	Q	No[c]
299-W22-45	C	S	S	S	S	S	S	No[d]
299-W22-47	C	Q	Q	Q	Q	Q	Q	Yes
299-W22-49	C	S	S	S	S	S	S	No[e]
299-W22-50	C	Q	Q	Q	Q	Q	Q	No[f]
299-W22-69	C	A	A	A	A	A	A	Yes
299-W22-72	C	A	A	A	A	A	A	Yes
299-W22-80	C	A	A	A	A	A	A	Yes
299-W22-81	C	A	A	A	A	A	A	Yes
299-W22-82	C	A	A	A	A	A	A	Yes
299-W22-83	C	A	A	A	A	A	A	Yes
299-W22-84	C	A	A	A	A	A	A	Yes
299-W22-85	C	S	S	S	S	S	S	Yes
299-W22-86	C	A	A	A	A	A	A	Yes
299-W22-89	C	A	A	A	A	A	A	Yes
299-W22-94	C	S	S	S	S	S	S	Yes
299-W22-95	C	S	S	S	S	S	S	No[g]
299-W22-113	C	S	S	S	S	S	S	No[h]
299-W23-15	C	A	A	A	A	A	A	No[i]
299-W23-19	C	Q	Q	Q	Q	Q	Q	No[j]
299-W23-20	C	A	A	A	A	A	A	Yes
299-W23-21	C	A	A	A	A	A	A	Yes

Table B-77. Monitoring Wells and Constituents for Waste Management Area S-SX

Well Name[a]	WAC Compliant	RCRA	Nitrate	Supporting Constituents				Sampled as Scheduled in 2014?
		Chromium		Alkalinity	Anions[b]	Metals[b]	Field Parameters	

Notes: Requirements are from *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX* (DOE/RL-2009-73).

Wells completed at the top of the unconfined aquifer.

a. ***Bold italics*** indicate upgradient wells.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate. Metals (filtered and unfiltered) include, but are not limited to, calcium, magnesium, potassium, and sodium.

c. Well sample dry as of September 2013; replacement well scheduled for drilling.

d. June sampling event delayed until July; access restricted due to vapors from nearby waste tanks.

e. Well replaced by 299-W22-113; scheduled for December but sampled in January 2015 after pump was installed.

f. Well sample dry in June; replacement well scheduled for drilling.

g. December sampling event delayed until January 2015 due to well cap issue.

h. Well replaced 299-W22-49. December sampling event delayed until January for installation of a sample pump.

i. June sampling event delayed until August due to pump issue.

j. March sampling event delayed until April due to well access issues.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

RCRA = *Resource Conservation and Recovery Act of 1976*

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-78. Waste Management Area S-SX Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Water Remaining (ft)	Location
299-W22-44	1991	Dry	—	205.1	242	Dry	Downgradient
299-W22-45	1992	230.7	12/31/2014	198.1	233.6	2.9	Downgradient
299-W22-47	2005	238.5	12/10/2014	228.7	263.7	25.2	Downgradient
299-W22-49	1999	Dry	—	217.9	232.9	Dry	Downgradient
299-W22-50	2000	Dry	—	218.0	233.0	Dry	Downgradient
299-W22-69	2006	245.1	12/19/2014	238.0	273.1	28.0	Downgradient
299-W22-72	2006	246.0	12/19/2014	237.0	272.0	26.0	Downgradient
299-W22-80	2000	219.1	12/10/2014	205.0	240.1	21.0	Downgradient
299-W22-81	2001	240.1	12/19/2014	226.8	261.7	21.6	Downgradient
299-W22-82	2001	240.4	9/26/2014	226.1	261.2	20.8	Downgradient
299-W22-83	2001	241.9	12/17/2014	226.3	261.3	19.4	Downgradient
299-W22-84	2001	246.6	12/31/2014	232.0	267.0	20.4	Downgradient
299-W22-85	2001	232.2	12/31/2014	217.1	252.0	19.8	Downgradient
299-W22-86	2006	241.1	12/19/2014	231.4	266.5	25.4	Downgradient
299-W22-89	2010	237.9	9/26/2014	230.8	265.9	28.0	Downgradient
299-W22-94[a]	2013	245.2	12/19/2014	243.2	278.2	33.0	Downgradient
299-W22-95[b]	2013	248.0	12/19/2014	250.0	290.0	42.0	Downgradient
299-W22-113[c]	2014	232.7	10/2/2014	233.9	264.0	31.3	Downgradient
299-W23-15	1991	217.4	12/10/2014	185.7	222.4	5.0	Downgradient
299-W23-19	1999	226.6[d]	9/26/2014	210.7	241.3	14.7	Downgradient
299-W23-20	2000	228.2	9/26/2014	215.5	250.5	22.3	Upgradient
299-W23-21	2000	226.9	12/10/2014	212.6	249.7	22.8	Upgradient

a. 299-W22-94 is a replacement well for 299-W22-48 (sample dry).

b. 299-W22-95 is a replacement well for 299-W22-26 (sample dry).

c. 299-W22-113 is a replacement well for 299-W22-49 (sample dry).

d. Water-level measurements are not possible from 299-W23-19 because it is located within the tank farm fence line and sampled remotely from outside the fence. The water level was estimated by trend surface analysis of the 9/26/2014 measurements from nearby wells.

bgs = below ground surface

Table B-79. Waste Management Area S-SX Assessment Parameter Summary

Parameter	Range
Alkalinity	80,000 – 112,000 µg/L
Chromium (filtered)	1.0 – 460 µg/L
Chromium (unfiltered)	<1 – 497 µg/L
Nitrate	7.53 – 199 mg/L
pH Measurement	7.43 – 8.20
Specific conductance	227 – 561 µS/cm
Temperature	16.8 – 21.4°C
Turbidity	0.42 – 819 NTU

Table B-80. Monitoring Wells and Constituents for Waste Management Area T

Well Name[a]	WAC Compliant	RCRA Dangerous Constituent	Supporting Parameters			Field-Measured Parameters					Sampled as Scheduled in 2014?
		Hexavalent Chromium	Nitrate and Other Anions	Alkalinity	Metals, Unfiltered	pH	Specific Conductance	Turbidity	Temperature	Dissolved Oxygen	
299-W10-1	P	A	A	A	A	A	A	A	A	A	Yes
299-W10-4	P	A	A	A	A	A	A	A	A	A	No, well sample dry in 2013
299-W10-8	P	A	A	A	A	A	A	A	A	A	No, well sample dry in 2013
299-W10-23	C	B	B	B	B	B	B	B	B	B	Not scheduled for 2014
299-W10-24	C	A	A	A	A	A	A	A	A	A	Yes
299-W10-28	C	A	A	A	A	A	A	A	A	A	Yes
299-W11-39	C	A	A	A	A	A	A	A	A	A	Yes
299-W11-40	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W11-41	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W11-42	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W11-45[b]	C	Q	S	A	S	S	S	S	S	S	No
299-W11-47[c]	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes

Notes: Requirements are from *Interim Status Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area T* (DOE/RL-2009-66).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italics*** indicate upgradient wells.

b. Offline extraction well was converted to monitoring well in October 2014 and sampled once in December 2014.

c. Screened 9 to 18 m below water table.

A = to be sampled annually

B = to be sampled biennially

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed prior to WAC requirements

Q = to be sampled quarterly

RCRA = *Resource Conservation and Recovery Act of 1976*

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-81. Waste Management Area T Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-W10-1	1947	239	11/12/14	190	270	31	Upgradient
299-W10-4	1952	237	11/15/13	190	234	0	Assessment
299-W10-8	1973	248	3/8/13	211	251	3	Downgradient
299-W10-23	1998	243	3/17/14	226	261	18	Assessment
299-W10-24	1998	252	11/5/14	233	268	16	Downgradient
299-W10-28	2001	241	11/5/14	225	260	19	Upgradient
299-W11-39	2000	257	11/7/14	239	274	17	Downgradient
299-W11-40	2000	257	11/11/14	238	273	16	Downgradient
299-W11-41	2000	257	11/11/14	237	272	15	Downgradient
299-W11-42	2000	258	11/7/14	237	272	14	Downgradient
299-W11-45	2006	271	12/12/14	281	296	25	Far-field
299-W11-47	2006	257	11/7/14	274	305	48	Downgradient

bgs = below ground surface

Table B-82. Waste Management Area T Assessment Parameter Summary

Parameter	Range
Alkalinity (µg/L)	100,000 – 143,000
Calcium – unfiltered (µg/L)	6,500 – 58,300
Chloride (mg/L)	13.5 – 20.8
Chromium – unfiltered (µg/L)	19 – 109
Dissolved oxygen (mg/L)	7.28 – 10.26
Fluoride (µg/L)	190 – 4,570
Hexavalent chromium (µg/L)	6.8 – 67.4
Magnesium – unfiltered (µg/L)	2,010 – 19,900
Nitrate (as NO_3 mg/L)	77 – 456
pH (unitless)	7.54 – 8.56
Potassium – unfiltered (µg/L)	2,290 – 4,750
Sodium – unfiltered (mg/L)	12.7 – 172
Specific conductance (µS/cm)	470 – 1,115
Sulfate (mg/L)	34.5 – 57.3
Temperature	15.1 – 22.2
Turbidity (NTU)	0.95 – 31.3

Table B-83. Monitoring Wells and Constituents for Waste Management Area TX-TY

Well Name[a]	WAC Compliant	RCRA Dangerous Parameter	Supporting Parameters			Field-Measured Parameters					Sampled as Scheduled in 2014?
		Hexavalent Chromium	Nitrate and Other Anions	Alkalinity	Metals, Unfiltered	pH	Specific Conductance	Turbidity	Temperature	Dissolved Oxygen	
299-W10-26	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W10-27	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W14-11[b]	C	S	S	A	S	S	S	S	S	S	Yes
299-W14-13	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W14-14	C	S	S	A	S	S	S	S	S	S	Yes
299-W14-15	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W14-16	C	A	A	A	A	A	A	A	A	A	Yes
299-W14-17	C	A	A	A	A	A	A	A	A	A	Yes
299-W14-18	C	Q	S	A	S	Q	Q	Q	Q	Q	Yes
299-W14-19	C	S	S	A	S	S	S	S	S	S	Yes
299-W15-44	C	S	S	A	S	S	S	S	S	S	Yes
299-W15-763	C	S	S	A	S	S	S	S	S	S	Yes
299-W15-765[c]	C	S	S	A	S	S	S	S	S	S	Yes

Notes: Requirements are from *Interim Status Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area TX-TY* (DOE/RL-2009-67).

Wells completed at the top of the unconfined aquifer, unless specified otherwise.

a. ***Bold italic*** indicates upgradient well.

b. Screened 11 to 14.6 m below water table.

c. Well taken out of service as an extraction well and converted to a monitoring well in fourth quarter of calendar year 2012.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

RCRA = *Resource Conservation and Recovery Act of 1976*

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-84. Waste Management Area TX-TY Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Remaining Water Column (ft)	Location
299-W10-26	1998	242	11/18/2014	217	252	10	Downgradient
299-W10-27	2001	242	11/5/2014	221	256	14	Downgradient
299-W14-11	2005	241	11/11/2014	262	272	31	Downgradient
299-W14-13	1998	246	11/11/2014	217	252	6	Downgradient
299-W14-14	1998	243	11/18/2014	217	252	9	Downgradient
299-W14-15	2000	243	8/4/2014	220	255	12	Downgradient
299-W14-16	2000	246	11/4/2014	223	258	12	Far-field
299-W14-17	2000	245	11/4/2014	222	257	12	Far-field
299-W14-18	2000	243	11/11/2014	218	253	10	Downgradient
299-W14-19	2002	244	11/11/2014	224	259	15	Downgradient
299-W15-44	2002	235	5/27/2014	216	251	16	Downgradient
299-W15-763	2001	230	5/20/2014	212	247	17	Downgradient
299-W15-765	2001	241	11/7/2014	220	255	14	Upgradient

Table B-85. Waste Management Area TX-TY Assessment Parameter Summmary

Parameter	Range
Alkalinity (µg/L)	108,000 – 135,000
Aluminum – unfiltered (µg/L)	<12.9 – 106
Calcium – unfiltered (µg/L)	41,000 – 119,000
Chloride (mg/L)	14.3 – 43.4
Chromium – unfiltered (µg/L)	12.3 – 108
Dissolved oxygen (mg/L)	7.86 – 12.16
Fluoride (µg/L)	221 – 1,200
Hexavalent chromium (µg/L)	<8 – 144
Magnesium – unfiltered (µg/L)	14,000 – 35,200
Nitrate (as NO_3 mg/L)	49.1 – 536
pH (unitless)	6.78 – 8.08
Potassium – unfiltered (µg/L)	4,340 – 7,260
Sodium – unfiltered (mg/L)	17 – 136
Specific conductance (µS/cm)	447 – 1,505
Sulfate (mg/L)	31.6 – 81.6
Temperature	13.5 – 26.3
Turbidity (NTU)	0.47 – 367

Table B-86. Monitoring Wells and Constituents for Waste Management Area U

Well Name[a]	WAC Compliant	RCRA	Supporting Parameters					Sampled as Scheduled in 2014?
		Chromium	Nitrate	Alkalinity	Anions[b]	Metals[b]	Field Parameters	
299-W18-30	C	S	S	S	S	S	S	No[c]
299-W18-40	C	A	A	A	A	A	A	Yes
299-W19-12	N	S	S	S	S	S	S	Yes
299-W19-41	C	S	S	S	S	S	S	Yes
299-W19-42	C	S	S	S	S	S	S	Yes
299-W19-44	C	S	S	S	S	S	S	Yes
299-W19-45	C	S	S	S	S	S	S	Yes
299-W19-47	C	S	S	S	S	S	S	Yes

Notes: Requirement is from *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U* (DOE/RL-2009-74).

Wells completed at the top of the unconfined aquifer.

a. ***Bold italic*** indicates upgradient well.

b. Anions include, but are not limited to, chloride, nitrate, and sulfate. Metals (filtered and unfiltered) include, but are not limited to, calcium, magnesium, potassium, and sodium.

c. Well is dry; replacement well 299-W18-260 drilled at end of year; first sampling scheduled for April 2015.

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

N = well constructed prior to WAC requirements

S = to be sampled semiannually

Q = to be sampled quarterly

RCRA = *Resource Conservation and Recovery Act of 1976*

WAC = *Washington Administrative Code*

Table B-87. Waste Management Area U Water Level Summary

Well Name	Year Installed	Water Depth (ft bgs)	Water-Level Date	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Water Remaining (ft)	Location
299-W18-30	1991	Dry	—	197.5	233.7	Dry	Downgradient
299-W18-40	2001	225.8	12/10/2014	218.3	253.3	24.5	Upgradient
299-W19-12	1983	239.2	12/10/2014	210.0	247.0	7.8	Downgradient
299-W19-41	1998	239.2	12/10/2014	220.1	255.1	15.9	Downgradient
299-W19-42	1998	238.0	12/10/2014	220.3	255.4	17.4	Downgradient
299-W19-44	2001	241.9	12/10/2014	229.9	264.9	23.0	Downgradient
299-W19-45	2001	240.0	12/31/2014	224.1	259.0	19.0	Downgradient
299-W19-47	2004	238.2	7/11/2014	227.1	262.0	23.8	Downgradient

bgs = below ground surface

Table B-88. Waste Management Area U Assessment Parameter Summary

Parameter	Range
Alkalinity	68,000 – 110,000 µg/L
Chromium (filtered)	<5 – 13.9 µg/L
Chromium (unfiltered)	<5 – 21.1 µg/L
Nitrate	33.5 – 102 mg/L
pH Measurement	7.74 – 8.41
Specific conductance	343 – 556 µS/cm
Temperature	17.4 – 21.1°C
Turbidity	0.59 – 14 NTU

Table B-89. Monitoring Wells and Constituents for Environmental Restoration Disposal Facility

Well Name[a]	WAC Compliant	Alkalinity	Alpha	Anions	Beta	Carbon-14	Iodine-129	Metals	Radium[b]	Total Dissolved Solids	Technetium-99	TOX	Uranium	VOA	Sampled as Scheduled in 2014?
699-35-66A	P	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-36-66B	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-36-70A	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-37-66	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes

Notes: Requirements are from *Groundwater Protection Plan for the Environmental Restoration Disposal Facility* (WCH-198).

Wells completed at the top of the unconfined aquifer.

a. ***Bold italic*** indicates upgradient well.

b. Total alpha energy emitted from radium.

C = well is constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

S = to be sampled semiannually

TOX = total organic halides

VOA = volatile organic analyte

WAC = *Washington Administrative Code*

Table B-90. Monitoring Wells and Constituents for the KE and KW Basins

Well Name	WAC Compliant	Gross Alpha	Anions	Gross Beta	Carbon-14	Metals	Strontium-90	Technetium-99	Tritium	Sampled as Scheduled in 2014?
KE Basins										
199-K-11	P	A	A	A	A	—	—	A	A	Yes
199-K-13	P	A	A	A	A	A	A	A	A	Yes
199-K-23	P	A	A	A	A	A	A	A	A	Yes
199-K-32A	C	Q	Q	Q	S	—	—	S	Q	Yes
199-K-110A	C	S	S	S	—	S	—	—	S	Yes
199-K-111A	C	Q	Q	Q	A	A	—	A	Q	Yes
199-K-141	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
199-K-142	C	S	S	S	S	S	S	S	S	Yes
KW Basins										
199-K-31	P	S	S	S	A	S	A	A	S	Yes
199-K-34	C	Q	Q	Q	A	S	A	A	Q	Yes
199-K-106A	C	Q	Q	Q	A	S	—	—	Q	Yes
199-K-107A	C	Q	Q	Q	A	S	A	A	Q	No (August sample delayed until September)
199-K-108A	C	S	S	S	—	S	—	—	S	Yes
199-K-132	C	S	S	S	S	S	—	S	S	No (this well was analyzed only in June 2014)

Note: Requirements are modified from *Groundwater Monitoring and Assessment Plan for the 100-K Area Fuel Storage Basins* (PNNL-14033). The following wells were listed in PNNL-14033 but were decommissioned before 2011: 199-K-27, 199-K-29, 199-K-30, and 199-K-109A (KE Basins) and 199-K-33 (KW Basins). Wells 199-K-11, 199-K-13, 199-K-23, 199-K-31, 199-K-132, 199-K-141, and 199-K-142 were added to the networks. Newly constructed wells 199-K-202 and 199-K-203 are being considered for addition to the AEA monitoring network for KE Basin vicinity. Newly constructed well 199-K-204 is being considered for addition to the AEA monitoring network for KW Basin vicinity.

Table B-90. Monitoring Wells and Constituents for the KE and KW Basins

Well Name	WAC Compliant	Gross Alpha	Anions	Gross Beta	Carbon-14	Metals	Strontium-90	Technetium-99	Tritium	Sampled as Scheduled in 2014?

A = to be sampled annually

C = constructed as a resource protection well under WAC 173-160, "Minimum Standard for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-91. Monitoring Wells, Constituents, and Enforcement Limits for State-Approved Land Disposal Site

Well Name	Comment	WAC Compliant	Constituents with Enforcement Limits											Other Constituents					Sampled as Scheduled in 2014?
			pH	Acetone	Benzene	Cadmium[a]	Chloroform	Copper[a]	Lead[a]	Mercury[a]	Sulfate	Tetrahydrofuran	Total Dissolved Solids	Specific Conductance	Alpha	Beta	Strontium-90	Tritium	
299-W6-6	Bottom of unconfined	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	Yes
299-W6-11	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	Yes
299-W6-12	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	Yes
299-W7-3	Bottom of unconfined	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	S	Yes
299-W8-1	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	Yes
699-48-71	Unconfined	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	No[b]
699-48-77C	Ringold Formation unit E, middle to lower	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-48-77D	Ringold Formation unit E, upper	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-49-79	—	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	No[b]
699-51-75	—	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	S	No[c]
699-51-75P	Lower unconfined	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	Yes

Notes: Requirements are from *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site* (PNNL-13121). The following wells have gone dry: 299-W6-7, 299-W6-8, 299-W7-1, 299-W7-11, 299-W7-12, 299-W7-5, 299-W7-6, 299-W7-7, 299-W7-8, 299-W7-9, 299-W8-1, and 699-48-77A.

Wells are completed at the top of the aquifer, unless specified otherwise.

Table B-91. Monitoring Wells, Constituents, and Enforcement Limits for State-Approved Land Disposal Site

Well Name	Comment	WAC Compliant	Constituents with Enforcement Limits											Other Constituents					Sampled as Scheduled in 2014?
			pH	Acetone	Benzene	Cadmium[a]	Chloroform	Copper[a]	Lead[a]	Mercury[a]	Sulfate	Tetrahydrofuran	Total Dissolved Solids	Specific Conductance	Alpha	Beta	Strontium-90	Tritium	

a. Filtered and unfiltered samples.

b. January sampling event delayed until August; road work needed to access well.

c. May sampling event delayed until June; pump problem.

A = to be sampled annually

C = constructed as a resource protection well under WAC-173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Table B-92. Monitoring Wells and Constituents for Solid Waste Landfill

Well Name[b]	Comment	WAC Compliant	Contamination Indicator Parameters														Other Parameters				Sampled as Scheduled in 2014?
			Ammonia/Ammonium Ion	Chemical Oxygen Demand	Chloride	Iron (Filtered)	Manganese (Filtered)	Zinc (Filtered)	Nitrate	Nitrite	pH	Specific Conductance	Sulfate	Temperature (Field)	Coliform Bacteria	TOC	Anions	Metals (Filtered)	Arsenic (Filtered)	VOA	
699-22-35	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-23-34A	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	No; well sample dry as of 4th quarter 2013
699-23-34B	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-33	Information only; no statistical evaluation	P	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34A	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34B	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34C	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	No; well is sample dry
699-24-35	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-25-34C	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	No; well is sample dry

Table B-92. Monitoring Wells and Constituents for Solid Waste Landfill

Well Name[b]	Comment	WAC Compliant	Contamination Indicator Parameters														Other Parameters				Sampled as Scheduled in 2014?
			Ammonia/Ammonium Ion	Chemical Oxygen Demand	Chloride	Iron (Filtered)	Manganese (Filtered)	Zinc (Filtered)	Nitrate	Nitrite	pH	Specific Conductance	Sulfate	Temperature (Field)	Coliform Bacteria	TOC	Anions	Metals (Filtered)	Arsenic (Filtered)	VOA	
699-25-34E	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes[b]
699-26-35A	—	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes

Notes:

Requirements are from *Groundwater Monitoring Plan for the Solid Waste Landfill* (PNNL-13014). Wells 699-24-34C and 699-25-34C are sample dry.

Wells completed at the top of the unconfined aquifer.

a. ***Bold italics*** indicates upgradient well.

b. Well installed as a replacement for wells 699-24-34C and 699-25-34C. First sample collected in October.

C = well is constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before WAC requirements

Q = to be sampled quarterly

TOC = total organic carbon

VOA = volatile organic analyte

WAC = *Washington Administrative Code*

Table B-93. Analytical Results for Required Constituents at the Solid Waste Landfill, 2014

Constituent[a]	Date	699-22-35[c]	699-23-34A	699-23-34B	699-24-33	699-24-34A	699-24-34B	699-25-34E	699-24-35	699-26-35A
Ammonium ion (µg/L) BTV = 90 µg/L[b]	January	<6.44	—	<6.44	<6.44	<6.44	<6.44	NS	22.9	<6.44
	April	<6.44	—	<6.44	9.92	<6.44	<6.44	NS	<6.44	<6.44
	July	<17	—	<17	<17	27.7	<17	NS	<17	<17
	October	64.9	—	<10.1	42.9	<10.1	<17	<10.1	<10.1	No result
Chemical oxygen demand (mg/L) BTV = 10 mg/L	January	<10	—	<10	<10	<10	<10	NS	<10	<10
	April	**11**	—	**13**	<10	**27**	**19**	NS	<10	<10
	July	<6.5	—	<6.7	<6.5	**15.9**	<6.5	NS	**15**	<6.5
	October	<6.7	—	<1.1	<6.7	**11**	**17.4**	<1.1	<1.1	No result
Chloride (mg/L) BTV = 7.82 mg/L	January	6.06	—	5.41	5.92	6.55	7.40	NS	5.70	6.91
	April	6.34	—	5.65	6.24	6.44	6.27	NS	5.57	6.93
	July	6.60	—	6.21	6.70	6.72	6.26	NS	5.95	7.2
	October	6.18	—	7.00	6.21	7.20	6.70	**8.30**	6.30	7.09
Coliform bacteria (colonies/100mL) BTV = 1 col./ 100 mL	January	<1	—	<1	<1	<1	<1	NS	**6.3**	<1
	April	<1	—	<1	<1	<1	<1	NS	<1	<1
	July	<1	—	<1	<1	**9.6**	<1	NS	<1	<1
	October	<1	—	<1	<1	<1	**12**	**2**	<1	No result
Iron (filtered) (µg/L) BTV = 160 µg/L	January	<40	—	<40	<40	<40	50.5	NS	<40	<40
	April	<40	—	47.7	<40	85.4	41	NS	<40	<40
	July	16.1	—	<30	71.3	<30	56.9	NS	<30	<12.8
	October	<30	—	14.9	<30	23.8	43.2	<12.8	15.1	<30

Table B-93. Analytical Results for Required Constituents at the Solid Waste Landfill, 2014

Constituent[a]	Date	699-22-35[c]	699-23-34A	699-23-34B	699-24-33	699-24-34A	699-24-34B	699-25-34E	699-24-35	699-26-35A
Manganese (filtered) (µg/L) BTV = 18 µg/L	January	<4	—	<4	<4	<4	<4	NS	<4	<4
	April	<4	—	<4	<4	<4	<4	NS	<4	<4
	July	2.7	—	2.52	<1	<2	<1	NS	<2	2
	October	<2	—	<1	<2	<1	<2	2.4	<1	<2
Nitrate (mg/L) BTV = 29 mg/L	January	17.5	—	16.6	14.2	13.5	15.0	NS	12.4	18
	April	17.8	—	16.6	14.6	13.4	15.6	NS	11.8	18
	July	17.3	—	18.0	14.6	13.7	15.1	NS	12.4	18.6
	October	16.5	—	15.9	14.1	14.2	15.0	16.8	11.1	17.9
Nitrite (µg/L) BTV = 266 µg/L	January	<131	—	<131	<131	<131	<131	NS	<131	<131
	April	<131	—	<131	<131	<131	<131	NS	<131	<131
	July	<9.85	—	<125	<9.85	<125	<9.85	NS	<125	<9.85
	October	<125	—	<19.7	<125	<19.7	<125	<19.7	<19.7	<125

Table B-93. Analytical Results for Required Constituents at the Solid Waste Landfill, 2014

Constituent[a]	Date	699-22-35[c]	699-23-34A	699-23-34B	699-24-33	699-24-34A	699-24-34B	699-25-34E	699-24-35	699-26-35A
pH measurement BTV = 6.68-7.84	January	7.02	—	6.74	6.98	**6.55**	**6.55**	NS	**6.58**	7.11
	April	6.95	—	6.68	6.96	6.74	6.80	NS	7	7.36
	July	6.95	—	**6.67**	7.04	6.94	6.86	NS	6.95	7.47
	October	7.01	—	6.73	6.92	6.76	6.74	6.9	6.68	7.32
Specific conductance (µS/cm) BTV = 583 µS/cm	January	**808**	—	**728**	**738**	**628**	**648**	NS	542	522
	April	**765**	—	**690**	**725**	**607**	**662**	NS	543	529
	July	**793**	—	**714**	**749**	**661**	**670**	NS	559	548
	October	**796**	—	**720**	**713**	**632**	**665**	**627**	536	528
Sulfate (mg/L) BTV = 47.2 mg/L	January	42.0	—	43.5	43.7	45.0	45.4	NS	45	40.5
	April	41.5	—	42.9	43.5	43.8	45.0	NS	42.5	39.4
	July	38.8	—	**47.8**	43.1	45.1	43.5	NS	40	38.8
	October	41.1	—	40.4	41.9	41.5	43.8	39	39.8	38.9
Temperature (°C) BTV = 20.7°C	January	17.8	—	18.0	19.2	18.1	18.5	NS	17.7	19.2
	April	18.0	—	18.6	19.4	18.3	18.6	NS	17.7	19.3
	July	19.5	—	20.3	19.6	**27.8**	19.3	NS	18.9	19.8
	October	18.3	—	18.7	19.2	18.7	18.8	19.9	18.1	19.2
TOC (µg/L) BTV = 1,200 µg/L	January	611	—	638	767	458	448	NS	381	391
	April	652	—	645	**1,630**	573	684	NS	426	480
	July	<270	—	813	1,000	<330	<270	NS	478	<270
	October	839	—	<350	**1,510**	<350	812	<350	<350	584

Table B-93. Analytical Results for Required Constituents at the Solid Waste Landfill, 2014

Constituent[a]	Date	699-22-35[c]	699-23-34A	699-23-34B	699-24-33	699-24-34A	699-24-34B	699-25-34E	699-24-35	699-26-35A
Zinc (filtered) (µg/L) BTV = 42.3 µg/L	January	<5	—	<5	<5	<5	<5	NS	33.6	<5
	April	<5	—	<5	<5	<5	<5	NS	23.6	8.94
	July	10.3	—	<3.3	<8.3	<3.3	<8.3	NS	33.6	10.3
	October	<3.3	—	<8.3	<3.3	<8.5	<3.3	12.3	31.1	9.34

Note: Wells in **bold** are part of the upgradient network. Results in **bold** exceed background threshold values (BTV). Wells 699-24-34C and 699-25-34C are not included in table because wells sample dry, and no samples were collected in 2014.

a. WAC 173-304, "Minimum Functional Standards for Solid Waste Handling."

b. 2010 Background threshold values were obtained from Table C-41 of *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2* (DOE/RL-2010-11).

c. Sample collected and delivered to laboratory. Result not returned from laboratory due to quality control issues with sample batch.

— = no sample collected; well sample dry

BTV = background threshold value

NS = not sampled

TOC = total organic carbon

Table B-94. Solid Waste Landfill Groundwater Monitoring Results

Constituent (units)	Background Threshold Value	2014 Range	2014 Exceedance?	Wells Exceeded
Ammonium (µg/L)	90	<6.44 – 22.9	No	—
Chemical oxygen demand (µg/L)	10,000	<1,100 – 27,000	Yes	699-22-35 699-22-34B 699-24-34A 699-24-34B 699-24-35 (upgradient)
Chloride (µg/L)	7,820	5,410 – 8,300	Yes	699-25-34E
Coliform bacteria (colonies/100 mL)	1	<1 – 12	Yes	699-24-34A 699-24-34B 699-25-34E
pH	6.68 – 7.84	6.55 – 7.48	Yes	699-23-34B (low) 699-24-34A (low) 699-24-34B (low) 699-24-35 (low) (upgradient)
Iron – dissolved (µg/L)	174	<12.8 – 85.4	No	—
Manganese (µg/L)	27.5	<1 to <4 (2.7 highest detect)	No	—
Nitrate (µg/L)	29,000	12,400 – 18,600	No	—
Nitrite (µg/L)	165	<9.85 – <131	No	—
Specific conductance (µS/cm)	583	522 – 808	Yes	699-22-35 699-24-33 699-23-34B 699-24-34A 699-24-34B
Sulfate (µg/L)	47,200	38,800 – 47,800	Yes	699-23-34B
Temperature (degrees C)	20.7	17.7 – 27.8	Yes	699-24-34A
Total organic carbon (µg/L)	842	170 – 1,630	Yes	699-24-33
Zinc – dissolved (µg/L)	42.3	<3.3 – 33.6	No	—

Appendix C

Supporting Information for Aquifer Sampling Tubes

This page intentionally left blank.

Figures

Figure C-1. Aquifer Sampling Tube Dates in Relation to Columbia River Stage Elevation below Priest Rapids Dam C-3

Tables

Table C-1. Summary of Aquifer Tube Sampling Trips Scheduled or Performed in Calendar Year 2014 ..... C-4

Table C-2. Aquifer Tube Sample Dates and Depths C-4

This page intentionally left blank.

C Supporting Information for Aquifer Sampling Tubes

Sampling points in the aquifer adjacent to the Columbia River on the Hanford Site provide information about water quality near the point of groundwater discharge. These sampling points are known as aquifer sampling tubes or aquifer tubes.

Conventional aquifer tubes are small-diameter, flexible tubes that have a screen on one end. They are installed in the aquifer along the Columbia River shoreline by driving a temporary steel casing into the ground adjacent to the river. The temporary casing is filled with water to keep sediment from coming up into the casing, then the drive-tip on the casing end is knocked out and the screened end of a 0.25 in. diameter, flexible tube is inserted into the casing. The steel casing is then pulled out, leaving the tube in place. Water is withdrawn from the tube using a peristaltic pump. The head of the tubes are on dry ground when the Columbia River is at low to moderate levels. Most of the tubes become submerged when river stage is high, although some have been extended so they can be sampled at high river stage. Aquifer tubes are not constructed as resource protection wells as specified in WAC 173-160 and are not used as compliance points for groundwater decisions.

Over 580 aquifer tubes have been installed along the Hanford Site shoreline. Most aquifer tube sites include two or three separately installed tubes monitoring different depths, most commonly between 2 and 8 m (6.6 and 26 ft). The tube sites cover the Hanford Site shoreline, from just upstream of 100-BC to downstream at the 300 Area. Sites are more closely spaced along some segments where better spatial resolution of contaminant plumes is needed.

Aquifer tubes of a different design have been installed in 100-BC in recent years. Known as hyporheic sampling points (HSPs), these differ from the conventional aquifer tubes in their depth and construction. The HSPs are shallow (most are 0.5 m [1.6 ft] deep) and are designed to monitor the biologically active portion of the hyporheic zone. Most of them are 1.5 in. diameter, stainless-steel tubes that are submerged even at low river stage. In 2014, six new, shallower (0.15 m [0.5 ft]) HSPs were installed to supplement the previously installed HSPs (0.5 to 1 m [1.6 to 3.3 ft] depth). The 100-BC chapter of this report summarizes the HSP results for 2014.

A subset of aquifer tubes is sampled as specified in the following documents:

- *Sampling and Analysis Plan for Aquifer Sampling Tubes* (DOE/RL-2000-59), as modified by TPA-CN-327, TPA-CN-353, and TPA-CN-556. This plan includes aquifer tubes along the entire Hanford Reach of the Columbia River. As groundwater sampling and analysis plans for River Corridor OUs are revised, they will include aquifer tubes if needed to meet data quality objectives. Until those revisions are implemented, DOE/RL-2000-59 remains in effect.
- *100-FR-3 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-49, Rev. 2). Unlike previous versions of this plan, the September 2014 revision includes aquifer sampling tubes. This supersedes the requirements for 100-F aquifer tubes in DOE/RL-2000-59.
- *Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Unit Remedial Investigation/Feasibility Study* (DOE/RL-2009-44), as modified by TPA-CN-559, TPA-CN-593, and TPA-CN-602. These modifications include requirements for installation and monitoring of HSPs, which are not included in DOE/RL-2000-59. It is limited to a 2-year period (fall 2013 through fall 2015).

- *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit* (DOE/RL-2001-27, Rev. 1), Appendix A. This includes aquifer tubes downgradient of the apatite barrier. Requirements overlap and supplement DOE/RL-2000-59.
- *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2003-04, Rev. 1). This includes aquifer tubes in the eastern part of 200-PO. Requirements overlap and supplement DOE/RL-2000-59.

In total, 324 individual aquifer tubes were sampled in 2014. In order to monitor seasonal changes, the 100-BC HSPs are sampled monthly, many 100-N aquifer tubes are sampled quarterly, and some 100-D aquifer tubes are sampled semiannually. In addition to the tubes scheduled for sampling in 2014, over 100 aquifer tube sampling trips scheduled for fall 2013 were delayed into January and February 2014. This resulted in over 700 successful aquifer tube sampling trips performed during 2014. Fifty-six additional trips were delayed into early January 2015 because of a heavy sampling schedule in fall 2014. Table C-1 summarizes number of sampling trips performed or scheduled in 2014. Table C-2 includes specific sampling dates and depth of the conventional aquifer tubes. SGW-58308 includes a tally of 2014 sample dates for the 100-BC HSPs.

The question has been raised whether sampling aquifer tubes results in “short circuiting” (i.e., whether river water is being sucked through the sediment around the tube and into the screen). This problem could occur during periods when the entry point of the tube into the sediment is submerged. This effect could dilute samples with river water so they do not reflect ambient conditions in the hyporheic zone. Most of the conventional aquifer tubes are greater than 2 meters (6 ft) deep and they are sampled at low pumping rates, reducing the possibility of short-circuiting. A statistical evaluation of specific conductance data collected during and after sampling in 2010 demonstrated that no significant sample dilution occurred (Appendix C of DOE/RL-2011-01).

Inducing flow of river water into HSPs, which are less than 1 m (3 ft) deep, is minimized by pumping at rates of just 10 to 50 mL/min. Specific conductance data collected during purging and sampling are used to evaluate whether samples are representative of ambient conditions in the hyporheic zone (SGW-58308).

Figure C-1 illustrates river stage below Priest Rapids Dam, upstream of the Hanford Site, and the time periods when the bulk of the aquifer tube samples were collected in each area. The comprehensive, annual sampling occurred between late August 2014 and early January 2015. River stage was below its annual median during most of that period, but rose above the median in late December and January. The head ends of the aquifer tubes sampled in late summer and fall were above water during sampling. Some aquifer tubes sampled in December 2014 and January 2015 may have been submerged during or before sampling. Sampling during high river stage periods (e.g., 100-N quarterly tubes; 100-D semiannual tubes) is designed to occur when the tubes are submerged. These sites have tubing extended up the river bank to allow sampling under all river stage conditions. The 100-BC HSPs are submerged under all river stage conditions and are sampled from a boat.

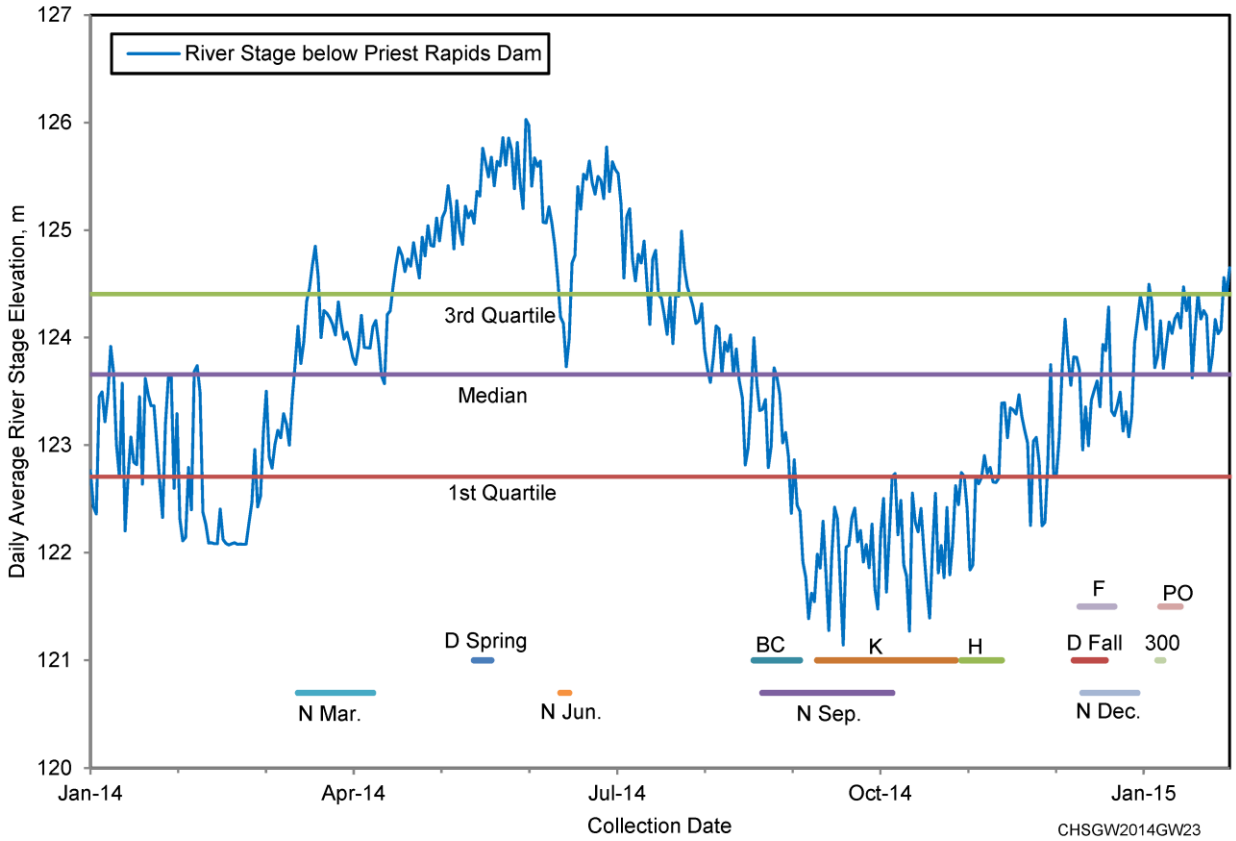


Figure C-1. Aquifer Sampling Tube Dates in Relation to Columbia River Stage Elevation below Priest Rapids Dam

Table C-1. Summary of Aquifer Tube Sampling Trips Scheduled or Performed in Calendar Year 2014

Shoreline Segment	Scheduled in 2013, Sampled in 2014	Scheduled 2014	Successful 2014	Unsuccessful 2014	Delayed to 2015	Total Trips CY 2014
100-BC	0	35	35	0	0	35
100-BC HSP	0	192	182	10	0	182
100-FR	2	13	11	2	0	13
100-HR-D	41	92	88	2	2	129
100-HR-H	40	61	52	4	5	92
100-KR	0	71	71	0	0	71
100-NR	18	149	145	2	2	163
200-PO	11	22	0	1	21	11
300-FF	7	28	0	2	26	7
Total	**119**	**663**	**584**	**23**	**56**	**703**

HSP = hyporheic sampling points

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100BC5	01-M	4.9	16.0	A	9/1/2014	8/25/2014	
100BC5	03-D	4.0	13.0	A	9/1/2014	8/25/2014	
100BC5	04-D	7.6	25.0	A	9/1/2014	8/25/2014	
100BC5	05-D	7.8	25.5	A	9/1/2014	8/25/2014	
100BC5	05-M	5.2	17.0	A	9/1/2014	8/25/2014	
100BC5	05-S	2.6	8.5	A	9/1/2014	8/25/2014	
100BC5	06-D	7.0	23.0	A	9/1/2014	8/27/2014	
100BC5	06-M	4.7	15.5	A	9/1/2014	8/27/2014	
100BC5	06-S	2.7	8.8	A	9/1/2014	8/27/2014	
100BC5	12-D	3.0	10.0	A	9/1/2014	9/2/2014	
100BC5	AT-B-1-M	4.0	13.3	A	9/1/2014	8/25/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100BC5	AT-B-2-D	5.8	19.0	A	9/1/2014	8/25/2014	
100BC5	AT-B-3-D	2.5	8.1	A	9/1/2014	8/26/2014	
100BC5	AT-B-3-M	4.3	14.2	A	9/1/2014	8/26/2014	
100BC5	AT-B-3-S	7.1	23.2	A	9/1/2014	8/26/2014	
100BC5	AT-B-5-D	7.3	24.0	A	9/1/2014	9/2/2014	
100BC5	AT-B-7-M	4.1	13.3	A	9/1/2014	9/2/2014	
100BC5	C6227	3.4	11.2	A	9/1/2014	8/25/2014	
100BC5	C6228	5.3	17.5	A	9/1/2014	8/25/2014	
100BC5	C6229	7.1	23.4	A	9/1/2014	8/25/2014	
100BC5	C6230	2.8	9.2	A	9/1/2014	9/2/2014	
100BC5	C6231	4.0	13.0	A	9/1/2014	9/2/2014	
100BC5	C6232	8.1	26.5	A	9/1/2014	9/2/2014	
100BC5	C6233	2.9	9.6	A	9/1/2014	9/3/2014	
100BC5	C6234	4.6	15.3	A	9/1/2014	9/3/2014	
100BC5	C6235	5.8	19.2	A	9/1/2014	9/3/2014	
100BC5	C7718	2.2	7.1	A	9/1/2014	8/26/2014	
100BC5	C7719	3.8	12.5	A	9/1/2014	8/26/2014	
100BC5	C7720	5.6	18.3	A	9/1/2014	8/26/2014	
100BC5	C7724	1.9	6.3	A	9/1/2014	8/26/2014	
100BC5	C7725	3.2	10.6	A	9/1/2014	8/26/2014	
100BC5	C7726	4.7	15.6	A	9/1/2014	8/26/2014	
100BC5	C7780	1.7	5.7	A	9/1/2014	8/27/2014	
100BC5	C7781	2.6	8.5	A	9/1/2014	8/27/2014	
100BC5	C7782	3.4	11.3	A	9/1/2014	8/27/2014	
100FR3	62-M	5.5	18.0	A	10/1/2014	12/10/2014	
100FR3	64-M	5.2	17.0	A	10/1/2014	12/10/2014	
100FR3	67-M	6.1	20.0	A	10/1/2014	12/18/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100FR3	72-M	5.5	18.0	A	10/1/2014		Canceled - no access
100FR3	74-D	8.8	29.0	A	10/1/2013	1/7/2014	Delayed from CY 2013
100FR3	74-D	8.8	29.0	A	10/1/2014	12/10/2014	
100FR3	75-D	8.2	27.0	A	10/1/2013	1/7/2014	Delayed from CY 2013
100FR3	75-D	8.2	27.0	A	10/1/2014	12/10/2014	
100FR3	76-D	7.6	25.0	A	10/1/2014	12/22/2014	
100FR3	77-D	7.5	24.5	A	10/1/2014		Damaged by animals; could not identify. Cancel
100FR3	C6302	2.6	8.5	A	10/1/2014	12/10/2014	
100FR3	C6303	4.1	13.3	A	10/1/2014	12/10/2014	
100FR3	C6306	4.4	14.3	A	10/1/2014	12/10/2014	
100FR3	C6309	4.9	16.2	A	10/1/2014	12/10/2014	
100FR3	C6315	5.6	18.4	A	10/1/2014	12/18/2014	
100HR3-D	36-M	4.3	14.0	A	11/1/2014	1/12/2015	
100HR3-D	36-S	2.4	8.0	A	11/1/2014	12/12/2014	
100HR3-D	38-D	5.0	16.5	A	11/1/2014	12/12/2014	
100HR3-D	38-M	3.0	10.0	A	11/1/2014	12/12/2014	
100HR3-D	AT-D-1-D	4.1	13.3	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-1-M	3.3	10.8	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-1-S	2.1	7.0	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-2-M	5.0	16.3	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-2-S	4.4	14.3	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-3-D	3.6	11.8	A	11/1/2014	12/12/2014	
100HR3-D	AT-D-3-M	2.7	8.8	A	11/1/2014	12/12/2014	
100HR3-D	AT-D-3-S	2.2	7.3	A	11/1/2014	12/12/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-D	AT-D-4-D	4.8	15.7	A	11/1/2014	12/12/2014	
100HR3-D	AT-D-4-M	4.2	13.8	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-4-S	3.8	12.4	A	11/1/2014	12/11/2014	
100HR3-D	AT-D-5-D	2.7	8.8	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	AT-D-5-D	2.7	8.8	A	11/1/2014	12/19/2014	
100HR3-D	AT-D-5-M	2.1	6.8	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	AT-D-5-M	2.1	6.8	A	11/1/2014	12/19/2014	
100HR3-D	C6266	2.9	9.6	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C6266	2.9	9.6	SA	5/1/2014	5/14/2014*	
100HR3-D	C6266	2.9	9.6	SA	11/1/2014	12/8/2014	
100HR3-D	C6267	3.9	12.7	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C6267	3.9	12.7	SA	5/1/2014	5/14/2014*	
100HR3-D	C6267	3.9	12.7	SA	11/1/2014	12/8/2014	
100HR3-D	C6268	6.6	21.7	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C6268	6.6	21.7	SA	5/1/2014	5/14/2014*	
100HR3-D	C6268	6.6	21.7	SA	11/1/2014	12/8/2014	
100HR3-D	C6269	2.4	8.0	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C6269	2.4	8.0	SA	5/1/2014	5/14/2014*	
100HR3-D	C6269	2.4	8.0	SA	11/1/2014	12/8/2014	
100HR3-D	C6270	3.9	12.8	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C6270	3.9	12.8	SA	5/1/2014	5/14/2014*	
100HR3-D	C6270	3.9	12.8	SA	11/1/2014	12/8/2014	
100HR3-D	C6271	5.6	18.3	SA	11/1/2013	1/15/2014	Delayed from CY 2013

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-D	C6271	5.6	18.3	SA	5/1/2014	5/14/2014*	
100HR3-D	C6271	5.6	18.3	SA	11/1/2014	12/8/2014	
100HR3-D	C6272	2.9	9.7	A	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	C6272	2.9	9.7	A	11/1/2014	12/11/2014	
100HR3-D	C6275	3.2	10.4	A	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	C6275	3.2	10.4	A	11/1/2014	12/12/2014	
100HR3-D	C6278	3.0	9.7	A	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	C6278	3.0	9.7	A	11/1/2014	12/12/2014	
100HR3-D	C6281	2.4	7.9	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	C6281	2.4	7.9	A	11/1/2014		Delayed; then river too high. Cancel
100HR3-D	C6282	4.7	15.6	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	C6282	4.7	15.6	A	11/1/2014		Delayed; then river too high. Cancel
100HR3-D	C7645	2.4	8.0	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C7645	2.4	8.0	A	11/1/2014	12/8/2014	
100HR3-D	C7646	3.7	12.3	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C7646	3.7	12.3	A	11/1/2014	12/8/2014	
100HR3-D	C7647	5.6	18.5	A	11/1/2014	12/8/2014	
100HR3-D	C7648	6.4	21.1	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	C7648	6.4	21.1	A	11/1/2014	12/8/2014	
100HR3-D	DD-06-2	3.7	12.0	A	11/1/2014	12/19/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-D	DD-06-3	4.9	16.0	A	11/1/2014	12/19/2014	
100HR3-D	DD-12-2	3.0	10.0	A	11/1/2014	12/19/2014	
100HR3-D	DD-12-4	6.4	21.0	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	DD-12-4	6.4	21.0	A	11/1/2014	12/19/2014	
100HR3-D	DD-15-2	4.6	15.0	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	DD-15-2	4.6	15.0	A	11/1/2014	12/19/2014	
100HR3-D	DD-15-3	6.4	21.0	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	DD-15-3	6.4	21.0	A	11/1/2014	12/19/2014	
100HR3-D	DD-15-4	7.8	25.5	A	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	DD-15-4	7.8	25.5	A	11/1/2014	12/19/2014	
100HR3-D	DD-16-3	5.3	17.5	A	11/1/2013	1/20/2014	Delayed from CY 2013
100HR3-D	DD-16-3	5.3	17.5	A	11/1/2014	12/12/2014	
100HR3-D	DD-16-4	7.8	25.5	A	11/1/2014	12/12/2014	
100HR3-D	DD-17-2	3.2	10.5	A	11/1/2014	12/12/2014	
100HR3-D	DD-17-3	4.6	15.0	A	11/1/2014	12/12/2014	
100HR3-D	DD-39-1	1.7	5.5	SA	11/1/2014	1/12/2015	
100HR3-D	DD-41-1	2.5	8.1	SA	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	DD-41-1	2.5	8.1	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-41-1	2.5	8.1	SA	11/1/2014	12/9/2014	
100HR3-D	DD-41-2	4.1	13.6	SA	11/1/2013	1/30/2014	Delayed from CY 2013
100HR3-D	DD-41-2	4.1	13.6	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-41-2	4.1	13.6	SA	11/1/2014	12/9/2014	
100HR3-D	DD-41-3	5.6	18.3	SA	5/1/2014	5/14/2014*	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-D	DD-41-3	5.6	18.3	SA	11/1/2014	12/9/2014	
100HR3-D	DD-42-2	3.2	10.4	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-42-2	3.2	10.4	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-42-2	3.2	10.4	SA	11/1/2014	12/9/2014	
100HR3-D	DD-42-3	4.5	14.9	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-42-3	4.5	14.9	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-42-3	4.5	14.9	SA	11/1/2014	12/9/2014	
100HR3-D	DD-42-4	5.5	18.0	SA	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	DD-42-4	5.5	18.0	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-42-4	5.5	18.0	SA	11/1/2014	12/9/2014	
100HR3-D	DD-43-2	3.0	10.0	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-43-2	3.0	10.0	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-43-2	3.0	10.0	SA	11/1/2014	12/8/2014	
100HR3-D	DD-43-3	3.0	10.0	SA	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-43-3	3.0	10.0	SA	5/1/2014	5/14/2014*	
100HR3-D	DD-43-3	3.0	10.0	SA	11/1/2014	12/8/2014	
100HR3-D	DD-44-3	4.4	14.3	SA	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	DD-44-3	4.4	14.3	SA	5/1/2014	5/20/2014*	
100HR3-D	DD-44-3	4.4	14.3	SA	11/1/2014	12/8/2014	
100HR3-D	DD-44-4	5.3	17.4	SA	5/1/2014	5/20/2014*	
100HR3-D	DD-44-4	5.3	17.4	SA	11/1/2014	12/8/2014	
100HR3-D	DD-49-1	3.5	11.5	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-49-1	3.5	11.5	A	11/1/2014	10/28/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-D	DD-49-2	4.6	15.2	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-49-2	4.6	15.2	A	11/1/2014	10/28/2014	
100HR3-D	DD-49-3	3.5	11.5	A	11/1/2014	10/28/2014	
100HR3-D	DD-49-4	4.6	15.2	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-49-4	4.6	15.2	A	11/1/2014	10/28/2014	
100HR3-D	DD-50-1	3.9	12.9	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-50-1	3.9	12.9	A	11/1/2014	10/28/2014	
100HR3-D	DD-50-2	5.9	19.3	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-50-2	5.9	19.3	A	11/1/2014	10/28/2014	
100HR3-D	DD-50-3	7.4	24.2	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-50-3	7.4	24.2	A	11/1/2014	10/28/2014	
100HR3-D	DD-50-4	9.1	30.0	A	11/1/2013	1/15/2014	Delayed from CY 2013
100HR3-D	DD-50-4	9.1	30.0	A	11/1/2014	10/28/2014	
100HR3-D	REDOX-1-3.3	1.0	3.3	SA	11/1/2013	1/20/2014	Delayed from CY 2013
100HR3-D	REDOX-1-3.3	1.0	3.3	SA	5/1/2014	5/20/2014*	
100HR3-D	REDOX-1-3.3	1.0	3.3	SA	11/1/2014	12/9/2014	
100HR3-D	REDOX-1-6.0	1.8	6.0	SA	5/1/2014	5/20/2014*	
100HR3-D	REDOX-1-6.0	1.8	6.0	SA	11/1/2014	12/9/2014	
100HR3-D	REDOX-2-6.0	1.8	6.0	SA	11/1/2013	1/20/2014	Delayed from CY 2013
100HR3-D	REDOX-2-6.0	1.8	6.0	SA	5/1/2014	5/20/2014*	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-D	REDOX-2-6.0	1.8	6.0	SA	11/1/2014	12/9/2014	
100HR3-D	REDOX-3-3.3	1.0	3.3	SA	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	REDOX-3-3.3	1.0	3.3	SA	5/1/2014	5/20/2014*	
100HR3-D	REDOX-3-3.3	1.0	3.3	SA	11/1/2014	12/9/2014	
100HR3-D	REDOX-3-4.6	1.4	4.6	SA	5/1/2014	5/20/2014*	
100HR3-D	REDOX-3-4.6	1.4	4.6	SA	11/1/2014	12/9/2014	
100HR3-D	REDOX-4-3.0	0.9	3.0	SA	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	REDOX-4-3.0	0.9	3.0	SA	5/1/2014	5/20/2014*	
100HR3-D	REDOX-4-3.0	0.9	3.0	SA	11/1/2014	12/9/2014	
100HR3-D	REDOX-4-6.0	1.8	6.0	SA	11/1/2013	1/16/2014	Delayed from CY 2013
100HR3-D	REDOX-4-6.0	1.8	6.0	SA	5/1/2014	5/20/2014*	
100HR3-D	REDOX-4-6.0	1.8	6.0	SA	11/1/2014	12/9/2014	
100HR3-H	44-M	2.6	8.5	A	11/1/2014	11/3/2014	
100HR3-H	45-D	7.0	23.0	A	11/1/2013	1/13/2014	Delayed from CY 2013
100HR3-H	45-D	7.0	23.0	A	11/1/2014	11/4/2014	
100HR3-H	45-M	4.6	15.0	A	11/1/2013	1/13/2014	Delayed from CY 2013
100HR3-H	45-M	4.6	15.0	A	11/1/2014	11/4/2014	
100HR3-H	45-S	2.4	8.0	A	11/1/2013	1/13/2014	Delayed from CY 2013
100HR3-H	45-S	2.4	8.0	A	11/1/2014	11/4/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-H	47-D	2.4	8.0	A	11/1/2014	11/12/2014	
100HR3-H	47-M	2.4	8.0	A	11/1/2014	11/12/2014	
100HR3-H	48-M	5.2	17.0	A	11/1/2014	11/13/2014	
100HR3-H	48-S	2.7	9.0	A	11/1/2014	11/13/2014	
100HR3-H	49-D	7.8	25.5	A	11/1/2014	11/13/2014	
100HR3-H	50-M	5.3	17.5	A	11/1/2013	2/26/2014	Delayed from CY 2013
100HR3-H	50-M	5.3	17.5	A	11/1/2014	1/13/2015	
100HR3-H	50-S	2.6	8.5	A	11/1/2014	1/13/2015	
100HR3-H	51-D	7.8	25.5	A	11/1/2014		Could not locate 9/9/2014. Cancel
100HR3-H	51-M	5.3	17.5	A	11/1/2014		Could not locate 9/9/2014. Cancel
100HR3-H	51-S	2.9	9.5	A	11/1/2014		Could not locate 9/9/2014. Cancel
100HR3-H	52-D	7.3	24.0	A	11/1/2013	2/18/2014	Delayed from CY 2013
100HR3-H	52-D	7.3	24.0	A	11/1/2014	12/18/2014	
100HR3-H	52-M	4.6	15.0	A	11/1/2013	2/18/2014	Delayed from CY 2013
100HR3-H	52-M	4.6	15.0	A	11/1/2014	12/18/2014	
100HR3-H	52-S	2.1	7.0	A	11/1/2013	2/18/2014	Delayed from CY 2013
100HR3-H	52-S	2.1	7.0	A	11/1/2014	12/18/2014	
100HR3-H	54-D	7.9	26.0	A	11/1/2013	2/18/2014	Delayed from CY 2013
100HR3-H	54-D	7.9	26.0	A	11/1/2014	12/18/2014	
100HR3-H	54-M	5.2	17.0	A	11/1/2013	2/18/2014	Delayed from CY 2013
100HR3-H	54-M	5.2	17.0	A	11/1/2014	12/18/2014	
100HR3-H	54-S	2.3	7.5	A	11/1/2013	2/18/2014	Delayed from CY 2013

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-H	54-S	2.3	7.5	A	11/1/2014	12/18/2014	
100HR3-H	AT-H-1-D	3.9	12.8	A	11/1/2014	1/13/2015	
100HR3-H	AT-H-1-M	3.4	11.0	A	11/1/2014	11/5/2014	
100HR3-H	AT-H-1-S	1.9	6.2	A	11/1/2014	11/5/2014	
100HR3-H	AT-H-2-D	3.7	12.0	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	AT-H-2-D	3.7	12.0	A	11/1/2014	11/6/2014	
100HR3-H	AT-H-2-M	2.8	9.2	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	AT-H-2-M	2.8	9.2	A	11/1/2014	11/6/2014	
100HR3-H	AT-H-2-S	1.6	5.3	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	AT-H-2-S	1.6	5.3	A	11/1/2014	11/6/2014	
100HR3-H	AT-H-3-D	2.2	7.3	A	11/1/2014	11/5/2014	
100HR3-H	AT-H-3-S	1.6	5.3	A	11/1/2014	11/5/2014	
100HR3-H	C5632	2.2	7.3	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5632	2.2	7.3	A	11/1/2014	10/30/2014	
100HR3-H	C5633	5.3	17.5	A	11/1/2014	10/30/2014	
100HR3-H	C5634	9.4	31.0	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5634	9.4	31.0	A	11/1/2014	10/30/2014	
100HR3-H	C5635	2.1	7.0	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5635	2.1	7.0	A	11/1/2014	10/30/2014	
100HR3-H	C5636	4.7	15.6	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5636	4.7	15.6	A	11/1/2014	10/30/2014	
100HR3-H	C5637	3.8	12.4	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5637	3.8	12.4	A	11/1/2014	10/30/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-H	C5638	1.7	5.7	A	11/1/2014	10/30/2014	
100HR3-H	C5641	1.4	4.7	A	11/1/2014	10/30/2014	
100HR3-H	C5644	2.0	6.4	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5644	2.0	6.4	A	11/1/2014	11/3/2014	
100HR3-H	C5673	1.6	5.2	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5673	1.6	5.2	A	11/1/2014	11/4/2014	
100HR3-H	C5674	2.5	8.1	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5674	2.5	8.1	A	11/1/2014	11/4/2014	
100HR3-H	C5676	1.6	5.4	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5676	1.6	5.4	A	11/1/2014	11/4/2014	
100HR3-H	C5677	2.4	7.9	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C5677	2.4	7.9	A	11/1/2014	11/4/2014	
100HR3-H	C5678	2.4	8.0	A	11/1/2014	11/4/2014	
100HR3-H	C5679	1.2	4.0	A	11/1/2013	1/14/2014	Delayed from CY 2013
100HR3-H	C5679	1.2	4.0	A	11/1/2014	11/4/2014	
100HR3-H	C5680	3.6	11.9	A	11/1/2013	1/14/2014	Delayed from CY 2013
100HR3-H	C5680	3.6	11.9	A	11/1/2014	11/4/2014	
100HR3-H	C5681	4.0	13.2	A	11/1/2014	12/22/2014	
100HR3-H	C5682	2.7	8.9	A	11/1/2014	11/5/2014	
100HR3-H	C6284	3.0	9.7	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C6284	3.0	9.7	A	11/1/2014	10/30/2014	
100HR3-H	C6285	4.5	14.6	A	11/1/2013	2/12/2014	Delayed from CY 2013

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-H	C6285	4.5	14.6	A	11/1/2014	10/30/2014	
100HR3-H	C6286	10.4	34.0	A	11/1/2013	2/12/2014	Delayed from CY 2013
100HR3-H	C6286	10.4	34.0	A	11/1/2014	10/30/2014	
100HR3-H	C6287	2.0	6.5	A	11/1/2013	1/14/2014	Delayed from CY 2013
100HR3-H	C6287	2.0	6.5	A	11/1/2014	10/30/2014	
100HR3-H	C6288	2.4	7.8	A	11/1/2013	1/14/2014	Delayed from CY 2013
100HR3-H	C6288	2.4	7.8	A	11/1/2014	10/30/2014	
100HR3-H	C6290	2.6	8.6	A	11/1/2013	1/13/2014	Delayed from CY 2013
100HR3-H	C6290	2.6	8.6	A	11/1/2014		Unsuccessful 11/5/14; Repaired 1/9/15, then river too high. Cancel
100HR3-H	C6291	4.0	13.0	A	11/1/2013	1/13/2014	Delayed from CY 2013
100HR3-H	C6291	4.0	13.0	A	11/1/2014	11/6/2014	
100HR3-H	C6293	2.4	7.9	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C6293	2.4	7.9	A	11/1/2014	11/5/2014	
100HR3-H	C6296	2.4	8.0	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C6296	2.4	8.0	A	11/1/2014	11/12/2014	
100HR3-H	C6297	4.0	13.1	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C6297	4.0	13.1	A	11/1/2014	11/12/2014	
100HR3-H	C6299	2.5	8.1	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C6299	2.5	8.1	A	11/1/2014	11/13/2014	
100HR3-H	C6300	3.8	12.6	A	11/1/2013	1/9/2014	Delayed from CY 2013

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100HR3-H	C6300	3.8	12.6	A	11/1/2014	11/13/2014	
100HR3-H	C6301	5.3	17.3	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C6301	5.3	17.3	A	11/1/2014	11/13/2014	
100HR3-H	C7649	1.7	5.5	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C7649	1.7	5.5	A	11/1/2014	1/13/2015	
100HR3-H	C7650	2.4	7.8	A	11/1/2013	1/9/2014	Delayed from CY 2013
100HR3-H	C7650	2.4	7.8	A	11/1/2014	1/13/2015	
100KR4	14-D	6.6	21.5	A	10/1/2014	10/21/2014	
100KR4	17-D	5.9	19.5	A	10/1/2014	9/16/2014	
100KR4	18-S	2.6	8.5	A	10/1/2014	12/11/2014	Not in AT; scheduled 100-KR only.
100KR4	19-D	6.7	22.0	A	10/1/2014	10/21/2014	
100KR4	19-M	3.0	10.0	A	10/1/2014	10/21/2014	
100KR4	21-M	4.6	15.0	A	10/1/2014	10/22/2014	
100KR4	21-S	3.4	11.0	A	10/1/2014	10/22/2014	
100KR4	22-D	3.7	12.3	A	10/1/2014	9/17/2014	
100KR4	22-M	2.3	7.5	A	10/1/2014	9/17/2014	
100KR4	23-M	2.1	7.0	A	10/1/2014	10/23/2014	
100KR4	25-D	2.3	7.5	A	10/1/2014	10/27/2014	
100KR4	26-D	7.0	23.0	A	10/1/2014	10/23/2014	
100KR4	26-M	4.3	14.0	A	10/1/2014	10/23/2014	
100KR4	26-S	1.8	6.0	A	10/1/2014	10/23/2014	
100KR4	AT-K-1-D	6.6	21.7	A	10/1/2014	9/10/2014	
100KR4	AT-K-1-M	4.6	15.0	A	10/1/2014	9/10/2014	Not in AT; scheduled 100-KR only.

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100KR4	AT-K-1-S	2.8	9.2	A	10/1/2014	9/10/2014	Not in AT; scheduled 100-KR only.
100KR4	AT-K-2-D	6.8	22.3	A	10/1/2014	9/10/2014	
100KR4	AT-K-3-D	7.0	23.0	A	10/1/2014	9/15/2014	
100KR4	AT-K-3-M	5.4	17.8	A	10/1/2014	9/11/2014	
100KR4	AT-K-3-S	4.1	13.4	A	10/1/2014	9/15/2014	
100KR4	AT-K-4-M	4.0	13.2	A	10/1/2014	9/16/2014	
100KR4	AT-K-4-S	3.4	11.0	A	10/1/2014	9/16/2014	
100KR4	AT-K-5-D	6.4	21.1	A	10/1/2014	9/15/2014	
100KR4	AT-K-5-M	4.8	15.7	A	10/1/2014	9/15/2014	
100KR4	AT-K-5-S	3.2	10.5	A	10/1/2014	9/15/2014	
100KR4	AT-K-6-D	6.6	21.6	A	10/1/2014	9/15/2014	
100KR4	AT-K-6-M	4.6	15.3	A	10/1/2014	9/15/2014	
100KR4	AT-K-6-S	3.5	11.4	A	10/1/2014	9/15/2014	
100KR4	C6236	3.0	9.7	A	10/1/2014	10/21/2014	
100KR4	C6237	4.6	15.0	A	10/1/2014	10/21/2014	
100KR4	C6238	6.6	21.6	A	10/1/2014	10/21/2014	
100KR4	C6239	3.1	10.2	A	10/1/2014	10/20/2014	
100KR4	C6240	4.5	14.9	A	10/1/2014	10/22/2014	
100KR4	C6241	6.7	21.8	A	10/1/2014	10/22/2014	
100KR4	C6242	3.9	12.7	A	10/1/2014	10/21/2014	
100KR4	C6243	6.3	20.7	A	10/1/2014	10/21/2014	
100KR4	C6244	8.4	27.5	A	10/1/2014	10/21/2014	
100KR4	C6245	3.4	11.2	A	10/1/2014	10/20/2014	
100KR4	C6246	5.1	16.6	A	10/1/2014	10/20/2014	
100KR4	C6247	7.0	23.1	A	10/1/2014	10/20/2014	
100KR4	C6248	3.1	10.1	A	10/1/2014	10/22/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100KR4	C6249	4.6	15.0	A	10/1/2014	10/22/2014	
100KR4	C6250	7.1	23.2	A	10/1/2014	10/22/2014	
100KR4	C6251	3.1	10.1	A	10/1/2014	10/22/2014	
100KR4	C6252	5.6	18.3	A	10/1/2014	10/22/2014	
100KR4	C6253	7.3	24.0	A	10/1/2014	10/22/2014	
100KR4	C6254	2.4	8.0	A	10/1/2014	10/22/2014	
100KR4	C6255	3.3	10.8	A	10/1/2014	10/22/2014	
100KR4	C6256	5.0	16.4	A	10/1/2014	10/22/2014	
100KR4	C6257	3.0	9.8	A	10/1/2014	10/23/2014	
100KR4	C6258	4.6	15.0	A	10/1/2014	10/23/2014	
100KR4	C6259	5.9	19.5	A	10/1/2014	10/23/2014	
100KR4	C6260	2.5	8.3	A	10/1/2014	10/23/2014	
100KR4	C6261	4.1	13.6	A	10/1/2014	10/23/2014	
100KR4	C6263	3.9	12.8	A	10/1/2014	10/28/2014	
100KR4	C6264	6.2	20.2	A	10/1/2014	10/28/2014	
100KR4	C6265	8.3	27.3	A	10/1/2014	10/28/2014	
100KR4	C7641	2.6	8.6	Q	1/1/2014	1/28/2014	Not in AT; scheduled 100-KR only.
100KR4	C7641	2.6	8.6	Q	4/1/2014	4/9/2014*	Not in AT; scheduled 100-KR only.
100KR4	C7641	2.6	8.6	Q	7/1/2014	7/28/2014*	Not in AT; scheduled 100-KR only.
100KR4	C7641	2.6	8.6	A	10/1/2014	10/20/2014	
100KR4	C7642	4.5	14.7	Q	1/1/2014	1/28/2014	Not in AT; scheduled 100-KR only.
100KR4	C7642	4.5	14.7	Q	4/1/2014	4/9/2014*	Not in AT; scheduled 100-KR only.

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100KR4	C7642	4.5	14.7	Q	7/1/2014	7/28/2014*	Not in AT; scheduled 100-KR only.
100KR4	C7642	4.5	14.7	A	10/1/2014	10/20/2014	
100KR4	C7643	5.3	17.2	Q	1/1/2014	1/28/2014	Not in AT; scheduled 100-KR only.
100KR4	C7643	5.3	17.2	Q	4/1/2014	4/9/2014*	Not in AT; scheduled 100-KR only.
100KR4	C7643	5.3	17.2	Q	7/1/2014	7/28/2014*	Not in AT; scheduled 100-KR only.
100KR4	C7643	5.3	17.2	A	10/1/2014	10/20/2014	
100KR4	DK-04-2	3.5	11.5	A	10/1/2014	10/23/2014	
100NR2	APT1	2.7	8.9	SA	6/1/2014	6/11/2014*	Not in AT; scheduled apatite.
100NR2	APT1	2.7	8.9	SA	9/1/2014	9/17/2014	Not in AT; scheduled apatite.
100NR2	APT5	3.1	10.0	SA	3/1/2014	3/28/2014*	Not in AT; scheduled apatite.
100NR2	APT5	3.1	10.0	SA	6/1/2014	6/11/2014*	Not in AT; scheduled apatite.
100NR2	APT5	3.1	10.0	SA	9/1/2014	9/23/2014	Not in AT; scheduled apatite.
100NR2	C6132	1.7	5.5	Q	3/1/2014	3/31/2014*	
100NR2	C6132	1.7	5.5	Q	6/1/2014	6/11/2014*	
100NR2	C6132	1.7	5.5	Q	9/1/2014	9/16/2014	
100NR2	C6132	1.7	5.5	Q	12/1/2014	12/29/2014	
100NR2	C6136	1.5	4.9	Q	9/1/2014	9/16/2014	Not in AT; scheduled apatite.
100NR2	C6317	2.4	7.9	A	9/1/2014	9/4/2014	
100NR2	C6318	4.1	13.5	A	9/1/2014	9/4/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	C6319	6.8	22.2	A	9/1/2014	9/4/2014	
100NR2	C6320	2.6	8.5	A	9/1/2014	9/4/2014	
100NR2	C6321	3.8	12.6	A	9/1/2014	9/4/2014	
100NR2	C6322	5.7	18.8	A	9/1/2014	9/4/2014	
100NR2	C6324	4.3	14.2	Q	3/1/2014	3/28/2014*	Not in AT; scheduled apatite.
100NR2	C6324	4.3	14.2	Q	6/1/2014	6/16/2014*	Not in AT; scheduled apatite.
100NR2	C6324	4.3	14.2	A	9/1/2014	9/23/2014	Not in AT; scheduled apatite.
100NR2	C6325	7.1	23.4	A	9/1/2014	9/24/2014	
100NR2	C6326	3.0	9.9	A	9/1/2014	9/24/2014	
100NR2	C6327	5.1	16.7	A	9/1/2014	9/24/2014	
100NR2	C6328	7.6	24.8	A	9/1/2014	9/24/2014	
100NR2	C6329	4.8	15.6	A	9/1/2014	9/4/2014	
100NR2	C6330	6.7	22.1	A	9/1/2014	9/4/2014	
100NR2	C6331	8.7	28.7	A	9/1/2014	9/8/2014	
100NR2	C6332	3.0	9.8	A	9/1/2014	9/9/2014	
100NR2	C6334	7.5	24.7	A	9/1/2014	9/9/2014	
100NR2	C6352	4.3	14.1	A	9/1/2014	9/8/2014	
100NR2	C7881	0.8	2.6	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	C7881	0.8	2.6	Q	3/1/2014	3/25/2014*	
100NR2	C7881	0.8	2.6	Q	6/1/2014	6/12/2014*	
100NR2	C7881	0.8	2.6	Q	9/1/2014	9/23/2014	
100NR2	C7881	0.8	2.6	Q	12/1/2014	12/21/2014	
100NR2	C7934	4.4	14.4	M	1/1/2014	1/28/2014	
100NR2	C7934	4.4	14.4	M	2/1/2014	2/13/2014	
100NR2	C7934	4.4	14.4	M	3/1/2014	3/25/2014*	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	C7934	4.4	14.4	M	4/1/2014	4/9/2014*	
100NR2	C7934	4.4	14.4	A	9/1/2014	9/8/2014	
100NR2	C7934	4.4	14.4	M	10/1/2014	10/28/2014	
100NR2	C7934	4.4	14.4	M	11/1/2014	12/11/2014	
100NR2	C7934	4.4	14.4	M	12/1/2014	12/22/2014	
100NR2	C7935	5.7	18.8	M	1/1/2014	1/28/2014	
100NR2	C7935	5.7	18.8	M	2/1/2014	2/13/2014	
100NR2	C7935	5.7	18.8	M	3/1/2014	3/25/2014*	
100NR2	C7935	5.7	18.8	M	4/1/2014	4/9/2014*	
100NR2	C7935	5.7	18.8	A	9/1/2014	9/8/2014	
100NR2	C7935	5.7	18.8	M	10/1/2014	10/28/2014	
100NR2	C7935	5.7	18.8	M	11/1/2014	12/11/2014	
100NR2	C7935	5.7	18.8	M	12/1/2014	12/22/2014	
100NR2	C7936	8.9	29.2	M	1/1/2014	1/28/2014	
100NR2	C7936	8.9	29.2	M	2/1/2014	2/13/2014	
100NR2	C7936	8.9	29.2	M	3/1/2014	3/25/2014*	
100NR2	C7936	8.9	29.2	M	4/1/2014	4/9/2014*	
100NR2	C7936	8.9	29.2	A	9/1/2014	9/8/2014	
100NR2	C7936	8.9	29.2	M	10/1/2014	10/28/2014	
100NR2	C7936	8.9	29.2	M	11/1/2014	12/11/2014	
100NR2	C7936	8.9	29.2	M	12/1/2014	12/22/2014	
100NR2	C7937	3.1	10.1	Q	4/1/2014	4/9/2014*	
100NR2	C7937	3.1	10.1	Q	9/1/2014	9/9/2014	
100NR2	C7937	3.1	10.1	Q	12/1/2014	12/22/2014	
100NR2	C7938	4.5	14.9	Q	4/1/2014	4/9/2014*	
100NR2	C7938	4.5	14.9	Q	9/1/2014	9/9/2014	
100NR2	C7938	4.5	14.9	Q	12/1/2014	12/22/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	C7939	5.8	19.1	Q	4/1/2014	4/9/2014*	
100NR2	C7939	5.8	19.1	Q	9/1/2014	9/9/2014	
100NR2	C7939	5.8	19.1	Q	12/1/2014	12/22/2014	
100NR2	N116mArray-0A	1.6	5.4	Q	3/1/2014	3/28/2014*	
100NR2	N116mArray-0A	1.6	5.4	Q	6/1/2014	6/11/2014*	Scheduled AT and apatite.
100NR2	N116mArray-0A	1.6	5.4	Q	9/1/2014	9/16/2014	Scheduled AT and apatite.
100NR2	N116mArray-0A	1.6	5.4	Q	12/1/2014	12/29/2014	
100NR2	N116mArray-10A	1.0	3.3	Q	12/1/2013	1/24/2014	Delayed from CY 2013
100NR2	N116mArray-10A	1.0	3.3	Q	3/1/2014	3/31/2014*	
100NR2	N116mArray-10A	1.0	3.3	Q	6/1/2014	6/16/2014*	Scheduled AT and apatite.
100NR2	N116mArray-10A	1.0	3.3	Q	9/1/2014	9/24/2014	Scheduled AT and apatite.
100NR2	N116mArray-10A	1.0	3.3	Q	12/1/2014	12/21/2014	
100NR2	N116mArray-11A	1.0	3.3	Q	12/1/2013	1/24/2014	Delayed from CY 2013
100NR2	N116mArray-11A	1.0	3.3	Q	3/1/2014	3/28/2014*	
100NR2	N116mArray-11A	1.0	3.3	Q	6/1/2014	6/16/2014*	Scheduled AT and apatite.
100NR2	N116mArray-11A	1.0	3.3	Q	9/1/2014	8/22/2014	Scheduled AT and apatite.
100NR2	N116mArray-11A	1.0	3.3	Q	12/1/2014	12/21/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	N116mArray-13A	1.6	5.2	Q	12/1/2013	1/24/2014	Delayed from 2013. Later found to be broken. Results not representative.
100NR2	N116mArray-13A	1.6	5.2	Q	9/1/2014	10/6/2014	Scheduled AT and apatite.
100NR2	N116mArray-13A	1.6	5.2	Q	12/1/2014	12/21/2014	Specific conductance same as river.
100NR2	N116mArray-15A	1.7	5.5	Q	12/1/2013	1/24/2014	Delayed from CY 2013
100NR2	N116mArray-15A	1.7	5.5	Q	3/1/2014	3/31/2014*	
100NR2	N116mArray-15A	1.7	5.5	Q	6/1/2014	6/16/2014*	Scheduled AT and apatite.
100NR2	N116mArray-15A	1.7	5.5	Q	9/1/2014	8/22/2014	Scheduled AT and apatite.
100NR2	N116mArray-15A	1.7	5.5	Q	12/1/2014	12/21/2014	
100NR2	N116mArray-1A	1.2	3.9	Q	12/1/2014	12/29/2014	
100NR2	N116mArray-2A	0.6	2.1	Q	3/1/2014	3/14/2014*	
100NR2	N116mArray-2A	0.6	2.1	Q	6/1/2014	6/11/2014*	Scheduled AT and apatite.
100NR2	N116mArray-2A	0.6	2.1	Q	9/1/2014	9/16/2014	Scheduled AT and apatite.
100NR2	N116mArray-2A	0.6	2.1	Q	12/1/2014	12/29/2014	
100NR2	N116mArray-3A	0.6	2.0	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	N116mArray-3A	0.6	2.0	Q	3/1/2014	3/25/2014*	
100NR2	N116mArray-3A	0.6	2.0	Q	6/1/2014	6/12/2014*	Scheduled AT and apatite.

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	N116mArray-3A	0.6	2.0	Q	9/1/2014	9/17/2014	Scheduled AT and apatite.
100NR2	N116mArray-3A	0.6	2.0	Q	12/1/2014	1/13/2015	
100NR2	N116mArray-4A	1.0	3.3	Q	3/1/2014	3/25/2014*	
100NR2	N116mArray-4A	1.0	3.3	Q	6/1/2014	6/12/2014*	Scheduled AT and apatite.
100NR2	N116mArray-4A	1.0	3.3	Q	9/1/2014	9/17/2014	Scheduled AT and apatite.
100NR2	N116mArray-4A	1.0	3.3	Q	12/1/2014	12/30/2014	
100NR2	N116mArray-6A	0.7	2.3	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	N116mArray-6A	0.7	2.3	Q	3/1/2014	3/14/2014*	
100NR2	N116mArray-6A	0.7	2.3	Q	6/1/2014	6/12/2014*	Scheduled AT and apatite.
100NR2	N116mArray-6A	0.7	2.3	Q	9/1/2014	8/22/2014	Scheduled AT and apatite.
100NR2	N116mArray-6A	0.7	2.3	Q	12/1/2014	12/21/2014	
100NR2	N116mArray-8.5A	1.1	3.5	Q	12/1/2014		Consistently no yield. Cancel.
100NR2	N116mArray-8A	1.0	3.3	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	N116mArray-8A	1.0	3.3	Q	3/1/2014	3/14/2014*	
100NR2	N116mArray-8A	1.0	3.3	Q	6/1/2014	6/12/2014*	Scheduled AT and apatite.
100NR2	N116mArray-8A	1.0	3.3	Q	9/1/2014	8/22/2014	Scheduled AT and apatite.
100NR2	N116mArray-8A	1.0	3.3	Q	12/1/2014	12/21/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	N116mArray-9A	1.0	3.3	Q	12/1/2013	1/24/2014	Delayed from CY 2013
100NR2	N116mArray-9A	1.0	3.3	Q	3/1/2014	3/31/2014*	
100NR2	N116mArray-9A	1.0	3.3	Q	6/1/2014	6/13/2014*	Scheduled AT and apatite.
100NR2	N116mArray-9A	1.0	3.3	Q	9/1/2014	8/22/2014	Scheduled AT and apatite.
100NR2	N116mArray-9A	1.0	3.3	Q	12/1/2014	12/21/2014	
100NR2	NVP1-1	1.0	3.3	Q	3/1/2014	3/14/2014*	
100NR2	NVP1-1	1.0	3.3	Q	6/1/2014	6/13/2014*	
100NR2	NVP1-1	1.0	3.3	Q	12/1/2014	1/13/2015	
100NR2	NVP1-2	1.2	4.1	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP1-2	1.2	4.1	Q	3/1/2014	3/14/2014*	
100NR2	NVP1-2	1.2	4.1	Q	6/1/2014	6/13/2014*	
100NR2	NVP1-2	1.2	4.1	Q	12/1/2014	12/21/2014	
100NR2	NVP1-3	1.7	5.6	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP1-3	1.7	5.6	Q	3/1/2014	3/14/2014*	
100NR2	NVP1-3	1.7	5.6	Q	6/1/2014	6/13/2014*	
100NR2	NVP1-3	1.7	5.6	Q	9/1/2014	10/6/2014	
100NR2	NVP1-3	1.7	5.6	Q	12/1/2014	12/21/2014	
100NR2	NVP1-4	1.7	5.7	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP1-4	1.7	5.7	Q	3/1/2014	3/14/2014*	
100NR2	NVP1-4	1.7	5.7	Q	6/1/2014	6/13/2014*	
100NR2	NVP1-4	1.7	5.7	Q	9/1/2014	9/24/2014	
100NR2	NVP1-4	1.7	5.7	Q	12/1/2014	12/21/2014	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	NVP1-5	2.2	7.2	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP1-5	2.2	7.2	Q	3/1/2014	3/14/2014*	
100NR2	NVP1-5	2.2	7.2	Q	6/1/2014	6/13/2014*	
100NR2	NVP1-5	2.2	7.2	Q	9/1/2014	9/24/2014	
100NR2	NVP1-5	2.2	7.2	Q	12/1/2014	12/21/2014	
100NR2	NVP2-115.1	1.9	6.2	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP2-115.1	1.9	6.2	Q	3/1/2014	3/14/2014*	
100NR2	NVP2-115.1	1.9	6.2	Q	6/1/2014	6/13/2014*	
100NR2	NVP2-115.1	1.9	6.2	Q	9/1/2014	9/24/2014	
100NR2	NVP2-115.1	1.9	6.2	Q	12/1/2014	12/21/2014	
100NR2	NVP2-115.4	1.6	5.3	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP2-115.4	1.6	5.3	Q	3/1/2014	3/14/2014*	
100NR2	NVP2-115.4	1.6	5.3	Q	6/1/2014	6/13/2014*	
100NR2	NVP2-115.4	1.6	5.3	Q	9/1/2014	9/24/2014	
100NR2	NVP2-115.4	1.6	5.3	Q	12/1/2014	12/21/2014	
100NR2	NVP2-115.7	1.3	4.3	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP2-115.7	1.3	4.3	Q	3/1/2014	3/14/2014*	
100NR2	NVP2-115.7	1.3	4.3	Q	6/1/2014	6/13/2014*	
100NR2	NVP2-115.7	1.3	4.3	Q	9/1/2014	9/24/2014	
100NR2	NVP2-115.7	1.3	4.3	Q	12/1/2014	12/21/2014	
100NR2	NVP2-116.0	1.0	3.3	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP2-116.0	1.0	3.3	Q	3/1/2014	3/25/2014*	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
100NR2	NVP2-116.0	1.0	3.3	Q	6/1/2014	6/13/2014*	Scheduled AT and apatite.
100NR2	NVP2-116.0	1.0	3.3	Q	9/1/2014	9/17/2014	Scheduled AT and apatite.
100NR2	NVP2-116.0	1.0	3.3	Q	12/1/2014	12/21/2014	
100NR2	NVP2-116.3	0.7	2.3	Q	12/1/2013	1/17/2014	Delayed from CY 2013
100NR2	NVP2-116.3	0.7	2.3	Q	3/1/2014	3/14/2014*	
100NR2	NVP2-116.3	0.7	2.3	Q	6/1/2014	6/13/2014*	
100NR2	NVP2-116.3	0.7	2.3	Q	9/1/2014	9/24/2014	
100NR2	NVP2-116.3	0.7	2.3	Q	12/1/2014	12/21/2014	
200PO1	82-M	4.4	14.5	A	12/1/2013	1/7/2014	Delayed from 2013. Not in AT; scheduled 200-PO.
200PO1	82-M	4.4	14.5	A	12/1/2014	1/7/2015	Not in AT; scheduled 200-PO.
200PO1	82-S	2.6	8.5	A	12/1/2013	1/7/2014	Delayed from 2013. Not in AT; scheduled 200-PO.
200PO1	82-S	2.6	8.5	A	12/1/2014	1/7/2015	Not in AT; scheduled 200-PO.
200PO1	84-D	6.7	22.0	A	12/1/2014	1/13/2015	Not in AT; scheduled 200-PO.
200PO1	84-M	4.3	14.0	A	12/1/2014	1/7/2015	Not in AT; scheduled 200-PO.
200PO1	84-S	2.4	8.0	A	12/1/2014	1/8/2015	Not in AT; scheduled 200-PO.

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
200PO1	85-D	7.9	26.0	A	10/1/2013	1/8/2014	Delayed from 2013. No yield 10/14/13.
200PO1	85-D	7.9	26.0	A	12/1/2014	1/8/2015	Scheduled AT and 200-PO.
200PO1	85-M	5.2	17.0	A	12/1/2013	1/8/2014	Delayed from 2013. Not in AT; scheduled 200-PO.
200PO1	85-M	5.2	17.0	A	12/1/2014	1/8/2015	Not in AT; scheduled 200-PO.
200PO1	85-S	0.0		A	12/1/2013	1/8/2014	Delayed from 2013. Not in AT; scheduled 200-PO.
200PO1	85-S	2.4	8.0	A	12/1/2014	1/8/2015	Not in AT; scheduled 200-PO.
200PO1	86-D	7.9	26.0	A	10/1/2013	1/8/2014	Delayed from CY 2013
200PO1	86-D	7.9	26.0	A	12/1/2014	1/9/2015	
200PO1	86-M	3.0	10.0	A	12/1/2014	1/9/2015	Not in AT; scheduled 200-PO.
200PO1	86-S	2.1	7.0	A	12/1/2013	1/8/2014	Delayed from 2013. Not in AT; scheduled 200-PO. Low yield.
200PO1	86-S	2.1	7.0	A	12/1/2014	1/9/2015	Not in AT; scheduled 200-PO.
200PO1	C6353	1.0	3.2	A	12/1/2014	1/14/2015	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
200PO1	C6356	1.0	3.4	A	12/1/2014	1/9/2015	
200PO1	C6359	1.3	4.3	A	12/1/2014	1/14/2015	
200PO1	C6362	2.0	6.6	A	10/1/2013	1/23/2014	Delayed from CY 2013
200PO1	C6362	2.0	6.6	A	12/1/2014	1/7/2015	
200PO1	C6368	2.0	6.4	A	12/1/2014	1/14/2015	
200PO1	C6374	2.1	6.8	A	10/1/2013	1/22/2014	Delayed from CY 2013
200PO1	C6374	2.1	6.8	A	12/1/2014	1/8/2015	Scheduled for field readings only, but substituted for C6375.
200PO1	C6375	2.7	8.9	A	10/1/2013	1/22/2014	Delayed from CY 2013
200PO1	C6375	2.7	8.9	A	12/1/2014		Broken. Cancel.
200PO1	C6378	1.5	5.1	A	12/1/2014	1/8/2015	
200PO1	C6380	0.5	1.5	A	12/1/2014	1/8/2015	
200PO1	C6383	2.2	7.1	A	10/1/2013	1/22/2014	Delayed from CY 2013
200PO1	C6383	2.2	7.1	A	12/1/2014	1/8/2015	
200PO1	C6384	4.4	14.3	A	12/1/2014	1/9/2015	
300FF5	AT-3-1-D(1)	6.4	21.1	A	12/1/2013	1/6/2014	Delayed from CY 2013
300FF5	AT-3-1-D(1)	6.4	21.1	A	12/1/2014	1/6/2015*	
300FF5	AT-3-1-M	5.1	16.8	SA	12/1/2013	1/6/2014	Delayed from CY 2013
300FF5	AT-3-1-M	5.1	16.8	A	12/1/2014	1/6/2015*	
300FF5	AT-3-1-S	3.5	11.6	A	12/1/2013	1/22/2014	Delayed from CY 2013
300FF5	AT-3-1-S	3.5	11.6	A	12/1/2014	1/6/2015*	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
300FF5	AT-3-2-M	5.1	16.6	SA	12/1/2013	1/23/2014	Delayed from CY 2013
300FF5	AT-3-2-M	5.1	16.6	A	12/1/2014		Repaired 1/9/15; attempted 1/14/15, no yield. Cancel
300FF5	AT-3-2-S	3.3	10.8	A	12/1/2013	1/6/2014	Delayed from CY 2013
300FF5	AT-3-2-S	3.3	10.8	A	12/1/2014	1/6/2015*	
300FF5	AT-3-3-D	8.9	29.1	A	12/1/2014	1/6/2015*	
300FF5	AT-3-3-M	4.6	15.1	A	12/1/2014	1/6/2015*	
300FF5	AT-3-3-S	2.1	6.9	A	12/1/2014	1/6/2015*	
300FF5	AT-3-4-D	2.9	9.6	A	12/1/2014	1/8/2015*	
300FF5	AT-3-4-M	2.8	9.2	A	12/1/2014		No yield 1/8/15; cancel.
300FF5	AT-3-4-S	2.1	7.0	A	12/1/2014	1/8/2015*	
300FF5	AT-3-5-S	2.3	7.7	A	12/1/2014	1/6/2015*	
300FF5	AT-3-6-D	11.8	38.6	A	12/1/2014	1/6/2015*	
300FF5	AT-3-6-M	6.7	21.8	A	12/1/2014	1/6/2015*	
300FF5	AT-3-6-S	2.9	9.6	A	12/1/2014	1/6/2015*	
300FF5	AT-3-7-D	11.4	37.3	SA	12/1/2013	1/23/2014	Delayed from CY 2013
300FF5	AT-3-7-D	11.4	37.3	A	12/1/2014	1/6/2015*	
300FF5	AT-3-7-M	6.4	20.8	A	12/1/2014	1/6/2015*	
300FF5	AT-3-7-S	2.6	8.6	A	12/1/2014	1/6/2015*	
300FF5	AT-3-8-M	4.3	14.0	A	12/1/2014	1/6/2015*	
300FF5	AT-3-8-S	2.4	8.0	A	12/1/2014	1/6/2015*	
300FF5	C6341	3.6	11.7	A	12/1/2014	1/6/2015*	
300FF5	C6342	5.3	17.5	A	12/1/2014	1/6/2015*	
300FF5	C6343	6.3	20.6	A	12/1/2014	1/6/2015*	

Table C-2. Aquifer Tube Sample Dates and Depths

Segment	Tube Name	Depth (m)	Depth (ft)	Frequency	Month Scheduled	Sample Dates	Comments
300FF5	C6344	2.2	7.3	A	12/1/2014	1/6/2015*	
300FF5	C6347	3.0	9.8	SA	12/1/2013	1/6/2014	Delayed from CY 2013
300FF5	C6347	3.0	9.8	A	12/1/2014	1/7/2015*	
300FF5	C6348	3.1	10.0	A	12/1/2014	1/7/2015*	
300FF5	C6350	2.6	8.4	A	12/1/2014	1/6/2015*	
300FF5	C6351	4.3	14.2	A	12/1/2014	1/6/2015*	

For hyporheic sampling points, see SGW-58308

A = annually

AT = aquifer tube sampling and analysis plan (DOE/RL-2000-59)

M = monthly

SA = semiannually

CY = calendar year

*Head end of aquifer tube head may have been below water at time of sampling

Appendix D

Confined Aquifers

This page intentionally left blank.

Contents

D1 Ringold Confined Aquifers D-1

D1.1 Groundwater Flow in Ringold Confined Aquifers D-1

D1.2 Groundwater Quality in Ringold Confined Aquifers D-2

D2 Upper Basalt-Confined Aquifer D-3

D2.1 Groundwater Flow in Upper Basalt-Confined Aquifer D-3

D2.2 Groundwater Quality in Upper Basalt-Confined Aquifer D-5

Figures

Figure D-1. Ringold Confined Monitoring Wells 6

Figure D-2. Potentiometric Surface for Ringold Unit A, March 2014 7

Figure D-3. Basalt-Confined Monitoring Wells 8

Figure D-4. Potentiometric Surface for Upper Basalt-Confined Aquifer, March 2014 9

Figure D-5. Comparison of Observed Heads for Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer, 2014 10

Tables

Table D-1. Groundwater Quality in Ringold Confined Aquifers D-11

Table D-2. Groundwater Quality in Upper Basalt-Confined Aquifer D-12

This page intentionally left blank.

D Confined Aquifers

This chapter describes groundwater flow and groundwater quality in confined aquifers within the Ringold Formation and the upper portion of the Columbia River Basalt Group.

D1 Ringold Confined Aquifers

Numerous wells at the Hanford Site monitor confined, water-bearing units in the Ringold Formation (Figure D-1). The most widespread Ringold confined aquifer is where the Ringold lower mud unit confines the underlying sediment of Ringold unit A. Approximately 40 wells are screened in Ringold unit A, although not all of these have been sampled in recent years. Most of the wells are located in or near the Central Plateau; others are located in the southern Hanford Site (including the 300 Area), and one well is in the 100 Area.

Local, water-bearing units in or beneath the Ringold upper mud unit exist in the northern Hanford Site. These are not believed to be interconnected into a regional aquifer. Nineteen wells in the 100 Area are screened in water-bearing units within or beneath this unit.

D1.1 Groundwater Flow in Ringold Confined Aquifers

This subsection describes groundwater flow in the confined aquifer of Ringold unit A in the region near the 200 Area and farther south. The elevation of this Ringold confined aquifer varies from 34 m (111.5 ft) above mean sea level (NAVD88, *North American Vertical Datum of 1988*) southwest of the 200 West Area (Plate 3 of PNNL-13858) to more than 128 m (420 ft) (NAVD88) northeast of the 200 East Area (Plate 3 of PNNL-12261). There are insufficient data from unit A in the northern part of the Hanford Site to interpret groundwater flow directions. Groundwater flow in the Ringold upper mud is not characterized because the water-bearing units are not known to be interconnected.

Figure D-2 presents the March 2014 potentiometric surface for a portion of the confined aquifer in the Ringold Formation unit A. This map is subject to uncertainty because only a few wells monitor this aquifer. However, generalized flow patterns can be inferred from available data when the hydrogeologic framework (that is, the extent of the confined unit, presence of basalt subcrops, and influence of the May Junction Fault) is considered.

Groundwater flow in the Ringold confined aquifer is generally west to east near the 200 West Area and west to east along the southern boundary of the aquifer near the Rattlesnake Hills. This flow pattern indicates that recharge occurs west of the 200 West Area in upgradient areas within the Cold Creek Valley, as well as in the Dry Creek Valley, and possibly the Rattlesnake Hills. Near the 200 East Area, flow in the Ringold confined aquifer converges from the west, south, and east before discharging to the unconfined aquifer where the Ringold Formation lower mud is absent (Section 4.2.3 of PNNL-12261). This water is thought to flow southeast over the top of the confining unit (Section 2.4.3 of DOE/RL-2008-59).

Three of the injection wells for the 200 West pump and treat system are screened beneath the Ringold lower mud unit. The 130 m (426.5 ft) contour in Figure D-2 illustrates the higher potentiometric surface around those wells. This was derived by simulation of groundwater injection at these wells (ECF-Hanford-14-0050, *Preparation of the March 2014 Hanford Site Water Table and Potentiometric Surface Maps*).

Artificially elevated water levels are present in the Ringold confined aquifer to the northeast of the 216-B-3 Pond (B Pond). The high water levels reflect mounding from past wastewater discharges and subsequently cause a southwest flow beneath B Pond where mounding is not as prevalent. Eastward

flow away from the region of elevated water levels does not occur due to the north-south trending May Junction Fault, located east of the B Pond area (Section 2.4.3 of DOE/RL-2008-59). Hydraulic head and water chemistry differences across this fault indicate it is a barrier to groundwater flow in the confined aquifers (Sections 4.2.3 and 4.3.2 in PNNL-12261). While impermeable units have been juxtaposed against permeable units along part of the fault, the mud units may also have smeared along the fault zone and sealed it (Plates 8 and 9 in PNNL-12261). South of the B Pond area, the flow of water divides, with some flow moving northwest toward the 200 East Area and some flow moving east or southeast. The exact location of the flow divide is not known because of a lack of water-level data in this area and uncertainty regarding the southward extent of the May Junction Fault.

The potentiometric contours for the Ringold confined aquifer (Figure D-2) are similar to the potentiometric surface contours for the upper basalt-confined aquifer system, indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. Basalt bedrock from the topographic low area at Gable Gap near the 200 East Area was eroded significantly by late Pleistocene catastrophic flooding (Section 7.0 of PNNL-19702), which facilitates intercommunication between the unconfined and confined aquifers. The 200 East Area is a discharge area for both of the confined aquifers, which explains the similar flow patterns.

The potentiometric surface responds to increased or reduced loading of the confined aquifer caused by water-level changes in the overlying unconfined aquifer. Hydraulic head declined in the confined aquifer between 2013 and 2014, continuing longer term trends. Small declines were evident in wells near 200 East and in the southeast part of the Hanford Site (0.02 to 0.09 m [0.066 to 0.295 ft] between 2013 and 2014). The largest declines were observed in 200 West Area (e.g., 0.54 m [1.77 ft] in Well 299-W22-24P, located in southern 200 West).

Hydraulic head east of 200 West Area has varied in recent years. Three pump and treat injection wells that are screened in the Ringold confined aquifer increased the head in 2013, interpreted as a “mound” in the potentiometric surface with a high head in nearby monitoring Well 699-43-69. The “mound” nearly dissipated in 2014 with a 2.28 (7.48 ft) decline in Well 699-43-69. The water level in 2014 was in line with the longer term, declining trend due to reduced loading in the overlying unconfined aquifer in this region.

D1.2 Groundwater Quality in Ringold Confined Aquifers

Wells monitoring Ringold confined aquifers are sampled in accordance with the objectives of the groundwater operable units in which they are located. The main text of this report discusses monitoring results and highlights are summarized in the following text.

With few exceptions, groundwater in the Ringold upper mud unit is not contaminated (Table D-1). Nineteen wells screened in this unit were sampled at least once between 2012 and 2014. Hexavalent chromium concentrations are greater than the 48 µg/L “Model Toxics Control Act—Cleanup” (WAC 173-340) standard in some Ringold upper mud wells in 100-H Area (higher than currently observed in the unconfined aquifer) and in one well in the Horn. It appears that portions of this unit east of 100-D Area were eroded, allowing contaminated cooling water into water-bearing units within the mud. This water moves more slowly than unconfined groundwater so the contamination persists.

Tritium and chromium concentrations are elevated in Ringold mud Well 199-N-80 (see 100-NR section of this report), although tritium levels are below the drinking water standard (DWS). This is the only well in 100-NR screened in the mud. Attempts to install another well in a similar, water-bearing zone in 2011 were unsuccessful; no water-bearing zone was encountered during drilling.

Twenty wells screened in unit A were sampled at least once between 2012 and 2014. The region just east of the 200 West Area is contaminated with carbon tetrachloride, chromium, and nitrate. These contaminants apparently reached unit A in a region of the 200 West Area where the lower mud unit is absent. As the groundwater continues to flow toward the east where the lower mud is present, it becomes confined. The 200-ZP section of this report discusses contaminant distribution with depth in the 200 West Area.

The Ringold confined aquifer (unit A) is the uppermost aquifer in a region east of 200 East (200-BP and 200-PO groundwater interest areas). Regional contaminants iodine-129 and tritium are detected in wells monitoring this aquifer (Table D-1). Contamination has not been observed in wells located downgradient of the contaminated wells, indicating it is of limited extent.

D2 Upper Basalt-Confined Aquifer

The upper basalt-confined aquifer groundwater system occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds within the upper Saddle Mountains Basalt. The thickest and most widespread sedimentary unit in this system is the Rattlesnake Ridge interbed, which is present beneath much of the Hanford Site. Groundwater also occurs within the Levey interbed, which is present only in the southern portion of the Hanford Site. A small interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and may be significant to the lateral transmission of water. The upper basalt-confined aquifer system is confined by the dense, low-permeability interior portions of the overlying basalt flows and in some places by silt and clay units of the lower Ringold Formation that overlie the basalt. Approximately 50 wells screened in the upper basalt-confined aquifer have been sampled or had water levels measured in recent years (Figure D-3).

An area of intercommunication between the unconfined and upper basalt-confined aquifers exists near the 200 East Area where the confining layers are eroded away or fractured. Several basalt-confined wells have shown evidence of intercommunication with the overlying unconfined aquifer (Section 3.0 of PNL-10817, *Hydrochemistry and Hydrogeologic Conditions within the Hanford Site Upper Basalt Confined Aquifer System*).

D2.1 Groundwater Flow in Upper Basalt-Confined Aquifer

Figure D-4 presents the interpreted March 2014 potentiometric surface for the upper basalt-confined aquifer system south of Gable Butte and Gable Mountain, based on measurements from 38 monitoring wells. The region to the north of Gable Butte and Gable Mountain was not contoured because of an insufficient number of wells in this area. Plate 1 of PNL-8869, *Preliminary Potentiometric Map and Flow Dynamic Characteristics for the Upper-Basalt Confined Aquifer System*, provides a generalized potentiometric surface map of this area. The upper basalt-confined aquifer system does not exist in the Cold Creek Valley and along the west portion of the Gable Mountain and Gable Butte structural area because of the absence of the Rattlesnake Ridge interbed.

Recharge to the upper basalt-confined aquifer system likely occurs from upland areas along the margins of the Pasco Basin and results from the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near ground surface. Recharge may also occur from the overlying aquifers (that is, the unconfined aquifer or confined aquifer in the Ringold Formation) in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge to this aquifer system. The Columbia River represents a discharge area for this aquifer system in the southeastern portion of the Hanford Site where the river has a lower head than the upper basalt-confined aquifer, but not for the northern portion of the site where the river head is higher (Section 3.2 of PNL-8869). Discharge also occurs to the overlying aquifers in areas where

the hydraulic gradient is upward. Discharge to the overlying unconfined aquifer near the Gable Butte and Gable Mountain structural area is believed to occur through windows eroded in the basalt.

South of Gable Butte and Gable Mountain, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site, toward the Columbia River. The north-south trending May Junction Fault, located east of B Pond, acts as a barrier to groundwater flow in the unconfined aquifer and the confined aquifer within the Ringold Formation (Section 2.4.3 of DOE/RL-2008-59). It may also impede the movement of water in the upper basalt-confined aquifer system by juxtaposing permeable units opposite impermeable units. As with the Ringold confined aquifer, a flow divide is interpreted to exist southeast of the 200 East Area and B Pond in the upper basalt-confined aquifer system, but the exact location of this divide is uncertain because of a lack of wells in the area.

Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated between 0.7 and 2 m/yr (2.3 and 6.6 ft/yr) (Section 4.2 of PNL-10817), which is a considerably lower flow rate than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone (with silts and clays) and is much less permeable than the sediment in the unconfined aquifer. In addition, the magnitude of the hydraulic gradient is generally lower than in the unconfined aquifer.

The vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer varies spatially, as shown by comparison of observed heads (Figure D-5). An upward gradient exists beneath most of the Hanford Site. A downward gradient exists in the western portion of the Hanford Site and near the B Pond recharge mound, as well as in regions north and east of the Columbia River. Near the B Pond, the vertical head gradient between the unconfined aquifer system and the upper basalt-confined aquifer system has diminished in recent years but remains downward. In 2014, the area of upward gradient beneath a portion of 200 West Area grew in response to groundwater extraction, which reduced heads in the unconfined aquifer.

In the 200 East Area, the potentiometric surface (Figure D-4) is similar to the potentiometric surface for the Ringold confined aquifer (Figure D-2). The basalt in this area was significantly eroded by late Pleistocene catastrophic flooding, which facilitates aquifer intercommunication (Section 7.0 of PNNL-19702). In the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer is upward. It is likely that the upper basalt-confined aquifer system currently discharges to the overlying aquifer in this region.

The 2014 potentiometric surface map (Figure D-4) shows flexures in the contours beneath 200 West and the region to the east. This interpretation shows the influence of groundwater mounds (injection) and depressions (extraction) in the overlying unconfined and Ringold confined aquifers.

Water levels declined slightly in most of the basalt-confined wells in 200 East and 200 West Areas between 2013 and 2014. The decreases ranged from less than 0.1 m (0.33 ft) in wells near the 200 East Area to 0.68 m (2.23 ft) in Well 699-47-80AP, north of the 200 West Area. The latter well is located near unconfined injection wells. The water level rose significantly between 2012 and 2013, but resumed its downward trend in 2014.

In the northern part of 200 East Area the basalt confined aquifer is in communication with the overlying unconfined aquifer. Hydraulic head in the confined aquifer resumed its declining trend in this region in 2014. Head had increased in 2013 in response to higher than normal Columbia River stage during the summers of 2011 and 2012, which affected head in the overlying unconfined aquifer. The overall decline in the potentiometric surface is a response to reduced loading of the confined aquifer (i.e., a reduction in

external stress) caused by water-level declines in the overlying unconfined aquifer and Ringold confined aquifer. Where the basalt is not confining, the water-level declines in the deeper aquifer are directly due to the declining water table. The water table in the unconfined aquifer is declining in response to reduced effluent disposal activities in the 200 Areas.

D2.2 Groundwater Quality in Upper Basalt-Confined Aquifer

The U.S. Department of Energy (DOE) monitors groundwater quality in the upper basalt-confined aquifer system because of the potential for downward migration of contaminants from the overlying unconfined aquifer in areas where confining units are absent or fractured. The upper basalt-confined aquifer system is not affected by contamination as much as the unconfined aquifer. Contamination found in the upper basalt-confined aquifer system is most likely to occur in areas where the confining units have been eroded away or were never deposited, and where past disposal of large amounts of wastewater resulted in downward hydraulic gradients. Researchers have identified areas of intercommunication between the contaminated unconfined aquifer and the upper basalt-confined aquifer by geochemical signatures and the presence of nitrate and tritium in groundwater in some basalt-confined wells near the 200 East Area (Chapter 3.0 of PNL-10817). However, groundwater monitoring data do not indicate that contamination has migrated into the upper basalt-confined aquifer. Because of poor seals in wells constructed prior to implementation of WAC 173-160 ("Minimum Standards for Construction and Maintenance of Wells"), intercommunication between aquifers has permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer in the past, increasing the potential to spread contamination (e.g., at Well 299-E33-12, discussed below). Section 2.14.2 of DOE/RL-2008-01 further discusses communication between the upper basalt-confined aquifer system and the overlying aquifers.

Eighteen wells screened in the upper basalt-confined aquifer were sampled between 2012 and 2014. Concentrations of contaminants are far below DWSs in the basalt-confined aquifer (Table D-2), except in a single well (299-E33-12) where past drilling practices and well construction allowed migration of groundwater from the overlying unconfined aquifer. The highest concentrations of contaminants continued to be observed in Well 299-E33-12 in the northwestern 200 East Area. This well was drilled in 1953 and was uncased from just above the bottom of the unconfined aquifer through the Rattlesnake Ridge interbed. Contamination is believed to have migrated from the unconfined aquifer, down the open borehole, to the Rattlesnake Ridge interbed (Section 2.14.2 of DOE/RL-2008-01). The well was sealed from the unconfined aquifer in 1979 with an additional seal placed in the well in 1990 to shorten the open interval. Concentrations of waste indicators cyanide, nitrate, technetium-99, and tritium continued to be elevated in samples from this well, and possibly in a small area of the confined aquifer. Well 299-E33-50, located near 299-E33-12, consistently shows levels of technetium-99 between 25 and 50 pCi/L. Other confined wells in this region showed no contamination. The hydraulic gradient is upward in this region (Figure D-5).

Tritium is detected at a concentration below the DWS in Well 699-42-40C, located east of 200 East (200-BP interest area) and concentrations generally are declining. The hydraulic gradient in this region remains downward (Figure D-5).

Groundwater in basalt-confined wells in other regions of the Hanford Site is uncontaminated, based on data from a small number of available wells that were sampled in recent years (Table D-2).

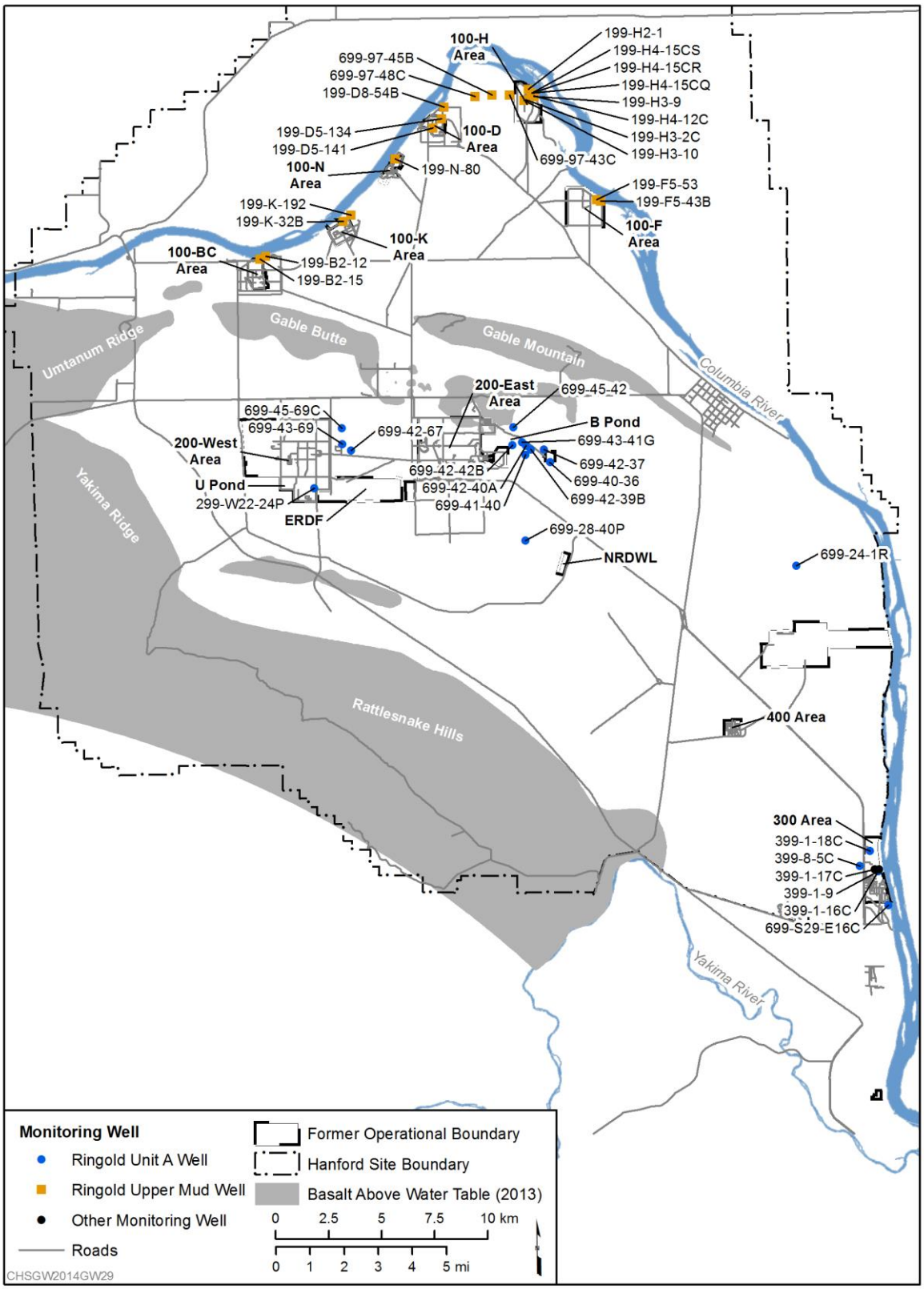


Figure D-1. Ringold Confined Monitoring Wells

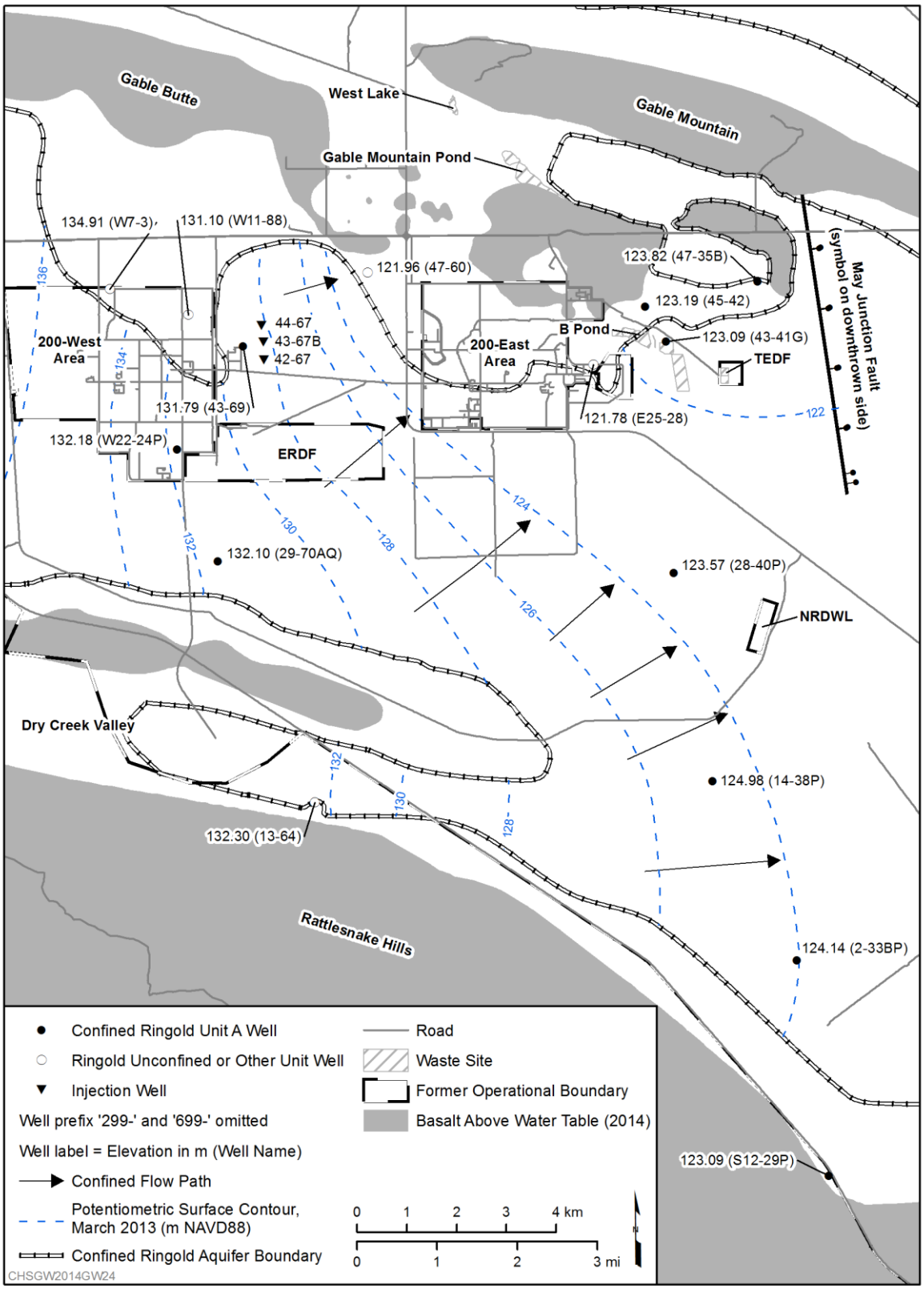


Figure D-2. Potentiometric Surface for Ringold Unit A, March 2014

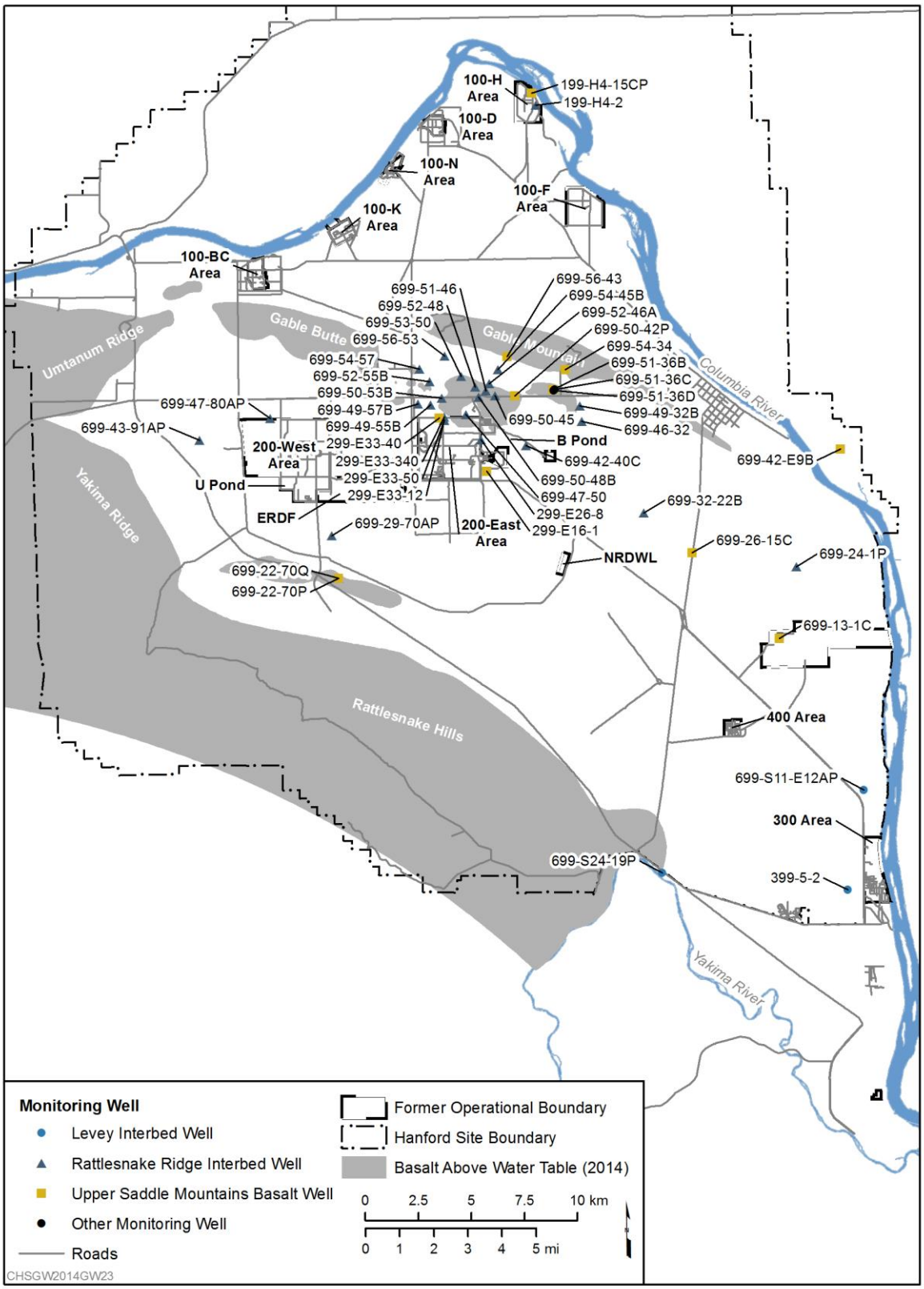


Figure D-3. Basalt-Confined Monitoring Wells

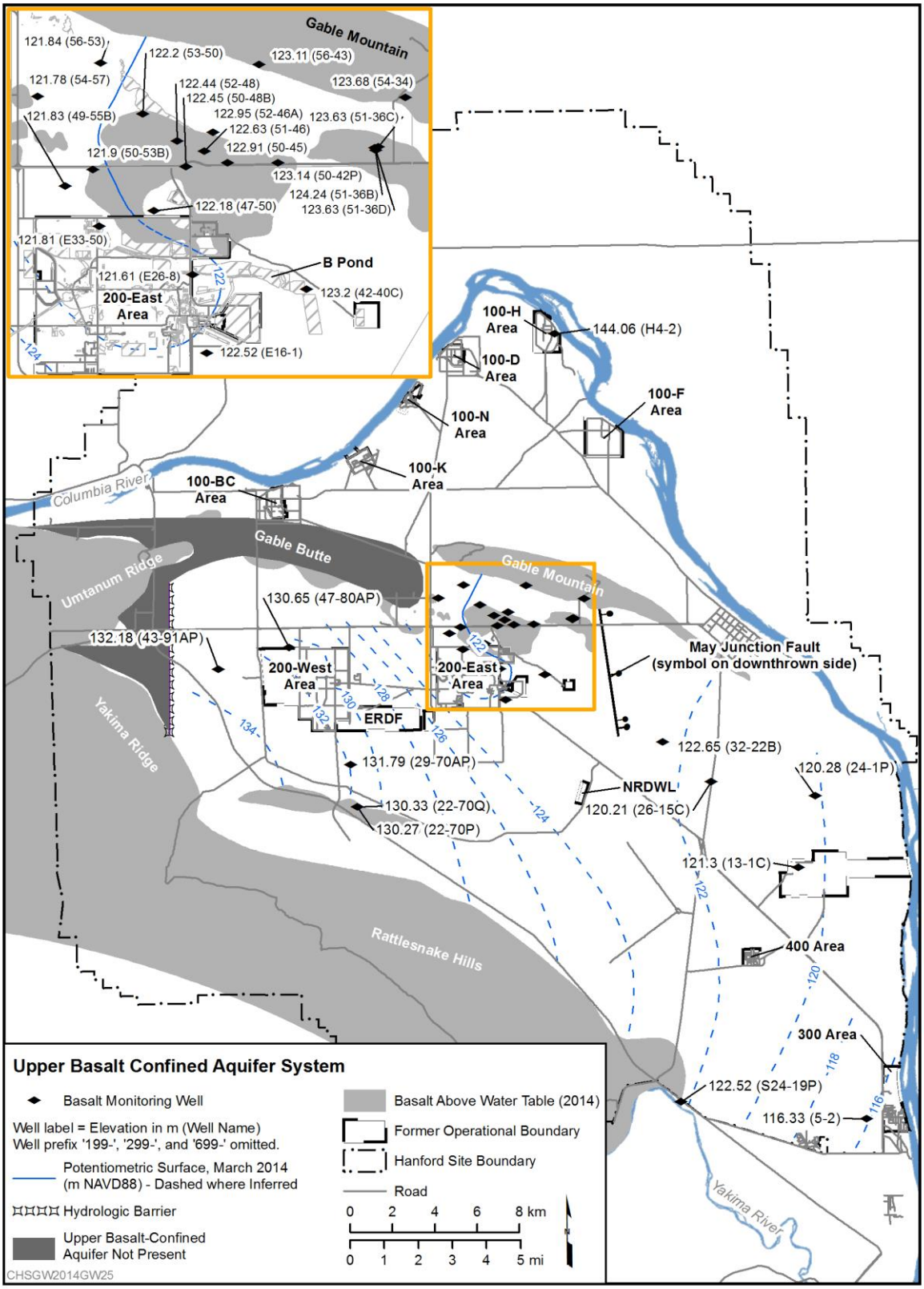


Figure D-4. Potentiometric Surface for Upper Basalt-Confined Aquifer, March 2014

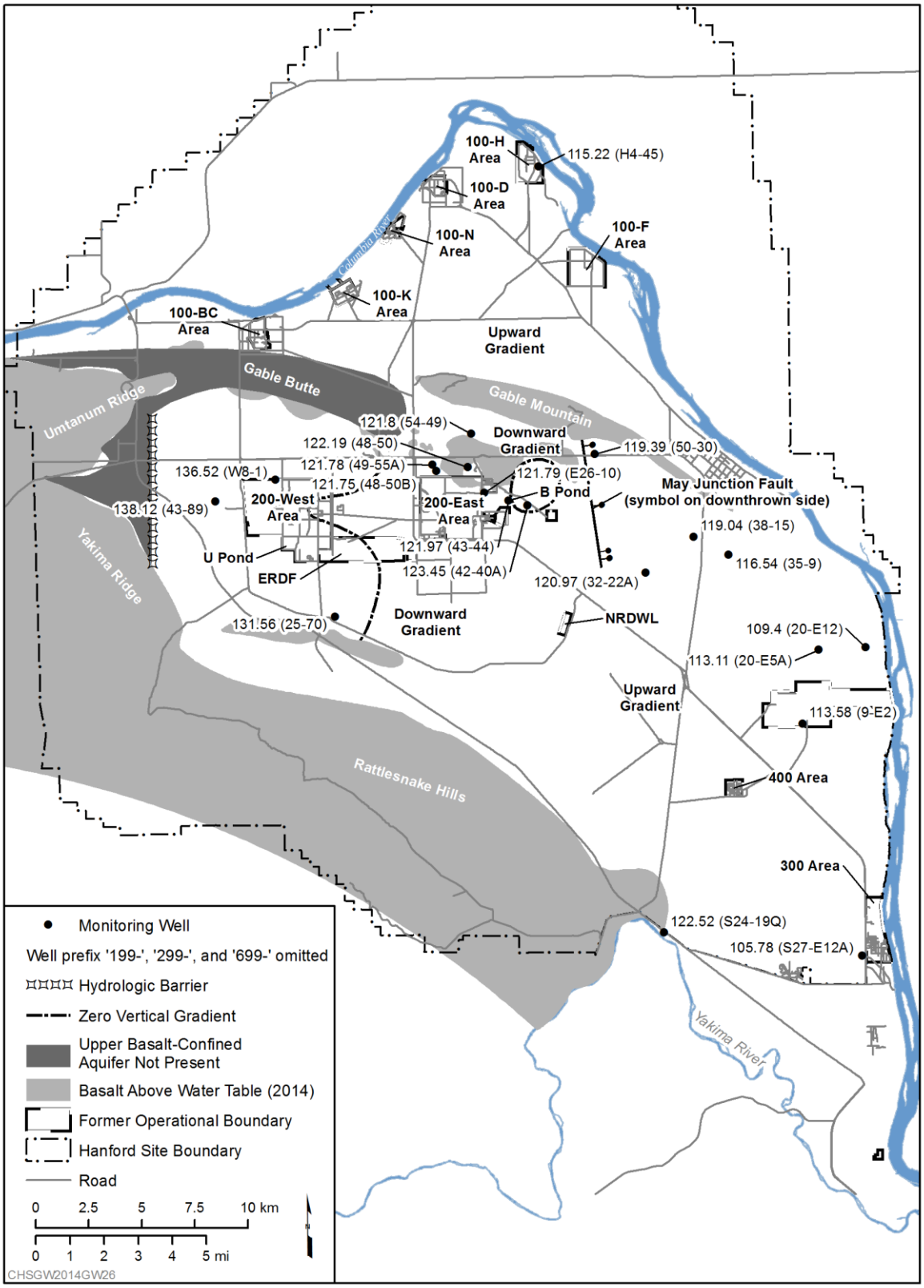


Figure D-5. Comparison of Observed Heads for Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer, 2014

Table D-1. Groundwater Quality in Ringold Confined Aquifers

Groundwater Interest Area	Wells Sampled	Groundwater Contamination[a] (DWS)
Wells Screened in Ringold Upper Mud Unit		
100-BC	199-B2-12, 199-B2-15	None
100-KR-4	199-K-32B, 199-K-192	None
100-NR	199-N-80	Hexavalent chromium (48 µg/L): up to 182 µg/L Tritium (20,000 pCi/L): up to 13,000 pCi/L
100-HR-D and 100-HR-H	199-D5-134, 199-D5-141, 199-D8-54B, 199-H2-1, 199-H3-10, 199-H3-2C, 199-H3-9, 199-H4-12C, 199-H4-15CS, 199-H4-90, 199-H4-91, 699-97-43C, 699-97-45B, 699-97-48C	Hexavalent chromium (48 µg/L): up to 179 µg/L
100-FR	199-F5-43B, 199-F5-53	None
Well Screened in Ringold Unit B		
100-HR-H	199-H4-15CR	None
Wells Screened in Ringold Unit A		
100-HR-H	199-H4-15CQ	None
200-ZP[b]	699-43-69, 699-45-69C	Carbon tetrachloride (5 µg/L) : up to 580 µg/L Chromium (filtered) (48 µg/L): up to 45.6 µg/L Nitrate (45 mg/L): up to 198 mg/L
200-UP	299-W22-24P, 699-42-67	Carbon tetrachloride (5 µg/L): up to 72 µg/L Nitrate (45 mg/L): up to 25.7 mg/L
200-BP	699-42-40A, 699-43-41G, 699-45-42	Iodine-129 (1 pCi/L): up to 2.2 pCi/L Tritium (20,000 pCi/L): up to 42,000 pCi/L
200-PO	699-24-1R, 699-28-40P, 699-40-36, 699-41-40, 699-42-37, 699-42-39B, 699-42-42B	Iodine-129 (1 pCi/L): up to 2.2 pCi/L Tritium (20,000 pCi/L): up to 34,000 pCi/L
300-FF	399-1-16C, 399-1-17C, 399-1-18C, 399-1-9, 399-8-5C, 699-S29-E16C	None

a. Evaluation based on data from 2012 through 2014.

b. Other wells in 200-ZP are screened in unit A where the lower mud is not present: 299-W6-6, 299-W7-3, 299-W11-88, 299-W12-2, 299-W12-3, 299-W14-73, and 299-W14-74. The aquifer is not confined at these locations, and results are not reported here.

Table D-2. Groundwater Quality in Upper Basalt-Confined Aquifer

Groundwater Interest Area	Wells Sampled	Groundwater Contamination[a]
100-H	199-H4-15CP	None
200-BP	299-E26-8, 299-E33-12, 299-E33-340, 299-E33-40, 699-42-40C, 699-49-55B, 699-49-57B, 699-50-45, 699-52-46A, 699-52-55B, 699-54-45B, 699-56-53	Cyanide: 27 µg/L[c] Iodine-129: undetected Nitrate: Up to 35.5 mg/L[c] Technetium-99: up to 1,000 pCi/L[c] Tritium: up to 3,200
200-PO	299-E16-1, 699-13-1C, 699-24-1P, 699-32-22B, 699-S11-E12AP, 699-S24-19P	None
300-FF	399-5-2	None
Offsite	699-42-E9B	None

a. Evaluation based on data 2011 through 2013.

b. Suspected corrosion product.

c. Not representative of basalt-confined aquifer. Migrated down wellbore from unconfined aquifer; see text.

Appendix E

Well Installation, Maintenance, and Decommissioning

This page intentionally left blank.

Contents

E1 Monitoring Well and Aquifer Tube Installation E-1

E2 Borings E-2

E3 Maintenance..... E-2

E4 Decommissioning..... E-2

Figures

Figure E-1. Categorization of Unique Well Identification Numbers..... E-4

Figure E-2. Hanford Site Wells and Aquifer Tubes Installed in 2014..... E-5

Tables

Table E-1. Hanford Site Well Types E-6

Table E-2. Wells Installed in 2014..... E-7

Table E-3. Aquifer Tubes Installed in 2014 ..... E-9

This page intentionally left blank.

E Well Installation, Maintenance, and Decommissioning

This chapter describes well installation, maintenance, and decommissioning activities on the Hanford Site in 2014. Numerous water wells were drilled or hand dug by early settlers for drinking water supplies, beginning in the early half of the 20th Century. Several thousand wells have been drilled since the early 1940s to support the Site's nuclear weapons production program. Since the 1990s, many additional wells have been drilled to support the Site's environmental cleanup mission.

All well types are tracked on the Hanford Site through the Well Information and Document Lookup (WIDL) database, which is available to users of the Hanford Local Area Network. Much of this information (borehole geophysical logging reports and data sheets) is also available to the public through the DOE Environmental Dashboard Application. Other data can be accessed via borehole summary reports that are generated for each drilling campaign.

Recognized well types onsite include aquifer tubes, borings, groundwater wells, hosted piezometers, independent piezometers, piezometer hosts, soil tubes, lysimeters, and vadose wells (Table E-1). All wells (cased and uncased), borings, aquifer tubes, soil tubes, piezometers, and other subsurface excavations are required to receive a unique Hanford well identification (ID) number. A total of 12,180 unique well ID numbers had been assigned on the Hanford Site by the end of 2014. The Washington State Department of Ecology (Ecology) also assigns a well ID number to each of these well types.

Figure E-1 presents the categorization of unique well ID numbers taken from WIDL and their approximate geographic designations. During 2014, 4,087 of these unique well ID numbers were documented to be in use, representing 2,990 wells, 122 piezometers within host wells, 79 lysimeters within host lysimeters, 509 aquifer tubes, and 387 soil tubes. Thus, of the 12,180 unique well IDs, 5,963 wells are candidates for decommissioning or have been decommissioned.

E1 Monitoring Well and Aquifer Tube Installation

DOE works with the appropriate regulatory agencies to define the need for new wells at the Hanford Site. Each year, DOE proposes new wells to meet the requirements of RCRA detection and assessment groundwater monitoring requirements; characterization, remediation, and monitoring for CERCLA; and long-term monitoring of regional groundwater plumes in accordance with DOE orders based on AEA requirements. These efforts may include new or ongoing RCRA assessment of groundwater contamination, replacement of monitoring wells that go dry because of the declining regional water table, replacement of wells that need to be decommissioned, improvement of spatial coverage for different monitoring networks and plume monitoring, and characterization of subsurface contamination.

New RCRA, CERCLA, and AEA monitoring well proposals are reviewed, prioritized, and approved annually in accordance with the Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) Milestone M-024. All new wells are constructed as either resource protection wells or water supply wells in accordance with WAC 173-160. Well requirements are integrated, prioritized, and documented through the budget development process, discussions between DOE and the regulatory agencies, and specific monitoring and characterization requirements.

During 2014, 30 wells were installed (Table E-2) and 6 aquifer tubes were installed (Table E-3) at the Hanford Site. The locations of the new wells are shown in Figure E-2. The 30 wells installed were completed (accepted) in 2014. In some cases, drilling began in 2013. Four of the wells installed were temporary wells (199-D5-155, 199-D5-156, 199-D5-157, and 199-D5-158), and were also decommissioned in 2014.

Water well reports for all newly constructed wells, as required by WAC 173-160, were submitted to Ecology. Detailed well information such as geologic and geophysical descriptions, characterization activities (that is, sediment and groundwater sampling, aquifer testing), and construction records for the new wells are stored in WIDL and consolidated in borehole summary reports. Much of this information is also accessible and available through the DOE Environmental Dashboard Application.

E2 Borings

During 2014, one boring was drilled for the 300-FF-5 Operable Unit (Figure E-2) to a depth of 12.1 m (39.7 ft). The borehole was drilled for post-ROD investigation purposes. Borings differ from wells in that no permanent casing or screen is installed and the borehole is decommissioned immediately after characterization is complete.

E3 Maintenance

During 2014, well maintenance was conducted 672 times on the different well types. Surface modifications included repair or replacement of locking well caps, surface casing repairs, diagnosis and repair of electrical wiring, labeling, electrical bonding, and modifications to surface pump and riser pipe discharge components and fittings. Subsurface tasks typically included repair and replacement of sampling pumps, downhole camera surveys, pump and equipment retrieval, and replacement of discharge tubing. Well rehabilitation activities included surging, swabbing, screen brushing, chemical treatment, and over-pumping to improve well performance.

Documentation for well maintenance activities is entered into the Well Maintenance Application database and accessible through WIDL. This information is also accessible externally through the DOE Environmental Dashboard Application.

E4 Decommissioning

This section describes the Hanford Site well decommissioned process. Four temporary wells in 100-D Area (199-D5-155, 199-D5-156, 199-D5-157, and 199-D5-158) were decommissioned in 2014. The wells were located in the 100-D-100 waste site excavation and were decommissioned so the excavation could be filled. In 2015

As part of DOE asset management, wells, boreholes, or other subsurface installations are identified for decommissioning when they are no longer useful for achieving the Hanford Site environmental cleanup mission. Well decommissioning is driven by DOE/RL-2005-70, *Hanford Site Well Decommissioning Plan*. Decommissioning is defined therein as the properly completed and documented sealing of water or resource protection wells in compliance with state groundwater protection laws (WAC 173-160). The plan lays out the basis, decision logic, and implementation process for prioritizing and decommissioning Hanford Site wells.

All candidate wells for decommissioning must be reviewed and approved by Hanford Site contractors, DOE, Ecology, EPA, and other potential well users such as the Pacific Northwest National Laboratory prior to decommissioning. The initial phase of decommissioning includes a thorough records review and physical inspection of each well to confirm the well's location and configuration (well attributes). Normally, a well becomes a candidate for decommissioning under one of the following conditions:

The well is no longer used for water level or contaminant monitoring, contaminant extraction, in situ remedial treatment of contaminated groundwater, permitted injection of treated effluent from a remedial action, water supply, research, or technology demonstration.

- The well has no specified future purpose.
- The well is unusable, abandoned, or permanently discontinued.
- The well is in such disrepair that its continued use is impractical.
- The well is an environmental, safety, or public health hazard (e.g.,, it does not meet WAC 173-160 requirements for well completion; however, there are special provisions for continued use of a non-WAC 173-160-compliant well).
- The well interferes with environmental remediation, excavation, and/or construction activities.

Decommissioning is performed in accordance with WAC 173-160-460 ("What Is the Decommissioning Process for Resource Protection Wells?"), applicable well decommissioning variances, and conditions defined in the Hanford Facility RCRA Permit (WA78900008967).

Decommissioning typically involves backfilling a well with impermeable material in both the annular space and the casing to prevent vertical movement of water and/or contaminants into the vadose zone and groundwater. For wells that are constructed according to WAC 173-160 requirements (compliant), decommissioning is performed by filling the well screen and the casing with an impermeable material (e.g., bentonite or cement grout). For older, noncompliant wells, the casing is either removed and the borehole is filled with seal material, or the casing is perforated and pressure grouted to create an external annular seal and then internally grouted to the surface. As far as possible, all casing is removed from the ground. A brass survey marker identifying the former well is typically set in cement grout at the ground surface over the decommissioned location. Decommissioning activities result in the permanent removal of a well, borehole, or piezometer from service and from the Hanford Site active well inventory.

A completed water well report form is required to be transmitted by the contractor or in-house driller to Ecology when a well is decommissioned. The report provides the details on the well's final construction and the steps taken to decommission the well.

Administratively decommissioned wells may be wells that can no longer be located and are determined to no longer exist; more generally, they are wells that were physically decommissioned but still require documentation describing this in the well database.

Each year a very limited number of previously unknown wells are usually discovered during the conduct of field activities. Once discovered, these wells are assigned a unique well ID number, assigned an appropriate well status, and added to WIDL. There were no well discoveries in 2014.

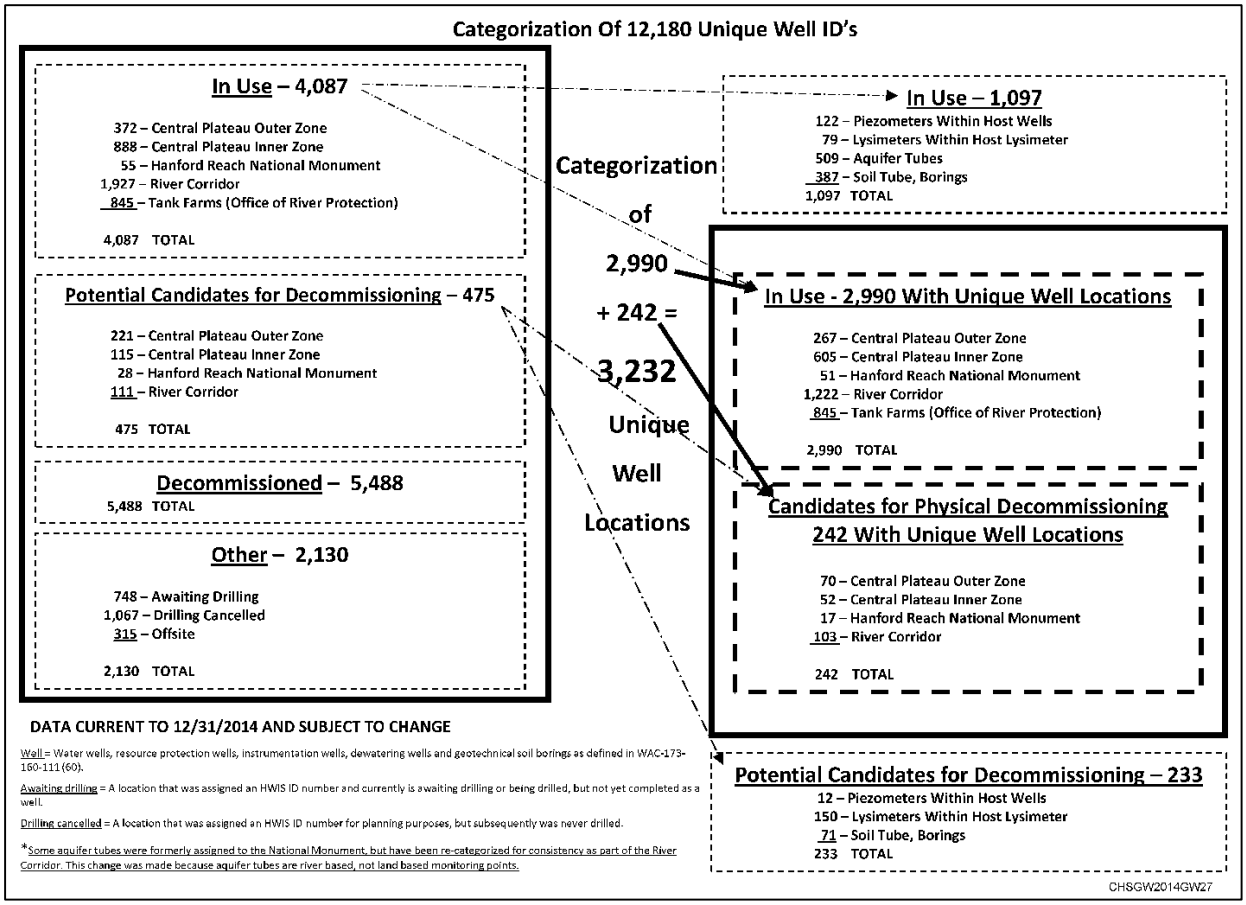


Figure E-1. Categorization of Unique Well Identification Numbers

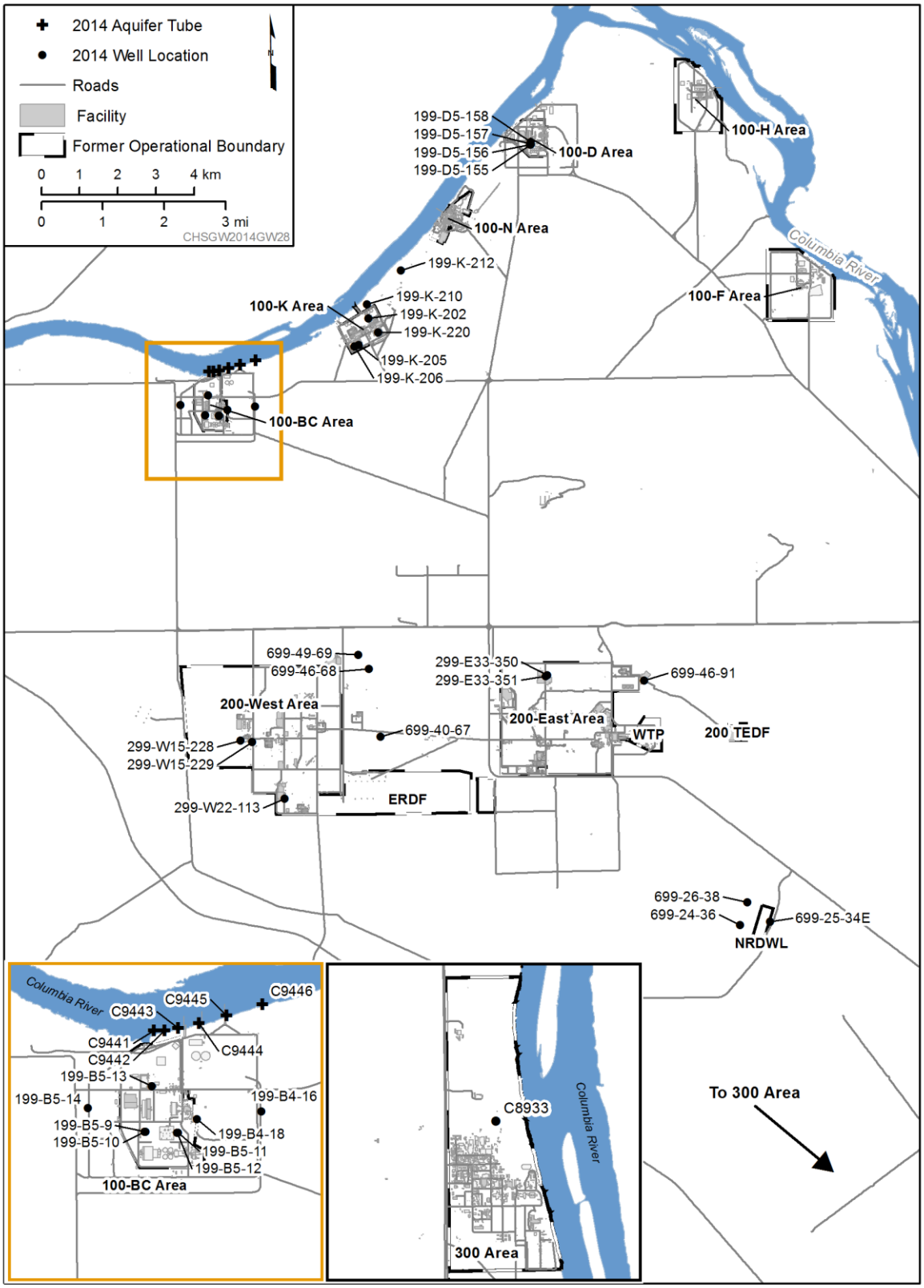


Figure E-2. Hanford Site Wells and Aquifer Tubes Installed in 2014

Table E-1. Hanford Site Well Types

Well Category	Description
Aquifer tube	A groundwater monitoring site installed along the river shoreline. Generally consists of a small diameter tube (less than one inch) and screen installed using push technology near the water table.
Boring	A borehole or direct push that was decommissioned immediately after drilling. Decommissioning generally would have been performed before the drill rig was removed from the site.
Groundwater well	A well constructed with the open interval extending below the water table. This is the general case and should not be used if the site could be otherwise classified as an aquifer tube, piezometer, or piezometer host.
Hosted piezometer	Groundwater monitoring well constructed inside of a host well. In most cases, hosted piezometers are one and one-half inch in diameter with the open interval extending below the water table.
Independent piezometer	Small diameter, independent, groundwater monitoring well not constructed inside of a host well. In most cases, the independent piezometers are one and one-half inch in diameter.
Lysimeter	Generally an in situ open bottom cylindrical core where the top is coincident with the ground surface, and with walls that prevent horizontal movement of moisture. A lysimeter is used to measure moisture or contaminant changes through time over a specific depth interval.
Piezometer host	A well with one or more piezometers constructed inside it.
Soil tube	Vadose zone monitoring site. A small diameter tube (less than two inches in diameter) and possibly a screen are left in place after the drilling is completed for sampling.
Vadose well	A vadose zone monitoring site where casing (greater than two inches in diameter) is left in place after drilling activities are completed. May have a screen, open bottom, or may be closed.

Table E-2. Wells Installed in 2014

Groundwater Interest Area	Well Name	Well ID	Well Purpose	Construction Depth (ft bgs)	Drilled Depth (ft bgs)	Acceptance Date
100-HR-D	199-D5-155	C8953	Temporary monitoring; multiple sampling ports	31.7	34.7	6/2/2014
100-HR-D	199-D5-156	C8954	Temporary monitoring; multiple sampling ports	31.9	35.9	6/2/2014
100-HR-D	199-D5-157	C8955	Temporary monitoring; multiple sampling ports	31.2	34.2	6/2/2014
100-HR-D	199-D5-158	C8956	Temporary monitoring; multiple sampling ports	28.7	32.8	6/2/2014
100-HR-D total = 4						
100-BC	199-B4-18	C8778	Monitoring	197.3	202.0	1/27/2014
100-BC	199-B5-13	C8783	Monitoring	172.9	223.4	1/27/2014
100-BC	199-B5-14	C8784	Monitoring	81.3	231.1	1/27/2014
100-BC	199-B5-9	C8779	Monitoring	189.3	205	1/27/2014
100-BC	199-B4-16	C8776	Monitoring	112.0	204.8	2/19/2014
100-BC	199-B5-10	C8780	Monitoring	98.0	100.7	2/19/2014
100-BC	199-B5-11	C8781	Monitoring	205.1	251.9	2/19/2014
100-BC	199-B5-12	C8782	Monitoring	104.0	104.4	2/19/2014
100-BC total = 8						
100-KR	199-K-202	C8289	Monitoring	157.1	160.1	4/7/2014
100-KR	199-K-205	C8292	100-KR-4 extraction (KW)	185.1	188.0	4/7/2014
100-KR	100-K-206	C8293	100-KR-4 injection (KW)	183.3	183.3	4/7/2014
100-KR	199-K-220	C8795	100-KR-4 extraction (KX)	169.2	171.3	7/16/2014
100-KR-	199-K-212	C8299	100-KR-4 extraction (KX)	81.9	85.8	7/16/2014
100-KR	199-K-210	C8297	100-KR-4 extraction (KX)	121.1	122.1	7/16/2014
100-KR total = 6						
200-UP	699-40-67	C8070	200 West Pump and Treat expansion – injection	534.9	535.1	9/2/2014
200-UP	299-W22-113	C8943	Monitoring	267.0	271.3	12/2/2014
200-UP total = 2						

Table E-2. Wells Installed in 2014

Groundwater Interest Area	Well Name	Well ID	Well Purpose	Construction Depth (ft bgs)	Drilled Depth (ft bgs)	Acceptance Date
200-PO	699-25-34E	C8200	Monitoring (SWL)	167.1	168.7	3/20/2014
200-PO	699-26-38	C8774	Monitoring (NRDWL)	169.1	169.9	3/20/2014
200-PO	699-24-36	C8772	Monitoring (SWL)	175.3	177.3	3/20/2014
200-PO total = 3						
200-BP	699-46-91	C8916	Monitoring	207.6	208.0	5/6/2014
200-BP	299-E33-350	C8914	Monitoring (perched water)	233.9	234.9	3/27/2014
200-BP	299-E33-351	C8915	Monitoring (perched water)	233.2	234.0	3/27/2014
200-BP total = 3						
200-ZP	699-46-68	C8067	200 West Pump and Treat expansion – injection	314.8	437	6/2/2014
200-ZP	299-W15-229	C8944	200 West Pump and Treat expansion – injection	455.0	479.5	9/24/2014
200-ZP	299-W15-228	C8716	200 West Pump and Treat expansion – injection	445.5	520.2	11/13/2014
200-ZP	699-49-69	C8786	200 West Pump and Treat expansion – injection	415	417.2	9/24/2014
200-ZP total = 4						
Grand total = 30						

bgs = below ground surface
ID = identification

Table E-3. Aquifer Tubes Installed in 2014

Groundwater Interest Area	Well Name	Well ID	Well Purpose	Construction Depth (ft bgs)	Drilled Depth (ft bgs)	Acceptance Date
100-BC	C9441	C9441	Remedial investigation	1	1	10/27/2014
100-BC	C9442	C9442	Remedial investigation	1	1	10/27/2014
100-BC	C9443	C9443	Remedial investigation	1	1	10/27/2014
100-BC	C9444	C9444	Remedial investigation	1	1	10/27/2014
100-BC	C9445	C9445	Remedial investigation	1	1	10/27/2014
100-BC	C9446	C9446	Remedial investigation	1	1	10/27/2014
100-BC total = 6						
Grand total = 6						

bgs = below ground surface
ID = identification

This page intentionally left blank.

Appendix F

Groundwater Monitoring Data Quality Assessment

This page intentionally left blank.

Contents

F1 Introduction F-1

F2 Purpose F-1

F3 Scope F-1

F4 Groundwater Monitoring Program Analytical Data Quality Requirements F-1

F4.1 Analyte Reporting Conventions F-4
F4.2 Field QC Sample Types F-4
F4.3 Laboratory Quality Control Sample Types F-7
F4.4 Qualification Flags F-8

F5 Data Completeness F-11

F5.1 Percentage of Successful Sampling Events F-11
F5.2 Percentage of Field Quality Control Samples Collected F-11
F5.3 Percentage of Useable Data F-11

F6 Laboratory Information and Analytical Methods F-16

F6.1 Laboratory Information F-16
F6.2 Analytical Methods F-16

F7 Sample Preservation and Holding Times F-19

F7.1 Sample Preservation F-24
F7.2 Holding Times F-25

F8 Field Quality Control F-27

F8.1 Field Blanks F-27
F8.2 Field Duplicate Samples F-37
F8.3 Quadruplicate Total Organic Carbon and Total Organic Halides Samples F-40
F8.4 Field Split Samples F-42

F9 Laboratory Quality Control F-44

F9.1 Laboratory Method Blanks F-48
F9.2 Laboratory Control Samples and Laboratory Control Sample Duplicates F-54
F9.3 Matrix Spikes and Matrix Spike Duplicates F-58
F9.3.1 Matrix Spikes by Laboratory F-66
F9.3.2 Matrix Spikes by Analyte Class F-67
F9.4 Laboratory Sample Duplicates F-68
F9.5 Surrogates and Surrogate Duplicates F-70

F10 Laboratory Performance F-74

F10.1 Quarterly Blind Standard Evaluations F-74
F10.2 National Performance Evaluation Studies F-79
F10.2.1 Water Pollution/Supply Performance Evaluation Studies F-79

F10.2.2InterLaB RadCheM Proficiency Testing Program Studies F-83
F10.2.3DOE Mixed Analyte Performance Evaluation Program F-84
F11 Data Usability Conclusions F-85
F11.1 Data Completeness F-85
F11.2 Sample Preservation and Holding Time F-85
F11.3 Field Quality Control F-85
F11.4 Laboratory Quality Control F-86
F11.5 Laboratory Performance F-86
F11.6 Conclusions F-87
F12 References F-89

Tables

Table F-1. Quality Control Acceptance Criteria for Groundwater Samples F-2
Table F-2. Quality Control Field Samples F-4
Table F-3. Laboratory Qualifier Data Quality Flags F-8
Table F-4. Review Qualifier Data Quality Flags F-9
Table F-5. Data Completeness Summarized by Method F-12
Table F-6. Analytical Methods F-17
Table F-7. Groundwater Sample Container, Preservative, and Holding Time Requirements F-21
Table F-8. Groundwater Sample Preservation Issues and Dispositions F-24
Table F-9. Missed Sample Holding Time Issues F-26
Table F-10. Field Blank Results Exceeding Quality Control Limits F-28
Table F-11. Out-of-Limit Field Blanks Compared with Out-of-Limit Method Blanks F-31
Table F-12. Field Duplicates Exceeding Quality Control Limits F-37
Table F-13. Total Organic Carbon and Total Organic Halide Quadruplicate Results Exceeding Quality Control Limits. F-41
Table F-14. Field Splits Exceeding Quality Control Limits F-42
Table F-15. Laboratory Quality Control Results by Laboratory F-44
Table F-16. Laboratory Quality Control Results by Analyte Class F-46
Table F-17. Method Blank Out-of-Limit Results F-49
Table F-18. Laboratory Control Sample Out-of-Limit Results F-54
Table F-19. Matrix Spike Out-of-Limit Results F-59
Table F-20. Laboratory Sample Duplicate Out-of-Limit Results F-68
Table F-21. Surrogate Out-of-Limit Results F-71
Table F-22. Groundwater Blind Standard Recovery and Precision Requirements[a,b] F-74

Table F-23. Blind Standards Laboratory Success Rates for CY2014 ..... F-75
Table F-24. CY2014 Blind Standard Out-of-Limit Results F-77
Table F-25. Summary of WSCF Performance Evaluation Studies F-80
Table F-26. Summary of TestAmerica Performance Evaluation Studies..... F-81
Table F-27. Summary of GEL Performance Evaluation Studies F-82

This page intentionally left blank

F Groundwater Monitoring Data Quality Assessment

F1 Introduction

This appendix presents the data quality assessment (DQA) for laboratory data generated from groundwater samples collected during calendar year 2014 (CY2014) as part of the Hanford Site groundwater monitoring program. The purpose of this DQA is to determine whether these data meet the data quality requirements specified in DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*, and CHPRC-00189, *CH2M HILL Plateau Remediation Company Environmental Quality Assurance Program Plan*.

For the groundwater monitoring program during CY2014, 1,271 wells, aquifer tubes, and springs were sampled over the extent of the Hanford Site. These sampling events generated 16,453 samples: 3,987 field samples, 3 common (field and lab) samples, and 12,463 laboratory samples. From these 16,453 samples, Field Sampling Operations generated 19,706 field measurements, and four analytical laboratories reported 147,457 laboratory results for a total of 167,163 measurements.

F2 Purpose

The purpose of this DQA is to determine whether the data generated from the CY2014 groundwater monitoring sampling effort meet the data quality requirements specified in DOE/RL-91-50 and CHPRC-00189. Meeting the data quality requirements of these documents provides assurance that the data collected are of sufficient quantity and quality for the groundwater monitoring program.

F3 Scope

This DQA focuses on the laboratory chemical and radiochemical data collected for the groundwater monitoring program. The data are evaluated to determine whether they meet the analytical criteria outlined in DOE/RL-91-50 and CHPRC-00189. The DQA methodology includes data verification and data usability evaluations.

- Data verification is the process of evaluating the completeness, correctness, and conformance/ compliance of a specific data set against the method, procedural, or contractual requirements. It includes confirmation that the specified sampling and analytical requirements have been completed as specified in DOE/RL-91-50 and CHPRC-00189. This evaluation is documented in Section F-5. In addition, verification is performed for field quality control (QC) samples in Section F-8 and for laboratory QC samples in Section F-9.
- The data usability assessment is a determination of the adequacy of the data to support the groundwater monitoring program requirements and is based upon the verification results. This evaluation is summarized in Section F-10.

F4 Groundwater Monitoring Program Analytical Data Quality Requirements

Table F-1 presents the groundwater monitoring program data requirements from DOE/RL-91-50 and CHPRC-00189. QC results for groundwater monitoring samples were evaluated against these requirements as part of this DQA (see Sections F-8 and F-9). The QC samples governed by the QC requirements may be divided into two components: field QC samples and laboratory QC samples. Sections F-4.2 and F-4.3 describe these two types of QC samples.

Table F-1. Quality Control Acceptance Criteria for Groundwater Samples

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action
General Chemical Parameters			
Alkalinity, chemical oxygen demand, conductivity, oil and grease, pH, total dissolved solids, total organic carbon, total organic halides, total petroleum hydrocarbons by GC[b]	MB[c] LCS DUP MS SUR EB, FTB Field Dup Field Split	<MDL 80% to 120% recovery ≤20% RPD[h] 75% to 125% recovery Statistically derived <2 times MDL ≤20% RPD[h] ≤20% RPD[i]	Flagged with "C" Data reviewed[d] Data reviewed[d] Flagged with "N" Data reviewed[d] Flagged with "Q" Flagged with "Q" Flagged with "Q"[e]
Ammonia and Anions			
Ammonia, anions, cyanide	MB LCS DUP MS EB, FTB Field Dup Field Split	<MDL 80% to 120% recovery ≤20% RPD[h] 75% to 125% recovery <2 times MDL ≤20% RPD[h] ≤20% RPD[i]	Flagged with "C" Data reviewed[d] Data reviewed[d] Flagged with "N" Flagged with "Q" Flagged with "Q" Flagged with "Q"[e]
Metals			
ICP metals, ICP-MS metals, mercury, uranium	MB LCS MS MSD EB, FTB Field Dup Field Split	<MDL[f] 80% to 120% recovery 75% to 125% recovery ≤20% RPD <2 times MDL ≤20% RPD[h] ≤20% RPD[i]	Flagged with "C" Data reviewed[d] Flagged with "N" Data reviewed[d] Flagged with "Q" Flagged with "Q" Flagged with "Q"[e]
Volatile Organic Compounds			
Volatiles by GC-MS	MB LCS MS MSD SUR EB, FTB, FXR Field Dup Field Split	<MDL[g] Statistically derived Statistically derived Statistically derived Statistically derived <2 times MDL[g] ≤20% RPD[h] ≤20% RPD[i]	Flagged with "B" Data reviewed[d] Flagged with "T" Data reviewed[d] Data reviewed[d] Flagged with "Q" Flagged with "Q" Flagged with "Q"[e]
Semivolatile Organic Compounds			
Herbicides by GC, PCBs by GC, pesticides by GC, phenols by GC, semivolatiles by GC-MS	MB LCS MS MSD SUR EB, FTB Field Dup Field Split	<2 times MDL Statistically derived Statistically derived Statistically derived Statistically derived <2 times MDL ≤20% RPD[h] ≤20% RPD[i]	Flagged with "B" Data reviewed[d] Flagged "N" or "T" Data reviewed[d] Data reviewed[d] Flagged with "Q" Flagged with "Q" Flagged with "Q"[e]

Table F-1. Quality Control Acceptance Criteria for Groundwater Samples

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action
Radiological Parameters			
Gamma scan, gross alpha, gross beta, iodine-129, plutonium (isotopic), strontium-89/90, technetium-99, tritium, tritium (low level), uranium (isotopic)	MB LCS DUP MS EB, FTB Field Dup Field Split	<2 times MDA 70% to 130% recovery ≤20% RPD[h] 60% to 140% recovery <2 times MDA ≤20% RPD[h] ≤20% RPD[i]	Flagged with "B" Data reviewed[d] Data reviewed[d] Flagged with "N" Flagged with "Q" Flagged with "Q" Flagged with "Q"[e]

Sources: DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*, and CHPRC-00189, *CH2M HILL Plateau Remediation Company Environmental Quality Assurance Program Plan*.

a. For the laboratory QC types LCS, DUP, MS, MSD, and SUR, laboratory-determined, statistical process-control limits were used when available, otherwise the limits shown is this table were used. For the laboratory duplicate types DUP, LCS duplicate, MSD, and SUR duplicate, the RPD limit of 20% was used if laboratory-determined limits were not available.

b. The source documents classify total petroleum hydrocarbons as a VOC. Total petroleum hydrocarbons have historically been classified as a general chemical parameter.

c. Does not apply to pH determinations.

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck, rerun, or flagging the associated groundwater monitoring data as suspect (Y flag) or rejected (R flag).

e. The source documents indicate that field splits with RPDs exceeding 20% are to be Q flagged. Prior to calendar year 2013, field splits were not Q flagged.

f. The source documents indicate that the method blank is to be compared to the required detection limit. Because the RDL is not readily accessible in the Hanford Environmental Information System database, the MDL was used instead. In most cases, the MDL is less than the required detection limit.

g. For the common laboratory contaminants 2-butanone, acetone, methylene chloride, toluene, and phthalate esters, the acceptance criterion is <5 times the MDL.

h. The RPD for duplicates is calculated only if at least one of the results is greater than or equal to five times the laboratory MDL or MDA.

i. The RPD for field splits is calculated only if at least one of the results is greater than or equal to five times the larger MDL or MDA of the two analyzing laboratories.

Data Flags:

B, C = Possible laboratory contamination (analyte was detected in the associated method blank).

N = Result may be biased (associated matrix spike result was outside the acceptance limits).

Q = Problem with associated field quality control sample (field blank, field duplicate, and/or field split results were out of limits).

T = Result may be biased (associated matrix spike result was outside the acceptance limits; used with GC-MS methods only).

DUP	= laboratory sample duplicate	MB	= method blank
EB	= equipment blank	MDA	= minimum detectable activity
FTB	= full trip blank	MDL	= method detection limit
FXR	= field transfer blank	MS	= matrix spike
GC	= gas chromatography	MSD	= matrix spike duplicate
GC-MS	= gas chromatography - mass spectrometry	PCB	= polychlorinated biphenyl
ICP	= inductively coupled plasma	RPD	= relative percent difference
ICP-MS	= inductively coupled plasma - mass spectrometry	SUR	= surrogate
LCS	= laboratory control sample		

F4.1 Analyte Reporting Conventions

To conform to the analyte reporting conventions used in the annual report and to provide comparability of analytical results among the reporting laboratories, the following analyte reporting conventions are used in this data quality assessment:

- **Ammonium:** Ammonia, nitrogen-in-ammonia, and nitrogen-in-ammonium results are converted to and evaluated as ammonium ion.
- **Nitrate:** Nitrogen-in-nitrate results are converted to and evaluated as nitrate.
- **Nitrite:** Nitrogen-in-nitrite results are converted to and evaluated as nitrite.
- **Phosphate:** Phosphorus-in-phosphate results are converted to and evaluated as phosphate.
- **Strontium-90:** Total-beta-radiostrontium results are evaluated as strontium-90.
- **Total organic halides:** Total-halogens-(all) results are evaluated as total organic halides (TOX).

F4.2 Field QC Sample Types

Field QC samples are used to assess the precision, repeatability, and potential contamination related to sampling and laboratory activities. Field QC samples include three types of field blanks (equipment blanks, full trip blanks, and field transfer blanks), field duplicates, and split samples. Table F-2 summarizes the various field QC sample types, their required collection frequencies, and the actual collection frequencies. Just as for groundwater samples, preservative reagents specific for the analyte(s) to be determined are added to the field QC sample bottles prior to the collection of the QC samples. All field QC samples are delivered to the laboratory without any differentiation between the field QC samples and actual groundwater samples. Table F-2 describes each type of field QC sample and its collection frequency.

Table F-2. Quality Control Field Samples

Field QC Sample Type	Number of Well Trips[a]	Number of QC Sample Sets Collected[b]	Frequency	
			Required[c]	Actual[d]
Full trip blanks	3,109	159	5%	5%
Field transfer blanks	211[e]	228	100%	108%
Equipment blanks	499[f]	72	10%[g]	14%
Field duplicates	3,109	210[h]	5%	7%
TOC quadruplicates	193[i]	209[j]	N/R	108%
TOX quadruplicates	189[i]	200[j]	N/R	106%
Field split samples	3,109	78[k]	as needed	3%

Sources: DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*, and CHPRC-00189, *CH2M HILL Plateau Remediation Company Environmental Quality Assurance Program Plan*.

a. Includes trips to wells, aquifer tubes, and springs. Well trips are counted only if they are associated with routine groundwater monitoring results in the Hanford Environmental Information System *RESULT* table.

Table F-2. Quality Control Field Samples

Field QC Sample Type	Number of Well Trips[a]	Number of QC Sample Sets Collected[b]	Frequency	
			Required[c]	Actual[d]

b. Values listed include only field blanks, field duplicates, and field split sample sets collected for routine groundwater monitoring sampling events. A QC sample set consists of all the QC samples of a particular QC sample type (e.g., full trip blanks or field duplicates) for a given well trip and may contain multiple sample numbers.

c. Required frequency is from DOE/RL-91-50 and CHPRC-00189.

d. Actual frequency = 100 x Number of QC Sample Sets / Number of Well Trips.

e. For each day that volatile organic compound samples are collected, one field transfer blank is required for each lab receiving that day's volatile organic compound samples. Multiple field transfer blanks may be required each day that volatile organic compound samples are collected if these samples are to be shipped to more than one lab for analysis.

f. Number of sampling events for which non-dedicated sampling equipment was used.

g. The 10% frequency is for routinely used, non-dedicated sampling equipment. For new types of non-dedicated sampling equipment, the equipment blank frequency is 100% until the decontamination procedure for the new equipment is shown to produce acceptable equipment blank results.

h. Number of pairs of field duplicate sample sets collected.

i. Number of well trips for which TOC or TOX samples were collected.

j. Number of sets of quadruplicate samples collected.

k. Number of pairs of field split sample sets collected.

N/R = not required

QC = quality control

TOC = total organic carbon

TOX = total organic halides

- Equipment blanks (EB) are samples of reagent water that are pumped or washed through non-dedicated sampling equipment. EBs are used to monitor the effectiveness of equipment decontamination procedures and to monitor for contamination associated with field sampling equipment.

- Full trip blanks (FTB) are samples that contain reagent water and any required preservatives. An FTB is used to check for contamination in sample bottles and laboratory sample preparation. The FTB is analyzed for all constituents of interest and is collected in the same types of sample bottles used to collect groundwater samples. The FTB is filled during bottle preparation using the same sample preparation used for regular well samples. FTBs are not opened in the field.

- Field transfer blanks (FXR) are analyzed for volatile organic compounds (VOC) and are used to check for VOC contamination associated with sampling activities. At the time of sample collection, the FXR is filled at the sampling site by pouring reagent water from a cleaned glass container into VOC sample vials pre-loaded with any required preservative. After collection, the FXR is treated in the same manner as the other samples collected during the sampling event. One FXR is collected each day groundwater samples are collected for VOCs. If the VOC samples collected on a given day will be shipped to multiple laboratories, then an FXR is collected for each laboratory for that day.

- Field duplicate samples are replicate samples collected to determine the precision of sampling and the laboratory analytical measurement process by comparing results with an identical sample collected at the same time and location. Matching field duplicates are collected and stored in separate containers and are analyzed as separate samples by the same laboratory.

- Split samples are replicate samples sequentially collected from the same location in the same sampling event and analyzed by different laboratories. Split samples are used to evaluate interlaboratory precision and comparability.

Field blank (FB) results are evaluated by comparison with two times the method detection limit (MDL) or minimum detectable activity (MDA) of the performing laboratory; field blank results that exceed that limit and the results for any samples associated with the FB are given a review qualifier of Q (Table F-4). Associated samples are those collected on the same day and analyzed by the same method as the corresponding FB.

Field duplicate sample results are evaluated only if at least one result is five times the laboratory MDL or MDA. Split sample results are evaluated only if at least one result is five times the larger of the laboratory MDL or MDA of the two analyzing laboratories. Field duplicate and field split samples that qualify are evaluated using the relative percent difference (RPD) between the duplicate or split sample pair. The RPD is a measure of precision and is calculated as shown in Equation F-1:

$$\mathrm{RPD} = \left| \frac{C_1 - C_2}{(C_1 + C_2)/2} \right| \times 100 \qquad \textbf{(Equation F-1)}$$

where:

C_1 = parent sample analyte concentration or activity

C_2 = duplicate sample analyte concentration or activity

A perfect match between the parent sample and its duplicate yields an RPD of 0%. Results for field duplicate samples that exceed the RPD limit of 20% are given a review qualifier of Q (Table F-4). Only the two samples of the duplicate pair are considered to be associated samples. Historically, split samples that exceed the RPD limit have not been Q flagged. However, split samples collected since CY2013 that have results exceeding the RPD limit have been Q flagged. Only the two samples of the split pair are considered to be associated samples.

Total organic carbon (TOC) and TOXs are *Resource Conservation and Recovery Act of 1976* (RCRA) indicator analytes; samples for these analytes are usually taken in quadruplicate (40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis"). Field quadruplicate sample results are evaluated only if at least one result is at least five times the laboratory MDL. Field quadruplicate results that qualify are evaluated using the percent relative standard deviation (%RSD) within the quadruplicate sample set. The %RSD is a measure of precision and is calculated as shown in Equation F-2:

$$\%\mathrm{RSD} = \frac{\sqrt{\frac{\Sigma_{i=1}^{n} (C_i - \overline{C})^2}{(n-1)}}}{\overline{C}} \times 100 \qquad \textbf{(Equation F-2)}$$

where:

C_i = i^{th} sample concentration

$\overline{C}$ = average sample concentration

n = number of results (usually four)

A perfect match of results within a quadruplicate sample set yields a %RSD of 0%. For any results in a qualifying quadruplicate data set that were less than the laboratory MDL, MDLs were used to compute the %RSD. Quadruplicate split sample results are evaluated only if at least one quadruplicate average is greater than or equal to five times the larger of the laboratory MDLs of the two analyzing laboratories. To determine the precision of a set of split quadruplicate samples, the RPD of the two averages for the quadruplicate split samples is determined and compared to 20%. Results for field quadruplicate samples that exceed a %RSD of 20% or quadruplicate split samples that exceed an RPD of 20% are not given a review qualifier.

F4.3 Laboratory Quality Control Sample Types

Laboratory quality assurance (QA)/QC requirements govern nearly all aspects of analytical laboratory operation, including instrument procurement, maintenance, calibration, and operation. During the analysis of groundwater samples, laboratory QC samples are used to assess potential sample contamination, precision, and accuracy related to laboratory activities. Laboratory QC samples may include method blanks (MB), laboratory control samples (LCS), laboratory control sample duplicates (LCSD), matrix spike (MS) samples, matrix spike duplicates (MSD), and surrogates. The following bullets describe each type of laboratory QC sample and the way they are evaluated.

- Laboratory MBs provide a measure of the cleanliness during sample preparation and analysis. The appearance of measurable analytes in the MB may indicate contamination of customer samples during the analytical process.
- Laboratory sample duplicates, LCSDs, MSDs, and surrogate duplicates provide a measure of the reproducibility of the analytical process. The RPD is the metric used to determine reproducibility (Equation F-1). Laboratory sample duplicates qualify for evaluation only if at least one result is five times the laboratory MDL.
- LCSs, MSs, and surrogates contain known amounts of analytes and provide a measure of the accuracy of the analytical process. Percent recovery is the metric used to determine analytical accuracy (Equation F-3). Percent recoveries consistently less than or greater than 100% may indicate a bias in the analytical process.

These laboratory QC samples are included in sample preparation and analytical batches along with customer samples. An analytical batch typically consists of a maximum of 20 customer samples. The numbers and types of QC samples included in sample batches are dictated by the analytical method being used. Analytical methods usually employ only a subset of the available types of QC samples. At a minimum, most sample preparation and analytical methods include a MB, one of the duplicate types (e.g., sample duplicate), and one of the standard types (e.g., laboratory control sample).

Laboratory analytical accuracy for LCSs, MSs, and surrogates is evaluated using percent recovery as shown in Equation F-3:

$$\text{Percent Recovery} = \frac{C_m}{C_a} \times 100 \qquad \textbf{(Equation F-3)}$$

where:

C_m = measured analyte concentration or activity

C_a = actual, known analyte concentration or activity

Perfect recovery of the measured analyte concentration or activity yields a percent recovery of 100%.

F4.4 Qualification Flags

During the generation and evaluation of environmental analytical data, any of several qualification flags may be assigned to an individual result. The Hanford Environmental Information System (HEIS) database carries qualification flags applied from three sources: the laboratory (laboratory qualifier), a data reviewer (review qualifier), or a third party data validator (validation qualifier). Table F-3 presents the laboratory qualifier flags and Table F-4 outlines the review qualifier flags. For the CY2014 groundwater monitoring data set, no third party validation was performed, and no validation qualifiers were applied to the data set.

Table F-3. Laboratory Qualifier Data Quality Flags

Flag	Definition
B	Inorganics and wetchem* – The analyte was detected at a value greater than or equal to the MDL but less than the CRDL. Organics – The analyte was detected in both the associated method blank and in the sample. Radionuclides – The associated method blank has a result >= 2x the MDA and, after corrections, the result is >= MDA for this sample.
C	Inorganics and wetchem* – The analyte was detected in both the sample and the associated method blank, and the sample concentration was less than or equal to five times the blank concentration.
D	All – Analyte was determined using a secondary dilution factor greater than one. The primary preparation required additional dilution either to bring the analyte within the calibration range or to minimize interference.
E	Inorganics – Reported value is estimated because of interference. See any comments that may be in the laboratory report case narrative. Organics – Concentration exceeds the calibration range of the GC-MS.
J	Organics – The analyte was detected at a value greater than or equal to the MDL but less than the CRDL.
N	All (except GC-MS methods) – The matrix spike recovery is outside control limits. The associated sample data may be biased.
O	All – The laboratory control sample recovery is outside control limits.
T	Organics (GC-MS methods only) – The matrix spike recovery is outside control limits. The associated sample data may be biased.
U	All – The constituent was analyzed for but was not detected.
X	All – Indicates a result-specific comment is provided in the data report and/or case narrative.

* Wetchem is a miscellaneous group of analytical methods such as the colorimetric determination of hexavalent chromium, the titrimetric determination of alkalinity, or the distillation and titrimetric determination of sulfide.

CRDL = contract required detection limit
GC-MS = gas chromatograph - mass spectrometer
MDA = minimum detectable activity
MDL = method detection limit

Table F-4. Review Qualifier Data Quality Flags

Flag	Definition
A	Indicates an issue with the chain of custody that could affect data integrity.
F*	Result is undergoing further review. This review qualifier is assigned when a RDR is first processed.
G*	Result has been reviewed through the RDR process and determined to be correct, or the laboratory has supplied a corrected result after reviewing the original result or after reanalyzing the sample.
H	Laboratory holding time was exceeded before the sample was analyzed.
P*	Potential problem. Collection/analysis circumstances make the result questionable.
Q	An associated QC sample is out of limits; the associated sample number is listed in the Result Comment field for the Q-flagged result. See Section F-4.2 for the definition of associated samples.
R*	Do not use. Further review indicates the result is not valid. This review qualifier is used only when documented evidence exists that the result is not valid. Generally, results that are "R" qualified will be excluded from statistical evaluations, maps, and other interpretations.
Y*	Result is suspect. Review had insufficient evidence to show result valid or invalid.
Z*	Miscellaneous circumstance exists. Additional information for this record may be found in the Result Comment field in the HEIS *RESULT* table and/or in the Sample Comment field in the HEIS Sample table.

* These flags are applied as part of the RDR process.

HEIS = Hanford Environmental Information System database

QC = quality control

RDR = Request for Data Review

Of the review qualifier flags, the Request for Data Review (RDR) process most commonly generates F, G, R, and Y flags (Table F-4). The F flag indicates the analytical result is under review within the RDR process; an F flag is typically resolved to a G flag, R flag, or Y flag during the RDR process. The G flag indicates that the result has been reviewed within the RDR process and determined to be valid. In some cases, the G flag is applied to a result after the old, reviewed result has been replaced by a new value from the laboratory; the new laboratory value may be a correction of the originally reported value or may be from a re-analysis of the sample. The R flag indicates the analytical result has been reviewed and rejected as invalid based upon a known reason such as an instrument calibration failure. The Y flag indicates the analytical result has been reviewed and is considered questionable based on additional evidence, such as a result that does not fit with the historical trend for the sample source and is inconsistent with related parameters.

The Q flag review qualifier is applied to the analytical results of those samples associated with field QC samples having analytical results that exceed the QC criteria given in DOE/RL-91-50 and CHPRC-00189 and outlined in Table F-1. Associated samples are defined in Section F-4.2.

This page intentionally left blank

F5 Data Completeness

Data completeness is a measure of how much of the data set is judged to meet the quality criteria and thus is useable for the groundwater monitoring program. The completeness goal is determined as a percentage of data judged "good" versus all data collected for the program and is set at a minimum of 85%[1] (DOE/RL-91-50). Completeness statistics are calculated and presented for:

- The percentage of successful sampling events during CY2014 versus the number of scheduled sampling events
- The percentage of field QC samples collected versus the number of QC samples required
- The percentage of the data set that meets quality criteria.

F5.1 Percentage of Successful Sampling Events

During CY2014, 2,987 sampling events were planned, and 2,981 of these sampling events were successfully executed for a sampling event completion rate of 99.8%. An additional 245 sample events originally scheduled for CY2013 were sampled in CY2014 for a total of 3,232 well trips during CY2014 in support of groundwater monitoring. Sources sampled included wells, aquifer tubes, and springs. This completion rate indicates that sufficient sampling events were completed to meet groundwater monitoring program requirements. The 3,109 well trips listed in Table F-2 reflect only those CY2014 sampling events that resulted in groundwater monitoring field and laboratory data appearing in the HEIS *RESULT* table.

F5.2 Percentage of Field Quality Control Samples Collected

The types and collection frequencies of field QC samples for the groundwater monitoring program are given in DOE/RL-91-50 and CHPRC-00189; the collection of quadruplicate samples at RCRA sites for TOC and TOX is mandated by 40 CFR 265.92. Section F-4.2 gives a more complete discussion of field QC samples. Table F-2 summarizes those QC types, their required collection frequencies, and the actual collection frequencies. The table indicates that the requirements for the minimum collection frequencies for groundwater monitoring field QC samples were met during CY2014.

To determine the collection frequency for EBs, the only non-dedicated sampling equipment currently tracked in the electronic database are "Bailer", "Kabis", and "Portable Grundfos." Non-dedicated sampling manifolds are also used for collection of some groundwater samples, but are not tracked in the database. Consequently, the number of well trips for EBs reported in Table F-2 underestimates the actual number of well trips that use non-dedicated sampling equipment, and the actual sampling frequency for EBs is less than 17%. Until the use of non-dedicated sampling manifolds is tracked, a more accurate estimate of the actual sampling frequency for EBs is unavailable.

For the TOC and TOX quadruplicate samples, the sampling frequency is slightly greater than 100% due to the collection of eleven split sample sets for TOC and a single split sample set for TOX.

F5.3 Percentage of Useable Data

This section provides an overview of data usability; subsequent sections provide detailed information regarding data compliance with quality requirements.

[1] DOE/RL-91-50 defines this completeness goal on a quarterly basis. For this data quality assessment, the completeness goal is applied over the entire calendar year.

Table F-5 summarizes the percentage of useable groundwater monitoring data generated from samples collected during CY2014; overall data completeness is 96.7%. This is well above the data completeness goal of 85% as specified in DOE/RL-91-50 and indicates that the large majority of data collected for the groundwater monitoring program is useable. The CY2014 data completeness rate of 96.7% is similar to the 97.4% rate of CY2013 and the 96.6% rate of CY2012.

Data completeness was judged on the following:

- F, R, and Y review qualifier flags associated with the data[2]
- Q-flag review qualifiers for data associated with FBs exhibiting possible contamination, data with poor field-sample-duplicate reproducibility, or data with poor field-split reproducibility
- Samples with missed holding times
- Samples with laboratory qualifiers indicating MB contamination.

Table F-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
Overall Percent Complete = 96.7%								
Overall Totals:	***167,163***	***853***	***131***	***809***	***1,704***	***787***	***1,380***	***5,486***
General Chemical Parameters: Percent Complete = 98.4%								
Totals	***27,167***	***14***	***14***	***159***	***150***	***73***	***44***	***429***
160.1_TDS	12	1	-	-	-	-	-	1
1664A_OILGREASE	11	-	-	4	2	1	-	7
2320_ALKALINITY	2,880	-	2	40	34	4	-	80
2540C_TDS	22	-	-	-	-	-	4	4
310.1_ALKALINITY	2,017	2	2	-	42	64	5	98
360.1_OXYGEN_FLD	2,282	2	2	13	-	-	-	17
410.4_COD	32	-	-	-	-	-	-	-
8015M_TPH_GC	21	-	-	-	-	-	-	-
9020_TOX	947	-	-	-	59	4	-	61
9060_TOC	1,305	4	-	62	7	-	35	102
9223_COLIFORM	32	-	-	-	-	-	-	-
CONDUCT_FLD	3,986	3	3	10	-	-	-	16
PH_ELECT_FLD	3,990	1	1	10	-	-	-	12

[2] The F flag review qualifier ("result in review") was included in the assessment of CY2013 groundwater monitoring results for this report. After the RDR review, F-flagged results will be resolved to one of the other RDR flags as appropriate.

Table F-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
REDOX_PROBE_FLD	1,468	-	1	-	-	-	-	1
TEMP_FLD	3,990	-	1	10	-	-	-	11
TURBIDITY_FLD	3,980	1	2	10	-	-	-	13
WTPH_DIESEL	153	-	-	-	4	-	-	4
WTPH_GASOLINE	39	-	-	-	2	-	-	2
Ammonia and Anions: Percent Complete = 92.3%								
Totals	***12,885***	***6***	***9***	***50***	***208***	***696***	***60***	***993***
300.0_ANIONS_IC	8,373	6	7	50	154	410	41	646
300.7_CATIONS_IC	25	-	-	-	-	-	-	-
350.1_AMMONIA	113	-	-	-	11	8	6	20
376.1_SULFIDE	8	-	-	-	-	-	-	-
4500D_SULFIDE	29	-	-	-	-	-	-	-
4500E_CN	78	-	-	-	-	2	-	2
9012_CYANIDE	164	-	1	-	2	-	9	10
9034_SULFIDE	15	-	-	-	2	-	4	5
9056_ANIONS_IC	4,080	-	1	-	39	276	-	310
Metals: Percent Complete = 95.9%								
Totals	***80,716***	***828***	***96***	***563***	***737***	***18***	***1,161***	***3,306***
200.8_METALS_ICPMS	7,023	5	2	397	251	2	35	671
6010_METALS_ICP	32,334	10	9	124	118	-	292	551
6010_METALS_ICP_TR	15,265	24	57	-	139	-	312	513
6020_METALS_ICPMS	22,430	22	14	-	208	-	519	713
7196_CR6	3,059	761	14	42	4	16	1	835
7470_HG_CVAA	136	-	-	-	-	-	2	2
COLOR_TK_FE_FLD	10	-	-	-	-	-	-	-
UTOT_KPA	459	6	-	-	17	-	-	21
Volatile Organic Compounds: Percent Complete = 97.8%								
Totals	***25,326***	***-***	***9***	***20***	***445***	***-***	***108***	***563***

Table F-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
8015_VOA_GC	65	-	1	-	-	-	-	1
8260_VOA_GCMS	25,256	-	8	20	445	-	108	562
RSK175_VOA_HDSPC_GC	5	-	-	-	-	-	-	-
Semi-Volatile Organic Compounds: Percent Complete = 100.0%								
Totals	***11,486***	***-***	***-***	***-***	***-***	***-***	***2***	***2***
8081_PEST_GC	461	-	-	-	-	-	-	-
8082_PCB_GC	175	-	-	-	-	-	-	-
8270_SVOA_GCMS	10,850	-	-	-	-	-	2	2
Radiological Parameters: Percent Complete = 98.0%								
Totals	***9,583***	***5***	***3***	***17***	***164***	***-***	***5***	***193***
906.0_H3_LSC	441	-	1	-	3	-	-	3
906.0ML_H3_LSC	11	-	-	-	-	-	-	-
9310_ALPHABETA_GPC	1,346	2	-	-	17	-	-	19
ALPHA_GPC	297	-	-	-	4	-	-	4
AMCMISO_EIE_PLT_AEA	12	-	-	-	-	-	-	-
AMCMISO_EIE_PREC_AEA	10	-	-	-	-	-	-	-
AMCMISO_IE_PREC_AEA	13	-	-	-	3	-	-	3
BETA_GPC	358	-	1	-	50	-	-	51
C14_LSC	315	-	-	-	-	-	-	-
GAMMA_GS	3,134	-	-	-	-	-	-	-
I129_SEP_LEPS_GS	36	-	-	-	-	-	-	-
I129LL_SEP_LEPS_GS	370	-	-	1	14	-	-	15
NP237_IE_PRECIP_AEA	25	-	-	-	-	-	-	-
NP237_LLE_PLATE_AEA	10	-	-	-	-	-	-	-
PUISO_IE_PRECIP_AEA	68	-	-	-	-	-	-	-
PUISO_PLATE_AEA	126	-	-	-	-	-	-	-
SE79_SEP_IE_LSC	19	-	-	-	2	-	-	2
SRISO_SEP_PRECIP_GPC	171	-	-	-	-	-	-	-

Table F-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
SRTOT_SEP_PRECIP_GPC	829	3	1	5	30	-	2	41
TC99_3MDSK_LSC	271	-	-	1	19	-	-	20
TC99_EIE_LSC	276	-	-	-	5	-	-	5
TC99_ETVDSK_LSC	312	-	-	-	-	-	-	-
TC99_SEP_LSC	4	-	-	-	-	-	-	-
THISO_IE_PLATE_AEA	75	-	-	-	-	-	-	-
TRITIUM_DIST_LSC	425	-	-	-	2	-	-	2
TRITIUM_EIE_LSC	392	-	-	10	5	-	-	15
UISO_IE_PLATE_AEA	9	-	-	-	1	-	-	1
UISO_IE_PRECIP_AEA	183	-	-	-	9	-	3	12
UISO_PLATE_AEA	45	-	-	-	-	-	-	-

a. Groundwater monitoring results were pulled from the HEIS on February 12, 2015 and include both field and laboratory results.

b. Results in review have a review qualifier of F-

c. Suspect results have a review qualifier of Y.

d. Rejected results have a review qualifier of R.

e. The value in the *Results Flagged* column may be less than the sum of the values in the individual flag columns if the same result has multiple QC issues.

HEIS = Hanford Environmental Information System database

QC = quality control

Of the 167,163 total results noted in Table F-5, 96.7% met QC requirements. Of the 5,486 QC failures summarized in the table, 31.1% of the results were due to out-of-limit field QC and were Q-flagged, and 25.2% were due to out-of-limit MBs. Of the 1,704 Q-flagged results, 81.8% were Q-flagged for associated out-of-limit field blanks, 13.6% for field duplicates exceeding the RPD limit, and 5.6% for field splits exceeding the RPD limit. These Q-flag percentages may sum to greater than 100% because a result may be flagged for multiple field QC issues (e.g. out-of-limit field blank and out-of-limit field duplicate). Details of the issues associated with these QC failures are provided in subsequent sections.

The poorest completion rate was 92.3% for ammonia and anions; most of the failures were for anions determined by ion chromatography (EPA Method 300.0, *Determination of Inorganic Anions by Ion Chromatography*, and EPA Method 9056, *Determination of Inorganic Anions by Ion Chromatography*). Of the QC failures for ammonia and anions, 70.1% were due to missed holding times.

After ammonia and anions, metals had the next poorest completion rate at 96.2%. Hexavalent chromium had the largest number of review-qualified results. Nearly all the hexavalent chromium results with review qualifiers of F, P, R, or Y were generated at TARL. After the closure of the WSCF facility, TARL

became the primary laboratory performing hexavalent chromium determinations for groundwater samples. To handle the increased sample load, TARL adopted an automated method to replace their manual method. Initially, the automated method did not perform sample turbidity corrections (WSCF's automated hexavalent chromium method did perform turbidity corrections). Consequently, many samples that were not field filtered showed a high bias in hexavalent chromium results compared to filtered sample results, ICP-MS total chromium values, and historical trends of hexavalent chromium values. Those hexavalent chromium values that have a review qualifier of F at the time of this report will be resolved to G, P, R, or Y flags after further data review. TARL implemented automated turbidity corrections in January, 2015, after Soil and Groundwater Remediation Project personnel identified the issue.

Of the other metals, nickel had the Q review qualifier applied to 108 of 3,471 results. Most (87.0%) of the Q flags were applied for contamination of an associated FB.

The remaining completion rates were 98.4% for the general chemical parameters, 97.8% for the volatile organic compounds, 100.0% for the semivolatile organic compounds, and 98.0% for the radiochemical parameters.

F6 Laboratory Information and Analytical Methods

Samples collected for the groundwater monitoring program were sent to the four laboratories described in Section F-6.1 for analysis. Each sample is tracked by a unique HEIS database number. Analytical requests for chemical and radiochemical services to be completed by the laboratories were documented on the chain-of-custody forms. Analytical results provided by the laboratories were documented by sample data group (SDG) in data packages. The analytical results were also electronically uploaded and stored in the HEIS database.

F6.1 Laboratory Information

The samples collected were analyzed at the following four laboratories:

- GEL Laboratories, LLC (GEL, Charleston, South Carolina) provided sample analysis for chemical and radiochemical constituents; GEL Laboratories generated about 33.3% of the analytical laboratory results.
- TestAmerica Richland (TARL, Richland, Washington) provided sample analysis for chemical and radiochemical constituents; TARL generated 5.0% of the analytical laboratory results.
- TestAmerica St. Louis (TASL, St. Louis, Missouri) provided sample analysis for chemical and some radiochemical constituents; TASL generated 29.0% of the analytical laboratory results.
- Waste Sampling and Characterization Facility (WSCF, Hanford Site, managed by Mission Support Alliance, LLC) performed chemical and radiochemical analyses on groundwater samples. WSCF generated 32.7% of the analytical laboratory results. This laboratory was shut down by the U.S. Department of Energy (DOE) in 2014. As of May 5, 2014, WSCF's groundwater monitoring sample load was redirected to the three commercial laboratories listed above.

Sections F-8 and F-9 discuss the analytical data provided by these laboratories.

F6.2 Analytical Methods

For the analysis of chemical constituents, the analyzing laboratories used standard methods from U.S. Environmental Protection Agency (EPA), ASTM International (formerly American Society for

Testing and Materials), and the American Public Health Association. For radiological constituents, the analyzing laboratories employed methods that are recognized as acceptable within the radiochemical industry.

Samples were analyzed using the methods listed in Table F-6. Both single-component and multiple-component analytical methods were used. Single-component analytical methods, such as EPA Method 9012 for cyanide or EPA method 7470 for mercury, yield a single analytical result per analysis. Multi-component analytical methods, such as EPA Method 200.8 for inductively coupled plasma - mass spectrometry metals or EPA method 8260 for gas chromatography - mass spectrometry for VOCs, yield results for multiple analytes per analysis. Multi-component methods may generate results for both target and non-target analytes.

Table F-6. Analytical Methods

Parameter	Analytical Method	Source
General Chemical Parameters		
Alkalinity	EPA Method 310.1	EPA[a]
Alkalinity	Standard Method 2320	Standard Methods[b]
Chemical Oxygen Demand	EPA Method 410.4	EPA[c]
Coliform	Standard Method 9223	Standard Methods[b]
Oil and Grease	EPA Method 1664A	EPA[d]
Total Dissolved Solids	EPA Method 160.1	EPA[a]
Total Dissolved Solids	Standard Method 2540C	Standard Methods[b]
Total Organic Carbon (TOC)	EPA Method 9060	EPA[e]
Total Organic Halides (TOX)	EPA Method 9020	EPA[e]
Total Petroleum Hydrocarbons	EPA Method 8015 (modified)	EPA[e]
Total Petroleum Hydrocarbons - Gasoline	NWTPH-Gx	Washington State Department of Ecology[f]
Total Petroleum Hydrocarbons - Kerosene	NWTPH-Dx	Washington State Department of Ecology[f]
Ammonia and Anions		
Ammonium Ion	EPA Method 350.1	EPA
Anions by Ion Chromatography	EPA Method 300.0	EPA[g]
Anions by Ion Chromatography	EPA Method 9056	EPA[e]
Cations by Ion Chromatography	EPA Method 300.7	EPA[h]
Cyanide	Standard Method 4500E-CN	Standard Methods[b]
Cyanide	EPA Method 9012	EPA[e]
Sulfide by Titrimetry	EPA Method 376.1	EPA
Sulfide	EPA Method 9034	EPA[e]
Sulfide	Standard Method 4500D-Sulfide	Standard Methods[b]

Table F-6. Analytical Methods

Parameter	Analytical Method	Source
Metals		
Hexavalent Chromium	EPA Method 7196	EPA[e]
Mercury	EPA method 7470	EPA[e]
Metals by ICP-AES	EPA Method 6010	EPA[e]
Metals by ICP-MS	EPA Method 200.8	EPA[i]
Metals by ICP-MS	EPA Method 6020	EPA[e]
Uranium	ASTM D5174	ASTM
Volatile Organic Compounds		
Non-Halogenated Volatiles by GC	EPA Method 8015	EPA[e]
Non-Halogenated Volatiles by Headspace Equilibrium - GC	EPA Method RSKSOP-175	EPA
Volatile Organic Compounds by GC-MS	EPA Method 8260	EPA[e]
Semivolatile Organic Compounds		
Organochlorine Pesticides	EPA Method 8081	EPA[e]
Polychlorinated Biphenyls	EPA Method 8082	EPA[e]
Semivolatile Organic Compounds	EPA Method 8270	EPA[e]
Radiological Parameters		
Americium-Curium Isotopes	Ion-exchange Separation/Electroplate/AEA	Lab Specific
Americium-Curium Isotopes	Ion-exchange Separation/Precipitation/AEA	Lab Specific
Carbon-14	Chemical Oxidation/LSC	Lab Specific
Gamma-Emitting Isotopes	Gamma Energy Analysis	Lab Specific
Gross Alpha-Beta by GPC	Gas Proportional Counter	Lab Specific
Gross Alpha-Beta by GPC	EPA Method 9310	EPA[e]
Iodine-129	Separation/Precipitation/LEPS	Lab Specific
Neptunium-237	Ion-exchange Separation/Precipitation/AEA	Lab Specific
Plutonium Isotopes	Ion-exchange Separation/Precipitation/AEA	Lab Specific
Plutonium Isotopes	Separation/Electroplate/AEA	Lab Specific
Selenium-79	Ion-exchange Separation/LSC	Lab Specific
Strontium-90	Separation/Precipitation/GPC	Lab Specific
Strontium-90 (total-beta radiostrontium)	Separation/Precipitation/GPC	Lab Specific
Technetium-99	Ion-exchange Separation/LSC	Lab Specific

Table F-6. Analytical Methods

Parameter	Analytical Method	Source
Technetium-99	Disk Separation/LSC	Lab Specific
Thorium Isotopes	Ion-exchange Separation/Electroplate/AEA	Lab Specific
Tritium	EPA Method 906.0	EPA
Tritium	Distillation/LSC	Lab Specific
Tritium	Ion-exchange Purification/LSC	Lab Specific
Uranium Isotopes	Ion-exchange Separation/Electroplate/AEA	Lab Specific
Uranium Isotopes	Ion-exchange Separation/Precipitation/AEA	Lab Specific
Uranium Isotopes	Separation/Electroplate/AEA	Lab Specific

a. EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*.

b. APHA/AWWA/WEF, 2012, *Standard Methods For the Examination of Water and Wastewater*.

c. O'Dell, 1993, *Method 410.4 The Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry*.

d. EPA-821-R-98-002, *Method 1664, Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) by Extraction and Gravimetry*.

e. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*.

f. ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*.

g. EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*.

h. Peden, 1986, *Methods for Collection and Analysis of Precipitation*.

i. EPA-600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement I*.

AEA = alpha energy analysis
ASTM = ASTM International
EPA = U.S. Environmental Protection Agency
GC = gas chromatography
GC-MS = gas chromatography-mass spectrometry
GPC = gas-flow proportional counter
ICP-AES = inductively coupled plasma–atomic emission spectroscopy
ICP-MS = inductively coupled plasma–mass spectrometry
LEPS = low-energy photon spectroscopy
LSC = liquid scintillation counting

F7 Sample Preservation and Holding Times

Sample preservation and holding times are designed to ensure the analytical results generated from a sample are representative of the sample's source. Sample preservation is any method used to ensure the analyte of interest is not altered between the time the sample is acquired and the time it is analyzed. Sample preservation includes selecting the correct sample container material (such as plastic or glass), and may include cooling the sample to ≤ 6°C, adjusting the sample pH with acids or bases, or adding other chemicals (such as sodium bisulfite) to prevent oxidation of the analyte of interest. Typically, any

preservation chemicals are added to the sample container during container preparation prior to taking the container to the sample site.

Holding times are defined as the time from sample collection or sample extraction to sample analysis. An extraction holding time is the time from sample collection to sample extraction. Holding times are calculated from the date of sample collection as recorded on the sample's chain of custody. Analytes that may change quickly with time, such as coliform or hexavalent chromium, have short holding times while other analytes, such as acid-preserved metals and radionuclides, have much longer holding times.

Table F-7 lists the sample preservation and holding time requirements for the groundwater monitoring program. Upon receipt of a groundwater sample set, the analyzing laboratory inspects the contents of the sample set container, usually an ice chest, to ensure that the samples received reflect what is listed on the accompanying chains of custody. During the receipt inspection, the samples are usually checked for any anomalies, such as missing samples, broken sample bottles, or absent tamper tape. The as-received sample temperature is also usually checked. Samples that are received immediately from the field will not have had time to cool to a preservation temperature ≤ 6°C; in this circumstance, the as-received condition of the samples is noted and normal processing of the samples for analysis proceeds. Either at the time of receipt, or immediately before sample preparation and analysis, the pH of samples that require pH adjustment is checked to ensure the sample was properly preserved. If the pH is not correct for the sample type (e.g., pH is greater than 2 for inductively coupled plasma [ICP] metals or is less than 12 for cyanide samples), then the laboratory notes the anomaly and may perform adjustment of the sample pH. Any anomalies noted during sample receiving or with sample preservation are reported to the Soil and Groundwater Remediation Project via Sample Issue Resolution requests. If the Project does not deem the anomaly will affect the sample results, the laboratory is instructed to proceed with the analysis. The Project may decide that the anomaly (e.g., a cyanide sample with a pH less than 12) could jeopardize the integrity of the sample results; in this instance, the laboratory will be instructed to cancel the sample analysis.

Table F-7. Groundwater Sample Container, Preservative, and Holding Time Requirements

Parameter	Container	Preservative	Holding Time	Source
General Chemical Parameters				
Alkalinity	G/P	Cool to ≤6 °C	14 days	40 CFR 136, Table II
Chemical oxygen demand	G/P	Cool to ≤6 °C; H_2SO_4 to pH <2	28 days	40 CFR 136, Table II
Coliform	G/P	Cool to ≤10 °C; 0.0008% $Na_2S_2O_3$	8 hours	40 CFR 136, Table II
Dissolved oxygen	G	None	As soon as possible	40 CFR 136, Table II
Hydrogen ion (pH)	G/P	None	As soon as possible	40 CFR 136, Table II
Oil and grease / Hexane extractable material	G	Cool to ≤6 °C; HCl or H_2SO_4 to pH <2	28 days	SW-846, Table 3-2
Specific conductance	G/P	None	28 days	40 CFR 136, Table II
Total dissolved solids	G/P	Cool to ≤6 °C	7 days	APHA/AWWA/WEF, 2012, SM 2540c
Total organic carbon	aG	Cool to ≤6 °C; HCl or H_2SO_4 to pH <2	28 days	40 CFR 136, Table II
Total organic halides	G	Cool to ≤6 °C; H_2SO_4 to pH <2	28 days	SW-846, Method 9020B
Total petroleum hydrocarbons	aGs	Cool to ≤6 °C; HCl or H_2SO_4 to pH <2	14 days	SW-846, Table 4-1
Total petroleum hydrocarbons - diesel	aGs	Cool to ≤6 °C; HCl to pH<2	14 days before extraction, 40 days after extraction	ECY 97-602
Total petroleum hydrocarbons - gasoline	aG	Cool to ≤6 °C; HCl to pH<2	14 days	ECY 97-602
Ammonia and Anions				
Ammonia	G/P	Cool to ≤6 °C; H2SO4 to pH <2	28 days	40 CFR 136, Table II
Cyanide	G/P	Cool to ≤6 °C; 50% NaOH to pH>12	14 days	SW-846, Table 3-2
Bromide, chloride, fluoride, sulfate	G/P	Cool to ≤6 °C	28 days	SW-846, Table 3-2
Nitrate, nitrite, phosphate	G/P	Cool to ≤6 °C	48 hours	SW-846, Table 3-2

Table F-7. Groundwater Sample Container, Preservative, and Holding Time Requirements

Parameter	Container	Preservative	Holding Time	Source
Sulfide	G/P	Cool to ≤6 °C; zinc acetate and NaOH to pH >9	7 days	SW-846, Table 3-2
Metals				
Hexavalent chromium	G/P	Cool to ≤6 °C	24 hours	SW-846, Table 3-2
Mercury	G/P	HNO_3 to pH<2	28 days	SW-846, Table 3-2
All other metals	G/P	HNO_3 to pH<2	6 months	SW-846, Table 3-2
Volatile Organic Compounds				
Volatile organic compounds	aGs	Cool to ≤6 °C; HCl or H_2SO_4 to pH <2	14 days	SW-846, Table 4-1
Semivolatile Organic Compounds				
Semivolatile organic compounds, Organochlorine pesticides and herbicides	aG / PTFE-lined cap	Cool to ≤6 °C	7 days before extraction, 40 days after extraction	SW-846, Table 4-1
Phenols	aG / PTFE-lined cap	Cool to ≤6 °C; 0.008% $Na_2S_2O_3$	7 days before extraction, 40 days after extraction	40 CFR 136, Table II
Polychlorinated biphenyls	aG / PTFE-lined cap	Cool to ≤6 °C	None	SW-846, Table 4-1
Polychlorinated dibenzo-p-dioxins, Polychlorinated dibenzofurans	aG / PTFE-lined cap	Cool to ≤6 °C	30 days before extraction, 45 days after extraction	SW-846, Methods 8280 & 8290
Radiological Parameters				
Gross alpha, gross beta	G/P	HNO_3 to pH<2	6 months	SW-846, Table 2-40(B)
Carbon-14, tritium	G	None	6 months	Laboratory procedure
Americium isotopics, Gamma spectroscopy radionuclides, Plutonium isotopics, Radium isotopics,	G/P	HNO_3 to pH<2	6 months	Laboratory procedure

Table F-7. Groundwater Sample Container, Preservative, and Holding Time Requirements

Parameter	Container	Preservative	Holding Time	Source
Strontium-90, Uranium isotopics				
Technetium-99	G/P	HCl or HNO_3 to pH<2	6 months	Laboratory procedure

40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants."

APHA/AWWA/WEF, 2012, *Standard Methods For the Examination of Water and Wastewater*.

ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*.

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-A.*

aG = amber glass

aGs = amber glass with septum cap

G = glass

P = plastic

PTFE = polytetrafluorinatedethylene

SM = standard method

F7.1 Sample Preservation

Of the 12,466 groundwater monitoring laboratory samples acquired during CY2014, only 26 samples, or 0.2% of all laboratory samples, were associated with sample preservation issues. Of the 26 samples with sample preservation issues, analyses of only 8 were cancelled. This indicates that incorrect sample preservation is not a major issue for the groundwater monitoring program. Table F-8 lists the preservation issues and the analytes affected for the CY2014 groundwater monitoring effort.

GEL reported an additional 110 samples as improperly preserved. Most of these samples were for metals or radiochemical constituents and were reported as having a pH greater than 2. The disposition of these samples was for laboratory personnel to adjust the pH and hold the sample for 24 hours before sample preparation and analysis to meet preservation requirements. However, neither TARL nor TASL were routinely reporting samples outside pH preservation requirements. GEL sample receiving personnel were using pH strips to determine proper pH preservation. Soil and Groundwater Remediation Project personnel requested that GEL examine its use of pH strips. Consequently, GEL personnel began checking the results of their pH strips with a pH meter and discovered that the strips were generating "false positives;" that is, the pH strips were indicating out-of-limit pH values when in fact the pH of the samples met preservation requirements. Groundwater monitoring project scientists and project coordinators determined that the addition of more preservative to those samples thought to be out of pH limits was of no consequence, and the results of those samples were accepted.

Table F-8. Groundwater Sample Preservation Issues and Dispositions

Preservation Issue / Analytes	Disposition / Number of Samples Affected				
	No Action - Report Results	Adjust pH and Report Results	Cancel Analysis	Filter and Report Results	Totals
Totals	**14**	**3**	**8**	**1**	**26**
Incorrect pH	**—**	**3**	**1**	**—**	**4**
Alkalinity	—	—	1	—	1
Strontium-90	—	3	—	—	3
Incorrect Temperature*	**14**	**—**	**—**	**—**	**14**
Alkalinity	2	—	—	—	2
IC Anions	2	—	—	—	2
ICP-AES (6010) Metals	4	—	—	—	4
ICP-MS (6020) Metals	2	—	—	—	2
GC-MS (8260) VOC	2	—	—	—	2
TOC	2	—	—	—	2
Incorrect Preservative	**—**	**—**	**7**	**—**	**7**
IC Anions	—	—	1	—	1
Technetium-99	—	—	1	—	1

Table F-8. Groundwater Sample Preservation Issues and Dispositions

Preservation Issue / Analytes	Disposition / Number of Samples Affected				
	No Action - Report Results	Adjust pH and Report Results	Cancel Analysis	Filter and Report Results	Totals
TOC	—	—	1	—	1
Total Dissolved Solids	—	—	2	—	2
Tritium	—	—	2	—	2
Not Field Filtered	**—**	**—**	**—**	**1**	**1**
Mercury	—	—	—	1	1

a. The 14 samples affected by temperatures greater than 6°C upon sample receipt were all delivered to TASL. The commercial carrier did not deliver the samples overnight as expected, and the delayed delivery allowed the samples to warm before the delivery was completed.

GC-MS = gas chromatography – mass spectrometry
IC = ion chromatography
ICP-AES = inductively coupled plasma – atomic emission spectroscopy
ICP-MS = inductively coupled plasma – mass spectrometry
TOC = total organic carbon
VOC = volatile organic compound

F7.2 Holding Times

Table F-5 summarizes the number of sample results for each analytical method with missed holding times. Of the 147,457 groundwater monitoring laboratory results reported during CY2014, 787 analytical results, or 0.5% of the groundwater monitoring data set, were affected by missed holding times. This is not as good as CY 2013's 109 analytical results (0.08%) and is approximately the same as CY2012's 703 analytical results, or 0.5% of the groundwater monitoring data set with missed holding times. Table F-9 lists the reasons for those sample results documented by the Sample Issue Resolution (SIR) process. Most of the samples with missed holding times were analyzed within two times the holding time; groundwater monitoring project scientists and project coordinators deemed these results acceptable for the groundwater monitoring program.

With the closure of the WSCF laboratory, analytes with short holding times, especially hexavalent chromium and the ion-chromatography anions, were shipped to the off-site commercial laboratories for determination. The additional shipping time frequently resulted in missed holding times for those analytes. To avoid the flood of SIRs that would have otherwise been associated with all the missed holding times, Soil and Groundwater Remediation Project personnel instructed GEL and TASL to submit SIRs only for those short-holding time analytes that were analyzed outside two times the holding time. All missed holding times were to always be noted in the case narratives of the laboratory analytical reports.

Of the 787 analytical results with missed holding times, 685 were for nitrate, nitrite, sulfate, and phosphate (48-hour holding time), eight were for ammonium ion (28 day holding time), 16 were for hexavalent chromium (24-hour holding time), two were for mercury (28-day holding time), four for total

organic halides (TOX) (28-day holding time), 68 were for alkalinity (14-day holding time), two were for cyanide (14-day holding time), one for chloride (28-day holding time), and one for oil and grease (28-day holding time). By laboratory, GEL reported 296 results with missed holding times, TARL with none, TASL with 486, and WSCF with five.

Table F-9. Missed Sample Holding Time Issues

Missed Holding Time Issue	Number of Results*	Percentage of All Missed Holding Times
Totals	**289**	**100.0%**
Late sample delivery (insufficient time)	80	27.7%
Analyst error	59	20.4%
Late sample delivery (carrier)	54	18.7%
Instrument failure	38	13.1%
Dilution / Reanalysis	33	11.4%
Incorrect LIMS entry	16	5.5%
QC failure / Reanalysis	5	1.7%
Other laboratory issue	4	1.4%

*The 289 results listed in this table are those documented by the Sample Issue Resolution process.

An explanation of the holding time issues follows:

- *Late sample delivery (insufficient time)*: This missed holding time reason covers delivery of a sample with insufficient or no time left to complete the analysis before the holding time expired. This issue affected five hexavalent chromium results, 70 nitrate/nitrite results, and five phosphate results. The primary cause of this issue was the shutdown of the WSCF facility which stopped receiving samples on May 5, 2014. Samples slated for analysis of short holding time analytes were then shipped overnight to the GEL and TASL laboratories. Consequently, those analytes with 24-hour (hexavalent chromium) and 48-hour (nitrate, nitrite, and phosphate) holding times were received with insufficient or no time available for sample preparation and analysis to meet the holding time requirements for those analytes. TARL began receiving groundwater samples for anion determinations during the fourth quarter of CY2014. With the addition of this capability near the Hanford Site, the anticipation is that fewer holding times for anions will be missed during CY2015.

- *Analyst error*: This issue covers missed holding times caused by the analyst failing to observe the sample holding time. Of the 59 results affected by this issue, 52 results were for alkalinity (including bicarbonate, carbonate and hydroxide), five results for ammonium ion, and one each for nitrate and nitrite.

- *Late Sample Delivery (carrier)*: This missed holding time reason covers late delivery of a sample because the commercial transportation carrier did not deliver the samples to the laboratory overnight as expected. All 54 results affected by this issue were for the short holding time anions nitrate, nitrite and phosphate.

- *Instrument failure*: This issue covers missed holding times caused by failure of an automated instrument to perform the analysis. Weather-caused power outages were the cause of some of the instrument failures. Of the 38 results affected by this issue, 36 were for nitrate/nitrite and two were for total organic halides.
- *Dilution / Reanalysis*: When an analyte exceeded the calibration range during analysis, the sample was diluted and reanalyzed after the holding time lapsed. All 33 results affected by this issue were for anions determined by ion chromatography: 31 for nitrate, nitrite, and phosphate, and one each for chloride and sulfate.
- *Incorrect LIMS entry*: This missed holding time reason covers incorrect entry of sample information into the laboratory's laboratory information management system. This issue affected 16 results reported for alkalinity, bicarbonate, carbonate, and hydroxide.
- *QC failure / Reanalysis*: This missed holding time reason covers samples that were reanalyzed after the holding lapsed because of the failure of one or more QC samples to meet QC requirements during the initial analysis. This reason affected three results for phosphate and two results for ammonium ion.
- *Other laboratory issue*: This issue covers miscellaneous laboratory issues that caused missed holding times. This issue affected two cyanide results and one result each for mercury and total organic halides.

F8 Field Quality Control

This section discusses the CY2014 groundwater monitoring field QC data that exceeded the QC acceptance criteria listed in Table F-1. The types of field QC samples that are evaluated in this section are discussed in Section F-4.2.

F8.1 Field Blanks

FBs are used to assess potential contamination associated with sampling and laboratory activities. Analytical results for the FBs are assessed against the acceptance limits listed in Table F-1. Overall, the percentage of acceptable FB results evaluated during this reporting period was 97.8% (compared to 98.2% for 2013 and 98.1% for 2012), indicating little problem with contamination during sampling and analysis.

FB results greater than the acceptance criterion of two times the MDL or MDA are identified as suspected contamination. For the common laboratory contaminants 2-butanone, acetone, methylene chloride, toluene, and phthalate esters, the limit is five times the MDL. Results for samples associated with FBs that are above these criteria are given a review qualifier of Q in the HEIS database to indicate potential contamination issues. Associated samples for blanks are defined in Section F-4.2. Table F-10 presents the FB results that exceeded QC limits and Table F-11 compares out-of-limit FBs with out-of-limit MBs that were analyzed in the same analytical batch.

Table F-10. Field Blank Results Exceeding Quality Control Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Total Field Blanks Out = 325						
General Chemical Parameters: Total Out = 32						
Alkalinity	FTB	55	10	18.2	1080 – 2900 ug/L	2000 – 126000 ug/L
Alkalinity	EB	30	2	6.7	1080 - 2900 ug/L	2000 - 10000 ug/L
Bicarbonate	FTB	30	3	10	1450 - 2900 ug/L	2100 - 2700 ug/L
Bi-carbonate alkalinity	EB	6	2	33.3	1080 - 2200 ug/L	2000 - 10000 ug/L
Bi-carbonate alkalinity	FTB	18	6	33.3	1080 - 2200 ug/L	2000 - 126000 ug/L
Total organic carbon	EB	6	1	16.7	200 - 660 ug/L	640 ug/L
Total organic halides	FTB	60	7	11.7	3.6 - 10 ug/L	3.9 - 16.7 ug/L
Total petroleum hydrocarbons - gasoline range	EB	3	1	33.3	20 - 100 ug/L	25 ug/L
Ammonia and Anions: Total Out = 39						
Ammonium ion	FTB	9	1	11.1	12.88 - 36.01 ug/L	40.14 ug/L
Chloride	FTB	94	11	11.7	40 - 268 ug/L	46 - 3500 ug/L
Chloride	EB	56	6	10.7	40 - 1340 ug/L	58 - 829 ug/L
Fluoride	EB	56	1	1.8	12.5 - 660 ug/L	210 ug/L
Nitrate	EB	56	4	7.1	31.3 - 2920 ug/L	62 - 221 ug/L
Nitrate	FTB	94	6	6.4	35.4 - 584 ug/L	37.2 - 13300 ug/L
Phosphate	EB	16	3	18.8	156 - 822 ug/L	260 - 334 ug/L
Sulfate	EB	56	2	3.6	62.5 - 2660 ug/L	329 - 378 ug/L
Sulfate	FTB	94	4	4.3	100 - 532 ug/L	257 - 18200 ug/L
Sulfide	FTB	4	1	25	66 - 166 ug/L	600 ug/L
Metals: Total Out = 109						
Aluminum	EB	58	2	3.4	20 - 40 ug/L	35.7 - 274 ug/L
Aluminum	FTB	55	1	1.8	25.8 - 150 ug/L	84.7 ug/L
Antimony	EB	81	1	1.2	0.6 - 40 ug/L	10 ug/L

Table F-10. Field Blank Results Exceeding Quality Control Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Barium	EB	81	4	4.9	0.4 - 8 ug/L	0.52 - 0.8 ug/L
Boron	FTB	54	4	7.4	8 - 40 ug/L	23.2 - 39.4 ug/L
Boron	EB	57	3	5.3	4 - 20 ug/L	26 - 114 ug/L
Calcium	EB	78	1	1.3	100 - 108.4 ug/L	163 ug/L
Calcium	FTB	145	5	3.4	100 - 500 ug/L	124 - 2600 ug/L
Chromium	FTB	149	1	0.7	0.4 - 20 ug/L	1.57 ug/L
Cobalt	EB	81	2	2.5	0.1 - 8 ug/L	0.7 - 1.4 ug/L
Copper	EB	81	4	4.9	0.2 - 8 ug/L	0.456 - 1.2 ug/L
Copper	FTB	139	2	1.4	0.4 - 8 ug/L	0.96 - 1.96 ug/L
Hexavalent chromium	EB	53	2	3.8	1.5 - 8 ug/L	3.5 - 4.3 ug/L
Hexavalent chromium	FTB	120	7	5.8	1.5 - 8 ug/L	1.8 - 7.6 ug/L
Iron	EB	78	1	1.3	25.6 - 80 ug/L	25.7 ug/L
Lead	EB	64	1	1.6	0.1 - 1 ug/L	0.352 ug/L
Manganese	EB	81	7	8.6	0.2 - 8 ug/L	0.47 - 4.8 ug/L
Manganese	FTB	139	3	2.2	0.4 - 10 ug/L	0.73 - 24.4 ug/L
Molybdenum	EB	58	1	1.7	0.1 - 2 ug/L	0.264 ug/L
Nickel	EB	81	14	17.3	0.2 - 20 ug/L	0.408 - 6.2 ug/L
Nickel	FTB	139	3	2.2	0.4 - 20 ug/L	2.68 - 3.11 ug/L
Potassium	FXR	1	1	100	100 ug/L	159 ug/L
Silver	EB	81	6	7.4	0.1 - 10 ug/L	0.166 - 0.404 ug/L
Silver	FTB	139	1	0.7	0.2 - 10 ug/L	2.3 ug/L
Sodium	FTB	145	3	2.1	200 - 1000 ug/L	525 - 1310 ug/L
Strontium	EB	74	7	9.5	0.12 - 16 ug/L	0.27 - 1.37 ug/L
Strontium	FTB	86	5	5.8	0.12 - 20 ug/L	0.7 - 1.19 ug/L
Tin	EB	58	2	3.4	0.1 - 2.2 ug/L	0.242 - 3 ug/L
Tin	FTB	55	5	9.1	0.2 - 10 ug/L	2.5 - 4 ug/L
Uranium	EB	70	2	2.9	0.1 - 0.49 ug/L	1.2 - 374 ug/L
Uranium	FTB	83	1	1.2	0.1 - 0.67 ug/L	3.84 ug/L

Table F-10. Field Blank Results Exceeding Quality Control Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Zinc	EB	81	2	2.5	4 - 16.6 ug/L	15 - 21.5 ug/L
Zinc	FTB	139	5	3.6	6.6 - 35 ug/L	12 - 31.1 ug/L
Volatile Organic Compounds: Total Out = 132						
Acetone	FXR	227	5	2.2	1.7 - 25 ug/L	1.8 - 3.3 ug/L
Carbon tetrachloride	FXR	227	1	0.4	0.26 - 2 ug/L	2.7 ug/L
Chlorobenzene	FTB	35	2	5.7	0.3 - 2 ug/L	0.38 - 0.69 ug/L
Methylene chloride	EB	10	1	10	1.35 - 8 ug/L	6.3 ug/L
Methylene chloride	FTB	35	12	34.3	1.35 - 13.5 ug/L	2.2 - 130 ug/L
Methylene chloride	FXR	227	110	48.5	1.35 - 8 ug/L	1.4 - 67 ug/L
Trichloroethene	FXR	227	1	0.4	0.5 - 2 ug/L	0.62 ug/L
Semivolatile Organic Compounds: Total Out = 0						
Radiochemical Parameters: Total Out = 13						
Americium-241	FTB	4	1	25	0.098 - 0.454 pCi/L	0.11 pCi/L
Gross beta	FTB	39	2	5.1	2.62 - 7.86 pCi/L	7.1 - 17 pCi/L
Gross beta	EB	21	1	4.8	3.44 - 30 pCi/L	5.6 pCi/L
Iodine-129	FTB	24	1	4.2	0.286 - 1.846 pCi/L	3.38 pCi/L
Selenium-79	FTB	2	1	50	24 - 29.8 pCi/L	34.8 pCi/L
Strontium-90	EB	18	1	5.6	0.81 - 3.88 pCi/L	1.17 pCi/L
Strontium-90	FTB	38	3	7.9	0.592 - 3.9 pCi/L	1.3 - 111 pCi/L
Technetium-99	FTB	38	2	5.3	11.2 - 24 pCi/L	15 - 60.7 pCi/L
Technetium-99	EB	16	1	6.2	11.88 - 29.4 pCi/L	150 pCi/L

*Because method detection limits are specific to the laboratory and may change during the reporting period, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.

EB = equipment blank

FTB = full trip blank

FXR = field transfer blank

QC = quality control

Table F-11. Out-of-Limit Field Blanks Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	Field Blank Result	Method Blank Result	Units	FB Lab Qualifier *
General Chemical Parameters											
B2WDV4	5/15/2014	199-D5-39	FTB	Alkalinity	TASL	310.1_ALKALINITY	123128	2,000	1,250	µg/L	BC
B2WDX0	5/15/2014	199-D5-97	EB	Alkalinity	TASL	310.1_ALKALINITY	123128	2,000	1,250	µg/L	
B2X9F7	8/6/2014	199-D5-157	FTB	Alkalinity	TASL	310.1_ALKALINITY	137048	122,000	2,500	µg/L	N
B2XD07	9/4/2014	199-D5-97	EB	Alkalinity	TASL	310.1_ALKALINITY	142855	10,000	1,250	µg/L	
B2XK04	9/23/2014	299-E25-2	FTB	Alkalinity	TASL	310.1_ALKALINITY	148960	126,000	2,500	µg/L	
B2Y529	10/1/2014	199-D5-158-3	FTB	Alkalinity	TASL	310.1_ALKALINITY	148963	10,000	1,250	µg/L	
B2XW48	10/28/2014	199-D8-96	FTB	Alkalinity	TASL	310.1_ALKALINITY	153306	82,000	1,750	µg/L	
B2Y814	10/31/2014	199-H3-6	FTB	Alkalinity	TASL	310.1_ALKALINITY	156153	64,000	1,250	µg/L	
B2YHC3	12/16/2014	299-E27-24	FTB	Alkalinity	TASL	310.1_ALKALINITY	164573	10,000	1,250	µg/L	C
B2WDV4	5/15/2014	199-D5-39	FTB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	123128	2,000	1,250	µg/L	BC
B2WDX0	5/15/2014	199-D5-97	EB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	123128	2,000	1,250	µg/L	
B2X9F7	8/6/2014	199-D5-157	FTB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	137048	122,000	2,500	µg/L	N
B2XD07	9/4/2014	199-D5-97	EB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	142855	10,000	1,250	µg/L	
B2XK04	9/23/2014	299-E25-2	FTB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	148960	126,000	2,500	µg/L	
B2Y529	10/1/2014	199-D5-158-3	FTB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	148963	10,000	1,250	µg/L	

Table F-11. Out-of-Limit Field Blanks Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	Field Blank Result	Method Blank Result	Units	FB Lab Qualifier *
B2XW48	10/28/2014	199-D8-96	FTB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	153306	82,000	1,750	µg/L	
B2Y814	10/31/2014	199-H3-6	FTB	Bi-carbonate alkalinity	TASL	310.1_ALKALINITY	156153	64,000	1,250	µg/L	
Ammonia and Anions											
B2WD21	5/12/2014	699-38-70B	EB	Chloride	TASL	300.0_ANIONS_IC	122210	70	54	µg/L	BC
B2WJW3	5/9/2014	199-K-119A	EB	Chloride	TASL	300.0_ANIONS_IC	125000	99	37	µg/L	BC
B2X9K7	8/6/2014	199-D5-157-7	FTB	Chloride	TASL	300.0_ANIONS_IC	137142	46	64	µg/L	BC
B2Y7L1	11/6/2014	199-D5-34	FTB	Chloride	TASL	300.0_ANIONS_IC	156814	350	151	µg/L	BND
B2YFB5	11/6/2014	199-D5-155-7	FTB	Chloride	TASL	300.0_ANIONS_IC	156814	120	151	µg/L	BDN
B2Y990	11/23/2014	199-K-125A	EB	Chloride	TARL	300.0_ANIONS_IC	4327012	202	197	µg/L	CB
B2YLH1	12/4/2014	299-E27-155	FTB	Chloride	TARL	300.0_ANIONS_IC	4338059	301	140	µg/L	DCB
B2Y8X6	11/21/2014	699-98-51	EB	Nitrate	TARL	300.0_ANIONS_IC	4325081	168	164	µg/L	CB
B2YMF8	12/5/2014	699-S6-E4E	FTB	Nitrate	TARL	300.0_ANIONS_IC	4339061	168	75	µg/L	DCB
B2Y8X6	11/21/2014	699-98-51	EB	Sulfate	TARL	300.0_ANIONS_IC	4325081	378	391	µg/L	CB
B2YMF8	12/5/2014	699-S6-E4E	FTB	Sulfate	TARL	300.0_ANIONS_IC	4339061	266	146	µg/L	DCB
B2YCC8	12/11/2014	AT-D-2-M	FTB	Sulfate	TARL	300.0_ANIONS_IC	4346034	455	457	µg/L	DCB
B2PHW4	1/23/2014	699-44-64	FTB	Sulfide	TASL	9034_SULFIDE	102149	600	100	µg/L	B
Metals											
B2XD07	9/4/2014	199-D5-97	EB	Aluminum	TASL	6020_METALS_ICPMS	146348	274	19	µg/L	

Table F-11. Out-of-Limit Field Blanks Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	Field Blank Result	Method Blank Result	Units	FB Lab Qualifier *
B2XD07	9/4/2014	199-D5-97	EB	Barium	TASL	6020_METALS_ICPMS	146348	0.52	0.56	µg/L	BC
B2XD13	9/4/2014	199-D5-97	EB	Barium	TASL	6020_METALS_ICPMS	146348	0.72	0.56	µg/L	BC
B2XH67	9/29/2014	199-N-188	EB	Barium	TASL	6020_METALS_ICPMS	151561	0.53	0.85	µg/L	BC
B2XH73	9/29/2014	199-N-188	EB	Barium	TASL	6020_METALS_ICPMS	151561	0.80	0.85	µg/L	BC
B2X9F7	8/6/2014	199-D5-157	FTB	Calcium	TASL	6010_METALS_ICP_TR	137547	2,600	62	µg/L	
B2X9F7	8/6/2014	199-D5-157	FTB	Calcium	TASL	6010_METALS_ICP_TR	137547	2,600	141	µg/L	
B2X9F7	8/6/2014	199-D5-157	FTB	Calcium	TASL	6010_METALS_ICP_TR	137547	2,600	447	µg/L	
B2XD07	9/4/2014	199-D5-97	EB	Calcium	TASL	6010_METALS_ICP_TR	145653	163	69	µg/L	BC
B2XK04	9/23/2014	299-E25-2	FTB	Calcium	TASL	6010_METALS_ICP_TR	150308	197	67	µg/L	BC
B2XK04	9/23/2014	299-E25-2	FTB	Calcium	TASL	6010_METALS_ICP_TR	150308	197	80	µg/L	BC
B2XK04	9/23/2014	299-E25-2	FTB	Calcium	TASL	6010_METALS_ICP_TR	150308	197	112	µg/L	BC
B2XD07	9/4/2014	199-D5-97	EB	Copper	TASL	6020_METALS_ICPMS	146348	1.20	0.54	µg/L	C
B2YLF7	12/4/2014	299-E27-155	FTB	Copper	TASL	6020_METALS_ICPMS	169082	0.96	0.67	µg/L	BC
B2WBJ7	5/21/2014	299-W14-13	FTB	Manganese	TASL	6020_METALS_ICPMS	127042	0.91	0.95	µg/L	BC
B2XD07	9/4/2014	199-D5-97	EB	Manganese	TASL	6020_METALS_ICPMS	146348	4.80	0.30	µg/L	
B2XD13	9/4/2014	199-D5-97	EB	Manganese	TASL	6020_METALS_ICPMS	146348	0.53	0.30	µg/L	BC
B2YLF7	12/4/2014	299-E27-155	FTB	Manganese	TASL	6020_METALS_ICPMS	168946	24	0.26	µg/L	
B2YLF7	12/4/2014	299-E27-155	FTB	Manganese	TASL	6020_METALS_ICPMS	168946	24	0.45	µg/L	
B2YLF7	12/4/2014	299-E27-155	FTB	Manganese	TASL	6020_METALS_ICPMS	168946	24	0.49	µg/L	

Table F-11. Out-of-Limit Field Blanks Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	Field Blank Result	Method Blank Result	Units	FB Lab Qualifier *
B2Y6D7	11/5/2014	299-E33-339	FTB	Silver	TASL	6010_METALS_ICP_TR	160105	2.3	1.0	µg/L	BC
B2XDR4	9/8/2014	699-S6-E4L	EB	Strontium	TASL	6010_METALS_ICP_TR	146340	0.60	0.60	µg/L	BC
B2XD07	9/4/2014	199-D5-97	EB	Strontium	TASL	6020_METALS_ICPMS	146348	0.77	0.74	µg/L	BC
B2XD13	9/4/2014	199-D5-97	EB	Strontium	TASL	6020_METALS_ICPMS	146348	1.20	0.74	µg/L	BC
B2XK04	9/23/2014	299-E25-2	FTB	Strontium	TASL	6010_METALS_ICP_TR	150308	0.70	0.90	µg/L	BC
B2XK08	9/23/2014	299-E25-2	FTB	Strontium	TASL	6010_METALS_ICP_TR	150308	0.80	0.90	µg/L	BC
B2YLF7	12/4/2014	299-E27-155	FTB	Strontium	TASL	6020_METALS_ICPMS	168946	0.76	0.08	µg/L	B
B2YLF7	12/4/2014	299-E27-155	FTB	Strontium	TASL	6020_METALS_ICPMS	168946	0.76	0.14	µg/L	B
B2WNJ7	6/16/2014	199-B2-14	FTB	Tin	TASL	6020_METALS_ICPMS	130554	2.6	1.4	µg/L	C
B2WNK2	6/16/2014	199-B2-14	FTB	Tin	TASL	6020_METALS_ICPMS	130554	3.6	1.4	µg/L	C
B2YLF7	12/4/2014	299-E27-155	FTB	Tin	TASL	6020_METALS_ICPMS	168946	2.8	1.6	µg/L	C
B2YLF7	12/4/2014	299-E27-155	FTB	Tin	TASL	6020_METALS_ICPMS	168946	2.8	1.6	µg/L	C
B2XDD3	9/15/2014	299-E27-155	EB	Uranium	TARL	UTOT_KPA	4265051	374	1.4	µg/L	
B2XK04	9/23/2014	299-E25-2	FTB	Zinc	TASL	6010_METALS_ICP_TR	150308	23	8.5	µg/L	C
B2YH99	12/4/2014	299-E27-155	FTB	Zinc	TASL	6010_METALS_ICP_TR	167928	24	11	µg/L	C
B2YH99	12/4/2014	299-E27-155	FTB	Zinc	TASL	6010_METALS_ICP_TR	167928	24	24	µg/L	C
B2YH99	12/4/2014	299-E27-155	FTB	Zinc	TASL	6010_METALS_ICP_TR	167928	24	24	µg/L	C
Volatile Organic Compounds											
B2R201	5/21/2014	199-K-107A	FXR	Trichloroethene	GEL	8260_VOA_GCMS	1391711	0.62	0.65	µg/L	BJ

Table F-11. Out-of-Limit Field Blanks Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	Field Blank Result	Method Blank Result	Units	FB Lab Qualifier *

* See Table F-3 for the explanation of the laboratory data quality flags.

EB = equipment blank

FB = field blank

FTB = full trip blank

FXR = field transfer blank

GEL = GEL laboratory

TARL = TestAmerica Richland laboratory

TASL = TestAmerica St. Louis laboratory

WSCF = Waste Sampling and Characterization Facility

The remainder of the FB discussion in this section provides additional context for the information in Tables F-10 and F-11.

For CY2014, 459 FB sets were obtained consisting of 959 samples that were analyzed to generate 15,115 sample results of which 325 (2.2 %) exceeded QC limits. By blank type, 72 EB sets were acquired consisting of 217 EB samples; these samples yielded 3,648 results of which 97.6% met the acceptance criteria. For FTBs, 159 blank sets were acquired consisting of 514 samples that yielded 6,813 analytical results of which 98.3% met the acceptance criteria. For FXRs, 228 blank samples yielded 4,654 analytical results of which 97.5% met the acceptance criteria.

By compound class, the 483 general chemical parameter FB results yielded 32 results (6.6%) that exceeded QC limits, including 12 alkalinity, three bicarbonate, eight bi-carbonate alkalinity, one TOC, seven TOX, and one total petroleum hydrocarbons-gasoline range measurements. Of the 849 ammonia/anion results, 39 (4.6%) exceeded QC limits, including one ammonium ion, 17 chloride, one fluoride, 10 nitrate, three phosphate, six sulfate, and one sulfide results.

Of the 5,359 FB metals results for CY2014, 109 (2.0%) exceeded QC limits. Nickel was the worst offender with 17 results exceeding the acceptance criterion followed by strontium (12 results), and manganese (10 results). The remaining 70 out-of-limit results were scattered among 18 other metals. Fifteen blank samples (B2V633, B2XD13, B2XH67, B2XD07, B2WDV4, B2YLF7, B2V630, B2XH73, B2VNY0, B2WDX0, B2XWT1, B2WP77, B2VNX4, B2W0F5, and B2W0F9) had at least five metal analytes that exceeded the acceptance criterion. FBs with out-of-limits metal results are frequently the result of a mix-up between the actual blank sample and a groundwater sample either in the field or in the laboratory.

CY2014 groundwater monitoring FBs yielded 6,421 VOC results. Of these results, 132 (2.1%) exceeded QC limits and included 123 methylene chloride results. The remaining VOC analytes and the number of results out of limits were acetone (5), carbon tetrachloride (1), chlorobenzene (2), and trichloroethene (1). During CY2012, a study of VOC contamination in groundwater FBs determined that the deionized water used to generate the FBs is the most likely source of the methylene chloride and to a lesser extent, carbon tetrachloride and chloroform found in the FBs (SGW-52194). The same study also concluded that the appearance of acetone, bromomethane, carbon disulfide, chloromethane, tetrachloroethene, and toluene in laboratory MBs indicates that these volatile organic analytes may be introduced as contaminants during laboratory sample preparation and analysis and may appear as spurious analytes in groundwater samples. Corrective actions to decrease the appearance of spurious organic compounds in groundwater monitoring FBs and samples have been initiated, but are yet to be completed.

Of the 1,420 SVOC results, none exceeded QC limits. Of the 583 radiochemical parameter results, 13 (2.2%) exceeded QC limits. The 13 out-of-limit results were distributed over six radiochemical parameters.

Table F-11 compares out-of-limit FB results with out-of-limit MB results. Many of the table entries show that the FB and MB results are similar in value indicating that the source of FB contamination is more likely caused by laboratory sample handling and preparation and is not the result of sample bottle preparation and sample collection activities. One clear exception to this statement is sample alkalinity; field sample preparation and handling appears to be the primary cause of sample contamination for that analyte.

F8.2 Field Duplicate Samples

Field duplicate samples are replicate groundwater samples sent to the same laboratory and are used to assess field sampling and laboratory measurement precision. According to Table F-1, the results of field duplicates must have a precision less than or equal to 20% as measured by the RPD (Equation F-1). Field duplicates with at least one result greater than five times the MDL or MDA were evaluated. Field duplicate results that have an RPD greater than 20% are given a review qualifier of Q in the HEIS *RESULT* table to indicate potential precision issues. Field duplicate values with a review qualifier of Y were included in the assessment of duplicate precision.

For CY2014, 210 duplicate sample sets were acquired consisting of 715 sample pairs. These 715 sample pairs yielded 9,805 pairs of results of which 3,008 result pairs (30.7%) met the evaluation criterion. Of these 3,008 result pairs, 2,859 (95.0%) were acceptable, indicating reasonable field sampling and intra-laboratory precision. Table F-12 presents the duplicate results that exceeded QC limits. For comparison, the CY 2013 percentage of acceptable duplicate results was 95.2%, and the CY2012 percentage of acceptable duplicate results was 94.2%.

Metals had the largest number of duplicate result failures with 91 data pairs exceeding the RPD criterion of 20%. Historically, many of the out-of-limit duplicates for metals were attributed to unfiltered samples in which suspended solids in the samples tend to cause discrepancies between result pairs. However, for CY2014, the metals duplicate result failures occurred in almost as many filtered samples as unfiltered samples. This may indicate possible sample swaps either in the field or in the laboratory, a sample contamination event that affected one of the duplicate pair but not the other, or a dilution error during sample preparation.

Table F-12. Field Duplicates Exceeding Quality Control Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Total Field Duplicate Results Out = 149						
General Chemical Parameters: Total Out = 9						
Alkalinity	TASL	36	36	3	8.3	21.4 - 27.4
Bi-carbonate alkalinity	TASL	33	33	3	9.1	21.4 - 27.4
Chemical Oxygen Demand	TASL	1	1	1	100	114.3
Total dissolved solids	TASL	2	2	1	50	196
Total petroleum hydrocarbons - diesel range	TASL	5	1	1	100	159.3
Ammonia and Anions: Total Out = 12						
Ammonium ion	GEL	1	1	1	100	85.2
Chloride	TASL	40	40	1	2.5	61.2
Cyanide	TASL	7	5	1	20	194.4

Table F-12. Field Duplicates Exceeding Quality Control Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Fluoride	TASL	40	37	3	8.1	20.7 - 26.3
Fluoride	WSCF	43	16	1	6.2	28.3
Nitrate	GEL	51	51	1	2	21.2
Nitrate	TASL	40	40	1	2.5	62.4
Nitrate	WSCF	43	43	1	2.3	23.2
Phosphate	TASL	5	2	1	50	50
Sulfate	TASL	40	40	1	2.5	63.6
Metals: Total Out = 91						
Aluminum	GEL	28	2	2	100	55.6 - 130.1
Arsenic	WSCF	86	24	4	16.7	21.2 - 25.7
Barium	GEL	78	78	1	1.3	36.7
Barium	TASL	83	77	1	1.3	29.2
Barium	WSCF	74	73	3	4.1	22.3 - 31.8
Boron	TASL	25	4	1	25	23.3
Calcium	WSCF	68	68	1	1.5	31.9
Chromium	GEL	80	53	2	3.8	27.8 - 51.3
Chromium	TASL	91	49	1	2	33.9
Chromium	WSCF	74	35	3	8.6	23.8 - 151.2
Cobalt	GEL	78	2	2	100	134 - 145.9
Cobalt	WSCF	74	3	1	33.3	139
Copper	GEL	78	6	4	66.7	36.8 - 79.2
Copper	TASL	83	7	5	71.4	21.3 - 168.2
Copper	WSCF	74	13	8	61.5	35.7 - 99.5
Hexavalent chromium	TARL	106	55	6	10.9	33.1 - 116.4
Hexavalent chromium	WSCF	30	22	1	4.5	23.8
Iron	GEL	70	10	2	20	96.1 - 131.8
Iron	TASL	83	21	6	28.6	23.9 - 52
Lead	TASL	33	5	1	20	163.6

Table F-12. Field Duplicates Exceeding Quality Control Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Magnesium	WSCF	68	68	1	1.5	28.4
Manganese	GEL	78	14	5	35.7	21.6 - 80.6
Manganese	TASL	83	17	3	17.6	42.5 - 68.2
Manganese	WSCF	74	14	4	28.6	21.2 - 188.7
Molybdenum	WSCF	24	20	1	5	20.2
Nickel	GEL	78	8	1	12.5	56.5
Nickel	TASL	83	15	2	13.3	27.1 - 75.2
Nickel	WSCF	74	17	2	11.8	25.7 - 26
Potassium	WSCF	68	68	1	1.5	39.1
Silver	WSCF	74	2	1	50	58
Strontium	WSCF	57	57	4	7	23.8 - 31.6
Tin	TASL	25	1	1	100	76.5
Tin	WSCF	20	1	1	100	98.5
Uranium	TASL	25	23	1	4.3	29.8
Uranium	WSCF	37	37	4	10.8	21.1 - 64.9
Vanadium	GEL	70	48	1	2.1	20.5
Zinc	TASL	83	3	1	33.3	124.2
Zinc	WSCF	74	3	2	66.7	88.4 - 180
Volatile Organic Compounds: Total Out = 2						
Carbon tetrachloride	WSCF	16	7	2	28.6	26.1 - 35.3
Semivolatile Organic Compounds: Total Out = 0						
Radiochemical Parameters: Total Out = 35						
Gross alpha	GEL	22	4	1	25	30.9
Gross alpha	WSCF	22	3	2	66.7	38.2 - 78.3
Gross beta	GEL	22	17	5	29.4	23.9 - 30.7
Gross beta	TARL	28	20	5	25	24.5 - 32.4
Gross beta	WSCF	28	15	6	40	23.4 - 66.7
Iodine-129	TARL	33	11	6	54.5	22.8 - 173.6

Table F-12. Field Duplicates Exceeding Quality Control Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Strontium-90	GEL	20	7	1	14.3	27.6
Technetium-99	WSCF	22	15	1	6.7	26.7
Tritium	GEL	29	22	1	4.5	33.9
Tritium	WSCF	33	16	2	12.5	35.9 - 64.6
Uranium-233/234	WSCF	6	5	1	20	31.6
Uranium-234	GEL	2	2	1	50	23.7
Uranium-235	WSCF	6	3	2	66.7	29.9 - 41.9
Uranium-238	WSCF	6	5	1	20	34.5

a. Duplicates with at least one result five times greater than the method detection limit or minimum detectable activity were evaluated.

b. Duplicate control limit is a relative percent difference less than or equal to 20%.

c. In cases where a non-detected result was compared with a measured value, the method detection limit or minimum detectable activity was used for the non-detected concentration.

GEL = GEL Laboratory

RPD = relative percent difference

TARL = TestAmerica Richland Laboratory

TASL = TestAmerica St. Louis

WSCF = Waste Sampling and Characterization Facility

F8.3 Quadruplicate Total Organic Carbon and Total Organic Halides Samples

TOC and TOX are classified as RCRA indicator analytes, and the samples for these analytes are usually taken in quadruplicate (40 CFR 265.92). For these analytes, the %RSD of the quadruplicate results was determined as described in Section F-4.2 and compared to a precision limit of 20%. Field quadruplicate sample results are evaluated only if at least one result is at least five times the laboratory MDL.

For TOC, 209 quadruplicate sample sets were taken. Of these 209 sample sets, 22 sets (10.5%) met the evaluation criterion and of these, only one set exceeded the precision criterion of 20% with a %RSD of 27.2%. This represents reasonable reproducibility for TOC samples. Table F-13 presents the quadruplicate sample sets that exceeded QC limits. One possible explanation for these failures may be inconsistent removal of inorganic carbon (typically present as bicarbonate or carbonate) from the sample prior to the determination of organic carbon in the sample. If inorganic carbon is not consistently and completely removed from the sample before determining organic carbon, the apparent concentration of organic carbon is likely to vary across a set of quadruplicate samples.

For TOX, 200 quadruplicate sample sets were taken. Of these 200 sample sets, 21 sets (10.5%) met the evaluation criterion and of these, six (28.6%) exceeded the 20% RSD criterion. One possible explanation for these failures may be inconsistent rinsing of inorganic chloride from the sample prior to the

determination of organic halides in the sample. If inorganic chloride is not consistently and completely removed from the sample before determining organic halides, the apparent concentration of organic halides is likely to vary across a set of quadruplicate samples.

Table F-13. Total Organic Carbon and Total Organic Halide Quadruplicate Results Exceeding Quality Control Limits.

Well Name	Lab	RL µg/L	Result 1 µg/L		Result 2 µg/L		Result 3 µg/L		Result 4 µg/L		%RSD*
Total Organic Carbon: Total Out = 1											
299-E17-14	WSCF	100	542	—	400	—	299	B	335	—	27.2
Total Organic Halides: Total Out = 6											
299-E17-19	TASL	1.8	2.6	B	2.7	B	12.6	—	4.3	B	85.8
299-E25-19	TASL	1.8	9.5	—	5.0	—	7.2	—	6.0	—	28.0
299-E25-47	TASL	1.8	9.8	—	8.8	—	9.6	—	5.2	—	25.7
299-E27-17	TASL	1.8	6.5	—	9.4	—	4.4	B	4.9	B	35.8
299-E32-5	TASL	1.8	5.8	—	9.5	—	6.4	—	5.5	—	27.0
299-E32-7	TASL	1.8	5.0	—	1.8	UN	16.9	—	14.4	—	76.3

*The percent RSD was compared to the field duplicate relative percent difference limit of 20%.

Laboratory qualifier flags:

B = analyte detected between the reporting limit and the estimated quantitation limit (WSCF)
U = analyte not detected above the reporting limit
X = greater than 10% breakthrough detected between first and second adsorption columns (WSCF TOX)

RL = reporting limit

%RSD = percent relative standard deviation

TOX = total organic halide

WSCF = Waste Sampling and Characterization Facility

F8.4 Field Split Samples

Field split samples are duplicate samples that are sent to two different laboratories to allow interlaboratory comparisons of analytical results. These interlaboratory comparisons are used to evaluate the performance of the laboratories, to determine the extent of any analytical problems, and to confirm out-of-trend results. According to Table F-1, the precision acceptance criterion for field splits is an RPD less than or equal to 20%. Only those field split results pairs with at least one result greater than five times the MDLs or MDAs of both laboratories were evaluated. If the laboratory reported an estimated quantitation limit instead of an MDL, the evaluation criterion was one times the estimated quantitation limit instead of five times the MDL. For TOC and TOX split samples, a matching set of quadruplicate samples was submitted to each of the two laboratories. To evaluate the interlaboratory reproducibility for TOC and TOX, an average result was first calculated for each laboratory's quadruplicate sample set, and then the average values from the two laboratories were used to calculate the RPD.

For CY2014, 67 field split sample sets consisting of 242 sample pairs yielded 2,961 pairs of field split data. Of the 2,961 data pairs, 813 pairs (27.5%) met the evaluation criterion. For the evaluated field splits, 738 pairs (90.8%) met the 20% RPD criterion. For comparison, the percentage of pairs within the limit was 86.8% for CY2013 and 86.4% for CY2012. Table F-14 summarizes the results for field splits that exceeded the 20% RPD limit.

Table F-14. Field Splits Exceeding Quality Control Limits

Constituent	Total Number of Splits	Number of Splits Evaluated[a]	Number Out of Limits	Percent Out of Limits	Range of Out-of-Limit Relative Percent Difference[b]
Total Field Split Results Out = 75					
General Chemical Parameters: Total Out = 2					
Oil and grease	1	1	1	100	157
Total petroleum hydrocarbons - diesel range	4	1	1	100	60
Ammonia and Anions: Total Out = 13					
Chloride	41	41	3	7.3	27.4 - 58.7
Fluoride	41	21	6	28.6	20.4 - 86
Nitrate	41	40	2	5	20.8 - 57.5
Sulfate	41	41	2	4.9	34.9 - 74.6
Metals: Total Out = 47					
Aluminum	21	2	2	100	73.1 - 131.7
Barium	89	83	3	3.6	21.6 - 33.2
Boron	21	3	2	66.7	158.8 - 169.7
Calcium	81	81	1	1.2	23.4
Chromium	89	28	1	3.6	35.8

Table F-14. Field Splits Exceeding Quality Control Limits

Constituent	Total Number of Splits	Number of Splits Evaluated[a]	Number Out of Limits	Percent Out of Limits	Range of Out-of-Limit Relative Percent Difference[b]
Cobalt	89	1	1	100	172.3
Copper	89	4	1	25	44.1
Hexavalent chromium	32	11	5	45.5	20.7 - 195.6
Iron	81	10	5	50	65 - 180.1
Lead	21	1	1	100	70
Magnesium	81	81	1	1.2	61.8
Manganese	89	10	2	20	83.8 - 164.7
Molybdenum	21	2	2	100	22.5 - 35.1
Nickel	89	11	6	54.5	27.5 - 175.8
Potassium	81	67	1	1.5	99
Sodium	81	81	1	1.2	35
Strontium	73	73	2	2.7	20.4 - 23.9
Tin	21	1	1	100	139.4
Uranium	46	40	8	20	20.1 - 36.8
Zinc	89	1	1	100	170.8
Volatile Organic Compounds: Total Out = 2					
Trichloroethene	13	3	2	66.7	29.3 - 33.1
Semivolatile Organic Compounds: Total Out = 0					
Radiochemical Parameters: Total Out = 11					
Gross beta	19	8	4	50	22 - 41.2
Strontium-90	27	10	3	30	25 - 28.7
Tritium	32	18	3	16.7	143 - 184.6
Uranium-238	1	1	1	100	27.1

a. Splits sample results were evaluated when at least one result was greater than five times the method detection limit or minimum detectable activity of both laboratories. In cases where a non-detected result was compared with a measured value, the method detection limit or minimum detectable activity was used as the non-detected result.

b. Split control limit is a relative percent difference less than or equal to 20%.

The metals analyses constituted 60% of the total split failures. The majority of these failures occurred on unfiltered samples; hence, the variability of suspended solids in the samples is a likely cause of discrepancies in the results for non-filtered samples. Other possible causes for the discrepancies are samples swapped either in the field or in the laboratory and possible dilution errors at the time of analysis.

After the metals analyses, the ammonia/anions and radiochemical results each accounted for 32% of the split sample failures. For ammonia and anions, split failures were for chloride (3), fluoride (6), nitrate and sulfate with two each.

For the radiochemical parameters, the majority of the splits failures were posted for gross beta (four), strontium-90 and tritium (3 each), and uranium-238 with one failure. The four gross beta failures were between TARL and WSCF and did not show any consistent bias between the two laboratories.

For the two remaining analyte classes, VOCs had two split pair failures, or 2.7% of the total failures. The four failures were for trichloroethene and were between TASL and WSCF; no consistent bias was detected between the two laboratories. No split pair results passed the evaluation criterion for the semivolatile organic compounds. General chemical parameters also had two split pair failures, or 2.7% of the total failures. The two failures were for oil and grease and TPH-diesel range.

F9 Laboratory Quality Control

This section discusses the CY2014 groundwater monitoring laboratory batch QC data that exceeded the QC acceptance criteria listed in Table F-1. The types of laboratory QC samples that are evaluated in this section are discussed in Section F-4.3. Table F-15 summarizes the laboratory QC data by laboratory, and Table F-16 summarizes the laboratory QC data by analyte class. Overall, the laboratory QC data indicate that laboratory analytical measurements for the groundwater monitoring program are produced within the QC limits of Table F-1. Of the 111,731 laboratory batch QC measurements reported with groundwater monitoring results, 98.1% of the measurements met the groundwater monitoring QC requirements; this is comparable to the 98.5% reported for CY2013. When the laboratories detect failures in batch QC samples, the laboratories usually apply a QC laboratory qualifier to the data as noted in Table F-3.

Table F-15. Laboratory Quality Control Results by Laboratory

QC Parameter	GEL	TARL	TASL	WSCF	Total
Total Laboratory QC Results	42,023	4,409	41,404	23,895	111,731
Laboratory QC Results Out	610	129	975	379	2,093
Laboratory QC Results Out Percent	1.5%	2.9%	2.4%	1.6%	1.9%
Method Blanks Total	10,470	1,503	8,500	6,654	27,127
Method Blanks Out	163	36	514	45	758
Method Blanks Out Percent	1.6%	2.4%	6.0%	0.7%	2.8%
Lab Control Samples Total	9,048	1,313	10,077	4,503	24,941
Lab Control Samples Out Low	10	3	1	8	22
Lab Control Samples Out High	13	3	113	17	146
Lab Control Samples Out Percent	0.3%	0.5%	1.1%	0.6%	0.7%

Table F-15. Laboratory Quality Control Results by Laboratory

QC Parameter	GEL	TARL	TASL	WSCF	Total
Lab Control Sample Duplicates Total	117	0	2,017	1	2,135
Lab Control Sample Duplicates Out	5	0	22	0	27
Lab Control Sample Duplicates Out Percent	4.3%	-	1.1%	0.0%	1.3%
Matrix Spikes Total	12,782	801	11,079	6,077	30,739
Matrix Spikes Out Low	204	7	130	100	441
Matrix Spikes Out High	148	6	123	56	333
Matrix Spikes Out Percent	2.8%	1.6%	2.3%	2.6%	2.5%
Matrix Spike Duplicates Total	5,706	206	5,053	2,938	13,903
Matrix Spike Duplicates Out	43	0	29	83	155
Matrix Spike Duplicates Out Percent	0.8%	0.0%	0.6%	2.8%	1.1%
Sample Duplicates Total	892	586	563	189	2,230
Sample Duplicates Out	19	74	4	6	103
Sample Duplicates Out Percent	2.1%	12.6%	0.7%	3.2%	4.6%
Surrogates Total	3,008	0	4,115	3,194	10,317
Surrogates Out Low	4	0	13	20	37
Surrogates Out High	1	0	26	39	66
Surrogates Out Percent	0.2%	-	0.9%	1.8%	1.0%
Surrogate Duplicates Total	0	0	0	339	339
Surrogate Duplicates Out	0	0	0	5	5
Surrogate Duplicates Out Percent	-	-	-	1.5%	1.5%

GEL = GEL Laboratory
QC = quality control
TARL = TestAmerica Richland Laboratory
TASL = TestAmerica St. Louis
WSCF = Waste Sampling and Characterization Facility

Table F-16. Laboratory Quality Control Results by Analyte Class

Quality Control Parameter	General Chemical Parameters	Ammonia / Anions	Metals	Volatile Organic Compounds	Semivolatile Organic Compounds	Radiochemical Parameters	Total
Total Laboratory QC Results	3,273	9,822	50,901	30,423	13,098	4,214	111,731
Laboratory QC Results Out	174	450	700	399	313	57	2,093
Laboratory QC Results Out Percent	5.3%	4.6%	1.4%	1.3%	2.4%	1.4%	1.9%
Method Blanks Total	889	2,563	11,682	6,179	3,729	2,085	27,127
Method Blanks Out	123	84	533	7	0	11	758
Method Blanks Out Percent	13.8%	3.3%	4.6%	0.1%	0.0%	0.5%	2.8%
Lab Control Samples Total	742	2,589	11,846	6,731	1,703	1,330	24,941
Lab Control Samples Out Low	9	0	1	3	4	5	22
Lab Control Samples Out High	2	5	9	23	101	6	146
Lab Control Samples Out Percent	1.5%	0.2%	0.1%	0.4%	6.2%	0.8%	0.7%
Lab Control Sample Duplicates Total	14	-	70	1,975	76	-	2,135
Lab Control Sample Duplicates Out	-	-	-	22	5	-	27
Lab Control Sample Duplicates Out Percent	0.0%	-	0.0%	1.1%	6.6%	-	1.3%
Matrix Spikes Total	789	3,002	18,063	5,896	2,640	349	30,739
Matrix Spikes Out Low	24	124	76	198	18	1	441

Table F-16. Laboratory Quality Control Results by Analyte Class

Quality Control Parameter	General Chemical Parameters	Ammonia / Anions	Metals	Volatile Organic Compounds	Semivolatile Organic Compounds	Radiochemical Parameters	Total
Matrix Spikes Out High	3	192	41	36	58	3	333
Matrix Spikes Out Percent	3.4%	10.5%	0.6%	4.0%	2.9%	1.1%	2.5%
Matrix Spike Duplicates Total	190	514	8,865	2,948	1,320	66	13,903
Matrix Spike Duplicates Out	6	0	15	57	76	1	155
Matrix Spike Duplicates Out Percent	3.2%	0.0%	0.2%	1.9%	5.8%	1.5%	1.1%
Sample Duplicates Total	316	1,154	375	1	-	384	2,230
Sample Duplicates Out	3	45	25	-	-	30	103
Sample Duplicates Out Percent	0.9%	3.9%	6.7%	0.0%	-	7.8%	4.6%
Surrogates Total	324	0	0	6,575	3,418	0	10,317
Surrogates Out Low	4	0	0	0	33	0	37
Surrogates Out High	0	0	0	48	18	0	66
Surrogates Out Percent	1.2%	-	-	0.7%	1.5%	-	1.0%
Surrogate Duplicates Total	9	0	0	118	212	0	339
Surrogate Duplicates Out	0	0	0	5	0	0	5
Surrogate Duplicates Out Percent	0.0%	-	-	4.2%	0.0%	-	1.5%

F9.1 Laboratory Method Blanks

Laboratory MBs are used to assess potential contamination associated with laboratory sample preparation and analysis. Of the 27,127 laboratory MB results evaluated for CY2014, 97.2% met the QC criteria outlined in Table F-1 indicating little problem with laboratory contamination. This is poorer than the 98.1% reported for CY 2013 and the 98.5% reported for CY2012.

Evaluation of MB results was based on the MB QC limits listed in Table F-1. For the common laboratory contaminants 2-butanone, acetone, methylene chloride, phthalate esters, and toluene, the QC limit is five times the MDL. The laboratories flag results associated with out-of-limit blank results in the laboratory qualifier field in the HEIS database as described in Table F-3. For inorganic analytes (including the indicator analytes TOC and TOX), results associated with an out-of-limit MB are flagged with a C. For organic analytes, results associated with an out-of-limit MB are flagged with a B. The laboratory may not flag the groundwater sample result if the analyte concentration in the MB is less than 5% of the concentration of the analyte in a groundwater sample analyzed in the same batch. Table F-17 summarizes the CY2014 out-of-limit MB results.

In CY2014, by laboratory, TASL had the lowest success rate of 93.0% for the 7,360 MB results reported by that laboratory. TASL reported 115 general chemical parameter MB failures. For the anions, TASL reported 56 MB failures. For the metals, TASL reported 338 out-of-limit MBs. TASL reported five VOC MB failures. No SVOC failures were reported by any laboratory.

The TARL laboratory's success rate for MBs was 97.6%. Most of the MB failures were for the anions.

The remaining laboratories reported MB success rates greater than 98%.

By analyte category, general chemical parameters had the lowest MB success rate at 86.2% with 123 MB failures. Metals had the next lowest success rate at 95.4% with 533 failed MBs. Anions had the next lowest success rate at 96.7% with 84 failed MBs. The remaining analyte classes had MB success rates greater than 99%.

Table F-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Total Method Blanks Out = 758						
General Chemical Parameters: Total Out = 123						
Alkalinity	TASL	56	55	98.2	140 – 270 ug/L	250 – 3750 ug/L
Bi-carbonate alkalinity	TASL	55	54	98.2	140 - 270 ug/L	250 - 3750 ug/L
Dissolved organic carbon	TASL	6	2	33.3	470 ug/L	605 - 723 ug/L
Total dissolved solids	TASL	5	1	20	3500 ug/L	6000 ug/L
Total dissolved solids	WSCF	6	1	16.7	10000 ug/L	21000 ug/L
Total organic carbon	GEL	55	2	3.6	330 ug/L	354 - 415 ug/L
Total organic carbon	TASL	28	3	10.7	270 - 350 ug/L	313 - 495 ug/L
Total organic carbon	WSCF	33	1	3	45 ug/L	47.9 ug/L
Total organic halides	GEL	55	2	3.6	3.33 ug/L	3.46 - 5.18 ug/L
Total petroleum hydrocarbons - diesel range	GEL	21	2	9.5	50 - 200 ug/L	75.7 - 89 ug/L
Ammonia and Anions: Total Out = 84						
Ammonium ion	GEL	21	6	28.6	18.0 ug/L	21.3 - 43.2 ug/L
Ammonium ion	TASL	11	2	18.2	10.7 ug/L	125 - 35.0 ug/L
Chloride	GEL	159	1	0.6	67 ug/L	75.6 ug/L
Chloride	TARL	31	5	16.1	50 - 200 ug/L	140 - 250 ug/L
Chloride	TASL	140	41	29.3	20 ug/L	20.9 - 151 ug/L
Cyanide	TASL	26	4	15.4	1.5 - 2.9 ug/L	2.25 - 29.99 ug/L
Fluoride	TARL	31	2	6.5	12.5 - 50 ug/L	26 - 51 ug/L
Fluoride	TASL	122	1	0.8	10 ug/L	23.7 ug/L

Table F-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Nitrate	TARL	31	6	19.4	31.253208 - 110.67 ug/L	66.402 - 163.7916 ug/L
Phosphate	TASL	37	5	13.5	78 ug/L	174 - 286 ug/L
Sulfate	TARL	32	8	25	62.5 - 250 ug/L	129 - 457 ug/L
Sulfate	TASL	139	1	0.7	50 ug/L	52.8 ug/L
Sulfide	TASL	10	2	20	83 - 2000 ug/L	100 ug/L
Metals: Total Out = 533						
Aluminum	TASL	85	10	11.8	12.9 ug/L	12.97 - 23.63 ug/L
Antimony	GEL	234	23	9.8	1 - 3.5 ug/L	1.05 - 8.86 ug/L
Antimony	TASL	196	8	4.1	1.7 - 4 ug/L	1.72 - 3.25 ug/L
Arsenic	GEL	239	14	5.9	1.7 - 5 ug/L	1.76 - 9.68 ug/L
Arsenic	TASL	200	9	4.5	1.2 - 2 ug/L	1.9 - 4.1 ug/L
Barium	GEL	232	3	1.3	0.6 - 1 ug/L	1.18 - 2.62 ug/L
Barium	TASL	195	14	7.2	0.22 - 4 ug/L	0.248 - 4.49 ug/L
Barium	WSCF	99	1	1	0.2 - 4 ug/L	0.209 ug/L
Beryllium	GEL	165	1	0.6	0.2 - 1 ug/L	1.09 ug/L
Beryllium	TASL	142	1	0.7	0.28 - 0.61 ug/L	0.3 ug/L
Boron	GEL	98	1	1	4 ug/L	4.44 ug/L
Boron	TASL	91	12	13.2	7.2 - 10 ug/L	7.4 - 27.6 ug/L
Cadmium	GEL	231	1	0.4	0.11 - 1 ug/L	2.45 ug/L
Cadmium	TASL	195	5	2.6	0.1 - 0.91 ug/L	0.116 - 0.4 ug/L
Calcium	TASL	166	53	31.9	54.2 - 106 ug/L	54.3 - 478 ug/L

Table F-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Calcium	WSCF	61	2	3.3	50 ug/L	82.9 - 179 ug/L
Chromium	GEL	234	3	1.3	1 - 2 ug/L	2.05 - 2.77 ug/L
Chromium	TASL	213	4	1.9	1 - 3.4 ug/L	1.27 - 1.66 ug/L
Chromium	WSCF	99	2	2	0.1 - 5 ug/L	0.123 - 0.371 ug/L
Cobalt	GEL	232	2	0.9	0.1 - 1 ug/L	0.136 - 1.15 ug/L
Cobalt	TASL	196	1	0.5	0.22 - 4.9 ug/L	0.388 ug/L
Copper	GEL	232	4	1.7	0.35 - 3 ug/L	0.351 - 5.61 ug/L
Copper	TASL	196	22	11.2	0.45 - 4.6 ug/L	0.464 - 256.9 ug/L
Hexavalent chromium	GEL	18	1	5.6	3 ug/L	3.47 ug/L
Hexavalent chromium	TARL	341	4	1.2	1.5 - 8 ug/L	1.6 - 2.1 ug/L
Iron	GEL	162	6	3.7	30 ug/L	31.2 - 62 ug/L
Iron	TASL	144	14	9.7	12.8 - 28.2 ug/L	13.7 - 34.7 ug/L
Iron	WSCF	61	1	1.6	40 ug/L	44.5 ug/L
Lead	TASL	103	9	8.7	0.17 - 0.6 ug/L	0.182 - 1.1 ug/L
Lead	WSCF	47	1	2.1	0.05 - 25 ug/L	0.138 ug/L
Manganese	GEL	231	1	0.4	1 - 2 ug/L	2.66 ug/L
Manganese	TASL	195	33	16.9	0.25 - 3.3 ug/L	0.258 - 1.4 ug/L
Mercury	TASL	16	2	12.5	0.06 ug/L	0.0886 - 0.124 ug/L
Molybdenum	GEL	120	2	1.7	0.165 - 2 ug/L	0.189 - 0.204 ug/L
Nickel	TASL	196	4	2	0.4 - 13.3 ug/L	0.459 - 3.53 ug/L
Potassium	GEL	165	22	13.3	50 ug/L	51.3 - 104 ug/L

Table F-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Potassium	WSCF	61	11	18	250 ug/L	252 - 646 ug/L
Selenium	TASL	85	6	7.1	1.6 ug/L	1.7 - 3.11 ug/L
Silver	GEL	232	2	0.9	0.2 - 1 ug/L	1.41 - 3.41 ug/L
Silver	TASL	194	4	2.1	0.77 - 6 ug/L	1 - 1.2 ug/L
Sodium	GEL	164	7	4.3	100 ug/L	101 - 331 ug/L
Sodium	TASL	163	4	2.5	105 - 324 ug/L	148.4 - 2300 ug/L
Sodium	WSCF	61	17	27.9	100 ug/L	102 - 338 ug/L
Strontium	GEL	176	1	0.6	1 - 2 ug/L	1.67 ug/L
Strontium	TASL	152	42	27.6	0.06 - 0.54 ug/L	0.07 - 0.9 ug/L
Thorium	GEL	100	6	6	0.383 ug/L	0.437 - 1.38 ug/L
Tin	GEL	100	4	4	1 ug/L	1.15 - 6.07 ug/L
Tin	TASL	84	21	25	1 - 1.1 ug/L	1.11 - 3.81 ug/L
Uranium	GEL	135	6	4.4	0.067 - 1.16 ug/L	0.068 - 0.396 ug/L
Uranium	TARL	52	3	5.8	0.00832 - 0.0835 ug/L	0.177 - 3.82 ug/L
Uranium	TASL	86	1	1.2	0.23 ug/L	0.364 ug/L
Vanadium	GEL	162	2	1.2	1 ug/L	1.04 - 1.1 ug/L
Vanadium	TASL	135	2	1.5	2.4 - 4.4 ug/L	4.5 - 5.2 ug/L
Zinc	GEL	231	34	14.7	3.3 - 3.5 ug/L	3.39 - 8.62 ug/L
Zinc	TASL	198	57	28.8	5.2 - 8.3 ug/L	6.1 - 70.22 ug/L
Zinc	WSCF	99	7	7.1	2 - 5 ug/L	2.8 - 10.5 ug/L
Volatile Organic Compounds: Total Out = 7						

Table F-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
1,1-Dichloroethene	TASL	60	1	1.7	0.08 ug/L	0.0848 ug/L
Acetone[b]	TASL	60	2	3.3	1.7 ug/L	1.88 - 2.13 ug/L
Methacrylonitrile	TASL	17	1	5.9	0.5 ug/L	0.686 ug/L
Tetrahydrofuran	GEL	44	1	2.3	1.5 - 50 ug/L	1.72 ug/L
Trichloroethene	GEL	78	1	1.3	0.3 - 5 ug/L	0.65 ug/L
Trichloromonofluoromethane	TASL	17	1	5.9	0.11 ug/L	0.243 ug/L
Semivolatile Organic Compounds: Total Out = 0						
Radiochemical Parameters: Total Out = 11						
Gross beta	TARL	67	2	3	3.22 - 4.2 pCi/L	4.09 - 8.35 pCi/L
Strontium-90	GEL	35	2	5.7	1.068 - 8.06 pCi/L	1.54 - 2.78 pCi/L
Strontium-90	TARL	83	5	6	0.616 - 2.12 pCi/L	0.861 - 3.95 pCi/L
Uranium-233/234	WSCF	13	1	7.7	0.076 - 42 pCi/L	0.082 pCi/L
Uranium-238	TARL	9	1	11.1	0.0772 - 0.772 pCi/L	0.622 pCi/L

a. For general chemical parameters, ammonia and anions, metals, and volatile organic compounds, the quality control limit for method blanks is the method detection limit. For semivolatile organic compounds, the quality control limit is twice the method detection limit. For radiochemical constituents, the quality control limit is twice the minimum detectable activity.

b. The quality control limit for this analyte is five times the method detection limit.

GEL = GEL Laboratory

QC = quality control

TARL = TestAmerica Richland Laboratory

TASL = TestAmerica St. Louis

WSCF = Waste Sampling and Characterization Facility

F9.2 Laboratory Control Samples and Laboratory Control Sample Duplicates

LCS recoveries give a measure of the accuracy of an analytical result, and the LCS duplicate RPD gives a measure of the repeatability of the analytical result. Laboratories may apply a laboratory qualifier of O or X and an accompanying explanatory note when LCS recoveries or LCSD RPDs are outside QC limits. LCS results were available across all the analyte categories while LCSD results were available primarily for VOCs and SVOCs.

Overall, 99.3% of the percent recoveries for the 24,941 reported LCSs and 99.6% of the RPDs for the 3,711 reported LCSDs met the QC criteria cited in Table F-1. This is comparable to the acceptance rates of 99.4% for LCS percent recoveries and 99.1% of the RPDs for the LCSD RPDs during CY2013 and the acceptance rates of 99.2% for LCS percent recoveries and 99.3% for LCSD RPDs during CY2012. These success rates for percent recoveries and RPDs provide assurance that the analytical measurement processes are in good control and are producing results with sufficient accuracy and precision to meet the needs of the groundwater monitoring program. Table F-18 summarizes the CY2014 out-of-limits LCS and LCSD results.

Table F-18. Laboratory Control Sample Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of LCSD	Percent RPD Out of Limit
General Chemical Parameters: Recovery Limits = 80% - 120%, RPD Limit = 20%[b]						
Chemical oxygen demand	TASL	4	0	25	0	0
Total petroleum hydrocarbons - diesel range	GEL	20	15	0	0	0
Total petroleum hydrocarbons - diesel range	TASL	18	0	5.6	1	0
Total petroleum hydrocarbons - kerosene range	GEL	8	75	0	4	0
Ammonia and Anions: Recovery Limits = 80% - 120%, RPD Limit = 20%[b]						
Ammonium ion	TASL	11	0	18.2	0	0
Nitrite	TASL	123	0	0.8	0	0
Phosphate	GEL	62	0	3.2	0	0
Metals: Recovery Limits = 80% - 120%, RPD Limit = 20%[b]						
Calcium	TASL	166	0	2.4	0	0
Hexavalent chromium	TARL	355	0	0.3	0	0
Potassium	TASL	163	0	0.6	0	0
Silver	WSCF	99	1	1	0	0
Sodium	TASL	163	0	0.6	0	0

Table F-18. Laboratory Control Sample Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of LCSD	Percent RPD Out of Limit
Zinc	WSCF	99	0	1	0	0
Volatile Organic Compounds: Recovery and RPD Limits = Laboratory Specific (Statistically Derived)						
1,1,1-Trichloroethane	TASL	119	0	6.7	59	0
1,1,2,2-Tetrachloroethane	WSCF	21	4.8	0	0	0
1,1-Dichloroethene	TASL	119	0	0.8	59	0
1,2-Dibromo-3-chloropropane	TASL	33	0	0	16	6.2
1,2-Dichloropropane	WSCF	21	4.8	0	0	0
1-Butanol	TASL	93	0	0	46	8.7
2-Butanone	TASL	119	0	0	59	5.1
2-Hexanone	TASL	33	0	0	16	12.5
4-Methyl-2-pentanone	TASL	119	0	0	59	1.7
Acetone	GEL	67	0	3	0	0
Acetone	TASL	119	0	0	59	3.4
Acrolein	GEL	16	0	6.2	0	0
Carbon disulfide	TASL	119	0	2.5	59	0
Carbon disulfide	WSCF	39	2.6	2.6	0	0
Carbon tetrachloride	TASL	119	0	0.8	59	0
Chloroprene	GEL	16	0	18.8	0	0
Isobutyl alcohol	TASL	31	0	3.2	15	26.7
Methyl methacrylate	TASL	33	0	0	16	6.2
Methylene chloride	TASL	119	0	0	59	1.7
Tetrachloroethene	TASL	119	0	0.8	59	0
Tetrahydrofuran	TASL	93	0	0	46	4.3
trans-1,2-Dichloroethylene	TASL	93	0	0	46	2.2
Vinyl chloride	TASL	119	0	0.8	59	0
Semivolatile Organic Compounds: Recovery and RPD Limits = Laboratory Specific (Statistically Derived)						
2,4,5-Trichlorophenol	TASL	10	0	70	0	0
2,4,6-Trichlorophenol	TASL	10	0	70	0	0

Table F-18. Laboratory Control Sample Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of LCSD	Percent RPD Out of Limit
2,4-Dichlorophenol	TASL	13	0	69.2	0	0
2,4-Dimethylphenol	WSCF	22	4.5	0	0	0
2,4-Dinitrophenol	TASL	10	0	10	0	0
2,4-Dinitrotoluene	TASL	7	0	14.3	0	0
2,6-Dinitrotoluene	TASL	6	0	16.7	0	0
2-Chlorophenol	TASL	10	0	20	0	0
2-Methylnaphthalene	TASL	6	0	16.7	0	0
2-Methylphenol (cresol, o-)	TASL	13	0	30.8	0	0
2-Methylphenol (cresol, o-)	WSCF	23	4.3	0	0	0
2-Nitroaniline	TASL	6	0	16.7	0	0
2-Nitrophenol	TASL	13	0	38.5	0	0
3,3'-Dichlorobenzidine	TASL	6	0	33.3	0	0
3+4 Methylphenol (cresol, m+p)	TASL	13	0	23.1	0	0
3-Nitroaniline	TASL	6	0	50	0	0
4,4'-DDD (Dichlorodiphenyldichloroethane)	TASL	11	0	18.2	2	0
4,4'-DDE (Dichlorodiphenyldichloroethylene)	TASL	11	0	9.1	2	0
4-Chloro-3-methylphenol	TASL	10	0	40	0	0
4-Chloroaniline	TASL	6	0	66.7	0	0
4-Chlorophenylphenyl ether	TASL	6	0	16.7	0	0
4-Nitroaniline	TASL	6	0	33.3	0	0
4-Nitrophenol	GEL	9	11.1	0	0	0
4-Nitrophenol	TASL	10	0	40	0	0
Benzo(a)pyrene	GEL	7	0	0	1	100
Benzo(ghi)perylene	GEL	7	0	0	1	100
Benzo(k)fluoranthene	GEL	7	0	0	1	100
Bis(2-ethylhexyl) phthalate	TASL	10	0	20	0	0
Bis(2-ethylhexyl) phthalate	WSCF	16	0	43.8	0	0

Table F-18. Laboratory Control Sample Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of LCSD	Percent RPD Out of Limit
Butylbenzylphthalate	TASL	6	0	33.3	0	0
Chrysene	TASL	7	0	14.3	0	0
Delta-BHC	TASL	11	0	9.1	2	0
Dibenz[a,h]anthracene	GEL	7	0	0	1	100
Dibenz[a,h]anthracene	TASL	7	0	14.3	0	0
Diethylphthalate	TASL	6	0	33.3	0	0
Dimethyl phthalate	TASL	6	0	50	0	0
Di-n-butylphthalate	WSCF	10	0	20	0	0
Di-n-octylphthalate	TASL	6	0	16.7	0	0
Di-n-octylphthalate	WSCF	10	0	10	0	0
Endrin	GEL	5	0	40	1	0
Fluorene	TASL	7	0	14.3	0	0
Heptachlor	TASL	11	0	9.1	2	0
Indeno(1,2,3-cd)pyrene	GEL	7	0	0	1	100
Isophorone	TASL	6	0	16.7	0	0
Methoxychlor	GEL	5	0	60	1	0
Methoxychlor	TASL	11	0	9.1	2	0
Naphthalene	TASL	11	0	9.1	0	0
Phenol	TASL	13	7.7	15.4	0	0
Pyrene	TASL	7	0	14.3	0	0
Radiochemical Parameters: Recovery Limits = 70% - 130%, RPD Limit = 20%[b]						
Cobalt-60	TARL	47	2.1	0	0	0
Gross alpha	WSCF	53	3.8	0	0	0
Iodine-129	TARL	62	1.6	0	0	0
Neptunium-237	TARL	5	0	20	0	0
Uranium-233/234	TARL	9	0	11.1	0	0
Uranium-235	TARL	3	33.3	0	0	0
Uranium-238	WSCF	13	0	30.8	0	0

Table F-18. Laboratory Control Sample Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of LCSD	Percent RPD Out of Limit

a. Includes both laboratory control samples and laboratory control sample duplicates.

b. Laboratory-specific limits were used if provided. Otherwise the stated limits were used to evaluate LCS/LCSDs.

LCS = laboratory control sample

LCSD = laboratory control sample duplicate

RPD = relative percent difference

GEL = GEL Laboratory

TARL = TestAmerica Richland Laboratory

TASL = TestAmerica St. Louis Laboratory

WSCF = Waste Sampling and Characterization Facility

In CY2014, for all four reporting laboratories, greater than 99% of their LCS recoveries met QC recovery criteria. For the LCSDs, WSCF and TARL met the RPD QC requirement for 100% of that laboratory's LCSD results. Of the 2,561 LCSD results TASL reported, 99.5% met RPD requirements; of the 243 LCSD results GEL reported, 98% met RPD requirements. These LCS and LCSD results indicate sufficient method control, analytical accuracy, and analytical repeatability to meet the data needs for the groundwater monitoring program.

F9.3 Matrix Spikes and Matrix Spike Duplicates

Matrix spikes provide a measure of the accuracy of an analytical result and are used to determine if sample matrix effects may have affected analytical results. MSDs give a measure of the repeatability of the analytical result. Only those samples that were spiked at a level at least one-fourth of the sample concentration were evaluated. For MS recovery failures, the laboratories apply a laboratory qualifier of N for non-gas chromatography – mass spectrometry methods, and a laboratory qualifier of T for gas chromatography – mass spectrometry methods. MS and MSD results were available across all the analyte categories although the MSD RPD data for the radiochemical parameters are limited to gross alpha and gross beta analyses from GEL. In this discussion, the set of MS recoveries also includes recoveries for MSDs.

Of the 31,805 MS results reported for CY2014, 30,739 (96.6%) met the evaluation criterion. Of the 30,739 evaluated MS results, 97.5% met the percent recovery QC criteria cited in Table F-1. Of the 14,419 MS/MSD pairs reported, 13,903 (96.4%) met the evaluation criterion; of the 13,903 evaluated pairs, 98.9% met the RPD QC criteria of Table F-1. These success rates for percent recoveries and RPDs are similar to those for the LCS and LCSD QC and provide additional assurance that the laboratories are producing data with sufficient accuracy and precision to meet the needs of the groundwater monitoring program. By comparison, 97.8% of the percent recoveries and 99.1% of the RPDs met QC criteria in CY 2013, and 99.2% of the percent recoveries and 99.4% of the RPDs met QC criteria in CY2012. Table F-19 summarizes the CY2014 out-of-limits MS and MSD results.

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
General Chemistry Parameters: Recovery Limits = 75% - 125%, RPD Limit = 20%[b]						
Alkalinity	TASL	54	5.6	0	0	0
Bi-carbonate alkalinity	TASL	46	4.3	0	0	0
Chemical oxygen demand	TASL	3	0	66.7	0	0
Oil and grease	GEL	1	100	0	0	0
Total organic halides	GEL	51	2	0	0	0
Total organic halides	TASL	37	2.7	2.7	0	0
Total organic halides	WSCF	140	0.7	0	70	1.4
Total petroleum hydrocarbons - diesel range	GEL	40	35	0	20	15
Total petroleum hydrocarbons - diesel range	TASL	33	0	0	17	11.8
Total petroleum hydrocarbons - gasoline range	WSCF	4	25	0	2	0
Ammonia and Anions: Recovery Limits = 75% - 125%, RPD Limit = 20%[b]						
Ammonium ion	GEL	21	9.5	19	0	0
Ammonium ion	TASL	11	0	90.9	0	0
Bromide	TASL	23	0	4.3	1	0
Chloride	GEL	173	0	23.7	0	0
Chloride	TASL	163	0.6	8.6	7	0
Chloride	WSCF	174	10.9	4	87	0
Cyanide	GEL	29	3.4	0	0	0
Fluoride	GEL	171	0.6	1.2	0	0
Fluoride	TASL	149	0	6.7	4	0
Fluoride	WSCF	206	1.5	0.5	103	0
Nitrate	GEL	171	0	17	0	0
Nitrate	TASL	155	1.3	3.9	7	0
Nitrate	WSCF	184	2.7	0.5	92	0
Nitrite	GEL	171	0.6	1.2	0	0
Nitrite	TARL	31	9.7	9.7	0	0
Nitrite	TASL	148	44.6	4.1	4	0
Nitrite	WSCF	206	0	1.5	103	0

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
Phosphate	GEL	50	12	0	0	0
Phosphate	TARL	2	50	0	0	0
Phosphate	TASL	40	20	32.5	1	0
Sulfate	GEL	172	0	19.8	0	0
Sulfate	TASL	153	2	1.3	5	0
Sulfate	WSCF	97	2.1	1	48	0
Sulfide	TASL	10	0	20	0	0
Metals: Recovery Limits = 75% - 125%, RPD Limit = 20%[b]						
Antimony	WSCF	124	1.6	0	62	1.6
Barium	WSCF	126	0.8	0	63	0
Beryllium	GEL	265	0	0.8	132	0
Beryllium	WSCF	88	0	0	44	2.3
Boron	GEL	185	0	1.1	92	0
Boron	TASL	160	0	1.2	80	0
Boron	WSCF	44	4.5	2.3	22	4.5
Calcium	GEL	57	5.3	7	28	0
Calcium	TASL	114	3.5	1.8	58	0
Calcium	WSCF	112	8.9	0	56	0
Copper	GEL	397	0.5	0	198	0
Hexavalent chromium	TARL	529	0.6	0	206	0
Hexavalent chromium	WSCF	118	5.1	1.7	0	0
Iron	GEL	325	0.3	0	162	0.6
Iron	WSCF	118	0	0.8	59	1.7
Lead	WSCF	56	1.8	0	28	0
Magnesium	GEL	284	0.4	0.7	141	0.7
Magnesium	TASL	308	2.3	0.3	155	0.6
Magnesium	WSCF	122	0.8	0	61	0
Molybdenum	WSCF	52	3.8	0	26	7.7
Potassium	GEL	328	0.3	0.6	163	0.6
Potassium	TASL	310	0	0.3	156	0.6
Selenium	TASL	149	1.3	0	75	0

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
Silver	GEL	399	0.5	0	199	0
Sodium	GEL	199	0.5	0	99	1
Sodium	TASL	271	3	3.7	136	0.7
Sodium	WSCF	106	2.8	0	53	0
Strontium	GEL	186	1.6	3.8	91	0
Strontium	WSCF	90	1.1	0	45	0
Thallium	WSCF	42	2.4	0	21	0
Tin	WSCF	42	4.8	0	21	4.8
Uranium	GEL	222	0.5	0	93	0
Uranium	TARL	48	0	2.1	0	0
Uranium	WSCF	84	1.2	0	42	0
Zinc	GEL	394	1	0.3	196	0.5
Volatile Organic Compounds: Recovery and RPD Limits = Laboratory Specific (Statistically Derived)						
1,1,1-Trichloroethane	WSCF	72	2.8	2.8	36	5.6
1,1,2,2-Tetrachloroethane	WSCF	18	5.6	11.1	9	11.1
1,1,2-Trichloroethane	TASL	106	0.9	0	53	0
1,1,2-Trichloroethane	WSCF	72	1.4	2.8	36	8.3
1,1-Dichloroethane	WSCF	72	2.8	2.8	36	5.6
1,1-Dichloroethene	GEL	74	1.4	0	37	0
1,1-Dichloroethene	TASL	106	1.9	0.9	53	5.7
1,1-Dichloroethene	WSCF	72	6.9	2.8	36	8.3
1,2-Dichloroethane	WSCF	72	1.4	1.4	36	5.6
1,2-Dichloropropane	WSCF	18	5.6	0	9	11.1
1-Butanol	TASL	26	0	0	13	7.7
2-Butanone	GEL	74	67.6	0	37	0
2-Butanone	TASL	108	0	0	54	3.7
2-Hexanone	GEL	26	57.7	0	13	0
4-Methyl-2-pentanone	GEL	74	5.4	0	37	0
4-Methyl-2-pentanone	TASL	108	0	0	54	3.7
Acetone	GEL	74	100	0	37	0
Acetone	TASL	112	0	0	56	7.1

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
Benzene	WSCF	72	1.4	1.4	36	5.6
Bromodichloromethane	WSCF	18	5.6	0	9	11.1
Bromoform	WSCF	18	5.6	5.6	9	22.2
Carbon disulfide	TASL	108	0	0.9	54	3.7
Carbon disulfide	WSCF	72	6.9	2.8	36	8.3
Carbon tetrachloride	GEL	74	12.2	0	37	0
Carbon tetrachloride	TASL	110	0	1.8	55	0
Chlorobenzene	WSCF	72	1.4	0	36	5.6
Chloroprene	GEL	26	0	15.4	13	0
cis-1,2-Dichloroethylene	WSCF	46	2.2	2.2	23	4.3
Dibromochloromethane	WSCF	18	5.6	5.6	9	22.2
Dichlorodifluoromethane	GEL	26	3.8	7.7	13	0
Ethanol	GEL	2	0	0	1	100
Ethanol	WSCF	2	0	50	1	0
Ethyl acetate	GEL	2	0	100	1	0
Ethylbenzene	WSCF	70	1.4	1.4	35	2.9
Isobutyl alcohol	GEL	26	7.7	0	13	0
Methane	TASL	2	0	50	1	0
Methanol	TASL	8	0	0	4	25
Methylene chloride	TASL	112	7.1	2.7	56	3.6
Styrene	WSCF	18	5.6	0	9	22.2
Tetrahydrofuran	TASL	26	0	0	13	7.7
Toluene	WSCF	72	1.4	0	36	5.6
trans-1,2-Dichloroethylene	WSCF	42	4.8	2.4	21	14.3
trans-1,3-Dichloropropene	WSCF	18	5.6	0	9	22.2
Trichloroethene	WSCF	78	1.3	0	39	2.6
Semivolatile Organic Compounds: Recovery and RPD Limits = Laboratory Specific (Statistically Derived)						
1,2,4-Trichlorobenzene	WSCF	18	0	0	9	11.1
1,4-Dichlorobenzene	TASL	12	0	8.3	6	0
1,4-Dichlorobenzene	WSCF	24	0	0	12	8.3
1,4-Dioxane	GEL	12	0	0	6	16.7

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
1,4-Dioxane	WSCF	24	0	0	12	8.3
2,3,4,6-Tetrachlorophenol	GEL	10	0	0	5	20
2,4,5-Trichlorophenol	GEL	10	0	0	5	20
2,4,5-Trichlorophenol	TASL	16	0	6.2	8	0
2,4,6-Trichlorophenol	GEL	10	0	0	5	20
2,4,6-Trichlorophenol	TASL	16	0	12.5	8	0
2,4-Dichlorophenol	GEL	16	0	0	8	12.5
2,4-Dichlorophenol	TASL	20	0	5	10	0
2,4-Dichlorophenol	WSCF	40	0	0	20	5
2,4-Dimethylphenol	GEL	10	0	0	5	20
2,4-Dimethylphenol	TASL	16	0	6.2	8	0
2,4-Dimethylphenol	WSCF	34	0	0	17	5.9
2,4-Dinitrophenol	GEL	10	0	20	5	40
2,4-Dinitrotoluene	WSCF	18	0	0	9	11.1
2,6-Dichlorophenol	GEL	10	0	0	5	20
2-Chlorophenol	GEL	18	0	0	9	11.1
2-Chlorophenol	WSCF	34	0	0	17	5.9
2-Methylphenol (cresol, o-)	GEL	16	0	0	8	12.5
2-Methylphenol (cresol, o-)	WSCF	40	0	0	20	5
2-Nitroaniline	WSCF	18	0	0	9	11.1
2-Nitrophenol	GEL	16	0	0	8	12.5
2-Nitrophenol	TASL	20	0	5	10	0
2-Nitrophenol	WSCF	40	0	0	20	5
2-Picoline	WSCF	22	0	0	11	9.1
3,3'-Dichlorobenzidine	WSCF	18	0	0	9	11.1
3+4 Methylphenol (cresol, m+p)	GEL	14	0	0	7	14.3
4,4'-DDD (Dichlorodiphenyldichloroethane)	TASL	12	0	33.3	6	0
4,4'-DDE (Dichlorodiphenyldichloroethylene)	TASL	12	0	16.7	6	0
4,4'-DDT (Dichlorodiphenyltrichloroethane)	GEL	6	0	16.7	3	33.3

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
4,4'-DDT (Dichlorodiphenyltrichloroethane)	TASL	12	0	8.3	6	0
4,6-Dinitro-2-methylphenol	GEL	8	0	0	4	25
4-Chloro-3-methylphenol	GEL	18	0	0	9	11.1
4-Chloro-3-methylphenol	WSCF	34	0	0	17	5.9
4-Chloroaniline	WSCF	18	0	0	9	11.1
4-Nitrophenol	GEL	18	11.1	0	9	11.1
4-Nitrophenol	WSCF	34	0	0	17	5.9
Acenaphthene	GEL	18	0	0	9	11.1
Acenaphthene	WSCF	18	0	0	9	11.1
Acenaphthylene	GEL	10	0	0	5	20
Alpha-BHC	TASL	12	0	25	6	0
Alpha-Chlordane	TASL	14	0	7.1	7	0
Anthracene	GEL	10	0	0	5	20
Anthracene	WSCF	18	0	0	9	11.1
Benzo(a)anthracene	GEL	10	0	0	5	20
Benzo(a)pyrene	GEL	10	0	0	5	20
Benzo(a)pyrene	TASL	12	16.7	0	6	16.7
Benzo(a)pyrene	WSCF	18	0	0	9	11.1
Benzo(b)fluoranthene	TASL	12	16.7	0	6	16.7
Benzo(ghi)perylene	GEL	10	0	0	5	20
Benzo(ghi)perylene	TASL	12	16.7	8.3	6	16.7
Benzo(k)fluoranthene	TASL	12	16.7	0	6	16.7
Benzyl alcohol	WSCF	18	0	0	9	11.1
Bis(2-chloro-1-methylethyl)ether	WSCF	18	0	0	9	11.1
Bis(2-Chloroethoxy)methane	TASL	8	0	12.5	4	0
Bis(2-ethylhexyl) phthalate	WSCF	24	0	66.7	12	8.3
Carbazole	WSCF	18	0	0	9	11.1
Chrysene	GEL	10	0	0	5	20
Delta-BHC	TASL	12	0	33.3	6	0
Dibenz[a,h]anthracene	GEL	10	0	0	5	20

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
Dibenz[a,h]anthracene	TASL	12	16.7	16.7	6	16.7
Dibenzofuran	WSCF	18	0	0	9	11.1
Dimethoate	WSCF	18	11.1	0	9	11.1
Di-n-butylphthalate	WSCF	18	0	11.1	9	11.1
Di-n-octylphthalate	WSCF	18	0	5.6	9	11.1
Endosulfan II	GEL	6	0	16.7	3	0
Endrin	GEL	6	0	16.7	3	0
Endrin	TASL	12	0	8.3	6	0
Fluoranthene	GEL	10	0	0	5	20
Fluorene	GEL	10	0	0	5	20
Fluorene	WSCF	18	0	0	9	11.1
Hexachlorobenzene	WSCF	18	0	0	9	11.1
Hexachloroethane	WSCF	18	0	0	9	11.1
Hexachlorophene	WSCF	18	0	0	9	11.1
Indeno(1,2,3-cd)pyrene	GEL	10	0	0	5	20
Indeno(1,2,3-cd)pyrene	TASL	12	16.7	16.7	6	16.7
Methoxychlor	GEL	6	0	33.3	3	0
Naphthalene	GEL	16	0	0	8	12.5
Naphthalene	TASL	16	0	6.2	8	0
Naphthalene	WSCF	24	0	0	12	8.3
n-Nitrosodimethylamine	WSCF	18	0	0	9	11.1
n-Nitrosodi-n-dipropylamine	WSCF	18	0	0	9	11.1
Pentachlorophenol	GEL	26	0	0	13	7.7
Pentachlorophenol	TASL	18	0	11.1	9	0
Pentachlorophenol	WSCF	40	0	0	20	5
Phenanthrene	GEL	10	0	0	5	20
Phenol	GEL	26	0	0	13	15.4
Phenol	WSCF	40	0	0	20	5
Pyrene	WSCF	18	0	0	9	11.1
Tributyl phosphate	WSCF	22	9.1	0	11	9.1

Table F-19. Matrix Spike Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Percent Out of Limit Low	Percent Out of Limit High	Number of MSD	Percent RPD Out of Limit
Radiochemical Analytes: Recovery Limits = 60% - 140%, RPD Limit = 20%[b]						
Gross alpha	GEL	66	0	0	33	3
Gross beta	GEL	66	0	1.5	33	0
Technetium-99	TARL	66	0	3	0	0
Tritium	WSCF	34	2.9	0	0	0

a. Includes both matrix spike and matrix spike duplicates.

b. Laboratory-specific limits were used if provided. Otherwise the stated limits were used to evaluate MS/MSDs.

GEL = GEL Laboratory

MS/MSD = matrix spike / matrix spike duplicate

RPD = relative percent difference

TARL = TestAmerica Richland

TASL = TestAmerica St. Louis

WSCF = Waste Sampling and Characterization Facility

F9.3.1 Matrix Spikes by Laboratory

By laboratory, GEL reported an overall success rate for MS recoveries at 97.2%. Percentage-wise, 5.9% (16 results) of the GEL MS/MSD recoveries for general chemistry parameters were outside of QC limits, all being low recoveries; 12.3% (123 results) of the MS/MSD recoveries for anions were outside of QC parameters, almost all (112) being high recoveries; 0.5% (39 results) of the MS/MSD recoveries for metals were outside of QC parameters, nearly evenly split between high and low recoveries; 6.9% (164 results) of the MS/MSD recoveries for VOCs were outside of QC parameters, with nearly all (156) low recoveries; 0.9% (9 results) of the MS/MSD recoveries for SVOCs being outside of QC parameters, 7 high and 2 low recoveries; and 0.5% (1 result) of the MS/MSD recoveries for radionuclides were out of QC parameters with the single result being a high recovery. GEL had the highest number of analytes (20) that had MSD RPDs that exceeded the 20% RPD criterion. These ranged from 20 to 100%.

TARL reported an overall success rate for MS recoveries at 98.4%. Percentage-wise, 4.4% (7 results) of the TARL MS/MSD recoveries for anions were outside of QC limits with 4 high and 3 low recoveries; 0.7% (4 results) of the MS/MSD recoveries for metals were outside of QC parameters, 3 high recoveries and 1 low; and 3.0% (2 results) of the MS/MSD recoveries for radionuclides were outside of QC parameters, both high recoveries. No MS/MSD recovery results for general chemistry parameters, VOCs or SVOCs were recorded for TARL. No analytes had MSD RPDs that exceeded the 20% RPD criterion for TARL.

TASL reported an overall success rate for MS recoveries at 97.7%. Percentage-wise, 3.8% (9 results) of the TASL MS/MSD recoveries for general chemistry parameters were outside of QC limits, with 6 low and 3 high recoveries; 16.5% (164 results) of the MS/MSD recoveries for anions were outside of QC parameters, with 80 being low and 64 high recoveries; 0.6% (37 results) of the MS/MSD recoveries for metals were outside of QC parameters, nearly evenly split between high and low recoveries; 0.8%

(19 results) of the MS/MSD recoveries for VOCs were outside of QC parameters, with 11 low and 8 high recoveries; 4.5% (44 results) of the MS/MSD recoveries for SVOCs being outside of QC parameters, 32 high and 12 low recoveries; and none of the MS/MSD recoveries for radionuclides were out of QC parameters. One analyte also had an MSD RPD that exceeded the 20% RPD criterion: methanol.

WSCF reported an overall success rate for MS recoveries at 97.4%. Percentage-wise, 0.7% (2 results) of the TASL MS/MSD recoveries for general chemistry parameters were outside of QC limits, both with low recoveries; 4.3% (42 results) of the MS/MSD recoveries for anions were outside of QC parameters, with 29 being low and 13 high recoveries; 1.3% (37 results) of the MS/MSD recoveries for metals were outside of QC parameters, 33 being low and 4 being high recoveries; 5.0% (51 results) of the MS/MSD recoveries for VOCs were outside of QC parameters, with 31 low and 20 high recoveries; 2.6% (23 results) of the MS/MSD recoveries for SVOCs being outside of QC parameters, 19 high and 4 low recoveries; and one (low) of the MS/MSD recoveries for radionuclides were out of QC parameters. Four analytes also had MSD RPDs that exceeded the 20% RPD criterion: bromoform, dibromochloromethane, styrene, and trans-1,3-dichloropropene.

F9.3.2 Matrix Spikes by Analyte Class

By analyte class, the highest MS out-of-limit recovery rates were: anions at 4.8%, VOCs at 3.2%, and SVOCs at 1.8%. The general chemical parameters had a 1.1% out-of-limit recovery rate; all but one TASL MS result for total organic halides are discussed previously in the WSCF MS section. Radiochemical parameters had an out-of-limit rate of only 0.4%. The rates of MSDs that exceeded RPD limits were: radiochemical parameters at 22.2% (this represents only two of nine total reported MSDs for radiochemical parameters), SVOCs at 2.1%, VOCs at 1.8%, and general chemical parameters at 1.5%. Ammonia/anions and metals had rates of out-of-limit MSD RPDs at less than 1%.

For the general chemical parameters, 2,686 MSs met the evaluation criteria with 124 MS recoveries less than the lower recovery limits and 192 results greater than the upper recovery limits. GEL, TASL, TARL, and WSCF reported all the anion MS results. The out-of-limit MS results were distributed over 10 analytes. For the anion MSDs, 514 MSD results were evaluated; of these, none exceeded the 20% RPD criterion. The MSD results were reported by TASL and WSCF.

For the anions, 762 MSs met the evaluation criteria with 24 MS recoveries less than the lower recovery limits and 3 results greater than the upper recovery limits. GEL, TASL, and WSCF reported all the general chemistry parameter MS results. The out-of-limit MS results were distributed over six analytes. For the general chemistry parameter MSDs, 190 MSD results were evaluated; of these, none exceeded the 20% RPD criterion. The MSD results were reported by GEL, TASL, and WSCF.

For the metals, 17,946 MSs met the evaluation criteria with 76 MS recoveries less than the lower recovery limits and 41 results greater than the upper recovery limits. GEL, TASL, TARL, and WSCF reported all the anion MS results. The out-of-limit MS results were distributed over 20 metals. For the metals MSDs, 8,865 MSD results were evaluated; of these, none exceeded the 20% RPD criterion. The MSD results were reported by GEL, TARL, TASL, and WSCF.

For the VOCs, 5,662 MSs met the evaluation criteria with 198 MS recoveries less than the lower recovery limits and 36 results greater than the upper recovery limits. GEL, TASL, and WSCF reported all the VOC MS results. The out-of-limit MS results were distributed over 36 polar and non-polar VOC analytes. For the VOC MSDs, 2,948 MSD results were evaluated; of these, 6 exceeded the 20% RPD criterion. The MSD failures were reported by GEL, TASL and WSCF and were distributed over five polar and non-polar compounds. The out-of-limit RPD values ranged from 22.2% to 100%.

For the SVOCs, 2,564 MSs met the evaluation criteria with 18 MS recoveries less than the lower recovery limits and 58 recoveries greater than the upper recovery limits. GEL, TASL, and WSCF reported all the SVOC MS results. The MS failures were distributed over 17 polar and non-polar SVOC analytes. For the SVOC MSDs, 1,320 MSD results were evaluated; of these, 76 exceeded the 20% RPD criterion. The MSD failures were reported by GEL, TASL, and WSCF and were distributed over 17 polar and non-polar compounds. The out-of-limit RPD values ranged from 20% to 40% (2,4-dinitrophenol).

For the radionuclides, 345 MSs met the evaluation criteria with one MS recovery less than the lower recovery limits and three recoveries greater than the upper recovery limits. GEL, TARL, TASL, and WSCF reported all the radionuclide MS results. For the radionuclide MSDs, 66 MSD results were evaluated; of these none exceeded the 20% RPD criterion.

F9.4 Laboratory Sample Duplicates

Laboratory sample duplicates give a measure of the repeatability of an analytical result. Only those sample results with values five times greater than the MDL or the MDA, or one times the estimated quantitation limit were evaluated. The RPDs for sample duplicates that met the evaluation criteria were compared to either the laboratory-specific statistically derived RPD maximum or to a maximum of 20% if no laboratory-specific RPD was available. When laboratory sample duplicate RPDs are outside QC limits, laboratories may apply a laboratory qualifier of X and an accompanying explanatory note.

Of the 5,235 reported laboratory sample duplicates, 2,230 (42.6%) met the evaluation criterion; of these, 103 RPDs exceeded the precision criteria for an overall acceptance rate of 95.4%. Table F-20 summarizes the out-of-limit results for laboratory sample duplicates.

Table F-20. Laboratory Sample Duplicate Out-of-Limit Results

Constituent	Laboratory	Number of Laboratory Duplicates	Number Laboratory Duplicates Evaluated*	Percent RPD Out of Limit	Range of RPD Out
General Chemical Parameters: RPD Limit = 20%					
Alkalinity	GEL	87	80	1.2	67.4
Total organic halides	TASL	22	7	28.6	24 - 29
Ammonia and Anions: RPD Limit = 20%					
Ammonium ion	GEL	21	7	42.9	61.2 - 196
Chloride	TARL	31	31	35.5	30.8 - 74.8
Chloride	TASL	123	111	0.9	22
Cyanide	GEL	29	14	14.3	25.9 - 29.1
Fluoride	GEL	171	92	1.1	33.9
Fluoride	TARL	31	31	16.1	21.7 - 42.4
Fluoride	TASL	118	93	1.1	25
Nitrate	TARL	31	29	34.5	68.1 - 138.1

Table F-20. Laboratory Sample Duplicate Out-of-Limit Results

Constituent	Laboratory	Number of Laboratory Duplicates	Number Laboratory Duplicates Evaluated*	Percent RPD Out of Limit	Range of RPD Out
Sulfate	TARL	31	30	36.7	67.8 - 138.5
Metals: RPD Limit = 20%					
Hexavalent chromium	TARL	330	234	9.4	21.6 - 345.5
Uranium	TARL	51	49	6.1	23.3 - 34.8
Volatile Organic Compounds: RPD Limit = 20%					
Semivolatile Organic Compounds: RPD Limit = 20%					
Radiochemical Parameters: RPD Limit = 20%					
Cesium-137	GEL	39	1	100	28.5
Cobalt-60	TARL	46	1	100	33.9
Gross alpha	GEL	33	3	66.7	22.8 - 30.1
Gross alpha	WSCF	53	4	50	20.4 - 63.5
Gross beta	GEL	34	21	14.3	21 - 32
Gross beta	TARL	67	34	8.8	21 - 28
Gross beta	WSCF	60	27	3.7	30.4
Iodine-129	GEL	12	1	100	20.3
Iodine-129	TARL	59	14	21.4	25 - 57.9
Neptunium-237	TARL	5	1	100	33.3
Plutonium-238	TARL	17	1	100	26.1
Strontium-90	GEL	37	17	17.6	23.5 - 27
Uranium-233/234	TARL	9	8	12.5	69.9
Uranium-234	GEL	10	5	20	36.5
Uranium-235	TARL	9	2	50	55.2
Uranium-235	WSCF	13	7	42.9	25.1 - 55.7
Uranium-238	GEL	10	6	16.7	42
Uranium-238	TARL	9	7	14.3	22.6

* Meets the evaluation criterion that the sample-duplicate pair has at least one result greater than or equal to five times the method detection limit or the minimum detectable activity.

RPD = relative percent difference
GEL = GEL Laboratory
TASL = TestAmerica St. Louis
WSCF = Waste Sampling and Characterization Facility

Table F-20. Laboratory Sample Duplicate Out-of-Limit Results

Constituent	Laboratory	Number of Laboratory Duplicates	Number Laboratory Duplicates Evaluated*	Percent RPD Out of Limit	Range of RPD Out

TARL = TestAmerica Richland

By laboratory, TARL had the lowest laboratory sample duplicate success: of its 472 sample duplicates that met the evaluation criterion, 398 met the 20% limit for an 84.3% success rate. The three most significant sample duplicate failures were for chloride (35.5%), nitrate (34.5%), and sulfate (36.7%).

GEL reported 247 laboratory sample duplicate results that met the evaluation criterion with 228 (92.3%) that met RPD criteria. The most significant failures were for cyanide, gross beta, and strontium-90. .

TASL reported 211 laboratory sample duplicate results that met the evaluation criterion with 207 (98.1%) that met the 20% RPD criterion. The RPD failures were for total organic halides, chloride, and fluoride.

WSCF reported 38 sample duplicate results that met the evaluation criterion with 32 (84.2%) that met the 20% RPD criterion. The RPD failures were for gross alpha, gross beta, and uranium-235.

By analyte class, the radiochemical parameters had the largest percent of laboratory sample duplicate failures: of the 160 duplicates that met the evaluation criterion, 30 (18.8%) failed the RPD criteria.

F9.5 Surrogates and Surrogate Duplicates

Surrogates and surrogate duplicates are used to monitor percent recovery and precision during the analysis of samples for total petroleum hydrocarbons (TPHs), VOCs, and SVOCs. Surrogates are typically deuterated, fluorinated, or brominated organic compounds with chemical properties similar to those of the analytes of interest in a sample but are not normally found in groundwater samples. Known amounts of the surrogates are added to the sample prior to sample preparation and analysis to monitor the recovery of the organic compounds during the analytical process.

For the current reporting period, GEL, TASL, and WSCF reported surrogate data for TPHs, VOCs, and SVOCs. As Table F-1 indicates, percent recoveries for surrogates are compared to statistically derived laboratory-specific process control limits. The precision limit for surrogate duplicate RPDs was 20% unless the laboratory provided a statistically derived precision limit. The laboratories may apply a laboratory qualifier of X and an accompanying explanatory note in the data report or case narrative when laboratory surrogate/surrogate duplicate percent recoveries or RPDs are outside QC limits.

Tables F-15 and F-16 indicate that 99% of the percent recoveries for the 10,317 reported surrogates and 98.5% of the RPDs for the 339 reported surrogate duplicates met the QC criteria for CY2014. These success rates, along with those for the other measures of laboratory accuracy and precision, continue to provide assurance that the laboratories are producing data with sufficient accuracy and precision to meet the needs of the groundwater monitoring program. The CY2014 surrogate success rates are similar to the CY2013 success rates of 98.8% for surrogate percent recoveries and 95.1% for surrogate RPDs and the CY2012 success rates of 98.4% for surrogate percent recoveries and 98.1% for surrogate RPDs. Table F-21 lists the out-of-limit surrogate results for the current reporting period.

Table F-21. Surrogate Out-of-Limit Results

Surrogate	Lab	Method	Number of Surrogates	Percent Out of Limit Low	Percent Out of Limit High	Number of Surrogate Duplicates	Percent RPD Out of Limit*
General Chemical Parameters: Recovery Limits = Laboratory Specific (Statistically Derived)							
o-Terphenyl	GEL	WTPH_DIESEL	172	2.3	-	0	-
Volatile Organic Compounds: Recovery Limits = Laboratory Specific (Statistically Derived)							
1,2-Dichloroethane-d4	TASL	8260_VOA_GCMS	767	-	0.7	0	-
1,2-Dichloroethane-d4	WSCF	8260_VOA_GCMS	501	-	3.2	39	5.1
4-Fluorobromobenzene	TASL	8260_VOA_GCMS	767	-	0.3	0	-
4-Fluorobromobenzene	WSCF	8260_VOA_GCMS	501	-	2.6	39	2.6
Dibromofluoromethane	TASL	8260_VOA_GCMS	767	-	0.3	0	-
Toluene-d8	WSCF	8260_VOA_GCMS	501	-	2.0	39	5.1
Semivolatile Organic Compounds: Recovery Limits = Laboratory Specific (Statistically Derived)							
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	GEL	8081_PEST_GC	23	-	4.3	0	-
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	TASL	8081_PEST_GC	52	3.8	3.8	0	-
2,4,5,6-Tetrachloro-m-xylene	TASL	8081_PEST_GC	52	-	1.9	0	-
2,4,6-Tribromophenol	TASL	8270_SVOA_GCMS	131	-	8.4	0	-
2,4,6-Tribromophenol	WSCF	8270_SVOA_GCMS	242	5.0	-	33	-
2-Fluorobiphenyl	TASL	8270_SVOA_GCMS	144	-	0.7	0	-
2-Fluorobiphenyl	WSCF	8270_SVOA_GCMS	191	0.5	-	24	-
2-Fluorophenol	WSCF	8270_SVOA_GCMS	191	2.1	-	24	-

Table F-21. Surrogate Out-of-Limit Results

Surrogate	Lab	Method	Number of Surrogates	Percent Out of Limit Low	Percent Out of Limit High	Number of Surrogate Duplicates	Percent RPD Out of Limit*
2-Methylnaphthalene-d10	WSCF	8270_SVOA_GCMS	191	0.5	-	24	-
Nitrobenzene-d5	TASL	8270_SVOA_GCMS	144	-	0.7	0	-
Nitrobenzene-d5	WSCF	8270_SVOA_GCMS	191	0.5	0	24	0
Phenol-d5	WSCF	8270_SVOA_GCMS	191	0.5	0	24	0
p-terphenyl-d14	TASL	8270_SVOA_GCMS	144	7.6	0.7	0	0

* Sample duplicate RPD limit of 20% was used to evaluate surrogate duplicates.

GEL = GEL Laboratory

RPD = relative percent difference

TASL = TestAmerica St. Louis Laboratory

WSCF = Waste Sampling and Characterization Facility

Overall, 10,317 surrogates and 339 surrogate duplicates were analyzed. Only 1% of surrogates were out of limit, and 1.5% of surrogate duplicates were out of limit. Surrogates and surrogate duplicates results were reported from GEL, TASL, and WSCF. None were reported from TARL.

By laboratory, WSCF had the lowest surrogate percent recovery rate at 98.2%; GEL, TASL, and TARL reported no surrogate duplicate results. WSCF also had the only five out of limit RPDs, all for VOCs.

By analyte class, general chemical parameters (o-terpenyl), GEL had 4 out of low limit surrogates; VOCs had 9 (1,2-Dichloroethane-d4, 4-Fluorobromobenzene, and dibromofluoromethane) out of high limit surrogates for TASL and 39 (1,2-Dichloroethane-d4, 4-Fluorobromobenzene, and Toluene-d8) out of high limit for WSCF; SVOCs had 1 (2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl) out of high limit surrogates for GEL and 17 (Table F-21) out of high limit for TASL.

F10 Laboratory Performance

During CY2014, laboratory performance was tracked using two methods: the groundwater quarterly blind standards program and laboratory performance evaluation programs. The results of the blind standards program are discussed in Section F-10.1 and the laboratory performance evaluation programs are discussed in Section F-10.2.

F10.1 Quarterly Blind Standard Evaluations

The groundwater monitoring program issues blind standards to the supporting laboratories to provide a measure of intra- and inter-laboratory precision and accuracy. These standards help groundwater staff troubleshoot analytical problems identified through data reviews and QC evaluations. The blind standards also may be used to confirm the adequacy of corrective actions to resolve analytical problems. Blind standards are required to be submitted to the participating laboratories on a quarterly basis (DOE/RL-91-50 and CHPRC-00189); this requirement was not met during CY2014; CY2014 third quarter blinds were not submitted, and the fourth quarter blind standards were not submitted to the laboratories until after January 1, 2015. The quality requirements and control limits for the groundwater monitoring blind standards are given in DOE/RL-91-50 and CHPRC-00189 and are listed in Table F-22. A success rate is calculated for the results returned by each supporting laboratory:

$$\text{Success Rate} = \frac{\text{number of results meeting QC recovery criteria}}{\text{total number of results reported}} \times 100 \qquad \textbf{(Equation F-4)}$$

The acceptance criterion for the success rate is 80% (CHPRC-00189).

Table F-22. Groundwater Blind Standard Recovery and Precision Requirements[a,b]

Analyte Class	Recovery Limits (% Recovery)	Precision Limit[c] (% RSD)
General Chemical Parameters	75 - 125	≤ 25
Ammonia and Anions	75 - 125	≤ 25
Metals	80 - 120	≤ 20
Volatile Organic Compounds	75 - 125	≤ 25
Semivolatile Organic Compounds[d]	N/R	N/R
Radiological Parameters	70 - 130	≤ 20

a. Sources: DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*, and CHPRC-00189, *CH2M HILL Plateau Remediation Company Environmental Quality Assurance Program Plan*.

b. Blind standards are required to be submitted to participating laboratories on a quarterly basis; the identity of the analytes and their concentrations vary from quarter to quarter.

c. If the results are less than five times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

d. The blind standards program does not require semivolatile organic compound standards.

N/R = not required

RSD = relative standard deviation

During CY2014, the groundwater monitoring program sent blind standards to GEL, TARL, TASL, and WSCF. In summary, the evaluation of the double-blind standards for 2014 indicates that, with some exceptions, the participating laboratories generally met the 80% success rate requirement for the groundwater monitoring program. Performance was somewhat uneven over the reporting period with GEL and TASL turning in one quarter with a success rate less than 80%. Of the blind results for all laboratories for 2014, 75% of the blind sample determinations were acceptable. This percentage is similar to the historical success rates of 88.5% for 2012, 83.6% for 2011, and 86.6% for 2010. Table F-23 presents the available success rates for each laboratory by quarter during CY2014.

Table F-23. Blind Standards Laboratory Success Rates for CY2014

Laboratory	Success Rate (%) by Quarter[a]			
	Q1	Q2	Q3	Q4
GEL	88.2	76.9	N/A	N/A
TARL	84.8	88.9	N/A	N/A
TASL	97.5	73.2	N/A	N/A
WSCF	86.1	N/A	N/A	N/A

a. Success Rate = 100 x number of results within QC recovery criteria / total number of results submitted. The minimum acceptable success rate is 80% (CHPRC-00189, *CH2M HILL Plateau Remediation Company Environmental Quality Assurance Program Plan*). Success rates less than the 80% criterion are denoted by shaded cells.

GEL = GEL Laboratory

N/A = not applicable

TARL = TestAmerica Richland Laboratory

TASL = TestAmerica St. Louis Laboratory

WSCF = Waste Sampling and Characterization Facility

Blind standards were generally prepared in triplicate and submitted to the laboratories to check the accuracy and precision of analyses. For most constituents, the blind standards were prepared in a groundwater matrix from an appropriate background well to simulate actual groundwater samples. Multi-metal blind standards for analysis by ICP techniques were prepared in deionized water using commercially prepared metals standards. The blind standards were submitted to the laboratories as regular groundwater samples.

After analysis, the laboratories' results were compared with the spiked concentrations to generate percent recoveries and the %RSDs were determined for the results. The percent recoveries and %RSDs were compared to the control limits to determine whether the data met the QC criteria[3]. Out-of-limit results were reviewed for errors. In situations where several results for the same method were unacceptable, an RDR may be generated to reanalyze the blind samples (if within holding times) or for recheck of the results. Any remaining out-of-limit results were discussed with the laboratory, potential problems were investigated, and corrective actions were requested when appropriate. Table F-24 summarizes the blind

[3] If the blind standard concentration is less than five times the required detection limit for the analyte, the secondary precision criterion is used: the difference between the maximum and minimum value reported must be less than the required detection limit (DOE/RL-91-50).

standards that exceeded the recovery or precision criteria during 2014; results that are outside the recovery or precision limits are in shaded cells.

The most notable observations for the CY2014 blind standards were:

- *Total organic carbon*: During the first quarter of the reporting period, TASL and GEL returned TOC recoveries that trended high with one result from each lab that exceeded the upper recovery limit; the acceptable recovery range is 75% to 125%. For the second quarter of CY2014, the TOC recoveries were within the acceptance range.
- *Total organic halides*: Two types of standards were used to generate TOX blind samples each quarter: one based on the relatively non-volatile compound 2,4,5-trichlorophenol and one based on the same standards as those used for the VOC blind standard containing carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene. For the trichlorophenol-based standard, most of the recoveries reported by GEL, TASL, and WSCF were within the 75% and 125% recovery limits. In contrast, the VOA-based TOX standards showed generally low recoveries with all three laboratories reporting some TOX recoveries less than the lower recovery limit of 75%. Out-of-limit low recoveries ranged from 57.5% to 74.3%. The predominantly low recoveries may reflect TOX recoveries for actual groundwater samples because the TOX content of many Hanford-Site groundwater samples is likely due to volatile organic compounds.
- *Anions*: For the second quarter, both GEL and TASL reported recoveries of fluoride between 16% and 17%. Because the fluoride results were so nearly identical between the two laboratories, a make-up error in the standard is strongly suspected, and these results are not considered to be out of limits.
- *Metals*: All four participating laboratories returned results for metals blind standards during CY2014. GEL, TASL, and WSCF reported metals determined by inductively coupled plasma – atomic emission spectroscopy (ICP-AES) and inductively coupled plasma – mass spectrometry (ICP-MS). TARL and WSCF reported hexavalent chromium by colorimetry, and GEL and TARL reported total uranium by kinetic phosphorescence analysis (KPA). The recovery acceptance limits for the metals are 80% to 120%. Barium, iron, mercury, and strontium exhibited low out-of-limit recoveries that ranged from 45.5% to 77.3%. Aluminum, uranium, and zinc, exhibited high out-of-limit recoveries that ranged from 122% to 134%.

Table F-24. CY2014 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL / MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
CY2014 1st Quarter													
TOC	GEL	1,010	1000	330	ug/L	75 - 125	128.7	111.9	112.9	122.8	25	6.8	N*
TOC	TASL	1,010	1000	270	ug/L	75 - 125	128.7	118.8	108.9	99.0	25	11.2	N*
TOX (phenol)	GEL	505	10	3.33	ug/L	75 - 125	82.4	87.3	88.5	72.9	25	8.6	N
TOX (VOA)	GEL	510	10	3.33	ug/L	75 - 125	72.2	71.8	73.5	—	25	1.3	N
TOX (VOA)	TASL	510	10	1.8	ug/L	75 - 125	78.0	74.3	75.9	—	25	2.5	N
TOX (VOA)	WSCF	510	10	25	ug/L	75 - 125	69.6	72.0	65.5	—	25	4.7	N
Aluminum	GEL	196	20	15	ug/L	80 - 120	93.5	97.5	133.8	—	20	20.5	Y
Barium	WSCF	196	5	0.40	ug/L	80 - 120	98.1	103.2	55.2	—	20	30.9	Y
Iron	GEL	196	50	30	ug/L	80 - 120	45.5	76.6	51.6	—	20	28.5	Y*
Strontium	WSCF	196	10	0.4	ug/L	80 - 120	94.0	99.1	53.1	—	20	30.7	Y
Uranium	GEL	49.5	1	2.05	ug/L	80 - 120	116.6	110.9	122.2	—	20	4.9	N
Zinc	WSCF	24.5	10	4	ug/L	80 - 120	108.2	123.7	133.5	—	20	10.5	N*
Tetrachloroethene	WSCF	5.00	5	1	ug/L	75 - 125	66.0	76.0	76.0	—	25	8.0	N*
Trichloroethene	WSCF	97.4	5	0.5	ug/L	75 - 125	67.8	82.1	78.0	—	25	9.7	N
Gross alpha	GEL	302	3	2.95	pCi/L	70 - 130	141.2	116.7	111.0	—	20	13.0	N
Gross alpha	TARL	302	3	3.88	pCi/L	70 - 130	97.8	62.0	59.7	—	20	29.2	Y
Gross alpha	WSCF	302	3	6	pCi/L	70 - 130	43.1	49.7	63.0	—	20	19.5	N
Gross beta	WSCF	31.6	4	6.2	pCi/L	70 - 130	117.2	110.8	136.2	—	20	10.9	N
Plutonium-239	GEL	1.47	1	0.653	pCi/L	70 - 130	122.4	94.6	208.2	—	20	41.8	Y*
Plutonium-239	TARL	1.47	1	0.241	pCi/L	70 - 130	62.2	68.7	60.4	—	20	6.4	N*
Plutonium-239	WSCF	1.47	1	0.066	pCi/L	70 - 130	74.8	95.2	61.9	—	20	21.9	N*
CY2014 2nd Quarter													
TOX (VOA)	GEL	247	10	3.33	µg/L	75 - 125	59.5	57.5	57.5	—	25	2.0	N
TOX (VOA)	TASL	247	10	1.8	µg/L	75 - 125	71.3	70.4	72.9	—	25	1.7	N
Cyanide	GEL	206	5	3.34	µg/L	75 - 125	130.1	120.4	126.2	—	25	3.9	N
Mercury	GEL	5.03	0.5	0.067	µg/L	80 - 120	77.3	69.8	80.5	—	20	7.3	N
Carbon tetrachloride	GEL	543	5	1.5	µg/L	75 - 125	67.4	71.1	67.2	—	25	3.2	N

Table F-24. CY2014 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL / MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
Carbon tetrachloride	TASL	543	5	1.30	µg/L	75 - 125	49.7	49.7	49.7	—	25	0.0	N
Chloroform	GEL	221	5	1.5	µg/L	75 - 125	70.6	70.6	69.2	—	25	1.1	N
Chloroform	TASL	221	5	1	µg/L	75 - 125	45.2	45.2	45.2	—	25	0.0	N
Tetrachloroethene	GEL	9.67	5	0.3	µg/L	75 - 125	68.0	58.9	62.0	—	25	7.4	N*
Tetrachloroethene	TASL	9.67	5	0.18	µg/L	75 - 125	48.6	50.7	51.7	—	25	3.1	N*
Trichloroethene	GEL	202	5	1.5	µg/L	75 - 125	64.4	43.5	48.3	—	25	21.0	N
Trichloroethene	TASL	202	5	2.5	µg/L	75 - 125	43.6	44.1	43.1	—	25	1.1	N
Carbon-14	TASL	985	200	10.8	pCi/L	70 - 130	100.4	102.6	28.3	—	20	54.8	Y*
Gross alpha	TARL	50.1	3	4.79	pCi/L	70 - 130	59.1	54.5	58.1	—	20	4.2	N
Iodine-129	GEL	1.50	1	0.545	pCi/L	70 - 130	46.1	130.7	94.0	—	20	47.4	Y*
Iodine-129	TARL	1.50	1	0.37	pCi/L	70 - 130	132.0	113.3	107.3	—	20	10.8	N*

* The blind standard concentration was less than five times the required detection limit for this analyte. Hence, the secondary precision criterion was used: the difference between the maximum and minimum value reported must be less than the required detection limit.

GEL = GEL Laboratory
MDA = minimum detectable activity
MDL = method detection limit
RDL = required detection limit
RSD = relative standard deviation
TARL = TestAmerica Richland Laboratory
TASL = TestAmerica St. Louis Laboratory
TOC = total organic carbon
TOX = total organic halide
VOA = volatile organic analysis
WSCF = Waste Sampling and Characterization Facility

- *Volatile Organic Compounds*: GEL, TASL, and WSCF reported results for VOC blind standards during CY2014. The recovery acceptance limits for the VOCs are 75% to 125%. The VOC blind standards contained carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene at concentrations that ranged from 5 to 500 µg/L. Most of the reported recoveries trended low with a number of recoveries less than the lower recovery limit of 75%; this continues the historical trend of low recoveries for the VOC blind standards. Low recoveries for these analytes are attributed in part to losses of the VOCs from those blind standards during standards make-up and sample handling.

- *Radiochemical parameters*: All four participating laboratories returned results for radiochemical blind standards during CY2014. The recovery acceptance limits for radiochemical parameters are 70% to 130%. The following bullets discuss the highlights of those results.

  - *Gross alpha*: GEL, TARL, and WSCF returned gross alpha results for this reporting period. TARL and WSCF reported gross alpha results each during CY2014; the recoveries for these results all trended less than 100% with a total of 15 recoveries less than the lower recovery limit of 70% for this analysis. A corrective action is in place to investigate and resolve the low recovery issue at the two laboratories; this corrective action should be completed during CY2015. For the two quarters that GEL analyzed gross alpha blind standards, the laboratory reported recoveries well within the 70% to 130% recovery limits.

  - *Iodine-129*: GEL and TARL reported results for iodine-129 blind standards during CY2014. For the first quarter, both labs returned recoveries well within the acceptance limits of 70% to 130%. The spike value for the first quarter was 9.8 pCi/mL which is approximately ten times the MDAs for the two laboratories. For the second quarter, two GEL recoveries were outside the acceptance limits with one low and one high recovery. TARL reported one iodine-129 recovery just outside the upper acceptance limit~~s~~. The second quarter spike value was 1.5 pCi/L which is only about three times the laboratories' MDAs. Consequently, it is no great surprise that more failures and greater variability were observed for the second quarter iodine-129 results.

  - *Plutonium-239*: GEL, TARL, and WSCF returned plutonium-239 blind standard results for CY2014. For the first quarter, the plutonium spike value was 1.47 pCi/L and each of the three labs had at least one value fall outside the acceptance range. For the second quarter, the spike value was 10.2 pCi/L, and the two reporting labs, GEL and TARL, were well within the recovery acceptance range.

F10.2 National Performance Evaluation Studies

During 2014, Environmental Resources Associates (ERA) and DOE conducted national studies to evaluate laboratory performance for chemical and radiological constituents. GEL, TARL, TASL, and WSCF participated in the EPA-sanctioned water pollution/supply (WP/WS) performance evaluation studies conducted by ERA. GEL, TARL, and TASL, also participated in ERA's InterLaB RadCheM Proficiency Testing Program (RAD) and in DOE's Mixed Analyte Performance Evaluation Program (MAPEP). Because of its closure in early 2014, WSCF's participation in the performance evaluation programs was limited. The results of those studies related to groundwater monitoring at the Hanford Site are described in this section.

F10.2.1 Water Pollution/Supply Performance Evaluation Studies

The purpose of WP/WS performance evaluation studies is to evaluate the performance of laboratories in analyzing selected organic and inorganic compounds in water matrices. An accredited agency, e.g. ERA,

distributes standard water samples to participating laboratories. These samples contain specific organic and inorganic analytes at concentrations unknown to the participating laboratories. After analysis, the laboratories submit results to the accredited agency, which uses regression equations to determine acceptance and warning limits for the study participants. The results of these studies are expressed as a percentage of the results that the accredited agency found acceptable and independently verify the level of laboratory performance. If there is an unacceptable result, the laboratories may order an ERA QuiK[4]Response sample to verify successful corrective action. QuiK™Response samples are similar to water pollution/water supply samples, and results are reported in a comparable fashion.

For the one water pollution performance evaluation study (ERA WP-228) in which WSCF participated during the reporting period, the percentage of results within the acceptance limits was 99% of 109 total results reported (Table F-25). One constituent, TOX~~s~~, had an unacceptable result.

Table F-25. Summary of WSCF Performance Evaluation Studies

Study Number	Date	Correct Results / Total Results
WatR[b] Pollution/WatR[b] Supply Performance Evaluation Studies, Environmental Resource Associates		
WP-228	January 2014	108/109[a]
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates		
RAD-96	January 2014	5/5

a. Unacceptable result was for total organic halide.

b. WatR is a trademark of Environmental Resource Associates, Golden Colorado.

For the three WP/WS performance evaluation studies in which TASL participated during 2014 (ERA WP-114, WP-238 and WP-714), the percentage of results within the acceptance limits was 97% of 752 total results reported (Table F-26). As noted in Table F-26, 18 different constituents had unacceptable results, seven (ammonia, BOD and 5 VOA constituents) of which were repeated across two studies. However, because TARL does not report BOD and rarely reports ammonia for groundwater samples, these two failures are not germane to groundwater monitoring data quality. Acceptable results were achieved in the subsequent Rapid Response samples for all constituents that originally failed. As noted, the number of constituents reported by TASL in the water pollution studies was considerably greater than those constituents reported by WSCF; therefore, the percentages from the two laboratories are not directly comparable.

For the four water pollution performance evaluation studies (ERA WP-228, WP-234, WP-236 and WP-237) in which TARL participated during the reporting period, the percentage of results within the acceptance limits was 98% of 63 total results reported (Table F-26). Antimony had an unacceptable result; however, because TARL does not report this constituent for groundwater samples, the failure is not germane to groundwater monitoring data quality. Again, the number of constituents evaluated was very limited; therefore, the percentage of results is not comparable to that of the other laboratories.

[4] QuiKResponse is a trademark of Environmental Resource Associates, Golden, Colorado.

Table F-26. Summary of TestAmerica Performance Evaluation Studies

Study Number	Date	Correct Results / Total Results	
		TASL	TARL
WatR[a] Pollution/WatR[a] Supply Performance Evaluation Studies, Environmental Resource Associates			
WP-114	January 2014	342/357[b]	—
WP-228	January 2014	—	22/23[c]
WP-234	July 2014	—	25/25
WP-236	September 2014	—	6/6
WP-237	October 2014	—	9/9
WP238	November 2014	71/71	—
WP-714	July 2014	313/324[d]	—
13921 Rapid Response	September 2014	69/72[e]	—
DOE Mixed Analyte Performance Evaluation Program, Radiological and Environmental Sciences Laboratory			
MAPEP-14-MaW30	February 2014	31/36[f]	18/19[g]
MAPEP-14-GrW30	February 2014	2/2	2/2
MAPEP-14-XaW30	February 2014	1/1	1/1
MAPEP-14-OrW30	February 2014	80/80	—
MAPEP-14-MaW31	November 2014	32/35[h]	15/15
MAPEP-14-GrW31	November 2014	2/2	2/2
MAPEP-14-XaW31	November 2014	1/1	1/1
MAPEP-14-OrW31	November 2014	80/80	—
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates			
RAD-93	April 2013	12/12	14/17[j]
RAD-97	April 2014	12/13[i]	18/19[j]
RAD-99	October 2014	—	13/19[k]
MRAD-20	March 2013	15/15	—
ERA QR 060614M	July 2014	—	1/1

a. WatR is a trademark of Environmental Resource Associates, Golden Colorado.

b. Unacceptable results were for thallium, BOD, ammonia, pH, carbon tetrachloride, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, ethylbenzene, toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, m+p xylene, and xylenes (total).

c. Unacceptable result was for antimony.

Table F-26. Summary of TestAmerica Performance Evaluation Studies

Study Number	Date	Correct Results / Total Results	
		TASL	TARL

d. Unacceptable results were for BOD, TSS, ammonia, total phosphorus, 1,2-dichlorobenzene, 1,3-dichlorobenzene, ethylbenzene, naphthalene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and benzo(b)fluoranthene.

e. Unacceptable result was for total phosphorus.

f. Unacceptable results were for beryllium, mercury, nickel, thallium and iron-55.

g. Unacceptable result was for potassium-40.

h. Unacceptable results were for antimony, lead, and Pu-239/240.

i. Unacceptable result was for gross beta.

j. Unacceptable result was for radium-226.

k. Unacceptable results were for barium-133, cesium-134, csium-137, cobalt-60, zinc-65 and iodine-131.

For the seven WP/WS performance evaluation studies in which GEL participated during 2014 (ERA WP-222, WP-231, WP-237 and WS-210, WS-213, WS-216, and WS-217), the percentage of results within the acceptance limits was 99% of 1005 total results reported (Table F-27). Eleven different constituents had unacceptable results. Ortho-Phosphate was missed in three separate studies and was also missed in the MAPEP study, however it passed in in the remaining studies and was also passed in two different make up programs. All other constituents with unacceptable results passed in subsequent QuiKResponse or QT program sample analyses.

Table F-27. Summary of GEL Performance Evaluation Studies

Study Number	Date	Correct Results / Total Results
WatR[a] Pollution/WatR[a] Supply Performance Evaluation Studies, Environmental Resource Associates		
WP-228	January 2014	28/29[b]
WP-231	April 2014	340/342[c]
WP-237	October 2014	331/334[d]
WS-210	January 2014	144/148[e]
WS-213	April 2014	5/5
WS-216	July 2014	142/145[f]
WS-217	August 2014	2/2
011014L – Quick Response	February 2014	1/1
040114H – Quick Response	May 2014	5/5
062514K – Quick Response	June 2014	1/1
082614F – Quick Response	September 2014	9/9
QT-0000010	September 2014	2/2
QT-0000011	August 2014	51/52[g]

Table F-27. Summary of GEL Performance Evaluation Studies

Study Number	Date	Correct Results / Total Results
QT-0000012	August 2014	4/4
DOE Mixed Analyte Performance Evaluation Program, Radiological and Environmental Sciences Laboratory		
MAPEP-14-MaW30	June 2014	25/26[h]
MAPEP-14-OrW30	June 2014	80/80
MAPEP-14-GrW30	June 2014	2/2
MAPEP-14-XaW30	June 2014	1/1
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates		
RAD-96	January 2014	25/25
RAD-98	July 2014	23/25[i]
MRAD-20	March 2014	25/26[j]

a. WatR is a trademark of Environmental Resource Associates, Golden Colorado.

b. Unacceptable result was for amenable cyanide.

c. Unacceptable results were for total phosphorus and ortho-phosphate.

d. Unacceptable results were for 1,2-dichloropropane, low level residual chlorine and calcium hardness.

e. Unacceptable results were for aluminum, beryllium, phosphate and freon-113.

f. Unacceptable results were for ortho-phosphate, hexavalent chromium and total dissolved solids.

g, Unacceptable result was for extractable organic halides.

h. Unacceptable result was for ortho-phosphate.

i. Unacceptable result was for strontium-89

j. Unacceptable result was for americium-241.

DOE = U.S. Department of Energy

F10.2.2 InterLaB RadCheM Proficiency Testing Program Studies

The purpose of the RAD Proficiency Testing Program (also conducted by ERA) is to evaluate the performance of laboratories in the analysis of selected radionuclides. This program provides blind standards that contain specific amounts of one or more radionuclides in a water matrix to participating laboratories. After sample analysis, the results are forwarded to ERA for comparison with the known values and with results from other laboratories. ERA bases its control limits on the EPA's *National Standards for Water Proficiency Testing Studies, Criteria Document* (EPA NERL-Ci-0045).

During the reporting period, WSCF participated in one study, RAD-96 (Table F-25), with an acceptance percentage of 100% of 5 results.

TARL participated in two studies, RAD-97 and RAD- 99 (Table F-26), with an acceptance percentage of 82% of 38 results with seven unacceptable. Six of the unacceptable results are the result of one gamma analysis. The lab has investigated the issue and implemented corrective actions. They have also passed subsequent gamma evaluations.

TASL participated in two studies, RAD-97 and MRAD-20 (Table-26), and analyzed a total of 28 constituents with an acceptance percentage of 96% with 1 unacceptable result for gross beta. However, TASL does not report this constituent for groundwater samples, so failure is not germane to groundwater monitoring data quality.

GEL participated in three studies (RAD-96, RAD-98 and MRAD-20) and analyzed a total of 76 constituents with an acceptance percentage of 96% with 3 unacceptable results (Table F-27).

F10.2.3 DOE Mixed Analyte Performance Evaluation Program

DOE's MAPEP examines laboratory performance in the analysis of soil and water samples containing metals, SVOCs, and radionuclides. This report considers only results from the water samples. The program is conducted at the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho. DOE evaluates the accuracy of the MAPEP results for radiological, inorganic, and organic analytes by determining if the results fall within 30% of the reference value. Two studies were available for all labs during the reporting period: MAPEP-14-30 and MAPEP-14-31. TARL, and TASL, participated in both studies, and GEL participated in MAPEP-14-30. WSCF did not report any MAPEP results.

TASL analyzed inorganics, semi-volatile organics, and radionuclides including gross alpha/beta for the MAPEP studies (Table F-26). Of 237 analytes, eight had unacceptable results yielding a 97% acceptable result rate. The missed analytes were beryllium, mercury, nickel, thallium, iron-55 antimony, lead, and Pu-239/240 (both studies). All of these unacceptable results were isolated events (not repeated in both studies or in the previous year).

TARL reported results for radionuclides, including gross alpha/beta, for the two MAPEP studies (Table F-26). Of 40 constituents, one had unacceptable results, yielding a 98% acceptable result rate. The missed analyte was the naturally occurring Potassium-40 and was not missed in the subsequent study.

For the one reported MAPEP study, GEL analyzed inorganics, semi-volatile organics, and radionuclides, including gross alpha/beta (Table F-27). Of 119 analytes, GEL had a 100% acceptable result rate.

F11 Data Usability Conclusions

In general, this quality assessment for CY2014 groundwater monitoring data shows that the great majority of the data are useable for the purposes of groundwater monitoring. This assessment also noted some limitations in the data set. These limitations are summarized in the following subsections.

F11.1 Data Completeness

As detailed in Section F-5 and in Tables F-2 and F-5, 99.8% of groundwater samples planned for CY2014 was collected, the requirements for the number of field QC samples were met or exceeded, and 96.7% of the analytical results met the completeness criteria. Based on the review performed in this DQA, nearly all required samples, field QC, and analytical results were collected in accordance with the groundwater monitoring requirements of DOE/RL-91-50 and CHPRC-00189.

F11.2 Sample Preservation and Holding Time

As noted in Section F-7, improper sample preservation was a very minor issue with only 0.2% of all laboratory samples affected by sample preservation issues; only 8 analyses were cancelled as a result of this issue. Missed holding times had a somewhat greater impact on the groundwater monitoring data set with 0.5% of the analytical results associated with missed holding times. Most of the results with missed holding times were still generated within two times the holding time and hence were deemed useable by the groundwater monitoring program.

F11.3 Field Quality Control

Field QC samples were collected and analyzed in accordance with the groundwater monitoring requirements of DOE/RL-91-50 and CHPRC-00189. Field QC issues generated minimal impact to data usability. Section F-8 discusses groundwater monitoring field QC samples in detail.

For the FBs, the number and types of FBs collected met groundwater monitoring collection requirements, and 97.8% of the FB results were found to meet groundwater monitoring criteria. Of the 325 FB results that exceeded the criteria, 109 were for metals and 132 for VOCs. Many of the out-of-limit metal results were likely due to sample swaps of the FB with a groundwater sample either in the field or at the laboratory. Most of the out-of-limit VOC results were traced to probable contamination of the deionized water source used to generate the blank (methylene chloride) or to laboratory contamination during sample preparation and analysis (acetone).

For the field sample duplicates, 30.7% of the reported duplicate laboratory results met the evaluation criterion, and of these duplicate results, 95.0% were acceptable, indicating reasonable precision for field sampling operations laboratory analysis.

For the field sample TOC and TOX quadruplicates, 10.5% of the reported quadruplicate laboratory results met the evaluation criterion, and of these quadruplicate results, 83.7% met the reproducibility criterion. This represents fair reproducibility although some deficiencies in the laboratory sample preparation and analysis of these analytes may still exist. Groundwater monitoring personnel will continue to evaluate groundwater TOC and TOX data to determine what course of corrective action to take on this issue.

Of the CY2014 split sample results, 27.5% met the evaluation criterion and 90.8% of those results met the precision criterion. This success rate for split sample results is in keeping with historical trends for split samples and indicates reasonable analytical agreement between laboratories. The metals analyses constituted 60% of the split failures and may have resulted from samples swapped either in the field or in

the laboratory, heterogeneous distribution of metal-containing particulates between the split samples, and/or possible dilution errors at the time of analysis.

F11.4 Laboratory Quality Control

Overall, the frequency at which laboratory QC samples were analyzed met the requirements of DOE/RL-91-50 and CHPRC-00189. About 98% of laboratory QC sample results met requirements. This indicates reasonable control of sample preparation and analytical methods at the laboratories with respect to cleanliness, precision, and accuracy. Section F-9 discusses the laboratory QC associated with groundwater monitoring samples in detail.

Of the laboratory MBs, 97.2% met the QC requirements. This indicates adequate cleanliness during laboratory sample preparation and analysis. Numerically, most of these failures were for the ICP metals with 533 of 11,682 blank results (4.9%) exceeding QC criteria. By percent, the general chemistry parameters experienced the highest out-of-limit rate with 123 of 889 MBs (13.8%) exceeding QC criteria. Most of these MB failures were associated with alkalinity.

As a measure of analytical accuracy, 99.3% of the results for LCS, 97.5% of the MSs, and 99.0% of the surrogates met QC requirements. This indicates that the analytical methods are yielding adequate accuracy for the groundwater monitoring program.

With respect to analytical precision, 98.7% of the LCSDs and 98.9% of the MSDs met QC precision requirements, while 95.4% of sample duplicates and 98.5% of surrogate duplicates met QC precision requirements. These precision results indicate that the analytical methods are producing groundwater monitoring data that meet groundwater monitoring precision requirements.

F11.5 Laboratory Performance

The blind standards program and the performance evaluation studies provided an additional check on laboratory performance.

For the blind standards program, two laboratories, TARL and TASL, each had one quarter during CY2014 in which the laboratory did not meet the 80% success rate criterion defined in CHPRC-00189. Other issues observed as a result of the blind standards program are:

- *Total organic halides*: GEL, TASL, and WSCF reported the VOA-based TOX standards with generally low recoveries with all three laboratories reporting some TOX recoveries less than the lower recovery limit of 75%. Out-of-limit low recoveries ranged from 57.5% to 74.3%.
- *Volatile Organic Compounds*: GEL, TASL, and WSCF reported recoveries that trended low with a number of recoveries less than the lower recovery limit of 75%; this continues the historical trend of low recoveries for the VOC blind standards.
- *Gross alpha*: TARL and WSCF reported gross alpha results that trended low with 15 recoveries less than the lower recovery limit; GEL reported gross alpha recoveries well within the recovery limits. A corrective action is in place to investigate and resolve the low recovery issue and should be completed during CY2015.

These issues will continue to be monitored during and corrective actions sought as warranted.

The results of the performance evaluation studies indicate that the participating laboratories are, overall, providing analytical results within acceptable accuracy limits for analytes of interest to groundwater monitoring.

F11.6 Conclusions

Based on this DQA, sample results appear to accurately represent target analyte concentrations in Hanford Site groundwater, and the analytical data are sufficient in quantity and quality to be usable for the groundwater monitoring program. The percent useable data for the CY2014 groundwater monitoring data set is 96.7%; this easily exceeds the DOE/RL 91-50 groundwater monitoring requirement of 85% data usability. Furthermore, 98.1% of the laboratory QC samples met QC requirements. This high rate of acceptable laboratory QC results indicates that laboratory accuracy, precision, and contamination control during sample preparation and analysis support the use of the data set for the groundwater monitoring program. Field QC samples were collected and laboratory QC samples were analyzed at the frequencies required in DOE/RL 91-50 and CHPRC-00189.

This page intentionally left blank

F12 References

40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol24/xml/CFR-2012-title40-vol24-part136.xml.

40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2008-title40-vol25/pdf/CFR-2008-title40-vol25-sec265-93.pdf.

APHA/AWWA/WEF, 2012, *Standard Methods For the Examination of Water and Wastewater*, 22nd Edition, American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.

CHPRC-00189, 2014, *CH2M HILL Plateau Remediation Company Environmental Quality Assurance Program Plan*, Rev. 12, CH2M HILL Plateau Remediation Company, Richland, Washington.

DOE/RL-91-50, 2013, *Hanford Site Environmental Monitoring Plan*, Rev. 6A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/DOE-RL-91-50-6A.pdf.

ECY 97-602, 1997, *Analytical Methods for Petroleum Hydrocarbons*, Toxics Cleanup Program and The Ecology Environmental Laboratory, Washington State Department of Ecology, Olympia, Washington. Available at: https://fortress.wa.gov/ecy/publications/publications/97602.pdf.

EPA-600/R-94/111, 1994, *Methods for the Determination of Metals in Environmental Samples, Supplement I*, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=300036HL.txt.

EPA-600/4-79/020, 1983, *Methods for Chemical Analysis of Water and Wastes*, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://nepis.epa.gov/Exe/ZyNET.exe/30000Q10.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C76thru80%5CTxt%5C00000001%5C30000Q10.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL.

EPA/600/R-93/100, 1993, *Methods for the Determination of Inorganic Substances in Environmental Samples*, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://monitoringprotocols.pbworks.com/f/EPA600-R-63-100.pdf.

EPA-821-R-98-002, 1999, *Method 1664, Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) by Extraction and Gravimetry*, Office of Water, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://water.epa.gov/scitech/methods/cwa/oil/upload/2007_07_10_methods_method_oil_1664.pdf.

EPA Method 300.0, 1993, *Determination of Inorganic Anions by Ion Chromatography*, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/2007_07_10_methods_method_300_0.pdf

EPA Method 9056, 1994, *Determination of Inorganic Anions by Ion Chromatography*, U.S Environmental Protection Agency, Washington D.C. Available at: http://www.caslab.com/EPA-Methods/PDF/EPA-Method-9056.pdf

EPA NERL-Ci-0045, 1998, *National Standards for Water Proficiency Testing Studies, Criteria Document*, U.S. Environmental Protection Agency, Washington, D.C.

O'Dell, James W., 1993, *Method 410.4 The Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry*, Rev. 2.0, Inorganic Chemistry Branch, Chemistry Research Division, Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/2007_07_10_methods_method_410_4.pdf.

Peden, Mark E., 1986, *Methods for Collection and Analysis of Precipitation*, ISWS Contract Report 381, Illinois State Water Survey, Analytical Chemistry Unit, Champaign, Illinois. Available at: http://www.isws.illinois.edu/pubdoc/CR/ISWSCR-381.pdf.

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

SGW-52194, 2012, *Volatile Organic Compound Contamination in Groundwater Samples and Field Blanks*, Rev. 0, J.G. Douglas, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0091690.

SW-846, 2007, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.