8.0 Groundwater Monitoring

MJ Hartman

Part of DOE's nuclear weapons complex, the Hanford Site encompasses 580 mi^2 (1,500 km^2) along the Columbia River in southeastern Washington State. During World War II and the Cold War period (1945–1991), the government built a total of nine 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, 200 West, 300, and 100 reactor areas along the river (e.g., 100-BC, 100-K; Figure 8.1). Since 1989, using its authority under CERCLA, DOE has worked to remediate this contamination. Key elements associated with managing the Hanford Site's groundwater and vadose zone contamination are to protect the Columbia River and groundwater from further contamination, develop a cleanup decision process, and restore groundwater to its highest beneficial use.

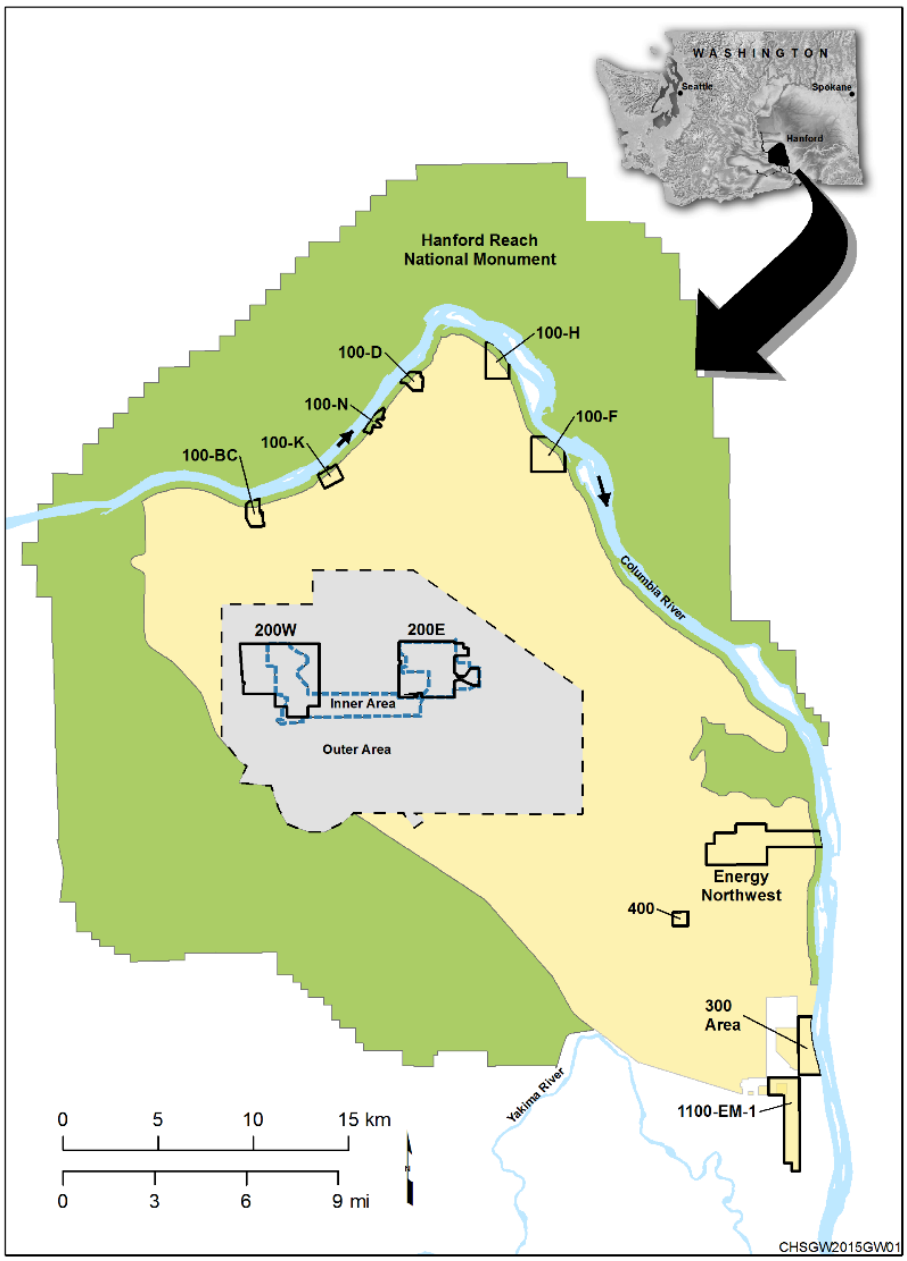

Figure 8.1. Regions of the Hanford Site

Groundwater 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 8.2).

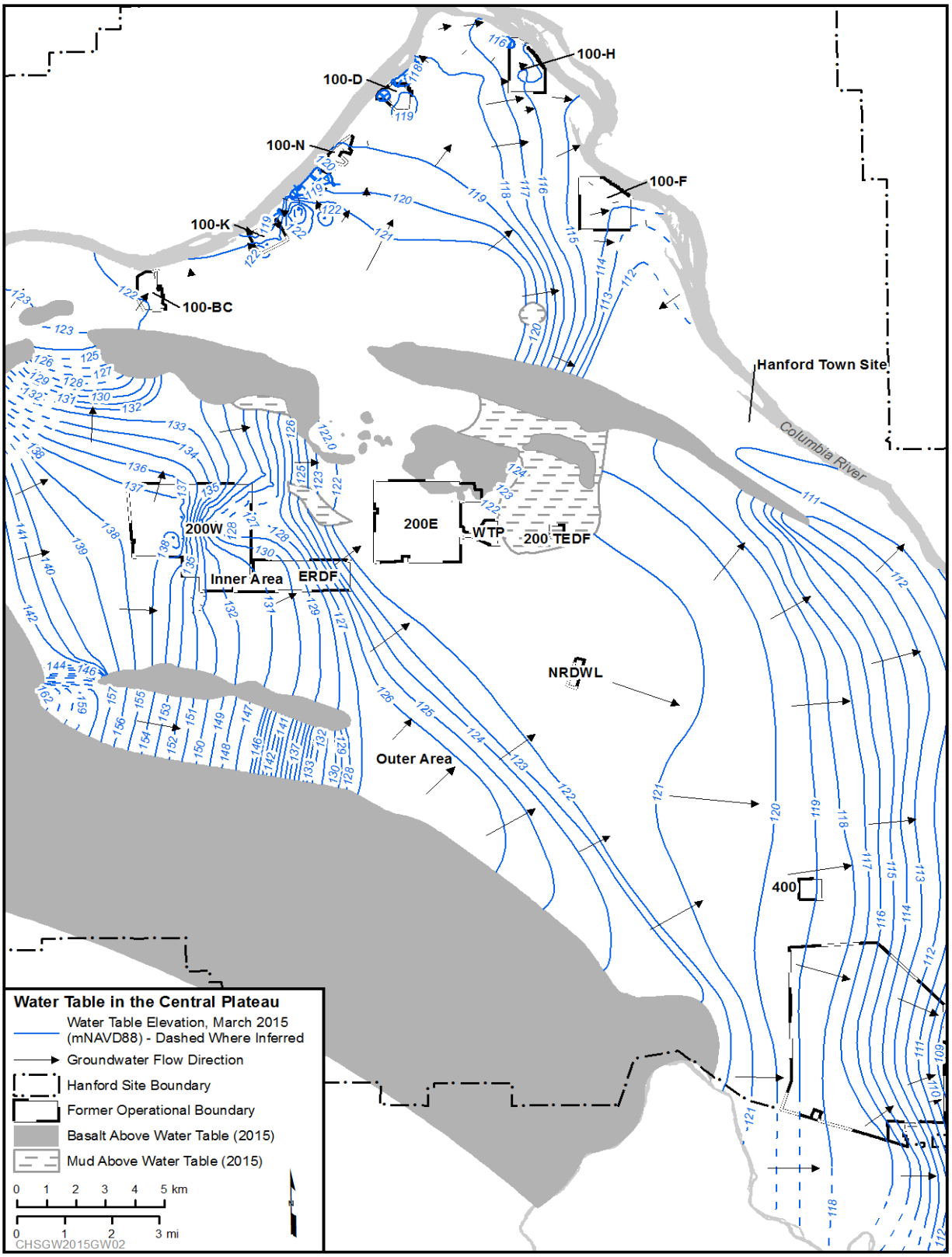

Figure 8.2. Hanford Site 2015 Water Table and Directions of Groundwater Flow

Maximum concentrations of key groundwater contaminants are presented in Tables 8.1 and 8.2. Figure 8.3 presents time-series graphs of plume areas 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, which also include carbon-14, cyanide, strontium-90, technetium-99, trichloroethene, total petroleum hydrocarbon-diesel, and uranium.

Table 8.1. Overview of River Corridor Groundwater Interest Areas

Ground-water Interest Area	Primary Operations	Status of Waste Site Remediation[a]	Status of Groundwater ROD	Groundwater Contamination: Maximum Concentration and Plume Area						
				Carbon-14 (pCi/L)	Hexavalent Chromium (µg/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Trichloro-ethene (µg/L)	Tritium (pCi/L)	Uranium (µg/L)
100-BC	Reactor operations -- B Reactor 1944-69; C Reactor 1952-69	94% complete	None to date	N	58	26	35	N	13,800	6.2
100-K	Reactor operations -- KE Reactor 1955-71; KW Reactor 1955-70	51% complete	Interim action pump-and-treat	14,200	348	75	199	8.7	701,000	14
100-N	Reactor operations -- N Reactor 1963-87	93% complete	Interim action permeable reactive barrier	62	120	308	13,600	N	876,000	8.9
100-D & 100-H	Reactor operations -- D Reactor 1944-67; DR Reactor 1950-64; H Reactor 1949-65	97% complete	Interim action pump-and-treat	5.9	614	45.2	32.7	N	14,400	16.3
100-F	Reactor operations -- F Reactor 1945-65; Biological experiments until 1976	100% complete	Final action MNA	N	51	120	176	18.3	N	15.6
300	Nuclear fuel fabrication and research -- 1940s-1960s	95% complete	Final action enhanced attenuation, MNA	N	8.9	(b)	N	2.2	877,000	5,580
1100 and Offsite	Vehicle maintenance, 1954-85; solid waste landfill --1950s-1970	100% complete	Final action MNA; goals met	N	N	(b)	N	0.61	98	(b)
Standards[c]				2,000	10	45	8	5	20,000	30
Half-life				5,730 yr	N/A	N/A	28.8 yr	N/A	12 yr	>159,000 yr
Mobility in subsurface				High	High to Moderate	High	Slight	Moderate	High	Moderate

Legend

Colors indicate maximum concentration in 2015

- ≥1000 x standard
- ≥100 x standard and <1000 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 (January 15, 2016).

(b) Nitrate in 300-FF-5, and nitrate and uranium in 1100-EM-1, originate 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

CHSGW2015GW19

Table 8.2. Overview of Central Plateau Groundwater Interest Areas

Ground-water Interest Area	Primary Operations	Status of Ground-water ROD	Groundwater Remedial Action	Groundwater Contamination: Maximum Concentration and Plume Area									
				Carbon Tetrachloride (µg/L)	Chromium (µg/L)	Cyanide (µg/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Strontium-90 (pCi/L)	Trichloroethene (µg/L)	Technetium-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)
200-BP	B Plant Pu separation: 1945-1952; B Plant Sr and Cs recovery: 1967-1985	FS Drafted in 2015 (with 200-PO-1)	B Complex groundwater extraction treatability test 2015; Perched water P&T 2011-2015	0.31	51	1,680	6.1	1,330	1,100	4.8	35,600	45,200	5,600
200-PO	PUREX Plant Pu separation: 1956-1972 and 1983-1989	FS Drafted in 2015 (with 200-BP-5)	Vadose zone desiccation test: 2011	N	52[a]	N	10.1	139	14.1	1.5	3,020	525,000	43.1
200-UP	REDOX Plant (Pu separation) 1952-1967; U Plant (U recovery) 1952-1957	Signed 2012 (interim action)	Uranium plume P&T began 2015; I-129 containment began 2015; S-SX P&T 2012-present; U plant P&T 1994-2011	See 200-ZP	406	N	6.1	3190	3.1	See 200-ZP	51,400	271,000	1,550
200-ZP	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	1,980	198	N	1.2	810	N	10.4	20,500	60,200	2.9
Standards[b]				5	48	200	1	45	8	5	900	20,000	30
Half-life (years)				N/A	N/A	N/A	1.60E+07	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 2015

- ≥100 x standard and <1000 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

a. Chromium plume originated in UP-1 and tallied with that area.

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

ABBREVIATIONS

FS = Feasibility Study; MTCA = Model Toxics Control Act; P&T = Pump and Treat; Redox = Reduction-Oxidation

MNA = Monitored Natural Attenuation; N/A = Not Applicable; PUREX = Plutonium Uranium Extraction; ROD = Rrecord of Decision

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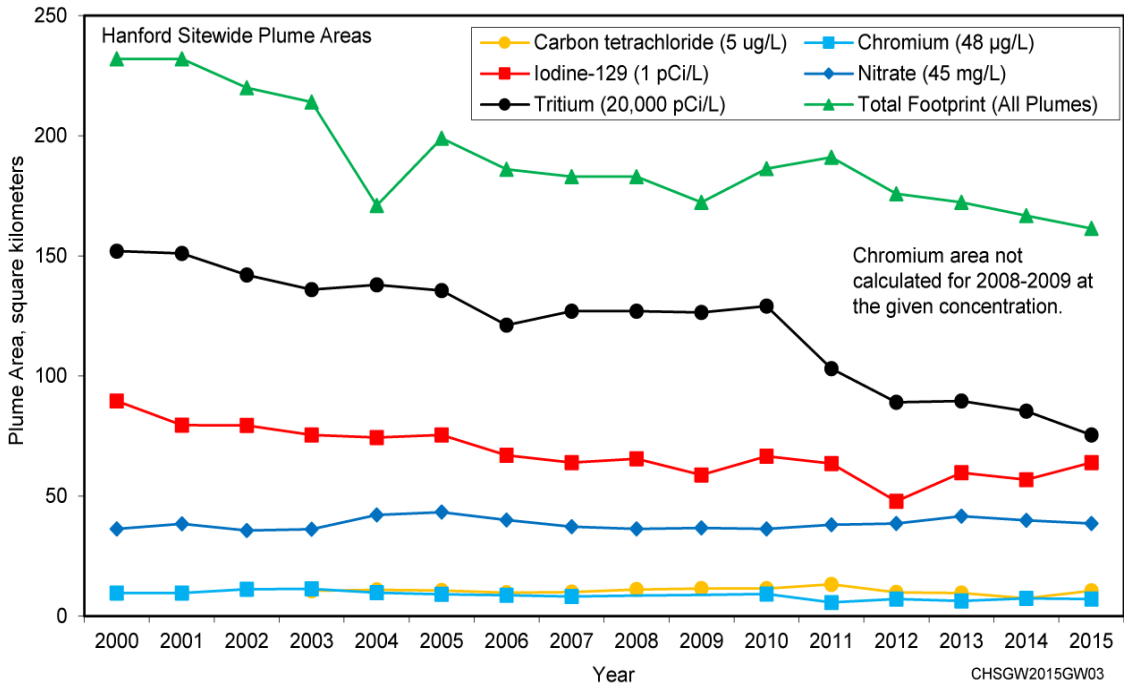

Figure 8.3. Hanford Site Plume Areas

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).

DOE operates an extensive groundwater monitoring program on the Hanford Site, collecting thousands of samples from hundreds of wells each year (Figure 8.4). In addition to monitoring wells, DOE monitors hundreds of sampling points near the Columbia River, known as aquifer tubes, for general information about groundwater approaching the river.

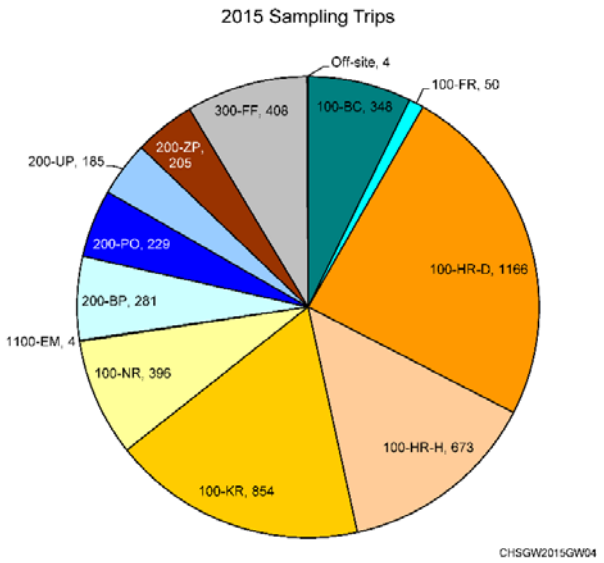

Figure 8.4. 2015 Sampling Events (Wells and Aquifer Tubes)

Figure 8.5 compares maximum concentrations of the major groundwater contaminants in various parts of the Site in 2015. These contaminants are discussed further in the following sections. This chapter is organized by geographic regions known as "groundwater interest areas" (Figure 8.5) within the River Corridor (100 and 300 areas) and Central Plateau (200 Areas).

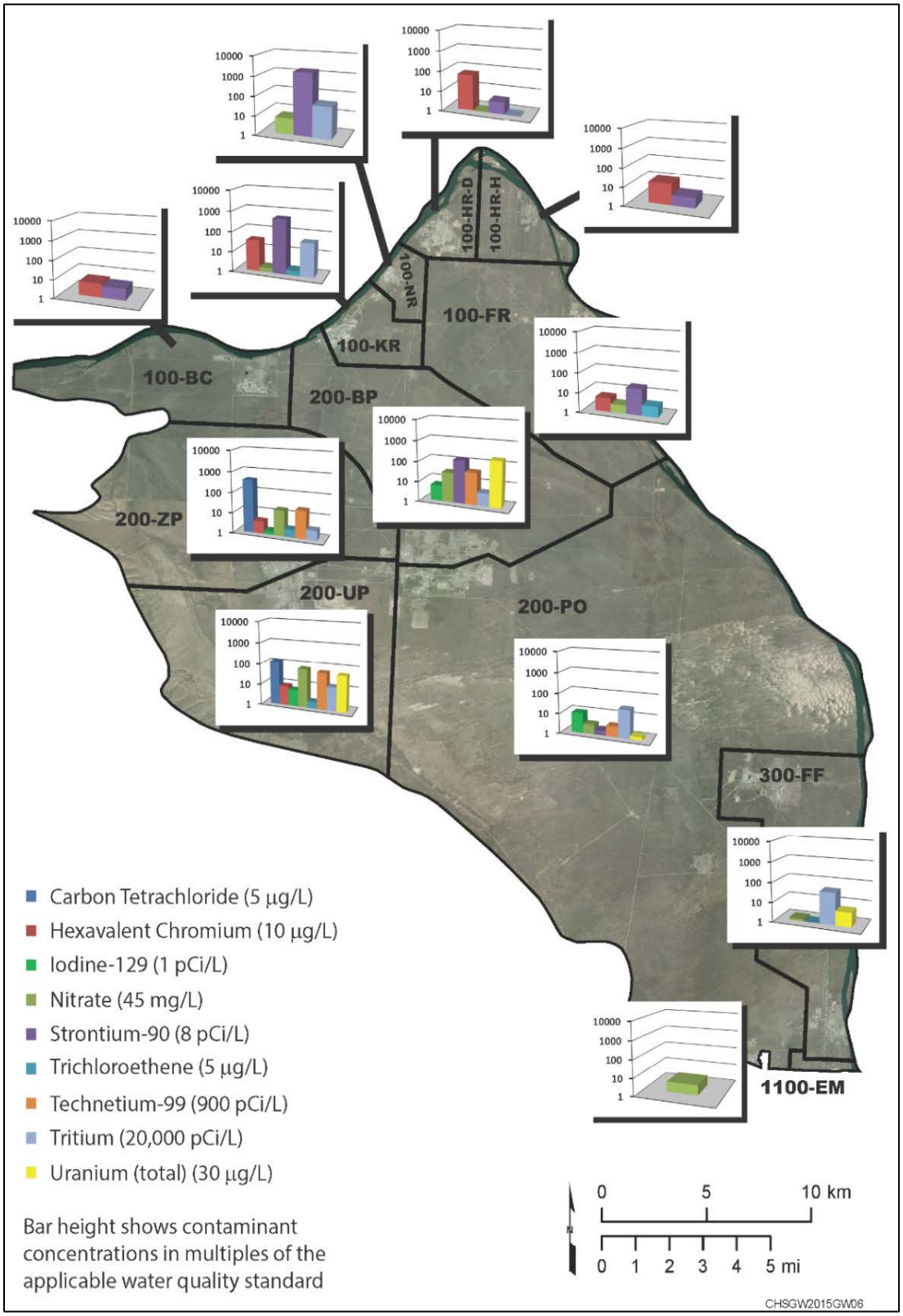

Figure 8.5. Maximum Concentrations of Groundwater Contaminants in Each Groundwater Interest Area in 2015 Expressed as Multiples of Water Quality Standards

8.1 River Corridor

Since the 1990s, DOE has been remediating waste sites and groundwater in the River Corridor under interim action RODs. Removal of contaminated soil has reduced the potential for exposure to contaminants, including future groundwater impacts. As of the end of 2015, 92% of the waste sites in the River Corridor had been remediated or were classified as not needing remediation under interim action RODs. Cleanup of the remaining sites is underway.

Table 8.1 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 (COC) in the 100 Area are hexavalent chromium, strontium-90, nitrate, trichloroethene, and tritium (Figure 8.6). 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.

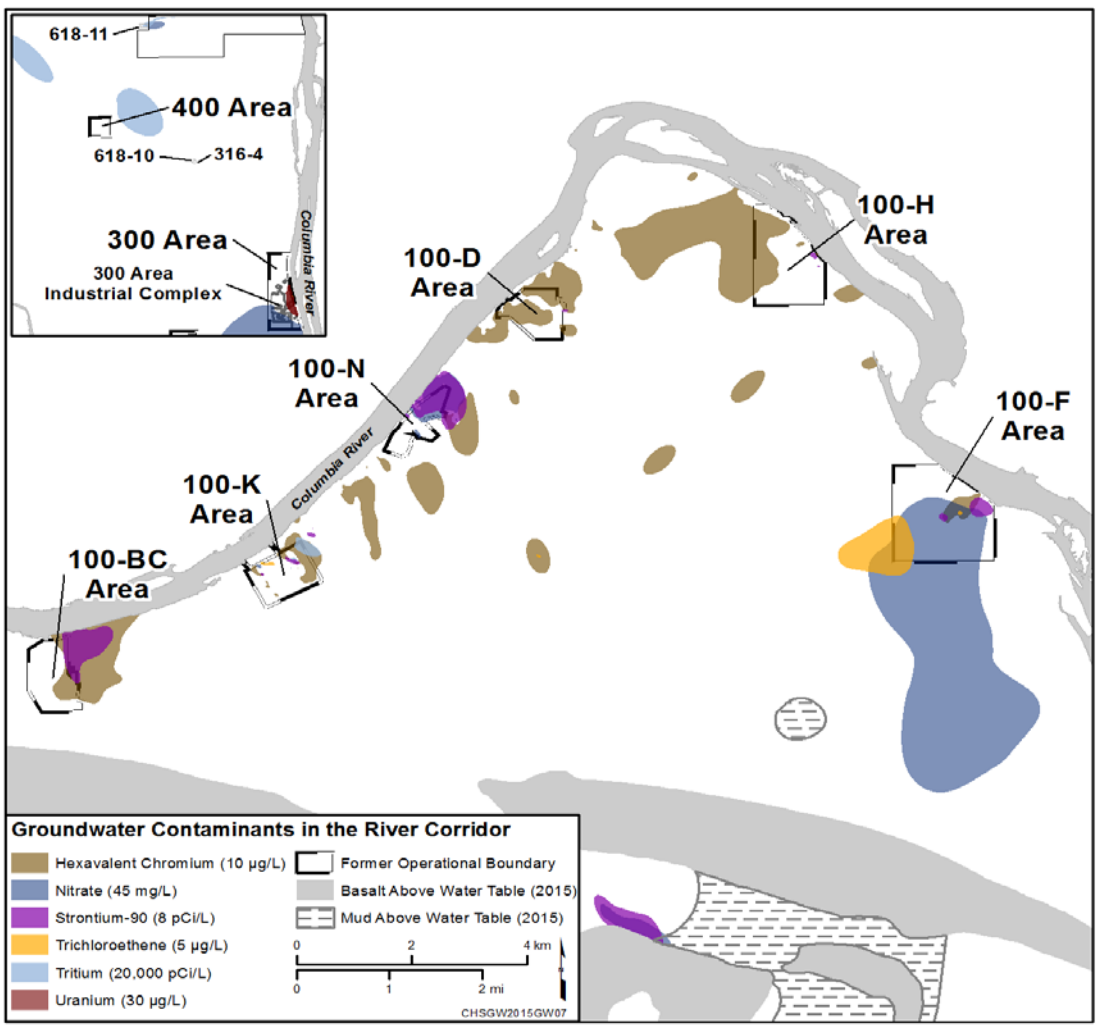

Figure 8.6. Maximum Concentrations of Groundwater Contaminants in Each Groundwater Interest Area in 2015 Expressed as Multiples of Water Quality Standards

Under interim action RODs, groundwater remediation systems in the 100-HR-3 and 100-KR-4 operable units (OUs) are limiting the amount of contamination reaching the Columbia River and reducing the mass of contaminants. The primary contaminant addressed is hexavalent chromium and the remedial action goal 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.

Final action RODs have been signed for 100-FR-3, 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.

8.1.1 100-BC

Groundwater contaminants of potential concern in 100-BC include hexavalent chromium, strontium 90, and tritium. Hexavalent chromium concentrations and the size of the plume declined between 2014 and 2015. The strontium 90 plume remained stable and tritium concentrations remained below the DWS in 2015. Sampling of water in the shallow river bed showed that Cr(VI) concentrations exceed the aquatic standard in pore water of the river bed.

DOE has completed interim action remediation of 100-BC waste sites. Vadose zone sampling indicated that at most sites, no substantive quantities of residual contaminant mass remain in the vadose zone. However, at a few sites, data from deep vadose soils and the rewetted zone, and the presence of persistent groundwater contamination, suggest that minor quantities of residual contamination may remain.

Remedial investigation studies continued in 100-BC in 2015, with additional sampling of wells and river shoreline sampling points installed in 2013. Data from the studies that concluded in January 2016 are being incorporated into a remedial investigation/feasibility study report to support remedy decisions for groundwater cleanup.

8.1.2 100-FR

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. DOE has completed remediation of 100-FR waste sites, and sampling indicated that no substantive quantities of residual contaminant mass remain in the vadose zone.

Under a 2014 ROD, the groundwater remedy is monitored natural attenuation (MNA) of nitrate, trichloroethene, strontium 90, and hexavalent chromium. Contaminant concentrations are below cleanup standards near the river and are declining.

8.1.3 100-HR

The 100-HR-3 Groundwater OU in the northern part of the 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 8.6).

About 97% of the former waste sites have been remediated or were determined not to require remediation under an interim action ROD. At the 100-D-100 waste site, once a major source of hexavalent chromium contamination, efforts to excavate contaminated sediment down into the top portion of the aquifer were successfully completed in 2015. Remediation of other waste sites continued in 2015.

Two P&T systems continued to operate in 2015 under an interim action ROD to remove hexavalent chromium from groundwater. In 2015, 688 million gal (2.6 billion L) of groundwater were pumped from 80 extraction wells. Since 1997, the P&T systems have removed 5,211 lbs (2,364 kg) of hexavalent chromium. The overall areal extent of the plumes and the length of affected shoreline have declined between 1999 and 2015 (Figure 8.7). The changes are a result of groundwater contaminant removal, remediation of sources, hydraulic control, and natural processes.

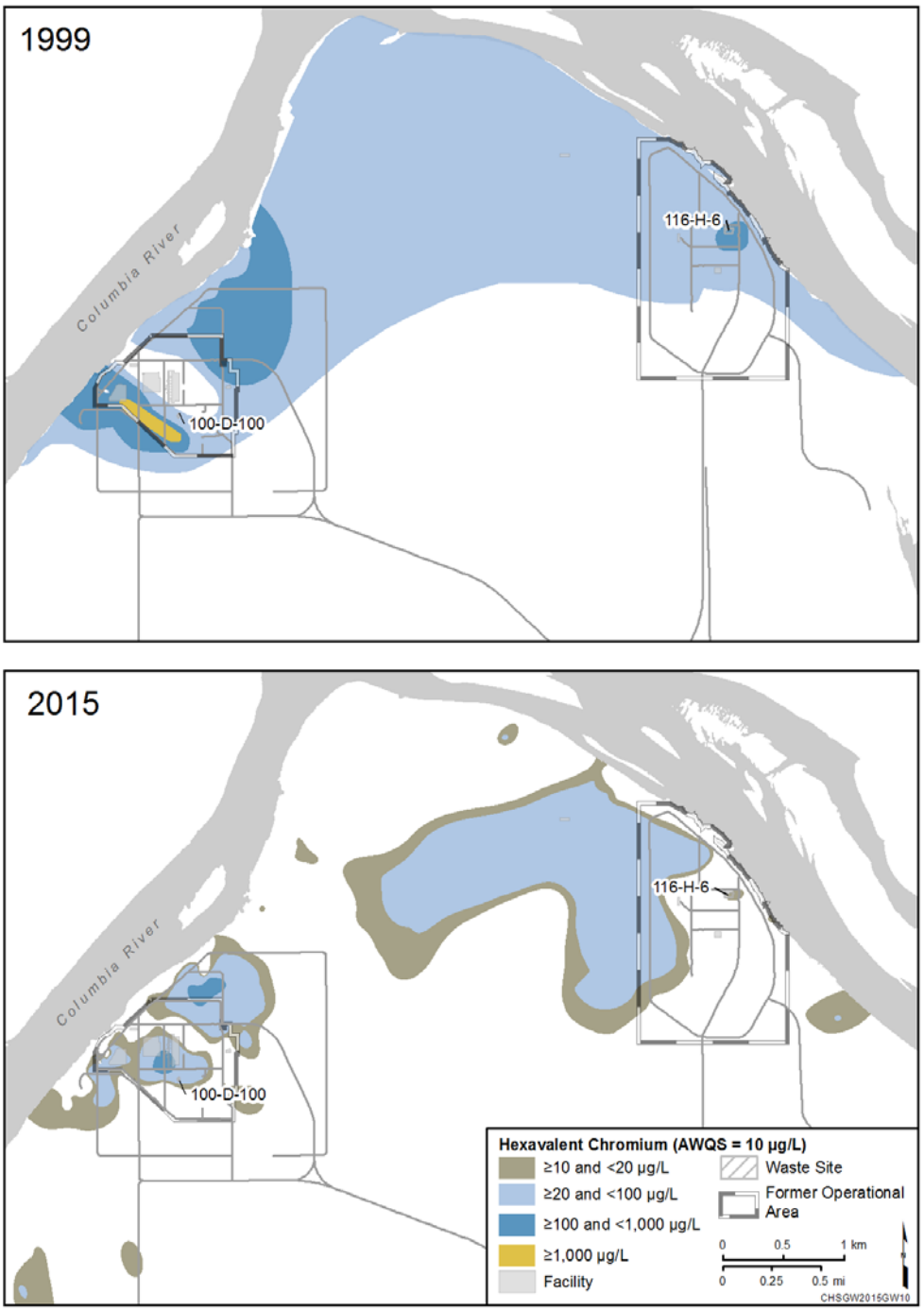

Figure 8.7. 100-HR Hexavalent Chromium Plume in 1999 (early in interim action period) and 2015 (during interim action)

The CERCLA process is underway to make final cleanup decisions for 100-HR. The proposed plan for remediation is expected to be available for public comment in 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 unit in 100-HR. The unit is monitored in accordance with RCRA corrective action requirements during the post-closure period to track contaminant trends during operation of the CERCLA P&T interim action for hexavalent chromium.

8.1.4 100-KR

Hexavalent chromium is the primary contaminant in 100-KR groundwater. Smaller plumes of carbon-14, tritium, strontium-90, nitrate, and trichloroethene also are present. About 51% of the waste sites in 100-KR have been remediated or were determined not to require remediation under an interim action ROD. Waste site cleanup continued in 2015.

Three P&T systems continued to operate in 100-KR in 2015, removing hexavalent chromium from groundwater. In 2015, over 764 million gal (2.89 billion L) of groundwater were pumped from 42 extraction wells. A total of 1,843 lbs (836 kg) of hexavalent chromium have been removed from 100-KR groundwater to date.

The hexavalent chromium plume area (greater than 20 µg/L) was estimated to be 0.23 mi^2 (0.59 km^2) in 2015, a decrease of 29% from 2014. Since 2007, the plume area above 20 µg/L has decreased by 70%, and the length of shoreline that the plume intersects has decreased from 7,200 ft (2,200 m) to less than 330 ft (100 m; Figure 8.8).

In addition to hexavalent chromium, smaller plumes of carbon 14, tritium, strontium 90, nitrate, and trichloroethene also are present (Figure 8.6). 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. In 2015, two boreholes were drilled near the KE fuel storage basins and 116-KE-3 Crib and reverse well in support of source characterization activities. The results will be incorporated into the RI/FS and proposed plan, which will be revised in 2017.

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 2015 did not show new groundwater impacts from the basins.

Figure 8.8. 100-KR Hexavalent Chromium Plume in 1996 (before interim action) and 2015 (during interim action)

8.1.5 100-NR

Principal groundwater activities for 100-NR include RCRA monitoring and remediation of strontium-90 and total petroleum hydrocarbons. Other groundwater contaminants include nitrate, total chromium, hexavalent chromium, and tritium. About 93% of the waste sites in 100-NR have been remediated. Remedial action and planning are expected to continue in 2016.

Originating at the 116-N-1 and 116-N-3 waste sites, strontium-90 is the primary COC. 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 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. Under an interim action ROD, a 900 ft (170 m) section of a permeable reactive barrier is in place along the shoreline to reduce the amount of strontium-90 migrating from groundwater into the river (Figure 8.9). Expansion of the barrier to its full 2,500 ft (760 m) length is pending.

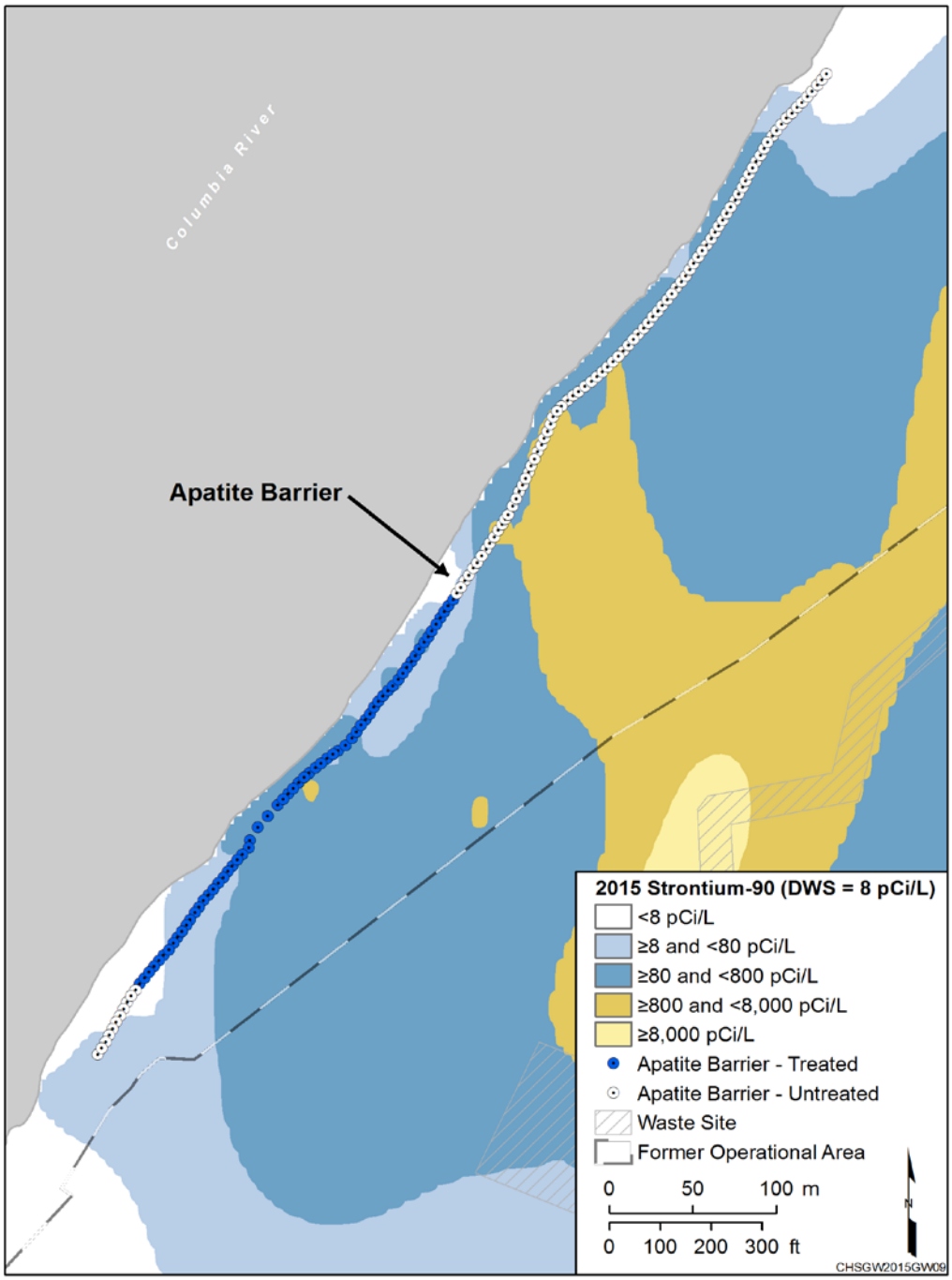

Figure 8.9. 100-NR 2015 Strontium-90 Plume and Apatite Barrier

DOE submitted a draft RI/FS report and proposed plan to Ecology for review in 2013. In 2015, DOE continued to respond to Ecology's comments on the documents. When finalized, these documents will be used to develop a ROD documenting remediation of waste sites and groundwater.

In 2015, 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.

8.1.6 300-FF

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 (inset map on Figure 8.6). About 95% of the waste sites have been remediated or classified as not requiring remediation. Remediation is continuing at the remaining sites.

EPA and DOE signed a ROD in 2013. The remedial action of groundwater includes enhanced attenuation of uranium using sequestration by phosphate application. The first stage of enhanced attenuation was completed in 2015. 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 (Figure 8.10). Uranium and chromium from the 618-7 Burial Ground was mobilized by waste site remediation activities in recent years, with some contamination reaching groundwater.

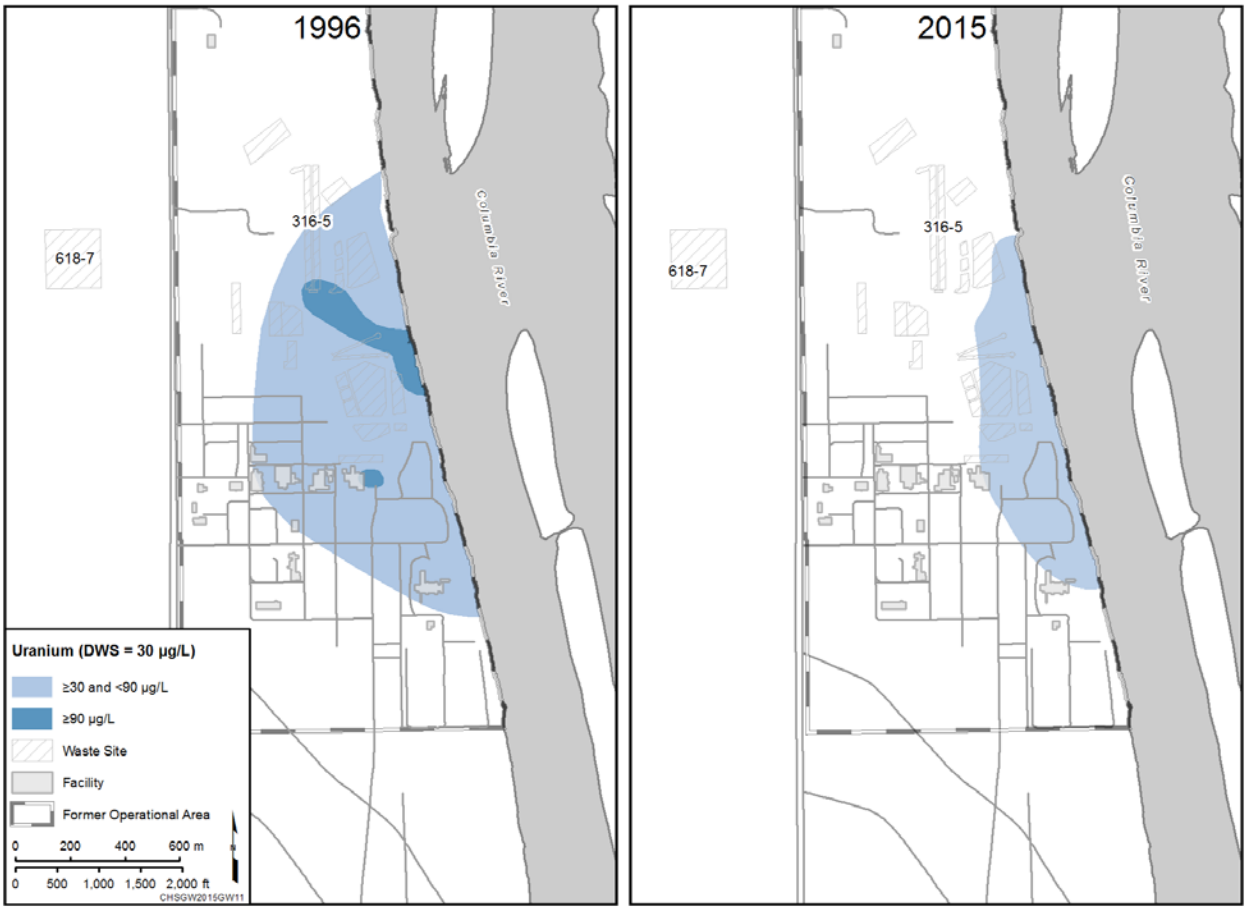

Figure 8.10. 300-FF Uranium Plume in 1996 and 2015

Trichloroethene concentrations were below the cleanup level (4 µg/L) in 300-FF monitoring wells in 2015. Cis-1,2-dichloroethene continued to exceed the cleanup level (16 µg/L) in one well. Concentrations of nitrate above 45 mg/L are present in groundwater beneath part of the 300 Area Industrial Complex, but these originated from offsite sources; nitrate in the 300 Area Industrial Complex is not a COC for the 300-FF-5 OU.

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; the waste site has not yet been remediated. Nitrate concentrations near the 618-11 Burial Ground also continued to exceed 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. Uranium and cis-1,2-dichloroethene continued to exceed Permit limits in 2015. Remediation will be coordinated under the 300-FF-5 Groundwater OU.

8.1.7 1100-EM and Richland North

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 for volatile organic compounds, with institutional controls preventing drilling of new water supply wells. Trichloroethene was the primary COC, but concentrations have remained below the cleanup level since 2001 and CERCLA groundwater monitoring ceased in 2015.

DOE monitors wells in and near the North Richland well field, which is part of the municipal water supply system. Groundwater in this region has not been impacted by Hanford Site contamination.

Uranium concentrations in Hanford Site wells near the DOE inactive Horn Rapids Landfill have increased gradually since 1996, exceeding the DWS in 2015. The presence of uranium at these locations is attributed to a plume moving northeast from a former surface impoundment at AREVA NP, Inc., an off-site nuclear fuel production facility that has been remediated.

8.2 Central Plateau

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 Areas in the Central Plateau portion of the Site. Ponds, cribs, and ditches used for liquid waste disposal were primary sources of groundwater contamination. There are also seven single shell tank WMAs in the 200 Areas. Some of these tanks have leaked, contaminating the vadose zone and groundwater.

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

Large groundwater contaminant plumes of tritium, nitrate, and iodine-129 formed when the waste discharged to ponds and cribs in the Central Plateau reached the aquifer. Plume sizes have decreased over the years because of dispersion and, in the case of tritium, radioactive decay. A large carbon tetrachloride plume originated in the Plutonium Finishing Plant area of the 200 West Area. Other groundwater contaminants in the Central Plateau include technetium-99, uranium, strontium-90, trichloroethene, hexavalent chromium, cyanide, and other dangerous waste constituents (Table 8.2; Figure 8.11).

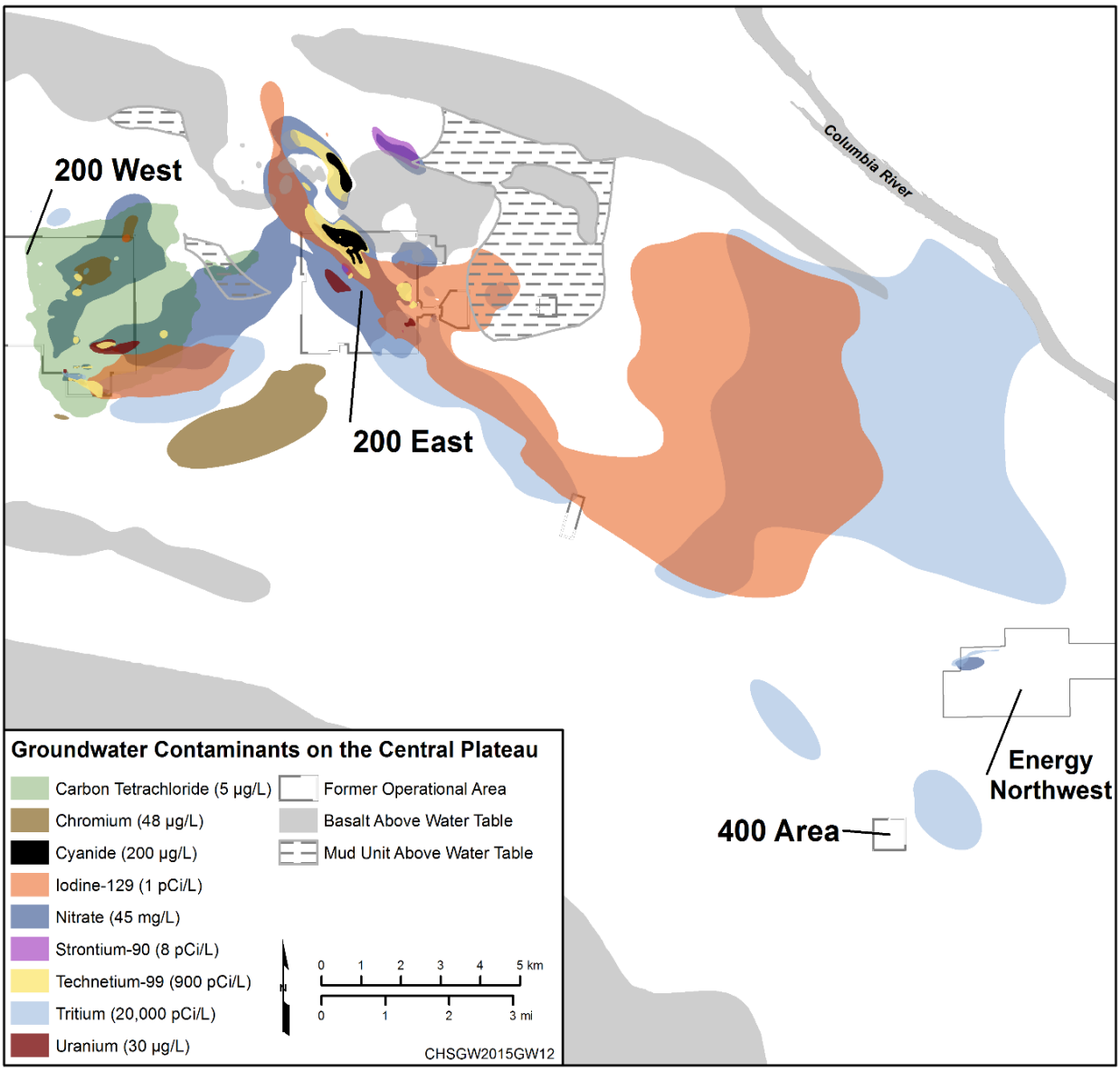

Figure 8.11. Groundwater Contaminants in the Central Plateau

8.2.1 200-BP

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 beneath waste sites in the northwestern portion of the 200 East Area. Nitrate, iodine-129, and technetium-99 exceed DWSs and 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 8.12). Smaller plumes of uranium, cyanide, strontium-90, and tritium also exceed their respective DWSs. Cesium-137 and plutonium-239/-240 contamination is limited to only one or two wells adjacent to the 116-B-5 injection well, where effluent was historically discharged into the aquifer. DOE drilled two deep investigation wells near B Plant in 2015 to evaluate concentrations of nitrate, tritium, and uranium with depth.

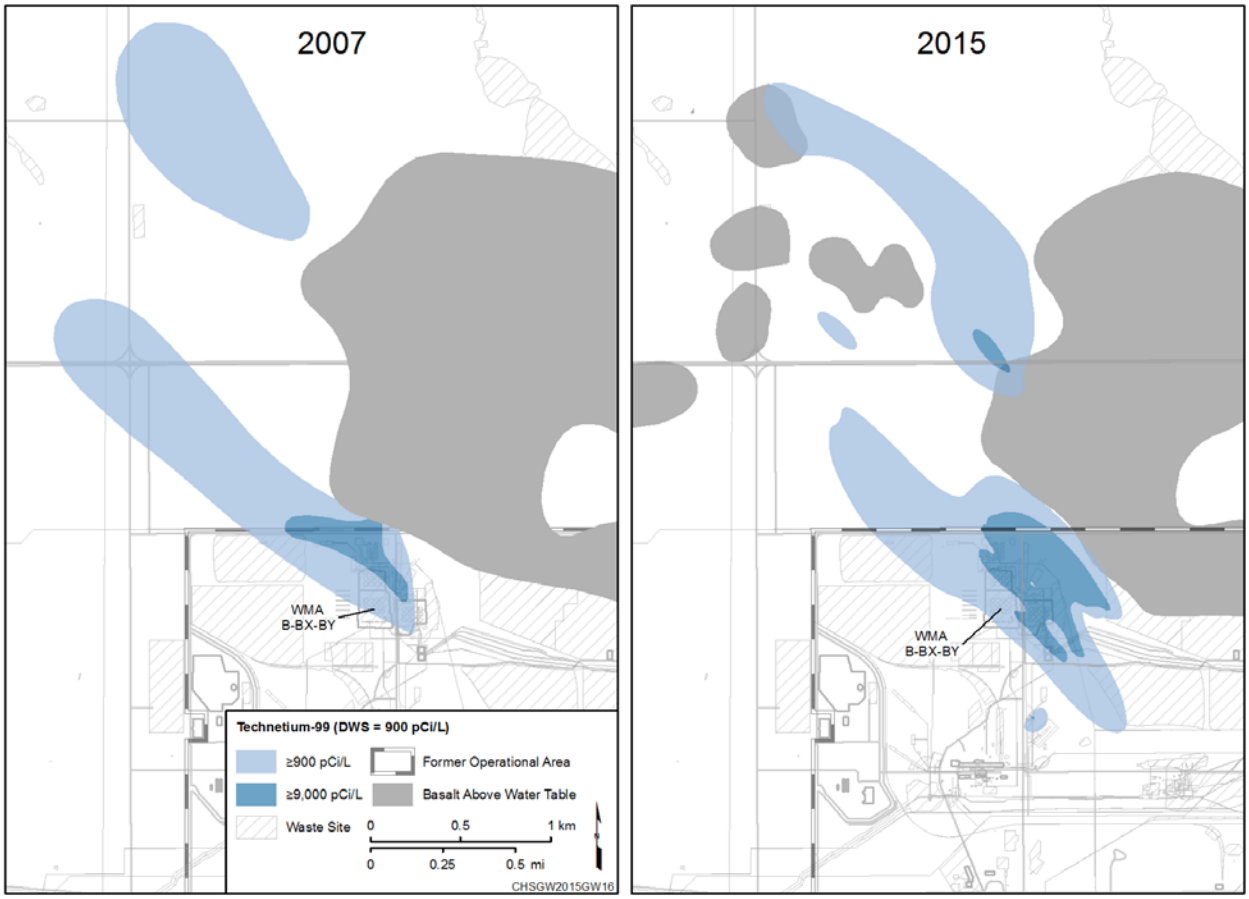

Figure 8.12. 200-BP Technetium-99 Plume in 2007 and 2015

Beneath WMA B-BX-BY, a zone of perched water lies above the water table with high concentrations of uranium and other contaminants (200-CV-1 OU). Water is pumped from this perched zone to prevent more from draining to the underlying aquifer, and approximately 37 lbs (17 kg) of uranium was removed in 2015.

DOE conducted a treatability test that involved long-term groundwater extraction in 2015. Results indicated that pumping rates greater than 155 gal (586 L) per minute can be sustained in the unconfined aquifer at B Complex; therefore, P&T may be a plausible alternative in the 200-BP-5 OU FS.

DOE submitted a draft remedial investigation report for the 200-BP-5 OU to Ecology in 2015, describing the nature and extent of contamination and identifying contaminants of potential concern to support a future feasibility study.

Six RCRA WMAs 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 originated in the WMAs. In 2015, RCRA contamination indicator evaluation monitoring continued at the 216-B-63 Trench and two low-level waste management areas (LLWMA): LLWMA-1 and LLWMA-2. Results continued to show that these units have not impacted groundwater quality. DOE monitors the Liquid Effluent Retention Facility (LERF) under a RCRA final status detection program and results showed no indication that the site has affected groundwater. DOE installed one RCRA monitoring well for LERF in 2015.

8.2.2 200-PO

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 area of 26.6 mi^2 (69 km^2) above the 20,000 pCi/L DWS in 2015, a 14% decrease from 2014. Concentrations of tritium are declining as the groundwater plume attenuates naturally from 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 because 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 45 mg/L. Other 200-PO contaminants include strontium-90, technetium-99, and uranium in smaller areas near their discharge sources (Figure 8.11).

The size of the regional tritium plume (Figure 8.13) from 200-PO has decreased by 63% since 1980 (from 71.4 to 26.6 mi^2 [185 to 69 km^2]). The maximum concentration has declined from over 6 million pCi/L in the 1980s to 525,000 pCi/L in 2015.

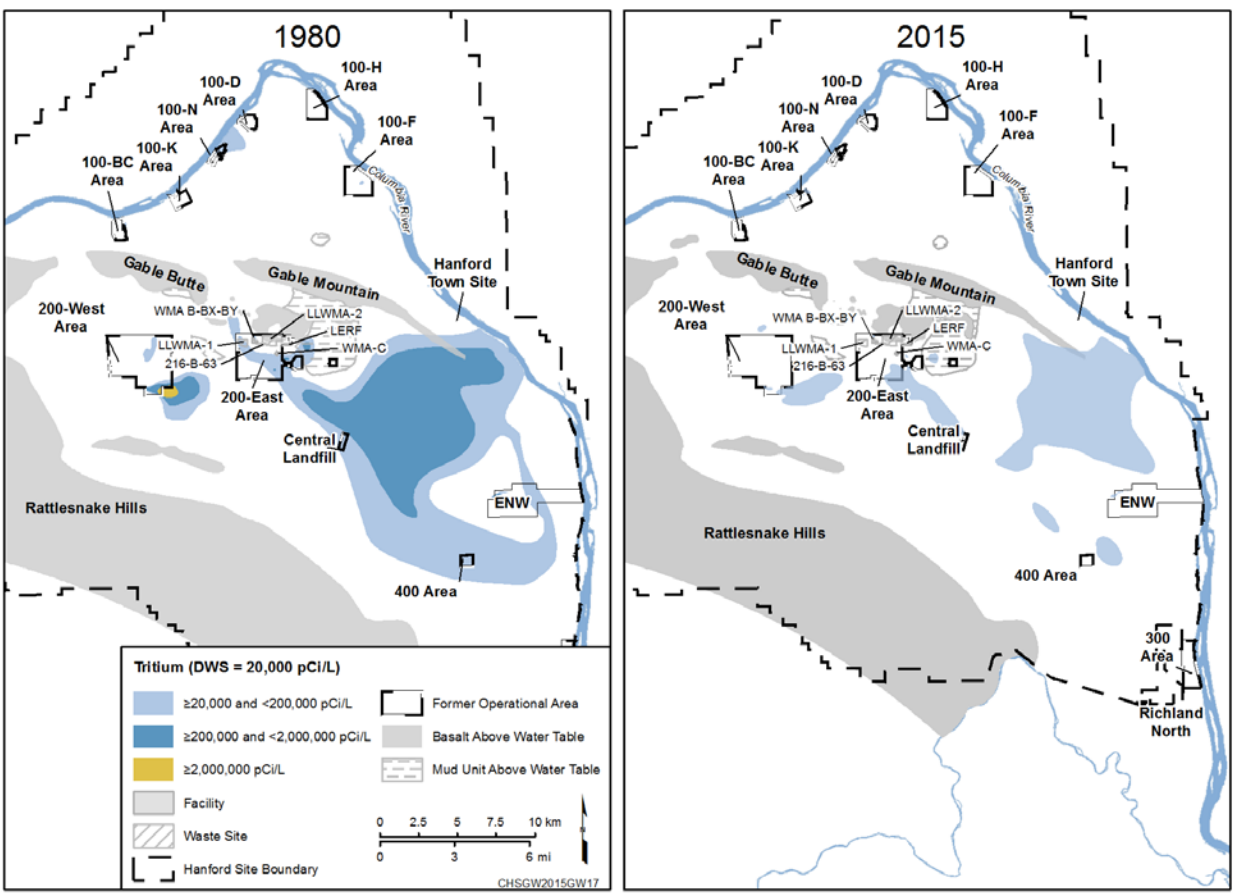

Figure 8.13. Hanford Site Tritium Plumes in 1980 and 2015

DOE provided Draft A of a remedial investigation addendum to Ecology in 2015. The addendum updates the risk assessment for the 200-PO-1 OU based on additional groundwater data collected since the remedial investigation was completed in 2009.

RCRA groundwater monitoring continued in 2015. Revised monitoring plans for WMA A-AX, 216-A-36B Crib, 216-A-37-1 Crib, 216-B-3 Pond, and the Nonradioactive Dangerous Waste Landfill were drafted in 2015 and are expected to be implemented in 2016. Specific conductance continued to exceed the critical mean value in three downgradient wells at the 216-A-29 Ditch. As agreed to with Ecology, an assessment program will be implemented in 2016 based on the current exceedances of the specific conductance critical mean. 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.

Other groundwater monitoring in 200-PO includes the Solid Waste Landfill, regulated under Washington State solid waste handling regulations, and three on-site water supply wells that provide drinking water and serve as an emergency water supply for the 400 Area. Because the 400 Area is in the path of the Hanford Site-wide tritium plume, DOE routinely monitors the wells for tritium. Concentrations remained below the DWS in 2015.

8.2.3 200-UP

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.

An interim action ROD addressing all of the major contaminant plumes in the 200-UP-1 Groundwater OU was published in 2012. The selected remedy in the ROD is a combination of P&T, MNA, hydraulic containment, and institutional controls. Portions of this selected remedy began in 2015. The U Plant uranium/technetium-99 groundwater extraction system began operating two extraction wells in September. Comprising three injection wells east of 200 West Area, the iodine-129 hydraulic containment system began operating in October.

Wells near WMA S-SX monitor the highest technetium-99 activities on the Hanford Site, and the plume has grown in recent years (Figure 8.14). A P&T system at WMA S-SX continued to operate in 2015, and concentrations began to decline. From 2012 to 2015, the system removed 2.18 Ci of technetium-99, 50,000 lbs (22,600 kg) of nitrate, 79.6 lbs (36.1 kg) of chromium, and 87.1 lbs (39.5 kg) of carbon tetrachloride from groundwater.

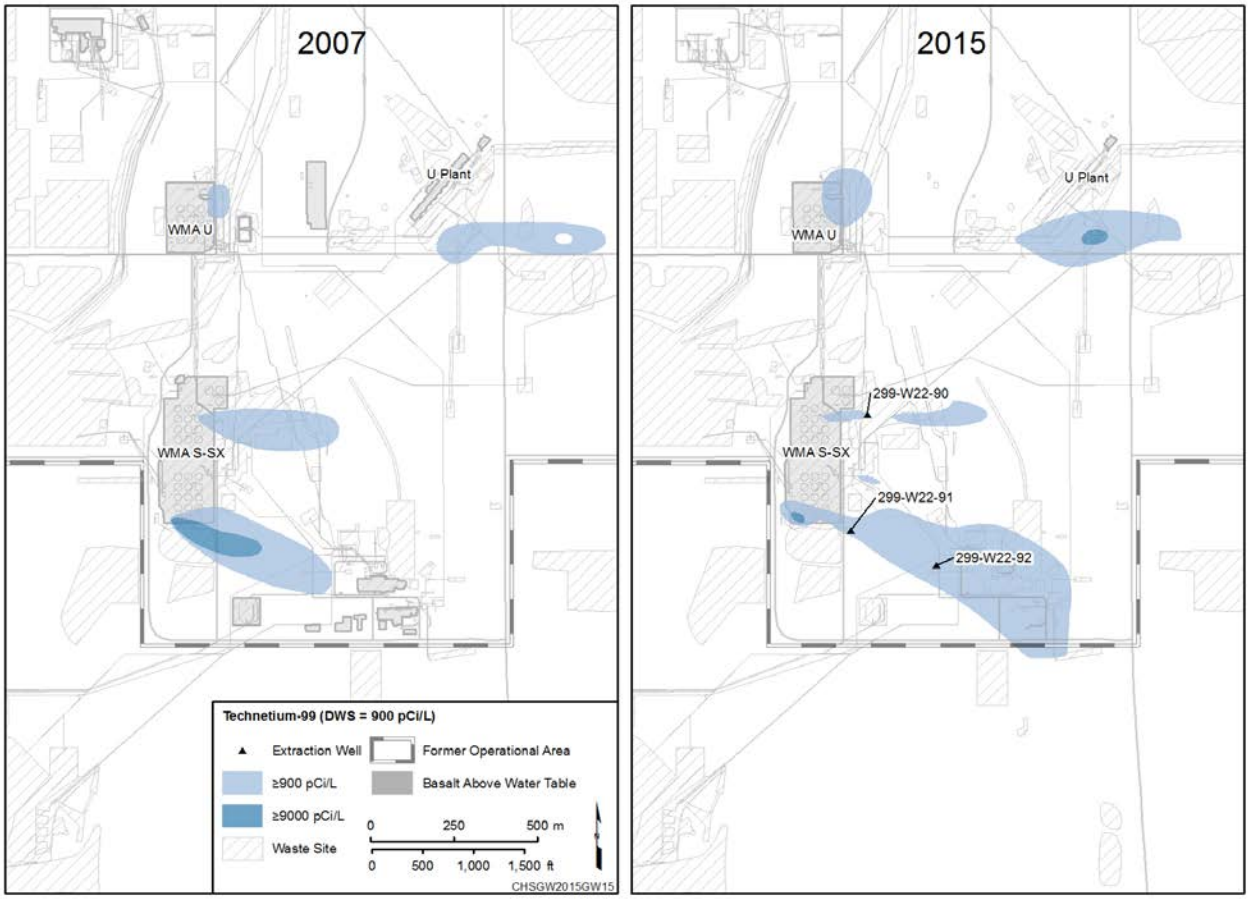

Figure 8.14. WMA S-SX Technetium-99 Plume in 2007 and 2015

RCRA monitoring in 200-UP includes interim status groundwater quality assessment monitoring at WMA S-SX and WMA U, and interim status indicator 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. Three replacement wells were drilled and put into service in 2015, and a fourth well will begin operating in 2016. Sources within WMA U have contaminated groundwater with nitrate, chromium, and the non-RCRA constituent technetium-99. The groundwater beneath this tank farm is within the capture zone of a nearby extraction well. One new well was added to the network in 2015 to replace a dry well. Indicator parameters did not exceed statistical comparison values at the 216-S-10 Pond and Ditch during 2015.

The Environmental Restoration Disposal Facility is a CERCLA disposal facility used for disposal of low-level radioactive mixed waste generated by remedial actions. The results of 2015 groundwater monitoring continued to indicate that the facility has not impacted groundwater.

8.2.4 200-ZP

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

A P&T system has reduced the area of the carbon tetrachloride plume with concentrations greater than 2,000 µg/L from 0.20 mi^2 (0.53 km^2) in 1996 to zero in 2014 and 2015 (Figure 8.15). The interpreted plume area above 5 µg/L increased from 5.1 to 6.8 mi^2 (13 to 18 km^2) between 2014 and 2015 as a result of a reinterpretation based on data collected during drilling of new wells and a model update.

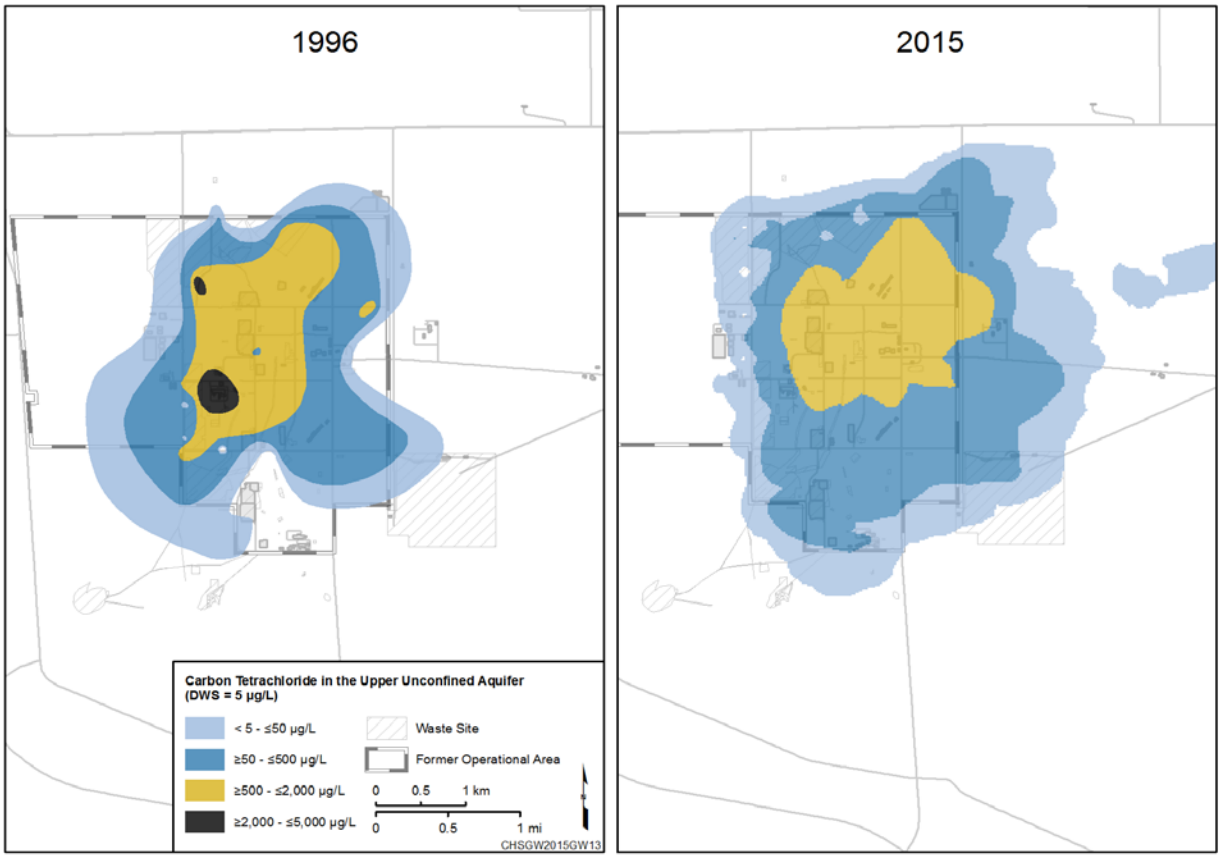

Figure 8.15. 200 West Carbon Tetrachloride Plume in 1996 (upper part of confined aquifer) and 2015 (including available vertical interval data)

In 2015, 26 extraction wells and 26 injection wells were in use, and the system processed 1.0 billion gal (3.8 billion L) of groundwater, removing 6,142 lbs (2,786 kg) of carbon tetrachloride, 768,159 lbs (348,431 kg) of nitrate, and other contaminants from groundwater. Combined, the final, interim, and soil vapor extraction systems have removed 227,698 lbs (103,282 kg) of carbon tetrachloride from the subsurface.

Four RCRA units were monitored in 200-ZP in 2015. LLWMA-3 and LLWMA-4 are monitored under interim status contaminant indicator evaluation programs. Monitoring results showed no indication that these LLWMAs are contaminating groundwater. RCRA assessment monitoring continued at WMA T and

WMA TX TY to track hexavalent chromium from the WMAs in groundwater. Groundwater beneath both WMAs is affected by CERCLA remediation activities (i.e., operation of the 200 West P&T system).

The State-Approved Land Disposal Site receives treated water from the Hanford Site Effluent Treatment Facility. It is regulated under a State Waste Discharge Permit and has created a local tritium plume. The Permit was renewed effective January 1, 2015 for 5 years. All groundwater sampling results from the proximal wells were within Permit compliance limits during 2015.

8.3 Confined Aquifers

Most Hanford Site groundwater contamination is found in the unconfined aquifer, but 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, chromium, and nitrate have entered this unit in a portion of the 200 West Area (200-ZP) 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 the 200 East Area (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 Ringold upper mud unit, 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. Groundwater monitoring data do not indicate that contamination has migrated into the upper basalt-confined aquifer.

8.4 Wells

Over the lifetime of the Hanford Site, DOE has installed thousands of wells to monitor and remediate groundwater and provide geologic data. During 2015, DOE installed 76 new wells, mostly to support groundwater remediation.

DOE identifies wells, boreholes, or other subsurface installations for decommissioning when they are no longer needed. This involves sealing the wells in compliance with Washington State standards for construction and maintenance of wells. In 2015, 38 borings and wells were decommissioned.

8.5 Additional Information

The data presented in this chapter and additional groundwater monitoring details are available in the *Hanford Site Groundwater Monitoring Report for 2015* (DOE/RL-2016-09) which, along with previous groundwater annual and related reports, is or will soon be available at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Additional information including environmental data, monitoring well locations, construction details, and screened intervals, can be found through the DOE Environmental Dashboard Application at https://ehs.hanford.gov/eda/ or on the PNNL-Hanford Online ENvironmental Information eXchange (PHOENIX) website at http://phoenix.pnnl.gov.

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