

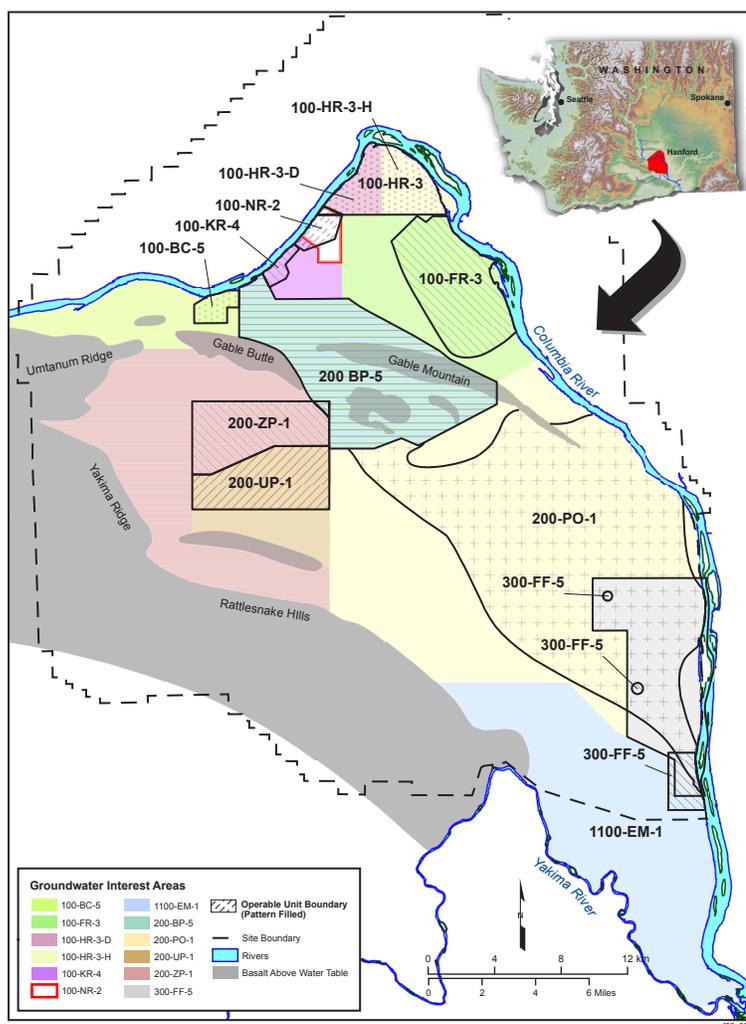
Summary

Introduction

The Hanford Site, part of the U.S. Department of Energy's (DOE) nuclear weapons complex, encompasses ~1,500 km² in southeastern Washington State. The Columbia River flows through the Site. The federal government acquired the Site in 1943, and until the 1980s used it to produce plutonium for national defense. Management of waste associated with plutonium production has been a major activity throughout the Site's history and continues today at a much reduced scale. Beginning in the 1990s, the DOE has focused on cleaning up the site.

The DOE is committed to protecting the Columbia River, human health, and the environment from the Site's contaminated groundwater. As part of this commitment, the DOE's groundwater management plan lays out steps for addressing groundwater and vadose zone contamination.

The Hanford Site Groundwater Strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater.



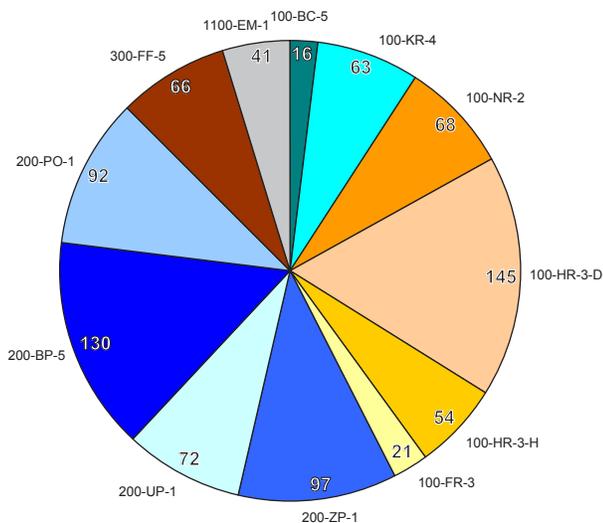
Hanford Site groundwater monitoring is organized by areas of interest, which are informally named after the groundwater operable units. The areas of interest are useful for planning and scheduling groundwater monitoring and interpreting data.

The DOE monitors groundwater at the Hanford Site to fulfill a variety of state and federal regulations, including the *Atomic Energy Act of 1954* (AEA), the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and *Washington Administrative Code*.

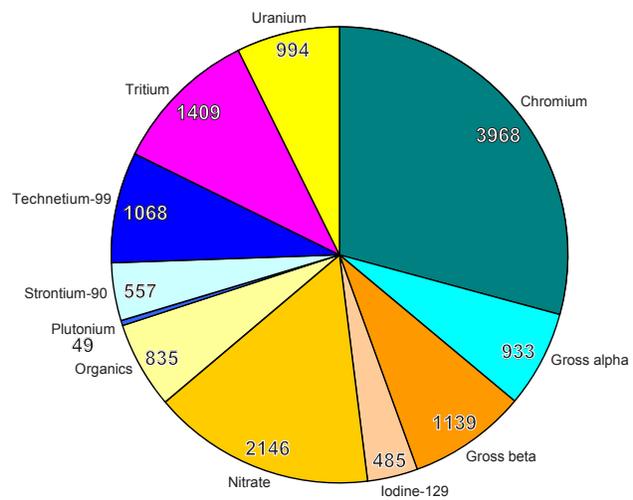
DOE Order 450.1, "Environmental Protection Program," implements requirements of the AEA. This Order requires environmental monitoring to detect, characterize, and respond to releases from the DOE activities, assess impacts, and characterize exposure pathways. The Order recommends implementing a site-wide approach for groundwater protection. The Order requires compliance with other applicable environmental protection requirements.

The Hanford Site has been divided into operable units, or groupings of similar waste units within a geographic area, so that the CERCLA process can be efficiently implemented. Most operable units are source operable units, but eleven are groundwater operable units. The concept of the groundwater operable unit was adopted to allow separate characterization of the waste sites and the groundwater. Separate characterization recognizes differences between localized contaminants in the soil column at the sources and the more widespread, mingled contamination in groundwater. Monitoring wells are located and sampled to define the nature and extent of the contaminant plumes. Groundwater also is monitored to assess the effectiveness of groundwater remediation.

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



This chart shows the number of wells sampled in each groundwater interest area in FY 2008.



The groundwater project requests specific laboratory analyses based on the wells' locations, historical contaminant trends, and regulatory requirements. This graph shows the number of analyses for the most common constituents during FY 2008.

RCRA groundwater monitoring is conducted under one of three possible phases.

Indicator Parameter (or final status detection). Initially, a detection program uses groundwater data to determine and monitor the impact, if any, of the facility on groundwater. Monitoring results for Low-Level Waste Management Area 4 and the Nonradioactive Dangerous Waste Landfill exceeded a critical mean value. These two sites will be monitored under assessment programs in FY 2009.

Assessment (or final status compliance). If the detection monitoring results indicate a statistically significant change in chemistry, then an assessment or compliance phase of monitoring begins.

Corrective Action (via administrative order for interim status sites or during final status). If the source of the contamination is determined to be the RCRA unit and the concentration exceeds applicable limits, then Washington State Department of Ecology (Ecology) may require corrective action. Groundwater is monitored to determine if the corrective action is effective.

In fiscal year (FY) 2008, workers sampled 865 monitoring wells and 297 shoreline aquifer tubes to determine the distribution and movement of contaminants. Many of the wells and some of the aquifer tubes were sampled multiple times during the year.

A total of 3,968 samples of Hanford Site groundwater were analyzed for chromium, 2,146 for nitrate, and 1,409 for tritium. Other constituents frequently analyzed include gross beta (1,139), technetium-99 (1,068), uranium (994), gross alpha (933), and carbon tetrachloride (835). These totals include results for routinely sampled groundwater wells, pump-and-treat operational samples, and aquifer tube samples.

The DOE sampled 865 wells during FY 2008. Chromium, nitrate, and tritium are constituents most frequently analyzed.

Items of Interest

This section briefly describes some of the high-priority groundwater topics for FY 2008.

River Corridor Baseline Risk Assessment. To support the decision-making process for final CERCLA remedial actions within the Columbia River Corridor, the DOE is conducting a CERCLA remedial investigation including a baseline risk assessment for the River Corridor portion of the Hanford Site. The risk assessment consists of three components: the 100 Area and 300 Area Component, the Inter-Area Component, and the Columbia River Component. The 100 Area and 300 Area Component and the Inter-Area Component will be integrated with groundwater into a series of final CERCLA remedial investigation reports for the operational areas of the River Corridor.

The DOE is focusing remediation efforts on activities that protect the Columbia River.

Systematic Planning for the 100 Area. A systematic planning process uses a common sense, graded approach to ensure that the level of detail in planning is commensurate with the importance of the work being planned. The DOE, U.S. Environmental Protection Agency (EPA), Ecology, Tribal Nations, and stakeholders initiated the systematic planning process for the 100 Area in FY 2008. Using this process, the DOE is preparing a work plan for a remedial investigation and feasibility study to support selection of a final remedy under CERCLA for source and groundwater operable units in the 100 Area. The work plan will document how decisions are made and specify collection details for required data. It also

will describe the procedures for evaluating cleanup alternatives and identifying the preferred remedy.

100-KR-4 Pump-and-Treat Expansion. The DOE installed new extraction and injection wells and constructed a new treatment system with a designed treatment capacity of 2,271 L/min. When it begins to operate in FY 2009, the expansion will allow the pump-and-treat for hexavalent chromium to capture more of the plume around the 116-K-2 Trench.

100-N Apatite Barrier. Workers conducted a second round of injections of apatite-forming chemicals into a line of groundwater wells along the 100-N Area shoreline in FY 2008. Strontium-90 concentrations initially increased in many wells, but then declined as the remediation began to take effect. Tests are also being conducted to emplace apatite into the vadose zone by surface infiltration.

100-HR-3 Characterization and Testing. The DOE continued characterization and research in the 100-D and 100-H Areas in FY 2008. The objectives were to characterize the chromium plume between 100-D and 100-H Areas; locate the source of the chromium plume in southern 100-D Area; characterize deep chromium contamination; test biostimulation, an in situ remediation method for chromium in the aquifer; test nanometer-size iron injection, a method to increase effectiveness of the redox barrier in 100-D Area; and test electrocoagulation, a water-treatment process.

200-ZP-1 Record of Decision. In September 2008, the DOE, EPA, and Ecology (Tri-Parties) signed a final record of decision for groundwater remediation in the 200-ZP-1 Operable Unit. The selected remedy combines pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls.

300-FF-5 Studies. Scientists continued an aggressive campaign to investigate the uranium plume in the 300 Area in FY 2008. Recent work included updating computer simulations of groundwater flow and uranium transport; conducting a limited field investigation of uranium involving multiple characterization boreholes; updating to the human health and ecological risk assessment; and conducting an assessment of potential remedial action technologies for the 300 Area uranium plume.

New Aquifer Tubes. The DOE installed 139 new aquifer tubes in 61 locations along the Columbia River shoreline from the 100-B/C Area to the 300 Area. The tube locations were chosen to fill gaps in the existing aquifer tube network. The section of the shoreline where the 200 Area tritium plume approaches the river now has 11 new monitoring locations. Early data from the new tubes confirm the known distribution of contaminants in groundwater near the river.

Tri-Party Well Installation Agreement. The Tri-Parties approved an agreement in August 2008 that provides a three-year rolling, prioritized well drilling schedule through calendar year 2011. The Tri-Parties will hold discussions and update this milestone each year.

Groundwater Flow

General directions of groundwater flow are illustrated on the water-table map for March 2008. The direction of groundwater flow is inferred from water-table elevations, barriers to flow (e.g., basalt or mud units at the water table), and the distribution of contaminants. Groundwater enters the unconfined aquifer from recharge areas to the west and eventually discharges to the Columbia River. Additional

In FY 2008, the DOE, EPA, and Ecology signed a final record of decision for the 200-ZP-1 Operable Unit.

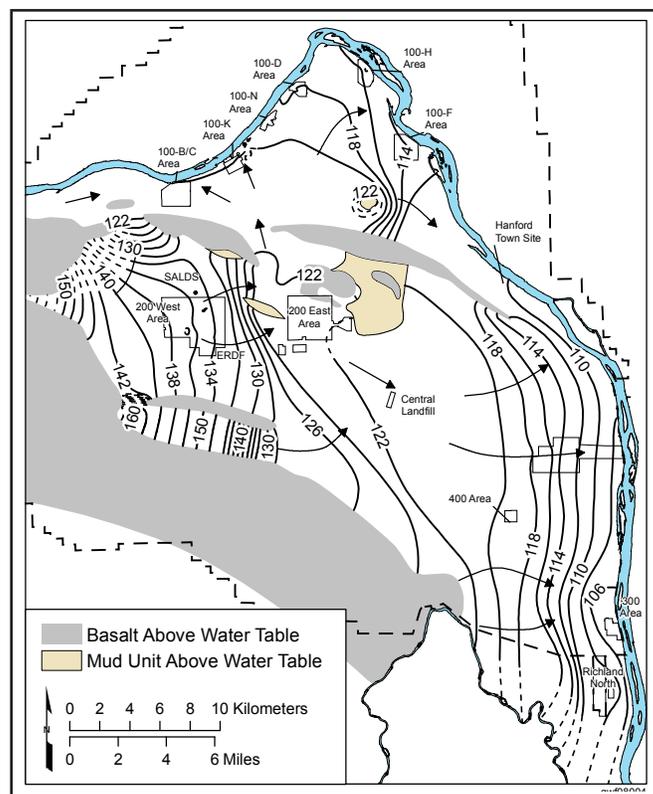
water infiltrates through the vadose zone beneath the Hanford Site. Hydrologists estimate that the total discharge of groundwater from the Site aquifer to the Columbia River is in the range 1.1 to 2.5 m³/sec. This rate of discharge is less than 0.075% of the average flow of the river (~3,400 m³/sec).

The water table beneath the 200 East Area is relatively flat because of the presence of highly permeable sediment of the Hanford formation at the water table. Groundwater enters the vicinity of the 200 East Area from the west and southwest. The flow of water divides, with some flowing to the north through a gap between Gable Butte and Gable Mountain (Gable Gap) and some flowing southeast toward the central part of the Site. This groundwater divide may be located near the central part of the 200 East Area, but its precise location is unknown. Ongoing studies will help determine the direction of groundwater flow in this region. In the southern part of the Hanford Site, groundwater enters the 300 Area from the northwest, west, and southwest.

The natural pattern of groundwater flow was altered during the Hanford Site's operating years by water-table mounds. The mounds were created by the discharge of large volumes of wastewater to the ground and were present in each reactor area and beneath the 200 Area. Since effluent disposal decreased significantly in the 1990s, these mounds have dissipated in the reactor areas and have declined considerably in the 200 Area. Currently, wastewater is discharged to the ground at the State-Approved Land Disposal Site, north of the 200 West Area (67.8 million liters in 2008), and at the Treated Effluent Disposal Facility, east of the 200 East Area (2.76 million liters).

Groundwater flow in the unconfined aquifer is currently altered where extraction or injection wells are used for pump-and-treat systems. Extraction wells in the 100-K, 100-D, 100-H, and 200 West Areas capture contaminated water from the surrounding areas. Water flows away from injection wells, which are upgradient of the contaminant plumes, so the injection increases the hydraulic gradient toward the extraction wells.

A confined aquifer occurs within sand and gravel of the lowest sedimentary unit of the Ringold Formation. It is confined between basalt and the lower mud unit. The unconfined aquifer does not extend east of the 200 East Area due to the presence of Ringold Formation mud units at the water table (shaded tan on the water-table map), so the Ringold Formation confined aquifer is the uppermost aquifer in this area. Beneath the Ringold Formation confined aquifer is the upper basalt-confined aquifer, which exists mainly in the Rattlesnake Ridge interbed, the uppermost widespread sedimentary interbed between basalt flows. Groundwater within these confined aquifers is influenced by a residual recharge mound in the vicinity of the B Pond. Several wells north and east of the 200 East Area have shown evidence of intercommunication between the upper basalt-confined aquifer and the overlying aquifers. The intercommunication has been attributed to erosion of the upper Saddle



This map shows the water table and inferred flow directions in March 2008.

Mountains Basalt and a downward hydraulic gradient. Since an upward gradient exists elsewhere in the 200 East Area/Gable Gap region, the upper basalt-confined aquifer likely discharges to the overlying aquifers, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

The sampling and analysis of groundwater provides data to help characterize the nature, potential fate, and transport of contaminants in the environment.

Groundwater Monitoring and Remediation

Some Hanford Site contaminants have moved downward from waste sites, through the vadose zone, into the groundwater, and then toward the Columbia River. Sampling groundwater helps determine how the contaminants move through the environment. The DOE works with regulatory agencies (e.g., the EPA and Ecology) to make cleanup decisions based on sound technical information.

The DOE has developed a plan with steps for cleaning up groundwater and the vadose zone. Key elements include the following.

- Continue to implement remedies that are working.
- Gather characterization data to help make informed decisions.
- Address emerging problems.
- Work with regulatory agencies to make remediation decisions.
- Identify new cleanup technologies.
- Continue to monitor groundwater to detect emerging problems and determine how well remedies are working.

Final groundwater cleanup remedies have been selected for two portions of the Hanford Site: the 200-ZP-1 and 1100-EM-1 Operable Units. Interim remedial actions are underway in other portions of the site: the 100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, and 300-FF-5 Operable Units. Records of decision for groundwater cleanup have not yet been established for the remaining portions of the site (the 100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1 Operable Units) because groundwater

Major Groundwater Contaminants on the Hanford Site.					
Contaminant	Primary Locations	Plume Area (km²)	Drinking Water Standard	Remediation in Place?	Mobility and Half-Life
Carbon Tetrachloride	200-ZP-1	11.2	5 µg/L	Yes	Mobile (denser than water)
Chromium	100-KR-4, 100-HR-3	2.1	100 µg/L	Yes	Mobile (hexavalent)
Cyanide	200-BP-5	0.3	200 µg/L	No	Mobile
Iodine-129	200-BP-5, 200-PO-1, 200-UP-1	65.5	1 pCi/L	No	Mobile; 15.7 million years
Nitrate (as NO ₃)	100-FR-3, 200 Area	36.3	45 mg/L	No	Mobile
Strontium-90	100-NR-2, 200-BP-5	2.2	8 pCi/L	Yes, 100-NR-2	Moderate; 28.8 years
Technetium-99	200-BP-5, 200-UP-1	2.4	900 pCi/L	Yes, 200-UP-1	Mobile; 211,000 years
Trichloroethene	100-FR-3, 200-ZP-1	0.7	5 µg/L	Yes, 200-ZP-1	Mobile
Tritium	200 Area, 300-FF-5	127	20,000 pCi/L	No	Mobile; 12.3 years
Uranium	200-UP-1, 200-BP-5, 300-FF-5	1.5	30 µg/L	Yes, 200-UP-1	Moderate; 246,000 years (U-234), 4.5 billion years (U-238)
Combined plumes		183			

Groundwater Remediation.		
Remedial Action Site	Dates Active	Progress from Start to September 2008
100-K Area - 100-KR-4 Pump-and-Treat System	1997-present	Decreases chromium to river; 330 kg removed. System being expanded.
100-K Area - KW Pump-and-Treat System	2007-present	Decreases chromium to river; 31 kg removed. System being expanded.
100-N Area - 100-NR-2 Pump-and-Treat System	1995-2006	1.8 Ci of strontium-90 removed
100-N Area - Apatite Barrier	2006-present	Test injections of low- and high-concentration solutions; apatite barrier beginning to form
100-D Area - 100-HR-3 Pump-and-Treat System	1997-present	Decreases chromium to river; 287 kg removed
100-D Area - 100-DR-5 Pump-and-Treat System	2004-present	Decreases chromium to river; 211 kg removed
100-D Area - In Situ Redox	1999-present	Decreases chromium concentrations downgradient of barrier. Showing breakthrough; amendments being tested.
100-H Area - 100-HR-3 Pump-and-Treat System	1997-present	Decreases chromium to river; 51 kg removed.
200 West Area - 200-ZP-1 Pump-and-Treat System	1994-present	Prevents high-concentration portion of carbon tetrachloride plume from spreading; 11,415 kg removed. System being expanded to implement final ROD.
200 West Area - Soil-Vapor Extraction	1992-present	Reduces carbon tetrachloride movement to groundwater; 79,400 kg removed from vadose zone.
200 West Area - WMA T Pump-and-Treat System	2007-present	Removes technetium-99 from the aquifer. 23.8 g (0.4 Ci) removed.
200 West Area - 200-UP-1 Pump-and-Treat System	1994-2005 2007-present	Decreases lateral migration of contaminants; 141.6 g technetium-99 (2.4 Ci) and 218.2 kg of uranium removed.
200 West Area - WMA S-SX Pump-and-Treat System	2003-present	Decreases technetium-99 concentrations; 0.38 g (0.0064 Ci) removed.
300 Area - 300-FF-5 Natural Attenuation	ongoing	Trichloroethene concentrations in upper aquifer below target level; uranium concentrations above target level
1100-EM-1 Natural Attenuation	complete	Trichloroethene concentrations below 5 µg/L since 2001

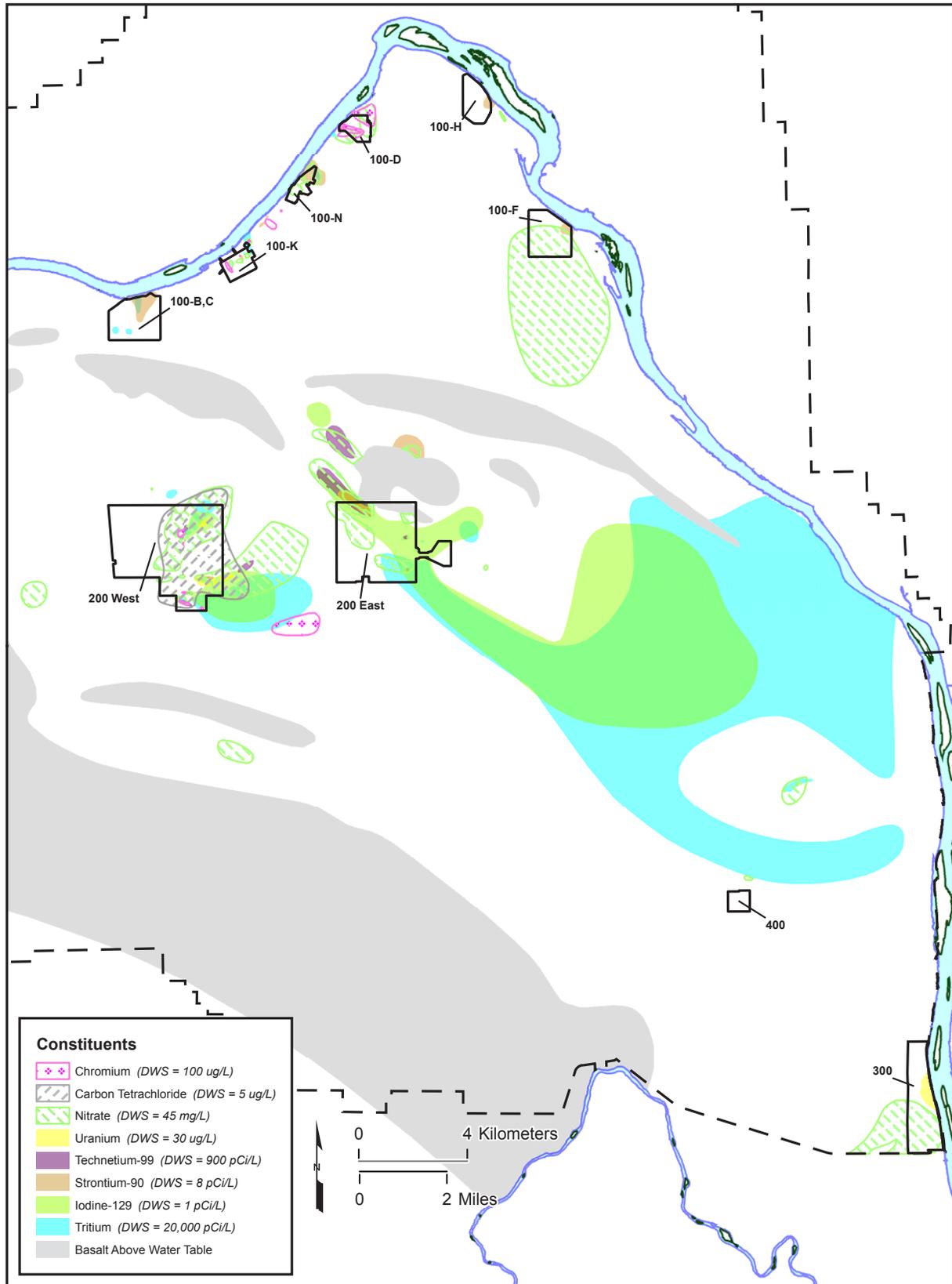
conditions do not warrant interim remedial measures. However, final remedies are being developed for all of the operable units.

Sitewide Plumes

The map on page xviii shows the extent of eight groundwater contaminant plumes in the upper part of the unconfined aquifer. The footprint of the combine plumes occupies approximately 183 km², or about 12% of the total area of the Hanford Site. The area of the major plumes is declining gradually.

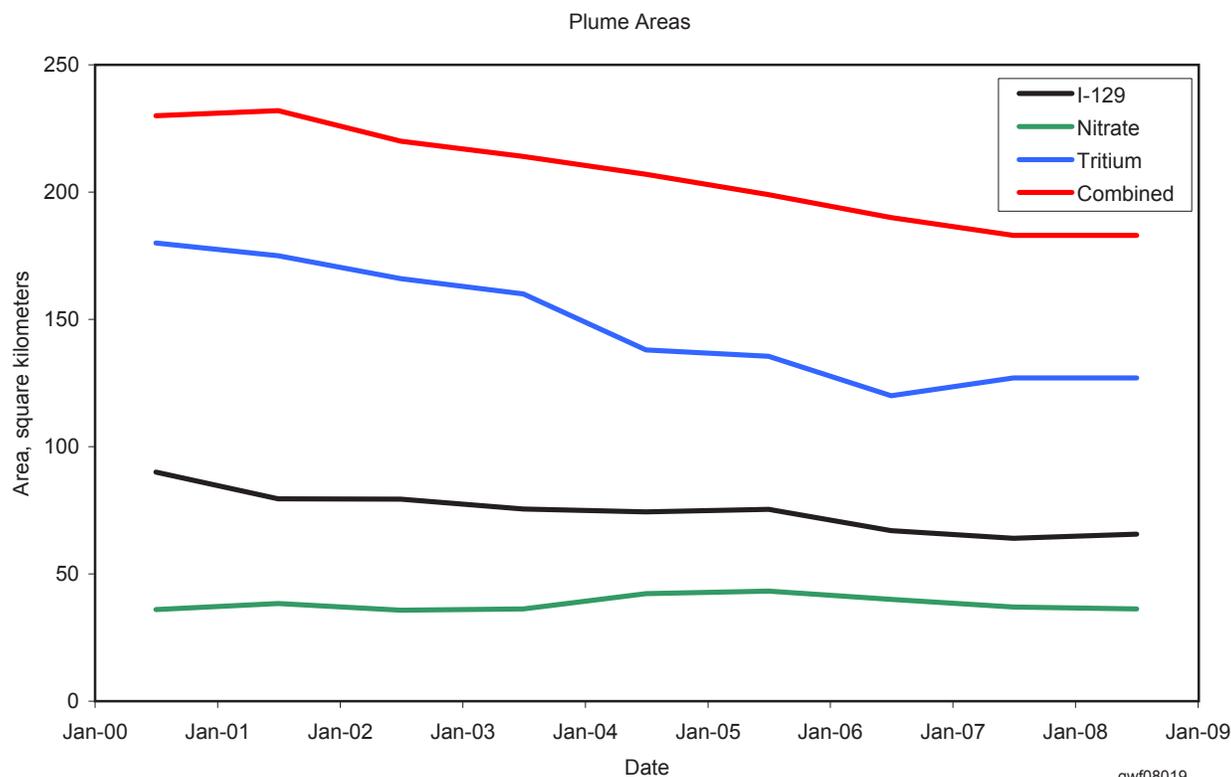
Of the radionuclide plumes, tritium and iodine-129 have the largest areas with concentrations above drinking water standards. The dominant plumes had sources in the 200 East Area and extend toward the east and southeast. Less extensive tritium and iodine-129 plumes also are present in 200 West Area. Technetium-99 exceeds its standard in the 200 East and 200 West Areas. One technetium-99 plume extends northward, beyond the 200 East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; plumes containing uranium are found in the 200 East, 200 West, and 300 Areas. Strontium-90 exceeds standards in the 100 Areas, 200 East Area, and beneath the former Gable Mountain Pond. Cesium-137, cobalt-60, and plutonium exceed drinking water standards in only a few wells in the 200 East Area.

Nitrate is a widespread chemical contaminant in Hanford Site groundwater; plumes originate from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride is the most widespread organic contaminant on the Hanford Site, forming a large plume beneath the 200 West Area. Other organic contaminants include chloroform (found in 200 West Area) and trichloroethene. The 100-F Area has a plume of trichloroethene and the 100-K Area has one well that exceeded the trichloroethene standard. Wells completed in a fine-grained layer beneath the 300 Area also detected trichloroethene at levels above the drinking water standard. Chromium at levels



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This map shows the distribution of the major contaminant plumes at concentrations above the drinking water standard during FY 2008 in the upper part of the unconfined aquifer.



The areal extent of the major contaminant plumes is declining.

above the 100 µg/L drinking water standard underlies portions of the 100-K and 100-D Areas. Chromium exceeds Washington State's aquatic standard (10 µg/L) in these areas and portions of the 100-B/C, 100-H, 100-F, and 600 Areas. Local plumes of chromium contamination also are present in the 200 Areas.

The following text discusses groundwater contamination, monitoring, and remediation for each of the groundwater operable units or groundwater interest areas and in the confined aquifers.

100-BC-5 Operable Unit

Most of the groundwater contamination is found in the northern portion of the 100-B/C Area, beneath former waste trenches and retention basins. Tritium and strontium-90 concentrations exceeded drinking water standards in several wells. Nitrate and chromium concentrations continued to be below drinking water standards in recent years, but chromium levels exceed the 10 µg/L aquatic standard.

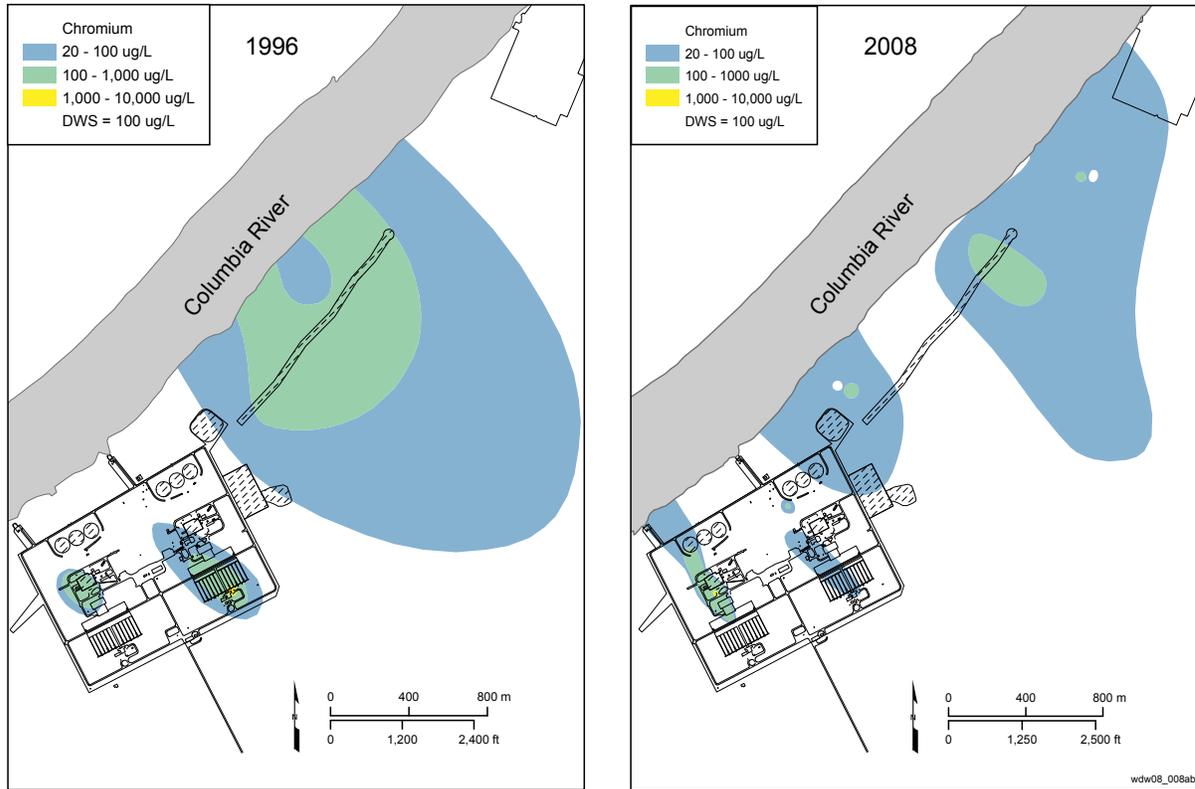
A record of decision has not yet been developed for the 100-BC-5 Operable Unit, and no active remediation of groundwater is underway. Groundwater monitoring has continued since the initial remedial investigation and while waste site remedial actions are being conducted.

100-KR-4 Operable Unit

The principal groundwater issues in this operable unit include cleaning up chromium in groundwater; tracking plumes from past-practices sites; and monitoring groundwater near the KE and KW Basins. Interim remedial action involves two pump-and-treat systems that remove chromium from groundwater.

Interim Remedial Action. A pump-and-treat system is removing hexavalent chromium from the aquifer beneath the 116-K-2 Trench. Approximately 330 kg of chromium have been removed since startup in 1997. New wells installed in FY 2008

New wells were installed to expand the 100-K Area Pump-and-Treat System near the 116-K-2 Trench. The new wells will start operating in FY 2009.



These maps show chromium in the upper part of the unconfined aquifer in the 100-K Area. Two pump-and-treat systems reduce the amount of chromium entering the Columbia River.

showed that one portion of the plume with concentrations above 100 $\mu\text{g/L}$ is larger than was previously known. Chromium concentrations in most of the compliance wells near the river have decreased. The concentration goal for the interim remedial action is 22 $\mu\text{g/L}$ at compliance wells.¹ New extraction and injection wells were installed in FY 2008 and will begin to operate in FY 2009. The expanded system will increase the amount of contaminated groundwater being treated, and will prevent the plume from moving downgradient into the 100-N Area.

In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. Concentrations in this plume are the highest in the 100-K Area. The DOE has operated a pump-and-treat system to clean up the plume since 2007. The system has removed 31 kg of chromium from the aquifer, and concentrations in the extraction wells have declined. Plans are underway to expand the KW system in FY 2009.

Monitoring Past-Practice Waste Sites. Other contaminants of potential concern in the operable unit are carbon-14, nitrate, strontium-90, trichloroethene, and tritium. Levels remained above drinking water standards, and these contaminants will be addressed under an upcoming remedial investigation/feasibility study work plan and final record of decision.

Tritium concentrations in two new wells near the south end of the 116-K-2 Trench are much higher than in surrounding wells. The source for tritium at this location is uncertain; it may represent past disposal to the 116-KE-1 Crib or 116-K-2 Trench, or tritium from a source farther inland, such as the 118-K-1 Burial Ground.

¹ Certain monitoring wells are designated compliance wells in the interim action records of decision. Chromium concentrations in samples from these wells are compared to the remediation goal to determine if the remedial action is effective.

KE and KW Basins. These concrete basins are integral parts of each reactor building. From the late 1970s to 2004, they were used to store irradiated fuel from the last run of the 100-N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. In FY 2008, monitoring of water levels in the basins and groundwater in downgradient wells indicated no new leaks. Shielding water has been removed from the KE Basin and demolition of the basin has begun, so the groundwater monitoring strategy will be reviewed.

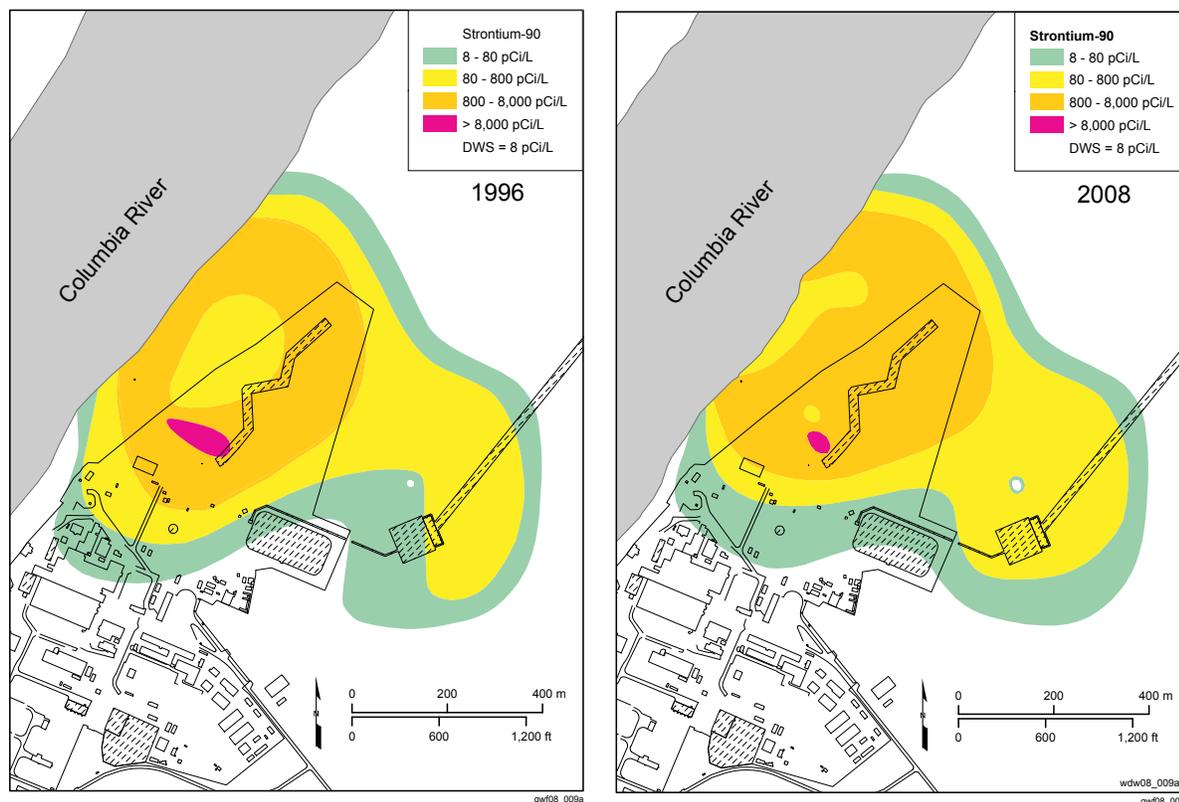
100-NR-2 Operable Unit

The primary groundwater contaminant plume in the 100-N Area is strontium-90, which originated at two liquid waste disposal facilities. Tritium, nitrate, sulfate, and petroleum hydrocarbons also are present in the groundwater.

Interim Remedial Action. The DOE is applying an in situ technology, apatite sequestration, in the 100-N Area. The goal is to create a permeable, reactive barrier that will capture strontium-90 as groundwater flows through it to the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shore in FY 2007 and 2008. As the injected chemicals reacted with the aquifer, strontium-90 levels initially increased in downgradient wells and aquifer tubes. However, in the weeks and months after the injections, the chemical reactions progressed and strontium-90 levels declined. Concentrations in the barrier wells were much lower at the end of FY 2008 than they were before the injections.

Other forms of remediation being investigated at the 100-N Area include apatite infiltration and phytoremediation (plants) to treat contamination above the average water table and in shallow groundwater.

Strontium-90 concentrations temporarily increased in response to injections to the 100-N Area apatite barrier. Levels subsequently dropped and are expected to continue declining.



The overall shape of the 100-N Area strontium-90 plume at the 8 pCi/L level has not changed in many years, despite the operation of the pump-and-treat system from 1995 until March 2006.

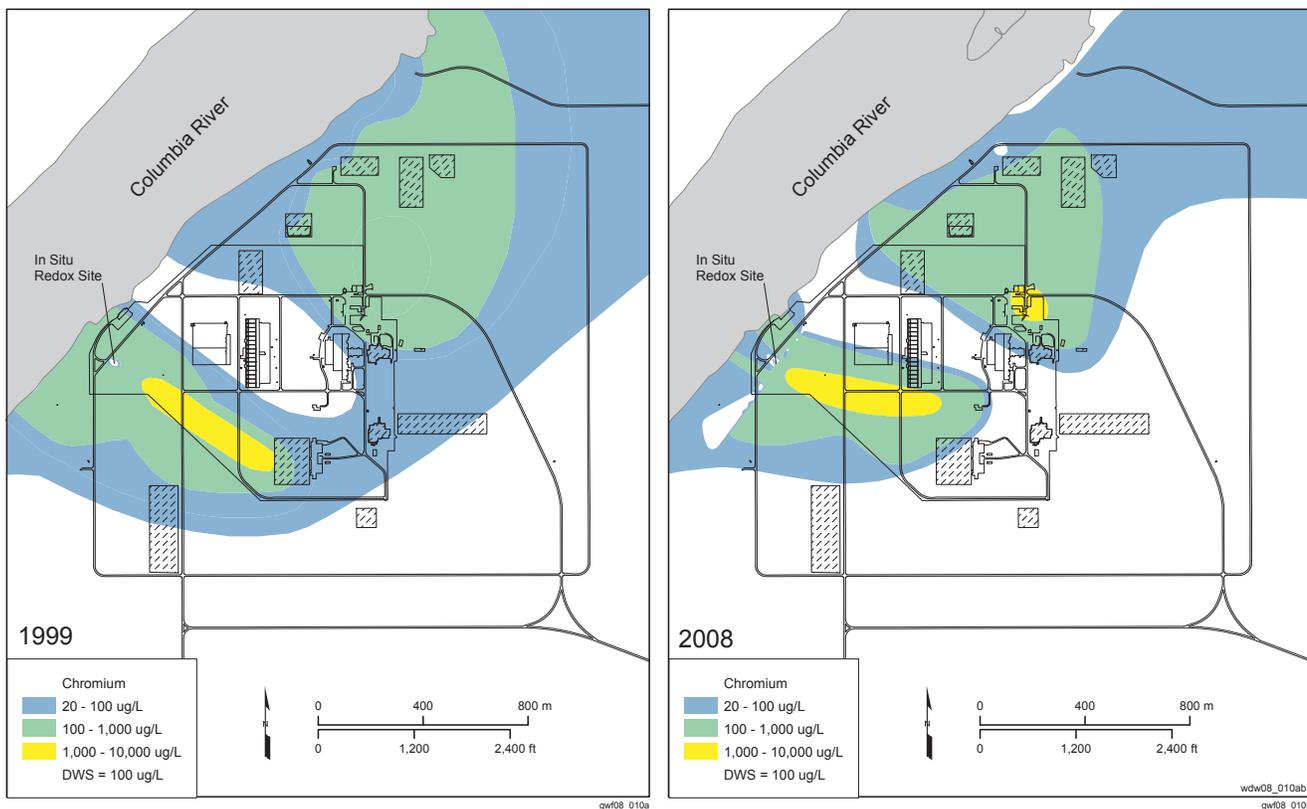
116-N-1, 116-N-3, 120-N-1, and 120-N-2 Facilities. Four RCRA units are located in the 100-N Area. During FY 2008, the sites remained in detection monitoring programs. AEA and CERCLA monitoring continued to track strontium-90 and tritium plumes from the 116-N-1 and 116-N-3 Facilities and sulfate from the 120-N-1 Percolation Pond.

Hexavalent chromium concentrations in 100-D Area groundwater are the highest on the Hanford Site.

100-HR-3-D Groundwater Interest Area

The 100-HR-3 Operable Unit underlies the 100-D Area, 100-H Area, and the region between them. The western portion of this operable unit is the 100-HR-3 groundwater interest area. Hexavalent chromium is the principal contaminant of concern in groundwater beneath the operable unit. A principal cause for this contamination was the routine disposal of reactor coolant, which contained sodium dichromate as a corrosion inhibitor. Periodic spills and leaks of sodium dichromate stock solution to the ground were another source of contamination. Chromium is distributed in northern and southern plumes. Other contaminants include tritium, nitrate, strontium-90, and sulfate.

Interim Remedial Actions. The northern chromium plume is the target of a pump-and-treat system, which is designed to reduce the amount of chromium entering the Columbia River. A second pump-and-treat system intercepts groundwater in the central 100-D Area near the shoreline. In FY 2008, chromium concentrations remained above the remediation goal (22 µg/L for the pump-and-treat systems) in compliance wells. The two extraction systems have removed 497 kg of chromium from the aquifer since 1997. The southern chromium plume is being remediated with a permeable barrier that immobilizes chromium in the aquifer. Data from recent years



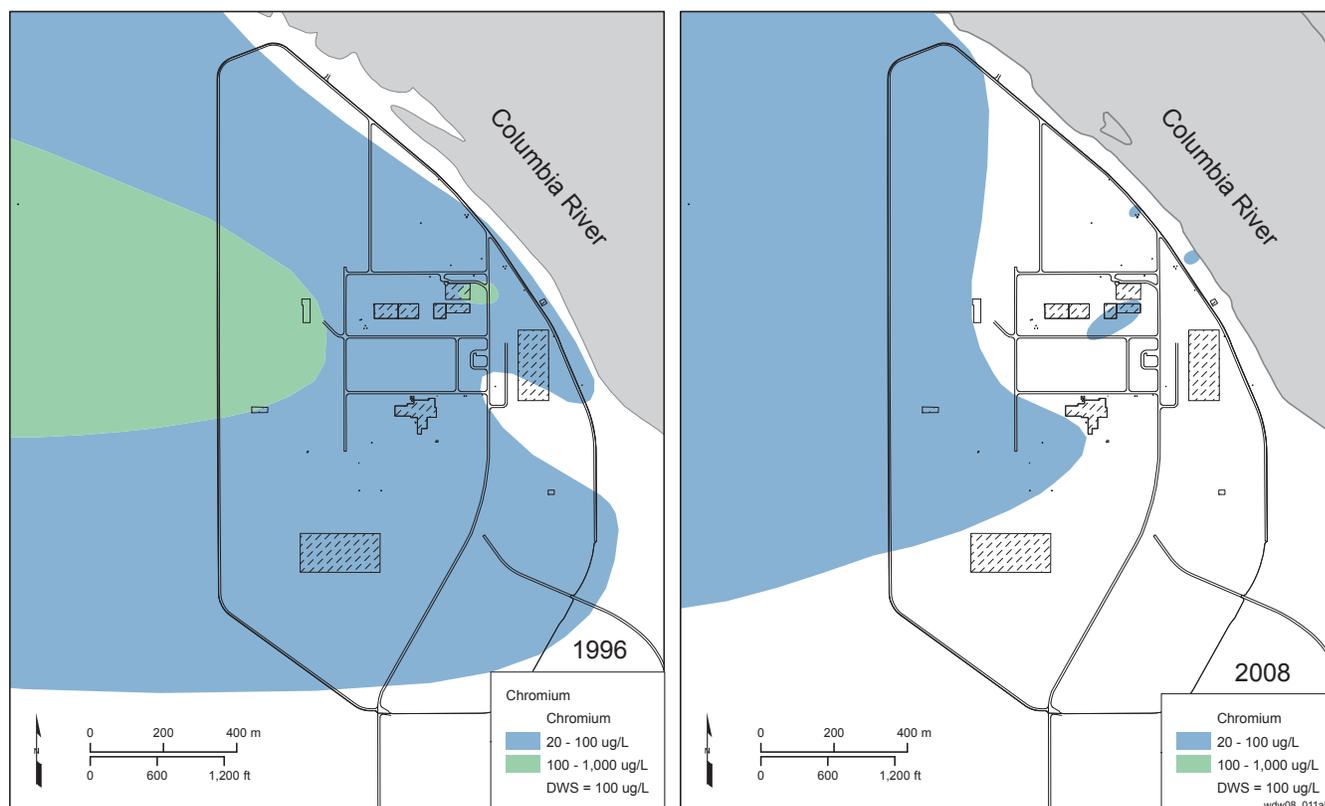
These maps show chromium plumes in the upper part of the aquifer in the 100-D Area. To reduce the amount of chromium entering the Columbia River, the DOE operates two pump-and-treat systems in the north and an in situ treatment system in the south.

indicate that, in some locations, chromium has migrated through the barrier. At the end of FY 2008, concentrations in barrier wells ranged from below detection limits to 780 $\mu\text{g/L}$. Most of the elevated concentrations are in the northeastern half of the barrier. The remediation goal (20 $\mu\text{g/L}$ for the permeable barrier) was met at only two of the seven compliance wells. However, concentrations have declined overall in most of the compliance wells.

Five-Year Review Actions. The DOE continued several investigations in the 100-HR-3 Operable Unit that address items identified in a November 2006 CERCLA review.

- *Chromium Plume in the Horn.* The DOE installed wells and aquifer tubes to define the plume between 100-D and 100-H Areas, the region known as the “horn” of the Hanford Site. Data show that concentrations exceeding 20 $\mu\text{g/L}$ extend across the horn.
- *Zero-Valent Iron Injection.* Scientists think that injecting tiny particles of iron into redox barrier wells will help “repair” the chromium breach in the barrier. Test injections occurred in August 2008. Initial results showed that the groundwater affected by the iron eliminates hexavalent chromium from the aquifer.
- *Electrocoagulation tests.* The DOE tested electrocoagulation for treating chromium-contaminated groundwater. Results indicated that the technology has the potential to meet the performance goal for groundwater treatment, but system operation was problematic.

Data from new wells help pinpoint the source of chromium in the 100-D Area vadose zone and characterize the chromium plume east of the 100-D Area.



A pump-and-treat system in the 100-H Area has reduced the amount of chromium entering the Columbia River. Concentrations have decreased beneath the 100-H Area, but remain elevated in a plume to the west (upgradient).

- *Chromium Source Investigation.* The DOE installed wells to obtain samples from the vadose zone and to monitor groundwater near suspected sources in the southern 100-D Area. Chromium levels in some of the wells were the highest ever observed in Hanford Site groundwater.

Other research. The DOE conducted additional studies in FY 2008, including characterizing chromium geochemistry in the vadose zone and in situ biostimulation as a method of treating chromium contamination in groundwater.

100-HR-3-H Groundwater Interest Area

The eastern part of the 100-HR-3 Operable Unit (100-HR-3-H groundwater interest area) underlies the 100-H Area. Hexavalent chromium is the principal contaminant of concern in this area, but the plume is smaller and concentrations are lower than in the 100-D Area. Nitrate levels also are above background, but have declined from their peak historical levels. Strontium-90 exceeds the drinking water standard (8 pCi/L) beneath former retention basins. Technetium-99 and uranium concentrations are detected in a small area, but have been below drinking water standards in recent years.

Interim Remedial Action. The chromium plume in the 100-H Area is the target of a pump-and-treat system. The remediation of the plume has removed ~51 kg of hexavalent chromium from the aquifer since 1997. Hexavalent chromium concentrations in compliance wells were mostly below the 22 µg/L remedial action goal in FY 2008.

116-H-6 (183-H) Solar Evaporation Basins. These former basins are the only RCRA site in the 100-H Area. Leaks from the basins contaminated groundwater with chromium, nitrate, technetium-99, and uranium. Concentrations of all four contaminants were below drinking water standards in FY 2008. The site is monitored during the postclosure period to track contaminant trends during the operation of the CERCLA interim action for chromium.

100-FR-3 Operable Unit

Nitrate concentrations in groundwater exceed the drinking water standard beneath much of the 100-F Area and the downgradient region. A few wells in the eastern 100-F Area have strontium-90 concentrations above the drinking water standard. Two wells in the southwestern 100-F Area exceed the standard for trichloroethene, but concentrations are declining steadily. Hexavalent chromium concentrations exceed the 10 µg/L aquatic standard in some wells.

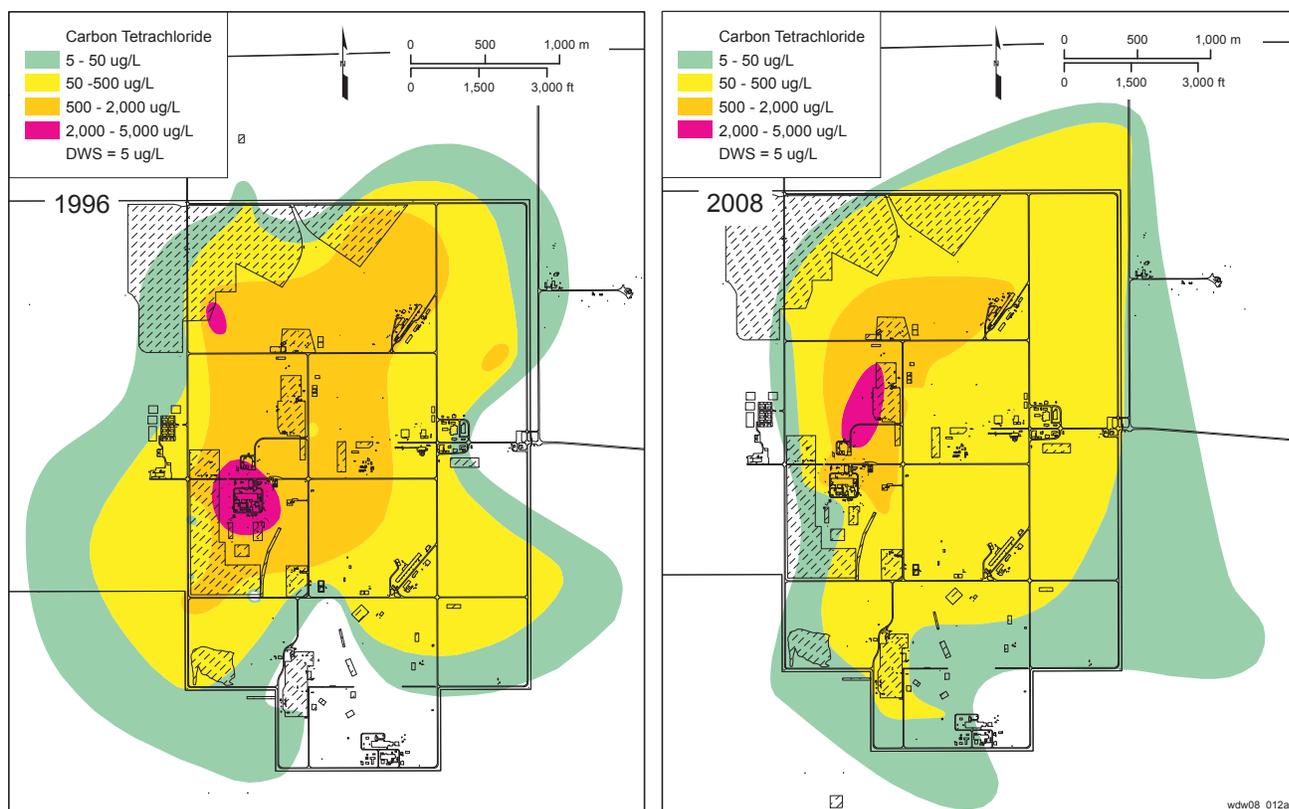
During remediation of a burial ground in southwestern 100-F Area, the excavation reached the water table in one location and a small puddle of water formed. Samplers collected some of the water and strontium-90 was detected. The DOE installed a new monitoring well downgradient of the burial ground in FY 2008 and will begin sampling it in FY 2009.

A record of decision has not yet been developed for the 100-FR-3 Operable Unit and no active remediation of groundwater is underway. Monitoring contaminant conditions has continued since the initial remedial investigation and while waste site remedial actions are conducted.

200-ZP-1 Operable Unit

This operable unit encompasses the northern and central portions of the 200 West Area. The principal contaminant of concern is carbon tetrachloride. Other

Chromium concentrations in 100-H Area have declined because of remediation and natural processes.



These maps show the carbon tetrachloride plume beneath the 200 West Area in the upper part of the unconfined aquifer. Since 1996, a pump-and-treat system in the 200-ZP-1 Operable Unit is helping prevent further spreading of the core of the plume.

contaminants include tritium, nitrate, chloroform, chromium, fluoride, iodine-129, technetium-99, trichloroethene, and uranium.

In September 2008, the Tri-Parties signed a final record of decision for groundwater remediation in the 200-ZP-1 Operable Unit. The goal of the final remedy is to design and implement a remediation system to remove carbon tetrachloride and other contaminants throughout the vertical extent of the aquifer. Further expansion is planned as the final remedy is implemented.

The final record of decision combines pump-and-treat, monitored natural attenuation, flow-path control through injection of treated water, and institutional controls. The pump-and-treat system will be designed to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride and co-contaminants throughout the operable unit by a minimum of 95% in 25 years.

Carbon tetrachloride contamination occurs at increasing depth to the east (downgradient) of the known source areas. In this area, natural and artificial recharge may have led to reduced carbon tetrachloride concentrations in the upper portion of the aquifer. Carbon tetrachloride is denser than water, which also affects its vertical distribution.

The 200-ZP-1 groundwater interest area contains one CERCLA interim action for groundwater, one remediation system for the vadose zone, four facilities monitored under RCRA (in conjunction with CERCLA and AEA), and one state-permitted unit.

Final groundwater remediation in the 200-ZP-1 Operable Unit will include pump-and-treat and flow-path control.

Groundwater and vadose zone remediation systems have removed over 90,800 kg of carbon tetrachloride from the subsurface.

Interim Remedial Action. Since 1994, the DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride in the upper part of the aquifer from spreading. In FY 2008, four monitoring wells were converted to extraction wells, bringing the number of extraction wells to 14, with a combined pumping rate of approximately 1,514 L/min. In support of expansion activities, the pump-and-treat system was shut down in late May and, except for process and acceptance testing, remained offline the remainder of FY 2008. The system has removed 11,415 kg of carbon tetrachloride from groundwater since 1994.

Soil-Vapor Extraction. Soil-vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. The system has removed ~79,400 kg of carbon tetrachloride from the vadose zone since operations started in 1991.

Low-Level Burial Grounds Waste Management Area 3. RCRA groundwater monitoring continued under interim status requirements in FY 2008. The groundwater flow direction changed after liquid effluent discharges in 200 West Area ceased and water levels declined. The change left Low-Level Waste Management Area 3 without any upgradient wells. Until new upgradient wells are installed and background conditions are established, statistical evaluations have been suspended.

Low-Level Burial Grounds Waste Management Area 4. RCRA groundwater monitoring continued under interim status requirements in FY 2008. The remaining upgradient wells went dry in FY 2008. Total organic carbon concentrations in one downgradient well exceeded the critical mean value in August 2008 and in a subsequent confirmatory sample. Groundwater will be monitored under an assessment program in FY 2009. Concentrations of the indicator parameter total organic halides have been affected by the regional carbon tetrachloride plume.

Waste Management Area T. RCRA assessment monitoring continued in FY 2008. The waste management area has introduced technetium-99 and other tank waste constituents to the uppermost aquifer in the area. In September 2007, two downgradient wells on the east side of the tank farms were converted to extraction wells to remove technetium-99 from the aquifer. In FY 2008, technetium-99 concentrations decreased sharply in some downgradient wells and increased in others, most likely as a result of the extraction.

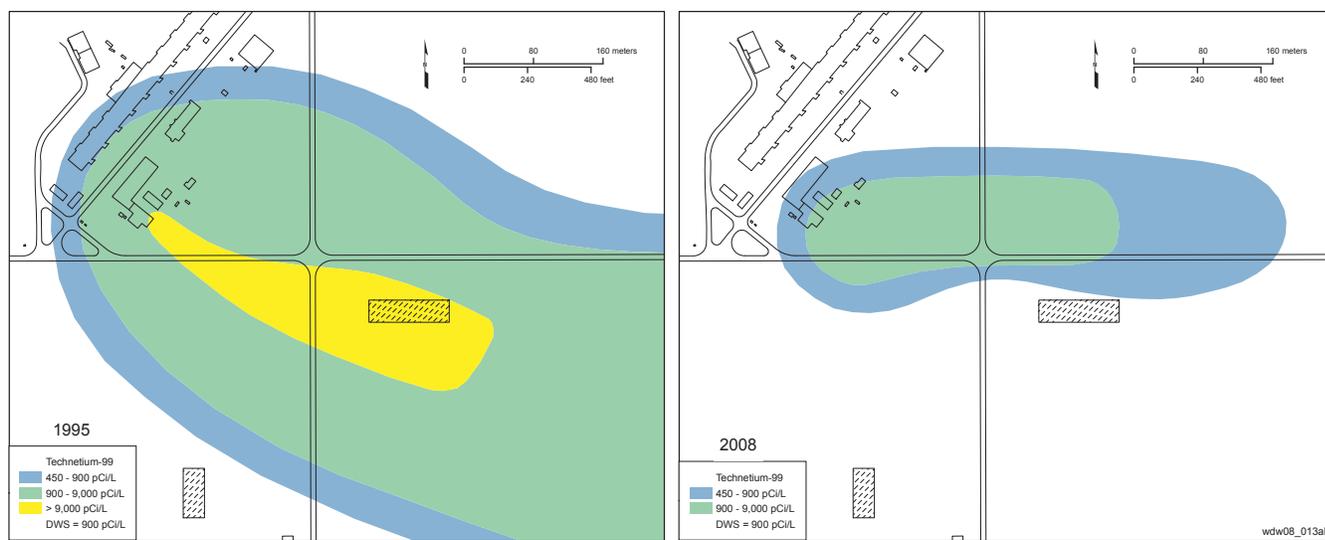
Waste Management Area TX-TY. RCRA assessment monitoring continued in FY 2008. Sources in the waste management area have contaminated groundwater with chromium, technetium-99, and other tank waste constituents. Groundwater flow beneath Waste Management Area TX-TY is changing because of the operation of the 200-ZP-1 Pump-and-Treat Remediation System. Extraction wells operate south and west (upgradient) of the waste management area.

State-Approved Land Disposal Site. This active disposal facility is regulated under a state waste discharge permit. Groundwater is monitored for tritium and 15 other constituents. Concentrations of all constituents considered in the permit did not exceed enforcement limits during FY 2008.

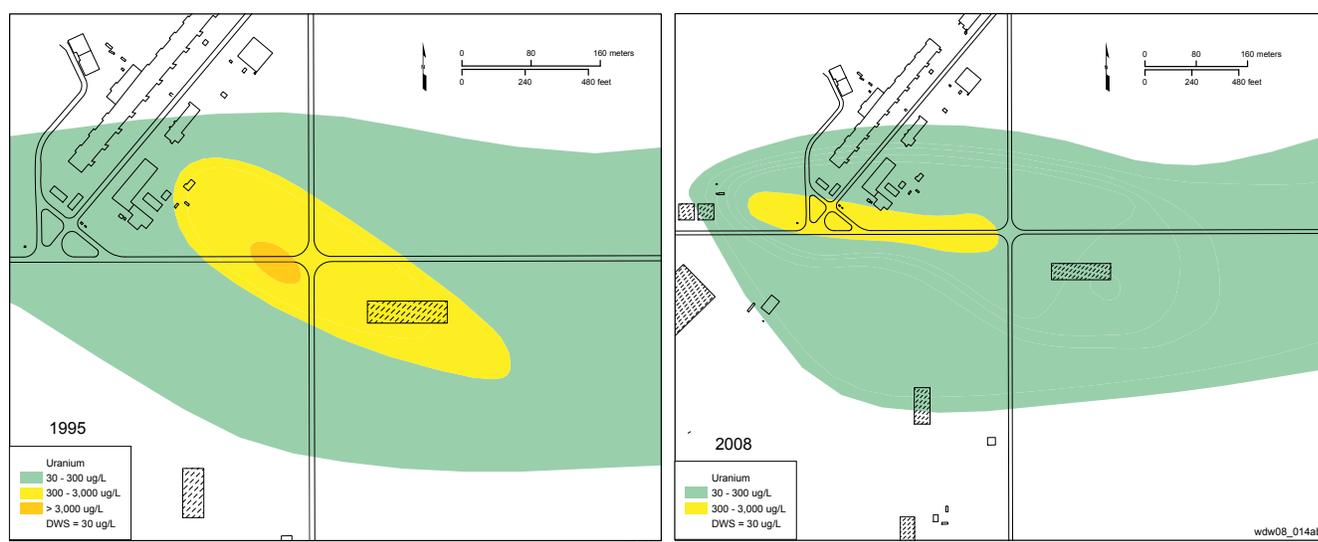
200-UP-1 Operable Unit

This operable unit underlies the south portion of 200 West Area. The principal contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit. Eight new monitoring wells were drilled in this operable unit in FY 2008.

A pump-and-treat system near U Plant has removed 2.4 Ci of technetium-99 and 218 kg of uranium from the groundwater.



A pump-and-treat system at the 200-UP-1 Operable Unit (200 West Area) has decreased the size of the technetium-99 plume in the upper part of the aquifer. The system began to operate in fall 1995.



Uranium contamination in the 200-UP-1 Operable Unit (200 West Area) does not respond to the pump-and-treat system as quickly as technetium-99. Unlike technetium-99, uranium interacts with sediment grains, slowing its movement and response to remediation.

The 200-UP-1 Operable Unit contains one CERCLA interim action, three facilities monitored under RCRA (in conjunction with CERCLA and AEA), and one CERCLA disposal site.

Interim Remedial Action. The DOE operated an interim remedial action pump-and-treat system for technetium-99 and uranium from 1994 until early 2005. The effort successfully reduced contaminant concentrations below remedial action goals. The DOE shut down the system in January 2005 and conducted a rebound study. The remedial action goal for uranium was ten times the Washington State Model Toxics Control Act cleanup standard at the time the record of decision was issued, which was 48 $\mu\text{g}/\text{L}$. Since that time, EPA established a drinking water standard of 30 $\mu\text{g}/\text{L}$. In expectation that the remedial action goal will be revised to 300 $\mu\text{g}/\text{L}$ (ten

times the current standard), the DOE resumed groundwater extraction in April 2007 and continue to operate it in FY 2008.

Waste Management Area S-SX. RCRA assessment monitoring continued in FY 2008. Groundwater beneath this waste management area is contaminated with tank waste constituents, which include nitrate, chromium, and technetium-99 attributed to two general source areas within the waste management area. The highest technetium-99 concentrations in the operable unit occur in the southern plume, which represents a growing contamination issue because the plume is increasing in size. Each time the well with the highest concentrations is sampled (quarterly), extra groundwater is removed and treated to remove some technetium-99 from the groundwater. Chromium, nitrate, and technetium-99 concentrations also continued to increase in the northern plume at this waste management area.

Waste Management Area U. RCRA assessment monitoring continued in FY 2008. The waste management area has been identified as the source of groundwater contamination that is limited to the downgradient (east) side of the site. Plume constituents of interest include nitrate and technetium-99.

216-S-10 Pond and Ditch. The 216-S-10 Facility continued to be monitored under a RCRA interim status detection program in FY 2008. One upgradient well and two downgradient wells were installed in FY 2008 as part of the 200-UP-1 Operable Unit work plan, and also will be sampled as 216-S-10 Facility monitoring wells beginning in FY 2009.

Environmental Restoration Disposal Facility. This facility is a low-level, mixed waste facility where waste generated from surface remedial actions and other activities on the Hanford Site is disposed. The site was built under CERCLA and is designed to meet all hazardous landfill standards. Results of groundwater monitoring continued to indicate that the facility has not adversely impacted groundwater quality. During FY 2008, two downgradient wells were decommissioned to allow for facility expansion to the east. Two new downgradient wells were constructed as replacements.

200-BP-5 Operable Unit

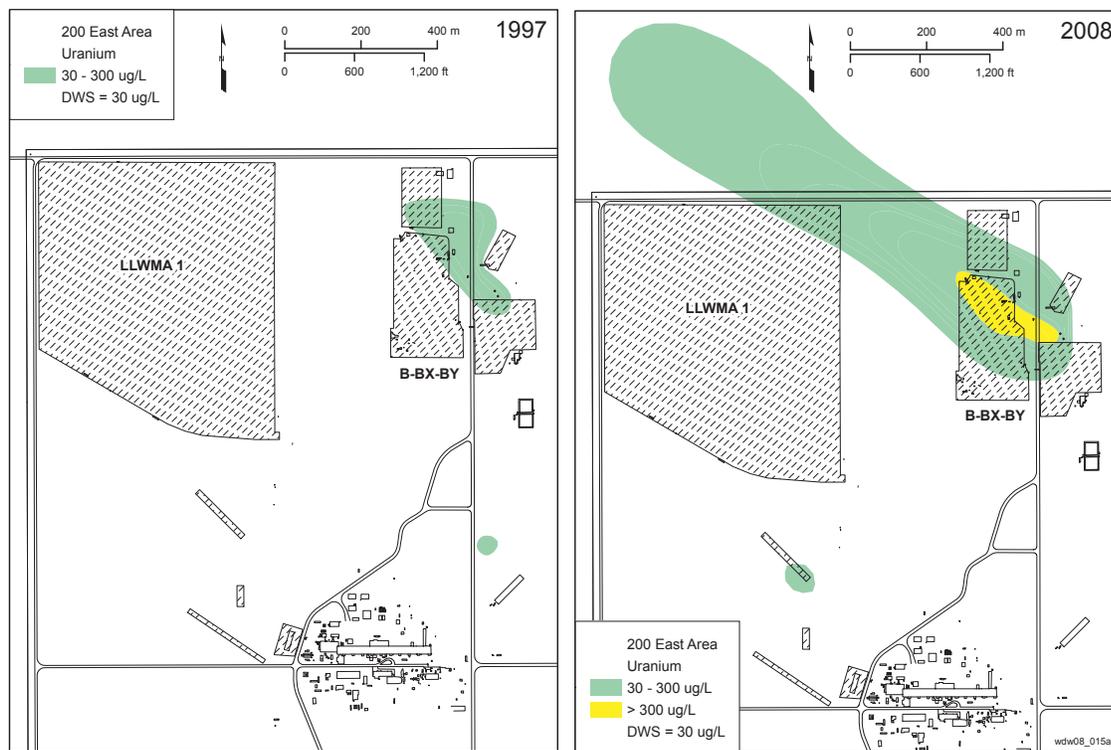
This operable unit includes groundwater beneath the northern 200 East Area and the region to the northwest, where mobile contaminants, including tritium and technetium-99, historically moved northward between Gable Mountain and Gable Butte. Most of the groundwater contamination originated in facilities in the northwestern corner of the 200 East Area, known as the B Complex.

The water table in the northern 200 East Area is virtually flat, making it difficult to determine current directions of groundwater flow. Studies in recent years suggest that groundwater continues to flow slowly to the northwest from the B Complex area.

Technetium-99 and tritium plumes extend northward between Gable Mountain and Gable Butte. Uranium forms a narrow plume that extends northwest of the 200 East Area. Nitrate forms a plume that extends to the north and probably originated from multiple sources within the 200 East Area. Other contaminants include cesium-137, cobalt-60, cyanide, iodine-129, plutonium-239/240, strontium-90, sulfate, and uranium.

In FY 2008, the DOE continued to work on the 200-BP-5 Operable Unit remedial investigation/feasibility study. Drillers installed nine new wells.

The highest concentrations of technetium-99, uranium, cobalt-60, cesium-137, plutonium, cyanide, and nitrate on the Hanford Site in FY 2008 were in wells in the 200-BP-5 Operable Unit.



A uranium plume has developed in the northwestern corner of the 200 East Area. The plume appears to have sources in Waste Management Area B-BX-BY.

Six facilities in the 200-BP-5 Operable Unit are monitored under RCRA in conjunction with CERCLA and AEA.

Waste Management Area B-BX-BY. RCRA assessment monitoring continued at this site in FY 2008. Contaminants include uranium, technetium-99, and nitrate. A new well located on the northwestern corner of the B Tank Farm had the maximum uranium concentration in FY 2008.

216-B-63 Trench. This RCRA site continued to be monitored under an interim status detection-monitoring program, with no indication that it has affected groundwater quality adversely.

Low-Level Waste Management Area 1. This site continued to be monitored under RCRA interim status requirements. Specific conductance continued to exceed its critical mean value, but exceedances previously were reported and do not appear to indicate contamination from the waste management area.

Low-Level Waste Management Area 2. This site continued to be monitored under RCRA interim status requirements, with no indication that it has affected groundwater quality adversely.

Liquid Effluent Retention Facility. The water table has dropped into the fractured basalt flow top in all but two monitoring wells. The DOE and Ecology are pursuing an agreement for environmental monitoring. Two new wells were installed that monitor the fractured basalt flow-top and weathered zone.

Waste Management Area C. This site continued to be monitored under an interim status RCRA detection program in FY 2008, but is sampled quarterly to meet requirements of a tank waste retrieval work plan. RCRA indicator parameters did

The PUREX cribs contributed to plumes of iodine-129, nitrate, and tritium. Nitrate and tritium concentrations are generally declining.

not exceed critical mean values, but specific conductance in one well is very close to the critical mean.

200-PO-1 Operable Unit

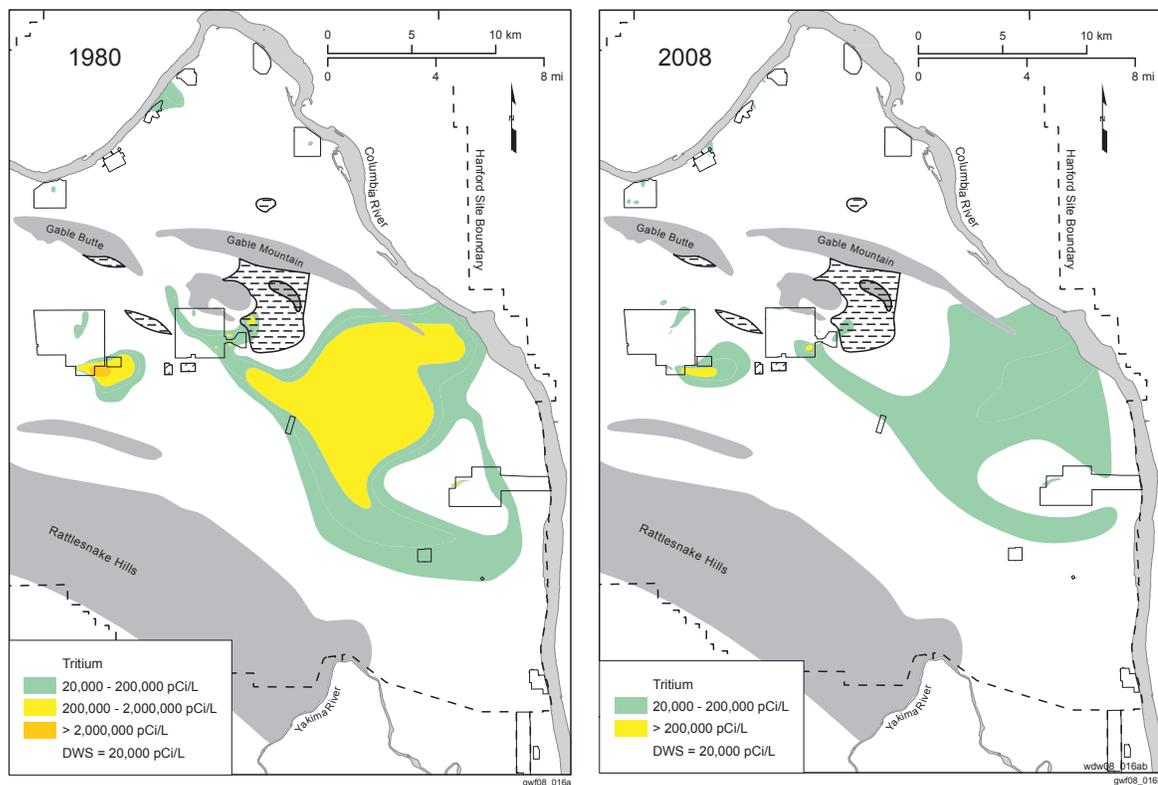
This operable unit encompasses the southern portion of the 200 East Area and a large region to the east and southeast that is contaminated with plumes of tritium and iodine-129. Concentrations of tritium continued to decline as the plume attenuates naturally because of radioactive decay and dispersion. Nitrate forms a large plume but mostly at levels below the drinking water standard. Other contaminants include strontium-90 and technetium-99, but these are limited to smaller areas.

During FY 2008, the remedial investigation/feasibility study process generated a work plan. The document includes a sampling and analysis plan for routine groundwater monitoring of wells and a characterization sampling and analysis plan.

Groundwater is monitored at eight regulated units in the 200-PO-1 Operable Unit. Water supply wells in the 400 Area, which falls within the footprint of the 200-PO-1 Operable Unit, also are monitored.

Integrated Disposal Facility. This facility will be an expandable, lined, RCRA-compliant landfill that will be used for disposal of low-level radioactive waste and hazardous waste. Until the facility begins to operate, results from semiannual monitoring will be added to the background data set.

PUREX Cribs. The 216-A-10, 216-A-36B, and 216-A-37-1 Cribs are monitored jointly under a RCRA interim status assessment program, CERCLA, and AEA. The



These maps show site-wide tritium plumes in the upper part of the unconfined aquifer in 1980 and 2008. Concentrations in the core of the plume have decreased over the years and the south margin is no longer spreading.

cribs have contributed to widespread contaminant plumes in the area, including nitrate, tritium, and iodine-129. The nitrate and tritium plumes are generally attenuating throughout most of their area.

Waste Management Area A-AX. RCRA assessment monitoring continued in FY 2008. Technetium-99 concentrations continued to exceed the drinking water standard (900 pCi/L) in two wells. A new downgradient well was installed in FY 2008 to replace two wells that had corroded, and were decommissioned.

216-A-29 Ditch. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations, with no indication that it has affected groundwater quality adversely. Specific conductance remains elevated in three downgradient wells, but is consistent with regional groundwater chemistry.

216-B-3 Pond. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations, with no indication that it has affected groundwater quality adversely.

200 Area Treated Effluent Disposal Facility. A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at this facility. No permit criteria for constituents in groundwater were exceeded in FY 2008. Because no unconfined aquifer exists beneath the facility, groundwater monitoring wells are installed in the locally confined aquifer below the Ringold Formation lower mud unit.

Nonradioactive Dangerous Waste Landfill. This RCRA site is located in the 600 Area, within the footprint of the 200-PO-1 Operable Unit regional plume. Interim status detection monitoring continued FY 2008. Total organic carbon concentrations in one downgradient well exceeded the critical mean value in August 2008 and in a confirmatory sample in October 2008. Groundwater will be monitored under an assessment program in FY 2009.

Solid Waste Landfill. This facility is adjacent to the Nonradioactive Dangerous Waste Landfill and is regulated under state solid waste regulations. As in previous years, some downgradient wells showed higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, sulfate, total organic carbon, and lower pH than upgradient wells. Some of these constituents may be related to past disposal of sewage materials to the landfill.

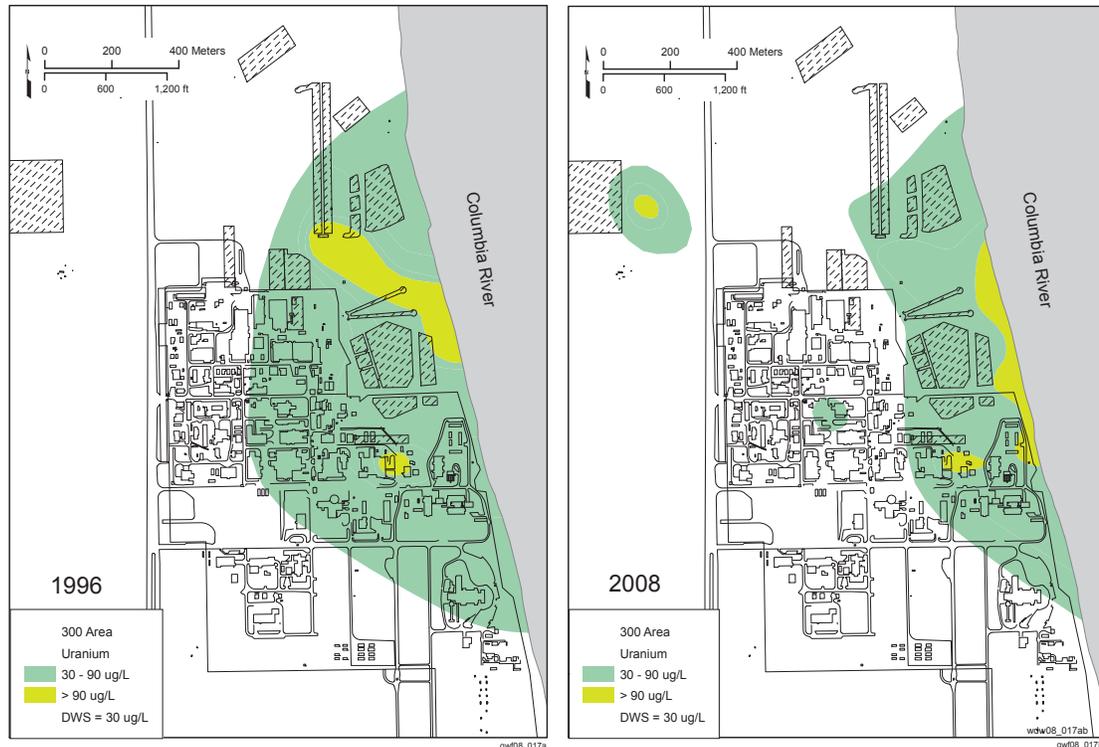
400 Area Water Supply Wells. Three water supply wells provide drinking water and emergency supply water for the 400 Area. Because the 400 Area is in the path of the site-wide tritium plume, the wells are routinely monitored for tritium. Tritium concentrations in all samples were below the drinking water standard in FY 2008.

300-FF-5 Operable Unit

This operable unit includes three geographic regions: the 300 Area, the 618-11 Burial Ground region, and the 618-10 Burial Ground/316-4 Cribs region. The operable unit is currently regulated under an interim record of decision that calls for groundwater monitoring and institutional controls on the use of groundwater. In FY 2008, the DOE installed 35 wells to characterize uranium geochemistry and mobility, and 3 wells to define trichloroethene distribution.

Recent work in this operable unit included updating computer simulations of groundwater flow and uranium transport; conducting a limited field investigation of uranium involving multiple characterization boreholes; updating to the human health and ecological risk assessment; and conducting an assessment of potential remedial

*The DOE is
investigating
remediation methods
for uranium in the
300 Area.*



The uranium plume in the 300 Area, at the 30 $\mu\text{g}/\text{L}$ level, is attenuating slowly. The DOE is investigating alternatives for more rapid remediation.

action technologies for the 300 Area uranium plume. Many of these additional activities essentially were completed during FY 2008. Continuing work will be conducted for interim action monitoring and characterization activities, and systematic planning of a new work plan for continued remedial investigation and feasibility study activities. These activities are intended to develop information that will lead to a proposed plan for final remediation efforts.

Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and cis-1,2-dichloroethene. Monitoring and plume characterization activities indicate relatively constant or gradually decreasing levels for these contaminants. Uranium is the principal contaminant of concern and remains above the drinking water standard (30 $\mu\text{g}/\text{L}$) beneath part of the 300 Area. Trichloroethene continued to be below the 5 $\mu\text{g}/\text{L}$ drinking water standard in wells monitoring the top of the unconfined aquifer. However, higher concentrations were detected in a deeper, fine-grained unit in a limited area.

Tritium concentrations continued to decline downgradient of the 618-11 Burial Ground.

Groundwater downgradient of the 618-11 Burial Ground is contaminated by a high-concentration tritium plume, probably originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from greater than 8 million pCi/L in 2000 to 780,000 pCi/L in September 2008.

300-FF-5 Operable Unit Phase III Feasibility Study. Because the uranium plume beneath the 300 Area has not decreased in concentration as rapidly as predicted by earlier studies, the DOE continued a detailed investigation of the natural processes that cause the plume to persist and the residual sources that may supply uranium to the plume. Results did not reveal evidence for high levels of uranium in the vadose zone, nor for a zone of elevated contaminants near the water table. Also, water samples collected from the saturated zone at various depths confirmed that contamination is

generally limited to the uppermost hydrologic unit (i.e., saturated Hanford gravels). Concentrations in the samples were consistent with those observed during routine groundwater monitoring.

Uranium Treatability Test. In FY 2008, the DOE monitored results of a treatability test to immobilize uranium in the aquifer. The test, conducted in FY 2007, involved injecting polyphosphate into the aquifer. Monitoring during FY 2008 indicated that the method has not performed as well as hoped in permanently sequestering uranium on aquifer solids. The heterogeneity in aquifer sediment and dynamic nature of hydrologic conditions present challenges to potential in situ remedies.

Integrated Field-Scale Research Challenge. This basic research project has focused on the geochemistry and mobility of uranium in the vadose zone at the 300 Area. Initial field activities included drilling 35 characterization boreholes at a location with a good potential of encountering residual uranium in the vadose zone. Geophysical investigations associated with this research project also continued during FY 2008.

316-5 Process Trenches. This former liquid waste disposal site was the last in the 300 Area to receive uranium-bearing effluent, with discharges ending in the early 1990s. The site, which has been remediated, is regulated under RCRA in conjunction with CERCLA and AEA. Uranium currently exceeds the drinking water standard in wells downgradient from the waste site, although concentrations appear to be decreasing with time. Cis-1,2-dichloroethene concentrations exceed the standard at only one downgradient well completed near the bottom of the aquifer.

1100-EM-1 Groundwater Interest Area

The 1100-EM-1 groundwater interest area is located in the southern part of the Hanford Site. It includes the former 1100-EM-1 Operable Unit, which was recently removed from the National Priorities List (40 CFR 300, Appendix B) and is no longer classified as a CERCLA operable unit. Groundwater also is monitored south of the Hanford Site, including the areas formerly designated as the 1100 and 3000 Areas of the Hanford Site, the city of Richland's landfill, and the North Richland Well Field.

Trichloroethene was the principal contaminant of concern in the operable unit. Contaminants also flow into the area from offsite sources (e.g., nitrate from agriculture and industry). The final remedy selected for 1100-EM-1 Operable Unit groundwater was monitored natural attenuation of volatile organic compounds. Concentrations of trichloroethene have remained below the drinking water standard since FY 2001.

Wells in the North Richland Well Field are monitored frequently to detect any changes in Hanford Site contaminants near these wells. The tritium plume originating from sources in the 200 East Area has not been detected in these wells. Low levels of tritium, similar to those detected in Columbia River water, continued to be detected.

Elevated levels of gross alpha occur downgradient of an offsite industrial facility. If gross alpha is attributed to uranium, then uranium exceeded the 30 µg/L drinking water standard. Uranium concentrations in wells downgradient of the DOE's inactive Horn Rapids Landfill have been increasing since 1996, but remained below the standard in FY 2008.

In the 1100-EM-1 groundwater interest area, trichloroethene concentrations continued to be below the cleanup level.

Technetium-99, cyanide, and nitrate were elevated in a new basalt-confined well. The contamination migrated down an old, poorly-constructed well nearby, in the past.

The DOE samples groundwater near the Columbia River via aquifer tubes and springs.

Confined Aquifers

Although most of the Hanford Site's groundwater contamination is in the unconfined aquifer, the DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination and the potential migration of contamination off Site through the basalt confined aquifer. No evidence of offsite migration via the confined aquifer has been detected.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation. It is confined below by basalt and above by the Ringold lower mud unit. While effluent disposal was occurring at the B Pond System, mounding within the unconfined aquifer in this area led to downward migration of groundwater into the Ringold Formation confined aquifer. During FY 2008, seven wells were sampled that are completed in the Ringold Formation confined aquifer. No contaminants exceeded primary drinking water standards.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds. In FY 2008, six basalt-confined aquifer wells were sampled. Tritium continued to be detected at low levels in some basalt-confined wells. One elevated tritium concentration near the 200 East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer. Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits in the upper basalt-confined aquifer. One new well monitoring the upper basalt-confined aquifer in the northwestern part of the 200 East Area shows contamination with technetium-99, cyanide, and nitrate. Migration of high-salt waste from the vadose zone or unconfined aquifer via an older, poorly-constructed well nearby is responsible for this contamination. The old well has been sealed.

Shoreline Monitoring

The DOE monitors groundwater near the Columbia River via aquifer tubes, which are small diameter, flexible tubes that are implanted in the shallow aquifer and natural seep points or springs.

Concentrations of strontium-90 continued to exceed the 8 pCi/L drinking water standard in aquifer tubes in the 100-B/C, 100-N, and 100-H Areas. Levels exceeded the 1,000 pCi/L derived concentration guide in 100-N Area tubes, reaching 75,000 pCi/L in one tube in July 2008. This high concentration represented a brief spike in response to the nearby injection of apatite-forming chemicals.

Tritium concentrations exceeded the 20,000 pCi/L drinking water standard in one tube at the upstream end of 100-D Area. The source is believed to be the 100-N Area plume. Tritium also exceeded the standard in springs and aquifer tubes at the Hanford townsite.

Uranium concentrations exceed the 30 µg/L drinking water standard in aquifer tubes and springs in the 300 Area.

Hexavalent chromium concentrations exceeded the 100 µg/L drinking water standard in 100-D Area aquifer tubes. Concentrations in aquifer tubes or springs exceeded the 10 µg/L aquatic standard in the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas.

Nitrate concentrations exceeded the 45 mg/L drinking water standard in aquifer tubes in the 100-K, 100-N, and 100-H Areas. An aquifer tube in the southern 300 Area also exceeded the standard; the source of this nitrate is a plume from sources off the Hanford Site.

Trichloroethene is detected in several aquifer tubes in the 300 Area and continued to exceed the 5 µg/L drinking water standard in some tubes that monitor a fine-grained unit.

Vadose Zone

Vadose zone activities in FY 2008 included leachate monitoring, soil-vapor extraction and monitoring, surface geophysics, and borehole geophysical logging.

Leachate Monitoring at Environmental Restoration Disposal Facility. This facility is used for disposal of radioactive and mixed waste generated during waste management and remediation activities at the Hanford Site. Leachate is collected and sent to the Effluent Treatment Facility. The composite leachate samples contained detectable concentration of common metals, anions, and mobile radionuclides. Constituents that were generally increasing in concentration include gross alpha and total uranium. Gross alpha concentrations in groundwater show a slight long-term decrease and gross beta concentrations show an increase in most downgradient wells. Gross alpha and gross beta in groundwater will be closely monitored in the future.

Leachate and Soil-Gas Monitoring at the Solid Waste Landfill. Leachate is sampled and tested quarterly. Concentrations in the past year were similar to previous concentrations and did not identify any areas of concern. Soil gas is monitored quarterly to determine concentrations of oxygen, carbon dioxide, methane, and several key volatile organic compounds. Results were consistent with previous years. Contaminants of concern were near or below detection limits.

Soil-Vapor Extraction. This remedial action is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area. As of September 2008, ~79,400 kg of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Tank Farm Vadose Zone Activities. The Vadose Zone Integration Program is responsible for implementing the Tank Farm RCRA Corrective Action Program through field characterization, laboratory analyses, technical analyses, risk assessment for past tank leaks, and application of interim measures that will reduce the threat from contaminants until permanent solutions can be found. In FY 2008, the Vadose Zone Integration Program installed several direct push boreholes for soil sampling and geophysical logging in the C and TY Tank Farms, completed surface geophysical surveys at Waste Management Area TX-TY, and conducted a well-to-well geophysical survey of the SX Tank Farm. An interim surface barrier was completed over a portion of the T Tank Farm to reduce the infiltration of precipitation through the remnants of a 1973 tank leak.

Well Installation, Maintenance, and Decommissioning

The DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that could no longer be used. Ecology, EPA, and DOE worked together to develop a prioritized list of new

As of September 2008, ~79,400 kg of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

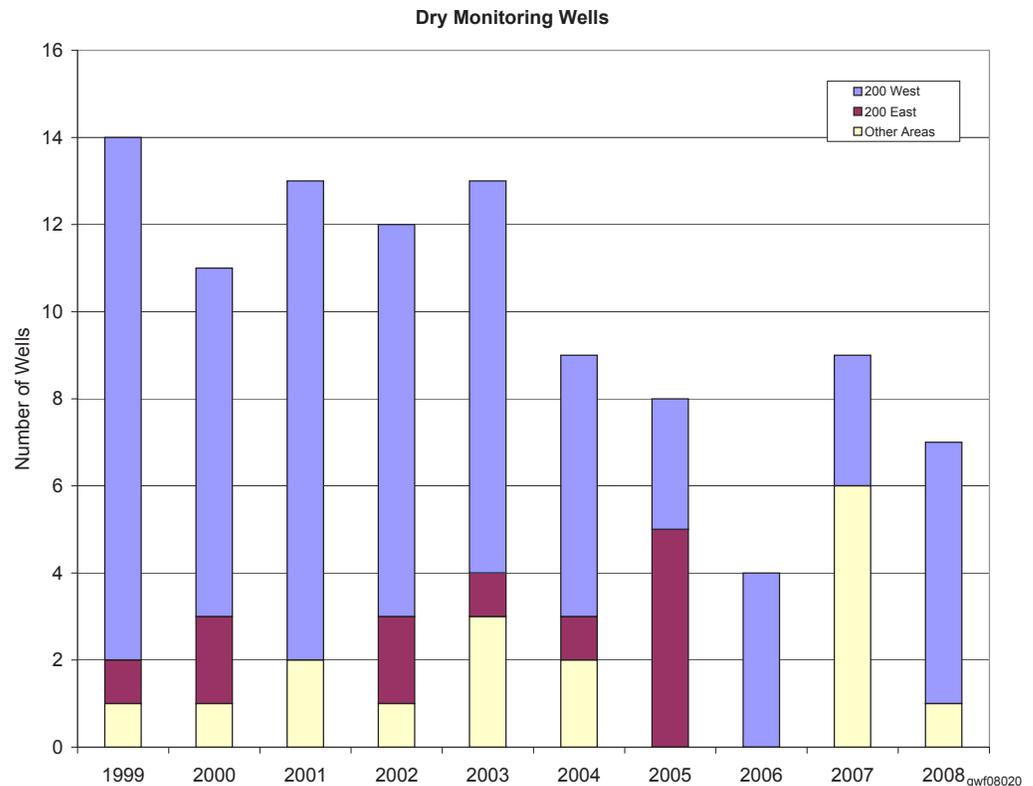
During FY 2008, the DOE installed 113 new wells and decommissioned 103 wells.

wells needed to meet requirements of various groundwater monitoring regulations. In FY 2008, the DOE installed 113 new wells.

During FY 2008, 386 temporary characterization boreholes were installed around the Hanford Site to support various projects. The temporary boreholes are installed for subsurface characterization of radiological constituents, volatile organics (e.g., carbon tetrachloride), or hydrogeologic property determination (e.g., moisture, grain size distribution). While typically installed to characterize the vadose zone, borings can be drilled to groundwater to obtain a one-time sample and then be decommissioned.

Wells Installed in FY 2008.	
Location (Facility)	Number of New Wells
100-FR-3	1
100-HR-3 Horn	15
100-HR-3-D	4
100-KR-4	27
100-NR-2	6
200-BP-5	8
200-BP-5 (LERF)	1
200-PO-1 (WMAA-AX)	1
200-UP-1	4
200-UP-1 (216-S-10)	2
200-UP-1 (ERDF)	2
200-ZP-1	3
200-PW-1 (soil-vapor)	1
300-FF-5	38
Total	113

Approximately 9,695 unique well identification numbers have been identified within the Hanford Site. These include all wells, characterization boreholes, aquifer tubes, soil gas probes, piezometers, or other subsurface installations. To date, 4,272 (~44%) of these have been either administratively removed from the well inventory or decommissioned (sealed with grout). Wells are decommissioned when they are no longer needed; are in poor condition; are in the path of intended remediation or construction activities; or pose an environmental, safety, or public health hazard. The DOE maintains a list of wells that are candidates for decommissioning. All candidate wells must be reviewed and approved by potential well users prior to decommissioning. During FY 2008, a total of 3,384 unique well identification numbers were documented as “in use.” A total of 103 wells were physically decommissioned during FY 2008 and 221 temporary boreholes were administratively decommissioned by records management.



This chart shows the number of monitoring wells that went dry each year since 1999. Most of the wells were in the 200 West Area, where the water table declined the most.

Staff performed maintenance on 275 wells in FY 2008. Surface maintenance includes labeling wells, maintaining well caps, and repairing surface casing, wiring, or pump-discharge fittings. Subsurface tasks include repairing and replacing sampling pumps, performing camera surveys, retrieving pumps and equipment, and replacing tubing.

Continued Monitoring

The DOE will continue to monitor groundwater to meet the requirements of AEA, CERCLA, RCRA, and DOE Orders. During ongoing groundwater remediation, the groundwater project will monitor, assess, and report on activities at groundwater operable units. Both the unconfined and upper-confined aquifers are monitored and data are maintained and managed in a centralized database. Monitoring well locations, frequencies, and analytical constituents will continue to be documented each year. Water-level monitoring will continue to be performed to characterize groundwater flow and to determine the impact of Hanford Site operations on the flow system.

Groundwater monitoring remains a part of the Hanford Site baseline throughout the cleanup mission and will remain a component of long-term stewardship after remediation is completed.

Details about the Hanford Site Groundwater Remediation Project can be found online at <http://www.hanford.gov/cp/gpp/>.

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