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Pacific Northwest
National Laboratory
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U.S. Department of Energy

Summary of Hanford Site Groundwater Monitoring for Fiscal Year 2006

Editors
M. J. Hartman
L. F. Morasch
W. D. Webber

March 2007

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Prepared for Fluor Hanford, Inc. and the U.S. Department of Energy by Pacific Northwest National Laboratory under Contract DE-AC05-76RL01830, with contributions from CH2M HILL Hanford, Inc.; Fluor Hanford, Inc.; Vista Engineering Technologies, LLC; and Washington Closure Hanford, LLC

Pacific Northwest National Laboratory
Richland, Washington 99352

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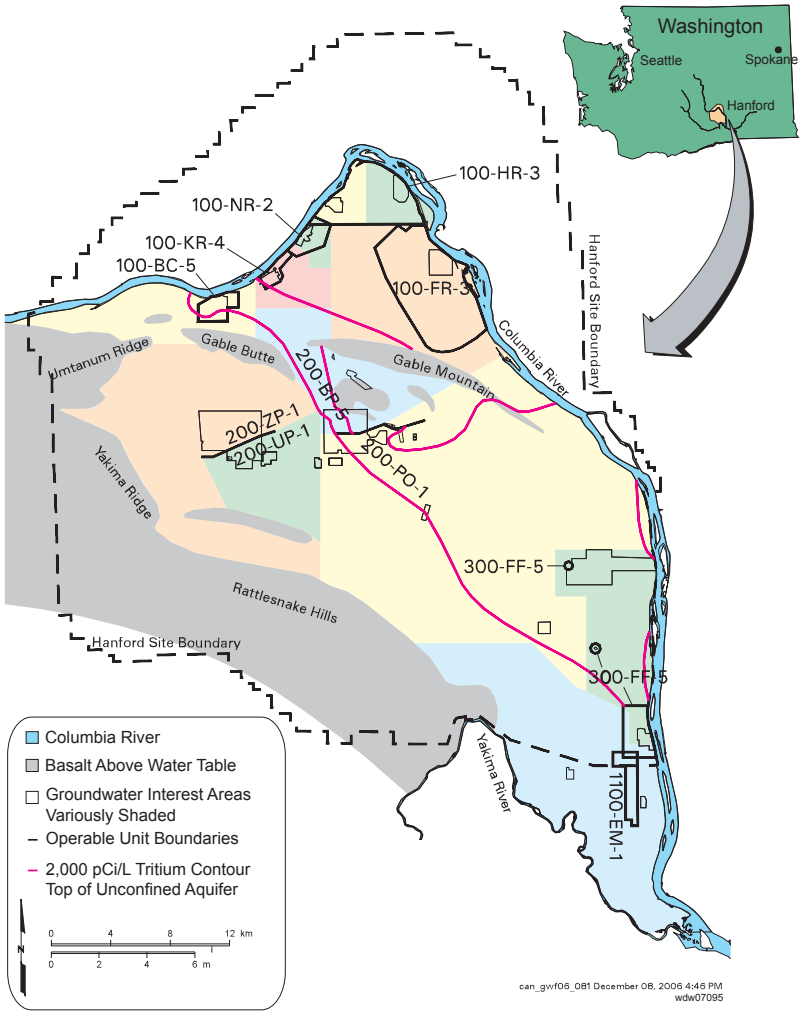
Summary

Introduction

The Hanford Site, a facility in the U.S. Department of Energy (DOE) nuclear weapons complex, encompasses ~1,517 square kilometers northwest of the city of Richland along the Columbia River in southeast Washington State. The federal government acquired the site in 1943, and until the 1980s, it was dedicated primarily to the production of plutonium for national defense. Management of waste associated with plutonium production has been a major activity throughout Hanford's history and continues today at a much reduced scale. Beginning in the 1990s, DOE has focused on cleaning up the site.

DOE is committed to protecting the Columbia River from being impacted by contaminated groundwater and returning groundwater to its beneficial use where practicable. The Hanford Site Groundwater Strategy, developed collaboratively by DOE, the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA),

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.

presents a means for multiple regulatory authorities and government agencies to protect and restore groundwater at the Hanford Site. The strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater.

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

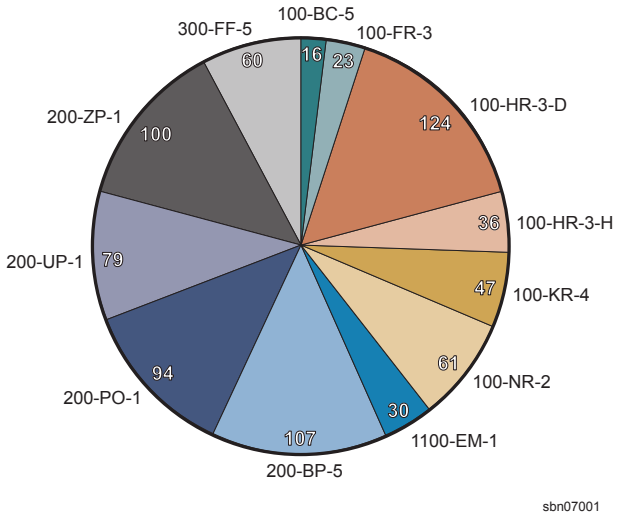
DOE sampled 778 wells during FY 2006. Chromium, nitrate, and tritium are constituents most frequently analyzed.

The groundwater monitoring requirements for Hanford's RCRA units fall into one of two categories: interim status or final status. A permitted RCRA unit requires final status groundwater monitoring as specified in WAC 173-303-645. RCRA units that have not yet been incorporated into permits require interim-status groundwater monitoring as specified in WAC 173-303-400, which invokes 40 CFR 265.

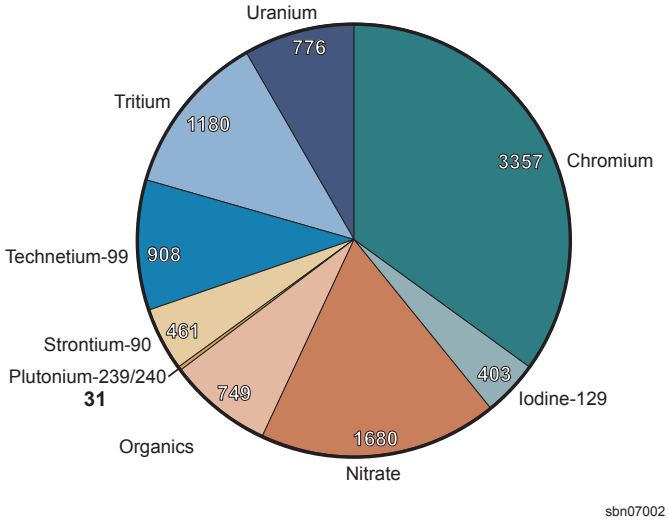
RCRA groundwater monitoring is conducted under one of three possible phases:

- Indicator Parameter (or final status detection). Initially, a detection program is developed using groundwater monitoring data collected from the facility network wells to determine and monitor the impact, if any, of facility operations on the groundwater.
- Assessment (or final status compliance). If the detection monitoring results indicate a statistically significant increase in the concentration of dangerous waste constituents or chemical parameters in the groundwater beneath the regulated units, then an assessment or compliance phase of monitoring and investigation is initiated.
- 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 the concentration limits as defined in the monitoring plan or permit, then Ecology may require a groundwater monitoring corrective action program to determine the effectiveness of the corrective action to reduce the contaminant hazards to the public and environment.

Some contaminants reached the Columbia River by moving downward from waste sites, primarily liquid discharge sites, through the vadose zone, into the groundwater, and then



This chart shows the number of wells sampled in each groundwater interest area in FY 2006.



The groundwater project requests specific laboratory analyses based on the well's location, historical contaminant trends, and regulatory requirements. This graph shows the number of analyses for the most common constituents during FY 2006.

into the river. The analysis of groundwater samples provides data that help characterize the nature, potential fate, and transport of contaminants in the environment. DOE works with regulatory agencies such as the EPA and Ecology to make cleanup decisions based on sound technical information and the technical capabilities available.

In fiscal year (FY) 2006, workers sampled 778 monitoring wells and 247 shoreline aquifer tubes to determine the distribution and movement of contaminants. This was an increase from the previous fiscal year of more than 100 wells and 75 aquifer tubes. Many of the wells were sampled multiple times during the year for a total of 1,919 sampling trips.

A total of 3,357 samples of Hanford groundwater were analyzed for chromium, 1,680 for nitrate, and 1,180 for tritium. Other constituents frequently analyzed include technetium-99 (908), uranium (776), and carbon tetrachloride (749). These totals include results for routinely sampled groundwater wells, pump-and-treat operational samples, and aquifer tube samples.

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

Emerging Items of Interest

This section briefly describes some of the high-priority groundwater topics for FY 2006. The groundwater chapter of the full report contains additional details.

KW Reactor Chromium Plume. In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. Design and construction of a new pump-and-treat system to remediate this chromium plume began during FY 2006. Four new wells were installed, and two existing wells will be incorporated into the network. New well 199-K-137 had chromium concentrations over 2,000 μg/L in early FY 2007. The pump-and-treat system will begin to operate in FY 2007.

100-N Pump-and-Treat Alternatives. The 100-N Area pump-and-treat system was placed on standby (pumps shut off) in March 2006 and an alternative remediation method is being tested. Apatite-forming chemicals were injected into two wells along the 100-N shoreline (one in June and the other in September 2006), and the concentrations of strontium-90 and other parameters are being monitored around the injection sites. DOE plans to install a 90-meter apatite barrier in FY 2007.

100-H Area Pump-and-Treat. Concentrations of hexavalent chromium in 100-H Area groundwater have declined since 1997 when a pump-and-treat system was initiated as an interim action. The decline, due to remediation and natural processes, continued in FY 2006. In September 2006, concentrations in compliance wells were all below the remedial action goal of 22 μg/L.

DOE continued to study strontium-90 sequestration by apatite. Field tests were initiated in FY 2006.

Vertical Distribution of Carbon Tetrachloride in 200 West Area. In recent years, depth-discrete sampling in existing wells, and sampling during drilling of new wells, have provided new information on how carbon tetrachloride concentrations change with depth in the unconfined aquifer. The results of a new study in FY 2006 created a conceptual model of the plume geometry. The extent of carbon tetrachloride contamination deeper in the aquifer indicates that a significantly greater mass of carbon tetrachloride is present in the unconfined aquifer than previously calculated.

Technetium-99 at Waste Management Area T. Technetium-99 concentrations in wells east of Waste Management Area T, in the 200 West Area, continued to increase. The highest concentrations in the technetium-99 plume downgradient of the south part of the waste management area are near the water table, while the highest concentrations downgradient of the north part are at about 10 meters below the water table.

Trichloroethene in 300-FF-5 Operable Unit. During the limited field investigation in the 300 Area, volatile organic compounds were found in water samples collected during the drilling of four characterization boreholes. Samples collected from a relatively fine-grained

unit within the upper portion of the Ringold Formation at a depth other than typical screened intervals unexpectedly detected some high concentrations of trichloroethene.

CERCLA Five-Year Review. The second 5-year review of records of decision for remedial actions under CERCLA underwent public review in FY 2006 and a revised document was published in early FY 2007. DOE conducted the review in coordination with the EPA, which is responsible for certifying the review. More information on the 5-year review is available at: www.hanford.gov, "CERCLA Five-Year Review." The purpose of the review is to evaluate the implementation and performance of the remedies in order to determine if they are protective of human health and the environment.

CERCLA 2006 Five-Year Review Conclusions Regarding Groundwater	
100 Areas	Most of the groundwater interim actions are meeting remedial action objectives.
	The interim action for the 100-N strontium-90 plume is not meeting objectives and an alternative technology is being tested.
200 Areas	The 200-ZP-1 interim action is being expanded to address additional portions of the carbon tetrachloride plume.
	The vapor extraction system has proven to be effective and will continue operation.
	The 200-UP-1 interim action has met remedial action objectives.
300 Area	Monitored natural attenuation of uranium has not achieved remedial action objectives and additional treatability studies are underway.
1100 Area	The final remedies selected for this area met the remedial action objectives and the remedy remains protective.
Determinations of long-term protectiveness for the 100, 200, and 300 Areas are deferred until more complete remedies are selected.	

EM-22 Technology Proposals. In FY 2006, the U.S. Congress authorized 10 million dollars for "...analyzing contaminant migration to the Columbia River, and for the introduction of new technology approaches to solving contamination migration issues." These funds will be administered through DOE's Office of Environmental Management (EM-22). It is anticipated that these funds will be spent in FY 2006, 2007, and part of FY 2008. Nine proposals have been funded after addressing comments from a peer review panel. The funded proposals include

- Five pertaining to hexavalent chromium in 100-K and 100-D Areas
- Two pertaining to strontium-90 in 100-N Area
- One pertaining to carbon tetrachloride in 200 West Area
- One pertaining to uranium in the 300 Area

Nine additional proposals are being considered for funding. More information on the EM-22 proposals is available at www.hanford.gov/cp/gpp/science/em21.cfm.

Hanford groundwater flows into the Columbia River, which is used for recreation, drinking water, agriculture, and wildlife habitat. Therefore, DOE is focusing remediation efforts on activities that protect the Columbia River.

Groundwater Flow

Groundwater in the unconfined aquifer generally flows from west to east across the Hanford Site to discharge areas north and east along the Columbia River. 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.

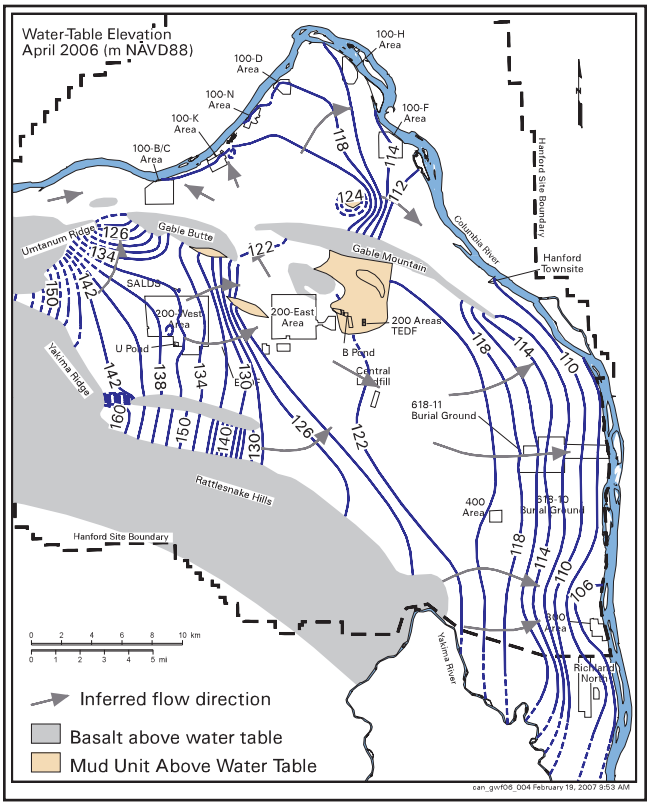
General directions of groundwater flow are illustrated on the water-table map for April 2006. Groundwater enters the unconfined aquifer from recharge areas to the west and eventually discharges to the Columbia River. Additional water infiltrates through the vadose zone beneath the Hanford Site. Hydrologists estimate that the total discharge of groundwater from the Hanford Site aquifer to the Columbia River is in the range 1.1 to 2.5 cubic

meters/second. This rate of discharge is very small compared to the average flow of the river, ~3,400 cubic meters/second.

In the part of the site north of Gable Mountain and Gable Butte, unconfined groundwater flows generally toward the river. 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 divides, with some migrating to the north through Gable Gap and some moving southeast toward the central part of the site. In the south part of the Hanford Site, groundwater converges on 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 Areas. Since effluent disposal decreased significantly in the 1990s, these mounds have dissipated in the reactor areas and have declined considerably in the 200 Areas. Currently, wastewater is discharged to the ground at the State-Approved Land Disposal Site, north of the 200 West Area, affecting groundwater flow locally.

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 located upgradient of the contaminant plumes so the injection increases the hydraulic gradient toward the extraction wells.



This map shows the water table and inferred flow directions in April 2006. Areas shaded in gray or tan show where the unconfined aquifer is absent.

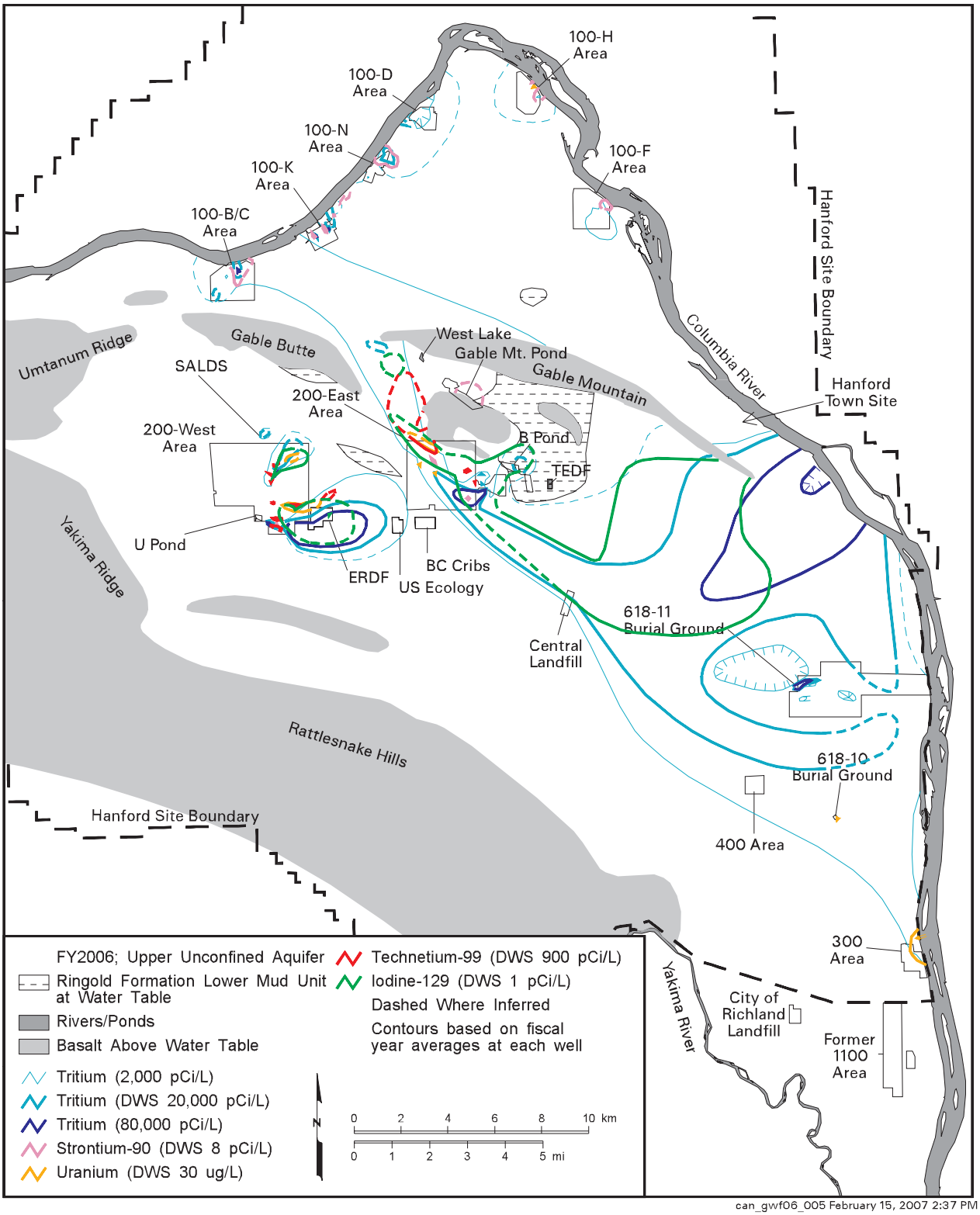
A confined aquifer occurs within sand and gravel of the lowest sedimentary unit of the Ringold Formation. It is confined below by basalt and above by the lower mud unit. East of the 200 East Area there is no unconfined aquifer, and groundwater in the Ringold confined aquifer is still influenced by a residual recharge mound.

Groundwater Monitoring and Remediation

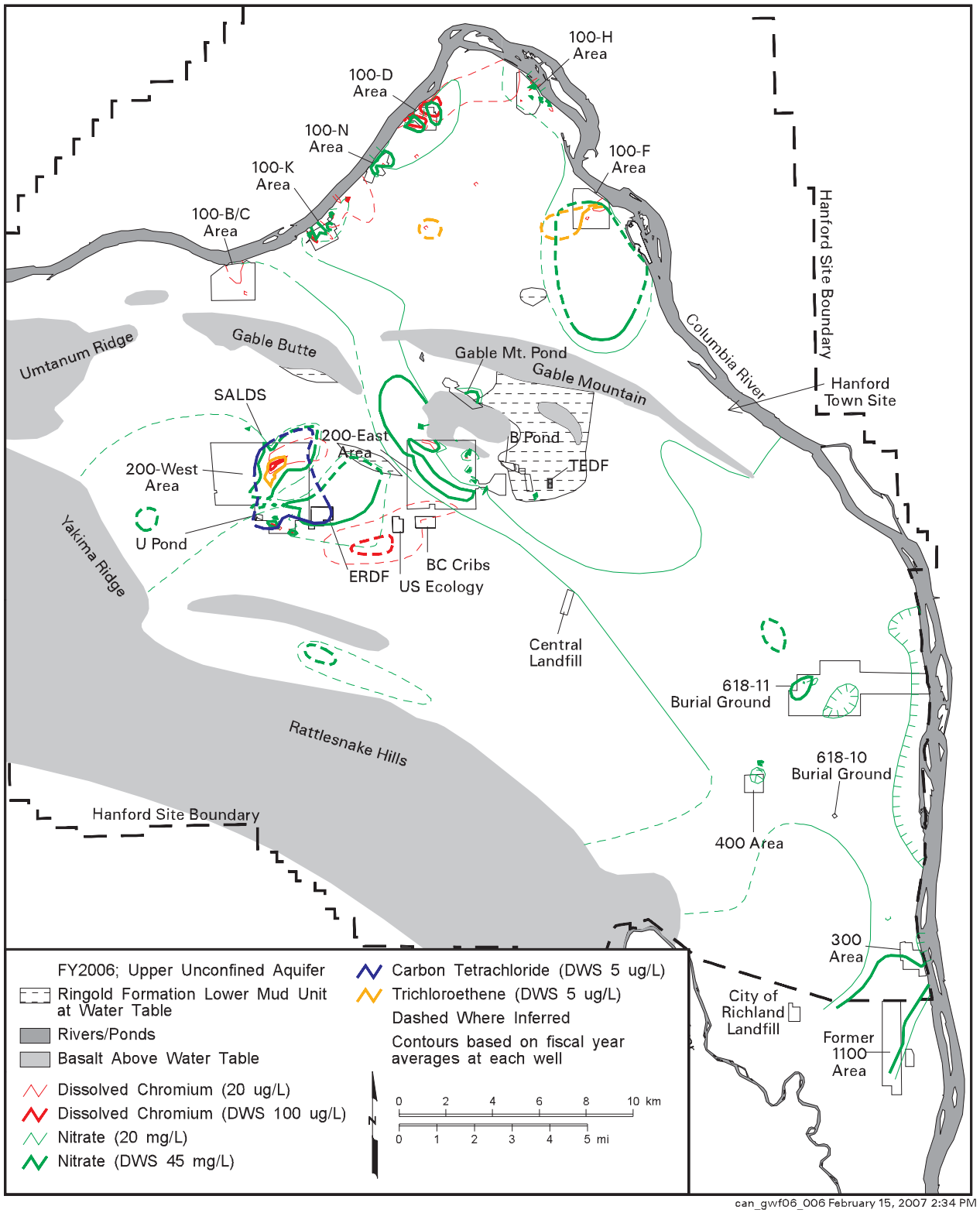
DOE has developed a plan to clean up Hanford's groundwater, which will return it to its beneficial use where practicable or will at least prevent further degradation. Under the plan DOE will (a) remediate high-risk waste sites, (b) shrink the contaminated area, (c) reduce natural and artificial recharge, (d) remediate groundwater, and (e) monitor groundwater. The maps on the following pages show the distribution of nine principal groundwater contaminant plumes.

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 are also present in 200 West Area. Technetium-99 exceeds standards in plumes within both the 200 East and 200 West Areas. One technetium-99 plume has moved northward from 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, the 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.

DOE's cleanup plan includes the following elements: (a) remediate high-risk waste sites, (b) shrink the contaminated area, (c) reduce recharge, (d) remediate groundwater, and (e) monitor groundwater.

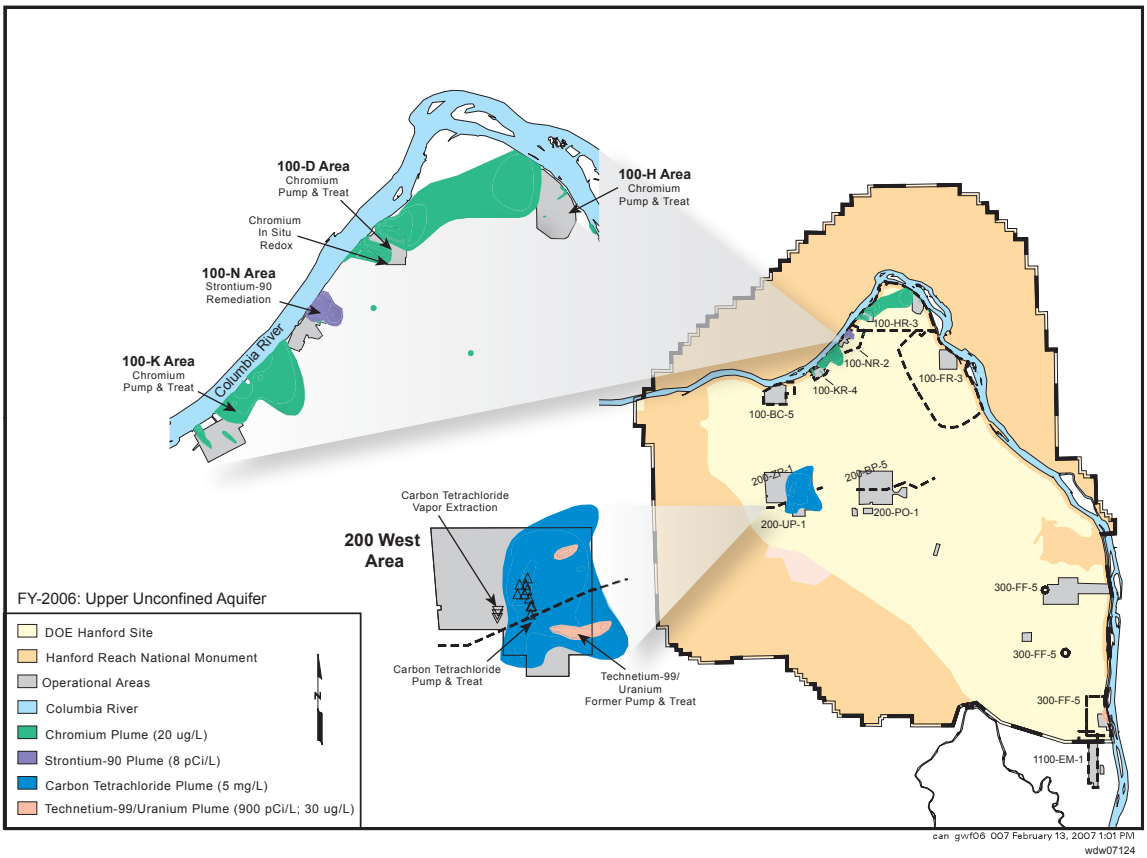


This map shows the distribution of radionuclides in groundwater at concentrations above drinking water standards during FY 2006 in the upper part of the unconfined aquifer.



This map shows the distribution of hazardous chemicals in groundwater at concentrations above drinking water standards during FY 2006 in the upper part of the unconfined aquifer.

Groundwater Remediation		
Remedial Action Site	Startup Date	Progress From Startup to September 2006
100-K Area – 100-KR-4 Pump-and-Treat	1997	Decreases chromium to river; 291 kilograms removed.
100-N Area – 100-NR-2 Pump-and-Treat	1995	1.8 curies of strontium-90 removed. Extraction ceased March 2006. Testing alternative remediation methods.
100-D Area – 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 243 kilograms removed.
100-D Area – DR-5 Pump-and-Treat	2004	Decreases chromium to river; 105 kilograms removed.
100-D Area – 100-HR-3 In Situ Redox	1999	Decreases chromium concentrations downgradient of barrier.
100-H Area – 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 47 kilograms removed.
200 West Area – 200-ZP-1 Pump-and-Treat	1994	Prevents high-concentration portion of carbon tetrachloride plume from spreading; 10,197 kilograms removed.
200 West Area – Soil-Vapor Extraction	1992	Reduces carbon tetrachloride movement to groundwater; 78,900 kilograms removed.
200 West Area – 200-UP-1 Pump-and-Treat	1994	Decreases lateral migration of contaminants; 119 grams technetium-99 (2.02 curies) and 212 kilograms uranium removed through January 2005. No extraction FY 2006.
Waste Management Area S-SX – Well 299-W23-19 Pump-and-Treat	2003	Decreased technetium-99 concentrations; 0.27 grams (0.0046 curie) of technetium-99 removed.
300 Area – 300-FF-5 Natural Attenuation	Not applicable	Average trichloroethene concentrations below target level in wells; uranium concentrations above target level.
1100-EM-1 – Natural Attenuation	Not applicable	Average trichloroethene concentrations below 5 µg/L since 2001.



DOE operates groundwater and vadose zone remediation systems to remove contaminants and limit their movement in groundwater and the vadose zone.

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, the most widespread organic contaminant on the Hanford Site, forms a large plume beneath the 200 West Area. Other organic contaminants include chloroform, found in 200 West Area, and trichloroethene. Trichloroethene plumes that exceed the drinking water standard are found in the 100-K, 100-F, and 200 West Areas. New wells in the 300 Area detected trichloroethene at levels above the drinking water standard at depth in the aquifer. Chromium at levels above the 100-µg/L drinking water standard underlies portions of the 100-K and 100-D Areas. Chromium exceeds the state's aquatic standard (10 µg/L) in these areas and portions of the 100-B/C, 100-H, and 100-F Areas. Local plumes of chromium contamination also are present in the 200 Areas, particularly the north part of 200 West Area.

The following text discusses groundwater contamination, monitoring, and remediation for each of the 11 groundwater operable units and in the confined aquifers.

Area of Contaminant Plumes at Levels Above Drinking Water Standards (square kilometers)

Constituent (drinking water standard)	Fiscal Year 2000	Fiscal Year 2005	Fiscal Year 2006
Carbon tetrachloride (5 µg/L)	9.8	10.8	9.8
Chromium (100 µg/L)	2.8	2.0	2.0
Iodine-129 (1 pCi/L)	89.7	75.4	67.0
Nitrate (45 mg/L)	36.3	43.3	40.0[a]
Strontium-90 (8 pCi/L)	2.8	2.4	2.4
Technetium-99 (900 pCi/L)	2.3	2.5	3.9[b]
Trichloroethene (5 µg/L)	4.2	3.8	3.0
Tritium (20,000 pCi/L)	176	135.5	121.2
Uranium (20/30 µg/L)[c]	2.0	1.4	1.6
Combined Plumes[d]	232	199	186[a]

(a) Excludes 1100-EM-1 plume from offsite sources.
(b) Increase is the result of changing interpretation of plume size in 200-BP-5 interest area due to data from a new well.
(c) Area of uranium plume based on 20 µg/L standard in 2000 and 30 µg/L standard in subsequent years.
(d) Area with one or more constituent above drinking water standards.

100-BC-5 Operable Unit

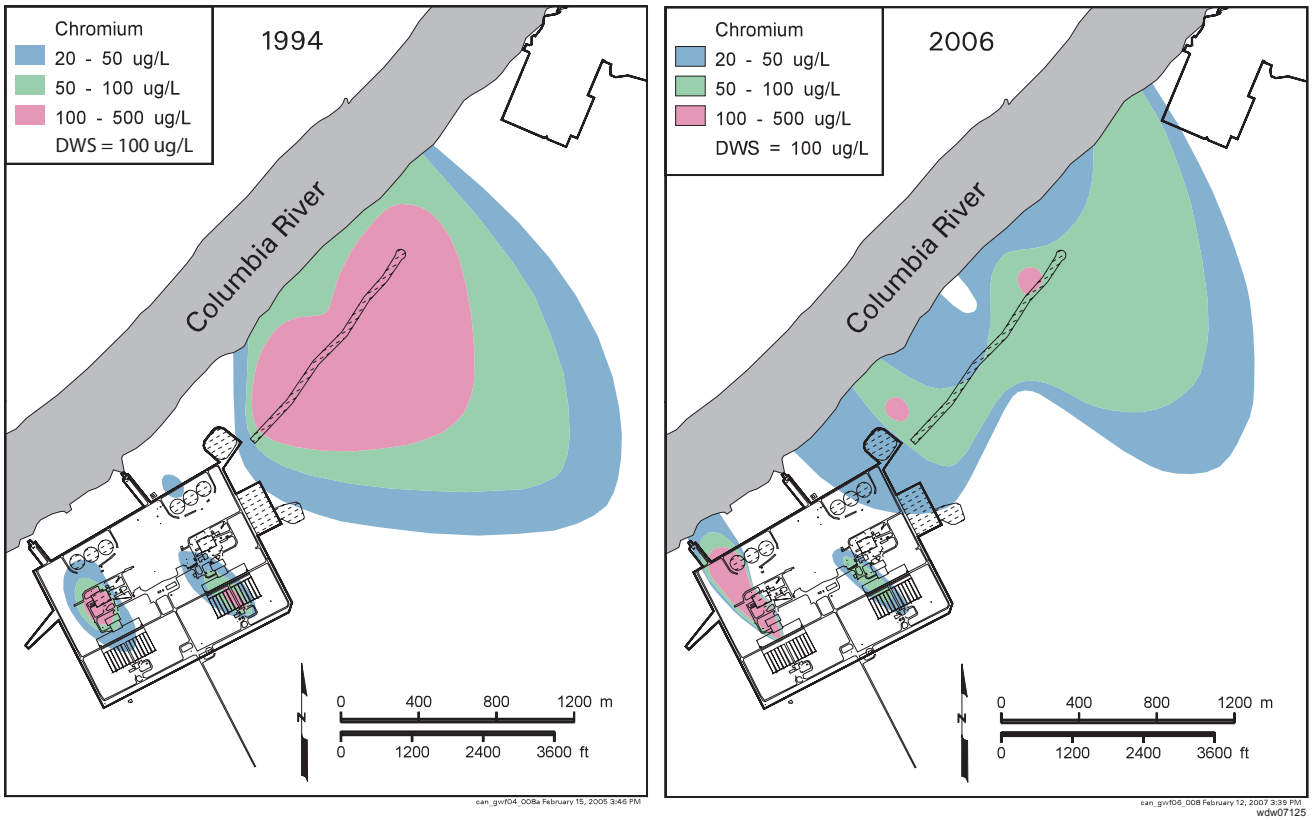
A complete discussion of the 100-BC-5 Operable Unit can be found in Section 2.2. This operable unit includes the groundwater beneath the 100-B/C Area, located in the northwest Hanford Site. Most of the groundwater contamination is found in the north portion of the area, beneath former waste trenches and retention basins. Tritium and strontium-90 exceeded drinking water standards in several wells. Tritium concentrations in two wells in the northeast 100-B/C Area spiked in recent years, but the reason for the variability is not known. Tritium also exceeds the drinking water standard in a well near a burial ground where tritium was recently found at elevated levels in the vadose zone. Nitrate and chromium continued to be below drinking water standards in recent years in the 100-B/C Area, but chromium exceeds the 10-µg/L aquatic standard.

Tritium levels are variable in two wells in the northeast 100-B/C Area.

A record of decision has not yet been developed for the 100-BC-5 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 being conducted. Draft B of a pilot project risk assessment were published in FY 2006, which will serve as a prototype for risk assessments in the other reactor areas. The pilot risk assessment characterized the potential risks to human health and the environment under the cleanup standards implemented in remedial actions performed to date.

100-KR-4 Operable Unit

A complete discussion of the 100-KR-4 Operable Unit can be found in Section 2.3. The principal groundwater issues in this operable unit include (a) remediation of chromium-contaminated groundwater; (b) tracking plumes from past-practices sites; and (c) monitoring groundwater near the KE and KW Basins. Interim remedial action involves a pump-and-treat system that removes chromium from groundwater and injects the treated water upgradient of the plume.



These maps show chromium in the upper part of the unconfined aquifer in the 100-K Area. A pump-and-treat system reduces the amount of chromium entering the Columbia River. Concentrations decreased in most areas since 1994.

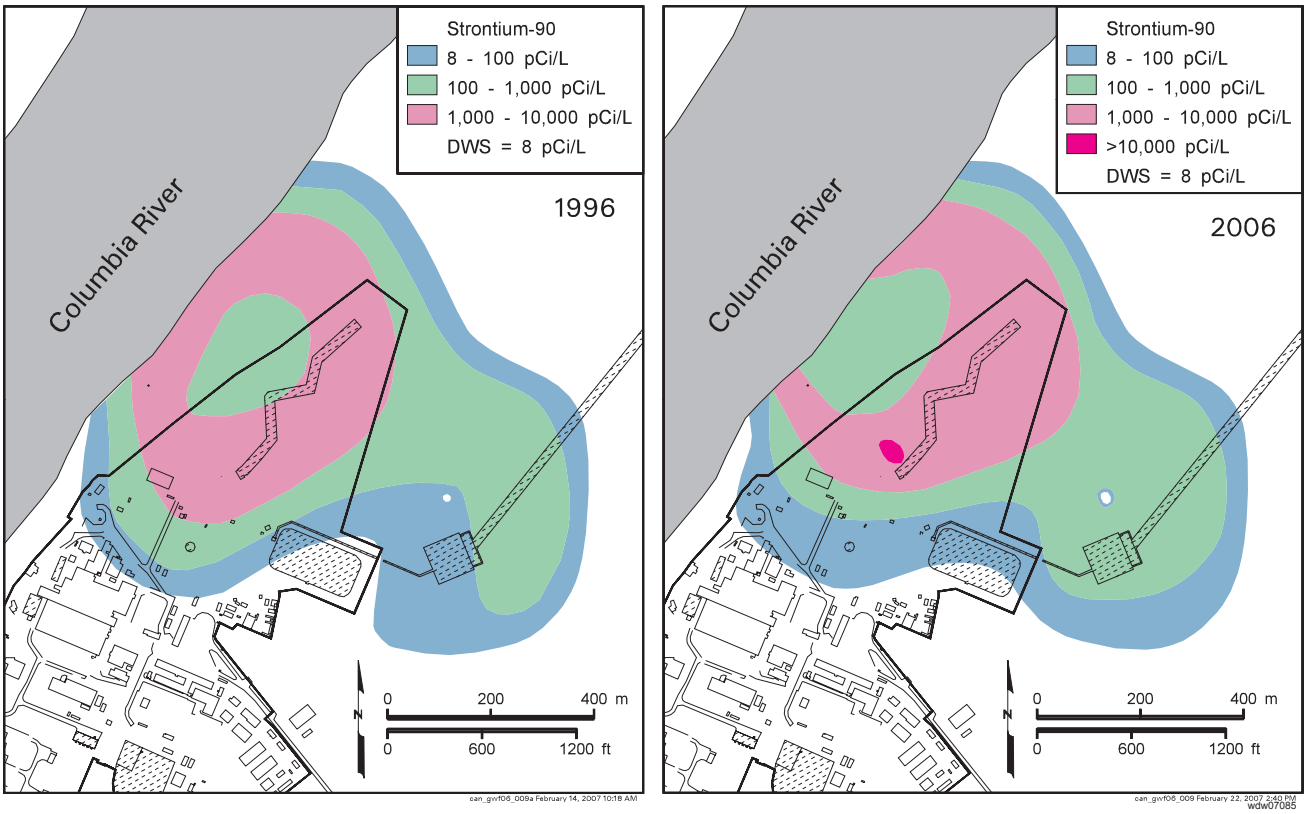
The 100-K Area pump-and-treat system is being expanded.

Interim Remedial Action. A pump-and-treat system is being used to remove hexavalent chromium from the aquifer beneath the 116-K-2 infiltration trench. Approximately 291 kilograms of chromium have been removed since startup in 1997. Although the mapped extent of contamination has remained fairly constant during the past 10 years, the area of highest concentrations (>100 µg/L) has decreased markedly. The concentration goal for the interim remedial action is 22 µg/L in groundwater near the Columbia River.

In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. Although an exact source for this chromium has not been identified, it is most likely related to past sodium dichromate handling. In FY 2006, chromium concentrations continued to increase in a well between the reactor building and the river. Four extraction wells were installed for use in a new pump-and-treat system that is planned to begin operating in FY 2007.

The four wells installed in 2005 northeast of the 100-K Area to perform a treatability test using calcium polysulfide were sampled monthly throughout FY 2006. This test evaluated the practicality of treating chromium in the groundwater as an alternative to pump-and-treat systems. During the test, hexavalent chromium concentrations dropped to levels near to or below detection limits in the wells used to monitor the effectiveness and longevity of the treatment.

Monitoring Past-Practice Waste Sites. Other contaminants of potential concern in the operable unit are carbon-14, nitrate, strontium-90, trichloroethene, and tritium. These contaminants are associated with waste disposal and facility operations that occurred during the reactor operating years (1955 to 1971). While levels remain above drinking water standards, risks to the river ecosystem are deemed low, so decisions regarding remedial



The overall shape of the 100-N 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.

actions have been deferred until remedial actions of source areas are complete. Some recent variability in tritium concentrations near KW Reactor is believed to be the result of remobilization of contaminants held in the vadose zone.

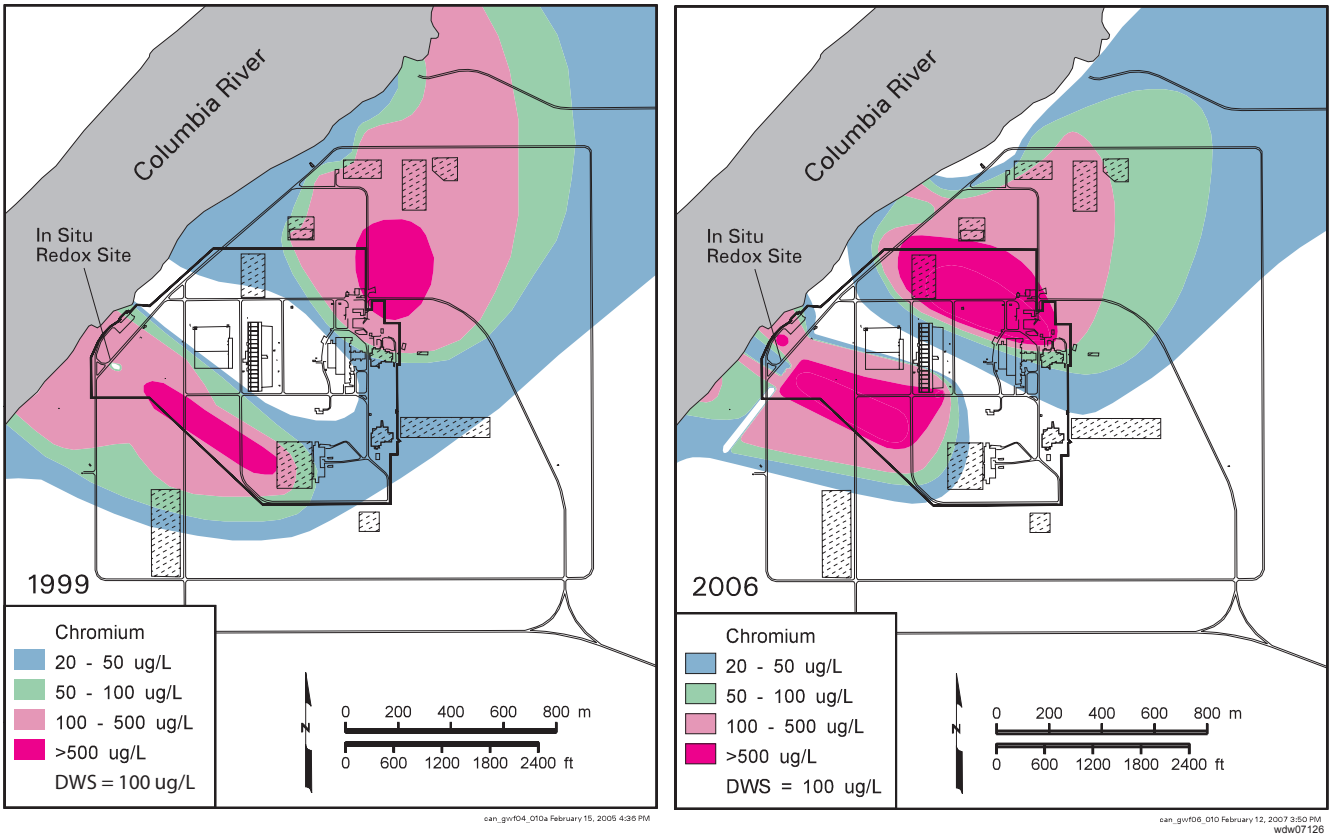
K Basins. The KE and KW Basins are integral parts of each reactor building. Since the late 1970s, they have been used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered from cleanup at other reactor areas. DOE has removed the fuel and is nearly finished removing radioactive sludge from KE Basin. Following sludge removal, basin interior concrete surfaces will be decontaminated, shielding water will be removed, and the basin will be demolished.

100-NR-2 Operable Unit

A complete discussion of activities in the 100-NR-2 Operable Unit can be found in Section 2.4. The primary groundwater contaminant plume in the 100-N Area is strontium-90, which originated at two liquid waste disposal cribs. A tritium plume also originated at the 100-N Area cribs. Tritium concentrations in groundwater are declining, and the plume is shrinking. Nitrate, sulfate, and petroleum hydrocarbons also are present in 100-N Area groundwater.

The 100-N Area pump-and-treat system was put on standby in FY 2006.

Interim Remedial Action. A pump-and-treat system for strontium-90, which operated as a CERCLA interim action, was put on standby in FY 2006. DOE continued to evaluate an alternative treatment method, apatite sequestration. Twenty-nine wells were installed along the shoreline in FY 2006 to support this technology. Apatite-forming chemicals were injected into two test wells during the year, and the concentrations of strontium-90 and other parameters are monitored in surrounding wells and aquifer tubes. The goal is to create a permeable, reactive barrier near the shoreline that will capture strontium-90 as groundwater



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, DOE operates two pump-and-treat systems in the north and an in situ treatment system in the south.

Chromium concentrations in 100-D Area groundwater are the highest on the Hanford Site. Three remediation systems operate to reduce the amount of chromium reaching the Columbia River.

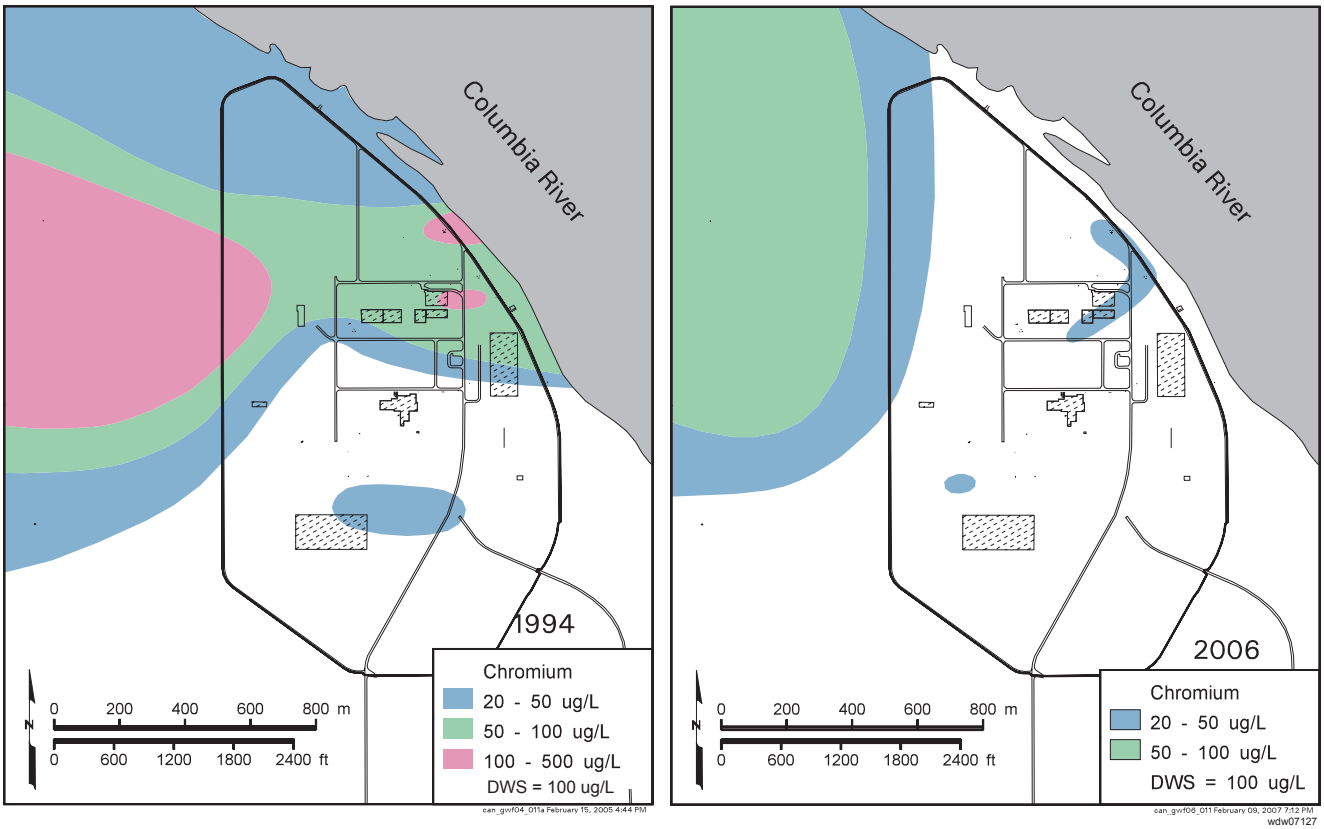
flows through it to the river. DOE is also researching phytoremediation using Coyote Willows to remove shallow groundwater and soil contamination adjacent to the river.

116-N-1, 116-N-3, 120-N-1, and 120-N-2 (1301-N, 1325-N, 1324-N/NA) Facilities. Four RCRA units are located in the 100-N Area. During FY 2006, 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 pond.

100-HR-3-D Operable Unit

The 100-HR-3 Operable Unit underlies the 100-D and 100-H Areas and the region between. Hexavalent chromium is the primary contaminant of concern in groundwater beneath the 100-D Area, which comprises the west part of the operable unit (100-HR-3-D; described in Section 2.5). A principal cause for this contamination was the routine discharge of reactor coolant, which contained sodium dichromate as a corrosion inhibitor, to disposal facilities, such as trenches. A second cause was periodic spillage and leakage of sodium dichromate stock solution to the ground. Chromium is distributed in north and southwest plumes and other contaminant plumes include tritium, nitrate, and sulfate exist in the same general area.

Interim Remedial Actions. The north 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. FY 2006, chromium concentrations remained above the remediation goal (22 µg/L)



A pump-and-treat system in the 100-H Area has reduced the amount of chromium entering the Columbia River. Between 1994 and 2006, concentrations decreased through most of the plume.

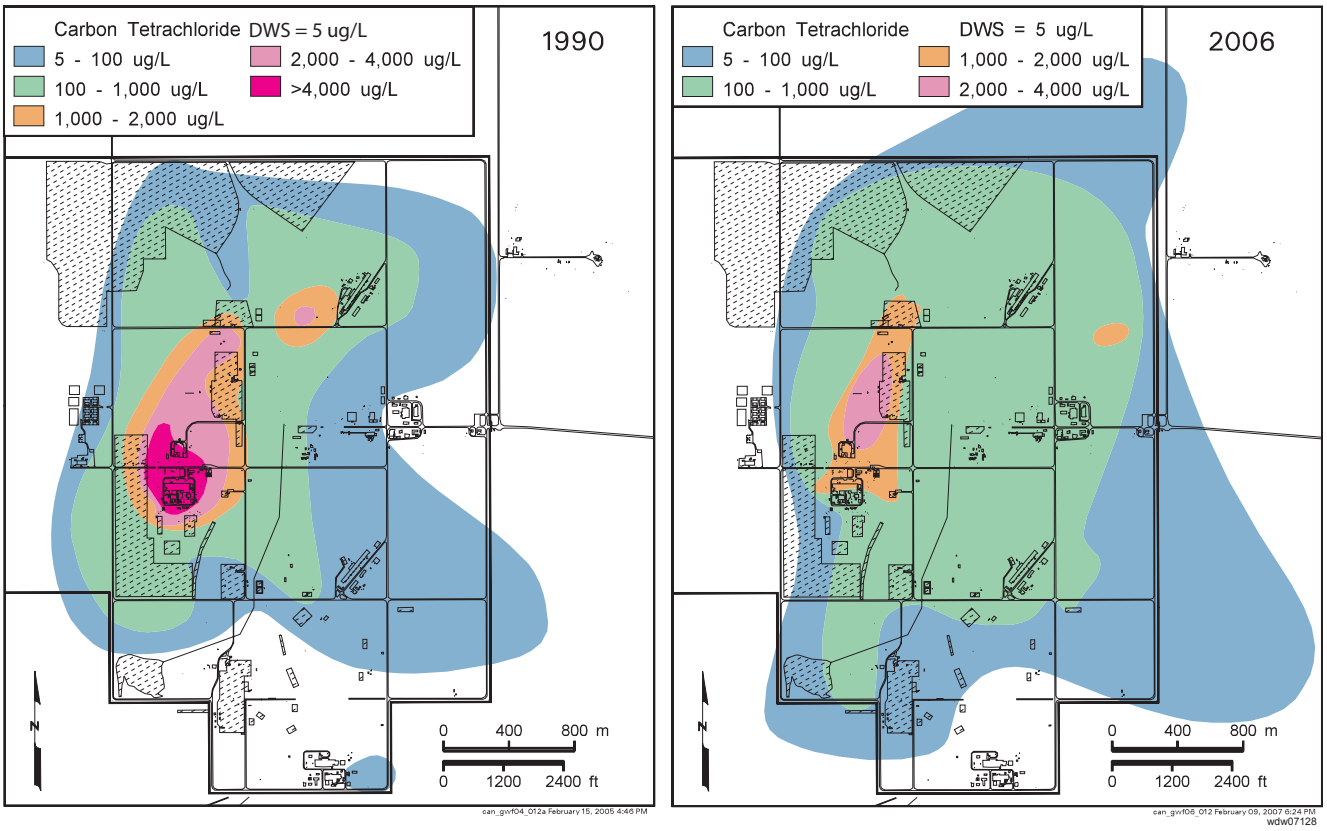
in compliance wells. The two extraction systems have removed 348 kilograms of chromium from the aquifer since 1997. The southwest chromium plume is being remediated with a permeable barrier that immobilizes chromium in the aquifer. Data from recent years indicate that chromium is breaking through the barrier. At the end of FY 2006, concentrations in barrier wells ranged from below detection limits to 380 µg/L, with concentrations in ~66% of the wells below the remedial action goal of 20 µg/L. Most of the elevated concentrations are in the northeast half of the barrier. Downgradient of the barrier, the 20-µg/L goal was met at two of the seven compliance wells.

100-HR-3-H Operable Unit

A complete discussion of the east part of the 100-HR-3 Operable Unit (100-HR-3-H), which underlies the 100-H Area, can be found in Section 2.6. Hexavalent chromium is the primary contaminant of concern in this area, but the plume is smaller and concentrations are lower than in the 100-D Area. Nitrate also is elevated, but concentrations have declined from their peak historical levels. Strontium-90 exceeds the drinking water standard (8 pCi/L) beneath former retention basins, and technetium-99 and uranium are elevated in a small area.

Chromium concentrations in 100-H Area have declined due to remediation and natural processes.

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 47 kilograms of hexavalent chromium from the aquifer since 1997. Hexavalent chromium concentrations continued to decline in FY 2006 in the one remaining compliance well and in former compliance wells that have been converted to extraction wells. In September 2006, concentrations in all of those wells were below the 22 µg/L remedial action goal.



These maps show the carbon tetrachloride plume beneath the 200 West Area in the upper part of the unconfined aquifer. The edges of the plume spread between 1990 and 2006. 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, shown here in pink and red.

116-H-6 (183-H) Evaporation Basins. These former basins comprise the only RCRA site in the 100-H Area. Leakage from the basins contaminated groundwater with chromium, nitrate, technetium-99, and uranium. The site is monitored during the post-closure period to track contaminant trends during the operation of the CERCLA interim action for chromium.

DOE expanded the pump-and-treat system for carbon tetrachloride in the 200 West Area to capture a portion of the plume beyond the reach of the former system.

100-FR-3 Operable Unit

A complete discussion of the 100-FR-3 Operable Unit can be found in Section 2.7. Nitrate concentrations in groundwater exceed the drinking water standard beneath much of the 100-F Area and the downgradient region. Other groundwater contaminants include strontium-90 and trichloroethene. Chromium exceeds the 10-µg/L aquatic standard in some wells.

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

A complete discussion of the 200-ZP-1 Operable Unit can be found in Section 2.8. This operable unit encompasses the north portion of the 200 West Area. The primary contaminant of concern is carbon tetrachloride, which forms the largest plume of chlorinated hydrocarbons on the Hanford Site. The carbon tetrachloride contamination had sources associated with waste disposal from the Plutonium Finishing Plant, where organic chemicals

were used to process plutonium. Trichloroethene and chloroform also are associated with this plume. Other contaminants in the 200-ZP-1 Operable Unit include tritium, nitrate, chromium, fluoride, iodine-129, technetium-99, and uranium.

Work on the feasibility study for the 200-ZP-1 groundwater Operable Unit is ongoing. In FY 2006, potential remediation methods for the 200-ZP-1 Operable Unit were screened. The screening considered the eight major contaminants and used a generalized conceptual model of the lateral extent and depth of contamination.

The distribution of carbon tetrachloride is complex because of its potential to migrate as a dense, non-aqueous phase liquid, in the gaseous state, and dissolved in water. Depth-discrete data for 19 wells were evaluated in the 200-ZP-1 remedial investigation report in FY 2006. The results were integrated with geologic information to form a conceptual model of the plume geometry. The plume extends to the top of the Ringold lower mud unit where the mud is present and to the top of basalt where the mud is absent. The contamination occurs at increasing depth to the east of the known source areas. Relatively low concentrations are seen at the water table in the east-central part of the 200 West Area. The extent of carbon tetrachloride contamination deeper in the aquifer indicates that a significantly greater mass of carbon tetrachloride is present in the unconfined aquifer than previously estimated.

The extent of carbon tetrachloride contamination deeper in the aquifer indicates that a significantly greater mass of carbon tetrachloride is present in the unconfined aquifer than previously estimated.

The 200-ZP-1 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.

Interim Remedial Action. Since 1994, DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride in the upper part of the aquifer from spreading. The remediation system was extended to the north in late FY 2005 to capture carbon tetrachloride contamination at levels above 2,000 µg/L extending beyond the capture zone of the former system. An additional monitoring well was converted to an extraction well in September 2006.

Soil-Vapor Extraction. Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. As of the end of September 2006, ~78,900 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Low-Level Burial Grounds Waste Management Areas 3 and 4. RCRA groundwater monitoring continued under interim status requirements in FY 2006. Three new monitoring wells were installed at Low-Level Waste Management Area 3 and one at Low-Level Waste Management Area 4. The changing flow direction has 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.

Waste Management Area T. RCRA assessment monitoring continued in FY 2006 under a revised assessment plan. The waste management area has introduced technetium-99 and other tank waste contaminants to the uppermost aquifer in the area. Two new wells were installed in FY 2006. The highest concentrations of technetium-99 downgradient of the south part of the waste management area are near the water table, while the highest concentrations downgradient of the north part are at about 10 meters below the water table.

Data collected in recent years have helped define vertical distribution of contaminants around Waste Management Areas T and TX-TY.

Waste Management Area TX-TY. RCRA assessment monitoring continued in FY 2006. Sources in the waste management area have contaminated groundwater with chromium, technetium-99, and other tank waste constituents. Other nearby sources of contamination make source determinations uncertain for some contaminants. Nitrate concentrations increased sharply in three wells. The highest chromium concentrations are observed at depths near the water table. Groundwater flow beneath Waste Management Area TX-TY is changing due to the operation of the 200-ZP-1 pump-and-treat remediation system. Extraction wells operate south and west of the waste management area. Because of the change in flow direction, the monitoring network no longer performs as originally designed.

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 2006.

200-UP-1 Operable Unit

A groundwater pump-and-treat system operated near U Plant to contain the technetium-99 and uranium plumes there. Rebound monitoring continued in FY 2006 and contaminant concentrations remained below remedial action goals.

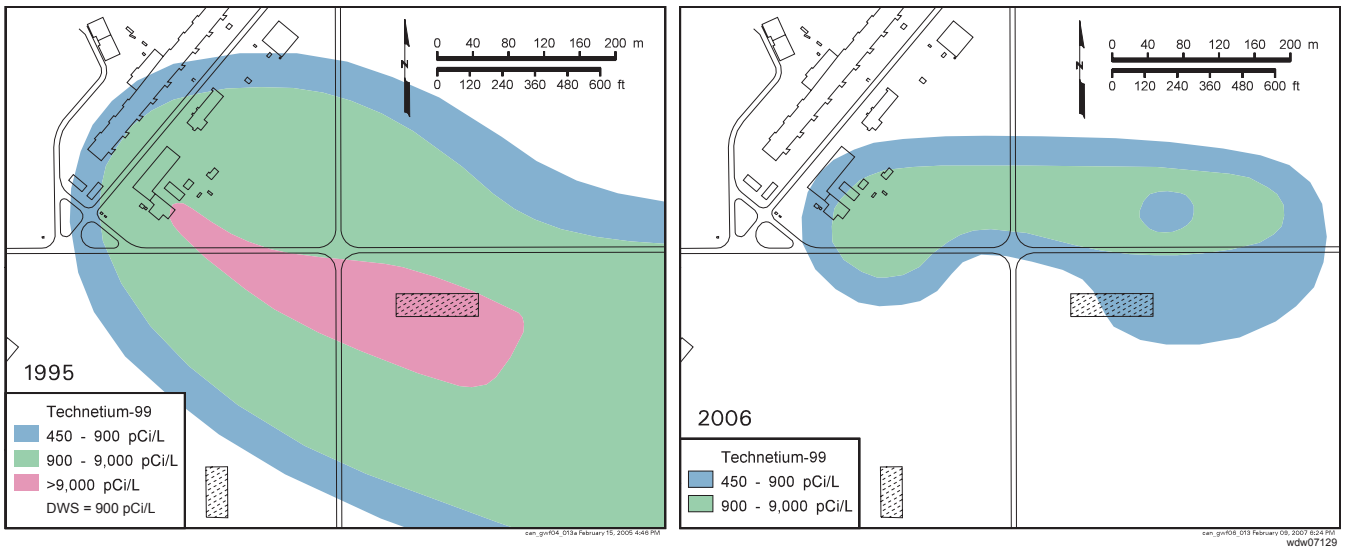
A complete discussion of the 200-UP-1 Operable Unit can be found in Section 2.9. This operable unit underlies the south portion of 200 West Area. The primary contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit. Six wells were drilled in this operable unit in FY 2006.

A study of vertical contaminant distribution in the 216-U-1,2 crib plume showed that in most areas, the highest technetium-99 concentrations are near the water table. In three wells, concentrations were higher 19 to 33 meters below the water table. Uranium was limited to the portion of the aquifer near the water table.

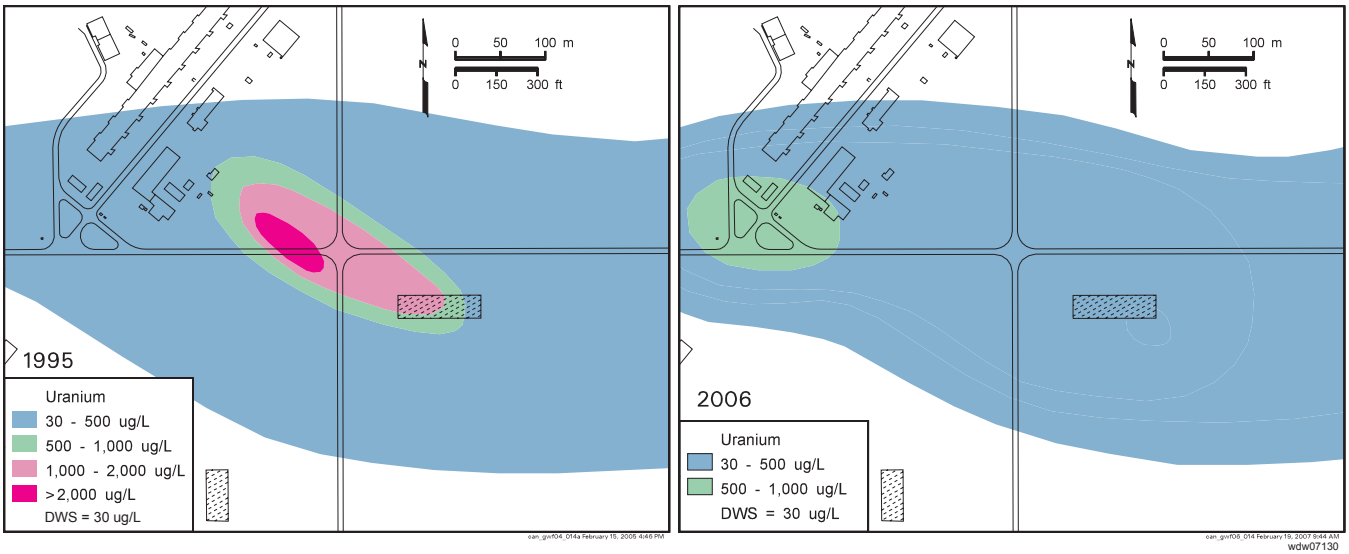
Four facilities are being monitored under RCRA (in conjunction with CERCLA and AEA), one CERCLA interim action, and a CERCLA disposal site in the 200-UP-1 Operable Unit. Monitoring activities are summarized in the following paragraphs.

Interim Remedial Action. A groundwater pump-and-treat system operated near U Plant to contain the technetium-99 and uranium plumes located in this area. In January 2005, groundwater extraction ceased and a rebound study was initiated to determine if contaminant concentrations will remain below the remedial action goal under natural groundwater flow conditions. The rebound study concluded in January 2006. For the remainder of FY 2006, semi-annual groundwater monitoring around the baseline plume area continued. Ecology is currently preparing an Explanation of Significant Difference which may revise the remedial action objective for uranium. After the Explanation of Significant Difference is issued, a decision will be made on whether or not to restart the pump-and-treat system.

The results of the rebound study and semiannual groundwater sampling indicate that enough technetium-99 and uranium was removed from the aquifer that concentrations of both constituents remained below their respective remedial action goals at all wells for FY 2006.



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 and was shut down in January 2005, when DOE began to conduct a rebound study.



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

Waste Management Area S-SX. RCRA assessment monitoring continued in FY 2006. Groundwater beneath this waste management area is contaminated with tank waste constituents, which include nitrate, hexavalent chromium, and technetium-99 attributed to two general source areas within the waste management area. The south plume represents a growing contamination issue. Data from new wells indicate that both plumes extend farther downgradient than previously interpreted.

Waste Management Area U. RCRA assessment monitoring continued in FY 2006. 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-U-12 Crib. RCRA assessment monitoring continued in FY 2006. The crib is one of several sources that have contributed to a nitrate plume in the area. Closure of the crib will be coordinated between RCRA and CERCLA. The monitoring plan was revised in FY 2006 to incorporate a new upgradient well.

216-S-10 Pond and Ditch. The 216-S-10 facility continued to be monitored under a RCRA interim status detection program in FY 2006. The current RCRA monitoring network consists of only two shallow downgradient wells and one deeper downgradient well, because other wells have gone dry. Three new wells are planned for installation in 2008.

Environmental Restoration Disposal Facility. This facility is a low-level, mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. The site is designed to meet RCRA standards, although it is not permitted as a RCRA unit. Results of groundwater monitoring continued to indicate that the facility has not adversely impacted groundwater quality.

Dry Monitoring Wells

Some wells that were formerly sampled for the groundwater project have gone dry as the water table declined. Most of the wells are in the 200 Areas.

Fiscal Year	200 West	200 East	Other Areas	Total
1999	12	1	1	14
2000	8	2	1	11
2001	11	0	2	13
2002	9	2	1	12
2003	9	1	3	13
2004	6	1	2	9
2005	3	6	0	9
2006	4	0	0	4
Total	**62**	**13**	**10**	**85**

200-BP-5 Operable Unit

A complete discussion of the 200-BP-5 Operable Unit can be found in Section 2.10. This operable unit includes groundwater beneath the north 200 East 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, nitrate, nitrite, plutonium, strontium-90, sulfate, and uranium.

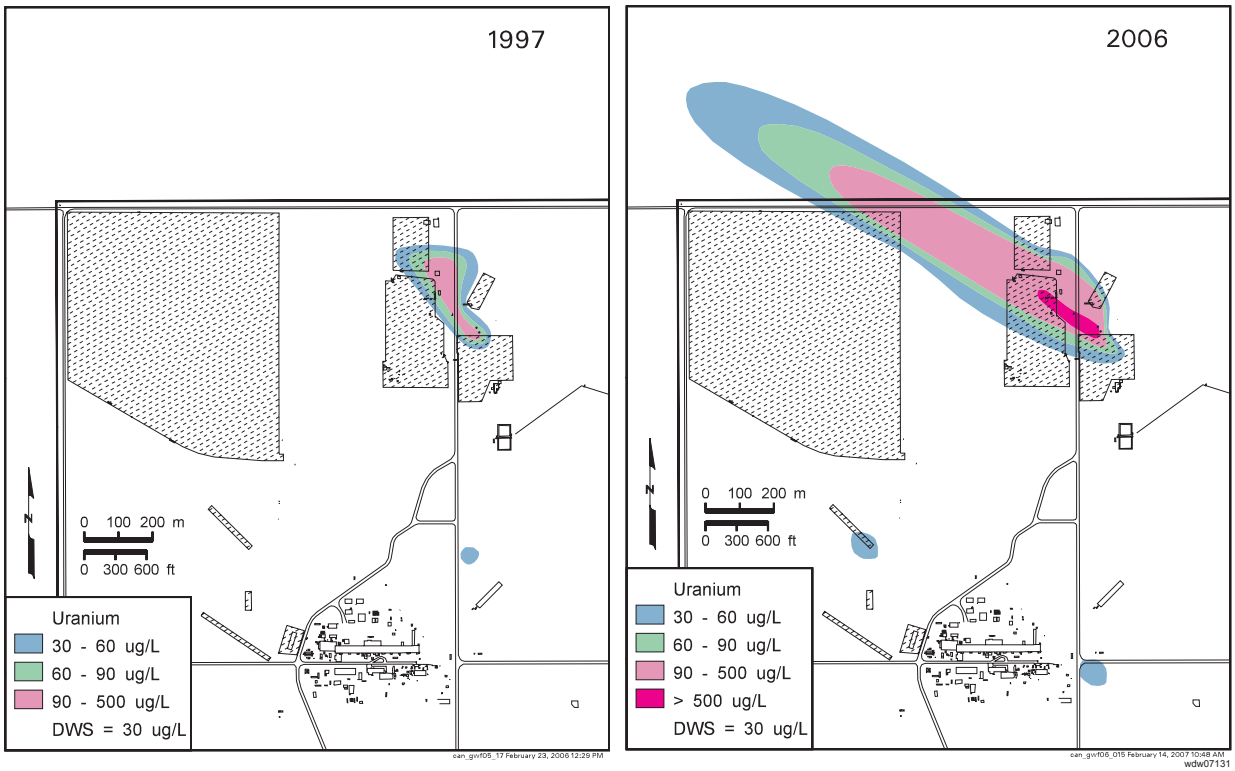
A uranium plume continues to reside below the B-BX-BY tank farms and has spread to the northwest.

Groundwater monitoring under CERCLA continued in FY 2006. No active groundwater remediation is being undertaken in this operable unit, and final remediation decisions are yet to be made.

Five facilities in the 200-BP-5 Operable Unit are monitored under RCRA in conjunction with CERCLA and AEA. Monitoring activities are summarized in the following paragraphs.

Waste Management Area B-BX-BY. RCRA assessment monitoring continued at this site in FY 2006. Contaminants include uranium, technetium-99, and nitrate. Concentrations of these contaminants continued to increase to new maximum levels in FY 2006.

Waste Management Area C. This site continued to be monitored under an interim status RCRA detection program in FY 2006, but is sampled quarterly at Ecology's request. RCRA indicator parameters did not exceed critical mean values. However, nitrate, technetium-99, and sulfate are elevated in the groundwater near the waste management area. Concentrations of sulfate in upgradient wells indicate an upgradient source. Although high levels of technetium-99 have been observed upgradient in the past, the plume is currently



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

affecting only downgradient wells at levels above the drinking water standard (900 pCi/L). Cyanide, a tank waste constituent, continued to be detected in an upgradient well at levels below the drinking water standard.

Nitrate, technetium-99, and sulfate are elevated near Waste Management Area C.

216-B-63 Trench. This RCRA site continued to be monitored under an interim status detection monitoring program.

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 were reported previously and do not appear to indicate contamination from the waste management area. Specific conductance and major ions increased sharply in one well. The transient nature of these changes suggests that the well is near a localized plume.

Low-Level Waste Management Area 2. This site continued to be monitored under RCRA interim status requirements. Two more wells in this area went dry in early FY 2006. Most wells in the north part of the waste management area are dry, and the water table has dropped below the top of basalt bedrock surface.

Liquid Effluent Retention Facility. The water table has dropped below the top of basalt in all but two monitoring wells. A 2001 letter from Ecology directed DOE to discontinue RCRA statistical evaluation of groundwater sample results. DOE has continued to sample the two remaining wells but is not conducting statistical analyses of the results. DOE and Ecology are pursuing an agreement for permit conditions for environmental monitoring.

200-PO-1 Operable Unit

A complete discussion of the 200-PO-1 Operable Unit can be found in Section 2.11. This operable unit encompasses the south portion of the 200 East Area and a large portion of the Hanford Site extending to the east and southeast that is contaminated with plumes of tritium, nitrate, and iodine-129 that exceed drinking water standards. Concentrations of tritium continued to decline as the plume attenuates naturally due to radioactive decay and dispersion. Other contaminants include strontium-90 and technetium-99, but these are limited to very small areas near cribs or tank farms.

CERCLA groundwater monitoring continued in FY 2006 under a revised sampling and analysis plan. Currently, no active groundwater remediation is occurring in this operable unit and final remediation decisions are yet to be made.

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

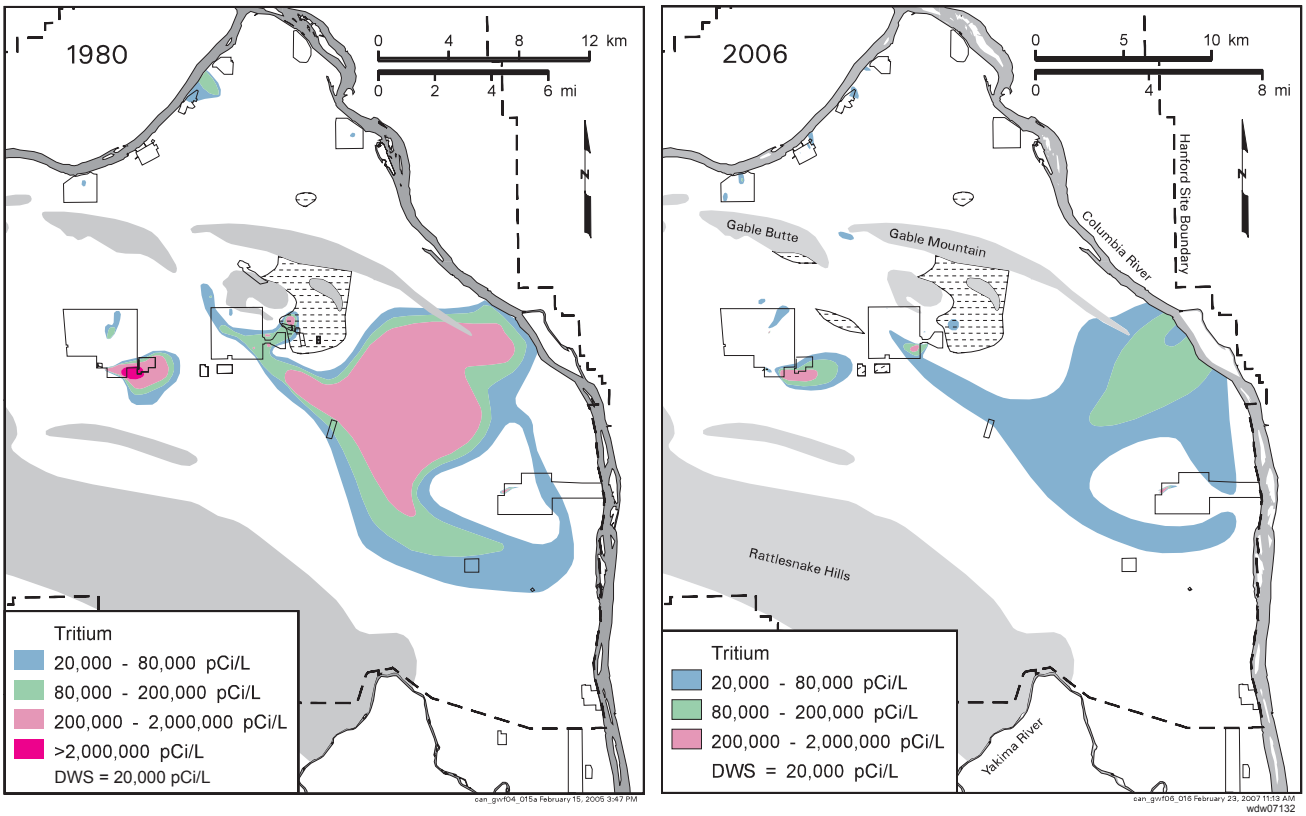
Groundwater is monitored at eight regulated units in the 200-PO-1 Operable Unit. Water supply wells in the 400 Area, which falls within the footprint of the 200-PO-1 Operable Unit, also are monitored.

Integrated Disposal Facility. This facility will be an expandable, lined, RCRA-compliant landfill. The facility is scheduled to receive its first waste in 2010. Background monitoring was completed in FY 2006. Until the facility begins to operate, results from semi-annual monitoring will be added to the background data set.

PUREX Cribs. Three cribs (216-A-10, 216-A-36B, and 216-A-37-1) are monitored jointly under a RCRA interim status assessment program, CERCLA, and AEA. The 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. A revised monitoring plan was implemented in FY 2006.

Waste Management Area A-AX. RCRA assessment monitoring continued in FY 2006. Technetium-99 concentrations increased in FY 2006 and now exceeds the drinking water standard (900 pCi/L) in two wells.

216-A-29 Ditch. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations. Except for specific conductance, RCRA indicator parameters in downgradient wells did not exceed critical mean values in FY 2006. Specific conductance continued to exceed its critical mean value in downgradient



These maps show site-wide tritium plumes in the upper part of the unconfined aquifer in 1980 and 2006. Concentrations in the core of the plume have decreased over the years; the south margin has ceased its southward migration.

wells as groundwater quality returns to ambient conditions in response to the cessation of effluent disposal at B Pond. Groundwater quality beneath the ditch closely resembles regional patterns.

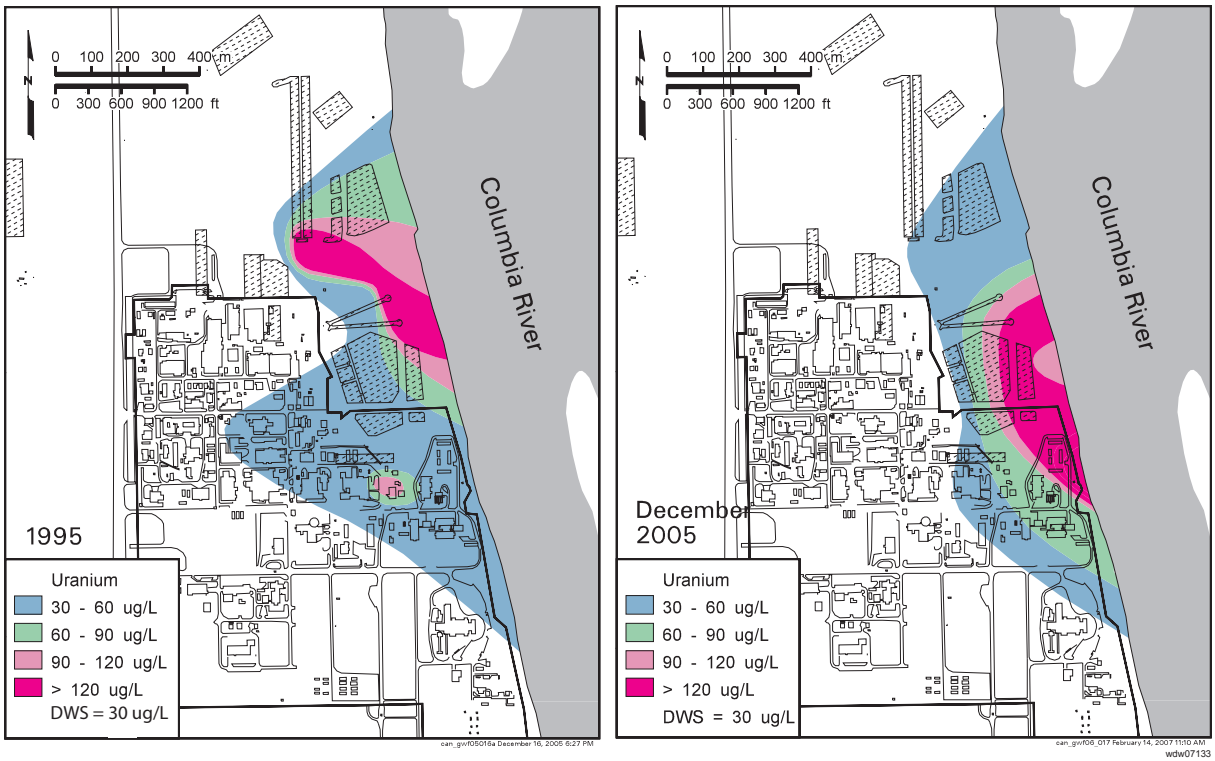
216-B-3 Pond. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations.

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 2006. The groundwater monitoring network continues to show that effluent from the facility is not taking a direct route to the uppermost aquifer, which is confined.

Nonradioactive Dangerous Waste Landfill. This RCRA site is located in the 600 Area, within the footprint of the 200-PO-1 regional plume. Interim status detection monitoring continued FY 2006.

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, and sulfate, and lower pH than upgradient wells. Some of these constituents may be related to past disposal of sewage materials to the Solid Waste 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 lies in the path of the site-wide tritium plume, the wells are routinely monitored for tritium. The main water supply well is completed deep in the unconfined aquifer and has low tritium values. Two backup



The uranium plume in the 300 Area, at the 30-µg/L level, is attenuating slowly. DOE is investigating alternatives for more rapid remediation.

wells are shallower and have higher tritium levels, but tritium concentrations in all samples were below the drinking water standard in FY 2006.

300-FF-5 Operable Unit

A complete discussion of the 300-FF-5 Operable Unit can be found in Section 2.12. This operable unit includes three geographic subregions: the 300 Area, the 618-11 burial ground subregion, and the 316-4 cribs/618-10 burial ground subregion. The operable unit is currently regulated under a record of decision that calls for continued monitoring of groundwater conditions and institutional controls on the use of groundwater as an interim action, until source remedial actions are complete. The operable unit includes groundwater associated with a former liquid waste disposal site regulated under a RCRA final status, corrective action monitoring program. In FY 2006, DOE installed 13 new wells for a uranium treatability test or aquifer characterization.

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

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 primary contaminant of concern and remains above the drinking water standard (30 µg/L) beneath part of the 300 Area.

Trichloroethene continued to be below the 5-µg/L drinking water standard in groundwater samples. However, during drilling of four characterization boreholes for the limited field investigation in the 300 Area, trichloroethene was found at unexpectedly high concentrations in water samples at a different depth than is routinely monitored by existing wells. The highest concentration was 630 µg/L in a deep sample from a well adjacent to the south side of 316-3 process trench. All of the samples with high concentrations came from a relatively fine-grained unit within the upper portion of the Ringold Formation.

Groundwater downgradient of the 618-11 burial ground is still contaminated by a high-concentration tritium plume, whose origin is believed to be irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from >8 million pCi/L in 2000 to 996,000 pCi/L in June 2006.

At the 316-4 cribs and 618-10 burial ground waste sites, uranium and tributyl phosphate are contaminants of potential concern. Both contaminants are associated with the 316-4 cribs, which were removed in 2004. Tributyl phosphate concentrations were elevated for a brief period in early 2004, along with uranium, during the period when crib removal actions were underway. Since then, concentrations have remained very low.

Groundwater characterization in the 300 Area found unexpectedly high levels of trichloroethene.

During excavation of the 618-2 burial ground in 2006, plutonium and other radiological contamination was detected unexpectedly. Some contamination was measured in a test pit excavated to the water table, leading to concerns about previously undetected impacts to groundwater. Increased monitoring was conducted at the nearest monitoring well (399-1-2) and no evidence for plutonium was uncovered to date. Previous measurements at other wells in the vicinity have not revealed detectable plutonium.

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 remedial investigations, 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. Key aspects of the Phase III feasibility study that continued during FY 2006 included a limited field investigation, three-dimensional computer modeling of groundwater flow and uranium transport, laboratory studies associated with potential remedial action technologies, and an updated risk assessment. During FY 2006, DOE assembled an inventory of potential remedial action technologies for reducing the level of uranium contamination in groundwater. Promising technologies include in situ methods to permanently sequester or reduce the mobility of uranium in the environment. Preliminary screening of these technologies was completed for two of three criteria—applicability and effectiveness. Screening for the third criterion, relative cost, will continue during 2007. A treatability test to immobilize uranium in the aquifer by injecting polyphosphate began in FY 2006.

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 the 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 that is completed near the bottom of the aquifer.

1100-EM-1 Operable Unit

In the 1100-EM-1 Operable Unit, trichloroethene concentrations continued to be below the cleanup level.

A complete discussion of the 1100-EM-1 Operable Unit, located in the south part of the Hanford Site, can be found in Section 2.13. Trichloroethene was the primary contaminant of concern. Contaminants also flow into the area from off-site sources (e.g., nitrate from agriculture and industry).

The final remedy selected for 1100-EM-1 Operable Unit groundwater is monitored natural attenuation of volatile organic compounds. Concentrations of trichloroethene have remained below the drinking water standard since FY 2001.

Wells in the city of Richland well field are monitored frequently to detect any changes in Hanford 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 Columbia River water, continued to be detected.

Uranium concentrations in wells downgradient of DOE's inactive Horn Rapids Landfill have been increasing since 1996, but remained below the 30-µg/L drinking water standard in FY 2006.

Confined Aquifers

A complete discussion of the confined aquifers can be found in Section 2.14. Although most of Hanford's groundwater contamination is in the unconfined aquifer, DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination and the potential migration of contamination offsite 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 lower mud unit. Groundwater in this aquifer flows generally west to east in the vicinity of the 200 West Area. In the central portion of the aquifer, flow appears to converge into the 200 East Area from the west, south, and east. Groundwater likely discharges from the confined aquifer to the overlying unconfined aquifer where the confining mud unit has been removed by erosion.

While effluent disposal was occurring at the B Pond system, mounding within the unconfined aquifer in this area forced groundwater a limited distance into the Ringold Formation confined aquifer. During FY 2006, four wells were sampled that are completed in the Ringold Formation confined aquifer. Iodine-129 in a single well was the only contaminant present at concentrations above the drinking water standard.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds. Groundwater in the upper basalt-confined aquifer generally flows from west to east across the Hanford Site, up through fractures or other pathways in the confining layers, into the unconfined aquifer, and into the Columbia River. Vertical gradients between the basalt-confined aquifer and the unconfined aquifer are upward on most of the Hanford Site. Downward gradients are measured in the west portion of the Hanford Site, near B Pond, and north and east of the Columbia River.

Cyanide, nitrate, and technetium-99 were elevated in only one basalt-confined well. Contaminant migration via the well bore during well construction is suspected.

In the area of Gable Mountain, shown above, erosion into the basalt or lack of deposition has resulted in isolated communication between the unconfined aquifer and the upper basalt-confined aquifer.

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 (see Section 2.14). Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits in the upper basalt-confined aquifer. Cyanide, nitrate, and technetium-99 were elevated in an upper basalt-confined aquifer well in the northwest part of the 200 East Area. Migration of high-salt waste from the vadose zone or unconfined aquifer via the well bore during well construction is responsible for this contamination.

Shoreline Monitoring

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 seepage points or springs. Results are discussed in the following paragraphs and along with other groundwater monitoring data in the applicable sections of this report.

Concentrations of strontium-90 continued to exceed the 8-pCi/L drinking water standard in aquifer tubes in the 100-BC-5 and 100-NR-2 interest areas. Levels exceed the 1,000-pCi/L derived concentration guide in 100-N Area tubes.

Tritium concentrations exceeded the 20,000-pCi/L drinking water standard in springs at the Hanford town site, but were below the standard in aquifer tube samples.

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.

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 seepage points or springs.

Nitrate concentrations exceed the 45-mg/L drinking water standard in aquifer tubes at the 100-K, 100-D, 100-H, and 300 Areas. Levels have exceeded the standard in a tube downgradient of the 100-F Area in the past, but the tube was not sampled in FY 2006. Levels and springs were below the standard.

Trichloroethene is detected in several aquifer tubes in the 300 Area. Most results were below the 5-µg/L drinking water standard, but one sample from September 2006 detected 96 µg/L in the deepest tube at site AT-3-3.

Wells Installed in 2006	
Interest Area or RCRA Site	Number of New Wells FY 2006
100-KR-4	4
100-NR-2	29
100-HR-3-H	2
200-ZP-1 vadose characterization	2
200-UP-1	6
300-FF-5	4
Low-Level Waste Management Areas 3 and 4	4
Waste Management Area T	2
Total	**53**

Well Installation, Maintenance, and Decommissioning

A complete discussion of the well installation, maintenance, and decommissioning can be found in Chapter 4. DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that are no longer needed. Ecology, EPA, and DOE worked together to develop a prioritized list of new wells needed to meet requirements of various groundwater monitoring regulations. Fifty-three new wells were installed during FY 2006. These include monitoring wells and wells to support tests of new technologies for groundwater remediation.

Approximately 7,544 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, a total of 3,094 (41%) have been either administratively removed from the well inventory or decommissioned (sealed with grout) because they were no longer needed, were in poor condition, were in the path of intended remediation or construction activities, or posed an environmental, safety, or public health hazard. 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 2006, a total 2,934 wells were in use and 82 vadose zone wells were physically decommissioned (filled with grout).

During FY 2006, 82 unneeded wells were physically decommissioned and filled with grout; 2,934 wells remain in use.

Based on groundwater monitoring requirements, DOE, EPA, and Ecology agree on new wells needed and prioritize the requirements of RCRA, CERCLA, and AEA. During FY 2006, 53 new wells were installed on the Hanford Site:

- ***Sixteen for CERCLA/RCRA/AEA monitoring (fulfilling Tri-Party Agreement Milestone M-24-57 commitments).***
- ***Thirty-seven to support groundwater contaminant barrier studies, treatability testing, and ongoing or new groundwater investigations.***

Well maintenance is performed to support groundwater sampling. Non-routine maintenance varies and depends on specific problems identified in the field. During FY 2006, 209 wells received non-routine maintenance.

Wells are decommissioned when they are no longer used; they are in poor condition; they pose an environmental, safety, or health hazard; or they are in the path of remediation activities. During FY 2006, 82 vadose zone monitoring wells were decommissioned. Another 357 wells were administratively decommissioned during FY 2006.

Vadose Zone

Subsurface source characterization, vadose zone monitoring, soil-vapor monitoring, and sediment sampling were conducted in FY 2006. The complete discussion of these activities can be found in Chapter 3.

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. The facility is lined, and there is no evidence of impacts to groundwater.

Leachate and Soil-Gas Monitoring at 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.

DOE conducted vadose zone sampling inside tank farms in FY 2006.

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 2006, ~78,900 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Tank Farms Investigations. DOE conducted a series of sampling efforts inside tank farms during FY 2006. To accomplish the work, a recently developed version of direct push technology was used. This direct push approach, the Hydraulic Hammer Unit, was demonstrated in several areas both inside and outside of the tank farms. The Hydraulic Hammer Unit provides optimal mobility for operating in the tank farm environment where infrastructure precludes access by many larger pieces of drilling equipment. Rates of advancement are as high as a few meters per minute.

The hydraulic hammer is a tool that is helping to improve the characterization of contaminants in the vasdose zone.

In FY 2006, DOE conducted investigations of the T and S Tank Farms and surrounding areas for subsurface contamination using electrical resistivity methods. The primary objective of this investigation was to demonstrate the ability to map subsurface contamination in and around the tank farms using electrical resistivity methods. The results show that the demonstration was successful and that technical challenges associated with deploying these methods in a tank farm environment can be managed by a combined analysis of data acquired from both surface electrodes and steel-cased wells. Additionally, the method provides a basis for defining regions that are free from contamination.

Hanford scientists performed detailed analyses on vadose zone sediments from C Tank Farm. In FY 2006, a report was published containing all the geologic, geochemical, and selected physiochemical characterization data collected on vadose zone sediment recovered from two boreholes. Results indicated there is no similarity between the present or past groundwater contamination and current pore water compositions from the contaminated borehole sediments.

Borehole Geophysics. Radiation measurements by borehole geophysical methods have been performed since the early days of the Hanford Site to detect manmade radionuclides in the subsurface. During 2006, DOE logged 128 boreholes. Of these, eight were classified as baseline logging. Sixty-nine, or more than half, were logged in support of the well decommissioning program. Another 29 boreholes were logged in support of remedial investigation efforts, and 22 groundwater wells were logged.

Tank Farm Interim Cover Test. The largest known Hanford Site tank leak occurred from the T-106 tank in 1973. Many of the contaminants from that leak still reside within the vadose zone beneath the T Tank Farm. DOE seeks to minimize movement of this residual contamination by placing an interim cover on the surface. In FY 2006, two instrument nests were installed to monitor the future cover. Each instrument nest contains a neutron probe access tube, five sensors to measure water content, four heat-dissipation units to measure water potential, and a drain gauge to measure soil water flux.

Continued Monitoring

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.

As such, 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/.

Glossary

Aquifer – A water-bearing, geologic formation below the surface of the earth that can supply water for a well or spring.

CERCLA – *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (42 USC 9601 et seq. as amended); federal law, enacted in 1980 and amended in 1986, that governs the cleanup of hazardous, toxic, and radioactive substances.

Confined aquifer – An aquifer bounded above and below by less-permeable layers. Groundwater in the confined aquifer is under a pressure greater than atmospheric pressure. Aquifers within the Columbia River Basalt underlying the Hanford Site are confined aquifers.

Groundwater – Groundwater is water that occurs below the earth's surface. It is found within the pores of sand and gravel or the cracks of fractured rock beneath the land and is invisible to the naked eye. Gravity causes groundwater under the Hanford Site to move toward the Columbia River. In this manner, groundwater may carry contamination from Hanford into the river.

Pore water – Water in the minute spaces of the substrate that forms the bottom of the Columbia River; for example, groundwater in springs between rocks.

RCRA – *Resource Conservation and Recovery Act of 1976* (42 USC 6901 et seq. as amended, Public Law 94-580); federal law enacted in 1976 to address the treatment, storage, and disposal of hazardous waste.

Unconfined aquifer – An aquifer containing groundwater that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At Hanford, the unconfined aquifer is the uppermost aquifer and is most susceptible to contamination from site operations.

Vadose zone – The hydrogeologic region between the surface of the land and the water table.

Water table – Theoretical surface represented by the elevation of water surfaces in wells penetrating only a short distance into the unconfined aquifer.

More information about the Hanford Site Groundwater Remediation Project is available online at http://www.hanford.gov/cp/gpp.

This report is available from the U.S. Department of Energy's Information Bridge at http://www.osti.gov/bridge/