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Revision 0

Hanford Site Groundwater Monitoring for Fiscal Year 2007

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

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Abstract

This report presents the results of groundwater monitoring for fiscal year (FY) 2007 on the U.S. Department of Energy's (DOE's) Hanford Site in southeast Washington. Results of groundwater remediation and vadose zone studies are summarized.

Contaminant plumes occupy an area of ~183 square kilometers at levels exceeding one or more drinking water standards, compared to the total area (1,500 square kilometers) of the Hanford Site. The most extensive contaminant plumes in groundwater are tritium, iodine-129, and nitrate. These contaminants originated from multiple sources and are very mobile in groundwater. The largest portions of these plumes are migrating from the central Hanford Site to the southeast, toward the Columbia River, and concentrations generally are declining. Carbon tetrachloride and associated organic constituents form a relatively large plume beneath the west-central part of the Hanford Site. Hexavalent chromium is present in plumes beneath the reactor areas along the river and beneath the central part of the site. Strontium-90 concentrations exceed drinking water standards beneath portions of all but one of the reactor areas. Technetium-99 and uranium plumes exceeding standards are present in the 200 Areas. A uranium plume exceeding standards also underlies part of the 300 Area. Small contaminant plumes with concentrations greater than standards include carbon-14, cesium-137, cis-1,2-dichloroethene, cyanide, fluoride, plutonium, and trichloroethene.

Levels of some contaminants exceed drinking water standards in water samples collected from aquifer sampling tubes along the river shore. The most significant exceedances were strontium-90 in the 100-N Area, chromium in the 100-D Area, and uranium in the 300 Area. Uranium also exceeded the drinking water standard in a riverbank spring in the 300 Area. Tritium was near the drinking water standard in a spring at the former Hanford town site.

Monitoring for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) is conducted in 11 groundwater operable units. The purpose of this monitoring is to define and track plumes and to monitor the effectiveness of interim remedial actions. Interim groundwater remediation in the 100-K, 100-D, and 100-H Areas, using a combination of pump-and-treat and in situ methods, continued to reduce the amount of chromium reaching the Columbia River. An in situ treatment system for strontium-90 is being implemented in the 100-N Area. A pump-and-treat system and a soil-gas extraction system in the northern half of the 200 West Area continued to be used to decrease the spread of the carbon tetrachloride plume. A pump-and-treat system for technetium-99 and uranium in the south part of the 200 West Area was restarted in FY 2007.

Resource Conservation and Recovery Act (RCRA) groundwater monitoring continued at 25 waste management areas during FY 2007:

- 15 under interim or final status detection programs, with the objective of determining whether or not they are adversely affecting groundwater
- 8 under interim status groundwater quality assessment programs to assess contamination
- 2 under final status corrective-action programs

During calendar year 2007, drillers completed 57 new wells for monitoring, remediation, or characterization. Ninety-one unneeded wells were decommissioned (filled with grout).

This report is available on the Internet through the Hanford Site Groundwater Remediation Project (http://www.hanford.gov/cp/gpp).

Acknowledgements

This report represents the work of dozens of people who contribute to the Soil and Groundwater Remediation Project: planners, schedulers, samplers, laboratory technicians, data management staff, scientists, editors, and graphics staff.

We greatly appreciate the expertise of our technical editor, Launa Morasch. Her contributions help make the report more consistent and intelligible... not an easy task with such a large team of scientist-authors.

The graphics and production team included Angela Corbett, John McDonald, Chris Newbill, Julie Rediker, JoAnne Rieger, and Wally Williams. JoAnne Rieger also retrieved and formatted data for maps and tables. We are grateful for their willingness to put in long hours and their ability to maintain a healthy sense of humor when it was most needed.

Thanks also to the many reviewers whose comments and suggestions helped us improve this report.

Mary Hartman
Bill Webber

Report Contributors

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Acronyms and Abbreviations

AEA	*Atomic Energy Act*
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
DOE	U. S. Department of Energy
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U. S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FY	fiscal year
HEIS	Hanford Environmental Information System
HWIS	Hanford Well Information System
LIGO	Laser Interferometer Gravitational Wave Observatory
LLBG	low-level burial ground
PUREX	Plutonium-Uranium Extraction (Plant)
QA	quality assurance
QC	quality control
RCRA	*Resource Conservation and Recovery Act*
REDOX	Reduction Oxidation (Plant)
ROD	record of decision
SALDS	State-Approved Land Disposal Site
TEDF	Treated Effluent Disposal Facility
TPA	Tri-Party Agreement
WIDS	Waste Information Data System
WMA	waste management area

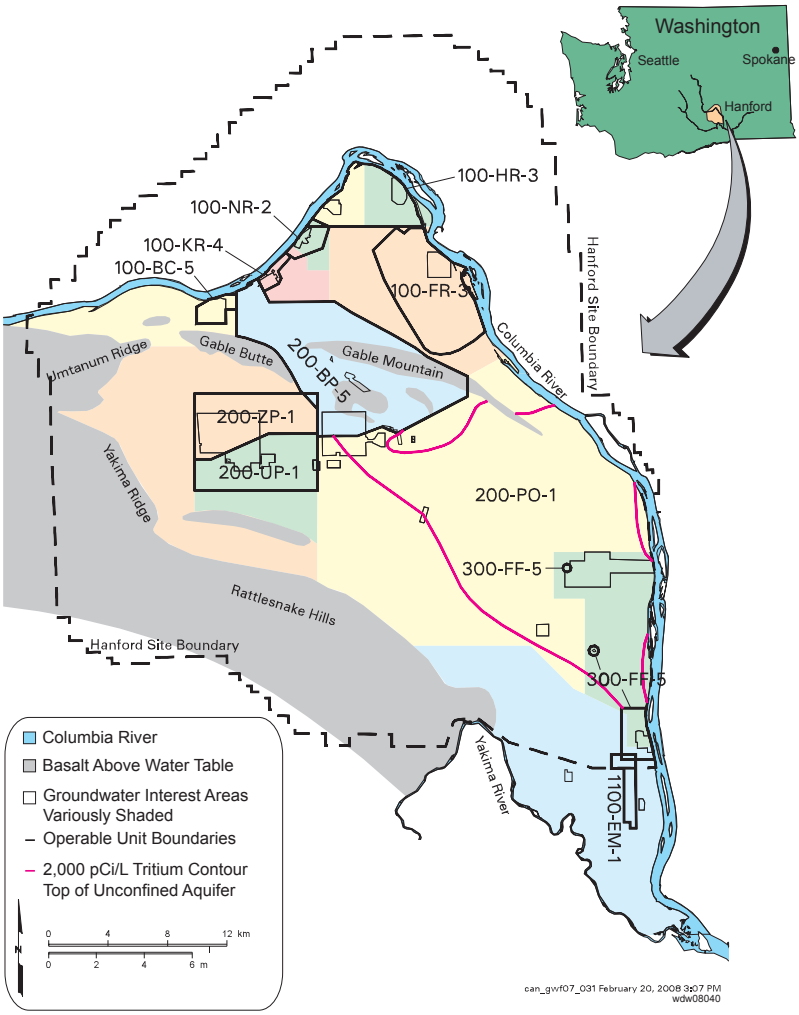
Summary

Introduction

The Hanford Site, part of the U.S. Department of Energy's (DOE) nuclear weapons complex, encompasses ~1,500 square kilometers in southeast Washington State. The Columbia River flows through the site. The federal government acquired the Hanford 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 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, human health, and the environment from Hanford's contaminated groundwater. As part of this commitment, DOE updated their groundwater management plan in 2007. The 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.

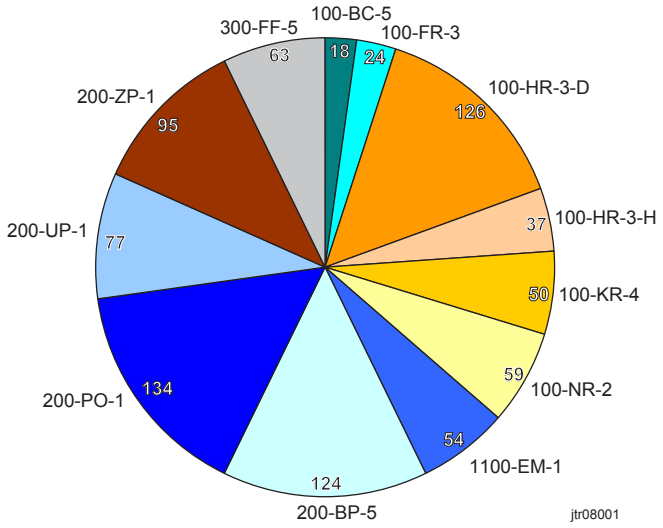
DOE monitors groundwater at the Hanford Site to fulfill a variety of state and federal regulations, including the *Atomic Energy Act* (AEA), the *Resource Conservation and Recovery Act* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and *Washington Administrative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

DOE Order 450.1, "Environmental Protection Program," implements requirements of the AEA. This Order requires environmental monitoring to detect, characterize, and respond to releases from 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.

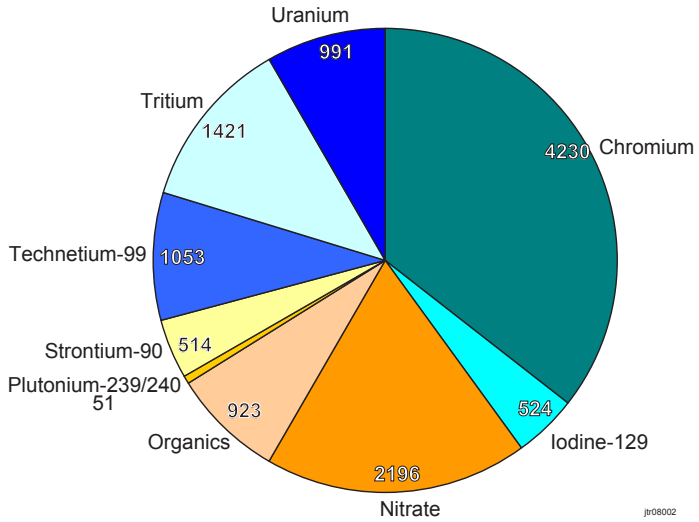
DOE sampled 861 wells during FY 2007. Chromium, nitrate, and tritium are constituents most frequently analyzed.

The Hanford Site has been divided into 56 operable units, or groupings of similar waste units within a geographic area, so that the CERCLA process can be efficiently implemented. Forty-six are source operable units and 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 wide spread, mingled contamination in groundwater. Monitoring wells are located and sampled in accordance with remedial investigation/feasibility study work plans to define the nature and extent of the contaminant plumes. Groundwater also is monitored under CERCLA to assess the effectiveness of groundwater remediation.

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 monitoring as specified in WAC 173-303-645. RCRA units that have not yet been incorporated into permits require interim-status monitoring as specified in WAC 173-303-400, which invokes 40 CFR 265.



This chart shows the number of wells sampled in each groundwater interest area in FY 2007.



The groundwater project requests specific laboratory analyses based on the wells location, historical contaminant trends, and regulatory requirements. This graph shows the number of analyses for the most common constituents during FY 2007.

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.
- **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.

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

Some contaminants reached the Columbia River by moving downward from waste sites, through the vadose zone, into the groundwater, and then into the river. Sampling groundwater helps determine how the contaminants move through the environment. DOE works with regulatory agencies such as the Environmental Protection Agency (EPA) and Ecology to make cleanup decisions based on sound technical information.

In fiscal year (FY) 2007, workers sampled 861 monitoring wells and 202 shoreline aquifer tubes to determine the distribution and movement of contaminants. This was an increase from the previous fiscal year of more than 84 wells. Many of the wells were sampled multiple times during the year.

A total of 4,230 samples of Hanford groundwater were analyzed for chromium, 2,196 for nitrate, and 1,421 for tritium. Other constituents frequently analyzed include technetium-99 (1,053), uranium (991), and carbon tetrachloride (923). These totals include results for routinely sampled groundwater wells, pump-and-treat operational samples, and aquifer tube samples.

Emerging Items of Interest

This section briefly describes some of the high-priority groundwater topics for FY 2007. The groundwater chapter (2.0) of the full report contains additional details.

Integrating Hanford's Groundwater and Vadose Zone Activities. DOE has instituted a series of business processes to enhance integration across the projects engaged in groundwater and vadose zone activities at Hanford. Integrated Project Teams have been formed to ensure effective coordination of field investigations and timely communication of emerging data.

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

CERCLA Five-Year Review. In November 2006, DOE published the second five-year review of records of decision for remedial actions. The purpose of the review was to evaluate whether the remedies protect human health and the environment. The review recommended several actions relating to groundwater and DOE began to work on these in FY 2007, as discussed in the body of this report. More information on the five-year review is available at: http://www.hanford.gov, "CERCLA Five-Year Review."

KW Reactor Chromium Plume. In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. A new pump-and-treat system began to operate in FY 2007 and removed 15.8 kilograms of chromium from groundwater.

100-N Apatite Barrier. Workers injected apatite-forming chemicals into a line of wells along the 100-N Area shoreline in spring and summer 2007. Strontium-90 concentrations initially increased in many wells, but then declined to levels below those observed before treatment began.

A new treatment system in the 100-N Area, apatite sequestration, is immobilizing strontium-90 in the aquifer.

100-HR-3 Characterization and Testing. DOE installed 26 wells in the 100-HR-3 Operable Unit in FY 2007. The objectives of this work were to (a) characterize the chromium plume between 100-D and 100-H Areas; (b) locate the source of the chromium plume in south 100-D Area; (c) characterize deep chromium contamination, (d) test biostimulation, an in situ remediation method for chromium; (e) test micron-size iron injection, a method to increase effectiveness of the redox barrier in 100-D Area; and (f) test electrocoagulation, a water-treatment process.

200-ZP-1 Pump-and-Treat Expansion. DOE issued a draft feasibility study and proposed plan for groundwater remediation in September 2007. The goal is to design a remediation system to remove carbon tetrachloride throughout the vertical extent of the aquifer. The expanded system will affect groundwater flow and contaminant movement through much of the operable unit.

Treatability Test for Technetium-99 in 200-ZP-1 Extraction Wells. Groundwater in two of the carbon tetrachloride extraction wells west of Waste Management Area TX-TY have increasing technetium-99 concentrations. In FY 2007, DOE ran a treatability test to remove technetium-99 prior to carbon tetrachloride treatment so the radionuclide would not contaminate the groundwater around injection wells. The treatability test ran through October 2007, and results will be used to determine further actions.

Technetium-99 Extraction at Waste Management Area T. Two wells downgradient (east) of Waste Management Area T, in the 200 West Area, were converted to extraction wells in May 2007. The wells are screened at the top of the aquifer and technetium-99 concentrations were over 22,000 pCi/L in one of the wells in FY 2007.

200-UP-1 Pump-and-Treat. DOE restarted the pump-and-treat system for technetium-99 and uranium after a 2-year hiatus. Although concentrations had not risen to levels above current remedial action goals, DOE anticipated the cleanup goal for uranium changing to a lower concentration.

300-FF-5 Studies. Scientists continued an aggressive campaign to investigate the uranium plume in the 300 Area in FY 2007. They updated computer simulations of groundwater flow and uranium transport, conducted a limited field investigation involving multiple characterization boreholes, updated the human health and ecological risk assessment, and assessed potential remedial action technologies for the uranium plume. DOE also continued to investigate the distribution of organic contaminants in groundwater beneath the 300 Area.

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." DOE's Office of Environmental Management (EM-22) administers these funds. Fluor Hanford, Inc. is leading the research on the following studies, which are summarized in this document:

- 100-D Area south chromium plume
  - Inject micron-size iron into the deteriorating portions of the redox barrier.
  - Refine location of the chromium source.
- 100-D Area north chromium plume
  - Field test electrocoagulation for accelerated cleanup.

Pacific Northwest National Laboratory is leading the research on other EM-22 projects:

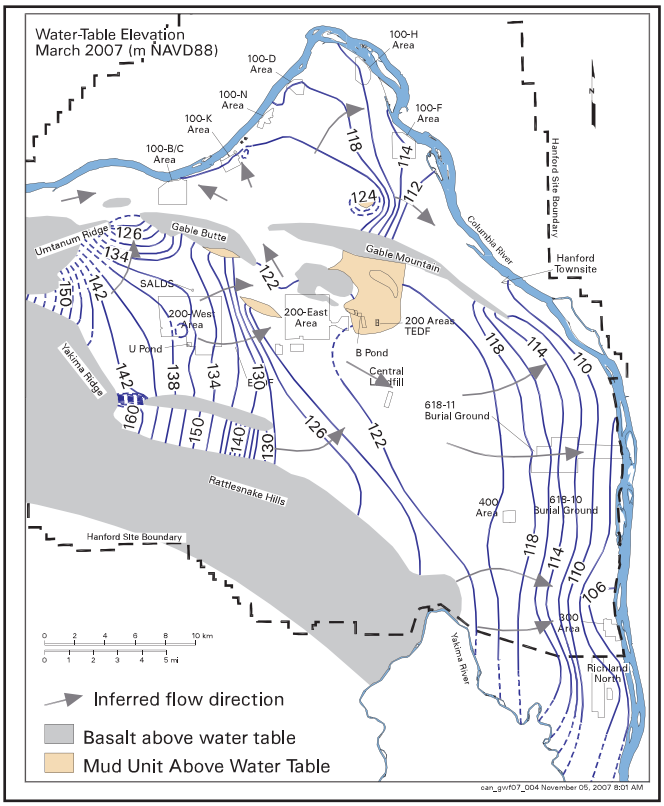
- Characterize chromium geochemistry in 100 Areas vadose zone sediment.
- Test biostimulation for remediation of chromium in 100-D Area.
- Investigate phytoremediation for strontium-90 in 100-N Area.
- Treat vadose zone strontium-90 in 100-N Area with surface infiltration of apatite.
- Study carbon tetrachloride and chloroform attenuation parameters.
- Stabilize uranium plume in 300 Area using polyphosphate.

More information on the EM-22 projects is available at http://www.hanford.gov/cp/ gpp/science/em21.cfm.

Groundwater Flow

General directions of groundwater flow are illustrated on the water-table map for March 2007. 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 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 a gap between Gable Butte and Gable Mountain (Gable Gap) and some moving southeast toward the central part of the site. This groundwater divide is located near the



This map shows the water table and inferred flow directions in March 2007. Areas shaded in gray or tan show where the unconfined aquifer is absent.

northwest 200 East Area, but its precise location is not known. Ongoing studies will help determine the direction of groundwater flow in this region. In the south 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 waste water 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, waste water 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.

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, where the water-table map is shaded tan, there is no unconfined aquifer, and groundwater in the Ringold Formation confined aquifer is still influenced by a residual recharge mound. Several wells north and east of the 200 East Area have shown evidence of intercommunication between the unconfined and confined aquifers. The intercommunication has been attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient. An upward gradient exists elsewhere in the 200 East Area/Gable Gap region, so it is expected that the upper basalt-confined aquifer discharges to the overlying unconfined aquifer, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

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.

Groundwater Monitoring and Remediation

DOE has developed a plan that lays out steps for cleaning up groundwater and the vadose zone. Key elements include:

- 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.

The maps on pages xviii and xix 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 extends 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, 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.

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

Constituent (drinking water standard)	Fiscal Year 2000	Fiscal Year 2006	Fiscal Year 2007
Carbon tetrachloride (5 µg/L)	9.8	9.8	10.1
Chromium (100 µg/L)	2.8	2.0	2.2
Iodine-129 (1 pCi/L)	90	67	64
Nitrate (45 mg/L)	36	40 [(a)]	37.3[(a)]
Strontium-90 (8 pCi/L)	2.8	2.4	2.3
Technetium-99 (900 pCi/L)	2.3	3.9[(b)]	2.3[(b)]
Trichloroethene (5 µg/L)	4.2	3.0	2.6
Tritium (20,000 pCi/L)	180	120	127
Uranium (20/30 µg/L)[(c)]	2.0	1.6	1.4
Combined Plumes[(d)]	230	190[(a)]	183[(a)]

(a) Excludes 1100-EM-1 plume from offsite sources.
(b) Change is the result of changing interpretation of plume 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 constituents above drinking water standards.

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-F and 200 West Areas; a single well exceeded the standard in the 100-K Area. Wells completed at depth in the aquifer in the 300 Area also detected trichloroethene at levels above the drinking water standard. Chromium at levels above the 100-µg/L drinking water standard underlies portions of the 100-K and 100-D Areas, and the 600 Area west of 100-H Area. Chromium exceeds the 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, particularly the north part of 200 West Area.

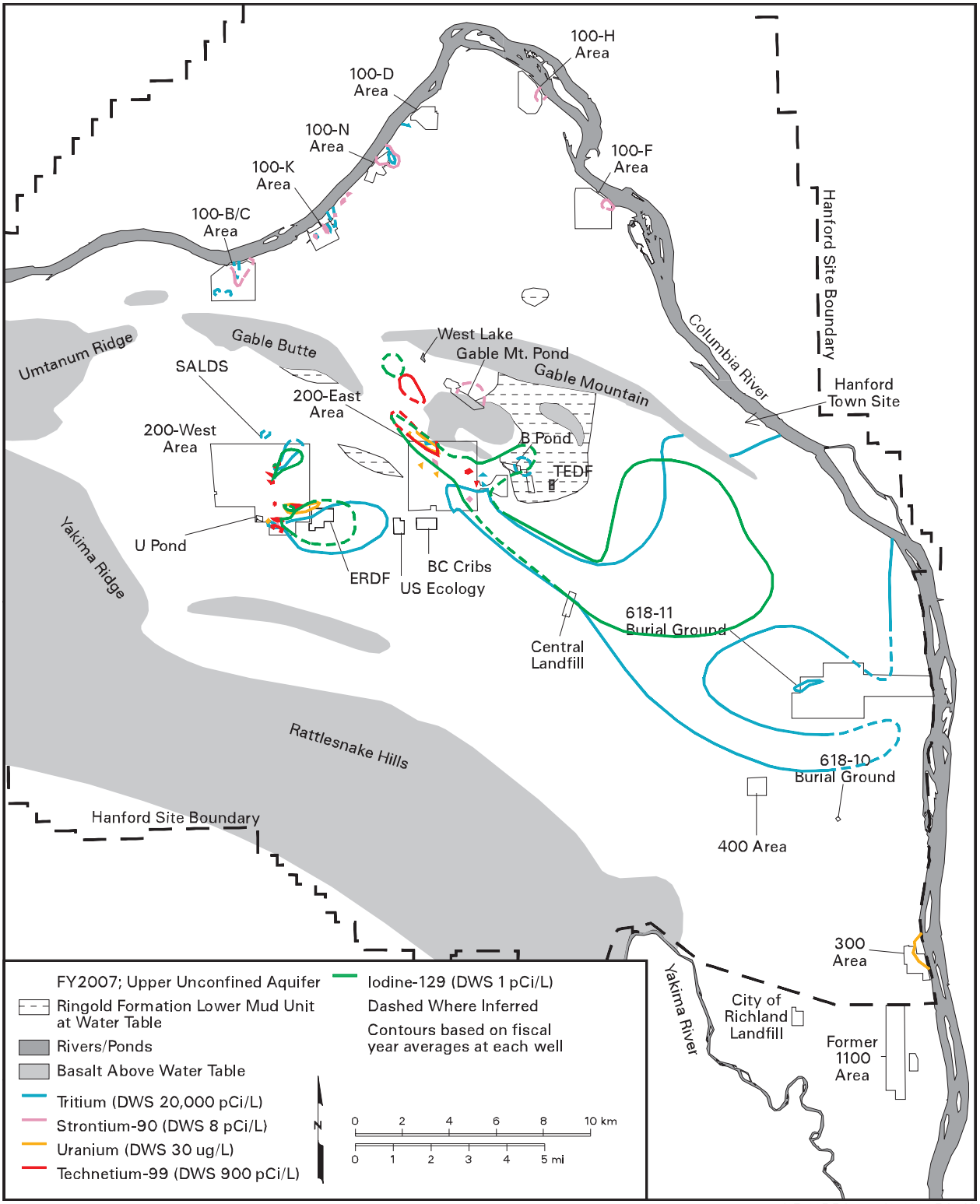
The following text discusses groundwater contamination, monitoring, and remediation for each of the 11 groundwater operable units and in the confined aquifers.

100-BC-5 Operable Unit

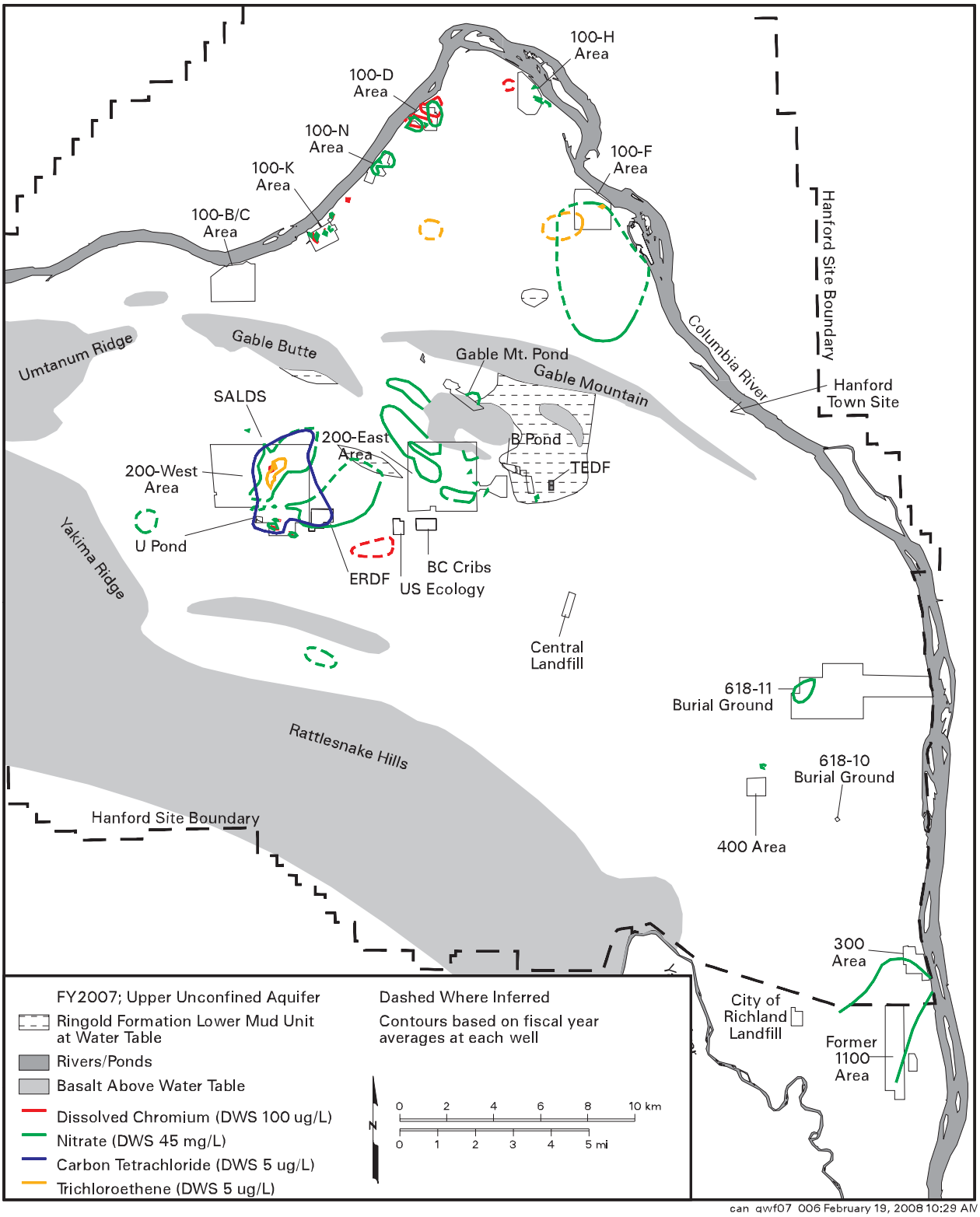
A complete discussion of the 100-BC-5 Operable Unit can be found in Section 2.2. Most of the groundwater contamination is found in the north portion of the area, beneath former waste trenches and retention basins. Tritium and strontium-90 exceeded drinking water standards in several wells. Tritium concentrations in two new wells in the south 100-B/C Area were unexpectedly high, exceeding the drinking water standard in one well. 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.

Two new wells in the south 100-B/C Area had elevated levels of tritium but low levels of chromium.

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.

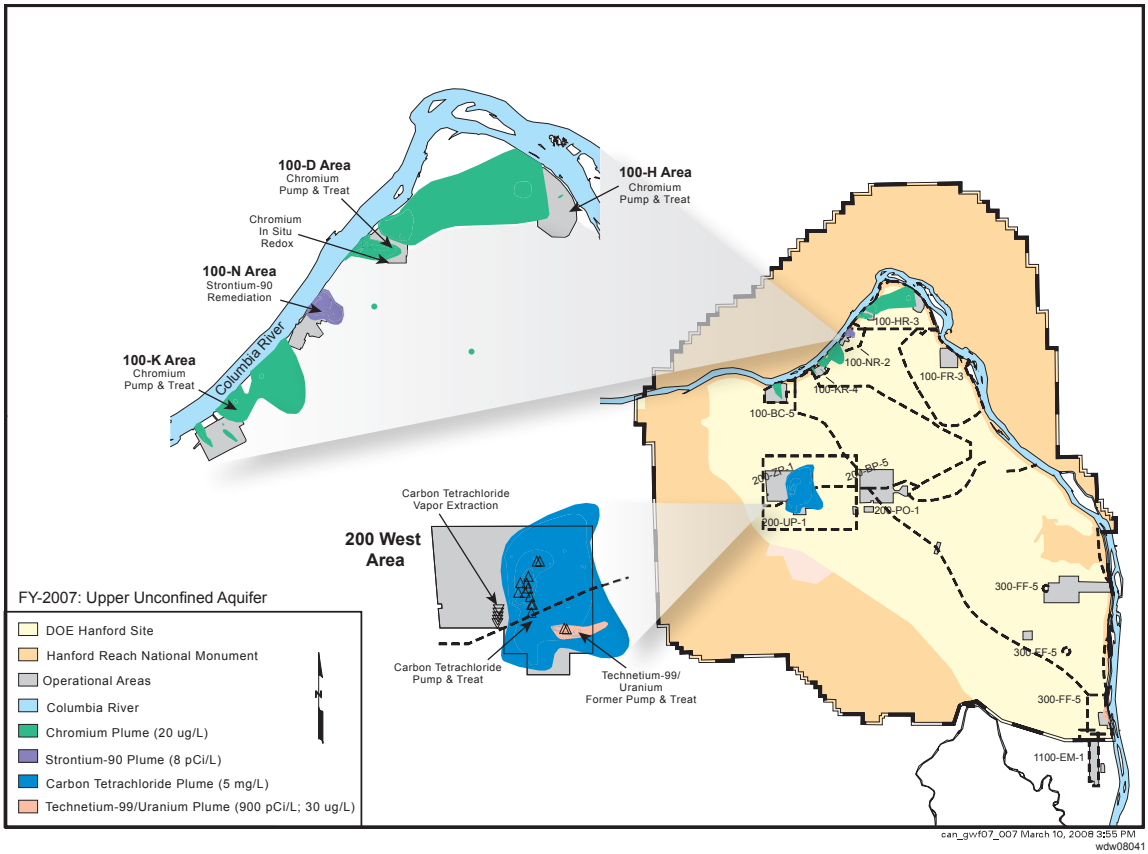


This map shows the distribution of radionuclides in groundwater at concentrations above drinking water standards during FY 2007 in the upper part of the unconfined aquifer.

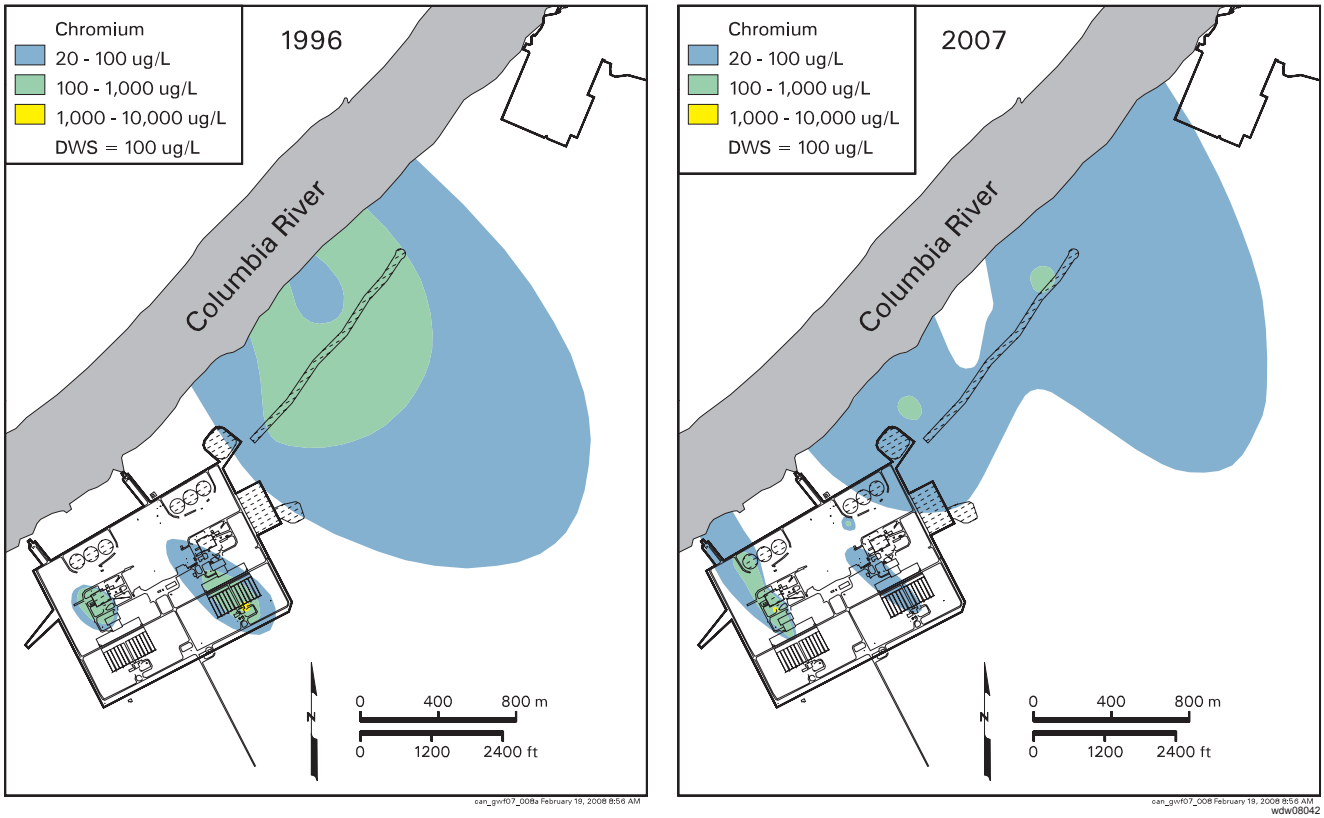


This map shows the distribution of hazardous chemicals in groundwater at concentrations above drinking water standards during FY 2007 in the upper part of the unconfined aquifer.

Groundwater Remediation		
Remedial Action Site	Startup Date	Progress From Startup to September 2007
100-K Area – 100-KR-4 Pump-and-Treat	1997	Decreases chromium to river; 328 kilograms removed.
100-N Area – 100-NR-2 Pump-and-Treat	1995	1.8 curies of strontium-90 removed. Extraction ceased March 2006. Injected apatite-forming chemicals to create permeable barrier in aquifer near shore.
100-D Area – 100-HR-3 Pump-and-Treat	1997	Decreases chromium to river; 264 kilograms removed.
100-D Area – DR-5 Pump-and-Treat	2004	Decreases chromium to river; 160 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; 49 kilograms removed.
200 West Area – 200-ZP-1 Pump-and-Treat	1994	Prevents high-concentration portion of carbon tetrachloride plume from spreading; 10,980 kilograms removed.
200 West Area – Soil-Vapor Extraction	1992	Reduces carbon tetrachloride movement to groundwater; 79,200 kilograms removed.
200 West Area – 200-UP-1 Pump-and-Treat	1994	System restarted January 2007. Decreases lateral migration of contaminants; 119 grams technetium-99 (2.02 curies) and 213 kilograms uranium removed.
Waste Management Area S-SX – Well 299-W23-19 Pump-and-Treat	2003	Decreased technetium-99 concentrations; 0.31 grams (0.0053 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.



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.

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) cleaning up of chromium in groundwater; (b) tracking plumes from past-practices sites; and (c) 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 being used to remove hexavalent chromium from the aquifer beneath the 116-K-2 infiltration trench. Approximately 312 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.

The 100-K Area pump-and-treat systems now address a region near the KW Reactor and a region near the 116-K-2 trench.

In 1998, chromium concentrations in groundwater near the KW Reactor began to rise. One new monitoring well had chromium concentrations >2,000 µg/L, higher than other wells in the area. In FY 2007, DOE began operating a new pump-and-treat system to clean up the KW plume. The system removed 15.8 kilograms of chromium during the year.

Monitoring Past-Practice Waste Sites. Other contaminants of potential concern in the operable unit are carbon-14, nitrate, strontium-90, trichloroethene, and tritium. Levels remain above drinking water standards, and decisions regarding groundwater remedial actions have been deferred until remedial actions of source areas are complete.

Strontium-90 levels rose sharply in some of the 100-N Area aquifier tubes in August 2007. The increase was likely caused by side effects of apatite injections in nearby wells. Levels are expected to decline.

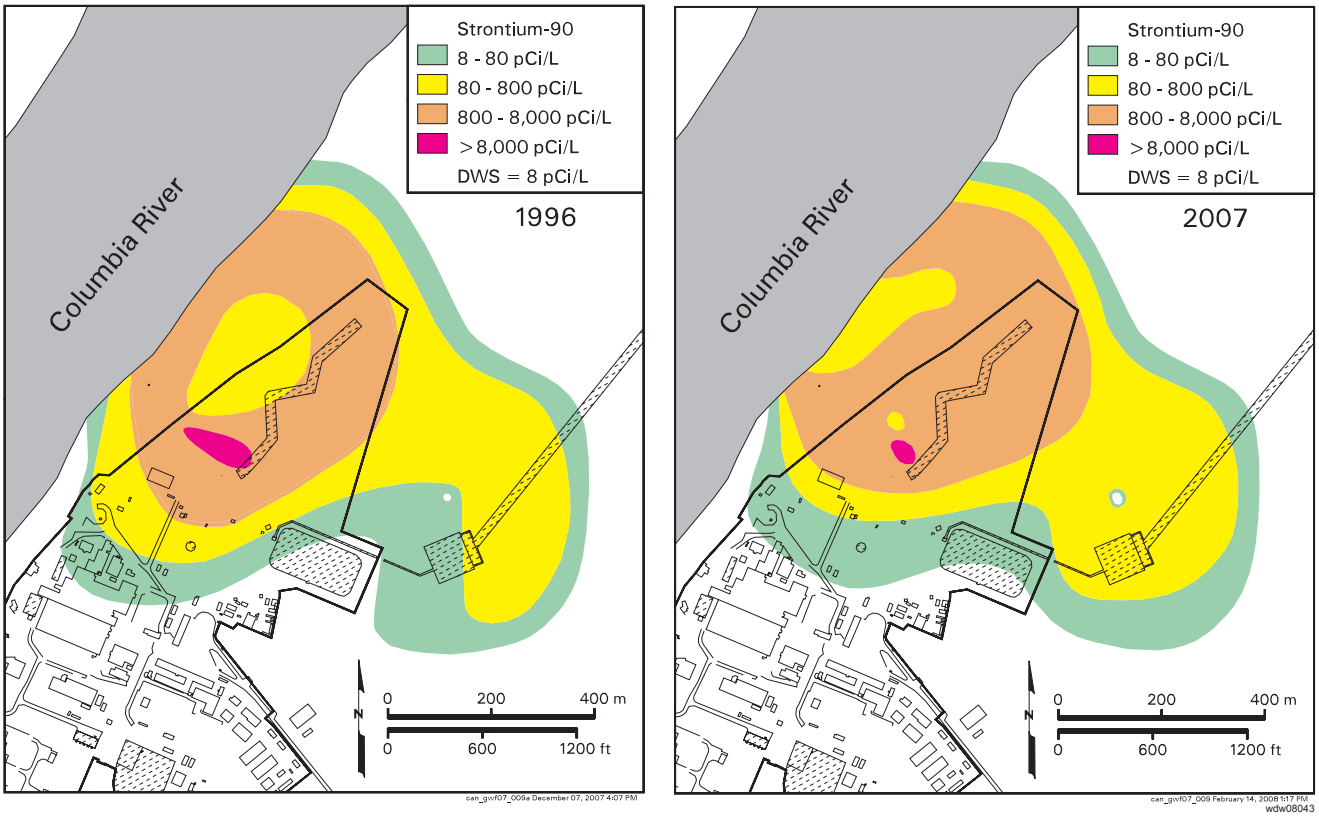
K Basins. The KE and KW Basins are integral parts of each reactor building. From the late 1970s to 2004, they were used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered from cleanup at other reactor areas. The basins still contain contaminated water, which DOE will remove in coming years. In FY 2007, monitoring of water levels in the basins and groundwater in downgradient wells indicated no new leaks.

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. Tritium, nitrate, sulfate, and petroleum hydrocarbons also are present in 100-N Area groundwater.

Interim Remedial Action. DOE is applying an in situ technology to immobilize strontium-90 in the aquifer to prevent it from entering the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shore in FY 2007. The goal is to create a permeable, reactive barrier that will capture strontium-90 as groundwater flows through it to the river. Monitoring shows strontium-90 concentrations declined below baseline levels within the barrier and in downgradient monitoring wells. However, strontium-90 concentrations increased to new maxima in aquifer tubes downgradient of the barrier.

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 2007, 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.



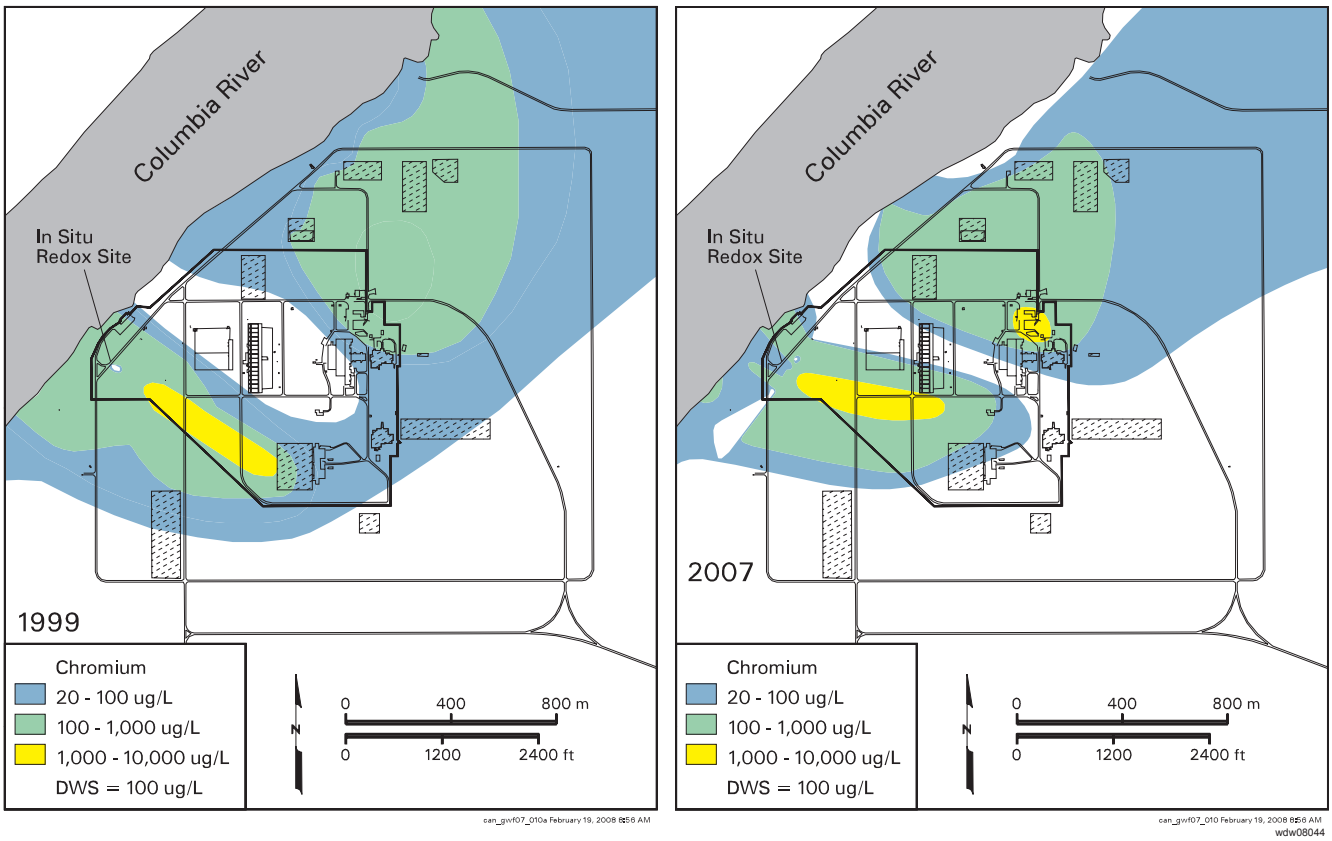
The overall shape of the 100-N strontium-90 plume at the 8-pCi/L level has not changed in many years, despite the operation of the pump-and-treat system from 1995 until March 2006.

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 disposal of reactor coolant, which contained sodium dichromate as a corrosion inhibitor. A second cause was periodic spillage and leakage of sodium dichromate stock solution to the ground. Chromium is distributed in north and southwest plumes. Other contaminant plumes include tritium and nitrate.

Three remediation systems in the 100-D Area operate to reduce the amount of chromium reaching the Columbia River. Data from new wells help characterize chromium in the vadose zone and east of the 100-D 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 2007, chromium concentrations remained above the remediation goal (22 µg/L) in compliance wells. The two extraction systems have removed 424 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 2007, concentrations in barrier wells ranged from below detection limits to 880 µg/L, with concentrations in ~69% 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.



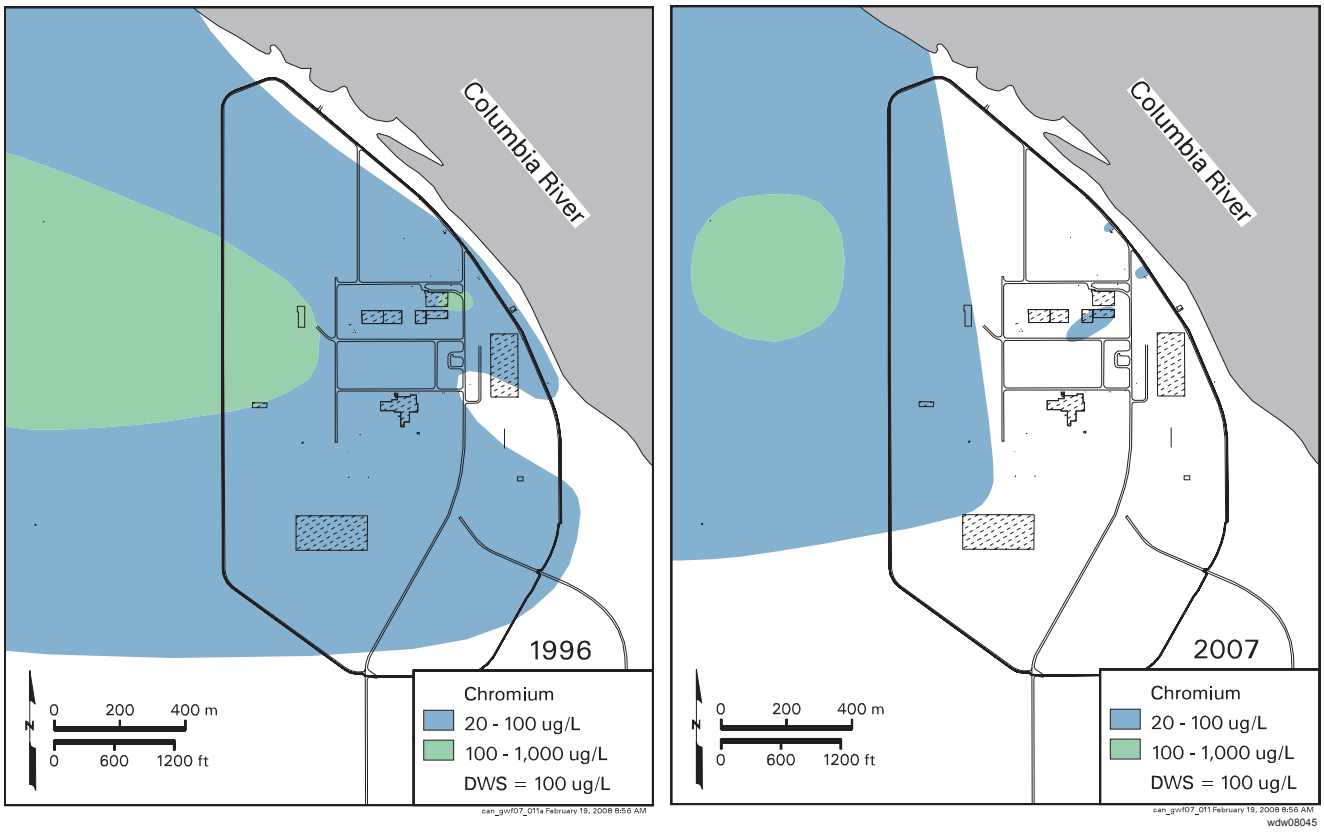
These maps show chromium plumes in the upper part of the aquifer in the 100-D Area. To reduce the amount of chromium entering the Columbia River, DOE operates two pump-and-treat systems in the north and an in situ treatment system in the south.

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

- *Chromium Source Investigation.* DOE installed wells to obtain samples from the vadose zone and to monitor groundwater near suspected sources in the south 100-D Area. Chromium levels in some of the wells were the highest ever observed in Hanford groundwater.
- *Chromium Plume in the Horn.* 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 >20 µg/L extend across the horn.
- *Micron-Size Iron Injection.* Scientists think that injecting tiny particles of iron into redox barrier wells will help "repair" the barrier where chromium has been breaking through. A contractor conducted laboratory tests in FY 2007 to support this effort.

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 levels also are above background, but have declined from their peak historical levels.



A pump-and-treat system in the 100-H Area has reduced the amount of chromium entering the Columbia River. Between 1996 and 2007, concentrations decreased through most of the plume.

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 did not exceed drinking water standards in FY 2007.

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 49 kilograms 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 2007.

Five-Year Review Action. DOE installed three wells as part of additional characterization of a deeper aquifer within the Ringold Formation upper mud unit.

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.

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

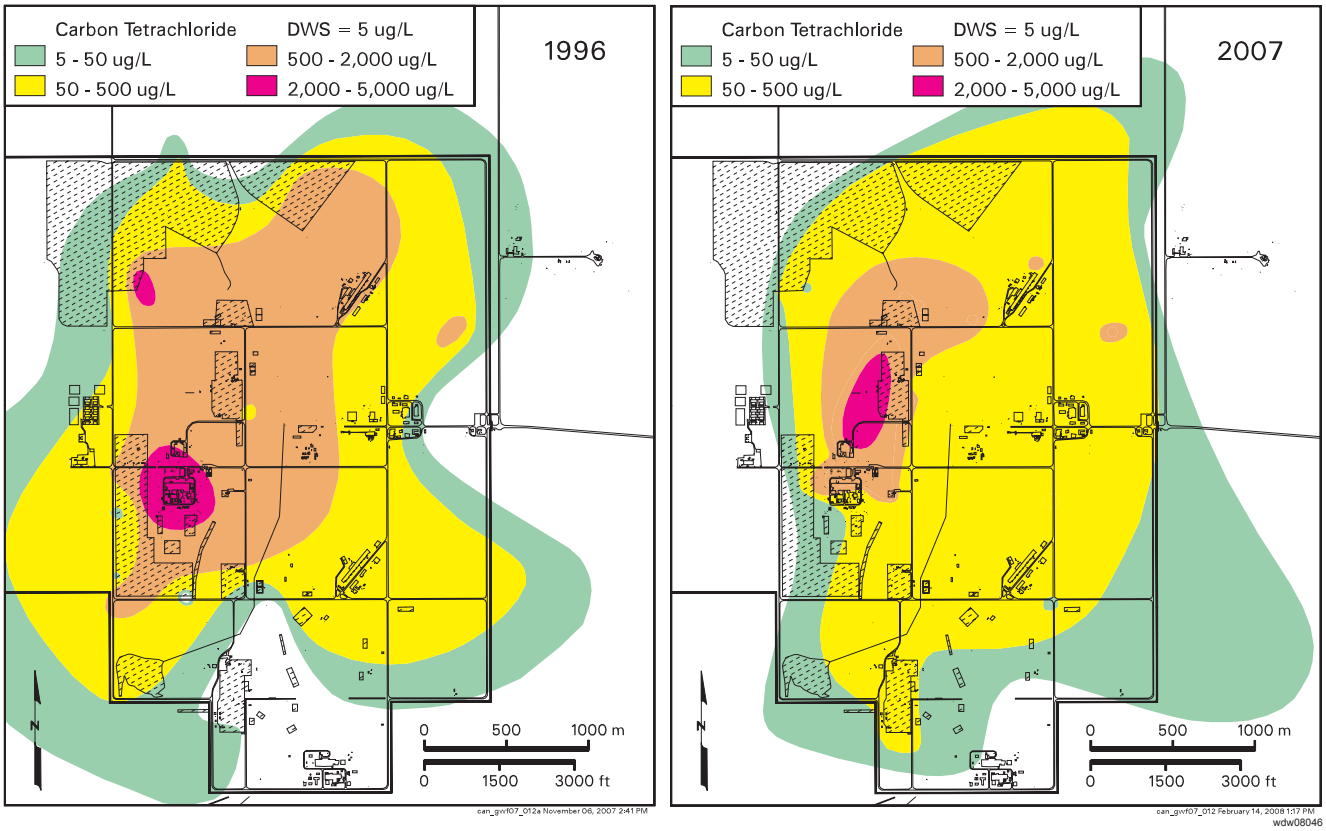
Work on the feasibility study for the 200-ZP-1 Groundwater Operable Unit is ongoing. DOE published the remedial investigation report in October 2006 and a draft of the feasibility study/proposed plan in September 2007. DOE installed four new monitoring wells in this operable unit in FY 2007.

Carbon tetrachloride contamination varies with depth in the aquifer.

The distribution of carbon tetrachloride is complex because it can migrate as a dense, non-aqueous phase liquid, as a gas, and dissolved in water. The 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. Contamination in wells screened deeper in the aquifer indicates that a greater mass is present in the unconfined aquifer than previously calculated.

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



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.

Groundwater and vadose zone remediation systems have removed over 90,000 kilograms of carbon tetrachloride from the subsurface.

from spreading. The system has removed ~11,000 kilograms of carbon tetrachloride from groundwater.

Soil-Vapor Extraction. Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. The system has removed ~79,200 kilograms of carbon tetrachloride from the vadose zone since operations started in 1991.

Low-Level Burial Grounds Waste Management Areas 3 and 4. RCRA groundwater monitoring continued under interim status requirements in FY 2007. The groundwater flow direction changed after liquid effluent discharges in 200 West Area ceased. 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.

Waste Management Area T. RCRA assessment monitoring continued in FY 2007. The waste management area has introduced technetium-99 and other tank waste contaminants 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.

Waste Management Area TX-TY. RCRA assessment monitoring continued in FY 2007. 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 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 2007.

200-UP-1 Operable Unit

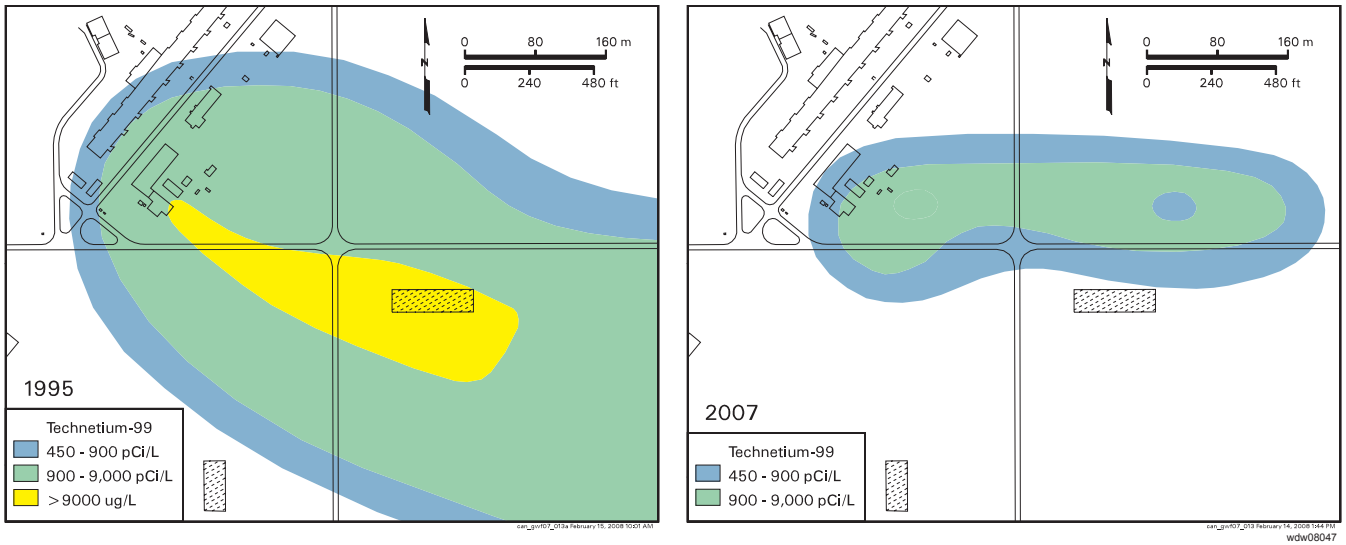
A complete discussion of the 200-UP-1 Operable Unit can be found in Section 2.9. This operable unit underlies the south portion of 200 West Area. The primary contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit. One new monitoring well was drilled in this operable unit in FY 2007.

DOE resumed operation of a pump-and-treat system near U Plant to contain the technetium-99 and uranium plumes there.

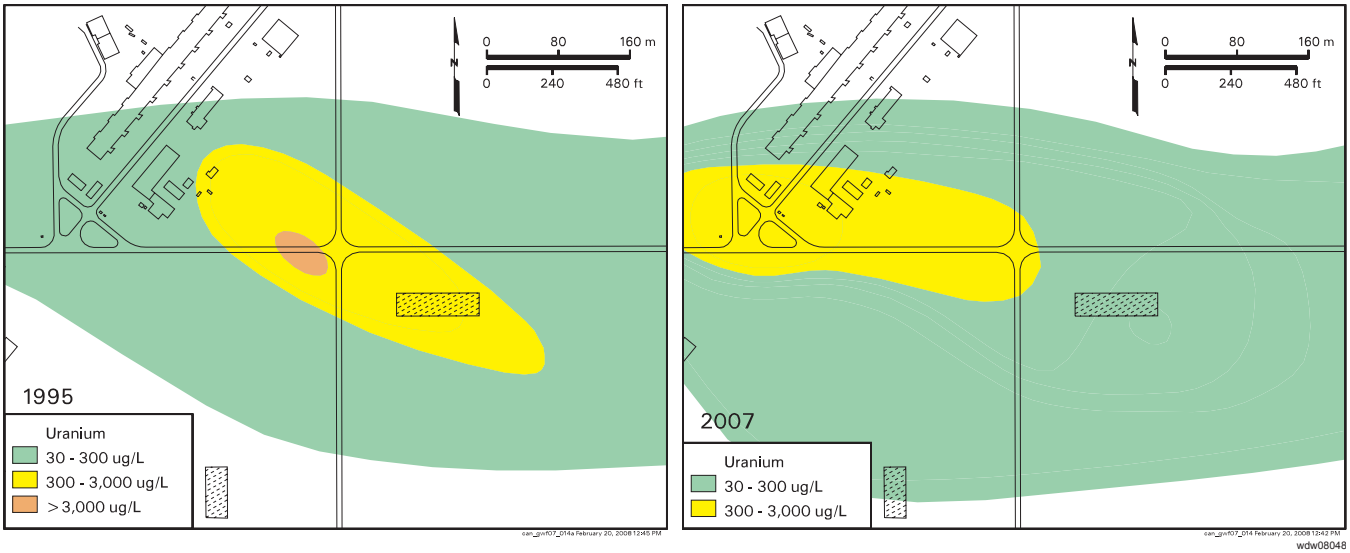
The 200-UP-1 Operable Unit contains four facilities monitored under RCRA (in conjunction with CERCLA and AEA), one CERCLA interim action, and one CERCLA disposal site.

Interim Remedial Action. 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. 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 µg/L. Since that time, EPA established a drinking water standard of 30 µg/L. In expectation that the remedial action goal will be revised to 300 µg/L (ten times the current standard), DOE resumed groundwater extraction in April 2007. Restarting the pump-and-treat system was a response to an action identified in the November 2006 CERCLA five-year review.

Waste Management Area S-SX. RCRA assessment monitoring continued in FY 2007. Groundwater beneath this waste management area is contaminated with tank waste constituents, which include nitrate, chromium, and technetium-99



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), 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.

attributed to two general source areas within the waste management area. In the north plume, concentrations of the mobile tank waste constituents increased in FY 2007. Both plumes continued to expand in a downgradient direction.

The 216-U-12 Crib has been reclassified as a RCRA past-practice unit.

Waste Management Area U. RCRA assessment monitoring continued in FY 2007. 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. One monitoring well went dry during FY 2007.

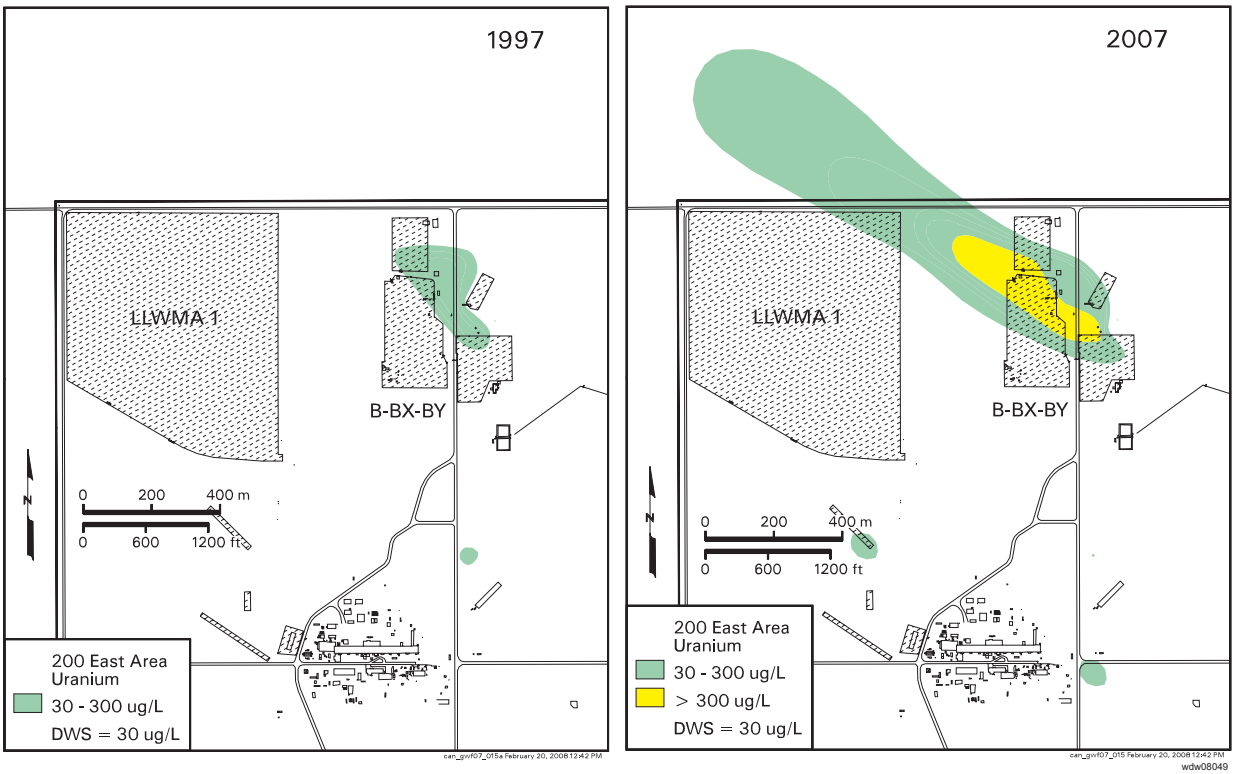
216-U-12 Crib. RCRA assessment monitoring continued in FY 2007. The crib is one of several sources that have contributed to a nitrate plume in the area. In June 2007, the Tri-Parties approved two Tri-Party Agreement change requests reclassifying the crib from a RCRA treatment, storage, or disposal unit to a RCRA past-practice unit. Based on this approval, RCRA groundwater monitoring will be discontinued for FY 2008. DOE will continue to monitor groundwater near the crib under CERCLA.

216-S-10 Pond and Ditch. The 216-S-10 facility continued to be monitored under a RCRA interim status detection program in FY 2007. 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 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.

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. The water table is flat in this portion of the Hanford Site, so it is not possible



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.

to determine groundwater flow directions from water-table data alone. One of the primary objectives of the remedial investigation in the 200-BP-5 Operable Unit is to define contaminant migration.

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, plutonium, strontium-90, sulfate, and uranium.

DOE continued to characterize the vadose zone and aquifer in the 200-BP-5 Operable Unit.

In FY 2007, DOE continued to work on the 200-BP-5 Operable Unit remedial investigation/feasibility study. An aggressive characterization program will support decisions during this process. DOE released a data quality objectives summary report and a draft work plan. Drillers installed three new wells in FY 2007 and will add ten more in FY 2008. Scientists continued to characterize the vadose zone and groundwater in the operable unit through sampling, geophysics, and aquifer tests.

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 2007. Contaminants include uranium, technetium-99, and nitrate. Concentrations of these contaminants continued to increase in FY 2007.

Waste Management Area C. This site continued to be monitored under an interim status RCRA detection program in FY 2007, 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 wells monitoring the waste management area.

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.

Low-Level Waste Management Area 2. This site continued to be monitored under RCRA interim status requirements.

Liquid Effluent Retention Facility. The water table has dropped below the top of basalt in all but two monitoring wells. DOE and Ecology are pursuing an agreement for environmental monitoring. Two new wells are planned that will explore the possibility of monitoring the basalt flow-top and weathered zone.

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 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 due to radioactive decay and dispersion. Nitrate forms a large plume but mostly at levels below the drinking water standard. Other contaminants include nitrate, strontium-90 and technetium-99, but these are limited to smaller areas.

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

During FY 2007, DOE published a data quality objectives report for groundwater remediation and started to develop a work plan for a 2-year groundwater site characterization study.

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. Until the facility begins to operate, results from semi-annual monitoring will be added to the background data set.

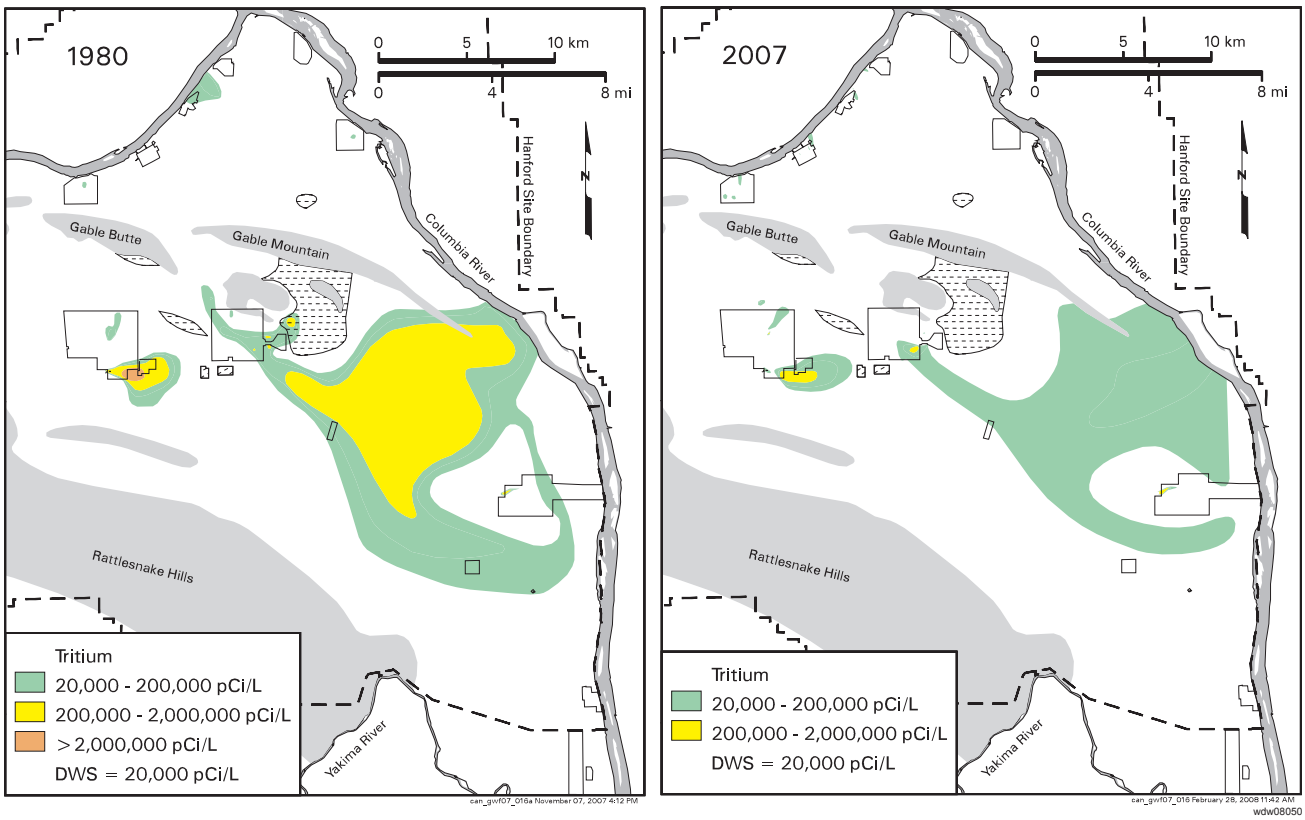
PUREX Cribs. Three cribs (216-A-10, 216-A-36B, and 216-A-37-1) are monitored jointly under a RCRA interim status assessment program, CERCLA, and AEA. The cribs have contributed to widespread contaminant plumes in the area, including nitrate, tritium, and iodine-129. The nitrate and tritium plumes are generally attenuating throughout most of their area.

Waste Management Area A-AX. RCRA assessment monitoring continued in FY 2007. Technetium-99 concentrations exceeded the drinking water standard (900 pCi/L) in two wells, but levels decreased in FY 2007.

216-A-29 Ditch. The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations. 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 2007.



These maps show site-wide tritium plumes in the upper part of the unconfined aquifer in 1980 and 2007. Concentrations in the core of the plume have decreased over the years and the south margin is no longer spreading.

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. Thus, groundwater beneath the facility is isolated from the effects of the effluent.

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 2007.

600 Area Central 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 600 Area Central 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. Tritium concentrations in all samples were below the drinking water standard in FY 2007.

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 regions: the 300 Area, the 618-11 burial ground region, and the 316-4 cribs/618-10 burial ground region. The operable unit

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

is currently regulated under an interim record of decision that calls for groundwater monitoring and institutional controls on the use of groundwater. In FY 2007, DOE installed 16 new wells for a uranium treatability test or aquifer characterization.

In the 300 Area, trichloroethene concentrations exceed drinking water standards in a fine-grained layer of sediments. Concentrations in the shallower, more permeable part of the aquifer are below the standard.

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 wells monitoring the top of the unconfined aquifer. However, characterization samples collected in FY 2006 detected higher concentrations from a fine-grained unit within the upper portion of the Ringold Formation. Wells subsequently completed to monitor this unit showed only low levels of trichloroethene (<1 μg/L). This suggests contamination in a relatively small area.

Groundwater downgradient of the 618-11 burial ground is 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 850,000 pCi/L in September 2007.

During excavation of the 618-2 burial ground in 2006, plutonium and other radiological contamination was detected unexpectedly. To investigate this occurrence, workers drilled three boreholes within the excavated burial ground. No plutonium was detected in groundwater.

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. During FY 2007, DOE prepared a report describing the screening of potential remedial action technologies. The most promising technologies are those that use in situ methods to reduce the mobility of uranium in the environment

In FY 2007, scientists continued a comprehensive program of simulation, laboratory, and field research tasks to support the 300-FF-5 feasibility study. The project's objective is to improve conceptual and transport-simulation models for uranium movement.

A treatability test to immobilize uranium in the aquifer continued during FY 2007. The test involved injecting polyphosphate into the aquifer. Preliminary information indicates that the timing of injections relative to seasonal conditions is very important in the implementation of this technology.

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

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 that is completed near the bottom of the aquifer.

1100-EM-1 Operable Unit

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 those detected in Columbia River water, continued to be detected.

In the 1100-EM-1 Operable Unit, trichloroethene concentrations continued to be below the cleanup level. Groundwater monitoring was reduced to annual sampling of three wells.

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 2007.

DOE reduced groundwater monitoring for the 1100-EM-1 Operable Unit in response to an action item identified by the CERCLA five-year review published in November 2006. A Tri-Party Agreement change notice, approved in June 2007, specifies annual monitoring of three wells.

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.

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

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 led to downward migration of groundwater into the Ringold Formation confined aquifer. During FY 2007, eighteen wells were sampled that are completed in the Ringold Formation confined aquifer. Tritium in a single well near the former B Pond 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.

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, reaching 15,000 pCi/L in one tube in August 2007.

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 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.

Nitrate concentrations were all below the 45-mg/L drinking water standard in aquifer tubes in FY 2007. Levels have exceeded the standard in the 100-F, 100-H, and 300 Areas in the past.

Trichloroethene is detected in several aquifer tubes in the 300 Area. Concentrations are highest in deep tubes. The maximum in FY 2007 was 290 µg/L in tube AT-3-3-D. The value is under review to see if it is representative. The next highest result was 57 µg/L in tube AT-3-7-D.

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-seven new wells were installed during FY 2007.

During FY 2007, a number of temporary characterization boreholes were installed around the Hanford Site to support various projects. The temporary boreholes are installed to characterize subsurface contamination or determine hydrogeologic properties (e.g., moisture, grain-size distribution). In FY 2007, 100 temporary boreholes were installed. Four borings were drilled to groundwater, the remainder extended no farther than the vadose zone.

Approximately 8,836 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, 3,948 of these, or ~45% of the total, 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. 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 2007, a total of 3,085 unique well identification numbers were documented as "in use." This number includes 2,310 wells, 129 piezometers within host wells, 354 aquifer tubes, and 292 soil gas boreholes. A total of 91 wells were physically decommissioned during FY 2007 and a 623 temporary boreholes and subsurface installations were administratively decommissioned by records management.

Wells Installed in 2007

Interest Area or RCRA Site	Number of New Wells FY 2007
100-BC-5	2
100-KR-4	4
100-NR-2	0
100-HR-3-D	20
100-HR-3-H	0
100-HR-3 Horn chromium investigation	6
200-PO-1	1
200-BP-5	3
200-ZP-1	4
200-UP-1	1
300-FF-5	16
Total	**57**

Staff performed maintenance on 186 wells in FY 2007. Surface tasks include labeling wells, fixing or replacing

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	5	0	9
2006	4	0	0	4
2007	3	0	6	9
Total	**65**	**12**	**16**	**93**

locking well caps, repairing casing, repairing or replacing sampling pumps, and performing camera surveys.

Vadose Zone

Vadose zone activities in FY 2007 included leachate monitoring, soil-vapor extraction and monitoring, surface geophysics, and borehole geophysical logging. 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. Leachate is collected and sent to the Effluent Treatment Facility. Composite leachate samples contained detectable concentration of common metals, anions, and mobile radionuclides. Constituents that were generally increasing in concentration include chromium, specific conductance, bromide, nitrate, gross alpha, and uranium. 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.

During FY 2007, 91 unneeded wells were physically decommissioned and filled with grout; 3,085 wells remain in use.

Soil-Vapor Extraction. This remedial action is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area. Three new vapor extraction wells were installed in FY 2007. As of September 2007, ~79,200 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

Direct Push Boreholes and Sampling. The hydraulic hammer unit was deployed in B, T, and U Tank Farms during FY 2007 to evaluate subsurface contamination in the vadose zone. A hydraulic hammer is a modern type of pile driver that can be used to collect samples or place monitoring equipment into the vadose zone.

Surface Geophysical Exploration. Surface geophysical exploration, a combination of surface deployed geophysical techniques, was applied in Waste Management Area B-BX-BY during FY 2007. The analyses point to several regions worthy of further characterization using more conventional approaches such as drilling. The analysis of the surface geophysical exploration data is being used to direct the locations of several groundwater monitoring wells to be drilled during FY 2008 and beyond.

Geophysical Logging. Radiation measurements have been taken in boreholes since the early days of the Hanford Site to detect manmade radionuclides in the subsurface. Geophysical logging at Waste Management Area B-BX-BY in FY 2007 indicated an increase of uranium-235 in the deep vadose zone.

Deep Vadose Zone Treatability Test Plan. In FY 2007, DOE began work on a treatability test plan for investigating remediation of technetium-99 and uranium in the deep vadose zone beneath the 200 Areas. The objective of this plan is to provide a strategy to evaluate specific technologies including the appropriate laboratory, modeling, and field tests for deep vadose zone remediation.

Geophysical logging at Waste Management Area B-BX-BY indicated an increase of uranium-235 in the deep vadose zone.

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.

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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1.0 Introduction

M. J. Hartman and H. Anastos

The Hanford Site, part of the U.S. Department of Energy's (DOE) nuclear weapons complex, encompasses ~1,500 square kilometers in southeast Washington State. The Columbia River flows through the site. The federal government acquired the Hanford 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 Hanford's history and continues today at a much reduced scale. Beginning in the 1990s, DOE has focused on cleaning up the site.

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

DOE is committed to protecting the Columbia River from Hanford's contaminated groundwater. As part of this commitment, DOE updated their groundwater management plan in 2007. The *Hanford Integrated Groundwater and Vadose Zone Management Plan* (DOE/RL-2007-20) lays out steps for addressing groundwater and vadose zone contamination. Key elements of the management plan include:

- Continue to implement remedies that are working.
- Gather characterization data, especially on deep vadose zone contamination, to help make informed decisions.
- Address emerging problems.
- Work with regulatory agencies to make remediation decisions.
- Identify new technologies to solve problems that are beyond the reach of conventional approaches.
- Continue to monitor groundwater to detect emerging problems and determine how well remedies are working.

In addition, the plan implements commitments made to Congress to:

- Integrate groundwater, vadose zone, and source area cleanup decisions.
- Consolidate modeling and risk assessment work for the Hanford Site.
- Consolidate groundwater and vadose zone activities under a single project, i.e., DOE's Groundwater Remediation Project (groundwater project; managed by Fluor Hanford, Inc.).

The groundwater project continues to have three major objectives: (1) take actions necessary to prevent degradation of the groundwater, (2) remediate groundwater to

This report is designed to meet the following objectives:

- ***Provide a comprehensive report of groundwater conditions on the Hanford Site.***
- ***Fulfill the reporting requirements of RCRA, CERCLA, DOE Orders, and Washington Administrative Code.***
- ***Summarize the results of groundwater monitoring conducted to assess the effects of interim remedial actions conducted under CERCLA.***
- ***Describe the results of monitoring, characterization, and studies associated with the vadose zone.***
- ***Summarize the installation, maintenance, and decommissioning of Hanford Site monitoring wells.***

restore it to its highest beneficial use where practicable and protect the Columbia River, and (3) monitor groundwater to identify emerging problems and guide the remediation process. Groundwater monitoring fulfills 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*.

1.1 Purpose and Scope

During FY 2007, staff sampled 861 wells and 202 aquifer tubes for radiological and chemical constituents.

This document presents results of groundwater monitoring to meet the requirements of the AEA, RCRA, and those CERCLA units where cleanup decisions have not yet been made (Table 1.0-1). Other CERCLA units have independent reporting requirements and this report summarizes results reported elsewhere. This report also summarizes vadose zone and well installation activities. The report covers the period from October 1, 2006, through September 30, 2007 (i.e., fiscal year [FY] 2007). Appendix A lists supporting information for CERCLA monitoring. Appendix B contains tables and figures that support RCRA and other facility monitoring.

Background information, including descriptions of regulatory requirements, waste sites, analytical methods, regional geology, and statistics is published separately in a companion volume, *Hanford Site Groundwater: Settings, Sources, and Methods* (PNNL-13080), and in the most recent update, which was provided in Appendix C of PNNL-13788. Those changes have been incorporated into the electronic version of PNNL-13080, provided with this groundwater monitoring report.

1.2 Groundwater Monitoring

Hanford's waste sites are grouped into source operable units, and the groundwater is divided into groundwater operable units. The concept of operable units is to group the waste sites into manageable components for investigation and to prioritize the cleanup work. The groundwater operable units do not cover the entire Hanford Site. Therefore, to provide scheduling, data review, and interpretation for the entire site, groundwater staff have defined informal "groundwater interest areas" that include the groundwater operable units and intervening regions. Figure 1.0-1 illustrates these interest areas and the operable unit boundaries.

During FY 2007, Hanford Site staff sampled 861 wells and 202 aquifer tubes. Many of the wells were sampled multiple times. An additional 13 well trips scheduled for FY 2007 were delayed until early October 2007. Some of the wells needed maintenance and some were delayed because of scheduling conflicts.

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

Chromium (total or hexavalent) was the most frequently analyzed constituent. Anions, tritium, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds were other commonly analyzed constituents (Table 1.0-2).

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Figures 1.0-2, 1.0-3, and 1.0-4 show their distribution in the upper unconfined aquifer. The most prominent portions of these plumes originated at waste sites in the 200 Areas and spread toward the southeast. Nitrate and tritium also had significant sources in the 100 Areas.

Table 1.0-3 lists maximum concentrations of selected groundwater contaminants in each groundwater interest area. Electronic data files accompany this report and include FY 2007 and historical data.

Groundwater monitoring objectives of RCRA, CERCLA, and AEA often differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated units, monitoring focuses on nonradioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) may be monitored in some RCRA unit wells to support objectives of monitoring under AEA and/or CERCLA. Please note that pursuant to RCRA, the source, special nuclear, and by-product material components of radioactive mixed waste are not regulated under RCRA and are regulated by the DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

Monitoring groundwater quality along the Columbia River is accomplished by collecting samples from aquifer tubes, riverbank springs, and monitoring wells near the river.

1.3 Shoreline Monitoring

DOE monitors groundwater quality along the river by collecting samples from aquifer tubes and riverbank seeps (springs). Hydrologists estimate that groundwater currently flows from the Hanford Site aquifer to the Columbia River at a rate between 1.1 and 2.5 cubic meters/second (PNNL-13447; PNNL-14753). This rate is very small compared to the average flow of the Columbia River, ~3,400 cubic meters/second.

1.3.1 Aquifer Tubes

Aquifer tubes are small-diameter flexible tubes that have a screen at the lower end. The tubes are implanted into the aquifer along the Columbia River shore by driving a temporary steel casing into the ground and inserting a tube with attached screen into the casing. The steel casing is then pulled out, leaving the tube in place. Water is withdrawn from the tube using a small pump. Most tube sites include two or three individual tubes monitoring different depths from ~1 to ~8 meters.

Representatives from the U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) meet annually with DOE and its contractors to plan the annual sampling event, which usually occurs during the fall months (DOE/RL-2000-59). SGW-35028 presents aquifer tube results for FY 2007. The individual operable unit sections of this report summarize aquifer tube results and include location maps.

Table 1.0-3 lists maximum contaminant levels in aquifer tubes sampled in FY 2007. Concentrations of strontium-90 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 DOE derived concentration guide in 100-N Area tubes.

Uranium concentrations exceed the 30-µg/L drinking water standard in most of the aquifer tubes at the 300 Area.

Hexavalent chromium exceeded the 100-µg/L drinking water standard in 100-D Area aquifer tubes, and exceeded the 10-µg/L aquatic standard

(WAC 173-201A) in the 100-B/C, 100-K, 100-D, and 100-H Areas (Figure 1.0-5).

Nitrate concentrations exceeded the 45-mg/L drinking water standard in an aquifer tube at the 100-H Area in FY 2007. Levels have also exceeded the standard in 100-K, 100-D, 100-H, 100-F and 300 Areas in previous years.

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.

1.3.2 Shoreline Seeps

Columbia River seeps (springs) are sampled each autumn by DOE's Surface Environmental Surveillance Project. Some seeps are sampled to support CERCLA operable unit requirements. Analytical results for seep samples, along with results for adjacent river water, are published in the annual Hanford Site Environmental Report (e.g., PNNL-16623). Contaminant concentrations are typically much lower in seep water than in groundwater samples from wells and aquifer tubes. In FY 2007, seeps were sampled in October and November 2006.

Chromium concentrations in filtered samples from seeps were all below the 100-µg/L drinking water standard, but exceeded the 10-µg/L aquatic standard (WAC 173-201A) in the 100-B, 100-D, 100-H, and 100-F Areas. The maximum concentration in a filtered sample was 21 µg/L in a 100-H Area spring.

Evaluation of the groundwater project quality assurance program indicates that the majority of data for FY 2007 are reliable and defensible.

Strontium-90 concentrations exceeded the drinking water standard (8 pCi/L) in seep wells in the 100-N Area.[(a)] The seep wells were not sampled in FY 2007. The highest strontium-90 concentration in a regular shoreline seep was 3.6 pCi/L in a 100-H Area seep.

Tritium concentrations were all below the 20,000-pCi/L drinking water standard in seep samples in FY 2007. However, a seep at the former Hanford town site had a concentration just below the standard, at 19,100 pCi/L. The maximum concentration in FY 2006 in a seep was 38,600 pCi/L.

Uranium exceeded the 30-µg/L drinking water standard in 300 Area seeps. The highest concentration was 130 µg/L (total uranium, converted from isotopic data).

1.4 Quality Control Highlights

Groundwater data quality is assessed and enhanced by a multifaceted quality assurance/quality control program. Major components of the program include performance evaluation studies, field quality control samples, blind standards, laboratory quality control samples, and laboratory audits. Overall evaluation of these components indicates that the data for FY 2007 are reliable and defensible. Specific data values that are associated with out-of-limits quality control results are flagged in the Hanford Environmental Information System (HEIS) so that users can be circumspect when using them for interpretation. Details of the quality control program for FY 2007 are included in Appendix C. Highlights include the following:

- During FY 2007, 94% of the groundwater monitoring data was considered complete, i.e., not rejected, suspect, associated with a missed holding time, or out-of-limit quality control criteria.

(a) Seep wells are shallow casings open on the bottom that facilitate collecting samples of riverbank springs in the 100-N Area.

- During the fiscal year, a majority of the analytical services supporting groundwater monitoring were transferred from four offsite contract laboratories to the Waste Sampling and Characterization Facility (WSCF), an on-site laboratory operated by Fluor Hanford, Inc.
- The four laboratories supporting groundwater monitoring participated in several national performance evaluation studies. Overall, the percentage of acceptable results for FY 2007 was 96%; the percentages for the individual laboratories ranged from 82% to 100%.
- Field quality control samples include three types of field blanks (full trip, field transfer, and equipment blanks), field duplicates, and split samples. Greater than 97% of field blank and field duplicate and 95% of split sample results for FY 2007 were acceptable, indicating little problem with contamination and good precision overall.
- A comparison of filtered and unfiltered hexavalent and total chromium validates the working assumption that filtered total chromium results are equivalent to hexavalent chromium in Hanford groundwater samples (Section C.6.4 of Appendix C).
- Recommended holding times were met for 96% of non-radiological sample analysis requests for both long-term and interim-action monitoring. In general, the missed holding times should not have a significant impact on the data.
- Laboratory performance on blind standards was good overall – 88% of the results were acceptable.
- Approximately 98% of the laboratory quality control results for FY 2007 were within the acceptance limits, suggesting that the analyses were in control and reliable data were generated. Specifically, 98% of method blanks, 99% of the laboratory control samples, 97% of the matrix spikes, 98% of the matrix duplicates, and 98% of the surrogates were within the acceptance limits.
- Audits and assessments of the laboratories were conducted by DOE and its contractors. Several findings and observations were identified along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

Websites

Documents relating to Hanford Site groundwater are available on the following websites:

Tri-Party Agreement Administrative Record and Public Information Repository — http://www2.hanford.gov/arpir/

DOE Public Reading Room — http://reading-room.pnl.gov/

DOE Information Bridge — http://www.osti.gov/bridge/

Hanford Technical Library — http://libraryweb.pnl.gov/

Hanford Site Groundwater Remediation Project — http://www.hanford.gov/cp/gpp/

1.5 Related Reports

Other reports and databases relating to Hanford Site groundwater include the following:

- Hanford Environmental Information System (HEIS) — This is the main environmental database for the Hanford Site that stores groundwater chemistry data, as well as other environmental data (e.g., soil chemistry, survey data).
- Annual summary reports for interim actions — These reports evaluate the performance of pump-and-treat or other remediation systems in the 100 and 200 Areas. Results are summarized in the applicable sections of this report.

- Quarterly RCRA data transmittals — DOE transmits informal reports quarterly to Ecology after groundwater data have been verified and evaluated (PNNL-16439; SGW-33492; SGW-34359; SGW-35502). These reports describe changes or highlights of the quarter with reference to HEIS for the analytical results.
- *Aquifer Sampling Tube Results for Fiscal Year 2007* (SGW-35028) — This report discusses chemical and radiological monitoring of aquifer tubes in greater detail than presented in the groundwater annual report.
- *Hanford Site Environmental Report for Calendar Year 2006* (PNNL-16623) — This annual report summarizes environmental data, including riverbank springs and river water. It also describes environmental management performance and reports the status of compliance with environmental regulations.
- *RCRA Facility Investigation Report for Hanford Single-Shell Tank Farms* (DOE/ORP-2008-001) — This document provides a detailed description of the state of knowledge needed for tank farm performance assessments.

1.6 CERCLA Five-Year Review

Whenever contaminants remain in the environment following a remedial action decision, CERCLA regulations require that the regulatory agency conduct a review of the decision at least every five years. DOE released *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) in November 2006. The purpose of the review was to determine whether the selected remedies are protective of human health and the environment, and recommend appropriate corrective actions if the remedy is not achieving the established goals. The report made the following conclusions regarding groundwater operable units:

- 100-KR-4 and 100-HR-3 Groundwater Operable Units: Because the groundwater interim actions in the 100 Areas are not designed to be remedial actions, the protectiveness of the selected remedies could not be assessed. There may be contaminants other than the selected principle threat contaminants addressed in the interim actions that may need to be addressed in the final records of decision.
- 100-NR-2 and 300-FF-5 Groundwater Operable Units: The interim remedies have not achieved their objectives. Institutional controls are effective in protecting human health. However, determinations of protectiveness are being deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process.
- 100-BC-5 and 100-FR-3 Groundwater Operable Units: Records of decision for groundwater remediation have not been established for these areas. Previous assessments have not identified groundwater conditions that warrant interim remedial measures, assuming that the source control measures will meet established remedial action objectives designed to reduce contaminant recharge to the aquifer.
- 200-BP-5 and 200-PO-1 Groundwater Operable Units: Records of decision for groundwater remediation have not been established for these areas.

- 200-ZP-1 Groundwater Operable Unit: Protectiveness determinations for the pump-and-treat and vapor extraction systems are being deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process.
- 200-UP-1 Groundwater Operable Unit: This system has met the remedial action objectives identified in the record of decision for interim action. The need for additional work will be assessed through the CERCLA remedial investigation/feasibility study process.
- 1100-EM-1 Groundwater Operable Unit: The remedial actions selected for the 1100 Area Operable Unit have been completed and the remedy remains protective.

The review identified 20 issues and associated corrective actions that are recommended such that the selected remedies remain protective of human health and the environment. Actions that pertain to individual groundwater operable units are discussed in the applicable sections of this report. Three actions pertain to the river corridor, and thus cut across operable unit boundaries. Table 1.0-4 describes their current status.

1.7 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." DOE's Office of Environmental Management (EM-22) administers these funds. This report summarizes the status of the following studies that were underway in FY 2007:

- 100-D Area south chromium plume
  - Inject micron-size iron into the deteriorating portions of the redox barrier.
  - Refine location of the chromium source.
- 100-D area north chromium plume
  - Field test electrocoagulation for accelerated cleanup.

Pacific Northwest National Laboratory is leading the research on other EM-22 projects:

- Characterize chromium geochemistry in 100 Areas vadose zone sediment.
- Test biostimulation for remediation of chromium in 100-D Area.
- Investigate phytoremediation for strontium-90 in 100-N Area.
- Treat vadose zone strontium-90 in 100-N Area with surface infiltration of apatite.
- Study carbon tetrachloride and chloroform attenuation parameters.
- Stabilize uranium plume in the 300 Area using polyphosphate in the 300 Area.

More information on the EM-22 projects is available at http://www.hanford.gov/cp/gpp/science/em21.cfm.

1.8 Conventions Used in This Report

Contaminant plume maps in this report, unless specified otherwise, are based on average results for samples collected in FY 2007 for each well, excluding data that appear unrepresentative.[b] Averaging data allows the maps to include wells that were sampled at different times and at different frequencies. In some locations, it is advantageous to construct maps based on data from a single sampling event (e.g., uranium in the 300 Area in June 2007).

Plume maps in this report show average concentrations in the upper part of the aquifer.

Contour levels are chosen to meet a number of objectives:

- Drinking water standards and multiples of 10 (e.g. 8, 80 and 800 pCi/L for strontium-90).
- Cleanup levels, where applicable (e.g. 20 µg/L for chromium).
- Levels lower than drinking water standards to show areas affected by contamination (e.g., 2,000 pCi/L for tritium).
- Intermediate levels to help define plumes (e.g., 60 and 90 µg/L for uranium).

Mapped data are rounded to two significant digits. The maps are interpretations by project staff using current and historical data, source knowledge, and groundwater flow directions. Staff use data from FY 2005 and 2006 if there were no new data for a well in FY 2007. These older data, and data from aquifer tubes along the Columbia River, are given less weight than the current well data when the maps are contoured. The maps show data from wells completed in the upper part of the unconfined aquifer (generally the top ~10 meters).

Results less than detection limits (flagged "U" in HEIS) are treated in one of two ways when constructing maps:

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

Conventions for handling undetected values do not adversely affect data interpretation for most constituents because the contour intervals are far above

(b) A table of data excluded from the plume maps, and the rationale for exclusion, is included in the electronic files that accompany this report. The excluded data have been deemed unrepresentative of upper aquifer conditions for reasons such as laboratory error or unusual sampling conditions (e.g., samples collected during drilling or using a method not comparable to routine monitoring).

detection limits. A notable exception is iodine-129 that is contoured at 1 pCi/L (the drinking water standard), which in some cases is less than the laboratory's detection limit. Historically, samples containing significant concentrations of technetium-99 required pretreatment to remove technetium-99 prior to iodine-129 analysis (see Section C.6.1 of PNNL-15070). Despite this practice, some values >1 pCi/L were reported as undetected. Currently, the laboratory is able to process technetium-99 containing samples without the pretreatment, while maintaining the minimum detectable activity at 1 pCi/L. However, the laboratory still requires that both primary and secondary energy peaks are present before they consider iodine-129 detected. Requiring the secondary (less sensitive) energy peak adds conservatism to the laboratory's report (i.e., they do not report a detection unless they are very sure of it). Many of the U-flagged values are believed to be real detections, and they are contoured as such. The contour lines are dashed to show that the distribution of iodine-129 at levels near the drinking water standard is less certain than other contaminants.

Dissolved chromium in Hanford Site groundwater is virtually all hexavalent.

Trend plots generally include all analytical results, even those that appear to be erroneous if they do not distort or obscure the scale and data trends. If the outlying data distort the figure, they are not plotted and the figure notes the omission. All of the data, with appropriate data quality flags, are included in the data files that accompany this report and are available in the HEIS database. Trend plots in this report use open symbols to show values so low the laboratory could not detect them. These results are typically reported and plotted as values that represent the detection limit for chemical parameters, and reported values for radiological parameters. Discussion of increasing or decreasing trends generally are based on qualitative observation, not statistical evaluation.

This report uses the following conventions for chemical results:

- Text, figures, and tables express nitrate and nitrite as the NO_3^- and NO_2^- ions, respectively.
- Maps showing chromium include total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples. Dissolved chromium in Hanford Site groundwater is virtually all hexavalent (WHC-SD-EN-TI-302), so filtered, total chromium data effectively represent hexavalent chromium. Appendix C compares chromium data from filtered, unfiltered, total, and hexavalent analyses.
- Contaminant concentrations are compared with state or federally enforceable drinking water standards (Table 1.0-5). Although Hanford Site groundwater is not generally used for drinking, these levels provide perspective on contaminant concentrations. Radionuclide concentrations also are compared with DOE derived concentration guides and risk-based concentrations based on cancer risk coefficients (Table 1.0-6).

Table 1.0-1. Reporting Requirements for Groundwater Monitoring

Operable Unit or Facility	Formal Report	Supplemental Reports or Summaries
CERCLA		
Operable units without RODs (100-BC-5, 100-FR-3, 200-BP-5, 200-PO-1)	This report	Unit manager's meeting presentations
Operable units with interim action RODs managed by FHI (100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, 200-ZP-1)	Interim action annual reports (summarized in this report)	Unit manager's meeting presentations; this report
Operable unit with interim action ROD managed by PNNL (300-FF-5)	This report	Unit manager's meeting presentations; this report
Operable unit with final ROD (1100-EM-1)	This report	None
ERDF	Separate annual report covers groundwater and leachate (summarized in this report)	This report
RCRA Units		
Operating RCRA units (IDF, LERF, LLBG)	This report	Informal quarterly reports
Closure RCRA units (116-N-1 and -3; 120-N-1 and-2)	This report	Informal quarterly reports
Post-closure RCRA units (116-H-6 and 316-5)	Semiannual reports to Ecology; this report	Informal quarterly reports
Interim-status assessment RCRA sites (216-U-12, PUREX cribs, WMA A-AX, B-BX-BY, S-SX, T, TX-TY, and U)	This report; also occasional assessment reports	Informal quarterly reports
Interim-status detection (216-A-29, 216-B-63, 216-S-10 Pond, NRDWL and WMA C)	This report	Informal quarterly reports
Other Facilities		
AEA sites (K Basins, 400 Area water supply wells)	This report	Quarterly K Basins reports to facility operators and DOE
SALDS (WAC 173-216)	Separate annual report	This report
TEDF (WAC 173-216)	This report	None
SWL (WAC 173-304)	This report for groundwater; separate report for leachate and soil gas	None

AEA = *Atomic Energy Act*.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*.
DOE = U.S. Department of Energy.
Ecology = Washington State Department of Ecology.
ERDF = Environmental Restoration Disposal Facility.
FHI = Fluor Hanford, Inc.
IDF = Integrated Disposal Facility (planned).
LERF = Liquid Effluent Retention Facility.
LLBG = Low-level burial grounds.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PNNL = Pacific Northwest National Laboratory.
PUREX = Plutonium-Uranium Extraction (Plant).
RCRA = *Resource Conservation and Recovery Act*.
ROD = Record of decision.
SALDS = State-Approved Land Disposal Site.
SWL = Solid Waste Landfill.
TEDF = Treated Effluent Disposal Facility.
WAC = Washington Administrative Code.
WMA = Waste management area.

Table 1.0-2. Number of Groundwater Analyses by Groundwater Interest Area, FY 2007

Constituent	Site Total
Chromium (total and hexavalent)	4,230
Iodine-129	524
Nitrate	2,196
Organics (carbon tetrachloride, trichloroethene)	923
Plutonium-239/240	51
Strontium-90	514
Technetium-99	1,053
Tritium	1,421
Uranium	991

Table 1.0-3. Maximum Concentrations of Selected Groundwater Contaminants in Groundwater Interest Areas, FY 2007 (Refer to Figure 1.0-1 for groundwater interest areas.)

Contaminant, units (alphabetical order)	DWS (DCG)[a]	100-BC-5		100-KR-4		100-NR-2		100-HR-3-D		100-HR-3-H		100-FR-3	
		Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells
Antimony (filtered), ug/L[b]	6	0.308			**33.3**				3.7		3.5	0.348	
Arsenic (filtered), ug/L	10			2.76		1.87		0.73	**5.5**			3.73	
Carbon tetrachloride, ug/L	5												
Carbon-14, pCi/L	2,000 (70,000)			321	**12,400**							38.2	
Cesium-137, pCi/L	200 (3,000)												
Chloroform, ug/L	100				0.85								0.38
Chromium (filt. or hex.) ug/L	100	51	64	82	**2,170**	**56**[d]	**172**	**199**	**7,290**	37	**113**	11	60.3
cis-1,2-Dichloroethene, ug/L	70				0.24								
Cobalt-60, pCi/L	100 (5,000)												
Cyanide, ug/L	200												
Fluoride, mg/L	4	0.181	0.334	0.248	0.33	0.239	0.85	0.158	0.45	0.18	0.25	**1.1**[c]	0.54
Gross alpha, pCi/L	15	4.18	9.6	3.8	**17**[c]	3.1	4.42		6.1	4	5.5		9.94
Gross beta, pCi/L	50	42	**82**	18	**1,500**	**29,000**	**27,000**		**220**	14	**66**		24
Iodine-129, pCi/L	1 (500)												
Mercury, ug/L	2												
Nitrate, mg/L	45	28.4	39.3	36.6	**137**	21.8	**294**	24.7	**89**	**45.2**	**66.4**	**1,240**[c]	**100**
Nitrite, mg/L	3.3	0.0854					1.5		**5.58**				
Plutonium-239/240, pCi/L	NA (30)												
Strontium-90, pCi/L	8 (1,000)	**12**	**38.2**		**757**	***15,000***	***12,800***		7.84	5.4	**30.7**	1.5	3.5
Technetium-99, pCi/L	900 (100,000)	59			34.6					5.4	99		
Tetrachloroethene, ug/L	5												
Trichloroethene, ug/L	5				**6.4**								3.3
Tritium, pCi/L	20,000 (2,000,000)	17,000	**59,000**	12,100	**370,000**	5,100	**23,000**	**21,000**	**28,500**		5,150	530	9,930
Uranium, ug/L	30				6.78				4.48	1.34	22.1		13.3

Note: Table lists highest value for FY 2007 in each groundwater interest area, excluding those flagged "R" or "Y." Excludes results from samples collected during drilling.
Concentrations in bold exceed DWS. Those in bold italics exceed DCG.
(a) DWS = drinking water standard; DCG = derived concentration guide. See Tables 1.0-5 and 1.0-6 for more information.
(b) Detection limit is higher than DWS. Not a known contaminant of interest in Hanford Site groundwater.
(c) Suspected error. Data point flagged as suspect or undergoing further review.
(d) This chromium value detected in tube AT-K-6-M, which monitors the north portion of the 100-K Area plume. 100-N aquifer tubes have chromium levels <5 ug/L.
(e) Nitrate from offsite sources.

Table 1.0-3. (contd)

Contaminant, units (alphabetical order)	DWS (DCG)[a]	200-ZP-1	200-UP-1	200-BP-5		200-PO-1		300-FF-5		1100-EM-1	
		Wells	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells
Antimony (filtered), ug/L[b]	6	**43.6**	**34.4**		**42.9**			0.307			
Arsenic (filtered), ug/L	10	**10.3**	6.7		8.2		**10.1**	2.84		1.69	
Carbon tetrachloride, ug/L	5	**3,400**	**1,600**				0.82	**720**[c]	0.22		
Carbon-14, pCi/L	2,000 (70,000)		12.1								
Cesium-137, pCi/L	200 (3,000)				**1,120**						
Chloroform, ug/L	100	**260**	35				2.3	7.3	1.3		0.14
Chromium (filt. or hex.) ug/L	100	**715**	**798**	14	77.4		42.1	2.65	10.1	1.34	5.3
cis-1,2-Dichloroethene, ug/L	70	1.7						2.9	**270**		
Cobalt-60, pCi/L	100 (5,000)	33.9			**599**						
Cyanide, ug/L	200	6.5	6.5		**3,990**						
Fluoride, mg/L	4	**5.6**	0.63	0.193	1.5	0.158	**7.7**	0.37	2.7	0.211	1.44
Gross alpha, pCi/L	15	3.11	8.93	2.3	**570**	2.8	**49**	**48**	**96**	4.3	4.61
Gross beta, pCi/L	50	**35,100**	**11,000**	**110**	**42,000**	11	**2,630**	22	**69.5**	8.5	12.8
Iodine-129, pCi/L	1 (500)	**45.4**	**38.7**		**5.01**		**8.18**				
Mercury, ug/L	2	0.069			**4.3**		0.067				
Nitrate, mg/L	45	**3,810**	**1,540**	26.6	**8,630**	9.43	**154**	40	**82.8**	30.1	**536**[e]
Nitrite, mg/L	3.3	0.79	0.686		1.95		0.126		**3.28**[c]		**15.4**[c]
Plutonium-239/240, pCi/L	NA (30)	0.039			***40.4***						
Strontium-90, pCi/L	8 (1,000)	1.8	0.447		***4,130***		**19.2**		2.63		
Technetium-99, pCi/L	900 (100,000)	***113,000***	**46,300**	130	**73,400**	7.1	**7,930**		227		58.3
Tetrachloroethene, ug/L	5	**6.4**	2.2				1.5	1.3	0.43		
Trichloroethene, ug/L	5	**21**	**13**				0.79	**290**[c]	4.8		2
Tritium, pCi/L	20,000 (2,000,000)	**1,760,000**	**310,000**	9,500	**173,000**	11,000	**580,000**	9,100	**1,060,000**		262
Uranium, ug/L	30	**56**	**613**		**935**		**75.3**	**159**	**218**	8.93	23

Note: Table lists highest value for FY 2007 in each groundwater interest area, excluding those flagged "R" or "Y." Excludes results from samples collected during drilling.
Concentrations in bold exceed DWS. Those in bold italics exceed DCG.
(a) DWS = drinking water standard; DCG = derived concentration guide. See Tables 1.0-5 and 1.0-6 for more information.
(b) Detection limit is higher than DWS. Not a known contaminant of interest in Hanford Site groundwater.
(c) Suspected error. Data point flagged as suspect or undergoing further review.
(d) This chromium value detected in tube AT-K-6-M, which monitors the north portion of the 100-K Area plume. 100-N aquifer tubes have chromium levels <5 ug/L.
(e) Nitrate from offsite sources.

Table 1.0-4. Status of Five-Year Review Action Items that Pertain to Multiple Operable Units

Issue	Action	Status
1. Additional risk assessment information is needed to evaluate the interim actions prescribed within the records of decision and to develop final cleanup decisions.	1-1. Submit Draft A of the *River Corridor Baseline Risk Assessment Report.*	Completed. DOE/RL-2007-21, Draft A, June 2007.
	1-2. Submit draft sampling and analysis plan for Inter-Areas Shoreline Assessment.	Completed August 2006[(a)]
2. A strategy has not been developed and agreed upon to obtain the final records of decision and integrate the waste sites, deep vadose zone, and groundwater.	2-1. Submit Draft A of the *River Corridor Strategy for Achieving Final Cleanup Decision in the River Corridor.* The document will identify issues for integration and provide alternatives for future discussion between the Tri-Parties on milestones for final records of decision in the river corridor.	Completed. WCH-71, February 2007.

(a) Letter 06-AMRC-0317 from JR Franco (U.S. Department of Energy, Richland Operations Office) to N Ceto (U.S. Environmental Protection Agency) and J Hedges (Washington State Department of Ecology), *Transmittal of the Sampling and Analysis Plan for the Inter-Areas Shoreline Assessment*, dated August 2, 2006.

Table 1.0-5. Drinking Water Standards

Constituent	DWS		Agency[a]
Aluminum	50 to 200	µg/L[b]	EPA, DOH
Antimony	6	µg/L	EPA, DOH
Arsenic	10	µg/L	EPA, DOH
Barium	2,000	µg/L	EPA, DOH
Cadmium	5	µg/L	EPA
Carbon tetrachloride	5	µg/L	EPA, DOH
Chloride	250	mg/L[b]	EPA, DOH
Chloroform (THM)[d]	80	µg/L	EPA
Chromium	100	µg/L	EPA, DOH
cis-1,2-Dichloroethene	70	µg/L	EPA, DOH
Copper	1,300	µg/L	EPA
	1,000	µg/L[b]	EPA, DOH
Cyanide	200	µg/L	EPA, DOH
1,4-Dichlorobenzene	75	µg/L	EPA
Fluoride	4	mg/L	EPA, DOH
	2	mg/L[b]	EPA, DOH
Iron	300	µg/L[b]	EPA, DOH
Lead	15	µg/L	EPA
Manganese	50	µg/L[b]	EPA, DOH
Mercury (inorganic)	2	µg/L	EPA, DOH
Methylene chloride	5	µg/L	EPA, DOH
Nitrate, as NO_3^-	45	mg/L	EPA, DOH
Nitrite, as NO_2^-	3.3	mg/L	EPA, DOH
Pentachlorophenol	1	µg/L	EPA, DOH
pH	6.5 to 8.5[b]		EPA
Selenium	50	µg/L	EPA, DOH
Silver	100	µg/L[b]	EPA, DOH
Sulfate	250	mg/L[b]	EPA, DOH
Tetrachloroethene	5	µg/L	EPA, DOH
Thallium	2	µg/L	EPA, DOH
Total dissolved solids	500	mg/L[b]	EPA
1,1,1-Trichloroethane	200	µg/L	EPA, DOH
Trichloroethene	5	µg/L	EPA, DOH
Zinc	5,000	µg/L[b]	EPA, DOH
Antimony-125	300	pCi/L[e]	EPA
Beta particle and photon activity	4	mrem/yr[f]	EPA, DOH
Carbon-14	2,000	pCi/L[e]	EPA
Cesium-137	200	pCi/L[e]	EPA
Cobalt-60	100	pCi/L[e]	EPA
Iodine-129	1	pCi/L[e]	EPA
Ruthenium-106	30	pCi/L[e]	EPA
Strontium-90	8	pCi/L[e]	EPA, DOH
Technetium-99	900	pCi/L[e]	EPA
Total alpha (excluding uranium)	15	pCi/L[e]	EPA, DOH
Tritium	20,000	pCi/L[e]	EPA, DOH
Uranium	30	µg/L	EPA, DOH

(a) DOH = Washington State Department of Health at WAC 246-290; EPA = U.S. Environmental Protection Agency at 40 CFR 141, 40 CFR 143, and EPA 822-R-96-001.
(b) Secondary standards are not associated with health effects, but with taste, odor, staining, or other aesthetic qualities.
(d) Standard is for total trihalomethanes (THM).
(e) EPA drinking water standards for radionuclides were derived based on a 4-mrem/yr dose standard using maximum permissible concentrations in water specified in *National Bureau of Standards Handbook 69* (U.S. Department of Commerce, as amended August 1963).
(f) Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose >4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.
DWS = Drinking water standard (maximum contaminant level for drinking water supplies).

Table 1.0-6. Derived Concentration Guides, 4-mrem Effective Dose Equivalent Concentrations, for Drinking Water Standards, and Risk-based Concentrations for Hanford Site Radionuclides in Groundwater

Radionuclide	Derived Concentration Guide [a,b,c] (pCi/L)	4-mrem Effective Dose Equivalent[d] (pCi/L)	Drinking Water Standard (pCi/L)	Risk-Based Concentration[e] (pCi/L) Industrial	Risk-Based Concentration[e] (pCi/L) Residential
Carbon-14	70,000	2,800	2,000	1,030	34
Cesium-137	3,000	120	200	60	1.7
Cobalt-60	5,000	200	100	102	3.4
Iodine-129	500	20	1.0	11	0.36
Plutonium-239/240	30	1.2	None	12	0.39
Strontium-90	1,000	40	8.0	29	0.95
Technetium-99	100,000	4,000	900	580	19
Tritium	2,000,000	80,000	20,000	2,600	160
Uranium-234[f]	500	20	None	23	0.75
Uranium-235[f]	600	24	None	23	0.76
Uranium-238[f]	600	24	None	25	0.83

(a) Concentration of a specific radionuclide in water that could be continuously consumed at average annual rates and not exceed an effective dose equivalent of 100 mrem/yr.
(b) Values in this column represent the lowest, most conservative derived concentration guides considered potentially applicable to Hanford Site operations, and may be adjusted upward (larger) if accurate solubility information is available.
(c) From DOE Order 5400.5.
(d) Concentration of a specific radionuclide in water that would produce an effective dose equivalent of 4 mrem/year if consumed at average annual rates. EPA drinking water standards for radionuclides listed in Table 1.0-5 were derived based on a 4-mrem/year dose standard using maximum permissible concentrations in water specified in *National Bureau of Standards Handbook 69* (U.S. Department of Commerce, as amended August 1963). The 4-mrem/yr dose standard listed in this table was calculated using a more recent dosimetry system adopted by DOE and other regulatory agencies (as implemented in DOE Order 5400.5 in 1993).
(e) Based on slope factors from EPA's risk website: "Radionuclide Carcinogenicity Slope Factors," http://epa.gov/radiation/heast/index.html, in turn based on FGR-13 (EPA 402-R-99-001). These slope factors represent the risk of getting cancer if a person ingested water contaminated with each radionuclide over a lifetime (residential) or over a working lifetime (industrial). The tritium calculation also considers inhalation of tritium in air; for the other radionuclides this path is insignificant.
(f) See Table 1.0-5 for total uranium.
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.

For additional information on contaminants that are found at the Hanford Site, see "Summary Fact Sheets for Selected Environmental Contaminants to Support Health Risk Analysis" (Peterson et al. 2002), available on the web site of Environmental Assessment Division, Argonne National Laboratory (http://www.ead.anl.gov). Click on "publications" and search for the title.

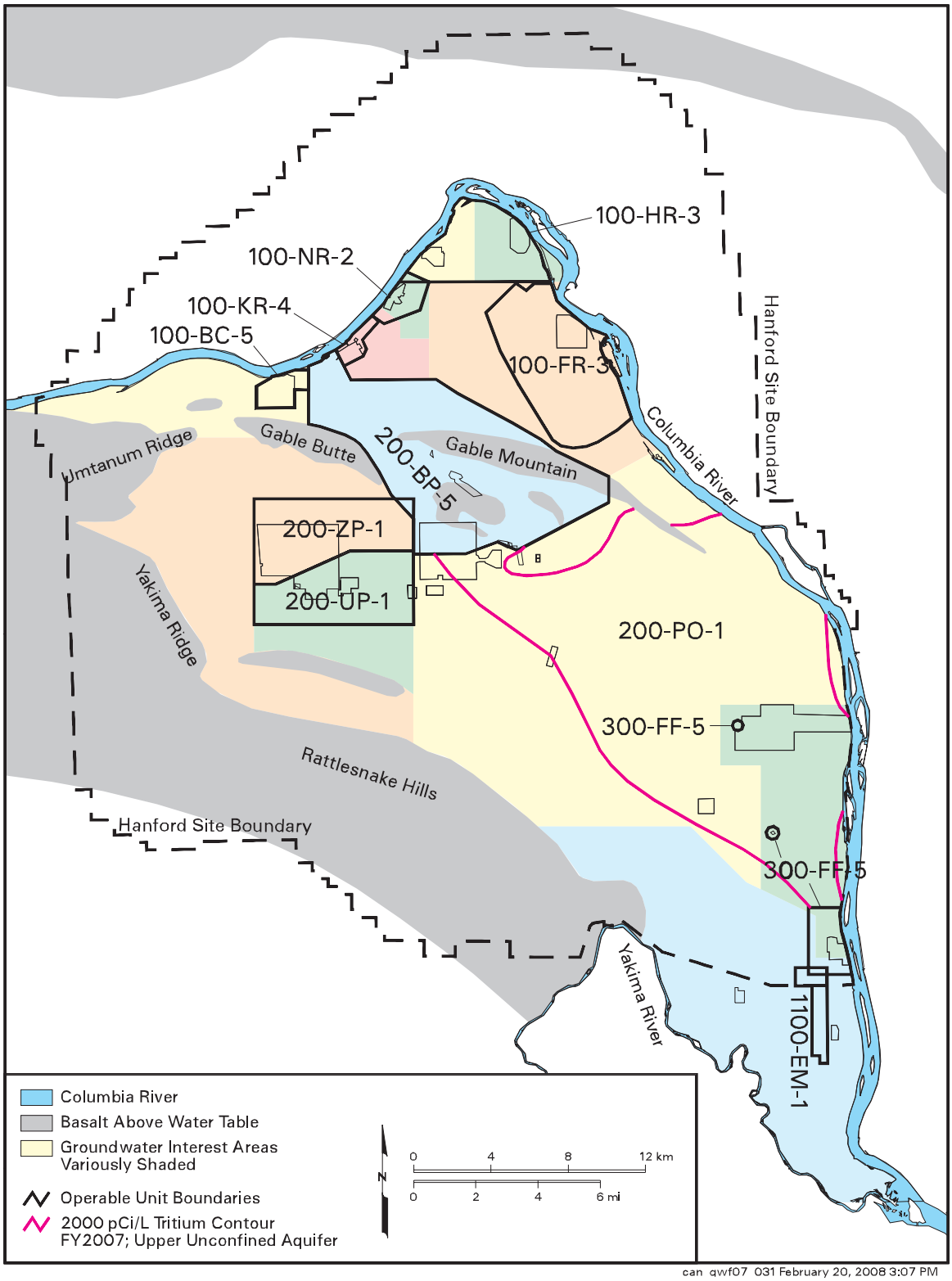

Figure 1.0-1. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site

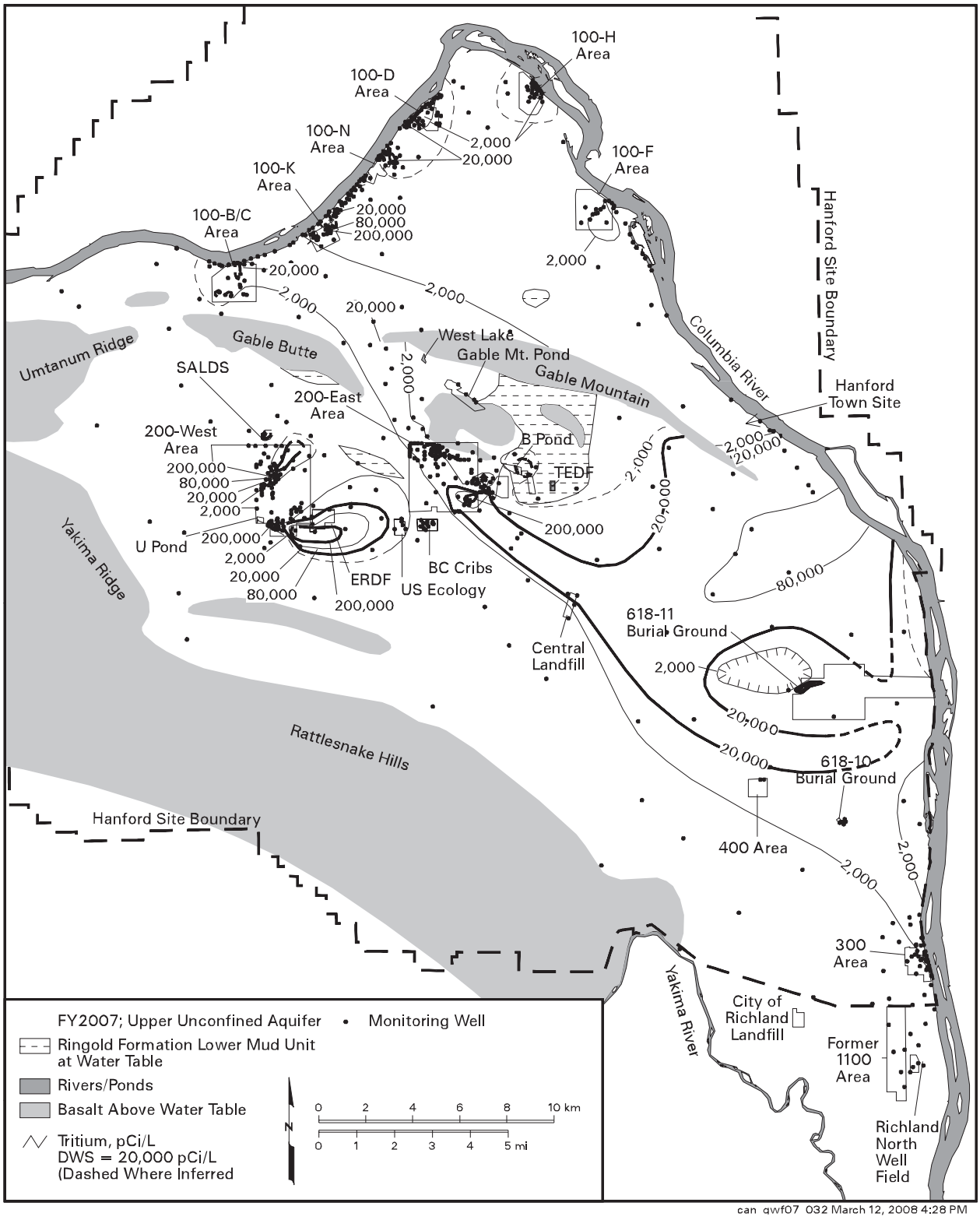

Figure 1.0-2. Average FY 2007 Tritium Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer

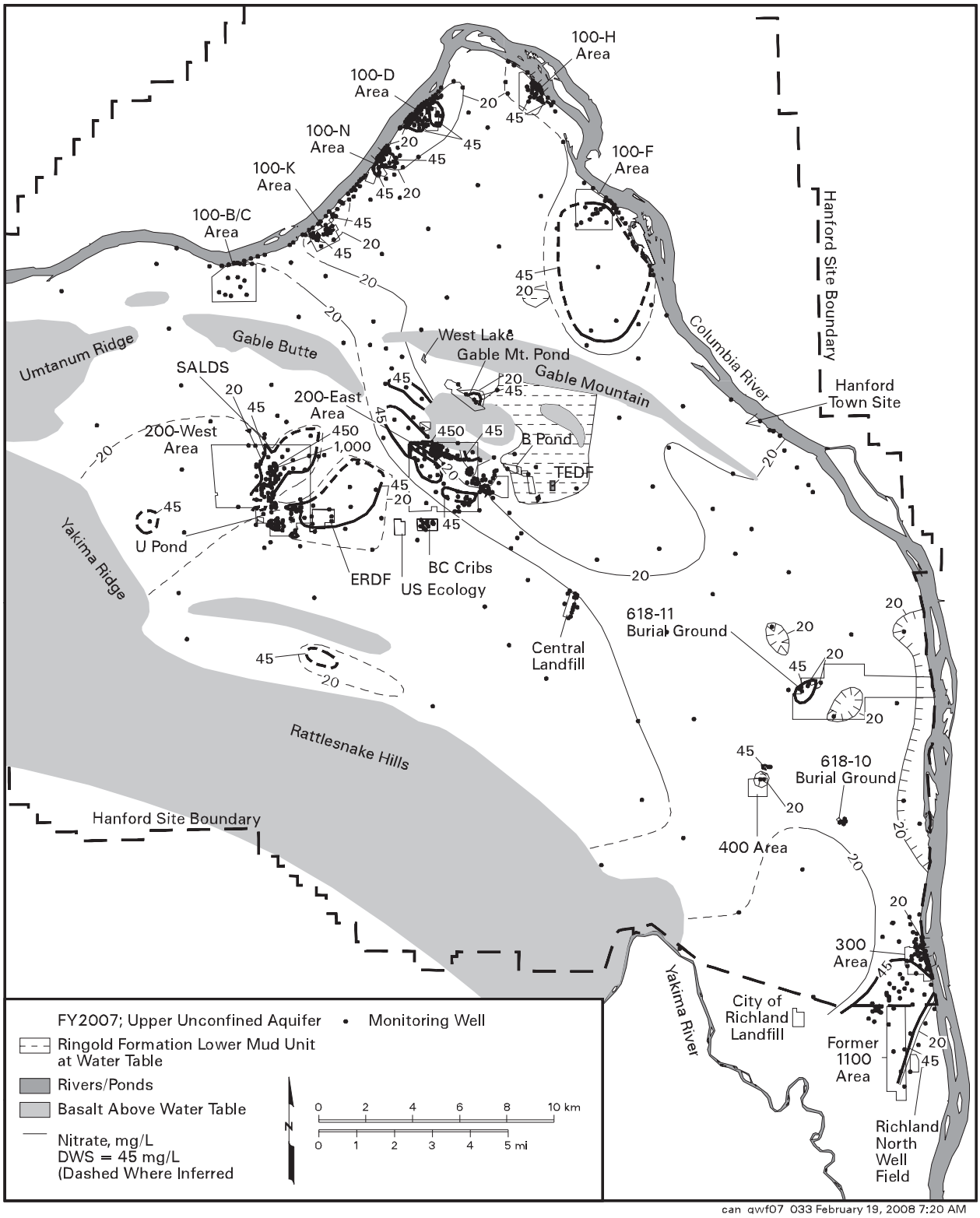

Figure 1.0-3. Average FY 2007 Nitrate Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer

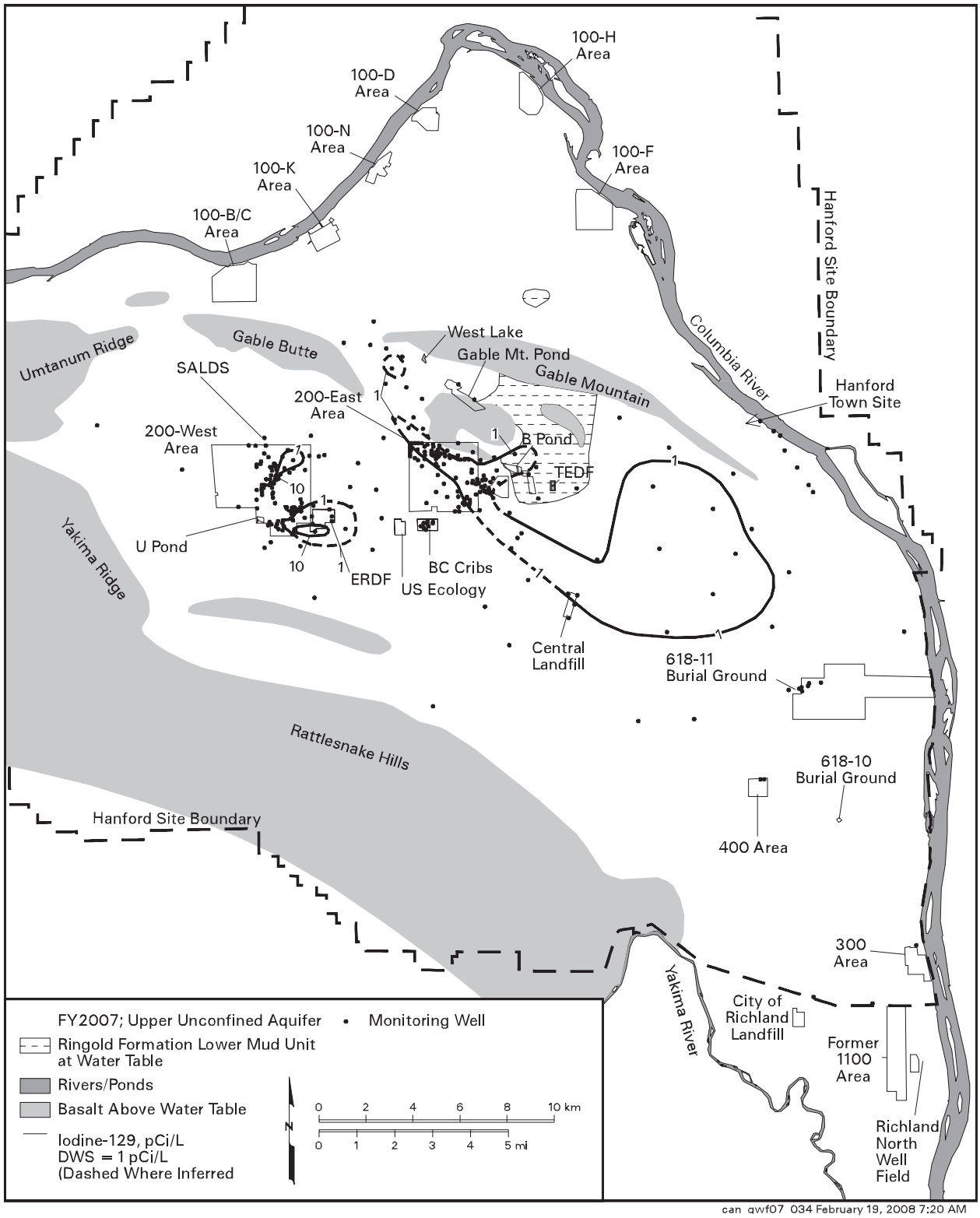

Figure 1.0-4. Average FY 2007 Iodine-129 Concentrations on the Hanford Site, Upper Part of Unconfined Aquifer

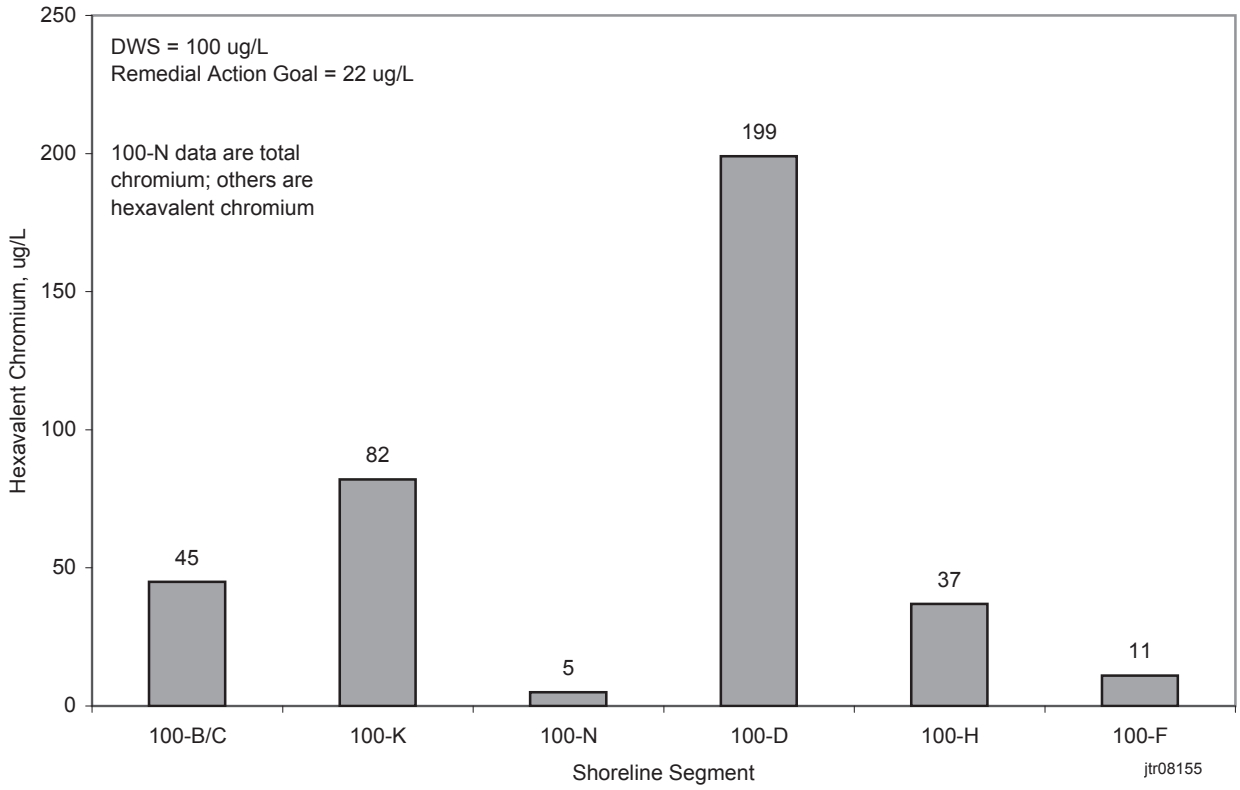

Figure 1.0-5. Maximum Hexavalent Chromium in Aquifer Tubes, FY 2007

2.0 Groundwater

This section discusses groundwater flow and chemistry on the Hanford Site. Section 2.1 gives a general overview of site-wide flow. Sections 2.2 through 2.13 describe groundwater for each of the groundwater interest areas/operable units. These regions are presented in geographic order (north to south, west to east). Monitoring of specific units under the *Comprehensive Environmental Response, Compensation, and Liability Act; Resource Conservation and Recovery Act*; *Atomic Energy Act*; or Washington Administrative Code are discussed within relevant sections. Section 2.14 describes groundwater flow and chemistry in the confined aquifers.

Waste sites, hydrogeology, and methods of sampling and analysis are described in *Hanford Site Groundwater: Settings, Sources, and Methods* (PNNL-13080).

2.1 Overview of Groundwater Flow

J. P. McDonald

This section provides a broad picture of groundwater flow beneath the Hanford Site. The uppermost aquifer beneath most of the Hanford Site is unconfined and is composed of unconsolidated to semi-consolidated sediment of the Hanford formation and Ringold Formation, which was deposited on the basalt bedrock. In some areas, deeper parts of the aquifer are confined locally by layers of silt and clay. Deeper confined aquifers also occur within the underlying basalt and associated sedimentary interbeds. Well location maps for each geographic region are included in Sections 2.2 through 2.14. Wells in the 600 Area, which cover portions of the Hanford Site other than the former operational areas, are shown in Figure 2.1-1.

During March 2007, 882 water-level measurements were collected from wells monitoring the unconfined aquifer system and the underlying confined aquifers beneath the Hanford Site. These data were used to (1) prepare contour maps that indicate the general direction of groundwater movement within an aquifer; (2) determine hydraulic gradients, which in conjunction with the hydraulic properties of the aquifer, are used to estimate groundwater flow velocities; (3) support conceptual and numerical groundwater model development, modification, and maintenance; and (4) interpret sampling results. This section describes the results of a regional-scale analysis of these data for the unconfined aquifer, which is the aquifer most affected by Hanford operations. Local groundwater flow in each groundwater operable unit is described in Sections 2.2 through 2.13. Flow characteristics in the confined aquifers present in the lower Ringold Formation and in the upper basalt aquifer system are discussed in Section 2.14.

During March 2007, 882 water-level measurements were collected across the Hanford Site. This information helps scientists understand the direction and velocity of groundwater flow.

2.1.1 Water-Table Interpretation for March 2007

Figure 2.1-2 presents the Hanford Site water-table map representative of conditions during March 2007. Groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge area north and east along the Columbia River. Steep gradients occur in the west, east, and north regions of the site. Shallow gradients occur southeast of the 100-F Area and in a broad arc extending from west of the 100-B/C Area to the southeast between Gable Butte and Gable Mountain (Gable Gap), and through the 200 East Area into the central portion of the site. The steep gradients in the west and east are due to the presence of the relatively low permeability sediment of the Ringold Formation at the water table, while the low gradients are associated with areas where the highly permeable sand and gravel of the Hanford formation is present at the water table.

North of Gable Butte and Gable Mountain, groundwater flow directions vary from northwest to east depending on the location. Groundwater enters this region through the gaps between Gable Mountain, Gable Butte, and Umtanum Ridge, as well as from natural recharge. The Columbia River also recharges the unconfined aquifer west of the 100-B/C Area. Groundwater flow patterns suggest that Gable Gap is the dominant source of recharge. Water flowing north through Gable Gap spreads out and flows north-northwest toward the Columbia River, as well as toward the northeast and east along the north side of Gable Mountain. Recharge water from

the Columbia River and the gap between Umtanum Ridge and Gable Butte is thought to flow east toward the 100-B/C Area and discharge to the river. In the 100 Areas, the local groundwater flow is generally toward the Columbia River, although this pattern is altered to varying degrees by pump-and-treat remediation systems in the 100-K, 100-D, and 100-H Areas.

Groundwater in the unconfined aquifer generally flows west to east beneath the Hanford Site and discharges to the Columbia River.

An apparent groundwater mound exists ~2 kilometers north of Gable Mountain and is associated with low conductivity Ringold Formation mud at the water table. This mound is contoured as if it were part of the unconfined aquifer (Figure 2.1-2), but it could also represent a perched water table above the regional water table. There is insufficient information to distinguish between these alternatives. Water-level elevations indicate that groundwater moving east along Gable Mountain flows around this apparent mound.

South of Gable Butte and Gable Mountain, recharge to the aquifer comes from the Cold Creek Valley, Dry Creek Valley, Rattlesnake Hills, Yakima River, and infiltrating precipitation. Groundwater generally flows from west to east, although some of the flow from the 200 West Area or north of the 200 West Area is thought to turn north and flow through Gable Gap. Past effluent discharges at U Pond and other facilities caused a groundwater mound to form beneath the 200 West Area that significantly affected regional flow patterns in the past. These discharges largely ceased by the mid-1990s, but a remnant mound remains, which is apparent from the shape of the water-table contours passing through the 200 West Area. Currently, the water-table elevation is ~11 meters above an estimated water-table elevation prior to the start of Hanford operations.[a] When equilibrium conditions are once again established in the aquifer after dissipation of the mounding caused by artificial recharge, computer simulations suggest that the water table may still be ~5 to ~7 meters higher than the pre-Hanford water table (PNNL-14753). This may be due to modeling uncertainties, recent artificial recharge generated by increased irrigation activities in the region west of the Hanford Site, or the fact that Columbia River conditions are different than in pre-Hanford times due to the construction of hydroelectric dams. The water table beneath the 200 West Area is locally perturbed by discharges from the State-Approved Land Disposal Site, as well as by operation of a groundwater pump-and-treat remediation system at the 200-ZP-1 Operable Unit.

Groundwater flow in the central portion of the Hanford Site, encompassing the 200 East Area, is significantly affected by the presence of a buried flood channel, which lies in a northwest to southeast orientation (PNNL-12261). The water table in this area is very flat (i.e., the hydraulic gradient is estimated to be ~10^{-5}) due to the high permeability of the Hanford formation. Groundwater flow in this region is significantly affected by the presence of low permeability sediment (i.e., muds) of the Ringold Formation at the water table east and northeast of the 200 East Area, as well as basalt above the water table. These features constitute barriers to groundwater flow. The extent of the basalt units above the water table continues to increase slowly due to the declining water table, resulting in an even greater effect on groundwater flow in this area. The mapped extent of the basalt units above the water

(a) Based on the March 2007 water-level elevation in well 299-W18-15 (136.5 meters NAVD88) and the pre-Hanford water-table elevation at the location of this well estimated from BNWL-B-360 (~125.1 meters NAVD88). The peak historical water-level elevation within the 200 West Area occurred at well 299-W18-15 in 1984 (149.1 meters NAVD88).

table was revised during FY 2007 to account for the water-table decline over the past several years. The water table beneath the 200 East Area is ~2.0 meters higher than estimated pre-Hanford conditions.[b] Simulations of equilibrium conditions after site closure suggest that the water table in the 200 East Area will be near its pre-Hanford elevation (PNNL-14753).

The flat water table in the 200 East Area makes returning flow direction difficult.

The flat nature of the water table (i.e., very low hydraulic gradient) in the 200 East Area and vicinity makes determination of the flow direction difficult. This is because the uncertainty in the water-level elevation measurements is greater than the water-table relief. Therefore, determining the groundwater flow direction based on these data is problematic, so other evidence is used to infer flow directions. Water enters the 200 East Area and vicinity from the west and southwest, as well as from beneath the mud units to the east and from the underlying aquifers where the confining units have been removed or thinned by erosion. The flow of water divides, with some migrating to the north through Gable Gap and some moving southeast toward the central part of the site. The specific location of the groundwater flow divide is currently not known. It is known that groundwater flows north through Gable Gap, because the hydraulic gradient within the gap area is large enough to be determined using water-level data. During FY 2007, the gradient in Gable Gap averaged 7.2×10^{-5} along a north flow direction, but flow conditions vary during the year due to changes in Columbia River stage (see Section 2.1.4). Groundwater is inferred to flow southeast within the region between the 200 East Area and the Central Landfill, because the average water-level elevation at the landfill (121.89 meters NAVD88 for March 2007) is 0.14 meter less than the average elevation in the 200 East Area (122.03 meters NAVD88 for March 2007). This yields a regional hydraulic gradient of 1.8×10^{-5}. Efforts are underway to improve the accuracy of the water-level measurements so that hydraulic gradients can be determined for the 200 East Area.

Between the area southeast of the Central Landfill to the 300 Area, the highly permeable sediments of the Hanford formation occur above the water table. These sediments intercept the water table again at the 300 Area. For this reason, the hydraulic gradient in the 300 Area is also very low. Groundwater flow converges on the 300 Area from the northwest, west, and southwest, then generally moves along a southeast flow path and discharges to the Columbia River (PNNL-15127).

In addition to the Hanford Site water table, Figure 2.1-2 depicts the water table north and east of the Columbia River (using a 50-meter-contour interval), based on water-level measurements collected during March 2005. The offsite water table is heavily influenced by irrigation practices, and its configuration is significantly controlled by topography. Many of the contour flexures and mounds coincide with topographic valleys and higher plateau areas. Hydraulic heads north and east of the Columbia River are significantly higher than on the Hanford Site, as evidenced by the proximity of the 150-meter contour to the Columbia River. Therefore, it is unlikely that groundwater contaminants from the Hanford Site would migrate underneath the Columbia River to these offsite areas. PNL-8122 contains a more complete discussion of the offsite water table.

(b) Based on the average water-level elevation measured in 27 wells within the 200 East Area during March 2007, all of which have been corrected for deviations of the boreholes from vertical (122.03 meters NAVD88), and the pre-Hanford water-table elevation for the 200 East Area estimated from BNWL-B-360 (~120 meters NAVD88).

2.1.2 Water-Table Change from FY 2006

Over much of the Hanford Site, the water table continued to decline. The declining water table caused some monitoring wells to go dry; new wells are being installed.

The water-table elevation continued to decline over much of the site from April/May 2006 to March 2007. The decline is a result of the curtailment of effluent discharges to the ground during the 1980s and 1990s. The largest, widespread decline occurred in the 200 West Area, where the water table declined by an average of 0.31 meter (in those areas not influenced by the 200-ZP-1 pump-and-treat system) from April 2006 to March 2007. This amount is the same as was observed from March 2005 to April 2006 (PNNL-16346). Similar to previous years, the water-table elevation increased in Dry Creek Valley and along the Yakima River, signifying increased recharge to the aquifer from these areas. Water levels were also higher along the Columbia River due to a slightly higher river stage during early 2007 compared to 2006.

In the 200 East Area, the elevation of the water table declined by an average of 0.06 meter from April 2006 to March 2007. This is similar to the decline observed the previous year (PNNL-16346). The water-table elevation increased over much of the 200 East Area beginning in July 2007. The water-table elevation is known to respond to effluent discharges at the Treated Effluent Disposal Facility (PNNL-SA-49780), and discharges at this facility increased significantly during June 2007. The water-table elevation increase is shown in Figure 2.1-3 for well 299-E33-337 (northwest 200 East Area) and well 299-E24-24 (southeast 200 East Area). Work is ongoing to understand the effect that periods of increased discharges may have on groundwater flow in the 200 East Area.

2.1.3 Water-Table Change from 1979 to 2007

To gain a perspective on the amount that the water-table has declined at Hanford over the past ~3 decades, a map depicting the change in the water-table elevation between 1979 and 2007 was prepared (Figure 2.1-4). Between 1944 and 1979, the water-table elevation had increased significantly at Hanford due to the disposal of large volumes of effluent to the soil column. Effluent discharge volumes have been greatly reduced since 1979, and the water-table has responded by declining in elevation. The largest declines, almost 10 meters, occurred in the 200 West Area associated with the dissipation of the U Pond groundwater mound. As stated in Section 2.1.1, the water-table elevation beneath the 200 West Area is currently estimated to be ~11 meters higher than pre-Hanford conditions.

The water-table elevation in the 200 East Area has declined by ~1.8 meters between 1979 and 2007. This smaller decline, compared to the 200 West Area, results from a smaller increase between 1944 and 1979. The aquifer sediments in the 200 East Area are much more transmissive than in the 200 West Area, so the water table did not increase as much in elevation prior to 1979. The water-table elevation beneath the 200 East Area is currently estimated to be ~2.0 meters above pre-Hanford conditions.

North of Gable Butte and Gable Mountain, the water-table elevation decline since 1979 has been generally less than 1 meter. The water-table elevation increased in the Dry Creek valley, along the Rattlesnake Hills, and in the southern portion of the site between the Yakima and Columbia Rivers. These increases may be attributable to offsite irrigation practices.

2.1.4 Results of Water-Level Monitoring in Gable Gap

Beginning in June 2006, water-level measurements were collected twice monthly from a network of six wells within Gable Gap. The purpose of these measurements was to determine the hydraulic gradient response to seasonal changes in Columbia River stage, because Gable Gap may represent a transport pathway for contaminants migrating north from the 200 East Area. It has also been hypothesized that changes in groundwater flow through Gable Gap may affect the water-table elevation within the 200 East Area (PNNL-SA-49780). The six wells used for this study were 699-60-60, 699-61-62, 699-61-66, 699-64-62, 699-65-72, and 699-66-64 (Figure 2.1-5).

The water-level elevation data were analyzed using trend-surface analysis, in which a plane is fitted to the data using least squares regression. The direction and magnitude of the dip of the plane approximates the regional hydraulic gradient within the study area. During the initial analysis on all six wells, it was found that most of the results were not statistically significant, which meant that a plane was not a good representation of the water table across all six wells. Further examination indicated that well 699-65-72 exerted a significant influence on the trend surface results since it responds more quickly to river stage changes than the other wells (Figure 2.1-6). Further, this well is located more to the west of Gable Gap and closer to the river than the other wells. For these reasons, well 699-65-72 was omitted from the final trend-surface analyses. Of the 23 water-level data sets analyzed by trend surface analysis for FY 2007, 17 of the results were statistically significant with well 699-65-72 omitted.

Groundwater levels in Gable Gap vary in response to seasonal changes in Columbia River stage.

The water-table elevation within the Gable Gap area responds to seasonal changes in Columbia River stage, but there is a time lag associated with the response (Figure 2.1-6). The data for well 699-65-72 exhibits a ~2-month time lag, while the remaining wells exhibit a ~3- to ~4-month time lag. The magnitude and direction of the hydraulic gradient also change in response to the seasonal fluctuation of water levels (Figure 2.1-7). The largest gradient magnitudes of ~1.1×10^{-4} are associated with periods of low river stage, while the smallest gradients of ~4×10^{-5} occur with periods of high river stage (following a 3- to 4-month time lag). The direction of the gradient also changes seasonally. A flow direction to the north is associated with low river stage, while a northeast flow direction occurs in response to high river stage. Figure 2.1-8 presents a rose diagram of groundwater flow directions in Gable Gap for the fiscal year. The figure depicts the percentage of time during the year in which groundwater flowed in various directions in 10-degree intervals. The average hydraulic gradient in Gable Gap during FY 2007 was calculated to be 7.2×10^{-5} and the average direction (time weighted) was 011 degrees azimuth (north-northeast).

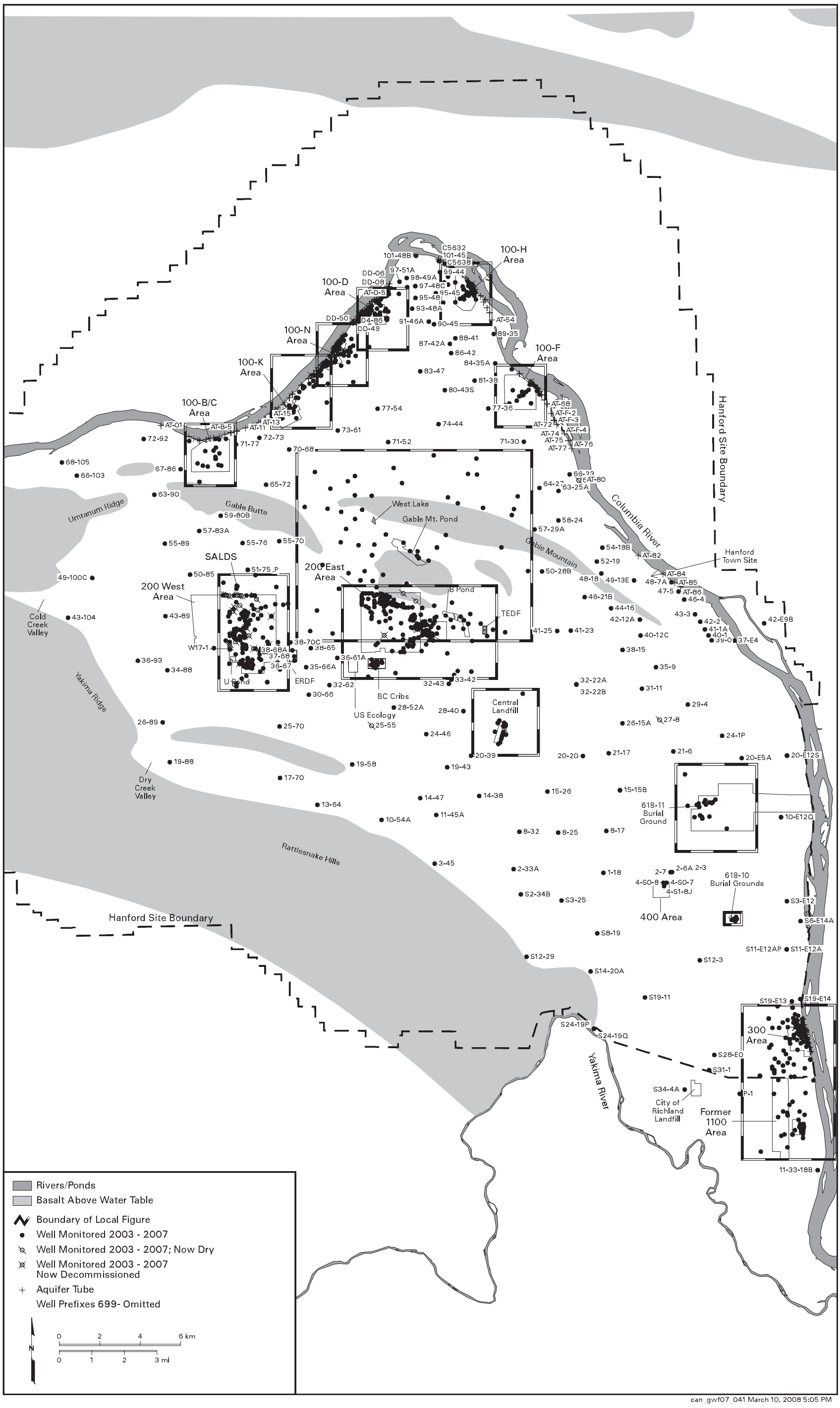

Figure 2.1-1 Groundwater Monitoring Wells on the Hanford Site

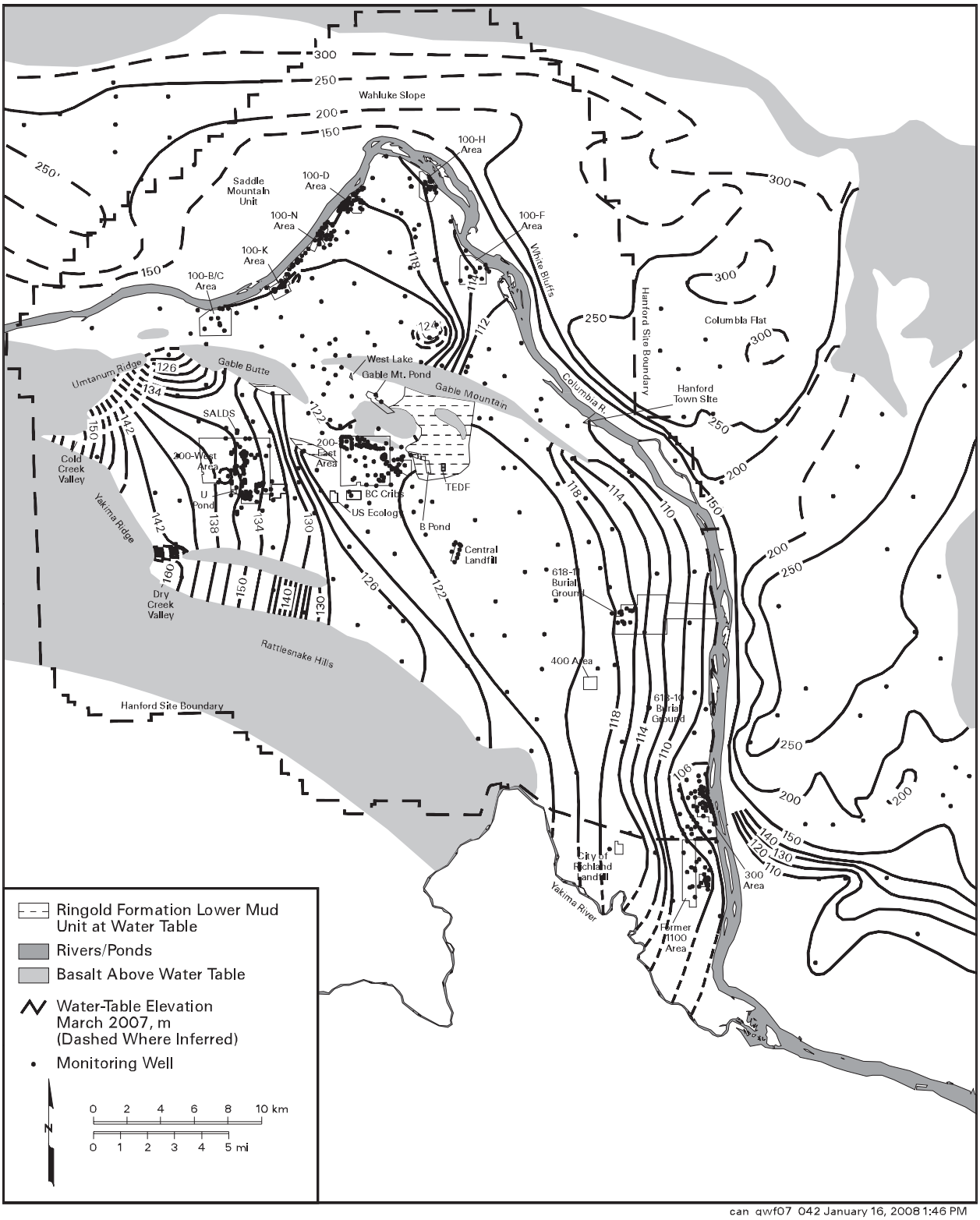

Figure 2.1-2. Hanford Site and Outlying Areas Water-Table Map, March 2007

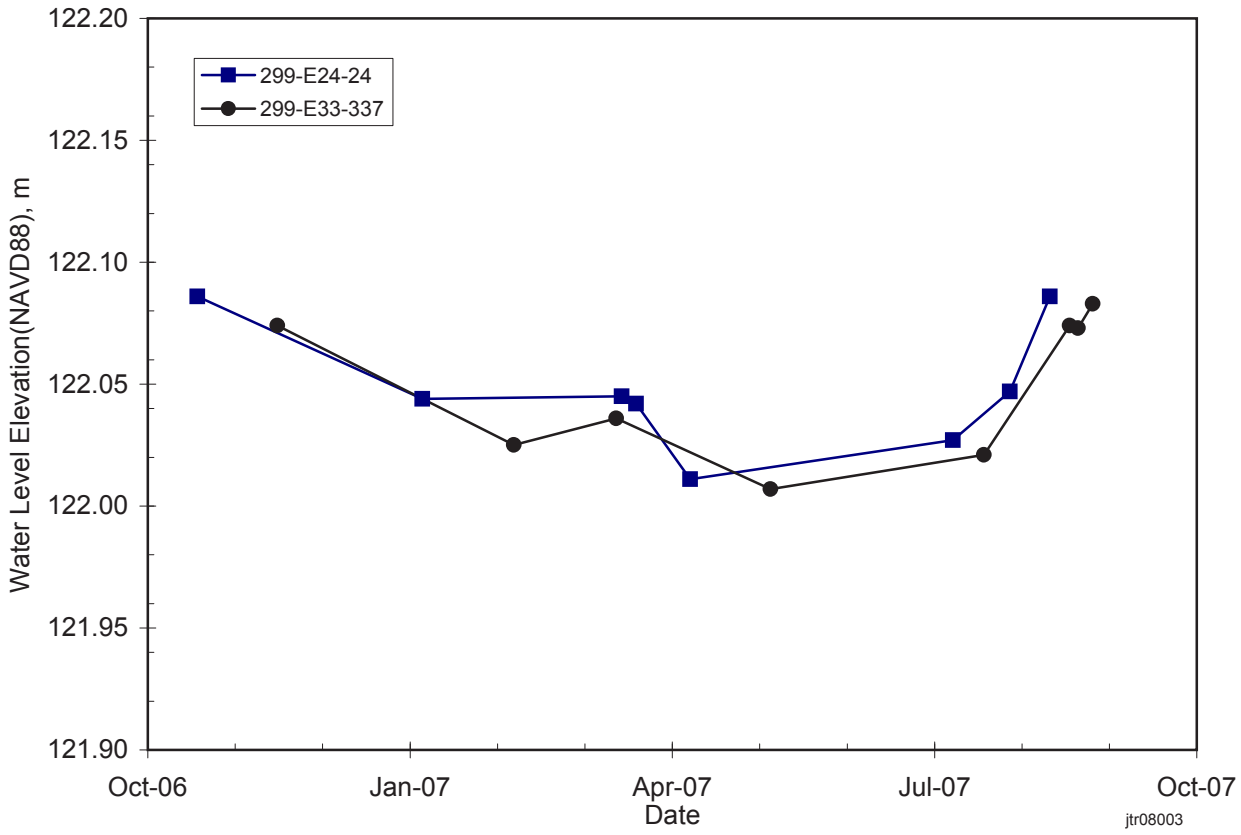

Figure 2.1-3. Water-Table Elevation in 200 East Area, FY 2007

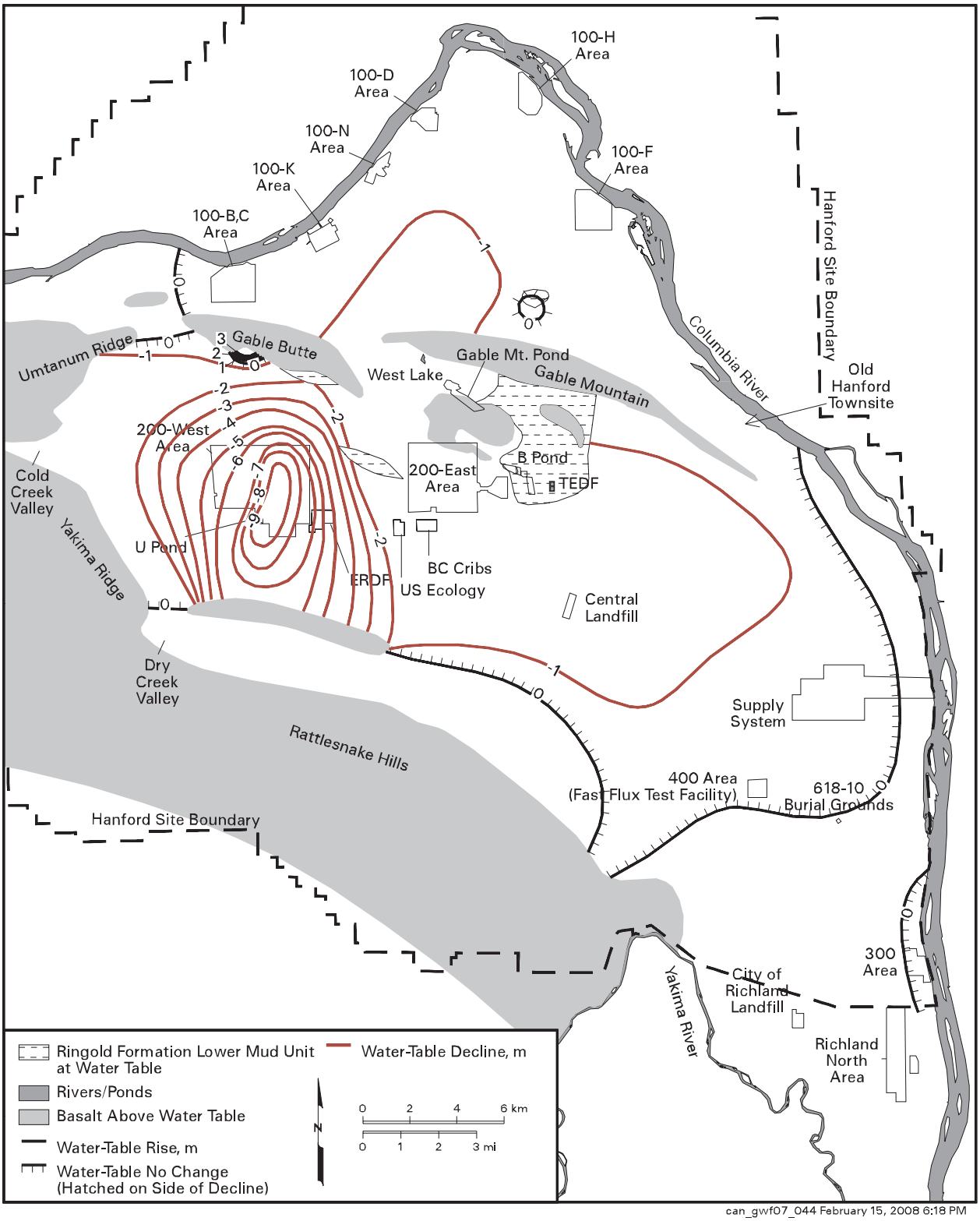

Figure 2.1-4. Changes in Water-Table Elevations at Hanford, 1979 through 2007

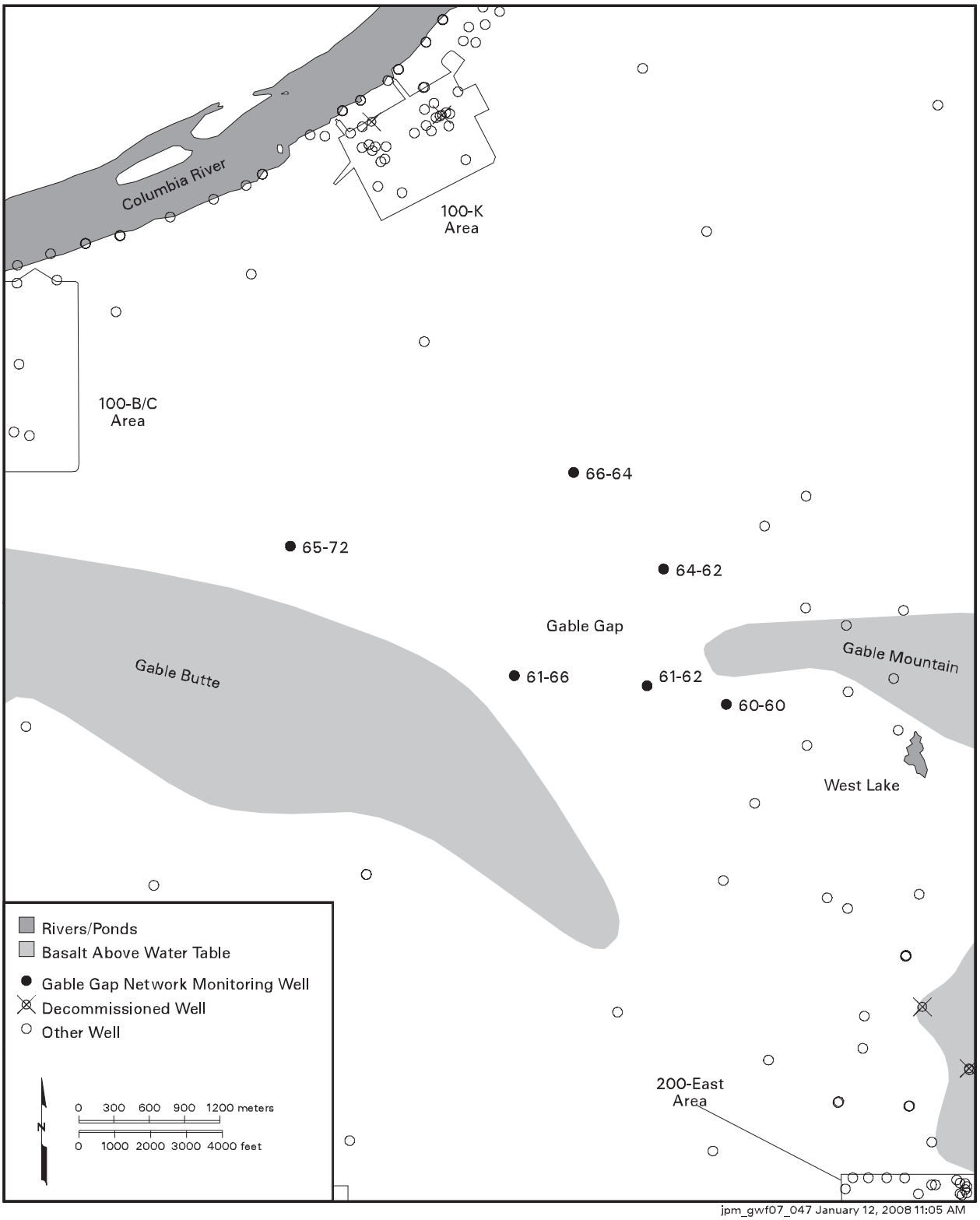

Figure 2.1-5. Wells Used for Water-Level Monitoring Study in Gable Gap

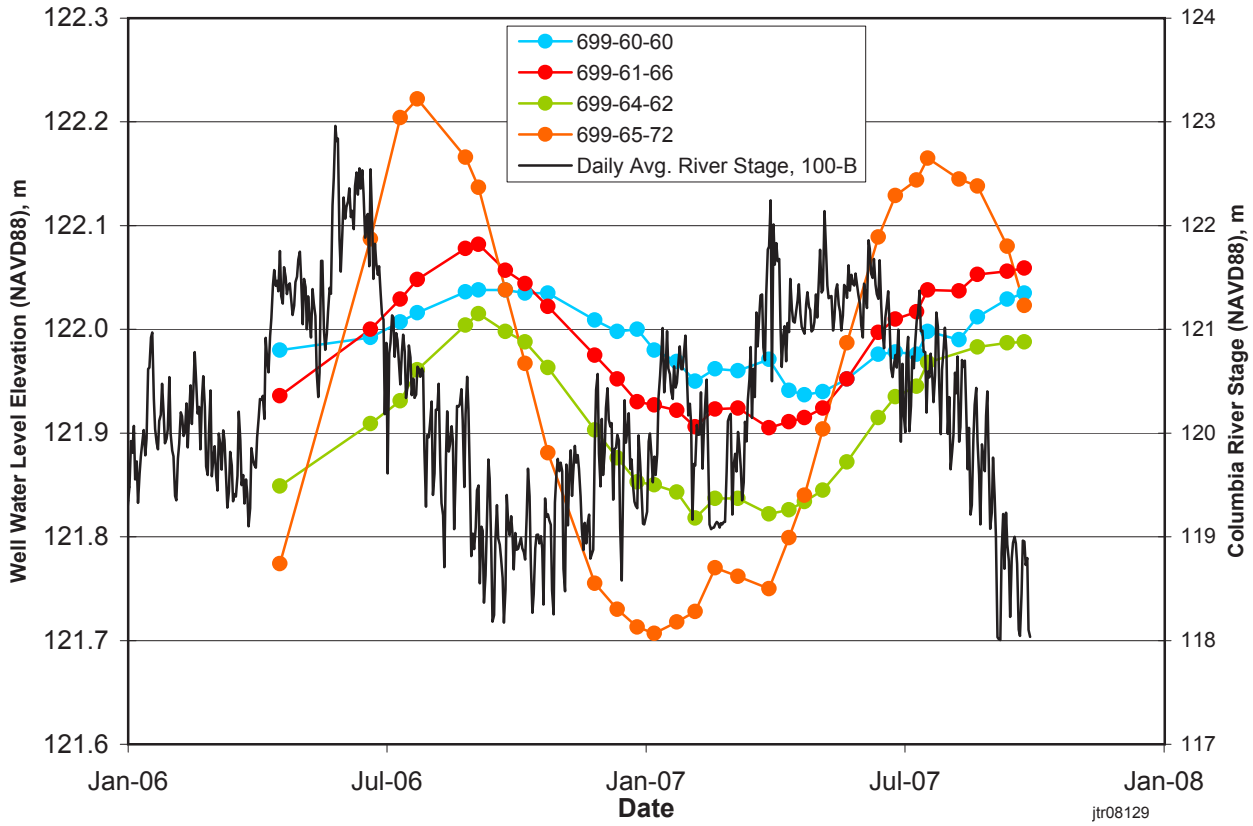

Figure 2.1-6. Association Between Columbia River Stage and Water-Level Elevations in Gable Gap

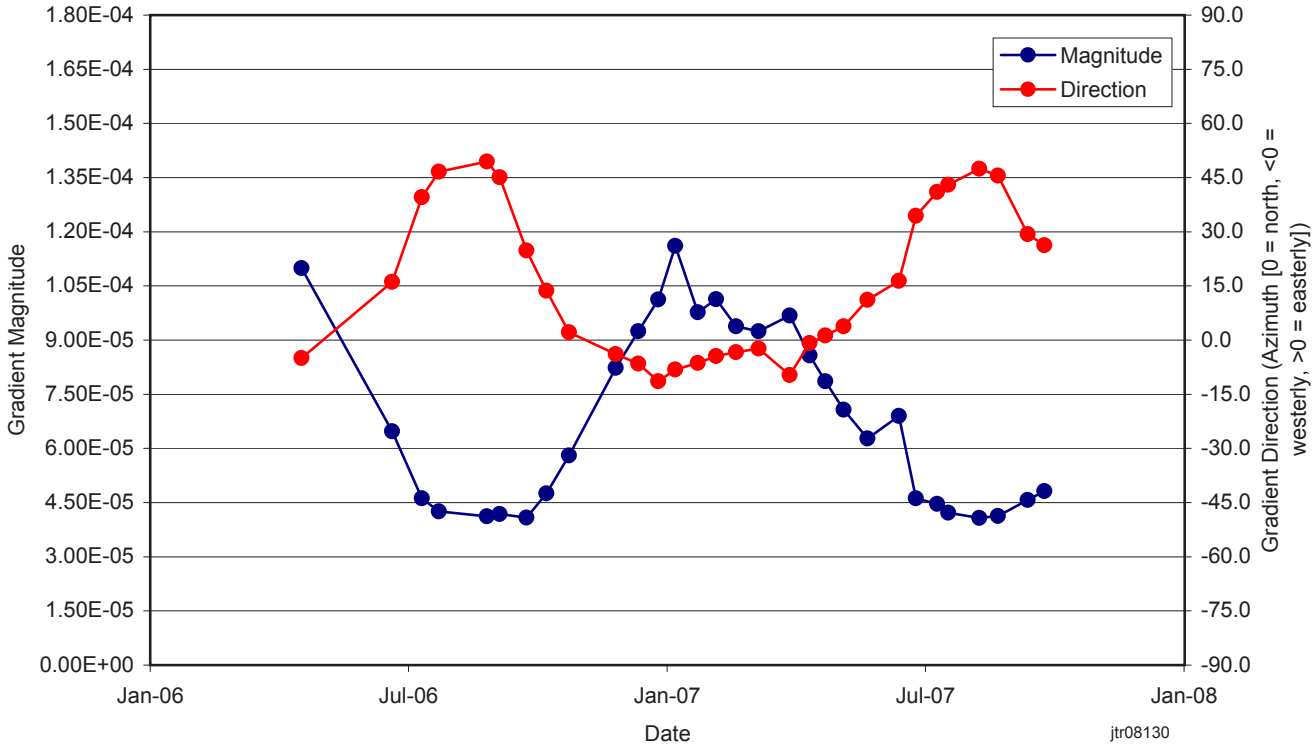

Figure 2.1-7. Variability of the Magnitude and Direction of the Hydraulic Gradient in Gable Gap

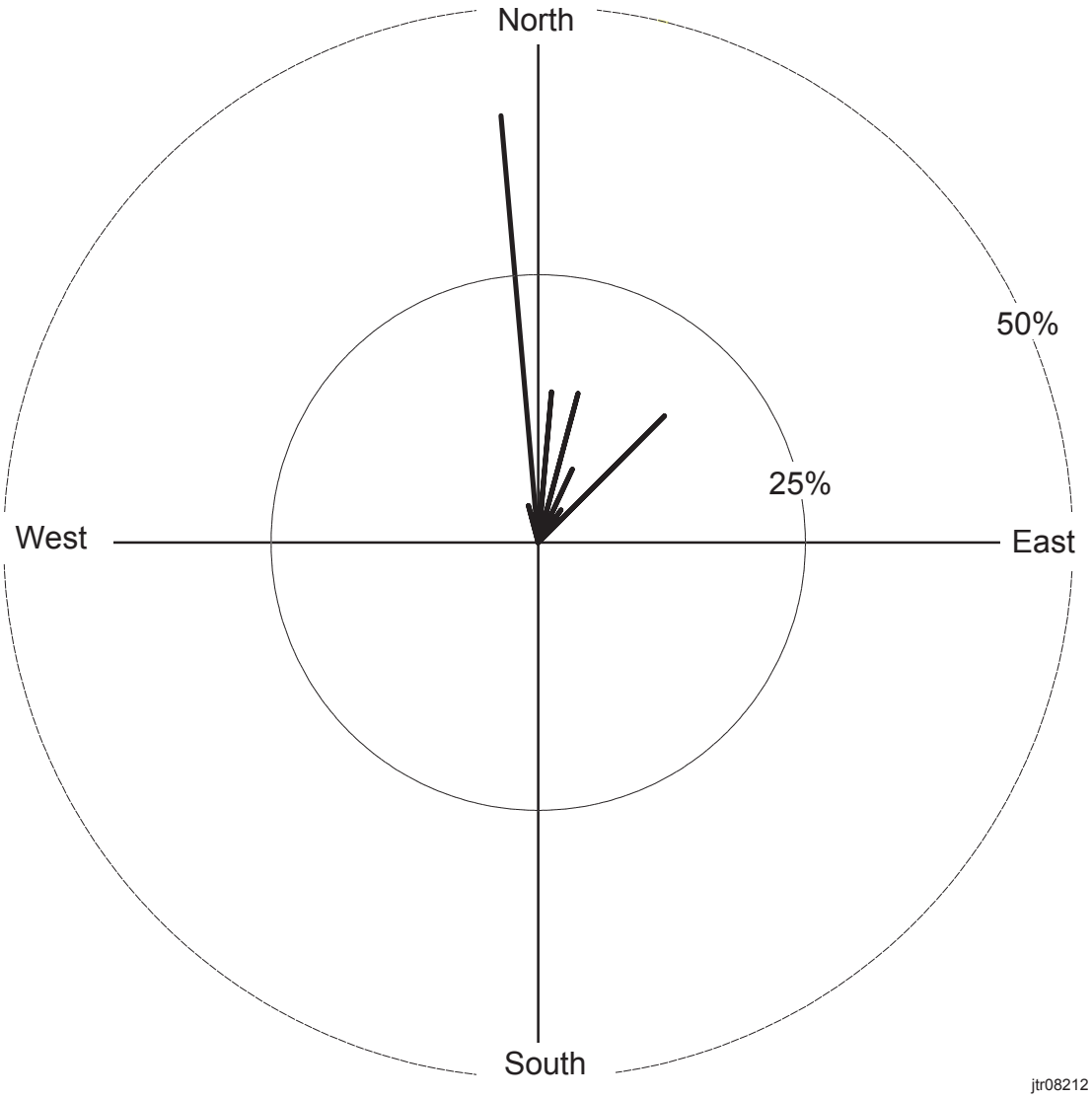

Figure 2.1-8. Rose Diagram of Groundwater Flow Directions in Gable Gap, FY 2007

2.2 100-BC-5 Operable Unit

M. J. Hartman

The scope of this section is the 100-BC-5 groundwater interest area, which includes the 100-BC-5 Operable Unit (see Figure 1.0-1 in Section 1.0). The "groundwater interest areas" are informal designations to facilitate scheduling, data review, and interpretation. Figure 2.2-1 shows facilities, wells, and shoreline monitoring sites in the 100-B/C Area.

Groundwater enters the 100-B/C Area from upgradient areas along the Columbia River and the gaps between Umtanum Ridge, Gable Butte, and Gable Mountain. Groundwater flows primarily to the north beneath the 100-B/C Area and discharges to the Columbia River (Figure 2.2-2). The hydraulic gradient is very flat in the south 100-B/C Area and in the west part of the interest area.

Strontium-90 and tritium exceeded drinking water standards in groundwater at the 100-BC-5 Operable Unit during FY 2007.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). Groundwater monitoring for the requirements of the *Atomic Energy Act* (AEA) are completely integrated with CERCLA monitoring. There are no active waste disposal facilities or *Resource Conservation and Recovery Act* (RCRA) sites in the 100-B/C Area.

2.2.1 Groundwater Contaminants

Wells in the 100-BC-5 Operable Unit are sampled quarterly to biennially for the contaminants of concern based on results of the data quality objectives process (PNNL-14287): strontium-90, tritium, and hexavalent chromium. This section describes distribution and trends of the groundwater contaminants of concern and nitrate beneath the 100-BC-5 groundwater interest area.

2.2.1.1 Strontium-90

A wedge-shaped plume of strontium-90 extends from the central 100-B/C Area north toward the Columbia River (see Figure 2.2-3 in PNNL-15670). The drinking water standard is 8 pCi/L. The plume has not changed significantly in over 10 years. The highest concentrations in FY 2007 were 37 pCi/L in well 199-B3-47 near the 116-B-11 retention basin and 38 pCi/L in well 199-B3-1 near the 116-C-1 trench. These levels were about the same as the previous year. Long-term trends are steady or declining.

Groundwater monitoring in the 100-BC-5 groundwater interest area includes integrated CERCLA and AEA monitoring:

- ***Twenty-five wells are sampled quarterly to biennially.***
- ***Fourteen aquifer tube sites and two seeps are scheduled for sampling annually. One tube was not sampled in FY 2007 (see Appendix A).***

Plume areas (square kilometers) at the 100-BC-5 Operable Unit:
Chromium, 20 µg/L — 0.82
Strontium-90, 8 pCi/L — 0.63
Tritium, 20,000 pCi/L — 0.23

Strontium-90 is limited to the upper part of the unconfined aquifer. Deep well 199-B2-12 consistently has no detectable strontium-90, while its shallow counterpart, well 199-B3-47, has levels above the drinking water standard. Similarly, deep aquifer tubes AT-05-D and AT-06-D had undetectable strontium-90 concentrations while their mid-depth counterparts had concentrations ~9 pCi/L in FY 2007. The shallow tubes at these sites had much higher levels of strontium-90 in FY 2007 than expected (26 pCi/L at tube AT-05-S and 45 pCi/L at AT-06-S). All tubes at site AT-05 and two tubes at site AT-06 were sampled again in November 2007 (FY 2008). Results will help determine whether the FY 2007 results were representative.

2.2.1.2 Tritium

The upper part of the unconfined aquifer beneath the 100-B/C Area is contaminated with tritium that exceeds the drinking water standard (20,000 pCi/L) in several wells (Figure 2.2-3). The distribution of tritium currently is interpreted as three separate plumes with levels above the drinking water standard.

One plume with concentrations above the drinking water standard extends from the 116-B-5 crib to the Columbia River. Wells 199-B4-1 and 199-B5-2, both located downgradient of the 116-B-5 crib, have shown spikes in tritium concentration in recent years (Figure 2.2-4). In FY 2007, concentrations declined from their peak values. The cause of these and previous spikes is unknown. This tritium plume is detected at the Columbia River in aquifer tubes. Tube AT-06-D had the highest concentration (17,000 pCi/L) in an aquifer tube in FY 2007. Concentrations have declined in the past 10 years; in 1998, the concentration in this aquifer tube was 66,000 pCi/L.

A second area where tritium concentrations exceed the drinking water standard is near the former 118-B-1 burial ground in the southwest 100-B/C Area. The burial ground has been excavated. The tritium plume in groundwater is poorly defined because there is only one monitoring well near the burial ground, well 199-B8-6 (Figure 2.2-5). The concentration in 2007 was 31,000 pCi/L, about the same as the previous 2 years. DOE drilled a borehole to help characterize the contamination in the vadose zone beneath the site and collected grab samples of groundwater before filling in the borehole. The maximum tritium concentration in the soil was 39,900 pCi/g at ~17 meters below land surface. Concentrations dropped three orders of magnitude in the soil between that depth and the water table at 25 meters, where tritium concentration was 42 pCi/g. Groundwater samples had 813 and 908 pCi/L tritium. Thus, it appears the tritium from the burial ground has moved downgradient and no longer remains in groundwater directly beneath the burial ground. Well 199-B8-6 will continue to be monitored for tritium.

Two new wells in the south-central 100-B/C Area contained elevated levels of tritium.

A third tritium plume was detected in two new wells in the south-central 100-B/C Area in FY 2007. Wells 199-B8-7 and 199-B8-8 were sampled in September 2007 and well 199-B8-8 contained 59,000 pCi/L tritium (Figure 2.2-3). The source of this tritium is unknown, because the nearby waste sites are not known sources of tritium. The 118-B-1 burial ground does not seem a likely source for the tritium in these wells because the wells are not downgradient. DOE will continue to monitor the new wells for tritium and other constituents (see Appendix A).

Well 199-B5-1, in the west-central 100-B/C Area, had very low tritium concentrations and specific conductance from 2004 through 2006. A fire hydrant leak

was discovered and repaired during FY 2006. The tritium concentration increased to 6,400 pCi/L in FY 2007.

Tritium concentrations from tube sites AT-B-5 and AT-B-7, located just east of the 100-B/C Area, remained elevated but below the drinking water standard (~17,000 pCi/L). Tritium east of the 100-B/C Area is believed to represent a plume from the 200 Areas that migrated northward. Elevated tritium also is observed in well 699-72-73, east of the 100-B/C Area. The FY 2007 result was 16,000 pCi/L.

2.2.1.3 Chromium

Hexavalent chromium is of potential concern to salmon and other aquatic life. Fall Chinook salmon and steelhead spawning areas have been recorded downstream and toward the center of the river channel, but not in areas along the 100-B/C Area shoreline. Shoreline areas provide rearing habitat for young salmon and steelhead, as well as for many of the other species of fish in the Columbia River (DOE/RL-2005-40). The aquatic standard for hexavalent chromium is 10 µg/L.

Chromium concentrations continued to be below the drinking water standard (100 µg/L), but exceeded 10 µg/L in wells and aquifer tubes in the east half of the 100-B/C Area (Figure 2.2-6). The highest concentration in a well was 64 µg/L in an unfiltered sample from well 199-B3-47, downgradient of the 116-B-11 retention basin. A filtered sample had a slightly lower concentration, 55 µg/L. These results are within the range observed since 1999. Deep monitoring well 199-B2-12, located adjacent to 199-B3-47, has no detectable chromium.

Chromium exceeded the 10-µg/L aquatic standard in several 100-B/C wells and aquifer tubes. Concentrations are steady or declining.

Figure 2.2-7 illustrates chromium concentrations with depth in the aquifer for the 100-B/C aquifer tubes and nearby wells. The highest concentrations in FY 2007 were in mid-depth tubes, with a maximum of 51 µg/L in AT-06-M.

Like tritium, chromium concentrations increased in well 199-B5-1 after several years of groundwater dilution from a leaking water line (Figure 2.2-8). The January 2007 result was 11 µg/L. Specific conductance rose to 328 µS/cm, which is comparable to levels before the dilution occurred. Based on observations at other sites with water leaks, it may take several years for contaminants like chromium to rebound completely. The source of formerly high chromium levels in this well is unknown. It could be known sources to the east but could be recently discovered sites like 100-C-7, south of this well.

In the southern 100-B/C Area, waste site investigations discovered chromium contamination in the vadose zone at the 100-C-7 site (see Figure 2.2-1 for location). Two boreholes were drilled at the site to sample sediment and groundwater. They were completed as groundwater monitoring wells 199-B8-7 and 199-B8-8, which will be monitored until the waste site is remediated. Initial chromium results for groundwater samples from the wells ranged from undetected to 11 µg/L.

Another waste site, 100-B-27, located in the northwest 100-B/C Area, also had chromium contamination in the vadose zone. DOE plans to drill a characterization borehole and collect soil and groundwater samples from this waste site (WCH-00225).

2.2.1.4 Nitrate

The *100-B/C Pilot Project Risk Assessment Report* (DOE/RL-2005-40) identified nitrate as a contaminant of concern based on its exceedance of the 45-mg/L drinking

water standard in well 199-B3-47 in 1998 and 1999. Concentrations subsequently decreased. Although the groundwater sampling and analysis plan (DOE/RL-2003-38) does not list nitrate as a contaminant of concern, it is monitored as a supporting parameter. The highest nitrate concentration in FY 2007 was 39 mg/L in well 199-B3-47, an increase from the previous few years (Figure 2.2-9). Nearby aquifer tube AT-06-M had a nitrate concentration of 28.4 mg/L in 2007.

Well 699-72-73, located between 100-B/C and 100-K Areas, had a nitrate concentration of 24.7 mg/L in 2007. Aquifer tubes east of the main 100-B/C Area also had somewhat elevated nitrate concentrations (26.6 and 25.2 mg/L in AT-14-D and AT-B-5-D, respectively). Like tritium, the source of this nitrate is believed to be the 200 East Area.

2.2.2 Operable Unit Activities

The groundwater sampling and analysis plan (DOE/RL-2003-38) specified annual sampling of 9 wells, 14 aquifer tube sites, and 2 seeps and biennial sampling of 14 wells (Appendix A). Of these, 16 wells and all of the aquifer tube sites and seeps were scheduled for sampling in FY 2007. Two new wells near the 100-C-7 waste site were added to the sampling schedule in September 2007. Tri-Party Agreement Change Notice (TPA-CN-182) documented this change to the sampling schedule. All of the wells, both seeps, and all but one of the aquifer tube sites were sampled as scheduled. Tube AT-12-D, located between 100-B/C and 100-K Areas, has not been sampled since 1997. It was sampled in November 2007 (FY 2008). Tubes on either side of it (AT-11 and AT-13) were sampled in FY 2007.

DOE plans to install several new wells in the 100-B/C Operable Unit and may also install additional aquifer tubes. Data from these sites will help define groundwater quality near recently-characterized waste sites.

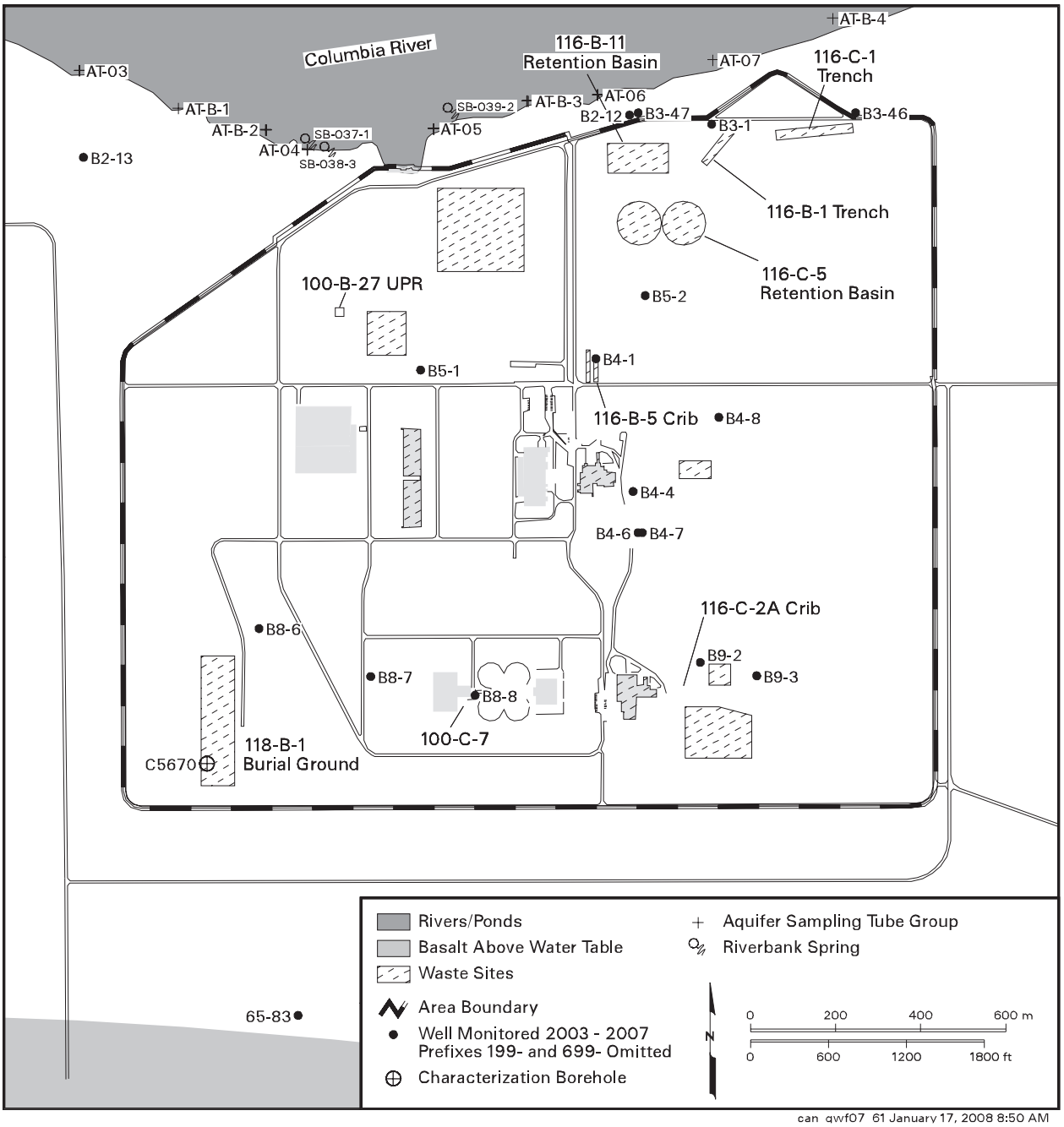

Figure 2.2-1. Groundwater Monitoring Wells in 100-B/C Area

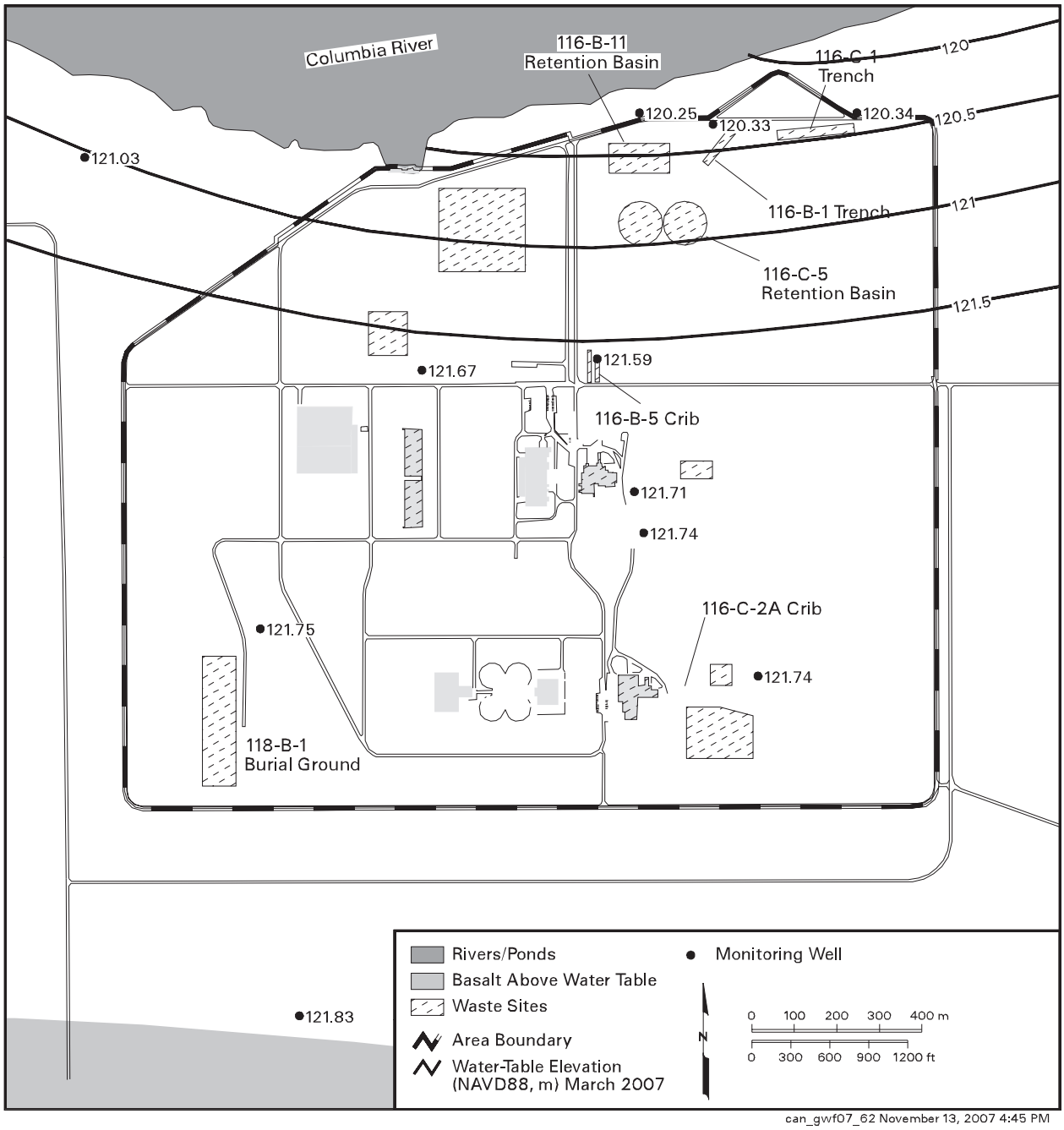

Figure 2.2-2. 100-B/C Area Water-Table Map, March 2007

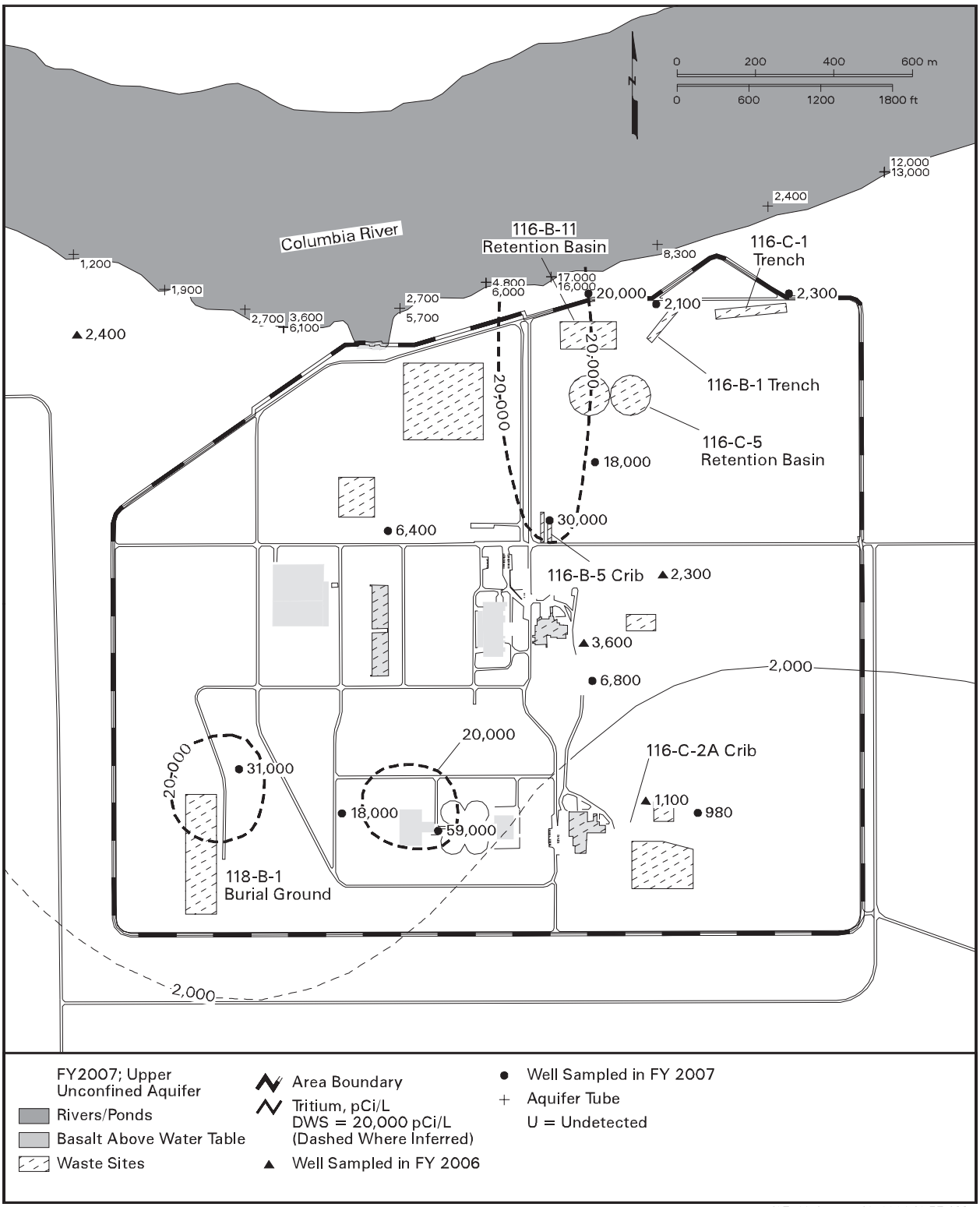

Figure 2.2-3. Average Tritium Concentrations in 100-B/C Area, Upper Part of Unconfined Aquifer

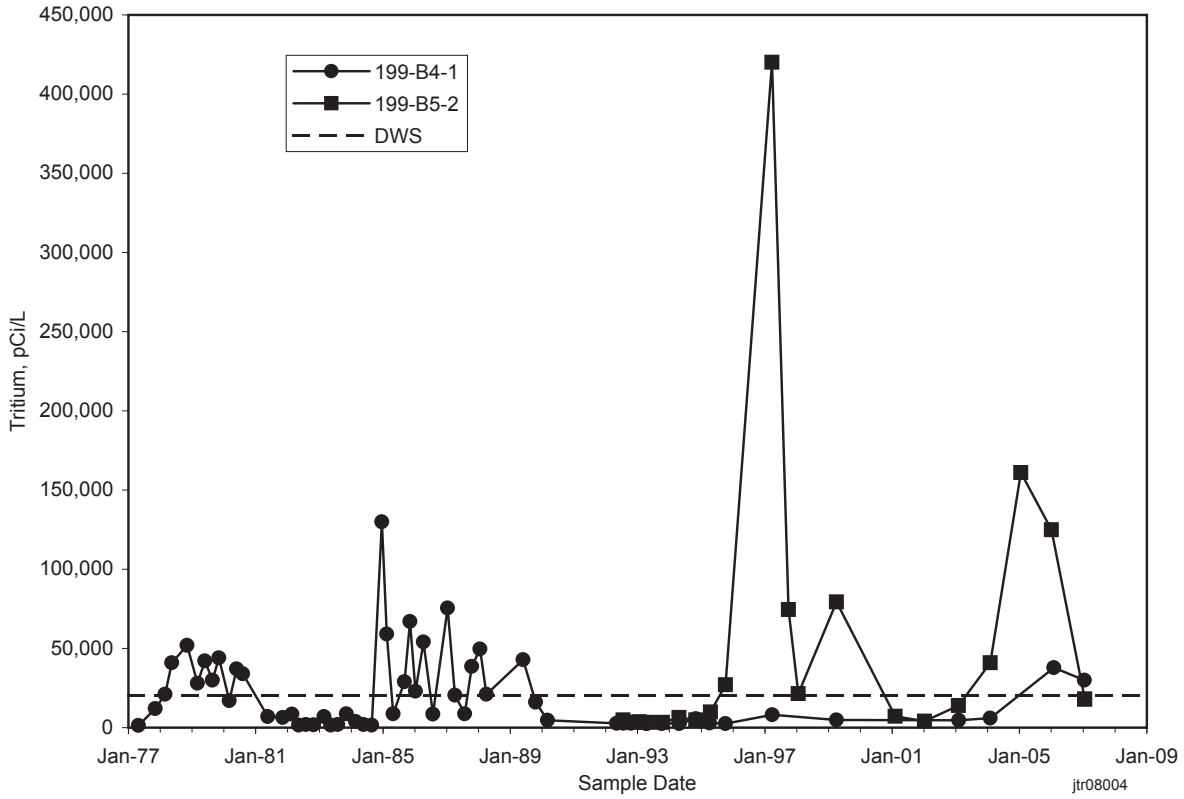

Figure 2.2-4. Tritium Concentrations Downgradient of the 116-B-5 Crib

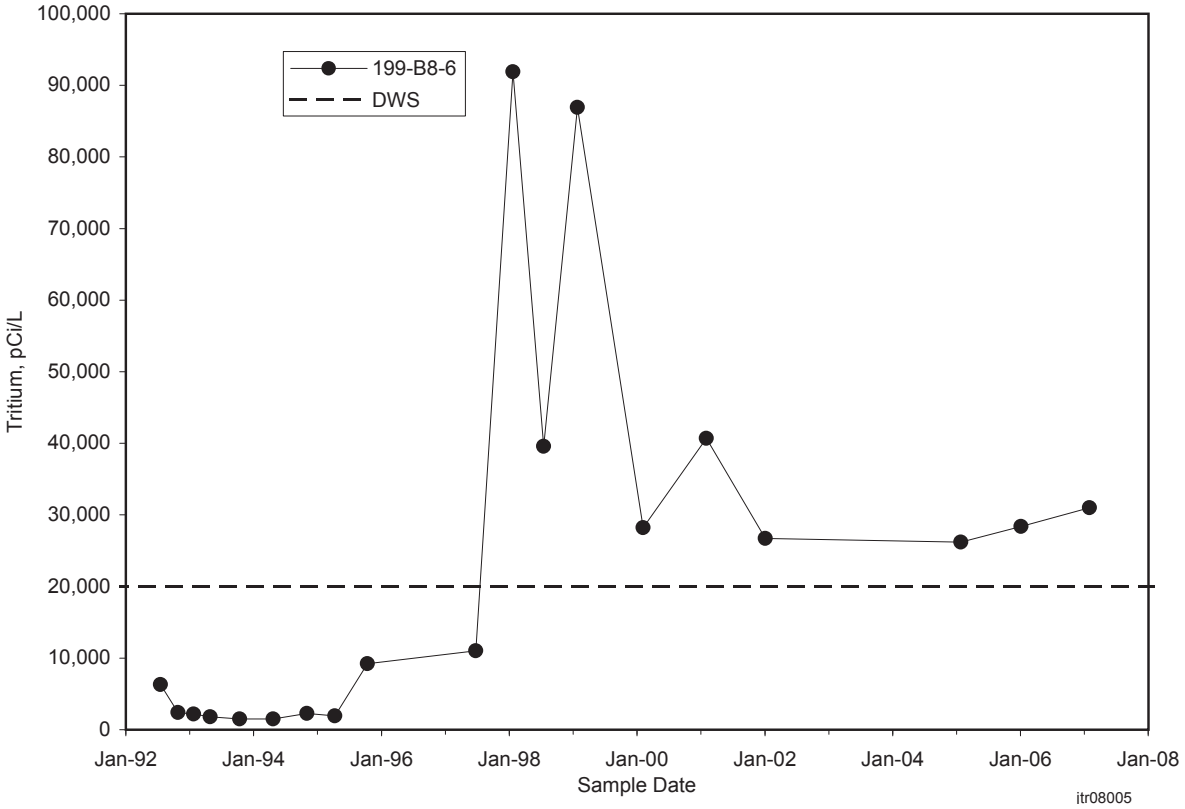

Figure 2.2-5. Tritium Concentrations Downgradient of the 118-B-1 Burial Ground

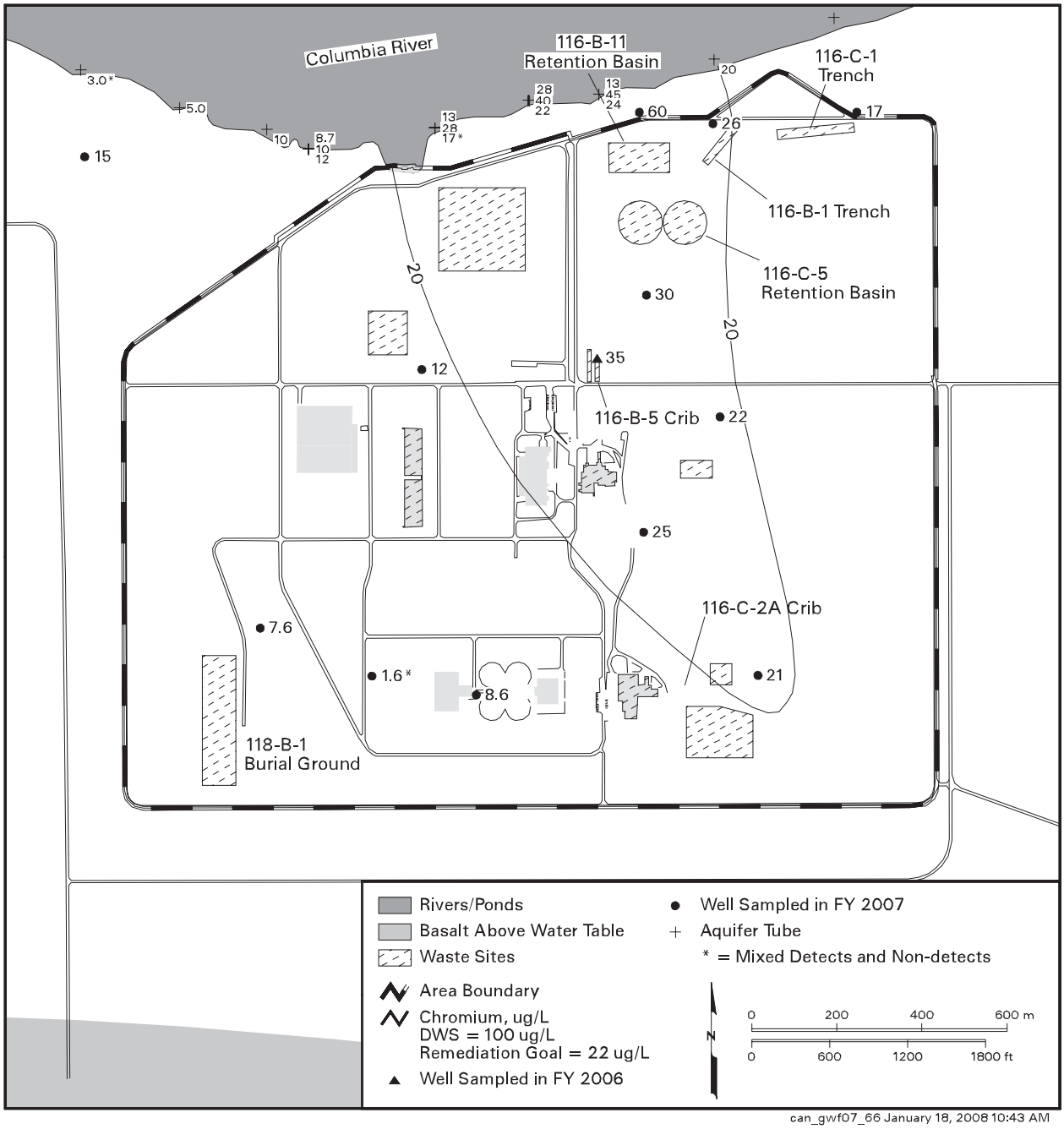

Figure 2.2-6. Average Chromium Concentrations in 100-B/C Area, Upper Part of Unconfined Aquifer

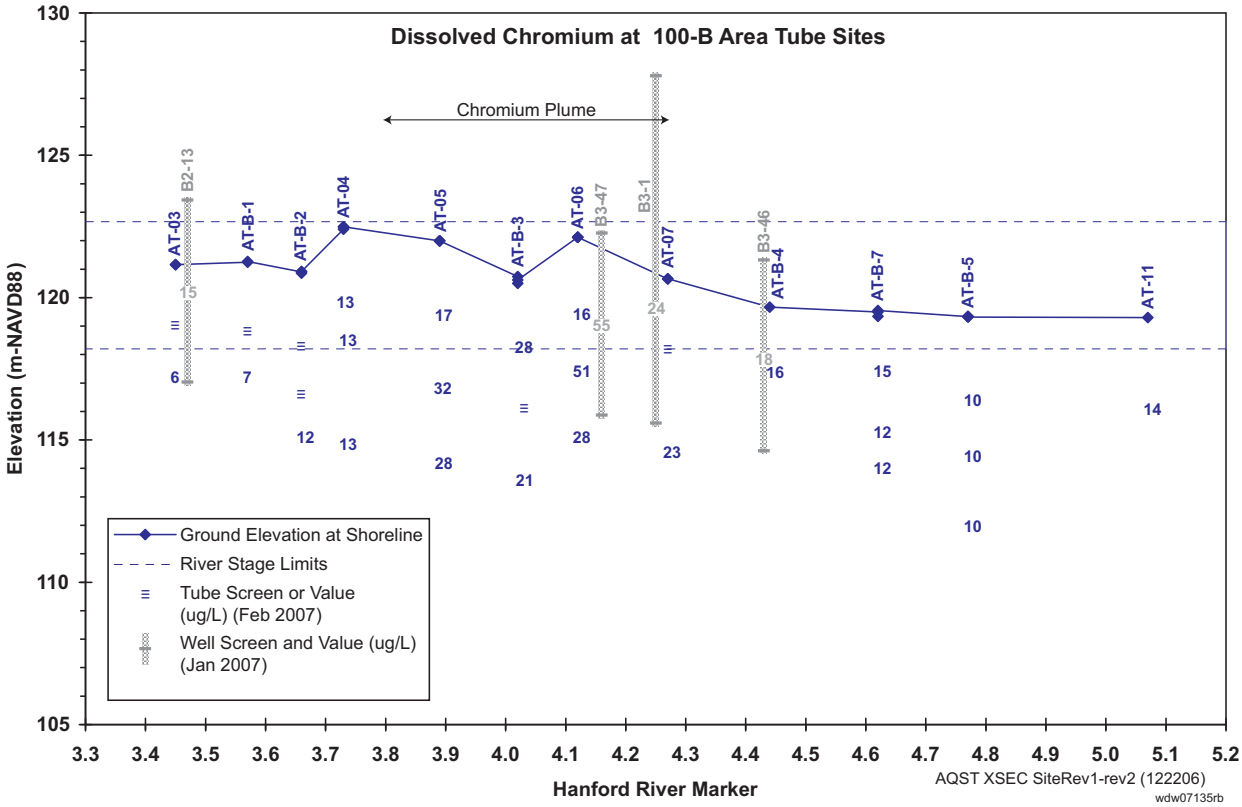

Figure 2.2-7. Sample Elevations and Chromium Concentrations in Wells and Aquifer Tubes in 100-B/C Area (modified from SGW-35028)

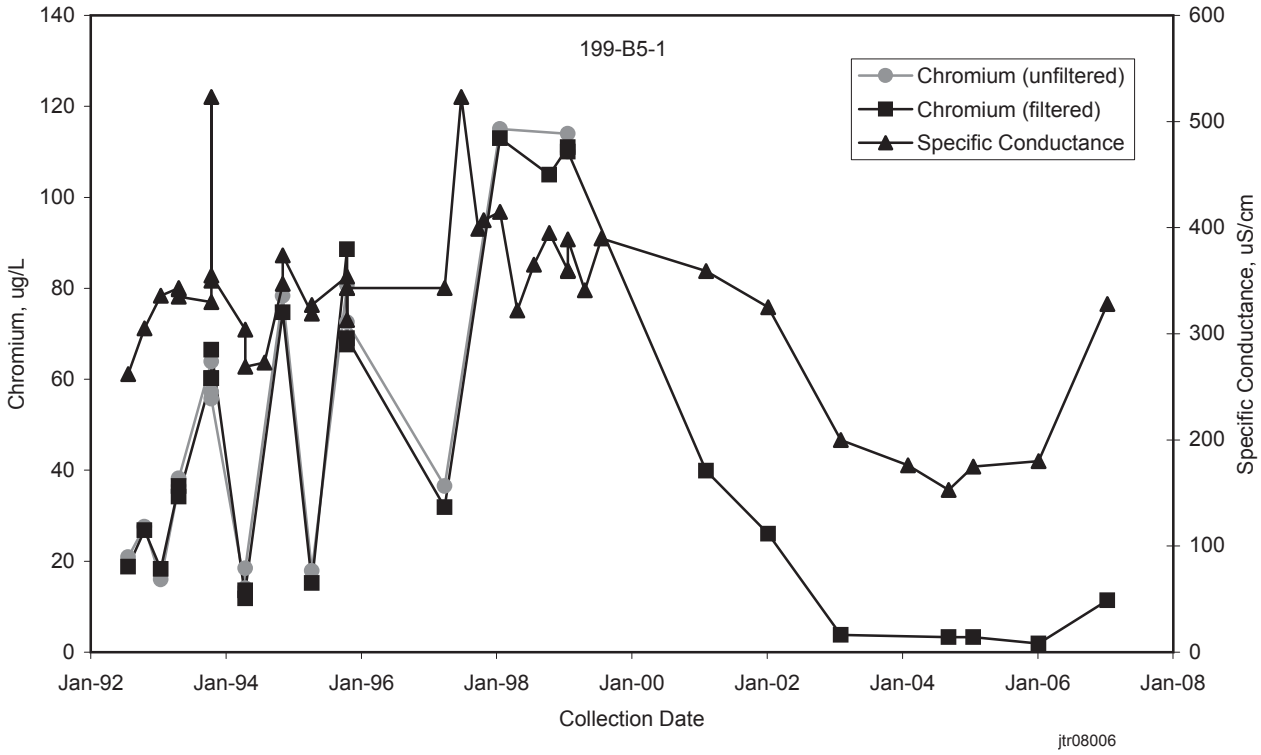

Figure 2.2-8. Chromium Concentrations and Specific Conductance in Well 199-B5-1, Northwest 100-B/C Area

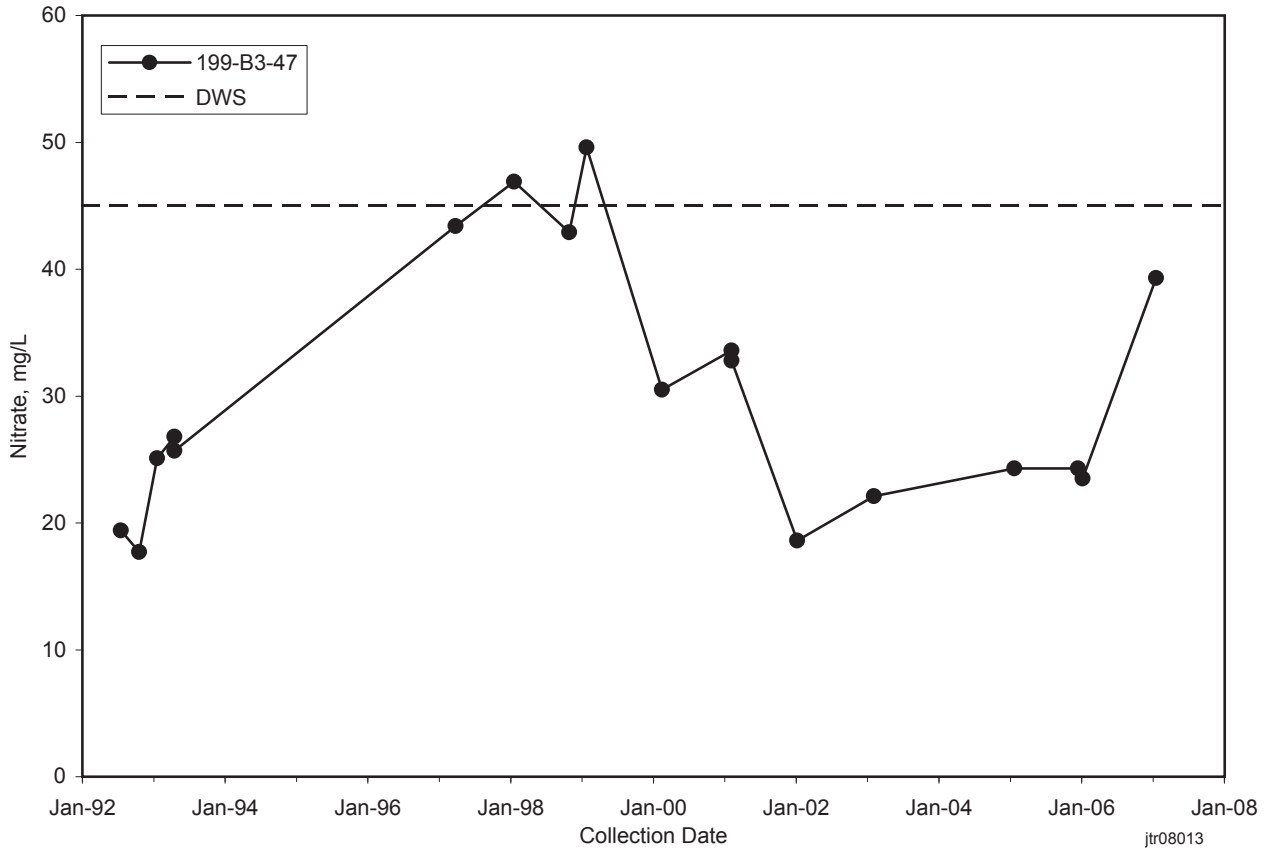

Figure 2.2-9. Nitrate Concentrations Downgradient of the 116-B-11 Retention Basin

2.3 100-KR-4 Operable Unit

M. J. Hartman, D. G. Horton, and R. F. Raidl

The 100-KR-4 Operable Unit includes groundwater affected by contaminant releases from facilities and waste sites within the 100-K Area. Most of the facilities and waste sites are associated with former operation of the KE and KW Reactors and their support facilities. The operable unit lies within a larger 100-KR-4 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (see Figure 1.0-1 in Section 1.0). Figure 2.3-1 shows monitoring wells, shoreline monitoring sites, waste sites, and facilities.

Chromium is the primary contaminant of concern in 100-K Area groundwater. Two pump-and-treat systems are cleaning up the aquifer.

Groundwater monitoring in the 100-K Area is conducted under two regulatory drivers: the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) governs the 100-KR-4 Operable Unit, while the *Atomic Energy Act* provides the basis for monitoring the fuel storage basins at each reactor building (i.e., K Basins). CERCLA requirements are further subdivided into monitoring conducted to (a) characterize and track all contaminants of concern or potential concern in the operable unit, and (b) evaluate the performance of the pump-and-treat systems that remove hexavalent chromium from groundwater.

Groundwater beneath the 100-K Area flows generally toward the northwest (Figure 2.3-2). Groundwater flow in 100-K Area is affected by two pump-and-treatment systems. The larger system has nine extraction wells between the 116-K-2 trench and the Columbia River and four injection wells upgradient of the trench. A water-table mound has formed causing a radial flow pattern to develop around the injection sites (Figure 2.3-2). The mound illustrated in Figure 2.3-2 was estimated using an analytical method that considered injection rates, transmissivity, and specific yield, as documented in PNNL-14031. Downgradient of the KW Reactor building, four wells extract groundwater, which is treated and injected into two wells south (upgradient) of the reactor building.

Groundwater monitoring in the 100-KR-4 groundwater interest area includes the following activities:

CERCLA Long-Term Monitoring (Appendix A)

- ***Twenty-nine wells are sampled monthly to biennially; one quarterly sample was missed.***
- ***Three riverbank springs and sixteen aquifer tubes sites are sampled annually along the 100-K Area river shore.***

CERCLA Interim Action Monitoring (Appendix A)

- ***Sixteen wells are sampled monthly to semiannually; six wells were not sampled as frequently as planned in FY 2007.***

Facility Monitoring (Appendix B)

- ***Fourteen wells are sampled quarterly to semiannually to detect potential shielding water loss to the ground from the KW and KE Basins.***
- ***Four wells are sampled monthly during basin cleanout.***

Near the Columbia River, the groundwater system is influenced by fluctuations in river stage, which is controlled primarily by releases from Priest Rapids Dam. The pattern of movement and the rate at which groundwater discharges to the river are affected by these fluctuations. Because river water infiltrates the banks during periods of high river stage, contaminants carried by groundwater may become diluted prior to their eventual release to the river through riverbed sediment and via riverbank springs.

Groundwater flows to the northwest, toward the Columbia River.

The river stage also affects the elevation of the water table beneath the 100-K Area. During periods of prolonged high river conditions, the elevated water table may contact and mobilize contaminants held in the normally unsaturated lower vadose zone. A good example of this phenomenon occurred during the seasonal high river conditions in 1996 and 1997, when higher than typical contaminant concentrations were observed at some locations associated with former liquid waste disposal sites.

2.3.1 Groundwater Contaminants

Chromium has been identified as a contaminant of concern that warrants interim remedial action in the 100-KR-4 Operable Unit (ROD 1996a). Where groundwater containing chromium discharges into the river environment, there exists a potential risk of harm to aquatic life. Other contaminants of interest in the operable unit include carbon-14, nitrate, strontium-90, technetium-99, trichloroethene, and tritium. These constituents are of interest primarily because their concentrations exceed drinking water standards. They are being monitored while waste sites are being remediated and while facilities are being decontaminated and decommissioned.

The following descriptions of contaminants in 100-K Area groundwater refer to conditions at wells that monitor the uppermost part of the unconfined aquifer. The 100-K Area contains only one well (199-K-32B) that is completed to monitor conditions below the upper aquifer; groundwater at that deep well is essentially free of contamination from past operations.

2.3.1.1 Chromium

Sodium dichromate was used in large quantities as a corrosion inhibitor at the KE and KW Reactors during their years of operation (1955 through 1971). The hexavalent form of chromium is soluble in water and is toxic to aquatic organisms and humans. The Washington State aquatic standard for hexavalent chromium is 10 µg/L, and the drinking water standard for total chromium is 100 µg/L. Chromium is a contaminant of concern for the 100-KR-4 interim action (ROD 1996a) with a cleanup goal of 22 µg/L.

Plume areas (square kilometers) at the 100-KR-4 Operable Unit:
Carbon-14, 2,000 pCi/L — 0.09
Chromium, 100 µg/L — 0.07
Chromium, 20 µg/L — 2.6
Nitrate, 45 mg/L — 0.11
Strontium-90, 8 pCi/L — 0.08
Tritium, 20,000 pCi/L — 0.17

Figure 2.3-3 illustrates the extent of chromium contamination beneath the 100-K Area in FY 2007. The largest chromium plume is associated with the 116-K-2 trench. A smaller plume lies downgradient of the KW Reactor building. In the KE area, one plume appears to originate near the KE water treatment plant, and a new well downgradient of the KE Reactor building also has elevated chromium.

Chromium Beneath the 116-K-2 Trench. The plume that originated at the 116-K-2 trench is largest in areal extent, but has relatively low concentrations (generally <100 µg/L). This trench received large volumes of reactor coolant from

1955 to 1971. The interpretation shown in Figure 2.3-3 assumes that chromium detected in wells 199-K-143 and 699-78-62, which are east of the trench, was pushed inland by radial flow around the large groundwater mound that was present during the operating years (HW-77170). Total chromium was detected above 100 µg/L in well 699-78-62 in 1988 and levels remained >20 µg/L in FY 2007. The trench plume is the target of interim remedial action (see Section 2.3.2).

Figure 2.3-4 is a cross section that illustrates the distribution of chromium with depth in the aquifer near the Columbia River. The concentrations shown are for samples collected during January and February 2007 from aquifer tubes. The variability in observed concentrations is the result of several factors, including vertical distribution of contamination in the groundwater plume, dilution of contaminants by river water at some tubes, and aquifer heterogeneity.

Concentrations at wells that monitor the trench plume are typically less than the drinking water standard and appear to be stable or decreasing, with exceptions at several locations. The overall decrease in the level of contamination is a combined consequence of the pump-and-treat operation and dispersion. Figures 2.3-5, 2.3-6, and 2.3-7 illustrate concentration trends for southwest, central, and northeast groups of wells, respectively.

At the southwest edge of the plume, well 199-K-18 presents an exception to the generally decreasing trends. Concentrations at well 199-K-18 have been increasing, with a maximum value of 156 µg/L in March 2007 (Figure 2.3-5). The start of the increasing trend at this location correlates with the start of the pump-and-treat system in October 1997, suggesting a relationship to the changes in groundwater flow patterns because of groundwater extraction and injection. Chromium concentrations are also relatively higher at nearby aquifer tube site AT-K-3 (80 µg/L in the deep tube in FY 2007).

Data from aquifer tubes suggest that chromium-contaminated groundwater is moving north from 100-K Area.

In the central portion of the plume, chromium levels have declined by an order of magnitude in extraction well 199-K-125A and compliance well 199-K-117A (Figure 2.3-6). Levels remain above the drinking water standard in well 199-K-22, near the trench, and fluctuate seasonally in extraction well 199-K-114A, near the river. Aquifer tubes monitoring the central portion of the trench show decreasing chromium trends (Figure 2.3-8). The decline may be due to the effects of the pump-and-treat system (Section 2.3.2.2).

At the northeast end of the trench, chromium trends are mixed (Figure 2.3-7). Concentrations are gradually decreasing in some wells (e.g., 199-K-129 and 199-K-130). Well 199-K-37 has a relatively stable trend for the past several years. Concentrations at well 199-K-131, which is located ~300 meters northeast of well 199-K-130, were up to 87 µg/L in FY 2007. Results from aquifer tubes for this part of the shoreline confirm the presence of the plume at this location (Figure 2.3-9). The tube site farthest north, AT-26, has had increasing chromium concentrations since 2002 and the FY 2007 maximum was 51 µg/L. The increase may indicate northward migration of the plume.

Chromium Near KE Reactor. Near KE Reactor, a plume with concentrations below the drinking water standard extends from the southeast side of the water treatment plant basins to the southwest corner of the reactor building. The source is likely to be contaminated soil in the vicinity of a former sodium dichromate storage tank and railcar transfer station (WHC-SD-EN-TI-239). Chromium concentrations have varied, as seen at well 199-K-36 (Figure 2.3-10).

DOE recently installed two new wells (199-K-141 and 199-K-142) downgradient of KE Reactor. Well 199-K-141 shows chromium levels above the drinking water standard, ranging from 186 to 288 µg/L in FY 2007. Nearby well 199-K-142 has much lower levels, 8 to 20 µg/L. The contamination in well 199-K-141 does not appear to be connected to that in wells 199-K-36 and 199-K-23, because wells located between these locations have very low chromium levels.

Well 199-K-32A, located farther downgradient of KE Reactor, had low levels of chromium in FY 2007 (14 µg/L). Chromium usually is undetected at aquifer tube sites AT-18 and AT-K-2.

A new pump-and-treat system is operating on the chromium plume near KW Reactor. One well had unexpectedly high concentrations (>2,000 µg/L).

Chromium Near KW Reactor. A chromium plume originating near KW Reactor exceeds the drinking water standard in several wells (see Figure 2.3-3). Concentrations were measured at >2,000 µg/L in new well 199-K-137 (Figure 2.3-11). The suspected source for this contamination is sodium dichromate in the vadose zone at unidentified locations. Candidate locations include the storage tank and transfer station at the southeast side of the KW Water Treatment Plant (same as at KE), and also the underground piping associated with the system used to add sodium dichromate to coolant water. Chromium concentrations in well 199-K-107A are ~500 µg/L and steady (Figure 2.3-11). Concentrations in three of the four extraction wells in the KW plume also were above the drinking water standard when first sampled, but declined during FY 2007 (Figures 2.3-12 and 2.3-13).

Chromium concentrations in aquifer tubes downgradient of the KW plume are very low. Tube sites AT-17 and AT-K-1 had FY 2007 levels <10 µg/L.

2.3.1.2 Tritium

Tritium was common in liquid effluent discharged to the ground during 100-K Reactor operations. However, some of the tritium currently observed in groundwater was introduced after the shutdown of the reactors in 1971. Current sources and potential sources for providing tritium to groundwater include loss of shielding water from the KE and KW Basins, the soil columns beneath the former gas condensate cribs located to the east of each reactor building, and possibly irradiated materials contained in the 118-K-1 burial ground. Tritium has a radioactive decay half-life of 12.3 years. The drinking water standard is 20,000 pCi/L.

Figure 2.3-14 shows the distribution of tritium in groundwater beneath the 100-K Area. The highest tritium concentrations are associated with locations immediately downgradient of the 116-KE-1 and 116-KW-1 cribs. During operating years, the cribs received liquid effluent containing high concentrations of tritium and carbon-14. These waste sites were excavated and backfilled with clean material during FY 2004. Some contaminated soil remained at the bottom of the excavations.

Because high concentrations of tritium are present in the shielding water of each fuel storage basin, tritium in groundwater is closely monitored for evidence of shielding water loss to the ground (PNNL-14033). Also, evidence exists to suggest that tritium is being released from materials in the 100-K burial ground and may be impacting groundwater in the area north of the burial ground.

Tritium Near KE Reactor. The KE tritium plume was formed from past disposal to the former 116-KE-1 condensate crib; leaks to the ground from KE Basin (1976 to 1979, and again in 1993); and possibly mobilization of contamination from the vadose zone beneath the 116-KE-3 drain field and associated catch tank. The tritium distribution pattern reflects a coalescing of plumes from these sources. Figure

2.3-15 shows concentration trends for tritium and co-contaminant carbon-14 at well 199-K-30, located near the core of this plume.

The leading edge of the tritium plume created by the 1993 leak from the KE Basin is believed to have reached the Columbia River. It took ~3 years for the plume to pass well 199-K-27, which is located at the KE Basin, so several years would also be necessary for the entire plume to cross the shore line. The plume from the 1993 leak has mixed with the tritium plume from the former KE condensate crib, and it is difficult to differentiate each plume in the shoreline region. Tritium concentrations in each of these plumes near the river are lower than the drinking water standard.

Tritium concentration trends at wells immediately downgradient of the KE Reactor are shown in Figure 2.3-16. Wells 199-K-27 and 199-K-109A are the wells most likely to detect loss of basin water to the ground. The increases at those wells that started in early 2003 remain unexplained, although there was no evidence from facility operations suggesting a significant loss of shielding water. Since 2003, technetium-99, a second indicator of shielding water, ranged from undetected to 77 pCi/L in these wells. Tritium concentrations in these wells were below the drinking water standard in FY 2007.

The highest tritium concentrations beneath 100-K Area are downgradient of the former KE and KW condensate cribs.

The tritium trend at well 199-K-29 also showed an increase that started in January 2001 (Figure 2.3-16). Levels fluctuated around the drinking water standard in FY 2007. This well is located off to the side of the flow path directly beneath the KE Basin. The trend most likely reflects downgradient migration and lateral spread of the plume associated with the former 116-K-1 condensate crib, rather than water loss from the KE Basin.

Tritium Near KW Reactor. The plume near the KW Reactor is most likely associated with effluent disposed during the operating years to the former 116-KW-1 condensate crib. An unexplained increase in tritium concentrations at well 199-K-106A, located downgradient of the crib, began in 2001, peaked sharply in 2003 and early 2005, and declined to 30,000 pCi/L by August 2007 (Figure 2.3-17). Other constituents showing a similar trend include chloride, nitrate, and possibly technetium-99. Carbon-14, which was disposed to the crib but is less mobile than tritium, does not follow the tritium trend. The cause for the trends at well 199-K-106A is presumed to be mobilization of contaminants associated with the crib and underlying soil column, although a driving mechanism has not been positively identified.

There is no evidence in groundwater monitoring data to suggest water loss to the ground from the KW Basin in recent years. Wells 199-K-34 and 199-K-107A are most likely to detect shielding water. FY 2007 tritium concentrations ranged from 2,900 to 10,000 pCi/L in well 199-K-34 and <1,000 pCi/L in well 199-K-107A.

Tritium Downgradient of the 118-K-1 Burial Ground. Tritium concentrations at well 199-K-111A, located at the northwest corner of the burial ground, began rising abruptly in mid-2000 to a peak value of 98,200 pCi/L in April 2002. Since that time, concentrations declined to a level of ~10,000 pCi/L. No monitoring wells exist along the direct downgradient flow path to the river. However, the nearest well just to the side of that flow path is well 199-K-18, located ~450 meters to the north of well 199-K-111A. Assuming a plume migration rate of 0.12 meter/day, the "pulse" of tritium that passed by well 199-K-111A starting in 2001 might possibly be detected at well 199-K-18 in ~10 years, i.e., ~2011. Tritium levels in well 199-K-18 have been between 20,000 and 40,000 pCi/L for at least 10 years.

The source for tritium in groundwater near the burial ground was the subject of a multifaceted investigation during 2002 and 2003 (PNNL-14031). Results suggested the likelihood of a tritium source in the burial ground, along with an underlying groundwater plume.

Tritium Near the 116-K-2 Trench. Tritium concentrations downgradient of the trench typically are below the drinking water standard. The exception occurs at the southwest end of the trench, where average concentrations during FY 2007 were ~29,000 and ~33,000 pCi/L at wells 199-K-18 and 199-K-120A (a pump-and-treat system extraction well), respectively. The source for tritium at this location is uncertain; it may represent past disposal to the 116-E-1 crib or 116-K-2 trench, or possibly tritium from a source farther inland, such as the 118-K-1 burial ground.

2.3.1.3 Carbon-14

Condensate from gas circulated through the KE and KW Reactors contained carbon-14 (along with tritium) and was discharged to infiltration cribs at the east side of each reactor building. Release of carbon-14 from the cribs, which were excavated and backfilled during 2004, is the source for the carbon-14 plumes near each reactor. The drinking water standard is 2,000 pCi/L, which continued to be exceeded during FY 2007 at several wells that monitor these plumes. The half-life for carbon-14 is 5,730 years. This radionuclide exchanges with carbon in carbonate minerals, and so its movement is more restricted and variable than a non-exchanging constituent like tritium.

Carbon-14 concentrations exceed the drinking water standard at several wells downgradient of former cribs near KE and KW Reactors.

The two plumes are positioned between the crib source locations and the Columbia River (see Figure 2.3-18 in PNNL-16346 for a FY 2006 map). Current concentrations of carbon-14 in groundwater at wells immediately downgradient of each crib continued to exceed the drinking water standard (Figures 2.3-15 and 2.3-17). Levels have declined in the past 10 years. Concentrations in aquifer tubes downgradient from the 116-KE-1 crib ranged from undetected to ~100 pCi/L. Aquifer tube 17-D, downgradient of KW Reactor, typically detects concentrations of carbon-14 in the hundreds of picocuries per liter, which are above background levels.

Carbon-14 also has been detected at well 199-K-108A in an area upgradient of the 116-KW-1 condensate crib. Concentrations exceeded the drinking water standard during the mid-1990s. During the period 2000 to 2004, groundwater at this location was diluted by clean water from an unknown source; specific conductance and contamination indicators were dramatically reduced in concentration. In 2005, dilution apparently ceased and concentrations began to rebound. In FY 2007, the carbon-14 concentration was 1,600 pCi/L, about the same as FY 2006.

2.3.1.4 Strontium-90

Strontium-90 was released to the environment at 100-K Area primarily via used reactor coolant. It may also have been present in fuel storage basin shielding water, which was discharged to nearby drain fields and injection wells during the reactor operating period. Strontium-90 continues to be present at relatively high concentrations in the shielding water at KE and KW Basins. The radionuclide is moderately mobile in the environment and has a half-life of ~29 years. The drinking water standard is 8 pCi/L.

Strontium-90 Near the KE Reactor. The highest concentrations in 100-K Area groundwater have been observed near the northwest corner of the KE Reactor, at well 199-K-109A, and reached a peak of ~18,000 pCi/L in 1997 (Figure 2.3-18). The

elevated concentrations during the period 1996 through 2000 correlate with a period of sustained high water-table conditions. The presumed source is contamination in the vadose zone beneath the former drain field/injection well. Concentrations declined following that peak value, and FY 2007 results ranged from 56 to 757 pCi/L. Strontium-90 was not analyzed in wells farther downgradient.

The highest concentration of strontium-90 in 100-K Area groundwater samples occurs near the northwest corner of the KE Reactor.

Strontium-90 Near the KW Reactor. Strontium-90 concentrations near KW Reactor are much lower than near KE Reactor. The maximum concentration in FY 2007 was 26.6 pCi/L in well 199-K-107A, part of a gradually declining trend. Strontium-90 concentrations downgradient in extraction wells 199-K-139 and 199-K-140 ranged from undetected to 1.6 pCi/L in FY 2007.

Strontium-90 Near the 100-K Trench. The effluent disposed to the former 100-K trench contained strontium-90, which is still present in groundwater. FY 2007 concentrations exceeded the 8-pCi/L drinking water standard in three wells. The highest concentration was 31 pCi/L in well 199-K-21, downgradient of the central portion of the trench. Trends are declining gradually in most wells.

2.3.1.5 Nitrate

Nitrate is widely distributed beneath the 100-K Area, mostly at levels below the 45-mg/L drinking water standard. Potential sources include currently active septic systems and past-practices waste sites, but the distribution pattern does not clearly delineate specific source sites. Six wells had FY 2007 average concentrations above the drinking water standard: three near KW Reactor, two near KE Reactor, and one near the 116-K-2 trench. The highest concentration was 137 mg/L in well 199-K-106A, located near KW Reactor.

Nitrate concentrations exceed drinking water standards in some portions of the 100-K Area.

2.3.1.5 Trichloroethene

Trichloroethene was analyzed in samples from wells 199-K-106A and 199-K-132, which are located downgradient of the former 116-KW-1 condensate crib. Well 199-K-106A, located nearest the crib, shows an overall declining trend (Figure 2.3-19), with a FY 2007 maximum of 5.1 µg/L. Extraction well 199-K-132, located farther downgradient, had a concentration of 6.4 µg/L, an increase from the previous results. The drinking water standard for trichloroethene is 5 µg/L.

2.3.2 Operable Unit Activities

This section summarizes activities relating to the 100-KR-4 Operable Unit. Two pump-and-treat systems operate as an interim remedial action for hexavalent chromium.

2.3.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified four actions pertaining to the 100-K Area.

- **Action 3-1**. Install three additional wells to further delineate the 116-K-2 trench chromium plume (August 2008). One well, 199-K-143, has been installed to date. Additional wells were installed in early FY 2008 (Section 2.3.2.2).
- **Action 4-1**. Construct a new pump-and-treat facility to address the chromium groundwater plume in the KW Reactor area (August 2008). The KW pump-and-treat system began to operate in January 2007. Section 2.3.2.3 provides more information.

DOE plans to expand groundwater remediation in the 100-K Area in 2008.

- **Action 5-1**. Expand the 100-K Area pump-and-treat system by 378.5 liters/minute to enhance remediation of the plume between the 116-K-2 trench and the N Reactor perimeter fence (August 2008). Expansion began in FY 2007 and is continuing in FY 2008 (Section 2.3.2.2).
- **Action 5-2**. Add additional wells between the 116-K-2 trench and the N Reactor perimeter fence for groundwater extraction, and connect the additional wells to the pump-and-treat system (March 2007). DOE plans to expand the system in FY 2008 (Section 2.3.2.2).

2.3.2.2 116-K-2 Pump-and-Treat System

Interim remedial action under CERCLA at the 100-KR-4 Operable Unit initially targeted the chromium plume beneath the 116-K-2 trench. A pump-and-treat system removes hexavalent chromium from extracted groundwater and injects the treated effluent upgradient of the former trench (see Figure 2.3-1). A second area of contamination, near the KW Reactor complex, was added to the interim remedial action, and a new pump-and-treat system became operational in 2007. The remedial action objectives and criteria for success remain the same as for the initial target plume.

As described in the remedial design/remedial action work plan for the initial interim action (DOE/RL-96-84), the performance criteria for these pump-and-treat systems include achieving hexavalent chromium concentrations that do not exceed 22 µg/L in near-river wells. DOE/RL-2006-76 presents results of operational monitoring and additional details about the pump-and-treat systems for calendar year 2006. Results for calendar year 2007 will be included in an upcoming report on the 100 Areas pump-and-treat systems.

DOE plans to expand the 116-K-2 pump-and-treat system in FY 2008, which will fulfill five-year review Action Items 5-1 and 5-2. DOE/RL-2006-75 describes the design of the planned expansion.

During FY 2007, the pump-and-treat system at the 116-K-2 trench involved nine extraction wells, five injection wells, and an ion-exchange resin treatment system (DOE/RL-2006-08). The system began operating in October 1997. Figures 2.3-5 and 2.3-6 show chromium trend charts for wells in the 116-K-2 trench plume. Appendix A includes lists of sampling frequencies and analyses.

During FY 2007, the pump-and-treat system extracted and treated ~535 million liters of groundwater and removed ~20 kilograms of hexavalent chromium. Since the startup of operations in October 1997, the system has treated ~4.15 billion liters of groundwater and removed ~312 kilograms of chromium. The FY 2007 average flow rate for each extraction well ranged between 48 and 155 liters/minute, with a combined average flow rate of 1,067 liters/minute (DOE/RL-2006-76). There were no major operational changes to the 100-KR-4 pump-and-treat network during FY 2007.

The remedial action objectives for the 100-KR-4 Operable Unit (ROD 1996a) are:

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminant in the groundwater.***
- ***Provide information that will lead to the final remedy.***

The contaminant of concern is hexavalent chromium. The record of decision specifies 22 µg/L as the concentration at compliance wells that is protective of aquatic organisms in the river environment.

Chromium concentrations within the target plume area show generally decreasing or stable trends (Figures 2.3-5, 2.3-6, and 2.3-7; see Section 2.3.1.1). During FY 2007, decreasing trends continued at wells 199-K-20 , 199-K-119A, and 199-K-120A. Relatively constant concentrations during FY 2007 were observed at wells 199-K-18, 199-K-117A, 199-K-125A, 199-K-37, 199-K-113A, 199-K-114A, 199-K-115A, 199-K-116A, 199-K-130, and 199-K-131. Concentrations consistently were at or below the remedial action goal (22 µg/L) only at wells 199-K-117A and 199-K-125A.

Several wells are strongly influenced by infiltration of river water, where contaminant concentrations are reduced by mixing of groundwater and river water. Periodic mixing is observed at well 199-K-114A, creating cyclic fluctuations of chromium concentrations (Figure 2.3-6). A continuous presence of river water is observed at well 199-K-117A, as indicated by the low specific conductance of the samples.

Chromium concentrations at some aquifer tube sites along the shore segment adjacent to the central portion of the plume have decreased with time (Figure 2.3-8). Concentrations were below the 22 µg/L remedial action goal at tube sites AT-21, AT-22, and AT-23 in FY 2007. At the northern end of the plume, chromium concentrations at tube sites have increased over the past four years (Figure 2.3-9). The increase suggests that the plume is moving northward.

The injection of treated effluent at five wells has created a water-table mound. The injected water has migrated downgradient and arrived at wells 199-K-20, 199-K-116A, 199-K-119A, and 199-K-125A, as shown by increasing tritium concentrations at those wells. Tritium is a good tracer for showing the effects of injection, as concentrations are higher in the treated effluent than in groundwater near most of the extraction wells.

Chromium concentrations are generally decreasing in the area of the 100-K trench pump-and-treat system.

Uncertainties regarding the pump-and-treat system's influence on aquifer conditions involve the (1) extent of plume inland of the trench, and whether or not chromium observed at well 699-78-62 is part of the plume; (2) source for chromium and tritium at wells 199-K-18 and 199-K-120A, where some concentration trends are increasing; (3) height and extent of the mound created at the injection site, and its influence on flow patterns; and (4) mass of potentially mobile chromium remaining in the lower vadose zone and in the aquifer upgradient of the trench.

Well 199-K-143 has been installed inland of the trench to help define the areal extent of the chromium plume (five-year review Action 3-1). Hexavalent chromium concentrations in this well ranged from 19 to 22 µg/L in FY 2007.

2.3.2.3 KW Pump-and-Treat System

DOE began to operate a new pump-and-treat system for chromium near KW Reactor in January 2007 (see Section 2.3.1.1 for description of the plume). This remedial action fulfills five-year review Issue 4, Action 4-1 (see Section 2.3.2.1). A remedial design/remedial action work plan (DOE/RL-2006-52) describes the new system. As currently designed, the system includes four extraction wells, two injection wells, and ion-exchange treatment equipment similar to that previously used in the 100-KR-4 and 100-HR-3 Operable Units. Initial treatment capacity is 379 liters/min, with provision for increases to 757 liters/min if required.

In FY 2007, the new pump-and-treat system extracted 122.5 million liters of water and removed 15.8 kilograms of hexavalent chromium. By the end of FY 2007, the hexavalent chromium concentrations in near-river extraction wells stabilized

at ~50 µg/L in well 199-K-138 and ~100 µg/L in well 199-K-132 (Figure 2.3-12). Concentrations in inland extraction wells stabilized at ~25 µg/L in well 199-K-140 and ~220 µg/L in well 199-K-139 (Figure 2.3-13). Upgradient monitoring well 199-K-137 had chromium concentrations ~2,200 µg/L in FY 2007, but concentrations in this range have not yet appeared in downgradient wells.

Two pump-and-treat systems have removed 328 kilograms of chromium from 100-K Area groundwater.

2.3.2.4 Calcium Polysulfide Treatability Test

Four wells installed in late 2005 adjacent to well 199-K-126 to perform a treatability test using calcium polysulfide were sampled monthly in FY 2007. Chromium concentrations increased to 51 µg/L in well 199-K-126 in October 2006, and stabilized between 40-45 µg/L by August 2007. This test evaluated the practicality of treating chromium in the groundwater as an alternative to pump-and-treat systems. The study concluded that hexavalent chromium effectively was eliminated from the treated aquifer (DOE/RL-2006-17). The aquifer was chemically reduced and was expected to remain a permeable reactive barrier that will treat groundwater as it flows through.

2.3.3 Facility Monitoring — K Basins

The fuel storage basins located within the KE and KW Reactor buildings were used from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin holds ~4.9 million liters of shielding water that is highly contaminated with long-lived radionuclides, some of which are mobile in the environment (e.g., tritium and strontium-90). The KE Basin has leaked in the past, and the leakage has affected groundwater. The vadose zone beneath the basin is also known to contain radionuclides that are absorbed onto the soil. Information on the removal of spent fuel and contaminated sludge, and the demolition of these basins, can be found at DOE's Richland Operations Office web site (http://www.hanford.gov/rl; communications tab, programs, Spent Nuclear Fuel). Tri-Party Agreement (Ecology et al. 1989) Milestone M-34-00 covers the fuel removal and basin cleanup project, the latter now referred to as the K Basins Closure Project.

The K Basins sampling and analysis schedule complements other schedules associated with the 100-KR-4 Operable Unit. The monitoring plan for K Basins (PNNL-14033) describes the objectives for the monitoring:

- Characterize groundwater conditions between the K Basins and the Columbia River to provide a periodic status of current conditions and the attenuation of plumes.
- Distinguish between groundwater contamination associated with K Basins and contamination from other past-practices sources to help guide operational and remedial action decisions.
- Maintain a strategy for the potential expansion of monitoring capabilities to respond to future basin-related issues.

These objectives remain valid as long as shielding water remains in the basins. Once actual demolition and removal of the basins begins, the strategy and objectives for groundwater monitoring will be revisited. In the interim, two additional monitoring wells (199-K-141 and 199-K-142) have been installed in the area between

KE Basin and the Columbia River. The installation of three new wells (199-K-138, 199-K-139, and 199-K-140) downgradient of the KW Basin, as part of a pump-and-treat system for chromium in that area, also improves the monitoring capability near the KW Basin.

The primary indicator for detecting shielding water in groundwater is tritium, which is present at concentrations in the millions of picocuries-per-liter range in KE and KW Basin water. Other less mobile radionuclides (e.g., strontium-90, cesium-137) are also present at relatively high concentrations in shielding water. However, if small volumes or low rates of leakage were to occur, the strontium-90 and cesium-137 might not reach groundwater because they would be retained in the vadose zone and tritium levels might be too low to detect. One additional tracer for shielding water is technetium-99, which is mobile, like tritium, but is at relatively low concentrations in the shielding water.

Wells 199-K-27 and 199-K-109A are located adjacent to the KE Basin in a position most likely to detect basin leakage. During FY 2007, tritium concentrations remained relatively constant at levels below the drinking water standard (see Figure 2.3-16 and Section 2.3.1.2). The average annual tritium concentration in well 199-K-27 was 6,800 pCi/L, down from 15,000 pCi/L during the previous year. The average annual tritium concentration in well 199-K-109A was 3,200 pCi/L, similar to the previous year. Some unexplained variability at well 199-K-27 continues, but concentrations remain in the range of long-term monitoring. There is still no clear explanation as to the cause for the abrupt increase in concentrations that started in January 2003 at these wells. There has been no unexplained loss of water from the basin to account for the trend changes in groundwater.

Near the KW Reactor, tritium concentrations at well 199-K-106A, located downgradient of the former 116-KW-1 condensate crib began to rise in 2001 and spiked in mid-2003 and 2005 to over 1 million pCi/L (Figure 2.3-17). Levels declined in FY 2006 and 2007. The last tritium concentration in FY 2007 (August) was unusually low at 30,000 pCi/L, similar to the pre-pulse concentrations in 2000. The source for the tritium is likely to be the vadose zone beneath the former crib and not related to potential water loss from the KW Basin.

The annual average concentration of strontium-90 exceeded the drinking water standard (8 pCi/L) in two wells monitoring the KW Reactor area and one well monitoring the KE Reactor area. The highest concentrations were in the KE area where strontium-90 averaged 480 pCi/L in well 199-K-109A during FY 2007, down substantially from an average of 1,200 pCi/L during the previous year. Well 199-K-34 and 199-K-107A, located in KW area, averaged 20 and 27 pCi/L in FY 2007. See Section 2.3.1.4 for more detailed discussion of strontium-90 contamination in the 100-K Area.

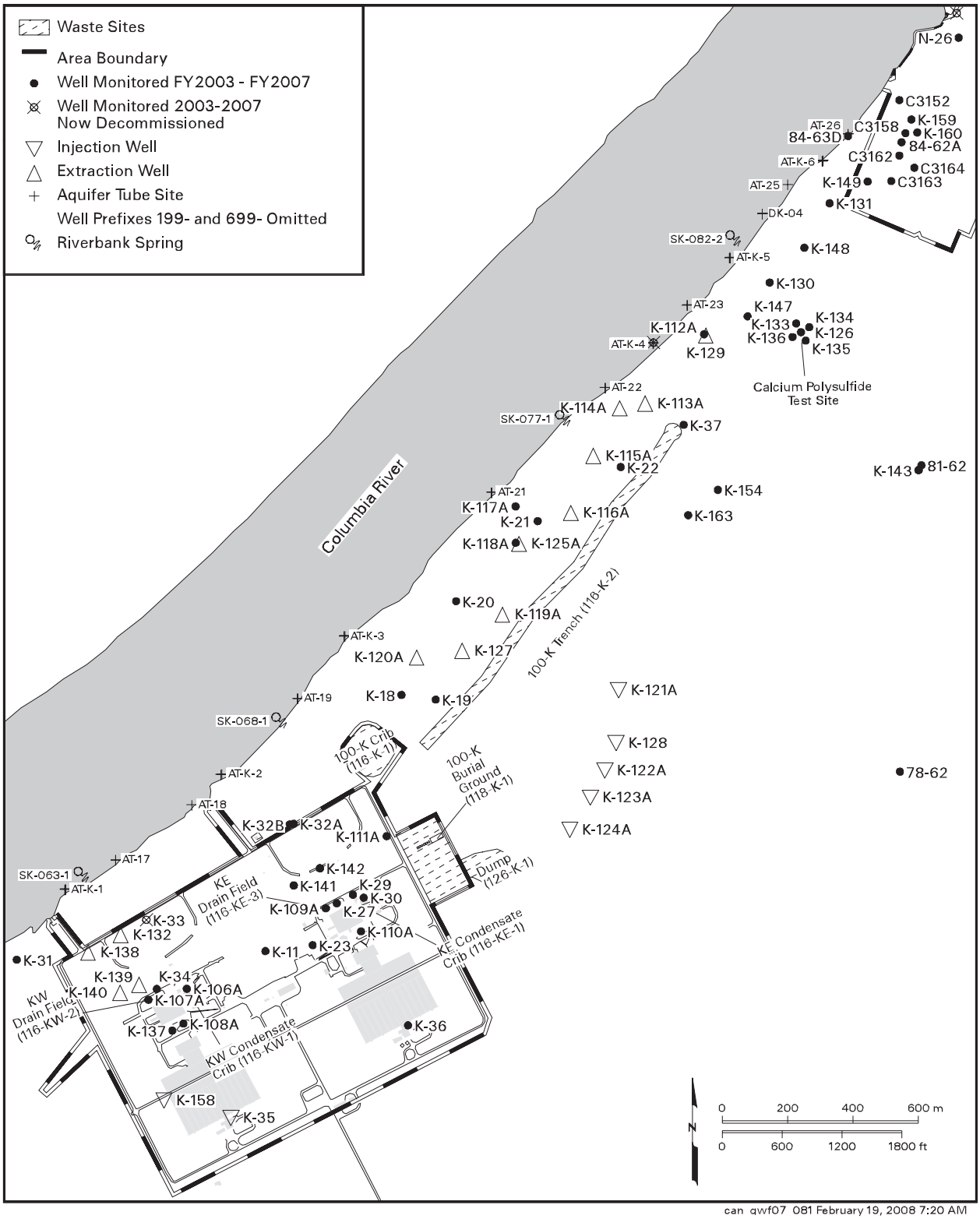

Figure 2.3-1. Groundwater Monitoring Wells in 100-K Area

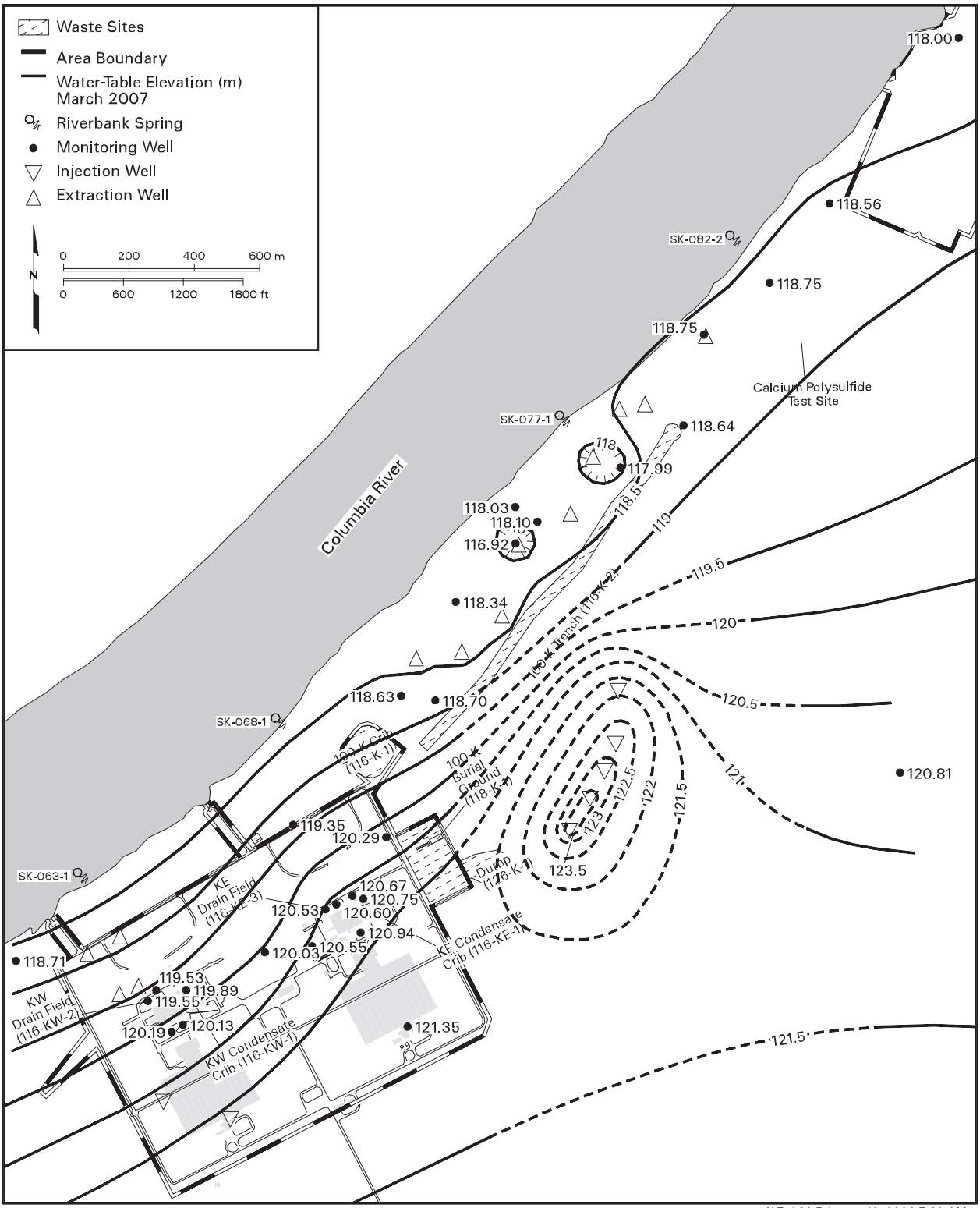

Figure 2.3-2. 100-K Area Water-Table Map, March 2007

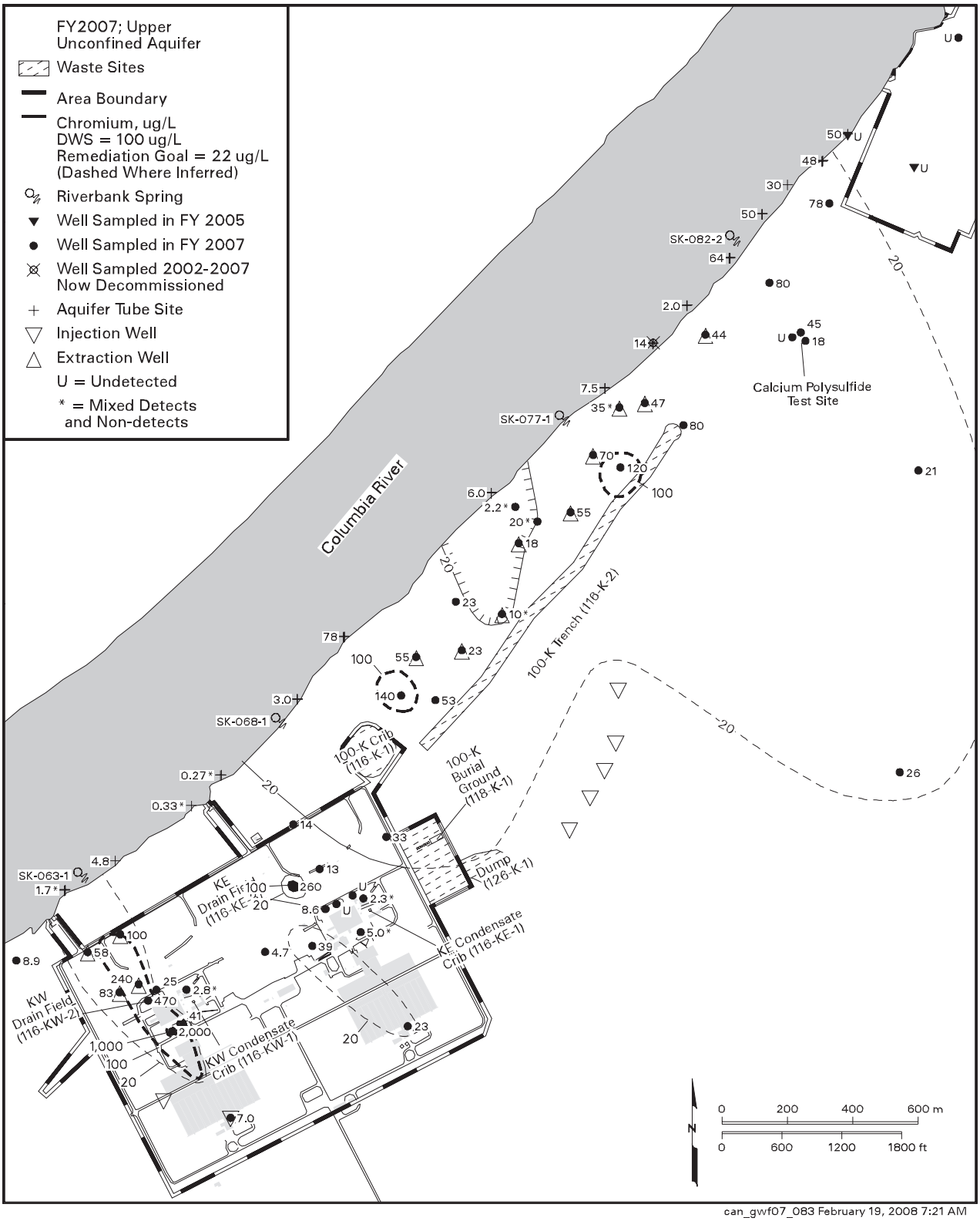

Figure 2.3-3. Average Chromium Concentrations in 100-K Area, Upper Part of Unconfined Aquifer

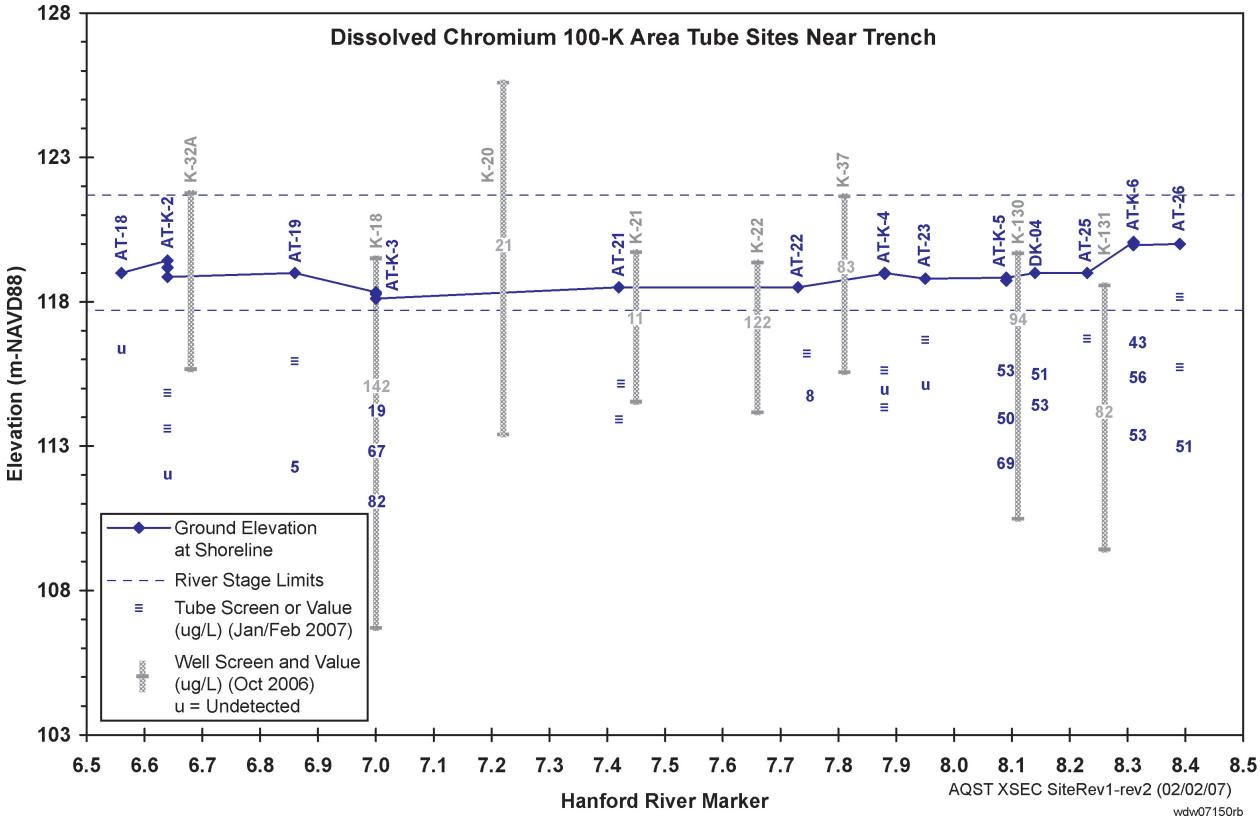

Figure 2.3-4. Sample Elevations and Chromium Concentrations in Wells and Aquifer Tubes in 100-K Area (from SGW-35028)

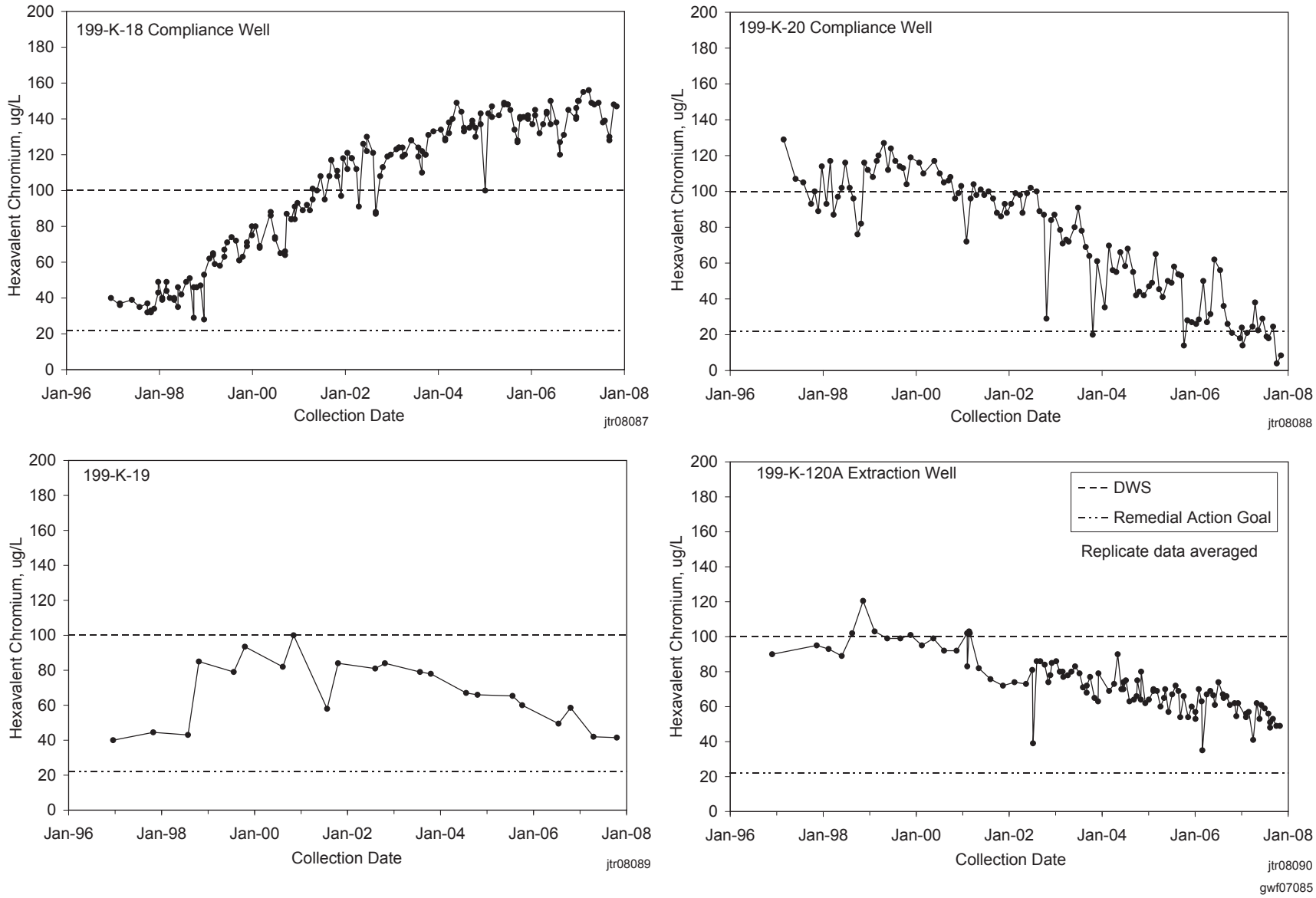

Figure 2.3-5. Chromium Concentrations at Wells Located at the Southwest Edge of the 116-K-2 Trench Plume

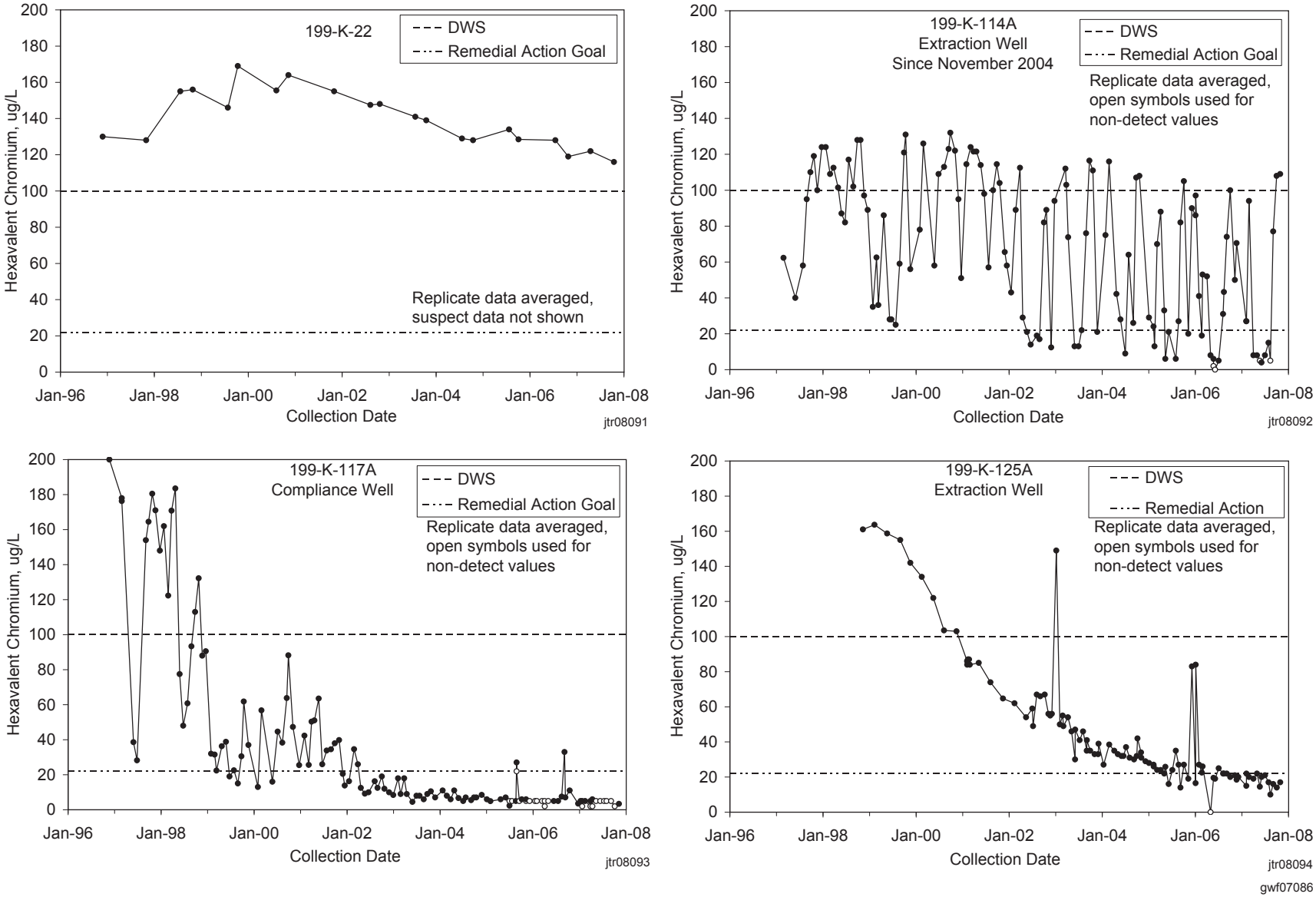

Figure 2.3-6. Chromium Concentrations at Wells Located in the Central Portion of the 116-K-2 Trench Plume

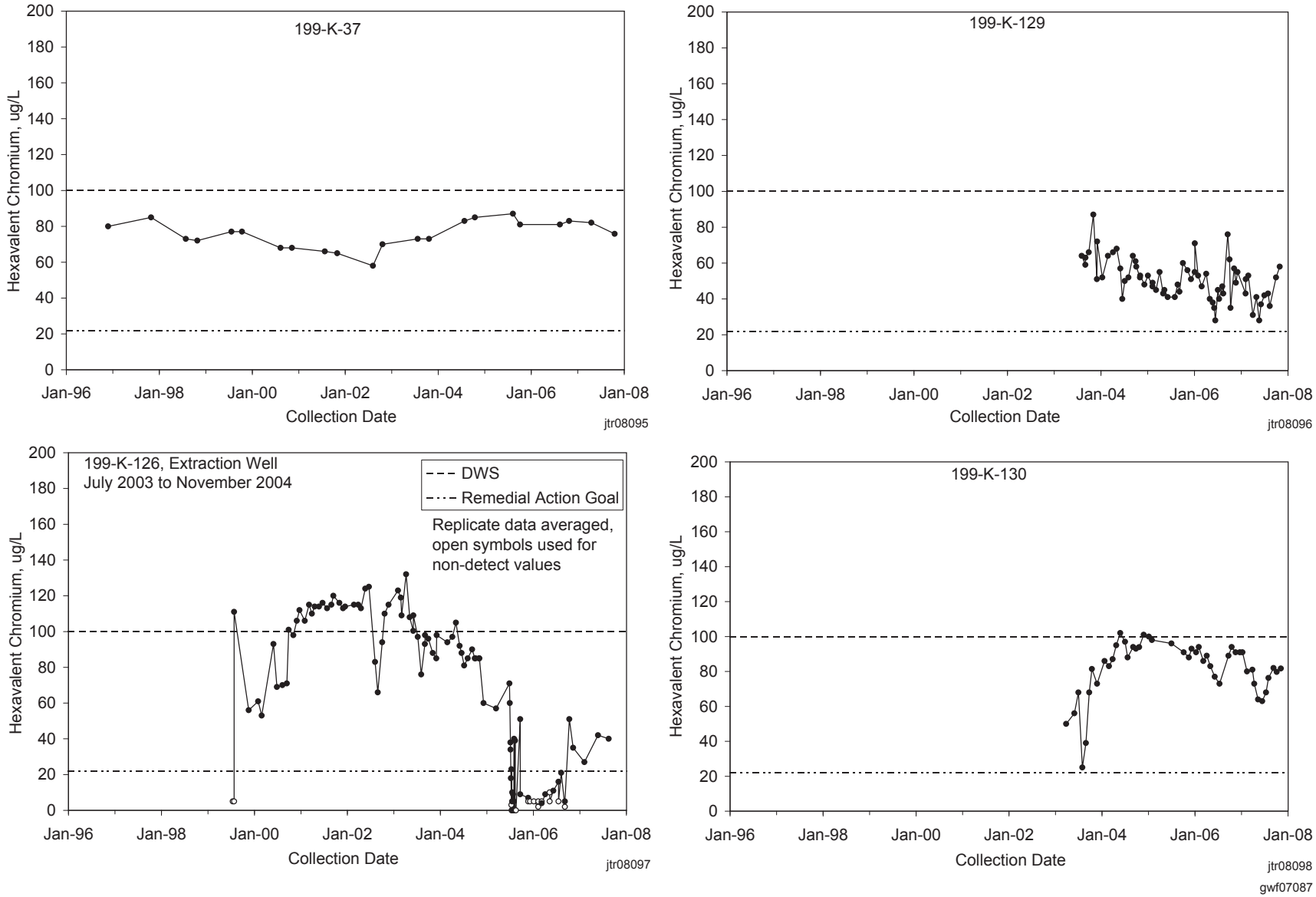

Figure 2.3-7. Chromium Concentrations at Wells Located at the Northeast Edge of the 116-K-2 Trench Plume

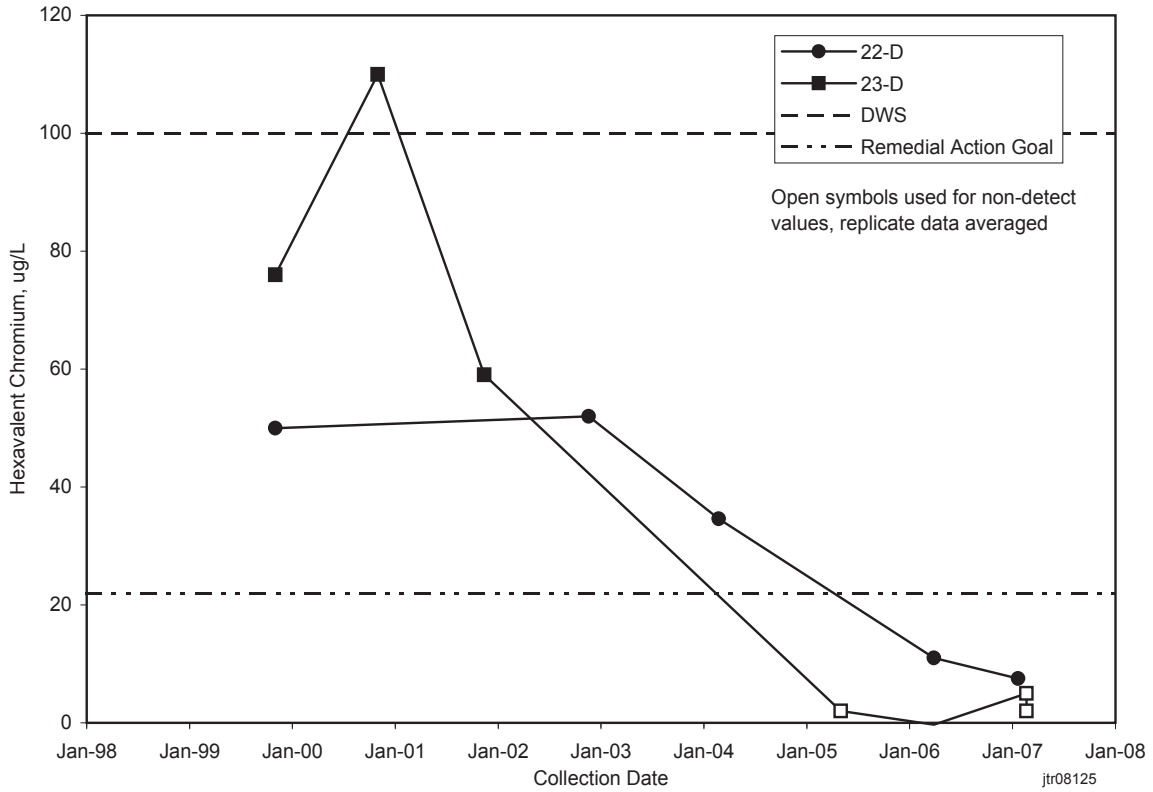

Figure 2.3-8. Chromium Concentrations in Aquifer Tubes Along Central Portion of 116-K-2 Trench Plume

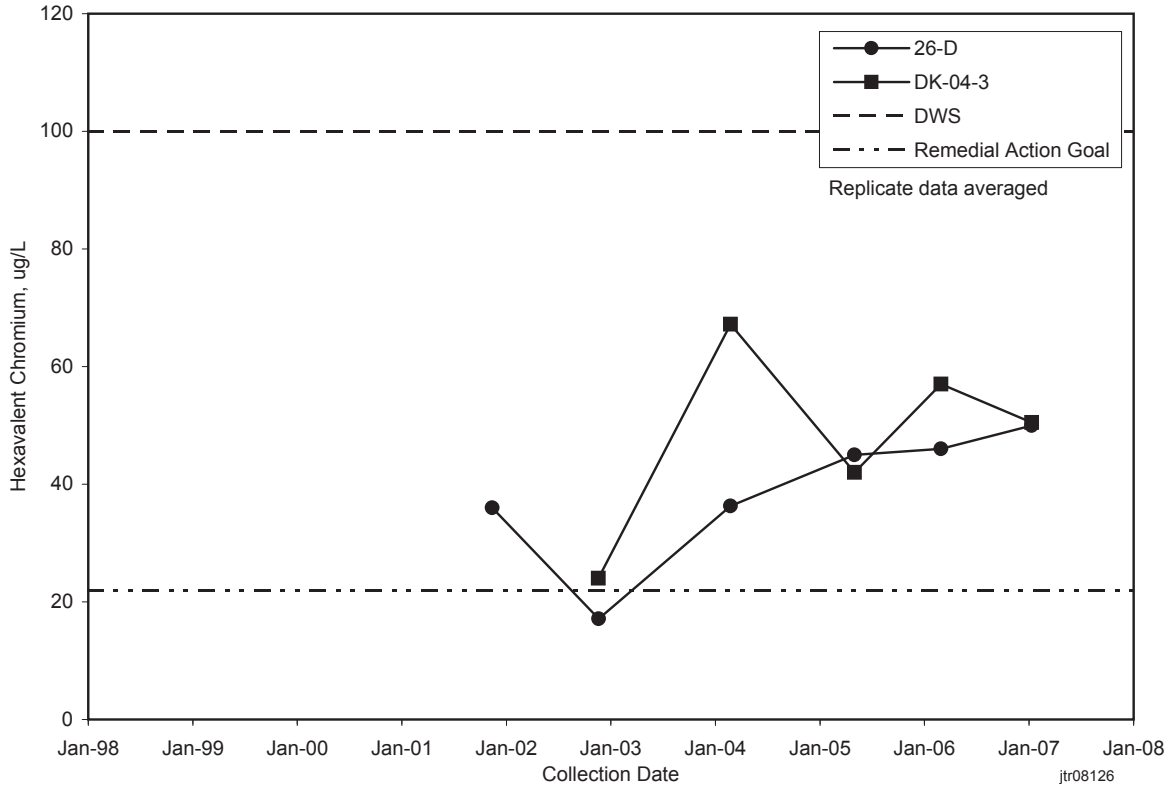

Figure 2.3-9. Chromium Concentrations at Aquifer Tubes Along North Portion of 116-K-2 Trench Plume

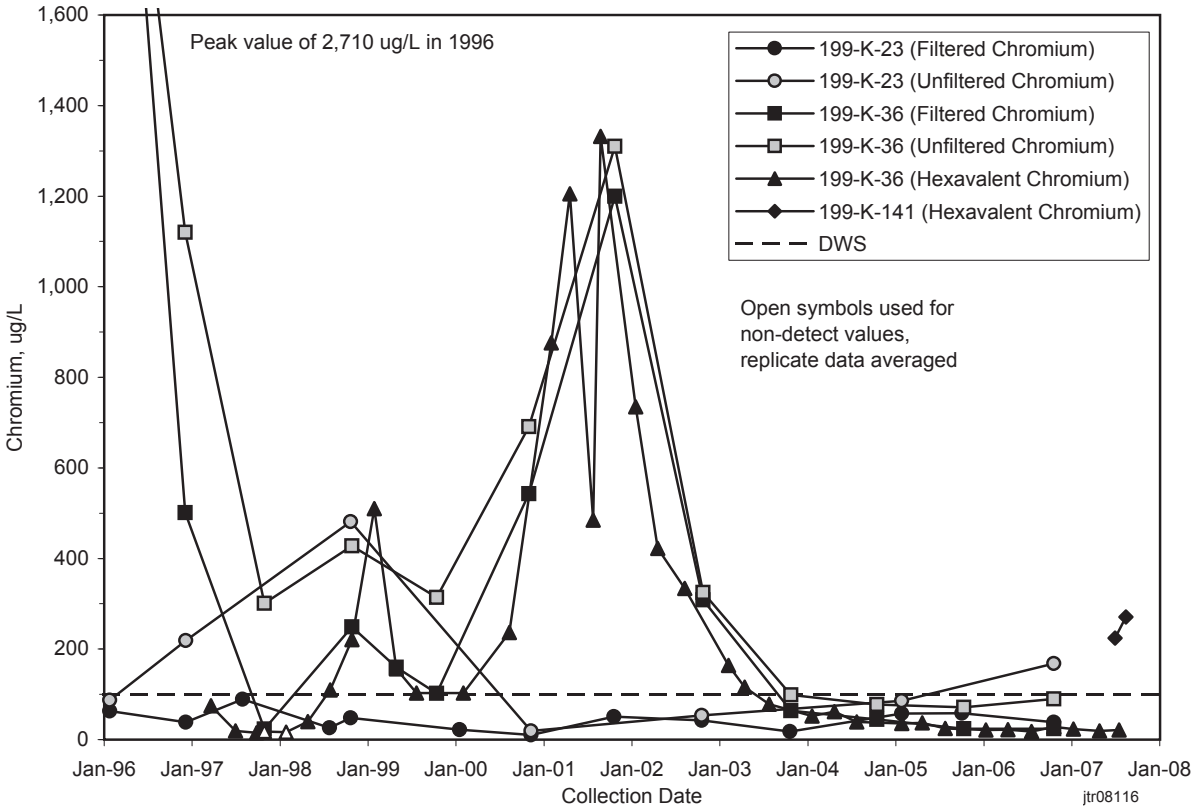

Figure 2.3-10. Chromium Concentrations Near KE Water Treatment Plant Basins and KE Reactor Building

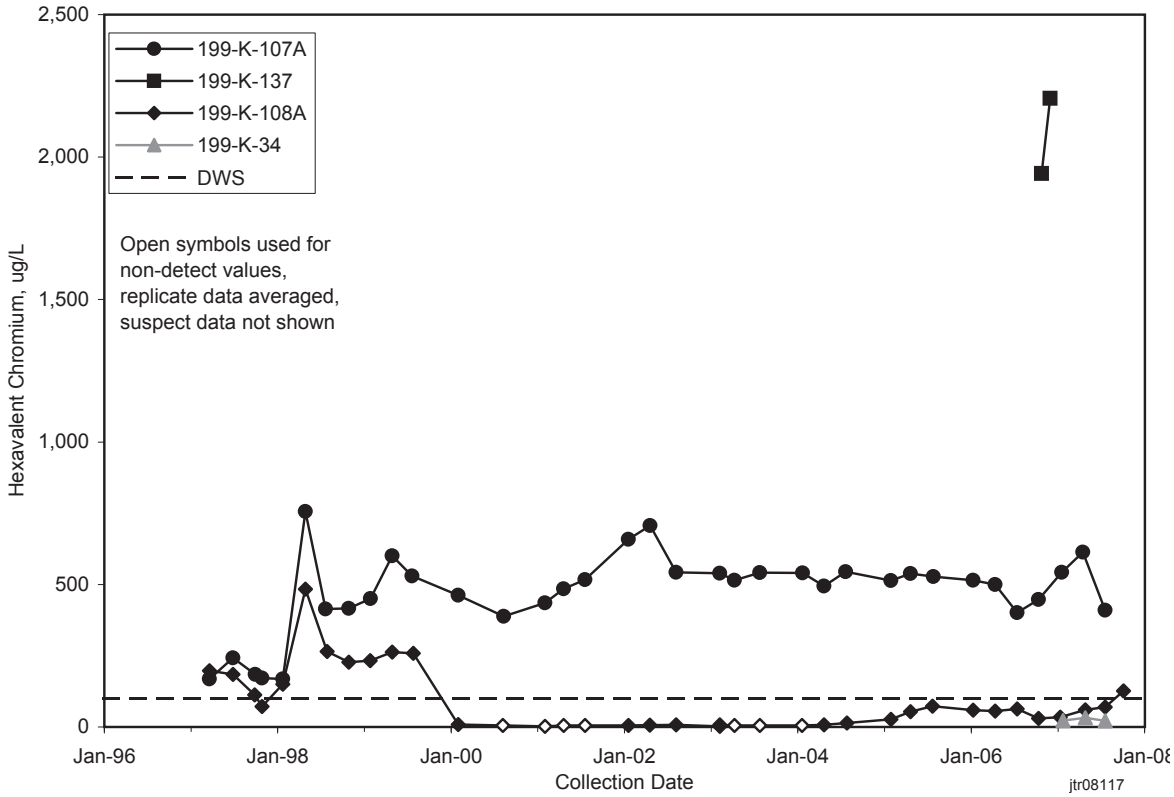

Figure 2.3-11. Chromium Concentrations Near KW Reactor Building

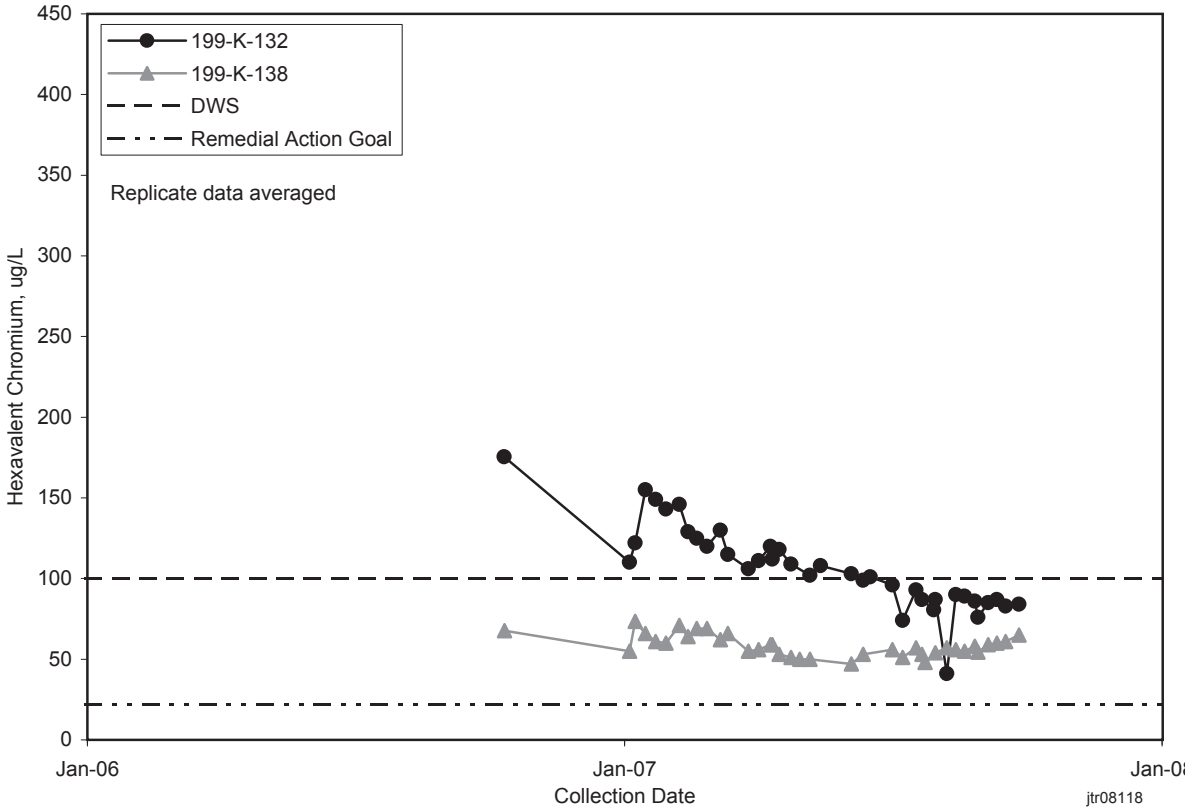

Figure 2.3-12. Chromium Concentrations in KW Near-River Extraction Wells

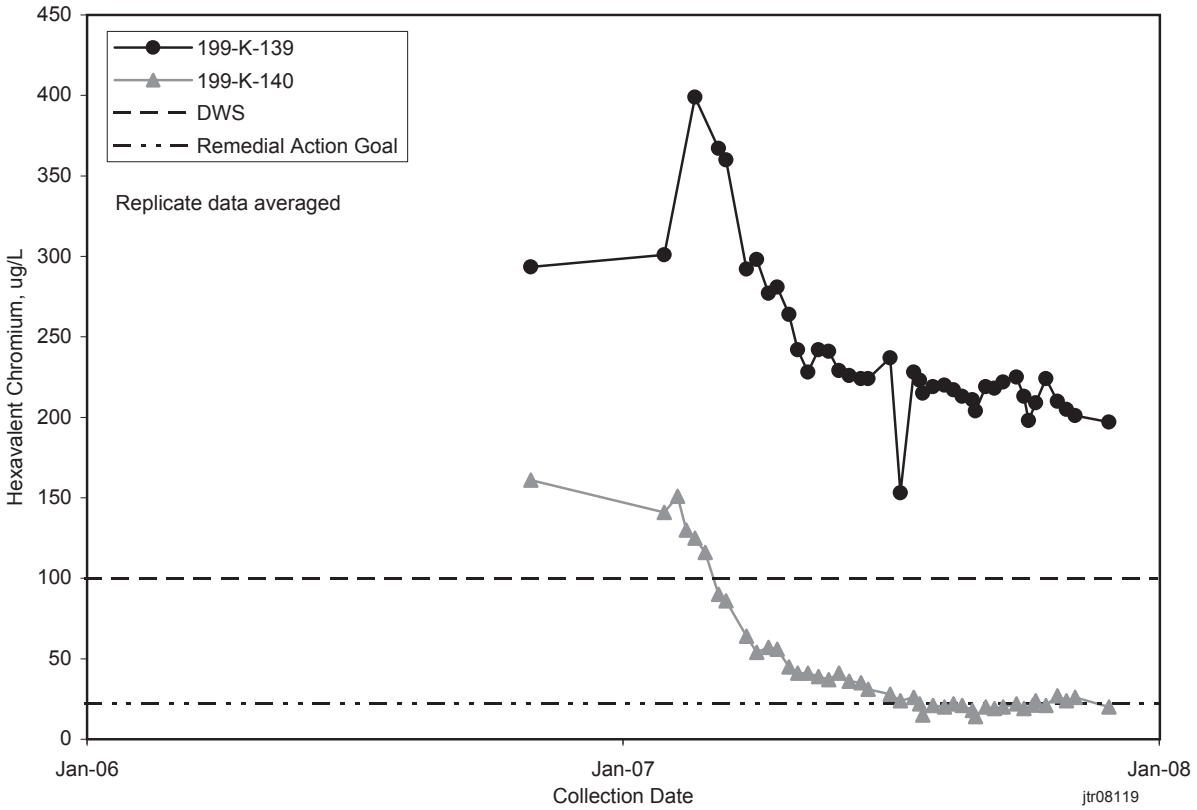

Figure 2.3-13. Chromium Concentrations in KW Inland Extraction Wells

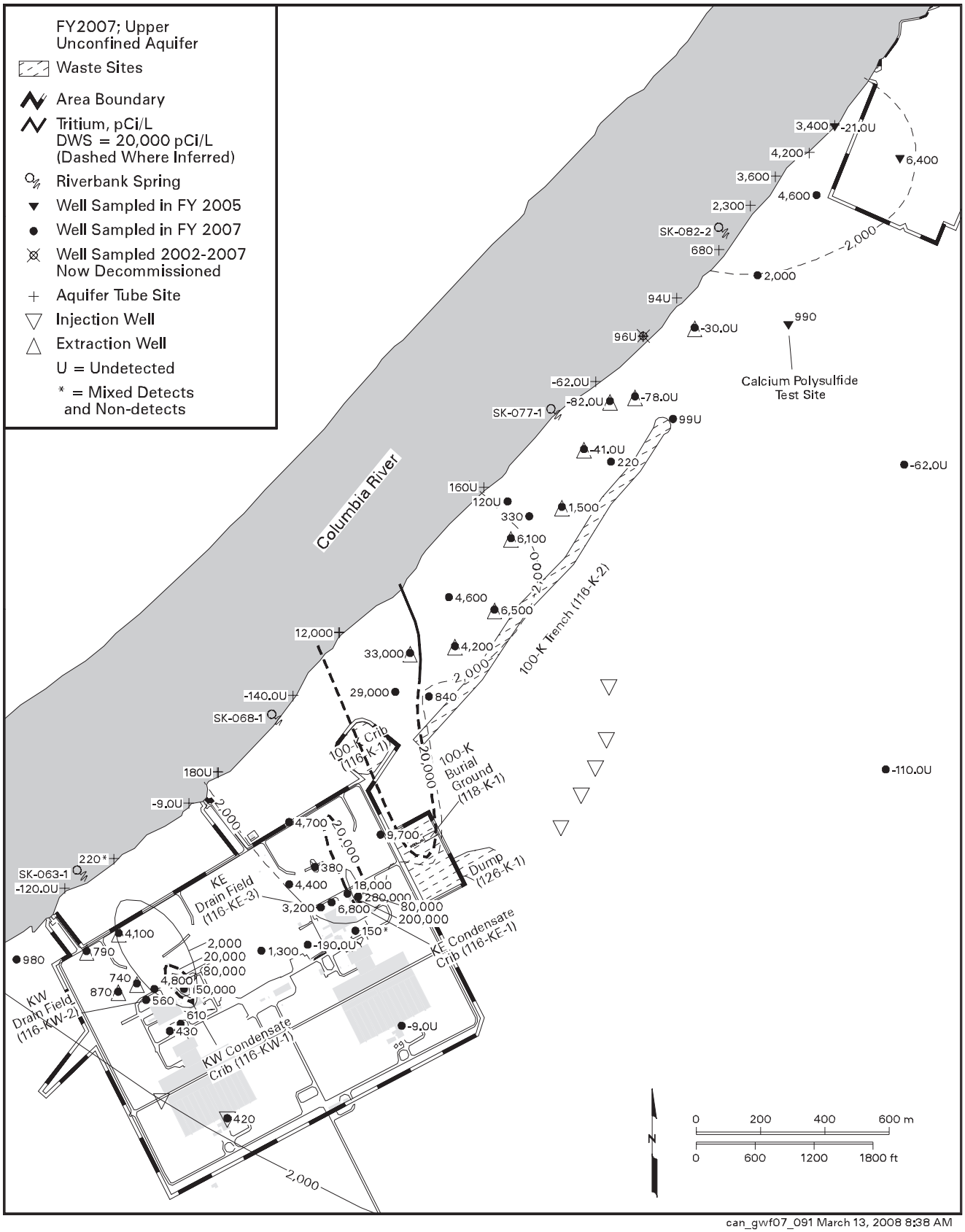

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Figure 2.3-14. Average Tritium Concentrations in 100-K Area, Upper Part of Unconfined Aquifer

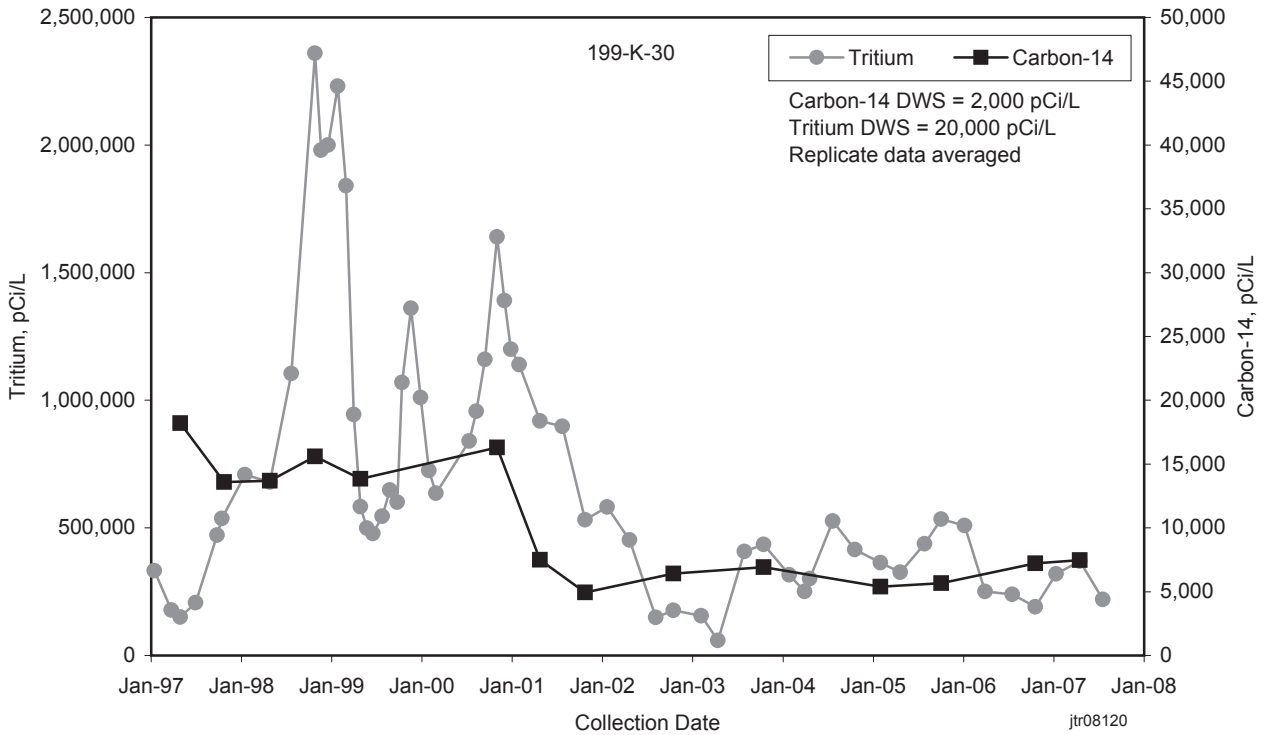


Figure 2.3-15. Tritium and Carbon-14 Concentrations Near Former 116-KE-1 Condensate Crib

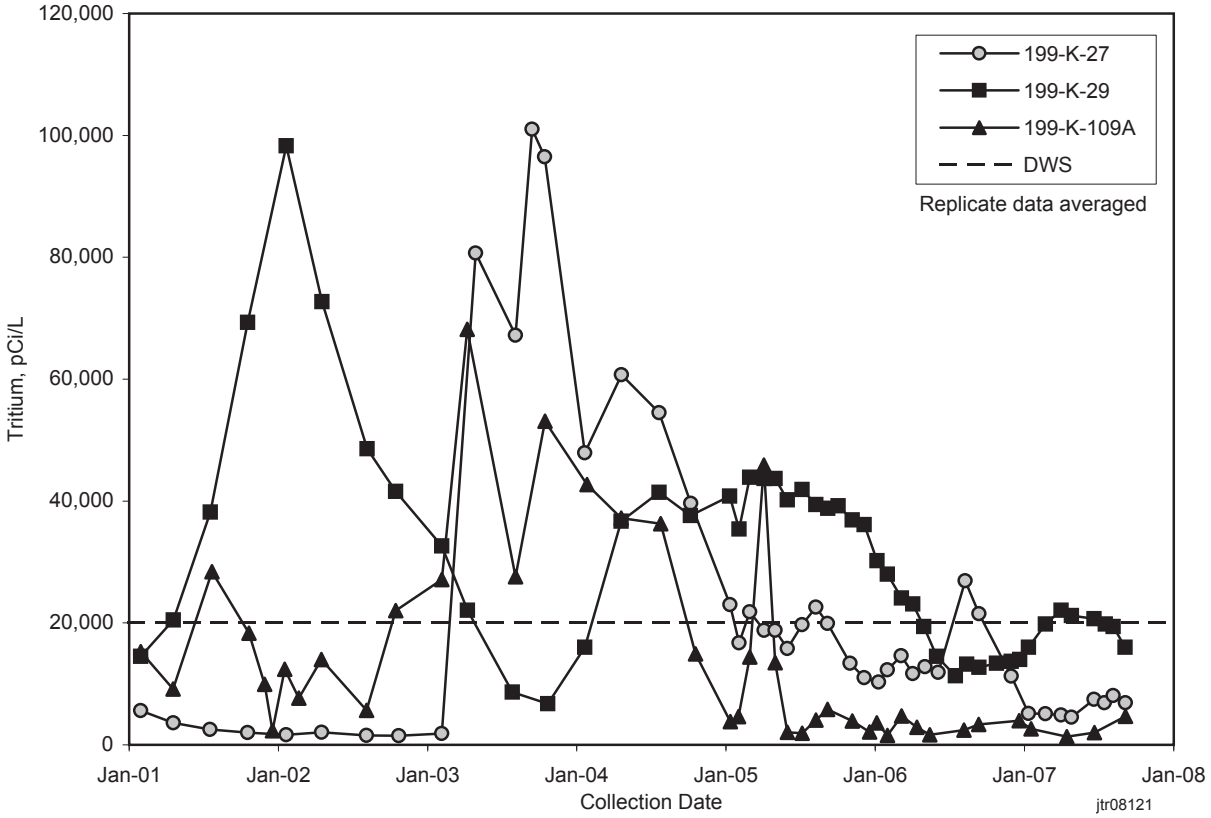


Figure 2.3-16. Tritium Concentrations Near KE Basin

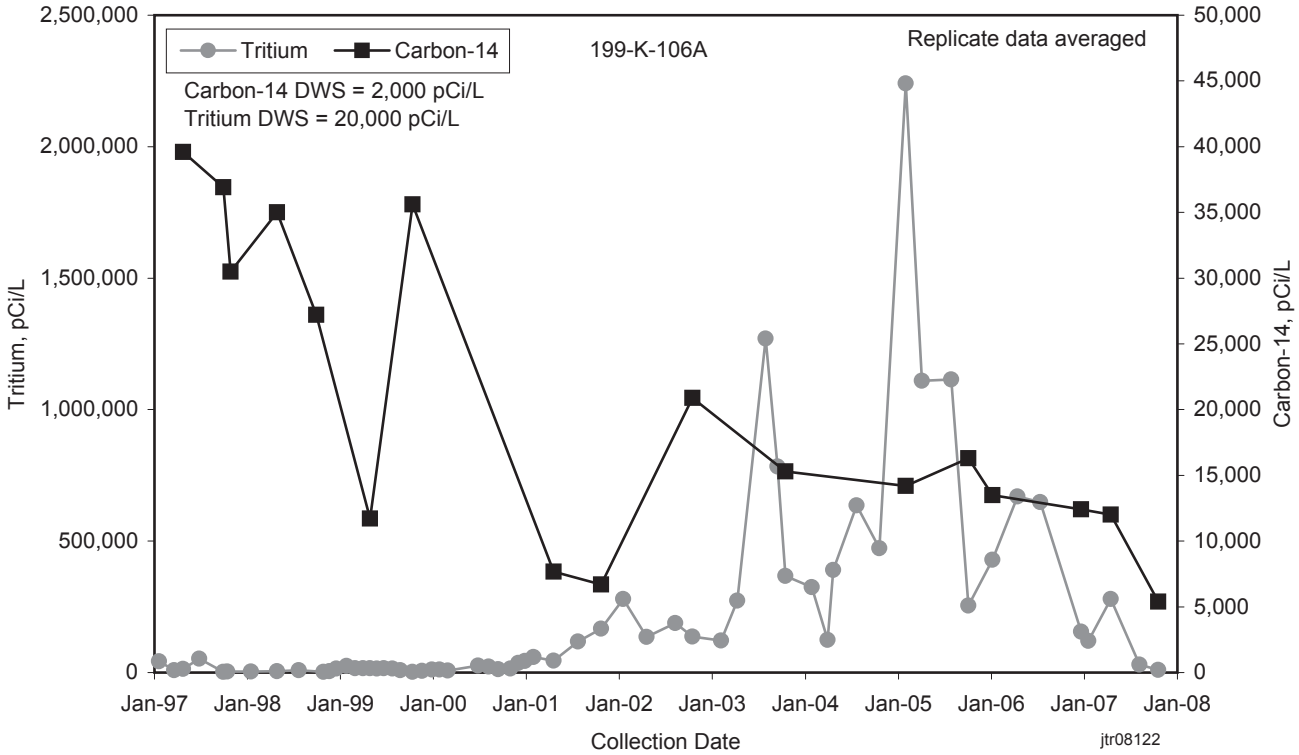


Figure 2.3-17. Tritium and Carbon-14 Concentrations Near Former 116-KW-1 Condensate Crib

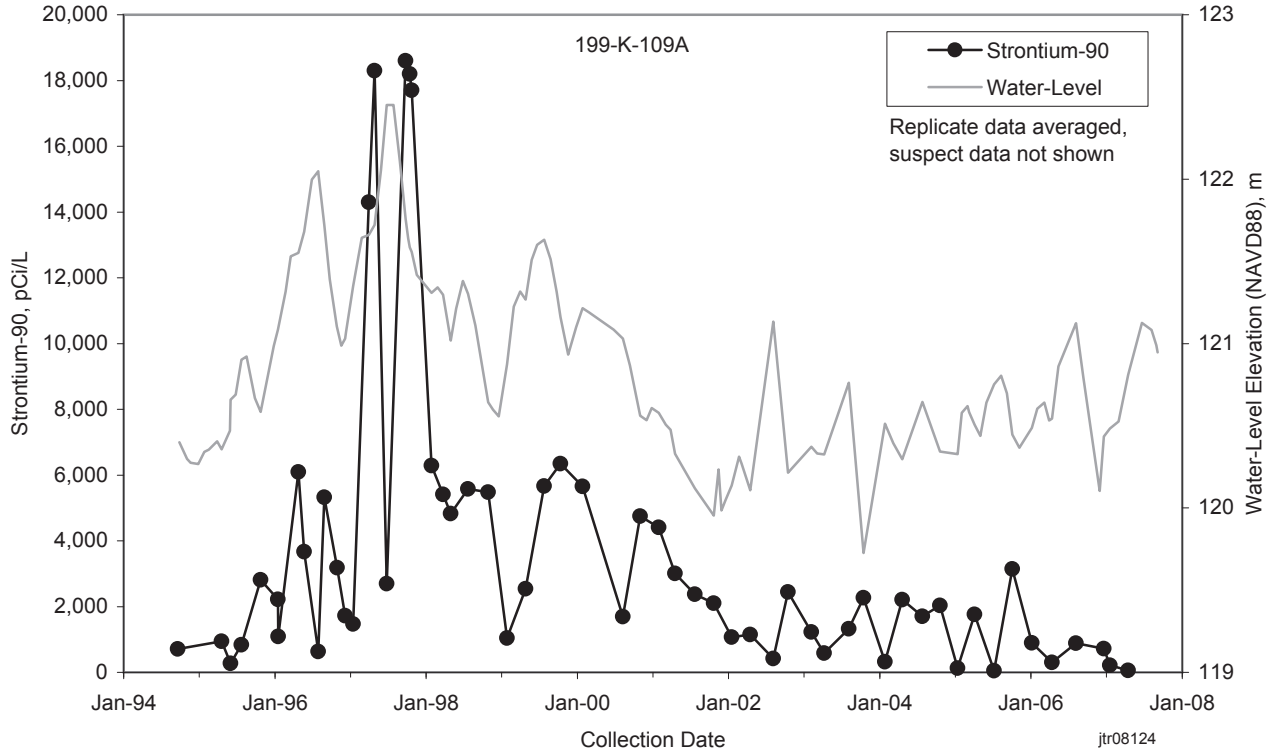


Figure 2.3-18. Strontium-90 Concentrations and Water-Table Elevation Near KE Basin

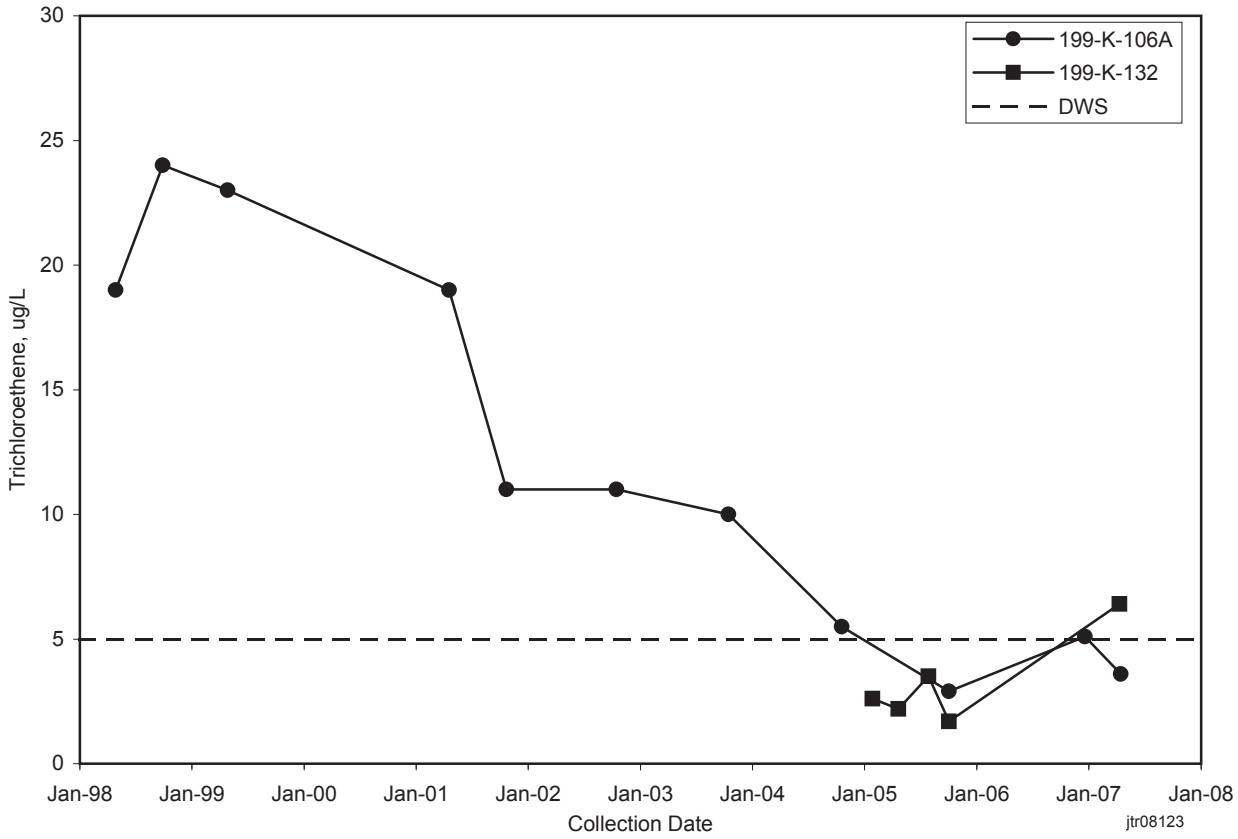


Figure 2.3-19. Trichloroethene Concentrations Near and Downgradient of KW Reactor Building

2.4 100-NR-2 Operable Unit

M. J. Hartman

The scope of this section is the 100-NR-2 groundwater interest area, which includes the 100-NR-2 Groundwater Operable Unit (see Figure 1.0-1 in Section 1.0). The "groundwater interest areas" are informally defined to facilitate scheduling, data review, and interpretation. Figure 2.4-1 shows facilities and wells in this region and Figure 2.4-2 shows shoreline monitoring sites and wells in an area of particular interest for monitoring. Strontium-90 is the contaminant of greatest significance in groundwater, and is the subject of a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim action (ROD 1999b). From 1995 until 2006, DOE operated a pump-and-treat system with a goal of reducing the amount of strontium-90 entering the Columbia River. In 2006 and 2007, DOE began to implement an in-aquifer method of remediation (Section 2.4.2). DOE also monitors groundwater at four *Resource Conservation and Recovery Act* (RCRA) units, and to track other contaminant plumes for the *Atomic Energy Act* (AEA).

Strontium-90 is the most significant groundwater contaminant beneath the 100-NR-2 Operable Unit. The general shape of the plume has not changed in many years.

Groundwater flows primarily to the north and northwest, toward the Columbia River (Figure 2.4-3). The water table is influenced by river stage, and until March 2006, was influenced by groundwater extraction near the 116-N-1 facility and injection near the 116-N-3 facility. As the effects of extraction and injection dissipated, the gradient evened out. In 2007, the 119-meter contour moved farther south and the 118-meter contour moved closer to the river.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under AEA, CERCLA, or RCRA monitoring.

Groundwater monitoring in the 100-NR-2 groundwater interest area includes the following monitoring activities:

CERCLA and AEA Monitoring (Appendix A)

- ***Twenty-six wells are sampled monthly to annually; several monthly samples could not be collected.***
- ***Twenty wells, twenty-three aquifer tubes, and three seep wells are sampled monthly to annually under a rebound/shoreline groundwater monitoring plan; some monthly samples and quarterly samples were not collected.***

Facility Monitoring (Appendix B)

- ***Five wells are sampled semiannually for the 116-N-1 liquid waste disposal facility for requirements of RCRA and AEA.***
- ***Five wells are sampled semiannually for the 120-N-1 percolation pond and 120-N-2 surface impoundment for requirements of RCRA and AEA; one well was sampled only once because of low water levels.***
- ***Five wells are sampled semiannually for the 116-N-3 liquid waste disposal facility for requirements of RCRA.***

2.4.1 Groundwater Contaminants

This section describes distributions and trends for groundwater contaminants in the 100-NR-2 Operable Unit (ROD 1999b): strontium-90, tritium, nitrate, sulfate, petroleum hydrocarbons, manganese, iron, and chromium.

2.4.1.1 Strontium-90

Strontium-90 was present in the liquid effluent discharged to the 116-N-1 facility (1963 to 1985) and the 116-N-3 facility (1983 to 1991). Both facilities were excavated to remove highly-contaminated soil, and backfilled with clean soil. The vadose zone and aquifer beneath the facilities remain contaminated with strontium-90, which binds to sediment grains and is moderately mobile in groundwater.

A record of decision stipulates interim remedial action for strontium-90 in the 100-N Area (ROD 1999b). From 1995 to March 2006, a pump-and-treat system operated between the 116-N-1 facility and the Columbia River to reduce the amount of contamination entering the river. Because strontium-90 binds to sediment, the pump-and-treat system was not effective in cleaning up the aquifer. DOE began to implement an in situ remedial action, apatite sequestration, in 2006 and 2007 (Section 2.4.2.3). The cessation of groundwater extraction and the apatite injections have affected strontium-90 concentrations in some areas, as discussed below.

The size and shape of the strontium-90 plume change very little from year to year. The plume extends from beneath the 116-N-1 and 116-N-3 facilities to the Columbia River at levels above the drinking water standard (8 pCi/L) (Figure 2.4-4). Concentrations >100 pCi/L are limited to the top ~3 meters of the aquifer (PNNL-16346).

Aquifer tubes on the 100-N Area shore have allowed a detailed depiction of the strontium-90 plume where it discharges to the Columbia River. Figure 2.4-5 shows strontium-90 concentrations in this region in August/September 2007. Maximum concentrations (>1,000 pCi/L) consistently are detected in tubes at the previously identified center of the plume.

Plume areas (square kilometers) at the 100-NR-2 Operable Unit:

Nitrate, 45 mg/L — 0.46
Strontium-90, 8 pCi/L — 0.58
Tritium, 20,000 pCi/L — 0.09

Strontium-90 trends in monitoring wells near the former waste sites show no obvious, long-term decline in concentrations, but significant variability related to water levels (Figure 2.4-6). When the water table rises beneath the former waste facilities, strontium-90 from the vadose zone is mobilized and concentrations in groundwater increase. Water levels and strontium-90 concentrations in wells near the 116-N-1 facility were high in the late 1980s, when liquid effluent was being discharged elsewhere in the 100-N Area, and declined after effluent discharges ceased in 1991. Concentrations rose again in the mid 1990s, which correlated with several years of relatively high river stage. Concentration peaks in 2006 and 2007 were correlated with periods of high water table.

Strontium-90 concentrations rebounded in three of the four former extraction wells after pump-and-treat operations ceased in March 2006 (Figure 2.4-7). The rebound was most evident in wells 199-N-75 and 199-N-103A, where concentrations increased from several hundred pCi/L in 2005 and 2006 to over 1,000 pCi/L after pumping ceased. Strontium-90 levels in 2006 and 2007 were also higher in well 199-N-105A than the previous few years, but the change was less distinct. Strontium-90 levels in well 199-N-106A, which has the highest concentrations of the four former extraction wells, continued a generally declining trend in 2006 and 2007.

Along the Columbia River shore, strontium-90 and gross beta[(a)] concentrations increased to new maxima in several aquifer tubes in August 2007. These tubes are all located in the core of the plume between Array-4A and Array-6A. Tube NVP2-116.0 detected the highest strontium-90 concentration: 15,000 pCi/L (Figure 2.4-8). As discussed in Section 2.4.2.3, the new remedial action (i.e., apatite injections) may temporarily increase strontium-90 concentrations. Concentrations also increased in monitoring wells downgradient of the apatite barrier, but changes were not as dramatic as in the aquifer tubes, and levels were much lower. The reason for this disparity may be the difference in the screened depths. The aquifer tubes showing strontium-90 peaks in August are screened between 115.4 and 116.7 meters elevation in the Ringold Formation (Figure 2.4-9). Aquifer tubes completed at shallower depths had lower concentrations. The screened intervals of the monitoring wells are larger, from ~115 to ~120 meters (i.e., above the water table).

Injection of apatite-forming chemical in shoreline wells caused variations in strontium-90 concentrations. One aquifer tube had a concentration up to 15,000 pCi/L.

2.4.1.2 Tritium

The tritium plume has diminished since 1991 when effluent discharge to the 116-N-3 facility ceased. In FY 2007, only two wells had concentrations exceeding the drinking water standard (20,000 pCi/L). The maximum concentration was 23,000 pCi/L in well 199-N-32, near the 116-N-3 facility.

Unlike strontium-90, tritium is present through the entire thickness of the unconfined aquifer. Concentrations in wells 199-N-69 and 199-N-70, completed at the base of the unconfined aquifer, are about the same as in nearby shallow wells. Tritium concentration in well 199-N-80, which monitors a confined aquifer in the Ringold Formation was 18,000 pCi/L in FY 2007, about the same as the previous year.

The shoreline aquifer tubes had very low or undetectable concentrations of tritium.

2.4.1.3 Nitrate

Nitrate concentrations exceed the drinking water standard (45 mg/L) beneath a portion of the 100-N Area (see Figure 2.4-14 in PNNL-16346 for FY 2006 map). The highest nitrate concentrations in FY 2007 were again in well 199-N-67 near the 116-N-1 facility, with a maximum concentration of 294 mg/L. Concentrations in other wells within the plume were much lower (<80 mg/L).

Figure 2.4-10 shows nitrate trend plots for two wells near the 116-N-1 facility for their entire period of record. The 116-N-1 facility was in use through 1985. Figure 2.4-11 shows the nitrate trend in a well near the 116-N-3 facility, which was in use from 1983 to 1991. At both sites, nitrate concentrations were high in the mid-1980s, declined sharply by 1990, and then began to increase again. Levels peaked in FY 2006 and remained high in FY 2007. The reason for the increase is not known.

Nitrate concentrations continued to exceed the drinking water standard in FY 2007.

Near the 120-N-1 percolation pond in south 100-N Area, nitrate concentrations also increased in the 1990s (Figure 2.4-12). During the pond's period of use (1977 to 1990), only low levels of nitrate (~1 mg/L) were detected in effluent to the facility (see Appendix B of DOE/RL-96-39). Monitoring began in 1987 and nitrate concentrations

(a) Gross beta values are equal to twice the strontium-90 concentration (PNNL-16894).

in groundwater were also low (1 to 4 mg/L). Nitrate levels exceeded the drinking water standard in well 199-N-59 since 1998. Nitrate levels have been increasing in nearby well 199-N-72, exceeding the standard since 2005.

Anomalously low nitrate concentrations (undetected) continued to be observed in well 199-N-18. The low concentrations are believed to be caused by chemical reduction of the nitrate caused by biodegradation of hydrocarbons (Section 2.4.1.5). Other chemical constituents and parameters also support the interpretation of chemical reduction around well 199-N-18: low dissolved oxygen, low pH, detectable nitrite, and high concentrations of metals (especially iron and manganese).

2.4.1.4 Sulfate

The former 120-N-1 percolation pond introduced sulfate and sodium to 100-N Area groundwater. In FY 2007 no wells exceeded the 250 mg/L secondary drinking water standard for sulfate. Sulfate concentrations remain elevated in groundwater north and northwest of the 120-N-1 site. A second area of elevated sulfate concentrations underlies the 116-N-3 trench. This contamination is residual from previous flow conditions that carried sulfate from the 120-N-1 percolation pond inland and then toward the north.

The highest sulfate concentration in FY 2007 was 239 mg/L in well 199-N-59, adjacent to the 120-N-1 site (Figure 2.4-13). This was the first time since 1996 the concentration in this well was below the secondary drinking water standard.

2.4.1.5 Petroleum Hydrocarbons

Petroleum hydrocarbons from a 1960s diesel fuel leak (DOE/RL-95-111) continued to be detected in 100-N Area groundwater. Of the affected wells, 199-N-18 is closest to the former leak site and had the highest levels of groundwater contamination. In September 2007, this well had 190 mg/L total petroleum hydrocarbons in the diesel range. April data from this well were inconsistent and flagged in the database as potentially erroneous.[(b)] Peak concentrations of thousands of milligrams per liter were observed in 2001 to 2003.

DOE continued a remedial action to remove free product from well 199-N-18 in FY 2007. The passive remediation method employs a polymer that selectively absorbs petroleum products from the surface of the water like a sponge. Four cylinders of this material are lowered into the well, where the material absorbs the contamination. The cylinders are changed every two months when they are saturated with oil.

Petroleum hydrocarbons continued to be detected in 100-N Area groundwater, but concentrations declined.

Evidence of low levels of hydrocarbon contamination have been observed in wells 199-N-3, 199-N-19, and 199-N-96A in the past (PNNL-14187, Section 2.4), but not in FY 2007. These wells are located near well 199-N-18 and may be influenced by contamination from the same source.

Total organic carbon concentrations were slightly elevated in shoreline wells 199-N-96A and 199-N-123. Concentrations ranged from undetected to 5,300 µg/L in FY 2007.

Petroleum hydrocarbons have been detected in some of the 100-N Area aquifer tubes. Appendix D of PNNL-16894 discusses evidence for this contamination. Low levels (<1 mg/L) of total petroleum hydrocarbons in the diesel range were reported in

(b) Samplers attempt to collect water samples from well 199-N-18 from the water column below the floating product. However, the well is sampled by lowering a bottle into the well, which disturbs the floating product. Thus, it is not surprising that concentraitons of hydrocarbons vary among samples.

several tubes around Array-0A. Workers observed a small oil sheen during installation of these tubes in January 2007.

Near the N Reactor building, well 199-N-16 also has evidence of petroleum contamination, believed to be from a separate past source. Total petroleum hydrocarbons (diesel) were measured at up to 7.2 mg/L in FY 2007, slightly lower than the previous year.

2.4.1.6 Manganese and Iron

Manganese continued to exceed its secondary drinking water standard (50 µg/L) in two wells affected by petroleum contamination: 199-N-16 (654 µg/L) and 199-N-18 (4,570 µg/L). Iron also exceeded its secondary drinking water standard (300 µg/L) in well 199-N-18 (16,400 µg/L). Natural biodegradation of the hydrocarbons creates reducing conditions, which increases the solubility of metals such as manganese and iron from the well casing or aquifer sediment.

Manganese exceeded the secondary drinking water standard in several wells near the apatite barrier, e.g. 199-N-122 and 199-N-147. The elevated metals are caused by reducing conditions associated with the treatment system. This is expected to be a transient effect.

2.4.1.7 Chromium

Only one well in the 100-N Area has chromium concentrations above the drinking water standard (100 µg/L). Well 199-N-80, which is completed in a thin, confined aquifer in the Ringold Formation, had a chromium concentration in FY 2007 of 172 µg/L in a field-filtered sample, a typical level for this well. Chromium was present in the effluent discharged to the 116-N-1 facility, but levels in wells monitoring the unconfined aquifer were low while the facility was in use, and remained low through FY 2007. Thus, it is unlikely that the chromium seen in deep well 199-N-80 originated at the 116-N-1 facility. A down-hole video survey of this well in 2001 observed corrosion of the screen, which could affect chromium levels.

The highest chromium concentration in the unconfined aquifer in FY 2007 was 33 µg/L in a filtered sample from well 199-N-64, in central 100-N Area. The well is not located near any of the three major liquid waste sites. Chromium concentrations were even higher in this well in the 1990s, exceeding the drinking water standard once. A down-hole video survey of this well in September 2000 showed screen corrosion, which is the probable cause of the elevated chromium.

2.4.2 Operable Unit Activities

This section summarizes activities related to groundwater in the 100-NR-2 Operable Unit. The primary contaminant of concern is strontium-90. Operable unit activities in FY 2007 included rebound monitoring of a former pump-and-treat system and emplacement of a permeable reactive barrier.

2.4.2.1 Status of Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified two issues pertaining to the 100-N Area and two follow-up actions. In FY 2007 DOE made progress on both actions, which are due September 2008:

- **Action 6-1**. Implement the treatability test plan for permeable reactive barrier using apatite sequestration (DOE/RL-2005-96). Workers injected apatite-forming chemicals into shoreline wells to create a 90-meter barrier in FY 2007. Section 2.4.2.3 discusses the apatite barrier.
- **Action 7-1**. Perform additional data collection to support risk assessment, provide previously collected data, and collect additional pore water data from new and existing aquifer tubes. Samplers continued to collect water from aquifer tubes in FY 2007. Section 2.4.1 discusses significant results. Data are included in electronic files accompanying this report. DOE is installing additional tubes in FY 2008 and is conducting additional studies of petroleum hydrocarbons along the Columbia River shore. Results will be reported to Ecology.

2.4.2.2 Rebound Monitoring

A pump-and-treat system operated from 1995 until March 2006 in the 100-N Area as part of a CERCLA interim action (ROD 1999b). The system removed ~1.8 curies of strontium-90 from the aquifer. Because strontium-90 binds to sediment grains, the pump-and-treat system was not effective in cleaning the aquifer. One of the requirements of the record of decision was to evaluate technologies to clean up the groundwater. Therefore, the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and U.S. Department of Energy (DOE) approved a Tri-Party Agreement change control form[c] in 2006 requiring the pump-and-treat system be put on cold standby and a permeable reactive barrier be constructed. The interim action record of decision allowed the pump-and-treat system to be shut down with Ecology approval; therefore, no explanation of significant difference to the 1999 record of decision was needed to place the system on cold standby.

The remedial action objectives in the 100-NR-2 Operable Unit (ROD 1999b) are:

- ***Protect the Columbia River from the adverse impact of groundwater contamination by limiting exposure pathways, reducing or removing sources, controlling groundwater movement, or reducing the concentration of contaminants.***
- ***Protect the unconfined aquifer by implementing remedial actions that reduce the concentration of contaminants.***
- ***Obtain information to evaluate technologies to remove strontium-90 and evaluate the impact to ecological receptors.***
- ***Prevent destruction of sensitive wildlife habitat and minimize the disruption of cultural resources.***
- ***In 2006, Ecology added a requirement for the pump-and-treat system to be put on standby, and an alternative, in situ treatment technology to be tested.***

The monitoring requirements for the 100-NR-2 interim action are specified by Tri-Party Agreement Change Control Form M-15-96-08. Wells, constituents, and sampling frequencies for interim action monitoring are shown in Appendix A. During FY 2007, all wells were sampled as scheduled except two wells scheduled for monthly sampling that were sampled less often.

DOE performed supplemental monitoring of the shoreline area (PNNL-15798). Some of the monthly samples were not collected in FY 2007 (see Appendix A). Section 2.4.1 presented results of shoreline groundwater monitoring.

(c) Federal Facility Agreement and Consent Order Change Control Form M-16-06-01, "Establish Interim Milestone M-016-14, Complete Construction of a Permeable reactive Barrier at 100-N." February 15, 2006.

Additional details on the pump-and-treat system and operational data for calendar year 2006 are available in DOE/RL-2006-76. An upcoming report will present results for calendar year 2007.

2.4.2.3 Permeable Reactive Barrier

DOE has agreed to construct and evaluate the effectiveness of a permeable reactive barrier, using apatite sequestration technology, as part of the CERCLA remedial investigation/feasibility study process and consistent with the 1999 interim remedial action record of decision for the 100-NR-1 and 199-NR-2 Operable Units (ROD 1999b).

DOE installed a 90-meter apatite permeable reactive barrier near the Columbia River shoreline in FY 2006 and 2007. Strontium-90 sequestration by this technology occurs through the injection of a calcium citrate phosphate solution. In situ biodegradation of the citrate results in apatite precipitation, adsorption of strontium-90 to the apatite, then apatite recrystallization with strontium substituting for calcium. Strontium-90 is held in place in the apatite mineral crystal structure where it decays naturally. A treatability test plan (DOE/RL-2005-96) describes the process.

In FY 2007, DOE injected chemicals into shoreline wells to create a permeable barrier designed to trap strontium-90 in the aquifer. The barrier is ~90 meters long across the most contaminated section of the shore.

Two pilot injection tests were conducted in June and September 2006. DOE used the results of these tests and subsequent bench-scale testing to modify the chemistry of the injected solution. DOE conducted two injection campaigns in FY 2007. The first campaign targeted the Ringold Formation when the water table was relatively low (February 28 through March 22). The second campaign targeted the Hanford formation when the water table was high (June 6 through July 10).

Researchers predicted a "salt effect" that could temporarily increase strontium-90 concentrations downgradient of the treatment zone. The injected solution has high total dissolved solids. As this water migrates from the treatment zone into an area where strontium-90 has not been sequestered by apatite, cations exchange with strontium adsorbed on aquifer sediments. The researchers modified the protocols to minimize this effect.

Figure 2.4-14 illustrates strontium-90 concentrations in wells 199-N-137 and 199-N-138. These wells were used for test injections in FY 2006 and in the full injection campaigns in FY 2007. A pronounced salt effect was evident following the 199-N-137 test injection in 2006. Smaller effects are evident following the FY 2007 injections in these and nearby wells. Strontium-90 concentrations at the end of FY 2007 were much lower than baseline levels.

Figure 2.4-15 illustrates strontium-90 concentrations in wells 199-N-122 and 199-N-123, located immediately downgradient of the treatment zone. As expected, there was a brief spike in strontium-90 levels after each injection. With each subsequent injection the desorbed strontium-90 was less and concentrations dropped in a shorter amount of time.

As discussed in Section 2.4.1, strontium-90 concentrations increased dramatically in aquifer tubes downgradient of the treatment zone (see Figure 2.4-8). Levels were much higher in the aquifer tubes than in the injection wells or downgradient monitoring wells. DOE will continue to monitor these tubes to determine if concentrations subside.

All low-concentration injections were completed in FY 2007. Injection well sampling continues monthly. An addendum to the treatability test plan will be

prepared which will allow high-concentration injections to be conducted in FY 2008 to enhance the performance of the barrier. An upcoming report will evaluate the effectiveness of the FY 2007 injections and make recommendations for future work.

Apatite injections treat the strontium-90 contamination in the aquifer, but much of the contamination is in the vadose zone. Pacific Northwest National Laboratory is conducting a study of apatite infiltration, under an Environmental Management Technology (EM-22) project (http://www.hanford.gov/cp/gpp/science/em21.cfm). Primary objectives of this project are to develop an infiltration strategy that defines apatite solution precipitation rate and strontium sequestration processes under variably saturated conditions, and with variable apatite concentrations. Results will be used to design an efficient and effective infiltration strategy that will be tested at a field scale.

2.4.2.4 Phytoremediation

K.M. Thompson, R.B. Rowley, S.W. Petersen, and J.S. Fruchter

Phytoremediation has been identified as a potential technology for the removal of strontium-90 from the soil as a filter for groundwater along the Columbia River at the 100-N Area. Phytoremediation is a managed remediation technology in which plants are used to extract or sequester soil contaminants. Greenhouse studies have demonstrated the viability of phytoremediation to remove strontium-90 from soil and water in the 100-N Area. The technology would be used in conjunction with the apatite barrier.

Pacific Northwest National Laboratory is conducting a study of phytoremediation, under a DOE EM-22 project (http://www.hanford.gov/cp/gpp/science/em21.cfm). A demonstration plot of coyote willow plants was constructed in March 2007 along the banks of the Columbia River at the 100-K Area. The area chosen for the test was not contaminated by strontium-90 or any other radionuclide. At this site, the willows were at least partially submerged for at least 12 hours a day from planting in March through the month of June. At times, they were totally submerged. The plants were harvested (all leaves and branches removed) in three stages during July, September, and October 2007. During actual remediation, harvesting would prevent leaf drop from spreading contamination. The willow shrubs recovered quickly after harvesting, with new shoots and leaves visible after a few weeks. The field study will continue in FY 2008 to determine growth during the second year.

2.4.3 Facility Monitoring

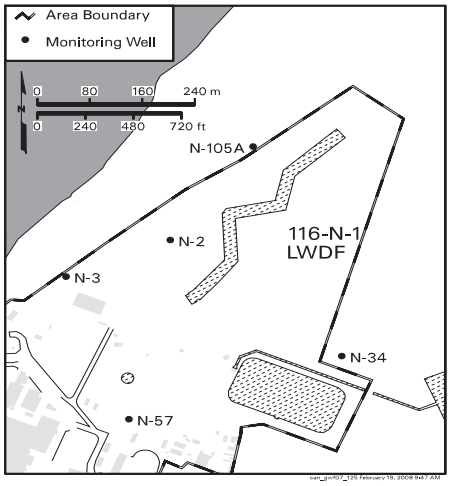
Strontium-90 and tritium concentrations exceed drinking water standards at the 116-N-1 liquid waste disposal facility.

This section describes results of monitoring individual facilities: the 116-N-1 and 116-N-3 facilities, 120-N-1 percolation pond, and 120-N-2 surface impoundment. Groundwater is monitored at these facilities to meet the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations for each facility. Groundwater data for these facilities are available in the Hanford Environmental Information System (HEIS 1994) and in the data files accompanying this report.

Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.4.3.1 116-N-1 (1301-N) Liquid Waste Disposal Facility

This facility contaminated groundwater with radionuclides during its period of use in the 1960s through 1985. Strontium-90 and tritium concentrations in groundwater exceed drinking water standards. Results of monitoring were discussed in Section 2.4.1. The facility was excavated to remove shallow vadose zone sediment, where most of the radionuclide contamination resided, and was backfilled in FY 2006. Wells downgradient of the 116-N-1 facility are sampled quarterly to annually for strontium-90 and gamma activity. No gamma-emitters were detected in FY 2007. Strontium-90 concentrations rebounded in several downgradient wells formerly used for groundwater extraction (see Section 2.4.1.1).



This facility is included in the Hanford Facility RCRA Permit (Ecology 1994a). The permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan and a supplemental plan (PNNL-13914) are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

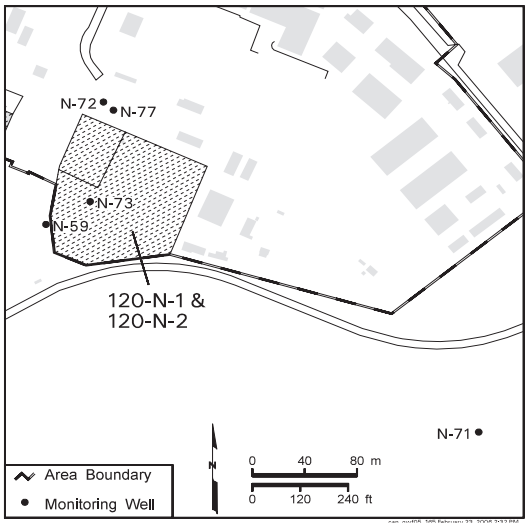
Groundwater flows to the northwest beneath the 116-N-1 facility, discharging to the Columbia River. The hydraulic gradient in March 2007 was 0.0016, and flow rate was estimated to be between 0.03 to 0.58 meter/day (Appendix B).

Upgradient and downgradient wells are scheduled for sampling twice each year for contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters. The wells were sampled as scheduled in FY 2007.

Average specific conductance in downgradient well 199-N-3 continued to exceed the critical mean value (1,165 µS/cm) in FY 2007. This was a continuation of previous exceedances, and prior assessment results (WHC-SD-EN-EV-003) indicated the elevated specific conductance is related to constituents from the 120-N-1 percolation pond. Recent data indicate this conclusion remains valid (see Appendix B).

In October 2006, well 199-N-3 exceeded the critical mean value for total organic carbon. This sampling event was delayed from FY 2006. Split sample sets were sent to two laboratories. The average result from one laboratory were below the critical mean value. The results from the other laboratory were rejected because of problems with the analysis (see Appendix C) (SGW-33492).

In September 2007, well 199-N-3 again exceeded the critical mean value (2,075 µg/L) for total organic carbon (Figure 2.4-16). This well is believed to be affected by the diesel plume that is detected in nearby well 199-N-18. However, total petroleum hydrocarbons contamination has remained below detection limits. Verification sampling for total organic carbon will be performed and results will be discussed in an upcoming RCRA quarterly report.



Upgradient/downgradient comparison values for indicator parameters have been revised based on recent data for use in FY 2008 comparisons (see Appendix B).

2.4.3.2 120-N-1 (1324-NA) Percolation Pond and 120-N-2 (1324-N) Surface Impoundment

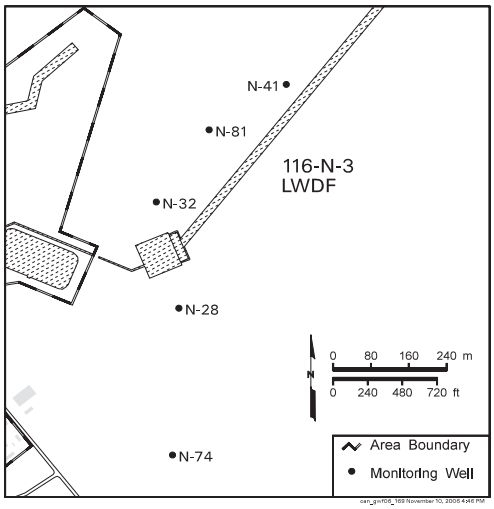
These facilities were used to treat and dispose of corrosive, non-radioactive waste from 1977 to 1990. They have been remediated and backfilled.

These facilities are included in the Hanford Facility RCRA Permit (Ecology 1994a). The permit states that RCRA monitoring during closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC-173-303-400). The two units are monitored as a single site (waste management area) because of their proximity and similar waste type.

Groundwater flows to the northwest beneath the 120-N-1 and 120-N-2 facilities, discharging to the Columbia River. The hydraulic gradient in March 2007 was 0.0026, and flow rate was estimated to be between 0.05 to 0.95 meter/day (Appendix B).

During FY 2007, four of the five monitoring wells for this site were sampled twice for contamination indicator parameters and groundwater quality and once for site-specific parameters, as planned (see Appendix B). Downgradient well 199-N-59 contained too little water to sample in December 2006, but was successfully sampled in June 2007. DOE plans to replace this well in FY 2008.

Average specific conductance values in wells downgradient of the facilities continued to exceed the critical mean value (490 µS/cm) in FY 2007. A previous groundwater quality assessment indicated that the high specific conductance is caused by sulfate and sodium (WHC-SD-EN-EV-003), which are not listed hazardous waste constituents. Recent data indicate this conclusion remains valid (see Appendix B). Other indicators remained below critical mean values in FY 2007.



Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2008 comparisons (see Appendix B).

2.4.3.3 116-N-3 (1325-N) Liquid Waste Disposal Facility

This facility contaminated groundwater with radionuclides during its period of use from 1983 to 1991. Strontium-90 and tritium concentrations in groundwater downgradient of the facility exceed drinking water standards. Results of monitoring were discussed in Section 2.4.1. The facility was excavated to remove the shallow vadose zone material, which contained the highest concentrations of radionuclides, and backfilled.

This facility is included in the Hanford Facility RCRA Permit (Ecology 1994a). The permit states that RCRA monitoring during

closure activities will follow the requirements of BHI-00725. That plan, and a supplemental plan (PNNL-13914), are similar to an interim status indicator evaluation program (40 CFR 265.93(b), as referenced by WAC 173-303-400).

Groundwater flows to the north beneath the 116-N-3 facility, then turns to the northwest and discharges to the Columbia River. The hydraulic gradient in March 2007 was 0.0010, and the groundwater flow rate was estimated to be between 0.02 to 0.37 meter/day (Appendix B).

All five wells were sampled twice for contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halides) and once for groundwater quality and site-specific parameters, as planned. However, samplers neglected to take quadruplicate field readings in one well in March (Appendix B).

Average specific conductance values in downgradient wells 199-N-32, 199-N-41, and 199-N-81 continued to exceed the critical mean value in FY 2007. This was a continuation of previous exceedances noted in 1999 through 2006. DOE notified Ecology of the original exceedance and submitted an assessment report[d] that concluded the exceedance was caused by past discharges to the 120-N-1 percolation pond. Recent data indicate this conclusion remains valid (see Appendix B).

Detection monitoring will continue in FY 2008. Upgradient/downgradient comparison values for indicator parameters were revised based on recent data for use in FY 2008 (see Appendix B).

(c) Letter from KM Thompson (U.S. Department of Energy, Richland, Washington) to J Hedges (Washington State Department of Ecology), Results of Assessment at the 1325-N Facility, dated July 22, 2000.

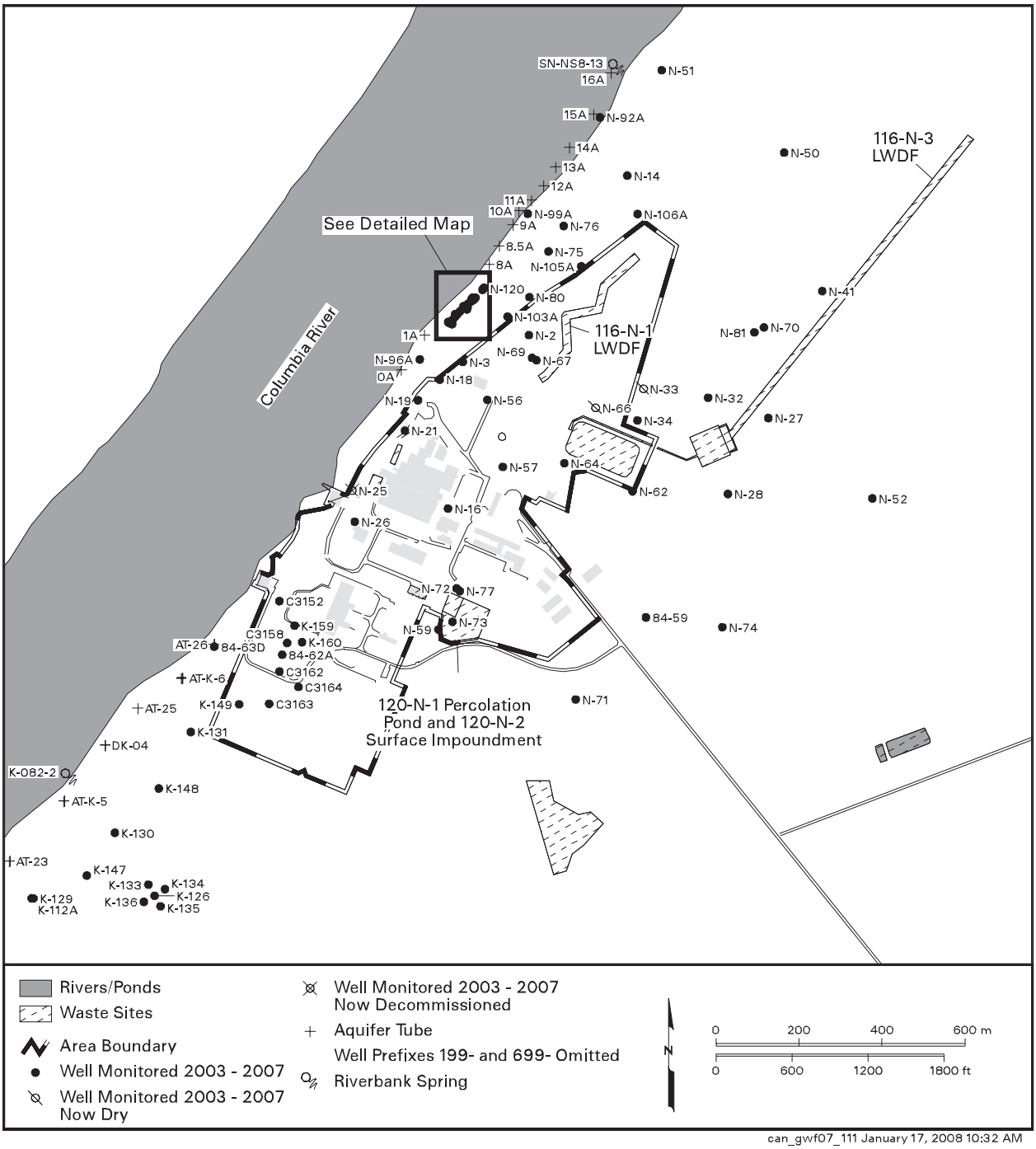


Figure 2.4-1. Groundwater Monitoring Wells in 100-N Area

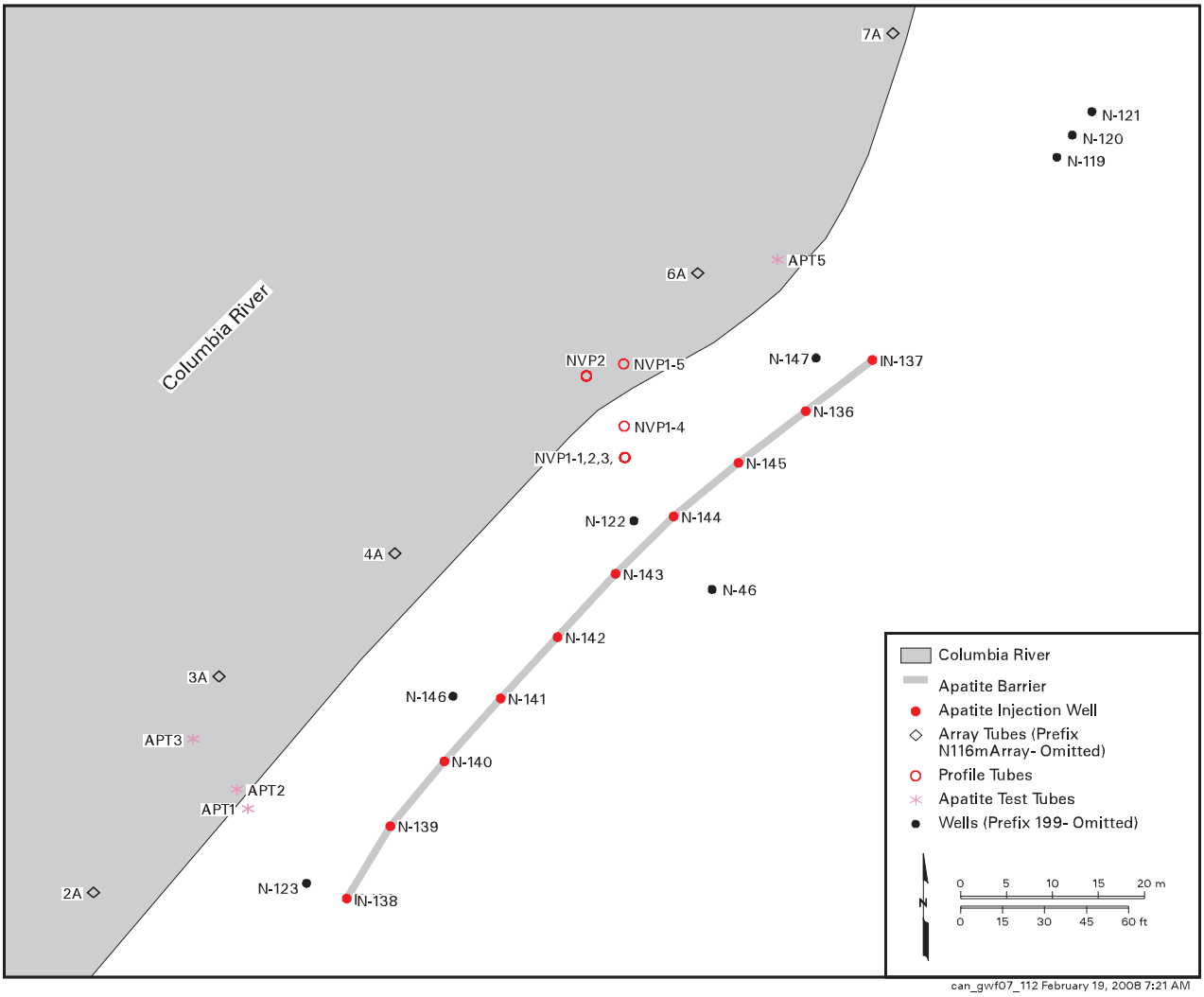


Figure 2.4-2. Aquifer Tubes, Seep Wells, and Monitoring Wells on 100-N Area Shoreline

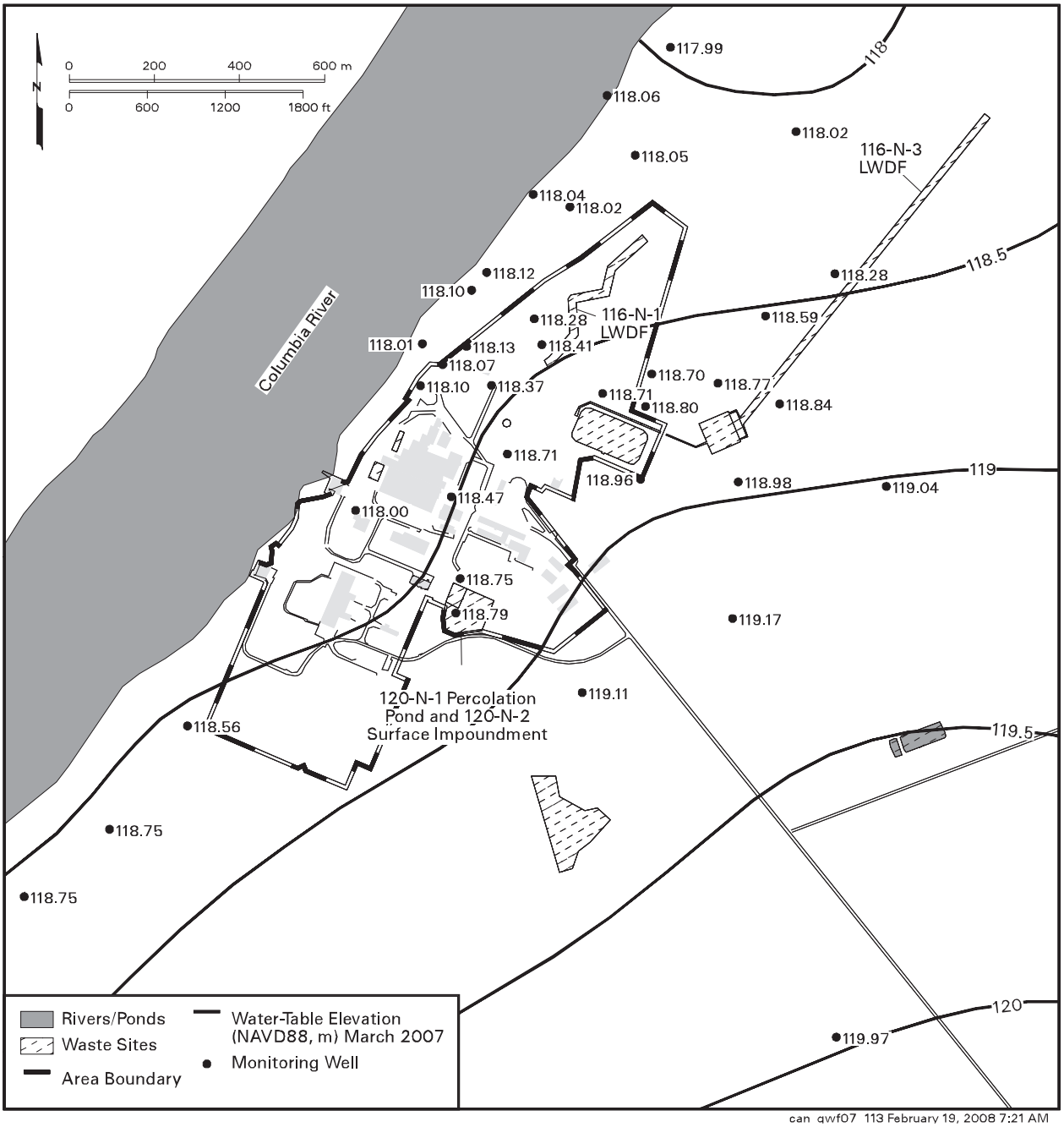


Figure 2.4-3. 100-N Area Water-Table Map, March 2007

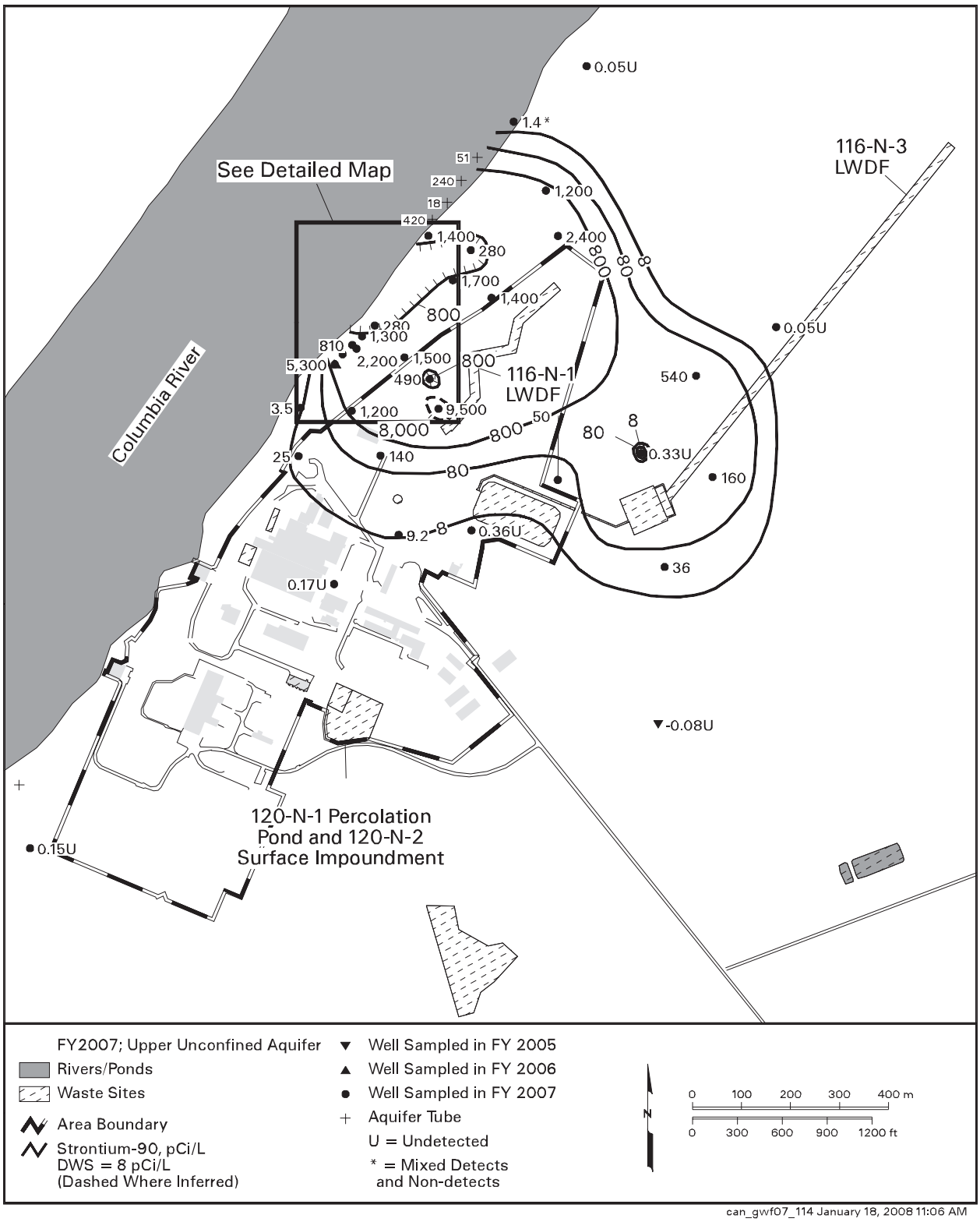


Figure 2.4-4. Average Strontium-90 Concentrations in 100-N Area, Upper Part of Unconfined Aquifer

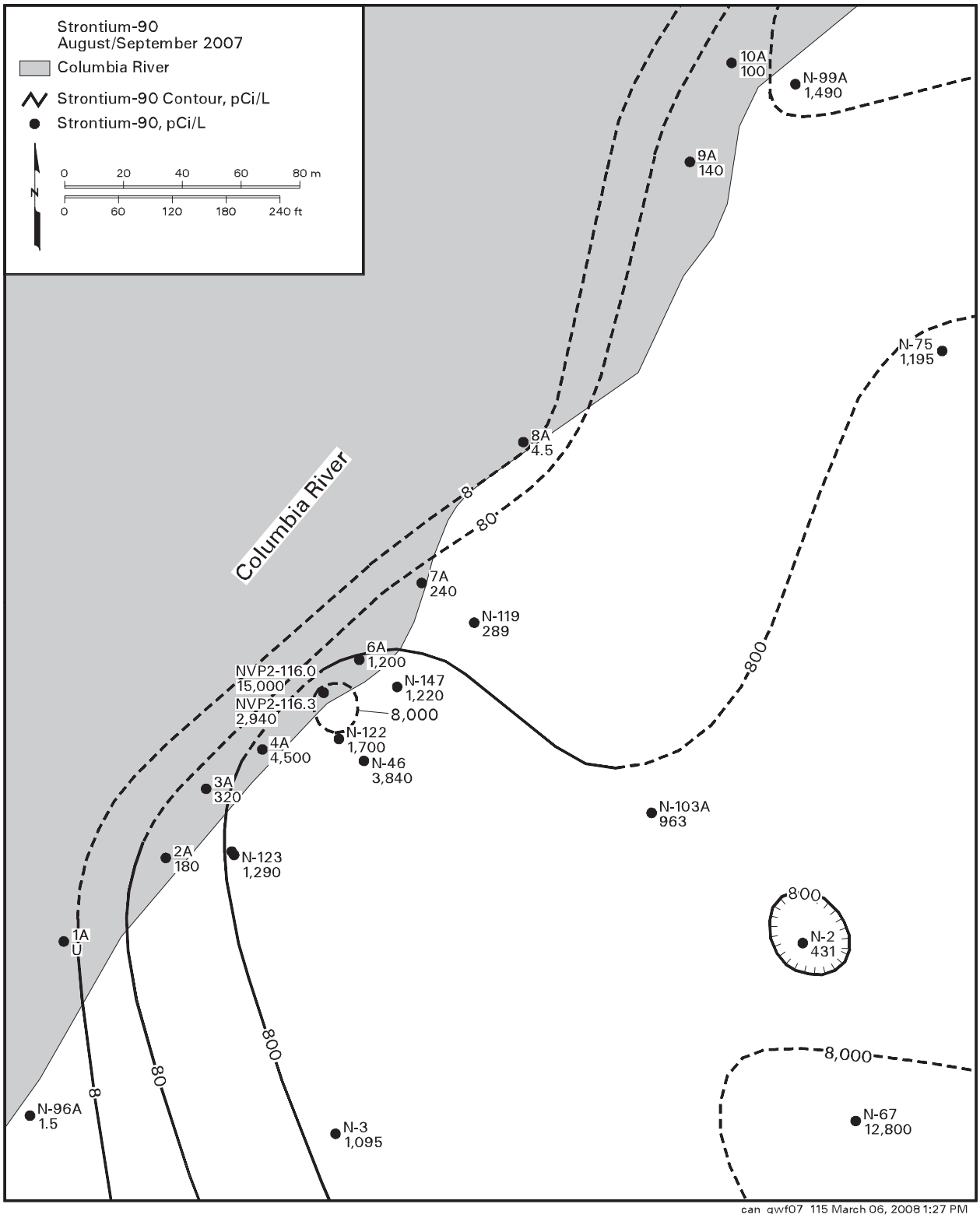
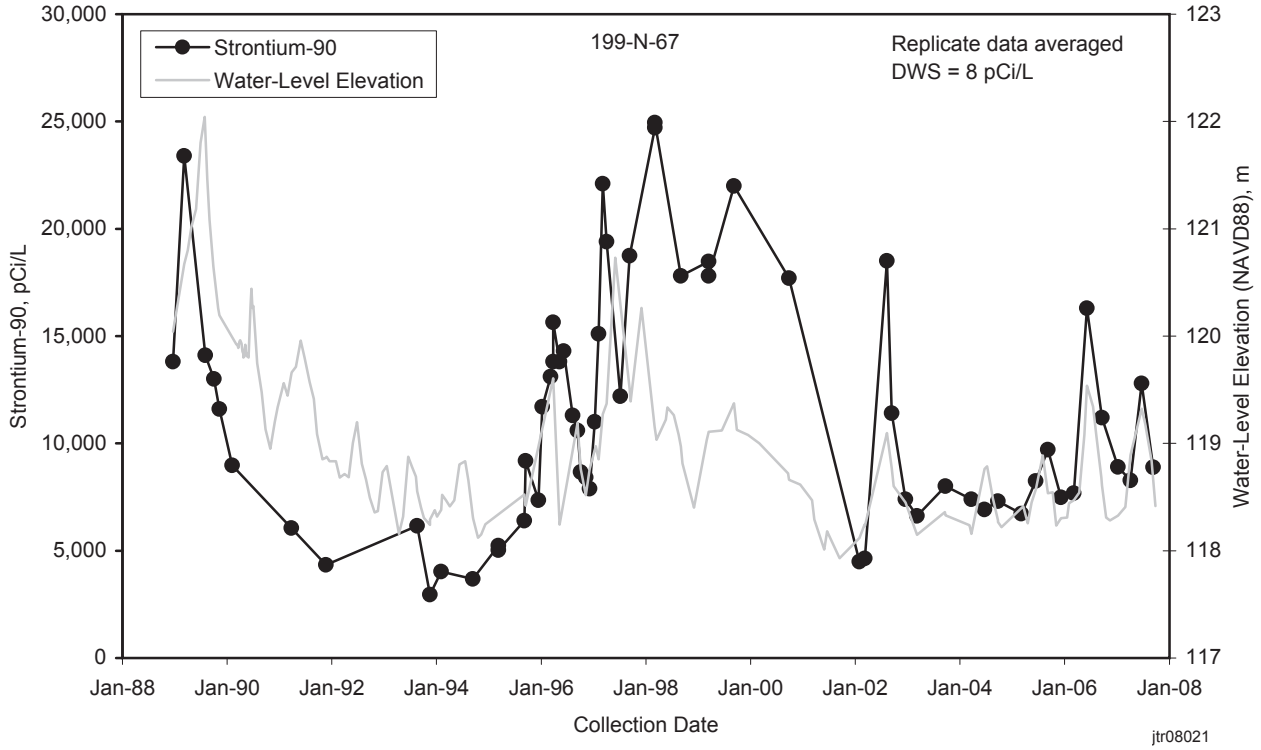


Figure 2.4-5. Strontium-90 in Groundwater at Shoreline Study Area, August/September 2007, Upper Part of Unconfined Aquifer



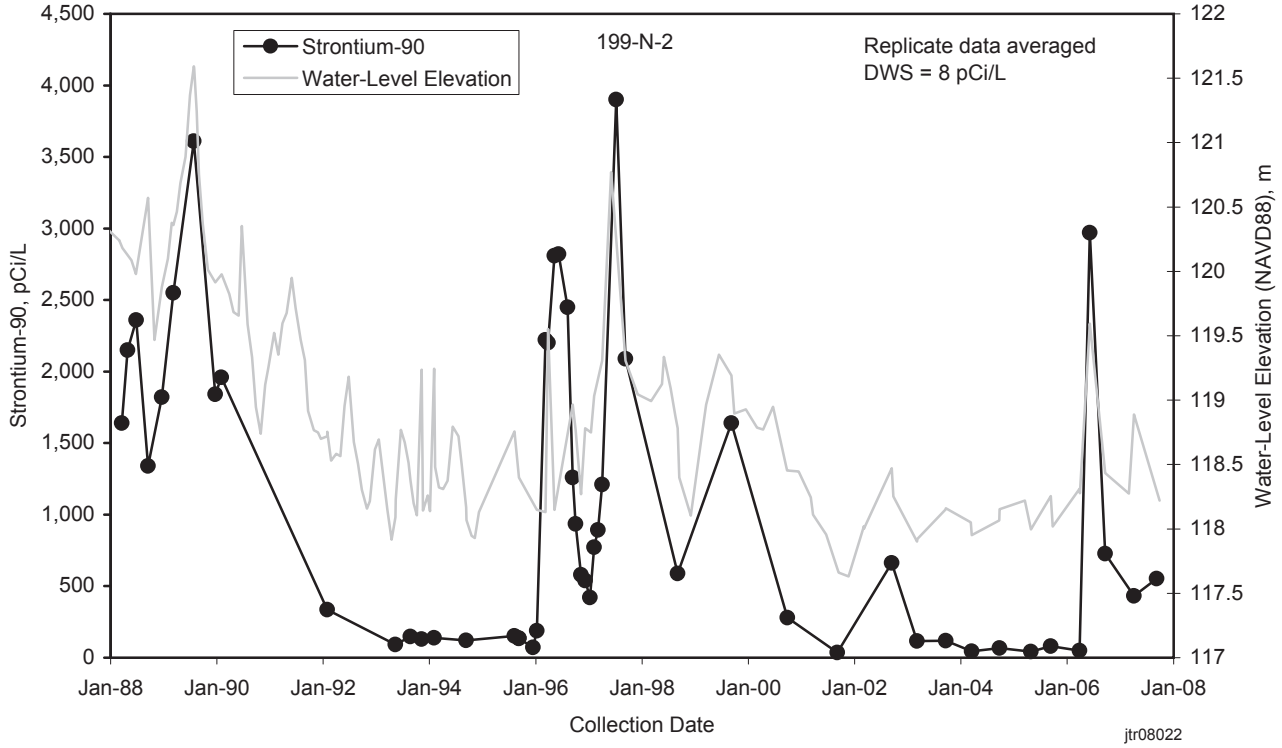


Figure 2.4-6. Strontium-90 Concentrations and Water Level Near 116-N-1 Facility

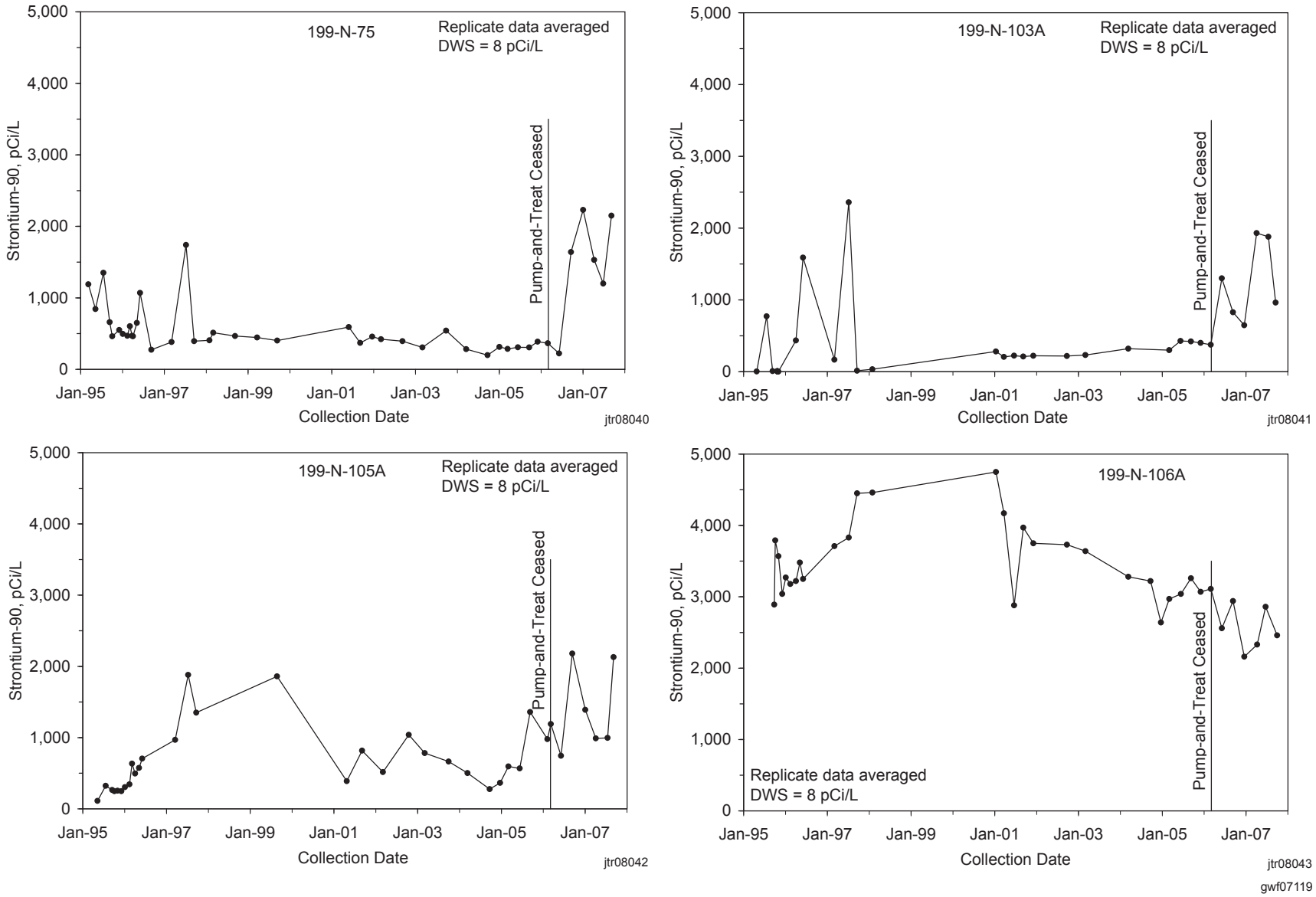


Figure 2.4-7. Strontium-90 Concentrations in Former Extraction Wells in 100-N Area

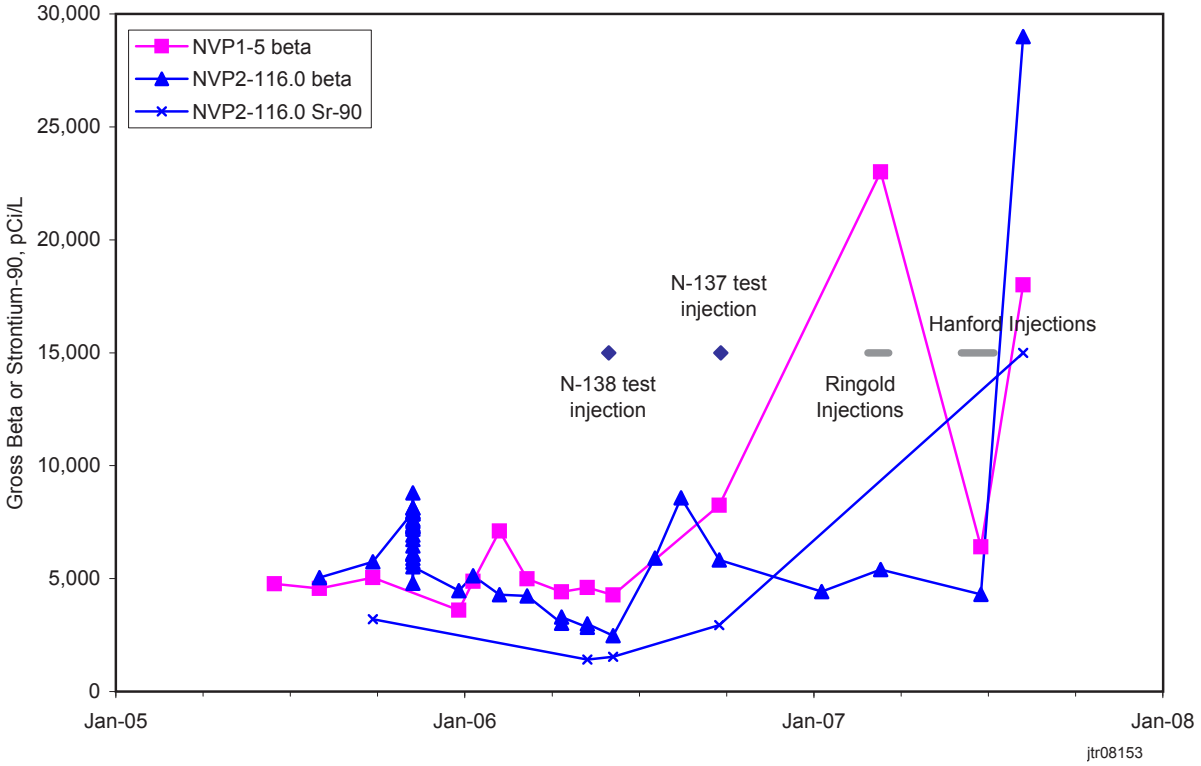


Figure 2.4-8. Gross Beta and Strontium-90 Concentrations in 100-N Area Aquifer Tubes

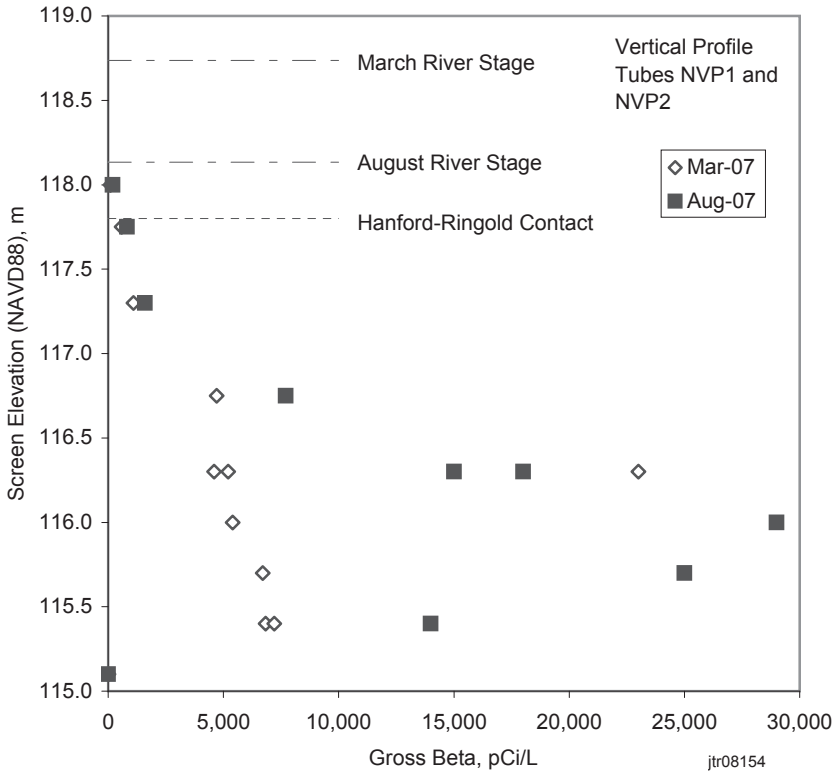


Figure 2.4-9. Strontium-90 Concentrations With Depth at 100-N Area Shoreline, March and August 2007

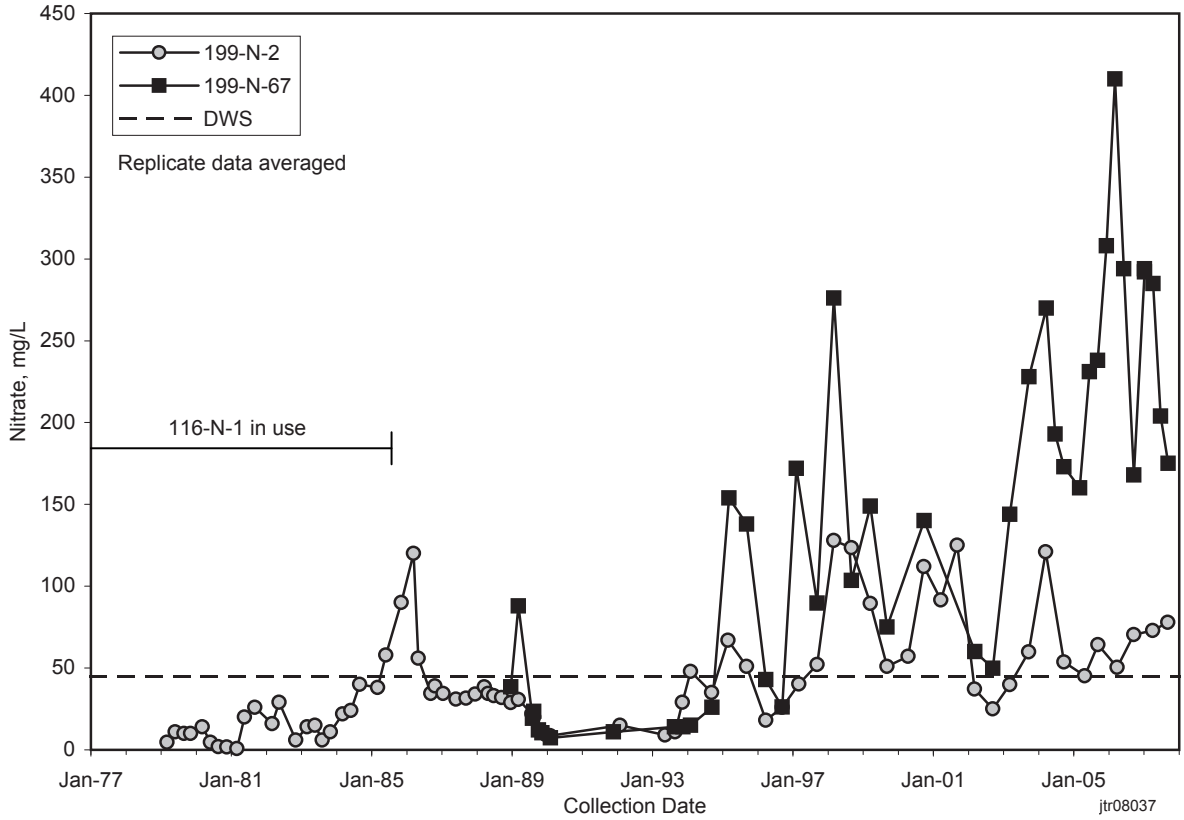


Figure 2.4-10. Nitrate Concentrations Near 116-N-1 Facility

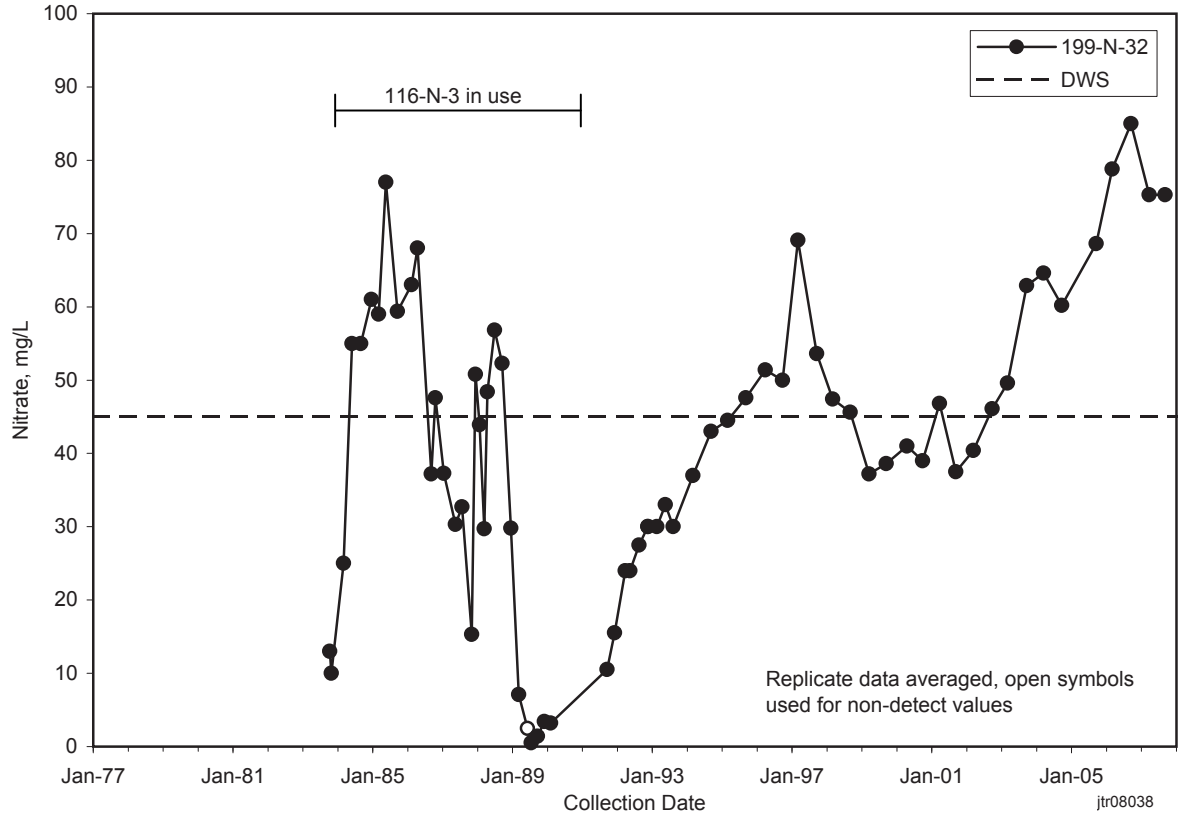


Figure 2.4-11. Nitrate Concentrations Near 116-N-3 Facility

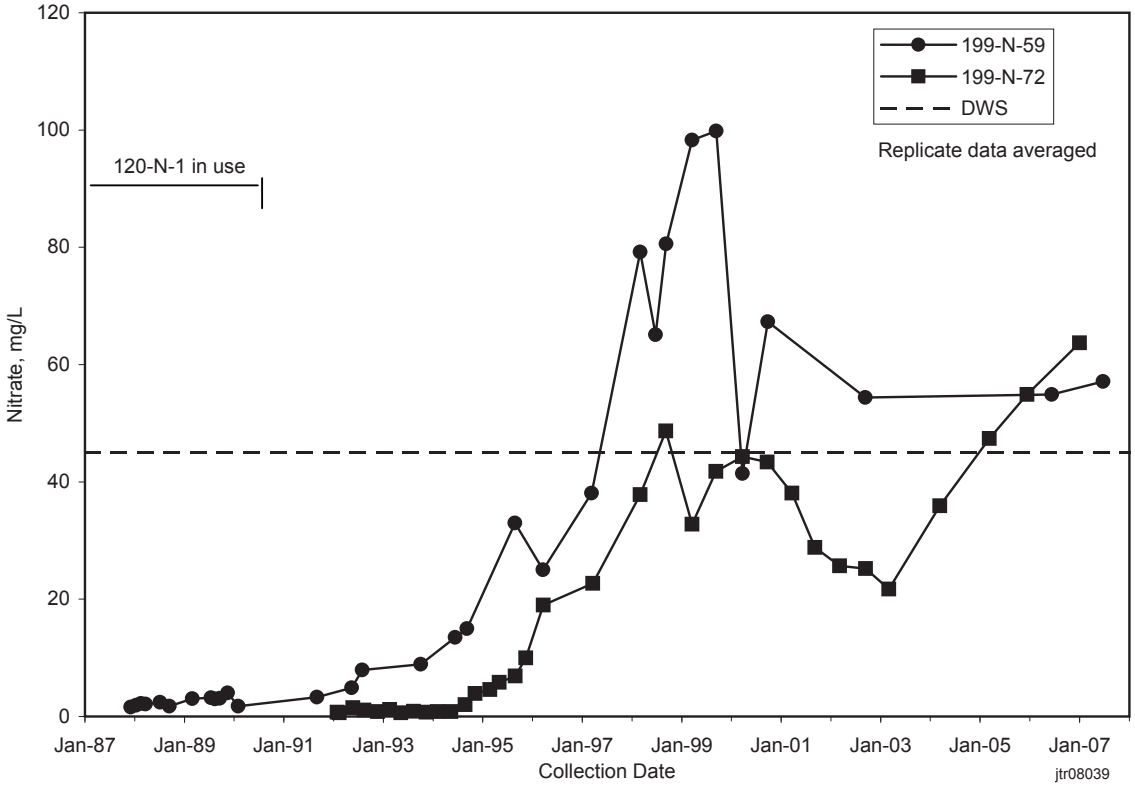


Figure 2.4-12. Nitrate Concentrations Near 120-N-1 Percolation Pond in South 100-N Area

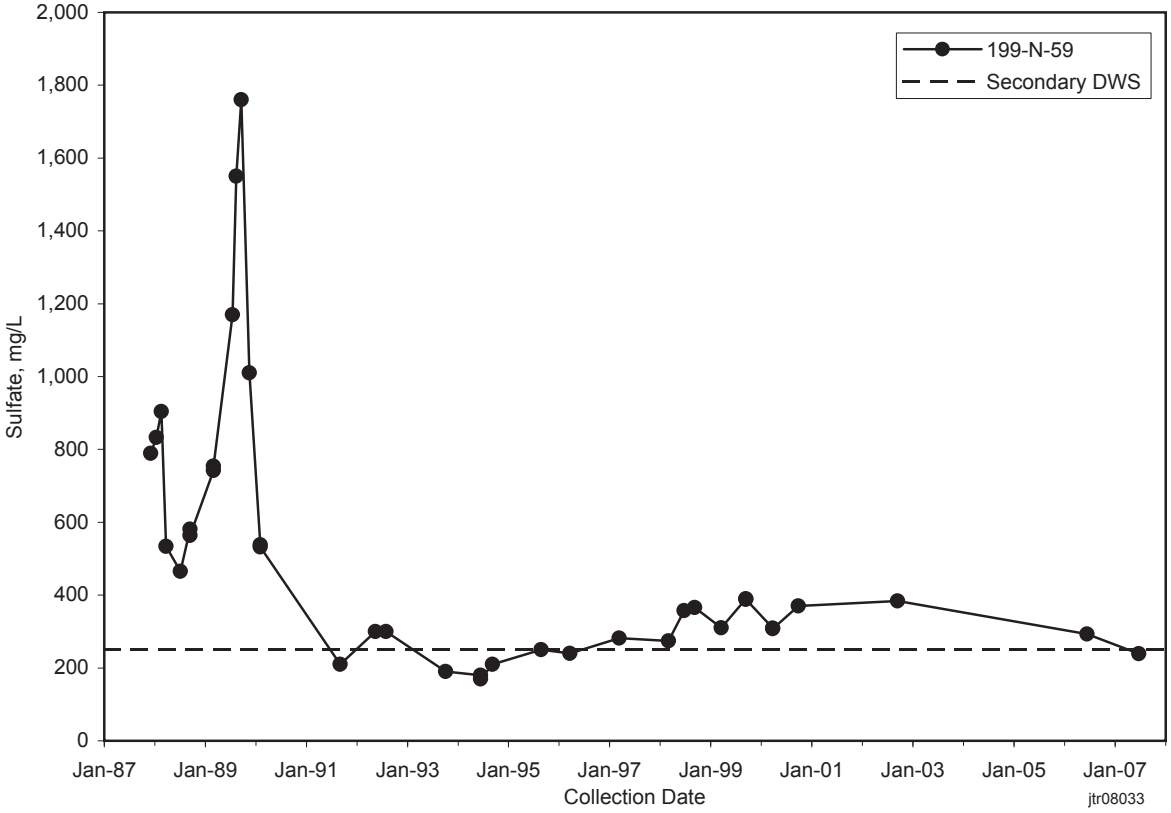


Figure 2.4-13. Sulfate Concentrations Near 120-N-1 Percolation Pond in South 100-N Area

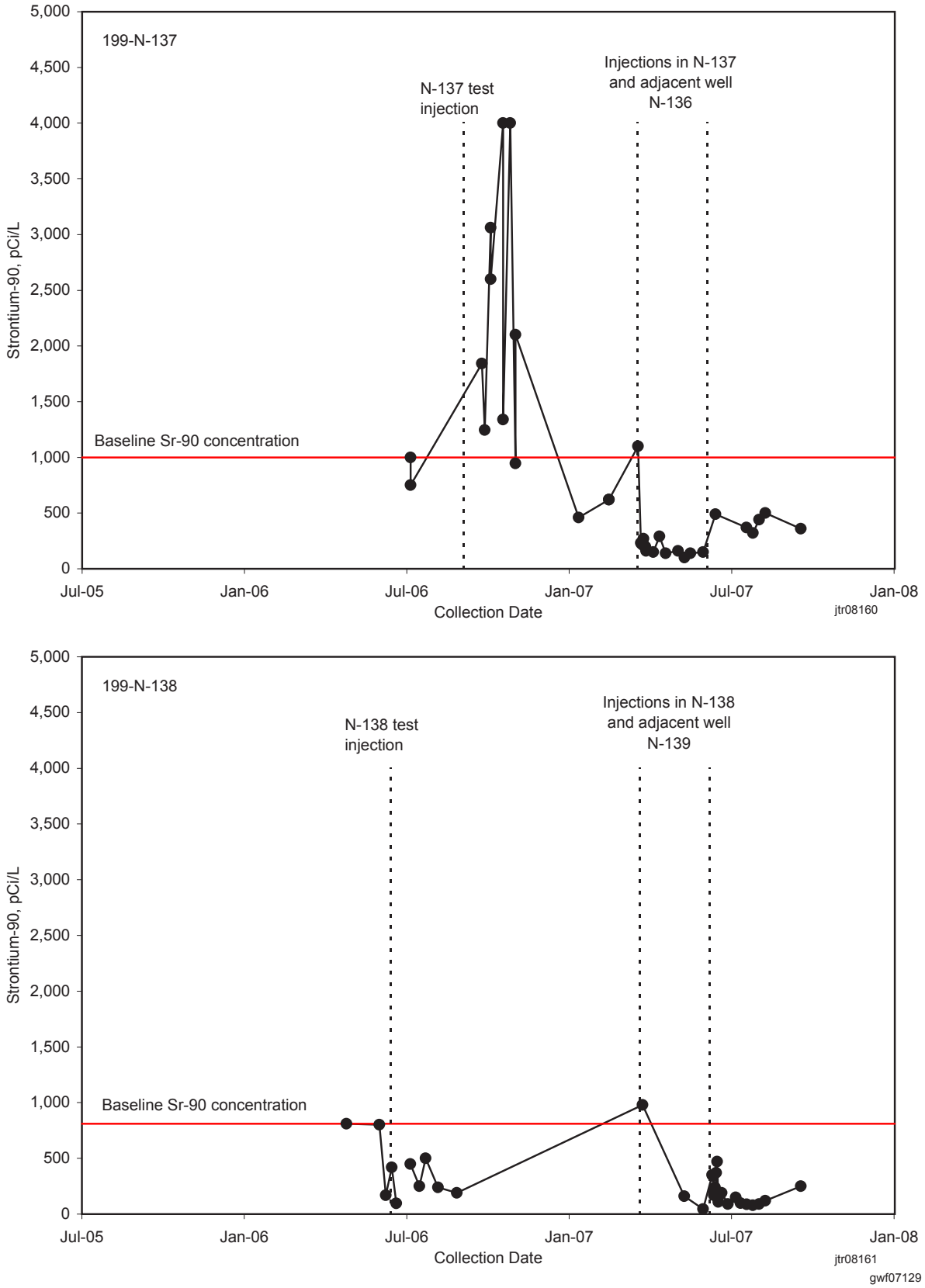


Figure 2.4-14. Strontium-90 Concentrations in Two Apatite Injection Wells (Data from HEIS and project database)

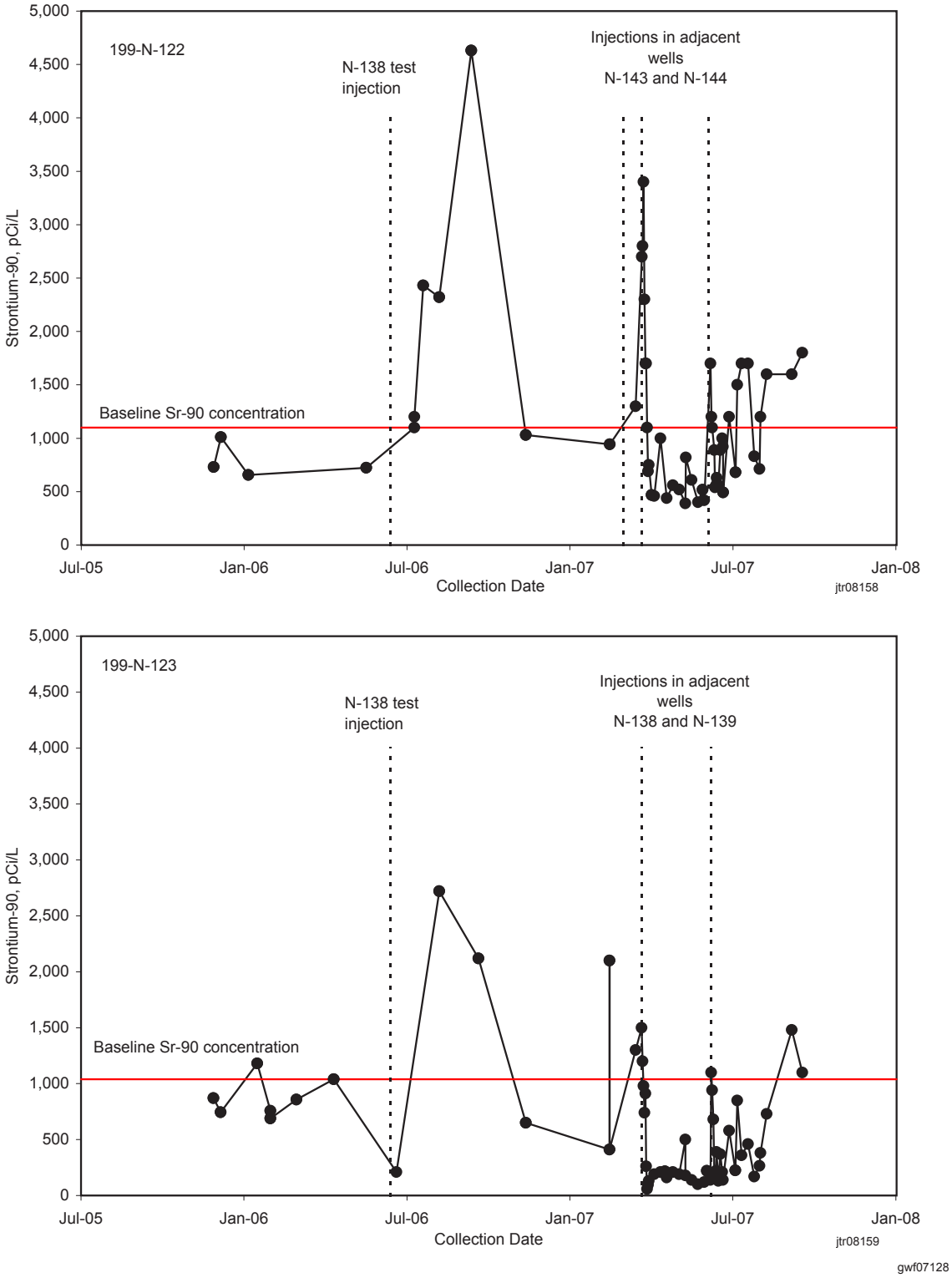


Figure 2.4-15. Strontium-90 Concentrations in Monitoring Wells Downgradient of Apatite Treatment Zone (Data from HEIS and project database)

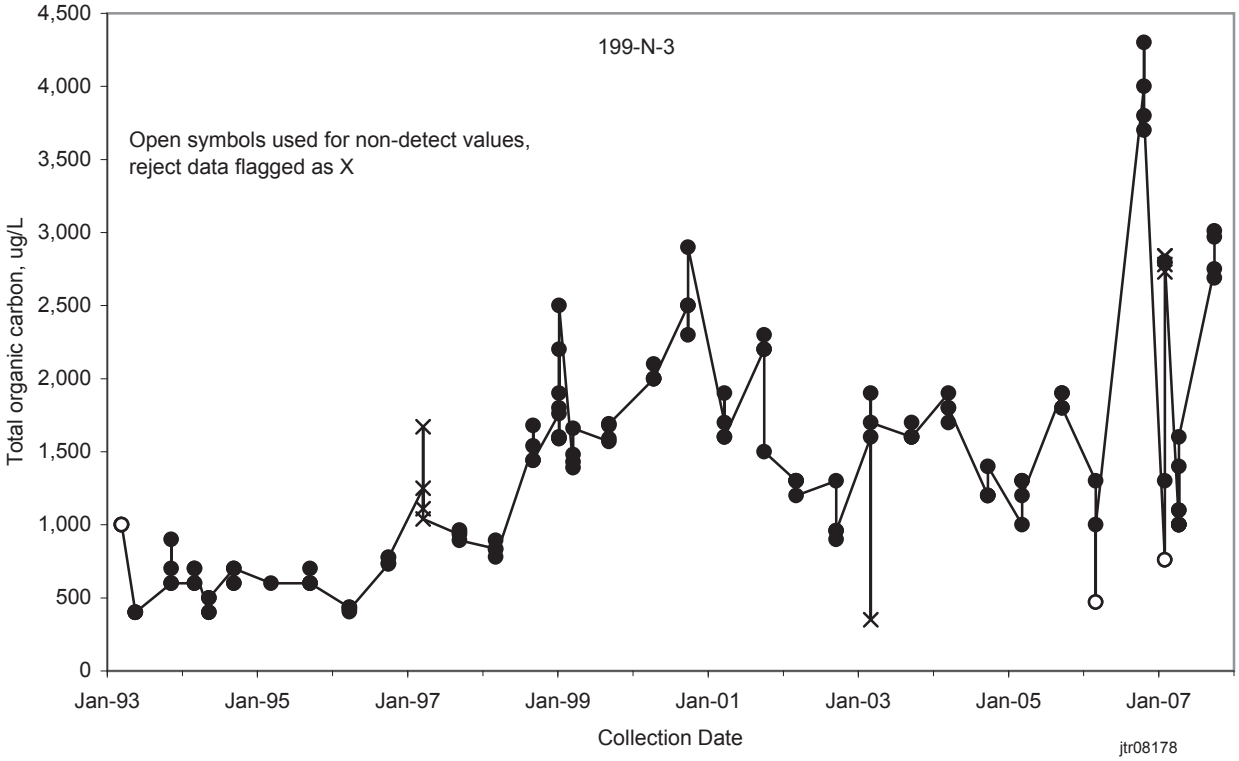


Figure 2.4-16. Total Organic Carbon in Well 199-N-3, Downgradient of 116-N-1 Facility

2.5 100-HR-3-D Operable Unit

M. J. Hartman

The scope of this section is the 100-HR-3-D groundwater interest area, which occupies the west half of the 100-HR-3 Operable Unit (see Figure 1.0-1 in Section 1.0). The "groundwater interest areas" are informal designations to facilitate scheduling, data review, and interpretation. Figures 2.5-1 and 2.5-2 show facilities, wells, and shoreline monitoring sites in this region. Hexavalent chromium is the primary contaminant of concern in groundwater. DOE monitors groundwater to assess the performance of three *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim actions for chromium: two pump-and-treat systems and an in situ reduction-oxidation (redox) manipulation system. Groundwater monitoring also tracks the nature and extent of other contaminants.

Hexavalent chromium is the primary contaminant of concern in the 100-D Area.

Groundwater flows primarily to the north and west, toward the Columbia River (Figure 2.5-3). Near the Columbia River, including the redox site, the average flow direction is toward the northwest. Farther inland, average flow is northward. Leakage from the 182-D reservoir (see Section 2.5.2.3) and injection of treated groundwater into well 199-D5-42 form a broad groundwater mound in the central region of the 100-D Area.

The remainder of this section describes contaminant plumes and concentration trends for the constituents of interest under CERCLA and *Atomic Energy Act* (AEA) monitoring.

2.5.1 Groundwater Contaminants

This section describes the distribution and trends of chromium, strontium-90, tritium, nitrate, sulfate, and gross beta in groundwater in the 100-D Area.

2.5.1.1 Chromium

Hexavalent chromium is a contaminant of concern for interim actions in the 100-HR-3 Operable Unit (ROD 1996a, 1999a). The remedial action goal for the pump-and-treat systems is 22 µg/L and for the in situ redox system is 20 µg/L.

Groundwater monitoring in the 100-HR-3-D groundwater interest area includes the following monitoring activities:

CERCLA and AEA Monitoring (Appendix A)

- ***Eight wells are sampled monthly to annually for the pump-and-treat systems; one monthly sample was missed in FY 2007.***
- ***Twenty-nine wells are sampled monthly to quarterly for the redox system. One well was sampled less frequently than planned in FY 2007.***
- ***Thirty-one wells throughout the 100-D Area are sampled monthly to biennially.***
- ***Eleven wells are sampled annually to biennially in the "horn" area between 100-D and 100-H Areas.***
- ***Six new wells were installed in the "horn" in FY 2007.***

Chromium contamination underlies most of the 100-D Area in two plumes. The north plume likely originated from cribs and trenches in the central 100-D Area and the south plume has sources near the former chromate transfer station (Figure 2.5-1).

Figure 2.5-4 shows chromium in the entire "horn" of the Hanford Site, which includes the 100-D and 100-H Areas and the 600 Area between. In fiscal year (FY) 2007 and early FY 2008, DOE installed 21 monitoring wells in the 600 Area to help define the plume in the horn. Chromium concentrations in most of these wells were above 20 µg/L,[a] confirming that the plume extends from 100-D Area to 100-H Area. A small portion of the plume west of 100-H Area had concentrations >100 µg/L. The contamination is believed to have migrated eastward from the 100-D Area when there was a groundwater mound beneath the retention basins. DOE also installed new aquifer tubes north of the 100-H Area in early FY 2008. Section 2.5.2.4 discusses the horn chromium investigation.

At 100-D Area, three remediation systems help reduce the amount of chromium reaching the Columbia River: two pump-and-treat systems in the north and an in situ remediation system in the southwest.

Figure 2.5-5 shows detail of chromium distribution at the redox site in southwest 100-D Area. The remediation has reduced chromium concentrations in this region. However, chromium concentrations remained elevated above 100 µg/L in several wells within and downgradient of the redox barrier. Section 2.5.2 discusses this "breakthrough" of chromium and describes the planned activities to mitigate it.

Aquifer tubes provide additional monitoring points along the 100-D Area shoreline (Figure 2.5-6). The highest concentration in FY 2007 was 199 µg/L at tube site AT-36, in the central portion of the shoreline. Figure 2.5-7 illustrates the depths of the aquifer tubes and screened intervals of wells near the shoreline. Chromium concentrations greater than 100 µg/L are detected in tubes from 1 to 8 meters below land surface near the shoreline. Concentrations in the shallowest tubes generally are lower than in deeper tubes because of mixing with river water, as indicated by specific conductance.

North Plume. The 100-µg/L contour of the north chromium plume extends from cribs, trenches, and pipelines near the former reactor building toward the north and west. At levels between 20 and 100 µg/L, the plume extends eastward to the 100-H Area.

Plume areas (square kilometers) at the 100-HR-3-D Operable Unit:

Chromium, 100 µg/L — 0.84
Chromium, 20 µg/L* — 3.2
Nitrate, 45 mg/L — 0.81
Tritium, 20,000 pCi/L — 0.03

****Includes chromium plume east to boundary with 100-HR-3-H interest area.***

Wells 199-D5-15 and 199-D5-16 are monitored near the sources of the north plume. Concentrations have increased dramatically in well 199-D5-15 over the past several years, reaching a maximum of 2,450 µg/L in May 2007 (Figure 2.5-8). The low chromium concentrations in 1999 to 2003 were caused by dilution from nearby leaking water lines. During this time, specific conductance was often low (<300 µS/cm), indicating that groundwater was being diluted with fresh water. Since 2003, the specific conductance has stabilized at ~600 µS/cm, suggesting the dilution has ceased. The cause of the continuing increase in chromium concentrations is unknown. Chromium concentrations in nearby well 199-D5-16 increased modestly in FY 2007 to just above the drinking water standard.

In the north 100-D Area near the original pump-and-treat system, compliance wells continued to show variable chromium concentrations, with the lowest concentrations in the early summer when river stage was high

(a) The plume map of Figure 2.5-4 includes results of samples collected from the new horn wells during well development. Results may not be representative and are considered preliminary. Continued monitoring will further delineate the plume.

(Figure 2.5-9). The concentrations were below the 22 µg/L remedial action goal from April through September in well 199-D8-69, and from May through August in well 199-D8-70 (these are compliance wells for the remedial action). The seasonal concentration peaks (fall and winter of each year) have declined since 2000. Section 2.5.2 contains more information about the pump-and-treat systems.

Chromium concentrations in wells on the southwest side of the north plume decreased from their peak values observed in 2004 (Figure 2.5-10). Wells 199-D5-20 and 199-D5-32 were converted to extraction wells in July 2004. Chromium concentrations in monitoring well 199-D5-41 dropped from ~2,000 µg/L in August 2006 to 225 µg/L in August 2007.

Well 199-D8-54B in the north 100-D Area monitors a silty sand unit within the Ringold Formation upper mud. In this deeper, confined unit, chromium is near the detection limit while an adjacent shallow well has concentrations above the drinking water standard.

New wells in the south 100-D Area will help characterize chromium sources there. Some of the new wells have the highest chromium concentrations on the Hanford Site.

South Plume. This chromium plume lies south and southwest of the 182-D reservoir and west of the 183-DR filter plant, extending to the Columbia River (Figures 2.5-4 and 2.5-5). The core of the chromium plume, with concentrations >1,000 µg/L, is oriented west-northwest. The redox barrier intersects the south chromium plume and terminates the highest-concentration portion of the plume.

In FY 2007, DOE installed new wells to investigate chromium sources in the south 100-D Area. New wells are 199-D2-11, 199-D5-97, 199-D5-98, 199-D5-99, 199-D5-102, 199-D5-103, and 199-D5-104 (see Figure 2.5-1). The wells were drilled in areas that were suspected sources of chromium contamination. The highest levels of chromium in groundwater in the new wells were in wells 199-D5-99 and 199-D5-104 (Figure 2.5-11). Section 2.5.2.7 discusses this investigation further.

Compliance monitoring wells downgradient of the redox barrier show inconsistent chromium trends (Figure 2.5-12). The northernmost well, 199-D4-83, shows variable chromium concentrations with decreasing peaks. Concentrations were below the 20-µg/L remedial action goal in February and May 2007. Well 199-D4-39, near the north end of the barrier, shows high variability since 2000. Concentrations in FY 2007 were about the same as FY 2006, with a maximum value of 651 µg/L in November 2006. Chromium concentrations were below the remedial action goal part of the year in wells 199-D4-23, 199-D4-85, and 199-D4-86. Concentrations in wells 199-D4-38 and 199-D4-84 remained above the remedial action goal, with FY 2007 maxima of 369 and 74 µg/L, respectively.

Chromium concentrations downgradient of the redox site have decreased since monitoring began in most of the aquifer tubes (Figure 2.5-13). The highest concentration in this region in FY 2007 was 171 µg/L in tube DD-43-3.

Chromium concentrations in the central 100-D Area (e.g., wells 199-D5-33 and 199-D5-44) are very low, separating the south and north chromium plumes. The low concentrations were probably caused by infiltration of clean water from the 182-D reservoir. Repairs and operational changes have reduced the amount of infiltration (see Section 2.5.2.3). In response, chromium concentrations increased sharply in well 199-D5-34 in FY 2006 (Figure 2.5-14). This well is located near the southeast corner of the reservoir. Specific conductance increased concurrently. This change may reflect decreased dilution from the 182-D reservoir. However, well 199-D5-33 continues to show no detectable chromium.

2.5.1.2 Strontium-90

Two locations in the 100-D Area have a history of strontium-90 detections in groundwater, i.e., near the former retention basins in the north and near the D Reactor building in central 100-D Area. All FY 2007 results were below the 8-pCi/L drinking water standard.

Well 199-D8-68, near the former retention basins, had the highest strontium-90 concentration in FY 2007. Duplicate samples in November 2006 had results of 7.8 and 4.9 pCi/L. Concentrations ranged from 2 to 14 pCi/L in this well over the past 6 to 8 years. Strontium-90 was also detected in wells 199-D8-53, 199-D8-54A, 199-D8-69, and 199-D8-70 in FY 2007.

Near the former D Reactor, strontium-90 continued to be detected in well 199-D5-15 at ~2 pCi/L. Nearby well 199-D5-16 continued to have no detectable strontium-90.

2.5.1.3 Tritium

Tritium contamination in the south 100-D Area may have originated in the 100-N Area.

Tritium concentrations remained below the 20,000-pCi/L drinking water standard in most wells in the 100-D Area, but continued to exceed the standard in three wells and one aquifer tube near the south part of the redox barrier (Figure 2.5-15). The tritium contamination is believed to have originated as part of the 100-N Area tritium plume to the south. A peak of contamination moved past well 199-D3-2 in the late 1990s. Concentrations in this well have increased again since 2004.

The tritium concentration declined below the drinking water standard in FY 2007 in well 199-D5-17, located near waste sites associated with the former DR Reactor. Since 1996, concentrations have ranged from 12,000 to 26,400 pCi/L with no obvious increasing or decreasing trend. Concentrations in nearby wells remained below the standard.

2.5.1.4 Nitrate and Nitrite

Nitrate distribution is generally similar to chromium in the 100-D Area; both constituents form two plumes (Figure 2.5-16). Nitrate concentrations continued to exceed the drinking water standard (45 mg/L) in both plumes, with a FY 2007 maximum concentration of 89 mg/L in well 199-D5-13 southeast of the former 120-D-1 pond.

The redox barrier intersects the south nitrate plume and converts nitrate to nitrite. Nitrate concentrations declined in wells downgradient of the barrier between 2000 and 2004 or 2005, but have increased in the past several years (Figure 2.5-17). The concentration in downgradient well 199-D4-38 increased to a level above the drinking water standard in FY 2007. These changes may relate to a reduction in the effectiveness of the redox barrier (see Section 2.5.3).

Nitrite was detected in many of the wells monitoring the redox barrier in FY 2007. Only one result exceeded the 3.3 mg/L drinking water standard: 5.58 mg/L in well 199-D4-62. The result was flagged as being associated with out-of-limits laboratory quality control samples, but is within the range of previous results.

2.5.1.5 Sulfate

Sulfate concentrations remained >100 mg/L beneath much of the 100-D Area. Excluding wells influenced by the redox system, concentrations all were below the

secondary drinking water standard (250 mg/L) in FY 2007. Past injections of sodium dithionite solution at the redox site increased sulfate concentrations to levels above the standard in the barrier and in some downgradient wells and aquifer tubes.

2.5.1.6 Gross Beta

Samples from several of the wells in the redox barrier are analyzed for gross beta, and a few of these exceed the 50-pCi/L drinking water standard. Analysis of previous samples show that the beta is caused by potassium-40 naturally present in the injected solution.

2.5.2 Operable Unit Activities

This section summarizes CERCLA activities in the 100-D Area. Remedial actions include two pump-and-treat systems and the in situ redox manipulation system, all of which treat chromium contamination. DOE also began work on several Environmental Management Technology (EM-22) proposals in the 100-D Area. DOE also began characterizing a chromium plume between the 100-D and 100-H Areas.

2.5.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified six actions pertaining to the 100-D Area.

- **Action 8-1**. Complete a field investigation to investigate additional sources of chromium groundwater contamination within the 100-D Area. Additional geologic and geochemical investigations of the vadose zone in the 100-D Area (March 2009). Section 2.5.2.7 provides more information on this investigation.
- **Action 9-1**. Perform additional characterization of the aquifer in the horn and evaluate the need to perform remedial action to meet the remedial action objectives of the 100-D record of decision for interim action (September 2009). Section 2.5.2.4 discusses the status of this investigation. Figure 2.5-4 illustrates chromium distribution across the horn.
- **Action 9-2**. Incorporate the horn into the 100-HR-3 interim ROD if Action 9-1 indicates the horn contains a plume that needs immediate remediation (September 2009). This action depends on the outcome of Action 9-1.
- **Action 10-1**. Direct the operating contractor to further minimize leakage from the 182-D reservoir (previously completed; see Section 2.5.2.3).
- **Action 11-1**. Initiate limited iron amendments to evaluate whether this enhances redox barrier performance (September 2007). Section 2.5.2.5 discusses the status of this action.
- **Action 11-2**. Expand groundwater pump-and-treat extraction within the 100-D Area by 378.5 liters/minute to enhance remediation of the chromium plume (no due date). DOE and the lead regulatory agency have agreed that this action will be resolved through continuing improvements to the pump-and-treat system. Currently, optimization of the pump-and-treat system and new technologies (electrocoagulation) for the treatment of extracted water are being evaluated.

During FY 2007, two pump-and-treat systems in the 100-D Area removed 75.9 kilograms of hexavalent chromium from the aquifer.

2.5.2.2 Pump-and-Treat Systems

R. F. Raidl

A pump-and-treat system in the north 100-D Area includes four extraction wells located near the former 116-D-7 and 116-DR-9 retention basins. The system began operating in July 1997 with two extraction wells (199-D8-53 and 199-D8-54A). In May 2002, wells 199-D8-68 and 199-D8-72 were converted to additional extraction wells.

The remedial action objectives of the 100-HR-3 Operable Unit (ROD 1996a, 1999a) are:

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminant in the groundwater.***
- ***Provide information that will lead to the final remedy.***

The contaminant of concern is hexavalent chromium. The records of decision set the cleanup goal at compliance wells as 22 µg/L for the pump-and-treat system and 20 µg/L for the redox system.

Extracted groundwater is transferred via pipeline to the 100-H Area where it is treated and injected into the aquifer. Monitoring requirements for this system are included in DOE/RL-96-90, as modified by DOE/RL-96-84. Long-term monitoring requirements in the 100-D Area were derived from Change Control Form 107. Appendix A lists wells, constituents, and sampling frequencies for interim action monitoring.

A second pump-and-treat system (DR-5 system) began operating at the end of July 2004 to treat increasing hexavalent chromium concentrations in the wells southwest of the original pump-and-treat system. The system was modified in FY 2005 to increase the rate of remediation and widen the capture zone. From August 2005 to present, the extraction wells have been 199-D5-20, 199-D5-32, 199-D5-39, and 199-D5-92. The extracted water is treated in the 100-D Area using a metal chelating medium and injected into well 199-D5-42.

The 100-D Area pump-and-treat systems have removed over 450 kilograms of hexavalent chromium from groundwater. The table below lists the volume of water treated and the mass of chromium removed by each system.

	Original Pump-and-Treat		DR-5 Pump-and-Treat		Pilot Scale Pump-and-Treat	Total	
	FY 2007	Since 1997	FY 2007	Since 2004	1992-1994	FY 2007	Since 1992
Mass of chromium removed (kg)	21.2	263.7	54.7	160.1	30	75.9	453.8

In FY 2007, chromium concentrations remained elevated in the 100-D Area, although the trend over the last 4 years is clearly decreasing in compliance wells 199-D8-69 and 199-D8-70 (Figure 2.5-9). Chromium concentrations vary inversely with river stage, and have remained above the 22-µg/L remedial action goal except for occasional readings during summer months when river stage is high and dilution occurs. Chromium in the vadose zone appears to be a continuing source of contamination on the inland portion of the plume.

DOE/RL-2006-76 presents results of operational monitoring and additional details about the pump-and-treat systems for calendar year 2006. Results for calendar year 2007 will be included in an upcoming report on the 100 Areas pump-and-treat systems.

2.5.2.3 In Situ Redox Manipulation System

R. O. Mahood

This treatment system uses a change in redox potential to reduce dissolved hexavalent chromium in groundwater to trivalent chromium, a much less soluble and less toxic species. Objectives of the redox interim action are the same as for the 100-D Area pump-and-treat system except that the remedial action goal for chromium at the redox site is 20 µg/L. Remedial action monitoring is described in DOE/RL-99-51.

The redox system has reduced chromium concentrations in the aquifer near the Columbia River.

The redox treatment zone is ~680 meters long, aligned parallel to the Columbia River and ~100 to 200 meters inland. The treatment zone is designed to reduce the concentration of hexavalent chromium in groundwater to ≤20 µg/L at seven compliance wells situated between the treatment zone and Columbia River. The system has lowered chromium concentrations in the aquifer near the Columbia River, as shown in the chromium plume maps of Figures 2.5-4 and 2.5-5. In FY 2007 the 20-µg/L goal was met[b] at two of the seven compliance wells: 199-D4-85 and 199-D4-86. Chromium trends in the other compliance wells were generally decreasing (Figure 2.5-12).

During FY 2007, as well as in recent years, chromium concentrations increased in redox barrier wells beyond what was expected based on the design. At the end of FY 2007, concentrations in barrier wells ranged from below detection limits to 880 µg/L, with concentrations in ~69% of the wells below the remedial action goal of 20 µg/L. Concentrations in 77% of the wells were <50 µg/L, 4% were between 50 and 100 µg/L, and 19% were greater than 100 µg/L. Most of the elevated concentrations are in the northeast half of the barrier. DOE is investigating methods to mitigate the chromium breakthrough (Section 2.5.2.5).

Results of water-level monitoring within the 182-D reservoir showed that ~6 million liters of water leaked to the ground between November 1, 2006 and December 8, 2006.[c] This was lower than the ~31 million liters that leaked in FY 2006. The leakage rate in FY 2007 was 106 liters/minute. The water table below the reservoir rose temporarily in response. The leakage occurred during a period of standby condition at the 182-D reservoir. The reservoir does not appear to have leaked during the rest of the fiscal year. Leakage from the 182-D reservoir was identified as an issue in the CERCLA five-year review (see Section 2.5.2.1). The operating contractor maintains the water level at 0.6 to 1.8 meters during pumping operations and 0.3 to 0.9 meter during standby conditions. Maintaining low water levels helps minimize leakage. Water is only pumped from the 182-D reservoir during emergency conditions, i.e., if unable to pump from the 182-B reservoir. There were three periods of emergency operations at the 182-D reservoir in FY 2007: September 24 to October 4, 2006; September 5 to 10, 2007; and September 17 to 25, 2007. At all other times, the 182-D reservoir is maintained in a standby condition. DOE/RL-2007-19 presents more information on the redox site for FY 2006. Results for FY 2007 will be presented in an upcoming report.

(b) FY 2007 average of filtered, total chromium and filtered, hexavalent chromium.

(c) The volume of leakage from the 182-D reservoir is estimated using the water level monitoring data for the reservoir and dimensions of the reservoir. The method is described in WMP-26568.

2.5.2.4 Chromium Investigation in the Horn

D. Weekes

In FY 2007 DOE began to investigate chromium contamination across the "horn" of the Hanford Site. New wells show that contamination extends from the 100-D Area to the 100-H Area.

DOE initiated a field study to characterize the extent, concentration, and movement of hexavalent chromium in groundwater underlying the area between 100-D and 100-H Areas (commonly called the "horn"). SGW-33224 provides the sampling and analysis instructions for the study.

By the end of September 2007, DOE had installed six wells in the horn area: 699-94-41, 699-94-43, 699-95-45, 699-95-48, 699-97-41, and 699-97-48C. Fifteen more wells and eighteen aquifer tubes were completed in early FY 2008.

Preliminary hexavalent chromium analyses from the new wells indicate continuous contamination across the horn between 100-D and 100-H Areas at levels above the 22-µg/L remedial action goal (see Section 2.5.1.1 and Figure 2.5-4). Water samples collected from the semi-confined aquifer within the Ringold upper mud also show hexavalent chromium contamination above the goal.

Results of the investigation will be published in an upcoming report in FY 2008.

2.5.2.5 Micron-Size Iron Injection

S. W. Petersen

In this project, micron-size iron will be tested for its ability to be injected into the redox wells and react with groundwater to reduce chromium. This is a unique application that has never been tested at Hanford.

During FY 2007, a contractor tested various iron compounds in the laboratory for their ability to be injected into Ringold Formation sediments and reduce chromium in groundwater. Laboratory tests will be completed by April 2008, with the goal of injecting one or two of the most suitable compounds during spring or summer of 2008.

2.5.2.6 Electrocoagulation Tests

S. W. Petersen

This project, conducted during the summer of 2007, tested electrocoagulation as an alternative to ion exchange for treating chromium-contaminated groundwater. Electrocoagulation is a water treatment process that has been used to remove a variety of suspended solids and dissolved pollutants from water by applying an electric field to steel plates. The electric field liberates iron and causes the pollutants to precipitate, forming a solid that can be removed and disposed. The test ran at ~190 liters/minute for several months. Water was extracted from wells 199-D5-13 and 199-D5-41. The treated water was injected into well 199-D5-106, upgradient of the northern chromium plume. A treatability test report is scheduled to be released in spring 2008.

2.5.2.7 Chromium Source Area Refinement

S. W. Petersen

Chromium concentrations in both 100-D Area plumes have not declined significantly, which strongly suggests that chromate is still present in the vadose

zone. Chromium concentrations are above 1,500 µg/L in both plumes and have been above 12,000 µg/L in some areas, which confirms that the source is not historic reactor cooling water but a considerably more concentrated solution.

Two EM-22 projects have been funded to refine the area of the source for each plume. DOE/RL-2006-74 presents the field investigation plan for this study. The objectives of this work are to obtain soil samples from the suspected source areas, and refine the source location by collecting groundwater samples for several months. The groundwater samples will be used to refine the location of the proximal portion of each of the plumes in the 100-D Area. DOE installed seven wells in the southern plume in February and March 2007 and has been sampling the wells bi-weekly since then. The wells have been instrumented to automatically measure the groundwater levels, which will aid in locating the source area. Plans for the northern plume include approximately fifteen vadose zone pushes to collect soil samples using a hydraulic hammer rig developed specifically for Hanford, and installing three groundwater monitoring wells. This work will be performed at the beginning of calendar year 2008.

2.5.2.8 Chromium Vadose Zone Characterization and Geochemistry

J. S. Fruchter, R. B. Rowley, S. W. Petersen, and K. M. Thompson

Pacific Northwest National Laboratory is conducting a study of chromium geochemistry as part of DOE's Environmental Management (EM-22) program (http://www.hanford.gov/cp/gpp/science/em21.cfm). The primary objectives of the study are to (1) determine the leaching characteristics of hexavalent chromium from contaminated sediments collected from 100 Area spill sites; (2) clarify possible mineral or chemical associations that may be responsible for chromium retention, through the use of solubility studies and characterization of contaminated sediments; and (3) from these data, construct a conceptual model of hexavalent chromium geochemistry in the 100 Area vadose zone.

During FY 2007, hexavalent chromium-contaminated sediments were collected from the 100-B/C and 100-D Areas. Some sediments in the cores were freshly contaminated from pipeline leaks. Other sediments were contaminated up to 40 years ago, and represented aged contamination. Various column-leaching experiments were completed on the core sediments. In all column-leaching studies, the majority of hexavalent chromium was released in the first pore volume, indicating that it remains highly soluble and mobile. However, at least some tailing was observed in all of the columns. The leaching behavior from sediments of common origin sometimes exhibited different behavior, and the amount of tailing did not correlate well with the age of the spill. Column experiments also were conducted in which fresh hexavalent chromium solution was introduced. In all cases, the retardation coefficient was close to one, showing that fresh hexavalent chromium acts as a conservative tracer. This behavior was independent of the influent concentration of chromium on the solutions. The next step in this project is to characterize the form of the hexavalent chromium in the various sediments.

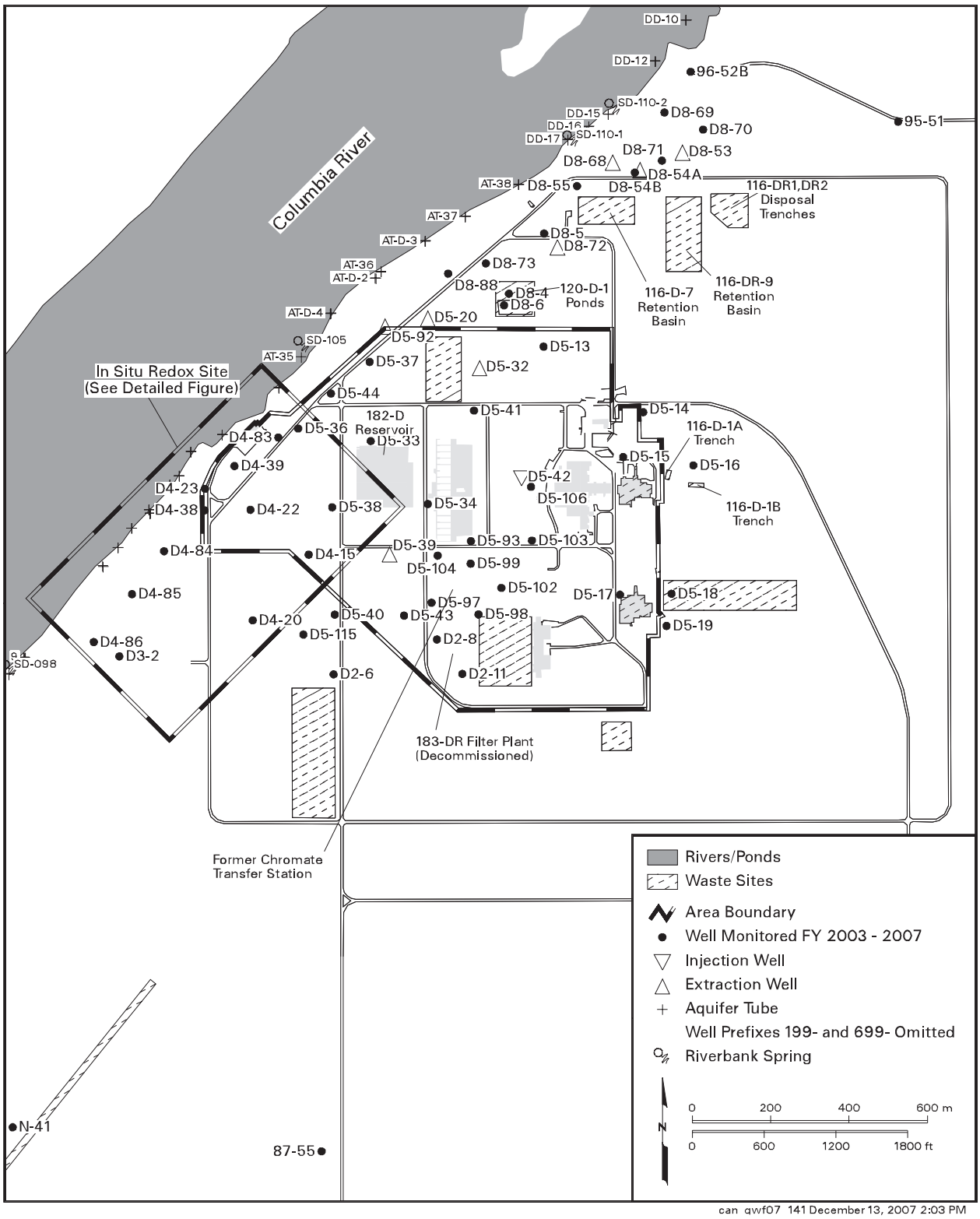


Figure 2.5-1. Groundwater Monitoring Wells in 100-D Area

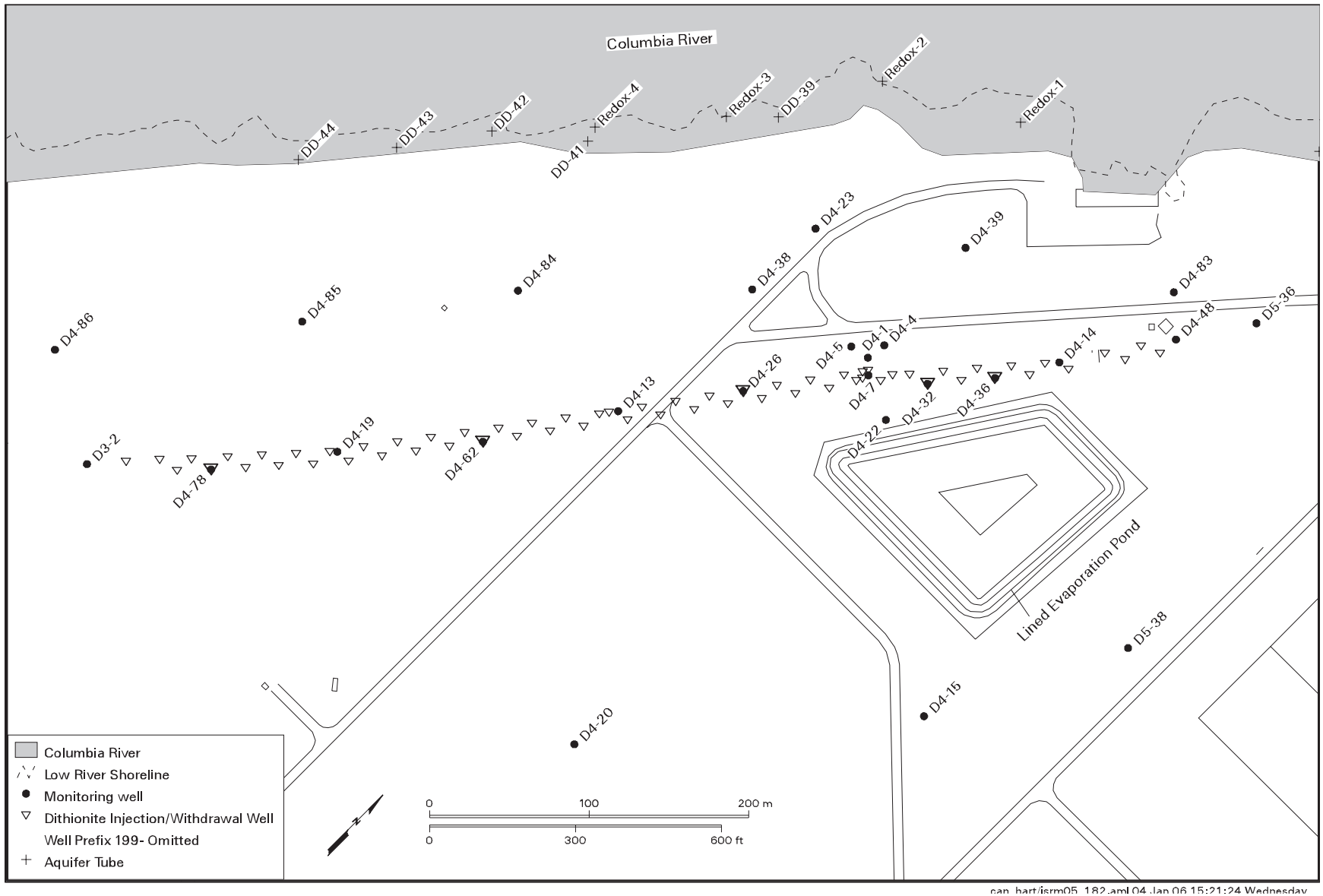


Figure 2.5-2. Groundwater Monitoring Wells Near Redox Site in 100-D Area

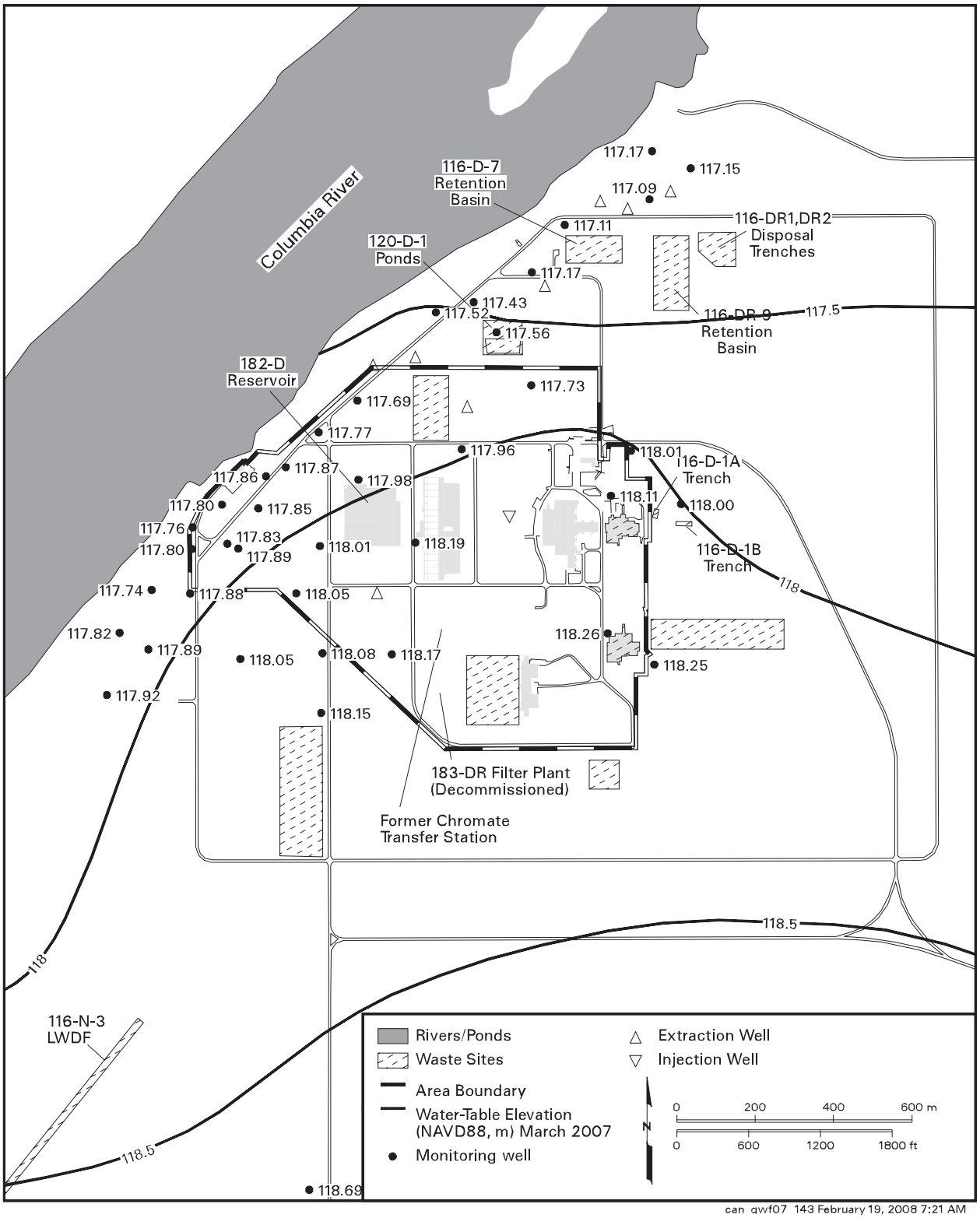


Figure 2.5-3. 100-D Area Water-Table Map, March 2007

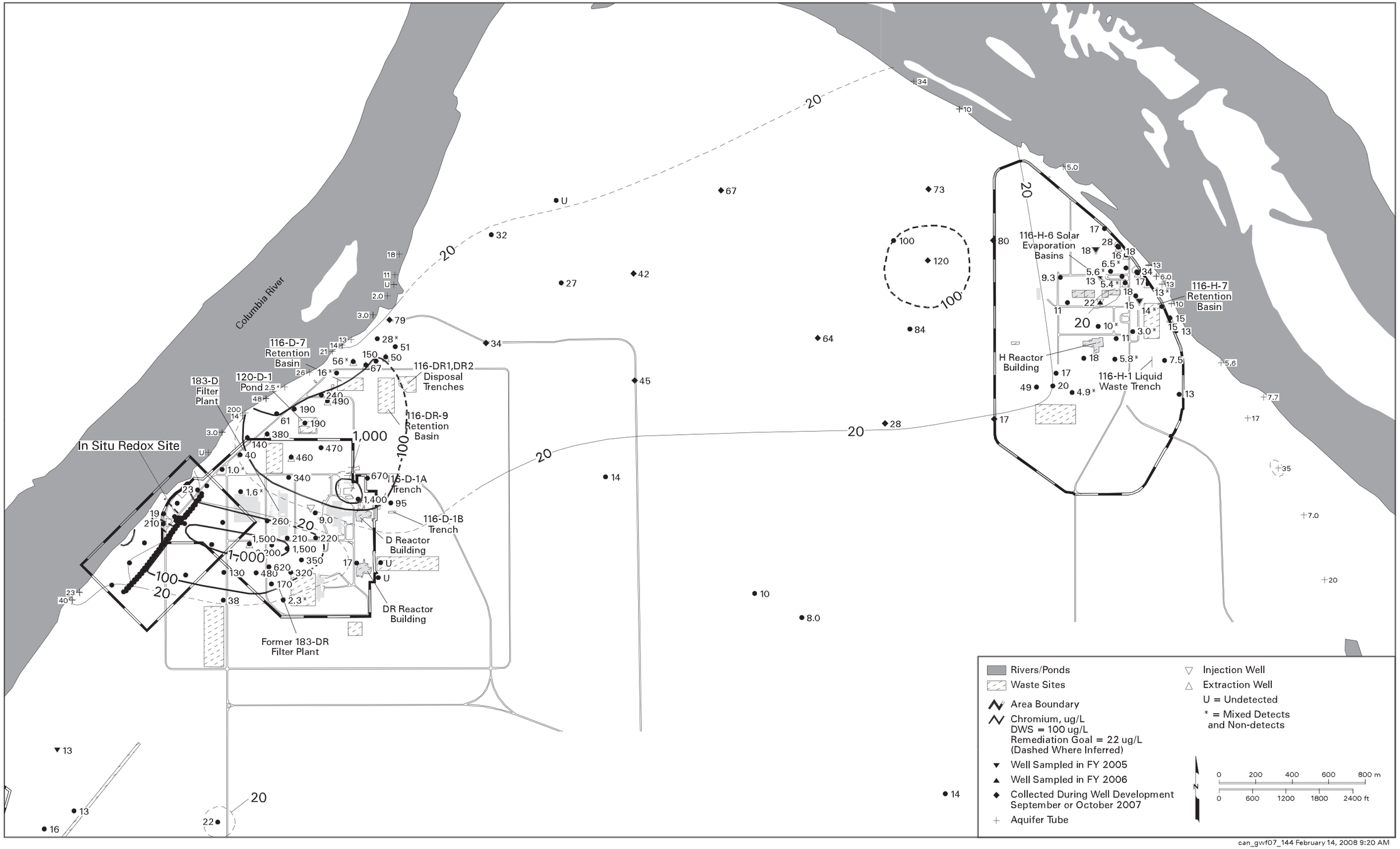


Figure 2.5-4. Average Chromium Concentrations in 100-D and 100-H Areas, Upper Part of Unconfined Aquifer

Figure 2.5-5. Hexavalent Chromium Concentrations Near Redox Site, 100-D Area, August 2007, Upper Part of Unconfined Aquifer

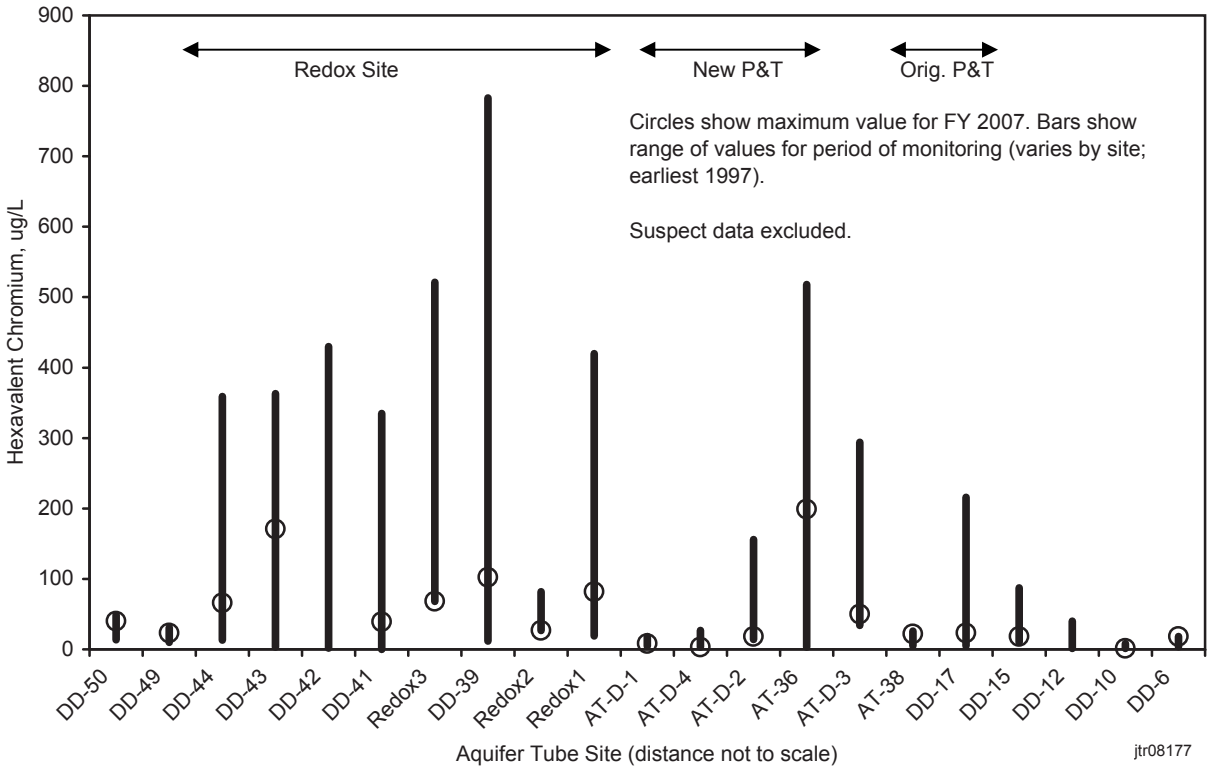


Figure 2.5-6. Hexavalent Chromium Concentrations at Selected Aquifer Tube Sites at 100-D Area

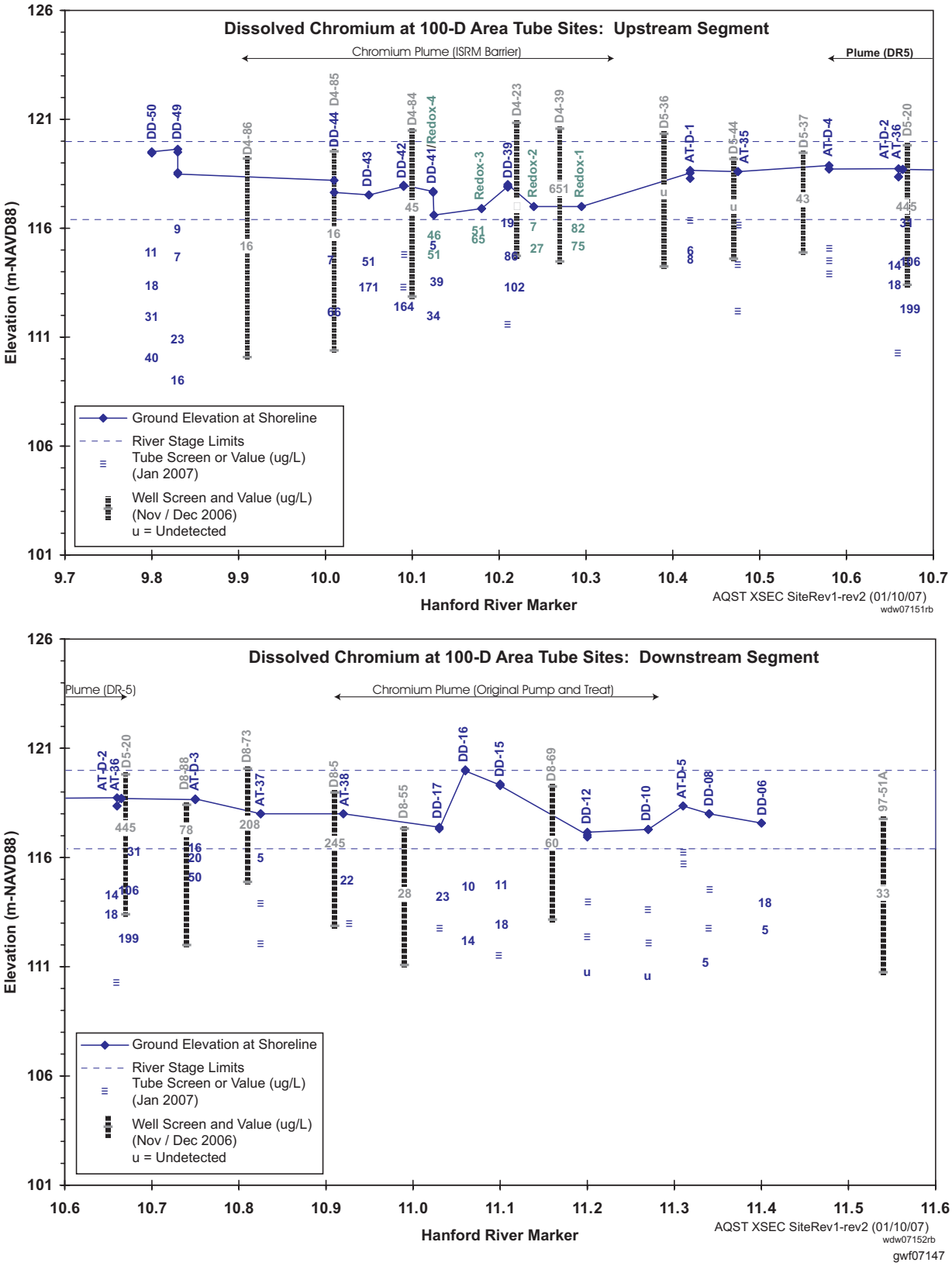


Figure 2.5-7. Cross-Section Parallel to Shoreline in 100-D Area Showing Aquifer Tube Depths, Projected Well Screen Intervals, and FY 2007 Hexavalent Chromium Concentrations (from SGW-35028)

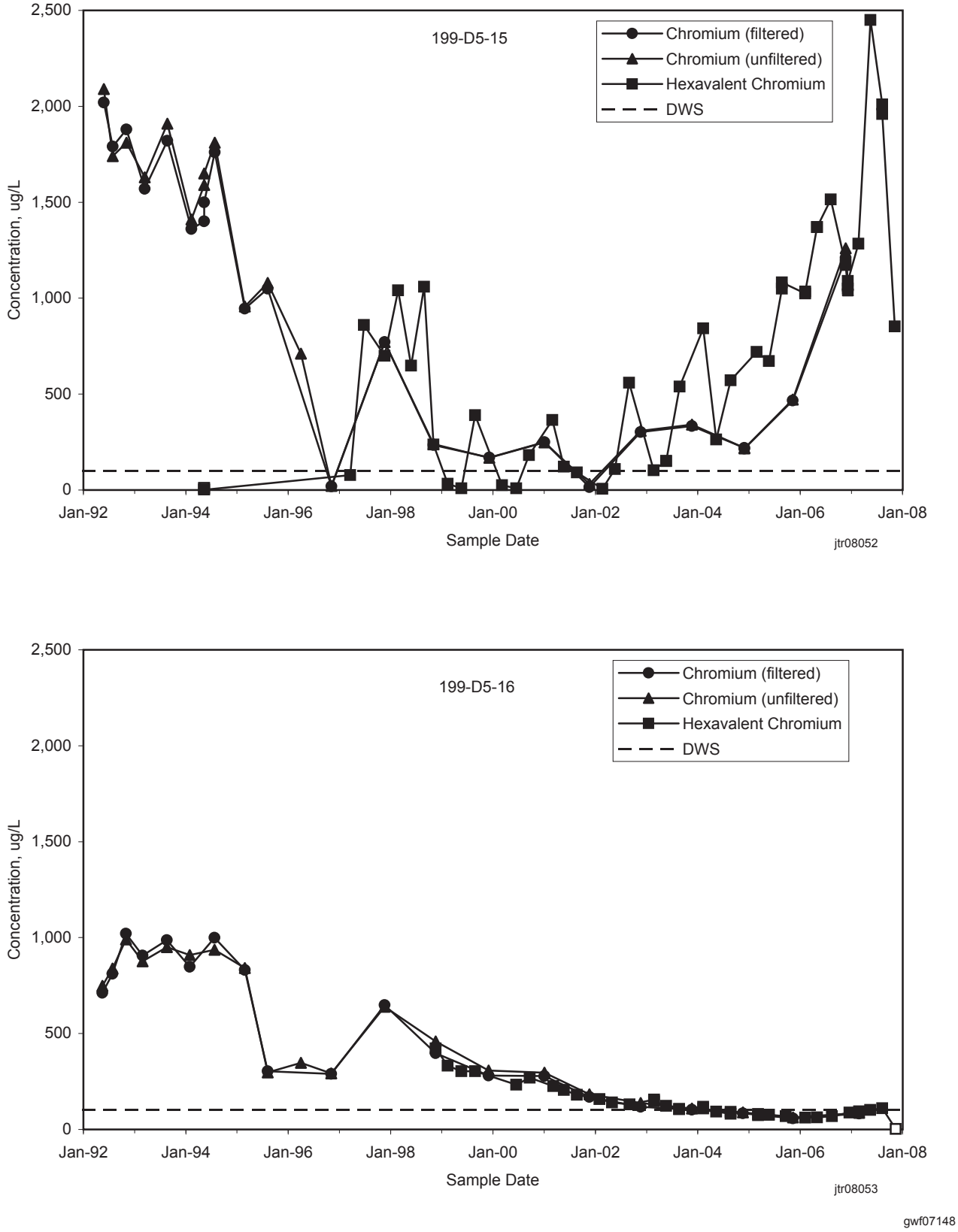


Figure 2.5-8. Chromium Concentrations in Wells Near Former D Reactor

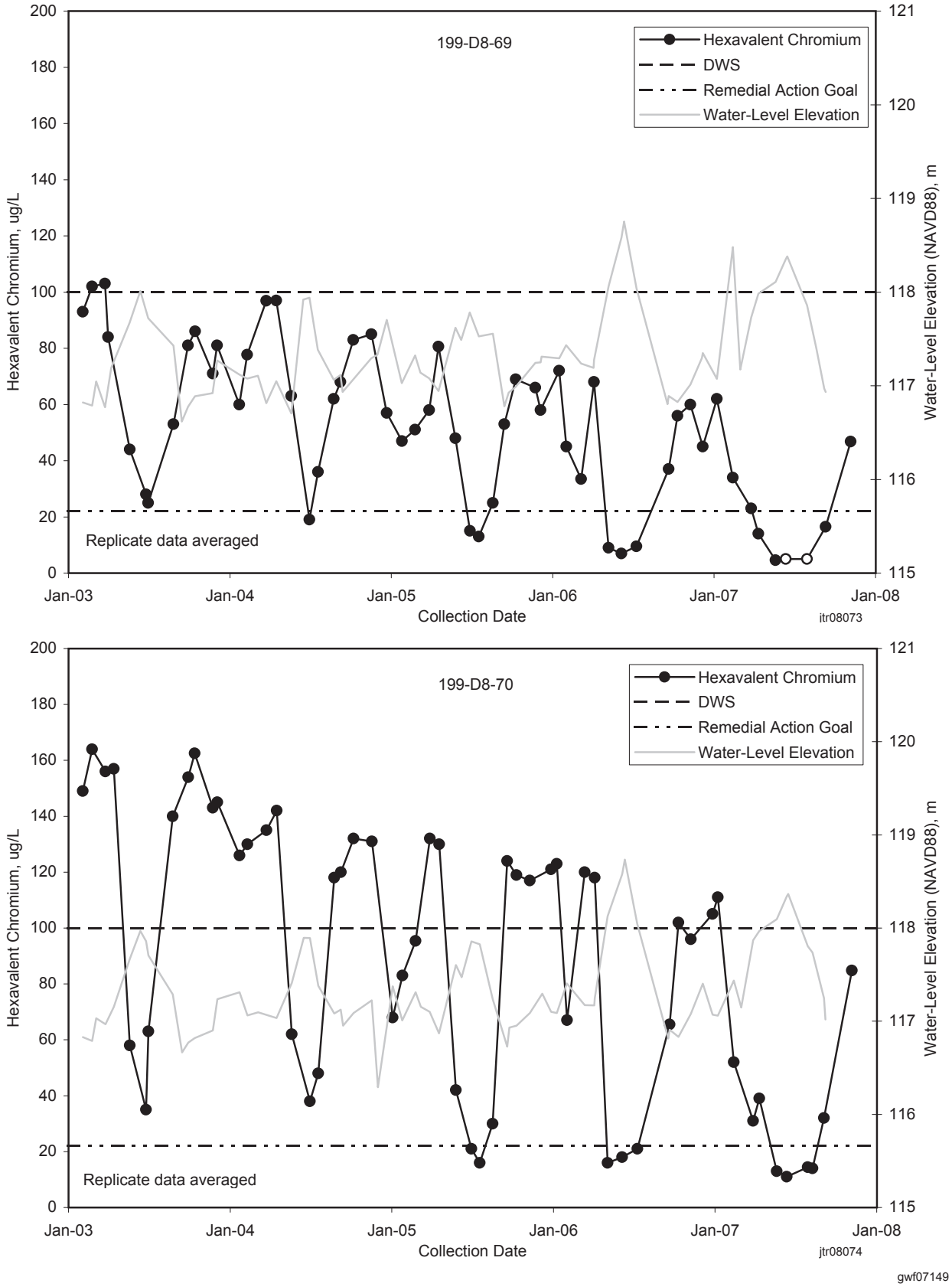


Figure 2.5-9. Hexavalent Chromium Concentrations and Water Levels in Compliance Wells for 100-HR-3 Pump-and-Treat System at 100-D Area

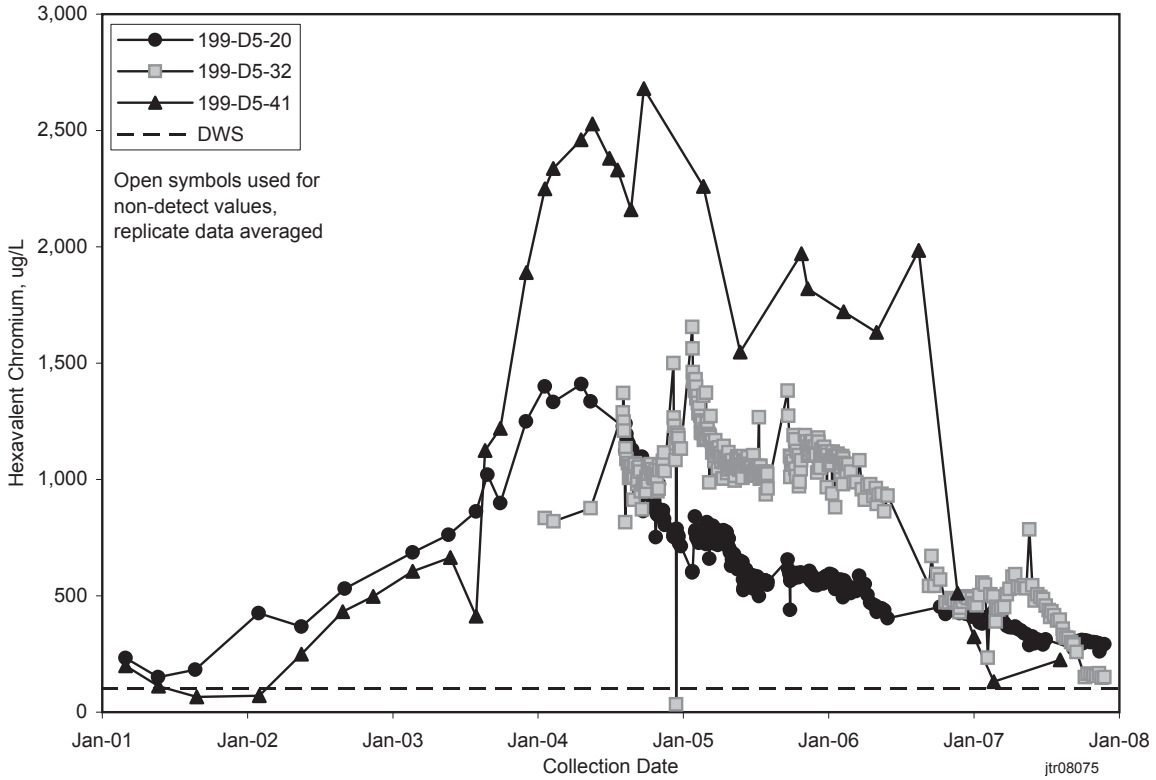


Figure 2.5-10. Hexavalent Chromium Concentrations in Central 100-D Area

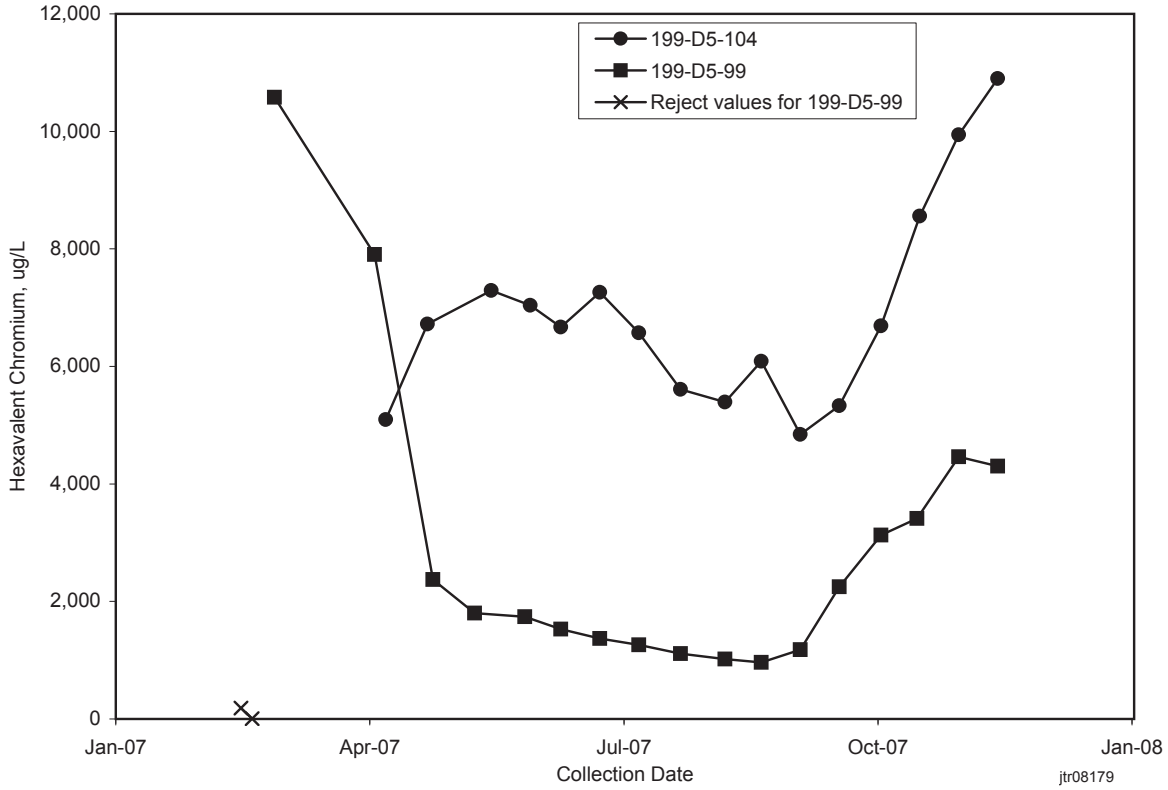


Figure 2.5-11. Hexavalent Chromium Concentrations in South Central 100-D Area

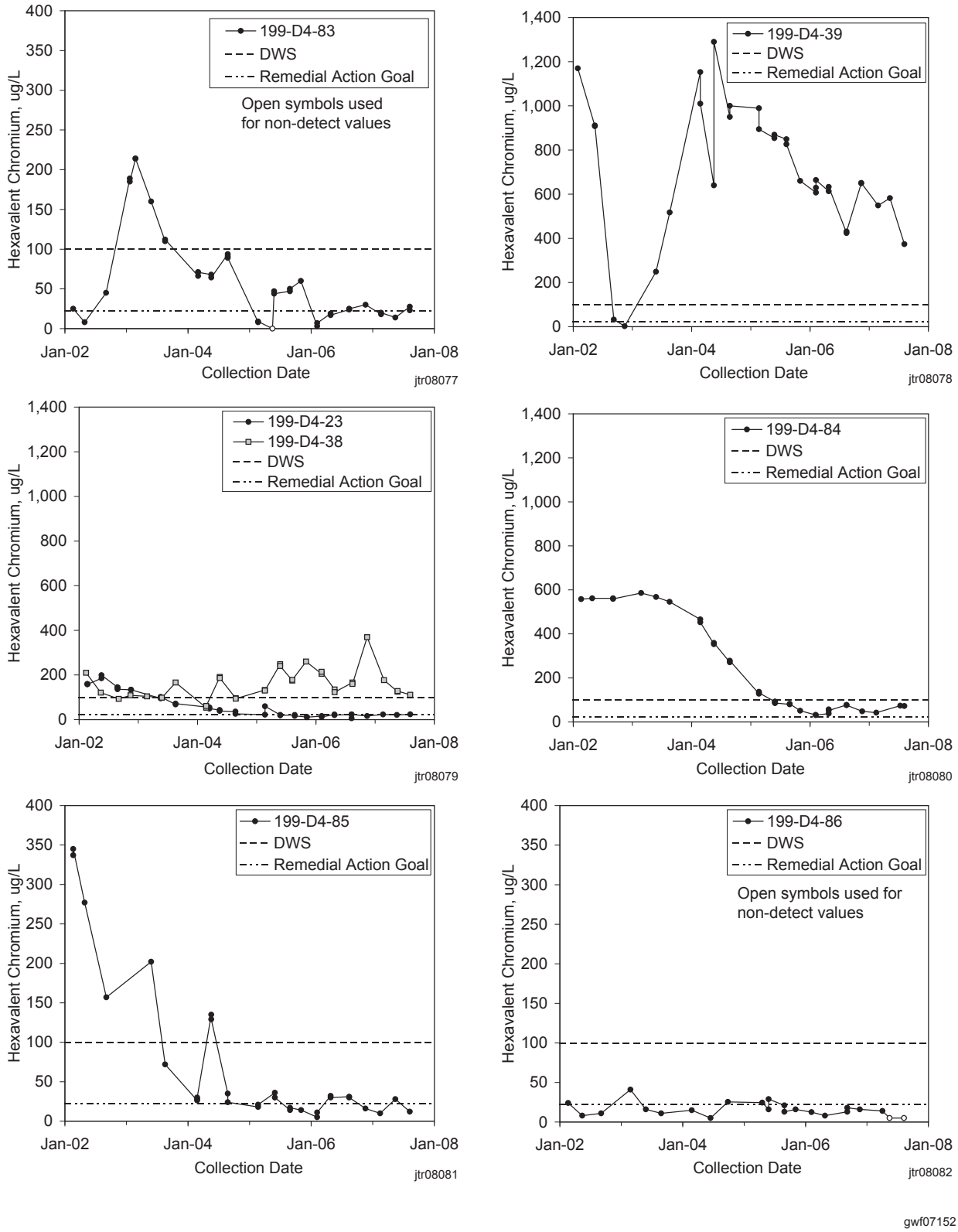


Figure 2.5-12. Hexavalent Chromium Concentrations in Compliance Wells Downgradient of Redox Barrier

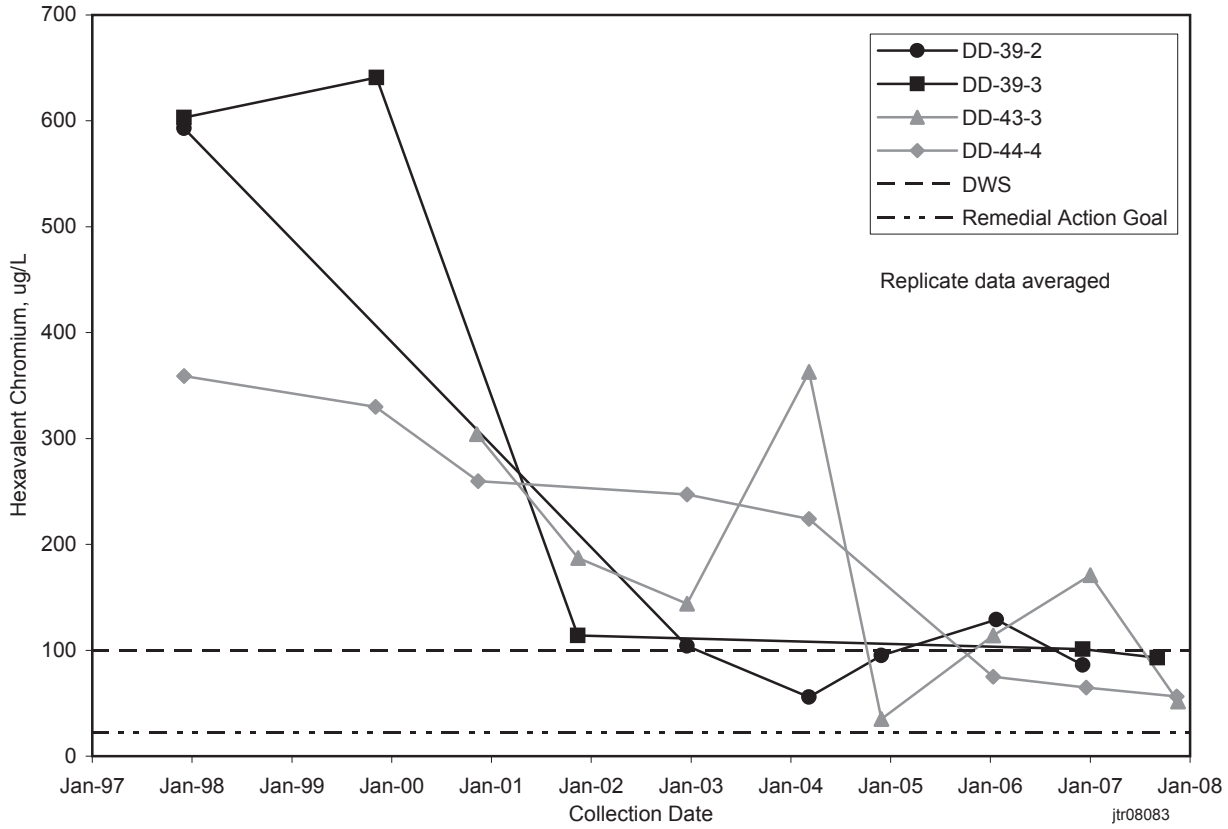


Figure 2.5-13. Hexavalent Chromium Concentrations in Aquifer Tubes Downgradient of Redox Barrier

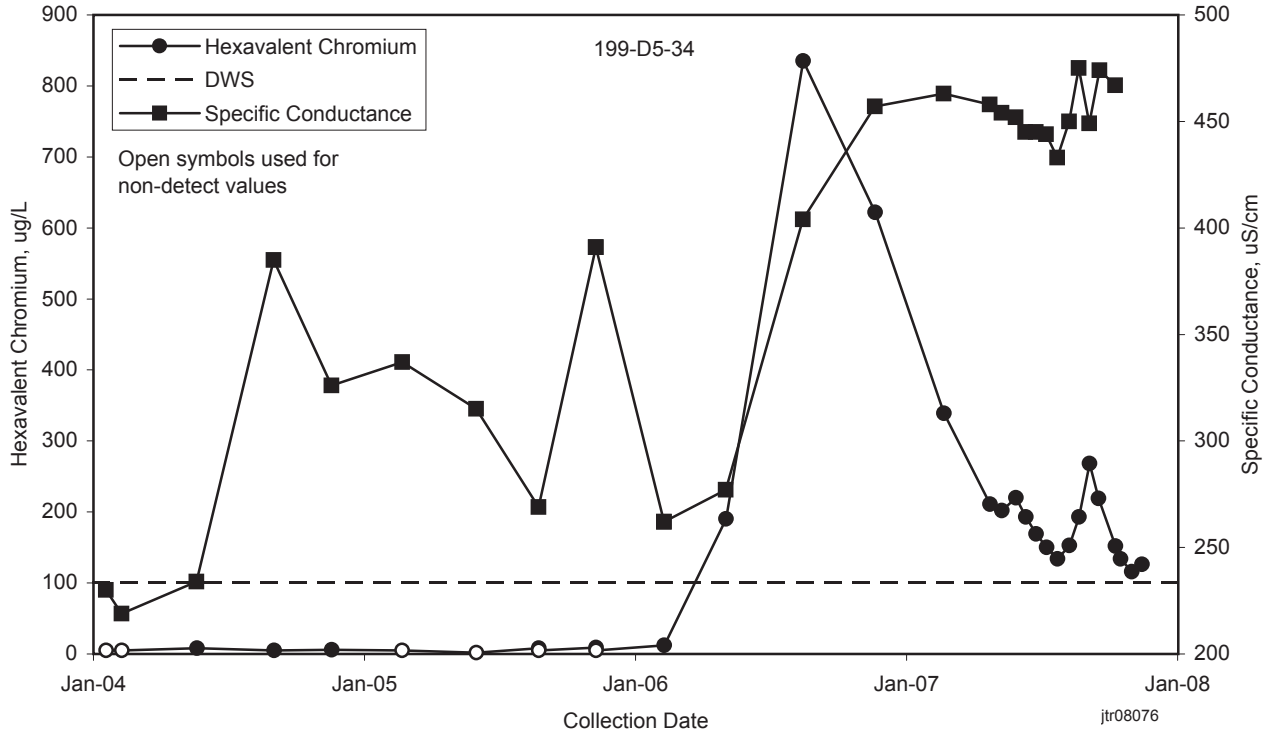
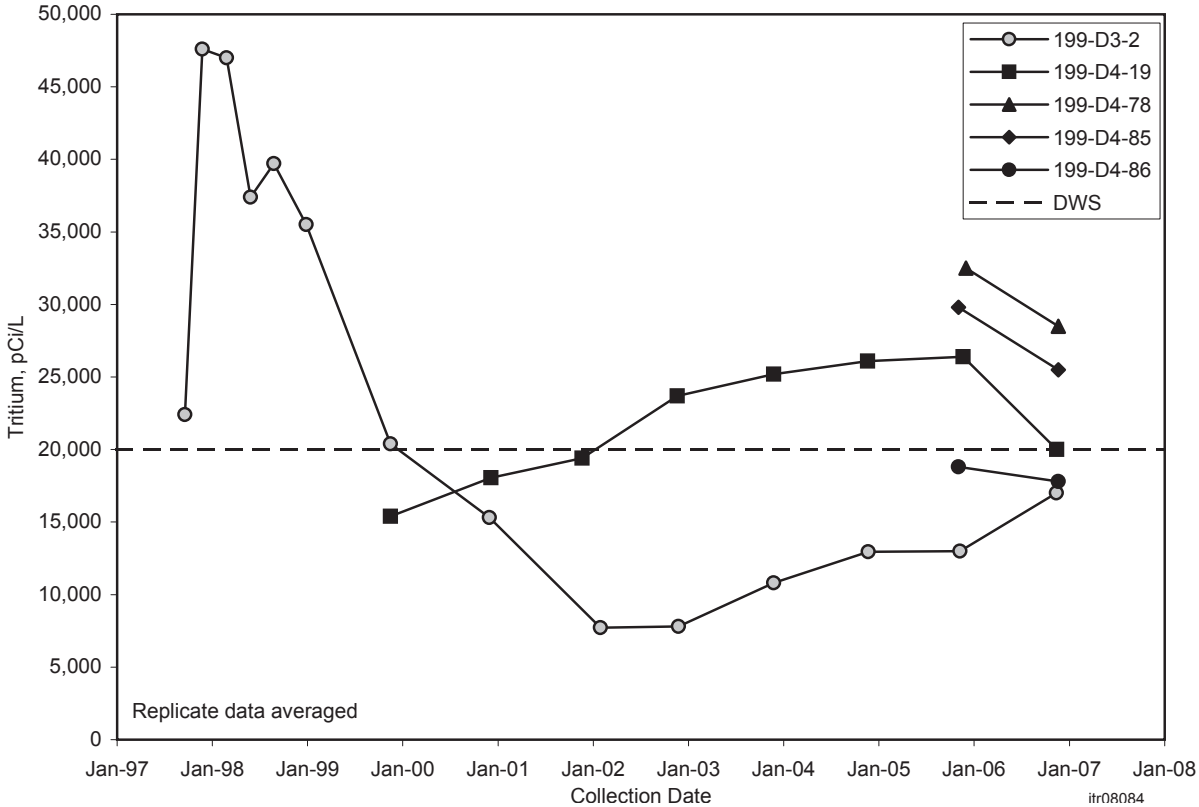


Figure 2.5-14. Hexavalent Chromium Concentrations and Specific Conductance Southeast of 182-D Reservoir



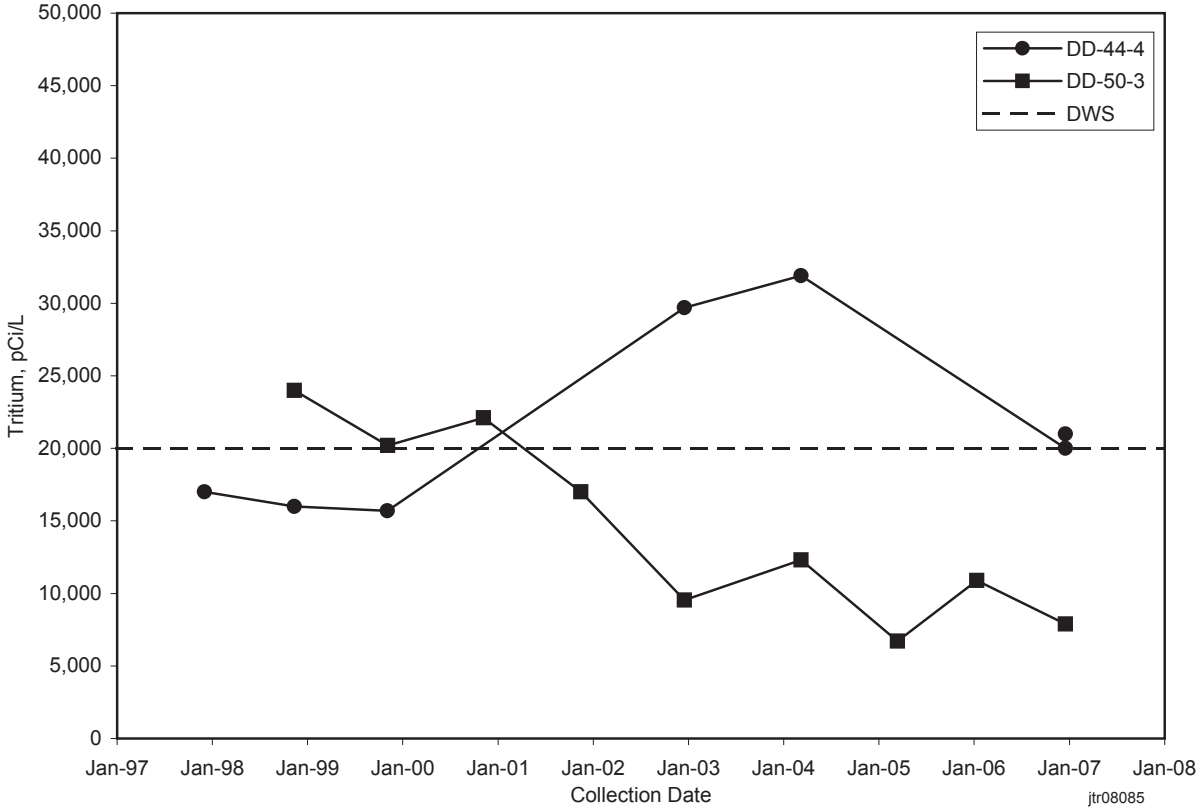


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Figure 2.5-15. Tritium Concentrations in South 100-D Area

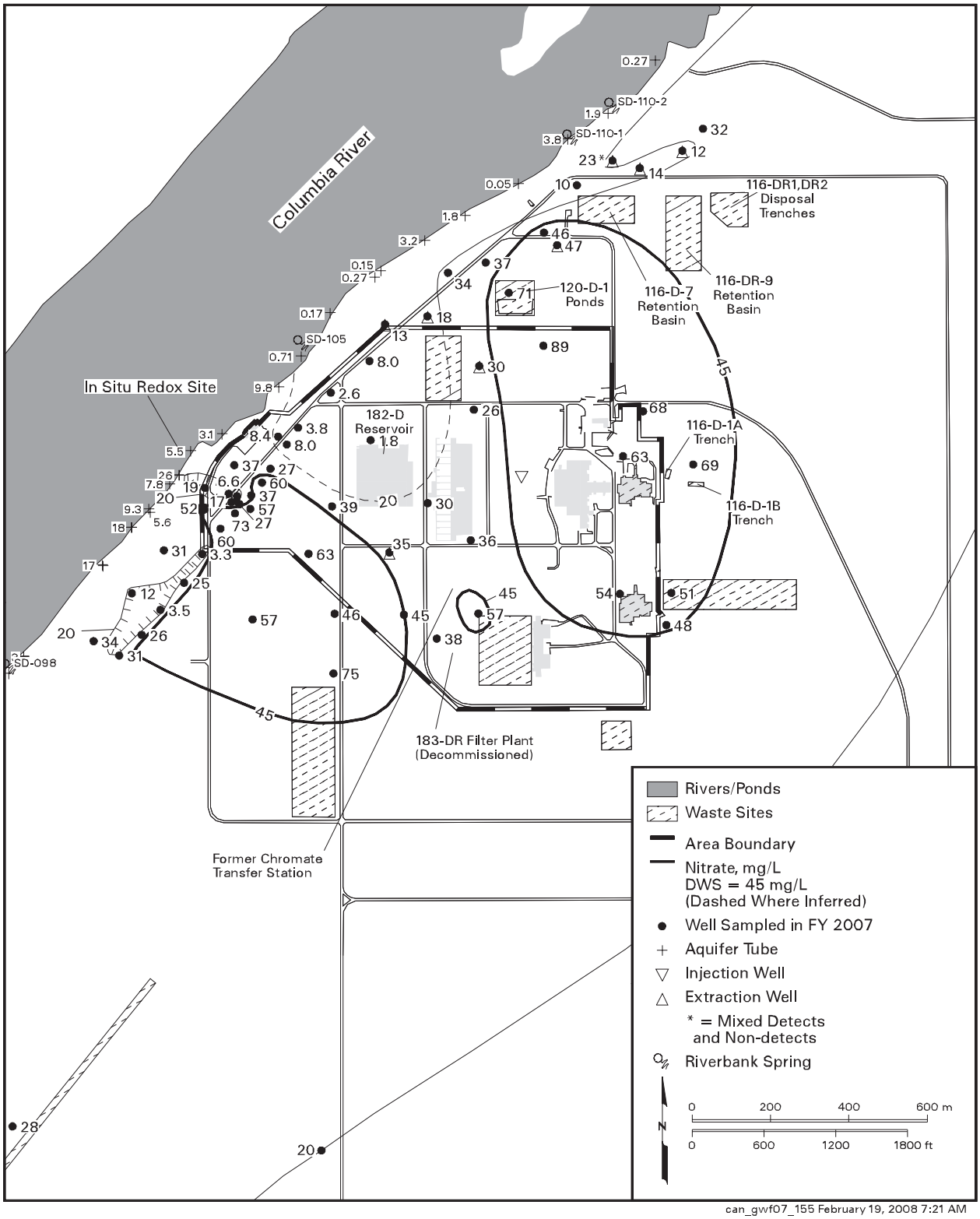


Figure 2.5-16. Average Nitrate Concentrations in 100-D Area, Upper Part of Unconfined Aquifer

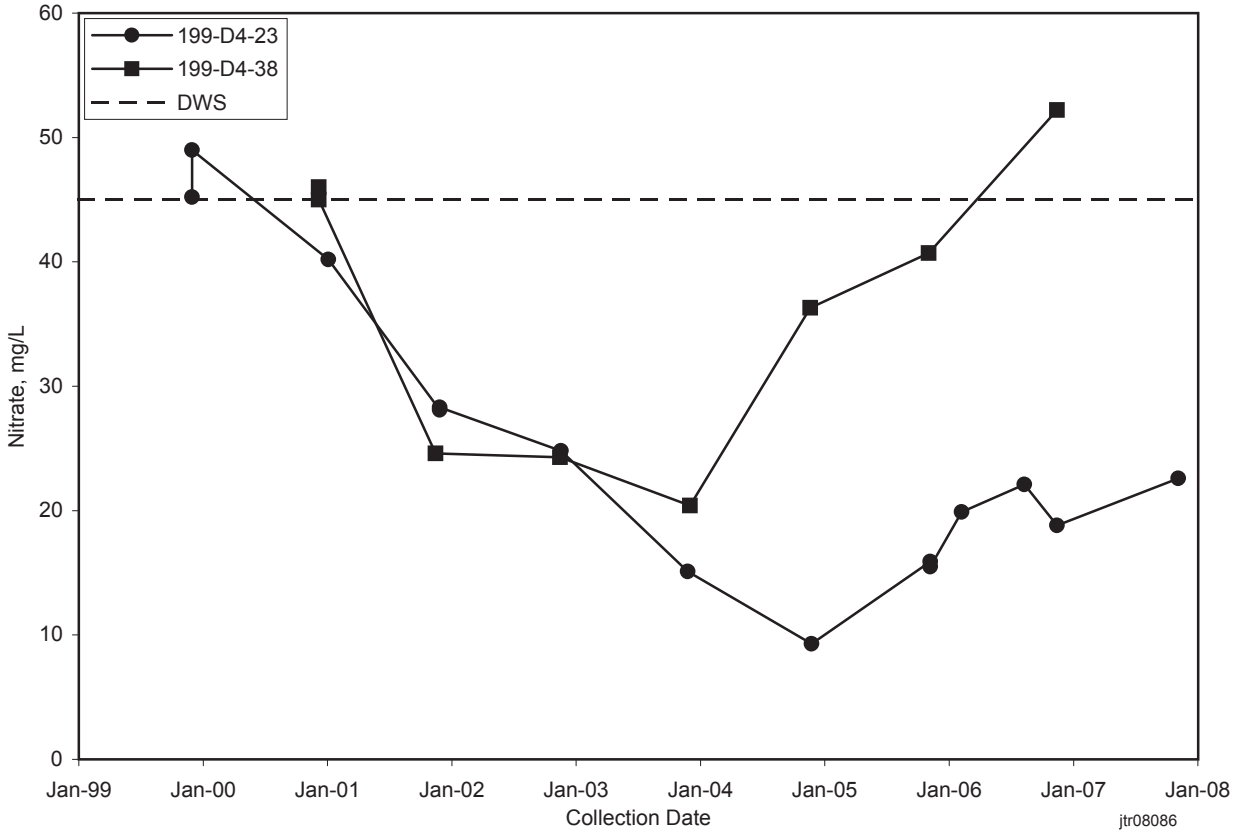


Figure 2.5-17. Nitrate Concentrations Downgradient of Redox Barrier

2.6 100-HR-3-H Operable Unit

M. J. Hartman and R. F. Raidl

The scope of this section is the 100-HR-3-H groundwater interest area, which is the east portion of the 100-HR-3 Operable Unit (see Figure 1.0-1 in Section 1.0). The "groundwater interest areas" are informally defined to facilitate scheduling, data review, and interpretation. Figure 2.6-1 shows facilities, wells, and shoreline monitoring sites in this region. Hexavalent chromium is the primary contaminant of concern in groundwater. Groundwater is monitored to assess the performance of a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim action pump-and-treat system for chromium, to track other contaminant plumes, and for the 116-H-6 evaporation basins, a *Resource Conservation and Recovery Act* (RCRA) unit.

Hexavalent chromium is the primary contaminant of concern in the 100-H Area. A pump-and-treat system helps reduce the amount reaching the Columbia River.

Groundwater flows primarily from the southwest to northeast beneath the 100-H Area, discharging to the Columbia River (Figure 2.6-2). Local flow directions are influenced by groundwater extraction and injection. Groundwater flows generally toward the northeast across the entire horn of the Columbia River north of Gable Mountain, so groundwater approaching the 100-H Area may contain contaminants that originated in the 100-D and 100-N Areas.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of interest (Section 2.6.1), summarizes operable unit activities (Section 2.6.2), and discusses groundwater monitoring of the 116-H-6 evaporation basins (Section 2.6.3).

2.6.1 Groundwater Contaminants

This section describes monitoring results for chromium, strontium-90, technetium-99, uranium, nitrate, and tritium.

2.6.1.1 Chromium

Hexavalent chromium is the contaminant of concern for the 100-HR-3 groundwater interim action (ROD 1996a), which includes the 100-H Area. The pump-and-treat system is discussed in Section 2.6.2. This section describes the distribution and trends of hexavalent chromium.

The portion of the chromium plume where concentrations exceed the remedial action goal of 22 µg/L has shrunk significantly in recent years (Figure 2.5-4 in

Groundwater monitoring in the 100-HR-3-H groundwater interest area includes the following monitoring activities:

CERCLA and AEA Monitoring (Appendix A)

- ***Twenty-one wells are sampled monthly to semiannually to monitor the pump-and-treat system.***
- ***Sixteen wells throughout the 100-H Area are sampled annually to biennially.***

Facility Monitoring – 116-H-6 Evaporation Basins (Appendix B)

- ***Four downgradient wells are sampled annually for requirements of RCRA and AEA.***

Section 2.5). Concentrations in all shallow wells have been below the 100-µg/L drinking water standard since 2001. The plume had various sources, but the highest concentrations in FY 2007 were in well 199-H4-3, located near the former 116-H-6 evaporation basins, ranging from 6 µg/L in October 2006 to 55 µg/L in June 2007 (Figure 2.6-3). Chromium concentrations in this well decreased more than an order of magnitude since the 1980s.

Plume areas (square kilometers) at the 100-HR-3-H Operable Unit:

Chromium,* 100 µg/L — 0.17

Chromium, 20 µg/L — 3.5

Nitrate, 45 mg/L — 0.11

Strontium-90, 8 pCi/L — 0.17

****Includes chromium plume west to boundary with 100-HR-3-D interest area.***

Chromium concentrations in the current six extraction wells are plotted in Figure 2.6-4. Concentrations in well 199-H4-3 spiked in June 2007 to a maximum of 55 µg/L. By August, concentrations were again below the remedial action goal. A similar increase occurred in summer 2006 in chromium and co-contaminants nitrate, technetium-99, and uranium. Concentrations of those contaminants rose only moderately in May 2007; they were not analyzed in the June 2007 sample that had the maximum chromium concentration. The cause of the variability is unknown, but may relate to movement of contamination from the vadose zone into groundwater.

Wells upgradient of the 100-H Area continued to have chromium concentrations near the drinking water standard (maximum 125 µg/L in well 699-97-43), but concentrations show an overall decline since the early 1990s (Figure 2.6-5). The source of this contamination is probably old contamination that originated in the 100-D Area when a water-table mound was present there (WHC-SD-EN-TI-023). The highest chromium concentration in the new "horn" wells was 117 µg/L in well 699-97-43B (October 2007). This well is screened at the top of the unconfined aquifer. This plume is the subject of an ongoing investigation (Section 2.5.2.4). An upcoming report will present results.

Chromium concentrations were all below the drinking water standard in the upper aquifer of 100-H Area, and most averaged less than the 22-µg/L remedial action goal in FY 2007.

Chromium levels rose in former injection wells 199-H3-3, 199-H3-4, and 199-H3-5 in south 100-H Area in FY 2007 (Figure 2.6-6). Levels remained lower than those measured in 1996, before injection began. The highest concentration in FY 2007 was 58 µg/L in February in well 199-H3-5. The chromium may have historical sources in the 100-H or 100-D Areas.

Chromium concentrations in aquifer tubes are highest upstream and downstream of the main 100-H Area (Figure 2.6-7). Tubes AT-43 and AT-44, north of the 100-H Area, intercept part of the plume that has moved across the horn, and concentrations have been as high as 50 µg/L in recent years. In FY 2007, the highest was 37 µg/L in tube AT-43-M. South of the main 100-H Area at tube sites 50 and 51, the maximum concentration in FY 2007 was 35 µg/L (Figure 2.6-8). This contamination south of the main 100-H Area could have moved south along the shoreline from 100-H Area sources. Chromium was lower (~10 µg/L) in tubes monitoring the shoreline downgradient of the 100-H Area pump-and-treat system.

Three wells that monitor a deeper portion of the Ringold Formation continued to have elevated chromium concentrations (Figure 2.6-9). These wells are screened at elevations ranging from 94 to 104 meters. Adjacent water-table wells are screened from 112 to 117 meters. Well 199-H3-2C is located on the west side of 100-H Area, upgradient of waste sites. Chromium concentrations in this well have increased over the last several years, reaching ~50 µg/L in FY 2007. An adjacent well completed at the water table has much lower chromium concentrations (11 µg/L). Well 199-H4-12C is located near the river, downgradient of the 116-H-6 basins and adjacent to extraction well 199-H4-12A. The deep well has declining chromium concentrations

at levels just below the drinking water standard (90 µg/L). Piezometer 199-H4-15CS is also adjacent to an extraction well. Chromium concentrations in the piezometer are steady at levels just above the drinking water standard. Three deeper piezometers in well 199-H4-15C showed much lower chromium levels when they were sampled in 1996 through 2004 (undetected to 32 µg/L). Concentrations of other contaminants that would indicate the influence of the 116-H-6 basins (nitrate, technetium-99, and uranium) are low in the deeper wells. The source of this deeper chromium is unknown.

In FY 2007 and early FY 2008, DOE installed new wells and aquifer tubes to help define chromium contamination between 100-D and 100-H Areas. This region is known as the "horn" of the Hanford Site, and is discussed in Section 2.5. Three of the new wells are completed in the Ringold upper mud, paired with adjacent wells completed at the water table. At the time of this writing, chromium data were available from two of these well pairs. Well 699-97-48B and C (shallow and deep, respectively), both had 42 µg/L hexavalent chromium. Closer to the 100-H Area, well 699-97-43B (shallow) had 117 µg/L chromium while its deep counterpart 699-97-43C had only 8 µg/L. Well locations are shown in Figure 2.1-1 of Section 2.1.

2.6.1.2 Strontium-90

Strontium-90 concentrations continued to exceed the drinking water standard (8 pCi/L) beneath a portion of the southeast 100-H Area near the former retention basin and disposal trenches. The plume distribution has not changed appreciably in over 10 years (see Figure 2.6-8 in PNNL-15670 for a FY 2005 map). Few wells were sampled for strontium-90 in FY 2007. The highest concentration was 30.7 pCi/L in well 199-H4-63, a decline from recent years.

Three aquifer tubes were sampled for strontium-90 in FY 2007: AT-47-D, AT-48-M, and AT-H-3-S. All results were below the drinking water standard. The highest was 5.4 pCi/L in AT-H-3-S.

2.6.1.3 Technetium-99 and Uranium

Technetium-99 and uranium concentrations are detected in groundwater downgradient of the former 116-H-6 evaporation basins, but levels did not exceed the drinking water standards in FY 2007. The highest technetium-99 concentration was 99 pCi/L in well 199-H4-3 (the drinking water standard is 900 pCi/L). Uranium showed a similar trend, with a maximum concentration of 22 µg/L in May 2007 (the drinking water standard is 30 µg/L). Figure 2.6-10 shows technetium-99 and uranium trends in this well.

Nitrate concentrations exceed drinking water standards near the former 116-H-6 evaporation basins.

Technetium-99 and uranium levels were very low in aquifer tubes in FY 2007. The highest concentrations were in tube AT-H-3-S, where technetium-99 and uranium were reported at 5.4 pCi/L and 1.34 µg/L, respectively.

2.6.1.4 Tritium

Tritium concentrations continued to decline in most wells. The highest concentration in the 100-H Area was 2,800 pCi/L in well 199-H4-15A. Well 699-97-43, located west (upgradient) of the 100-H Area, continued to have a higher tritium concentration than wells within the 100-H Area (5,150 pCi/L).

2.6.1.5 Nitrate

Nitrate concentrations continued to exceed the drinking water standard (45 mg/L) in a few wells near the former 116-H-6 evaporation basins. The highest concentration was 66 mg/L in well 199-H4-3 in May 2007.

A second nitrate plume in southeast 100-H Area is shrinking, and in FY 2007, the only results that exceeded the drinking water standard were in well 199-H4-46 (46.9 mg/L) and aquifer tube 50-M (45.2 mg/L). Nitrate concentrations have been stable at these sites in recent years.

The remedial action objectives for the 100-HR-3 Operable Unit (ROD 1996a) are:

- ***Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.***
- ***Protect human health by preventing exposure to contaminant in the groundwater.***
- ***Provide information that will lead to the final remedy.***

The contaminant of concern is hexavalent chromium. The record of decision specifies the cleanup goal at compliance wells as 22 µg/L.

2.6.2 Operable Unit Activities

This section summarizes activities associated with groundwater in the 100-H Area portion of the 100-HR-3 Operable Unit. These include a pump-and-treat system and investigation of chromium deeper in the Ringold Formation.

2.6.2.1 Status of Five-Year Review Action Item

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified one action[(a)] pertaining to the 100-H Area:

- **Action 12-1**. Perform additional characterization of the aquifer below the initial aquitard (September 2009).

DOE installed three wells in the 600 Area screened in this unit, and continued to monitor three wells in the 100-H Area. Section 2.6.1.1 presents monitoring results. DOE plans to conduct additional characterization of this aquifer in the 100-H Area.

2.6.2.2 Pump-and-Treat System

A pump-and-treat system operates in the 100-H Area as part of a CERCLA interim action for the 100-HR-3 Operable Unit (ROD 1996a). Interim remedial action monitoring is described in DOE/RL-96-90. Long-term monitoring requirements in the 100-H Area were derived from Change Control Form 107. Figure 2.6-1 displays locations of extraction and injection wells and Appendix A lists sampling frequencies and constituents.

During FY 2007, the pump-and-treat system extracted ~146.6 million liters of groundwater from the 100-H Area, removing ~2.4 kilograms of hexavalent chromium.

The 100-H pump-and-treat system is reducing overall contamination in the operable unit by removing contaminant mass. During FY 2007, the pump-and-treat system extracted ~146.6 million liters of groundwater from the 100-H Area, removing ~2.4 kilograms of hexavalent chromium.

The pump-and-treat system has removed ~49 kilograms of hexavalent chromium from the 100-H Area groundwater since startup in July 1997. This represents more than the ~42 kilograms estimated in the plume in 1992 (WHC-SA-1674-VA). That estimate did not include chromium from upgradient sources (100-D Area) nor in the vadose zone.

Chromium concentrations in 100-H Area groundwater have declined, and the plume in the uppermost aquifer has shrunk. Those changes are likely due to a combination of the effects of the pump-and-treat system and dispersion (i.e., natural processes). There were no changes made to the pump and treat network in the 100-H Area during FY 2007.

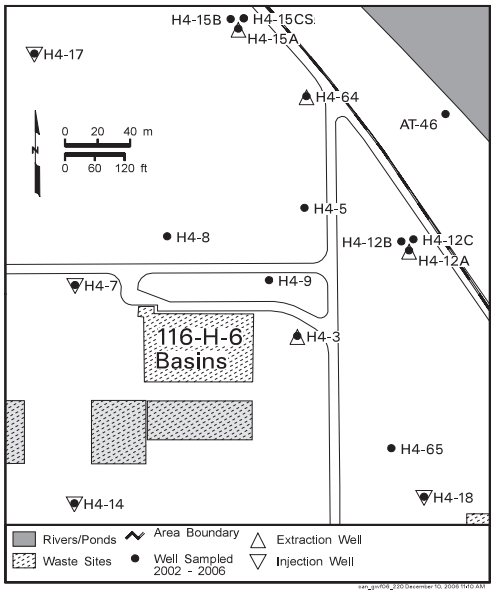
(a) Another issue pertained to chromium in the "horn" between 100-D and 100-H Areas. It is discussed in Section 2.5.

Hexavalent chromium concentrations stabilized in a range between 5 µg/L and 15 µg/L in compliance well 199-H4-5 during FY 2007. In September 2007, concentrations in former compliance wells 199-H4-4, 199-H4-63 and 199-H4-64 (now extraction wells) ranged from 10 to 25 µg/L (Figure 2.6-4). During FY 2007, concentrations ranged from 2 µg/L to 28 µg/L in these wells. The maximum chromium concentration in an extraction well during FY 2007 was 55 µg/L in well 199-H4-3.

Most chromium concentrations in the extraction wells were below the 22-µg/L remedial action goal.

- 199-H4-3: 6 of 28 hexavalent chromium results >22 µg/L (maximum 55 µg/L)
- 199-H4-4: 2 of 28 hexavalent chromium results >22 µg/L (maximum 26 µg/L)
- 199-H4-12A: 3 of 28 hexavalent chromium results >22 µg/L (maximum 27 µg/L)[(b)]
- 199-H5-15A: 7 of 28 hexavalent chromium results >22 µg/L (maximum 30 µg/L)[(b)]
- 199-H4-63: 1 of 31 hexavalent chromium results >22 µg/L (maximum 28 µg/L)
- 199-H4-64: 2 of 28 hexavalent chromium results >22 µg/L (maximum 25 µg/L)

Results of performance monitoring are incorporated with the discussion of general contamination in Section 2.6.1. Results of operational monitoring and additional details about the pump-and-treat system for calendar year 2006 can be found in DOE/RL-2006-76. Results for 2007 will be published in an upcoming annual report on the 100-HR-3, 100-KR-4, and 100-NR-2 pump-and-treat systems.



2.6.3 Facility Monitoring — 116-H-6 (183-H) Evaporation Basins

The 116-H-6 (183-H) evaporation basins are the only RCRA site in the 100-H Area. The unit was incorporated into the Hanford Facility RCRA Permit (Ecology 1994a). The site is monitored during the post-closure period under corrective action monitoring requirements of WAC 173-303-645(11)(g). The monitoring network comprises wells 199-H4-3, 199-H4-8, 199-H4-12A, and 199-H4-12C. Lists of wells and constituents monitored and a well location map are included in Appendix B.

The four wells in the RCRA network were sampled as scheduled in FY 2007 for the constituents of interest listed in the groundwater monitoring plan (PNNL-11573). Trends in the constituents of interest (except fluoride) were discussed in Section 2.6.1. Fluoride concentrations remained low (<300 µg/L) in groundwater downgradient of the 116-H-6 evaporation basins.

While the 100-HR-3 pump-and-treat system is operating, RCRA monitoring consists of annual sampling of four wells for chromium, fluoride, nitrate, technetium-99, and uranium. The latter two constituents are not regulated under RCRA but were included in the monitoring plan for completeness and were incorporated by reference in the Hanford Facility RCRA Permit (Ecology 1994a).

(b) Excluding erroneous high value in November 2006, which was traced to a defective analytical ampule.

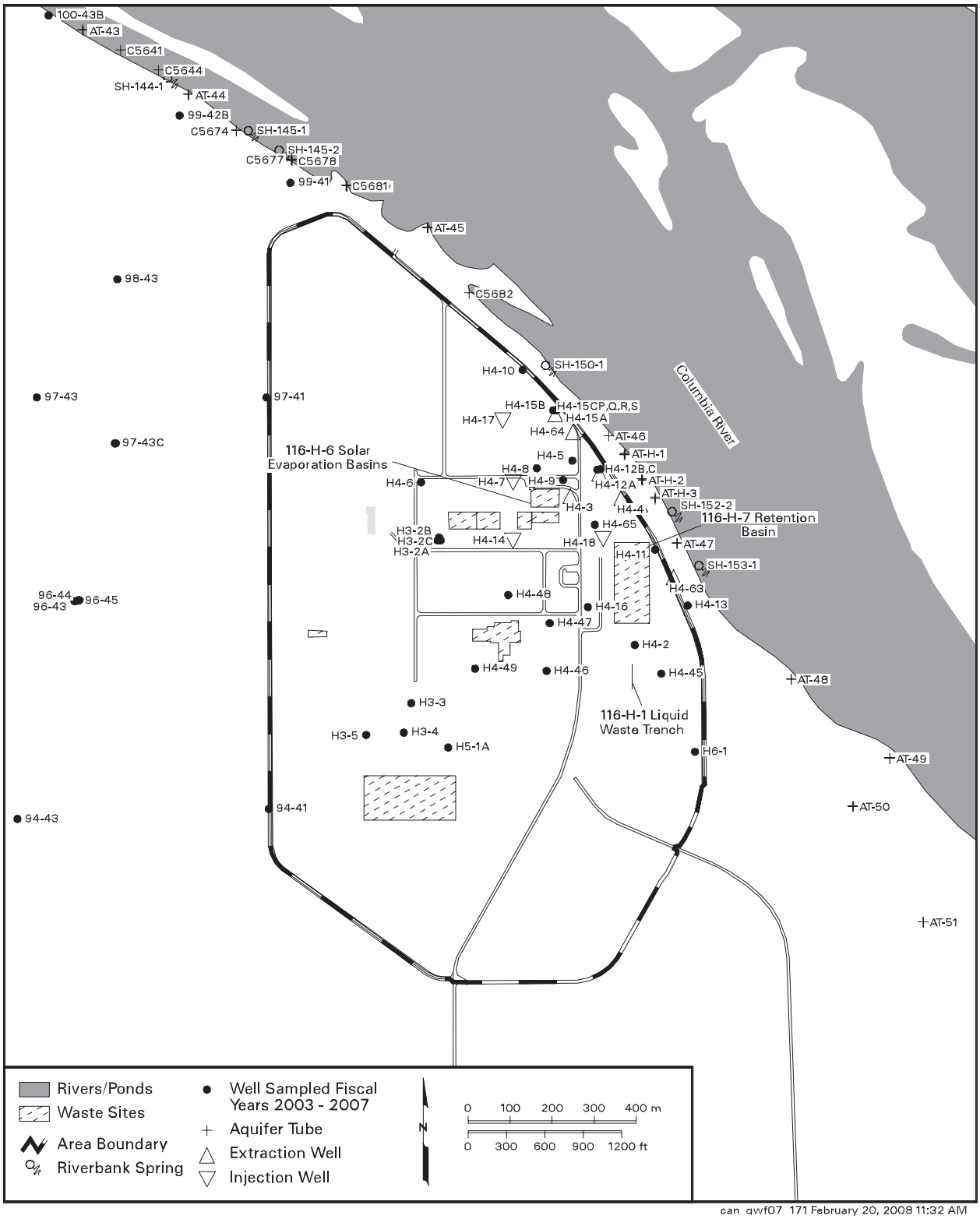


Figure 2.6-1. Groundwater Monitoring Wells in 100-H Area

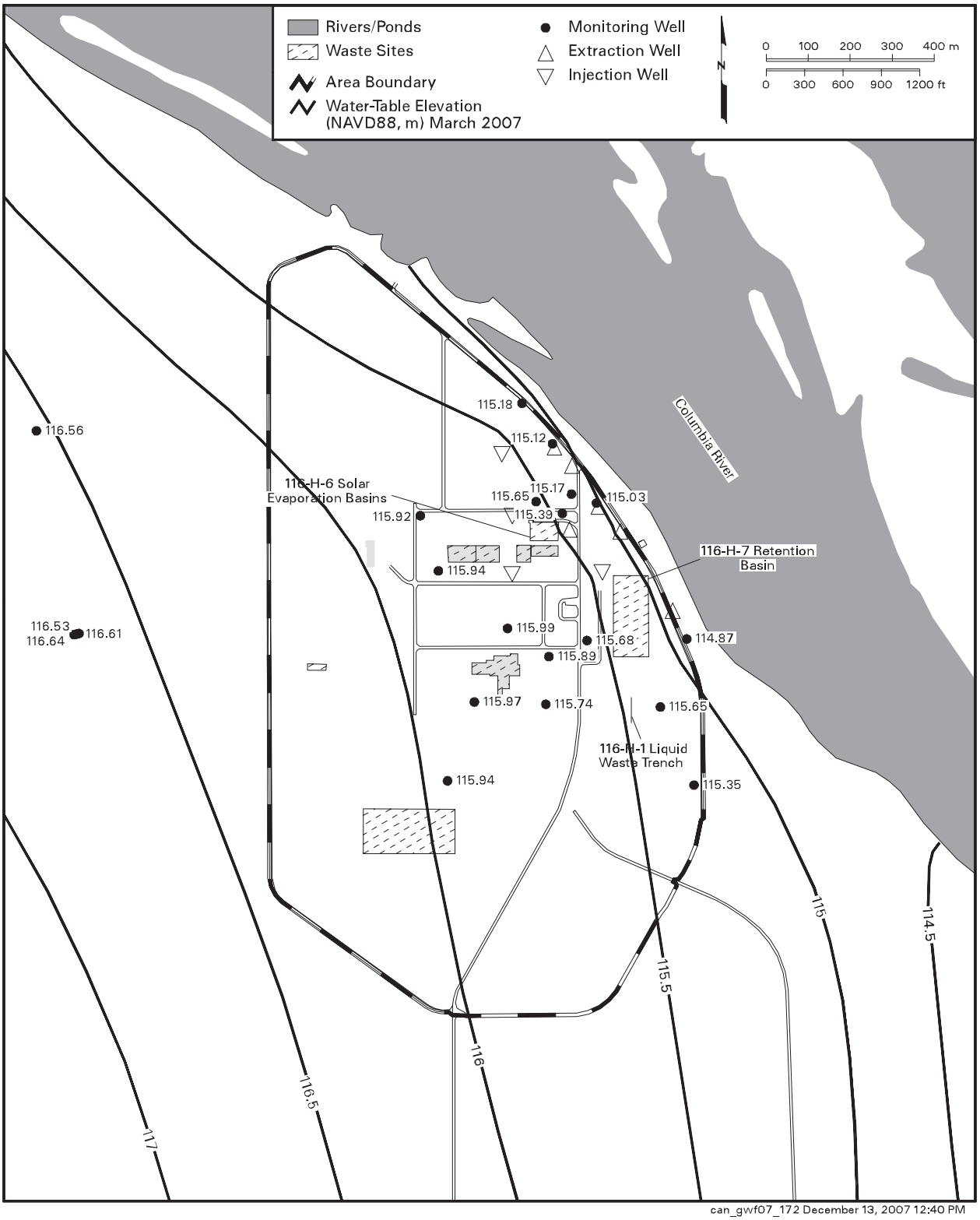


Figure 2.6-2. 100-H Area Water-Table Map, March 2007

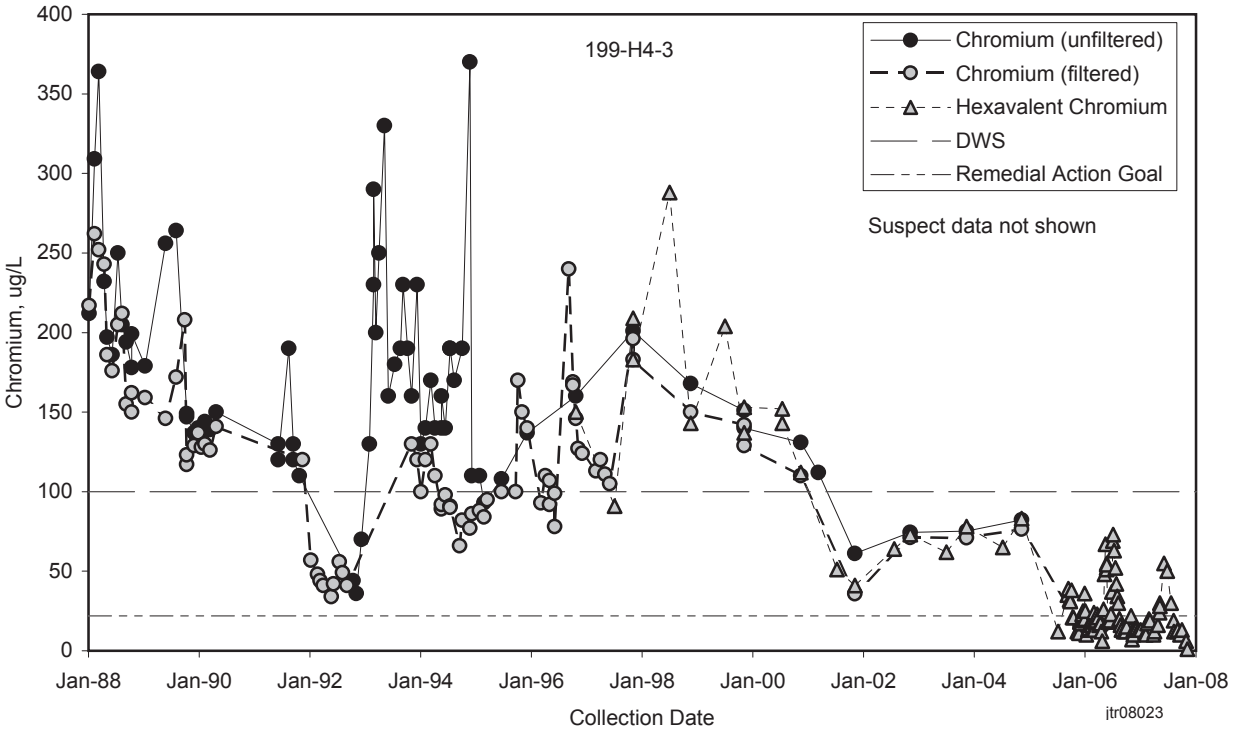


Figure 2.6-3. Chromium Concentrations East of 116-H-6 Evaporation Basins

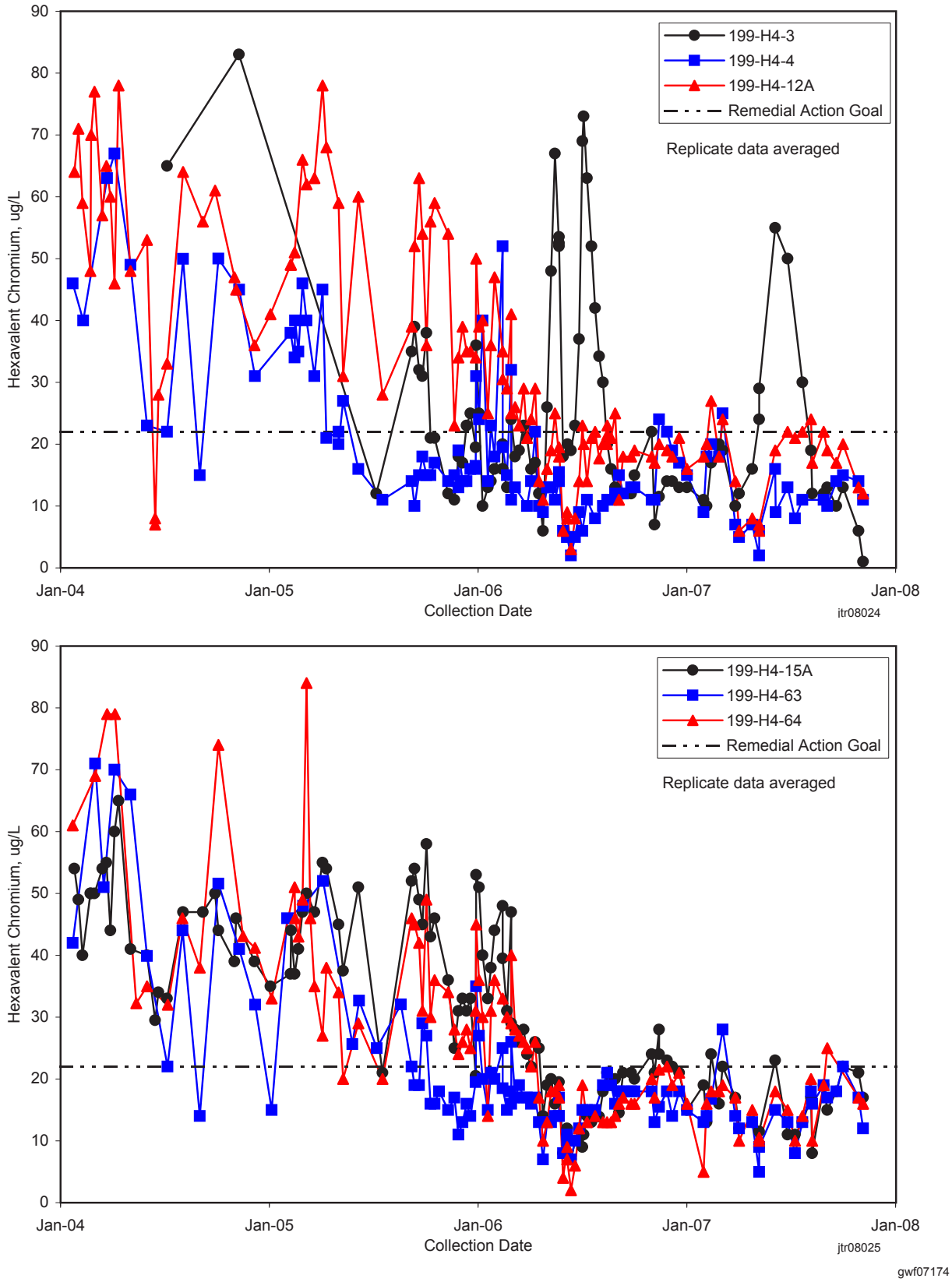


Figure 2.6-4. Chromium Concentrations in Extraction Wells for 100-HR-3 Pump-and-Treat System at 100-H Area

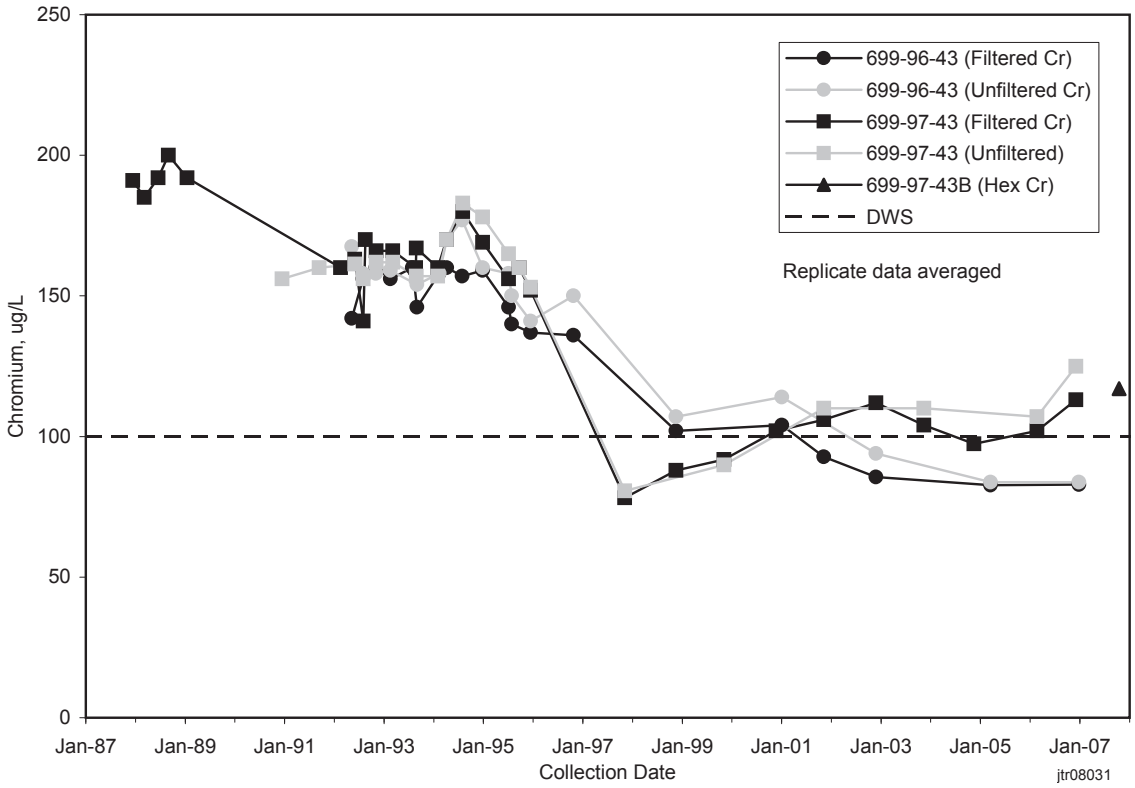


Figure 2.6-5. Chromium Concentrations Upgradient of 100-H Area

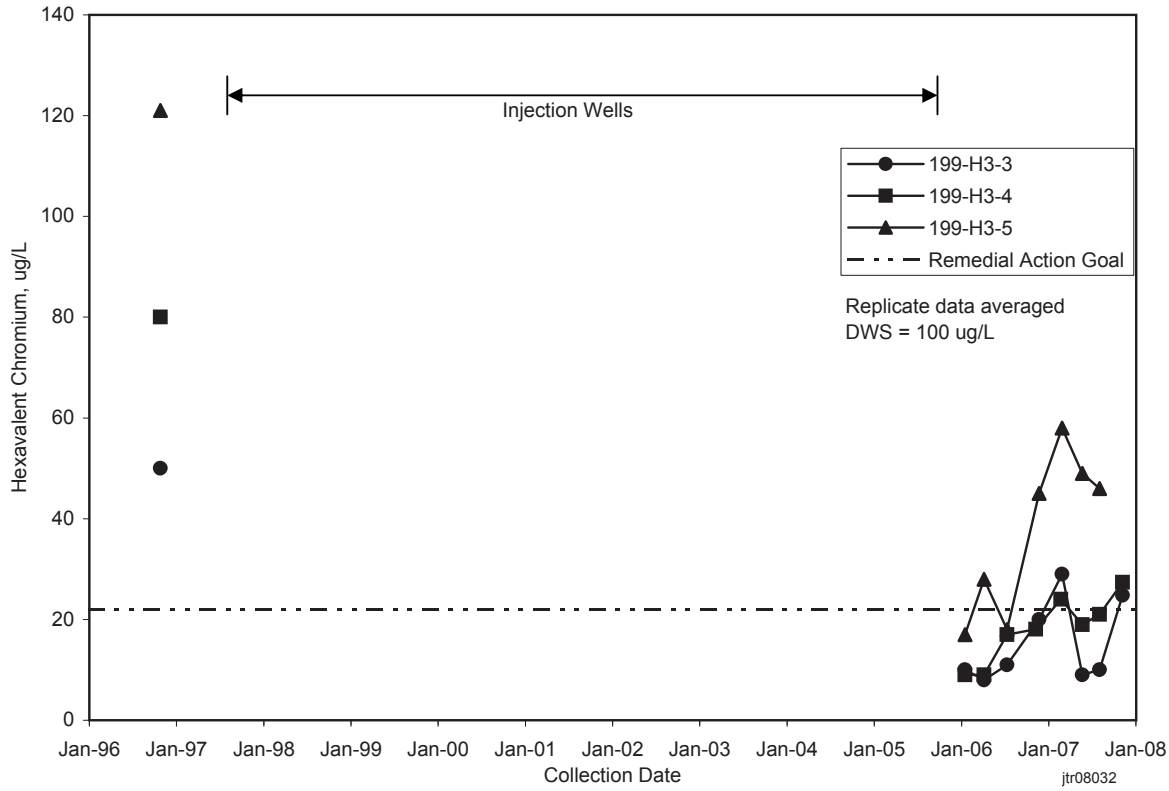


Figure 2.6-6. Chromium Concentrations in Former Injection Wells in South 100-H Area

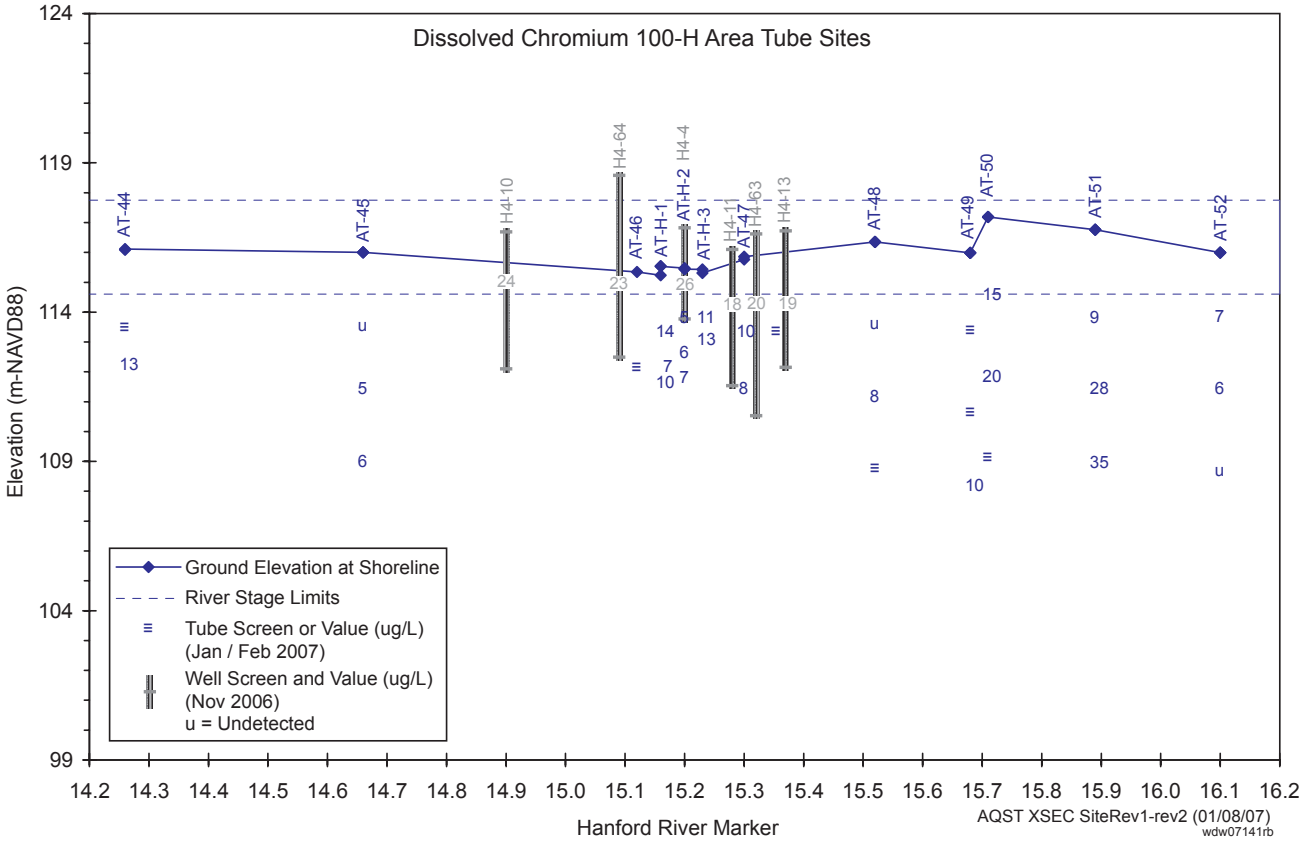


Figure 2.6-7. Sample Elevations and Chromium Concentrations in Wells and Aquifer Tubes in 100-H Area (from SGW-35028)

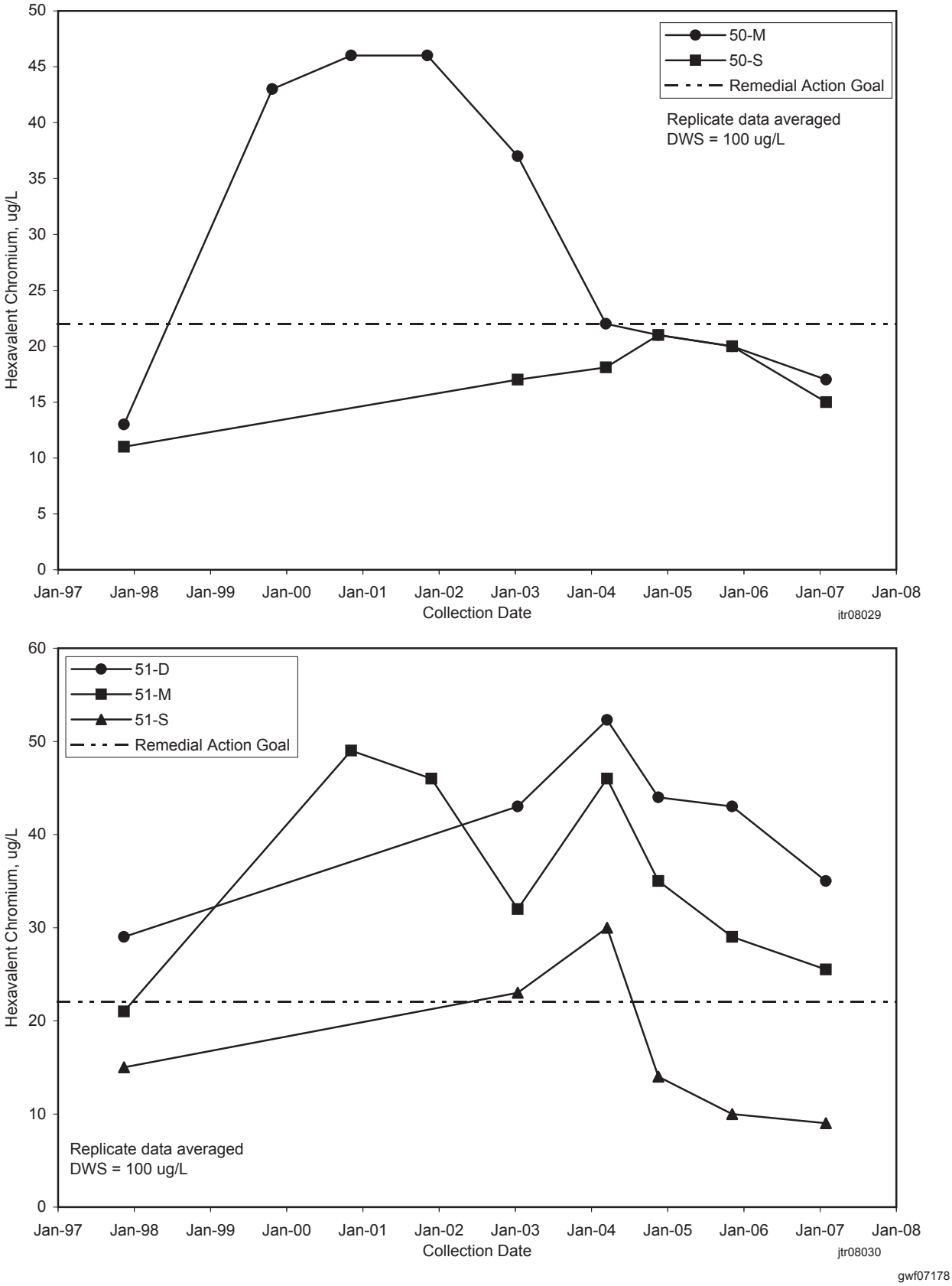


Figure 2.6-8. Chromium Concentrations in Aquifer Tubes South of 100-H Area

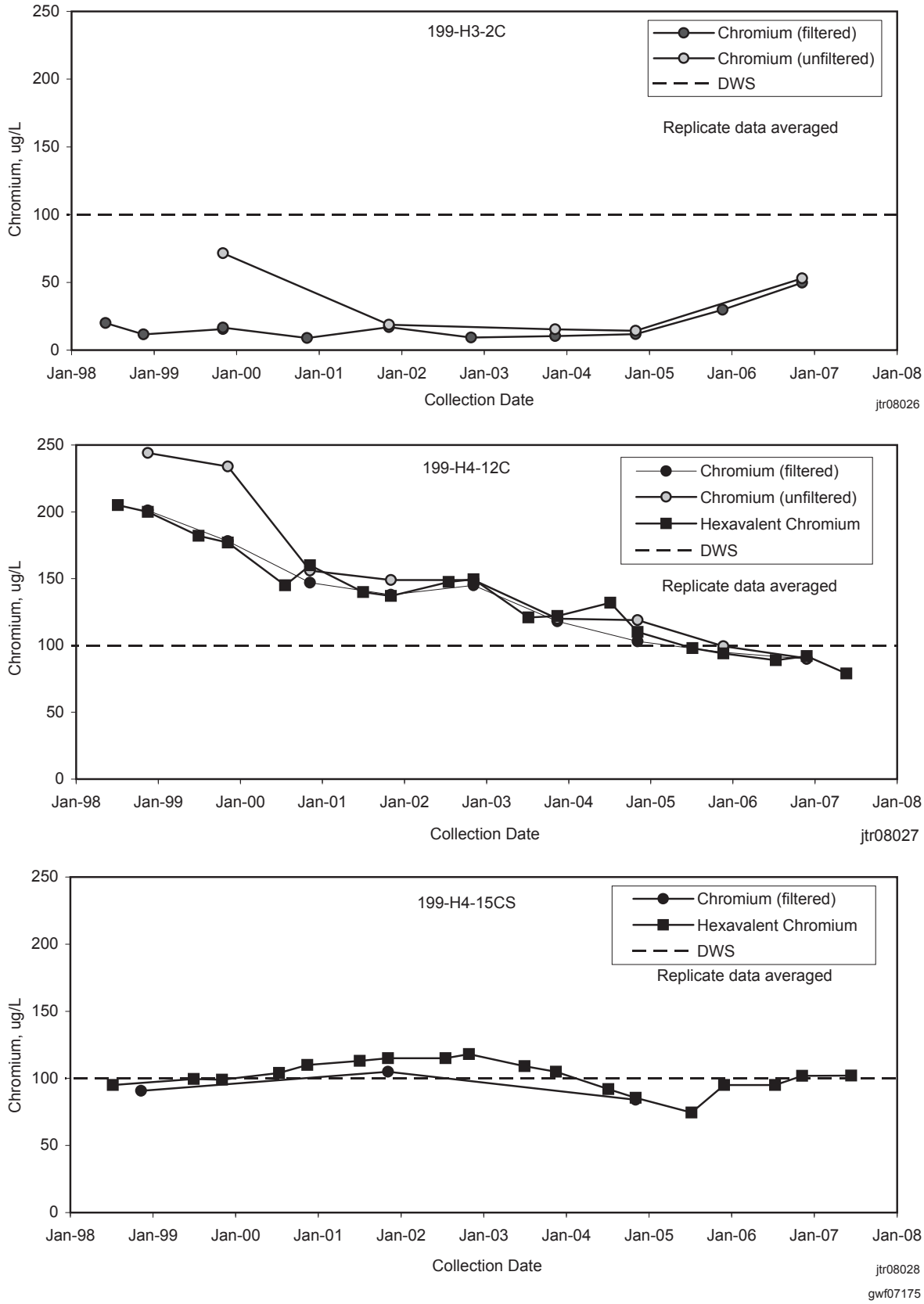


Figure 2.6-9. Chromium Concentrations in Wells Screened in the Ringold Upper Mud Unit

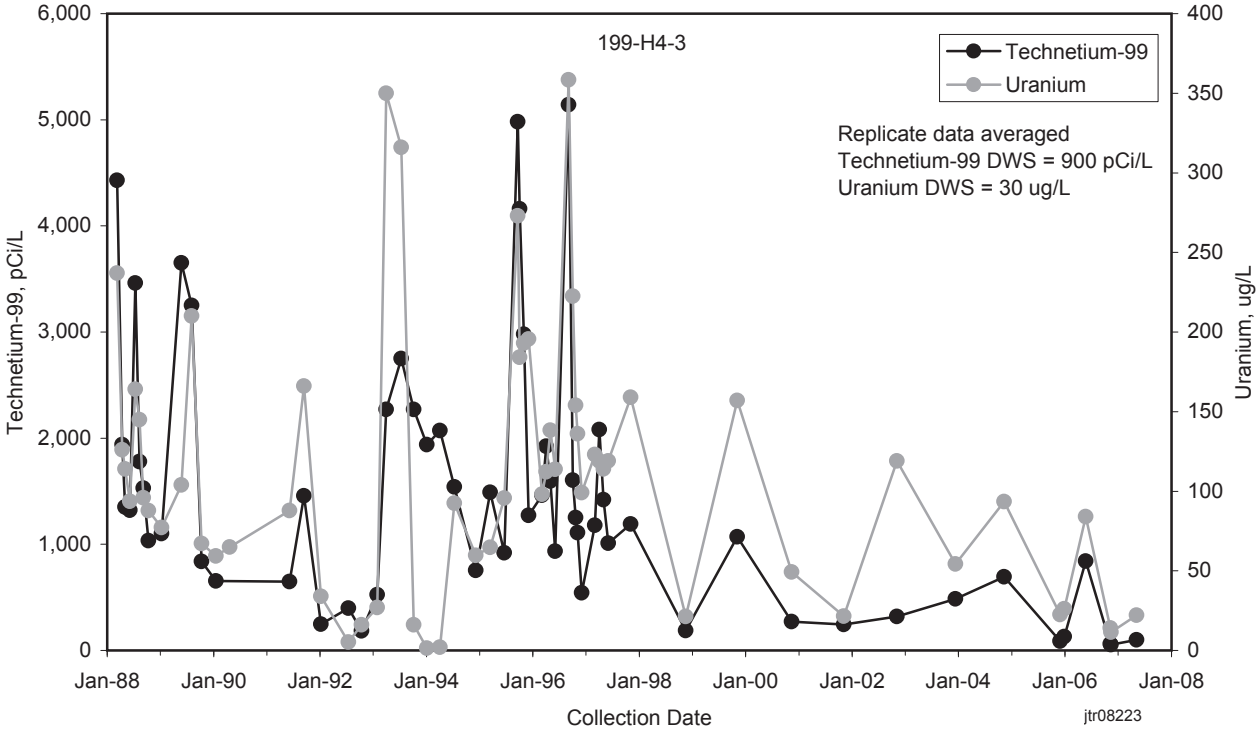


Figure 2.6-10. Technetium-99 and Uranium Concentrations East of 116-H-6 Evaporation Basins

2.7 100-FR-3 Operable Unit

M. J. Hartman

The scope of this section is the 100-FR-3 groundwater interest area, which encompasses the 100-FR-3 Operable Unit and a large section of the 600 Area north of Gable Mountain (see Figure 1.0-1 in Section 1.0). The "groundwater interest areas" are informally defined to facilitate scheduling, data review, and interpretation. Figure 2.7-1 shows facilities, wells, and shoreline monitoring sites in the 100-F Area.

Groundwater flows primarily to the east and southeast beneath the 100-F Area (Figure 2.7-2). Movement of the nitrate plume indicates flow to the south-southeast (Figure 1.0-3).

A nitrate plume with concentrations above the drinking water standard extends from the central 100-F Area about 5 kilometers south.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). Groundwater monitoring for the *Atomic Energy Act* (AEA) is integrated fully with CERCLA monitoring. Most of the former liquid waste sites in the 100-F Area have been excavated and backfilled. There are no active waste disposal facilities or *Resource Conservation and Recovery Act* (RCRA) sites in the 100-F Area.

2.7.1 Groundwater Contaminants

This section describes the distribution and trends of the contaminants of concern for the 100-FR-3 Operable Unit: nitrate, strontium-90, tritium, trichloroethene, gross alpha, uranium, and hexavalent chromium (DOE/RL-2003-49, Rev. 1).

2.7.1.1 Nitrate

A large nitrate plume extends from the 100-F Area southward nearly 5 kilometers, although data are sparse in the 600 Area (see Figure 1.0-3 in Section 1.0). The plume did not change significantly between fiscal years (FY) 2006 and 2007.

Wells in the main 100-F Area continued to show levels of nitrate that exceeded the drinking water standard (45 mg/L) in FY 2007. The highest FY 2007 nitrate concentration was 100 mg/L in well 699-71-30, south of the 100-F Area. The highest concentration in the 100-F Area was 92.5 mg/L in well 199-F8-2. Concentrations in the wells within the nitrate plume are steady or declining.

Aquifer tubes south of the main 100-F Area also have elevated nitrate concentrations. Tubes at site AT-75 previously exceeded the drinking water standard, but the tubes at this site could not be located in FY 2007. The tubes were found and sampled in FY 2008.

Groundwater monitoring in the 100-FR-3 groundwater interest area includes integrated CERCLA and AEA monitoring:

- ***Thirty-four wells are sampled annually or biennially.***
- ***Fourteen aquifer tube sites and three seeps are scheduled for annual sampling. Four aquifer tube sites and two seeps could not be sampled in FY 2007.***

2.7.1.2 Strontium-90

Strontium-90 concentrations exceed the drinking water standard (8 pCi/L) beneath a portion of the 100-F Area around the 116-F-14 retention basin and nearby disposal trenches. The extent of the plume has not changed significantly in over 10 years (see Figure 2.7-5 in PNNL-15670 for FY 2005 map).

Plume areas (square kilometers) at the 100-FR-3 Operable Unit:

Chromium, 20 µg/L — 0.17
Nitrate, 45 mg/L — 17.3
Strontium-90, 8 pCi/L — 0.16
Trichloroethene, 5 µg/L — 2.2

Well 199-F5-1 currently has the highest strontium-90 concentrations (48.6 pCi/L in FY 2006, the most recent data from this well). Strontium-90 also exceeded the drinking water standard in well 199-F5-46 (13 pCi/L). The trends are neither increasing nor decreasing overall.

Strontium-90 shows vertical stratification in the only shallow/deep well pair in the 100-F Area. Deep well 199-F5-43B consistently has no detectable strontium-90 while its shallow counterpart, well 199-F5-43A, typically detects 2 to 4 pCi/L of strontium-90. Strontium-90 concentrations also tend to be higher in shallow aquifer tubes than in deeper aquifer tubes, but all results for FY 2007 were below the 8-pCi/L drinking water standard. The maximum concentration was 1.5 pCi/L in tube 64-D (the mid-depth and shallow tubes at that site were not sampled).

2.7.1.3 Tritium

Tritium concentrations are somewhat elevated beneath the south 100-F Area, but do not currently exceed the drinking water standard (20,000 pCi/L). The plume extends to the southeast into the 600 Area at concentrations above 2,000 pCi/L (see Figure 1.0-2 in Section 1.0).

The only well where tritium historically exceeded the drinking water standard is well 199-F8-3, near the 118-F-1 burial ground, where concentrations were nearly 180,000 pCi/L in the mid-1990s. Concentrations in this well declined in the late 1990s, and in FY 2007, the concentration was 9,930 pCi/L (Figure 2.7-3).

Trichloroethene exceeds the drinking water standard in southwest 100-F Area.

2.7.1.4 Trichloroethene

Trichloroethene concentrations in the southwest 100-F Area exceed the drinking water standard (5 µg/L). The plume appears to be centered west of the 100-F Area. A soil-gas investigation (DOE/RL-95-99) helped define the area of contamination but did not identify the source of contamination.

Wells are sampled biennially for trichloroethene. The most recent data from the wells with the highest concentrations, 199-F7-1 and 699-77-36, were from FY 2006, 14 and 13 µg/L, respectively.

2.7.1.5 Uranium and Gross Alpha

Uranium concentrations in 100-F Area groundwater have remained below the drinking water standard (30 µg/L) since 1996. The maximum concentration in FY 2007 was 13.3 µg/L in well 199-F8-2 in the central 100-F Area (Figure 2.7-4). This well had high concentrations in the late 1980s, but levels have been low since then.

Gross alpha concentrations were all <10 pCi/L in FY 2007. The highest was 9.9 pCi/L in well 199-F8-4.

2.7.1.6 Hexavalent Chromium

Chromium concentrations in groundwater beneath the 100-F Area are all below the drinking water standard (100 µg/L). Only three wells, located near the 116-F-14 retention basins and the 116-F-9 trench, had levels >20 µg/L in recent data. The highest value in FY 2007 was 60 µg/L in well 199-F5-6. Concentrations in this well are variable but generally increasing (Figure 2.7-5). The plume has changed little in the past 10 years (see Figure 2.7-8 in PNNL-15670 for a FY 2005 map).

Chromium concentrations in 100-F Area aquifer tubes continued to be low in FY 2007. Only one value exceeded the 10-µg/L aquatic standard. A sample from tube AT-72-M, located downstream of the 100-F Area, had 11 µg/L hexavalent chromium. A split sample had 8 µg/L.

Chromium concentrations in 100-F Area groundwater remained below the drinking water standard in FY 2007.

2.7.2 Operable Unit Activities

A record of decision has not yet been developed for the 100-FR-3 Operable Unit. DOE continues monitoring contaminant conditions while waste site remedial actions are conducted.

The groundwater sampling and analysis plan (DOE/RL-2003-49, Rev. 1) calls for annual sampling of 9 wells, 19 aquifer tube sites, and 3 shoreline seeps, and biennial sampling of 25 wells (see Appendix A). All of the wells scheduled for sampling in FY 2007 were sampled successfully. Four of the aquifer tube sites, all located downgradient of the main 100-F Area, were not sampled. The tubes could not be located in FY 2007. DOE plans to install new aquifer tubes at key sites where tubes have been destroyed. Two seeps could not be sampled; seep sampling depends on field conditions and is not always possible.

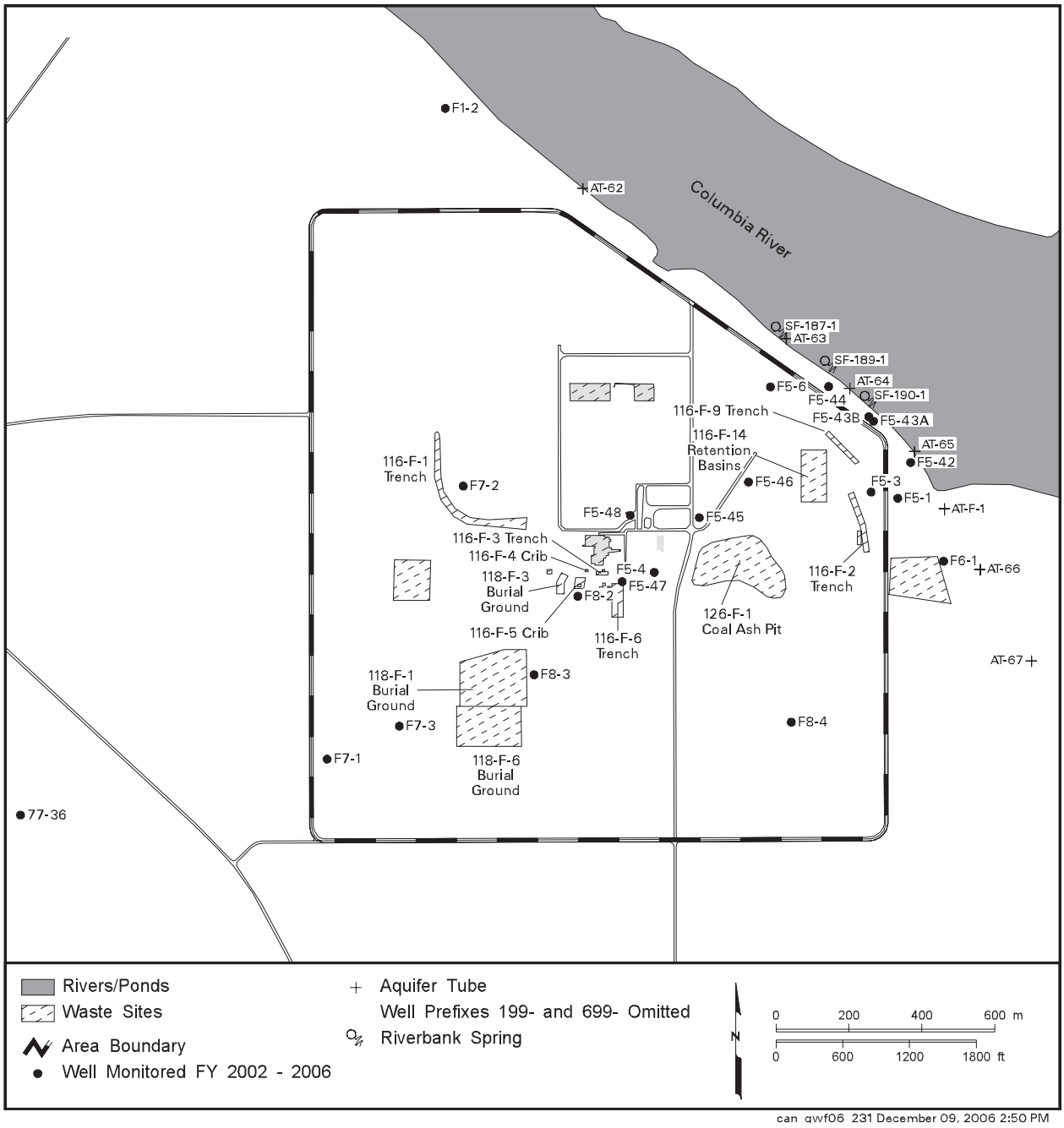


Figure 2.7-1. Groundwater Monitoring Wells in 100-F Area

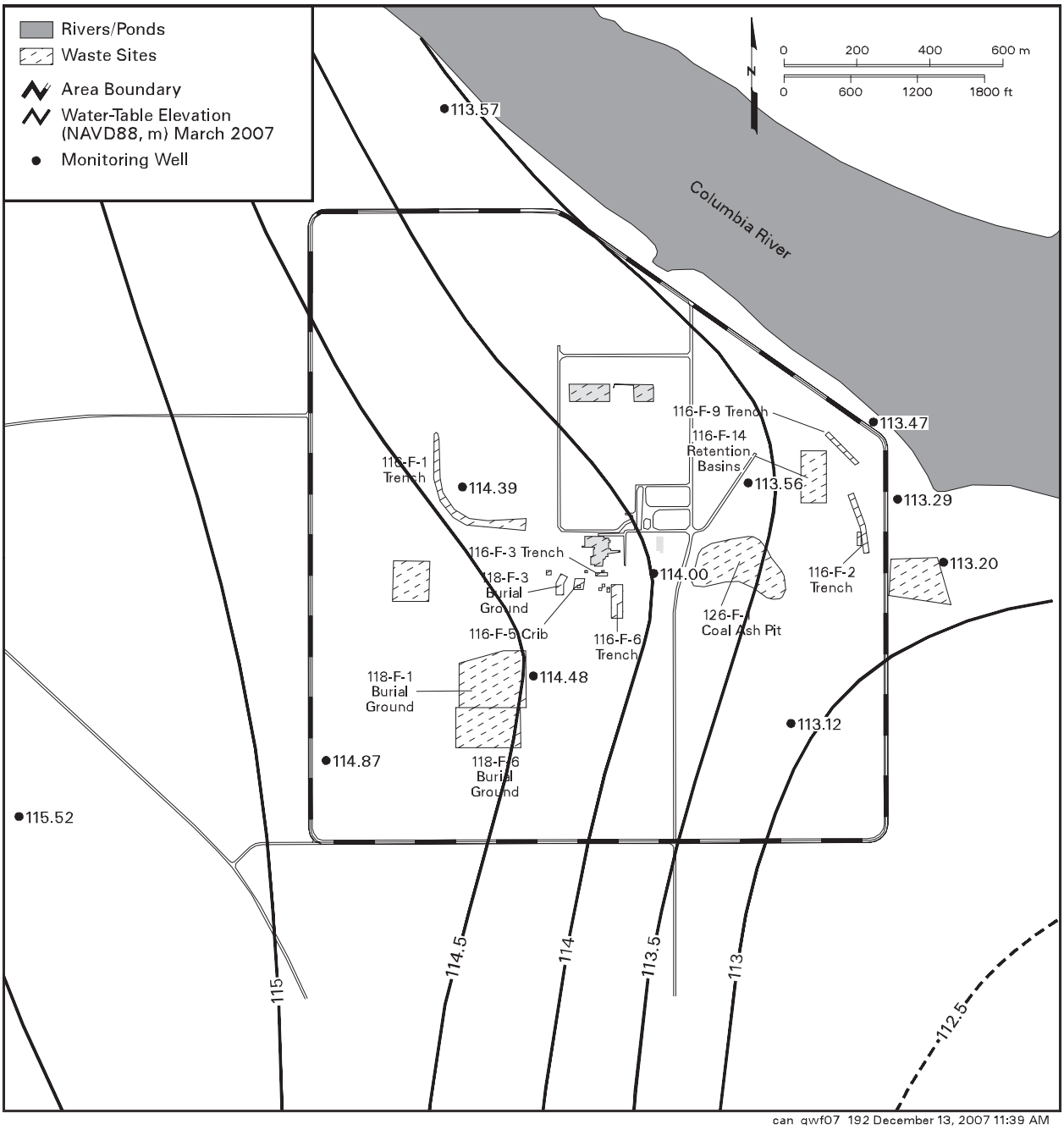


Figure 2.7-2. 100-F Area Water-Table Map, March 2007

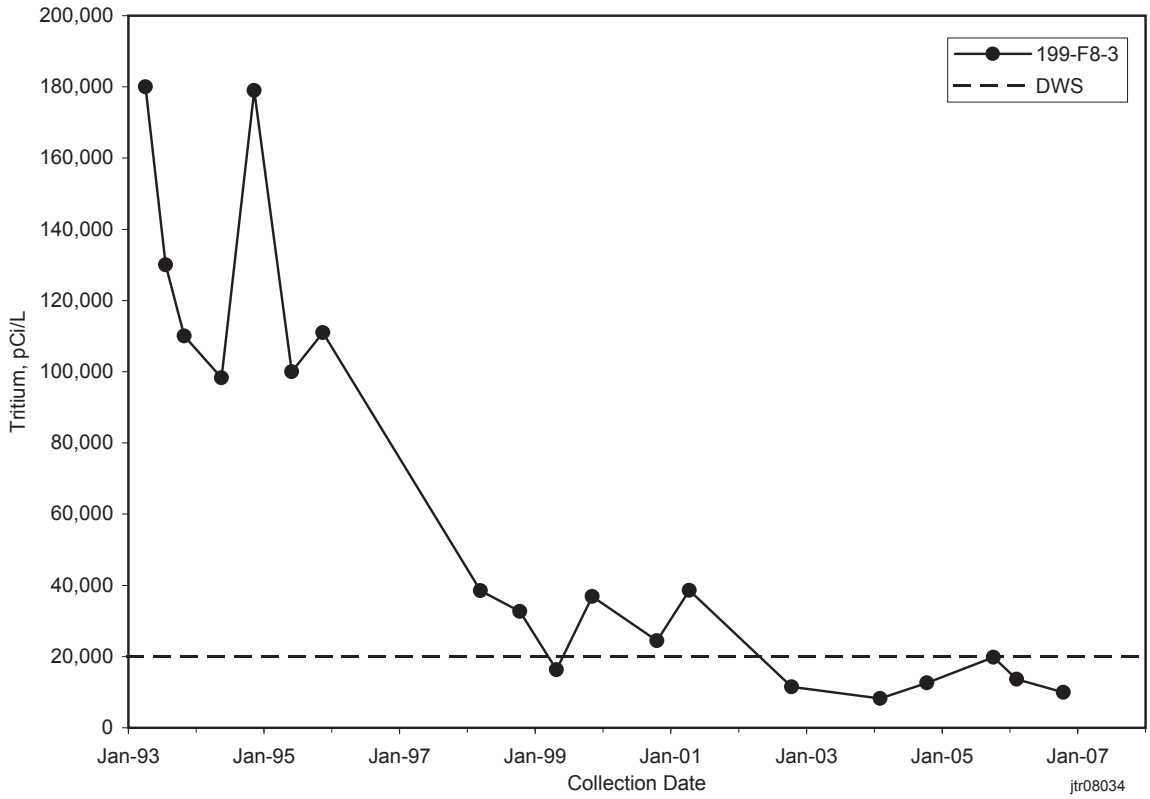


Figure 2.7-3. Tritium Concentrations Near 118-F-1 Burial Ground

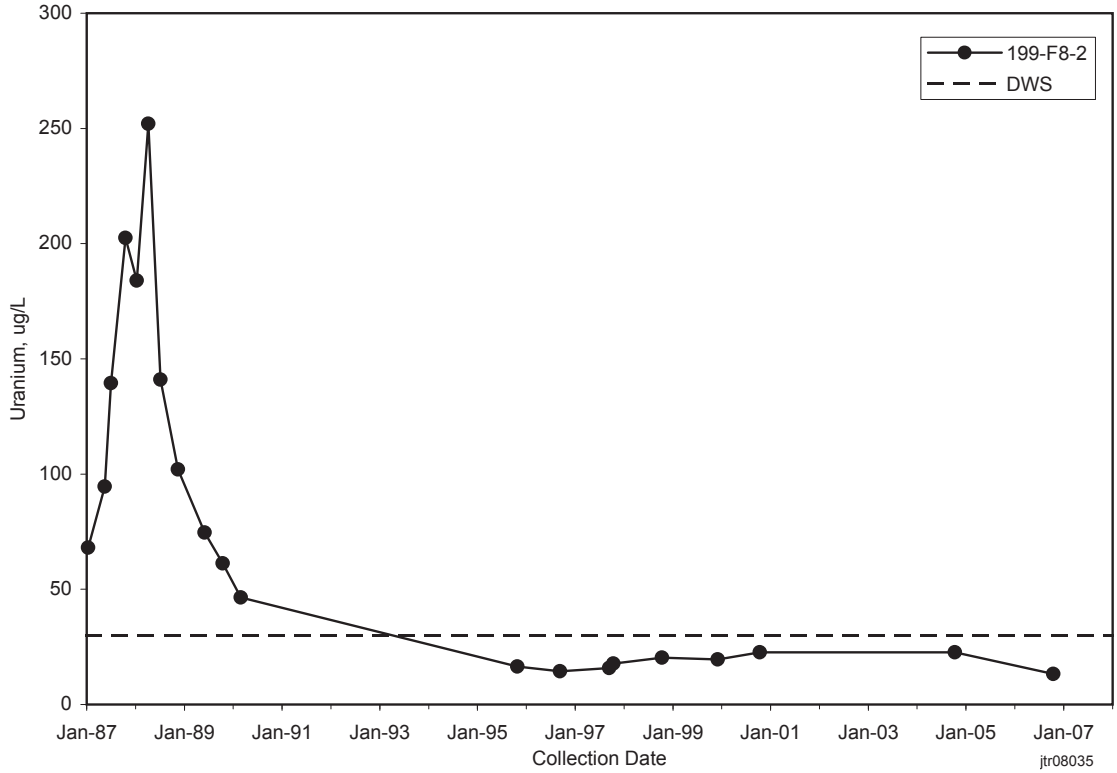


Figure 2.7-4. Uranium Concentrations in Well 199-F8-2, Near 116-F-5 Crib

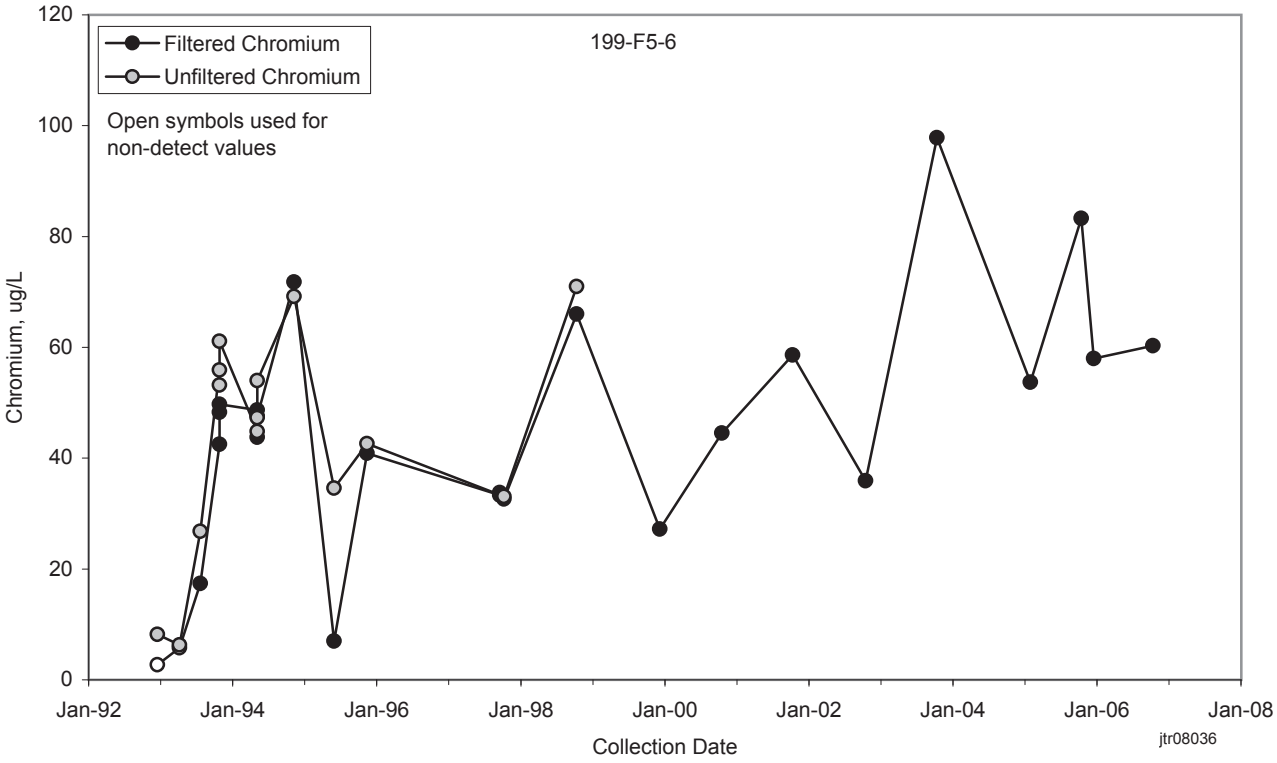


Figure 2.7-5. Chromium Concentrations in Well 199-F5-6 in Northeast 100-F Area

2.8 200-ZP-1 Operable Unit

D. B. Barnett, D. B. Erb and D. G. Horton

The 200-ZP-1 Operable Unit discussion includes the northern and central parts of the 200 West Area and the western 600 Area. This region is informally termed the 200-ZP-1 groundwater interest area (see Figure 1.0-1 in Section 1.0). The groundwater interest areas are defined to facilitate scheduling, data review, and interpretation. Figure 2.8-1 shows facilities and wells in this region. Groundwater is monitored to assess the performance of an interim action pump-and-treat system for carbon tetrachloride contamination, to track other contaminant plumes, and to support four *Resource Conservation and Recovery Act* (RCRA) units and the State-Approved Land Disposal Site. Data from facility-specific monitoring are also integrated into the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) groundwater investigations. The contamination plumes routinely mapped in this area are carbon tetrachloride, chloroform, trichloroethene, nitrate, chromium, fluoride, tritium, iodine-129, technetium-99, and uranium. Other contaminants are detected but at lower levels or in less extensive areas. Results of analyses of these contaminants and updates of other activities are discussed in this section.

Carbon tetrachloride is the primary contaminant of concern in the 200-ZP-1 Operable Unit.

Groundwater in the north portion of the 200 West Area predominantly flows toward the east-northeast but is locally influenced by the 200-ZP-1 Operable Unit pump-and-treat system and effluent discharges to the State-Approved Land Disposal Site (Figure 2.8-2). The water table in the 200 West Area was raised by past discharge of wastewater and the aquifer is still re-equilibrating after the termination of discharges. The flow direction in the north part of the operable unit has changed ~35 degrees over the past decade from a north-northeast direction to a more eastward direction, but the changes from year to year are becoming less apparent as the natural groundwater levels are approached.

Flow in the central part of the 200 West Area (the south part of the 200-ZP-1 Operable Unit) is strongly influenced by the operation of the 200-ZP-1 Operable Unit pump-and-treat remediation system. This system extracts water from ten extraction

Groundwater monitoring in the 200-ZP-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring (Appendix A)

- ***Sixty-three wells are sampled quarterly to biennially.***
- ***Several quarterly samples were missed and four were delayed until October 2007.***
- ***In FY 2007, five new wells were installed.***

Facility Monitoring (Appendix B)

- ***Seven wells are sampled semiannually for Low-Level Waste Management Area 3.***
- ***Ten wells are sampled semiannually for Low-Level Waste Management Area 4.***
- ***Sixteen wells are sampled quarterly to semiannually for Waste Management Area T. One quarterly sample was missed.***
- ***Sixteen wells are sampled quarterly to semiannually for Waste Management Area TX-TY.***
- ***Twelve wells are sampled quarterly to semiannually for the State-Approved Land Disposal Site. One semiannual sample was missed.***

The groundwater flow direction has changed ~35 degrees over the past decade, but the changes from year to year are becoming less apparent as the natural groundwater levels are approached.

wells in the vicinity of the 216-Z cribs and trenches and west of Waste Management Area TX-TY shown on Figure 2.8-1, removes carbon tetrachloride and other volatile organic compounds, then re-injects the water into the aquifer to the west of the area. A small groundwater mound is associated with the injection wells, and a region of draw down is associated with the extraction wells, causing flow to converge on the extraction zone from all directions. The re-injection wells, which are due west of the Low-Level Waste Management Area 4, have also affected groundwater flow and contaminant concentrations beneath this facility (see Section 2.8.2.1 and Appendix B). A more aggressive pump-and-treat system, which is currently in the conceptual stage, will affect these areas even more significantly (see Section 2.8.2). During the fiscal year, two of the extraction wells, located west of Waste Management Area TX-TY and containing significant technetium-99, were outfitted with a resin to remove the technetium-99 prior to re-injection (see Section 2.8.2.3).

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern, summarizes the status of groundwater remediation efforts, and discusses the results of monitoring of specific facilities under CERCLA, RCRA, state permits, and the *Atomic Energy Act* (AEA).

2.8.1 Groundwater Contaminants

Groundwater contaminants of concern discussed in this section are defined in the 200-ZP-1 remedial investigation/feasibility study work plan (DOE/RL-2003-55) and DOE/RL-2006-24. The contaminants of concern, their preliminary target action levels, and summary of detection statistics are listed in Table 2.8-1.

Plume areas (square kilometers) above the drinking water standard at the 200-ZP-1 Operable Unit:

****Carbon tetrachloride — 10.1***
Chromium — 0.05
Iodine-129 — 0.69
Nitrate — 5.9
Technetium-99 — 0.08
Trichloroethene — 0.44
Tritium — 0.75
Uranium — 0.09
****Also includes portion of plume beneath 200-UP-1 Operable Unit.***

2.8.1.1 Carbon Tetrachloride

Carbon tetrachloride contamination is found at levels greater than the drinking water standard (5 µg/L) in the groundwater under most of the 200 West Area (Figure 2.8-3). The main sources are three of the 216-Z cribs and trenches that received waste from the Plutonium Finishing Plant. The maximum carbon tetrachloride levels in groundwater were found in extraction well 299-W15-44, which had the highest concentration in a single sample (4,900 µg/L) and extraction well 299-W15-34, which had the highest average concentration (2,600 µg/L) during FY 2007. These wells are located southwest of Waste Management Area TX-TY.

Significant features of the carbon tetrachloride plume in the upper part of the aquifer include:

- Highest average carbon tetrachloride concentrations (2,608 µg/L) in the 200 West Area in FY 2007 occurred in extraction well 299-W15-34 (screened through the upper ~18 meters of the aquifer). This value is down from an average of 3,300 µg/L in FY 2006, and represents a continuing decrease in concentrations since the period 2001-2002.
- An area of carbon tetrachloride at levels >2,000 µg/L extends north to the vicinity of Waste Management Area TX-TY. The carbon tetrachloride contamination reaches the north part of Waste Management Area TX-TY where concentrations in well 299-W15-765 (screened through the upper 10.7 meters of the aquifer) averaged 1,925 µg/L in FY 2007 compared with 2,800 µg/L in FY 2006.

- The most recent analyses of carbon tetrachloride in well 699-48-71, located north of the northeast corner of 200 West Area, continue to show contamination increasing very gradually in this region northeast of the 200 West Area (Figure 2.8-4). Carbon tetrachloride in this well reached 42 µg/L in an average of two June 2007 samples (The average depicted in Figure 2.8-3 includes a low concentration of 20 µg/L from January 2007).
- The extent of carbon tetrachloride at the drinking water standard (5 µg/L) shown in Figure 2.8-3 did not change appreciably from that of FY 2006, but some zones of higher concentrations diminished during FY 2007. For example, the 50-µg/L contour interval in FY 2007 roughly coincides with the FY 2006 100-µg/L contour in most areas of 200-ZP-1, except the extreme northwest part of 200 West Area where concentrations remained mostly unchanged. The 1,000-µg/L contour that intersected the eastern boundary of Low-Level Waste Management Area 4 during FY 2006 has retreated to the eastward by about 100 meters. However, the area where concentrations remained >2,000 µg/L west of Waste Management Area TX-TY remained about the same as in FY 2006.
- Carbon tetrachloride is the primary constituent of concern for the 200-ZP-1 interim action record of decision (ROD 1995a). The target for remediation is the area with concentrations >2,000 µg/L in the vicinity of the 216-Z cribs and trenches. It is important to emphasize that the depiction of the extent of carbon tetrachloride in Figure 2.8-3 is the extent of contamination near the upper part of the aquifer, but the three-dimensional extent is considerably more complex. Ongoing drilling of new deep wells continues to indicate that the highest concentrations in some areas are found deeper in the aquifer. Some wells thus far completed to lower depths of the aquifer indicate high concentrations of carbon tetrachloride (>3,500 µg/L) 15 to 20 meters below the water table, especially beneath the disposal trenches. New characterization wells drilled in the last few years are helping to resolve the carbon tetrachloride extent downgradient and vertically within the suprabasalt aquifer (Figures 2.8-5, 2.8-6, and 2.8-7). Remediation activities and more details on the vertical contaminant distribution are summarized in Section 2.8.2.

Carbon tetrachloride contamination is found at levels greater than the drinking water standard (5 µg/L) in the groundwater under most of the 200 West Area.

Depth-discrete data for groundwater and soils in 19 wells were evaluated in the 200-ZP-1 remedial investigation report (DOE/RL-2006-24). Additional wells were drilled in FY 2007 that added to these data. Figures 2.8-6 and 2.8-7 illustrate the plume geometry in the vertical plane. Note that the contamination occurs at increasing depth to the east of the known source areas and relatively low concentrations are seen at the water table in the east-central part of the 200 West Area. Along the downgradient plume extent, recharge from natural infiltration and less-contaminated former waste water discharges may have contributed to reduced carbon tetrachloride concentrations in the upper portion of the unconfined aquifer. Also, the volume of discharges may have introduced significant vertical head, driving contamination deeper into the aquifer. 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.

The maximum trichloroethene concentration detected in FY 2007 routine monitoring was 21 µg/L in the November sample from well 299-W15-50, north of the 216-Z-9 trench.

2.8.1.2 Trichloroethene

Trichloroethene is detected at levels above the drinking water standard (5 µg/L) in the 200-ZP-1 Operable Unit. The main trichloroethene plume extends north and northeast from the vicinity of the 216-Z cribs and trenches, the 216-Z-9 trench

in particular. The maximum trichloroethene concentration detected in FY 2007 routine monitoring was 21 µg/L in the November sample from well 299-W15-50, north of the 216-Z-9 trench. This result is down from 27 µg/L in FY 2006. Well 299-W15-50 is screened ~7.6 to 18.3 meters below the water table and, thus, is not shown in Figure 2.8-8 because the figure focuses only on the upper portion of the aquifer. The size and configuration of the plume seen in Figure 2.8-7 is nearly identical to that of FY 2006. However, concentrations throughout the plume are slightly lower or unchanged in general. The most noticeable decline is in the western portion of Waste Management Area T (e.g., well 299-W10-4). The minor exception to this trend is the area near T Plant in the northwest portion of 200 West Area, where wells 299-W11-7 (11 µg/L) and 299-W11-37 (average 3.75 µg/L) show slight upward trends, with average concentrations higher in FY 2007 than in FY 2006.

Depth-discrete sampling for new wells drilled during FY 2007 contained chloroform, with the highest concentration of 86 µg/L found in well 299-W11-86 at a depth of 133 meters.

2.8.1.3 Chloroform

Average chloroform concentrations in the 200-ZP-1 wells remained below the 80-µg/L drinking water standard (the standard is defined for total trihalomethane) during FY 2007. Depth-discrete sampling for new wells drilled during FY 2007 showed chloroform at depth in the aquifer. The maximum chloroform in new well 299-W11-48, located north of Waste Management Area T, was 260 µg/L at 25 and 27 meters below the water table. The maximum chloroform found in new well 299-W11-86, east of T Plant, was 86 µg/L at 47 meters below the water table. Well 299-W10-33, completed near the bottom of the unconfined aquifer in September 2007 produced an average concentration of chloroform of 19.5 µg/L, with a maximum of 46 µg/L. Possible chloroform sources include biodegradation of carbon tetrachloride and sanitary sewer discharges to the 2607-Z tile field.

2.8.1.4 Nitrate

Nitrate concentrations in well 299-W10-27 on the northeast corner of Waste Management Area TX-TY increased in FY 2007.

Nitrate continued to be present in groundwater at concentrations above the drinking water standard (45 mg/L) beneath much of the 200-ZP-1 Operable Unit (Figure 2.8-9). The maximum concentration in this vicinity during FY 2007 was 3,810 mg/L in well 299-W10-4 near the 216-T-36 crib, south of Waste Management Area T. The average nitrate concentration in well 299-W10-4 was 2,264 mg/L for FY 2007, somewhat lower than in FY 2006. Multiple sources of nitrate probably exist in this area, including the cribs near Waste Management Area T and the 216-Z crib and trench disposal facilities.

Of three new wells with depth-discrete data, well 299-W11-86 had the highest nitrate concentration detected, with a concentration of 108 mg/L at a depth of 141 meters. This same well had a carbon tetrachloride concentration of 486 µg/L at a depth of 133 meters.

2.8.1.5 Chromium

Chromium contamination is found at levels above the drinking water standard (100 µg/L) in the immediate vicinity of Waste Management Areas T and TX-TY (Figure 2.8-9). Chromium at lower levels extends downgradient toward or past the 200 West Area boundary. Hexavalent chromium is included in this discussion because it is the most soluble and mobile form under Hanford aquifer conditions. Thus, all chromium in filtered groundwater samples is assumed to be soluble hexavalent chromium (see Appendix C).

Two areas of chromium contamination are shown on Figure 2.8-10. One is a small area centered on well 299-W14-13, east of Waste Management Area TX-TY. In

FY 2007, the maximum chromium concentration in well 299-W14-13 was 715 µg/L and the annual average was 660 µg/L, down from an annual average of 725 µg/L in FY 2006. The second area is larger and associated with Waste Management Area T and adjacent past-practice disposal facilities. There the highest average chromium concentration was 475 µg/L in well 299-W10-4, located southwest of the waste management area, down from 550 µg/L during the previous year. The chromium contamination at Waste Management Area T extends from well 299-W10-4 to the downgradient wells, although there are no wells within the tank farm to ensure continuation of the plume. Chromium near Waste Management Area T is discussed in more detail in Section 2.8.3.3 and near Waste Management Area TX-TY in Section 2.8.3.4.

Well 299-W14-13 had the highest chromium results in 200-ZP-1 Operable Unit at 715 µg/L.

2.8.1.6 Fluoride

Fluoride contamination at levels greater than the primary drinking water standard (4 mg/L) have occurred in a local area around Waste Management Area T in the past. In FY 2007, no water-table well exceeded this value, but well 299-W10-23 had the highest yearly average of 3.9 mg/L. The highest single fluoride result occurred northeast of Waste Management Area T in well 299-W11-48, which produced a maximum of 5.6 mg/L at ~12.2 meters below the water table. Several wells surrounding this tank farm have average concentrations above the secondary standard of 2 mg/L. Another area of anomalous concentrations (but all below the drinking water standard) occurs along the eastern edge of Waste Management Area TX-TY. Well 299-W14-11 produced an average of 1.4 mg/L in FY 2007. No trends are indicated in this area. Release of lanthanum fluoride used in the bismuth phosphate process is a possible cause of this contamination.

2.8.1.7 Tritium

Tritium contamination at levels greater than the drinking water standard (20,000 pCi/L) in the 200-ZP-1 Operable Unit is mainly restricted to a plume extending northeast from waste disposal facilities in the vicinity of Waste Management Areas T and TX-TY. Multiple potential sources of tritium exist in this vicinity. In addition, tritium from permitted discharges at the State-Approved Land Disposal Site is found in the groundwater (Figure 2.8-11). Tritium at the State-Approved Land Disposal Site is discussed in Section 2.8.3.5.

The highest tritium concentration was in a well east of Waste Management Area TX-TY where concentrations averaged 1.51 million pCi/L.

The tritium plume retains the same general configuration as in FY 2006, with the exception of the region southwest of Waste Management Area TX-TY. In this area, the 2,000-pCi/L contour has retreated to the north and east of extraction wells 299-W15-34, 299-W15-35 and 299-W15-43. The highest tritium concentrations in water-table wells remained at well 299-W14-13, located east of Waste Management Area TX-TY, where the concentration in FY 2007 ranged from 1.28 to 1.76 million pCi/L, with an average of 1.51 million pCi/L. These levels are down slightly from FY 2006. Tritium levels in the 200-ZP-1 Operable Unit continue on a downward trend in most wells in the network.

2.8.1.8 Iodine-129

Iodine-129 is found in the 200-ZP-1 Operable Unit that has origins in the vicinity of Waste Management Area TX-TY (Figure 2.8-12). The highest iodine-129 concentration detected during routine sampling in FY 2007 was in well 299-W14-13, where the concentration averaged 38.3 pCi/L, which is an increase from FY 2006 levels. Elevated iodine-129 is also found locally near the Waste Management Area T (see Section 2.8.3.3). Determining the extent of iodine-129 contamination is difficult

because the detection limit is often near, or above the drinking water standard of 1.0 pCi/L. In the past, the laboratory had problems analyzing for iodine-129 when significant concentrations of technetium-99 were present resulting in unusually high detection limits. This problem has been fixed so that the presence of high technetium-99 concentrations did not increase the detection limit for iodine-129 in FY 2007. See Section 1.8 for a more detailed discussion of iodine-129 analyses.

Technetium-99 within the 200-ZP-1 Operable Unit is found above the drinking water standard (900 pCi/L) downgradient of Waste Management Areas T and TX-TY.

2.8.1.9 Technetium-99

Technetium-99 within the 200-ZP-1 Operable Unit is found at levels significantly above the drinking water standard (900 pCi/L) on the east (downgradient) side of Waste Management Area T and centered on two areas in the vicinity of Waste Management Area TX-TY (Figure 2.8-13). Well 299-W11-39, near the northeast corner of Waste Management Area T, continued to produce the highest concentration in samples collected near the water table in this area with values in FY 2007 averaging 21,000 pCi/L. However, well 299-W11-46, which is screened between 6 and 12 meters below the water table, showed technetium-99 concentrations that averaged 96,850 pCi/L in FY 2007 with a maximum concentration of 113,000 pCi/L. This was up significantly from FY 2006 (maximum 63,200 pCi/L). Technetium-99 contamination around Waste Management Areas T and TX-TY is discussed in greater detail in Sections 2.8.3.3 and 2.8.3.4.

2.8.1.10 Uranium

The highest uranium result from groundwater in the 200-ZP-1 Operable Unit was found in well 299-W11-37, northeast of the 221-T building (see Figure 2.8-1). This well averaged a uranium concentration of 55.8 µg/L during FY 2007, but levels have been decreasing since FY 2001. This is the only well to exceed the drinking water standard (30 µg/L) in 200-ZP-1 Operable Unit during FY 2007. The next highest results were observed near the western edge (upgradient) of Low-Level Waste Management Area 4. Wells 299-W15-15, 299-W18-21, and 299-W18-23 produced average concentrations of 7.9, 20.7, and 9.0 µg/L, respectively.

Only one well exceeded the drinking water standard (30 µg/L) for uranium in the 200-ZP-1 Operable Unit.

2.8.1.11 Other Contaminants of Concern

Other contaminants of concern (Table 2.8-1) that were detected in groundwater at concentrations above the preliminary target action levels are discussed in this section. Antimony was reported as detected in several wells at levels above the drinking water standard (6 µg/L) in FY 2007. However, antimony results have been problematic. Detections are typically very close to the reported detection limit and sporadic. Most detections in FY 2007 and previous years, are believed to be false positives. In well 699-48-77D, antimony from a filtered sample was reported as detected at 43.6 µg/L, but the unfiltered sample from the same event was below detection. A result of 33.9 µg/L was also reported in February 2007 in a filtered sample from well 299-W10-28, but all results before and since have been below detection.

Arsenic was detected at levels above the 10-µg/L drinking water standard only in one well (299-W10-4) during FY 2007. The maximum concentration detected was 10.3 µg/L. This value is slightly lower than the previous year's maximum. The subsequent sample was below the drinking water standard. New well 299-W10-33 produced the next highest result at 8.29 µg/L in an unfiltered sample, but the average of several results in this well was only 2.2 µg/L. The Hanford groundwater background for arsenic is 11.8 µg/L (95th percentile) (DOE/RL-96-61).

Iron was present at levels above the 300-µg/L secondary drinking water standard in only three wells during FY 2007. The highest concentration (2,600 µg/L) was observed in an unfiltered sample from well 699-48-77A at the State-Approved Land Disposal Site. A filtered sample from the same event was below detection (<33 µg/L). Well 299-W14-19 produced a result of 384 µg/L in a filtered sample in February 2007. This result far exceeds any result before or since, and is suspected as an analytical error or particulate material. Iron is a naturally occurring component of the aquifer sediment and is found in well materials; thus, elevated iron levels in unfiltered samples due to particulate material are not surprising. Background iron concentration for Hanford Site groundwater is 55.3 µg/L (DOE/RL-96-61).

Manganese was detected at levels above the 50-µg/L secondary drinking water standard in filtered and unfiltered samples from several 200-ZP-1 wells in FY 2007. The highest concentration reported was 678 µg/L from well 299-W11-47. Elevated manganese values in the first few years of sampling are not uncommon for new wells at the Hanford Site, probably due to reaction of groundwater with freshly crushed rock surfaces. Background manganese concentration for Hanford Site groundwater is 2.2 µg/L (DOE/RL-96-61).

Methylene chloride was detected at levels above the drinking water standard (5 µg/L) in five wells in the 200-ZP-1 Operable Unit during FY 2007. The highest result reported was from well 299-W11-48 at 9.3 µg/L. Methylene chloride (dichloromethane) could be a degradation product or impurity in carbon tetrachloride (tetrachloromethane) but is also a common laboratory contaminant. Tetrachloroethene is often detected at levels below the drinking water standard (5 µg/L) in the 200-ZP-1 Operable Unit. In FY 2007, one well (299-W13-1) had a result 6.4 µg/L, which is identical with the result in this well in FY 2007. The well has a history of detections for this constituent, but at levels significantly below the maximum result for FY 2007.

2.8.2 Operable Unit Activities

Within the 200-ZP-1 Operable Unit, interim actions have been implemented for remediation of carbon tetrachloride, chloroform, and trichloroethene in the vicinity of the 216-Z liquid waste disposal units (216-Z cribs and trenches). Remediation of other groundwater contaminants will be determined through the remedial investigation/feasibility study process per Section 5.5 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). The most recent update of the status of the remediation is provided by SGW-34328.

Two pump-and-treatment systems and a vapor extraction system have been installed as interim actions to treat groundwater contamination in the 200 Areas.

2.8.2.1 Status of Five-Year Review of Action Items

The U.S. Department of Energy (DOE) published the second CERCLA five-year review in November 2006 (DOE/RL-2006-20). This document provided a comprehensive evaluation of the status of groundwater and source operable unit investigations and cleanup actions. Findings for the 200 Area National Priority List site that are pertinent to the 200-ZP-1 Operable Unit include the following summary statement:

"Two pump-and-treatment systems and a vapor extraction system have been installed as interim actions to treat groundwater contamination in the 200 Areas. The 200-ZP-1 Groundwater Operable Unit has a pump-and-treatment system to remove carbon tetrachloride from the groundwater. This system was designed to address only the most concentrated portion of the shallow portion of the plume and will be

Treatment options for technetium-99 centered on performing a treatability test at wells 299-W15-44 and 299-W15-765 using a Purolite-resin ion exchange column.

expanded through the CERCLA remedial investigation/feasibility study process to address the deeper portion of the plume. A protectiveness determination for the pump-and-treat interim remedy is being deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process."

Several issues and actions related to the 200-ZP-1 Operable Unit were identified:

- **Issue 13**. There is less than adequate deep groundwater monitoring data downgradient of T Tank Farm to define the nature and extent of technetium-99 contamination. Further characterize the technetium-99 groundwater plume near T Tank Farm.
  - **Action 13-1.** Complete a data quality objective process and sampling plan to further characterize the technetium-99 groundwater plume near T Tank Farm (due date March 2007).
  - **Response.** The data quality objectives Summary Report (WMP-28389, Rev. 0) was issued October 2007; the sampling and analysis plan (DOE/RL-2006-46) was issued August 2006.
- **Issue 14**. The recent expansion of the 200-ZP-1 extraction well network near the TX-TY Tank Farm may result in technetium-99 contamination being pulled into the 200-ZP-1 treatment system. Treatment options for groundwater contaminated with technetium-99 need to be assessed.
  - **Action 14-1**. Assess treatment options to address technetium-99 near T Tank Farm (due date September 2007).
  - **Response.** Treatment options for technetium-99 at the T Tank Farm centered on performing treatment at wells 299-W11-45 and 299-W11-46. These two wells have been converted to extraction wells. Groundwater is pumped to the Effluent Treatment Facility in 200 East Area for treatment. System operations began in September 2007.
- **Issue 16**. Efficiency and effectiveness of the 200-ZP-1 pump-and-treat system could be increased by increasing the pumping rate to fully utilize the treatment capacity.
  - **Action 16-1**. Increase the pump size in 200-ZP-1 extraction wells 299-W15-45 and 299-W15-47 (due date March 31, 2007).
  - **Response.** Specific capacity versus remaining wetted length of screen for both wells suggested that production only at well 299-W15-47 could benefit from installation of a larger pump. A 15-horsepower pump replaced the original 10 horsepower and yielded an additional 8 liters/minute for a total extraction rate of 235 liters/minute.

Remediation of other groundwater contaminants will be determined through the remedial investigation/ feasibility study process

- **Issue 17**. Efficiency of the carbon tetrachloride remediation could be increased by increasing the use of the 200-PW-1 (formerly the 200-ZP-2) vapor extraction system. The soil-vapor extraction system is in limited operation. Expanding the soil-vapor extraction operations should be evaluated.
  - **Action 17-1**. Evaluate expanding the soil-vapor extraction operations. Specifically review converting former groundwater extraction well 299-W15-32 to a soil-vapor extraction well (due date March 2007).
  - **Response.** An evaluation of soil vapor extract operations was conducted and it was agreed that the system could be expanded. Well 299-W15-32

was converted for soil-vapor extraction operations in FY 2006 and is ready for connection to the soil-vapor extraction system. Additional wells will be added to the system in the future.

2.8.2.2 CERCLA Investigations

A *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2003-55) was prepared in FY 2004 and implemented in FY 2005. The remediation investigation report (DOE/RL-2006-24) was published in October 2006 and the Draft A feasibility study/proposed plan was completed in September 2007 (DOE/RL-2007-28, Draft A; DOE/RL-2007-33, Draft A).

Work on the Draft A feasibility study for the 200-ZP-1 Operable Unit is ongoing to finalize the document. The feasibility study will include the detailed risk assessment. In FY 2006, potential remediation methods for the 200-ZP-1 Operable Unit were screened (PNNL-15954). The screening considered the eight major contaminants and used a generalized conceptual model of the lateral extent and depth of contamination. A data quality objectives report (WMP-28324) was prepared for investigation of the extent of deep groundwater contamination in the eastern part of the 200 West Area. This report proposed the installation of five new deep groundwater monitoring wells.

2.8.2.3 Interim Action for Carbon Tetrachloride

The current pump-and-treat system is operating in the 200-ZP-1 Operable Unit to contain and capture the high concentration portion of the carbon tetrachloride plume located north of the Plutonium Finishing Plant. The contaminants originating from discharges to the 216-Z-9, 216-Z-1A and 216-Z-18 cribs have migrated north and east of the waste sites. The pump-and-treat system was implemented as an interim remedial measure in three phases starting in 1996.

The remedial action objectives for the pump-and-treat system are to capture the high concentration area of the carbon tetrachloride plume to reduce contaminant mass and to gather information to support future remedial investigation/feasibility study decisions (ROD 1995a). The high concentration plume is defined by the 2,000- to 3,000-µg/L-plume contour, which was initially centered beneath the Plutonium Finishing Plant and related waste sites. In 2005, concentrations of carbon tetrachloride exceeding the 2,000-µg/L remedial action goal were reported at wells west of the TX and TY Tank Farms. Four monitoring wells were converted to extraction wells and connected to the 200-ZP-1 pump-and-treat system. Pumping began there in late July 2005 and continued through FY 2006. A tenth well, 299-W15-6, was added on September 28, 2006.

The interim remedial action objectives for the 200-ZP-1 Operable Unit (ROD 1995a) are:

- ***Reduce contamination in the area of highest concentration of carbon tetrachloride.***
- ***Prevent further movement of these contaminants from the highest concentration area.***
- ***Provide information that will lead to development of a final remedy that will protect human health and the environment.***

EPA specified enhancements needed for the system in their 5-year review (EPA 2001). The record of decision for the interim remedial measure states the high concentration portion of the plume corresponds to the area within the 2,000- to 3,000-µg/L contour of carbon tetrachloride.

Over 498 million liters of carbon tetrachloride contaminated groundwater were treated in FY 2007 and 755.2 kilograms of carbon tetrachloride were removed.

Carbon tetrachloride mass was reduced in the area of highest concentrations through pumping and treating over 498 million liters from ten groundwater extraction wells in FY 2007. The average extraction rate during FY 2007, factoring in all down time, was 950 liters/minute, compared to an average pumping rate of 810 liters/minute in FY 2006 and the remedial action target pumping rate of 568 liters/minute. Most of the increase is attributed to the steady operation of the extraction system. Processing rates of up to 1,300 liters/minute were achieved for significant periods of time. Figure 2.8-14 shows the current concentrations of carbon tetrachloride in the vicinity of the 200-ZP-1 pump-and-treat system.

An existing well, 299-W15-6 at the 216-Z-9 trench, was converted for extraction and brought online in late September 2006. This well is screened deeper in the unconfined aquifer above the Ringold Formation lower mud unit and was operated throughout FY 2007. The original purpose of pumping at this well was to evaluate dense nonaqueous phase liquid within the deep unconfined aquifer near the suspected waste site source areas. Although dense nonaqueous phase liquid was not encountered, extraction has continued with the goal of reducing contaminant mass.

Carbon tetrachloride mass was extracted at an average rate of 950 liters/minute, compared to an average pumping rate of 810 liters/minute in FY 2006 and the remedial action target pumping rate of 568 liters/minute.

Carbon tetrachloride concentrations ranged from a low value of 270 µg/L at extraction well 299-W15-36 to a high value of 3,400 µg/L at extraction well 299-W15-40. Concentrations at the pump-and-treat system's influent tank averaged 1,600 µg/L during the first half of FY 2007, a slight decrease from 2,096 µg/L in FY 2006. Treatment resulted in the removal of 755.2 kilograms of carbon tetrachloride from the 498 million liters of extracted groundwater in FY 2007. Since starting the pump-and-treat system in August 1994, over 10,953 kilograms of carbon tetrachloride have been removed from almost 3.69 billion liters of groundwater.

The most recent estimates of carbon tetrachloride inventories are given in DOE/RL-2006-58. The current estimate is between 570,000 and 920,000 kilograms of carbon tetrachloride discharged to the three primary waste sites, 216-Z-9, 216-Z-1A, and 216-Z-18. DOE/RL-2007-22, source term addendum report, presented an estimate of carbon tetrachloride in the unconfined aquifer. The dissolved carbon tetrachloride is estimated to be 55,900 to 64,600 kilograms, with 44,500 to 51,400 kilograms sorbed to the aquifer sediments. An estimated 13,700 to 15,800 kilograms of carbon tetrachloride has degraded to chloroform below the water table.

Extraction wells have been sampled for technetium-99 to monitor plume movement and to ascertain if the pump-and-treat system is being affected by radiological contamination that could require changes to operations. Unlike past years where technetium-99 concentrations in injected water did not exceed 200 pCi/L, concentrations in FY 2007 rose to 640 pCi/L in November 2006. Monthly analytical results from the treatment system's influent and effluent tanks indicate that technetium-99 is not being removed during the treatment process.

A treatability test of the Purolite resin-based ion exchange system to remove the technetium-99 started in late April 2007 at extraction wells.

To alleviate the increasing technetium-99 concentrations in the system, an ion exchange treatability test using the Purolite resin-based system was installed to remove the technetium-99. The ion exchange system was started in late April 2007 at extraction wells 299-W15-44 and 299-W15-765. A failed pipe connection delayed start of routine testing until July 2007, but the system ran uninterrupted for the remainder of the fiscal year.

The technetium-99 injected historically has served as an unintentional tracer and has been detected at wells downgradient from the injection wells. In well

299-W15-15 at Low-Level Waste Management Area 4, technetium-99 concentrations rose from 18.5 pCi/L in 1994 to 170 pCi/L in 2004 and to 327 pCi/L in July 2007. Simultaneously, carbon tetrachloride concentrations declined from 1,400 µg/L to a maximum of 3.6 µg/L in the same time period.

Concentrations of carbon tetrachloride at all baseline plume wells have continued to decline from previous years and three of the five wells in the baseline area were routinely below the 2,000-µg/L remedial action goal.

Carbon tetrachloride concentrations at all baseline plume wells have continued to decline from previous years and three of the five wells in the baseline area were routinely below the 2,000-µg/L remedial action goal. Concentrations in well 299-W15-36, the southernmost active extraction well, ranged between 270 and 450 µg/L in FY 2007. Wells 299-W15-34, 299-W15-40, 299-W15-44, and 299-W15-765 occasionally yielded carbon tetrachloride concentrations above 2,000 µg/L in FY2007. Wells 299-W15-43, 299-W15-45 and 299-W15-47 were usually above 1,000 µg/L.

Carbon tetrachloride concentrations at two of the four extraction wells that began operation in FY 2005 are consistently above the 2,000-µg/L remedial action goal. Extraction wells 299-W15-40 and 299-W15-765 each exceeded 3,000 µg/L (3,000 and 3,400 µg/L, respectively) on one or two occasions in the first 4 months of FY 2007, but did not maintain concentrations above 3,000 µg/L for the remainder of the year. Well 299-W15-43, the most westerly of the converted extraction wells, averaged ~1,500 µg/L. The capture zones for these wells have not yet exceeded the contoured plume.

Monitoring wells have shown declines in concentrations reflecting those observed at baseline extraction wells. Well 299-W15-1, located upgradient of extraction well 299-W15-34, averaged above 2,000 µg/L. Monitoring wells 299-W15-7 and 299-W15-11, remained at or well below the 2,000-µg/L remedial action goal. These data indicate that the area around the extraction wells is being remediated by the pump-and-treat system.

Carbon tetrachloride concentrations in upgradient monitoring wells 299-W15-30 and 299-W15-31A declined to around 360 µg/L at the end of FY 2007. Monitoring well 299-W15-49, located west of well 299-W15-45, exhibited a declining trend, from 270 to 170 µg/L in FY 2007. Correspondingly, technetium-99 trends increased to 65 to 101 pCi/L in these monitoring wells throughout the fiscal year. The declining carbon tetrachloride trends along with the increasing technetium-99 trends at these wells show the influence of the injection system in driving contaminated groundwater toward the extraction wells.

Deep aquifer monitoring at well 299-W13-1, located east of the remediation system, revealed an oscillating trend of carbon tetrachloride concentrations ranging between 1,600 and 2,100 µg/L in FY 2007. The well was screened at a depth of 121 to 130 meters based on elevated concentrations of carbon tetrachloride. The Ringold lower mud unit was expected at ~131-meter depth but a only a limited fining of sediments was observed. Well 299-W11-87 replaced well 299-W11-86, which was damaged during construction and yielded a concentration of 1,700 µg/L. The well is screened to monitor the aquifer directly above the Ringold lower mud unit. Wells 299-W14-71 and 299-W14-72, located south and west of well 299-W13-1, yielded carbon tetrachloride concentrations between 500 and 1,000 µg/L. Well 699-45-69C, located east of 200 West Area, yielded a vertical profile of carbon tetrachloride that suggested concentrations greater than 5-µg/L had passed this location for at least at one interval ~119 meters below ground surface (groundwater is ~90 meters below ground surface).

Regional water levels indicate groundwater flow in the vicinity of the pump-and-treat system is to the east-northeast. Because of draw down, the water level declined 0.21 meter in well 299-W15-49 to 0.40 meter at well 299-W15-39, and averaging at 0.24 meter for 16 wells within the area of remediation in FY 2007. For wells outside the extraction wells capture zone, the average water-level decline was 0.24 meter/year. Well 299-W14-14 declined by 0.21 meter/year whereas wells 299-W15-33 and 299-W13-1 increased by 0.04 meter/year and 0.12 meter/year, respectively. For wells 299-W15-38 and 299-W15-39, located close to extraction wells, water-level declines of 0.40 meter/year were observed. These wells are downgradient of well 299-W15-47.

2.8.2.4. Pump-and-Treat for Technetium-99

Regional water levels declined and indicated groundwater flow is to the east-northeast in the vicinity of the 200-ZP-1 pump-and-treat system.

The technetium-99 concentration in well 299-W11-39, located east (downgradient) of the Waste Management Area T, increased from ~4,400 pCi/L when it was first sampled in February 2001 to 23,500 pCi/L in August 2007. Well 299-W11-25B was drilled east of Waste Management Area T and ~6 meters from existing well 299-W11-39 in early 2005. The objective of the borehole was to determine the vertical distribution of contaminants in the unconfined aquifer at the location of well 299-W11-39. Borehole 299-W11-25B was drilled to the top of the Ringold Formation lower mud unit (~51 meters below the water table) and groundwater was sampled throughout the unconfined aquifer. High concentrations of technetium-99 were found during drilling. The highest technetium-99 concentration was about 182,000 pCi/L at ~10 meters below the water table. The technetium-99 concentration rapidly decreased to less than about 40,000 pCi/L at 15 meters below the water table but remained greater than about 20,000 pCi/L throughout the deeper part of the aquifer (PNNL-15670).

Well 299-W11-25B was damaged during construction and was replaced with well 299-W11-46 located about 3 meters away. Well 299-W11-46 was screened between 6 and 12 meters below the water table, the zone that contained the highest concentrations of technetium-99 found in well 299-W11-25B. The replacement well was first sampled in August 2005. Between then and August 2007, the technetium-99 concentration increased steadily from 36,000 pCi/L to 113,000 pCi/L.

Well 299-W11-45 was drilled about 80 meters east (downgradient) from well 299-W11-46 and to a depth of about 56 meters below the water table in late 2005. The purpose of well 299-W11-45 was to delineate the lateral extent of the high technetium-99 concentrations found in borehole 299-W11-25B. Well 299-W11-45 also was sampled with depth during drilling and technetium-99 concentration just over 15,000 pCi/L was noted at about 10 meters below the water table. The technetium-99 concentration dropped below the drinking water standard of 900 pCi/L at about 15 meters below the water table and remained less than 900 pCi/L throughout the deeper part of the aquifer. Well 299-W11-45 was completed and screened between 8.5 and 13 meters below the water table (PNNL-15670).

In September 2007, wells 299-W11-45 and 299-W11-46 were converted to groundwater extraction wells in an attempt to remove the very high technetium-99 concentrations from the aquifer. The wells initially pumped at a combined rate of 102 liters/minute but this was increased to about 182 liters/minute in October 2007. The extracted water is sent to the Effluent Treatment Facility for removal of contaminants. The first sampling of the wells after extraction began was October 2007; the technetium-99 concentration in well 299-W11-45 was 16,000 pCi/L and the technetium-99 concentration in well 299-W11-46 was 18,000 pCi/L.

2.8.2.5 Carbon Tetrachloride and Chloroform Attenuation Parameters

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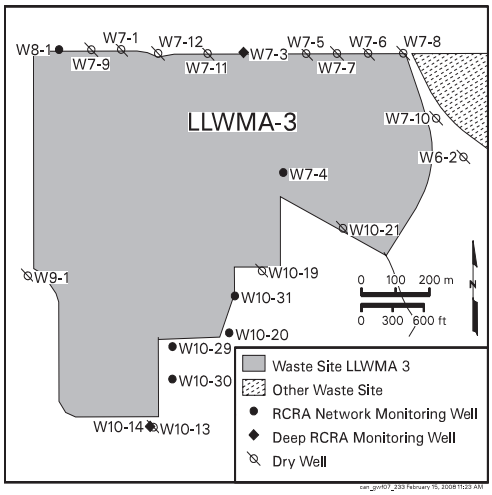
To support upcoming remediation decisions for the carbon tetrachloride plume in 200 West Area, more information is needed to assess the fate and transport of contamination. Parameters describing porosity, sorption, and physical degradation have the largest influence on predicted plume behavior. Researchers from Pacific Northwest National Laboratory are conducting a study of attenuation parameters under DOE's Environmental Management (EM-22) program (http://www.hanford.gov/cp/gpp/science/em21.cfm). Results of the new project will improve the ability to predict future movement of the plume. This effort will help define how much active remediation may be needed and estimate where the plume will eventually stabilize - key factors in determining the most appropriate remedy for the plume. During FY 2007, four minerals were selected and mineral surface experiments were initiated.

2.8.3 Facility Monitoring

This section describes results of monitoring individual facilities such as treatment, storage, or disposal units including two tank farm waste management areas (Waste Management Areas T and TX-TY). Groundwater at some of these facilities is monitored under the requirements of RCRA for hazardous waste constituents and AEA for radionuclides including source, special nuclear, and by-product materials. Data for facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Groundwater data for these facilities are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B. This section summarizes results of statistical comparisons, assessment studies, and other developments for FY 2007.

2.8.3.1 Low-Level Waste Management Area 3

Groundwater at Low-Level Waste Management Area 3 continued to be monitored under RCRA and AEA in FY 2007. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-14859; see Appendix B). All seven wells in the network were sampled as scheduled during FY 2007, except that quadruplicate results for indicator parameters were not received for two wells in the second semiannual event. New wells 299-W10-29, 299-W10-30, and 299-W10-31 were first sampled in October 2006.



The water table continued to decline in Low-Level Waste Management Area 3 monitoring wells during FY 2007 in response to the greatly reduced discharge of wastewater to surface facilities around the 200 West Area. The groundwater flow in this portion of the 200 West Area is to the east-northeast based on the March 2007 water-level data (Figure 2.8-2), measurements, with a calculated gradient of 0.0016 and a range in hydraulic conductivity values of 2.5 to 10 meters/day (PNNL-14753), the estimated flow rate at Low-Level Waste Management Area 3 is 0.04 to 0.16 meter/day (see Appendix B).

Emplacement of new upgradient wells has been postponed until the effects of the proposed expanded pump-and-treat activities in the 200 West Area have been evaluated.

Previously designated upgradient wells 299-W10-19, 299-W10-20, and 299-W10-21 are now dry because of declines in the water table. Nitrate and carbon tetrachloride routinely exceeded drinking water standards in these wells. Flow and monitoring data collected since RCRA monitoring was instituted in the 1980s indicate that these constituents are from plumes originating from sources to the south (see update in Appendix B). Since then, changes in flow directions have left Low-Level Waste Management Area 3 with no monitoring wells on the upgradient (west) side. For this reason, statistical upgradient/downgradient comparisons have been suspended until background statistics can be re-established. Emplacement of new upgradient wells has also been postponed until the effects of the proposed expanded pump-and-treat activities in the 200 West Area have been evaluated (see Section 2.8.2.2). No suitable upgradient wells are available for use in the interim.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 3 is designed to complement RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 3 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, tritium, and uranium are monitored specifically for performance assessment.

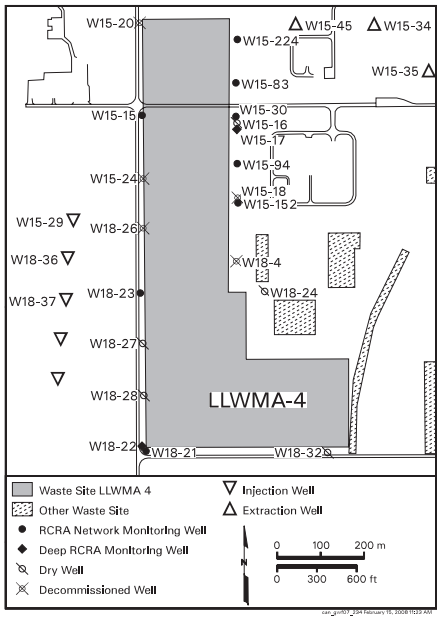
Contaminants detected in groundwater at Low-Level Waste Management Area 3 include the following:

- Technetium-99 concentrations are all <20 pCi/L and generally show steady or declining trends. Historically, the highest concentrations were in well 299-W10-20, located on the south edge of Low-Level Waste Management Area 3. Although this well is currently downgradient of part of the burial ground, it was initially designated an upgradient well when flow was toward the north and has likely been affected by contaminant sources to the south. Well 299-W10-20 went dry in FY 2006. During FY 2007, the highest technetium-99 result (15.5 pCi/L) occurred in well 299-W7-4. The technetium-99 distribution in the 200-ZP-1 Operable Unit is discussed in Section 2.8.1.9.
- Uranium concentrations at Low-Level Waste Management Area 3 were <2 µg/L (maximum 1.79 µg/L in well 299-W7-4).
- Iodine-129 was not detected during FY 2007 and has not been detected in any wells currently in use at Low-Level Waste Management Area 3.
- Low levels of tritium were detected in only two wells, 299-W8-1 (53.5 pCi/L) and 299-W7-3 (19.6 pCi/L), in FY 2007.
- Carbon tetrachloride and associated trichloroethene and chloroform concentrations in Low-Level Waste Management Area 3 wells are consistent with those seen in regional plumes. Only carbon tetrachloride was detected at levels above the drinking water standard. The highest concentration was 220 µg/L in well 299-W10-31 (the sample was collected in October 2006). Both wells 299-W10-31 and 299-W7-4 display downward trends in carbon tetrachloride and chloroform.
- The nitrate distribution at Low-Level Waste Management Area 3 is consistent with regional plumes, as discussed in Section 2.8.1.4. The maximum

concentration during FY 2007 (40.7 mg/L) was found in well 299-W8-1. Before going dry in FY 2006, well 299-W10-20 had a concentration of 58.9 mg/L.

2.8.3.2 Low-Level Waste Management Area 4

Groundwater at Low-Level Waste Management Area 4 is monitored under RCRA and AEA. Under 40 CFR 265.93(b) as referenced by WAC 173-303-400, the well network was sampled semiannually for RCRA indicator and site-specific parameters (PNNL-14859; see Appendix B for a table and map of well locations). New downgradient well locations had been identified and prioritized under the Tri-Party Agreement Milestone M-24, but impending, accelerated pump-and-treat activities have postponed the drilling of new wells in 200 West Area until the effects of the proposed expanded pump-and-treat system are evaluated.



The groundwater flow in this portion of the 200 West Area is interpreted to be generally to the east, based on water-table contours. The flow direction is affected to a large degree by the 200-ZP-1 pump-and-treat system, which has extraction wells to the east and injection wells to the west of this RCRA site. The gradient is steeper and has a component to the northeast in the north part of the area and is somewhat less steep with a component to the southeast in the south part of the area. The generalized flow direction based on the March 2007 water table for the 200 West Area (Figure 2.8-2), was east-northeast in the northern portion of the facility, to slightly south of east in the southern portion. The average hydraulic gradient is 0.004. With a range in hydraulic conductivity values of 10 to 25 meters/day, the estimated flow rate at Low-Level Waste Management Area 4 using these values is ~0.4 to 1.0 meter/day (see Appendix B).

As in previous years, downgradient wells 299-W15-30, 299-W15-83, 299-W15-94, and 299-W15-224 continued to exceed the statistical comparison value for total organic halides in all samples during FY 2007. Well 299-W15-30 is a replacement for well 299-W15-16, which has gone dry. DOE previously reported the exceedance of the statistical comparison value in well 299-W15-16 (now dry) to the U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) in August 1999. The elevated total organic halide concentrations are consistent with observed levels of carbon tetrachloride from Plutonium Finishing Plant operations (see Section 2.8.1.1 and 2.8.2) although more data are needed from the newer wells to establish trends. Carbon tetrachloride concentrations display downward trends in all wells in the network for which historical data are available. During FY 2007, the highest concentration was in well 299-W15-94 at 830 µg/L. This was down from 1,200 µg/L in FY 2006. Known sources of carbon tetrachloride include the 216-Z-9 trench, 216-Z-1A tile field, and 216-Z-18 crib (DOE/RL-2006-20). Based on historical groundwater monitoring and interpretations of carbon tetrachloride plumes in the 200 West Area (e.g., DOE/RL-92-16), these liquid disposal facilities were determined to be the overwhelming sources of this contaminant in 200 West Area groundwater. A further discussion of chlorinated-compounds contamination beneath Low-Level Waste Management Area 4 is found in Appendix B.

The general groundwater flow to the east at Low-Level Waste Management Area 4 is largely affected by injection wells to the west and extraction wells to the east.

The other indicator parameters, pH, specific conductance and total organic carbon did not exceed the comparison values for FY 2007. Statistical comparison values for use in FY 2008 are listed in Appendix B.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 4 is designed to complement the RCRA detection monitoring. The current goal of performance assessment monitoring at Low-Level Waste Management Area 4 is to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, tritium, and uranium are monitored specifically for performance assessment.

Contaminant characteristics at Low-Level Waste Management Area 4 include the following:

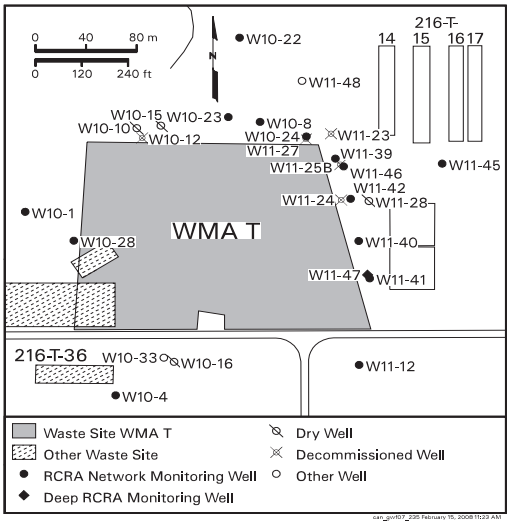
- Technetium-99 concentrations increased in several wells during FY 2007, particularly wells 299-W15-15 (327 pCi/L), 299-W18-21 (343 pCi/L), and 299-W18-23 (440 pCi/L) on the west (upgradient) side of Low-Level Waste Management Area 4. Technetium-99 concentrations also increased in upgradient wells 299-W15-30 (92 pCi/L), 299-W15-152 (199 pCi/L; highest downgradient result) and 299-W15-224 (144 pCi/L). Wells upgradient of Waste Management Area TX-TY were converted to extraction wells for the pump-and-treat system in mid-2005. Shortly thereafter, technetium-99 concentrations in those wells began increasing, reaching >1,000 pCi/L in two of those wells (299-W15-44 and 299-W15-765) by the beginning of 2006. The resulting increases in technetium-99 concentration in the injection water, coupled with a 20 to 25% increase in injection volume from the addition of new extraction wells, could be responsible for the increases in technetium-99 concentration in wells at Low-Level Waste Management Area 4. However, the increases in technetium-99 concentration at the beginning of 2007 are fairly abrupt and occur over a wide area suggesting that other factors also may be involved.
- Uranium concentrations are highest, but also declining, in upgradient wells 299-W15-15 (8.33 µg/L), 299-W18-23 (9.89 µg/L), and 299-W18-21 (21.3 µg/L; highest in the network for FY 2007). The highest uranium concentrations at downgradient locations occurred in well 299-W15-152 (2.16 µg/L). No ongoing trends are apparent in downgradient wells, partly because of the limited period of data collection in the newer wells.
- Iodine-129 was not detected in Low-Level Waste Management Area 4 wells during FY 2007.
- Tritium concentrations were highest in downgradient well 299-W15-83 at 1,910 pCi/L and display an upward trend in this well and adjacent well 299-W15-30 (1,000 pCi/L). Upgradient well 299-W18-23 (1,830 pCi/L) and downgradient well 299-W15-152 (1,750 pCi/L) show downward trends in tritium concentrations.
- Nitrate continued to exceed the drinking water standard at all monitoring wells in Low-Level Waste Management Area 4 except downgradient well 299-W15-17 (26 mg/L) and deep well 299-W18-22 (18.6 mg/L). The highest concentration in FY 2007 was in upgradient well 299-W18-23 (152 mg/L). This well and wells 299-W15-30 (97 mg/L) and 299-W18-21 (145 mg/L) exhibit upward trends in nitrate. This contamination is not believed to be related to waste disposal at the burial grounds. Some of the nitrate contamination is related to injection of 200-ZP-1 treated water upgradient of the burial ground. The treatment system does not remove nitrate from the water.

Nitrate continued to exceed the drinking water standard at all monitoring wells at Low-Level Waste Management Area 4 except two.

- Concentrations of carbon tetrachloride, trichloroethene and chloroform are consistent with regional plumes as shown in Sections 2.8.1.1, 2.8.1.2, and 2.8.1.3. The highest concentration of carbon tetrachloride during FY 2007 occurred in well 299-W15-94 (830 µg/L). All wells in the network with results above detection show decreasing trends of this constituent. Chloroform and trichloroethene concentrations remained below the drinking water standard. Only two wells, 299-W15-83 and 299-W15-94, produced trichloroethene concentrations above detection limits.

2.8.3.3 Waste Management Area T

Waste Management Area T is located in the north-central part of the 200 West Area and consists of the T Tank Farm with its ancillary equipment (e.g., diversion boxes and pipelines). The tank farm contains twelve 2-million-liter tanks and four 208,000-liter tanks constructed between 1943 and 1944. Seven of the tanks in the waste management area are known or suspected to have leaked (RPP-23405, Rev. 1). This section describes groundwater monitoring at Waste Management Area T. A well location map and a table of wells and analytes for this waste management area are included in Appendix B.



The objective of RCRA groundwater monitoring at Waste Management Area T is to assess the extent and rate of movement of dangerous waste in groundwater that have a source from the waste management area (40 CFR 265.93(d) as referenced by WAC 173-303-400). The groundwater assessment plan for Waste Management Area T is PNNL-15301. In addition to monitoring dangerous waste constituents for RCRA assessment, the site is monitored for CERCLA and AEA purposes. Waste Management Area T was originally placed in RCRA assessment monitoring because of elevated specific conductance in downgradient well 299-W10-15 (WHC-SD-EN-AP-132). This area remains in assessment because of continued elevated contaminants observed in downgradient wells.

Dangerous waste constituents found in groundwater near Waste Management Area T in FY 2007 are chromium and nitrate. These constituents probably originate from more than one source including the waste management area. Other constituents found near the waste management area in FY 2007 include carbon tetrachloride, trichloroethene, tritium, technetium-99, and cobalt-60. The carbon tetrachloride and trichloroethene do not appear to be from Waste Management Area T and are discussed in Sections 2.8.1.1 and 2.8.1.2. Most of the tritium is believed to be part of a regional plume, although a contribution from Waste Management Area T cannot be ruled out. The technetium-99 plume, located east (downgradient) of the T Tank Farm, is attributed, at least in part, to the tank farm.

The carbon tetrachloride and trichloroethene contamination does not appear to be from Waste Management Area T.

Calculated average linear groundwater flow velocities at Waste Management Area T range from 0.002 to 0.25 meter/day with most values <0.1 meter/day. Groundwater flow direction beneath the waste management area is to the east between 85 and 98 degrees from north as determined by trend surface analyses (PNNL-13378; PNNL-14113) and the most current water-table map (Figure 2.8-2).

The monitoring network for Waste Management Area T includes fourteen wells that are sampled quarterly and two wells sampled semiannually. All samples

were collected as scheduled in FY 2007 except the first quarter sample from well 299-W11-47. Well 299-W11-47 was not sampled because of mechanical difficulties. In September 2007, downgradient wells 299-W11-45 and 299-W11-46 were converted to extraction wells to remove technetium-99 from the aquifer east of Waste Management Area T.

In September 2007, downgradient wells 299-W11-45 and 299-W11-46 were converted to extraction wells to remove technetium-99 from the aquifer east of Waste Management Area T.

Two new monitoring wells were installed in FY 2007 as part of the 200-ZP-1 technetium-99 characterization at T Tank Farm. The first new well (299-W11-48) was constructed in July 2007 and was screened between 10 and 38 meters below the water table. Well 299-W11-48 is located north of the northeast corner of the Waste Management Area. The purpose of the well was to bound the northern extent of the technetium-99 plume located east of the Waste Management Area.

The second new well (299-W10-33) was started in June 2007 and completed in October 2007. This well is located south of the western part of the Waste Management Area and was screened between 49 and 55 meters below the water table. The purpose of this well was to determine whether high concentrations of technetium-99 existed deep in the aquifer in the area near the 216-T-36 crib and the 216-T-7 crib and tile field. Nether of the new wells are part of the Waste Management Area T monitoring network. However, both new wells were sampled during drilling and the data collected during drilling are discussed in the following paragraphs.

A data quality objectives process document, *T Area Technetium-99 Data Quality Objectives Summary Report* (WMP-28389), describes the locations of additional new wells needed to further delineate the technetium-99 plume located east of Waste Management Area T.

A plume map depicting the FY 2007 average chromium concentration in wells in the uppermost part of the aquifer near the Waste Management Area T is shown in Figure 2.8-10. The map shows that the chromium plume extends from the west and southwest part of the waste management area to northeast of the waste management area. The highest average chromium concentration in the upper part of the aquifer during FY 2007 was in well 299-W10-4 (average 470 µg/L) located at the southwest corner of the waste management area. The chromium concentration in upgradient well 299-W10-28, which had been above the drinking water standard for the past four years, decreased to an average concentration of 94 µg/L during FY 2007. The chromium concentration in the upper part of the aquifer also exceeded the drinking water standard in three downgradient wells.

The highest average chromium concentration found at Waste Management Area T was 641 µg/L.

The highest average chromium concentration found at Waste Management Area T was 641 µg/L (up from 290 µg/L during the previous year) in well 299-W11-46, completed deeper in the aquifer between 6 and 12 meters below the water table. The chromium concentration in adjacent well 299-W11-39, screened at the water table was 150 µg/L. Chromium in well 299-W11-45, located ~80 meters downgradient of well 299-W11-46 and completed between 8.5 and 13 meters below the water table, averaged 100 µg/L. These concentrations show that the chromium plume at Waste Management Area T extends relatively deep in the aquifer and laterally to at least 80 meters downgradient of the waste management area.

A fluoride plume extends from the southwest to the north and east of Waste Management Area T. The extent of the plume remained almost unchanged from the previous year. The highest fluoride concentrations measured in FY 2007 at Waste Management Area T were 4.4 and 4.3 mg/L in wells 299-W10-23 and 299-W10-8,

located north of the Waste Management Area (the drinking water standard for fluoride is 4 mg/L).

A local nitrate plume sits within the regional nitrate plume and beneath Waste Management Area T (Figure 2.8-9). The plume retains the same general configuration as in FY 2006. The highest average nitrate concentrations were in upgradient wells 299-W10-28 and 299-W10-4. More than one source, including the Waste Management Area T, probably contributed to the nitrate plume beneath the waste management area, but the higher upgradient concentrations indicate greater contributions from other sources. A discussion of nitrate contamination in the north central part of 200 West Area is given in Section 2.8.1.4.

The highest average nitrate concentrations were in upgradient well 299-W10-28 (1,977 mg/L) and well 299-W10-4 (2,896 mg/L).

Tritium exceeded the interim drinking water standard (20,000 pCi/L) in one well at Waste Management Area T. The average FY 2007 tritium concentration in well 299-W11-12, located at the southeast corner of the waste management area, was 38,000 pCi/L down slightly from 44,000 pCi/L during the previous year. The tritium concentration has been slowly decreasing in this well since 1998. The source of the tritium is thought to be farther south near the TX and TY Tank Farms (Figure 2.8-11).

A technetium-99 plume is located along the east (downgradient) side of Waste Management Area T (Figure 2.8-13). The highest technetium-99 concentrations in the upper part of the aquifer are in downgradient well 299-W11-39 at the northeast corner of the waste management area, where the average technetium-99 concentration was 22,000 pCi/L in FY 2007, slightly less than 24,000 pCi/L during the previous year. Technetium-99 also exceeds the drinking water standard in all other downgradient, water-table wells (Figure 2.8-15). The first indication of technetium-99 contamination in groundwater at Waste Management Area T was in well 299-W11-27, located at the northeast corner of the T Tank Farm, in late 1995 coincident with the cessation of surface water disposal in the 200 West Area. Discussions in PNNL-11809 suggest that the technetium-99 had arrived at well 299-W11-27 by the early 1990s, but was masked by dilution with water from a leaking water line located immediately adjacent to the well and the technetium-99 concentration became detectable only after surface water disposal was stopped. Detailed discussions of the history of groundwater contamination at Waste Management Area T can be found in PNNL-11809, PNNL-15837, PNNL-15301, PNNL-13928, and DOE/ORP-2008-01.

The technetium-99 concentration increased throughout the year in well 299-W11-46 to a maximum of 113,000 pCi/L.

Figure 2.8-16 shows the technetium-99 concentration versus time in three downgradient wells that are screened below the water table at Waste Management Area T. Well 299-W11-46 is located adjacent to well 299-W11-39 and screened between 6 and 12 meters below the water table. The well is the replacement well for well 299-W11-25B, which had 181,000 pCi/L technetium-99 at 10 meters below the water table when it was drilled in 2005. The technetium-99 concentration increased throughout the year in well 299-W11-46 to a maximum of 113,000 pCi/L. This compares to the average of 22,700 pCi/L in the adjacent well 299-W11-39 and shows that the highest technetium-99 concentrations in the area are below the screened interval in well 299-W11-39.

Well 299-W11-45 is located about 80 meters downgradient of well 299-W11-46 and screened between 8.5 and 13 meters below the water table; technetium-99 averaged 21,225 pCi/L in the well during FY 2007. The concentrations in this well show that the technetium-99 plume found east of the waste management area extends to at least 80 meters downgradient of the waste management area.

Iodine-129 exceeded the drinking water standard (1 pCi/L) in two of the deeper wells east of Waste Management Area T

Iodine-129 exceeded the drinking water standard (1 pCi/L) in two of the deeper wells east of Waste Management Area T throughout the year. The iodine-129 concentration remained fairly steady at 3 to 3.3 pCi/L in well 299-W11-45 but increased steadily from 6.6 to 13.6 pCi/L throughout FY 2007 in well 299-W11-46. Iodine-129 was not detected in any downgradient water-table well. Cobalt-60 was also found in well 299-W11-46 throughout FY 2007, the concentrations were between 24 and 34 pCi/L, less than the 100 pCi/L drinking water standard.

Manganese exceeded the secondary drinking water standard of 50 µg/L in wells 299-W11-39 (65.5 µg/L) and 299-W11-47 (85.8 µg/L). Well 299-W11-47 is a fairly new well and elevated manganese is common in new wells. The manganese concentration has been decreasing in well 299-W11-47 since it was drilled in March 2006. The reason for the elevated manganese in well 299-W11-39 is not known.

The pH exceeded 8.5 in three of the four quarters in FY 2007 in well 299-W10-24 (pH ranged from 8.46 to 8.7). The pH commonly slightly exceeds 8.5 in this well.

Wells 299-W10-33 and 299-W11-48 were drilled in calendar year 2007 to the top of the Ringold Formation lower mud unit. Well 299-W10-33 is screened between 49 and 55 meters below the water table and well 299-W11-48 is screened between 10 and 38 meters below the water table. Both wells were sampled with a pump at several depths during drilling. Figure 2.8-17 shows the distribution of contaminants with depth in both wells. Chromium exceeded the drinking water standard at ~5 meters below the water table in well 299-W10-33 and between 30 and 40 meters below the water table in well 299-W11-48. Carbon tetrachloride also exceeded the drinking water standard throughout most of the drilled depth in both wells. Technetium-99 is below the drinking water standard throughout the entire drilled depth of both wells.

Well 299-W10-33 is located near well 299-W10-4. The latter well has had extremely high concentrations of most major cations and anions since at least 2000. The concentrations of major cations (Figure 2.8-18) and anions (Figure 2.8-19) in well 299-W10-33 are also extremely high although not as high as in well 299-W10-4. Apparently, brackish water sampled in well 299-W10-4 (salinity of 3,274 mg/L) extends to well 299-W10-33 (salinity of 2,147 mg/L). (Most wells at Waste Management Area T have salinities of ~1,400 mg/L or less.) The source of the high ion concentrations is probably one or more of the past-practice disposal facilities west of the waste management area.

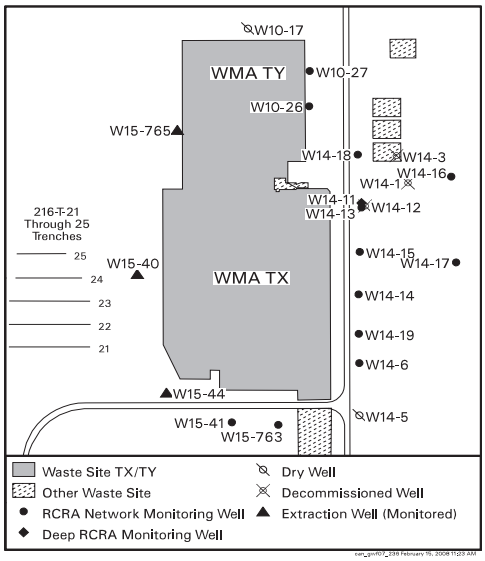
In 2005 and 2006, consultants to CH2M Hill Hanford Group, Inc. performed a series of surface geophysical surveys to map subsurface contaminant distribution beneath the T Tank Farm and surrounding area (RPP-RPT-28955). One tool used was high-resolution resistivity surveys. One of the surveys used 17 groundwater wells around the periphery of the tank farm as electrodes. Because the wells are in direct contact with the saturated zone, the results of the survey were interpreted to be at the depth of the water table.

The results of the survey showed four areas of low resistivity (high conductivity) at the water table (RPP-RPT-28955). The low resistivity is most likely associated with high nitrate concentration. One low-resistivity area is located beneath the disposal facilities west and southwest of Waste Management Area T. (The surveys using surface electrode arrays showed vadose zone contamination extending to groundwater in this area.) The contaminant plume in this area is reflected in the high salinity found in wells 299-W10-4 and 299-W10-33.

The second low-resistivity area is located at the northeast corner of the waste management area in the area of wells 299-W11-39, 299-W11-46, and 299-W11-42 where nitrate concentrations were on the order of 300 to 900 mg/L during 2007. The third low-resisitivity area is between well 299-W10-22 and 299-W10-23, north of the waste management area. Well 299-W11-48 was drilled through the eastern part of this area during FY 2007 and found relatively moderate nitrate concentrations between 100 and 200 mg/L near the water table. The final area of low resistivity at the groundwater is inside the tank farm fence and west of wells 299-W11-41 and 299-W11-47. Nitrate concentration in these wells was very high and between ~700 and 800 mg/L during 2007. The contamination in these wells may be related to the low resistivity area to the west.

2.8.3.4 Waste Management Area TX-TY

Waste Management Area TX-TY is located in the north-central part of the 200 West Area and consists of the TX and TY Tank Farms and ancillary equipment (e.g., diversion boxes and pipelines). The tank farms contain twenty-four 2.9-million-liter tanks constructed between 1944 and 1952. Twelve of the tanks in the waste management area are known or suspected to have leaked. A well location map and a table of wells and analytes for this waste management area are shown in Appendix B.



Waste Management Area TX-TY was originally placed in RCRA assessment monitoring (40 CFR 265.93(d) as referenced by WAC 173-303-400) because of elevated specific conductance in downgradient wells 299-W10-27 and 299-W14-12 (WHC-SD-EN-AP-132). The groundwater assessment plan for Waste Management Area TX-TY was updated in FY 2007 (PNNL-16005) to incorporate information obtained from new wells drilled since the most recent Interim Change Notice to the previous plan (PNNL-12072-ICN-1). The objective of RCRA groundwater monitoring at Waste Management Area TX-TY is to assess the extent and rate of movement of dangerous waste in groundwater that have a source from the waste management area. In addition to monitoring dangerous waste constituents for RCRA assessments, the site is monitored for AEA and CERCLA.

The monitoring network for Waste Management Area TX-TY includes 16 wells that are sampled quarterly. All upgradient wells for the waste management area were converted to extraction wells for the 200-ZP-1 pump-and-treat system in July 2005. Groundwater flow direction varies beneath the waste management area due to influences from the pump-and-treat operation. In the north part of the waste management area, groundwater flow is changing from eastward to westward due to the recently converted extraction wells. South of Waste Management Area TX-TY, groundwater flow direction is toward extraction wells located south or southwest of the waste management area.

Dangerous waste constituents found beneath Waste Management Area TX-TY in FY 2007 are chromium and nitrate.

Dangerous waste constituents found in groundwater near Waste Management Area TX-TY in FY 2007 are chromium and nitrate. Other constituents found near the waste management area in 2007 include carbon tetrachloride, trichloroethene, tritium, technetium-99, and iodine-129. The carbon tetrachloride and trichloroethene are attributed to Plutonium Finishing Plant operations and are discussed in Sections 2.8.1.1 and 2.8.1.2.

Twelve of the tanks in Waste Management Area TX-TY are known or suspected to have leaked.

Nitrate concentrations exceeded the drinking water standard (45 mg/L) in all wells in the Waste Management Area TX-TY monitoring network in FY 2007. Figure 2.8-9 shows a plume map for nitrate in the area. Overall, the nitrate concentrations remain fairly steady in most wells at the waste management area.

The highest average nitrate concentration at the waste management area during FY 2007 was 720 mg/L in well 299-W10-27. The highest nitrate concentrations at the waste management area for the previous several years has been in well 299-W14-13, located south of well 299-W10-27. It is unlikely that the nitrate plume at well 299-W14-13 has moved north to well 299-W10-27 because nitrate concentration in well 299-W10-26, located between wells 299-W10-27 and 299-W14-13, is lower than in the two adjacent wells. Nitrate has been increasing in well 299-W10-27 since the end of 2005.

The nitrate concentration increased in well 299-W14-15, located south of well 299-W14-13. The FY 2007 average nitrate concentration was 160 mg/L, up from an average of 107 mg/L in FY 2006. The concentrations of technetium-99 and iodine-129 also increased in well 299-W14-15 in FY 2007 and probably the contaminant plumes previously found in well 299-W14-13 are now encroaching on well 299-W14-15.

Much of the nitrate contamination at Waste Management Area TX-TY is attributed to Plutonium Finishing Plant operations as well as past-practice disposal to cribs and trenches in the area.

Much of the nitrate contamination at Waste Management Area TX-TY is attributed to Plutonium Finishing Plant operations as well as past-practice disposal to cribs and trenches in the area. Some nitrate contamination also may be from Waste Management Area TX-TY, although distinguishing the different sources is extremely difficult. More discussion of nitrate in north-central 200 West Area is given in Section 2.8.1.4.

Chromium was detected above the drinking water standard (100 µg/L) in two wells at Waste Management Area TX-TY during FY 2007. The annual average chromium concentration in well 299-W14-13 was 660 µg/L during the year, down from 740 µg/L during FY 2006. The chromium concentration has been elevated in this well since it was drilled in 1998 and was elevated in the early 1990s in adjacent but now dry well 299-W14-12. The chromium contamination in the area is accompanied by elevated concentrations of nitrate, iodine-129, technetium-99, and tritium.

Well 299-W14-11 is located next to well 299-W14-13 but is screened between 11.6 and 14.6 meters below the water table. The annual average chromium concentration in the well was below the drinking water standard and was 76 µg/L during the year, but the last sample collected in FY 2007 contained 111 µg/L chromium. This indicates that substantial chromium may exist deeper in the aquifer than indicated by wells screened at the water table, although the highest concentrations appear to be near the water table in the area.

The chromium contamination in the area is accompanied by elevated concentrations of nitrate, iodine-129, technetium-99, and tritium.

Well 299-W14-15 is located south of well 299-W14-13. The annual average chromium concentration in the well was 77 µg/L in FY 2007, but the chromium concentration increased throughout the year to 121 µg/L during the fourth quarter. The increase in chromium was accompanied by increases in iodine-129, nitrate, technetium-99, and tritium (Figure 2.8-20) suggesting that the contaminant plumes previously found in well 299-W14-13 are moving south to well 299-W14-15, possibly due to changes made to the 200-ZP-1 pump-and-treat system west and south of the waste management area. The source for the chromium is assumed to be Waste Management Area TX-TY because no alternative sources have been identified.

A small tritium plume exists along the east-central part of Waste Management Area TX-TY (Figure 2.8-11). The tritium concentration exceeded the drinking

water standard (20,000 pCi/L) in three wells in the area. The highest average tritium concentration was 1.5 million pCi/L in well 299-W14-13 during the fiscal year, which was down slightly from 1.7 million pCi/L during the previous year although concentrations have remained fairly stable since FY 2002. The average tritium concentration in the adjacent well, 299-W14-11 (screened from 11.6 to 14.6 meters below the water table), was 127,425 pCi/L. The tritium concentrations in these two wells indicate that the highest concentrations are near the water table in this area.

The tritium concentrations in well 299-W14-15, located south of well 299-W14-13, also exceeded the drinking water standard during the year with an average concentration of 97,000 pCi/L, up from 54,000 pCi/L during the previous year (Figure 2.8-20). The source for the high tritium in the area could be Waste Management Area TX-TY, the 242-T evaporator, the 216-T-19 crib and tile field (which received evaporator condensate from the 242-T evaporator), the 216-T-26 through 216-T-28 cribs, or a combination of these potential sources.

The annual average technetium-99 concentration was 6,658 pCi/L in well 299-W14-13 and 2,325 pCi/L in deeper well 299-W14-11. Both concentrations are down somewhat from the previous year

Technetium-99 exceeded the interim drinking water standard (900 pCi/L) in both wells in the well pair 299-W14-11 and 299-W14-13 at Waste Management Area TX-TY in FY 2007. The annual average technetium-99 concentration was 6,700 pCi/L in well 299-W14-13 and 2,325 pCi/L in deeper well 299-W14-11. Both concentrations are down somewhat from the previous year and continue to indicate that the highest technetium-99 concentrations are near the water table in that area, similar to chromium, nitrate, iodine-129, and tritium. The technetium-99 concentration also exceeded the drinking water standard in well 299-W14-15, located south of the wells 299-W14-13 and 299-W14-11. The average concentration was 1,700 pCi/L during the year, up from 940 pCi/L during the previous year. The source for the technetium-99 in these wells east of the waste management area could be the waste management area itself or one of the past-practice disposal facilities in the area or both.

Technetium-99 is also found at levels above the drinking water standard in wells south and west of the waste management area (Figure 2.8-13). Technetium-99 in these wells is thought to be drawn to the wells from beneath the TX and TY Tank Farms by extraction for the 200-ZP-1 pump-and-treat. Figure 2.8-21 shows the technetium-99 concentration versus time for four wells. Wells 299-W15-44 and 299-W15-765 were put into service as extraction wells for 200-ZP-1 Operable Unit in July 2005 and the technetium concentration began to increase in these wells shortly thereafter.

Iodine-129 was detected in three wells at Waste Management Area TX-TY during FY 2007. The highest iodine-129 concentration measured at the waste management area during the reporting period was 45.4 pCi/L in the August 2007 sample from well 299-W14-13. The average iodine-129 concentration in adjacent and deeper screened well 299-W14-11 was 4.8 pCi/L indicating that the iodine-129 contamination resides near the water table, similar to the other contaminants in the area. Iodine-129 also was detected in well 299-W14-15, located south of well 299-W14-13. The iodine-129 concentration in this well increased throughout the year from 2.08 pCi/L in November 2006 to 6.89 pCi/L in August 2007.

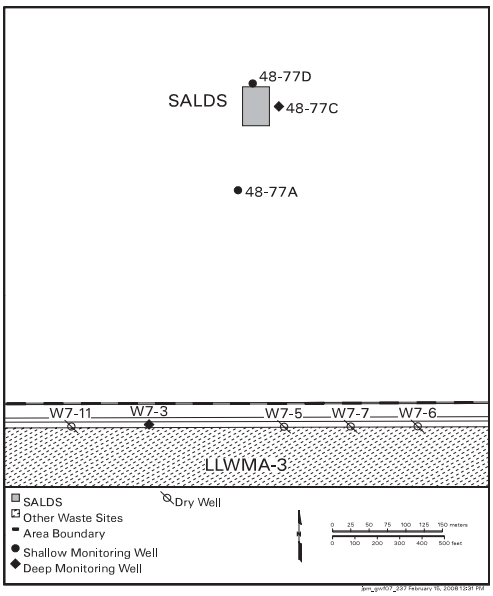
The highest iodine-129 concentration measured at the waste management area during the reporting period was 45.4 pCi/L in the August 2007

Manganese exceeded the secondary drinking water standard of 50 µg/L in well 299-W10-27 where the average FY 2007 concentration was 276 µg/L. The manganese concentration has been high in this well since it was first sampled in 2001 although the concentration has decreased dramatically since that time. It is common for new wells on the Hanford Site to have elevated manganese values during the first few years of sampling, but the elevated manganese in this well has persisted. The reason for the elevated manganese is not known.

Nickel-63 was found in well 299-W15-763 in August 2006 at 57.1 pCi/L. As a result, nickel-63 was added to the sampling schedule for the former upgradient wells at Waste Management Area TX-TY (now extraction wells for 200-ZP-1 pump-and-treat), selected wells between the waste management area and the pump-and-treat wells, and in downgradient wells 299-W14-13 and 299-W14-11. In FY 2007, the nickel-63 concentrations in the wells most affected by the pump-and-treat operation were very low between 4 and 8 pCi/L. The nickel concentrations in well 299-W14-13 were between 363 and 836 pCi/L and concentrations in well 299-W14-11 were between 63 and 163 pCi/L. One-twenty-fifth of the derived concentration guide (equivalent to 4 mrem or the drinking water standard for gross beta) for nickel-63 is 12,000 pCi/L, larger than the detected concentrations at the waste management area.

2.8.3.5 State-Approved Land Disposal Site

The Hanford Site 200 Area Effluent Treatment Facility processes contaminated aqueous waste from Hanford Site facilities. The treated wastewater occasionally contains tritium, which is not removed by the Effluent Treatment Facility, and is discharged to the 200 Area State-Approved Land Disposal Site. During FY 2007, 13.9 million liters of water were discharged to the State-Approved Land Disposal Site as compared to 15.7 million liters in FY 2006.



A state waste discharge permit (WAC 173-216) requires groundwater monitoring at this site. The permit was granted in June 1995 and the site began operations in December 1995. Groundwater monitoring requirements are described in the site monitoring plan (PNNL-13121). Groundwater monitoring for tritium only was conducted in 11 wells around the facility (Appendix B). The permit stipulates requirements for groundwater monitoring and establishes enforcement limits for concentrations of 15 constituents in three additional wells immediately surrounding the facility (Appendix B).

Wells immediately surrounding the facility were sampled four times in FY 2007. Tritium tracking wells were sampled either annually or semi-annually. Many of the wells south of the State-Approved Land Disposal Site in the tritium-tracking network have gone dry. Water-level measurements in the three wells nearest the State-Approved Land Disposal Site indicated a small localized groundwater mound beneath the site as a result of discharges. This mound results in radial flow outward a short distance before the regional northeastward flow predominates. This condition also places several wells south of the State-Approved Land Disposal Site hydraulically downgradient of the facility.

During FY 2007, 13.9 million liters of water were discharged to the State-Approved Land Disposal Site.

Average tritium concentrations decreased in two of three State-Approved Land Disposal Site proximal wells during FY 2007 compared with FY 2006 (Figure 2.8-22).

Concentrations of all chemical constituents with permit limits were within those limits during all of FY 2007. Acetone, benzene, chloroform and tetrahydrofuran were below method detection limits in all samples. Detectable concentrations of lead and

copper (maximum 1.69 and 3.29 µg/L, respectively) were reported at well 699-48-77A. Concentrations of major anions and cations continued at below-background levels observed prior to operation of the facility. The low concentrations are due to dilution by the otherwise clean water discharged to the State-Approved Land Disposal Site.

For all wells, the hydraulic head in March 2007 had declined an average of 0.25 meter from April 2006 level, or an annual decrease of 0.27 meter/year. The 200-UP-1 pump-and-treat system resumed in April 2007 and water from that system is discharged to the State-Approved Land Disposal Site. As a result, water levels are expected to increase in that area in the future. Water levels at the State-Approved Land Disposal Site proximal wells have declined at more rapid rates than outlying wells within the tritium-tracking system because discharge volumes decreased after cessation of the 200-UP-1 pump-and-treat system in January 2005. Numerical flow-and-transport modeling of the State-Approved Land Disposal Site was last conducted in August 2004, as required by the permit (PNNL-14898).

Table 2.8-1. Contaminants of Concern in all Wells in the 200-ZP-1 Groundwater Interest Area, FY 2007 (DOE/RL-2003-55)

Constituent	Filtered	Number of Wells, 2007	Number of Results	Detects	Rejects	Preliminary Target Action Level	Action Level Source	Results Above Standard	Wells Above Standard
1,1,1-Trichloroethane, ug/L	N	73	259	4		200	MCL		
1,1,1-Trichloroethane, ug/L	Y	1	2			200	MCL		
1,2-Dichloroethane, ug/L	N	73	259	1		5	CRDL		
1,2-Dichloroethane, ug/L	Y	1	2			5	CRDL		
2-Butanone, ug/L	N	73	306	8		4,800	CLARC		
2-Butanone, ug/L	Y	1	2			4,800	CLARC		
2-Pentanone, 4-Methyl, ug/L	N	73	259			640	CLARC		
2-Pentanone, 4-Methyl, ug/L	Y	1	2			640	CLARC		
Acetone, ug/L	N	73	307	20		800	CLARC		
Acetone, ug/L	Y	1	2			800	CLARC		
Antimony, ug/L	N	12	59	25		10	CRDL		
Antimony, ug/L	Y	72	259	3		10	CRDL	3	3
Arsenic, ug/L	N	5	52	50		10	CRDL		
Arsenic, ug/L	Y	11	30	18		10	CRDL	2	1
Benzene, ug/L	N	73	342	9		5	CRDL		
Benzene, ug/L	Y	1	2			5	CRDL		
Cadmium, ug/L	N	14	66	2		5	MCL		
Cadmium, ug/L	Y	72	261			5	MCL		
Carbon disulfide, ug/L	N	73	259	42		800	CLARC	1	1
Carbon disulfide, ug/L	Y	1	2			800	CLARC		
Carbon tetrachloride, ug/L	N	72	469	423	1	3	CRDL	407	59
Carbon tetrachloride, ug/L	Y	1	7	7		3	CRDL	7	1
Carbon-14, pCi/L	N	1	1			2,000	MCL		
Cesium-137, pCi/L	N	23	36			60	MCL		
Chlorobenzene, ug/L	N	37	195	1		100	MCL		
Chlorobenzene, ug/L	Y	1	2			100	MCL		
Chloroform, ug/L	N	73	466	419		7	CLARC	331	38
Chloroform, ug/L	Y	1	7	7		7	CLARC	4	1
Chromium, ug/L	N	12	59	52		100	MCL	6	3
Chromium, ug/L	Y	72	259	222		100	MCL	31	11
cis-1,2-Dichloroethene, ug/L	N	68	201	3		70	MCL		
Cresol (total):						80	CLARC		
2-Methylphenol (cresol, o-), ug/L	N	15	18						
3+4 Methylphenol (cresol, m+p), ug/L	N	15	18						
Cyanide, ug/L	N	2	9	1		200	MCL		
Ethylbenzene, ug/L	N	71	246	2		700	MCL		
Ethylbenzene, ug/L	Y	1	2			700	MCL		

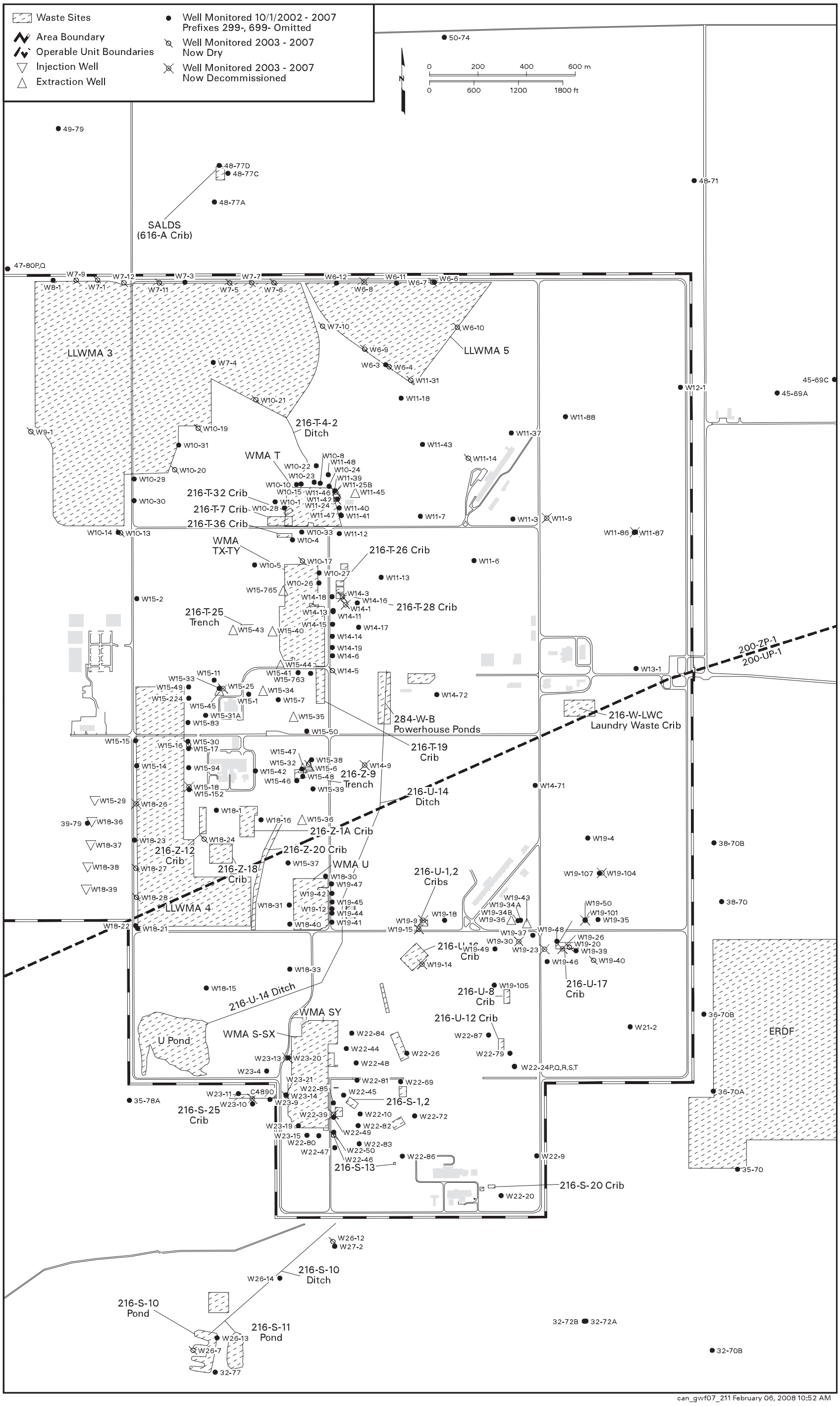
Table 2.8-1. (contd)

Constituent	Filtered	Number of Wells, 2007	Number of Results	Detects	Rejects	Preliminary Target Action Level	Action Level Source	Results Above Standard	Wells Above Standard
Fluoride, ug/L	N	90	420	418		4,000	MCL	8	4
Fluoride, ug/L	Y	2	2	2		4,000	MCL		
Hexavalent Chromium, ug/L	N	15	63	46		48	CLARC	12	3
Hexavalent Chromium, ug/L	Y	2	2			48	CLARC		
Iodine-129, pCi/L	N	60	185	20		1	MCL	20	6
Iodine-129, pCi/L	Y	1	2			1	MCL		
Iron, ug/L	N	12	59	37		300	2nd MCL	4	2
Iron, ug/L	Y	72	259	123		300	2nd MCL	1	1
Lead, ug/L	N	7	59	20		15	MCL		
Lead, ug/L	Y	19	35	1		15	MCL		
Magnesium, ug/L	N	12	59	59			TBD		
Magnesium, ug/L	Y	72	259	257	1		TBD		
Manganese, ug/L	N	14	66	57		50	2nd MCL	31	4
Manganese, ug/L	Y	72	261	111	1	50	2nd MCL	20	5
Mercury, ug/L	N	3	13	1		2	MCL		
Mercury, ug/L	Y	18	33	1		2	MCL		
Methylene chloride, ug/L	N	73	300	21		5	MCL	6	4
Methylene chloride, ug/L	Y	1	2	1		5	MCL	1	1
n-Butylbenzene, ug/L	N	1	6			320	CLARC		
Neptunium-237, pCi/L	N	1	1			15	MCL		
Nickel, ug/L	N	12	59	55		320	CLARC		
Nickel, ug/L	Y	72	259	71		320	CLARC		
Nitrate, ug/L	N	91	503	498	5	12,400	Background	461	84
Nitrate, ug/L	Y	3	8	8		12,400	Background	8	3
Nitrite, ug/L	N	89	411	40	71	3,268	MCL	7	3
Nitrite, ug/L	Y	1	1			3,268	MCL		
Pentachlorophenol, ug/L	N	15	18				TBD		
Phenol (total):							TBD		
2,3,4,6-Tetrachlorophenol, ug/L	N	15	17						
2,4,5-Trichlorophenol, ug/L	N	15	17						
2,4,6-Trichlorophenol, ug/L	N	15	17						
2,4-Dichlorophenol, ug/L	N	15	18						
2,4-Dimethylphenol, ug/L	N	15	17						
2,4-Dinitrophenol, ug/L	N	15	17						
2,6-Dichlorophenol, ug/L	N	15	17						
2-Chlorophenol, ug/L	N	15	17						
2-Nitrophenol, ug/L	N	15	18						
Dinoseb(2-secButyl-4,6-dinitrophenol), ug/L	N	15	17						

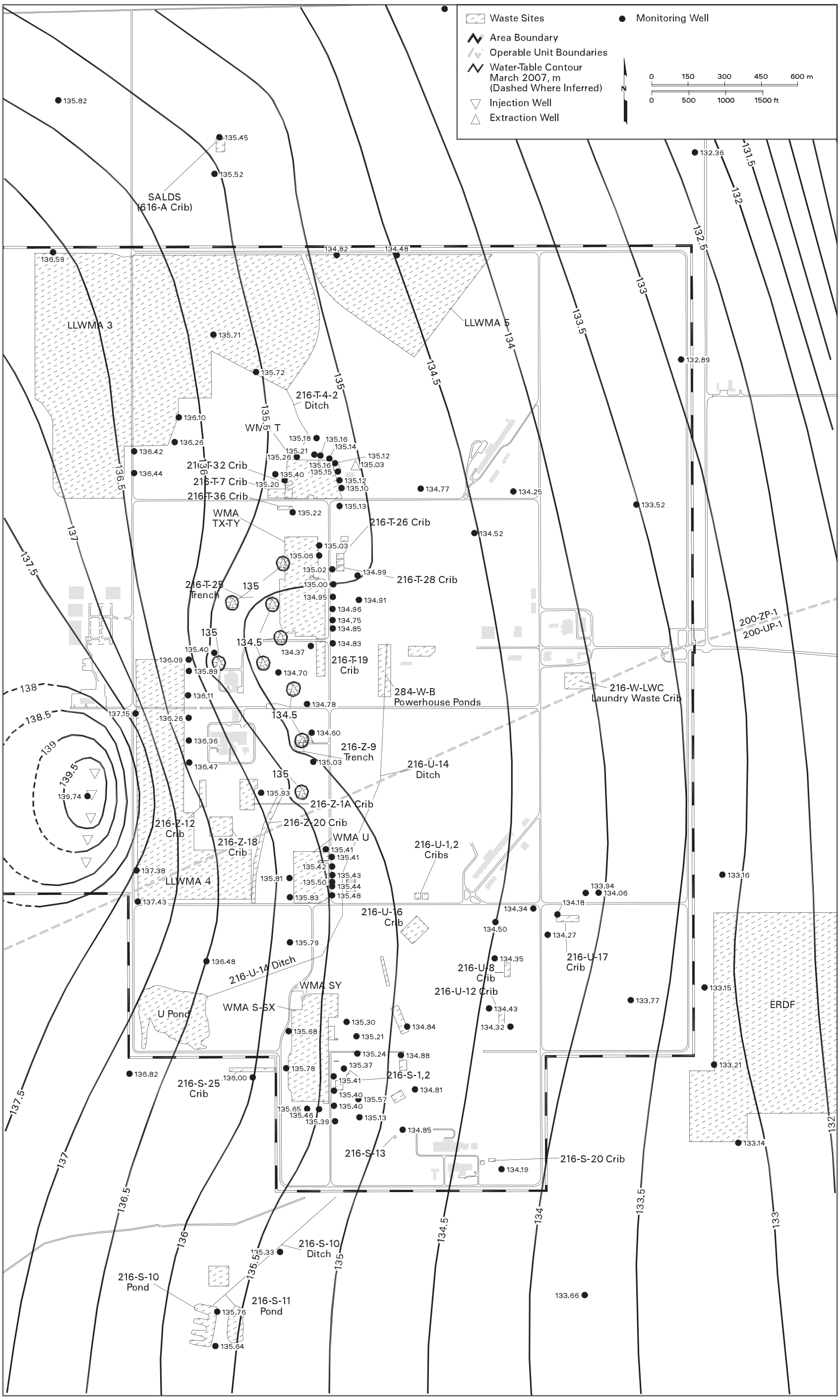
Table 2.8-1. (contd)

Constituent	Filtered	Number of Wells, 2007	Number of Results	Detects	Rejects	Preliminary Target Action Level	Action Level Source	Results Above Standard	Wells Above Standard
4,6-Dinitro-2-methylphenol, ug/L	N	15	17						
4-Chloro-3-methylphenol, ug/L	N	15	17						
4-Nitrophenol, ug/L	N	15	17						
Phenol, ug/L	N	15	18				TBD		
Phosphate, ug/L	N	7	79				TBD		
Selenium, ug/L	N	3	13	5		50	MCL		
Selenium, ug/L	Y	3	13	6		50	MCL		
Selenium-79, pCi/L	N	1	1				MCL		
Silver, ug/L	N	10	20	6		80	CLARC		
Silver, ug/L	Y	72	259	42		80	CLARC		
Strontium-90, pCi/L	N	22	78	2		8	MCL		
Strontium-90, pCi/L	Y	1	2			8	MCL		
Technetium-99, pCi/L	N	77	396	339	3	900	MCL	109	16
Technetium-99, pCi/L	Y	2	7	3		900	MCL		
Tetrachloroethene, ug/L	N	73	303	88		5	CRDL	1	1
Tetrachloroethene, ug/L	Y	1	7			5	CRDL		
Toluene, ug/L	N	73	342	5		1,000	MCL		
Toluene, ug/L	Y	1	2			1,000	MCL		
trans-1,2-Dichloroethylene, ug/L	N	68	200	1		100	MCL		
Trichloroethene, ug/L	N	73	471	342		5	CRDL	187	22
Trichloroethene, ug/L	Y	1	7	4		5	CRDL	1	1
Tritium, pCi/L	N	87	348	282	1	20,000	MCL	36	9
Tritium, pCi/L	Y	1	2	1		20,000	MCL		
Uranium, ug/L	N	38	146	146		30	MCL	2	1
Uranium, ug/L	Y	5	16	16		30	MCL		
Vanadium, ug/L	N	12	59	59		112	CLARC		
Vanadium, ug/L	Y	72	259	248		112	CLARC		
Xylenes (total), ug/L	N	73	259	1		10,000	MCL		
Xylenes (total), ug/L	Y	1	2			10,000	MCL		

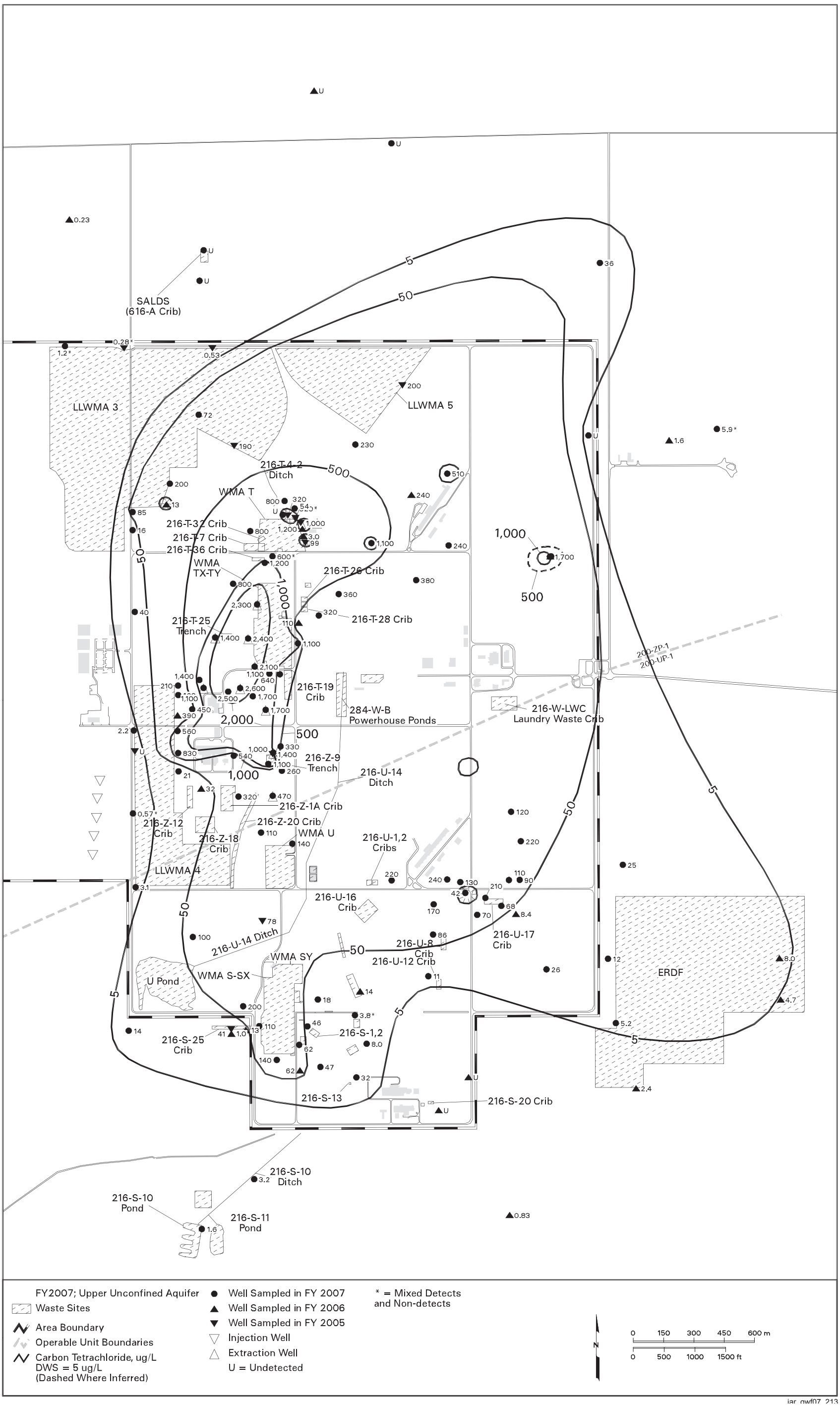
Shaded areas are groups of constituents with a single preliminary target action level.
CLARC = Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation (Ecology 2001).
CRDL = Contract-required detection limit.
MCL = Maximum contaminant level.
TBD = To be determined.



2.8-1. Groundwater Monitoring Wells in 200 West Area



2.8-2. 200 West Area Water-Table Map, March 2007



2.8-3. Average Carbon Tetrachloride Concentrations in 200 West Area, Upper Part of Unconfined Aquifer

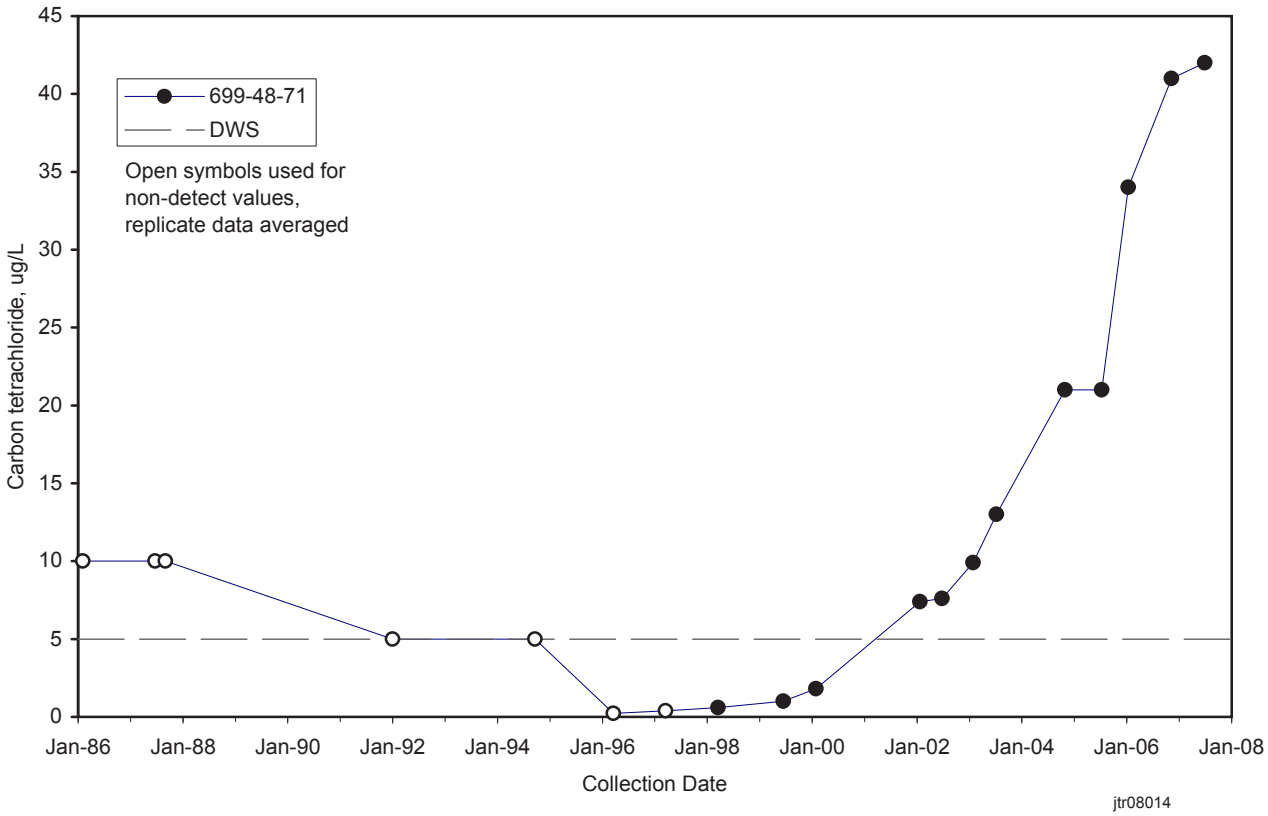


Figure 2.8-4. Carbon Tetrachloride Concentration at Well 699-48-71, Northeast of the 200 West Area

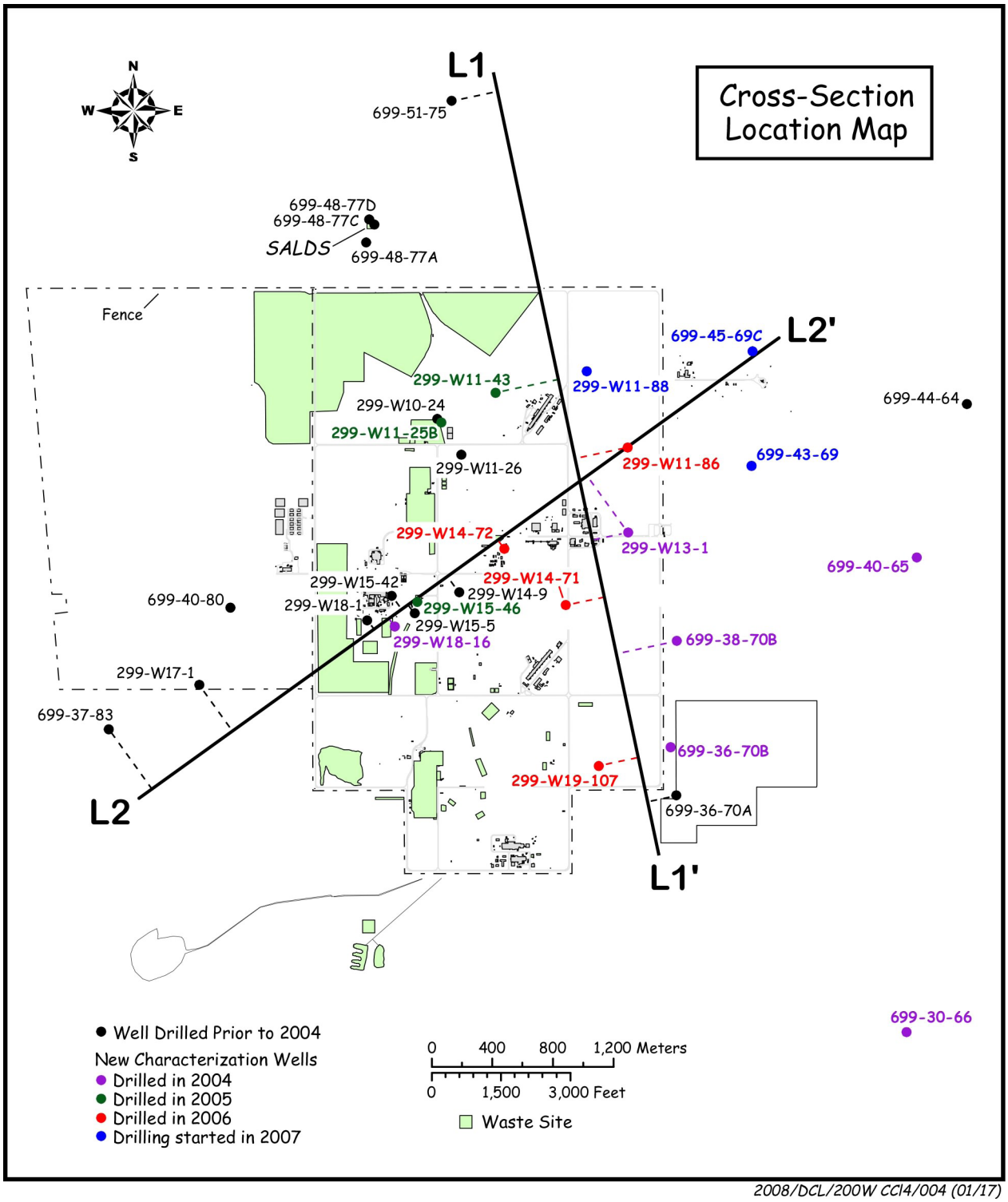


Figure 2.8-5. Location of Cross Sections Shown in Figures 2.8-6 and 2.8-7 Including Wells Used for Interpretation

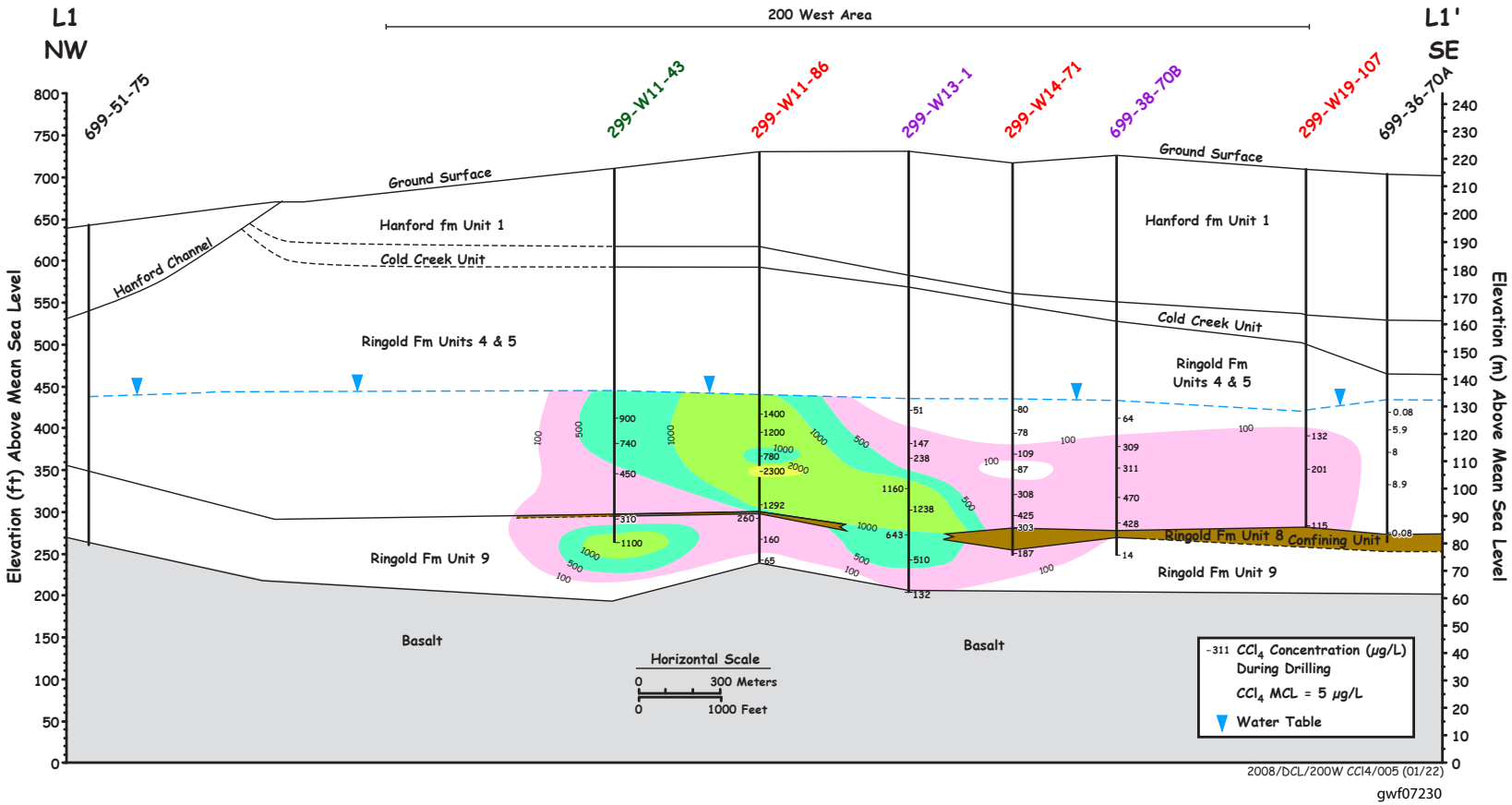


Figure 2.8-6. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Northwest to Southeast (modified from DOE/RL-2006-24)

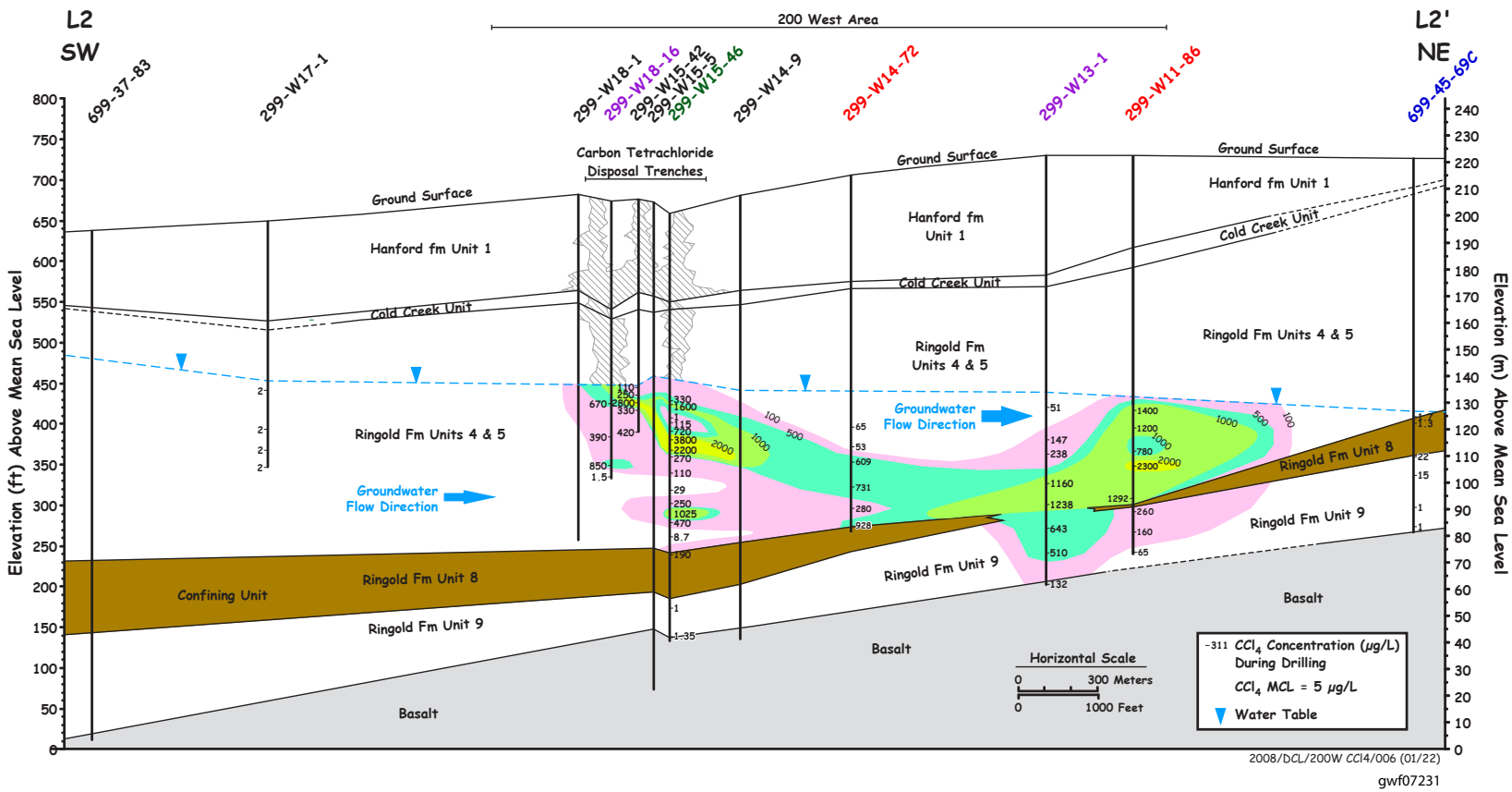


Figure 2.8-7. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Southwest to Northeast (modified from DOE/RL-2006-24)

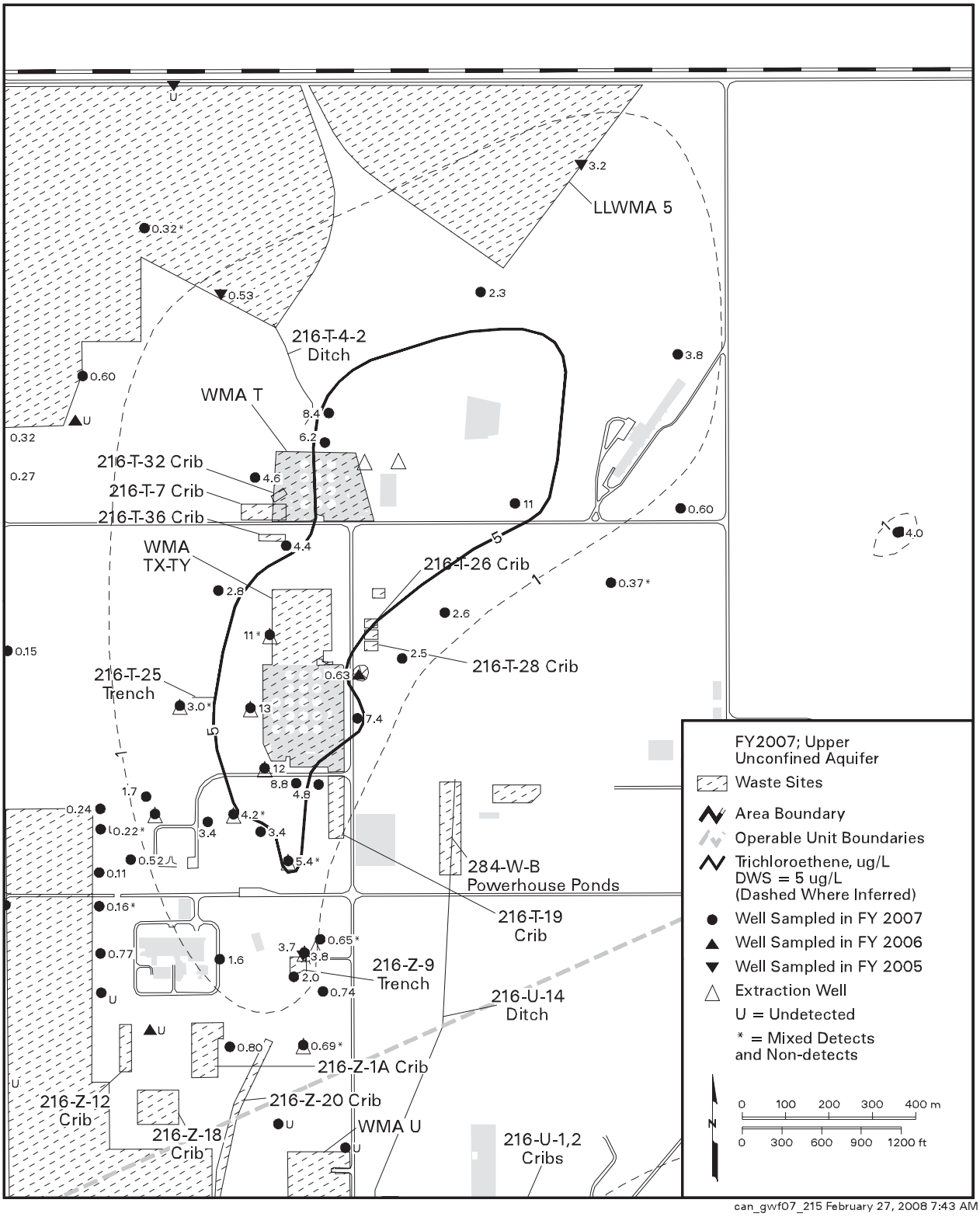


Figure 2.8-8. Average Trichloroethene Concentrations in Central and North 200 West Area, Upper Part of Unconfined Aquifer

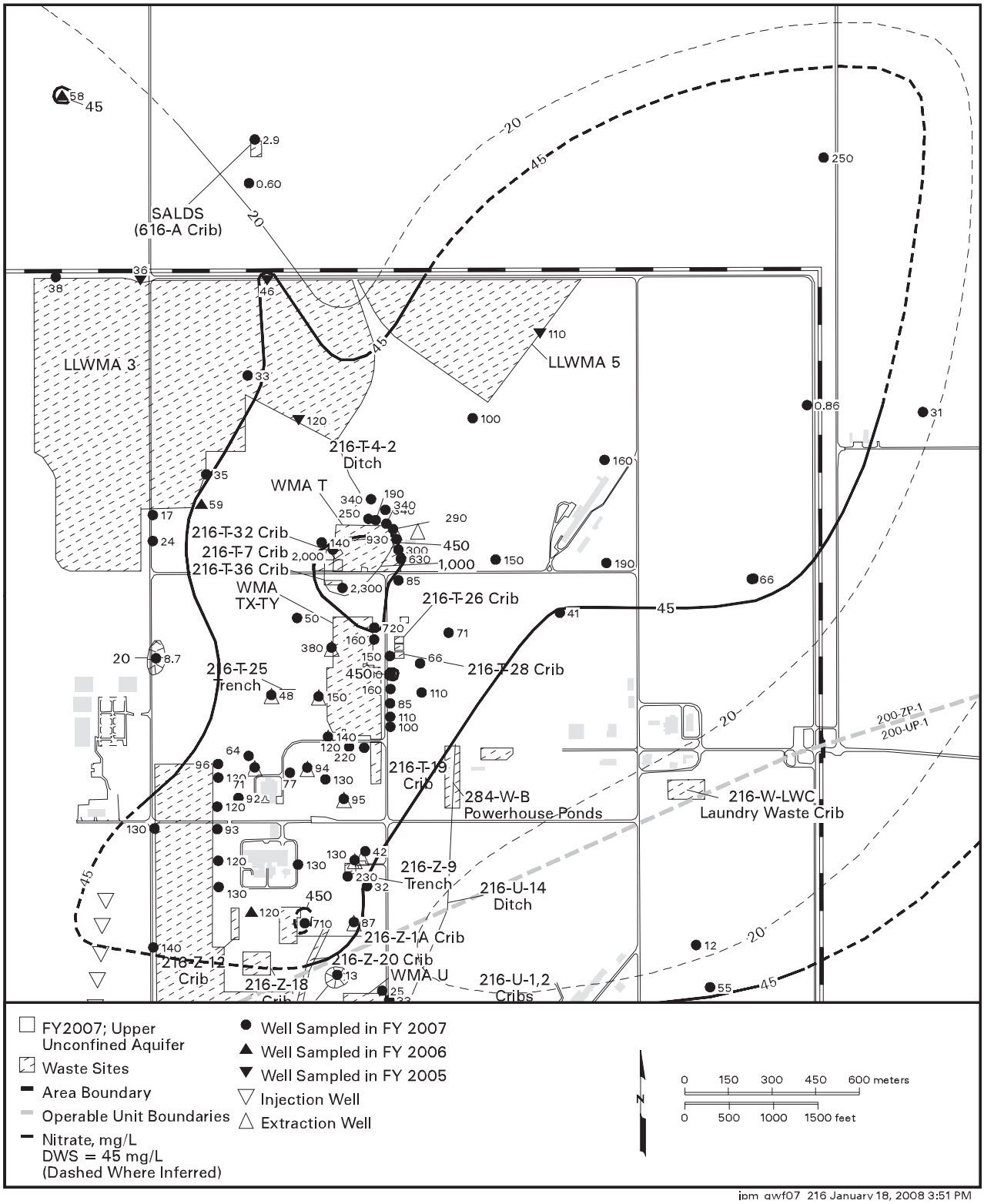


Figure 2.8-9. Average Nitrate Concentrations in Central and North 200 West Area, Upper Part of Unconfined Aquifer

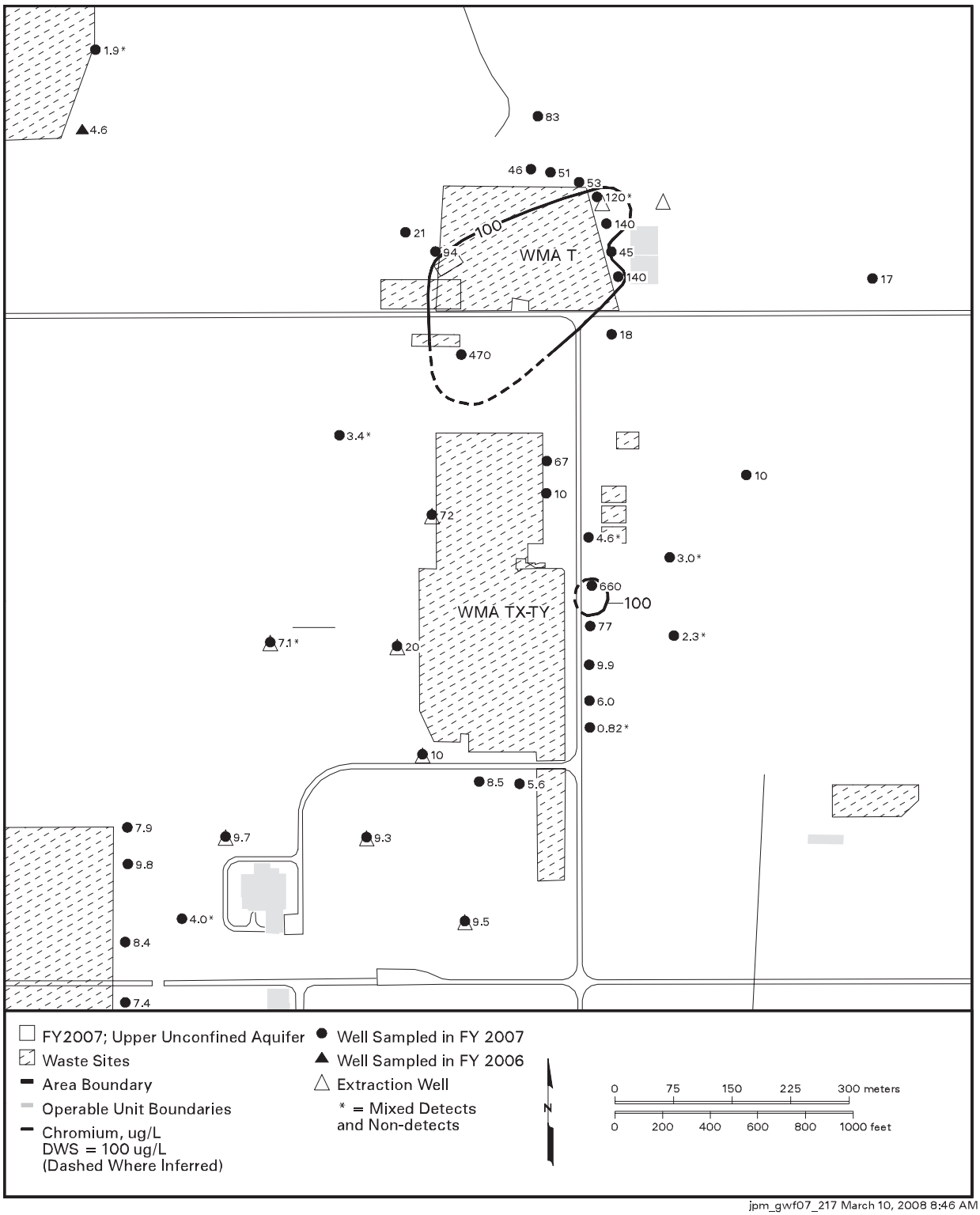


Figure 2.8-10. Average Chromium Concentrations Near Waste Manangement Areas T and TX-TY, Upper Part of Unconfined Aquifer

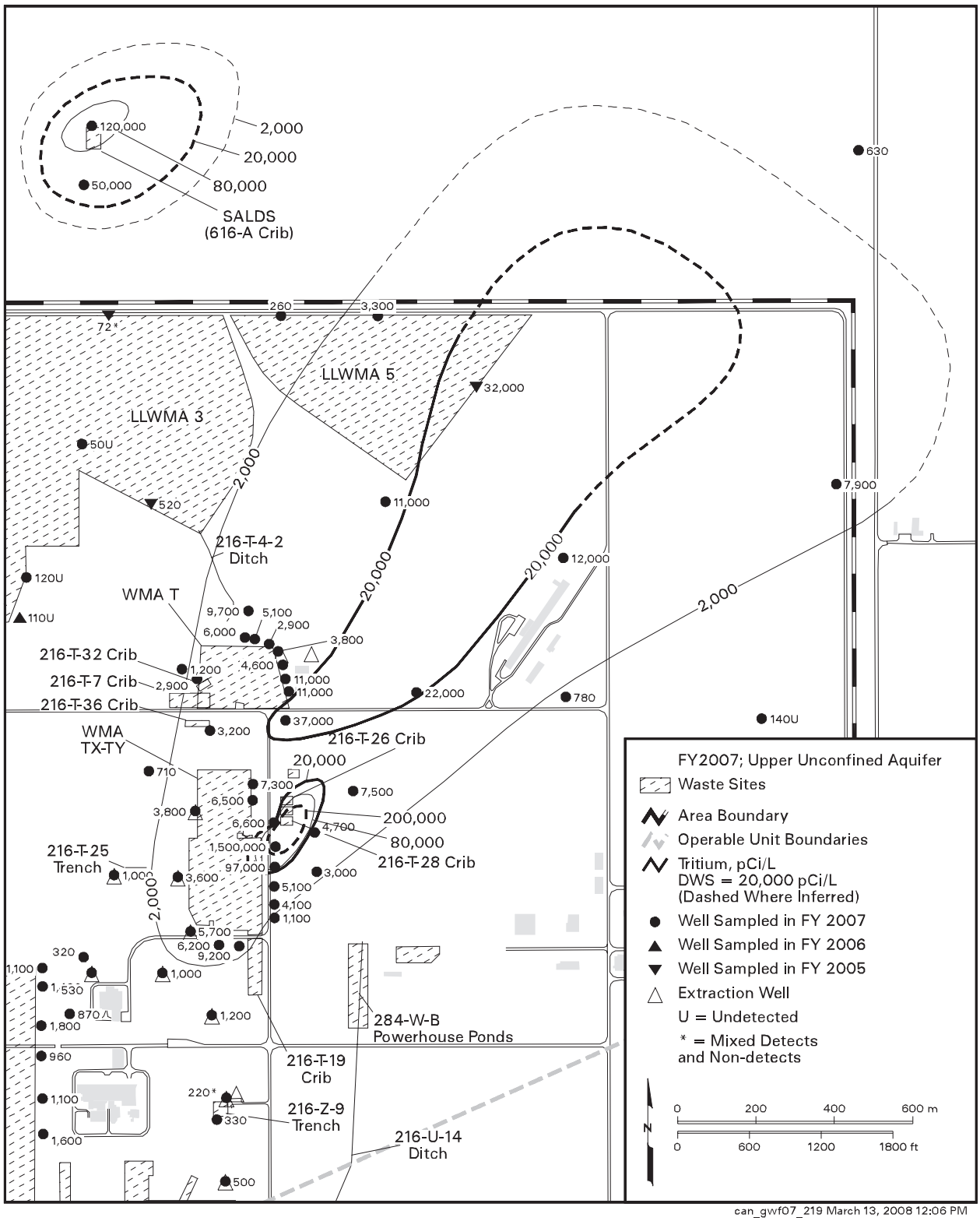


Figure 2.8-11. Average Tritium Concentrations in North 200 West Area, Upper Part of Unconfined Aquifer

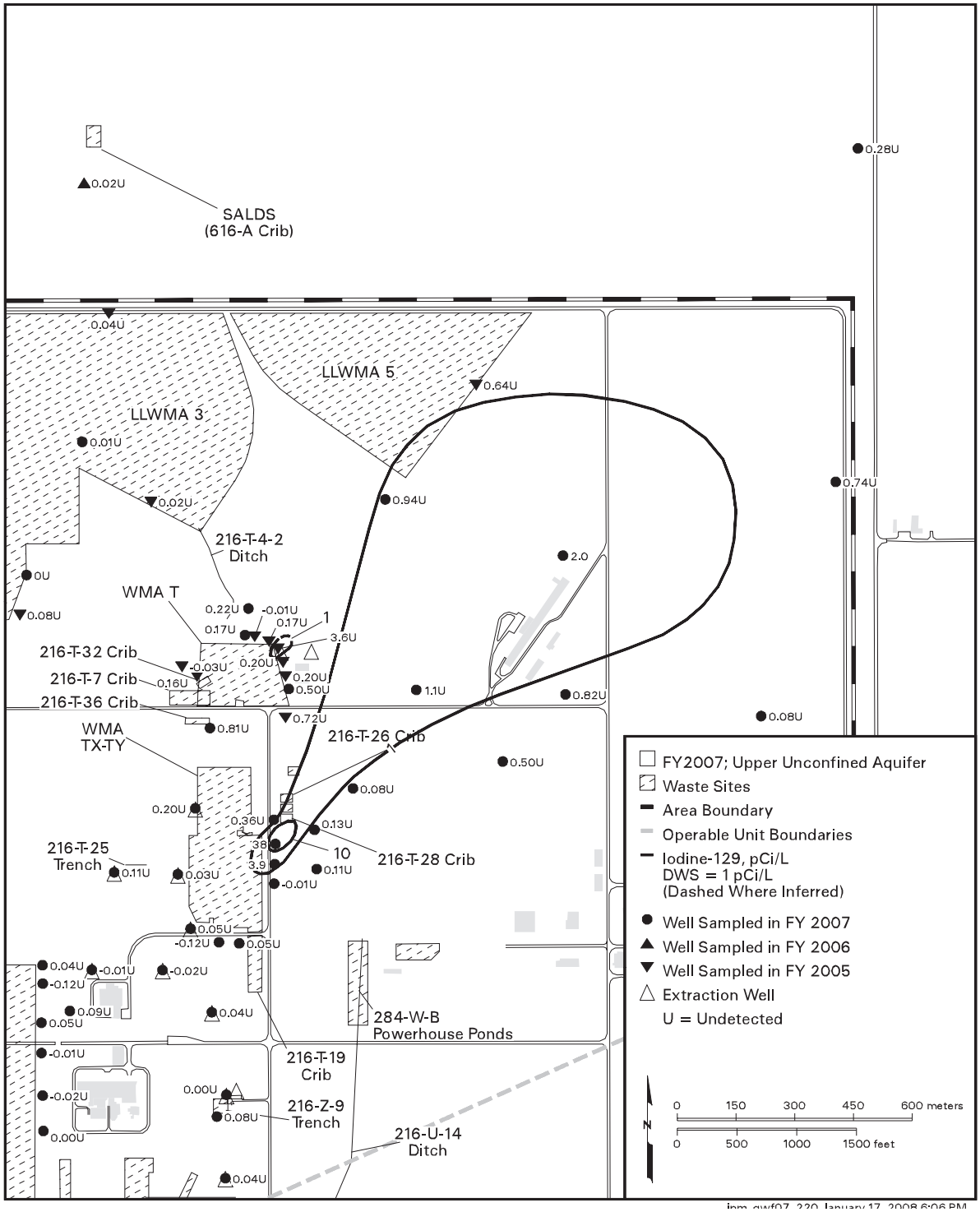


Figure 2.8-12. Average Iodine-29 Concentrations in North 200 West Area, Upper Part of Unconfined Aquifer

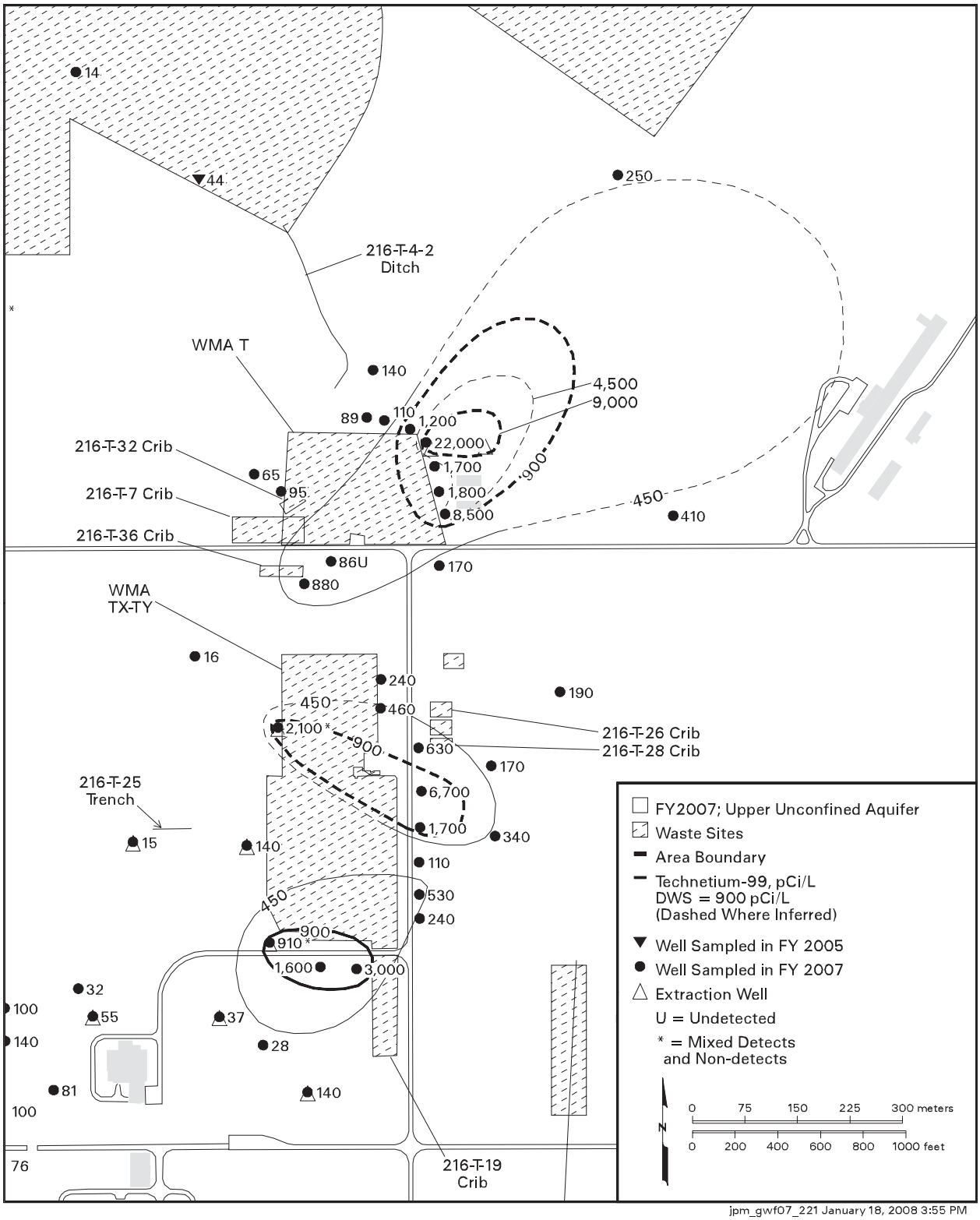


Figure 2.8-13. Average Technetium-99 Concentrations in North 200 West Area, Upper Part of Unconfined Aquifer

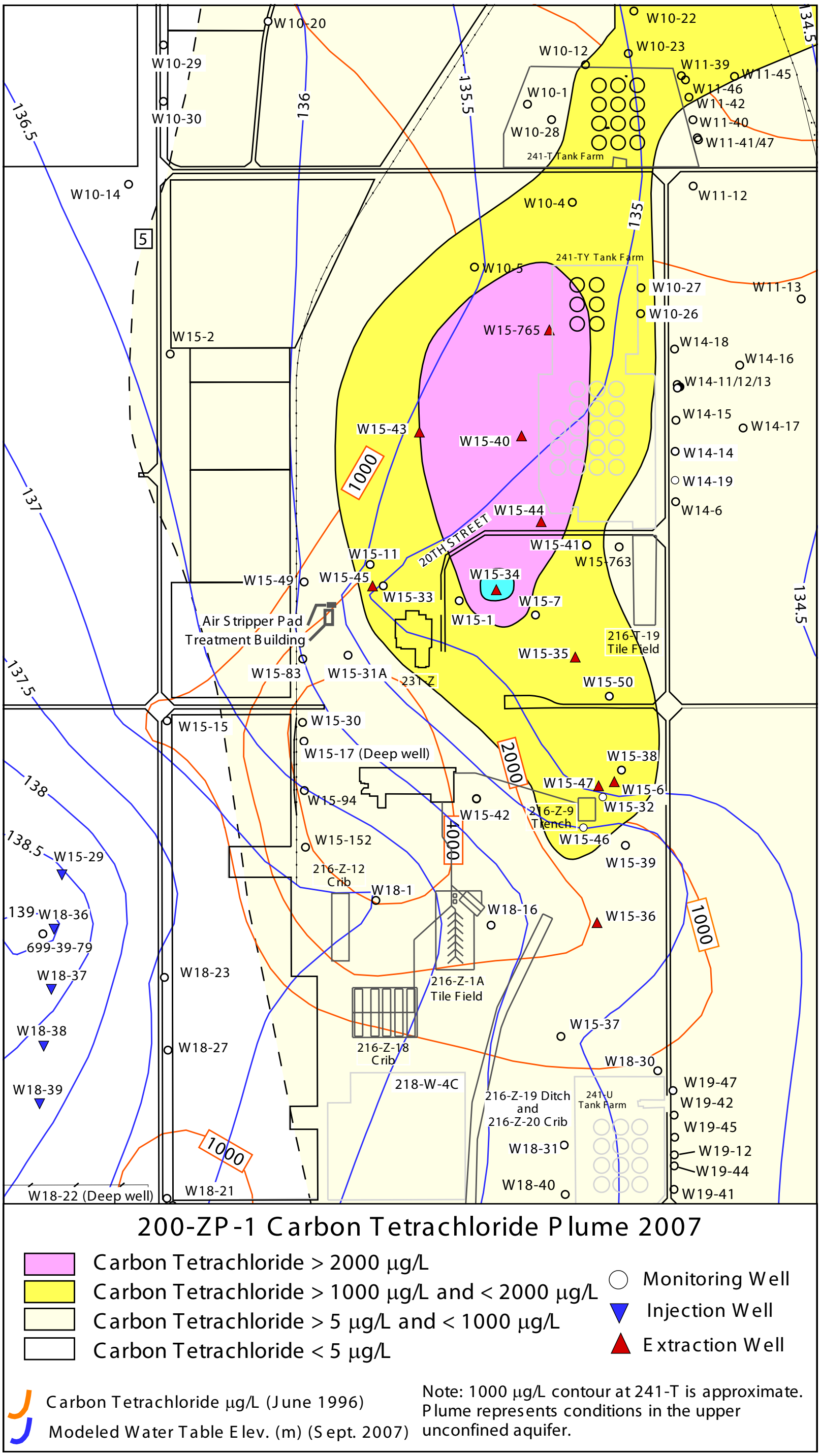


Figure 2.8-14. 200-ZP-1 Pump-and-Treat Map for Carbon Tetrachloride

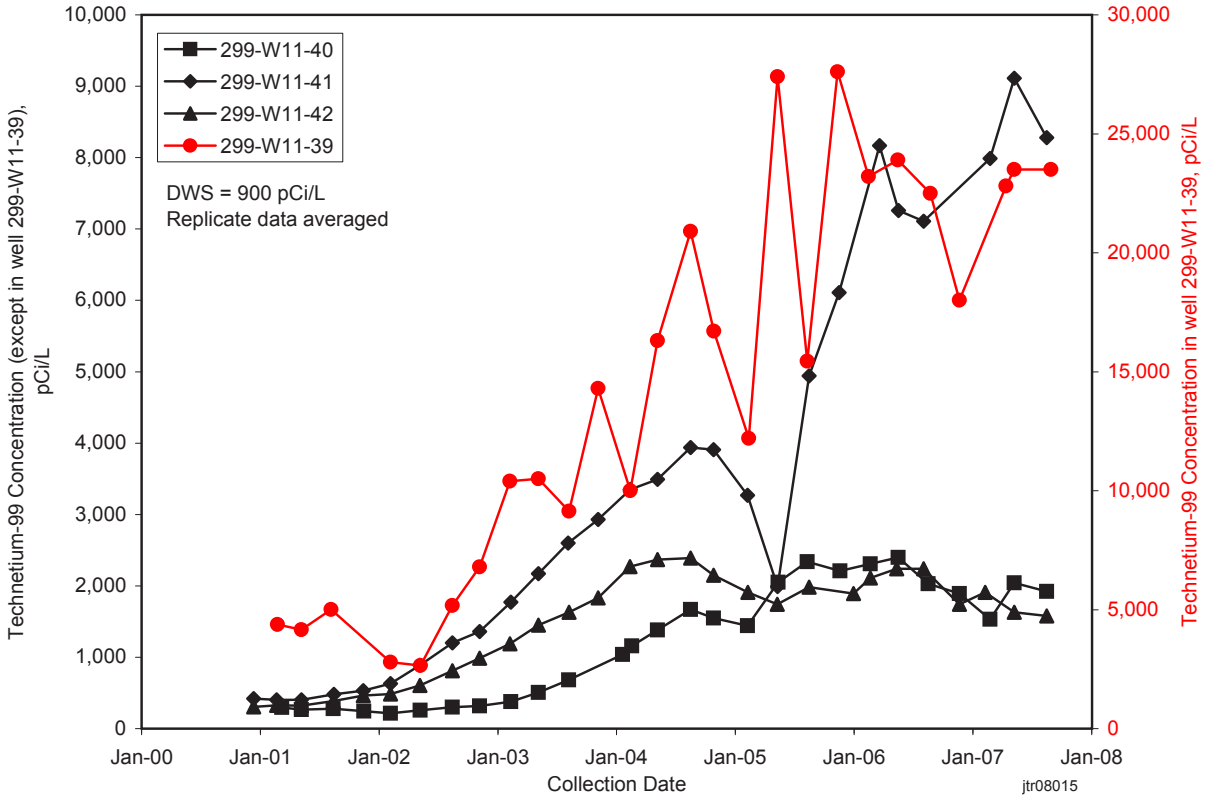


Figure 2.8-15. Technetium-99 Concentrations in Selected Downgradient Water-Table Wells at Waste Management Area T

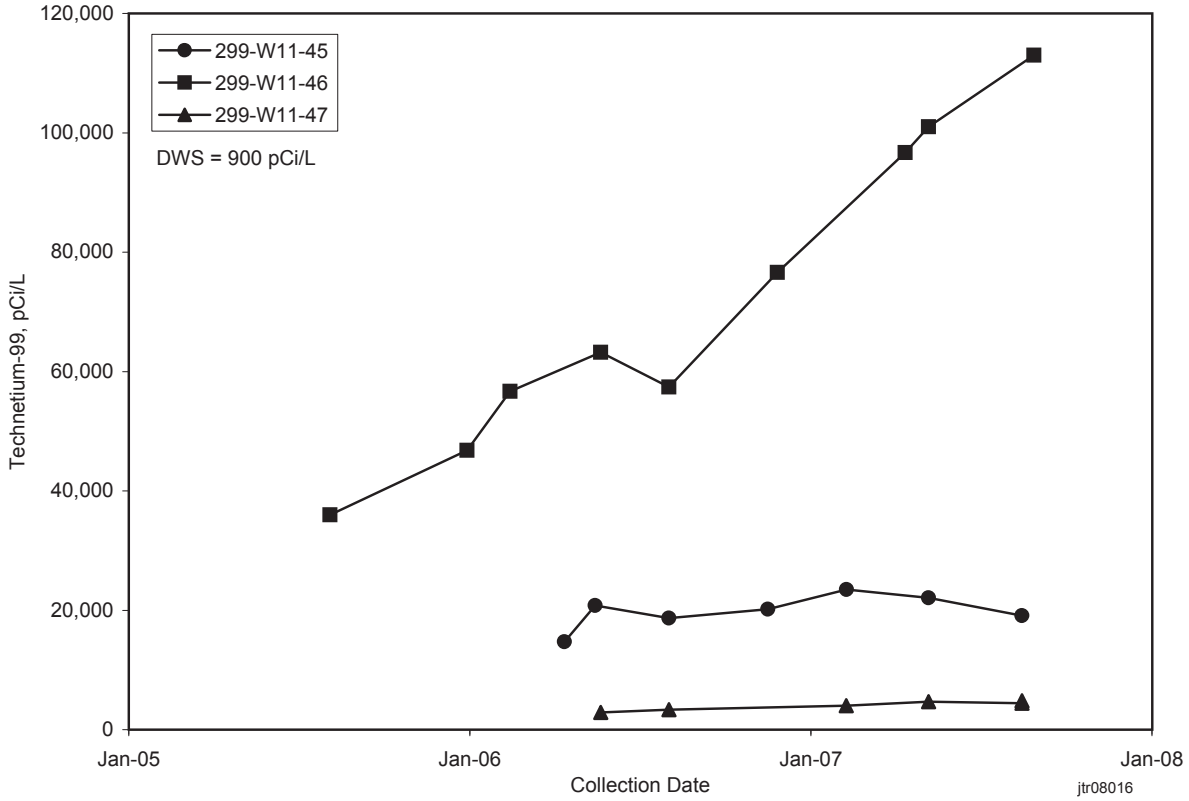


Figure 2.8-16. Technetium-99 Concentrations in Selected Downgradient Wells at Waste Management Area T (screened below the water table)

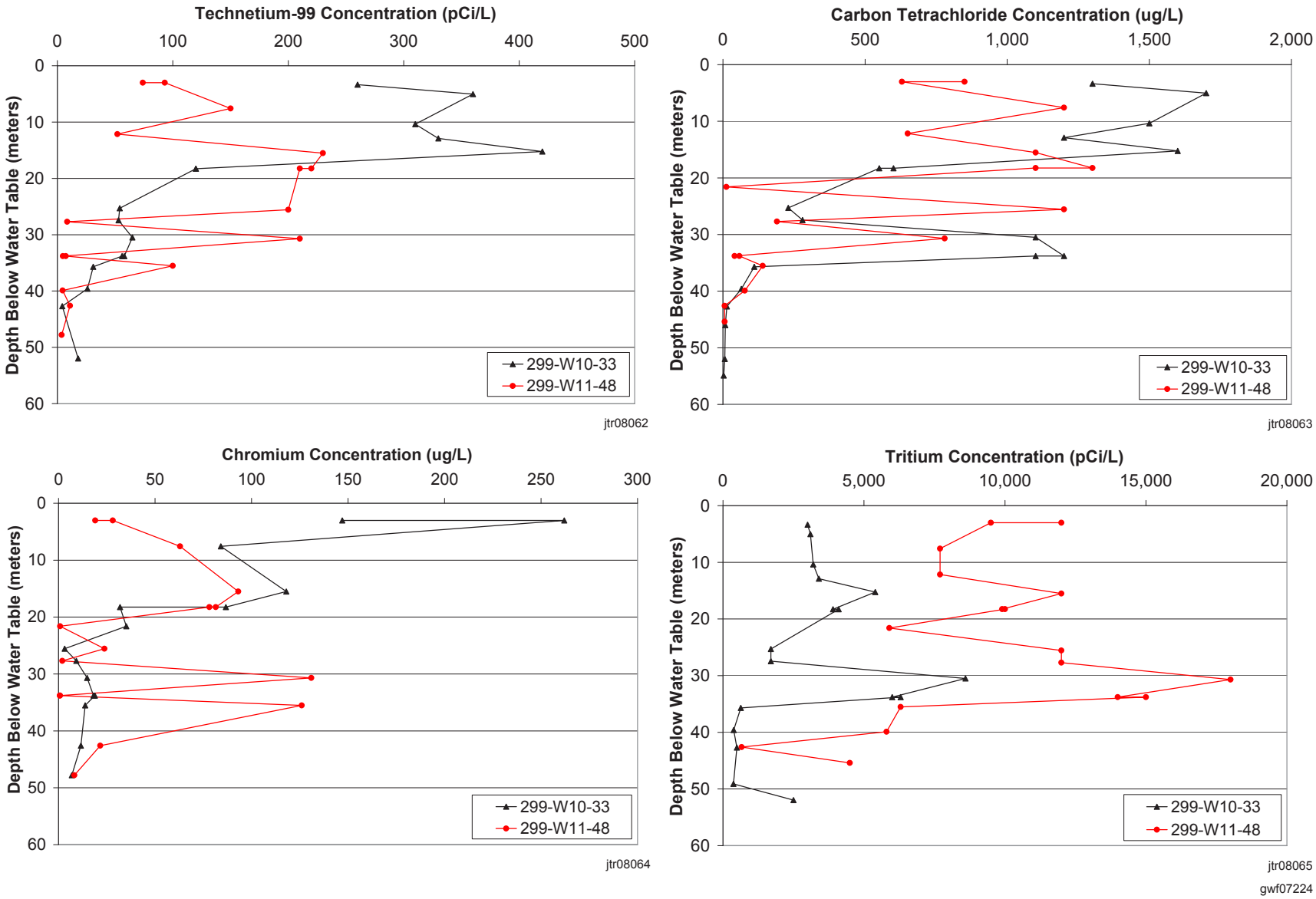


Figure 2.8-17. Concentrations with Depth of Contaminants in New Wells 299-W10-33 and 299-W11-48 (data collected during drilling)

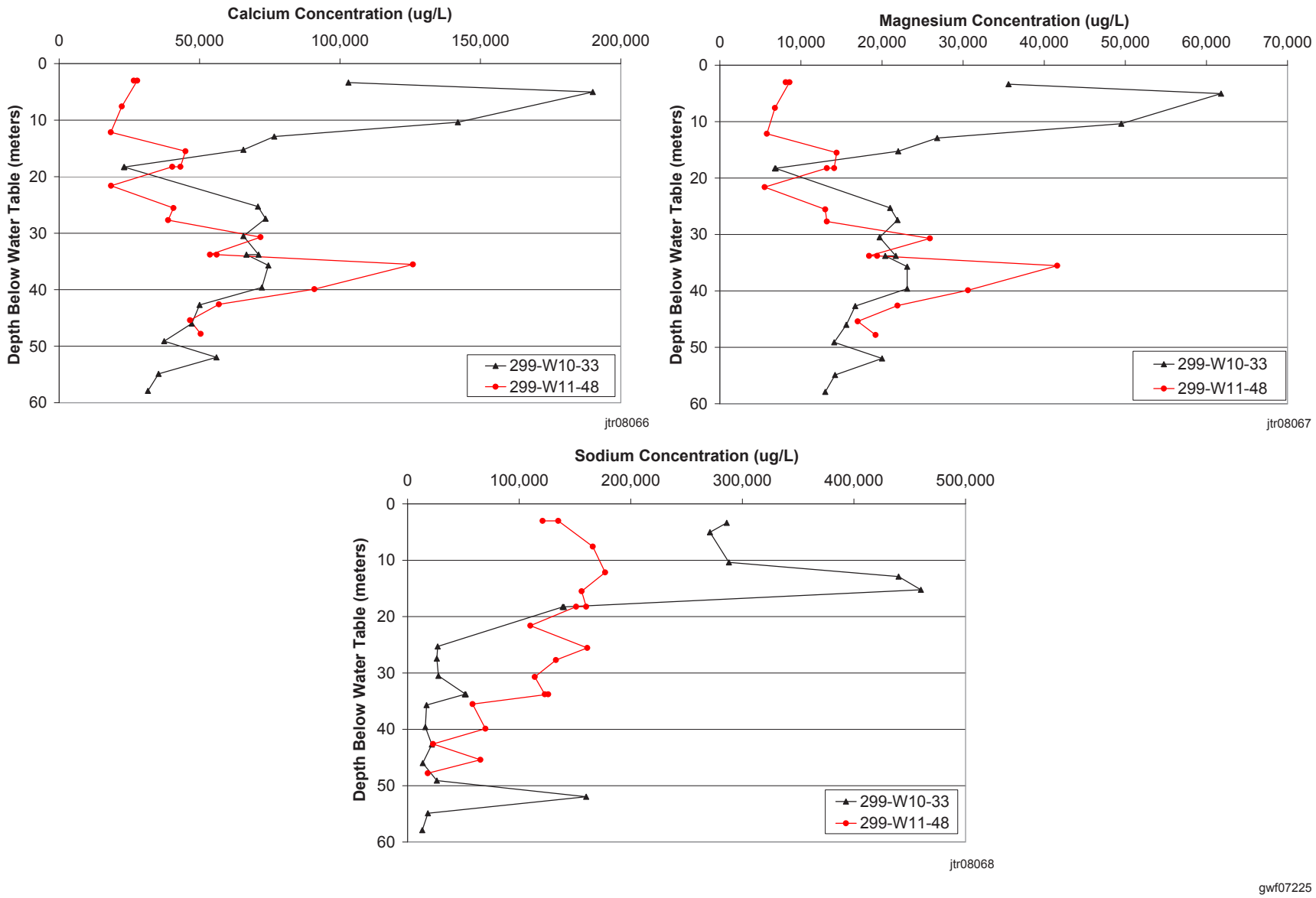


Figure 2.8-18. Major Metal Concentrations versus Depth in New Wells 299-W10-33 and 299-W11-48

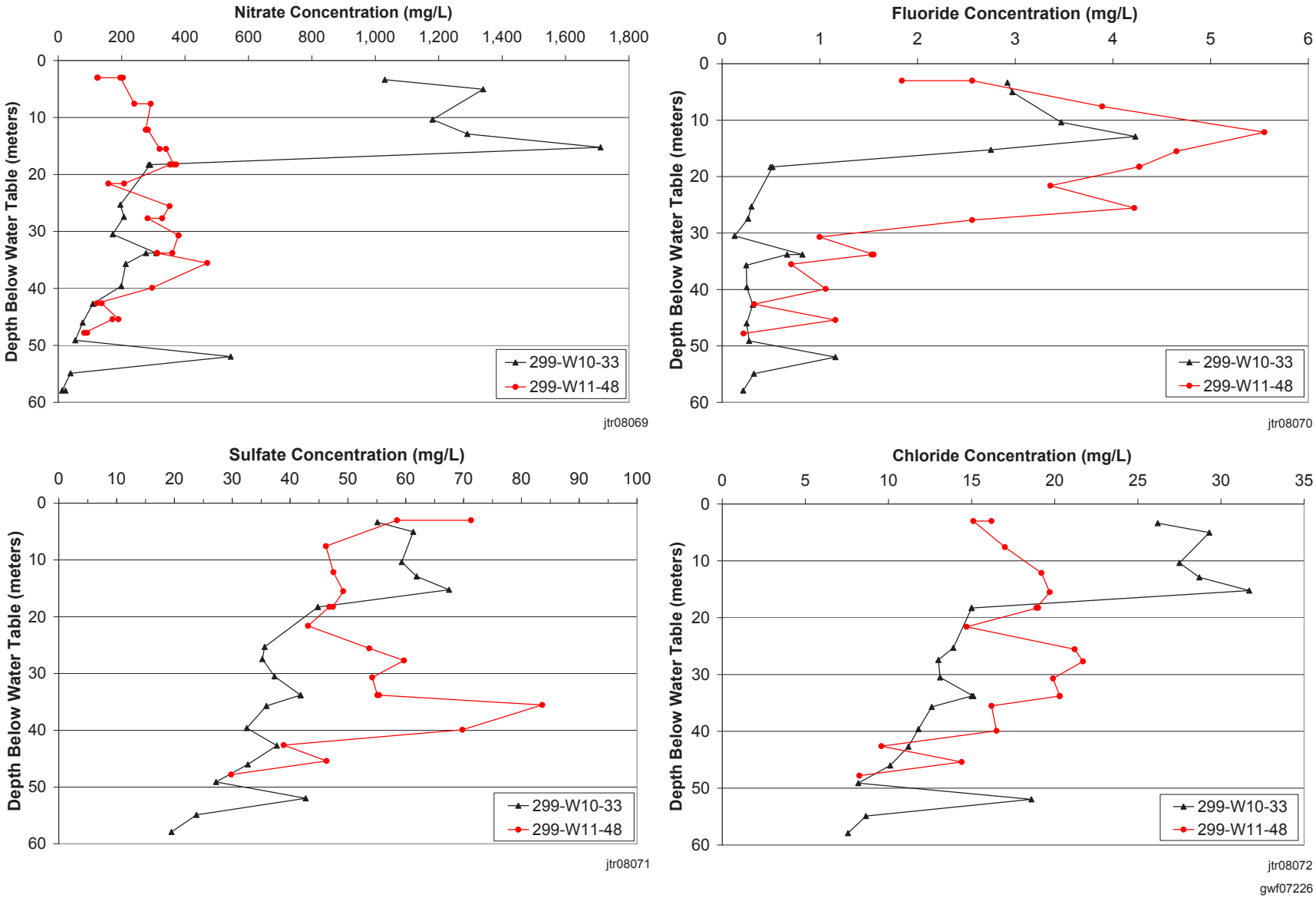


Figure 2.8-19. Anion Concentrations versus Depth in New Wells 299-W10-33 and 299-W11-48

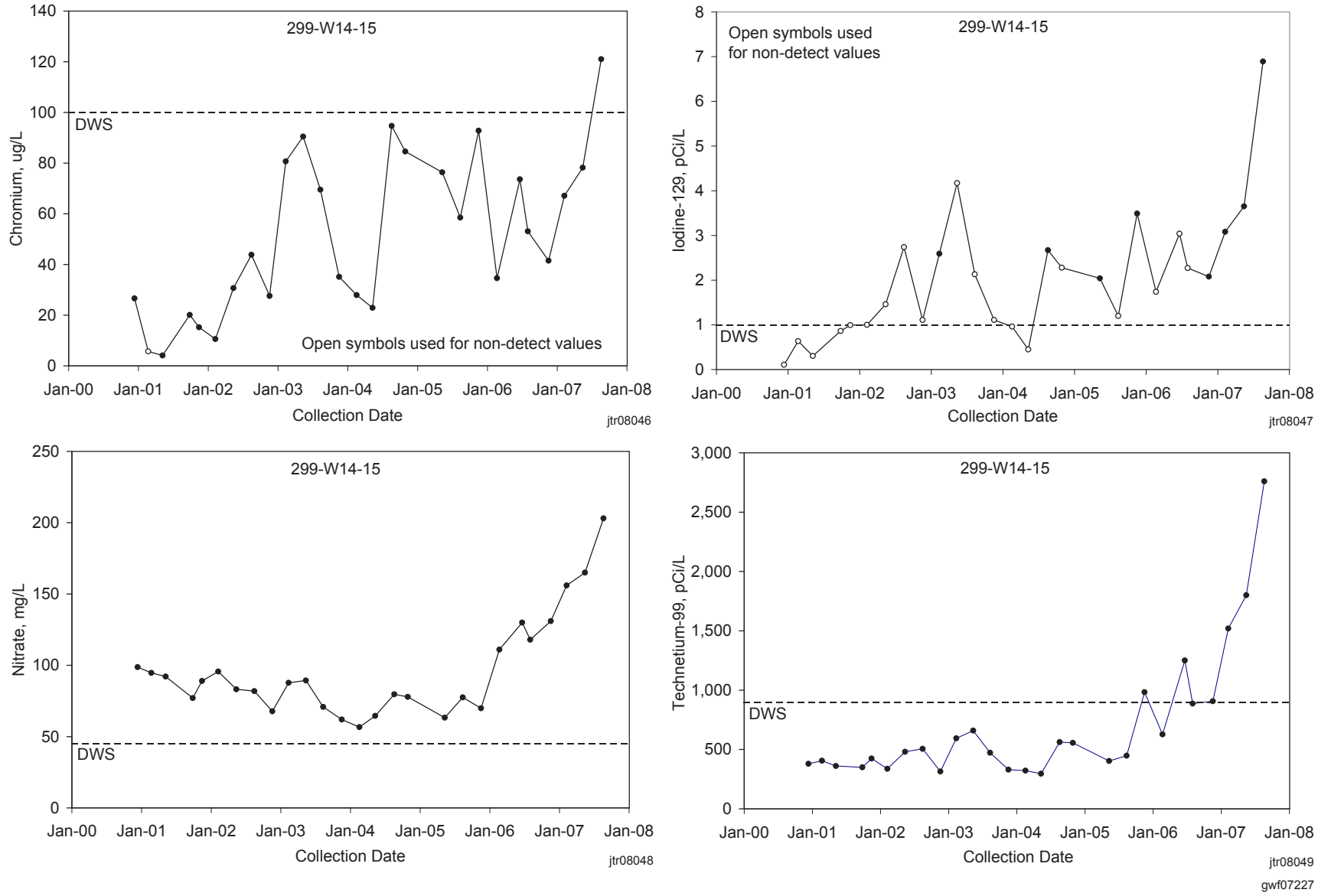


Figure 2.8-20. Concentrations of Selected Contaminants in Well 299-W14-15, Waste Management Area TX-TY

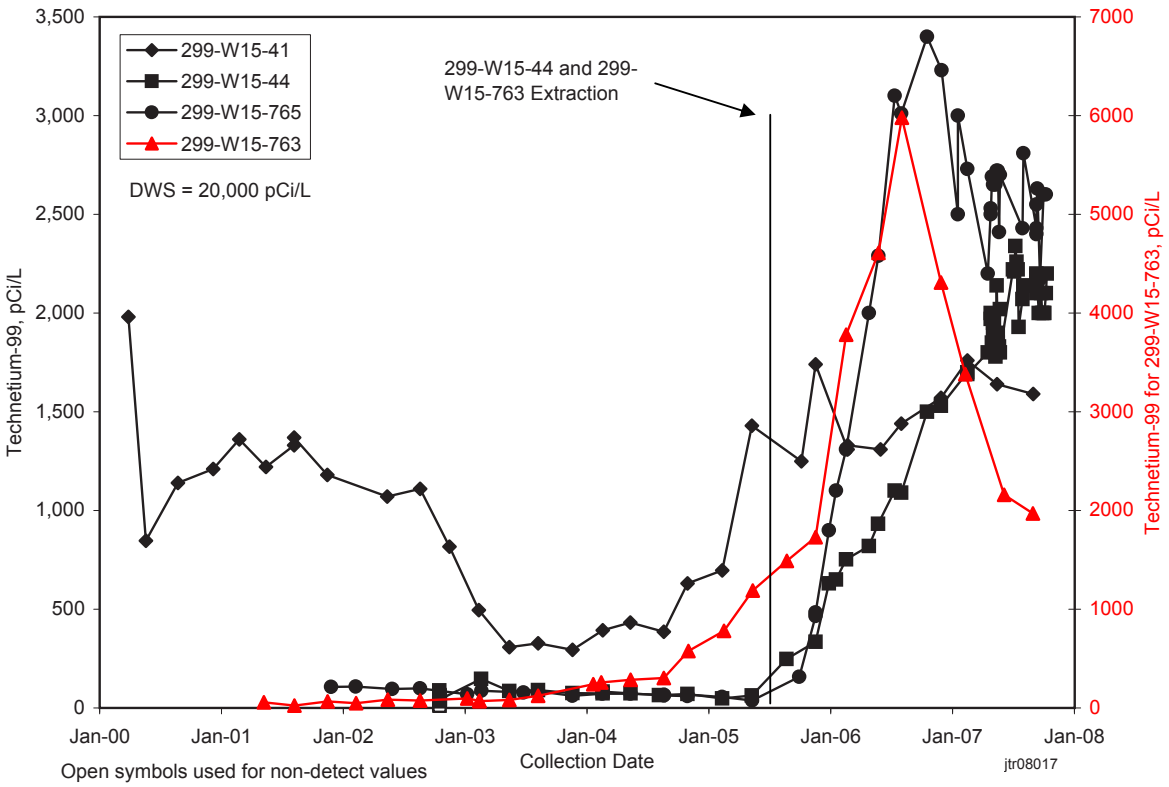


Figure 2.8-21. Technetium-99 Concentrations versus Time for Four Wells at Waste Management Area TX-TY Influenced by the 200-ZP-1 Pump-and-Treat System (wells 299-W15-44 and 299-W15-763 are extraction wells)

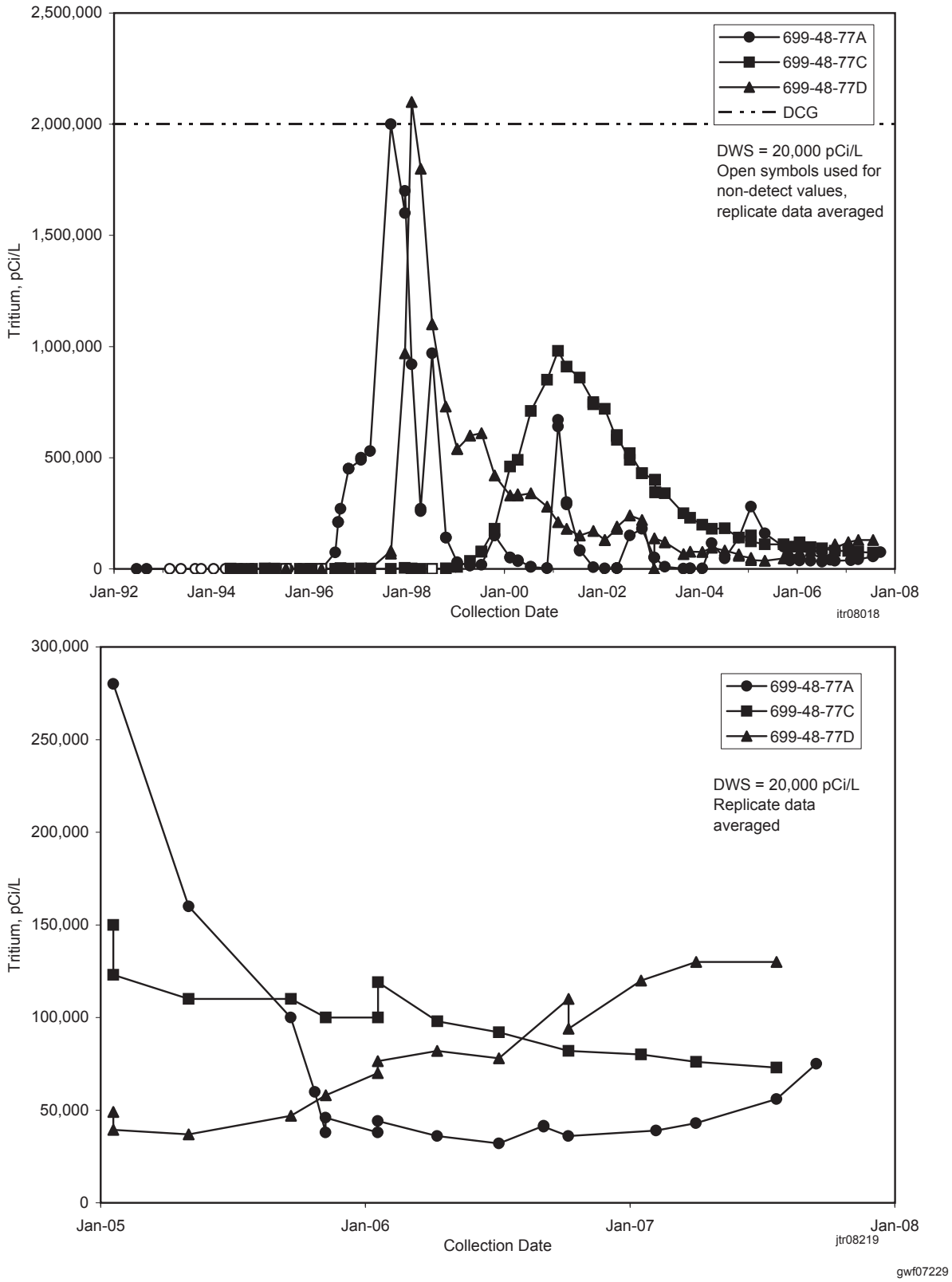


Figure 2.8-22. Tritium Concentrations in Wells Monitoring the State-Approved Land Disposal Site

2.9 200-UP-1 Operable Unit

J. P. McDonald, B. A. Williams, D. B. Erb, and R. L. Weiss

The scope of this section is the 200-UP-1 groundwater interest area, which addresses groundwater contaminant plumes beneath the southern third of the 200 West Area and adjacent portions of the surrounding 600 Area (see Figure 1.0-1 in Section 1.0). This region includes the 200-UP-1 Operable Unit. The "groundwater interest areas" are informal designations to facilitate scheduling, data review, and interpretation. Figure 2.9-1 shows facilities and wells in the 200-UP-1 Area. Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the region. In addition to these constituents, high-priority contaminants of concern also include strontium-90, trichloroethene, chloroform, chromium, cadmium, and arsenic (DOE/RL 92-76). Groundwater is monitored to:

- Evaluate the extent and migration of existing contaminant plumes within the interest area.
- Assess the technetium-99 and uranium concentration response to activities at an interim action pump-and-treat remediation system.
- Assess the rate and extent of contaminant migration from Waste Management Areas U and S-SX, as well as the 216-U-12 crib, under the *Resource Conservation and Recovery Act* (RCRA).
- Detect impacts to groundwater quality from the 216-S-10 pond and ditch under RCRA.

Technetium-99, uranium, tritium, iodine-129, nitrate, and carbon tetrachloride are the contaminants of greatest significance in groundwater and form extensive plumes within the 200-UP-1 groundwater interest area.

Groundwater monitoring in the 200-UP-1 groundwater interest area includes the following monitoring activities:

CERCLA and AEA Monitoring

- ***Fifty-five wells are sampled quarterly to biennially. Three wells were not sampled as scheduled (Appendix A).***
- ***Four wells are sampled semiannually at the Environmental Restoration Disposal Facility.***

Facility Monitoring (Appendix B)

- ***Nine wells are sampled quarterly at Waste Management Area U for RCRA and AEA. One well went dry in FY 2007.***
- ***Nineteen wells are sampled quarterly at Waste Management Area S-SX for RCRA and AEA. One sample was delayed until October 2007.***
- ***Three wells are sampled semiannually under RCRA for the 216-S-10 pond and ditch.***
- ***Four wells were sampled quarterly for RCRA at the 216-U-12 crib. This site has been reclassified from a RCRA treatment, storage, or disposal unit to a RCRA past-practice unit. Therefore, RCRA groundwater monitoring will be discontinued for FY 2008.***

- Detect impacts to groundwater quality from operation of the Environmental Restoration Disposal Facility under a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) record of decision (ROD 1995b).
- Identify emerging groundwater contamination issues within the interest area.

Plume areas (square kilometers) above the drinking water standard at the 200-UP-1 Operable Unit:

Chromium — 1.09
Iodine-129 — 4.55
Nitrate — 6.59
Technetium-99 — 0.30
Tritium — 6.97
Uranium — 0.42
****Carbon tetrachloride included in Section 2.8.***

Groundwater flow in the uppermost unconfined aquifer is primarily to the east within the 200-UP-1 groundwater interest area (see Figure 2.8-2 in Section 2.8). Water levels have been falling in this area since the 1980s, and flow directions have generally changed from southeast to east during this time. When U Pond and the 216-U-14 ditch were active, a groundwater mound resulted in radial flow in the northwest portion of the interest area (e.g., see PNNL-16069). Discharges to ground ceased in the mid-1990s, and the groundwater flow resumed its pre-Hanford flow direction toward the east. Based on water-level measurements in April 2006 and March 2007, the water-table elevation fell by an average of 0.27 meter in the south 200 West Area over the 11-month period.

One new monitoring well, 299-W14-71, was installed within the interest area during fiscal year (FY) 2007. It is located north-northeast of U Plant and was drilled through the Ringold Formation lower mud unit and completed just above that unit. Sampling results for this well are included in the following sections, as appropriate.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under CERCLA, RCRA, and *Atomic Energy Act* (AEA) monitoring.

2.9.1 Groundwater Contaminants

Large-scale waste disposal at the 200-UP-1 groundwater interest area began during the early 1950s when plutonium separation operations began at the Reduction-Oxidation (REDOX) Plant and uranium recovery operations began at U Plant. In general, the high-level radioactive waste was stored in underground storage tanks while other liquid waste streams were sent to ponds and cribs. Groundwater plumes of nitrate, tritium, and iodine-129 formed from the pond and crib waste. These plumes continued to grow in size while effluent disposal operations continued. Effluent disposal to the ponds and cribs ceased during the 1990s. At present, the groundwater plumes from these sources are dispersing naturally. However, constituents of lower mobility in the vadose zone beneath the ponds and cribs may potentially reach the water table in the future and affect groundwater quality.

Within the tank farms (Waste Management Areas U and S-SX), some of the underground storage tanks have leaked, resulting in contamination of the vadose zone beneath the tanks. Some of this contamination has migrated downward and reached the water table (e.g., PNNL-11810). Currently, plumes of nitrate, technetium-99, and chromium from the tank farms are found in groundwater and are generally growing in areal extent and exhibit increasing constituent concentrations. In addition, carbon tetrachloride is migrating into the 200-UP-1 groundwater interest area from the 200-ZP-1 interest area.

The following sections provide an overview of the contaminant plumes and contaminants of concern for the 200-UP-1 groundwater interest area. These sections

are a summary of the combined results of CERCLA, RCRA, and AEA monitoring performed in this area with the focus being the upper part of the unconfined aquifer. Information on the vertical distribution of contaminants in the aquifer is given where available.

2.9.1.1 Technetium-99

Technetium-99 concentrations occur above the drinking water standard (900 pCi/L) in three regions of the 200-UP-1 groundwater interest area: downgradient from the 216-U-1,2 cribs near U Plant, at Waste Management Area S-SX, and at Waste Management Area U (Figure 2.9-2). A technetium-99 plume originates from the 216-U-1,2 cribs, which were active in the 1950s and 1960s. The plume extends ~1.5 to 2 kilometers east into the 600 Area, but mostly at levels below the drinking water standard. When effluent was disposed at the nearby 216-U-16 crib in the mid-1980s, it migrated north along a caliche layer and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1,2 cribs, adding contaminant to the groundwater plume (DOE/RL-92-76). Historically, the highest measured technetium-99 concentration in the 216-U-1,2 cribs plume was 41,000 pCi/L in well 299-W19-24 (west of the 216-U-17 crib) during October 1989.

An interim remedial action pump-and-treat system operated in the central part of the 216-U-1,2 cribs plume from 1994 until early 2005. This system was successful in containing and recovering the high concentration portion of the plume; the lower concentration portion outside the capture zone has continued to migrate east into the 600 Area. The remediation effort was successful in reducing concentrations below the remedial action goal of 9,000 pCi/L. During January 2005, groundwater extraction was terminated and a rebound study was initiated. Monthly sampling was performed to assess plume response to the termination of pumping. The rebound study concluded in January 2006, and technetium-99 concentrations at all monitoring wells were below the remedial action goal throughout FY 2006. Groundwater extraction resumed at wells 299-W19-36 and 299-W19-43 on April 19, 2007, with the goal of reducing uranium concentrations. Shortly thereafter, the technetium-99 concentration in 299-W19-36 increased to 13,000 pCi/L during July 2007, presumably in response to the resumption of groundwater extraction. Sampling of this well in September 2007 yielded a technetium-99 result of 9,700 pCi/L. Section 2.9.2 gives a more thorough discussion of the pump-and-treat activities.

Concentrations of technetium-99 in well 299-W23-19, at Waste Management Area S-SX, were stable during the fiscal year at an average value of 41,000 pCi/L.

At Waste Management Area S-SX, a technetium-99 plume originates from the southwest corner of the waste management area and another plume originates from the north part. The technetium-99 concentration in well 299-W23-19 (located inside the SX Tank Farm) peaked at 137,000 pCi/L during September 2005 (Figure 2.9-3), then decreased during FY 2006. During FY 2007, concentrations remained relatively stable in this well, fluctuating between 35,100 and 46,300 pCi/L. The overall trend at this well indicates that technetium-99 is entering the aquifer in an episodic manner. The south plume from Waste Management Area S-SX represents a growing contamination issue because the plume is increasing in areal extent and concentrations are increasing.

The north plume at Waste Management Area S-SX originates from the S Tank Farm, and concentrations increased in this plume during the fiscal year. In well 299-W22-44, the technetium-99 concentration increased from 1,230 pCi/L during June 2006 to 10,000 pCi/L during September 2007, the highest concentration ever

measured in this plume. The other mobile tank waste constituents (chromium and nitrate) are also increasing, while concentrations of all three of these constituents remain low in the upgradient well 299-W23-20. The technetium-99 concentration is still relatively low compared to the south plume, but the increase during the fiscal year indicates that this plume is now a growing contamination issue. Section 2.9.3.2 has more information about technetium-99 at this waste management area.

U Tank Farm is a source of technetium-99 contamination.

Technetium-99 concentrations in the downgradient wells at Waste Management Area U are elevated compared to concentrations in the upgradient wells. Thus, the U Tank Farm is a source of technetium-99 contamination (PNNL-13282). However, concentrations are very low compared to Waste Management Area S-SX. The drinking water standard (900 pCi/L) was exceeded in four wells during FY 2007: 299-W18-30 at ~930 pCi/L, 299-W19-42 at ~1,300 pCi/L, 299-W19-45 at ~1,000 pCi/L, and 299-W19-47 at ~1,500 pCi/L. Concentrations are increasing in six wells, declining in two wells, and stable in one well. Refer to Section 2.9.3.1 for more information about technetium-99 at this waste management area.

In the previous annual report (PNNL-16346), maps showing the depth distribution of technetium-99 (and uranium) in groundwater within the 200-UP-1 interest area were presented. Information for these maps came from depth-discrete groundwater sampling during well installation between FY 2003 and FY 2006. The data indicated three locations within the interest area where technetium-99 occurred above the drinking water standard relatively deep below the water table: well 299-W19-46 southeast of U Plant (1,360 pCi/L at 19 meters below the water table with concentrations less than 300 pCi/L above this depth), well 299-W19-49 south of U Plant (1,320 pCi/L at 28 meters below the water table), and well 699-38-70C east of U Plant in the 600 Area (1,200 pCi/L down to the lower mud unit at 33 meters below the water table). At all other locations, technetium-99 concentrations above the drinking water standard were limited to the upper ~20 meters of the aquifer or less. Depth discrete sampling during installation of 299-W14-71 during FY 2007 indicated that no significant technetium-99 was found in the aquifer (all detections were less than 100 pCi/L).

2.9.1.2 Uranium

Within the 200-UP-1 groundwater interest area, uranium primarily occurs in an extensive plume downgradient from the 216-U-1,2 cribs (Figure 2.9-4) and is associated with the technetium-99 plume there. The plume extends a total of ~1.5 kilometers to the east at levels above the 30-µg/L drinking water standard. Uranium adsorbs to soil particles and is not as mobile in the aquifer as technetium-99. The uranium originated from the 216-U-1,2 cribs that were active in the 1950s and 1960s. As with technetium-99, additional mass was added to the plume when effluent disposed at the nearby 216-U-16 crib in the mid-1980s migrated north along a caliche layer in the vadose zone and mobilized the technetium-99 and uranium in the soil column beneath the 216-U-1,2 cribs (DOE/RL-92-76).

An interim remedial action pump-and-treat system operated on a high concentration part of this plume from 1994 until early 2005 (i.e., the same system used for the technetium-99 plume). The remediation effort was successful in reducing uranium concentrations below the remedial action goal of 480 µg/L, but concentrations at most wells continued to exceed the drinking water standard of 30 µg/L. During January 2005, groundwater extraction was terminated and a rebound study was initiated. Monthly sampling was performed to assess plume response to the termination of

pumping. The rebound study concluded in January 2006, and uranium concentrations at all monitoring wells were below the remedial action goal throughout FY 2006. However, during FY 2007, the uranium concentration in 299-W19-36 increased to 613 µg/L, above the remedial action goal.

Uranium responded more slowly than technetium-99 to the pump-and-treat system. All uranium concentrations were below the remedial action goal (480 µg/L) but above the drinking water standard (30 µg/L) within the pump-and-treat area.

The remedial action goal was ten times the *Model Toxics Control Act* standard at the time the interim record of decision was issued (ROD 1997), which was 48 µg/L. This standard has since been revised to 30 µg/L. In expectation that the remedial action goal will be revised to 300 µg/L (ten times the current standard), groundwater extraction was resumed in wells 299-W19-36 and 299-W19-43 on April 19, 2007. In response, the uranium concentration at 299-W19-36 declined to 343 µg/L by September. Section 2.9.2 gives a more thorough discussion of the pump-and-treat activities.

Near the source of the 216-U-1,2 cribs plume, uranium continues to be elevated in well 299-W19-18, although the concentration has decreased since 2004 (Figure 2.9-5). During FY 2007, uranium was measured twice at just over 400 µg/L, down from 600 µg/L in May 2004. The small change in uranium concentration in this well over the past 10 years may be due to an ongoing source of uranium to the aquifer water, such as continued leaching from the vadose zone beneath the 216-U-1,2 cribs or desorption of uranium from the aquifer sediment, or it may be due to the slow migration of uranium compared to technetium-99.

Maps of depth-discrete sampling results for uranium during well installation between FY 2003 and FY 2006 were presented in the previous annual report (PNNL-16346). Uranium was found above the drinking water standard only in the 216-U-1,2 cribs plume, and the data indicated that the plume is limited to the upper ~20 meters of the aquifer. There were no exceedances of the drinking water standard below 20 meters depth. Even in those wells (299-W19-46, 299-W19-49, and 699-38-70B) in which technetium-99 was found above the drinking water standard relatively deep in the aquifer, uranium was not elevated at the same depths. Uranium was not detected above the drinking water standard in the south part of the 200 West Area; all measured uranium concentrations were <5 µg/L.

2.9.1.3 Tritium

Disposal facilities associated with REDOX Plant are the primary sources of tritium in the 200-UP-1 groundwater interest area. The REDOX Plant operated from 1952 until 1967, although effluent releases continued to occur after that time. A large tritium plume from the REDOX Plant cribs originates from the south part of the 200 West Area and extends ~5 kilometers toward the east and northeast at levels above the 20,000-pCi/L drinking water standard. Two high concentration areas occur within this plume – a large one extending to the east and northeast from the 200 West Area and a smaller one extending ~550 meters to the east-southeast from the vicinity of the 216-S-25 crib (Figure 2.9-6).

The tritium plume originating from the south part of the 200 West Area is attenuating through dispersion and radiological decay.

Measured concentrations in the eastern high concentration area range from ~160,000 to 1 million pCi/L. Concentrations are generally declining at six wells and increasing at three, suggesting that the plume has localized areas of high concentrations. When these areas migrate past wells, increasing concentrations can occur. However, the plume overall exhibits declining concentrations and the areal extent as defined by the 2,000-pCi/L contour has changed little, indicating natural attenuation by dispersion and radiological decay.

Tritium occurs above the drinking water standard in nine wells downgradient of the 216-S-25 crib. Concentrations fluctuate in a single well (299-W23-9) on the downgradient side of the crib. Farther downgradient, trends are stable in three wells, decreasing in four wells, and increasing in one well. Radioactive liquid effluent was disposed to this crib from 1973 through 1980, and in 1985, effluent from a pump-and-treat system at the 216-U-1,2 cribs was disposed to this crib. In the vadose zone beneath this crib, tritium in the residual soil moisture is likely to be slowly migrating to the water table, which would account for the fluctuating tritium concentration trend in well 299-W23-9. The plume has migrated under Waste Management Area S-SX, but the tank farms are not considered a direct source of tritium to the groundwater. Tritiated water in the tanks was removed by the 242-S evaporator and disposed of at the 216-S-25 crib. The areal extent of the plume is growing as evidenced by increasing trends in the far-field downgradient wells 299-W22-82 and 299-W22-83 for Waste Management Area S-SX. The maximum concentration measured in this plume during the fiscal year was 150,000 pCi/L in 299-W23-9, adjacent to the crib.

The tritium concentration in groundwater near the 216-S-21 crib (west of Waste Management Area S-SX) has increased to above the drinking water standard (20,000 pCi/L) for the first time since 1989 (Figure 2.9-7). The August 2007 sample result was 26,000 pCi/L. This crib has been a major source of tritium in the past; the peak tritium concentration in 299-W23-4 occurred in 1963 and 1964 at 110 million pCi/L.

Information on the vertical distribution of tritium in the aquifer is sparse. Three of the eight wells (299-W19-48, 699-30-66, and 699-36-70B) installed within the operable unit during calendar year 2004 were sampled for tritium at different depths during drilling. The results indicated that tritium mainly occurs in the upper part of the aquifer near the water table. However, none of these wells were located in a high concentration portion of the plume. No tritium was detected in depth-discrete samples collected during drilling of 299-W14-71.

2.9.1.4 Iodine-129

A high concentration portion of the iodine-129 plume is migrating to the east out of the 200 West Area into the 600 Area.

Iodine-129 plumes in the 200-UP-1 groundwater interest area originate from both U Plant and REDOX Plant disposal facilities (Figure 2.9-8). One plume originates from the vicinity of the 216-U-1,2 cribs, while another originates from the south part of the 200 West Area. At the current level of monitoring detail, these plumes merge downgradient and become indistinguishable. This combined plume (as defined by the 1-pCi/L contour level) extends to the east a total distance of ~3.5 kilometers. Measured concentrations near the REDOX Plant cribs are below the drinking water standard (1 pCi/L) except at the 216-S-9 crib.

Groundwater sampling results near the 216-U-1,2; 216-U-12; and 216-S-9 cribs are flagged as non-detectable (Figure 2.9-8) but are believed to represent valid approximations of the iodine-129 concentration in the aquifer. The analytical laboratory is conservative, by requiring confirmation through the presence of a secondary (less sensitive) energy peak, prior to considering the iodine-129 detected (see Section 1.8). In the late 1980s, shortly after the large uranium release to the aquifer beneath the 216-U-1,2 cribs, iodine-129 was detected at ~30 pCi/L. Iodine-129 was detected at ~9 pCi/L in 2000 in a single well just before it went dry (well 299-W19-3). Similarly at the 216-U-12 crib, iodine-129 was detected at ~12 pCi/L during the 1990s. Thus, these cribs were a source of iodine-129, and it is reasonable to conclude that the vadose zone beneath these cribs contains residual

iodine-129 that may be currently leaching into the aquifer. The same may be true for the 216-S-9 crib, although there are no historical sample results for iodine-129 in the vicinity of this crib.

A high concentration part of the iodine-129 plume has migrated to the east out of the 200 West Area into the surrounding 600 Area. Measured concentrations in the central part of this plume typically range up to ~30 pCi/L. Concentrations are generally declining or stable throughout the plume, and dispersion is slowly reducing the plume size (i.e., the region of the plume above the drinking water standard). Radiological decay is not a factor in the declining areal extent, because iodine-129 has a long half-life (15.7 million years).

2.9.1.5 Strontium-90

During FY 2007, 30 analyses for strontium-90 were performed on samples collected from 11 wells within the groundwater interest area. Strontium-90 was detected in one sample from 299-W19-48 at 0.45 pCi/L, but was not detected in two other samples collected from this well. There were no other strontium-90 detections during the fiscal year. In prior years, strontium-90 has been routinely detected in well 299-W22-10, located downgradient of the 216-S-1,2 cribs, but this well was not sampled during FY 2007. The FY 2006 sample result was 27 pCi/L during December 2005, which is above the drinking water standard (8 pCi/L). Concentrations have been declining in this well after increasing to 76 pCi/L in December 2001. The 216-S-1,2 cribs received highly acidic waste from the REDOX Plant between 1952 and 1956. In 1955, the waste is believed to have corroded the casing of a nearby well 299-W22-3 (not shown in Figure 2.9-1, but the well is located 20 meters east of well 299-W22-2 at the 216-S-1,2 cribs), which allowed the effluent to bypass the soil column and flow down the well directly into groundwater (Waste Information Data System [WIDS]). This is the postulated pathway by which strontium-90 may have reached groundwater at this location.

2.9.1.6 Chlorinated Hydrocarbons

Carbon tetrachloride occurs above the drinking water standard (5 µg/L) in numerous wells within the 200-UP-1 groundwater interest area. At the water table, the plume is widespread in the south 200 West Area, and extends ~1 kilometer east into the 600 Area (Figure 2.8-3 in Section 2.8). The plume originated from waste disposal sites associated with the Plutonium Finishing Plant in the 200-ZP-1 groundwater interest area. Concentration trends are increasing in nine wells, decreasing in three wells, and fluctuating but generally stable in numerous wells. No clear spatial pattern is evident among wells having increasing or decreasing trends. Depth-discrete sampling in the eastern part of the plume shows that concentrations generally increase with depth to the Ringold Formation lower mud unit. This pattern was also observed at new well 299-W14-71 (Figure 2.9-9), located north of U Plant.

Carbon tetrachloride is widespread in the 200-UP-1 groundwater interest area, but this plume originated from disposal facilities in the 200-ZP-1 groundwater interest area.

The highest carbon tetrachloride concentration measured during FY 2007 was 1,600 µg/L in new well 299-W14-71, which was screened from 40.9 to 45.4 meters below the water table just above the Ringold Formation lower mud unit. This concentration is higher than what was measured during drilling (Figure 2.9-9); the reason for this discrepancy is not known. In the west part of the plume concentrations tend to be higher near the water table. Depth-discrete sampling during installation of well 299-W22-47 at Waste Management Area S-SX showed that concentrations peaked (at 96 µg/L) 12 meters below the water table and then quickly declined to

about the drinking water standard 37 meters below the water table. See Section 2.8 for more information regarding the vertical distribution of carbon tetrachloride in the aquifer.

Depth-discrete sampling during well installation shows that carbon tetrachloride, chloroform, and trichloroethene concentrations generally increase with depth in the eastern part of the operable unit.

Chloroform is a degradation product of carbon tetrachloride and tends to occur in the same wells with carbon tetrachloride. Thus, some degradation of carbon tetrachloride may be occurring, although chloroform could have been introduced to the aquifer from the 2607-Z tile field (see Section 2.8). A total of 135 chloroform analyses were performed on samples from 50 wells within the 200-UP-1 groundwater interest area, and no exceedances of the drinking water standard (80 µg/L) were observed in FY 2007. The maximum concentration measured during the fiscal year was 35 µg/L in new well 299-W14-71. Depth-discrete sampling during new well installation showed that concentrations tend to increase with depth, similar to carbon tetrachloride.

Trichloroethene is found within the 200-UP-1 groundwater interest area above the drinking water standard (5 µg/L) in the vicinity of the pump-and-treat system, as well as to the north at new well 299-W14-71. Depth-discrete sampling results show that concentrations tend to increase with depth. A total of 135 trichloroethene analyses were performed on samples from 50 wells within the interest area, and the drinking water standard was exceeded in four wells in FY 2007: 299-W14-71, 299-W19-34B, 699-38-70B, and 699-38-70C. All of these wells are screened deep within the unconfined aquifer just above the Ringold Formation lower mud unit. Concentrations are generally stable in wells 299-W19-34B, 699-38-70B, and 699-38-70C; more data are needed to establish a trend at well 299-W14-71. There were no exceedances of the drinking water standard in wells completed across the water table. The maximum concentration measured was 13 µg/L in new well 299-W14-71. The areal extent of trichloroethene does not coincide with the distribution of carbon tetrachloride suggesting a localized source in the U Plant area.

2.9.1.7 Chromium

In well 299-W23-19 at Waste Management Area S-SX, chromium concentrations were stable during the fiscal year at an average value of 740 µg/L.

Chromium is found in four regions of the 200-UP-1 groundwater interest area: at Waste Management Area S-SX, at the 216-S-10 pond and ditch, in the vicinity of the 216-S-20 crib, and in the 600 Area east and southeast of the 200 West Area. During FY 2007, samples from five wells exceeded the drinking water standard (100 µg/L) - four at Waste Management Area S-SX and one southeast of the 200 West Area. The highest concentrations occurred at well 299-W23-19, where the filtered total chromium trend was relatively stable during the fiscal year, averaging 740 µg/L (Figure 2.9-3). Filtered total chromium peaked in this well at 1,750 µg/L in December 2005. This well is near the source of a chromium, technetium-99, and nitrate plume originating from the SX Tank Farm. The chromium fluctuations in well 299-W23-19 are interpreted to indicate that the contaminant enters the aquifer from the vadose zone beneath the tank farm in an episodic manner.

A second plume occurs in the north part of Waste Management Area S-SX, downgradient from the S Tank Farm. At well 299-W22-44 in this plume, the filtered total chromium concentration increased from 74 µg/L during October 2006 to 345 µg/L during September 2007. The other mobile tank waste constituents, technetium-99 and nitrate, have also increased significantly during this time. In general, chromium concentrations are increasing at Waste Management Area S-SX and the areal extent of both plumes is growing. Chromium at Waste Management Area S-SX is further discussed in Section 2.9.3.2.

Filtered total chromium has been found above the drinking water standard in well 299-W26-7 at the 216-S-10 pond and ditch. The sample collected in June 2003 yielded a result of 209 µg/L. The well has since gone dry, so no further sampling is possible. The source for this contamination is unconfirmed, but it could be the 216-S-10 pond and ditch, even though well 299-W26-7 is an upgradient well. The areal extent of the plume appears to be small and stable, because chromium concentrations in downgradient and side-gradient wells are at minimal to non-detectable levels.

Filtered total chromium is frequently detected in wells east and southeast of the 200 West Area. An interpretation of the chromium extent in this area is shown on the map of major hazardous chemical plumes in the summary section of this report. The filtered total chromium concentration in well 699-32-62 was 152 µg/L in September 2007, little changed from the previous sampling two years earlier. Chromium concentrations have declined slowly since this constituent was first analyzed for at this well in 1992. Filtered total chromium is also above the drinking water standard at well 699-30-66 (102 µg/L in February 2006), which is completed deep in the aquifer just above the lower mud unit. This indicates that chromium may occur throughout the aquifer thickness in this region. The sources and extent of this contamination are uncertain. The location of this plume is consistent with disposal to the REDOX Plant ponds/ditches south and southwest of the 200 West Area. Chromium is detected in several other wells in this area, but its extent to the south is not well defined.

Filtered total chromium has also been found above the drinking water standard in well 299-W22-20, adjacent to the 216-S-20 crib. A concentration of 560 µg/L was measured in September 2004, and concentrations had been increasing since 2000. This well was not sampled for metals during FY 2007, but was sampled twice during FY 2006 with filtered total chromium results of 216 µg/L in December falling to 10 µg/L in August. This well has a perforated, carbon steel casing and is filling with fine sand. The sand is known to quickly destroy sample pump seals, so the well must be sampled with a bailer and cannot be purged. In addition, the well is going dry and manganese is elevated suggesting that reducing conditions are becoming prevalent. Another redox sensitive constituent, vanadium, has declined to nondetect levels, which is also consistent with reducing conditions. Thus, the FY 2006 sample results may not be representative of the aquifer.

Nitrate originates from multiple sources in the 200-UP-1 groundwater interest area and occurs in a large plume extending ~4 kilometers to the east-northeast.

2.9.1.8 Nitrate

Nitrate plumes in the 200-UP-1 groundwater interest area are thought to have originated from both the U Plant and REDOX Plant disposal facilities and are widespread throughout the area. Potential sources of nitrate from U Plant include the 216-U-1,2; 216-U-8; and 216-U-12 cribs. The nitrate plumes from these and other sources merge downgradient into a single large plume, which extends to the east and northeast a total distance of ~4 kilometers (Figure 2.9-10). Nitrate sources from REDOX Plant disposal facilities may also have contributed to this plume. With a few exceptions, concentrations throughout the large plume outside the 200 West Area are stable or declining. On the eastern margin of the plume, concentrations are stable in well 699-36-61A, increasing in well 699-40-62, and have started to decline in 699-44-64.

Within the pump-and-treat area, nitrate concentrations were generally stable in well 299-W19-43 during FY 2006 at ~1,600 mg/L. During FY 2007, the nitrate

concentration in this well began to decline, presumably in response to the resumption of groundwater extraction. The September 2007 sample result was 930 mg/L. This decline doesn't necessarily mean that concentrations are being significantly reduced in the aquifer. As the capture zone grows in response to pumping, water having a lower nitrate concentration, quite possibly from beneath the plume, is drawn into the extraction well and dilutes the water of higher nitrate concentration. During FY 2006, nitrate concentrations had begun to increase in 299-W19-37, and that trend continued for the first part of FY 2007; the concentration increased from 536 mg/L in August 2006 to 633 mg/L in April 2007. In September 2007, the concentration had declined to 268 mg/L, presumably in response to the resumption of groundwater extraction. The maximum nitrate concentration values seen in these wells are higher than concentrations measured historically at the 216-U-1,2 cribs in the 1970s and 1980s, which were typically ~100 to ~300 mg/L. Thus, it appears that nitrate may have a local source in the vicinity of the pump-and-treat area. Section 2.9.2 also discusses nitrate at the pump-and-treat area.

The occurrence of nitrate above the drinking water standard deep in the unconfined aquifer does not appear to be widespread.

The occurrence of nitrate above the drinking water standard deep in the unconfined aquifer does not appear to be widespread. The nitrate distribution depicted in Figure 2.9-10 represents nitrate concentrations in the upper portion of the unconfined aquifer, since most of the wells are screened across the water table. Of the wells actively sampled within the interest area, seven are screened deeper in the aquifer and five of these are within the mapped nitrate plume. In only one of these deeper wells, 699-38-70C, is nitrate found at levels above the 45-mg/L drinking water standard. The concentration trend in this well is stable at ~170 mg/L.

Waste Management Area U is a source of nitrate to groundwater (see Section 2.9.3.1). Nitrate concentrations in three of the downgradient wells were above the drinking water standard during FY 2007. The maximum measured nitrate concentration at the U Tank Farm during FY 2007 was 89 mg/L in well 299-W19-44.

Nitrate occurs in two small plumes associated with REDOX Plant disposal facilities: one near the 216-S-20 crib and another near the 216-S-25 crib. Well 299-W22-20 downgradient of the 216-S-20 crib had a nitrate concentration of 104 mg/L for September 2007. The concentration in this well has been declining since a maximum value occurred in December 2005 at 144 mg/L. From 1952 through 1972, this crib received waste from laboratory hoods and decontamination sinks in the 222-S Building, along with laboratory waste from the 300 Area. In well 299-W23-9, at the downgradient end of the 216-S-25 crib, concentrations have been elevated in recent years, suggesting that a pulse of nitrate has entered the aquifer from the soil column beneath the crib. A sample collected in August 2007 from this well showed a nitrate concentration of 216 mg/L, down from 317 mg/L in August 2006.

The nitrate plume originating from the 216-S-25 crib merges with a nitrate plume from Waste Management Area S-SX (see Section 2.9.3.2). Nitrate concentrations from the tank farm correlate with technetium-99 concentrations. In well 299-W23-19 at the southwest corner of Waste Management Area S-SX, the nitrate concentration was generally stable during FY 2007 (coincident with the technetium-99 and chromium trend) at ~390 mg/L.

2.9.1.9 Other Constituents

Arsenic and cadmium are listed as contaminants of concern for the 200-UP-1 Operable Unit (DOE/RL-92-76). During FY 2007, 40 analyses were performed

for arsenic in 20 wells and 178 analyses were done for cadmium in 51 wells. No detections above a drinking water standard (10 µg/L for arsenic and 5 µg/L for cadmium) were observed.

The contaminants of concern for the 200-UP-1 Operable Unit have been classified into an initial list of high priority constituents (i.e., strontium-90, iodine-129, technetium-99, uranium, tritium, carbon tetrachloride, chloroform, trichloroethene, chromium, arsenic, cadmium, and nitrate) to support integrated CERCLA and AEA long-term monitoring, as well as additional contaminants of concern specifically identified to support the remedial investigation/feasibility study (DOE/RL-92-76). These additional contaminants of concern are documented in the remedial investigation/feasibility study work plan (DOE/RL-92-76) and include an extended list of volatile organic compounds, metals, anions, ammonium ion, ammonia, cyanide, sulfide, cresols, phenols, total petroleum hydrocarbons (kerosene range), beta emitters (carbon-14 and selenium-79), alpha emitters (neptunium-237 and protactinium-231), and gamma emitters (cesium-137 and cobalt-60).

Wells 299-W19-105, 299-W19-107, 299-W22-69, 299-W22-72, 299-W22-86, and 299-W22-87 were specifically sampled for the additional contaminants of concern during FY 2007. Other than those constituents that are naturally present in groundwater (i.e., magnesium, manganese, and vanadium), only three constituents were detected at least once without a laboratory qualifier: carbon-14, cyanide, and iron. Carbon-14 was detected in three of four samples collected from 299-W22-72, but at levels far below the drinking water standard. The maximum concentration was 12 pCi/L, and the drinking water standard is 2,000 pCi/L. Cyanide was detected at 6.5 µg/L in one sample from 299-W19-107, but not in a second sample. The cyanide drinking water standard is 200 µg/L. Iron was detected in two samples from 299-W22-69, but not in seven other samples from this well. Iron was also detected in one sample from 299-W22-72, but not in eight other samples.

There were several qualified detections of an additional contaminant of concern. The qualifiers indicated the results were estimated values below the quantitation limit of the analytical method, or below the contract required detection limit, or that the constituents were also detected in an associated quality control blank. The constituents with qualified detections were acetone, ammonia, ammonium ion, cobalt, iron, and tetrachloroethene, and these results are considered to be false positives.

In FY 2002 and FY 2003, 1,4-dioxane was detected in 299-W22-20 near the 216-S-20 crib at levels of 110 to 160 µg/L. This constituent was detected again at 120 µg/L in a sample collected during August, 2006. No 1,4-dioxane analyses were performed for this well during FY 2007. 1,4-Dioxane is typically used as a solvent stabilizer and tends to occur in association with chlorinated solvent plumes. A federal drinking water standard has not been established for this constituent.

2.9.2 Operable Unit Activities

This section describes activities related specifically to the 200-UP-1 Groundwater Operable Unit. These activities involve the pump-and-treat system operating near U Plant and responses to the second CERCLA five-year review. The sampling and analysis plan for FY 2007 sampling of the 200-UP-1 Operable Unit is incorporated into the Remedial Investigation/Feasibility Study Work Plan for the

200-UP-1 Groundwater Operable Unit (DOE/RL-92-76). This plan integrates CERCLA and AEA monitoring, and is a revision of the original integrated plan issued during June 2002 (DOE/RL-2002-10). Appendix A presents the monitoring well network for the 200-UP-1 Operable Unit, including a well list, sampling frequencies, and analyte lists.

One new well (299-W14-71) was drilled within the operable unit during FY 2007. Planning was initiated to drill an additional 6 wells within the operable unit, which are the second half of 12 wells requested by Ecology (DOE/RL-92-76, Rev. 1).

2.9.2.1 Status of Five-Year Review Action Items

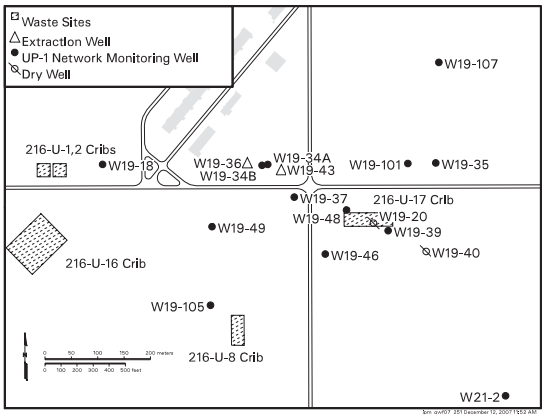
The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). One issue and associated action was identified for the 200-UP-1 Operable Unit:

Following a 27-month interval without pumping, groundwater extraction resumed at the 200-UP-1 pump-and-treat system during April 2007.

- **Issue 18**. The remedial action objective for uranium was based on the Washington State *Model Toxics Control Act* cleanup standard of 48 µg/L. Since this time, EPA has established a drinking water standard of 30 µg/L. There are also some other issues to be addressed within the record of decision, including the limited quarterly pumping requirement at well 299-W23-19, adjusting the pumping requirement for 200-UP-1 due to limited flow within the extraction well network, and technetium-99 groundwater contamination at other locations within the operable unit.
- **Action 18-1**. Prepare an explanation of significant difference for 200-UP-1 interim record of decision (due June 2008).
- **Response.** In anticipation of the release of the explanation of significant difference, the U.S. Department of Energy (DOE) directed on April 18, 2007, that the 200-UP-1 pump-and-treat system be restarted at wells 299-W19-36 and 299-W19-43 where uranium concentrations in groundwater exceeded 10 times the 30-µg/L drinking water standard.

2.9.2.2 Interim Groundwater Remediation for Technetium-99 and Uranium

Extraction wells 299-W19-36 and 299-W19-43 were restarted on April 19, 2007, following a 1-year rebound study and 15 months on hot standby during which the wells were maintained in a condition allowing for a quick restart. The system was active for the remainder of the fiscal year, and groundwater was pumped to the Liquid Effluent Retention Facility for eventual transfer to the Effluent Treatment Facility for removal of uranium along with technetium-99, carbon tetrachloride and nitrate. Restart was directed by DOE in anticipation of the Explanation of Significant Difference required by *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20). Restart was stipulated for wells where uranium concentrations exceeded 10 times the current 30-µg/L drinking water standard. During virtually all of the time the system was inactive, uranium concentrations at the 12 wells surrounding the original baseline uranium plume did not exceed the current 480 µg/L remedial action objective established by the interim record of decision (ROD 1997).



Progress During FY 2007. Restart of the extraction wells resulted in the discharge of 10 million liters of groundwater to Basin 43 at the Liquid Effluent Retention

Facility. Groundwater was extracted at an average rate of 43 liters/minute in the 162 days of operation following the restart. Treatment at the Effluent Treatment Facility was started on September 28, 2007 and over 2 million liters were treated by the end of the fiscal year. An estimated 1.1 kilograms of uranium, 0.27 gram of technetium-99, 53 grams of carbon tetrachloride, and 356 kilograms of nitrate were removed (Table 2.9-1). Over 855 million liters have been treated since startup of remediation activities in FY 1994. A total of 212.9 kilograms of uranium, 119.1 grams of technetium-99, 34.6 kilograms of carbon tetrachloride, and 35,072 kilograms of nitrate have been removed from the aquifer.

Hydraulic head trends at several groundwater wells within the 200-UP-1 baseline plume area were used to determine the decline in groundwater elevations. The water table declined an average of 0.31 meter/year in FY 2007 within the baseline plume area. This rate is greater than the 0.23 meter/year in FY 2005 and 2006, but is still significantly lower than that observed in FY 2004 and FY 2003 when the water level decline was 0.37 meter/year.

The interim remedial action objectives for the 200-UP-1 Operable Unit (ROD 1997) are:

- ***Reduce contamination in the areas with the highest concentration to below 480 µg/L for uranium and 9,000 pCi/L for technetium-99.***
- ***Reduce potential adverse human health risks through reduction of contaminant mass.***
- ***Prevent further movement of these contaminants from the highest contamination area.***
- ***Provide information that will lead to the development and implementation of a final remedy that will protect human health and the environment.***

Influence on Aquifer Conditions. Figures 2.9-11 and 2.9-12 show the technetium-99 and uranium plumes for the upper unconfined aquifer at the pump-and-treat area, based on average concentrations for the fiscal year. Maps depicting the baseline technetium-99 and uranium plumes in 1995 and the current plumes in FY 2007 are presented in the summary of this report.

Except for wells 299-W19-36 and 299-W19-37, uranium and technetium-99 concentrations at the wells monitored around the baseline plume for the rebound study were stable or declining for FY 2007. Uranium concentrations at well 299-W19-43 averaged 357 µg/L for the fiscal year, consistent with the trend in FY 2006 (Figure 2.9-13). Concentrations at well 299-W19-37 increased to a peak value of 350 µg/L in April 2007, and remained at that level (346 µg/L) in September. This well is expected to go dry in a few years; as of September, there was only 0.9 meter of water above the bottom of the screen. The concentration at well 299-W19-36 increased to 613 µg/L in April 2007, just prior to the resumption of groundwater extraction. Sample results following restart showed that uranium concentrations declined to 445 and 343 µg/L during July and September, respectively. Except for wells screened deeper in the aquifer or located farther away from the presumed source at 216-U-1,2 cribs, uranium concentrations were routinely above the 30 µg/L drinking water standard currently in effect.

With the exception of wells 299-W19-36 and 299-W19-37, most uranium and technetium-99 concentration trends within the pump-and-treat area were stable or declining during the fiscal year.

Technetium-99 concentrations were stable around the baseline plume except for well 299-W19-36. The technetium-99 trend in this well increased from 1,730 pCi/L in December 2006, to 3,700 pCi/L in April 2007, and then peaked at 13,000 pCi/L in July 2007 after the resumption of groundwater extraction (Figure 2.9-14). The September 2007, result declined to 9,700 pCi/L. This is a typical pattern for this well when pumping is resumed after a period of inactivity. The contaminant trend increases rapidly to a level above the remedial action objective and then rapidly declines once stable pumping conditions are achieved; the cause for this pattern is

not known. Only wells 299-W19-35, 299-W19-36, and 299-W19-43 exceeded the drinking water standard (900 pCi/L) for technetium-99.

For most wells, the secondary contaminants of concern, carbon tetrachloride and nitrate, did not exhibit responses to restart of the pump-and-treat system; concentration trends after the resumption of groundwater extraction were consistent with the trends observed during the rebound study. Carbon tetrachloride concentrations at all wells exceeded the 5 µg/L drinking water standard. Carbon tetrachloride at well 299-W19-36 displays an increasing trend and had reached 350 µg/L by the end of the fiscal year. Well 699-38-70B has consistently had the highest carbon tetrachloride concentrations of the rebound study wells; the FY 2007 sample results were 690 and 460 µg/L. Carbon tetrachloride concentrations were stable at well 299-W19-37 at an average value of 42 µg/L for the fiscal year. The source of the carbon tetrachloride is waste sites in the 200-ZP-1 operable unit near the Plutonium Finishing Plant.

Nitrate may have a local source in the pump-and-treat area.

Nitrate concentrations were above the drinking water standard of 45 mg/L in 6 of 11 wells monitored for the pump-and-treat area, two of which yielded nitrate concentrations consistently above 200 mg/L. The nitrate concentration at extraction well 299-W19-43 was at 930 mg/L in September 2007, but had declined from 1,540 mg/L in February 2007 (Figure 2.9-15). Concentrations in well 299-W19-37 increased to 633 mg/L in April 2007 but then declined to 268 mg/L in September 2007. Concentrations in well 299-W19-36 increased throughout the year from 76 mg/L in December 2006 to 214 mg/L in September 2007. The presumed source for the nitrate is the 216-U-1,2 cribs, although there may be a local source in the vicinity of the pump-and-treat area.

2.9.3 Facility Monitoring

This section describes the results of monitoring individual facilities such as treatment, storage, and disposal units, including tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and the AEA for source, special nuclear and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 1.2 pursuant to RCRA, the source, special nuclear, and by-product material component of radioactive mixed waste are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority.

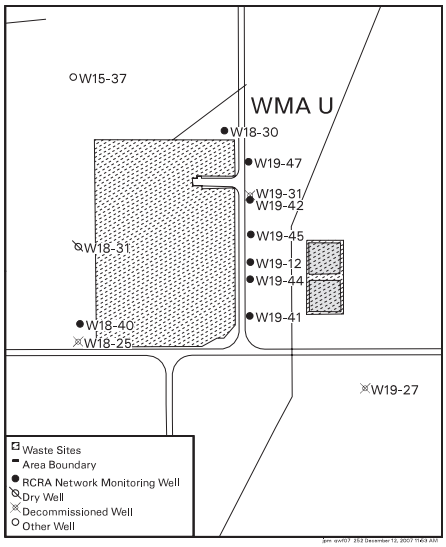
Detailed groundwater monitoring is conducted at five facilities within the 200-UP-1 Operable Unit. Four of these sites were monitored in accordance with RCRA regulations. Assessment monitoring was conducted at Waste Management Areas U and S-SX and the 216-U-12 crib, and detection monitoring was conducted at the 216-S-10 pond and ditch. The status of the 216-U-12 crib was changed from a RCRA treatment, storage, and/or disposal site to a RCRA past-practice site. Therefore, FY 2007 was the last year of RCRA assessment monitoring at this site. Groundwater monitoring at the Environmental Restoration Disposal Facility is conducted in accordance with a CERCLA record of decision (ROD 1995b). Groundwater data for these facilities are available from the Hanford Environmental Information System (HEIS 1994) and the data files accompanying this report.

2.9.3.1 Single-Shell Tank Waste Management Area U

The objective of RCRA monitoring at this waste management area is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer (40 CFR 265.93(d) and WAC 173-303-400). Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for Waste Management Area U.

Sources within Waste Management Area U have contaminated groundwater with nitrate and technetium-99.

Waste Management Area U was placed into assessment status in 2000 when specific conductance in groundwater monitoring wells downgradient of the waste management area exceeded upgradient levels (PNNL-13185). An assessment of that finding determined that the waste management area had affected groundwater quality as evidenced by elevated concentrations of nitrate and possibly chromium in wells downgradient of the waste management area (PNNL-13282). Contaminant concentrations did not exceed their respective drinking water standards, and the area affected appeared to be limited to the southeast corner of the waste management area. Groundwater quality is assessed at Waste Management Area U according to PNNL-13612. At the start of the fiscal year, the monitoring network included nine wells sampled quarterly consisting of two upgradient wells and seven wells downgradient of the waste management area. One upgradient well (299-W18-31) went dry during the fiscal year and was not sampled during the fourth quarter (but was sampled during the other three quarters). All other wells were sampled as scheduled in FY 2007. The monitoring network is adequate to assess the impact of the waste management area on groundwater quality beneath the site.



Groundwater Flow. Groundwater flow conditions at Waste Management Area U have varied greatly over the past several decades because of changing wastewater disposal in areas surrounding the waste management area, but groundwater flow has been generally to the east since 1996. During FY 2007, the water-table elevation declined at an average rate of 0.36 meter/year in the monitoring wells, but the long-term rate of decline since 2004 remains at 0.30 meter/year. Analysis of water-level data collected during March 2007 indicate the hydraulic gradient is 2.1×10^{-3}, and the groundwater flow rate (i.e., average linear velocity) ranges between 0.018 and 0.20 meter/day (6 and 73 meters/year), depending on the hydraulic conductivity and effective porosity. Using values believed to be most representative, 6.12 meters/day for the hydraulic conductivity and 0.17 for the effective porosity from a constant-rate pumping test conducted in well 299-W19-42 (PNNL-13378), the groundwater flow rate most representative for this site is 0.075 meter/day (27 meters/year).

Technetium-99 concentrations are higher in the northern wells at Waste Management Area U while nitrate concentrations are higher in the southern wells.

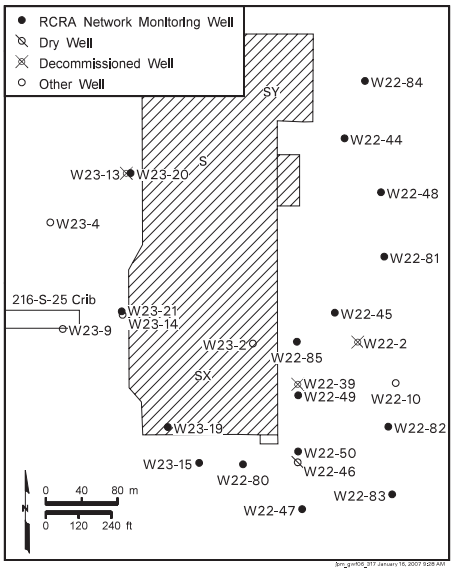
Groundwater Contamination. Waste Management Area U has been identified as the source of groundwater contamination limited to the downgradient (east) side of the site (PNNL-13282). Constituents found in the groundwater originally included chromium, nitrate, and technetium-99, but chromium concentrations decreased in the past to near the analytical detection limit where they remained in FY 2007. Nitrate and technetium-99 appear to have different sources within the waste management area, because nitrate concentrations are highest along the south half of the site and technetium-99 concentrations are highest along the north half (Figure 2.9-16). These constituents are both mobile in groundwater and would be expected to travel together if they were from the same source.

During FY 2007, measured technetium-99 concentrations exceeded the drinking water standard (900 pCi/L) in at least one sample from wells 299-W18-30, 299-W19-42, 299-W19-45, and 299-W19-47, all along the north downgradient side of the waste management area. FY 2007 was the first year in which concentrations at 299-W19-42 exceeded the drinking water standard. In 299-W18-30, the concentration increased sharply from 591 pCi/L in December 2006 to 933 pCi/L during February 2007, and then declined slightly to ~850 pCi/L for the remainder of the fiscal year. Concentrations are generally increasing at 299-W18-30, 299-W19-42, and 299-W19-47. At 299-W19-45, the concentration is decreasing and was below the drinking water standard in the August 2007 sample (866 pCi/L). The maximum technetium-99 concentration measured at the waste management area was 1,600 pCi/L in well 299-W19-47 during August 2007.

Sources within Waste Management Area S-SX have contaminated groundwater with nitrate, chromium, and technetium-99.

Nitrate concentrations continued to increase in all but one monitoring well at Waste Management Area U, including the two upgradient wells. Concentrations are higher in the downgradient wells compared to the upgradient wells, confirming that the waste management area is a source of nitrate to the aquifer. However, nitrate from an upgradient source is also affecting the groundwater quality. During FY 2007, nitrate concentrations were above the drinking water standard (45 mg/L) in at least one sample from upgradient well 299-W18-31, and from the downgradient wells 299-W19-12, 299-W19-41, and 299-W19-44. The concentration at 299-W19-12 increased to above the drinking water standard for the first time during the fiscal year, reaching a maximum value of 50 mg/L during August 2007. Concentrations are declining at 299-W19-41, but are still above the drinking water standard at ~60 mg/L. The maximum nitrate concentration measured at the waste management area was 89 mg/L in 299-W19-44 during August 2007.

Carbon tetrachloride is found in groundwater beneath Waste Management Area U at concentrations above its drinking water standard of 5 µg/L. Well 299-W18-30 is the only well in which samples are analyzed for carbon tetrachloride, and it contained a concentration of 140 µg/L in August 2007, down from 165 µg/L in August 2006. The regional carbon tetrachloride distribution (see Figure 2.8-3 in Section 2.8) indicates that the carbon tetrachloride found in the Waste Management Area U vicinity originates from liquid waste disposal sites at the Plutonium Finishing Plant located northwest of the waste management area.



2.9.3.2 Single-Shell Tank Waste Management Area S-SX

The objective of RCRA monitoring at this waste management area is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for Waste Management Area S-SX.

Waste Management Area S-SX was placed into assessment status (40 CFR 265.93(d) and WAC 173-303-400) in 1996 at the direction of Ecology because of elevated specific conductance and technetium-99 (not regulated by RCRA) in downgradient monitoring wells. An assessment of the waste management area determined (first determination) that multiple sources within the waste management area had affected groundwater quality with elevated concentrations of nitrate, technetium-99, and chromium in

wells downgradient of the waste management area (PNNL-11810). Groundwater is monitored according to PNNL-12114.

The monitoring network at Waste Management Area S-SX consists of 19 wells: 2 upgradient wells, 16 downgradient wells, and 1 well located within the waste management area. All the wells in the network are scheduled for quarterly sampling, and all were sampled as scheduled during the fiscal year, except the fourth quarter sampling of 299-W23-19 was delayed until October 1, 2007.

Concentrations of the mobile tank waste constituents nitrate, chromium, and technetium-99 increased significantly downgradient from the S Tank Farm during FY 2007.

Groundwater Flow. During FY 2007, the water-table elevation declined at an average rate of 0.25 meter/year in the monitoring wells, equal to the long-term rate of decline since 2004. Analysis of water-level data collected during March 2007 indicate the hydraulic gradient is 1.8×10^{-3}, and the groundwater flow rate (i.e., average linear velocity) ranges between 0.012 and 0.29 meter/day (4 and 104 meters/year), depending on the hydraulic conductivity and effective porosity. Using values of 6.1 meters/day for the hydraulic conductivity and 0.12 for the effective porosity (average values from multiple constant-rate pumping tests in wells at the waste management area [PNNL-13514, PNNL-14113, PNNL-14186]), the groundwater flow rate most representative value is 0.094 meter/day (34 meters/year). This is consistent with prior estimates of 0.07 to 0.14 meter/day (25 to 50 meters/year) based on the movement of tritium between wells (PNNL-12114, PNNL-13441).

Groundwater Contamination. Groundwater beneath this waste management area is contaminated with nitrate, chromium, and technetium-99 attributed to two general source areas within the waste management area. One source area is in the S Tank Farm and the other is located to the south in the SX Tank Farm. Nitrate also has other sources in the vicinity, most notably the 216-S-25 crib. The nitrate, chromium, and technetium-99 plumes are depicted in Figures 2.9-17, 2.9-18, and 2.9-19, which show average concentrations for the fiscal year. Carbon tetrachloride (see Figure 2.8-3 in Section 2.8) is also present in groundwater beneath the waste management area, but the sources are waste sites in the vicinity of the Plutonium Finishing Plant (PNNL-13441). Tritium is also present beneath the waste management area as seen in Figure 2.9-6, but its source is the 216-S-25 crib located just west (upgradient) of the SX Tank Farm (PNNL-13441).

In the north plume downgradient from the S Tank Farm, concentrations of the mobile tank waste constituents nitrate, chromium, and technetium-99 increased significantly in well 299-W22-44 during the fiscal year (Figure 2.9-20). During September 2007, total chromium increased to 345 µg/L (filtered) and 352 µg/L (unfiltered), nitrate increased to 146 mg/L, and technetium-99 increased to 10,000 pCi/L. These are the highest concentrations for these constituents ever measured in groundwater downgradient from the S Tank Farm. Concentrations of these constituents in the upgradient well for the S Tank Farm, 299-W23-20, were either non-detects or well below the drinking water standards indicating that the tank farm is the source. Tank S-104 is the only tank within the S Tank Farm known to have leaked. A surface electrical-resistivity survey conducted during FY 2006 indicated that a portion of the vadose zone plume beneath tank S-104 at the 2 to 5 ohm-meter level had apparently reached groundwater (RPP-RPT-30976). This is the presumed source of the north groundwater plume.

Nitrate, chromium, and technetium-99 concentrations in well 299-W23-19 at Waste Management Area S-SX were stable during the fiscal year.

Groundwater beneath the SX Tank Farm in the south portion of the waste management area is also contaminated with nitrate, chromium, and technetium-99. These plumes extend from the source area near well 299-W23-19 toward the east-southeast about 500 meters (Figure 2.9-19). There are low concentration areas

depicted in these plumes around wells 299-W22-80 and 299-W23-15. In well 299-W22-80, an in-well tracer test as well as time-series sampling during extensive purging has indicated that relatively clean water may be migrating into the bottom of the well, moving up the wellbore, and diluting plume concentrations in the upper part of the plume (PNNL-15070). A similar process is assumed to be occurring at well 299-W23-15. In the source area, concentrations of all three constituents were generally stable in well 299-W23-19 during the fiscal year. The average concentrations for the fiscal year were 385 mg/L for nitrate, 730 µg/L for filtered total chromium, and 41,000 pCi/L for technetium-99 (Figure 2.9-3).

Constituent concentrations in the south plumes at well 299-W22-50, about 150 meters downgradient from the source area, continued on the same trends as reported in FY 2006. Constituent concentrations in this well reached a peak in FY 2003 and have continued to decrease or remain stable throughout FY 2007 (Figure 2.9-21). Farther downgradient at well 299-W22-83, the nitrate and technetium-99 concentrations may have reached peak values during the fiscal year (Figure 2.9-21). This suggests a 4-year travel time between wells 299-W22-50 and 299-W22-83, which are ~115 meters apart. This yields a groundwater flow velocity of ~0.08 meter/day (~30 meters/year), consistent with the flow velocity estimates given above.

Groundwater Treatment. The feasibility of using well 299-W23-19 as a pump-and-treat extraction well to remediate the south plume from the SX Tank Farm was investigated in 2001. After performing an aquifer test in this well, it was concluded that the production capacity was too small for a pump-and-treat system (RPP-10757). To remove some technetium-99 from the groundwater, the practice of extended purging while sampling at well 299-W23-19 was agreed to by DOE and Ecology and began in 2003. After samples are collected from this well each quarter, purging of the well is continued at a higher flow rate until a minimum of 3,785 liters of water is removed from the aquifer. This water is transferred to the Effluent Treatment Facility for treatment and disposal. Table 2.9-2 presents the date, amount of water collected, and a calculation of the mass and activity of technetium-99 removed from the aquifer. A total of ~0.00083 curie (~0.049 gram) of technetium-99 was recovered during FY 2007. Since the start of this treatment in 2003, a total of ~0.0053 curie (~0.31 gram) of technetium-99 has been recovered.

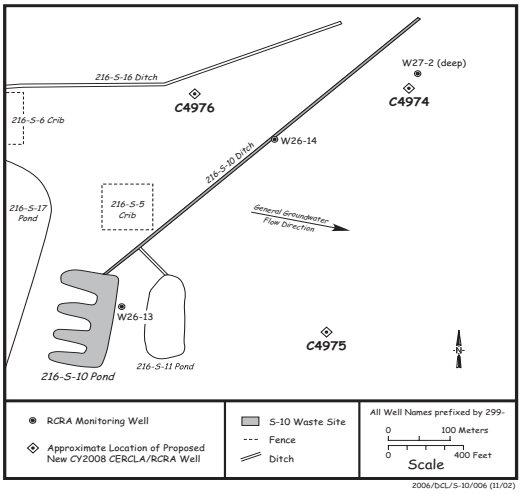
In 2003, DOE and Ecology agreed to the practice of extended purging during sampling at well 299-W23-19 to remove technetium-99 from the groundwater. This practice continued during FY 2007.

In-situ bioremediation is another remediation option being investigated as part of the 200-UP-1 Operable Unit activities. A treatability test of a technology known as Enhanced Anaerobic Reductive Precipitation/Enhanced Reductive Dechlorination developed under the (DOE's) Advanced Reradiation Technologies program is being planned for FY 2009. The test will be conducted near existing well 299-W-22-47, southeast of the SX Tank Farm, and the target analytes are technetium-99, chromium, nitrate, and carbon tetrachloride. A carbohydrate substance (e.g., molasses) will be injected into the aquifer to enhance microbial activity, which will generate reducing conditions. This will lead to the consumption of nitrate by the microbes, the precipitation of metals (technetium-99 and chromium), and the dechlorination of chlorinated hydrocarbons (carbon tetrachloride).

2.9.3.3 216-S-10 Pond and Ditch

The 216-S-10 pond and ditch was active from 1951 through 1991 and received effluent primarily from the REDOX Plant chemical sewer. The site is monitored semiannually under RCRA interim status indicator parameter monitoring (40 CFR 265.93(b) and WAC 173-303-400) to detect any effect on groundwater from past

facility operations. Groundwater monitoring under the AEA tracks radionuclides in the waste management area and surrounding vicinity. Appendix B includes a well location map and lists of wells and constituents monitored for the 216-S-10 pond and ditch.



RCRA groundwater monitoring has been conducted under interim status requirements since 1991. The 216-S-10 pond and ditch unit has not received liquid waste since October 1991. The treatment, storage, and disposal unit will be closed under RCRA and the Washington State Hazardous Waste Management Act (RCW 70.105). The RCRA closure plan for the 216-S-10 pond and ditch is being coordinated with the CERCLA 200-CS-1 source operable unit in accordance with Tri-Party Agreement Milestone M-15-39C.

The current RCRA monitoring network consists of two downgradient wells (the others having gone dry): well 299-W26-13 located near the pond and well 299-W26-14 located just east of the central portion of the ditch. Upgradient well 299-W26-7 went dry in 2003. The network also includes one deep downgradient well, 299-W27-2, which is screened at the bottom of the uppermost unconfined aquifer. RCRA requirements for interim status monitoring specify that a minimum of one upgradient and three downgradient monitoring wells are needed to monitor the site. All new RCRA wells installed at Hanford are negotiated annually by Ecology, DOE, and the U.S. Environmental Protection Agency (EPA) and approved under the Tri-Party Agreement (Ecology et al. 1989) Milestone M-24-00. One new upgradient well and two downgradient wells are currently planned under the Tri-Party Agreement Milestone M-24-57 to be installed in FY 2008. During FY 2007, all wells were sampled as scheduled.

All but three of the monitoring wells for the 216-S-10 pond and ditch have gone dry. New wells are planned for installation in FY 2008.

Groundwater Flow. Groundwater flow conditions beneath the 216-S-10 pond and ditch have varied greatly over the past several decades because of changing wastewater disposal in areas surrounding the site, but groundwater flow has been generally to the east-southeast for the last several years. During FY 2007, the direction and velocity of groundwater flow have remained the same as in the previous year. The rate at which the water table is dropping has also remained constant at ~0.3 meter/year in all of the monitoring wells during FY 2007. Therefore, the hydraulic gradient has not changed. The average linear velocity has remained essentially the same as in FY 2006 and ranges from 0.08 to 2.25 meters/day or 29 to 820 meters/year (see Appendix B).

Groundwater Sampling. The comparison of RCRA indicator parameters (specific conductance, pH, total organic carbon, and total organic halides) between upgradient and downgradient wells was conducted using the most recent collected background values of contaminant indicator parameters from well 299-W26-7 before it went dry in 2003 (see Appendix B). One new upgradient and two downgradient wells have been approved for installation surrounding the 216-S-10 pond and ditch in 2008 per Tri-Party Agreement Milestone M-24-57. When data from the new upgradient well become available, new background values will be calculated and used for the required upgradient/downgradient comparisons. Based on statistical evaluations of contamination indicator parameters conducted during FY 2007, there were no

statistically significant differences (i.e., constituents in the downgradient wells were not elevated compared to the upgradient well). Therefore, this site remains in detection monitoring.

No exceedances of an indicator parameter were found during FY 2007, so the 216-S-10 pond and ditch remain in detection monitoring.

There are several constituents detected in wells near the 216-S-10 pond and ditch that are being tracked by the monitoring network. Chromium is being tracked because it was elevated above the drinking water standard for several years in upgradient well 299-W26-7, which is now dry. Also, elevated concentrations of nickel (145 µg/L) and carbon tetrachloride (7.0 µg/L) have been detected again this year in the deep monitoring well 299-W27-2. Because there have been no detections of nickel in the shallow monitoring wells, the 216-S-10 pond and ditch is not believed to be the source of this constituent. Carbon tetrachloride concentrations in well 299-W27-2 have averaged above the drinking water standard (5 µg/L) since 2001. The source is believed to be liquid waste disposal sites at the Plutonium Finishing Plant.

Elevated chromium concentrations at well 299-W26-7 (now dry) had exceeded the drinking water standard (100 µg/L) during the past 10-year life of the well. This may have been caused by short-term releases migrating through the vadose zone from past effluent releases to the pond or from upgradient sources. Historical records document a 1983 release to the 216-S-10 ditch of a high-salt waste (simulated tank waste) containing hexavalent chromium. Although well 299-W26-7 was designated as an upgradient well, it is located very close to one lobe of the pond system and may have been affected by drainage spreading laterally in the vadose zone or by a mound on the water table when the facility was in operation (see Appendix B). A REDOX Plant disposal pond, which is located immediately upgradient of the 216-S-10 pond and ditch, is also a potential source of the chromium contamination. Chromium is a hazardous waste constituent for the treatment, storage, and disposal unit, and the 216-S-10 pond and ditch cannot currently be ruled out as the source of the contamination.

Nitrate concentrations were covariate with chromium concentrations in wells 299-W26-7, 299-W26-9, 299-W26-10, and 299-W26-12, which are now dry. The upgradient well 299-W26-7 had the highest nitrate concentrations. These and other data presented in PNNL-14070 suggest that the 216-S-10 pond could be the source of this nitrate and chromium increase. Although chromium and nitrate were elevated in the upgradient well 299-W26-7 prior to when it went dry, significant concentrations of these constituents have not been detected in the downgradient wells. But, well 299-W26-13 which is located downgradient of the pond and replaced well 299-W26-9, shows increasing levels of chromium (from 5 up to 15 µg/L) and nitrate (from 6.6 up to 10.2 mg/L), but not yet near their respective drinking water standards. By comparison chromium in the other down gradient well 299-W26-14, located away from the pond and centered along the ditch portion of the facility, remains essentially undetected. This difference could suggest that a localized source is present near the pond.

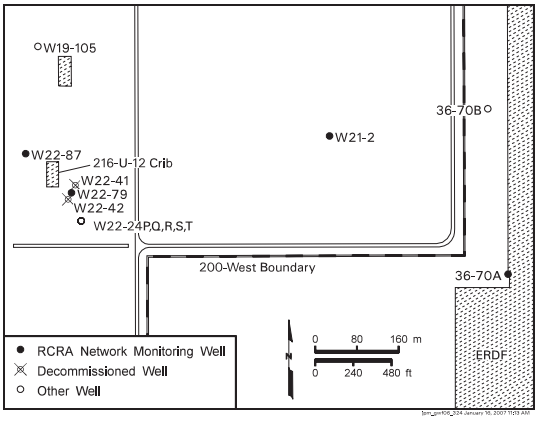
The 216-U-12 crib contributed to nitrate and technetium-99 contamination.

2.9.3.4 216-U-12 Crib

The 216-U-12 crib is located ~600 meters south of U Plant in the southeast portion of the 200 West Area. The crib is an unlined, gravel-bottom, percolation crib 3 meters by 30 meters, and 4.6 meters deep. The crib received process effluent from U Plant, including corrosive liquid condensate from the 224-U Building, and operated from 1960 through 1972 and again from 1981 until it was permanently retired in February 1988. A yearly average of over 10.2 million liters of effluent was disposed to the

crib from 1960 through 1972 (RHO-CD-673). Total volume disposed to the 216-U-12 crib exceeded 133 million liters from 1960 through 1972.

The objective of RCRA monitoring at the 216-U-12 crib was to assess the nature and extent of groundwater contaminated with hazardous constituents and determine their rate of movement in the aquifer. The site was in assessment for elevated specific conductance, and nitrate and was sampled quarterly. Groundwater monitoring under the AEA tracks radionuclides at this crib and surrounding vicinity. Appendix B includes a well location map and lists the wells and constituents monitored for the 216-U-12 crib.



In May 2005, DOE requested that the 216-U-12 crib be administratively closed because historical records demonstrated that hazardous waste was not discharged to the 216-U-12 crib after July 27, 1987. The agreed upon date between Ecology and DOE when the mixed waste rule applies is August 19, 1987. Therefore, on June 14, 2007, the Tri-Parties approved two Tri-Party Agreement (Ecology et al. 1989) change requests (B-05-01 and C-05-01) reclassifying the crib from a RCRA treatment, storage, or disposal unit to a RCRA past-practice unit. Based on this approval, RCRA groundwater monitoring will be discontinued for FY 2008 and RCRA groundwater sampling will not continue past the last planned sampling date in September 2007. The groundwater in the vicinity of the crib will continue to be monitored as part of the CERCLA 200-UP-1 Operable Unit.

During FY 2007, the 216-U-12 crib was regulated under a RCRA interim status assessment program (40 CFR 265.93(d) and WAC 173-303-400). The network included one upgradient and three downgradient wells sampled quarterly (see Appendix B).

The 216-U-12 crib was reclassified from a RCRA treatment, storage, or disposal unit to a RCRA past-practice unit. Because of this change, RCRA groundwater monitoring will be discontinued for FY 2008.

The objective of RCRA interim status assessment monitoring was to assess the migration of hazardous waste constituents out of the vadose zone into groundwater and to support the delineation of the existing known plumes that, through RCRA/CERCLA integration, will move forward under the CERCLA and AEA 200-UP-1 Operable Unit monitoring program. The existing 216-U-12 crib plumes co-mingle with plumes from other U Plant and REDOX Plant source areas, making it difficult to distinguish the areal extent of specific plumes originating from the crib.

Groundwater Flow. Based on the water-level elevations in the surrounding wells, the direction of groundwater flow beneath the 216-U-12 crib continued relatively unchanged toward the east-southeast to east (see Figure 2.8-2 Section 2.8). The pre-Hanford flow direction in the vicinity of the 216-U-12 crib is believed to have been from west to east, and it is expected that groundwater flow will eventually return to a more eastward direction. The water-table elevation continued to decline around the 216-U-12 crib and vicinity. Annual water-level declines in the monitoring wells ranged between ~0.21 to 0.38 meter. Average linear groundwater flow velocities remained essentially the same as last year, ranging from ~0.03 to ~0.05 meter/day or 11 to 18 meters/year (see Appendix B). The hydraulic gradient was calculated between new well 299-W22-87 and existing well 299-W22-79.

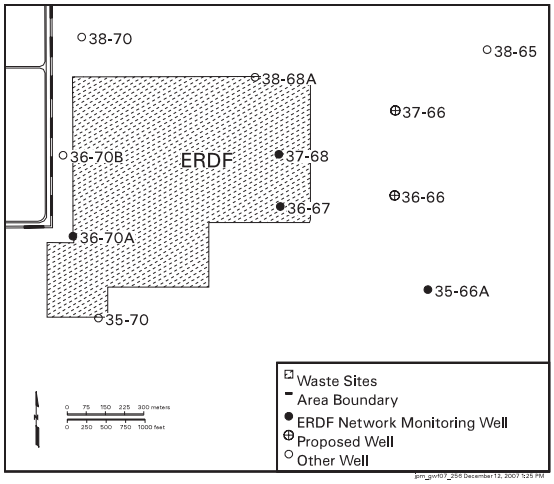
Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely affected groundwater quality.

Groundwater Contamination. During FY 2007, the key indicator parameter, specific conductance, continued to decline in the near field downgradient monitoring well 299-W22-79, and in the far field downgradient wells 299-W21-2 and 699-36-70A. Specific conductance is below the former critical mean (457.8 µS/cm) and declining in wells 299-W22-79 and 699-36-70A. Specific conductance remains just slightly above the former critical mean in 299-W21-2. Specific conductance in the upgradient well (299-W22-87) remained stable for the year at a concentration around 220 µS/cm. The data from these wells indicate that nitrate concentrations have peaked and are now decreasing downgradient from the 216-U-12 crib, suggesting that the bulk of the nitrate contamination has migrated to the groundwater and moved downgradient beyond the facility.

The regional nitrate and technetium-99 plumes are a co-mingled series of smaller plumes with sources from several cribs (216-U-1,2; 216-U-8; and 216-U-12) in the U Plant area. During FY 2007, nitrate concentrations decreased in all downgradient network wells, but remained above the drinking water standard in far-field wells 699-36-70A and 299-W21-2. Nitrate in the upgradient well (299-W22-87) was ~3 mg/L. The co-contaminant, technetium-99 (which is not regulated under RCRA), continued to be detected in all downgradient network wells but at levels well below the drinking water standard of 900 pCi/L. Technetium-99 was also found in upgradient well 299-W22-87 but at very low concentrations (~10 pCi/L). All other constituents remained on trend or near background throughout the year.

2.9.3.5 Environmental Restoration Disposal Facility

The Environmental Restoration Disposal Facility is a low-level radioactive mixed waste facility where waste from surface remedial actions on the Hanford Site is disposed. Groundwater monitoring is regulated under a CERCLA record of decision (ROD 1995b). The record of decision states that groundwater monitoring will be conducted according to RCRA regulations. Thus, the site was designed to meet RCRA standards, although it is not actually permitted as a RCRA facility. The groundwater flow direction beneath the site is toward the east-northeast. One upgradient well (699-36-70A) and three downgradient wells (699-37-68, 699-36-67, and 699-35-66A) are sampled semiannually, typically in March and September. All four wells were sampled as planned during FY 2007. Appendix B contains additional information regarding the Environmental Restoration Disposal Facility. For a discussion of leachate monitoring at this facility, see Section 3.1 and see WCH-189 for calendar year 2006 groundwater and leachate monitoring results. Calendar year 2007 results will be described in an upcoming report. See BHI-00873 for the groundwater sampling and analysis plan.



During FY 2007, an amendment to the Environmental Restoration Disposal Facility record of decision was issued (ROD 2007). The amendment allows several other Hanford programs to dispose waste to the Environmental Restoration Disposal Facility. No changes were made to the specific contaminants or concentrations allowed; the amendment essentially allows the same types of waste currently being disposed at the facility to be sent from additional Hanford Site sources.

Prior to sampling in FY 2008, the downgradient wells 699-36-67 and 699-37-68 will be decommissioned to allow for the next Environmental Restoration Disposal Facility expansion to the east. Two new downgradient wells will be constructed during FY 2008 as replacements, and these wells will be point-of-compliance wells along the downgradient boundary when the facility expansion is completed.

Groundwater Sampling. Results of groundwater monitoring at the Environmental Restoration Disposal Facility continued to indicate that the facility has not adversely impacted groundwater quality. Several constituents (tritium, iodine-129, nitrate, and carbon tetrachloride) are present in the groundwater near or above drinking water standards, but these constituents are elevated in both the upgradient and downgradient wells. Figures 2.9-6, 2.9-8, and 2.9-10 in this section, and Figure 2.8-3 in Section 2.8 indicate that these plumes originated in the 200 West Area and have migrated into the vicinity of the Environmental Restoration Disposal Facility.

Both filtered and unfiltered samples are collected for metals (except for uranium samples, which are unfiltered). No sampling results were noted significantly out of trend during FY 2007. Overall, uranium appears to be continuing to trend downward in all wells. Both technetium-99 and gross beta appear to be continuing to trend upward in two downgradient wells (699-37-68 and 699-35-66A) and downward in the upgradient well (699-36-70A) and one downgradient well (699-36-67). Nitrate levels appear to be decreasing except for well 699-35-66A where nitrate concentrations are stable at a very low level. These trends will continue to be monitored. Overall, the FY 2007 results appear stable. High turbidity (suspended solids), a common source for variability in the analytical results, was not seen in the FY 2007 sampling.

Table 2.9-1. Summary of Contaminant Mass Removed from the Aquifer during Pump-and-Treat Operations at 200-UP-1 Operable Unit (FY 2007 and totals since startup of operations)

Contaminant	FY 2007	Since Startup (March 1994)
Uranium	1.13 kg	212.9 kg
Technetium-99	0.27 g (0.005 Ci)	119.1 g (2.03 Ci)
Carbon Tetrachloride	0.053 kg	34.6 kg
Nitrate	356 kg	35,072 kg

Table 2.9-2. Quantity of Treated Groundwater and Technetium-99 Mass Removed from the Aquifer during Extended Purging at Well 299-W23-19, FY 2007

Sample Date	Volume of Water Treated liters (gal)	Technetium-99 Concentration (pCi/L)	Activity of Technetium-99 Removed (Ci)	Mass of Technetium-99 Removed (g)
19-Jan-07	4,936 (1,304)	46,300	0.00023	0.013
30-Mar-07	5,451 (1,440)	40,800	0.00022	0.013
26-Jun-07	5,224 (1,380)	35,100	0.00018	0.011
1-Oct-07	4,315 (1,140)	46,000	0.00020	0.012
Totals	19,926 (5,264)	NA	0.00083	0.049

NA = Not applicable.

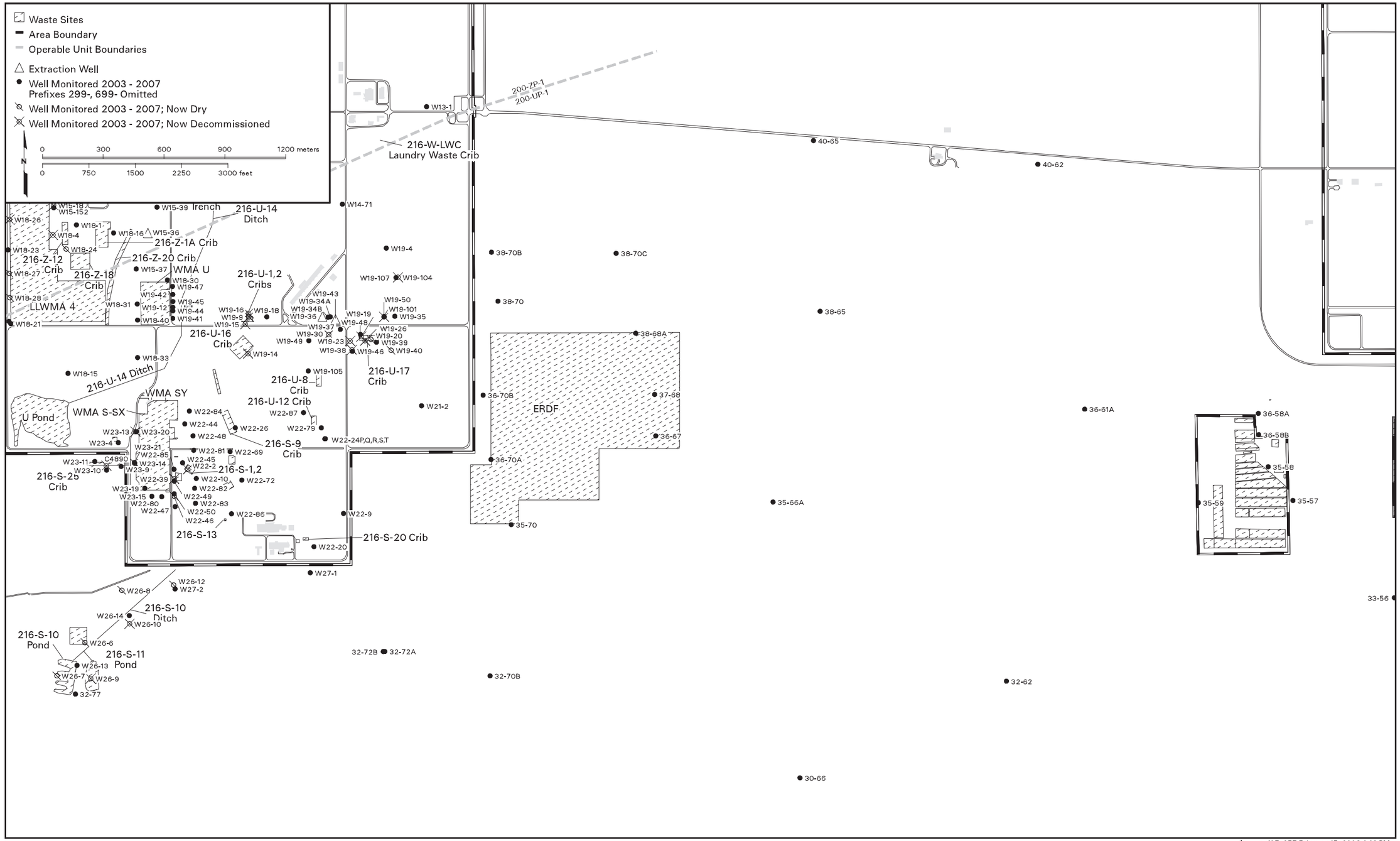


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Figure 2.9-1. Facilities and Groundwater Monitoring Wells in the 200-UP-1 Groundwater Interest Area

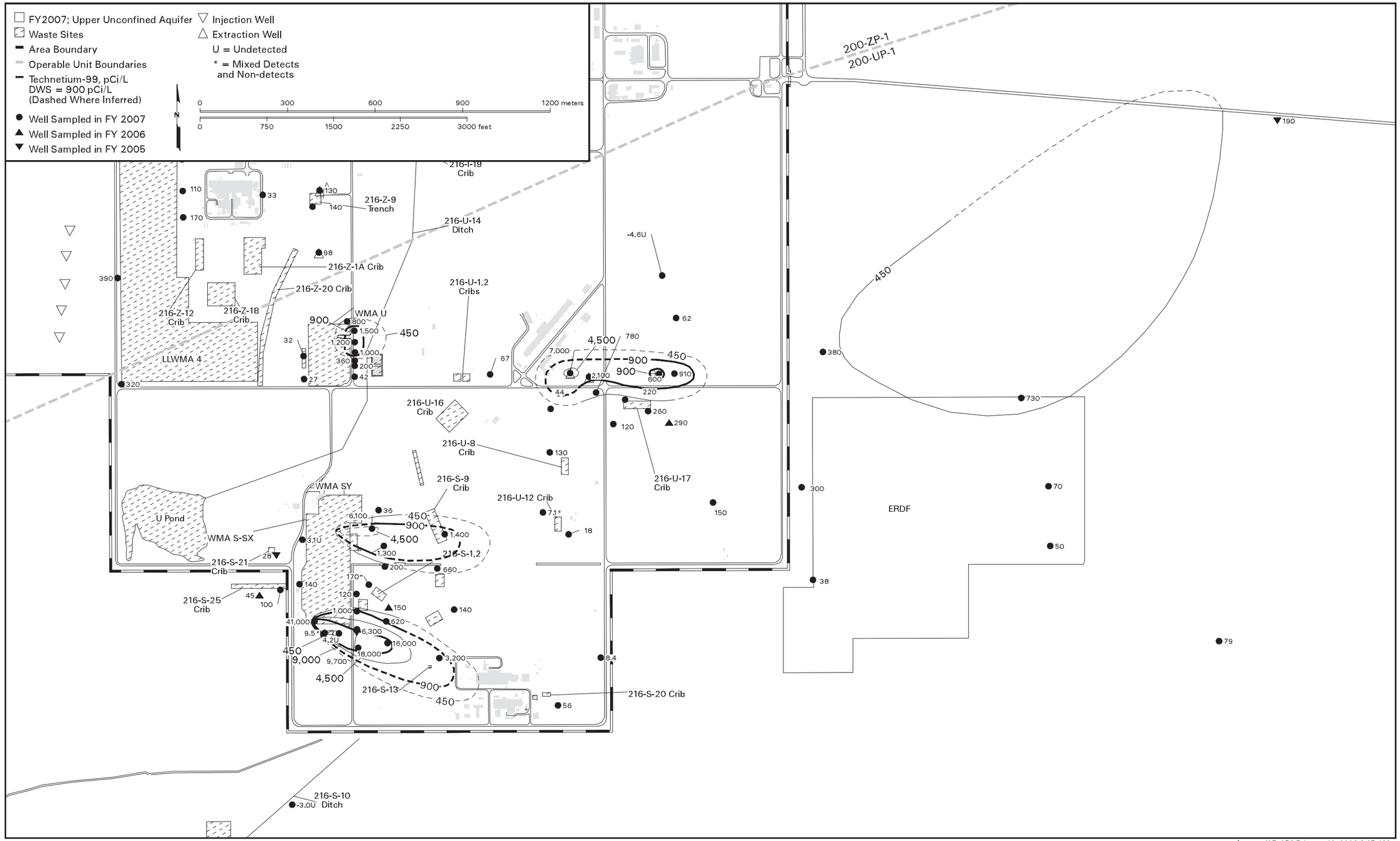

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Figure 2.9-2. Average Technetium-99 Concentrations in 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer

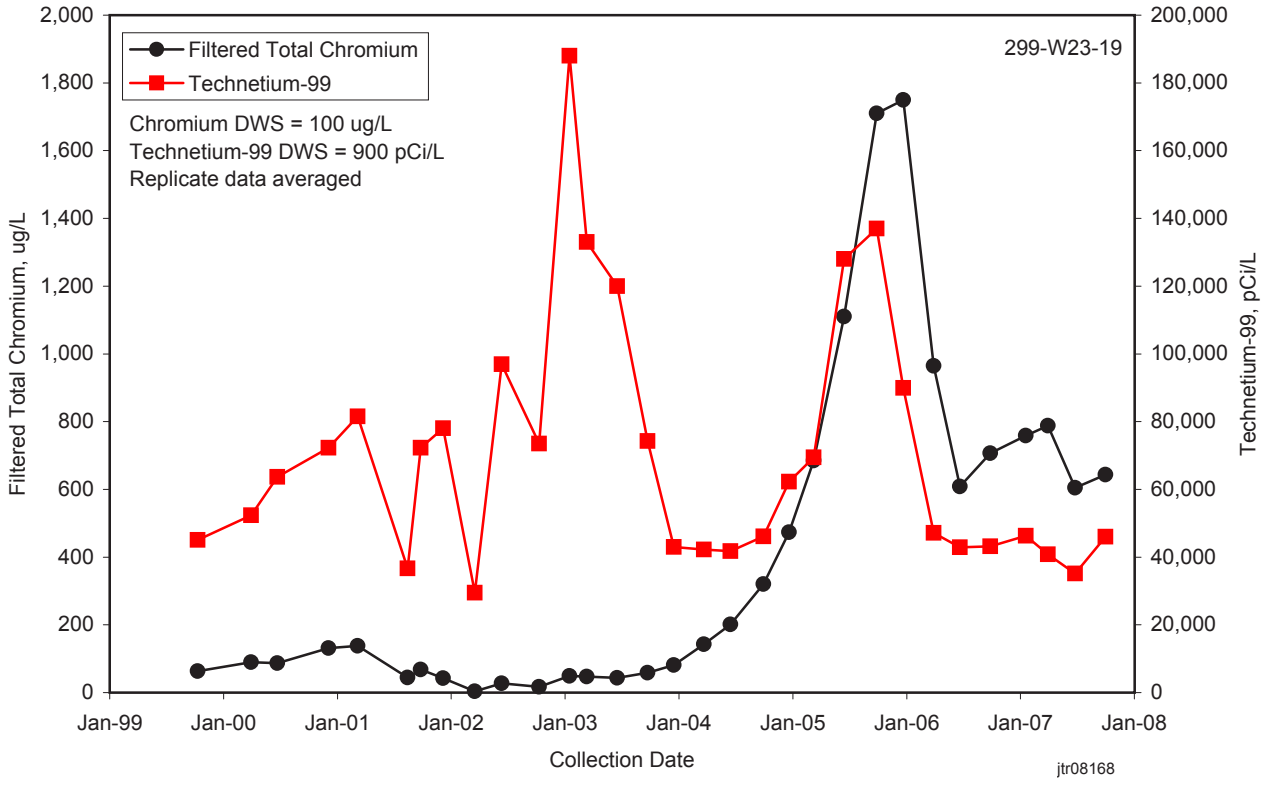

Figure 2.9-3. Chromium and Technetium-99 Concentrations in Well 299-W23-19 Near a Source Area Within the South Portion of Waste Management Area S-SX

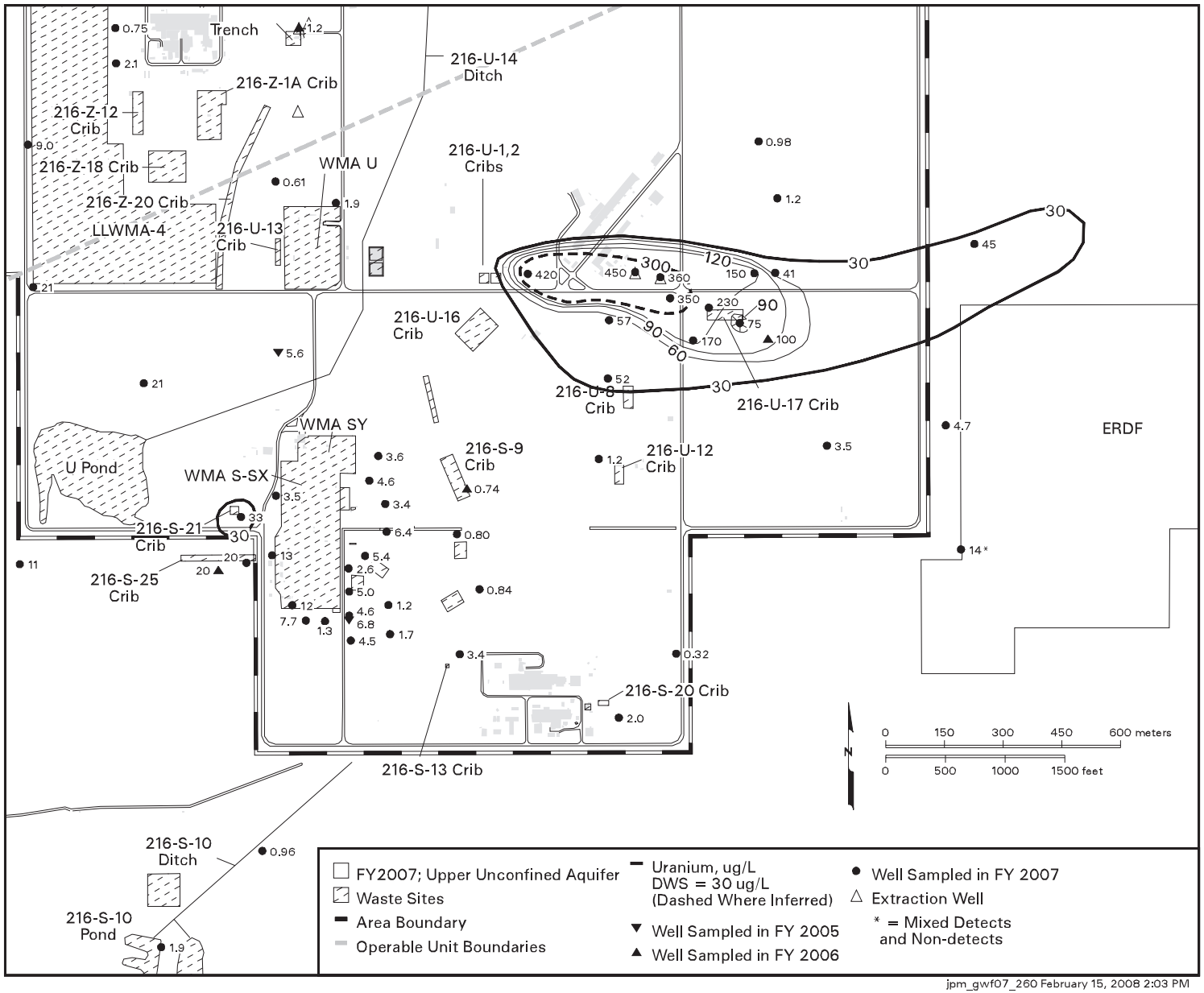

Figure 2.9-4. Average Uranium Concentrations in 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer

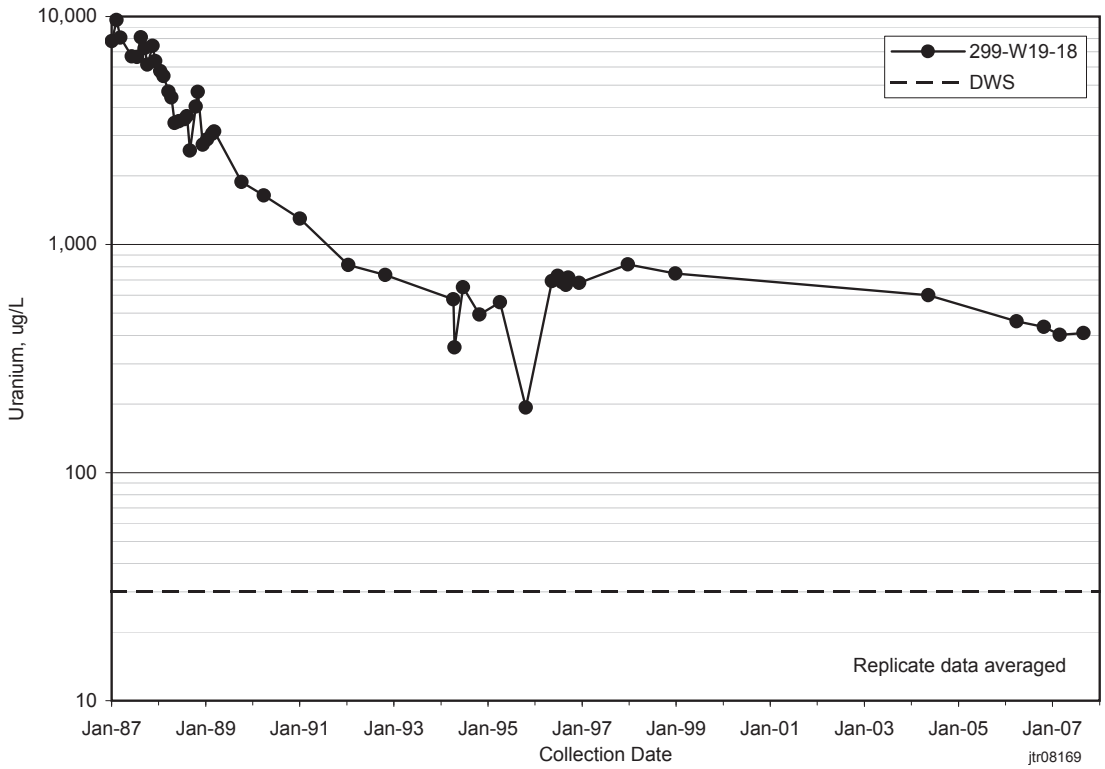

Figure 2.9-5. Uranium Concentrations in Well 299-W19-18 Near 216-U-1,2 Cribs

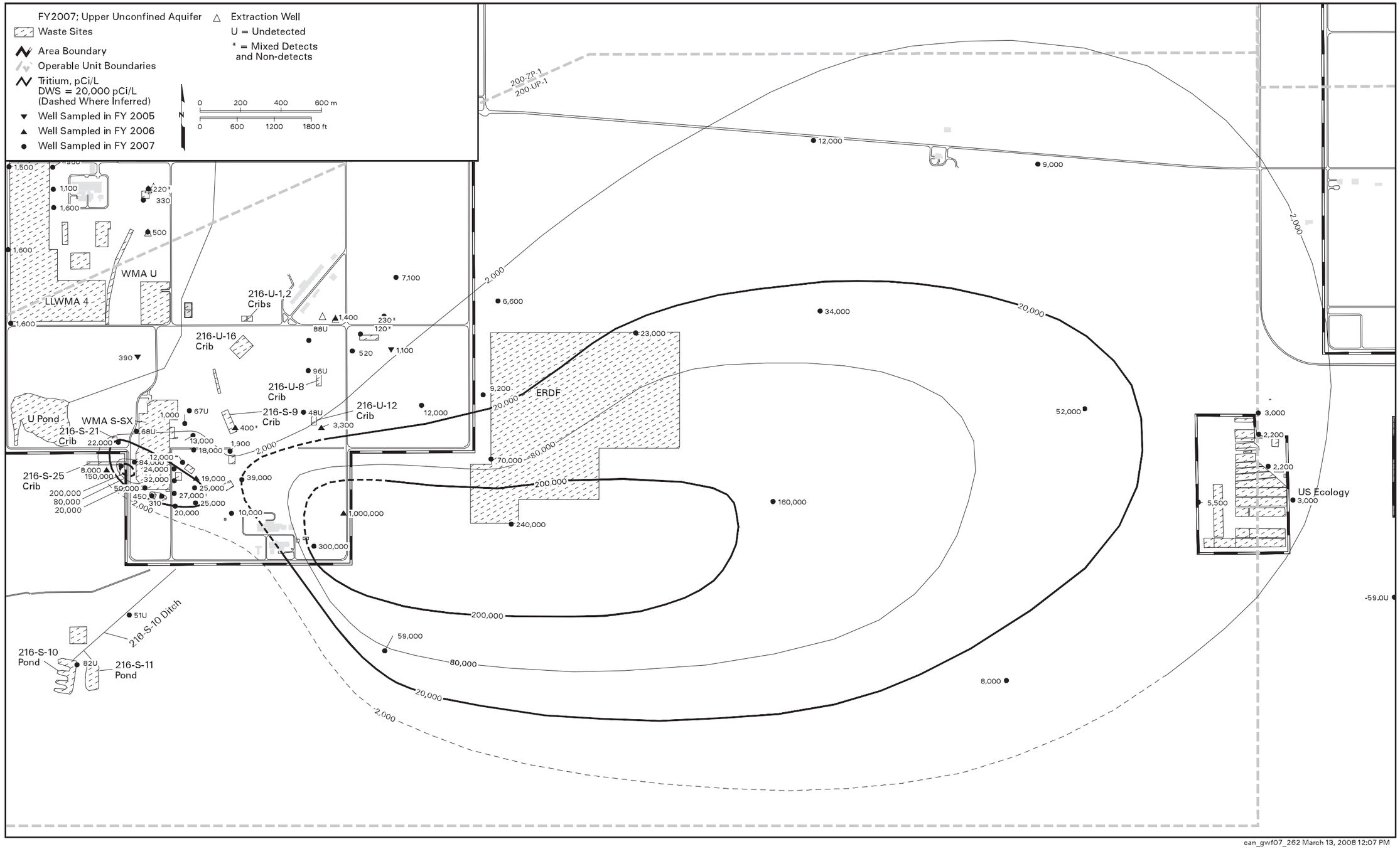

Figure 2.9-6. Average Tritium Concentrations in 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer

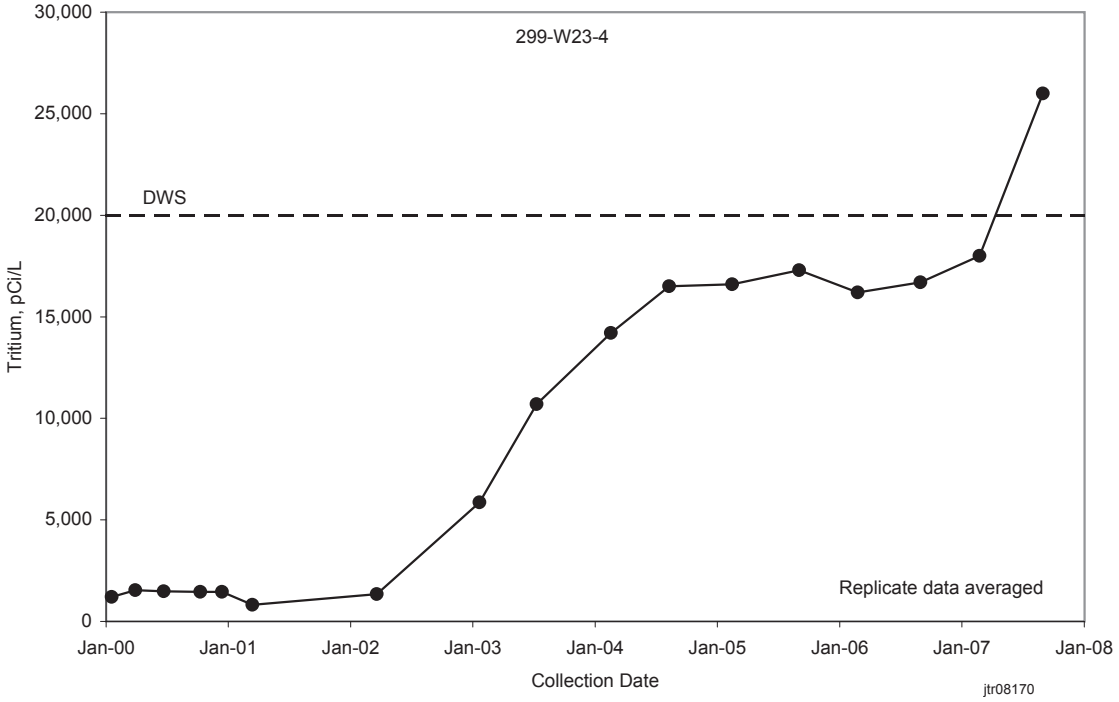

Figure 2.9-7. Tritium Concentrations in Well 299-W23-4 Near the 216-S-21 Crib

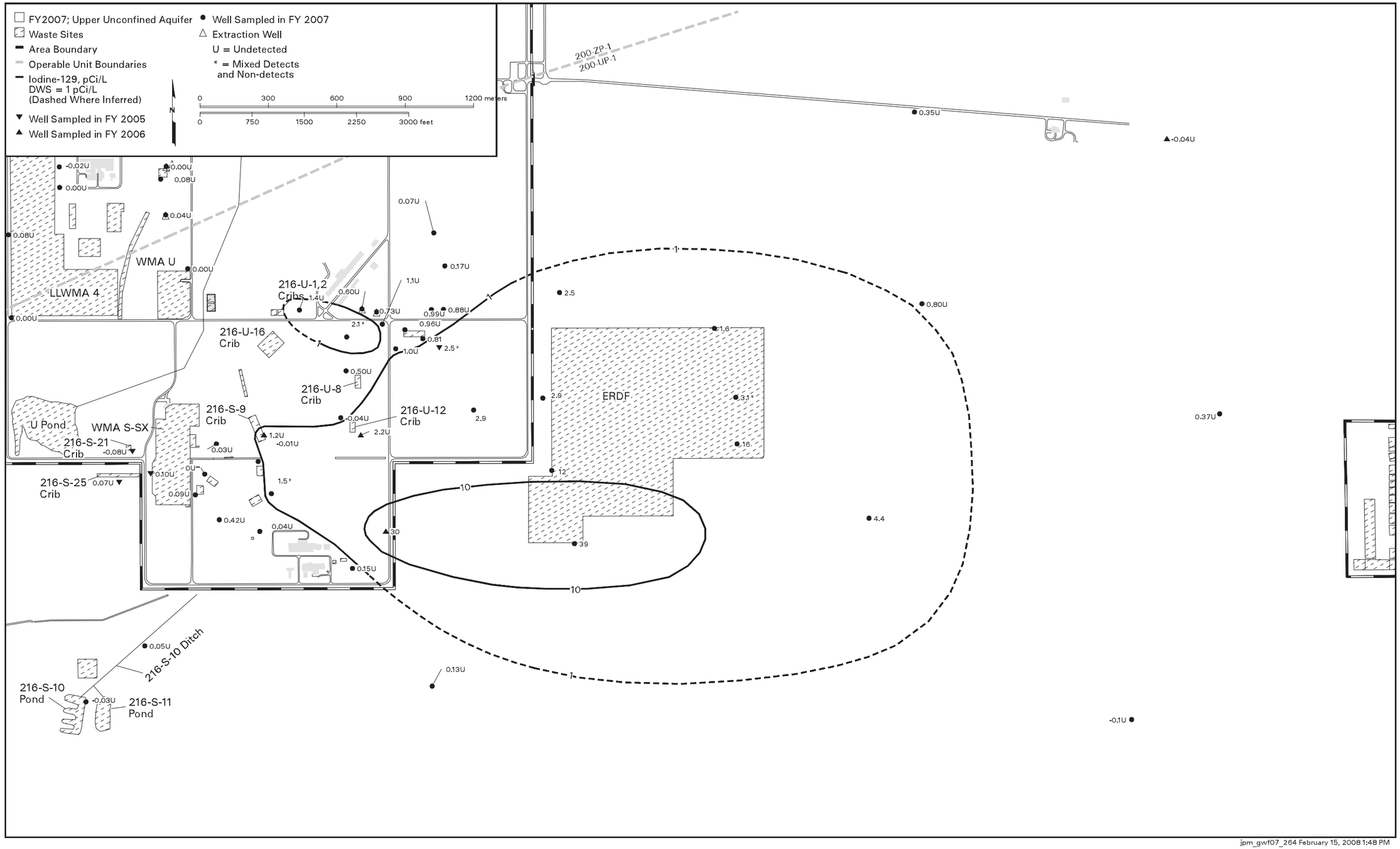

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Figure 2.9-8. Average Iodine-129 Concentrations in 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer

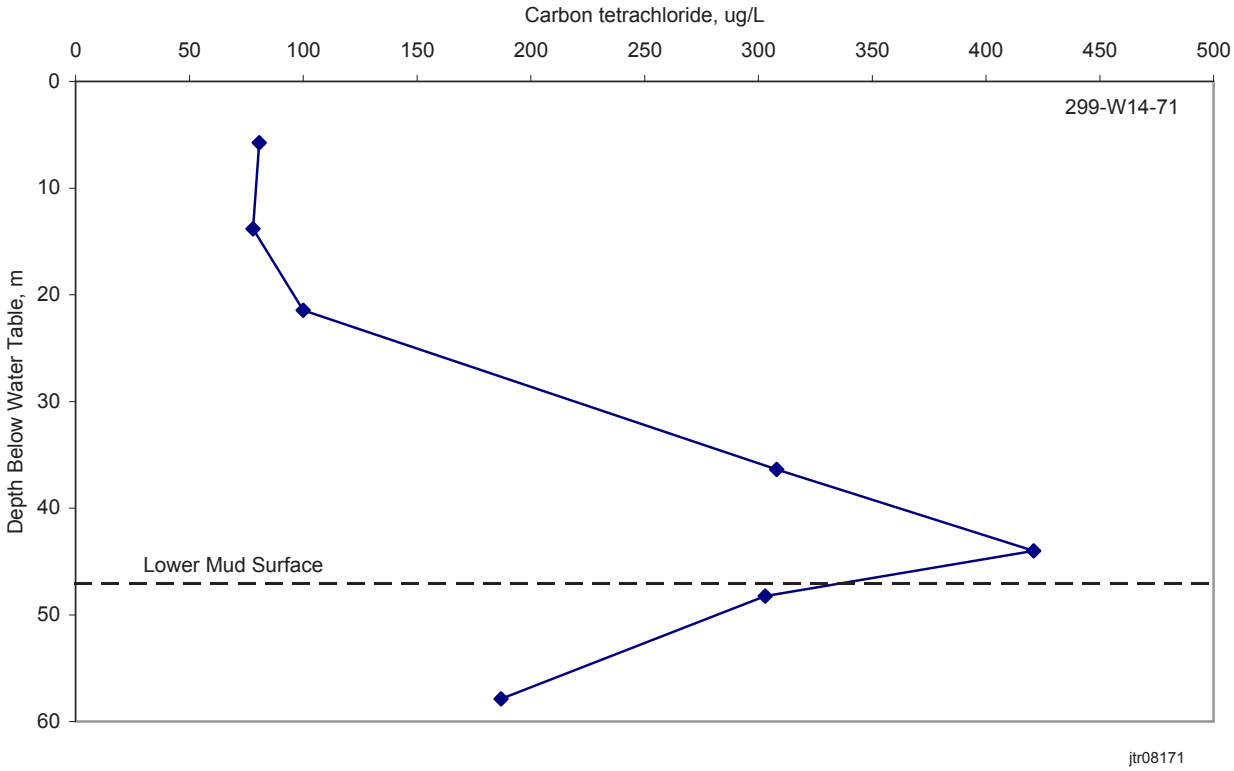

Figure 2.9-9. Depth-Discrete Sampling Results for Carbon Tetrachloride at New Well 299-W14-71 (Samples were collected during drilling between September 19, 2006 and October 13, 2006.)

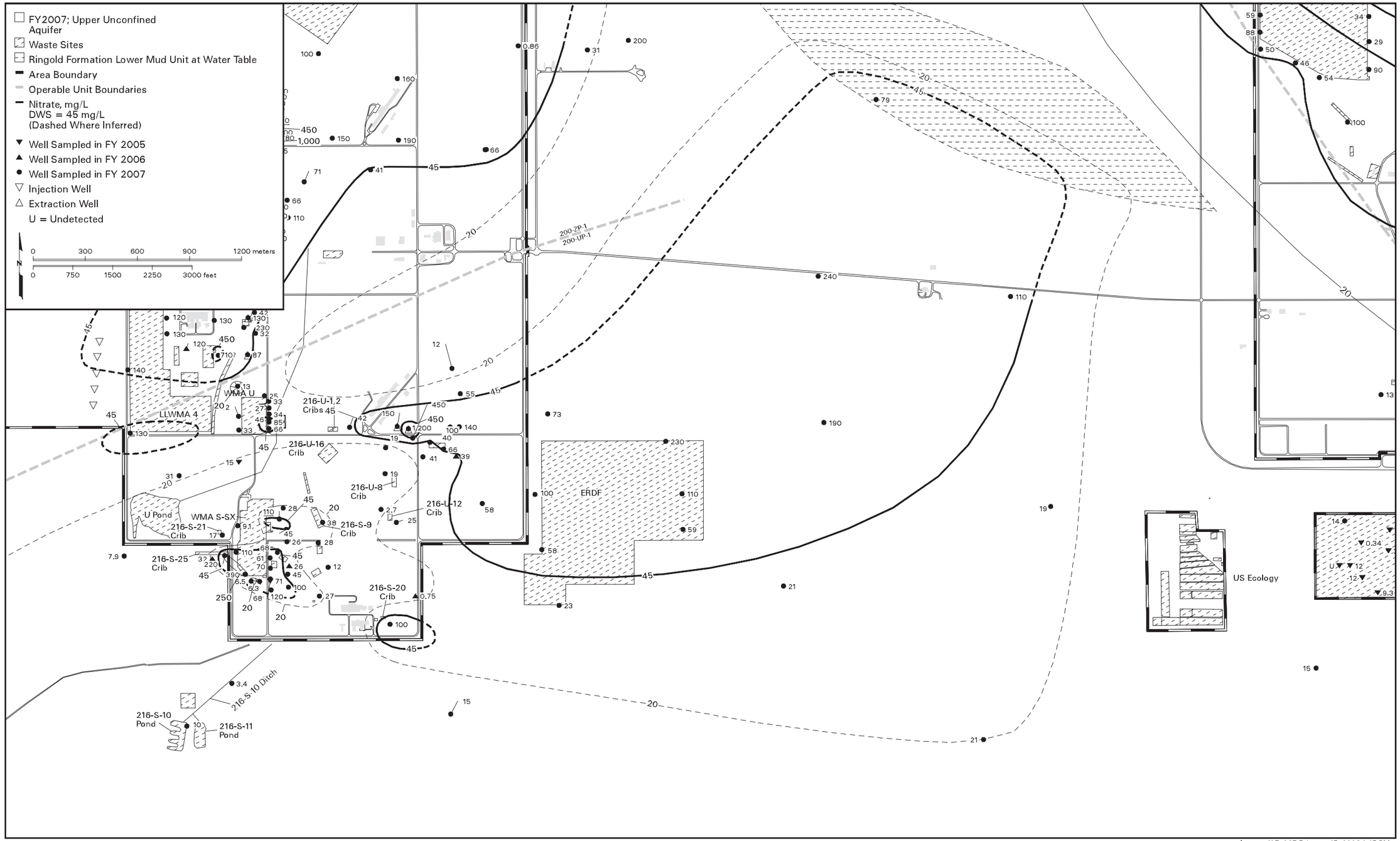

Figure2.9-10. Average Nitrate Concentrations in 200-UP-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer

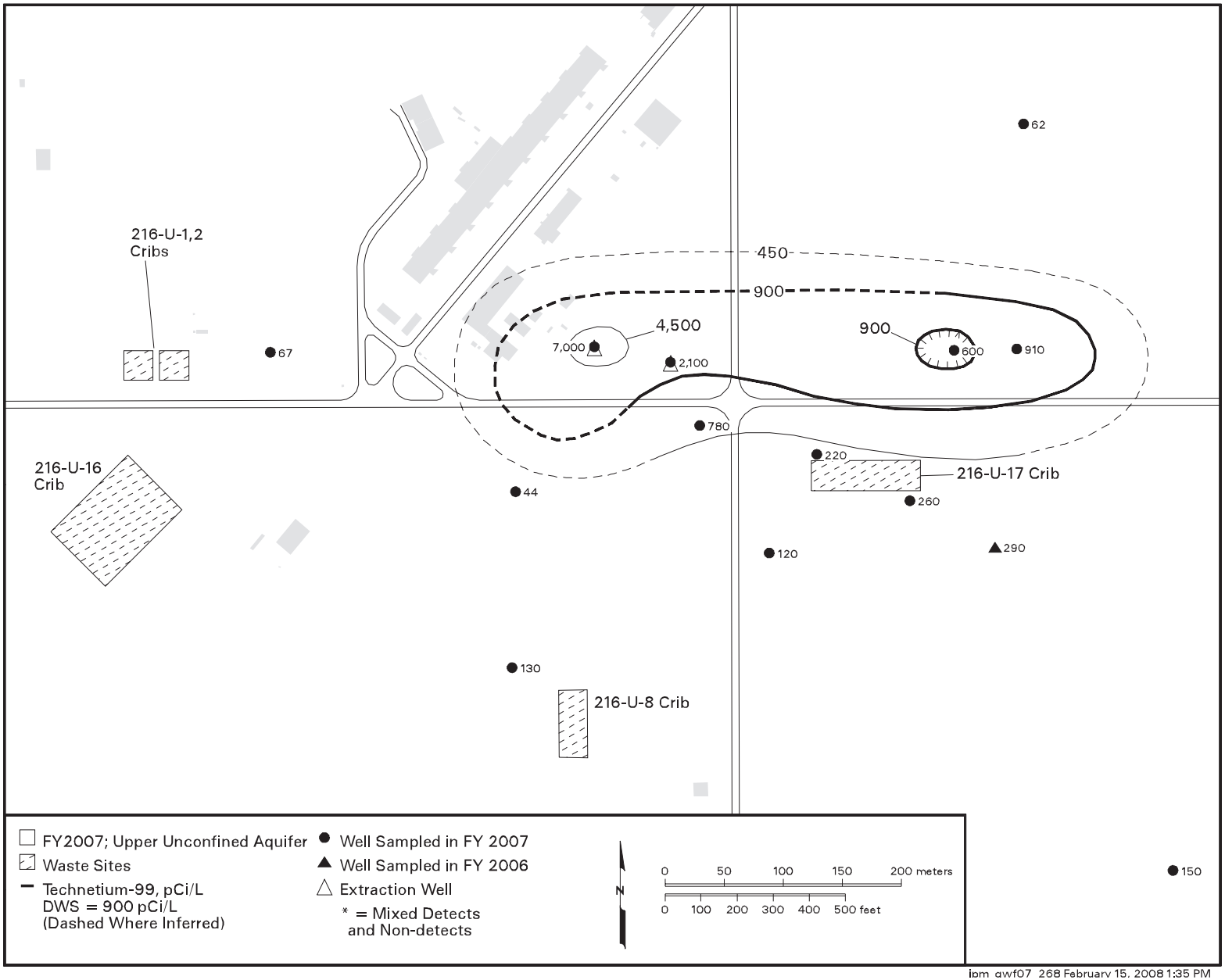

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Figure 2.9-11. Average Technetium-99 Concentrations in 200-UP-1 Pump-and-Treat Area, Upper Part of Unconfined Aquifer

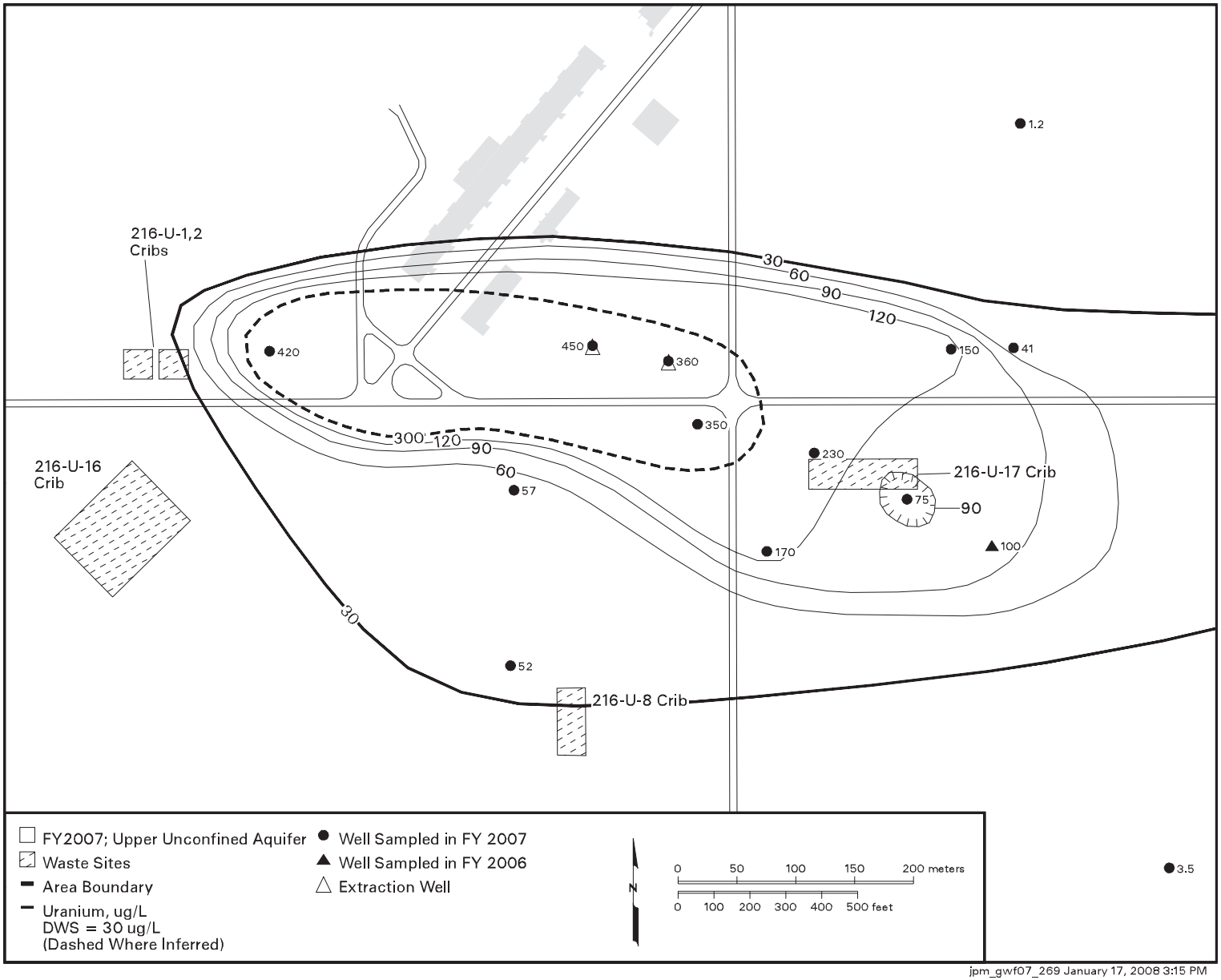


Figure 2.9-12. Average Uranium Concentrations in 200-UP-1 Pump-and-Treat Area, Upper Part of Unconfined Aquifer

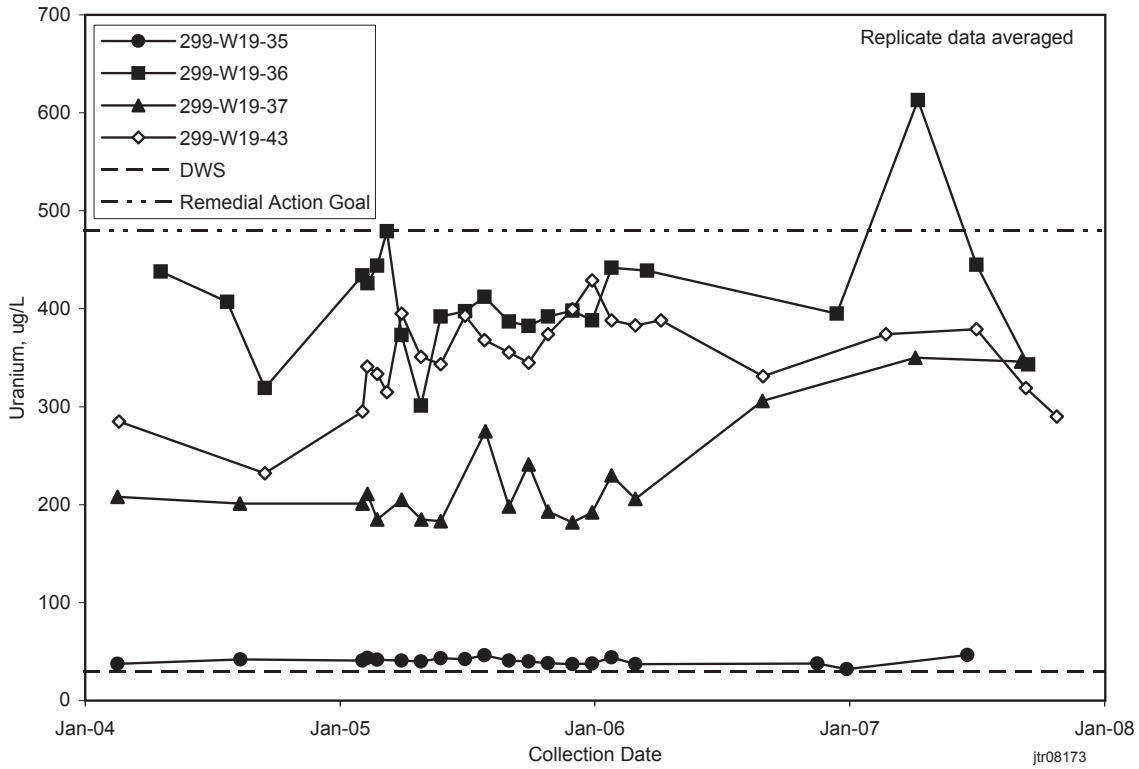


Figure 2.9-13. Uranium Concentrations in Selected Wells at 200-UP-1 Pump-and-Treat Area

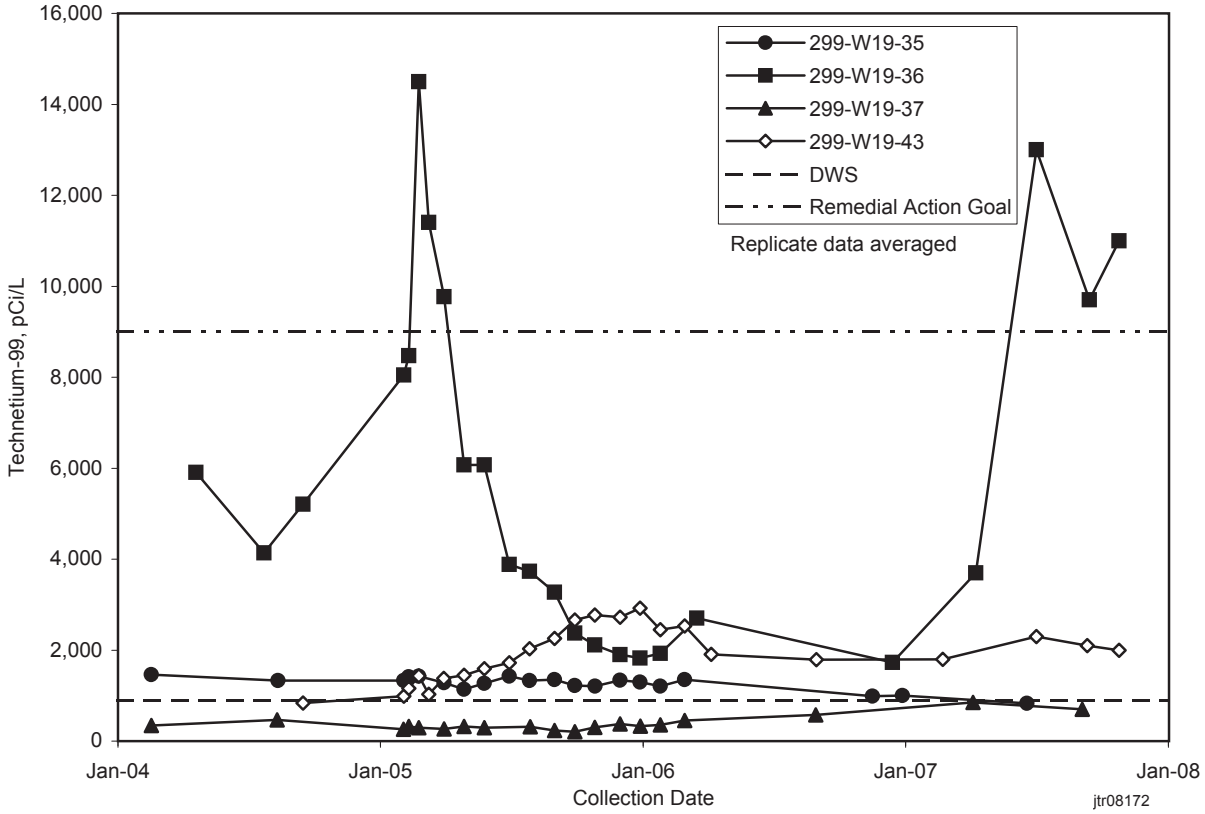


Figure 2.9-14. Technetium-99 Concentrations in Selected Wells at 200-UP-1 Pump-and-Treat Area

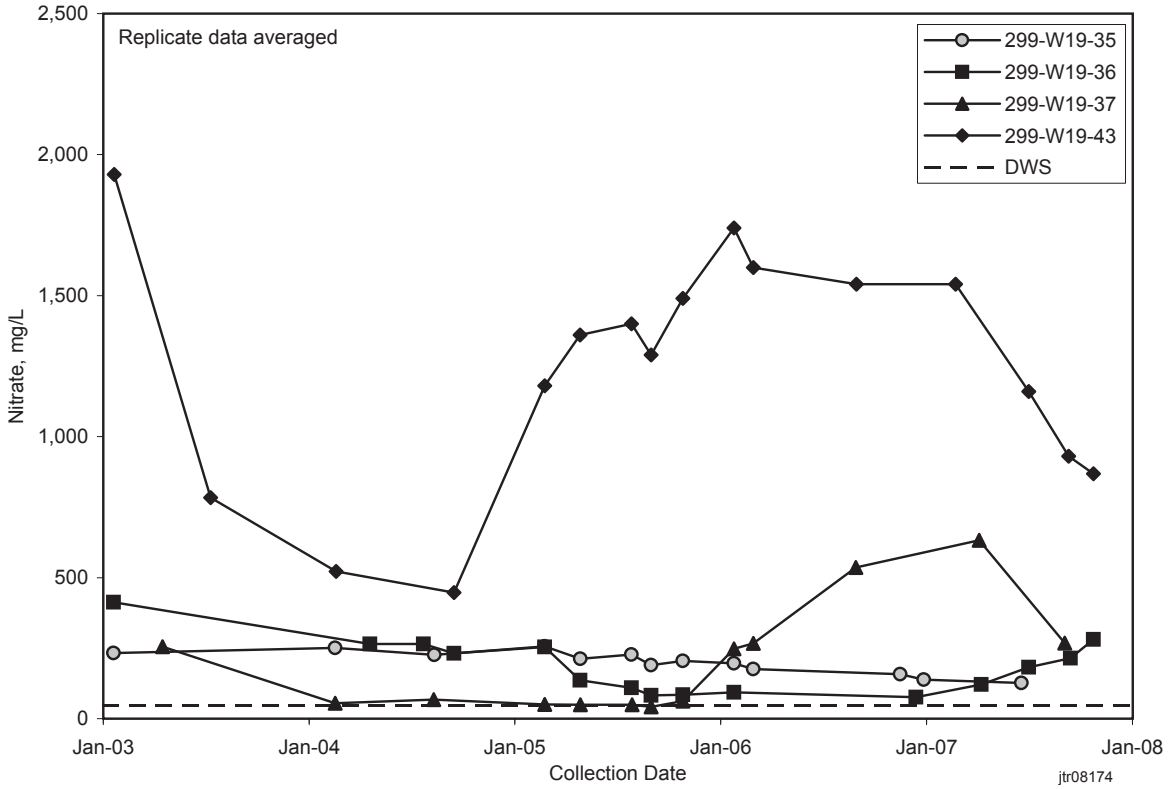


Figure 2.9-15. Nitrate Concentrations in Selected Wells at 200-UP-1 Pump-and-Treat Area

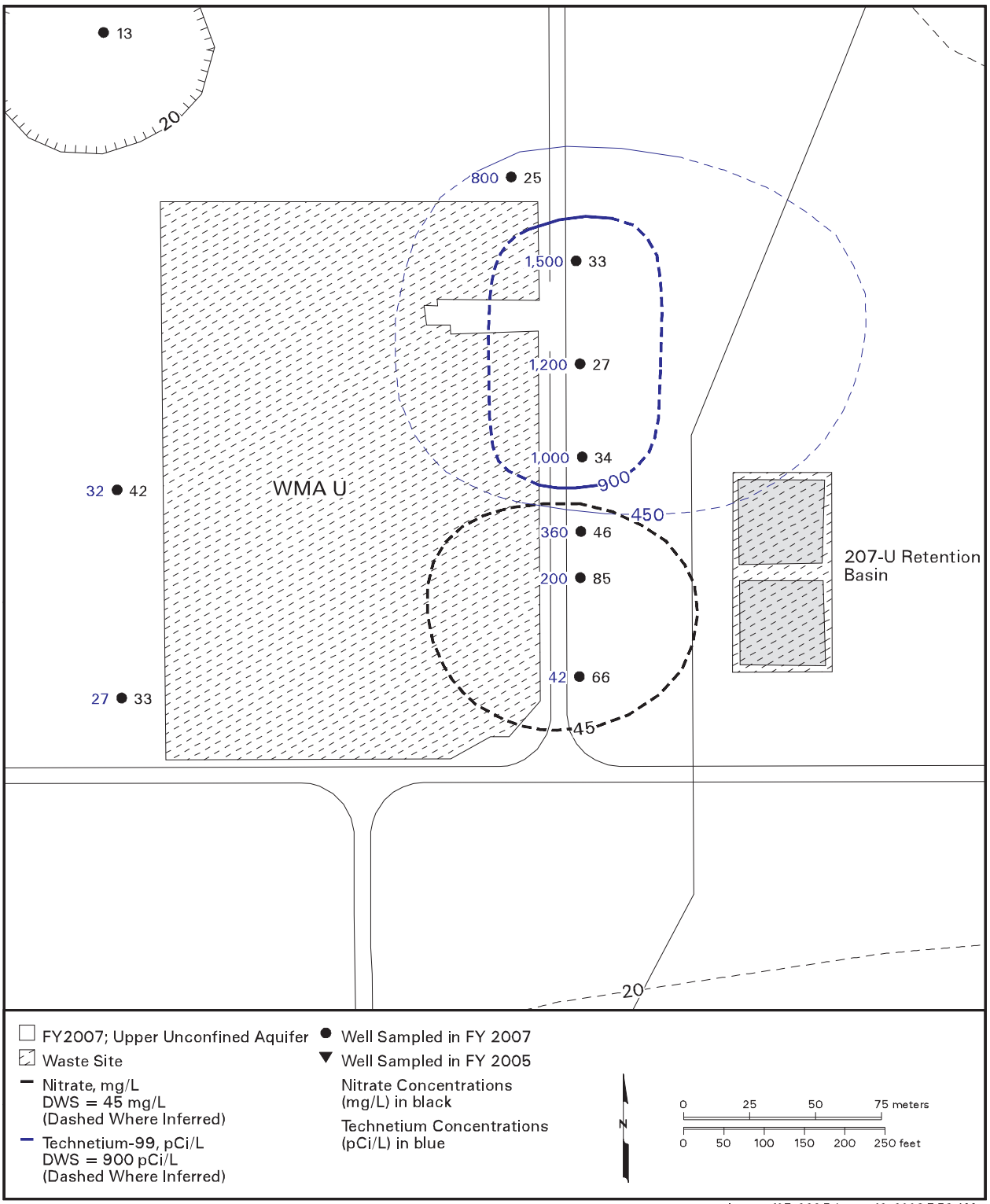


Figure 2.9-16. Average Nitrate and Technetium-99 Concentrations at Waste Management Area U, Upper Part of Unconfined Aquifer

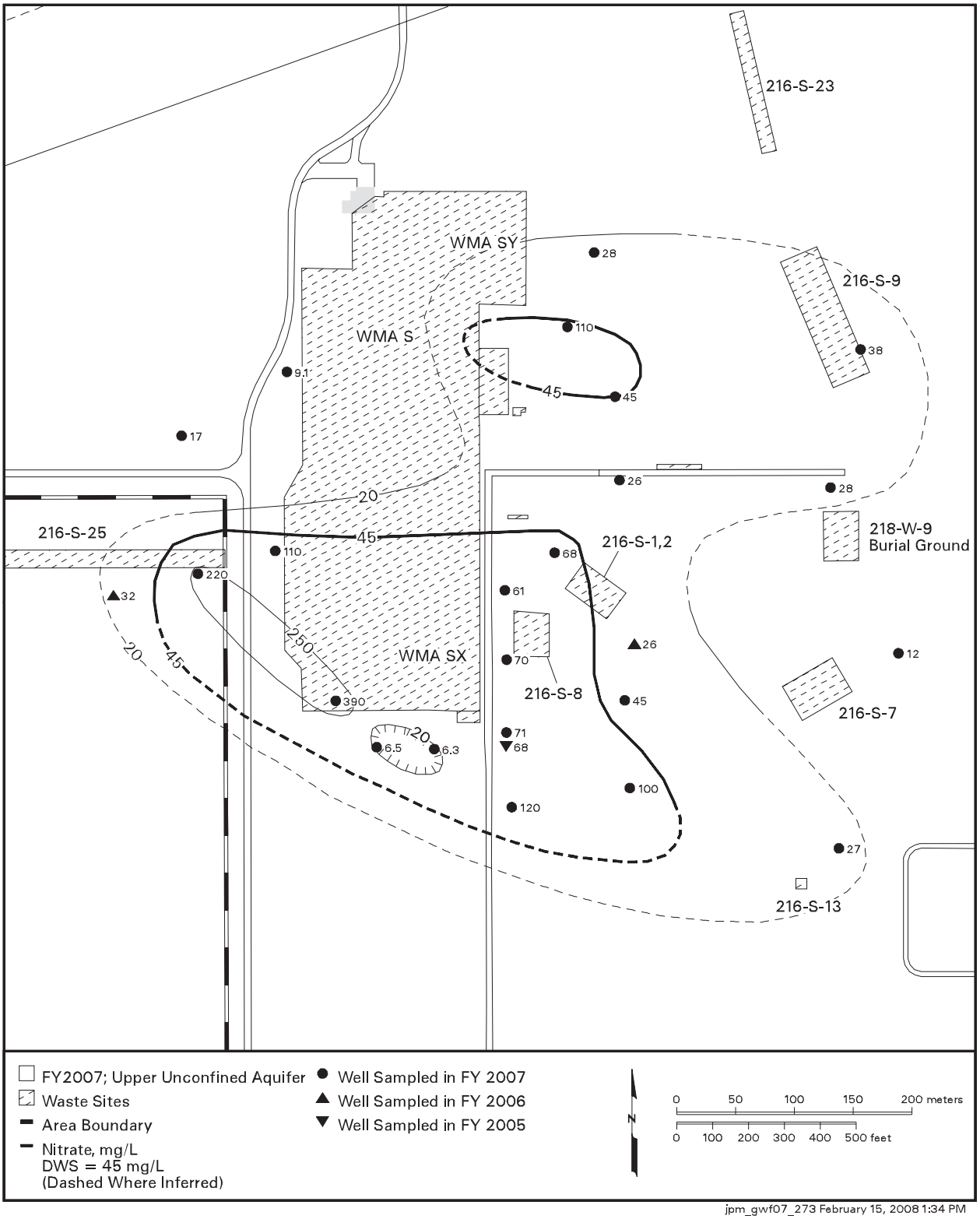


Figure 2.9-17. Average Nitrate Concentrations at Waste Management Area S-SX, Upper Part of Unconfined Aquifer

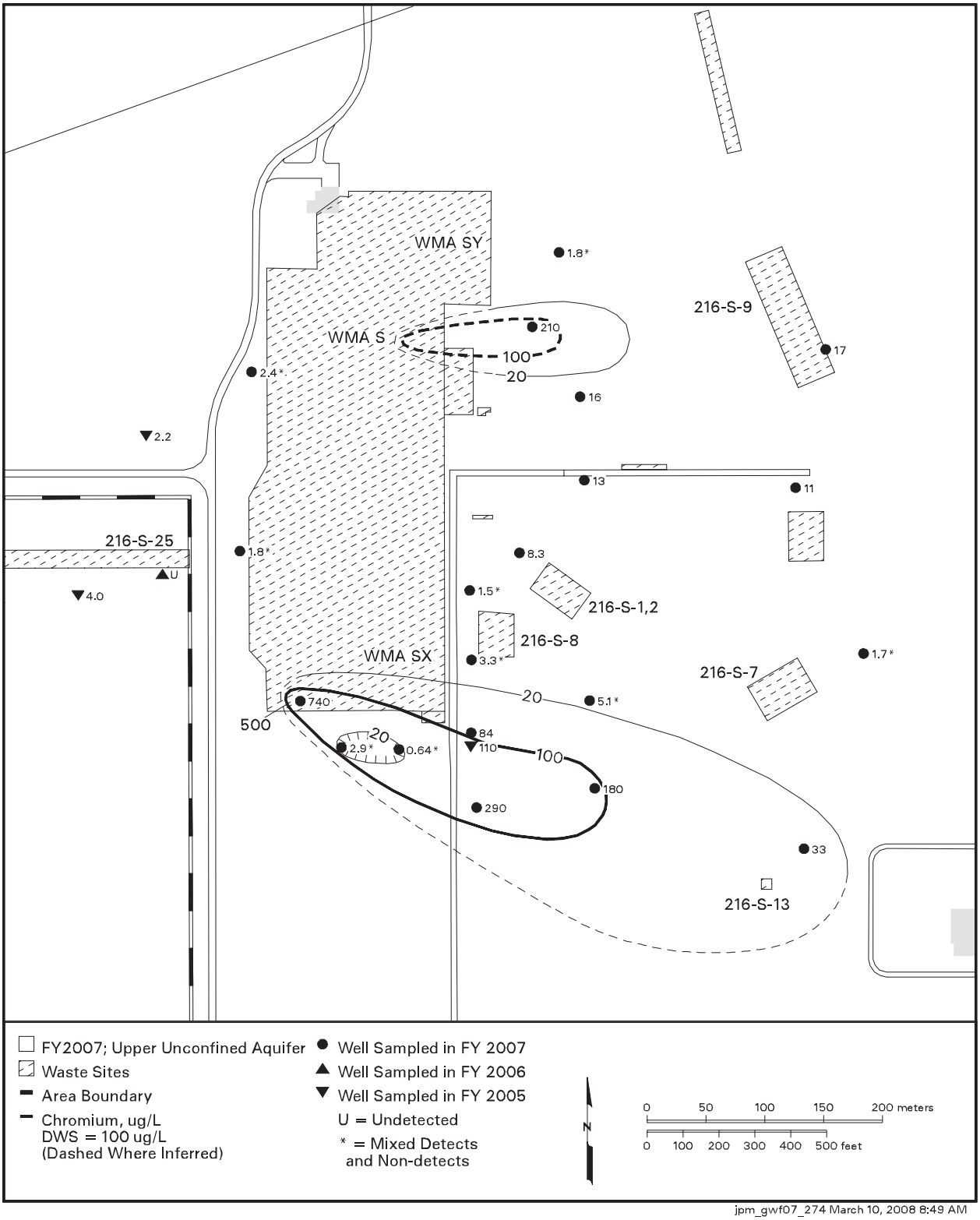


Figure 2.9-18. Average Chromium Concentrations at Waste Management Area S-SX, Upper Part of Unconfined Aquifer

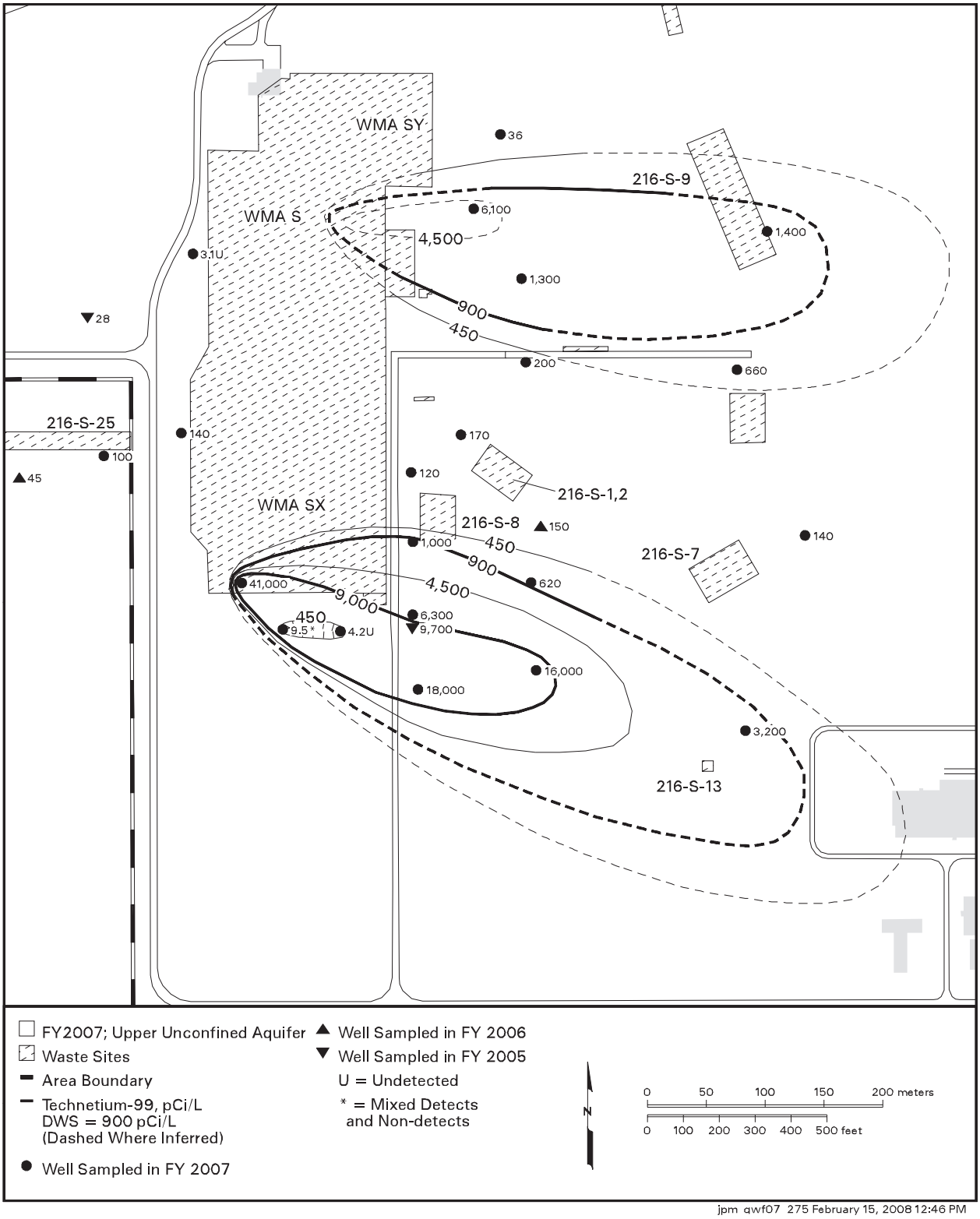


Figure 2.9-19. Average Technetium-99 Concentrations at Waste Management Area S-SX, Upper Part of Unconfined Aquifer

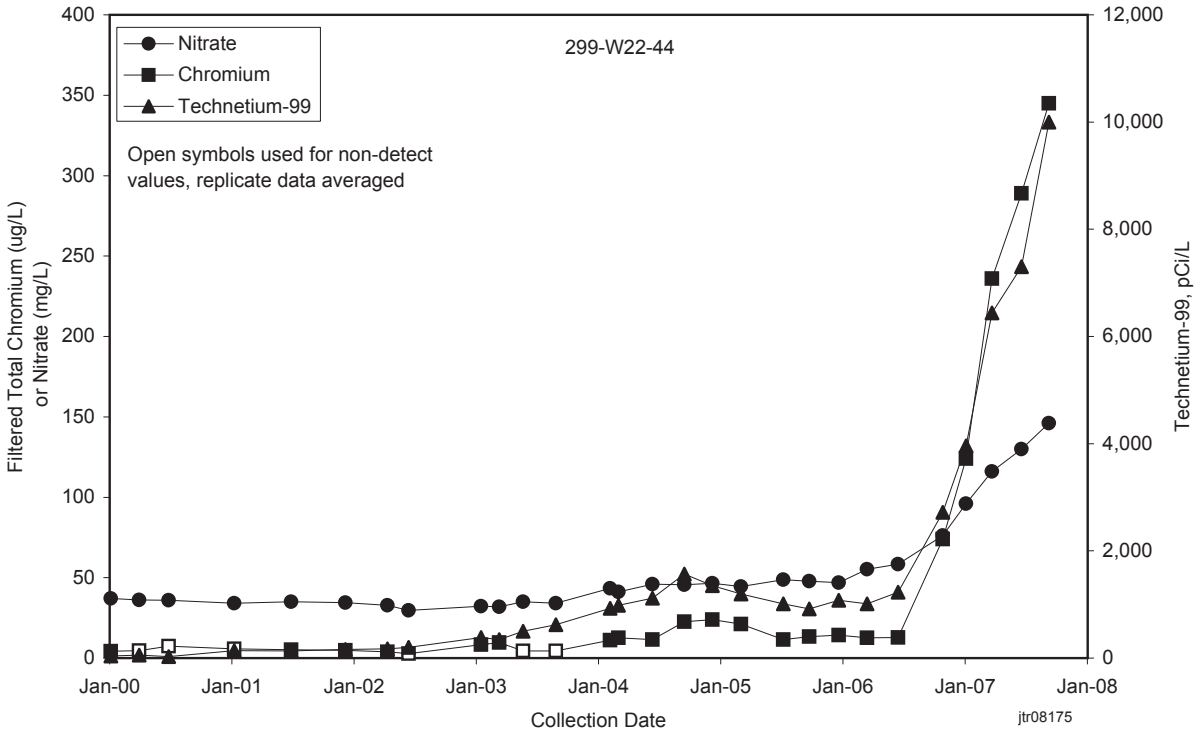


Figure 2.9-20. Concentrations of the Mobile Tank Waste Constituents Nitrate, Chromium, and Technetium-99 Downgradient from S Tank Farm

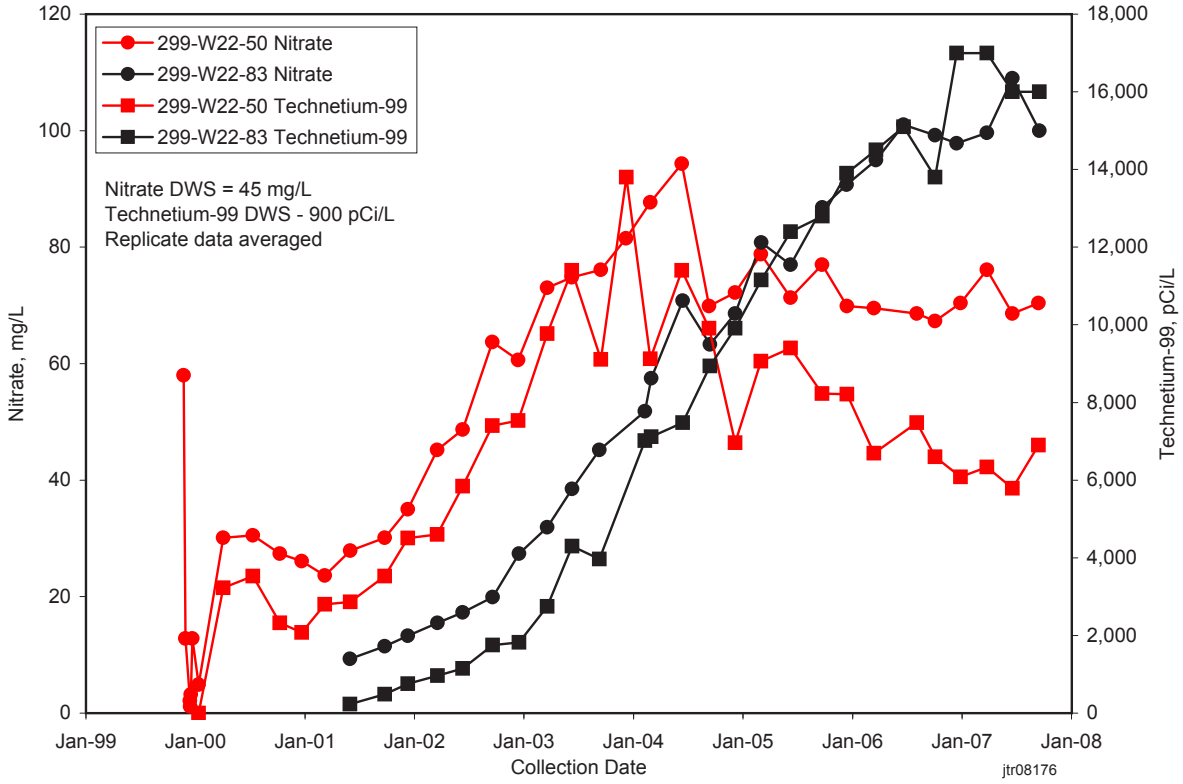


Figure 2.9-21. Nitrate and Technetium-99 Concentrations Within the South Plume Originating from Waste Management Area S-SX

2.10 200-BP-5 Operable Unit

G. S. Thomas, D. B. Barnett, and S. M. Narbutovskih

This section discusses the data, analyses and interpretations compiled in fiscal year (FY) 2007 for the 200-BP-5 Operable Unit including the groundwater under the northern half of the 200 East Area, the region north to West Lake, around Gable Mountain and through Gable Mountain Gap to the Columbia River (see Figure 1.0-1 in Section 1.0). Groundwater is monitored in the 200-BP-5 Operable Unit to track regional and local contaminant plumes, and to support six *Resource Conservation and Recovery Act* (RCRA) units and several *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) past-practice sites. Figures 2.10-1 and 2.10-2 show the operable unit boundaries and wells within the operable unit.

Groundwater is monitored in the 200-BP-5 Operable Unit to track regional and local contaminant plumes.

In parts of the operable unit large volumes of processing waste were discharged to the soil column, both intentionally and unintentionally. These discharges occurred over most of Hanford's operational history, from the mid-1940s through the late1980s. During this time, water levels rose and declined according to production schedules (Figure 2.10-3). The major sources of influence on regional flow were the B Pond and Gable Mountain Pond (Figure 2.10-4). These major effluent release sources were associated with relatively low contaminated water and used to intentionally control other areas hydraulically where liquid effluent releases were more contaminated. One such area, the B Complex area, in the northwest corner of the 200 East Area had numerous large volume effluent disposal sites and several storage facilities reporting unplanned releases. The waste discharge history combined with a sparse distal well network and a complex hydrogeologic environment has resulted in high levels of uncertainty in development of a defensible conceptual site model. This complexity has led to the development of several conceptual site models over the years, which are being investigated by the 200-BP-5 remedial investigation/feasibility study process.

Groundwater monitoring in the 200-BP-5 Operable Unit includes the following monitoring activities:

CERCLA and AEA Monitoring (Appendix A)

- ***Ninety-five wells are sampled annually to triennially. Two wells were delayed until October 2007.***
- ***In FY 2007, three new wells were installed.***

Facility Monitoring (Appendix B)

- ***Twenty-six wells are sampled quarterly to annually at Waste Management Area B-BX-BY. One quarterly sample was missed.***
- ***Twelve wells are sampled semiannually at the 216-B-63 trench.***
- ***Twenty-six wells are sampled semiannually at Low-Level Waste Management Areas 1 and 2.***
- ***Two wells are sampled semiannually at the Liquid Effluent Retention Facility.***
- ***Nine wells are sampled quarterly at Waste Management Area C.***

The water-level elevation only differs ~4 centimeters across most of the 200 East Area.

Three factors combine to form an extremely complex hydraulic environment within part of the operable unit. First, highly permeable sediments form an essentially flat gradient on the water table making flow direction and rate estimates based solely on water elevations questionable. Second, large volume waste discharges associated with Hanford operations changed the natural groundwater gradient and saturated areas not associated with the preexisting or natural unconfined aquifer. Third, variations in aquifer thickness possibly lead to structural controls in thin aquifer areas and unclear delineation of contaminants in thick aquifer areas. As mentioned above, an example of these factors is most evident in the B Complex area (e.g., Waste Management Area B-BX-BY and surrounding cribs and trenches).

The most current water table elevation of the unconfined aquifer is shown in Figure 2.10-5. The relief is not sufficient to warrant constructing contours across the 200 East Area. The map is based on water-level measurements collected in July 2007 for the Hanford Site. The measurements were collected over a short time period for the 200 East Area to reduce barometric effects associated with atmospheric pressure changes. The measured water-level elevation only differs ~4-centimeters across most of the 200 East Area, which is on the order of the total uncertainty associated with determining water-level elevations. Consequently, other methods are used to provide some estimate flow direction and rate.

Providing additional data to evaluate conceptual models is one focus of the 200-BP-5 Operable Unit remedial investigation.

Early groundwater monitoring wells were generally located near waste effluent sources to determine the effectiveness of cribbing criteria rather than determining the extent of various plumes. The cribbing criterion was devised to limit the migration and concentration of contaminants entering the groundwater. By this method less tank space would be needed for storage and groundwater would not be significantly impacted. However, certain mobile contaminant levels within the groundwater have in the past and recently been reported with significantly elevated concentrations. Due to the lack of distal wells and the addition of new waste sites or unplanned releases near older waste sites and unplanned releases it became increasingly difficult to define source and plume extent. Through the years various conceptual models were developed to explain the distal data with various levels of uncertainty. Providing additional data through various means to evaluate some of these past conceptual models is one focus of the 200-BP-5 Operable Unit remedial investigation. A more complete picture of the subsurface will facilitate the development of the baseline risk assessment and selection of appropriate remedial alternatives, resulting in a more effective solution. The planned scope of the remedial investigation/feasibility study for the 200-BP-5 Operable Unit is summarized in Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit and the appended Sampling and Analysis Plan (DOE/RL-2007-18).

Plume areas (square kilometers) above the drinking water standard at the 200-BP-5 Operable Unit:

Cyanide — 0.07
Iodine-129 — 5.37
Nitrate — 4.73
Strontium-90 — 0.65
Technetium-99 — 1.92
Tritium — 0.47
Uranium — 0.39

Before Hanford operations affected the water table, flow in the 200 East Area was thought to be from west to east. Early in the Hanford operation history a buried basalt ridge that extended along the northern boundary of the 200 East Area roughly parallel to Gable Mountain was considered a barrier for northern flow from 200 East Area (Figure 2.10-6). However, as increasing artificial recharge was planned for the PUREX operation, concern for contamination flow north to the gap between Gable Butte and Gable Mountain (Gable Gap) and to the Columbia River was considered (HW-49728). To offset the effects of discharge from PUREX to B Pond, the Gable Mountain Pond

was created (Figure 2.10-2). Although this hydraulic balance/dam was devised to immobilize groundwater contamination from moving north, groundwater contaminant data provide evidence of historic flow to the north from the 200 East Area. High nitrate contamination (e.g., 1,300 mg/L) in well 699-50-53A (Figure 2.10-2) located over the basalt anticlinal ridge was first reported in 1960. Also in 1975, tritium contamination was detected in well 699-49-57A with a maximum value of 400,000 pCi/L. These elevated concentrations of nitrate and tritium were associated with crib discharges to the south.

Understanding the influence of basalt structure on groundwater flow is important to understanding contaminant migration north of the 200 East Area.

Since the reduction and subsequent halt of liquid effluent discharges to the soil, the water table has slowly declined. While the water table has declined the areal extent of the basalt surface emerging from the unconfined aquifer has increased. Understanding the influence of basalt structure on groundwater flow is important to understanding and predicting contaminant migration north of the 200 East Area. For areas where the aquifer is very thin over the anticlinal high and the groundwater chemistry is apparently unchanging, there may be very little flow. This appears to be the case in wells 699-50-59, 699-55-57 and 699-52-57 (Figure 2.10-2). The present groundwater elevation in the aquifer at wells 699-50-59 and 699-55-57 is ~0.3 meters. Both these wells, where the aquifer is very thin, show unchanging contaminant concentrations over the past few years (Figure 2.10-7). In addition, well 699-52-57 has gone dry. However, well 699-49-57A, located in between these wells, has shown increasing uranium concentrations. Although uranium is increasing in well 699-49-57A, nitrate and technetium-99 values have shown no apparent trend in the past few years. Currently it is unknown if some transmissive aquifer channel associated with a Paleo Flood or ancestral Columbia River path may exist (Figure 2.10-6) or if past contaminant plumes in this area may be moving off the basalt subcrop. Further characterization may be necessary to ascertain the hydraulic conditions in the aquifer surrounding well 699-49-57A.

Better definition of contaminant migration and rate in the 200-BP-5 Operable Unit is one of the primary objectives of the remedial investigation activities. Recent work done in support of the 200-BP-5 Operable Unit remedial investigation/feasibility study use constituent migration over time to evaluate groundwater flow direction and rate in several areas across the operable unit (Sections 2.10.1.1, 2.10.3.1, and 2.10.3.6). Studies like these not only improve the estimate of flow direction and rate, but assist evaluating potential risks from the groundwater contamination and assist in making remedial decisions.

Better definition of contaminant migration is one of the primary objectives of remedial investigation activities.

The contaminant of greatest concern in the 200-BP-5 Operable Unit is technetium-99 because it is mobile, has a long half life and has a broad areal extent (DOE/RL-2007-18; WMP-28945; DOE/RL-2001-49, Rev. 1). Although it has a limited spatial distribution, uranium is also recognized as an important contaminant because of the high concentration reported in the groundwater. Groundwater is monitored in this operable unit to define the local extent of contamination associated with specific CERCLA and RCRA treatment, storage, and disposal units. The regional extent and distribution of technetium-99, uranium, nitrate, iodine-129, tritium, and other significant contaminants are also monitored. As mentioned above the monitoring program is being expanded to reduce uncertainty in the extent of certain contaminants for a more defensible baseline risk assessment.

The upper basalt-confined aquifer is also monitored in the 200-BP-5 Operable Unit to evaluate potential migration of contaminants from the overlying unconfined

aquifer (Section 2.14). This is evident in one well, 299-E33-12, which in the past was a conduit for contamination from the unconfined aquifer to the upper confined aquifer (RHO-RE-ST-12P). Also current increases in contamination at wells 699-53-55A and 699-53-55B may indicate potential contamination from the confined aquifer near an erosional window. The basalt north of the anticlinal high was significantly eroded by late Pleistocene flooding. The stratigraphy at two wells, 699-55-60A and 699-53-55A, show that all or most of the Elephant Mountain Basalt was removed allowing communication with the Rattlesnake Ridge interbed. The interbed is generally the uppermost confined aquifer (DOE/RL-2005-76). Due to contaminant concentrations at wells 299-E33-12, 699-53-55A, and 699-53-55B, further investigations in FY 2008 are planned to determine the extent of contamination potentially associated with the confined aquifer.

In general, groundwater currently enters the 200 East Area from the west.

Section 2.10.1 provides general information regarding contaminant plumes and concentration trends for contaminants of concern. Section 2.10.2 discusses aspects of groundwater monitoring specific to the 200-BP-5 Operable Unit. Specific information regarding contaminant distribution for RCRA units within the 200-BP-5 Operable Unit is presented in Section 2.10.3.

2.10.1 Groundwater Contaminants

This section summarizes the distribution of groundwater contamination in the 200-BP-5 Operable Unit. Specific information is provided for several CERCLA sites (the 216-B-5 reverse well, BY cribs, and Gable Mountain Pond) as well as general information regarding regional contaminant distribution, particularly in the area of the Gable Gap. Results are provided for tritium, nitrate, iodine-129, technetium-99, cyanide, uranium, cobalt-60, cesium-137, strontium-90, plutonium-239/240, sulfate, chloride, and mercury. See Figure 2.10-1 for locations of wells monitored in the 200 East Area and Figure 2.10-2 for locations of wells monitored in the 600 Area for the 200-BP-5 Operable Unit. Contaminant distribution maps presented in this section show annual averages where some wells have four quarters of data, some two quarters and some one value per year.

2.10.1.1 Tritium

Tritium contamination is widespread throughout the 200-BP-5 Operable Unit (Figure 2.10-8) extending from the 200 East Area north over the anticlinal high through the Gable Gap and to the Columbia River. The highest tritium concentrations for the 200-BP-5 Operable Unit occur under the BY cribs where a local plume extends west to the north side of Low-Level Waste Management Area 1 and within the Gable Gap at well 699-60-60.

The maximum tritium concentration in the operable unit in FY 2007 was located in the BY cribs in well 299-E33-4 at 173,000 pCi/L. This peak was a short duration event rising from a low of 53,400 pCi/L in November 2006 to the peak in July 2007 and back to 88,000 pCi/L by late September 2007. A spike was also seen in well 299-E33-7 in June 2007, which dissipated considerably by late August 2007. No other corresponding peaks were identified in the BY cribs. In addition, no corresponding peaks were reported in wells to the southeast or west as of the completion of FY 2007. Unfortunately, the absence of wells to the north, east, and west does not allow a full picture of migration from BY cribs.

Another local high is found in one well, 699-60-60, within the Gable Gap area with a concentration reported at the drinking water standard of 20,000 pCi/L. This is a decrease from 25,700 pCi/L reported last year. This small tritium plume appears to be the trailing remains from a more concentrated plume that migrated through the gap area during the 1990s. Tritium concentrations within the gap continue to decrease. Further south, in well 699-49-57A, where the historic maximum tritium concentration was 400,000 pCi/L in 1975 the value is now 11,500 pCi/L (Figure 2.10-9).

2.10.1.2 Nitrate

For FY 2007, the nitrate distribution is shown in Figures 2.10-10 and 2.10-11 using averaged values. Concentrations exceeding the drinking water standard (45 mg/L) occur in the following areas: southeast of Waste Management Area C, on the southeast corner of the Low-Level Waste Management Area 2, beneath the 216-B-5 reverse well, in the northwest portion of the 200 East Area to well 699-50-59 on the structural basalt high, Gable Mountain Pond, and from the 'basalt window' at well 699-53-55C northwest to well 699-55-57. For wells within and north of the Gable Mountain Gap to the Columbia River, nitrate concentrations were reported at levels less than the drinking water standard. Nitrate occurrences at the C Tank Farm, on the west side of Low-Level Waste Management Area 1 and at Low-Level Waste Management Area 2 are discussed in Sections 2.10.3.4 and 2.10.3.6, respectively.

The maximum nitrate concentration detected in the operable unit was located beneath the BY cribs in well 299-E33-4 at 8,630 mg/L. The duration of this peak was similar to tritium with concentration lows in November 2006 and September 2007. Overall during 2007, the average nitrate concentrations were higher in the northern BY crib wells (299-E33-4 and 299-E33-7) than the southern wells and wells to the southeast of the BY cribs. Note that the depth of the aquifer beneath the BY cribs is thickest in well 299-E33-7. Subsequent increases in nitrate contamination to the southeast of the BY cribs indicates possible migration. This directional increase is consistent with the following contaminants: technetium-99, cyanide, and cobalt-60. Limited depth-discrete studies of nitrate and technetium-99 in this area have indicated the contaminants may be migrating down the basalt contour. This is consistent with the basalt surface in this area. However, the absence of wells monitoring the area north and northwest of the cribs does not allow a full picture of migration from BY cribs (Figure 2.10-11). Based on pattern matching trends and contaminant suites, contamination from the BY cribs is also affecting groundwater along the northern border of Low-Level Waste Management Area 1.

The maximum nitrate concentration detected in the operable unit was located beneath the BY cribs in well 299-E33-4 at 8,630 mg/L.

At the 216-B-8 crib, the maximum nitrate value increased from 881 mg/L in FY 2006 to 956 mg/L in FY 2007 in well 299-E33-16 located beneath the 216-B-8 crib. The concentration increase indicates infiltration from the 216-B-8 crib. It should be noted that over the past few years, concentrations have increased beneath certain waste sites significantly, however, when the local area is mapped, the peripheral contours from 2001 through 2007 are comparable and movement appears to be nearly stagnant at least to the east, south, and west. Additional discussion is provided in Section 2.10.3.1.

Historically, nitrate is found extending beyond the northwest corner of the 200 East Area, over the basalt anticlinal high and toward the Columbia River within the Gable Gap (see Figure 2.10-11). Just north of the BY cribs where the basalt anticlinal high is located, values over 1,000 mg/L were reported during the 1960s in wells 699-49-57A and 699-50-53A (Figure 2.10-2). Values decreased through the early 1970s and then spiked up in 1973 and remained high through the 1970s in well

699-49-57A. However concentrations remained low in Gable Gap. From the late 1980s to the end of 2000, values have continued to increase primarily in well 699-49-57A as water levels have continued to decline. Nitrate also increased in well 699-49-57A some time between 2000 and 2003, remaining relatively unchanged since then (Figure 2.10-7). Levels decreased this last year from 277 mg/L in FY 2006 to 237 mg/L in FY 2007. These results are consistent with the recently installed well, 699-50-59, located ~700 meters northwest of well 699-49-57A, which has reported unchanging chemistry with a decrease in average concentration from 110 to 98 mg/L.

The unchanging chemistry in well 699-50-59 along with the results from well 699-50-56 (44 mg/L), located ~460 meters northeast of well 699-49-57A, appear to constrain the nitrate plume to the west and east, respectively. However, with high levels of contamination reported in well 699-49-57A along with the absence of full geochemistry (anions and cations for Stiff diagrams) and increasing concentrations of uranium there appears to be active transport near this well. Characterization efforts, planned as part of the operable unit remedial investigation/feasibility study, may require additional information to ascertain the hydraulic conditions in the aquifer surrounding well 699-49-57A.

Farther north, nitrate concentrations are found above the drinking water standard (45 mg/L) in well 699-53-55C, increasing from 132 to 135 mg/L this last year. This well is located in the 'basalt window' where the Elephant Mountain Basalt was removed during the Pleistocene floods leaving the unconfined aquifer in communication with the confined Rattlesnake interbed aquifer. The source of the nitrate may be related to past high levels found in the late 1980s in well 699-50-53A, where levels were 1,500 mg/L in the 1960s and 735 mg/L in the late 1980s to early 1990s. The extent of this contaminant plume is not understood at this time; however, concentrations have continued to steadily increase in wells 699-53-55B and 699-53-55C over the past decade. In support of the 200-BP-5 Operable Unit remedial investigation/feasibility study, further work will be planned to study this area to help address the extent of this contamination.

Characterization efforts may require additional information about the hydraulic conditions in the aquifer north of 200 East Area.

Downgradient of well 699-53-55C, nitrate levels are increasing in well 699-57-59 from 20.8 to 27 mg/L over the last year. This increasing trend appears to be associated with the increasing contaminant levels at well 699-53-55C as does the recently increasing values at well 699-60-60 where levels have increased from 31.4 to 40.3 mg/L over the last year.

Left from past facility discharges, nitrate continued to be detected in wells monitoring Gable Mountain Pond at levels above the drinking water standard of 45 mg/L. In general, trends are either decreasing or remain unchanged. For example, the highest values are found in well 699-53-48A where the nitrate concentrations have been decreasing since 1996, from 177 to 165 mg/L over this last year. In well 699-53-47A, nitrate levels have remained nearly constant with a change from 88 mg/L in FY 2006, to 93 mg/L in FY 2007.

The 216-B-5 injection well is located northeast of 221-B Building and has shown increasing nitrate levels since the mid-1990s. Over the last two years levels have increased from 29.7 mg/L in FY 2005 to 57.1 mg/L this last year. The groundwater at this location continues to be the only location within the 200-BP-5 Operable Unit that has elevated cesium-137 and plutonium-239. See Section 2.10.1.7 for further discussion of this facility.

2.10.1.3 Iodine-129

Iodine-129 contamination is present throughout the 200-BP-5 Operable Unit. The distribution of iodine-129 follows a pattern through 200 East Area similar to tritium (Figures 2.10-12 and 2.10-13). Groundwater concentrations exceeding the iodine-129 drinking water standard of 1 pCi/L in the 200-BP-5 Operable Unit are generally limited to the 200-East Area, but do extend north of the 200 East Area as far as well 699-57-59 (1.4 pCi/L), within Gable Gap. Concentrations exceeding the drinking water standard do not extend beyond Gable Gap.

In addition, a region of elevated iodine-129 concentrations is present in the B Complex area with values less than 5 pCi/L during FY 2007.

2.10.1.4 Technetium-99

The distribution of technetium-99 above the drinking water standard (900 pCi/L) includes Waste Management Area C, the B Complex area, the basalt anticlinal ridge north of the 200 East Area, and at the 'basalt window' in well 699-53-55A and extending to well 699-55-57 (Figures 2.10-14 and 2.10-15). North of well 699-55-57 and through the gap, values do not exceed the drinking water standard.

The highest technetium-99 concentrations in FY 2007 were reported under the BY cribs at 73,400 pCi/L.

The highest technetium-99 concentrations in FY 2007 were reported under the BY cribs at 73,400 pCi/L in well 299-E33-4. This is a significant increase from FY 2006 when the maximum value was 42,900 pCi/L. The technetium-99 concentration peaked similar to tritium and nitrate with lower concentrations in November 2006 and September 2007. Also similar to nitrate the average technetium-99 concentrations were higher in the northern wells than the southern wells under the BY cribs. The subsequent increases in technetium-99 contamination to the southeast of the BY cribs indicates migration which is consistent with co-contaminants nitrate, cyanide, and cobalt-60. Limited studies of co-contaminants nitrate and technetium-99 have indicated the contaminant suite may be migrating down the basalt contour. This is consistent with the basalt surface in this area, which dips generally to the south. However, the absence of wells monitoring the area north and northwest of the BY cribs does not allow a full picture of migration from BY cribs (Figure 2.10-15). Based on pattern matching of trends and contaminant suites, this contamination is also present in wells along the northern border of Low-Level Waste Management Area 1.

Significant increases in technetium-99 levels were also found in a number of wells south and southeast of the BY cribs during FY 2007. For example, well 299-E33-16 at the 216-B-8 crib peaked at 14,100 pCi/L in November 2006. Levels in well 299-E33-18, near the 216-B-7A/7B cribs averaged 13,750 pCi/L with little variation this last year. On the southern border of Waste Management Area B-BX, in well 299-E33-337 a short duration increase was reported from May 2006 to February 2007 with concentrations from 66.3 pCi/L to 3,230 pCi/L. Subsequent to this peak technetium-99 returned to 167 pCi/L by late August. These separate isolated areas with different groundwater chemistry suggest multiple sources. Further information on contaminant trends in the area is located in Section 2.10.3.1.

Limited studies of nitrate and technetium-99 indicated they may be migrating down the basalt contour.

Similar to nitrate, historical technetium-99 concentrations were high north of the 200 East Area providing part of the evidence for northern flow direction in the past (Section 2.10). As with nitrate, technetium-99 levels increased in well 699-49-57A sometime between 2000 and 2003 when data were not collected. However, since 2003, the concentration is relatively unchanging with a value of 4,850 pCi/L in

2003 and 4,480 pCi/L in 2007 (Figure 2.10-7). These results are consistent with the recently installed well 699-50-59, located ~700 meters northwest, which has reported unchanging chemistry (anion and cation balance) with a decrease in technetium-99 concentration from 1,370 to 1,130 pCi/L over the last year. The unchanging chemistry in well 699-50-59 along with the low technetium-99 results from well 699-50-56 (560 pCi/L), located ~460 meters northeast, appear to constrain the technetium-99 plume on the west and east, respectively. However, with high levels of contamination reported in well 699-49-57A along with the absence of full geochemistry and increasing concentrations of uranium there appears to be active transport near this well (Figure 2.10-15). Characterization efforts, planned as part of the operable unit remedial investigation/feasibility study, may require additional information to ascertain the hydraulic conditions in the aquifer surrounding well 699-49-57A.

Contamination is increasing in well 699-53-55C, located in an area where the Elephant Mountain Basalt has been eroded.

Another area of increasing contamination is at well 699-53-55C, within the 'basalt window,' an area where the Elephant Mountain Basalt has been eroded, creating a relatively thick aquifer. Technetium-99 concentrations increased from 2,600 to 2,750 pCi/L over the last year. As with nitrate, this contamination appears to be migrating northwest through the other wells sampled in the vicinity of Gable Mountain Gap. The Gable Gap wells (699-57-59, 699-59-58, and 699-60-60) showed slight increases in concentration over the last year (Figure 2.10-14). The concentrations for these gap wells are below the drinking water standard (900 pCi/L). As discussed in WMP-28945, the source of this rising contamination may be a vestige of the contamination observed in the late 1980s in well 699-50-53A. It is worth noting that high contamination (technetium-99 concentrations over 30,000 pCi/L) was observed at well 699-50-53A during the mid-1980s to early 1990s. The extent of this contaminant plume is not understood at this time; however, concentrations have continued to steadily increase in wells 699-53-55B and 699-53-55C over the past decade. In support of the 200-BP-5 remedial investigation/feasibility study, further work is planned to study this area to help address the extent of this contamination.

2.10.1.5 Cyanide and Cobalt-60

Uranium recovery waste was disposed directly to the soil column in seven of the eight BY cribs in the mid-1950s. The waste was transferred from tanks in the BY Tank Farm. Within the operable unit, cyanide is detected in the B Complex area and wells to the northwest and in a few wells at Waste Management Area C. Cyanide concentrations are above the drinking water standard (200 µg/L) under and southeast of the BY cribs and in well 299-E33-34, located in the northeast corner of Low-Level Waste Management Area 1 (Figure 2.10-16). Due to the significant concentrations of this contaminant in the groundwater from wells beneath the BY cribs, this constituent assists in distinguishing contaminant signatures associated with the BY cribs.

The maximum cyanide concentration detected in the operable unit in FY 2007 was located in the BY cribs in well 299-E33-4 at 3,990 µg/L. This value is an increase from the maximum value of 1,470 µg/L, reported last year. The increased value reported in this well is consistent with the increased values for technetium-99, nitrate, and cobalt. Overall during 2007, the average cyanide concentrations were more elevated in the northern wells (299-E33-4 and 299-E33-7)[a] than the southern wells and wells

(a) Well 299-E33-4 contains too little water (~0.3 meter) to sample by routine methods. It was sampled with a bailer in FY 2007 and sample turbidity ranged from 34 to 73 NTU. Well 299-E33-7 contains more water (~1 meter) and was sampled with a pump in FY 2007 and samples had low turbidity (<5 NTU).

to the southeast of the BY cribs. For example, the average cyanide concentration in well 299-E33-1A was 569 µg/L as compared to 341 µg/L at well 299-E33-13. The subsequent increase in cyanide contamination to the southeast of the BY cribs indicates migration which is also seen with technetium-99, nitrate, and cobalt-60. However, the absence of wells monitoring the area north and northwest of the cribs, does not allow a full picture of migration from BY cribs (Figure 2.10-16). Limited studies of contaminants nitrate and technetium-99 have indicated the contaminant suite may be migrating down the basalt contour. This is consistent with the basalt surface in this area. Additional discussion is provided in Section 2.10.3.1.

Cobalt-60 has a short half-life (5.3 years) making radioactive decay relevant for this constituent. Consequently, concentrations are usually found at less than the drinking water standard (100 pCi/L). Currently the only area where concentrations exceed the drinking water standards were in wells monitoring the BY cribs. The highest cobalt-60 concentration in FY 2007 was in well 299-E33-4 at 599 pCi/L, an increase from 290 pCi/L last year. The next highest values in well 299-E33-7, increased from 49.5 to 93.4 pCi/L during the year. As discussed previously, both wells had corresponding high cyanide, nitrate, technetium-99, and tritium levels.

The highest uranium concentrations in the operable unit during the last several years have been in well 299-E33-9 beneath the BY Tank Farm.

2.10.1.6 Uranium

Uranium concentrations exceed the drinking water standard (30 µg/L) in wells monitoring the B Complex and to the northwest, wells near the 216-B-62 crib, and wells near the 216-B-5 injection well (Figure 2.10-17).

The highest uranium concentrations in the 200-BP-5 Operable Unit during the last several years have been consistently reported in well 299-E33-9 beneath the BY Tank Farm. Although samples collected and analyzed at well 299-E33-9 had the highest average uranium for the site (786 µg/L) in FY 2007, well 299-E33-41 was reported with the highest peak value at 935 µg/L in August 2007. The average value at well 299-E33-41 for FY 2007 was 554 µg/L. Another location showing consistently high average uranium results this year was well 299-E33-18, near the 216-B-7A and 216-B-7B cribs at 754 µg/L (Figure 2.10-17). Other wells reporting concentrations greater than 10 times the drinking water standard (> 300 µg/L) included 299-E33-16 (beneath 216-B-8 cribs), 299-E33-31 (west of well 299-E33-9), and 299-E33-38 (northwest of well 299-E33-9).

The groundwater contamination in the B Complex area is present in a northwest-southeast pattern that, in recent years, has shown a broadening to the east, west and south as shown in the mapped time series of uranium in Figure 2.10-18.[b] Although it has been suggested the uranium contamination was moving quickly to the northwest (Christensen et al. 2004), the location of the 100-µg/L contour to the northwest for the past several years is nearly unchanged, indicating nearly stagnant groundwater conditions. This observation is based on contours which include wells 299-E33-26, 299-E33-34 and 299-E33-9, the three locations that define northwest flow in the past. Regardless of the uranium increases in the local area, the uranium does not seem to have significant movement along the edges of the plume.

Conversely, uranium concentrations have been increasing in well 699-49-57A in the last several years with a maximum of 18 µg/L in FY 2007. These increases

(b) Figure 2.10-18 shows a slightly different interpretation of the uranium plume than the PNNL-16346 (2006) and Figure 2.10-17 (2007). The alternative interpretation of Figure 2.10-18 shows separate plume centers beneath BY and B Tank Farms. Ongoing studies may clarify which interpretation is more valid.

suggest that groundwater in this area is moving (Figure 2.10-17). However, it should be noted that uranium concentrations reported at well 699-49-57A are at the same magnitude as uranium values reported in proximal wells in the 1990s.

Uranium concentrations have been increasing in well 699-49-57A, north of 200 East Area, with a maximum of 18 µg/L in FY 2007.

Uranium concentrations exceeded the drinking water standard in one well (299-E33-34) at Low-Level Waste Management Area 1. Uranium levels have decreased in this well from a maximum value of 107 µg/L in 2004 to the FY 2007 value of 74.8 µg/L. Concentrations in well 299-E28-27 on the southeast corner of the facility increased from 16.2 to 26.2 µg/L over the last year. Further information on contamination at Low-Level Waste Management Area 1 can be found in Section 2.10.3.3.

216-B-62 Crib. For the last 8 years, uranium has been detected at levels close to the drinking water standard (30 µg/L) in well 299-E28-18, which monitors the 216-B-62 crib. This crib is located northwest of B Plant (Figure 2.10-17). Uranium concentrations were over 200 µg/L in the mid-1980s, but declined to current levels by the late 1980s. The maximum FY 2007 uranium concentration at the 216-B-62 crib was 31 µg/L reported for well 299-E28-18. Well 299-E28-21 also monitors the crib but is located north of well 299-E28-18. Uranium concentrations have been decreasing at this location since the initial high values were observed in the mid-1980s. In FY 2007, the concentration was 10.9 µg/L, a decrease from the FY 2006 value of 13.3 µg/L. The source of uranium for these wells has been linked to the 216-B-62 crib, however, based on waste site soil inventory estimates for the crib, uranium may be from another source.

216-B-5 Injection Well. Uranium contamination is associated with the cesium-137, plutonium, and strontium-90 contamination found at the 216-B-5 injection well. The highest uranium concentration detected in FY 2007 at this site was 37.4 µg/L in well 299-E28-23, located ~1 meter from the injection well (Figures 2.10-17). Uranium concentrations are roughly stable in well 299-E28-23. Uranium values were significantly lower in wells 299-E28-24 (22.1 µg/L) and 299-E28-25 (15.4 µg/L) located farther from the injection well. During FY 2007, a uranium value of 39.5 µg/L was reported for well 299-E28-6, located south of the injection well. Uranium concentrations have been generally stable in well 299-E28-6 since 2002, with a slight decline in FY 2007. It is not known if the source of uranium contamination in this well is the 216-B-5 injection well.

2.10.1.7 Cesium-137, Strontium-90 and Plutonium-239/240

Cesium-137 contamination (>200 pCi/L) in the 200-BP-5 Operable Unit is limited to the 216-B-5 injection well. Cesium-137 has relatively low mobility and is generally found near the source. Well 299-E28-23 near the 216-B-5 injection well has consistently had concentrations of cesium-137 greater than the drinking water standard (200 pCi/L) but less than the U.S. Department of Energy (DOE) derived concentration guide (3,000 pCi/L). In FY 2007, a concentration of 1,120 pCi/L was reported for this well. All other wells sampled at this site had cesium-137 concentrations below the drinking water standard in FY 2007.

During FY 2007, strontium-90 contamination in the 200-BP-5 Operable Unit was reported in the groundwater at the 216-B-5 injection well and at Gable Mountain Pond. Four wells (299-E28-2, 299-E28-23, 299-E28-24, and 299-E28-25) near the 216-B-5 injection well had concentrations of strontium-90 above the drinking water standard (8 pCi/L) in FY 2007. Two of these wells continued to have strontium-90 concentrations greater than the DOE derived concentration guide (1,000 pCi/L). The

highest strontium-90 concentration was reported for well 299-E28-23, with reported values of 4,130 and 3,960 pCi/L in FY 2007. Concentrations have been declining in this well since 2000; however, the concentration in FY 2007 are slightly elevated over the FY 2006 concentrations of 3,390 and 3,290 pCi/L. Strontium-90 also exceeded the DOE derived concentration guide in well 299-E28-25, with a concentration of 1,590 pCi/L reported in FY 2007.

In several wells near Gable Mountain Pond, strontium-90 concentrations rose in the 1990s and have declined since 2000 but remain above the drinking water standard. The plume did not change significantly during FY 2007. Strontium-90 was detected in groundwater at levels above the DOE derived concentration guide in well 699-53-47A in FY 2000, but has been below the guide since FY 2003. The concentration in this well was 614 pCi/L in FY 2007, representing a slight decrease from the FY 2006 concentration of 679 pCi/L. Concentrations at well 699-53-48A decreased from 741 pCi/L in FY 2005 to 397 pCi/L in FY 2006 and to 329 pCi/L in FY 2007. Strontium-90 concentrations in both wells have decreased from their peaks in the late 1990s.

In several wells near Gable Mountain Pond, strontium-90 concentrations have declined since 2000 but remain above the drinking water standard.

Plutonium-239 and plutonium-240 were detected in past years in the groundwater near the 216-B-5 injection well. Plutonium contamination is relatively immobile and, therefore, is found only near the injection well. The highest reported plutonium concentration in FY 2007 was for well 299-E28-23 that had reported filtered values of 12.0 and 12.7 pCi/L and unfiltered values of 35.4 and 40.4 pCi/L. The unfiltered results were above the DOE derived concentration guide for plutonium (30 pCi/L). The lower concentration in the filtered versus unfiltered samples suggests that a portion of the plutonium is associated with particulates. The concentration of plutonium in well 299-E28-23 has not exhibited a clear change in trend in recent years. Other wells sampled near the 216-B-5 injection well site have also had plutonium levels below the DOE derived concentration guide in recent years.

2.10.1.8 Sulfate and Chloride

Sulfate and chloride concentrations have been increasing over part of the 200-BP-5 Operable Unit since the mid to late 1990s and have recently exceeded the secondary drinking water standards in a few locations. A distribution map of sulfate results for FY 2007 is provided in Figure 2.10-19. Relevant information on chloride concentrations is discussed in section 2.10.3.1.

The secondary drinking water standard of sulfate (250 mg/L) was exceeded in wells 299-E33-4, 299-E33-9, and 299-E33-16. These high values are, most likely associated with the other contaminants since sulfate compounds were used in the Hanford processing streams. However, along the sub-crop in Low-Level Waste Management Area 2 and Liquid Effluent Retention Facility where the aquifer is slowly receding down the basalt gradient, sulfate is increasing to values as high as 671 mg/L in well 299-E27-10 with no associated contaminants other than chloride (185 mg/L) and nitrate (109 mg/L). The increasing regional sulfate trend is affecting upgradient wells at Waste Management Area C (Section 2.10.3.6) and may be affecting the groundwater as far south as Waste Management Area A-AX (Section 2.11.3.3). The reason for the increasing sulfate is not known at this time.

2.10.1.9 Mercury

Low levels of mercury (drinking water standard, 2 μg/L) have appeared sporadically in a few wells monitoring the low-level burial grounds and the BY cribs. In most wells in this area, samples have been analyzed for mercury routinely as far back as

the late 1980s. All but a few results during this period have historically been below detection limits (minimum detection limits range from 0.05 to 0.2 µg/L). Recently, however, mercury results in a few wells have been above detection limits with the most conspicuous of these occurring in well 299-E33-7, located in the northern portion of the BY cribs in November 2006 at a concentration of 4.3 µg/L. A review of soil analyses for mercury beneath the BY cribs showed the concentrations were at or below Hanford Site background levels. Well 299-E33-34, at the northeast corner of Low-Level Waste Management Area 1, previously produced several sequential low-level (maximum 0.19 µg/L) detections, but was below detection (<0.09 µg/L) in FY 2007. Although mercury is not commonly detected in Hanford groundwater samples several wells during the Groundwater Background Study (DOE/RL-96-61) reported elevated concentrations of mercury.

2.10.2 Operable Unit Activities

CERCLA monitoring requirements in the 200-BP-5 Operable Unit have been defined in the sampling and analysis plan (DOE/RL-2001-49, Rev. 1). The sampling and analysis plan was revised in late FY 2004 to integrate *Atomic Energy Act* (AEA) monitoring and make slight modifications in the 200-BP-5 monitoring network. A second revision will be completed in early FY 2008 to incorporate the new wells being installed as part of the 200-BP-5 remedial investigation. CERCLA monitoring includes sampling of the regional plumes, and sites discussed in the above sections which include: B Complex waste sites, B Plant waste sites, Semi works waste sites and both the Gable Mountain and B Pond. However, due to the location of B Pond, the 200-PO-1 Operable Unit also monitors this area. Results of monitoring are discussed in Section 2.10.1.

An interim or final record of decision has not been established yet for the 200-BP-5 Operable Unit. This report is the only formal report presently being prepared on a regular basis for the unit.

A characterization program was designed to support decisions during the remedial investigation/feasibility study process (WMP-28945), including consolidation on a preferred conceptual model. During FY 2007, the following activities were completed for the 200-BP-5 Operable Unit CERCLA remedial investigation/feasibility study:

- Release of *Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process* (WMP-28945) in February, 2007.
- Release of Draft A *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit and the appended Sampling and Analysis Plan* (DOE/RL-2007-18) in March 2007.
- Installation and initial monitoring of three groundwater monitoring wells. Two wells, 699-50-56 and 699-48-50B, are located north of the 200 East boundary and monitor the unconfined aquifer. One well, 299-E33-50, is located north of the 216-B-8 Crib and monitors the confined aquifer.
- Design for 12 investigation wells of which 10 wells are planned for installation in FY 2008.
- Characterization activities associated with sediment and groundwater sample

collection, aquifer testing, borehole geophysical logging, elemental isotope studies, contaminant ratio analyses, and Stiff diagram investigations.

- Conducted surface resistivity surveys analyzed with inversion theory. Results were mapped and considered during placement of further characterization work.
- Development of local and regional conceptual models to provide a defensible and useful understanding of geology/hydrogeology, the natural and Hanford-induced hydraulic character and chemical evolution of the groundwater systems, including groundwater flow directions and rate.
- Planning and preparation for extensive hydraulic characterization with pumping tests and in situ tracer investigations to better characterize hydraulic properties plus depth-discrete groundwater sampling/analyses in select wells to map the vertical extent of contamination.
- Preliminary design work for possible future remedial activities was initiated.

Three new wells (299-E33-50, 699-48-50B, and 699-50-56) were added to the 200-BP-5 monitoring network in FY 2007. These wells will serve as groundwater monitoring wells for the 200-BP-5 Operable Unit and will support the 200-BP-5 Operable Unit remedial investigation/feasibility study. Well 299-E33-50 was completed in the Rattlesnake Ridge interbed confined aquifer and is located in the north-central portion of the 200 East Area of the Hanford Site just north of the 216-B-8 crib. Wells 699-48-50B and 699-50-56 were completed in the suprabasalt unconfined aquifer and are located in the 600 Area, directly north of the 200 East Area and south of the Gable Gap.

The 200-BP-5 monitoring network and analytes are listed in Appendix A. In FY 2007, sampling was planned for 91 wells. Of these, 89 wells were successfully sampled during FY 2007. Sampling of the remaining two wells was delayed until October 2007.

2.10.3 Facility Monitoring

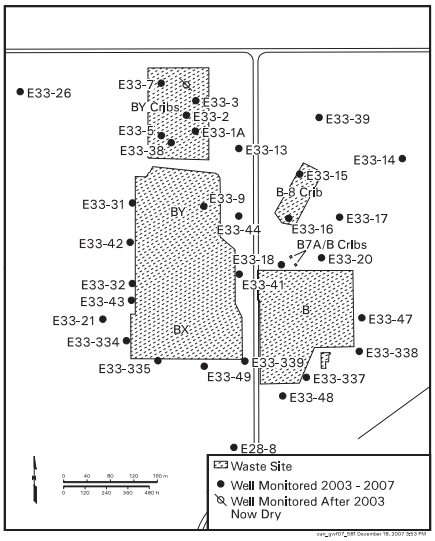
This section describes results of monitoring at individual units such as treatment, storage, and disposal units or tank farms. Some of these facilities are monitored under the requirements of RCRA for hazardous waste constituents and AEA for source, special nuclear, and by-product materials. Data from facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Hazardous constituents and radionuclides are discussed jointly in this section to provide comprehensive interpretations of groundwater contamination for each facility. As discussed in Section 1.2, pursuant to RCRA, the source, special nuclear, and by-product material components of radioactive mixed waste are not regulated under RCRA and are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

The 200-BP-5 Operable Unit contains six RCRA sites with groundwater monitoring requirements: Waste Management Area B-BX-BY, 216-B-63 trench, Low-Level Waste Management Areas 1 and 2, Liquid Effluent Retention Facility, and Waste Management Area C. This section summarizes results of statistical

comparisons, assessment studies, and other developments for FY 2007. Groundwater data are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

2.10.3.1 Waste Management Area B-BX-BY

Located in the northwest part of the 200 East Area, this waste management area consists of the B, BX and BY Tank Farms along with its ancillary equipment. The three farms, jointly, consist of 36 underground tanks ranging from 2- to 2.9-million-liter capacity and four 208,000-liter tanks constructed between 1945 and 1949. Seventeen of the larger tanks are known or suspected to have leaked in the past along with three of the smaller tanks. A well location map and table of wells along with analytes sampled for the waste management area this fiscal year are included in Appendix B.



Waste Management Area B-BX-BY is currently in a RCRA groundwater quality assessment program (PNNL-13022, Rev. 1). A first determination investigation showed contamination from past unplanned releases to the soil column associated with the farms, most likely, compromised groundwater quality (PNNL-11826, 1998). Consequently, the site continues in RCRA assessment with quarterly monitoring to assess the extent and rate of contaminant migration associated with the waste management area. Sampling is also conducted to monitor for new occurrences of groundwater contamination that may be associated with the farms or ancillary equipment. In addition to monitoring dangerous waste constituents for RCRA assessment, the site is monitored for CERCLA and AEA purposes under the 200-BP-5 Groundwater Operable Unit program.

In the past, the RCRA groundwater assessment work for the current fiscal year has been included in this report in lieu of a separate report. Although the same reporting will be done this year to capture FY 2007 RCRA groundwater assessment work, this may not be the case in outlying years. When significant results have been generated during the fiscal year, a data package to capture relevant data, analyses and interpretations may be prepared from which a summary will be included in this document. Consequently, the following detailed discussion should not set a precedent for future report contents.

The primary dangerous waste constituents found beneath Waste Management Area B-BX-BY in FY 2007 are nitrate, sulfate, chloride and cyanide along with the non-RCRA regulated constituents technetium-99, uranium, tritium and cobalt-60. In the past, elevated nitrite levels were also observed. These constituents are contributed to multiple facilities, including Waste Management Area B-BX-BY and the surrounding cribs. Also elevated values of iron and manganese are found in one location north of the site. Because the high concentrations of iron and manganese are found only under the BY cribs, past releases at these facilities are the most likely source.

Based on multiple methods of determining groundwater flow direction, the apparent direction at Waste Management Area B-BX-BY is to the south (PNNL-16346; Narbutovskih et al. 2002.) Work done in support of the 200-BP-5 Operable Unit remedial investigation along with in situ flow rate measurements and time series mapping of major plumes provides evidence of slow contaminant migration to the

south at this waste management area. Locally, the aquifer was formed by past Hanford operations associated with large volume releases (i.e., B Pond and the PUREX cribs). Presently, it is slowly receding in the direction of the dipping basalt surface as water levels decline, with current aquifer thicknesses ranging from 0.3 meter in the north to less than 5.5 meters south of the waste management area. The water has receded completely at one location under the 216-B-49 crib where the basalt is above the aquifer. Another location at the BY cribs has ~0.3 meter of aquifer left. Thus, the location of the edge of aquifer and the basalt surface above the aquifer is close to the north side of the BY cribs.

The rate of decline in the water table has decreased over the years since B Pond ceased operations. For example, the water table decreased by nearly 0.3 meter from 1998 to 1999, by 0.12 to 0.18 meter from 2001 to 2002, then 0.09 meter in 2005 to 0.06 meter in 2006. From 2006 to 2007, there was no decrease in the elevation of the water table at this site. In the artificially induced part of the aquifer, this decreasing rate of decline may reflect the slow flow rate as shown by in situ investigations. Least squares regression fits to hydrographs indicate most monitoring wells, screened across the entire aquifer, will remain useful for over 15 years provided the rate of decline does not increase.

The waste management area is surrounded with past-practice facilities where waste that is the same or similar to stored material in the tanks was intentionally discharged to the soil column. To distinguish non-tank groundwater contamination from tank-related contamination, the monitoring network includes 24 near-field and 5 far-field wells. Most wells are monitored quarterly to allow pattern matching of contaminate trends although a few wells are sampled semi-annually (see Appendix B for details).

Assessment studies have identified several distinct suites of contaminants depending on location within the B Complex area. (PNNL-13116; PNNL-14187; PNNL-14548, PNNL-15070; PNNL-16346). A brief description of these contaminants suites is provided in the following paragraphs.

This discussion for Waste Management Area B-BX-BY constitutes the annual RCRA groundwater assessment documentation of analyses and interpretations completed during FY 2007.

- ***Nitrate, Chloride, Sulfate, Technetium-99, and Uranium.*** These contaminants are located under the BY Tank Farm. In the past, elevated nitrite has also been found with this contaminant suite. Migration of contamination through the vadose zone may, at least partly, source this groundwater contamination. Further assessment of the source is ongoing although its proximity to the BY Tank Farm suggests a possible tank-related source.
- ***Tritium and Nitrate***. This contaminant suite was found on the southwest corner and along the south border of the waste management area. With the recent migration of technetium-99, uranium and nitrate from upgradient under the waste management area, this suite does not appear today as a distinct group. Movement of elevated tritium with low levels of nitrate from a perched water zone located ~4.5 meters above the water table under the BX Tank Farm, most likely, caused this local plume. In the 1960s and 1970s, large volumes of tritium were generated and moved through the tank farm waste transfer lines from the in-tank solidification process making this a possible tritium source for the perched water. For more information see PNNL-15070.
- ***Technetium-99, Nitrate, Uranium, Sulfate, Tritium, Cobalt-60, and Cyanide.*** This contaminant suite, found under and around the BY cribs, comprises

the highest levels of contamination in the groundwater at the B complex of facilities, except for uranium. Elevated iron and manganese are also in the groundwater above the drinking water standards (300 µg/L and 50 µg/L, respectively) under the BY cribs. This suite is, most likely, associated with waste released in the past to the BY cribs and for tritium, also the 216-B-57 crib. Evidence is presented that shows this contaminant suite is slowly impacting wells to the south during FY 2007.

- ***Nitrate, Technetium-99 and Uranium.*** Located under the 216-B-8 crib, this local area had the highest nitrate concentrations during the late 1990s. Although elevated nitrite was observed in 2005, analysis of recent sharp increases in all three main contaminants suggest the source is associated with past discharges to the 216-B-8 crib.

Although there is wide-spread contamination in the 200 East Area, there are local plumes of nitrate, technetium-99, uranium, chloride and tritium in the immediate region of the waste management area and surrounding disposal facilities. Time series mapping, trend plots, Stiff diagrams, nitrate to technetium-99 ratio, uranium isotopes and spectral gamma logs are used to investigate possible sources, identify wells with similar sources and delineate flow migration pathways. The following discussion pertains to the waste management area and the surrounding facilities.

Nitrate. A series of nitrate maps, shown in Figure 2.10-20, tracks the development of this contaminant plume across the waste management area from 1995 to the present in 3-year intervals. In 1995, elevated nitrate was found in a northwest to southeast pattern extending from the northeast corner of Low-Level Waste Management Area 1, through the BY cribs to northern part of the 216-B-8 tile field. From 1995 to 1998, within the B complex area, this northwest-southeast extending contaminant migrated to the southwest and south as shown by the change in location of the 30 mg/L (dark blue), 40 mg/L (green) and 50 mg/L (yellow) contours. By 2001, the plume migrated sufficiently to move the 100-mg/L contour (orange) to the southwest. During the time from 1995 to 2001, the water table dropped nearly one meter, indicating the groundwater, and consequently the contamination, was moving.

From 2001 to 2007, the plume expansion to the southwest has slowed with some southern movement of the 40- and 50-mg/L contour (green and yellow) on the west side of the BX Tank Farm. During this time period, the water dropped considerably less, approximately 0.4 meter. This drop equates to a 0.13 meter decline for a 3-year interval. The decrease in plume expansion appears to reflect a reduction in flow rate over the last several years. Also, the 50-mg/L contour (yellow) in 2001 through the BX Tank Farm marks the approximate location where the natural part of the aquifer begins, i.e., in pre-Hanford time there was no aquifer north of this location. South of this location, the plume tends to expand to the southeast, toward the 216-B-63 trench. This movement can be seen by comparing the location of the 30 mg/L (dark blue), 40 mg/L (green) and 50 mg/L (yellow) contours north of the B Tank farm in 2004 to southeast of the farm in 2007. Note also that throughout the time from 1995 to 2004, contours have moved to the southeast through Low-Level Waste Management Area 1 and south of the tank farms as shown by the southeast movement of the 10 mg/L (violet) and 30 mg/L (light blue) contours. This same movement is seen in regional nitrate contaminant maps found in annual groundwater reports (PNNL-11793; PNNL-13788; PNNL-15070; PNNL-16346). The pre-Hanford flow direction in this natural part of the aquifer was considered to be southeast, parallel to the natural edge of the unconfined aquifer against the basalt subcrop (RHO-ST-42).

The migration direction, based on these data, agree with results of tritium mapping and in situ methods (PNNL-13022, Rev. 0).

Superimposed on this slowly migrating background plume are developing contaminant centers, historically located under the BY cribs and at the 216-B-8 crib. For example, in the map for FY 2001, a value of 651 mg/L at the 216-B-8 crib and 624 mg/L at the BY cribs mark two local areas where nitrate is higher than at surrounding wells. Data on the 2004 map show significantly higher values under the BY cribs with a maximum of 1,070 mg/L (red). By 2007, the area with values over 1000 mg/L has increased noticeably to the south and southeast. During the same period, under the 216-B-8 crib, nitrate concentrations have increased from 558 mg/L to 956 mg/L, expanding to the southeast with a value of 673 mg/L (orange). Further discussion of these locally increasing nitrate trends along with the co-contaminants of uranium, technetium-99 and in some locales, cyanide, is found later in this section.

Time series mapping of contaminants indicates migration to the south at Waste Management Area B-BX-BY.

Technetium-99. Coincident with the nitrate plume is developing technetium-99 contamination. Time series mapping, covering the years from 2002 to 2007, is shown in Figure 2.10-21. As seen in the nitrate mapping, local centers of technetium-99 are developing within the larger slowly migrating plume under the BY cribs, at the 216-B-8 crib and near the 216-7A/7B cribs. For example, one feature displaying southern movement of the technetium-99 plume is the very slow migration of the 50-pCi/L (purple) contour from 2002 to 2004. Even the 200-pCi/L and 1,000-pCi/L contours do not show the movement on the west side of the waste management area like the nitrate data in Figure 2.10-21. However, from 2002 to 2005, there is a distinct southern movement of the 200 pCi/L contour reflecting rising contaminant level migrating over the southern border of the BX and B Tank Farms. It is important to note that there are no facilities or high levels of groundwater contamination southeast of the B Tank Farm that could source these increasing trends. Thus, the flow direction is generally from the north to the south.

Another distinct feature displaying southern movement is seen from 2004 to present day. The 10,000-pCi/L (yellow) contour demonstrated steady expansion from under the BY cribs to the south and southeast. As shown by the time-series mapping, migration is from north to south with the highest technetium-99 values found under the BY cribs. Further information on possible facility sources can be obtained by identifying the impact of water drivers with chloride concentrations and co-contaminants with trend plots.

Chloride. When water is released at the surface in arid environments, either intentionally, unintentionally, or from natural precipitation, the percolating moisture leaches chloride from buried soil horizons, bringing elevated chloride to the groundwater. By mapping the changes in groundwater chloride data, areas where water drivers are bringing contamination residing in the vadose zone to the groundwater may be identified (Scanlon 1991).

A comparison of changing chloride over time is presented in Figure 2.10-22 for the years 2001 and 2007. In 2001, the highest chloride value occurred under the BY Tank Farm suggesting a point of entry for contamination in this vicinity. Until recently, this was also the location of the highest historic uranium contamination. The center of the 20 mg/L contour is near the northwest corner of the BY Tank farm, the southwest corner of the BY cribs and the east side of the Hanford barrier over the 216-B-57 crib. This area is a local topographic low area.

Over the past 10 to 15 years, there is evidence that this locale was impacted by significant surface water from a variety of sources. For example, a distinct erosional feature developed during the 1990s to present day forming a channel ~1.2 meters deep between the B-57 Hanford Barrier and the northwest corner of the BY Tank Farm. A picture of this feature taken after heavy precipitation is shown in Figure 2.10-23. This location is only one of many where ponding after heavy precipitation was observed. This last year, the erosional feature was filled so water can no longer drain from the northwest corner (or south of the B-57 Barrier) to the BY cribs through this channel.

In addition, on the north side of the barrier, a water line valve was left open for extended time periods to irrigate deciduous trees planted during the mid-1990s in support of testing the Hanford Barrier. Between the water from channeling of natural precipitation, from long-term leaking or open water line valves, and from continuous, multiple-year use of the irrigation sprinkler system at the B-57 Barrier, the local chloride high may mark one approximate entry point for significant contaminant infiltration in this area.

By 2007, a discrete chloride high still exists under the BY Tank Farm as shown by the 50-mg/L and 60-mg/L contours. With the highly contaminated soils and known perching horizons in this vicinity (PNNL-13022, Rev. 1) combined with a slow flow rate, an influx of waterborne contamination from the vadose zone may explain the increasing contamination observed over the last 12 to 14 years in this local region.

Although higher chloride values are seen under the BY cribs, the most notable change within Waste Management Area B-BX-BY is the expansion of chloride to the south and southeast as seen by the migration of the 15-mg/L and 20-mg/L contours. This incursion of elevated chloride to the south and southeast is similar to movement of contours observed in both nitrate and technetium-99 indicating flow to the south.

Uranium. Within this slowly migrating background contamination are areas where nitrate, technetium-99, uranium and, in some places, cyanide concentrations may be migrating from the vadose zone into the groundwater. Over the last few years, these co-contaminants formed sharply rising trends in six wells in various parts of the B Complex area. At some of these sites, there does not appear to be much dispersion of the contamination before it encounters a nearby well suggesting the contaminants are entering the groundwater near the well bore. Co-varying trends between nitrate, uranium, technetium-99 and, in some places, cyanide show these constituents are co-contaminants traveling together in the groundwater. Thus, these contaminants may have a common source in the vadose zone.

The historic center of uranium contamination is under the BY Tank Farm in well 299-E33-9. However, during the last several years, this center has expanded to the south where sharp increases in uranium along with nitrate and technetium-99 are observed. The current maximum uranium concentration is southeast of the BY Tank Farm in well 299-E33-41 at 935 µg/L (Figure 2.10-24). Technetium-99 and nitrate concentrations increased with the uranium to maximum values for this locale of 5,850 pCi/L and 132 mg/L respectively. This is the closest groundwater monitoring well to the pocket of contaminated soil associated with a past leak from the 241-BX Tank Farm. At well 299-E33-18, near the 216-7A/7B cribs and just north of the 200 series tanks at the B Tank Farm, a local maximum uranium value of 844 µg/L was observed along with corresponding increases in technetium-99 to 15,000 pCi/L and

nitrate to 536 mg/L. The uranium at this well has associated technetium-99 and nitrate concentrations at three to four times greater than closer to well 299-E33-41.

Although at low levels, uranium continues to increase along the southwest and south sides of the waste management area as shown in Figure 2.10-25. With the natural uranium background at 2.5 µg/L (WHC-EP-0595), these data clearly indicate, along with the increasing nitrate and technetium-99 (Figures 2.10-20 and 2.10-21) that uranium is migrating to the south from the high values seen in the north.

Under the 216-B-8 crib at well 299-E33-16, sharply increasing and co-varying trends resulted in new local maximum contaminant values during FY 2007 with technetium-99 at 14,100 pCi/L, uranium at 386 µg/L and nitrate at 956 mg/L (Figure 2.10-26). The steeply increasing but short duration trends suggests the contamination is being driven to the water table close to the well. At the northwest corner of the BY Tank Farm, in well 299-E33-31, new maximum values of technetium-99, uranium and nitrate were also observed at 5,460 pCi/L, 398 µg/L and 427 mg/L, respectively. Low levels of cyanide have also been reported for the last year. This well is downgradient from the BY cribs, the only known locale of elevated cyanide in the groundwater.

The groundwater at two other areas displayed rapidly increasing changes in uranium and cyanide the last year. Located southeast of the BY cribs, contaminant levels in well 299-E33-13 have reached new maximum levels with 211 µg/L for uranium, 596 µg/L for cyanide, 10,900 pCi/L for technetium-99, and 1,020 mg/L for nitrate (Figure 2.10-27). It is important to note the strong corresponding trends between cyanide and uranium, indicating a common source for the cyanide and uranium. The elevated cyanide concentration indicates contamination observed at this well, including the uranium, is migrating from under the BY cribs similar to the time series mapping of nitrate and technetium-99 (Figures 2.10-20 and 2.10-21).

Also southeast of the BY cribs in well 299-E33-15, uranium, cyanide, technetium-99, and nitrate also sharply increased (Figures 2.10-27). For example, technetium-99 rose from 611 to 3,310 pCi/L while uranium increased from just over the background level (2.5 µg/L) at 4 µg/L to 25 µg/L and cyanide rose from 5.7 to 71 µg/L over the last fiscal year. These correlations between key contaminants associated with the scavenged waste discharged to soils at the BY cribs in the early 1950s and uranium strongly suggest migration of uranium from under the BY cribs to the south.

Comparisons of uranium concentrations to cyanide, technetium-99, and nitrate values indicate not only several common sources but a local flow from under the BY cribs to the south and southeast.

Under the BY cribs, the highest uranium concentration in FY 2007 was 372 µg/L in well 299-E33-38, up from 338 µg/L in FY 2006. However, other wells in the cribs have also shown increasing uranium along with cyanide, technetium-99 and nitrate. For example, uranium increased in well 299-E33-1A from about 29 to 134 µg/L while cyanide increased from about 13 to 645 µg/L and technetium-99 increased from 1,730 to 17,700 pCi/L over the last few years (Figure 2.10-28). The strong correlation between cyanide and uranium strongly suggests a common source in the soils under the BY cribs.

The only place where the trend in uranium has not continued to track with the other contaminants found in the groundwater is east of the BY Tank Farm in well 299-E33-44. Prior to 2003, the technetium-99, nitrate and uranium tracked together, indicating a common source for these co-contaminants. The maximum uranium value observed at this well was 567 µg/L in 2001. However, beginning in 2003, the uranium concentration began to decrease while the technetium-99 and nitrate levels

rose (Figure 2.10-29). This divergence of trends indicates a different contaminant plume has moved into this area, with higher nitrate and technetium-99 but lower uranium. The only location in the groundwater where higher values of nitrate and technetium-99 but lower concentrations of uranium were found during this time was upgradient under the BY cribs. Cyanide has also been increasing at this location over the past several years suggesting movement from the BY cribs to well 299-E33-44. However, use of trends plots are only one way to examine relationships between different groundwater constituents. Several other graphical means are used to further delineate locations with common sources and migration pathways.

Stiff Diagrams. As seen by the complexity in contaminant suites across the waste management area and surrounding facilities, not only are there large differences in contaminant concentrations across the site, the associated chemistry varies. To obtain a better understanding of the differences in groundwater contaminant chemistry and to trace the migration of similar groundwater signatures over the waste management area, two methods are employed to provide further insight to source chemistry and migration routes. Stiff diagrams, developed to depict water chemistry (Stiff 1951), are simple pictorial representations of the relative ionic analytical values. This method develops a graphical signature through time, based on multiple parameters affecting the groundwater at a specific location. A comparison of patterns both spatially and through time is used to identify regions of similar source and to trace migration patterns across the waste management area.

Chemistry in wells close to cribs is characteristically high in nitrate.

A relatively small number of inorganic solutes are generally present in concentrations greater than 5 mg/L (Kebow 2001). The cations are calcium, magnesium, potassium and sodium while the anions are chloride, bicarbonate and sulfate. Although usually considered a trace constituent in natural environments, it was necessary to include the nitrate values to allow the electrical charge to balance and to study contamination. The data from these eight ions were used to calculate Stiff graphs. In natural aquifer systems, different water types produce different shapes, providing a visual fingerprint of water chemistry. For this application, different contaminant sources produced distinct shapes providing characteristic visual signatures. Once a shape for a specific contaminant source area was established, a comparison of patterns allowed wells with similar trends to be identified.

The Stiff diagrams shown in Figure 2.10-30, cover the area from under the BY cribs to the southern border of the waste management area. Stiff diagrams in agreement are shown is the same colors to facilitate the following discussion. These correlations indicate the groundwater chemistry in these wells have similar sources. Note that chemistry in wells close to cribs is characteristically high in nitrate, replacing both bicarbonate and sulfate as the dominant anion. Also as contaminant levels rise, sodium is becoming more evident in crib-associated wells, especially in well 299-E33-16, under the 216-B-8 crib where sodium is replacing calcium as the dominant cation forming a unique sodium nitrate signature.

Beginning in the north, correlations are made between data from wells 299-E33-38 and 299-E33-1A, both located in the BY cribs and three wells to the south and southeast (wells 299-E33-13, 299-E33-15, and 299-E33-44). For example, data in well 299-E33-13 collected in 2005 and 2006 correlate with upgradient well 299-E33-1A for the years 2005 and 2007. Stiff diagrams at well 299-E33-38 from 1999 through early 2006 match data from later dates in well 299-E33-15 from 2001 to late 2006, indicating movement from the BY cribs to the southeast. These results

agree with comparisons of trend plots presented previously. Finally data from well 299-E33-38 in 1998 and 2004 match Stiff diagrams for well 299-E33-44 for later dates (1999 and 2005). Likewise, data from April 2006 at well 299-E33-1A agrees with the 2007 Stiff diagram in well 299-E33-44. When plotted on a Piper diagram, which is a set of tertiary plots relating major groundwater chemistry components, results from well 299-E33-44 fit closely to data from well 299-E33-1A, providing further support of a common source (Hem 1959). These results, also, agree with the southeast contaminant migration from the BY cribs as shown on the time series mapping of nitrate and technetium-99 and with the trend plots of uranium, cyanide, technetium-99 and nitrate (Figures 2.10-20, 2.10-21, 2.10-27, and 2.10-28).

Groundwater in well 299-R33-9, under the BY Tank Farm, has a unique Stiff diagram.

The groundwater chemistry forms a distinctly different Stiff pattern under the BY Tank Farm in well 299-E33-9, marked by low alkalinity (bicarbonate) with both high sulfate and nitrate balancing the even higher calcium and elevated sodium. Historically, this area marked the center of uranium contamination. This unique Stiff signature does not occur anywhere in the immediate B Complex region. The only agreement found to date is from the data collected in the late 1980s in well 699-50-53A. Located to the north on the anticlinal basalt high, the groundwater at this well showed elevated nitrate, technetium-99, cyanide and cobalt-60 in the mid- to late 1980s, believed to be sourced from the BY cribs. Well 699-50-53A is drilled into the basalt and showed evidence of fracture communication when water levels rose in the basalt during the 1950s. Well 299-E33-9 is located in a basalt low. Further data north of the BY cribs is being collected in FY 2008 to better evaluate possible connections and migration pathways.

The Stiff diagram at well 299-E33-31, located west of well 299-E33-9 has begun to take on some similar characteristics to well 299-E33-9. This location has the next highest value of elevated chloride after well 299-E33-9, suggesting a common water driver for the two locales. Along with the increasing calcium and decreasing alkalinity, some aspects of the shape are similar to that at well 299-E33-9. However the nitrate is already higher at well 299-E33-31 than at 299-E33-9, while the sulfate is lower. With low levels of cyanide beginning to occur in well 299-E33-31, this area may be experiencing some contamination locally from the vadose zone and some contamination regionally from the BY cribs. The changing shape of the Stiff diagram over time may provide more information in the future.

In the past, it was suggested the contamination in the groundwater and in the vadose zone on a perching horizon at wells, 299-E33-41 and 299-E33-18, is sourced from the pocket of contaminated soil associated with the 1951 metals waste leak from tank BX-102. A comparison of Stiff diagrams from 1998 to the present shows the pattern of major groundwater chemistry is different in the two locations. For example, in 1998, groundwater at well 299-E33-18, located north of the B Tank Farm, not only had higher total dissolved solids than in well 299-E33-41, as shown by the size of the Stiff diagram but was already displaying increasing nitrate, sodium, and calcium. By 2007, these differences are more pronounced even though both wells are increasing in groundwater contamination. It is important to note that well 299-E33-41 has less total dissolved solids and indeed, less contamination than well 299-E33-18, even though this well is significantly closer to the tank BX-102 contaminated soil.

This difference in groundwater chemistry is supported by recent results in mapping the increasing uranium found in the perching zone at both wells. Spectral gamma results from 2006 and 2007 in wells 299-E33-18 and 299-E33-41 clearly show higher levels of uranium in the perching zone farther from the tank BX-102 release in well

299-E33-18 than in the closer well 299-E33-41 (Figure 2.10-31). Also along with the increasing uranium, technetium-99 and nitrate seen in well 299-E33-18 this last year, a large increase in uranium was observed from 2006 to 2007 in the perching zone at well 299-E33-18 while very little increase in uranium levels were observed close to the tank BX-102 release in well 299-E33-41. Furthermore, a cross plot of uranium isotopes from the spectral gamma logging, displays two distinctly different trends for the two wells, suggesting there may be different sources of uranium in the area. The distinctly different Stiff signatures would agree with the possibility of more than one contaminant source operating at these locales.

Two other comparisons can be made with the Stiff diagrams. First the developing pattern of chemistry at well 299-E33-44 does not agree with that found at well 299-E33-41, even prior to the decrease in uranium at well 299-E33-44. Considering both locations are experiencing high levels of contamination, this difference would suggest different contaminant sources for each locale. Second, well 299-E33-337 is located on the southern border of the B Tank Farm. In the last few years, technetium-99, uranium, and nitrate impacted the groundwater at this recently installed well. Although the data only goes back to 2005 for this well, there does not appear to be a match to current or earlier data from well 299-E33-41, which is upgradient from this location. Although the contamination impacting the groundwater at this well is migrating from the north, it does not, at this time, appear to be the same source as seen in well 299-E33-41. In conclusion, Stiff diagrams provide a different but complementary way to study groundwater chemistry both between well locations and through time. Results presented here show that some wells south of the BY cribs are experiencing contaminant migration to the south while other wells continue to show the influence of, most likely, nearby facilities.

Results from nitrate to technetium-99 ratio plots, time-series contaminant mapping and Stiff diagrams indicate slow contaminant migration to the south.

Nitrate to Technetium-99 Ratios. Additional evidence that can increase our understanding of groundwater contamination is found by studying log-log ratio plots of nitrate and technetium-99. These ratios, like the graphical Stiff diagrams have been helpful to chemically fingerprint and identify different contaminant sources moving through the groundwater. When a pure waste source with a fixed nitrate to technetium-99 ratio enters the aquifer close to a well such that the contamination does not have the opportunity to mix with the ambient groundwater chemistry, the ratio will remain constant over time as the concentration of the nitrate and technetium-99 increases forming a horizontal line on a log-log plot. If the groundwater is already contaminated with another chemistry when the new vadose zone source enters the aquifer and there is enough travel distance in the groundwater to allow mixing, a diagonal two-part mixing curve will be formed over time on a log-log plot.

In the top panel of Figure 2.10-32, nitrate to technetium-99 ratios for well 299-E33-41 are compared to those of well 299-E33-18. When compared to the bottom panel of Figure 2.10-32, it is seen that technetium-99 in well 299-E33-41 increased from 410 to 5,850 pCi/L with similar large increases in nitrate during the last three years. This is shown in the linear trend on the nitrate to technetium-99 ratio plot, marked from 2005 through 2007 (Figure 2.10-32). Although data from both wells display linear two-part mixing curves, the trends are different, indicating different contaminant sources are impacting the groundwater at these two locations. Note that data from the BX-102 characterization borehole, 299-E33-45, does not fall on either linear trend. With this comparison, there are now three very different

lines of evidence, i.e., Stiff diagrams, spectral gamma logging results and nitrate to technetium-99 ratios, that the groundwater contamination at well 299-E33-18 is from a different source than at well 299-E33-41.

When well 299-E33-41, located close to the BX-102 release with high levels of uranium in the soil, is compared to well 299-E33-9, the location of the high uranium in the groundwater, there is no apparent correlation between the two data sets (Figure 2.10-32). Although the recent increasing contamination at 299-E33-41 displays a two-part mixing curve, there is no clear trend forming under the BY Tank Farm after a peak in contamination moved through in 2001. The groundwater in this area may be experiencing a change in source contamination that has not increased in concentration enough to form a linear trend. Regardless, there is not a correlation at this time between the two locations.

A correlation can be seen when recent contamination from 2003 to 2007 at well 299-E33-44 is compared to data from upgradient well 299-E33-38 (Figure 2.10-33). The nitrate to technetium-99 ratio at well 299-E33-38 forms a strong linear horizontal trend, indicating the contamination at this location is single-sourced (i.e., the ratio remains relatively constant over time). From the time technetium-99 and nitrate began increasing and the uranium began to decrease in well 299-E33-44, data from this well moved to a horizontal trend similar to that seen under the BY cribs. This correlation is further evidence that contamination from under the BY cribs has migrated to the groundwater at well 299-E33-44.

In the past, the groundwater at well 299-E33-44 had high levels of uranium. Since 2005, contaminant levels at well 299-E33-41 have increased. A comparison of nitrate to technetium-99 ratios between the two locations is shown in Figure 2.10-33. Not only is there no correlation for the current contaminant events at the two locations, even when uranium was high at well 299-E33-44 from 1998 to the peak in 2001, there is no connection. As with the data from well 299-E33-18, neither locale appears to have the same contaminant source.

The final comparison is made between well 299-E33-41, near the BX-102 Tank release and data from well 299-E33-337 (Figure 2.10-34). Technetium-99 levels recently exceeded 3000 pCi/L on the south side of the waste management area at this locale. The data shown for well 299-E33-41 are from the peak technetium-99 concentrations of 12,000 pCi/L, observed in 1997. In general, nitrate to technetium-99 ratios of 10 or less indicate a tank-associated source for contamination. As can be seen for data from well 299-E33-38, crib-related sources usually have significantly higher nitrate to technetium-99 ratios. The 1997 technetium-99 peak in well 299-E33-41 had a ratio of 4 indicating a tank-associated source (PNNL-11826). The data from well 299-E33-337 forms a strong linear two-part mixing trends with the low ratio of 13 for the highest technetium value of 3230 pCi/L. Although the trends are not exactly the same, the nitrate to technetium-99 ratio trend in well 299-E33-337 suggests a tank-associated source for this location. Note that the ratio from boring 299-E33-45 does correlate with data from either well.

By studying the groundwater data with multiple methods and incorporating results from vadose zone investigations, a picture of subsurface conditions at Waste Management Area B-BX-BY shows a slowly moving Hanford-induced aquifer receding to the south down the basalt gradient to the natural deeper aquifer. This direction is shown in time series mapping of mobile constituents such as nitrate,

technetium-99, tritium, and by the increasing uranium, technetium-99, and nitrate migrating south over the southern waste management area border.

There are multiple contaminated pockets of soil associated with numerous intentional and unintentional releases to the ground that are contributing to the contaminant plumes under and near these sites. Based on time series mapping, the region around the BY cribs is clearly the major source for contaminants although the soils at the 216-B-8 crib also contribute. Based on the last two years of groundwater monitoring, there appears to be more than one place the uranium is entering the groundwater. Elevated chloride, historically high uranium with relatively low nitrate and technetium-99 and a unique Stiff pattern suggest a point of entry under the BY Tank Farm. Recent spectral gamma logs along with sharp increases in uranium and technetium-99 in groundwater contamination suggest one or more points of entry near the 216-7A/7B cribs, just north of the B Tank Farm. The correlation of sharply increasing cyanide with uranium under the BY cribs suggest another point of entry may be located in the north. In addition, a spike in uranium, nitrate and technetium-99 under the 216-B-8 crib this last year, along with nitrate to technetium ratios and Stiff diagrams, suggests this locale as another point of entry. These locations are supported by recent surface geophysical exploration results that show conductive signatures nearby.

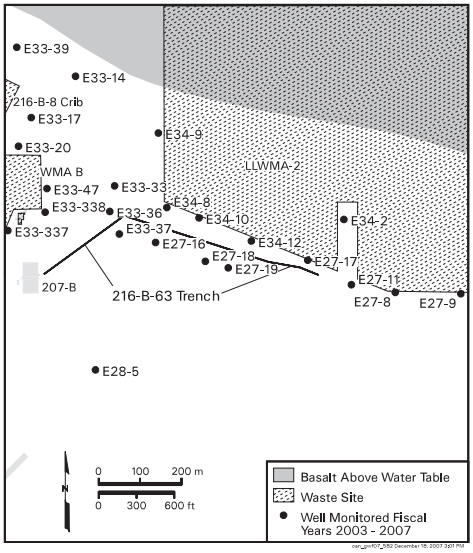
Groundwater chemistry results indicate that multiple vadose zone sources contribute to groundwater contamination that is migrating to the south.

The 200-BP-5 Operable Unit remedial investigation has developed an aggressive drilling and sampling program to further characterize and address uncertainties in contaminant sources with at least twelve new borings (Section 2.10.2). Once the results of this extensive investigation are analyzed, a more complete understanding of the subsurface will be obtained to guide risk analyses and contaminant remediation decisions.

2.10.3.2 216-B-63 Trench

Interim-status RCRA detection monitoring at the 216-B-63 trench requires that the 12 network wells be sampled semiannually for the four contamination/indicator parameters (total organic carbon, total organic halides, specific conductance, and pH), temperature, and turbidity (Appendix B).

Groundwater quality parameters including alkalinity, metals, anions and phenols are also monitored on an annual schedule.



No specific evidence for hazardous waste originating from the 216-B-63 trench has been detected in groundwater at the facility. None of the four contamination indicators exceeded critical means in any of the 216-B-63 wells during FY 2007. Specific conductance continued to rise in nearly all wells in the 216-B-63 network (Figure 2.10-35) during FY 2007, with exception of wells 299-E27-11 and 299-E27-19, which remain relatively unchanged. This rise can be attributed to increasing concentrations of nitrate, sulfate, and chloride. These anions may have reached a peak in the western extremity of the network, while in other wells concentrations are still climbing (Figure 2.10-36). Wells near the center of the facility, along an east-west line (e.g., 299-E34-12, 299-E27-11), display less obvious trends in these constituents.

Groundwater flow direction and rate beneath the 216-B-63 trench remained indeterminate during FY 2007. The hydraulic gradient is too low to define a dominant flow direction or rate with any degree of confidence. As such, the designation of "upgradient" and "downgradient"

wells, as well as the identification of specific sources of the anions, is problematic. The pattern of increase and decline of anions, such as sulfate, in some wells suggests these constituents are possibly moving from northwest to southeast at the western end of the facility.

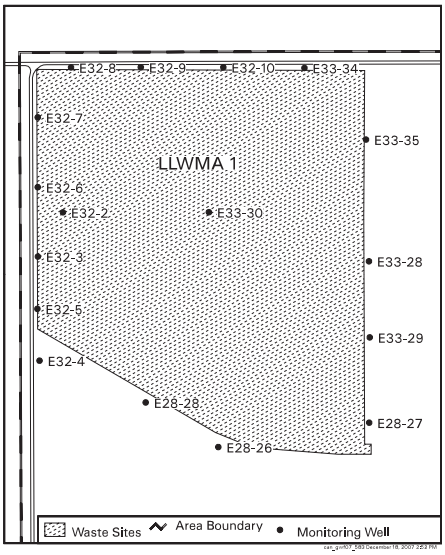
2.10.3.3 Low-Level Waste Management Area 1

Groundwater at Low-Level Waste Management Area 1 continued to be monitored under RCRA and AEA. During FY 2007, all 17 wells in the network were sampled semiannually for RCRA contamination indicator and site-specific parameters as dictated by the sampling and analysis plan (PNNL-14859; DOE/RL-2000-72). Appendix B includes a well location map, a list of wells, and the constituents monitored.

The groundwater gradient in this part of the 200 East Area is almost flat, making the determination of groundwater flow direction difficult (Figure 2.10-5). No meaningful flow rate could be calculated, given the variability and low gradient. Trend surface analysis conducted in FY 2007 was used to define a flow direction to the north. However, considerable uncertainty remained in FY 2007 in the determination of a dominant flow direction. In addition, the temporal and spatial variability in flow are not thoroughly understood. Trend surface analysis of hydraulic heads conducted in 2006 indicated a dominant northward flow direction beneath Low-Level Waste Management Area 1. However, tracking of contaminant plumes between wells indicates north, southeast, and southwest directions. Encroachment of some specific contaminants (e.g., cyanide and technetium-99) into the north and east portions of the facility (e.g., well 299-E33-34) are consistent with origins at BY cribs and/or Waste Management Area B-BX-BY, thus suggesting a west-to-southwestward movement. For these reasons, no attempt will be made to update the interim status designation of upgradient and downgradient wells until a stable flow direction is reestablished. A precision survey of wells began in early FY 2008 to further refine the trend surface analysis and hopefully provide more conclusive information about the gradient in the area around Low-Level Waste Management Area 1.

A precision survey of wells may improve the analysis of groundwater flow beneath Low-Level Waste Management Area 1.

Specific conductance continued to exceed the statistical upgradient/downgradient comparison value (critical mean) in northern wells 299-E33-34 and 299-E32-10, with the highest replicate average of 1,452 µS/cm occurring in June of 2007 in well 299-E33-34. Although generally increasing since 1998, the rates of increase in specific conductance in these two wells has been sporadic (Figure 2.10-37). Rising trends in specific conductance were occurring in FY 2007 in three northern (299-E32-8, 299-E32-9, and 299-E32-10) and two southern wells 299-E33-29 and 299-E28-27 (Figure 2.10-38). In these wells, elevated specific conductance is related to a regional nitrate plume (Figure 2.10-11), and to less well-defined but widespread occurrences of sulfate, chloride, and cations. These are discussed further in the following paragraphs. Well 299-E32-5 exceeded the critical mean of 808 µS/cm in December 2006 (858 µS/cm), but re-sampling in March 2007 produced an average result of only 570 µS/cm. This well is located near a storm water infiltration site and recently experienced a sudden but intermittent rise in major ions. The appearance and concentrations of these constituents are consistent with occurrences at other sites where clean water infiltration through the vadose zone caused leaching of natural salts (e.g., PNNL-13121). The pH and specific conductance results for all other



wells were below the critical mean in FY 2007. Statistical comparison values to be used for indicator parameters in FY 2008 are listed in Appendix B.

Rising concentrations of anions and cations continue to occur in several wells in Low-Level Waste Management Area 1.

Elevated and rising concentrations of anions and cations continue to occur in several wells in Low-Level Waste Management Area 1. Upward trends in sulfate, chloride, nitrate, calcium and magnesium are mostly restricted to the upgradient wells along the southeast border and downgradient wells along the northern border of the facility. Nitrate shows recent or ongoing upward trends in 10 wells, distributed around the periphery of the facility. In most cases, the upward trend for all of these constituents began in the early to late 1990s. Nitrate was above drinking water standards in every well in the network in FY 2007 except in two southern wells, 299-E33-28 and 299-E33-29. The highest nitrate concentration was found in well 299-E33-34 (544 mg/L) in December 2006. The ultimate source(s) of these ions is unknown, but they are probably associated with BY cribs, Waste Management Area B-BX-BY, and/or other nearby, historical disposal sites in the 200 East Area.

Several wells that produced detectable total organic carbon results in FY 2006 were below detection for FY 2007. Wells 299-E28-28 and 299-E32-10 produced replicate averages above comparison values for total organic halides and total organic carbon, respectively, in December 2006 and January 2007 samples, but subsequent samples from these two wells were below detection for both constituents. The elevated results appear to be related to laboratory error. No other wells had average concentrations for total organic halides or total organic carbon that were above the critical mean values (see Appendix B). Averages for pH were all within the critical range during FY 2007.

All wells in the network were sampled once for mercury during FY 2007, but only well 299-E33-30 produced a result (0.10 µg/L) above detection. Well 299-E33-34, located in the northeast corner of Low-Level Waste Management Area 1 had previously produced several sequential low-level (maximum 0.19 µg/L) detections of mercury, but was below detection (<0.09 µg/L) in FY 2007. The drinking water standard is 2 µg/L. Mercury is not commonly detected in Hanford groundwater samples and is not considered highly mobile under conditions typical of Hanford Site aquifers. For further discussion, see Section 2.10.9.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 1, under AEA authority, is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. Performance assessment monitoring at Low-Level Waste Management Area 1 is performed per DOE/RL-2000-72 to gather data to assess changes in concentrations at downgradient wells and to provide sufficient supporting information from upgradient wells to interpret the changes. Iodine-129, technetium-99, tritium, and uranium are monitored semiannually specifically for performance assessment.

Contaminant characteristics at Low-Level Waste Management Area 1 include the following:

- Technetium-99 concentrations continued to be above detection in all wells in the network during FY 2007, and is particularly elevated in wells 299-E33-34, 299-E32-10, and 299-E33-35 near the northeast corner of Low-Level Waste Management Area 1. The highest concentrations in FY 2007 remained in well 299-E33-34 (8,970 pCi/L in June 2007) but all three of these wells produced

average results lower than in FY 2006 (Figure 2.10-39). The maximum technetium-99 concentration was 11,000 pCi/L in the June 2006 sample. The contamination levels are consistent with regional distributions that appear to have originated in the vicinity of the BY cribs (Figure 2.10-15). Northern wells 299-E32-5 and 299-E32-9 and southern wells 299-E33-28 and 299-E28-27 also show generally increasing technetium-99 concentrations in recent years that continued in FY 2007. However, levels remained relatively low, with the highest result at 144 pCi/L in well 299-E33-28.

- Uranium concentrations decreased significantly in well 299-E33-34 in the northeast corner of the waste management area, producing an average uranium concentration of 72 µg/L and a maximum of 75 µg/L in the June 2007 sample. This contamination is associated with a relatively recent plume with possible origins in the vicinity of Waste Management Area B-BX-BY. Northern wells 299-E32-8, 299-E32-9 and southern wells 299-E33-28 and 299-28-27 have all shown upward trends during the past several years. Well 299-E28-27 in particular, produced a relatively significant rise, from an average of 15 µg/L in FY 2006 to 23 µg/L in FY 2007. All wells except 299-E33-34 remain below drinking water standards for uranium (30 µg/L). Wells on the west and southwest perimeter display downward trends in uranium concentrations from already low values.

Uranium concentrations decreased in well 299-E33-34 in FY 2007.

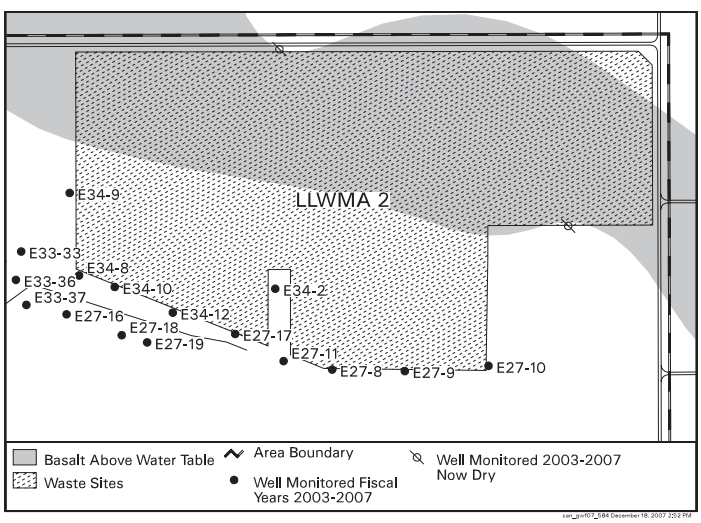
- Tritium contamination is also believed to be from regional contamination, not related to the burial grounds. Tritium concentrations were less than the drinking water standard in FY 2007 in all wells in the network, and are declining in most wells. The exceptions to this are wells 299-E33-34 and 299-E33-35 in the northeast corner of the facility, which appears to be associated with increases beneath and west of the BY cribs. Well 299-E33-34 produced a historical maximum (17,500 pCi/L) in June 2007, and well 299-E33-35 produced an historical high average of 9,800 pCi/L.
- Iodine-129 was above detection in three southern wells and five northern wells, with the maximum (4.20 pCi/L) occurring in well 299-E32-9. The activities and distribution of iodine-129 in this area has shown significant change over several years and is consistent with the regional distribution and believed to be from liquid waste facilities during active operations.
- Nitrate contamination at Low-Level Waste Management Area 1 displayed upward trends in four southern wells and four northern wells during FY 2007. The highest concentrations are in the northeast corner of the facility, approximately coincident with the highest technetium-99. Thus, the northeast nitrate plume has a likely source in the BY cribs, and possibly other nearby waste sites. Nitrate is still highest in well 299-E33-34, with an average concentration of 540 mg/L. This value is down from a spike of 713 mg/L that occurred in FY 2006.
- Low levels of chromium were detected in filtered samples in 10 wells during FY 2007. The highest value (22 µg/L) was detected in well 299-E33-34, which is the locus of several other contaminant maxima at Low-Level Waste Management Area 1.
- Cyanide (drinking water standard = 200 µg/L) was above detection in 12 wells in the Low-Level Waste Management Area 1 network during FY 2007. The highest concentration, and the only value above drinking water standard, was 357 µg/L

in well 299-E33-34. In general, concentrations were highest in the northern and western wells. Upward trends in cyanide are present in wells 299-E32-3, 299-E32-9, and 299-E32-10. The contaminant source appears to be associated with the BY cribs.

2.10.3.4 Low-Level Waste Management Area 2

Groundwater at Low-Level Waste Management Area 2 is monitored under RCRA (PNNL-14859) and AEA (DOE/RL-2000-72). During FY 2007, the well network was sampled semiannually for RCRA indicator and site-specific parameters. Sampling was successful at nine wells for both sampling rounds. Appendix B includes a well location map, a list of wells, and the constituents monitored.

The groundwater gradient in this part of the 200 East Area is virtually flat, making the determination of groundwater flow direction difficult. Basalt occurs above the water table beneath the northern half of Low-Level Waste Management Area 2. No attempt will be made to update upgradient well designations used in the statistical tests until a stable flow direction is evident. The basalt surface above the water table in the north part of Low-Level Waste Management Area 2 constrains possible flow directions for the unconfined aquifer. However, it is possible that the flow is influenced by continued drainage of the unsaturated sediment and recharge moving laterally on the basalt surface to the saturated aquifer sediment. Given the broad uncertainties in flow direction and low gradient in this area, flow rates and directions based on hydraulic head are not estimated. Flow to the southwest was indicated in FY 2006 by the movement of the nitrate plume from well 299-E34-7 (no sample, dry) to well 299-E27-10 and a possible south-southwesterly flow component is seen in wells in the southeast portion of the network (discussed further in the following paragraphs).



No critical mean values for the four indicator parameters, i.e, specific conductance, pH, total organic carbon, and total organic halide, were exceeded in the FY 2007 samples from Low-Level Waste Management Area 2. Appendix B lists the initial statistical comparison values to be used in FY 2008 based on data for the upgradient well 299-E27-10.

Specific conductance along the south side of the area has exhibited a generally increasing trend in wells 299-E27-10, 299-E27-9, and 299-E27-8 for the past several years. Incursion of sulfate, chloride, nitrate, and major cations that are widespread in the 200 East Area are the apparent cause of the increase in specific conductance. As exemplified by sulfate in Figure 2.10-40, wells farther east appear to lead the increase. The timing of arrival of inflections in sulfate concentrations identifiable in all three wells appears to support a component of flow to the south-southwest.

Performance assessment monitoring of radionuclides at Low-Level Waste Management Area 2, under AEA authority, is designed to complement the RCRA detection monitoring and is aimed specifically at monitoring radionuclide materials that are not regulated under RCRA. The current goal of performance assessment monitoring at Low-Level Waste Management Area 2 is to gather data to assess

changes in concentrations at downgradient wells using statistical tests and to provide sufficient supporting information from upgradient wells to interpret the changes. Under the current monitoring plan (DOE/RL-2000-72), technetium-99, iodine-129, and uranium are monitored specifically for performance assessment.

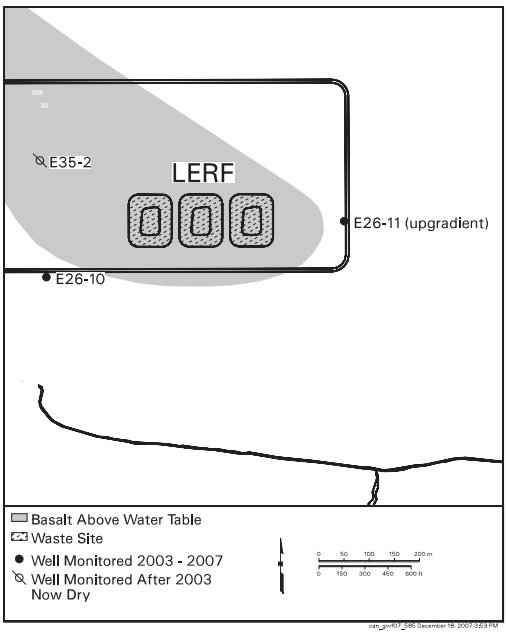
Contaminant characteristics at Low-Level Waste Management Area 2 include the following:

- Technetium-99 concentration continued to increase in well 299-E27-10 and at a slower rate in well 299-E27-9, south of Waste Management Area 2. Activities reached 100 pCi/L in well 299-E27-10 for FY 2007. This contamination is believed to be from past disposal of liquid waste in the 200 East Area and unrelated to Low-Level Waste Management Area 2. Well 299-E27-9 produced the only other detection of technetium-99 (maximum =15.20 pCi/L) during FY 2007.
- Tritium contamination was found at levels less than the drinking water standard in all wells in the network. The trends for tritium in the wells with detectable tritium were all downward, with the highest activity during FY 2007 at 616 pCi/L in well 299-E27-9. The tritium activities were consistent with regional distributions.
- Iodine-129 was detected in only two wells in Low-Level Waste Management Area 2; wells 299-E27-9 and 299-E27-8 produced results of 2.45 and 1.77 pCi/L, respectively, during FY 2007. Iodine-129 activities appear to be generally decreasing during past several years in wells with results above detection. These levels are consistent with the regional iodine-129 distribution (e.g., from Waste Management Area B-BX-BY and nearby liquid waste disposal sites) and do not appear to be related to a burial ground source.
- Uranium concentrations in Low-Level Waste Management Area 2 samples remain <5 µg/L and do not indicate a burial ground source.
- Nitrate contamination at levels above the drinking water standard was restricted to well 299-E27-10 on the south side of Low-Level Waste Management 2. Concentrations increased to 61 mg/L in this well during FY 2007.
- Major ions are increasing in wells mostly in the northwestern and eastern portions of the network, but with wells 299-E34-12, 299-E27-17, and 299-E27-11 notably exempt from this increase for most constituents.

Major ions are increasing in wells in the northwestern and eastern portions of the network.

2.10.3.5 Liquid Effluent Retention Facility

The Liquid Effluent Retention Facility operates under final status permit conditions stipulated as agreed to by Ecology and DOE. The current groundwater monitoring network is hydrogeologically inadequate to monitor the unit. Two of the three groundwater wells installed to monitor the compliance side of the unit are dry and the water table has dropped below the top of basalt beneath the facility. Therefore, statistical evaluation of the indicator parameters (specific conductance, pH, total organic carbon, and total organic halide) is not conducted. Ecology and DOE have negotiated a process to modify the RCRA permit that includes an evaluation plan to characterize Liquid Effluent Retention Facility hydrostratigraphy. Most specifically, two new wells are planned that will explore the possibility of a continuation of the uppermost aquifer into basalt flow-top and weathered zone. Until a monitoring approach is decided upon, it has been agreed that interim status detection monitoring requirements would be retained.



Specific conductance, nitrate, chloride and sulfate continued to rise in both remaining wells (299-E26-10 and 299-E26-11)during 2007. Specific conductance was highest in well 299-E26-10 at 867µS/cm (Figure 2.10-41). All of the anions are below drinking water standards in both wells. A regional rise of anions and cations is evident in wells located in the central and eastern portions of 200 East Area. Downgradient wells installed for the Liquid Effluent Retention Facility before it began receiving waste recorded the early indications of the regional rise in specific conductance. The rise of specific conductance and anions in upgradient well 299-E26-11 began much more recently, in 2005.

The current plan assumes that groundwater continues to move in a southwest direction, one of the flow directions outlined in previous reports (PNNL-14804). Because of the isolated situation of downgradient well 299-E36-10, and drops in the water table below the facility, no reasonable estimate of flow rate is possible for the immediate vicinity of the Liquid Effluent Retention Facility . Appendix B provides a general flow direction and rate based on regional estimates for the eastern portions of the 200 East area (see Section 2.0).

2.10.3.6 Waste Management Area C

A regional rise of anions and cations is evident in wells located in the central and eastern portions of 200 East Area.

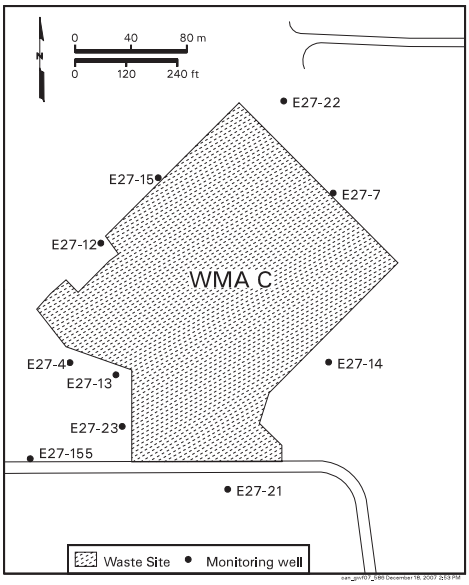
Waste Management Area C is located in the east central portion of the 200 East Area and consists of the C Tank Farm, the 244-CR vault and ancillary equipment such as waste transfer lines and seven diversion boxes. The tank farm contains twelve single-shell 100 series (2-million-liter) and four single-shell 200 series (208,000-liter) tanks constructed in 1943 and 1944. Three of the larger tanks and all four smaller tanks are confirmed or assumed leakers.

Required under 40 CFR 265.93(b) as referenced by WAC 173-303-400, groundwater is monitored under a RCRA interim status indicator program to detect if dangerous waste constituents associated with the facility have compromised groundwater quality. The current groundwater monitoring plan is PNNL-13024 as modified by PNNL-13024-ICN-4. Although semi-annual sampling is required, wells are sampled quarterly with a limited constituent list at the request of Ecology and in support of waste retrieval operations during sluicing events. These extra sampling events are not part of the required RCRA groundwater monitoring. Based on the required semi-annual sampling, indicator parameter critical means were not exceeded this fiscal year.

In addition to monitoring dangerous waste constituents for RCRA, the site is monitored for radionuclides under AEA and CERCLA (WMP-28945). For the 200-BP-5 Operable Unit remedial investigation/feasibility study, a new groundwater monitoring well is currently being installed southwest of the site to determine the extent of groundwater contamination and provide information for risk analyses. A well location map, a list of the nine RCRA network wells, the critical means values used for upgradient/downgradient comparisons in FY 2008 and the site specific constituents are available in Appendix B.

No discernible changes in flow direction were seen during FY 2007. Ranging from southwest to south-southwest, the flow direction was determined by in situ

flow measurements, contaminant migration, contaminant ratios and water elevations (PNNL-13788, RPP-23738). Based on work done in support of the 200-BP-5 Operable Unit remedial investigation/feasibility study, it was shown that sulfate is migrating from the northeast near the basalt subcrop and continues to affect the groundwater at this site. A time series of the 80-mg/L contour (Figure 2.10-42) illustrates the sulfate movement into and across the C Tank Farm. The flow rate, estimated from this contaminant's travel time, is 0.09 meter/day. The rate of water table decline continued to decrease from 10 and 7 centimeters per year reported in FY 2005 and FY 2006, respectively to 5 centimeters in FY 2007. Based on a least squares regression fit to the water table, older wells in the network may not require replacement for over 15 years provided the rate of decline does not increase.



The primary contaminants in the groundwater are sulfate, nitrate and the non-RCRA regulated constituent, technetium-99. Also there are elevated chloride concentrations and low levels of cyanide at some wells. With rising sulfate concentrations northeast of the farm, upgradient specific conductance values are high, ranging from 741 to 645 µS/cm. This sulfate control on the specific conductance is illustrated in Figure 2.10-43, which compares specific conductance to sulfate and nitrate concentrations in upgradient well 299-E27-7. Although sulfate concentrations to the northeast near the receding aquifer boundary have been over 650 mg/L, there does appear to be a local contaminant component of sulfate in some locations. For example, the drinking water standard for sulfate (250 mg/L) was recently exceeded southeast of the site in well 299-E27-14. This well is nearly cross gradient of the farm but down gradient of a waste transfer line. In addition at this well, technetium-99 is elevated at 1,850 pCi/L (drinking water standard 900 pCi/L). Also this locale is the only place where the nitrate concentration is above the drinking water standard (45 mg/L) at 64.2 mg/L in June 2007. Thus, cross gradient to downgradient of the site, sulfate concentrations may have a contaminant source.

Over most of the site, nitrate is elevated above the background value of 12.4 mg/L (WHC-EP-0595): however, as stated previously, the concentration is above the drinking water standard in only one location, well 299-E27-14 (Figure 2.10-44). A comparison between mapped nitrate concentrations for June 2005 and June 2007 (Figure 2.10-45) shows only a small increase in nitrate over the last two years. Although there was some increase in the nitrate concentration at upgradient in well 299-E27-7, larger increases were downgradient in wells 299-E27-14 and 299-E27-21. Overall, however, nitrate contamination remains at low levels.

Primary groundwater contaminants at Waste Management Area C are sulfate, nitrate, and technetium-99.

Currently, technetium-99 concentrations range from 56 pCi/L in upgradient well 299-E27-7 to 6,280 pCi/L in downgradient well 299-E27-23 (Figure 2.10-46). Currently, technetium-99 is increasing in only one well, 299-E27-23. Installed in 2003, this well is downgradient of the 244 –CR Vault and unplanned release 200-E-81, associated with the 241-CR-151 diversion box. Although the initial technetium-99 level (8,370 pCi/L) was high in well 299-E27-4 in 2004, concentrations continue to decline, currently at 2,510 pCi/L. This well is close to the 241-C-151 diversion box, the site of a past pipeline break in 1969, resulting in the loss of approximately 9,800 liters of PUREX Plant waste. Recent characterization work by the Tank Farm Vadose Zone Project has shown mobile contaminants in the vadose zone to a

depth of at least 24 meters, suggesting contamination may have migrated to greater depths. Of note is the increasing technetium-99 level in well 299-E27-12, located north of the 241-C-153 diversion box. Concentrations rose from 70.7 to 206 pCi/L from June 2006 to March 2007. Other downgradient wells have either decreased or remained nearly the same as during FY 2007. A comparison of the 900-pCi/L contour over the last 5 years (Figure 2.10-47) provides a spatial view of the changing technetium-99 pattern.

A better understanding of contamination that may be related to the tank farm is gained from comparing nitrate and technetium-99 trends. Nitrate to technetium-99 ratios plotted on a log-log plot against increasing technetium-99 (Figure 2.10-48) shows distinct mixing trends for the three downgradient wells on the southwest side of the site. Trend lines are shown indicating the direction of increasing time with changing technetium-99 concentrations. For example, the ratios for well 299-E27-13 display a linear trend from 1999 to 2003 during the time technetium-99 was increasing at this locale (see Figure 2.10-46 for comparison).

Several observations are made from these data. First, data from wells 299-E27-13 (1999 to 2003) and 299-E27-23 (2005 to 2007) form distinct linear trends. Although not as clear, from 2004 to 2005, a third trend may exist for well 299-E27-4. The technetium-99 concentration was already elevated when this well was installed in FY 2003 so the peak value, which would be nearest to the source value was not obtained. Second, each trend appears distinctly different from the others. Third the ratio for peak technetium-99 concentrations for each well is low, with a value of 2.64 for well 299-E27-4, 4.36 for well 299-E27-23 and 4.21 for well 299-E27-13. These low ratio values suggest tank-associated sources for each of these contaminant events (PNNL-14187, PNNL-14548). Because these nitrate to technetium-99 ratios form three distinct mixing curves, there may be three different sources for groundwater contamination on the southwest side of the site.

Further information is gained by comparing data between upgradient and downgradient locations. In Figure 2.10-48, a comparison of the nitrate to technetium-99 mixing curve for well 299-E27-23 is made to the peak technetium-99 value seen in upgradient well 299-E27-7 from 1998 through 2003. During this time, the technetium-99 concentration rose from 81 pCi/L to 2,760 pCi/L in 2002 then fell to 39.2 pCi/L by late 2003 (Figure 2.10-46). The ratio at peak technetium-99 contamination was 9.9 also suggesting a tank-related source. The mixing curve defined by this sharp pulse of technetium-99 matches closely that observed at downgradient well 299-E27-23, suggesting a common contaminant source for the groundwater at the two wells.

Another way to study groundwater chemistry is by comparing total ionic groundwater chemistry through Stiff diagrams. The milli-equivalent concentrations for total cations balanced against total anions are represented graphically on a scale of anions versus cations. Figure 2.10-49 shows results from a recent investigation. A comparison is made for groundwater data collected in September or October 2006, except for well 299-E27-15, which had data sets out of electrical balance. Data from earlier in the year was used for this well. The signature at the upgradient wells, 299-E27-22 and 299-E27-7, is clearly dominated by calcium and sulfate moving in from upgradient. Data for a few earlier years are shown for upgradient well 299-E27-7 to show the original calcium bicarbonate signature, lower in total dissolved solids. This bicarbonate pattern is characteristic of artificially recharged groundwater which

was prevalent throughout the region during times of large water releases at PUREX. Note the similar signatures seen at downgradient wells 299-E27-4 and 299-E27-23, which may not be as affected by the migration of calcium sulfate from upgradient. Downgradient well 299-E27-14, which has the highest calcium and sulfate levels has an even more pronounced calcium sulfate signature. However, chloride is greater in the upgradient wells than in well 299-E27-14, suggesting the slightly elevated chloride may be associated with the upgradient sulfate signature. In general, with the upgradient dominating influence from calcium sulfate, no distinct features are discerned to help differentiate tank farm sources from non-tank farm source. This situation may change as plume signatures develop over time.

Although seen sporadically at several locations, cyanide has been consistently elevated at upgradient well 299-E27-7 since 2004. However, this year, concentrations fell from 36.8 µg/L in June 2006 to 3.8 µg/L in June 2007 (drinking water standard 200 µg/L). In well 299-E27-14, concentrations, although still low, have ranged from 5.3 to 14.9 µg/L. The C Tank Farm is the only known local source for cyanide (HNF-SD-WM-TI-740). Consequently, like the low nitrate to technetium-99 ratios, the presence of cyanide in the groundwater suggests a tank-related source for some contamination observed in the groundwater. Further characterization work, planned by the 200-BP-5 Operable Unit remedial investigation/feasibility study and the Tank Farm Vadose Program, may provide additional information and data to assist in delineation the specific contaminant sources at this waste management area.

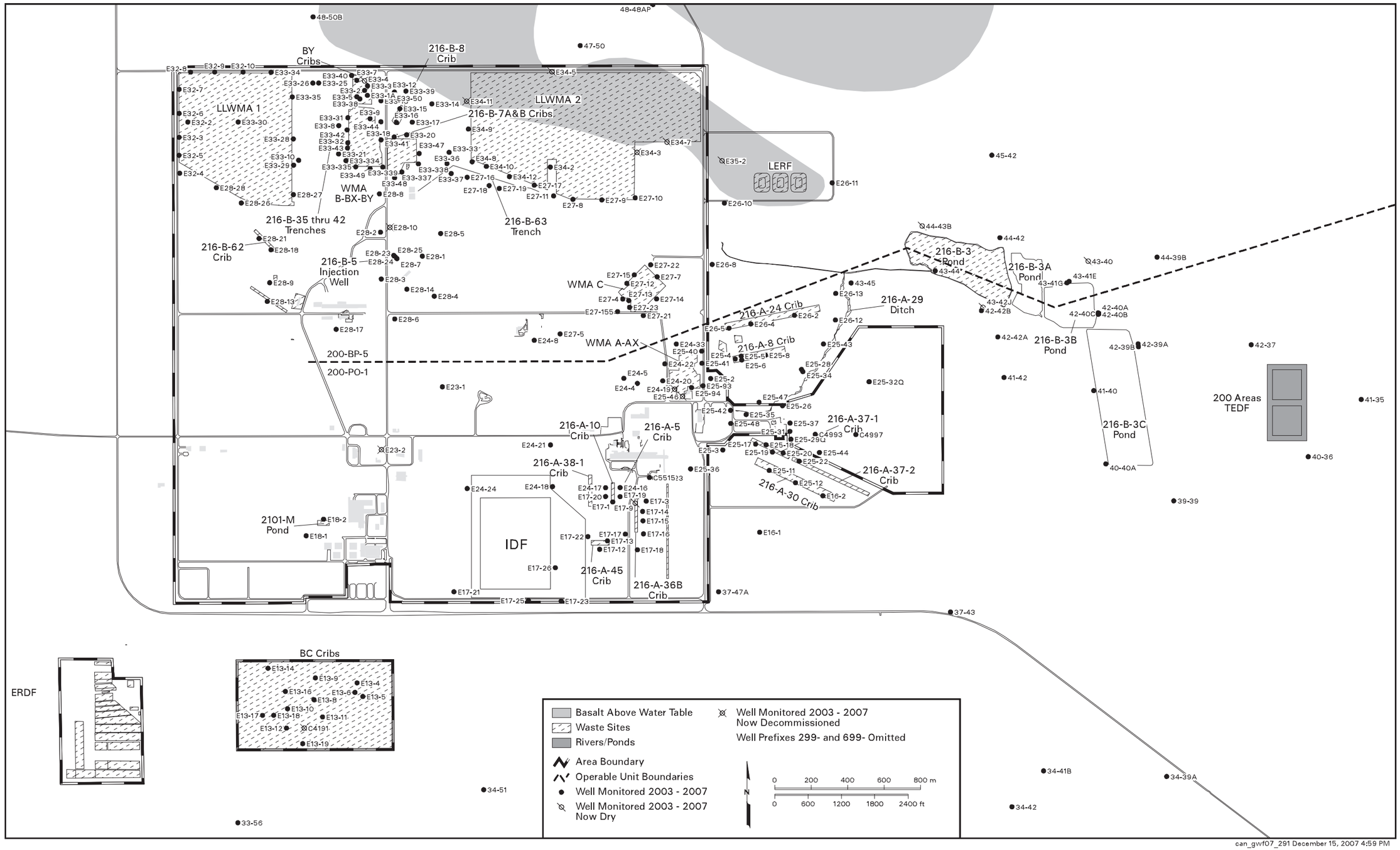


Figure 2.10-1. 200-BP-5 Operable Unit Groundwater Monitoring Wells in the 200 East Area

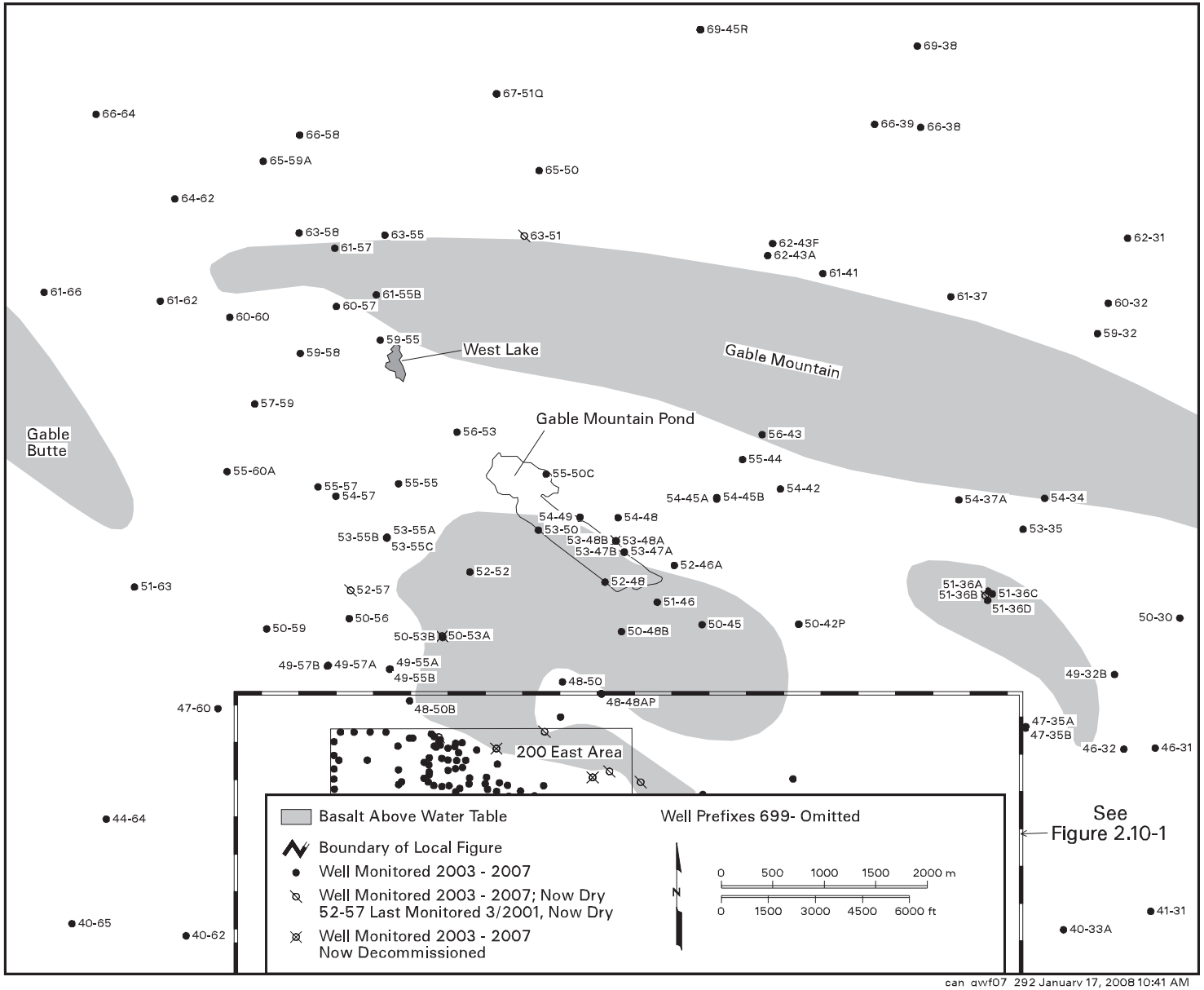


Figure 2.10-2. 200-BP-5 Operable Unit Groundwater Monitoring Wells Located in the 600 Area

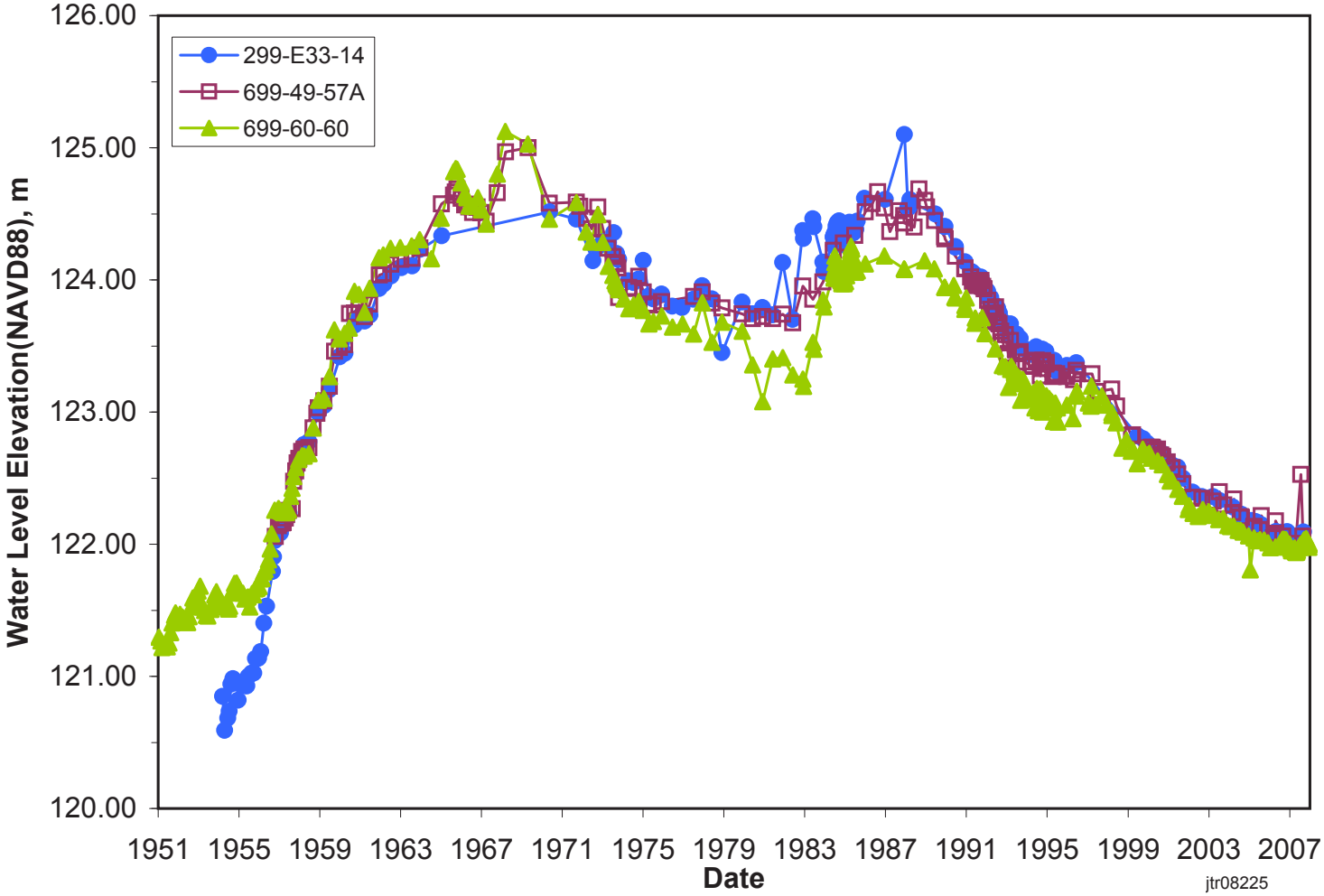


Figure 2.10-3. Water Elevations for Wells Monitoring the 200-BP-5 Operable Unit

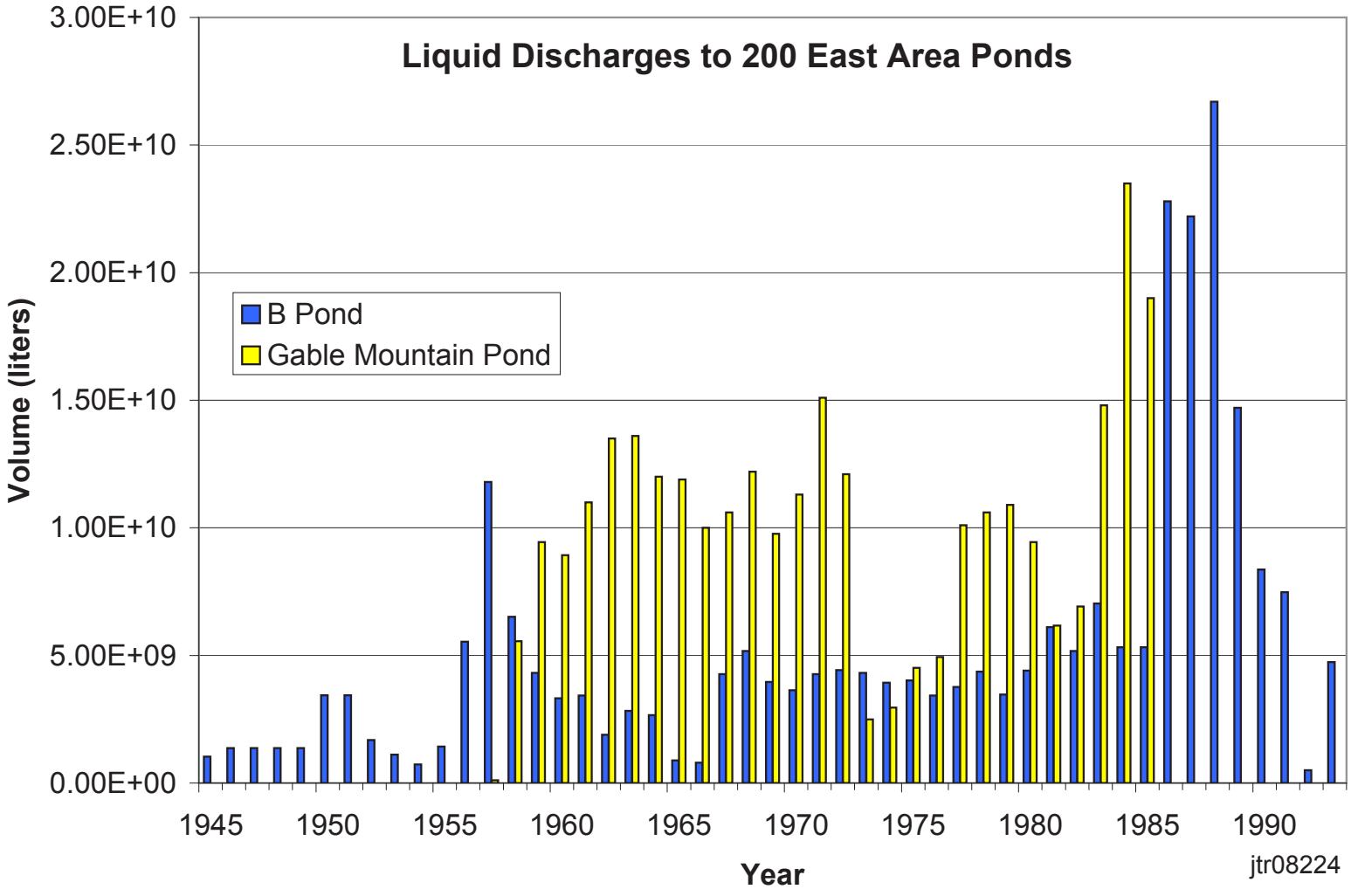


Figure 2.10-4. Liquid Discharges to 200 East Area Ponds

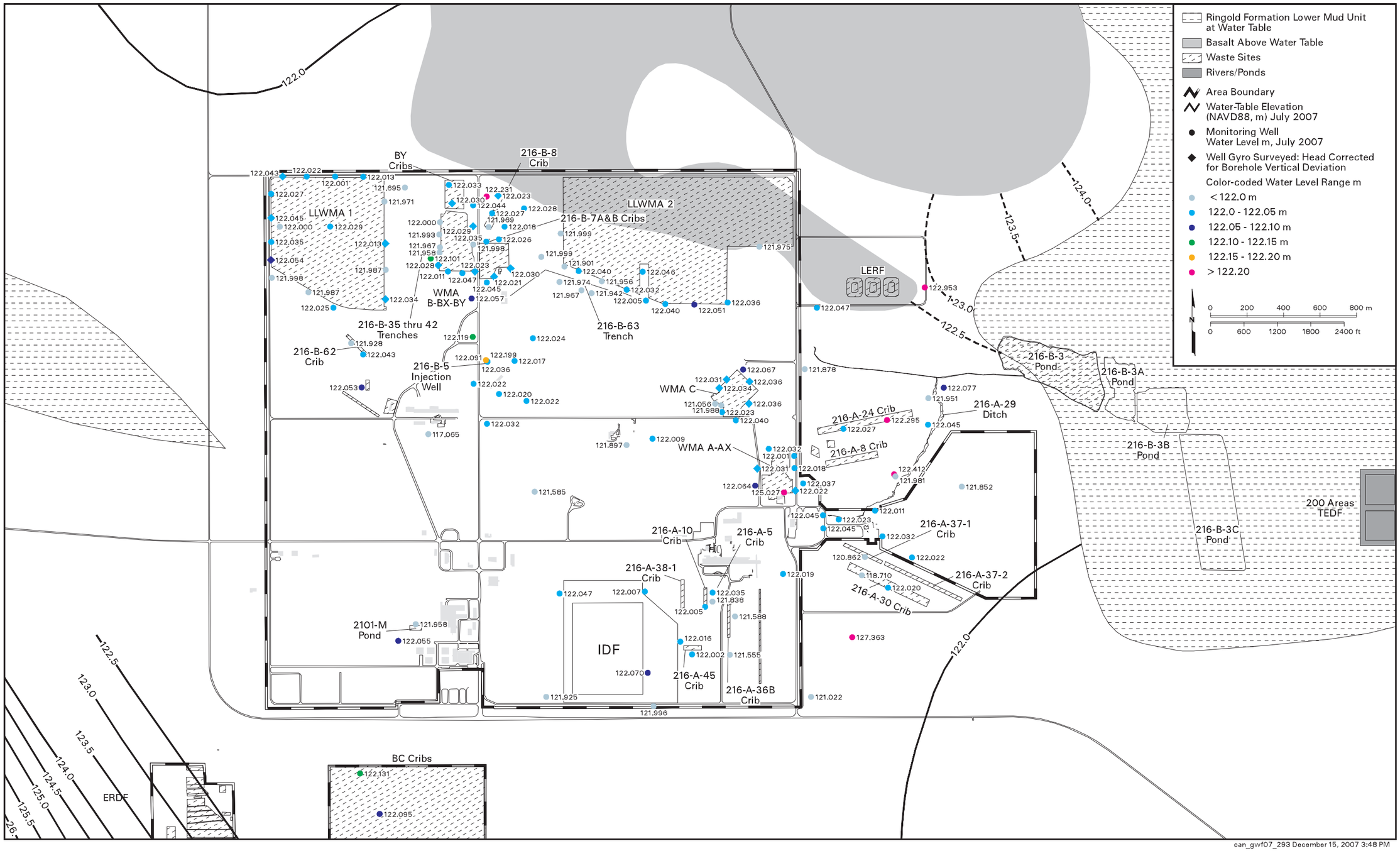


Figure 2.10-5. 200 East Area Water-Table Map, July 2007

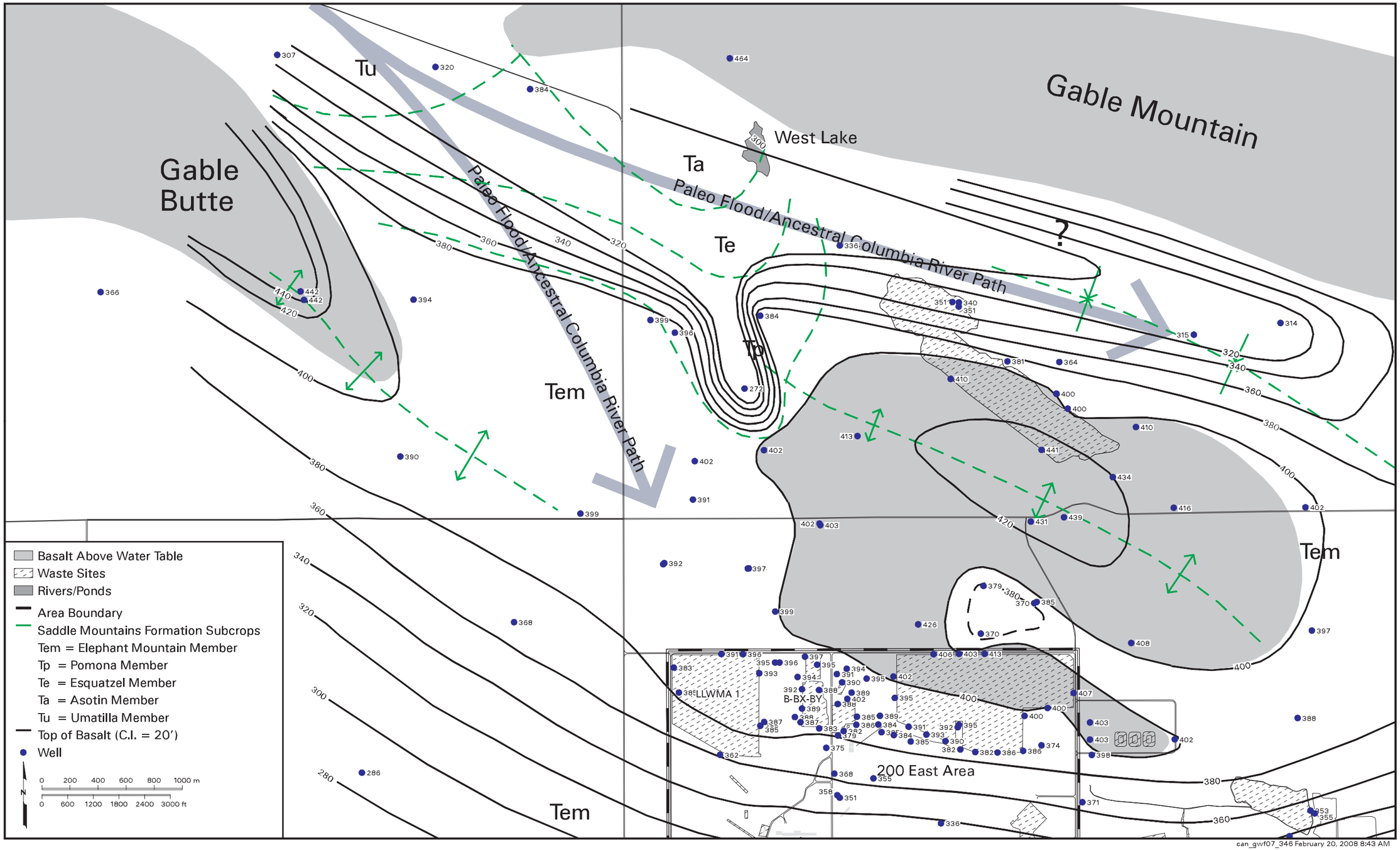


Figure 2.10-6. Basalt Contours and Anticlinal Ridges in Gable Gap Area (after PNNL-12261)

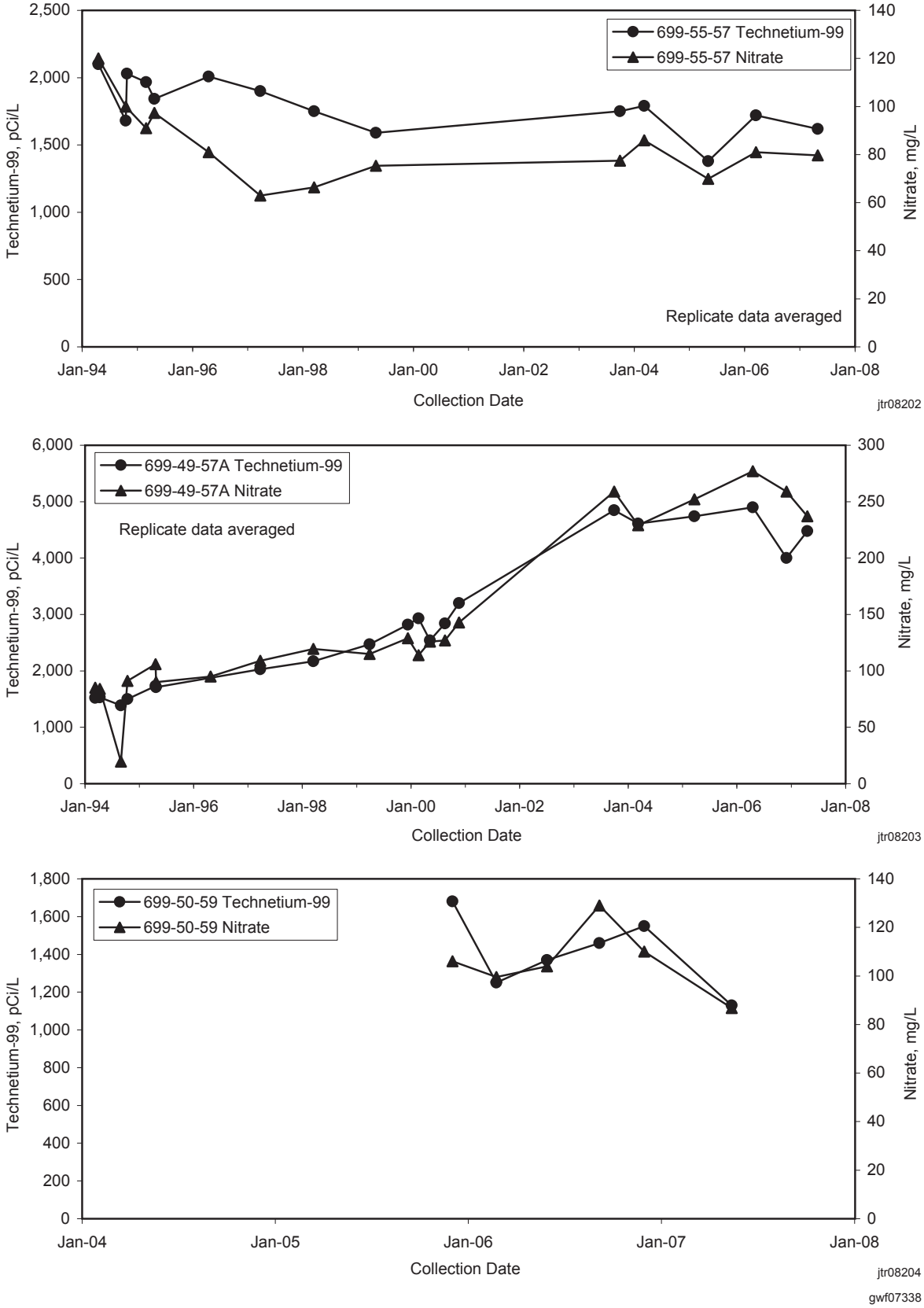


Figure 2.10-7. Technetium-99 and Nitrate Concentrations South of the Gap between Gable Butte and Gable Mountain and North of 200 East Area

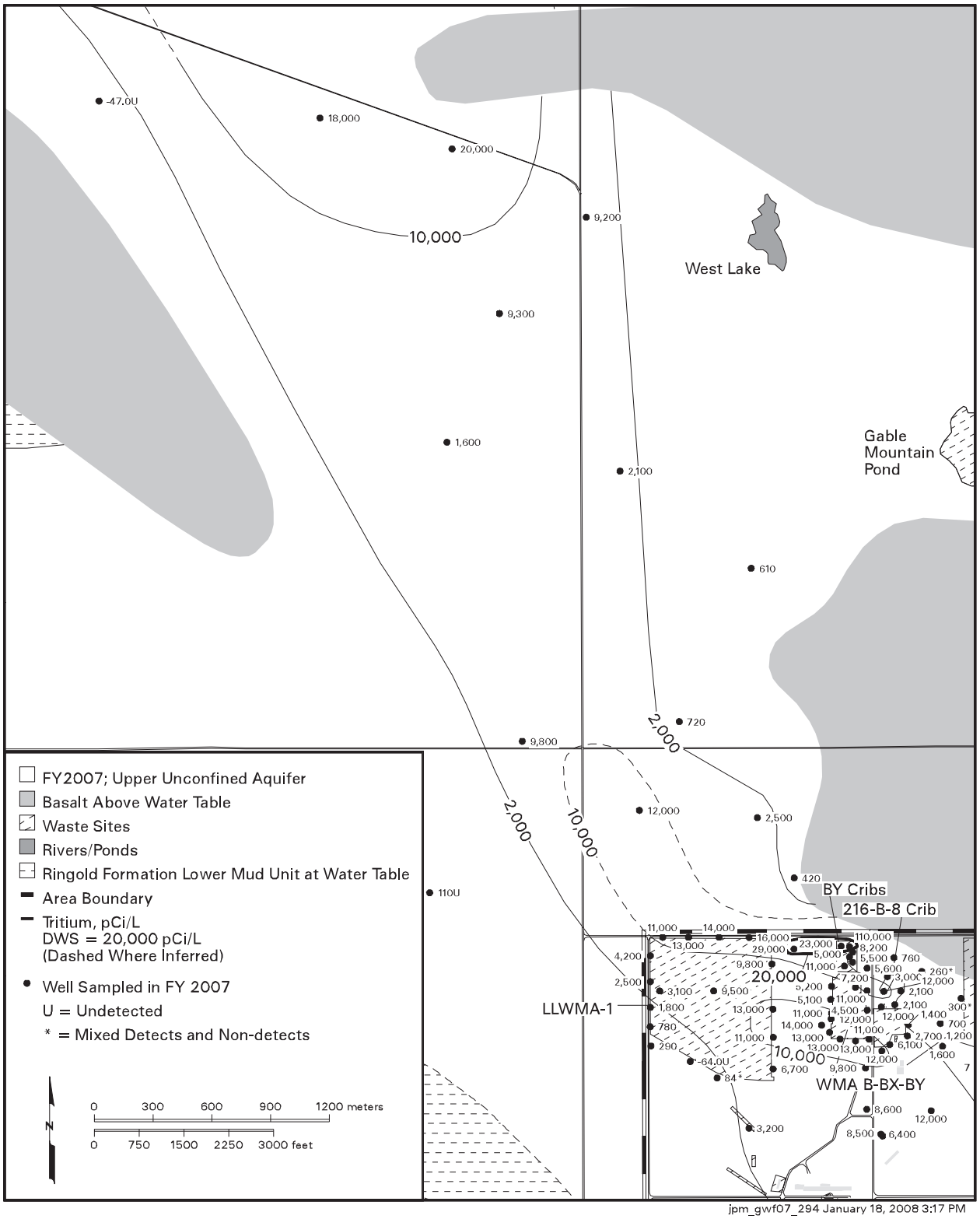


Figure 2.10-8. Average Tritium Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

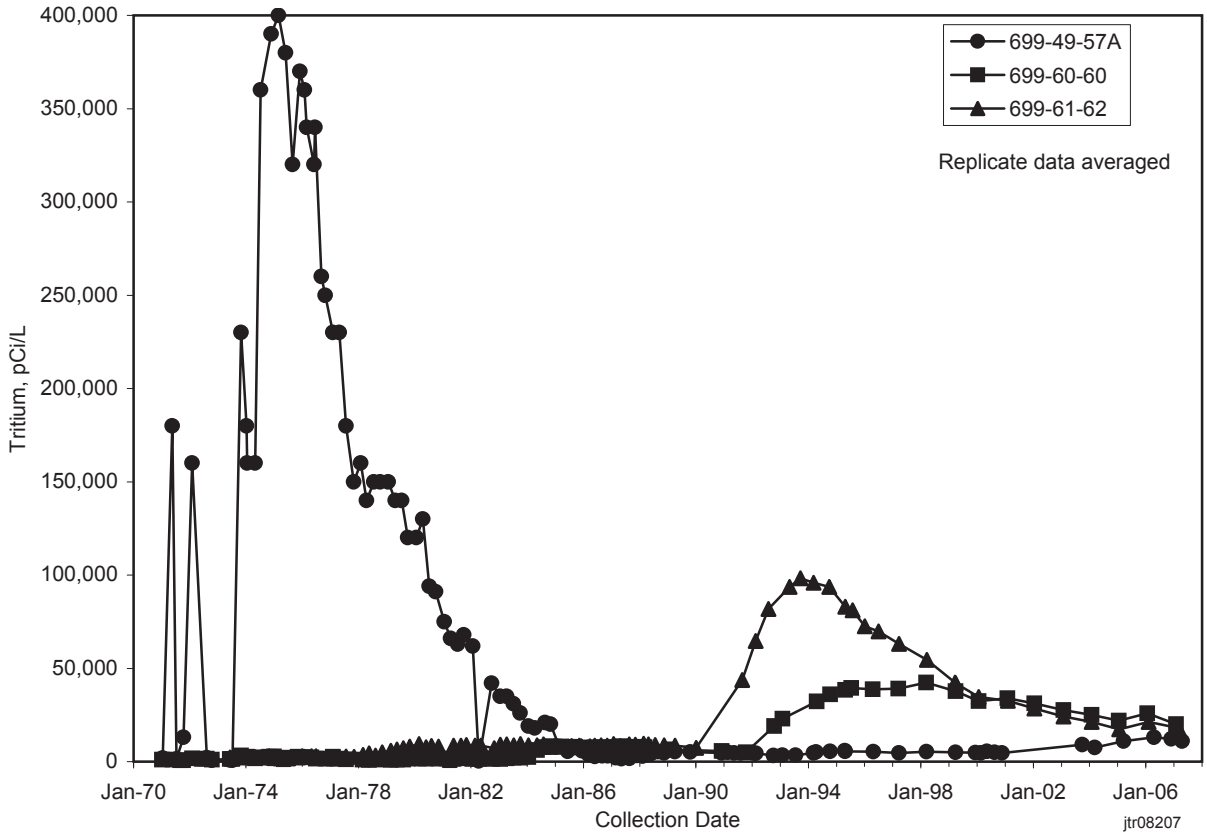


Figure 2.10-9. Historic Maximum Tritium Values During the Mid-1970s in Wells 699-49-57A, 699-60-60, and 699-61-62

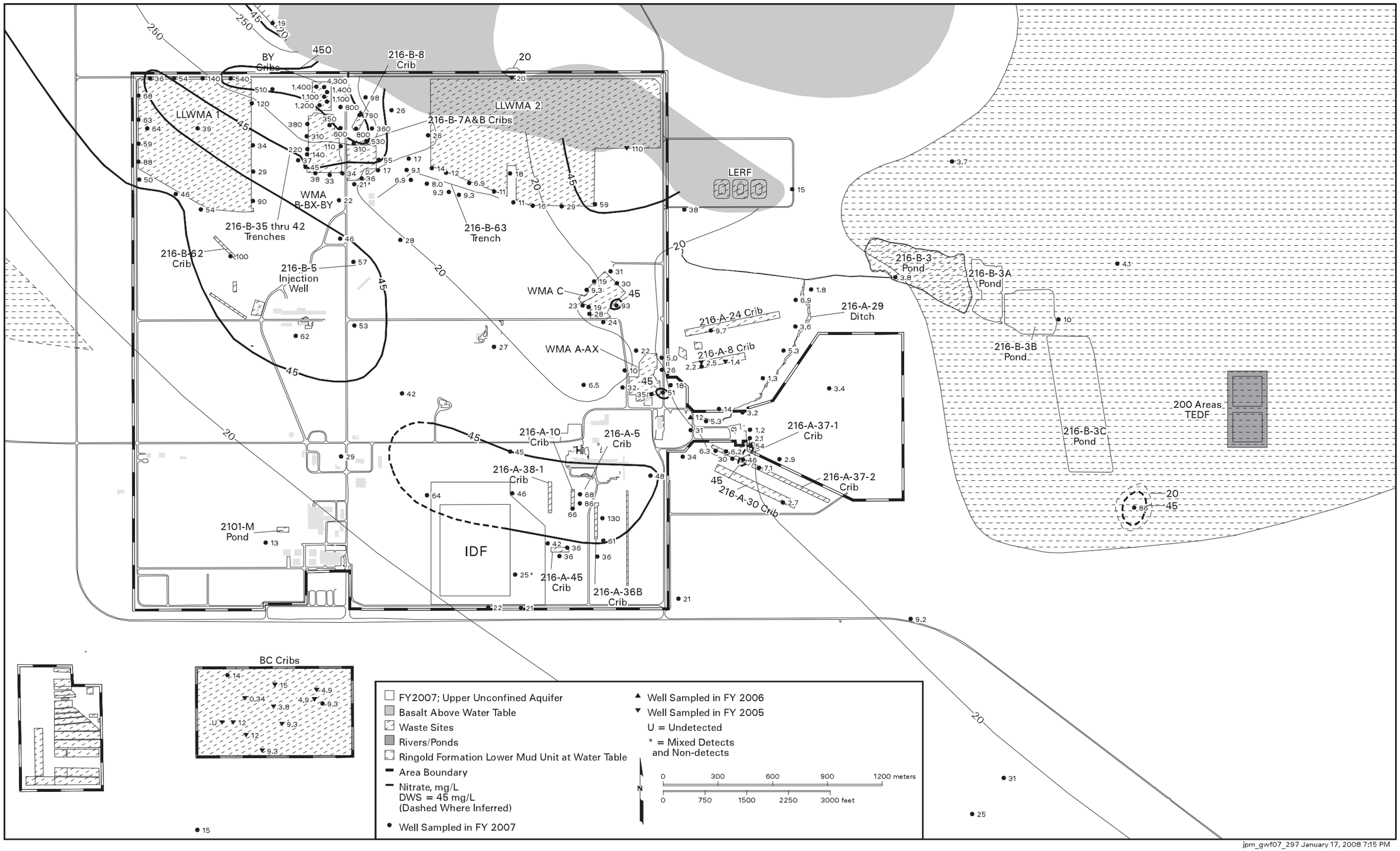


Figure 2.10-10. Average Nitrate Concentrations in 200 East Area, Upper Part of Unconfined Aquifer

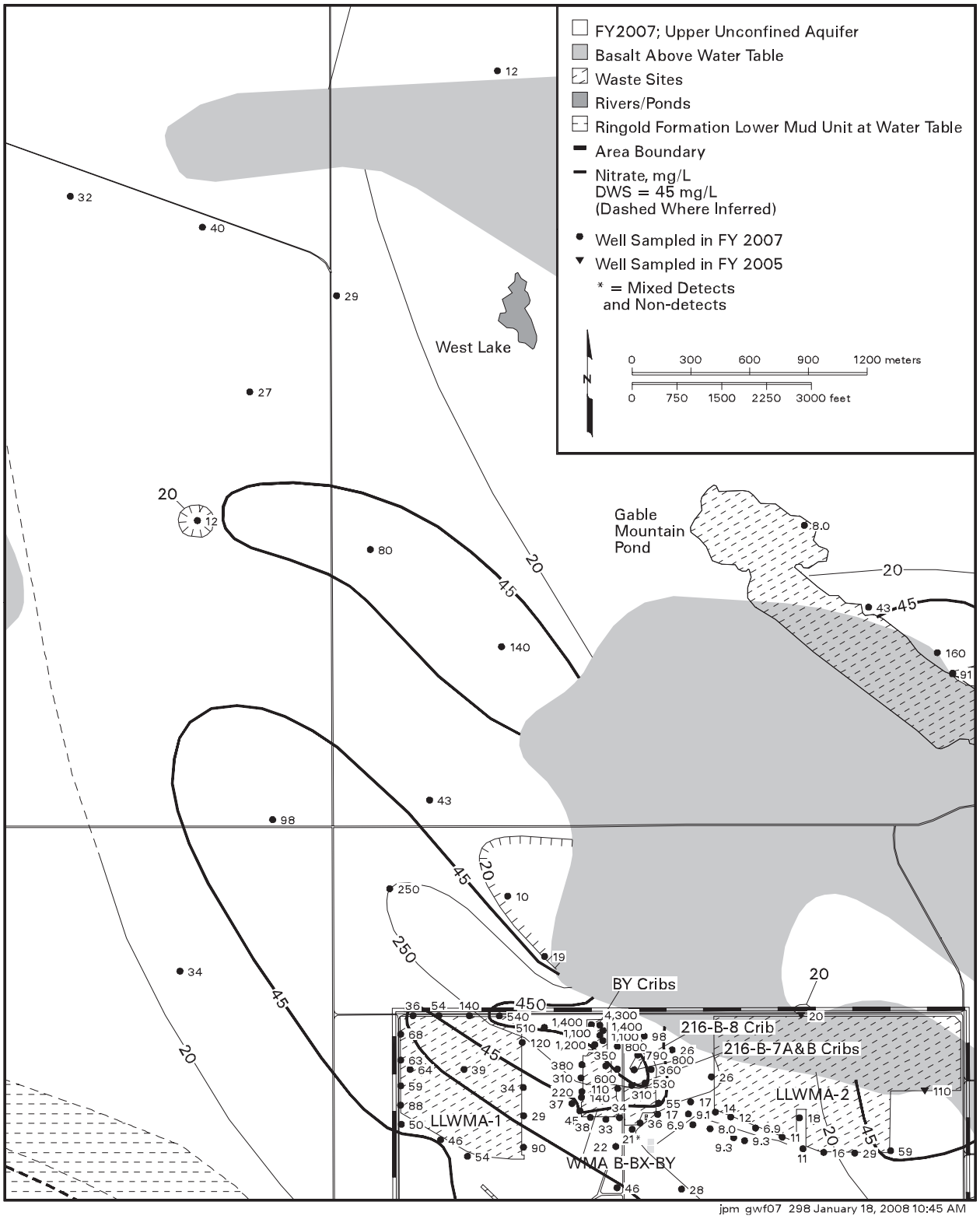


Figure 2.10-11. Average Nitrate Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

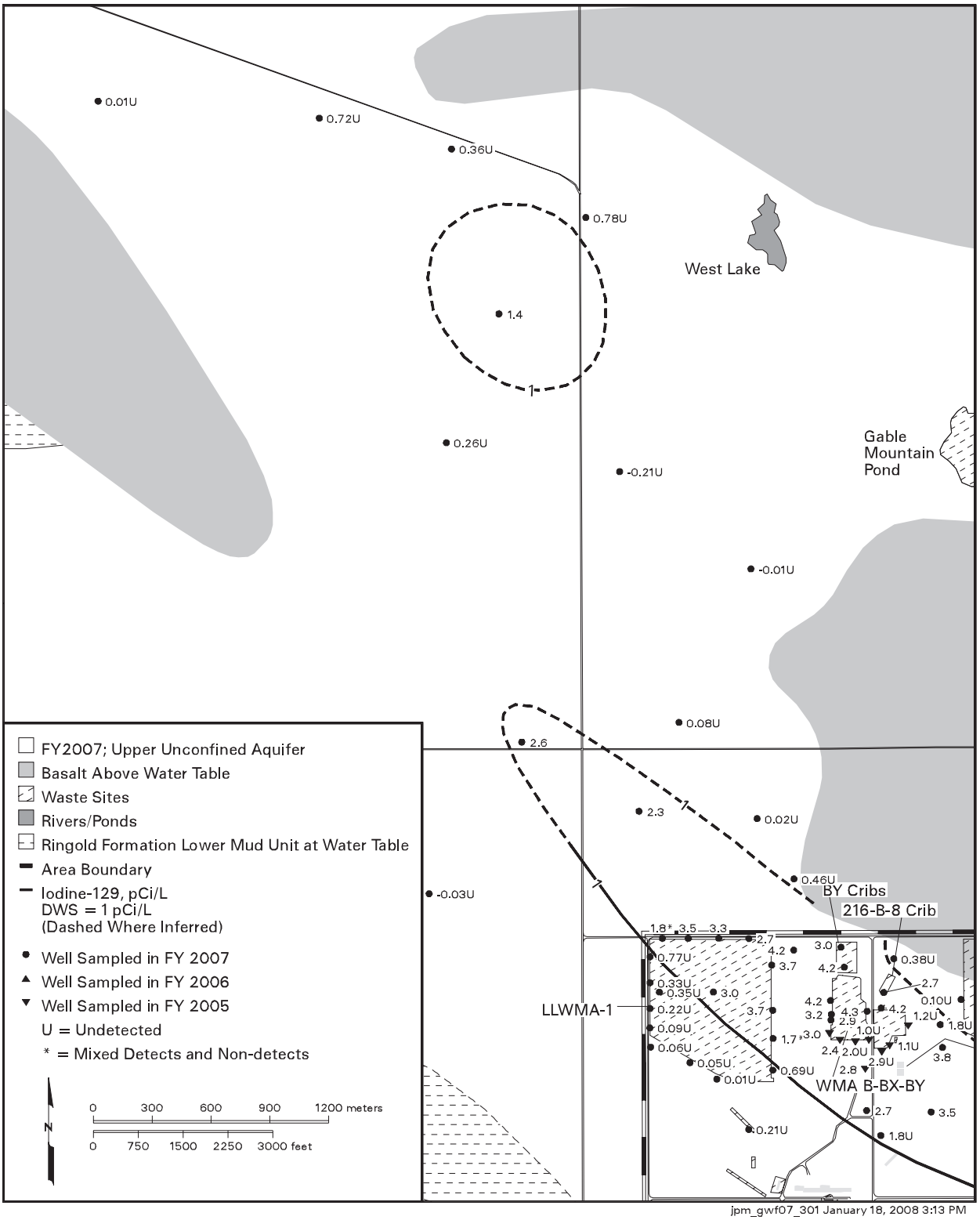


Figure 2.10-12. Average Iodine-129 Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Auifer

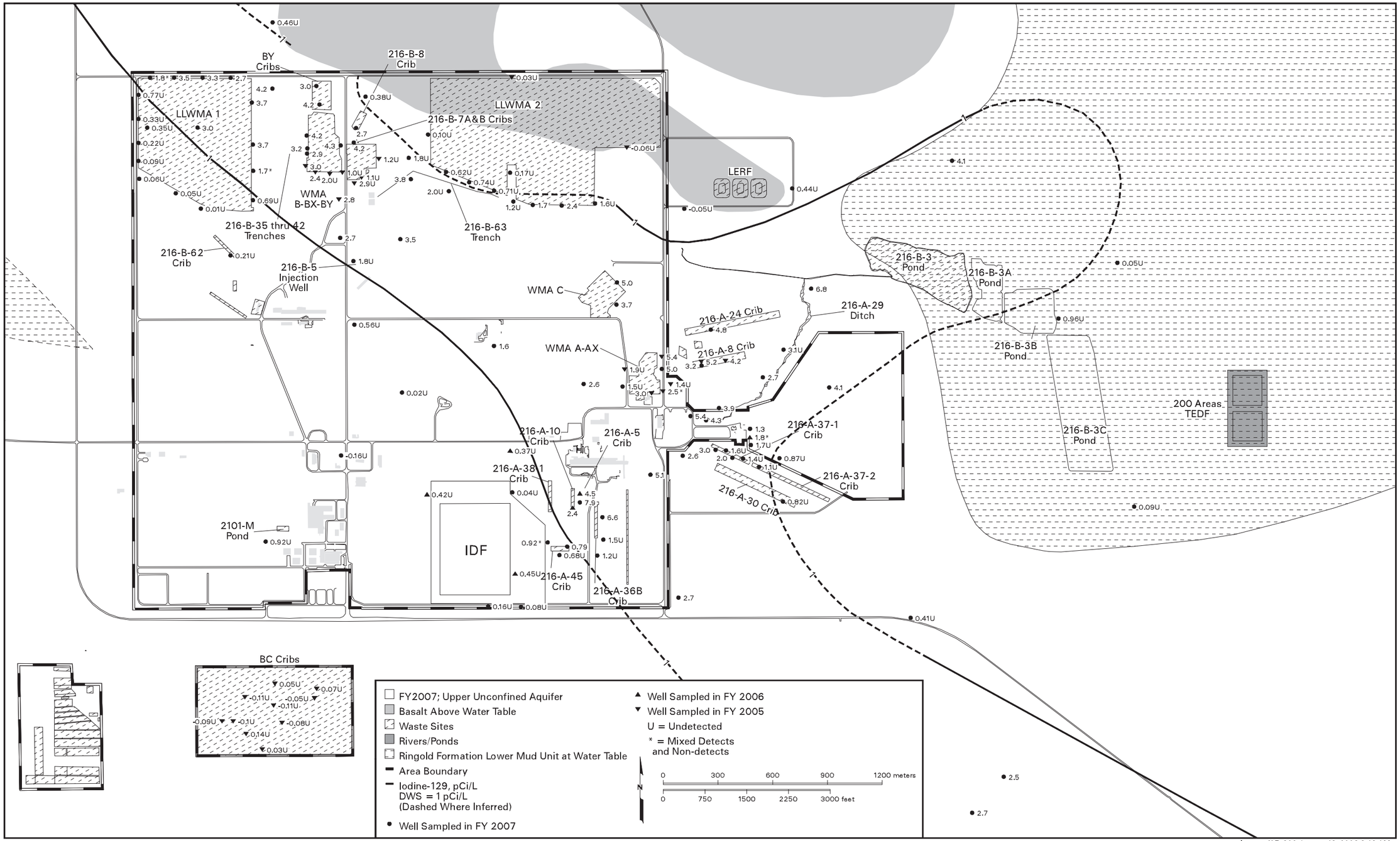


Figure 2.10-13. Average Iodine-129 Concentrations in 200 East Area, Upper Part of Unconfined Aquifer

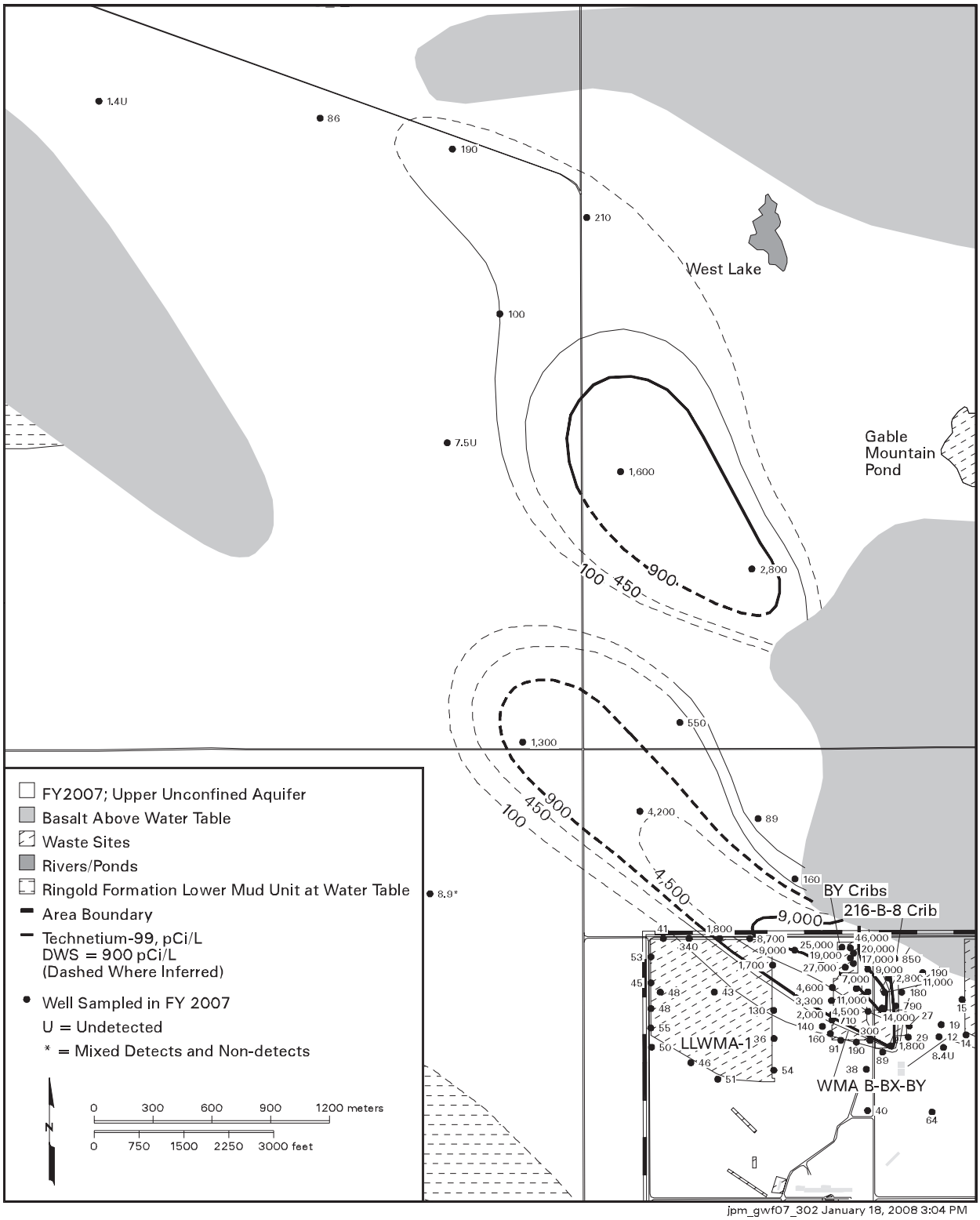


Figure 2.10-14. Average Technetium-99 Concentrations in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

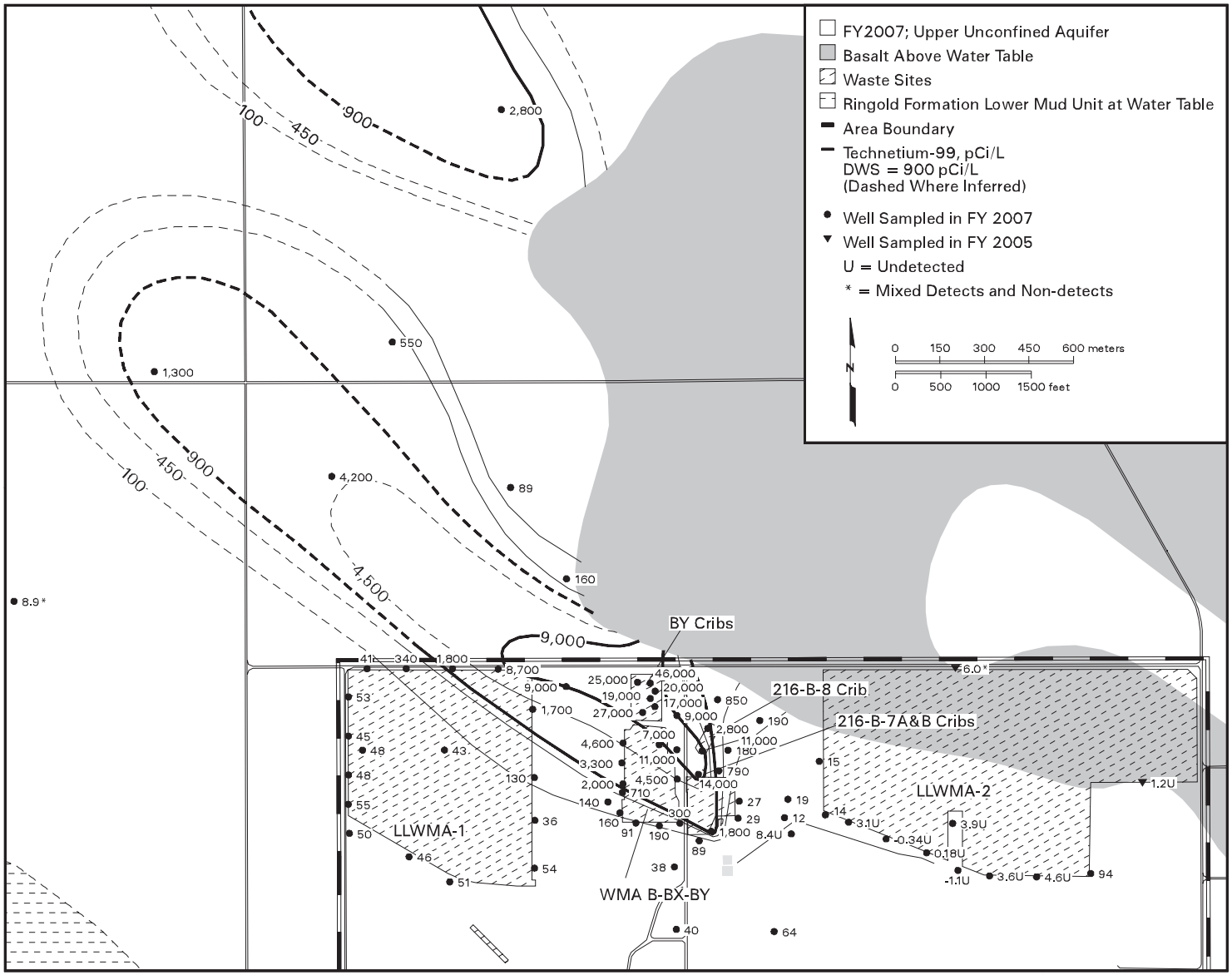


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Figure 2.10-15. Average Technetium-99 Concentrations in B Complex Area and Low-Level Waste Management Area 1, Upper Part of Unconfined Aquifer

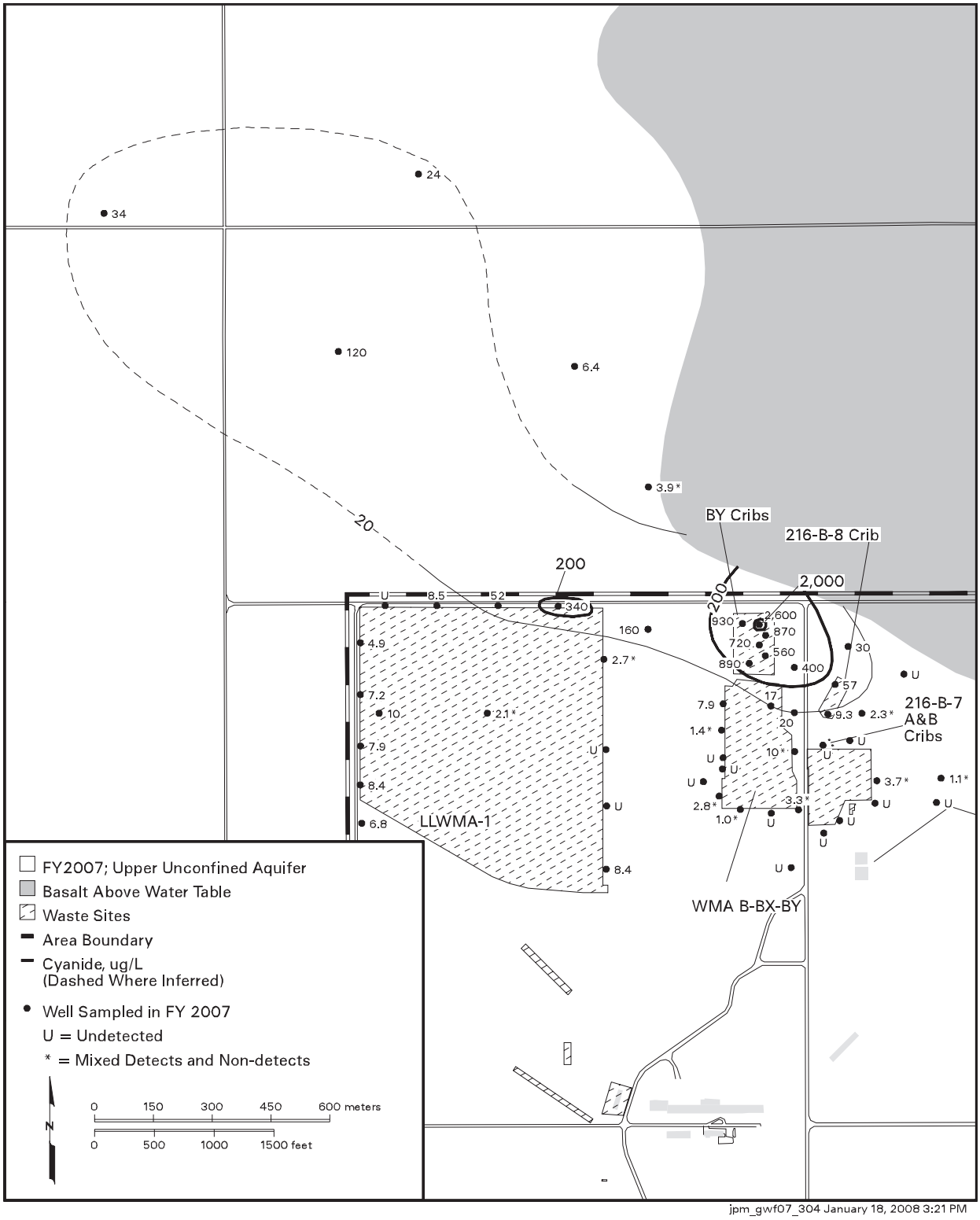


Figure 2.10-16. Average Cyanide Concentrations in Northwest 200 East Area, Upper Part of Unconfined Aquifer

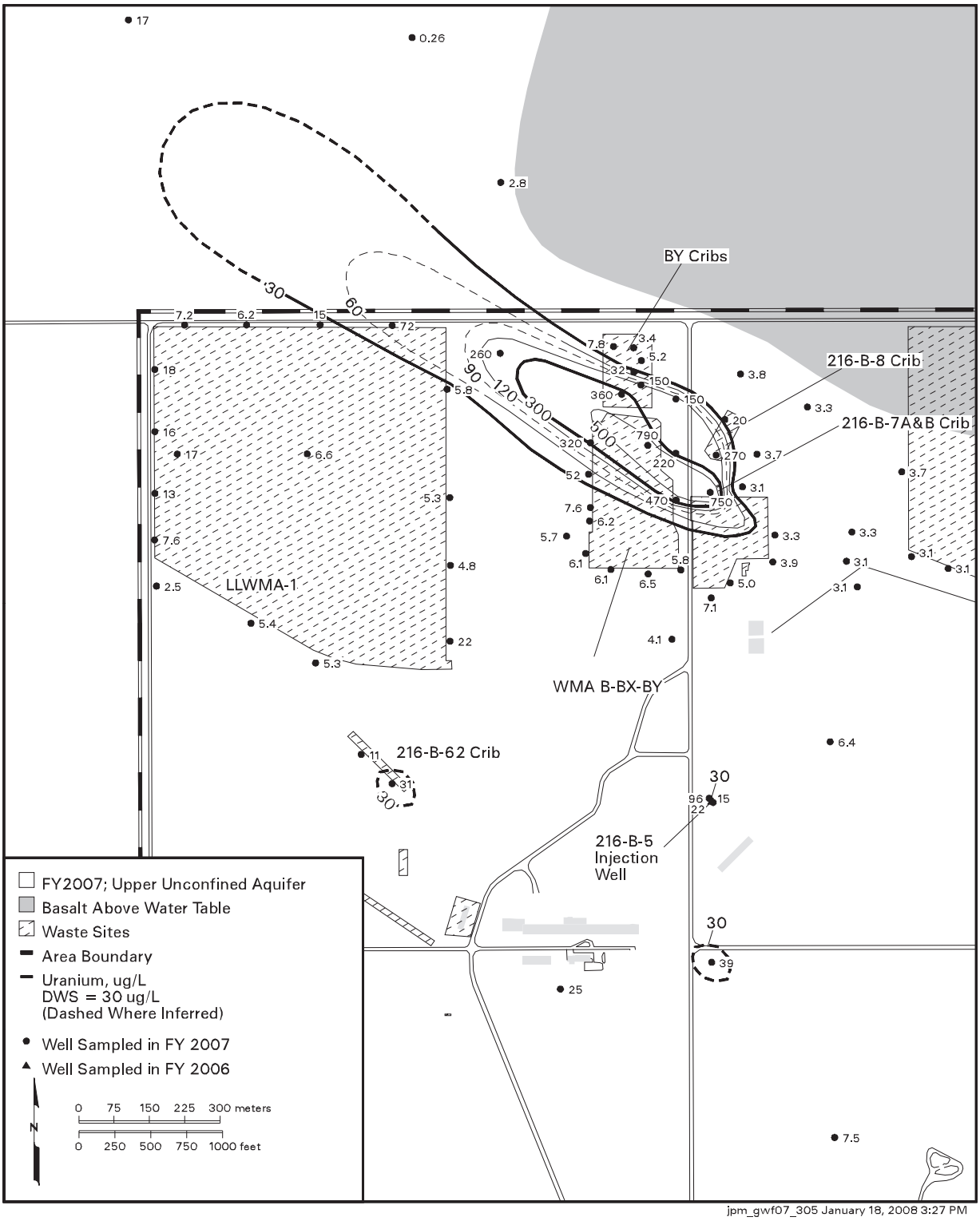


Figure 2.10-17. Uranium Concentrations in Northwest 200 East Area, Upper Part of Unconfined Aquifer

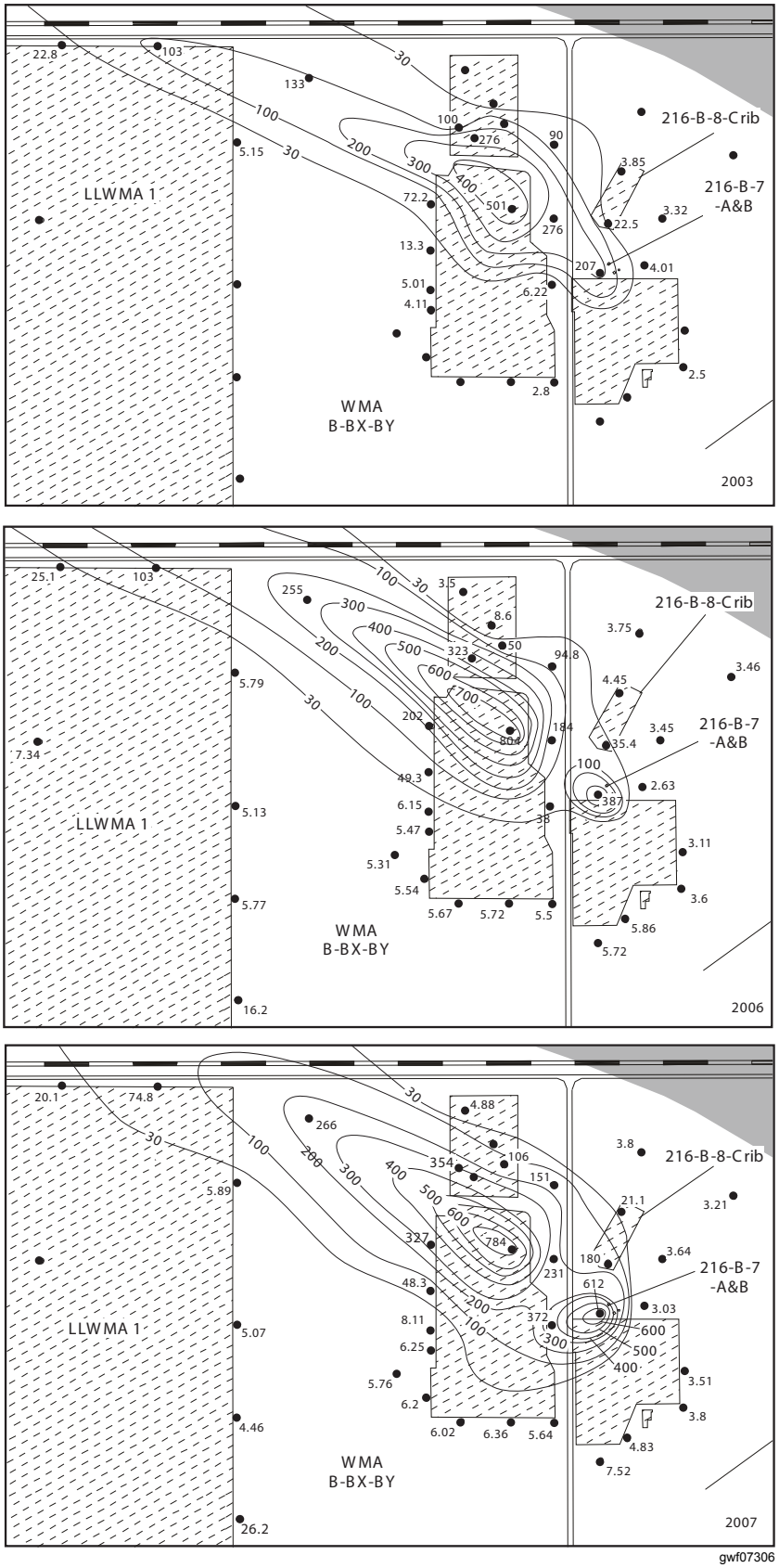


Figure 2.10-18. Time Series Maps of Uranium from 2003 to 2007

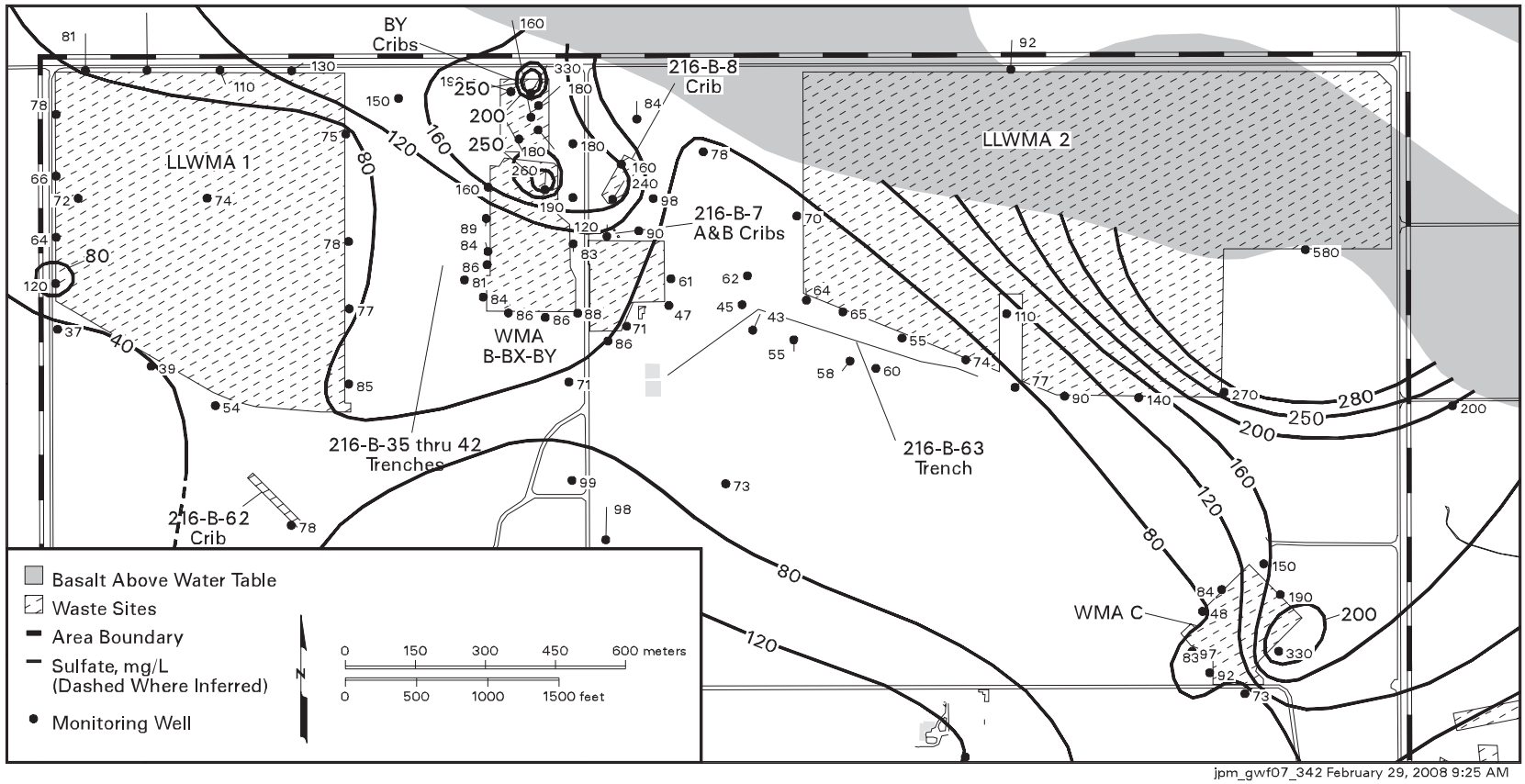


Figure 2.10-19. Average Sulfate Concentrations Along the Basalt Sub-crop in 200-BP-5 Operable Unit, Upper Part of Unconfined Aquifer

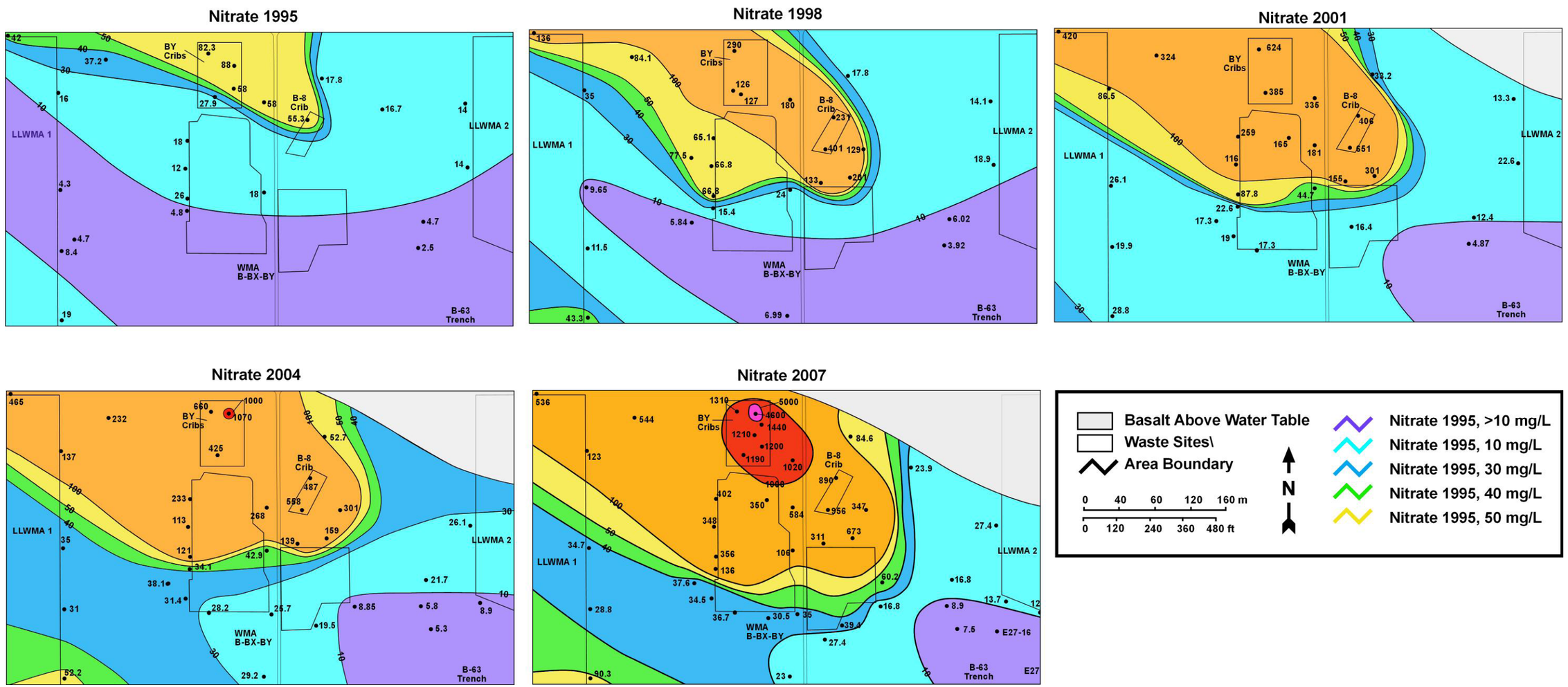


Figure 2.10-20. Time Series of Nitrate Plume Migration, 1995 to 2007

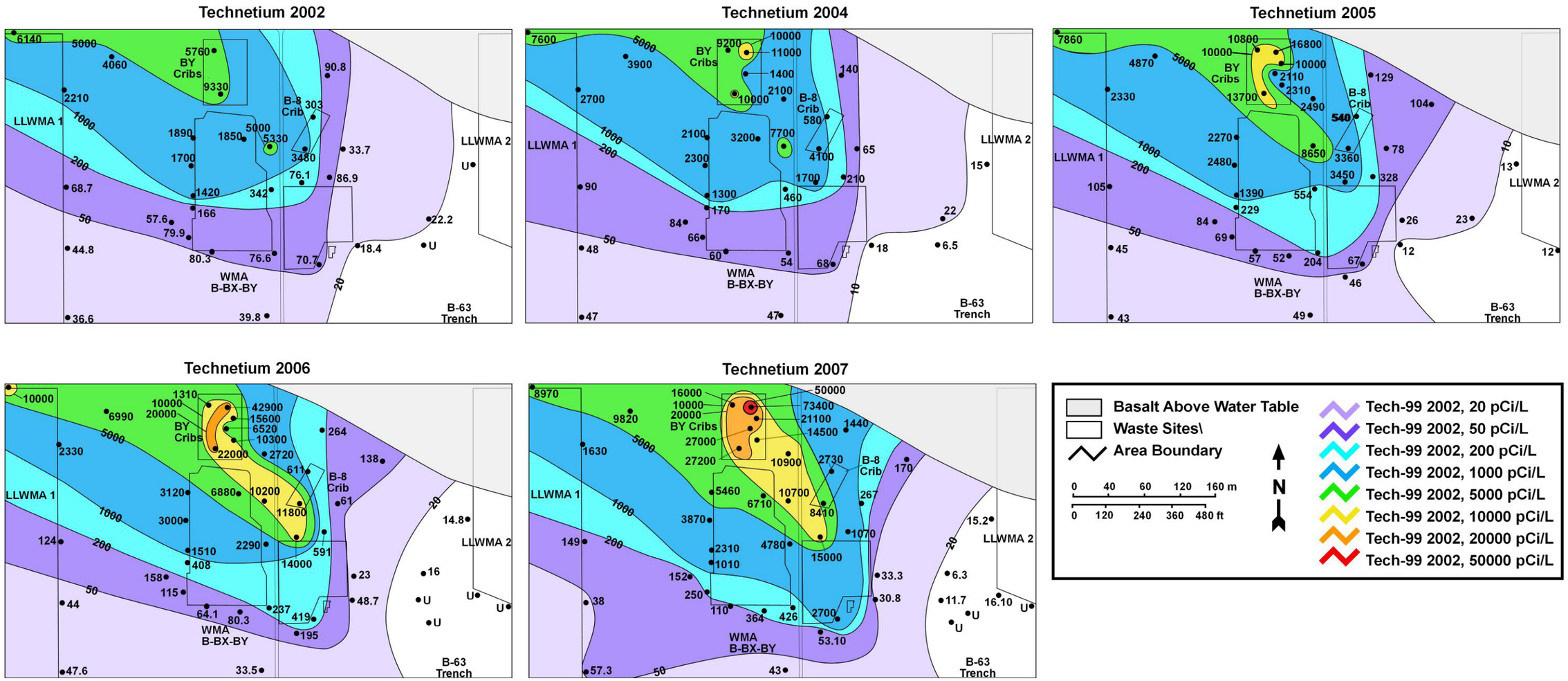
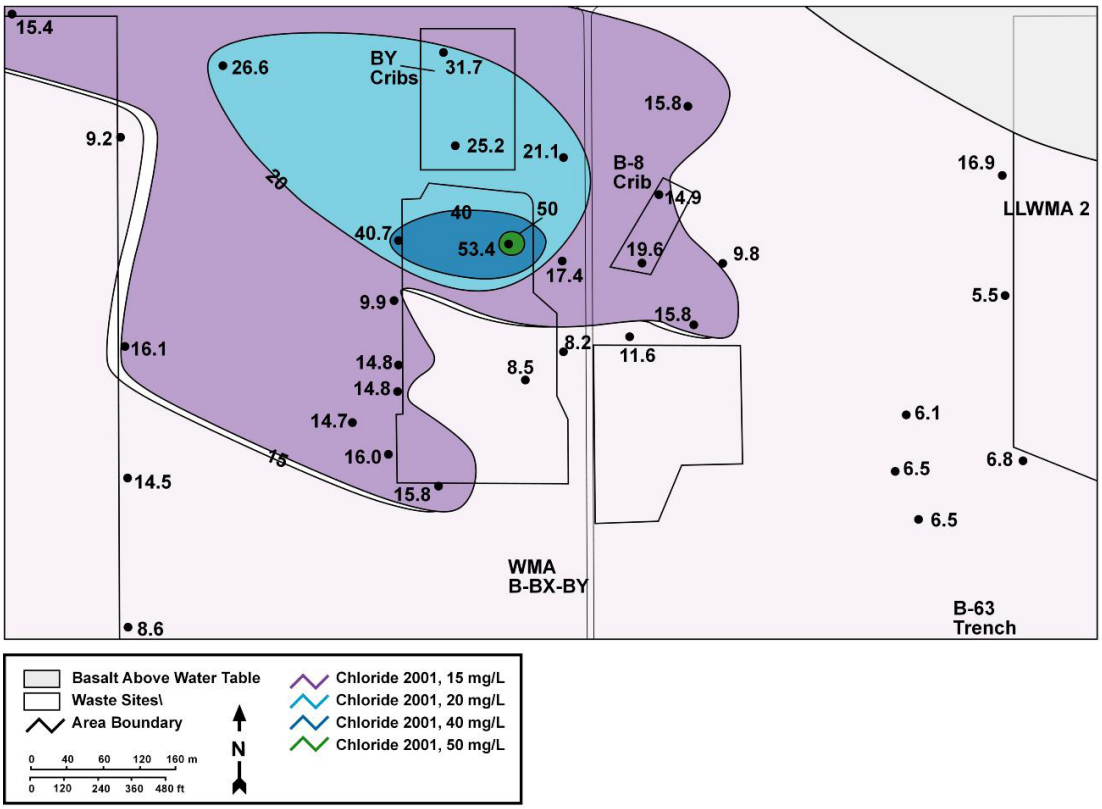


Figure 2.10-21. Time Series of Technetium-99 Plume Migration, 2002 to 2007

Chloride 2001



Chloride 2007

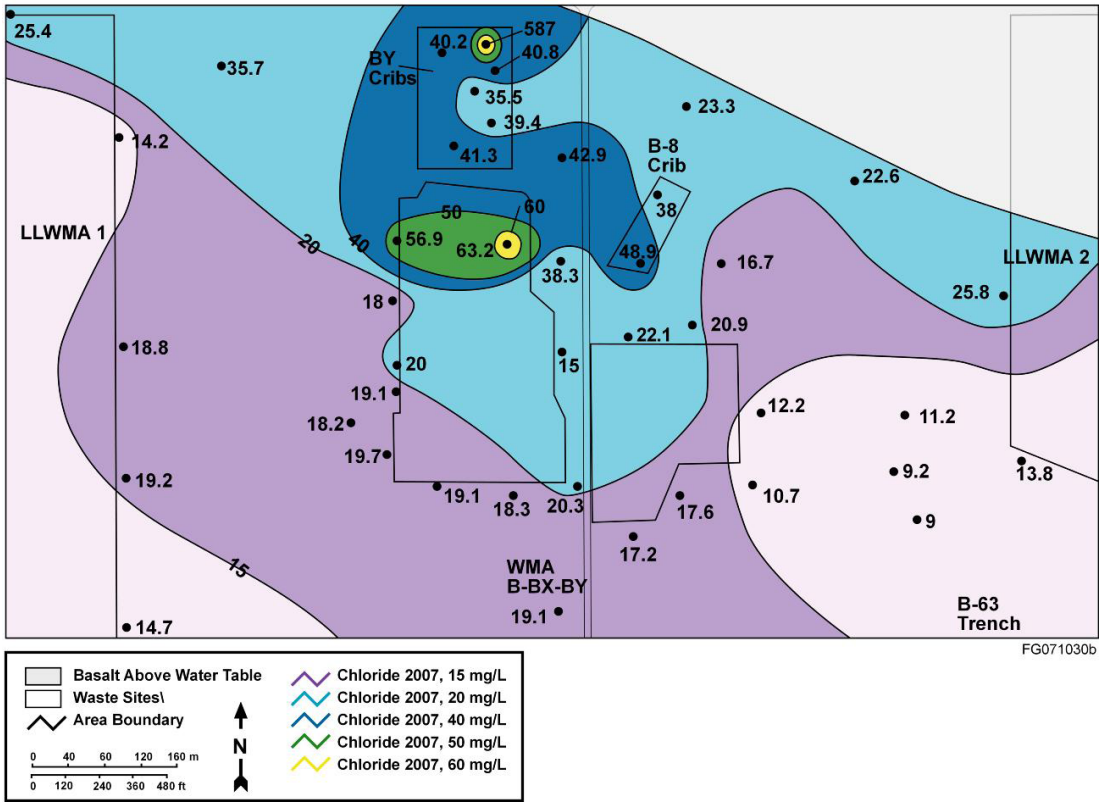


Figure 2.10-22. Migration of Chloride Plume, 2001 to 2007

Figure 2.10-23. Photograph of Erosion at BY Cribs Facing Southwest Between the BY Tank and the B-57 Barrier, June 2004

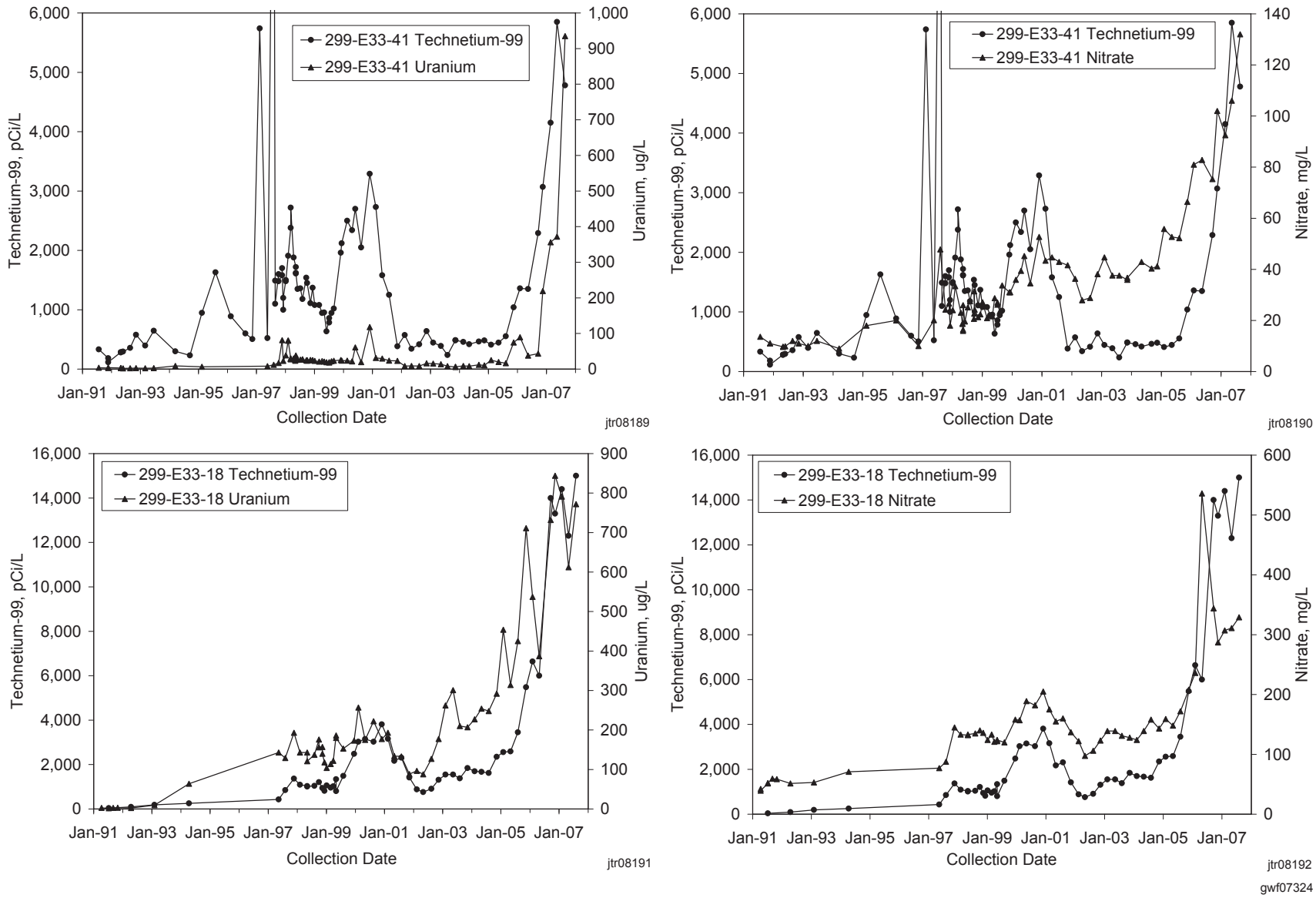


Figure 2.10-24. Technetium-99, Uranium, and Nitrate Concentrations for Wells 299-E33-18 and 299-E33-41

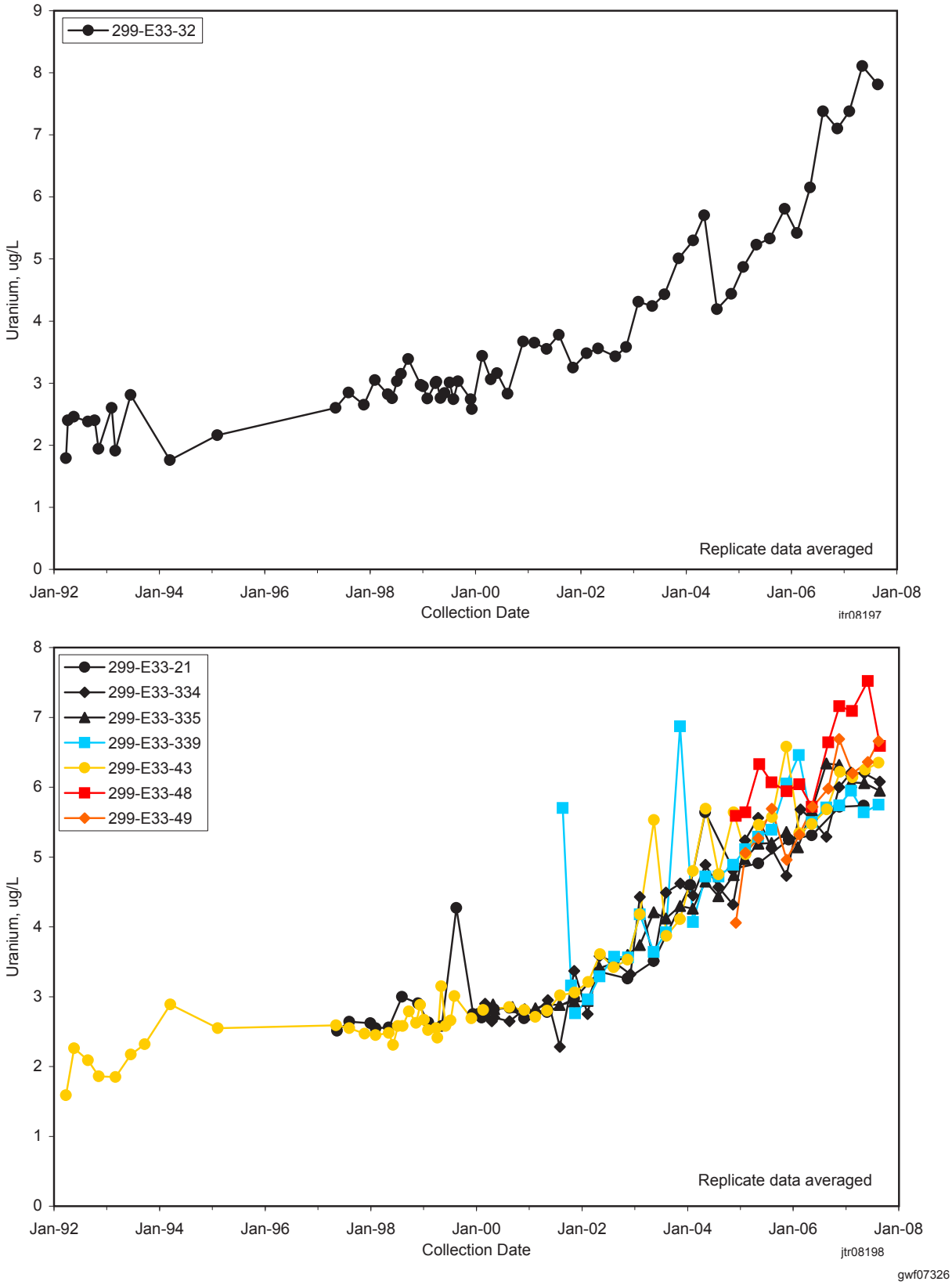


Figure 2.10-25. Uranium Concentrations on South Side of Waste Management Area B-BX-BY

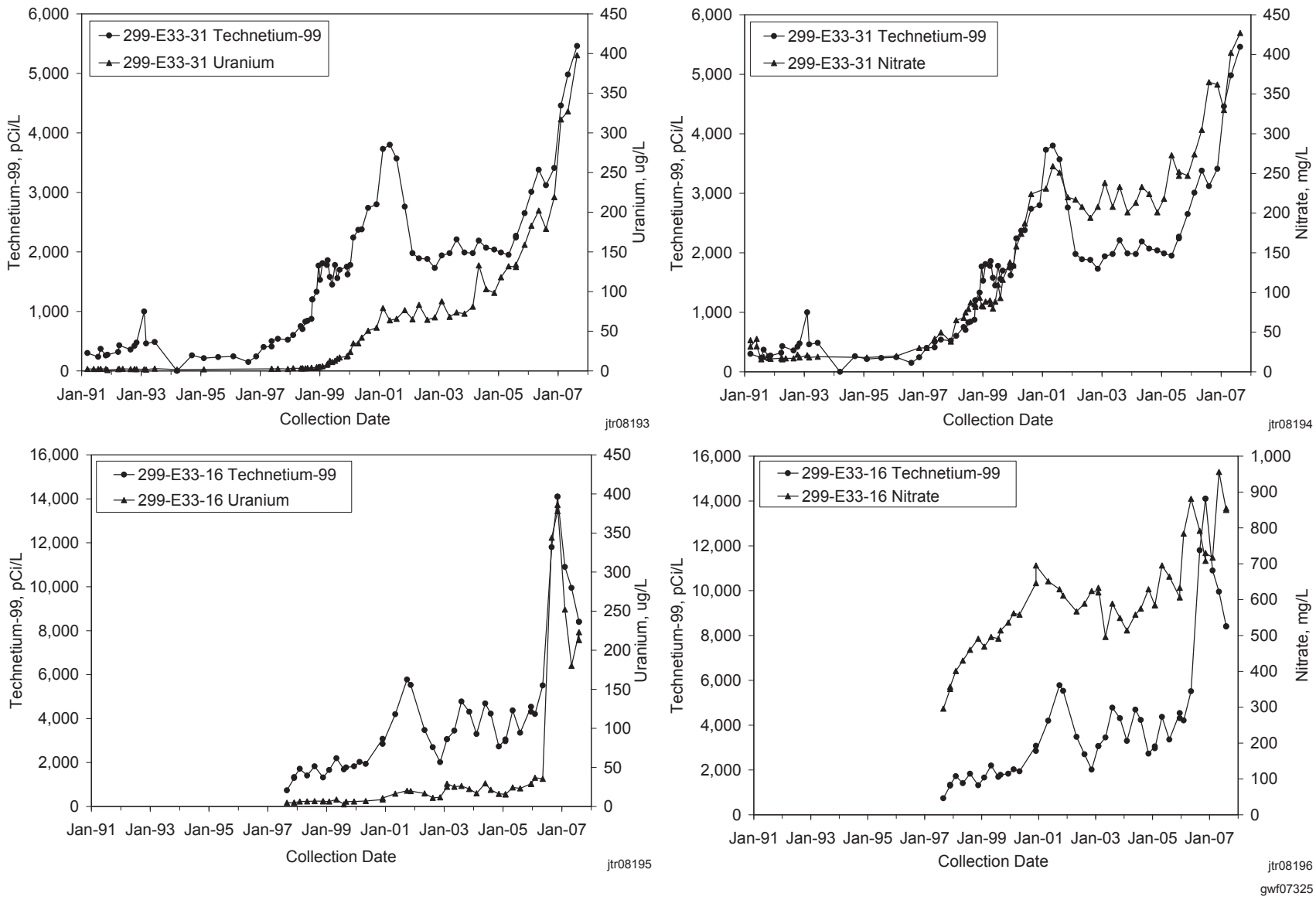


Figure 2.10-26. Technetium-99, Uranium, and Nitrate Concentrations for Wells 299-E33-31 and 299-E33-16

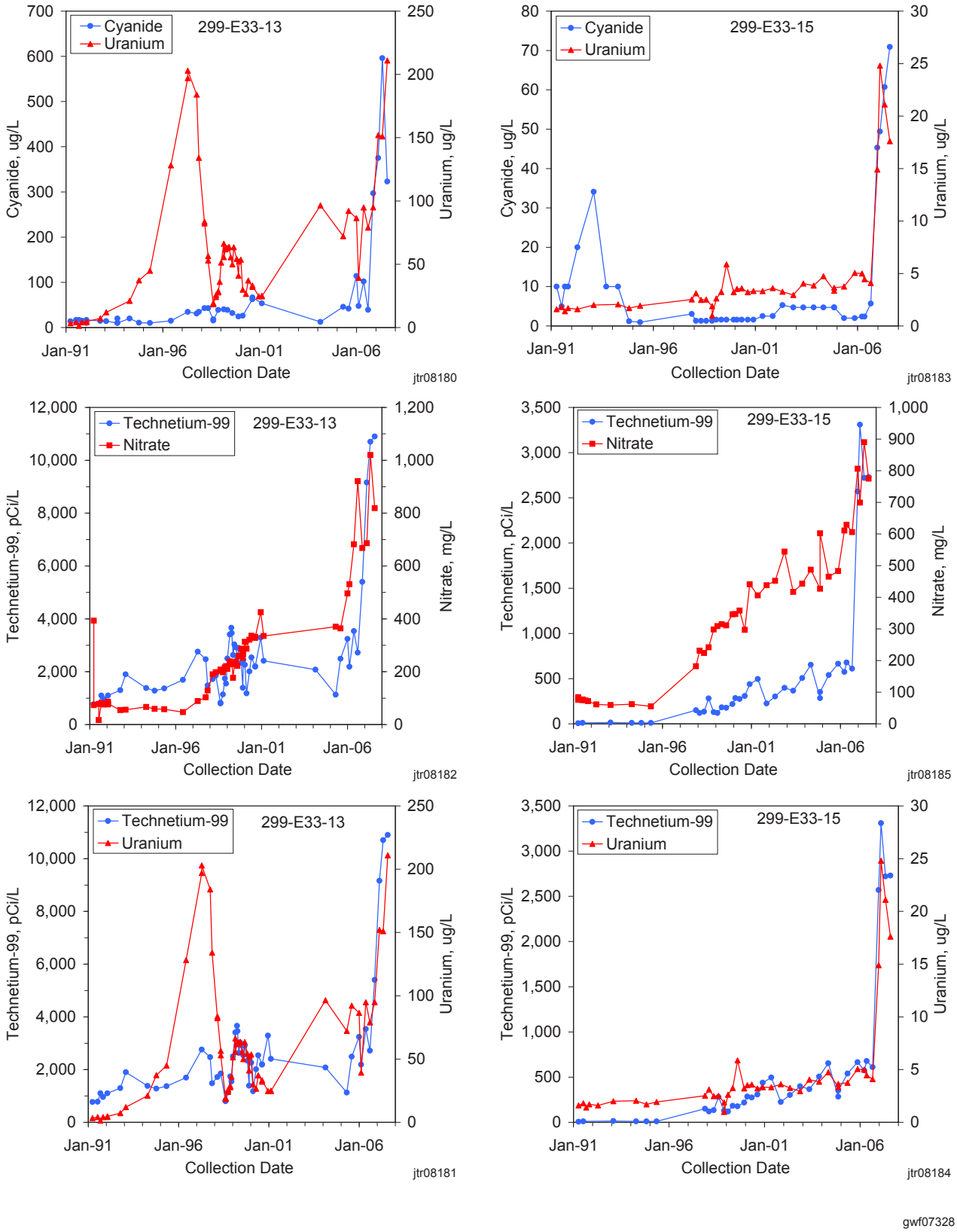


Figure 2.10-27. Cyanide, Uranium, Technetium-99, and Nitrate Concentrations for Well 299-E33-13 and 299-E33-15

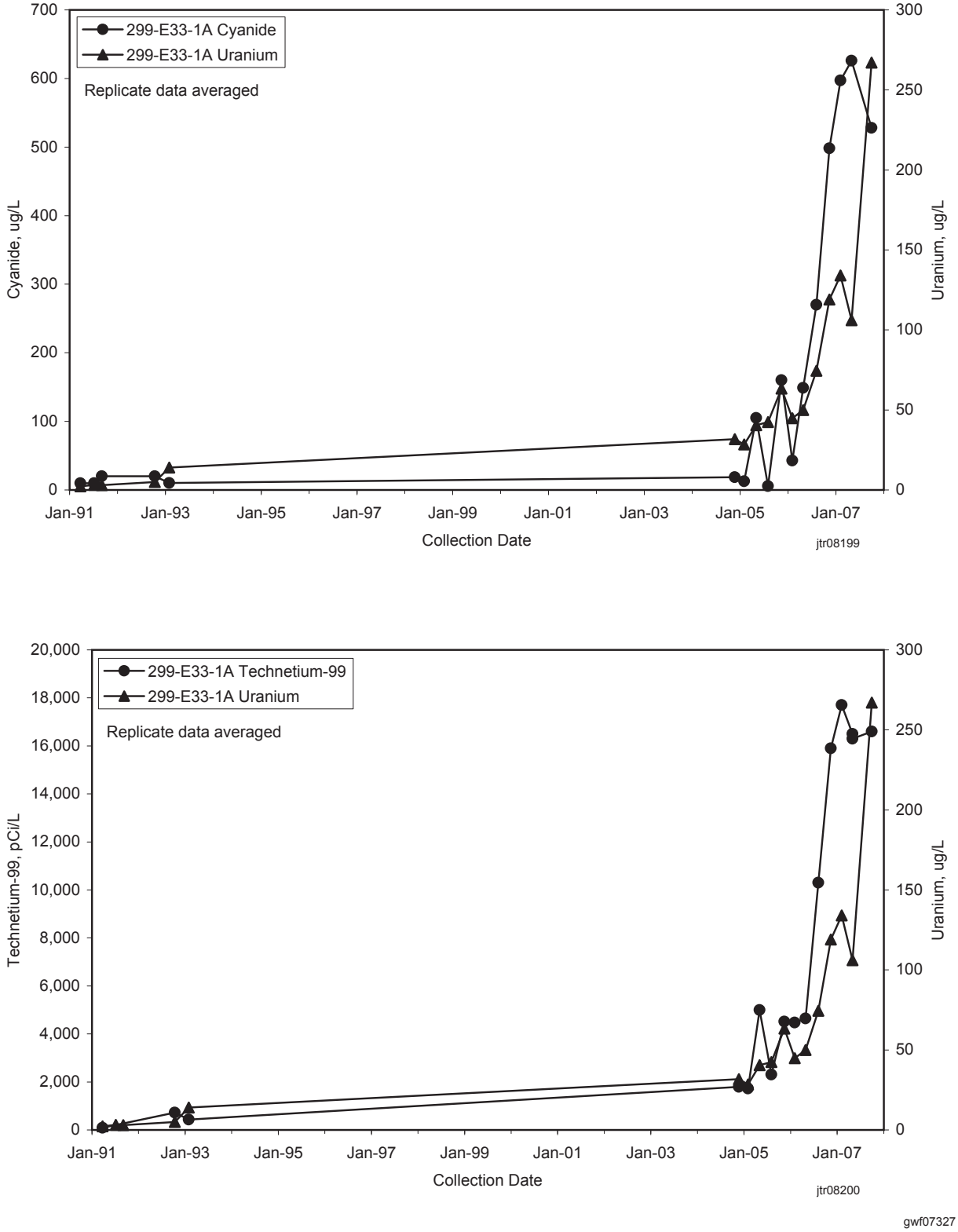


Figure 2.10-28. Uranium, Cyanide, and Technetium-99 Concentrations Beneath the BY Cribs in Well 299-E33-1A

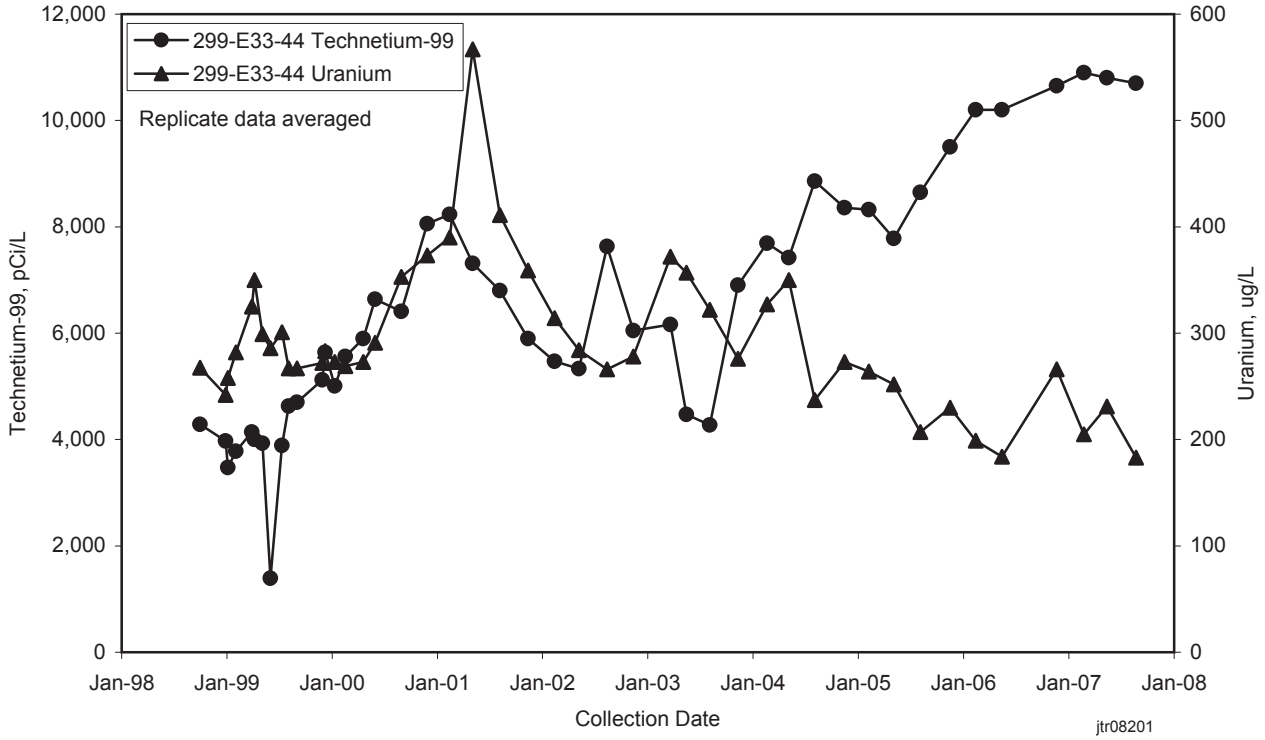


Figure 2.10-29. Increasing Technetium-99 and Decreasing Uranium Concentrations at Well 299-E33-44

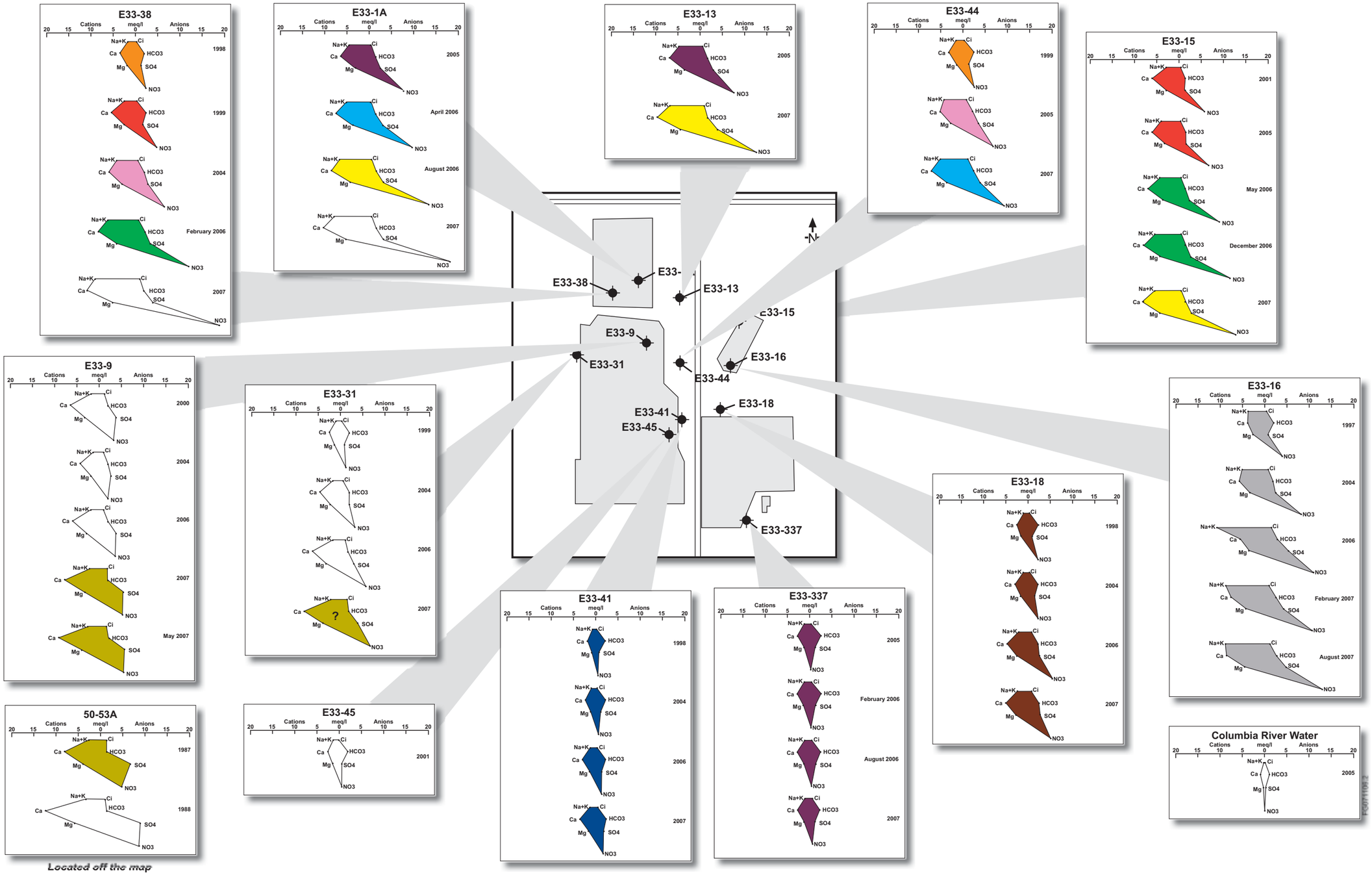


Figure 2.10-30. Stiff Diagrams for Wells at Waste Management Area B-BX-BY and Surrounding Facilities (Matching colors are Stiff Diagrams with common contaminant signatures.)

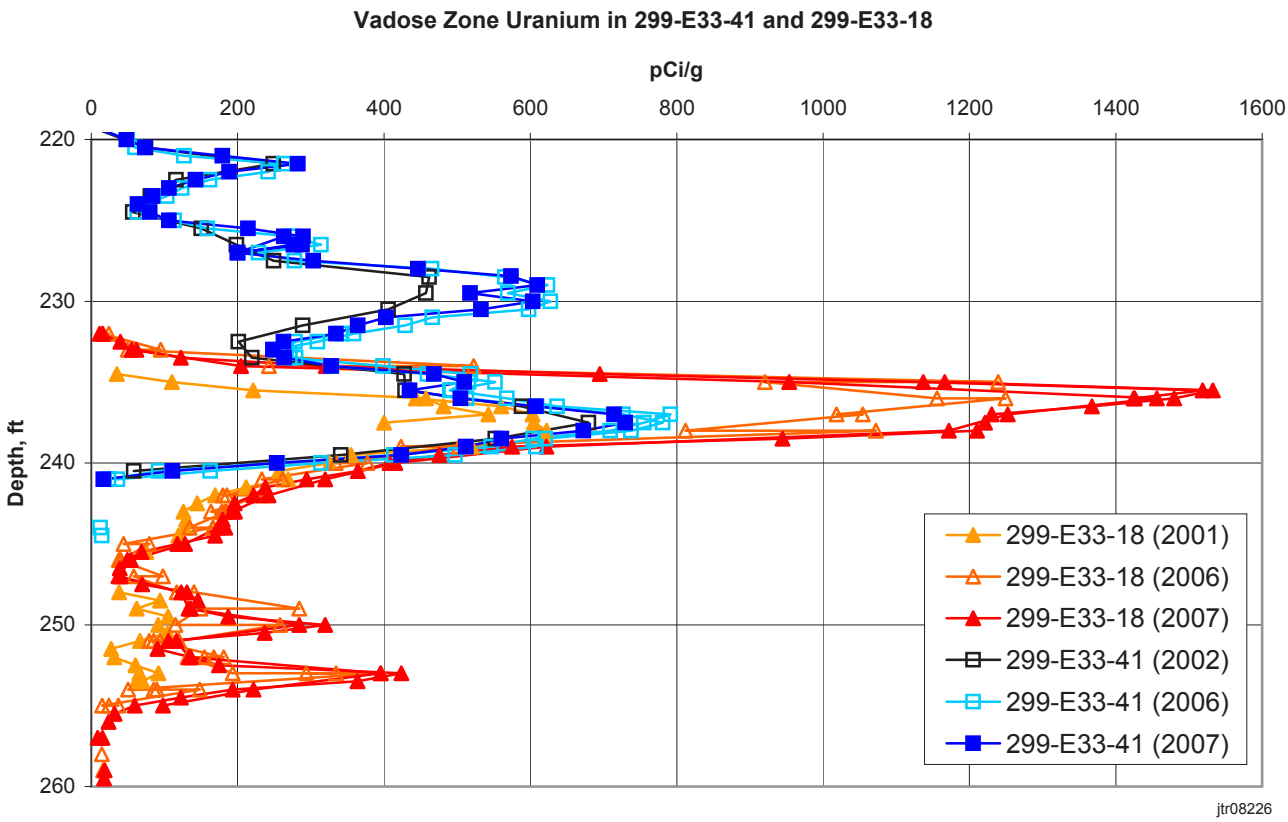
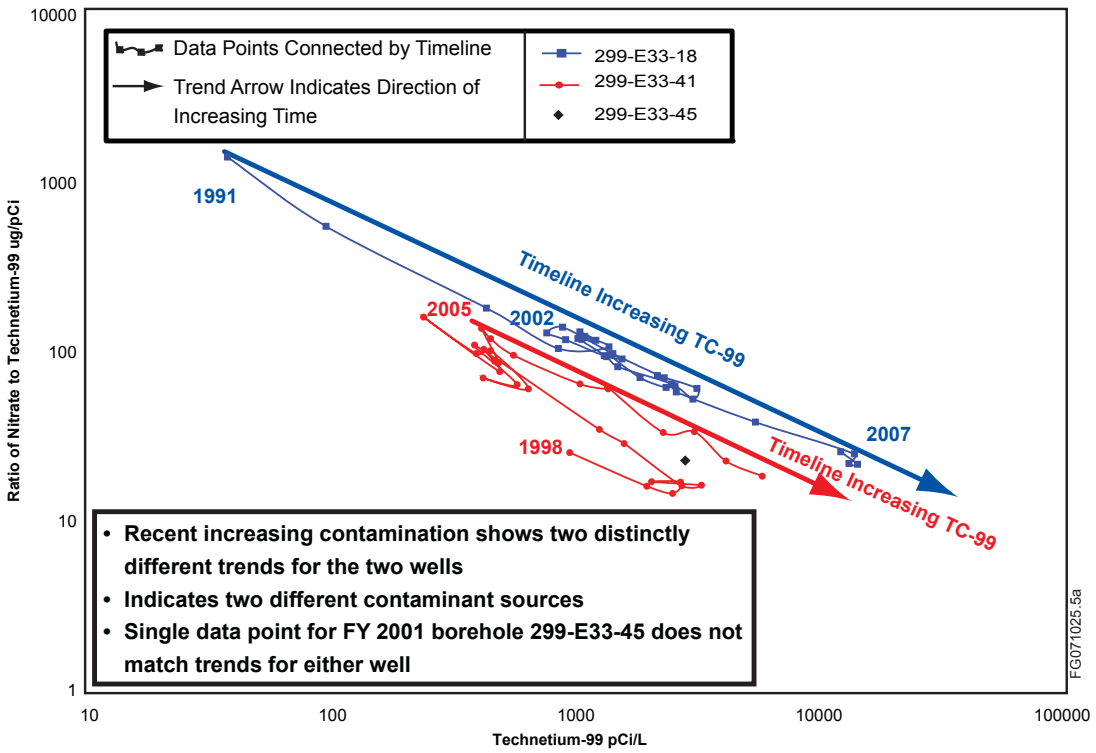


Figure 2.10-31. Spectral Gamma Results for Well 299-E33-18 and 299-E33-41, FY 2007



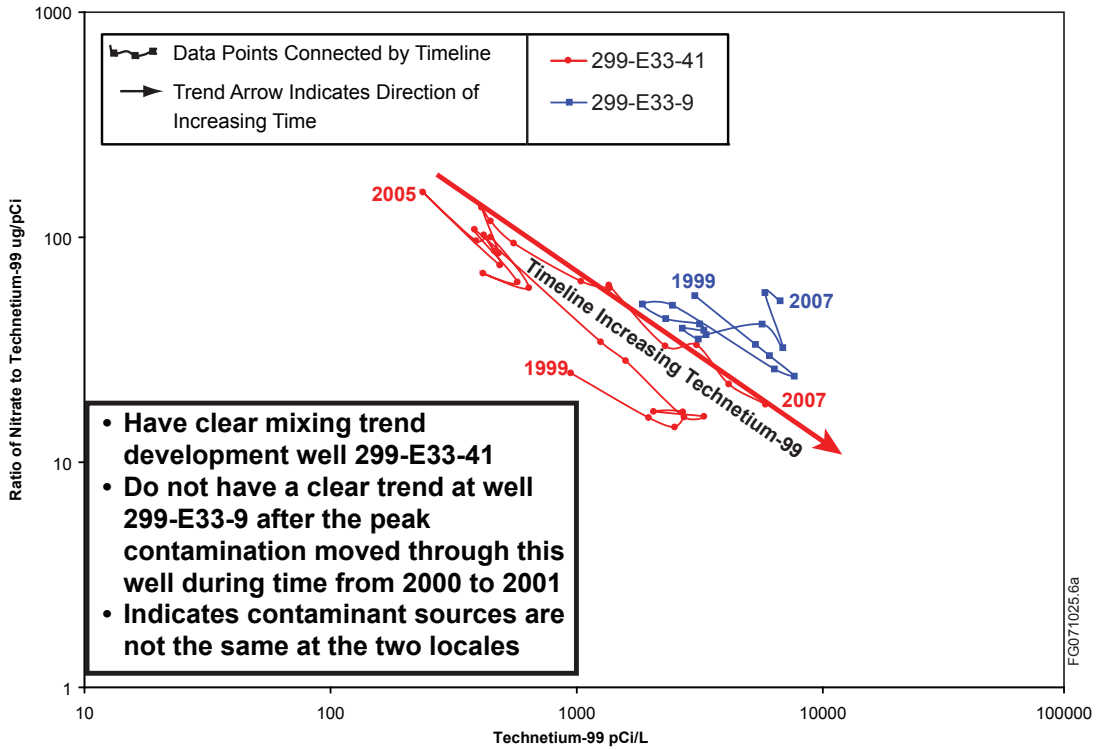
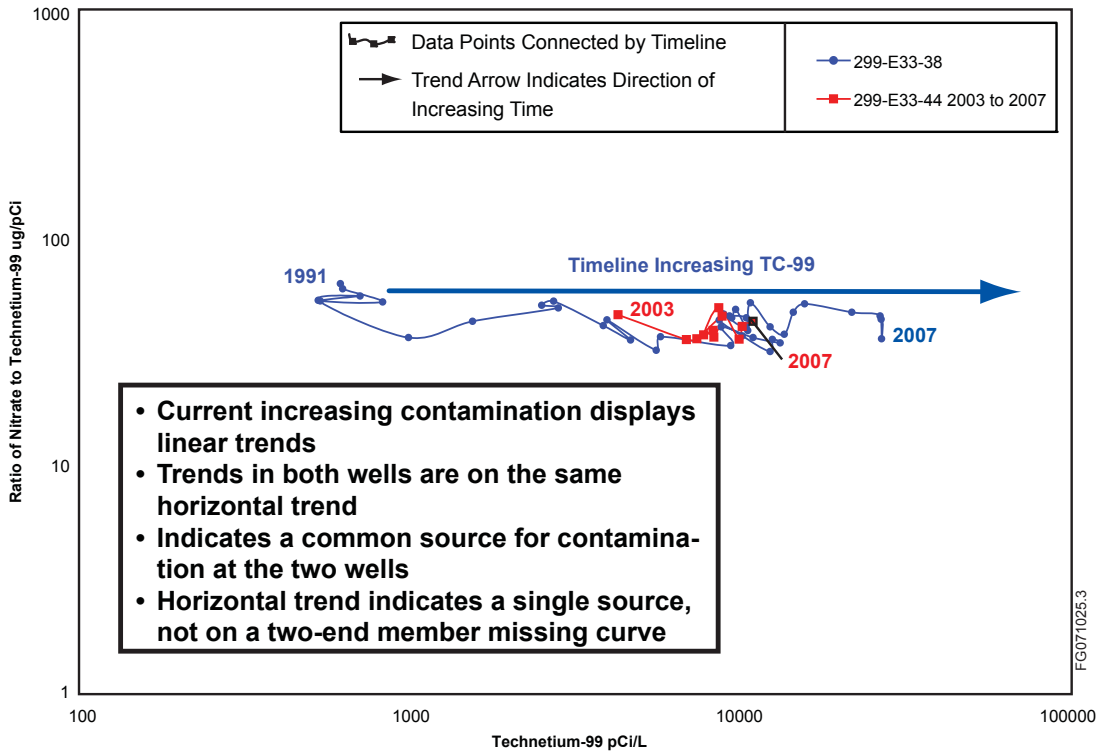


Figure 2.10-32. Nitrate to Technetium-99 Ratios Comparing Well 299-E33-18 to 299-E33-41 and Well 299-E33-41 to 299-E33-9



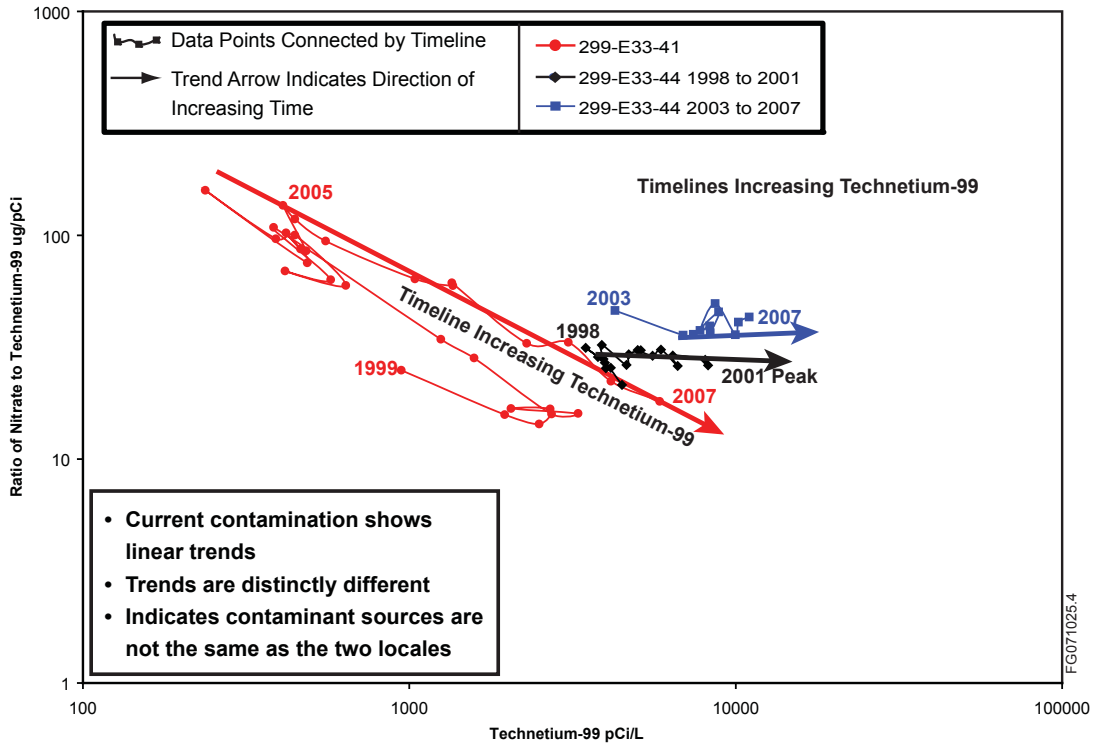


Figure 2.10-33. Nitrate to Technetium-99 Ratios Comparing Well 299-E33-38 to 299-E33-44 and Well 299-E33-41 to 299-E33-44

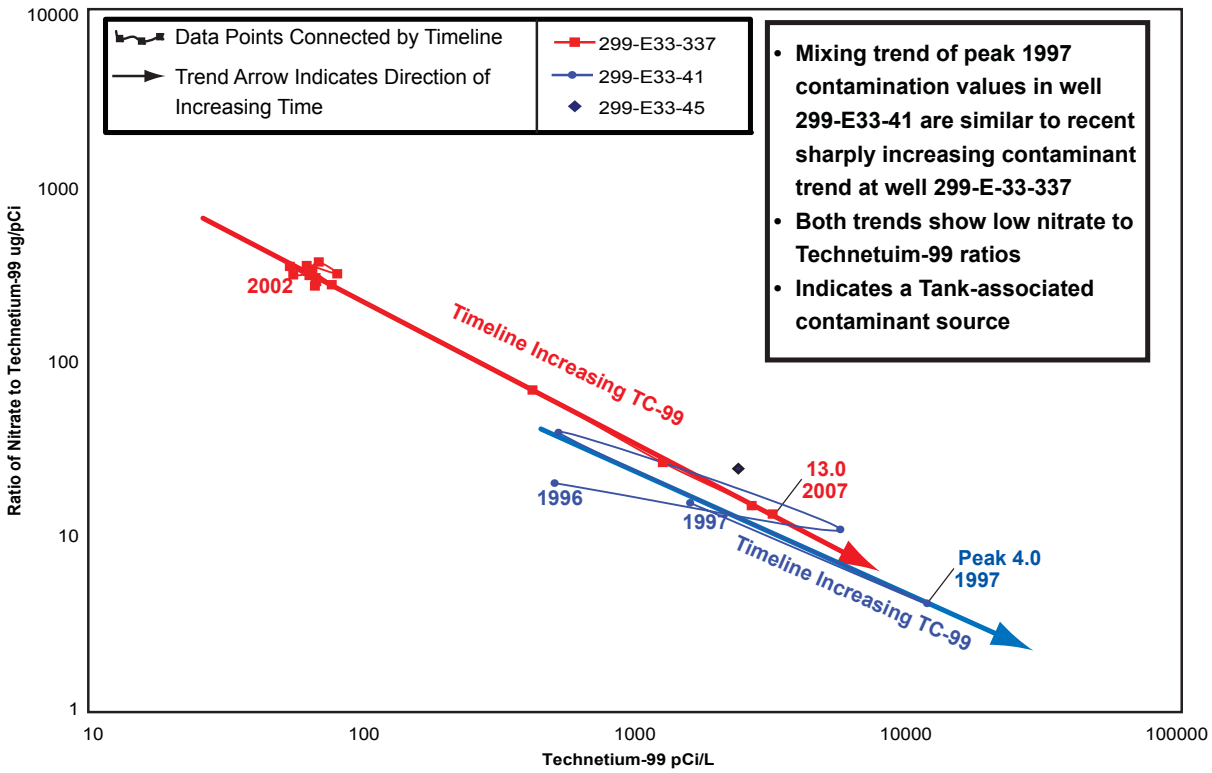


Figure 2.10-34. Nitrate to Technetium-99 Ratios Comparing Well 299-E33-337 to 299-E33-41 and Borehole 299-E33-45

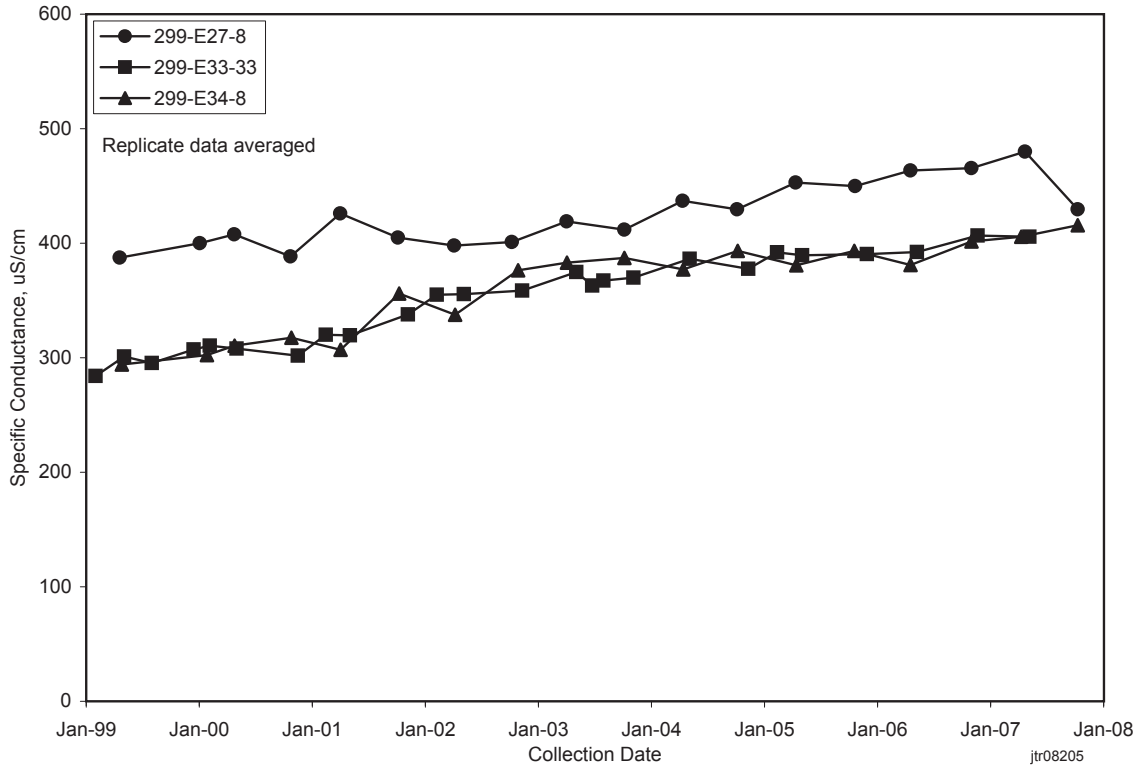


Figure 2.10-35. Specific Conductance Trends at the 216-B-63 Trench

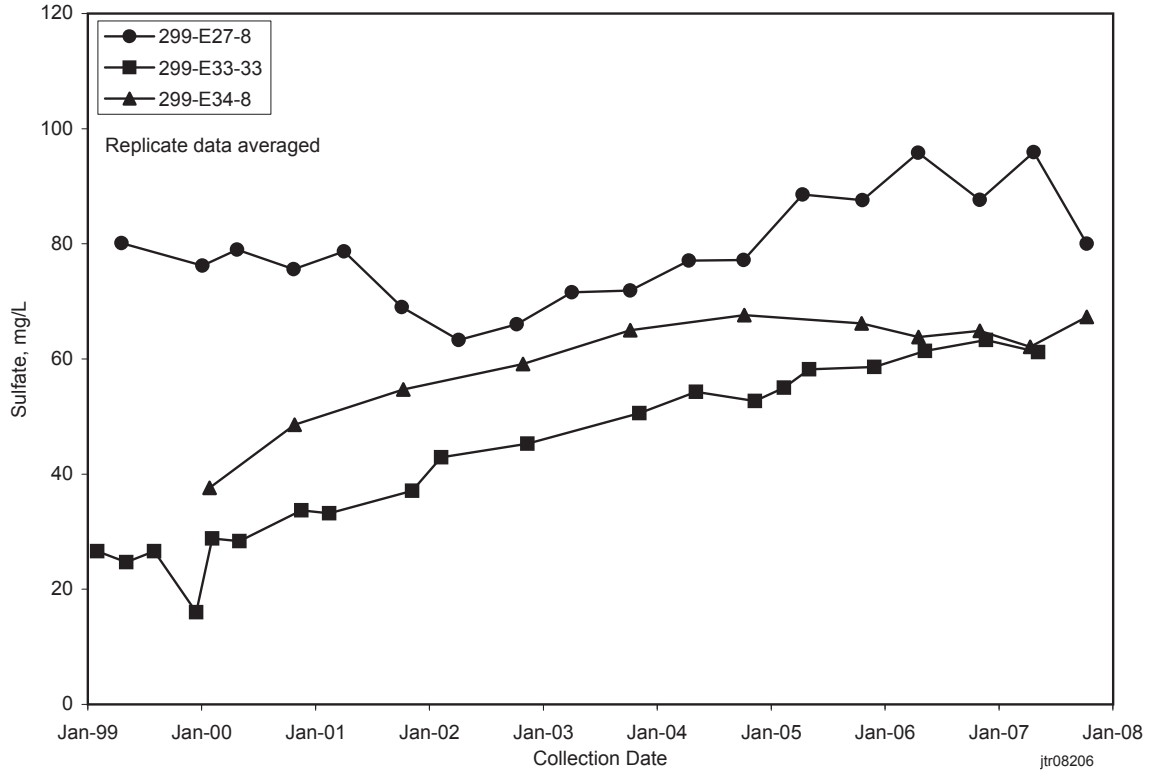


Figure 2.10-36. Sulfate Concentrations in Wells 299-E27-8, 299-E33-33 and 299-E34-8 at the 216-B-63 Trench

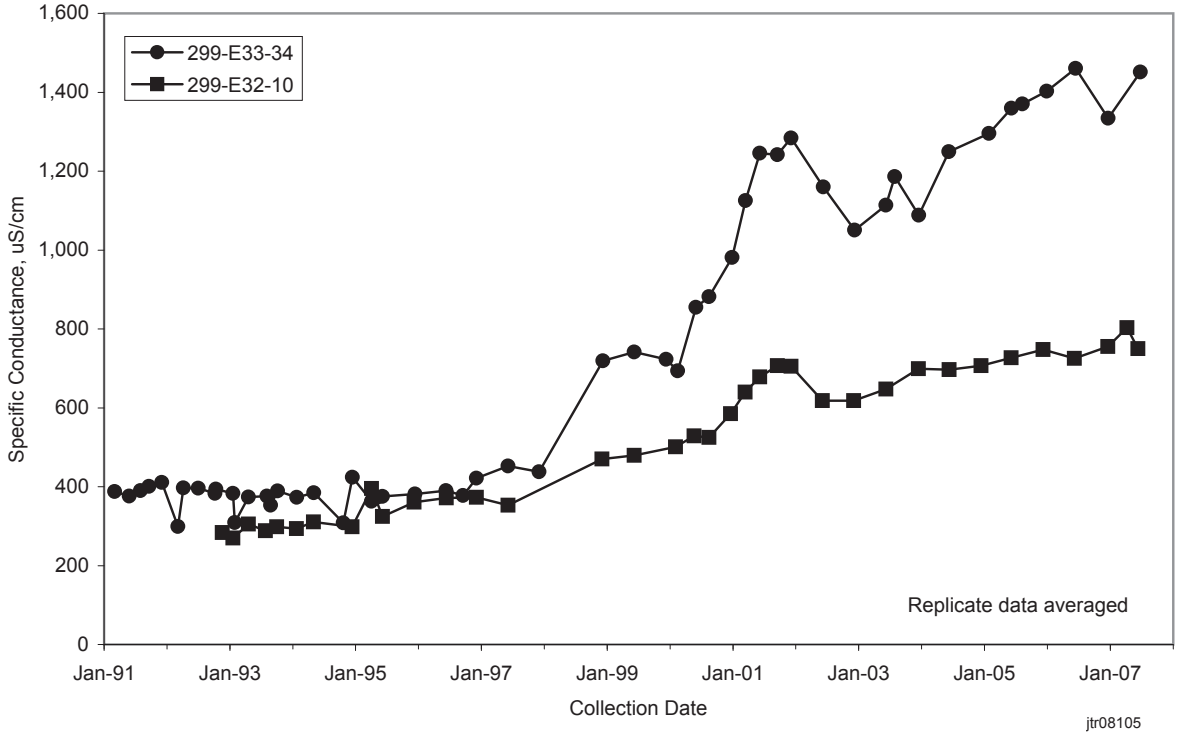


Figure 2.10-37. Specific Conductance in Wells 299-E33-34 and 299-E32-10 at Low-Level Waste Management Area 1

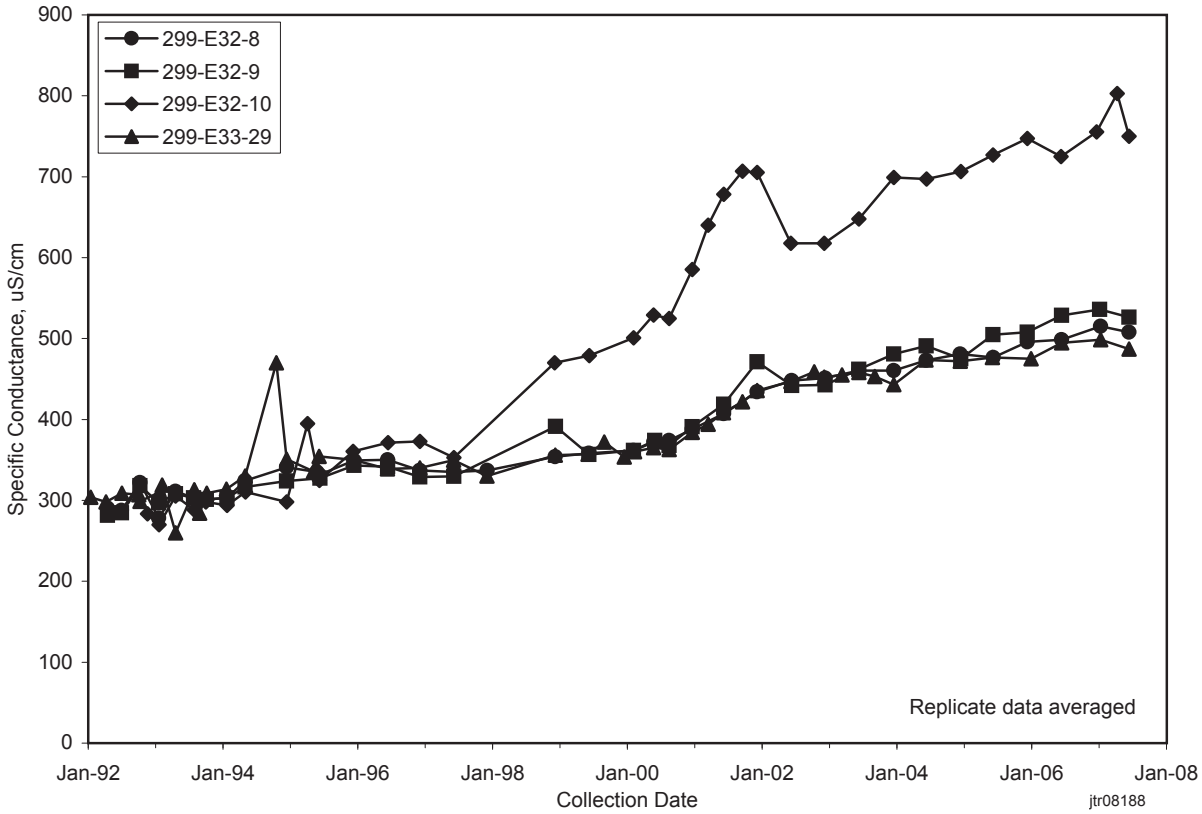


Figure 2.10-38. Specific Conductance at Low-Level Waste Management Area 1

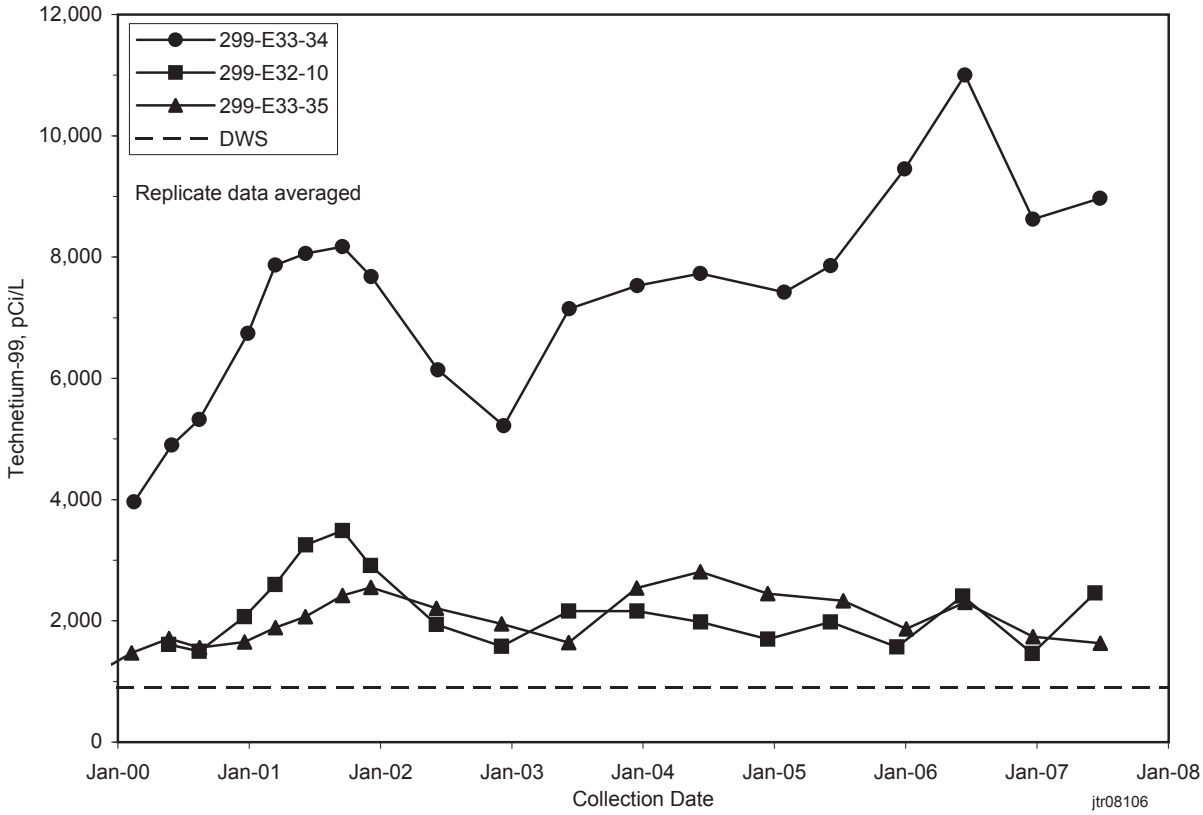


Figure 2.10-39. Technetium-99 Concentrations in Wells 299-E33-34, 299-E32-10, and 299-E33-35 at Low-Level Waste Management Area 1

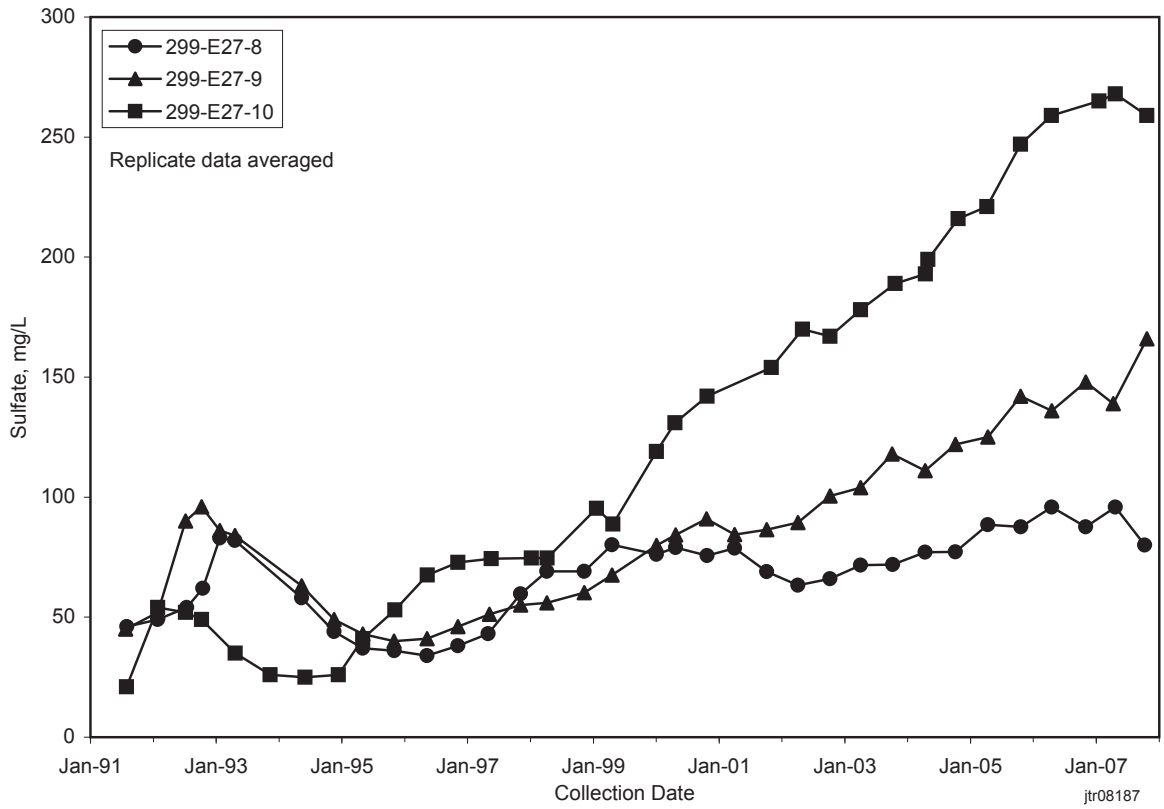


Figure 2.10-40. Sulfate Concentrations in the Southeastern Wells of Low-Level Waste Management Area 2

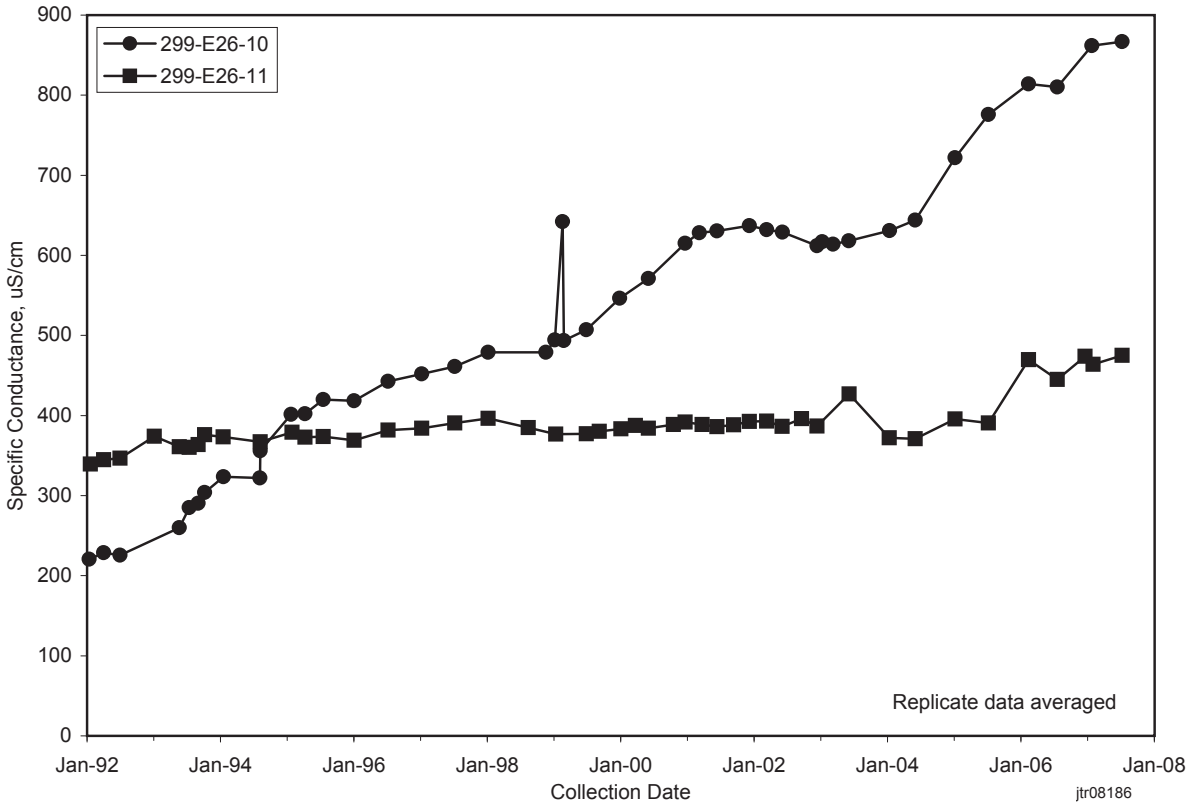


Figure 2.10-41. Specific Conductance in Wells 299-E26-10 and 299-E26-11 at Liquid Effluent Retention Facility

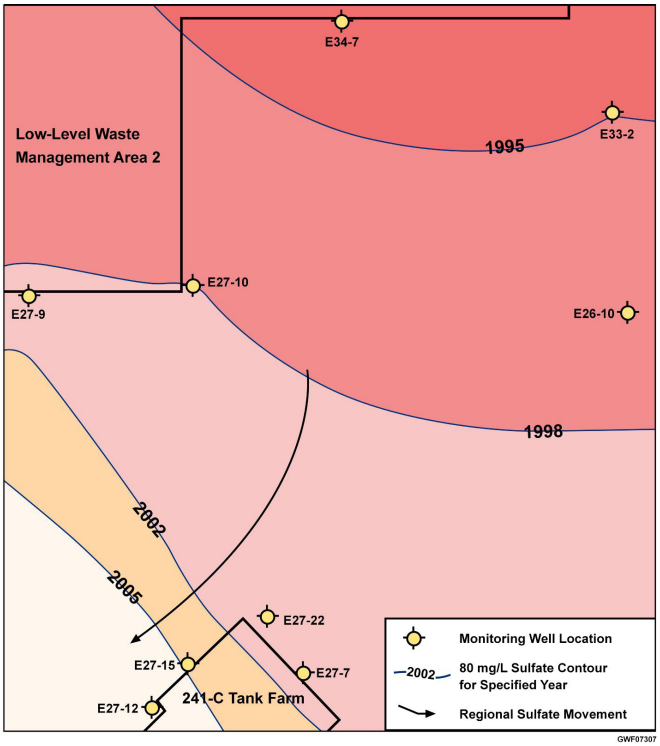


Figure 2.10-42. Migration of Sulfate Contamination Providing Flow Rate and Direction

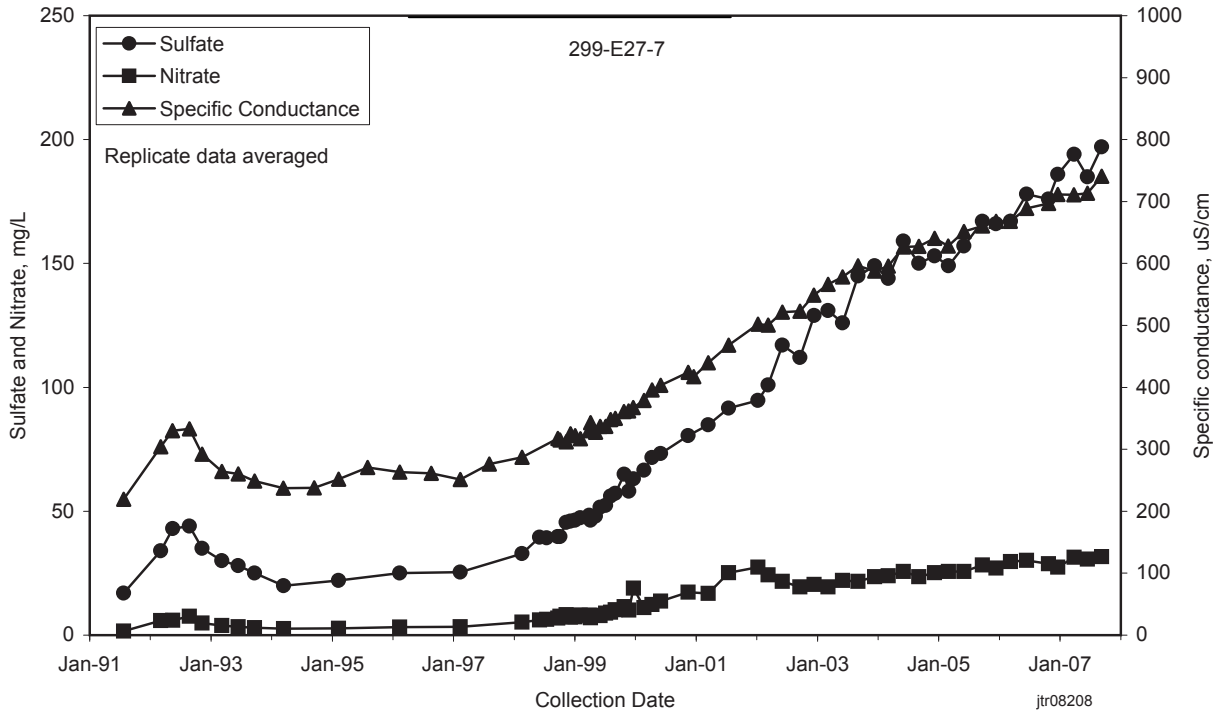


Figure 2.10-43. Sulfate, Nitrate, and Specific Conductance in Well 299-E27-7, Waste Management Area C

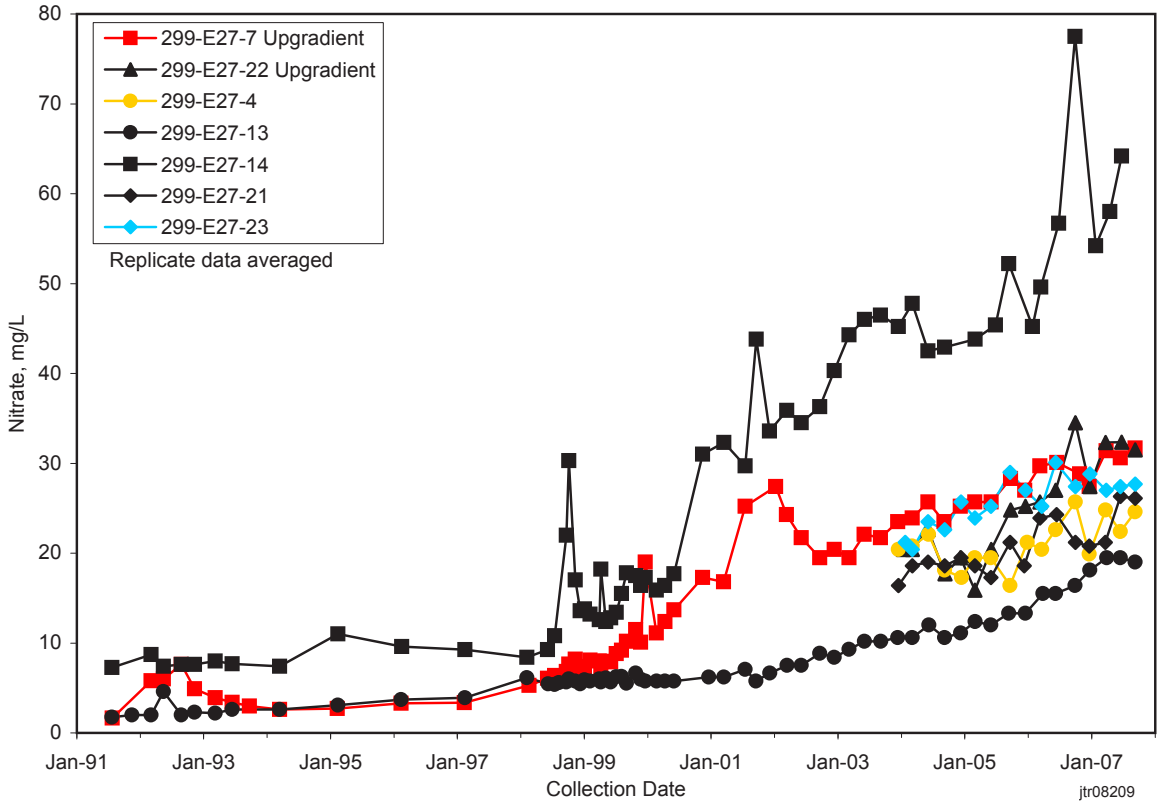


Figure 2.10-44. Nitrate Concentrations in Wells Monitoring Waste Management Area C

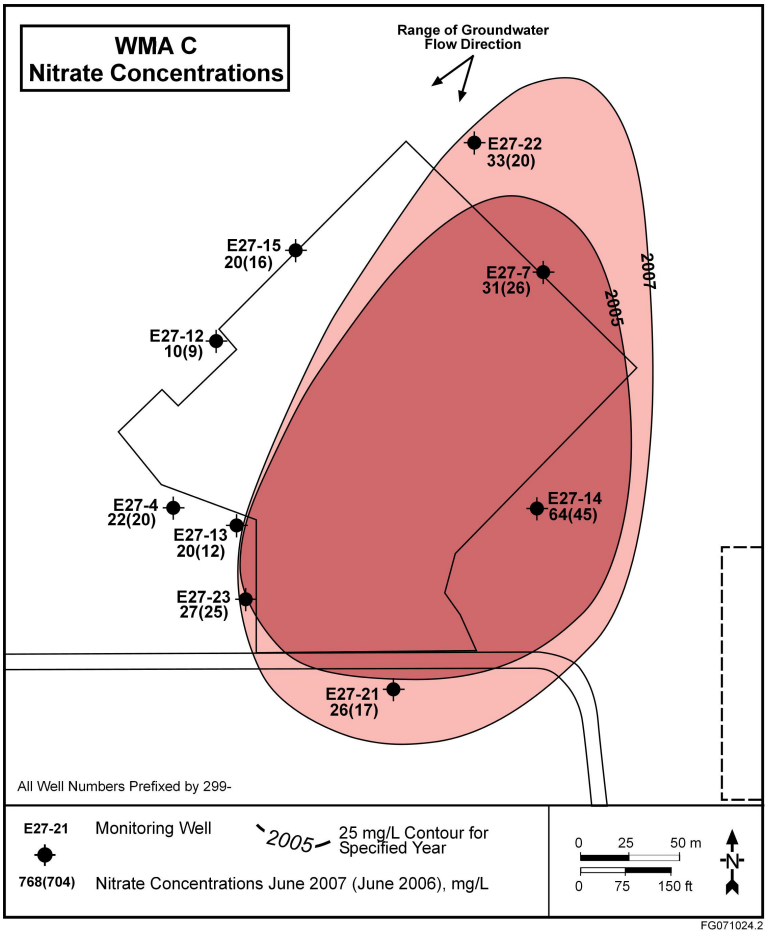


Figure 2.10-45. Nitrate Plume Migration at Waste Management Area C, June 2005 and June 2007

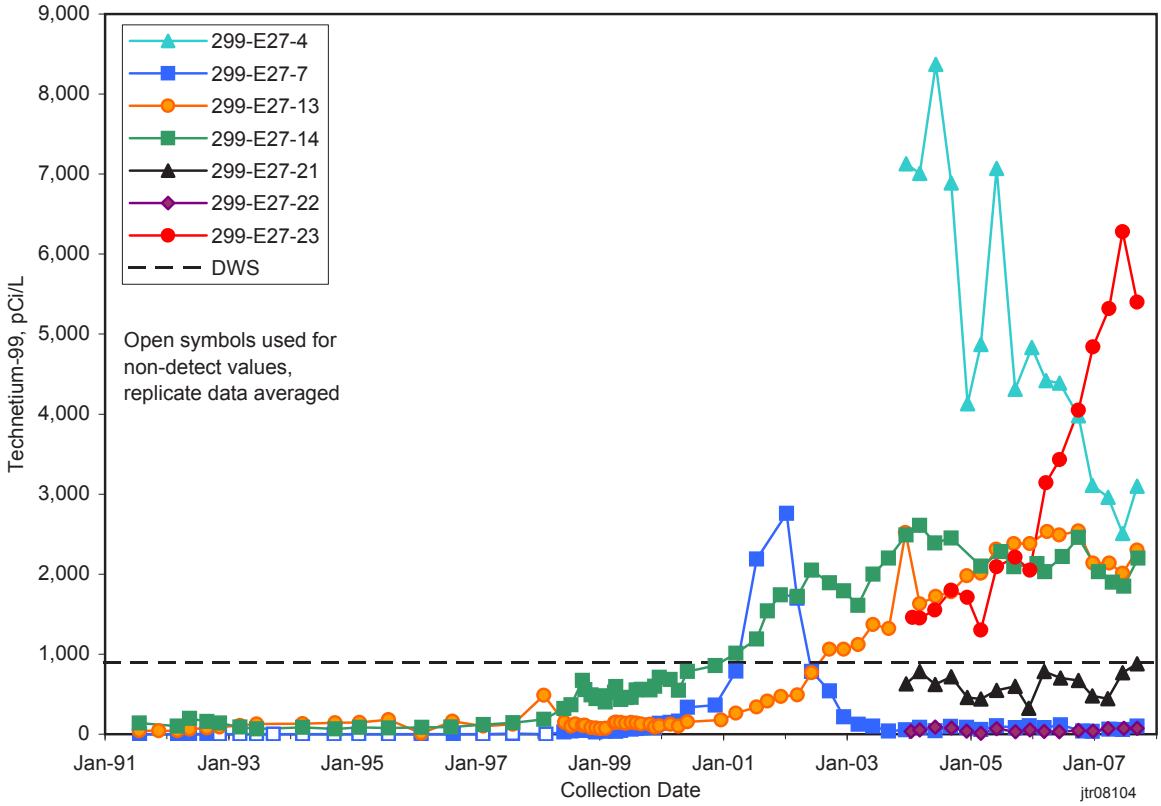


Figure 2.10-46. Technetium-99 Concentrations in Wells at Waste Management Area C

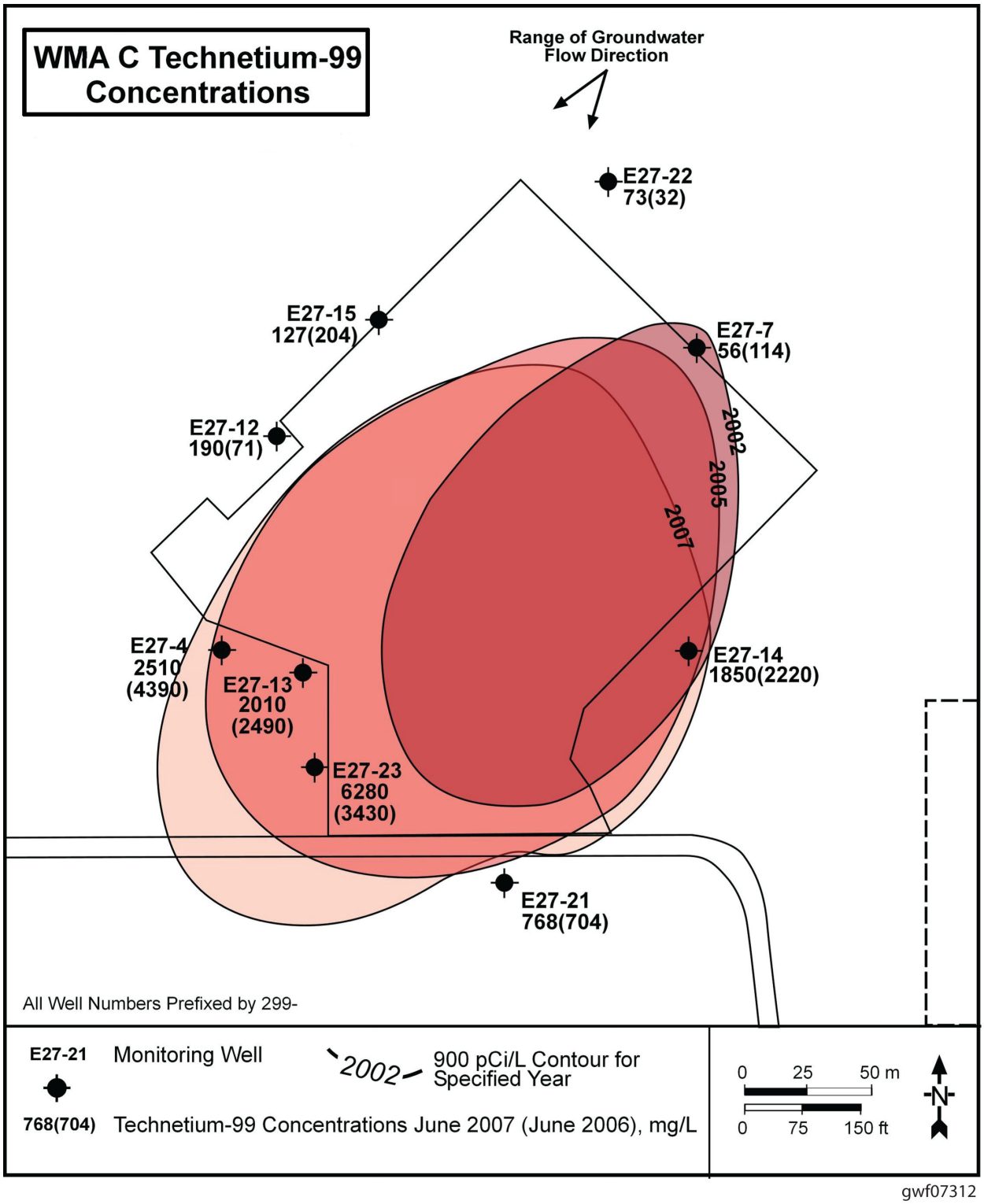


Figure 2.10-47. Technetium-99 Plume Migration at Waste Management Area C, June 2002, June 2005 and June 2007

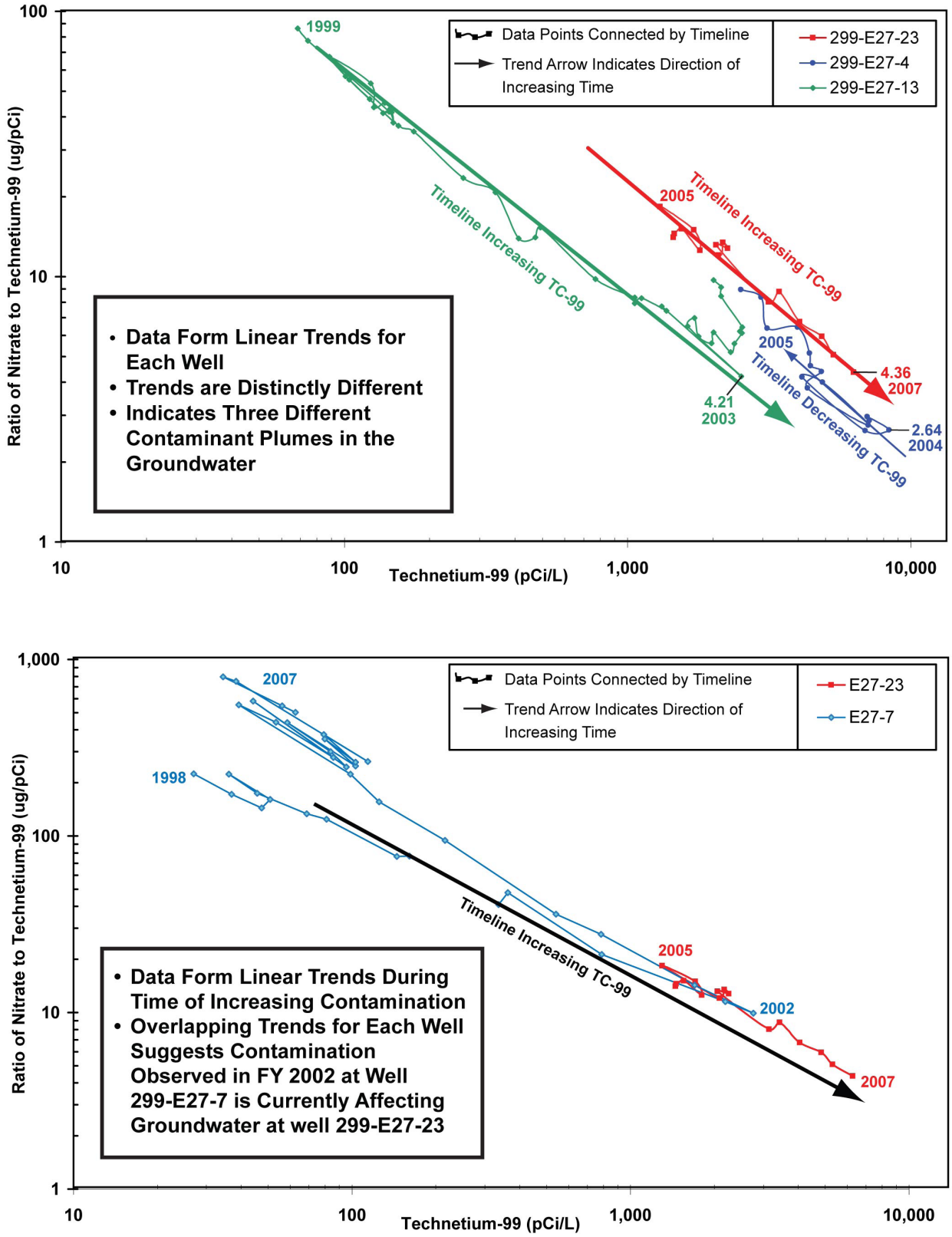


Figure 2.10-48. Ratios of Nitrate to Technetium-99 at Waste Management Area C

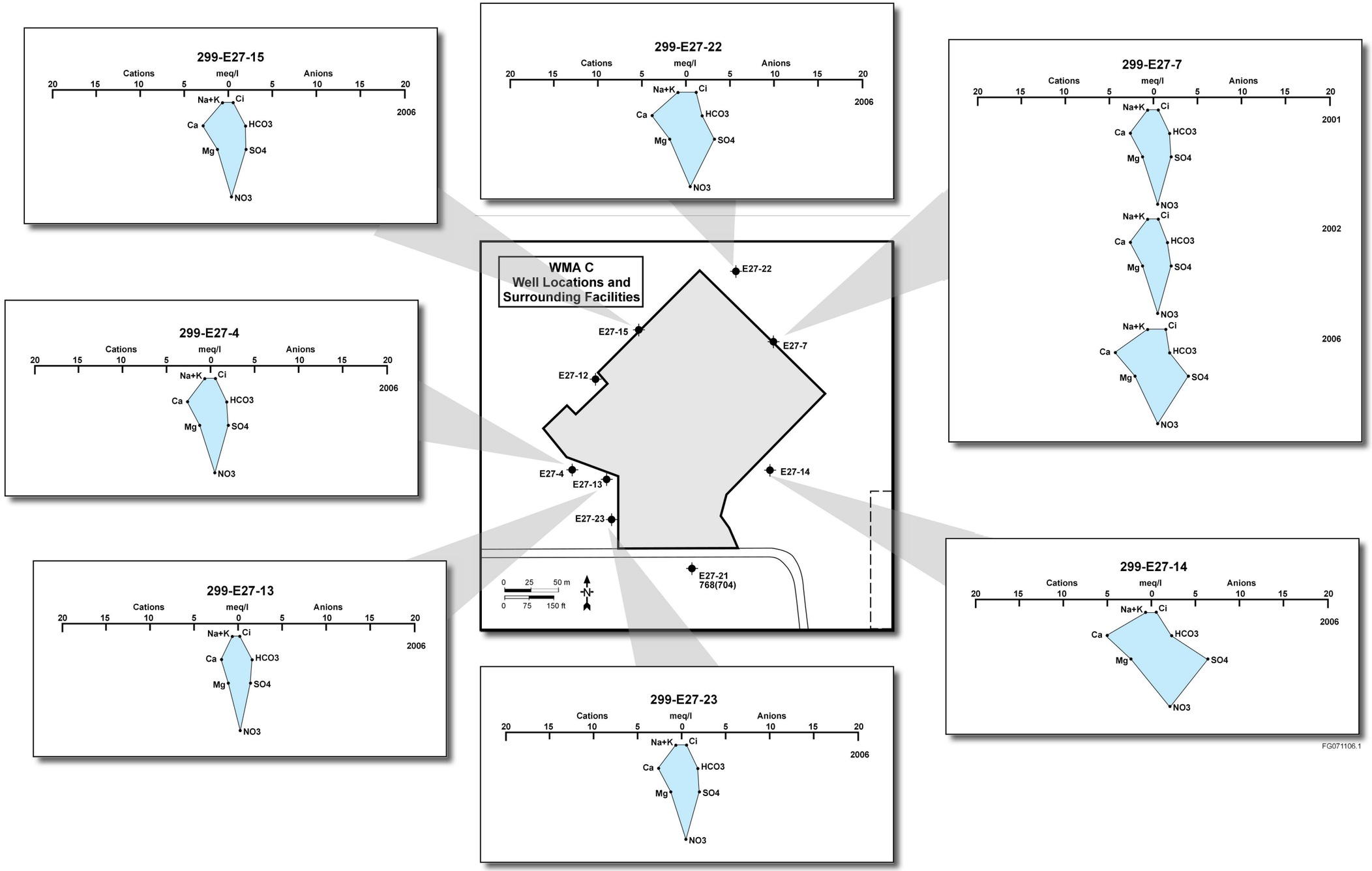


Figure 2.10-49. Stiff Diagrams Mapped to Show Total Ion Chemistry in the Groundwater at Waste Management Area C

2.11 200-PO-1 Operable Unit

J. W. Lindberg, D. B. Barnett, D. B. Erb, D. G. Horton, and S. M. Narbutovskih

The scope of this section is the 200-PO-1 groundwater interest area, which includes the 200-PO-1 Operable Unit (see Figure 1.0-1 in Section 1.0). The "groundwater interest areas" are informal designations to facilitate scheduling, data review, and interpretation. This area encompasses the south portion of the 200 East Area and a large triangle-shaped portion of the Hanford Site extending to the Hanford town site to the east and to the 300-FF-5 groundwater interest area to the southeast. The 216-B-3 pond (B Pond) straddles two operable units but is considered part of the 200-PO-1 interest area. The BC cribs and trenches are completely outside of the 200-PO-1 Operable Unit, but potential groundwater contamination there is discussed in this section to ensure potential groundwater impact from these cribs and trenches is not overlooked. The location of local facilities and wells used in near-field monitoring of the southern 200 East Area are shown in Figure 2.11-1. The locations of wells used in the remainder of the 200-PO-1 Operable Unit far-field area and shoreline monitoring sites within the 600 Area are provided in Figures 2.1-1 and 2.11-2.

Tritium, nitrate, and iodine-129 are the contaminants of greatest significance in this operable unit.

Groundwater monitoring in the 200-PO-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring (Appendix A)

- ***One-hundred twenty-two wells and six aquifer sampling tube sites (along the Columbia River) are sampled annually to triennially.***
- ***One new well was installed in FY 2007.***
- ***Two wells could not be sampled and three were delayed until October 2007; two aquifer tube sites could not be found.***

Facility Monitoring (Appendix B)

- ***Seven wells are sampled semiannually at the Integrated Disposal Facility.***
- ***Eleven near-field wells are sampled quarterly to semiannually at the RCRA PUREX cribs. Far-field wells are co-sampled with the 200-PO-1 Operable Unit. One well was delayed until October 2007.***
- ***Eight wells at the single-shell tank Waste Management Area A-AX are monitored quarterly.***
- ***Nine wells are sampled semiannually at the 216-A-29 ditch.***
- ***Four wells are sampled semiannually at the 216-B-3 pond (B Pond).***
- ***Three wells are sampled quarterly at the 200 Area Treated Effluent Disposal Facility under a Washington State waste discharge permit (WAC 173-216).***
- ***Nine wells are sampled semiannually at the Nonradioactive Dangerous Waste Landfill for RCRA monitoring.***
- ***Nine wells are sampled quarterly at the 600 Area Central Landfill under a Washington State permit (WAC 173-304).***
- ***Three water supply wells at the 400 Area are sampled quarterly to annually for AEA.***

Tritium, nitrate, and iodine-129 are the contaminants with the largest groundwater plumes. Other contaminants of concern in more localized areas include strontium-90 and technetium-99. Contaminants of potential concern include arsenic, chromium, manganese, vanadium, cobalt-60, cyanide, and uranium.

The primary monitoring objective is to meet the groundwater monitoring requirements for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), *Resource Conservation and Recovery Act* (RCRA), Washington Administrative Code (WAC), and *Atomic Energy Act* (AEA) as directed in U.S. Department of Energy (DOE) Orders. The goal for the 200-PO-1 Operable Unit is to monitor the contaminants of concern (and potential concern) until final clean-up decisions are made. Included within the operable unit are six RCRA units including the Plutonium-Uranium Extraction (PUREX) cribs (called the RCRA PUREX cribs), Waste Management Area A-AX (single-shell tanks), 216-A-29 ditch, Integrated Disposal Facility, B Pond, and the Nonradioactive Dangerous Waste Landfill. Two other facilities that are not regulated under RCRA but are subject to WAC requirements are the 200 Area Treated Effluent Disposal Facility and the 600 Area Central Landfill (formerly called the 600 Area Central Landfill). Water supply wells in the 400 Area are monitored primarily for tritium under AEA.

Groundwater in the 200-PO-1 Operable Unit generally flows to the southeast and east.

Groundwater in the unconfined aquifer generally flows southeastward in the west portion of the operable unit and northeastward, eastward, and southeastward in the east portions of the operable unit as groundwater approaches the Columbia River (see Figure 2.1-2 in Section 2.1). A detailed discussion of 200 East Area hydrogeology can be found in PNNL-12261. Further discussion of more local groundwater flow characteristics are found in Section 2.11.3.

The remainder of this section describes contaminant plumes and concentration trends for the contaminants of concern under CERCLA, RCRA, AEA, and WAC monitoring.

2.11.1 Groundwater Contaminants

This section describes the major contaminants of concern within the 200-PO-1 Operable Unit including tritium, iodine-129, nitrate, strontium-90, technetium-99, and other contaminants of potential concern. Greater details at various RCRA or WAC facilities are discussed in Section 2.11.3.

2.11.1.1 Tritium

Concentrations of tritium continue to decline in the far-field area as the plume is attenuating naturally.

The principal source for the large tritium plume that extends from the southeast portion of the 200 East Area to the Columbia River (Figure 2.11-3 and Figure 1.0-2 in Section 1.0) is in the vicinity of the PUREX cribs.[(a)] The highest concentrations of tritium (drinking water standard 20,000 pCi/L) in this plume remain near these cribs (Figure 2.11-4). The highest reported level of tritium during fiscal year (FY) 2007 was 570,000 pCi/L for a sample collected April 2007 at well 299-E17-14 near the 216-A-36B crib.

Concentrations of tritium generally continue to decline in the far-field area as the plume attenuates naturally due to radioactive decay and dispersion combined with

(a) The term "PUREX cribs" refers to all the cribs in the southeast part of the 200 East Area and east of the 200 East Area where PUREX wastewater was discharged. Three of these cribs are monitored under RCRA and are termed RCRA PUREX cribs (see Section 2.11.3.2).

the generally decreasing source that resulted from the termination of PUREX Plant operations.[b] Wells in the east portion of the 200-PO-1 Operable Unit have tritium concentrations above 80,000 pCi/L (Figure 2.11-3) from an early period of discharge to the PUREX cribs (PNNL-11141). The area of the tritium plume with concentrations above 80,000 pCi/L in the eastern portion of the Hanford Site is ~18 square kilometers. Ten years ago this portion of the plume was over ~60 square kilometers. The wells within this portion of the plume are expected to continue to experience decreasing concentrations as portions of the plume with higher concentrations (representing the two periods of PUREX Plant operations) move beyond the wells into the river or decay and disperse. Modeling suggested that groundwater at this location will continue to be contaminated with tritium at levels greater than the drinking water standard for 40 to 50 years (PNNL-11801). These wells more distant from the source are sampled once every three years, and most were sampled during FY 2007. Wells in the south of the 200-PO-1 Operable Unit, immediately north of the 300 Area, also have decreasing tritium concentrations indicating that the southward migration of the plume has slowed or stopped because of the effects of dispersion and radioactive decay (see more about tritium near the 300 Area in Section 2.12.1.3).

Wells in the near-field area closer to the source of the tritium groundwater contamination have higher tritium concentrations than wells in the far-field area and show steady to rising trends (Figure 2.11-5). Well 299-E17-14 near the 216-A-36B crib had a decreasing trend until 2005 when it began to rise. Well 299-E24-16 near the 216-A-10 crib had a decreasing trend until 2002 when it began rising again. Tritium concentrations at well 299-E25-19 near the 216-A-37-1 crib have been relatively stable since approximately 1998. It is possible that the vadose zone near the 216-A-10 and 216-A-36B cribs is still contributing tritium to the unconfined aquifer. However, a more likely reason for the changing tritium concentrations in these near-field wells is changing groundwater flow directions after the cessation of waste water discharges at B Pond. Determining a precise groundwater flow direction in the vicinity of the PUREX cribs is not possible at this time due to the extremely flat water table there. Plans have been made to refine the regional water table map during FY 2008 in the southeast portion of the 200 East Area to more precisely map water table contours at a smaller contour interval, and in turn, provide a better indication of groundwater flow direction and flow rate (see Section 2.11.2 for more information on the plans to refine the water table map in the vicinity of the PUREX cribs).

Wells in the near-field area show steady to rising tritium trends.

The zone of lower tritium concentration near Energy Northwest (Figure 2.11-3) is suspected to be due to the effect of a zone of lower hydraulic conductivity in the unconfined aquifer where the water table is within the upper portion of the Ringold Formation that locally may have a greater degree of cementation. Tritium at the 618-11 burial grounds located just west of Energy Northwest is discussed in Section 2.12.1.3.

The 200-PO-1 Operable Unit wells screened below the upper parts of the unconfined aquifer (in the middle portions or lower portions of the unconfined aquifer) or deeper in confined aquifers generally show very little groundwater contamination with tritium. Tritium was not detected in wells at the 200 Area Treated Effluent Disposal Facility during FY 2007. The wells there are screened at the first occurrence

(b) There were two periods of PUREX Plant operation, i.e., 1956 to 1972 and 1983 to 1988.

of groundwater below the Ringold Formation lower mud unit where the aquifer is locally confined (i.e., potentiometric surface is within the lower mud unit). Well 499-S1-8J (a water-supply well in the 400 Area) is screened in the lower portion of the Ringold Formation (but not confined) and had tritium levels during FY 2007 that ranged from 2,100 to 2,510 pCi/L. The nearby well 499-S0-7, screened at the water table, had tritium values that ranged from 9,200 to 11,000 pCi/L during FY 2007. Tritium was not detected in the Laser Interferometer Gravitational Wave Observatory (LIGO) well (699-S2-34B), which is screened in a basalt-confined aquifer, in a sample taken during January 2007. Similarly, five other deep 200-PO-1 wells screened in basalt aquifers (and sampled triennially) showed no detectable tritium during FY 2006, the last time they were sampled.

The iodine-129 plume is dispersing, but at a very slow rate.

2.11.1.2 Iodine-129

The iodine-129 plume (Figures 1.0-4 in Section 1.0 and Figure 2.11-6) extends southeast into the 600 Area from the 200 East Area and appears to coincide with the tritium and nitrate plume (see Figures 1.0-2 and 1.0-3 in Section 1.0 and Figure 2.11-3). The iodine-129 plume is dispersing at a very slow rate. During FY 2007, the highest concentrations of the iodine-129 plume were near the sources of the plume, i.e., the PUREX cribs, where concentrations ranged from below the analysis method detection limit to 8.18 pCi/L in well 299-E17-14 (near the 216-A-36B crib) (Figure 2.11-6). The generally decreasing trend for iodine-129 at well 299-E17-14 (Figure 2.11-7) is typical of the gradually decreasing trend for iodine-129 in the vicinity of the PUREX cribs. Iodine-129 was not detected during FY 2007 in the few wells that sample deeper in the unconfined aquifer or during FY 2006 in wells screened in confined aquifers.

Historically, samples containing significant concentrations of technetium-99 required pretreatment to remove technetium-99 prior to iodine-129 analysis (see Section C.6.1 of PNNL-15070). Despite this practice, some nondetect values were greater than the drinking water standard (>1 pCi/L). During FY 2007, the analytical laboratory has changed their procedures to help alleviate this problem thereby generally reducing the minimum detectable activity to levels <1 pCi/L. This problem is discussed in greater detail in Section 1.8.

Plume areas (square kilometers) at the 200-PO-1 Operable Unit:

Iodine-129, 1 pCi/L — 53.8
Nitrate, 45 mg/L —0.66
Strontium-90, 8 pCi/L — 0.01
Technetium-99, 900 pCi/L — <0.01
Tritium, 20,000 pCi/L — 117.6
Tritium, 80,000 pCi/L — 17.8

2.11.1.3 Nitrate

The extent of the nitrate plume that originated in the 200 East Area (Figure 2.11-8 and Figure 1.0-3 in Section 1.0) is nearly identical to the tritium plume. However, the area with nitrate concentration above the drinking water standard (45 mg/L) is more restricted than the area with tritium above its drinking water standard (20,000 pCi/L). Nitrate at levels above the drinking water standard north of the 400 Area and at Energy Northwest, within the area impacted by the PUREX cribs, can be attributed to waste water disposal activities in those areas. The highest reported concentration of nitrate during FY 2007 within the 200-PO-1 interest area was at well 299-E17-14 (Figure 2.11-9) with a reported value of 154 mg/L in January 2007. The overall nitrate plume (Figure 2.11-8) appears to have receded slightly over previous years throughout most of its extent except for the southern-most portions of the plume near the 300 Area (see Figure 2.12-20 in Section 2.12) and in the immediate vicinity of the PUREX cribs (PNNL-16346; PNNL-15670) and Waste Management Area A-AX.

Wells near the PUREX cribs in the southeast portion of the 200 East Area continued to show stable or increasing nitrate trends during FY 2007. The trend at well 299-E24-16 near the 216-A-10 crib is typical of the increasing trend (Figure 2.11-10). The increase in nitrate concentration was also observed at a few wells near Waste Management Area A-AX (see Section 2.11.3.3). This increase in nitrate at some of the wells in the southeast portion of the 200 East Area most likely is due to changing groundwater flow conditions related to the cessation of wastewater discharges at B Pond. These increasing concentrations would be consistent with a reversal of nitrate-contaminated groundwater that moved northwestward in the PUREX cribs area during the active life of B Pond.

Nitrate was detected in wells that are deeper in the Ringold Formation unconfined aquifer or lower confined aquifer. However, none of the deeper wells had reported nitrate concentrations exceeding the drinking water standard (45 mg/L). At the Nonradioactive Dangerous Waste Landfill, nitrate concentrations were as high as 19.4 mg/L in well 699-26-35C, which is a well screened at the top of the low permeability unit (bottom of the unconfined aquifer there) in the Ringold Formation. Beneath the Ringold Formation lower mud unit at B Pond and the 200 Area Treated Effluent Disposal Facility (the uppermost aquifer there), nitrate concentrations continue to be lower (below 6.9 mg/L). In the lower portions of the unconfined aquifer beneath the 216-A-29 ditch (well 299-E25-28), the nitrate concentration was 1.7 mg/L. In the water supply well 499-S1-8J in the 400 Area, which is screened in the lower portion of the Ringold Formation, the nitrate level was 0.41 mg/L, which is near the method detection level. Nitrate remains undetected in the Laser Interferometer Gravitational Wave Observatory well (699-S2-34B) and in three other wells screened in the lower basalt aquifers beneath the 200-PO-1 interest area.

The strontium-90 plume near the 216-A-36 crib is very localized.

2.11.1.4 Strontium-90

A localized area of strontium-90 (a beta-emitter) contamination exists near the 216-A-36B crib (a PUREX crib). Well 299-E17-14 was the only well with strontium-90 concentrations above the 8-pCi/L drinking water standard during FY 2007, with a maximum of 19.2 pCi/L. The trend for strontium-90 in well 299-E17-14 shows an increasing trend from 1997 to 2001, and then a fluctuating trend that overall is neither increasing nor decreasing (Figure 2.11-11). The impact is localized because of the low mobility of strontium-90 compared to tritium, iodine-129, and nitrate.

2.11.1.5 Technetium-99

Technetium-99 (a beta-emitter) continues to be detected at Waste Management Area A-AX at levels far above the drinking water standard (900 pCi/L) and was detected indirectly (from gross beta measurements) at the PUREX cribs. Although most wells at Waste Management Area A-AX had technetium-99 levels below the drinking water standard, groundwater samples from well 299-E25-93 had technetium-99 concentrations ranging 3,500 to 7,930 pCi/L during FY 2007. The trend for technetium-99 in this well is decreasing (Figure 2.11-12). For more information about technetium-99 at Waste Management Area A-AX, refer to Section 2.11.3.3.

One well at Waste Management Area A-AX had technetium-99 levels ranging from 3,500 to 7,930 pCi/L during FY 2007, which is a decrease from FY 2006.

2.11.1.6 Other Constituents

Other constituents such as filtered arsenic, chromium, manganese, and vanadium are also contaminants of concern or potential concern at various facilities within the 200-PO-1 Operable Unit (DOE/RL-2003-04, Rev. 0). Chromium, cobalt-60, cyanide, and uranium are contaminants of potential concern at the BC cribs and trenches.

Filtered arsenic was detected at nearly every well analyzed, in concentrations ranging from 10.1 µg/L to the analysis detection level at 2 µg/L during FY 2007. However, these concentrations are not significantly different from Hanford groundwater background values (DOE/RL-96-61).

A plume of chromium entering the 200 East Area from the southwest may be causing increased dissolved chromium levels in the southwestern portion of the 200 East Area and BC cribs.

During FY 2007, the highest filtered chromium concentration in the 200-PO-1 Operable Unit was 42.1 µg/L at well 299-E25-37 near the 216-A-29 ditch, and nearly that elevated (41.6 µg/L) in well 299-E13-14 at the BC cribs. (The drinking water standard is 100 µg/L.) The result of 42.1 µg/L in well 299-E25-37 is higher than the historical trend for this well and is under further review. Chromium concentrations in wells at the BC cribs area and southwest 200 Area may be influenced by a plume of chromium entering the area from the west or southwest (see Section 2.9.1.7 and this report summary). The trend for filtered chromium at this well has been relatively stable since 2000.

Two wells in the 200-PO-1 Operable Unit had manganese concentrations that exceeded the 50-µg/L secondary drinking water standard during FY 2007. The highest concentration reported was from the Q-piezometer installed in well 299-E25-29 (that is screened in the lower portion of the unconfined aquifer near the 216-A-37-1 crib). The only result for a sample collected in that piezometer had a April 2007 result of 97 µg/L. Well 299-E25-20, which is also located near the 216-A-37-1 crib had an April 2007 result of 51.9 µg/L. The source of the manganese is unknown. It may be related to waste water discharges to the 216-A-37-1 crib or possibly to the deterioration of the well screen or casing. The trend for manganese in the nearby well 299-E25-19 shows elevated, but stable manganese levels since approximately 1998 (Figure 2.11-13).

Vanadium concentrations ranged in the 200-PO-1 Operable Unit from 8 µg/L at well 299-E18-1 (west of the Integrated Disposal Facility) to 47.2 µg/L at well 299-E25-22 near the Waste Management Area A A-AX and 45 µg/L at well 299-E25-41 near the 216-A-37-2 crib. In wells having enough values to establish trends, the trends appear to be stable to declining slightly. There is no drinking water standard for vanadium.

Contaminants of potential concern at the BC cribs and trenches were either not detected or were similar to background concentrations during FY 2007.

Groundwater monitoring results at the BC cribs and trenches for FY 2007 showed that the contaminants of potential concern (chromium, cobalt-60, cyanide, and uranium, as well as the other 200-PO-1 Operable Unit contaminants of concern) were either not detected or were similar to background concentrations. The only exception was chromium at well 299-E13-14 with results of 42 and 38 µg/L for samples collected in April 2007. Elevated chromium concentrations in the BC cribs area may be due to the chromium plume flowing into the area from the west or southwest (see previous chromium discussed in this section).

Although fluoride (4-mg/L drinking water standard) is not a contaminant of concern in the 200-PO-1 Operable Unit, it was reported at a concentration of 7.7 mg/L in well 699-S2-34B (the LIGO well – at the Laser Interferometer Gravitational-Wave Observatory, located in the south-central Hanford Site). This deep well is screened in a basalt-confined aquifer that is known to have elevated concentrations of fluoride. Since the well was first sampled in 2001, fluoride results ranged from 5.8 to 8.5 mg/L.

In recent years uranium has been increasing in concentration in the PUREX cribs area. The highest concentration during FY 2007 was reported in the new well (299-E24-23 installed at the 216-A-4 crib) with a result of 79.5 µg/L. The nearby

well 299-E25-36 had a reported value of 75.3 µg/L for a sample collected April 2007. Although groundwater samples from these wells do not have enough historical results to establish a trend, the nearby well 299-E17-14 at the 216-A-36B crib, having uranium results since January 2005, shows a rising trend for uranium until 2006, and then stable since then (Figure 2.11-14).

In recent years uranium has been increasing in concentration in the PUREX cribs area.

2.11.2 Operable Unit Activities

The 200-PO-1 Operable Unit contains a large portion of the Hanford Site (Figure 1.0-1 in Section 1.0 and Figure 2.11-2). Its boundaries are generally defined by the largest contaminant plume of the operable unit – tritium. The north boundary is the line separating the 200-BP-5 Operable Unit with the 200-PO-1 Operable Unit in the 200 East Area and the 2,000-pCi/L tritium isopleth line that extends eastward to the Columbia River. The west or southwest boundary is the 2,000-pCi/L tritium isopleth line. The south boundary coincides with the north boundary of the 300-FF-5 Operable Unit, and east boundary is the Columbia River. The BC cribs and trenches, located south of the 200 East Area (Figures 2.11-1 and 2.11-2), are outside the 200-PO-1 Operable Unit boundary, but wells there are included in the 200-PO-1 Operable Unit monitoring network because it is the closest groundwater operable unit.

2.11.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified one issue and an associated action pertaining to the 200-PO-1 Operable Unit.

- **Issue 15**. Soil resistivity measurements have detected large regions of anomalously high soil conductivity in the area south of PUREX around the 216-A-4 crib and near the BC cribs and trenches.
  - **Action 15-1**. Complete data quality objective process and sampling plan to further characterize the high soil conductivity measurements detected at the BC cribs and trenches. The action due date is December 2007.

In FY 2007, the data quality objective process was completed and the report was released (SGW-34011) (see Section 2.11.2.2). A draft work plan is in the review process and is expected to be released in early FY 2008. The characterization sampling and analysis plan (containing the plans to further characterize the high soil conductivity measurements detected near the BC cribs and trenches) is included in the work plan as an appendix.

2.11.2.2 Remedial Investigation/Feasibility Study

Groundwater monitoring at the 200-PO-1 Operable Unit supports the remedial investigation/feasibility study process for the 200-PO-1 Groundwater Operable Unit. The goal is to monitor the groundwater contaminants of concern (and potential concern) under the guidance of the operable unit groundwater sampling and analysis plan (DOE/RL-2003-04, Rev. 1 or Rev. 2 when released) and any other sampling analysis plans generated by the remedial investigation/feasibility study process that require groundwater monitoring. During FY 2007, the only active sampling and analysis plan was DOE/RL-2003-04, Rev. 1, and the results of monitoring to that plan for FY 2007 are included in this report.

During FY 2006, work began on a data quality objectives report for groundwater remediation in the 200-PO-1 Operable Unit. That data quality objectives report

A data quality objectives report for groundwater remediation in the 200-PO-1 Operable Unit was completed in FY 2007.

(SGW-34011, Rev. 0) was completed during FY 2007, and work started on a work plan for a 2-year groundwater characterization study. Concurrently, a characterization sampling and analysis plan is being prepared to implement the requirements of the work plan. Groundwater monitoring in the characterization plan supplements (and does not overlap) groundwater monitoring activities already planned in the existing groundwater sampling and analysis plan (DOE/RL-2003-04). The work plan and companion characterization sampling and analysis plan are expected to be completed in FY 2008. Upon completion, groundwater monitoring for the remedial investigation/feasibility study for the 200-PO-1 Operable Unit will be conducted under the guidance of two sampling and analysis plans, (1) the existing groundwater sampling and analysis plan (DOE/RL-2003-04, Rev. 1) and (2) the characterization sampling and analysis plan.

Included in the characterization sampling and analysis plan is an effort to refine the water table map in the southeastern 200 East Area during FY 2008. Refinement of the water-table map for this area would be helpful to determine groundwater flow directions and flow rate because the water table there has an extremely low gradient. The gradient is so low that errors in measuring the depth to water are as large as, or larger than, the differences in water-table elevations between wells. Refining the water-table map for the southeastern portion of the 200 East Area will also assist in determining groundwater flow directions at RCRA sites at the Integrated Disposal Facility (Section 2.11.3.1) and PUREX cribs (Section 2.11.3.2). The solution is to decrease the amount of measurement error in determining water-table elevations at wells. Other than measurement variation caused by barometric effects, the two potential sources of significant error are (1) the surveys that provided well locations and elevations and (2) the deviation of the wells from vertical. (Note: For an error of 0.1 meter, a 100-meter well needs to be deviated only ~2.6 degrees from vertical.) Producing a corrected water-table map of the southeastern portion of the 200 East Area and interpreting groundwater flow directions will be attempted using the following three steps:

Efforts are underway to refine the water-table map for the southeastern 200 East Area.

- Resurvey well locations using state of the art methods to reduce vertical error to no more than 2 to 3 millimeters in a 100-meter well.
- Correct the depth-to-water measurements by checking the verticality of the wells using a down-hole gyroscope with an error of less than one degree.
- Conduct a trend surface analysis of the resulting water-table map to separate local from regional variability and determine any region trends on the water table surface (Davis 2002, p. 397-414).

2.11.2.3 Results of Operable Unit Monitoring for FY 2007

Groundwater monitoring results for the 200-PO-1 Operable Unit major contaminants of concern are discussed individually in Section 2.11.1. Results for the Southeast Transect, River Transect, and river aquifer tubes are discussed in the remainder of this section.

The 200-PO-1 Operable Unit sampling and analysis plan (DOE/RL-2003-04) specifies sampling of two lines of "guard wells" annually to screen for a comprehensive list of analytes. One of these lines of guard wells (the Southeast Transect) is located southeast of the 200 East Area (Figure 2.11-2) and ensures that unexpected contaminants do not migrate out of the 200 East Area undetected. The other line (the River Transect) is located along the Columbia River (Figure 2.11-2).

Its purpose is to assess the concentration of any groundwater contamination that may reach the river. The comprehensive list of analytes for both transects includes iodine-129, tritium, anions (including nitrate), gross alpha and beta, gamma scan, metals strontium-90, and volatile organic compounds.

The only constituents exceeding drinking water standards at the southeast transect during FY 2007 were iodine-129, pH, and tritium.

At the southeast transect, barium, calcium, chloride, chromium, fluoride, gross alpha and beta, iodine-129, iron, magnesium, manganese, nitrate, potassium, sodium, strontium, sulfate, and tritium were detected in groundwater samples during FY 2007. Many of these groundwater constituents occur naturally. A few volatile organic compounds were possibly detected at well 699-26-33 located near the Nonradioactive Dangerous Waste Landfill, but these were estimated values because they were at levels very close to the analysis method detection limit (see Section 2.11.3.7 for more information about volatile organic compounds at the Nonradioactive Dangerous Waste Landfill). The only constituents exceeding drinking water standards were iodine-129 in two wells, pH in one well, and tritium in four wells. The iodine-129 and tritium exceedances were consistent with their locations within the major iodine-129 and tritium plumes coming from the 200 East Area (see Sections 2.11.1.1 and 2.11.1.2). The elevated pH was in well 699-31-31 where the pH level has been gradually rising since 1990. Although well was reconditioned to collect groundwater samples near the water table (it formerly had two piezometers), the groundwater chemistry of samples collected from this well (including the elevated pH values) appear to be typical of groundwater deeper in the aquifer.

At the River Transect, seventeen groundwater constituents were detected, most of which are typical of background values. The detected constituents include barium, calcium, chloride, chloroform, fluoride, gross alpha and beta, iron, magnesium, manganese, nitrate, pH, potassium, sodium, strontium, sulfate, and tritium. Only pH (in one well) and tritium (in two wells) exceeded drinking water standards. The two wells where tritium exceeded the 20,000 pCi/L drinking water standard (699-41-1A and 699-46-4) are located near the Hanford town site. These results are consistent with known concentrations of the site-wide tritium plume at this location (see Section 2.11.1.1). The elevated pH (9.3) at well 699-20-E12O is similar to nature of the occurrence at well 699-31-31 in the Southeast Transect. In both cases the elevated pH is associated with wells that are older, complex wells with multiple piezometers, but the origin of the elevated pH is unknown.

Tritium and pH exceeded drinking water standards at the River Transect during FY 2007.

Three of the original six aquifer tube locations (84, 85, and 86) near the Hanford town site (see Figure 2.11-2 for location of the aquifer tubes) were sampled as scheduled during FY 2007. Aquifer tubes at the other three locations were either lost or destroyed since prior sampling in FY 1997. The specific tubes sampled at the three sites were 84-D, 85-M and 86-M.[c] Detected groundwater constituents included chloride, fluoride, gross alpha and beta, nitrate, sulfate, technetium-99, and tritium. None of these detected constituents had concentrations exceeding drinking water standards. The highest tritium and nitrate concentrations were 11,000 pCi/L and 9.4 mg/L (respectively) at aquifer tube 86-M. The highest technetium-99 level was 7.1 pCi/L, in a sample collected also from aquifer tube 86-M.

Three additional wells were sampled in the 200-PO-1 Operable Unit during FY 2007 in order to take advantage of two boreholes drilled to characterize the vadose

(c) Typical sampling practice for aquifer tubes is to collect water samples at a given aquifer tube location from the tube with the highest specific conductance (which, in turn, would provide samples with the highest groundwater to river water ratio).

zone near the 216-A-2 and 216-A-4 cribs (for locations see Figure 2.11-1) within the 200-MW-1 surface operable unit and another well scheduled for decommissioning. The vadose zone exploratory borehole at the 216-A-4 crib was completed as a groundwater monitoring well (compliant with WAC 173-160) that was screened at the water table. When completed, the new well was developed and sampled. The vadose zone exploratory borehole at the 216-A-2 crib was drilled to the water table but was not completed as a well. However, a grab sample of groundwater was collected prior to backfilling the borehole. Well 299-E23-2 located in the western portion of the 200-PO-1 Operable Unit, which had not been sampled since 1987 and was scheduled for decommissioning, was sampled one last time.

A vadose zone exploratory borehole at the 216-A-4 crib was completed as a groundwater monitoring well.

Groundwater samples from all three of the additional wells sampled were analyzed for a comprehensive list of potential groundwater contaminants (44) in order to be consistent with future site characterization planned in the work plan and characterization sampling and analysis plan discussed in Section 2.11.2.1 above. Analysis results were mostly typical of what would be expected for their locations. In well 299-E23-2, the only groundwater constituent above its drinking water standard was manganese (50 µg/L maximum contaminant level) with a reported value of 90 µg/L. Elevated levels of manganese are common in older, Hanford Site wells that were constructed of carbon steel casing and do not meet WAC 173-160 construction standards. The grab sample from the borehole drilled at the 216-A-2 crib had elevated iodine-129 (6.2 pCi/L), manganese (119 µg/L), nitrate (69.5 mg/L) and tritium (601,000 pCi/L). All four constituents exceed their respective drinking water standards. Except for manganese the results are typical of other wells in the vicinity. Manganese is often elevated in boreholes or wells sampled soon after drilling. The new well at the 216-A-4 crib (299-E24-23) had elevated iodine-129 (5.2 pCi/L), nitrate (64 mg/L), tritium (420,000 pCi/L), and uranium (80 µg/L). The uranium concentration is higher than surrounding wells, but uranium has been increasing in nearby wells in recent years. A sample collected from the nearby well 299-E25-36 in April 2007 had a reported uranium concentration of 75 µg/L. Another nearby well (299-E17-14 located near the 216-A-36B crib) has a potentially rising uranium trend (Figure 2.11-14) with FY 2007 results of 25 and 27 µg/L (for more information about uranium, see Section 2.11.1.6).

The new well at the 216-A-4 crib had elevated iodine-129, nitrate, tritium, and uranium.

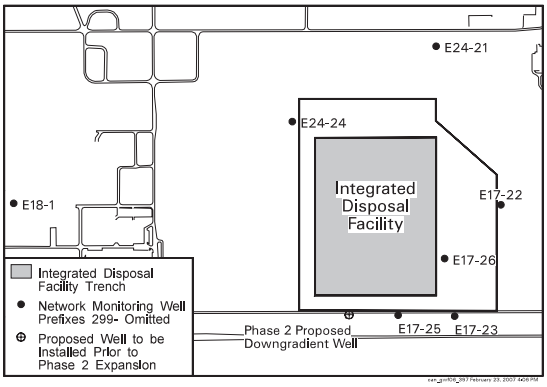
2.11.3 Facility Monitoring

This section describes results of monitoring individual facilities such as treatment, storage, or disposal units. Groundwater at some of these facilities is monitored under the requirements of RCRA for hazardous waste constituents and AEA for radionuclides including source, special nuclear, and by-product materials. Data for facility-specific monitoring are also integrated into the CERCLA groundwater investigations. Groundwater data for these facilities are available in the Hanford Environmental Information System (HEIS 1994) and on the data files accompanying this report. Additional information including well and constituent lists, maps, flow rates, and statistical tables are included in Appendix B.

The 200-PO-1 Operable Unit contains six RCRA sites, two sites regulated by the WAC, and one site regulated exclusively under AEA groundwater requirements. This section summarizes results of statistical comparisons, assessment studies, and other developments for FY 2007.

2.11.3.1 Integrated Disposal Facility

Construction of the Integrated Disposal Facility began in September 2004 and was completed in April 2006. DOE submitted a Part B RCRA permit application to the Washington State Department of Ecology (Ecology), and it was incorporated into the Hanford Facility RCRA Permit on April 9, 2006. The Integrated Disposal Facility operation is scheduled to begin in 2010.



The objective of RCRA and operational monitoring at the Integrated Disposal Facility is to determine whether the facility has impacted groundwater quality. The facility is not yet operational, and the current monitoring is directed at obtaining background values for monitored constituents. The current groundwater monitoring network consists of seven wells (Appendix B). Another well remains to be installed at a future date when required by facility expansion.

The Integrated Disposal Facility consists of an expandable, double-lined landfill with ~7 hectares of liner. The facility is located in the south-central part of 200 East Area (see Figure 2.11-1 for location of the site and Appendix B for a list of network wells, their locations, and groundwater constituents monitored). The landfill is divided lengthwise (north/south) into two distinct cells, one for the disposal of low-level radioactive waste (east cell) and the other for the disposal of mixed waste (west cell). The facility is a RCRA-compliant landfill (i.e., a double high-density polyethylene-lined trench with leachate collection and leak detection system). The constructed liner is ~442 meters wide by 160 meters in length and up to 15 meters deep. The landfill will contain four layers of waste containers separated vertically by 0.9 meter of soil. The current waste disposal capacity is ~163,000 cubic meters. The waste will be segregated into a RCRA-permitted side and a non-RCRA-permitted side.

Current monitoring at the Integrated Disposal Facility is directed at obtaining background values for monitoring constituents.

The delineation of groundwater flow directions and water-table gradients are difficult to estimate for the 200 East Area from water-level data due to a flat water table. Based on the geometry of existing contaminant plumes and on regional water-level measurements, the groundwater flow direction is estimated to be toward the east to southeast at rates between 0.002 to 0.0075 meter/day (see Appendix B).

Work planned for FY 2008 is designed to better understand the groundwater flow direction beneath the Integrated Disposal Facility. Gyroscope surveys will be completed on five of the monitoring wells (well 299-E17-26 and 299-E24-24 had gyroscope surveys completed in 2005). Also, new vertical elevation surveys will be done on all seven wells in the network. Finally, the Integrated Disposal Facility monitoring wells will be fitted with pressure transducers (to determine water level) for about one month to determine the response of each well to changes in barometric pressure. Afterward, the monitoring network will be scheduled for quarterly water level measurements. This detailed work will allow better definition of the water table in the area. (See Section 2.11.2.2 for more information on refining the regional water-table map in the southeastern portion of the 200 East Area.)

The Integrated Disposal Facility operational monitoring plan was published in 2005 (RPP-PLAN-26534). That plan called for analyses of gross alpha, gross beta, technetium-99, and iodine-129 in groundwater. Therefore, these constituents were

Groundwater monitoring at the Integrated Disposal Facility during FY 2007 included semiannual sampling (four independent sampling events each 6-month period).

added to the list of RCRA indicator parameters and supplemental groundwater quality parameters (alkalinity, anions, metals, temperature, and turbidity) for analysis. The complete sampling schedule including all constituents and sampling frequency is in Appendix B.

All groundwater monitoring wells in the Integrated Disposal Facility monitoring network initially were sampled twice quarterly for one year (June 2005 through May 2006) to determine baseline conditions. This was followed by collection of semi-annual samples (four independent sampling events each 6-month period) and semi-annual sampling continued throughout FY 2007. A RCRA permit modification is being finalized to reduce the number of independent samples from 8 per year to two per year during the pre-active life of the facility. Once the facility becomes active, groundwater monitoring will revert to the four samples per each 6-month period schedule.

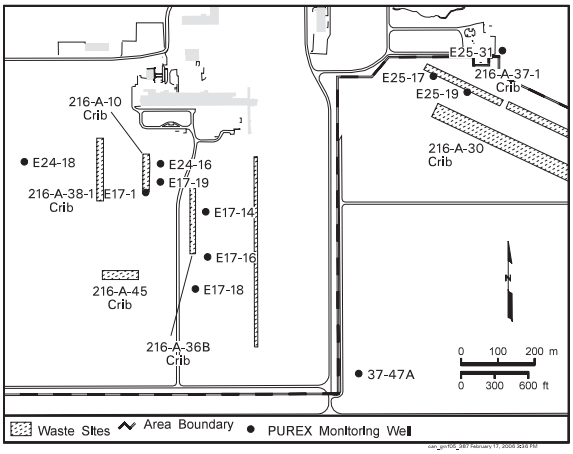
The Integrated Disposal Facility monitoring wells were sampled as scheduled in FY 2007 with the exception of most samples for AEA radionuclide analyses because of an administrative error. The laboratory has been asked to use groundwater left from other analytes to run the radionuclide analyses where possible, but results were not available at the writing of this report.

Permit condition III.11.E.1.a. requires "For the first sampling event (and only the first), samples for each well will include all constituents in 40 CFR 264 Appendix IX." The complete Appendix IX list was not obtained in July 2005 (the first year) but was analyzed in January 2007 instead. All data were received back from the laboratory by April 2007. No Appendix IX constituent had a concentration above the drinking water standard and only 79 of the 2,148 results were detectable (most of which had one or more data qualifiers).

Only iodine-129 and nitrate exceeded drinking water standards at the Integrated Disposal Facility during FY 2007.

Iodine-129 exceeded the drinking water standard (1 pCi/L) in one sample from well 299-E17-22 during FY 2007. The concentration was 1.08 pCi/L. This well is very near the edge of the regional 200 East Area iodine-129 plume, and the iodine-129 in the well most likely came from the nearby PUREX cribs.

Nitrate concentrations were routinely near or above the drinking water standard (45 mg/L) in samples from wells 299-E24-21, 299-E24-24, and 299-E17-22 during FY 2007. The highest nitrate concentration was 69.5 mg/L in well 299-E24-24. These wells are in the regional 200 East nitrate plume that is presumed to originate from the PUREX cribs east of the Integrated Disposal Facility (see Section 2.11.3.2).



2.11.3.2 RCRA PUREX Cribs

The RCRA PUREX cribs are located in the southeast part of the 200 East Area and include three cribs (216-A-10, 216-A-36B, and 216-A-37-1; Figure 2.11-1) monitored under RCRA interim status to assess groundwater quality. Other nearby cribs also received PUREX waste (e.g., 216-A-45 crib) but are not regulated as RCRA treatment, storage, or disposal units. They are monitored collectively under the 200-PO-1 Operable Unit.

The objective of RCRA monitoring at these cribs is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer per (40 CFR 265-93(d) as

referenced by WAC 173-303-400). Groundwater monitoring under AEA tracks radionuclides at the cribs and surrounding vicinity, and is reported under the 200-PO-1 Operable Unit (see Section 2.11.1). Appendix B includes a well location map and list of wells and constituents monitored for the RCRA PUREX cribs. The RCRA PUREX cribs groundwater monitoring plan is PNNL-11523.

The objective of RCRA monitoring at the PUREX cribs is to assess the nature and extent of groundwater contamination with hazardous constituents and determine their rate of movement in the aquifer.

Groundwater flow direction in the vicinity of the two west cribs (216-A-10 and 216-A-36B) is most likely toward the southeast; in the vicinity of the 216-A-37-1 crib, it is estimated to be to the south or southwest. These flow directions are supported mainly by the distribution of the tritium, nitrate, and iodine-129 plumes emanating from the vicinity of these cribs. (See Appendix B for more information on flow direction and rate and Section 2.11.2.2 for information on plans for refining the water-table map in the southeastern portion of the 200 East Area.) The RCRA PUREX cribs are located in a region where several groundwater contamination plumes contain constituents that exceed drinking water standards. The similarities in effluent constituents disposed to these cribs, as well as to the 216-A-45 crib, make determining the contribution of the RCRA PUREX cribs difficult.

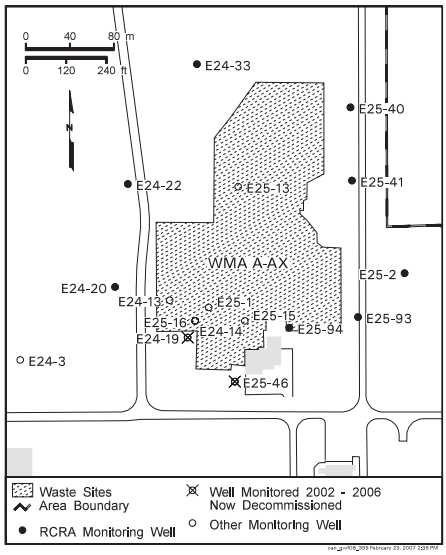
During FY 2007, all groundwater samples were collected as scheduled. Nitrate and iron were the only hazardous waste constituents exceeding drinking water standards. The nitrate drinking water standard (45 mg/L) was exceeded at seven of the 11 near-field monitoring wells during FY 2007, including the background well 299-E24-18 to the west. The highest concentration of nitrate in the RCRA PUREX cribs near-field monitoring network was 154 mg/L at well 299-E17-14 located near the 216-A-36B crib. The trend for nitrate in this well is stable to slightly increasing in concentration (Figure 2.11-10). Nitrate in downgradient wells is generally higher in concentration than in upgradient wells, which provides further evidence that the PUREX cribs are most likely the source for the large nitrate plume extending east and southeast to the Columbia River (see Section 2.11.1.3 for more information about nitrate in the 200-PO-1 Operable Unit).

The secondary drinking water standard for iron (300 µg/L) was exceeded at two wells located near the 216-A-37-1 crib during FY 2007. The highest concentration was 366 µg/L for a filtered sample collected from well 299-E25-19. This result is not consistent with historical trends at this well and is undergoing further review. The nearby well 299-E25-17 had the second to highest iron concentration with a reported value of 346 µg/L, but it was for an unfiltered sample. Elevated iron is relatively common in unfiltered groundwater samples from older Hanford Site wells (i.e., having carbon steel casings and not compliant with WAC 173-160).

None of the required groundwater quality constituents required by WAC 173-303-400 (chloride, iron, manganese, phenols, sodium, and sulfate) exceeded their respective drinking water standards during FY 2007, other than the anomalously elevated iron values in wells 299-E25-17 and 299-E25-17 (mentioned above). None of the phenols analyzed were detected. Both chloride and manganese are generally higher in concentration in downgradient wells than in upgradient wells possibly indicating a local source.

2.11.3.3 Single-Shell Tank Waste Management Area A-AX

Waste Management Area A-AX is located on the east-central border of the 200 East Area (see Figure 2.11-1) and consists of the A and AX Tank Farms, the 244-AR Vault and ancillary equipment (seven diversion boxes and waste transfer lines). The



farms contain ten 3.79-million-liter tanks constructed in 1954 and 1955. Five of the tanks in the waste management area are known or suspected to have leaked in the past. A well location map and a table of wells and analytes for this waste management area are shown in Appendix B.

Waste Management Area A-AX was placed in RCRA assessment monitoring (40 CFR 265.93(d) as referenced by WAC 173-303-400) because of elevated specific conductance in downgradient well 299-E25-93 in June 2005. The current groundwater assessment plan is PNNL-15315. The objective of RCRA groundwater monitoring at Waste Management Area A-AX is to assess if dangerous waste or dangerous waste constituents from the A and/or AX Tank Farms have compromised groundwater quality. Results from the Tank Farm Vadose Zone Project field characterization work inside the waste management area with further characterization conducted for the 200-PO-1 Operable Unit remedial investigation/feasibility study will assist in source determination of groundwater degradation at this site.

The objective of RCRA groundwater monitoring at Waste Management Area A-AX is to assess if dangerous waste or dangerous waste constituents from the A and/or AX Tank Farms have compromised groundwater quality.

The groundwater monitoring network for Waste Management Area A-AX consists of seven wells that are compliant with WAC 173-160 (RCRA-compliant) and one that is not compliant. The aquifer thickness is ~27 meters, while the saturated screened intervals range from 10.4 to 1.5 meters in RCRA-compliant wells. Based on five network wells, the average water table decline during FY 2007 was 5 centimeters, the same as FY 2006. Based on regression fits to water elevation data from 1991 to the present, replacement of older RCRA-compliant wells will not be required for over 15 years. This time estimate is valid only if the current rate of decline continues. During FY 2007, there were no changes in flow direction and only a slight increase in the estimated flow rate (see Appendix B, Table B.2). The flow direction, determined from local water levels, in situ flow measurements, and plume tracking ranges from east southeast to southeast (PNNL-14187). Independent results on flow direction reported in RPP-23740 confirm a southeast flow direction.

Potential dangerous waste constituents found beneath Waste Management Area A-AX in FY 2007 are nitrate and sulfate. Concentrations for both anions are below the drinking water standard (45 mg/L and 250 mg/L, respectively) except in one location, downgradient well 299-E25-93, where the June 2007 nitrate value was 48.7 mg/L. Technetium-99 concentrations in June 2007 were above the drinking water standard (900 pCi/L) in two wells, the upgradient well 299-E24-33 (994 pCi/L) and downgradient well 299-E25-93 (6,550 pCi/L).

Potential dangerous waste constituents found beneath Waste Management Area A-AX in FY 2007 are nitrate and sulfate.

In general, there were no significant changes in nitrate or technetium-99 during FY 2007 at Waste Management Area A-AX. Based on a time series of contaminant distributions, nitrate and technetium-99 values appear to separate into two separate plumes, one under the A Tank Farm in the south and one at the AX Tank Farm in the north (Figures 2.11-15 and 2.11-16) . For example, in Figure 2.11-15, the highest nitrate concentrations at the site were found in the south at both upgradient and downgradient wells, monitoring the A Farm. Note the migration of the nitrate high seen in upgradient well 299-E24-20 at 51 mg/L in June 2005 to the southeast at downgradient well 299-E25-93 in June 2006 where it remains through FY2007. The nitrate trends, shown in Figure 2.11-17, also illustrate the distinctively higher nitrate values around this tank farm (see trends in wells 299-E24-20, 299-E25-93

and 299-E25-94). Because the nitrate is also elevated upgradient of the site, it is likely some portion of the nitrate in the downgradient wells is from an upgradient source. In the north, the nitrate trends are relatively flat with the exception of well 299-E25-2, which increased slightly from 13.7 to 17.4 mg/L in FY 2007. This well is downgradient from well 299-E25-41, which has higher nitrate values. Well 299-E25-2 and upgradient well 299-E24-22 are distinctly lower than wells to the north or south causing the nitrate to appear as two different distributions.

When contaminant trends of technetium-99 are considered, the bifurcation into two distinct plumes is further delineated (Figure 2.11-16). In general, technetium-99 concentrations decreased for the plume around the AX Tank Farm as seen by the decreased area of the 400 pCi/L contour. In the south, technetium-99 concentrations increased only marginally in upgradient well 299-E24-20 from 57 to 77.5 pCi/L and in downgradient well 299-E25-94 from 488 to 574 pCi/L. Presently, technetium-99 is decreasing in this well from a maximum value of 642 pCi/L, reported in March 2007. The trend plots in Figure 2.11-18 illustrate the distinctly high technetium-99 concentration found in well 299-E25-93, downgradient from the A Tank Farm. Concentrations decreased from 7,740 pCi/L to 6,555 pCi/L during FY 2007. A comparison of the nitrate to technetium-99 ratio provide further evidence of two contaminant plumes with a value of 22 µg/pCi for upgradient of the AX Tank Farm (well 299-E24-33) and 7.4 µg/pCi downgradient of the A Tank Farm (well 299-E25-93).

While the high technetium-99 concentration and low nitrate to technetium-99 ratio may suggest a local source for the contamination observed at well 299-E25-93, upgradient of the AX Tank Farm, well 299-E24-33 has unique subsurface conditions. The presence of a perched water zone during drilling at 78 meters below the surface, shows that liquids migrated from the surface to depth. Also in the recent past, the sporadic data reporting coliform bacteria in the groundwater may provide further evidence that liquids have migrated from the surface to the vicinity of this well. Thus the increasing contaminant levels observed under the AX Tank Farm may have an upgradient source.

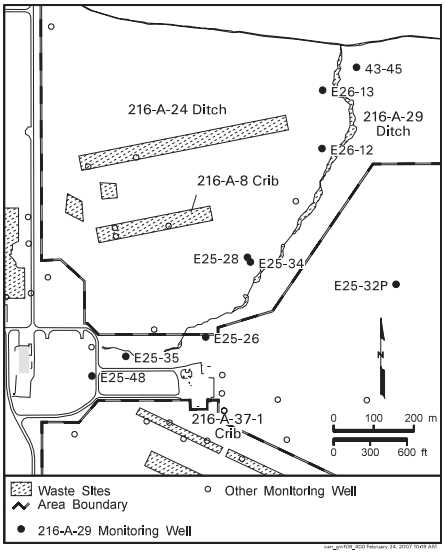
The high technetium-99 concentration and low nitrate to technetium-99 ratio may suggest a local source for the contamination observed at well 299-E25-93.

Five of the eight monitoring wells increased slightly in sulfate over the last year changing the contours shown on the time series maps from 2005 to 2007 (Figure 2.11-19). The sulfate plume appears to be broadening in the east-west direction with the 80 mg/L contour expanding to include well 299-E25-2 and the 100-mg/L contour expanding to include well 299-E25-94. Thus sulfate does not appear to have the distant two-plume pattern seen in the nitrate and technetium-99 data. This lack of upgradient/downgradient distinction may be results of regional influences on the local sulfate distribution. Alternatively, the high levels of sulfate observed in the groundwater on the southeast side of Waste Management Area C may be influencing sulfate at his site. Regardless as seen on the trends plots in Figure 2.11-20 sulfate is generally increasing albeit slowly. With regional trends displaying increasing sulfate and calcium across the northern part of the 200 East Area, separating local effects from these upgradient influences is difficult.

Over the last year, contaminant trends at Waste Management Area A-AX continue to display two distinct plumes for nitrate and technetium-99. In general, values have not changed significantly except for technetium-99 in downgradient well 299-E25-93, which decreased. The nitrate plume at the A Tank Farm, with the only occurrences above the drinking water standard (45 mg/L), appears to have an upgradient source.

Furthermore, a regional sulfate source may also be the main cause of increasing sulfate at the site. However, the locally high technetium-99 concentrations observed in the groundwater at downgradient well 299-E25-93 cannot be explained with upgradient contamination. Consequently, the locations of contaminated soils that may be the source of this groundwater contamination appear to be local. Recent field characterization work performed by the Tank Farm Vadose Zone Project along with further characterization efforts in support of the 200-PO-1 Operable Unit remediation investigation may provide results to assist in source determination for the elevated contamination at this site.

2.11.3.4 216-A-29 Ditch



The groundwater beneath the 216-A-29 ditch is monitored for evidence (detection) of hazardous waste migration as required by interim status RCRA regulations (40 CFR 265.93(b) as referenced by WAC 173-303-400). The nine wells of the groundwater monitoring network are sampled semiannually for contamination indicator parameters and annually for groundwater quality parameters and site-specific constituents (PNNL-13047; see Appendix B for list of wells, their locations, and groundwater constituents monitored). The well network is adequate for the current groundwater flow directions. Groundwater samples were collected and analyzed as scheduled at all nine wells monitoring the 216-A-29 ditch in FY 2007.

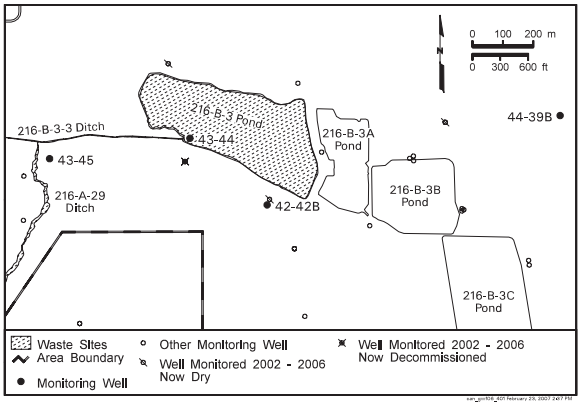
Specific conductance continues to remain above the critical mean in downgradient wells 299-E25-35, 299-E25-48, and 299-E26-13 during both semiannual sampling events (Figure 2.11-21) (see Appendix B). Sulfate, nitrate, chloride, and the major cations are also rising in these wells. Wells 299-E25-28 (deep completion) and 299-E25-34 appear to be least affected by these trends. The cause of this rise is unknown, but appears to coincide with a general, multi-year increase in ionic strength throughout much of the 200 East Area and adjacent areas (see sections on Liquid Effluent Retention Facility, 216-B-63, B Pond, Low-Level Waste Management Areas 1 and 2), and as such cannot be uniquely attributed to the 216-A-29 ditch. None of these constituents exceed drinking water standards. The remaining three contamination-indicator parameters (pH, total organic carbon, and total organic halides) were below critical means for all wells in the 216-A-29 network during FY 2007.

Specific conductance continued to remain above the critical mean in downgradient wells at the 216-A-29 ditch during FY 2007.

Based on general interpretations of the water table map in the 200 East Area (Section 2.1) the direction of groundwater flow near the 216-A-29 ditch is generally to the south or southwest. The water-table gradient in the immediate vicinity of the 216-A-29 ditch is too low to provide confidence in estimates of flow direction or rate.

2.11.3.5 216-B-3 Pond Facility (B Pond)

The original B Pond system included the main pond and three expansion ponds (Figure 2.11-1). The main pond and an adjacent portion of 216-B-3-3 ditch are regulated now under RCRA and require groundwater monitoring under 40 CFR 265.93(b) as referenced by WAC 173-303-400. These features are the regulated remnants of a more expansive system of ponds and ditches, most of which have been clean closed. The B Pond system continued in an interim status, indicator parameter evaluation program during FY 2007. The monitoring plan, including the well network, constituents of concern, sampling and analysis procedure, and a conceptual model is described by PNNL-15479.



The current network wells and hydraulic gradient configuration allows upgradient/downgradient comparisons as prescribed by RCRA and WAC procedures for interim status facilities. The groundwater monitoring well network for the B Pond system consists of a total of four wells (see Appendix B). Well 699-44-39B is located in an area currently upgradient of the B Pond with three wells (699-42-42B, 699-43-44, and 699-43-45) located at the downgradient edges of the main pond and 216-B-3-3 ditch (Figure 2.11-1). The wells are sampled semiannually for B Pond. In FY 2006, the second semiannual sampling event scheduled for July was postponed at B Pond due to extreme wildfire danger on the Hanford Site, which prevented access to off-road wells. These wells were rescheduled and sampled in November 2006, but no analytical results for that period were available in time for the FY 2006 report. Hence, in addition to the FY 2007 analytical results, the results discussed below include the November 2006 sampling event that was initially scheduled for July 2006.

During the entire period of November, 2006 through September 2007, no averaged replicate results exceeded the limits of quantitation for indicator parameters total organic halides and total organic carbon. Both pH and specific conductance were both within critical range/mean for all downgradient wells. Specific conductance remains below site-wide background (DOE/RL-96-61) in all B Pond network wells.

Nitrate, which had been rising in well 699-42-42B since 1998, continued to rise until July 2007, thereafter retreating from the historical high of 8.4 to 7 mg/L. Well 699-43-44 continued a rising trend in nitrate to a maximum of 3.8 mg/L in July 2007. Sulfate reached historic maxima in all three downgradient wells at B Pond during FY 2007, with the highest concentration of 24.8 mg/L in well 699-42-42B. Levels of both nitrate and sulfate remain below estimates of site-wide groundwater background concentrations. The cause of the low-levels for nitrate and sulfate may be the large volume of waste water discharged to B Pond, which may have caused dilution of these constituents.

During FY 2007, none of the indicator parameters exceeded their critical means at the 216-B-3 Pond Facility.

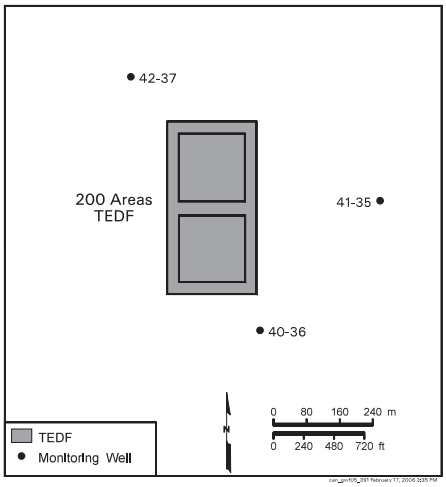
Gross beta in well 699-43-45 increased abruptly from 6.06 pCi/L in November 2006 to 15.1 pCi/L in April 2007 before retreating slightly to 11.0 pCi/L in July 2007. Upgradient well 699-44-39B is also displaying an upward trend in low levels of gross beta that began in early 2005. The maximum for this well was 10.0 pCi/L in July 2007 (Figure 2.11-22) . The reason for these small departures from historical trends is not known. However, other wells in the B Pond network, which have since gone dry or were part of the closed expansion ponds network, have also displayed brief, intermittent gross beta excursions of the same magnitude or higher. Well 699-42-40A, upgradient of B Pond, and screened just above basalt, also produced a result of 15 pCi/L in July of 2007 when it was sampled for the 200-PO-1 Operable Unit.

Based on a September 2007 gradient of 0.0016 calculated between wells 699-44-39B (upgradient well) 699-43-44, and 699-42-42B, an average hydraulic conductivity of 1.0 meter/day, and an estimated effective porosity of 0.25, the average linear flow velocity of groundwater is estimated at 0.01 meter/day (Appendix B) in a west-southwest direction.

Head measurements in vertically separated wells 699-43-41E (shallow) and 699-43-41G (deep) indicated that a downward flow potential still exists near the main

pond. The head difference between these two wells, as determined by September 8, 2007 water-level measurements, was ~0.49 meter. This translates to a downward head gradient of 0.03.

2.11.3.6 200 Area Treated Effluent Disposal Facility



The 200 Area Treated Effluent Disposal Facility is located southeast of the B Pond RCRA facility and has received effluent since June 1995. Groundwater beneath the facility is monitored under a Washington State waste discharge permit (WAC 173-216, PNNL-13032). Three wells, 699-40-36, 699-41-35 and 699-42-37, monitor groundwater beneath the facility.

Because no unconfined aquifer exists beneath the 200 Areas Treated Effluent Disposal Facility, the groundwater monitoring wells used are installed in the locally confined aquifer below the Ringold Formation lower mud unit (see also Section 2.14). Thus, these three wells are isolated from the effects of the effluent from the disposal facility by the relatively impermeable silts and clays of the Ringold Formation lower mud unit (PNNL-14098). The quarterly analytical results from these wells are used to demonstrate continuation of the isolation.

Based on hydraulic head measurements in FY 2007, and estimates of effective porosity and hydraulic conductivity, groundwater flow potential in the confined aquifer beneath the 200 Area Treated Effluent Disposal Facility is directed southwest at 0.0004 meter/day. Historically, major ionic composition and extremely low tritium concentration have suggested that groundwater in the Ringold Formation confined aquifer beneath this facility is isolated from groundwater in the adjacent unconfined aquifer, and its water quality is largely unaffected by Hanford Site operations. Results of annual low-level tritium analyses confirm this interpretation. Hydraulic head continues to decline in all three wells at the 200 Area Treated Effluent Disposal Facility as a result of the dissipating pressure effect of historical discharges at the nearby B Pond facility.

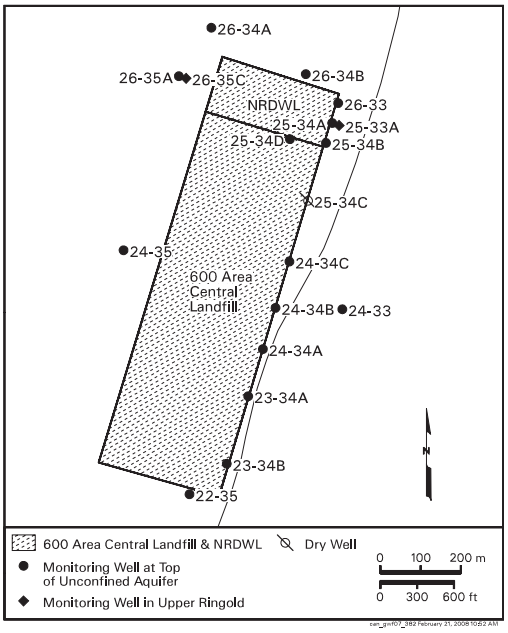
The three monitoring wells at the 200 Area Treated Effluent Disposal Facility are isolated from the effects of the effluent from the disposal facility by the relatively impermeable silts and clays of the Ringold Formation lower mud unit.

Groundwater samples are collected quarterly from wells for a list of constituents required by the state waste-discharge permit ST-4502 (Ecology 2000). Three of the constituents (cadmium, lead and pH) are compared with specific enforcement limits set by the permit (see Appendix B). All scheduled samples were collected during FY 2007, and no enforcement limits were exceeded. Most results for anions, metals and radionuclide indicators have been below Hanford Site groundwater background levels (e.g., WHC-EP-0595 and DOE/RL-96-61) since monitoring began at the site.

2.11.3.7 Nonradioactive Dangerous Waste Landfill

The Nonradioactive Dangerous Waste Landfill is located southeast of the 200 East Area (Figure 2.11-2) next to the 600 Area Central Landfill (formerly the Solid Waste Landfill). The objective of RCRA monitoring at the Nonradioactive Dangerous Waste Landfill is to determine if hazardous waste constituents from the landfill have contaminated groundwater (40 CFR 265.93(b) as referenced by WAC 173-303-400). Appendix B includes a well location map and lists of wells and constituents monitored for the landfill. Groundwater flow direction is southeast as determined from the general direction of movement of major 200 East Area plumes (see beginning of Section 2.11).

Monitoring of the Nonradioactive Dangerous Waste Landfill focuses on the RCRA interim status indicator parameters: pH, specific conductance, total organic carbon, and total organic halides (PNNL-12227; Appendix B). Volatile organic compounds are monitored because they may represent groundwater contamination originating from this landfill. Nitrate is present in groundwater and has a source in the 200 East Area (see Section 2.11.1.3). The groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate) are required analytes, but during FY 2007 were either not detected (i.e., phenols) or were reported in concentrations below their respective drinking water standards.



Wells at the Nonradioactive Dangerous Waste Landfill (Appendix B) are sampled semiannually, usually in February and August. During FY 2007, all Nonradioactive Dangerous Waste Landfill network wells were sampled as scheduled.

Three of the four indicator parameters (pH, total organic carbon, and total organic halides) did not exceed their critical means in downgradient network wells where valid upgradient/downgradient comparisons could be made. However, the critical mean for specific conductance (594 µS/cm) was exceeded at three downgradient wells during FY 2007 (699-25-34A, 699-25-34B, and 699-25-34D). Specific conductance at these three wells ranged from 594 to 624 µS/cm during FY 2007. The trend for specific conductance at these three wells increased from before 1990, but stabilized by about 2003 (Figure 2.11-23). The increase in specific conductance at the Nonradioactive Dangerous Waste Landfill is interpreted to be due to increases in the concentrations of non-hazardous constituents (e.g., calcium and magnesium) at the nearby 600 Area Central Landfill.

The critical mean for specific conductance (594 µS/cm) was exceeded at three downgradient wells during FY 2007.

When the specific conductance exceedance was first discovered in FY 2001, the DOE notified Ecology of the exceedance by letter on June 7, 2001.[(d)] An accompanying report served as both the assessment plan and assessment. The assessment plan proposed a continuing detection monitoring program at the site. Groundwater monitoring data collected at both the Non-radioactive Dangerous Waste Landfill, as well as the 600 Area Central Landfill, since 2001 (including FY 2007) continue to suggest that the increased levels of specific conductance are due to increases in non-hazardous waste constituents at the nearby 600 Area Central Landfill (see Appendix B for a reassessment of specific conductance exceedances at the Nonradioactive Dangerous Waste Landfill).

Drinking water standards of volatile organic compounds, as well as the groundwater quality parameters, were not exceeded at the Nonradioactive Dangerous Waste Landfill network wells during FY 2007.

2.11.3.8 600 Area Central Landfill

The 600 Area Central Landfill is located south of with the Nonradioactive Dangerous Waste Landfill (Figure 2.11-2). It is regulated by Ecology under WAC 173-304. WAC 173-304 constituents and site-specific constituents (including volatile organic compounds and filtered arsenic) are analyzed on groundwater samples

The 600 Area Central Landfill is regulated by Ecology under WAC 173-304 (Washington Solid Waste Regulations).

(d) Letter from JG Morse (U.S. Department of Energy, Richland, Washington) to J. Hedges (Washington State Department of Ecology), Results of Assessment at the Non-Radioactive Dangerous Waste Landfill, dated June 7 2001.

collected quarterly (PNNL-13014; Appendix B). Compliance is determined by comparing results from monitoring downgradient wells with statistically derived background threshold values from upgradient wells. Groundwater flow direction in this area is southeast as inferred from the general direction of movement of major 200 East Area plumes (see beginning of Section 2.11). The well network for the 600 Area Central Landfill includes two upgradient and seven downgradient wells and is shown in Appendix B. During FY 2007, all scheduled samples were collected at the 600 Area Central Landfill.

Disposed waste at the 600 Area Central Landfill has impacted groundwater with minor chlorinated hydrocarbon contamination.

A leachate collection system underlying one set of double trenches within the landfill has detected contamination from the landfill in past years. Arsenic and 1,4-dioxane were two constituents detected in the leachate that were not already being analyzed in groundwater samples. Therefore, they have already been added to the list of constituents analyzed in groundwater samples from the network wells. During FY 2007, ammonium ion, filtered iron, filtered manganese, filtered arsenic, filtered nickel, and 1,4-dichlorobenzene were detected in the leachate (FH-0702400). Of these detected constituents, ammonium, iron, manganese, and arsenic had concentrations that exceeded their respective groundwater quality criteria (WAC 173-200) or drinking water standards in the leachate. All of the constituents detected in the leachate collection system are analyzed in groundwater samples collected from 600 Area Central Landfill network wells. For more detail about vadose zone contamination and results of analyses in the 600 Area Central Landfill leachate collection system, see Section 3.2.

Disposed waste at the 600 Area Central Landfill has impacted groundwater with minor chlorinated hydrocarbon contamination (Table 2.11-1). The only chlorinated hydrocarbon exceeding its WAC 173-220-40 limit (0.8 µg/L) was tetrachloroethene. The highest reported tetrachloroethene result during FY 2007 was 1.5 µg/L at the downgradient well 699-24-33. In recent years, the trend for tetrachloroethene has been relatively stable to slightly decreasing in concentration at the 600 Area Central Landfill wells.

Some downgradient wells continue to show higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, sulfate, and lower pH. The lower pH apparently is a result of high concentrations of carbon dioxide in the vadose zone resulting from the degradation of sewage material disposed to the 600 Area Central Landfill (see Section 5.3 of DOE/RL-93-88; PNL-7174; WHC-SD-EN-TI-199). The elevated chemical oxygen demand, coliform bacteria, and possibly the specific conductance, may also be related to the disposed sewage material.

WAC 173-304 Parameters. Each WAC 173-304 parameter is discussed separately in the following paragraphs. See Appendix B (Table B.42) for a complete list of all results for required constituents at the 600 Area Central Landfill during FY 2007 and background threshold values. Table 2.11-1 shows concentration ranges of the chlorinated hydrocarbons during the same period. The increased amounts of detail in the discussions of individual groundwater constituents (compared to other sections of this report) is provided to meet the annual reporting requirements of the groundwater monitoring plan (PNNL-13014).

- *Ammonium* – Results for ammonium ion (background threshold value 90 µg/L) in 600 Area Central Landfill wells during FY 2007 ranged from less than the method detection limit (6.08 µg/L) to 34.3 µg/L at well 699-24-34B for a sample collected in December 2006. Ammonium ion was detected at the upgradient wells,

as well as the downgradient wells. Detections of this groundwater constituent have been sporadic in previous years at the 600 Area Central Landfill, and the sporadic occurrence continued in FY 2007.

- *Chemical Oxygen Demand* – Chemical oxygen demand (background threshold value 10 mg/L) ranged from less than the method detection limit (<10 mg/L) at both up- and downgradient wells to 285 mg/L at well 699-22-35. However, the 285 mg/L result at well 699-22-35 was outside the historical trend for the well so it is under further investigation. The next highest result was 63 mg/L at the background well 699-26-35A. Historically, chemical oxygen demand values are generally sporadic at the 600 Area Central Landfill, but have been increasing in the rate of occurrence in recent years. Elevated values of this constituent could be an indication of groundwater contaminated by sewage, which was known to be discharged to 600 Area Central Landfill trenches.
- *Chloride* – Chloride ranged in concentration from 2.9 mg/L at well 699-24-34C to 9.6 mg/L at well 699-23-34A. The background threshold value (7.8 mg/L) was exceeded six times at six different wells during the December 2006 and February 2007 sampling events. Chloride concentrations have been increasing slightly in some 600 Area Central Landfill wells for the last five to seven years, including well 699-24-35 (one of the upgradient wells).
- *Coliform Bacteria* – The background threshold value (of 1 col/100 ml groundwater) was exceeded three time at three different wells throughout FY 2007. The highest result was 345 col/100 ml at well 699-23-24A. Like chemical oxygen demand, coliform bacteria have been detected sporadically at 600 Area Central Landfill wells in past years, and the occurrences have been increasing in more recent years. Elevated values of coliform bacteria are expected with the known disposal of sewage disposed at the 600 Area Central Landfill.
- *Filtered iron* – None of the filtered iron results for FY 2007 exceeded the 160 µg/L background threshold value. The reported values ranged from less than 25 µg/L to 126 µg/L. Elevated filtered iron data are reported occasionally at the 600 Area Central Landfill in recent years but are not typical of the overall historical results.
- *Filtered manganese* – None of the filtered manganese results for FY 2007 exceeded the 11 µg/L background threshold value. Most results were less than the method detection limit (2.5 µg/L). The highest result was 6.8 µg/L at well 699-24-34C for a sample collected in May 2007.
- *Nitrate* – Nitrate results at 600 Area Central Landfill wells during FY 2007 were all less than the 29 mg/L background threshold value. The values ranged from 11.6 to 18.1 mg/L. The 600 Area Central Landfill is located on the western edge of the major nitrate plume emanating from the 200 East Area (Figure 2.11-8), and the nitrate reported in 600 Area Central Landfill wells may be mostly from the 200 East Area sources.
- *Nitrite* – Nitrite is historically not detected in 600 Area Central Landfill wells. However, February 2007 results at all of the 600 Area Central Landfill wells were elevated. Results for this sampling event ranged from 526 µg/L (at the background well 699-24-35) to 1150 µg/L at well 699-23-34A. The background threshold value was 59 µg/L. These elevated results are most likely sampling or laboratory errors and are under further review.

Downgradient wells at the 600 Area Central Landfill show elevated concentrations of chemical oxygen demand, chloride, coliform bacteria, specific conductance, sulfate, and lower pH.

Specific conductance values at all seven downgradient 600 Area Central Landfill wells exceeded the 583 µS/cm background threshold value during FY 2007.

- *Field pH* – Field pH remained within the 6.68 to7.84 background threshold range for eight of the nine 600 Area Central Landfill wells during FY 2007. However, two results at well 699-23-34A were 6.63 and 6.49 for December 2006 and September 2007, respectively. Trends of pH are relatively steady at 600 Area Central Landfill wells.
- *Specific Conductance* - Specific conductance values at all seven downgradient 600 Area Central Landfill wells exceeded the 583 µS/cm background threshold value during FY 2007. At the two background wells the values were lower. At least one result from each of the seven downgradient wells also exceeded the 700 µS/cm WAC 246-290-310 limit. The highest reported value during FY 2007 was 829 µS/cm at well 699-22-35 for a sample collected in December 2006. Specific conductance values at the 600 Area Central Landfill wells have remained relatively stable since 2001. Elevated specific conductance may be due to increased concentrations of sulfate and other anions in groundwater at the 600 Area Central Landfill.
- *Sulfate* – Reported results in downgradient wells ranged from 39.6 to 51.9 mg/L. Two of the downgradient wells (699-23-34A and 699-24-34B) had one result each that exceeded the 47.2 mg/L background threshold value. The overall trend for sulfate at 600 Area Central Landfill wells is stable to slightly increasing.
- *Temperature* – The temperature of groundwater measured at 600 Area Central Landfill wells during FY 2007 was less than the 20.7^{o} C background threshold. The range was 17.4 to 19.9^{o} C, and there was no significant difference between up- and downgradient wells.
- *Total organic carbon* – Not only were all total organic carbon results from 600 Area Central Landfill wells during FY 2007 less than the 2,700 µg/L background threshold value, all were also non-detect (<760 µg/L). In previous years, spurious values for total organic carbon have been reported in 600 Area Central Landfill wells.
- *Zinc* – Reported values for filtered zinc during FY 2007 ranged from less than the analytical method detection (9.6 µg/L) to 18.3 µg/L. The background threshold value was 43.2 µg/L.

Eight chlorinated hydrocarbons were detected in 600 Area Central Landfill network wells, including the upgradient wells, during FY 2007.

Site-Specific Parameters. Site-specific parameters at the 600 Area Central Landfill include chlorinated hydrocarbons and three waste constituents detected in the leachate collection system but were not included in the WAC 173-304 parameters list. The three constituents detected in the leachate collection system were 1,4-dioxane, filtered arsenic, and filtered nickel (FH-0702400). The detected chlorinated hydrocarbons and the three other waste constituents are discussed in the following paragraphs.

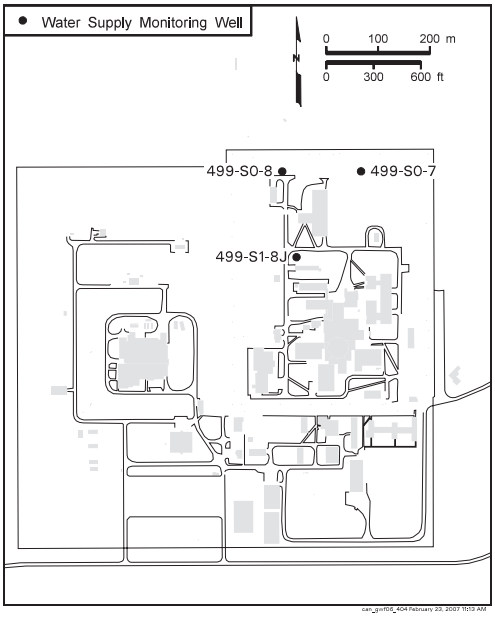
Eight chlorinated hydrocarbons were detected in 600 Area Central Landfill network wells, including the upgradient wells, during FY 2007. The concentration ranges of the detected chlorinated hydrocarbons are given in Table 2.11-1. The general trends for these detected chlorinated hydrocarbons in 600 Area Central Landfill wells are stable to decreasing. Of the chlorinated hydrocarbons detected, only tetrachloroethene exceeded its WAC 173-200 limit (0.8 µg/L). The 0.8-µg/L limit was exceeded in six wells, including the background well 699-24-35. The highest reported value was 1.5 µg/L in the downgradient well 699-24-33, where the trend for tetrachloroethene is decreasing slightly since 2001 (Figure 2.11-24). None of the chlorinated hydrocarbons exceeded federal drinking water standards in FY 2007. 1,4 Dioxane was not detected.

A potential cause of the widespread, low-level chlorinated hydrocarbon contamination at the 600 Area Central Landfill, including the upgradient wells and the adjacent Nonradioactive Dangerous Waste Landfill wells, is the dissolution of vadose zone vapors into groundwater. However, the source of the vapors is uncertain. One potential source is the chlorinated hydrocarbons dissolved in the liquid sewage of the catch tank liquid from the 1100 Area heavy equipment garage and bus shop that were disposed to the 600 Area Central Landfill (PNNL-13014).

Filtered arsenic and nickel were detected at only low concentrations during FY 2007 at the 600 Area Central Landfill. Most results for these two constituents were non-detect, and there were no differences between up- and downgradient wells. The highest concentration detected for filtered arsenic was 3.5 µg/L at well 699-24-34C. For arsenic, the federal drinking water standard is 10 µg/L, and the WAC 173-200 limit is 0.05 µg/L. The analytical method detection limit for arsenic was 2 µg/L. Filtered nickel was only detected at well 699-24-34A where the highest reported value during FY 2007 was 27.7 µg/L. The WAC 173-200 limit and federal drinking water standard for nickel are 100 µg/L, and the analytical method detection limit was 7.5 µg/L.

2.11.3.9 400 Area Water Supply Wells

Primary groundwater monitoring activities in the 400 Area involve monitoring of the 400 Area water supply wells. Monitoring is also conducted to provide information needed to describe the nature and extent of site-wide contamination (primarily tritium, nitrate, and iodine-129). This section discusses the monitoring of the 400 Area water supply wells, specifically tritium, and general aspects of groundwater chemistry in the 400 Area. The water supply wells were sampled quarterly as scheduled in FY 2007.



The Hanford Site water-table map (see Figure 2.1-2 in Section 2.1) indicates that flow in the unconfined aquifer is generally to the east-southeast across the 400 Area. The water table is located near the contact of the Ringold Formation and overlying Pleistocene cataclysmic flood deposits (informally-the Hanford formation), which is approximately 49 meters below ground surface (WHC-EP-0587). Hanford formation sediment dominates groundwater flow in the 400 Area because of its relatively high permeability compared to that of the sediments in the Ringold Formation.

Elevated levels of tritium associated with the groundwater plume originating from the vicinity of PUREX cribs in the 200 Area were identified in the 400 Area wells as in previous years (Figure 2.11-3 and Figure 1.0-2 in Section 1.0). Groundwater tritium levels are relevant to the water supply wells, which provide drinking water and emergency supply water for the 400 Area. Well 499-S1-8J serves as the main water supply well, while wells 499-S0-7 and 499-S0-8 are backup supply wells. Well 499-S1-8J has lower tritium concentrations because it is screened as a greater depth than the other two water supply wells. The tritium concentrations in wells 499-S0-7, 499-S0-8, and 499-S1-8J are compared in Figure 2.11-25 to that of the 400 Area drinking water supply. Tritium was measured at levels below the drinking water standard (20,000 pCi/L) in all three of the water supply wells in FY 2007. Tritium levels in well 499-S1-8J (the main water supply well) during FY 2007 ranged from 2,100 to 2,510 pCi/L.

Tritium was measured at levels below the drinking water standard (20,000 pCi/L) in all three of the water supply wells in FY 2007.

Tritium remained below the drinking water standard (20,000 pCi/L) and the 4-millirem/year dose equivalent in the drinking water supply, sampled at a tap, for all sampling events in FY 2007 (Figure 2.11-25). Nitrate remained below the drinking water standard in FY 2007 for the water supply wells. Data from FY 2007 and earlier from these wells indicate no other constituents are present at levels above their drinking water standards.

Table 2.11-1. Ranges of Detected Chlorinated Hydrocarbon Concentrations in 600 Area Central Landfill Wells, FY 2007

Constituent	Limit (ug/L)	699-22-35	699-23-34A	699-23-34B	699-24-33	699-24-34A	699-24-34B	699-24-34C	699-24-35	699-26-35A
1,1,1-Trichloroethane	WAC 200	0.99-1.2	0.98-1.3	1.0-1.4	0.78-0.96	0.84-1.0	0.89-1.0	0.72-0.93	0.85-1.0	0.61-0.78
1,1-Dichloroethane	WAC 1.0	0.42-0.45	0.42-0.5	0.35-0.51	0.32-0.4	0.27-0.33	0.32-0.36	0.21-0.3	0.19-0.21	<0.046
1,1-Dichloroethene	MCL 7.0	<0.045-0.17	<0.21	<0.21	<0.045	<0.21	<0.21	<0.21	<0.045	<0.045
1,4-Dichlorobenzene	WAC 4.0	<0.2	0.047-0.12	<0.2	<0.047	<0.2	<0.2	<0.2	<0.2	<0.047
Carbon Tetrachloride	WAC 0.3	<0.039-0.27	<0.15	<0.039-0.22	<0.039	<0.039-0.2	<0.039-0.27	<0.15	<0.1	<0.039
Chloroform	WAC 7.0	0.31-0.39	<0.1-0.24	0.21-0.36	<0.048	<0.19	<0.19	<0.19	<0.1	0.13-0.15
Tetrachloroethene	WAC 0.8	0.17-0.68	0.43-**1.1**	<0.17-0.65	**1.2-1.5**	0.41-**1.0**	0.71-**1.3**	0.52-**1.4**	0.23-**0.94**	0.31-0.62
Trichloroethene	WAC 3.0	0.37-0.46	<0.1-0.51	0.31-0.41	0.64-0.79	0.46-0.57	0.56-0.69	0.57-0.71	0.35-0.42	0.36-0.4

Values in **BOLD** exceed limits of WAC 173-200-40.
MCL = Maximum contaminant level (federal drinking water standard).
WAC = Washington Administrative Code (WAC 173-200-40).

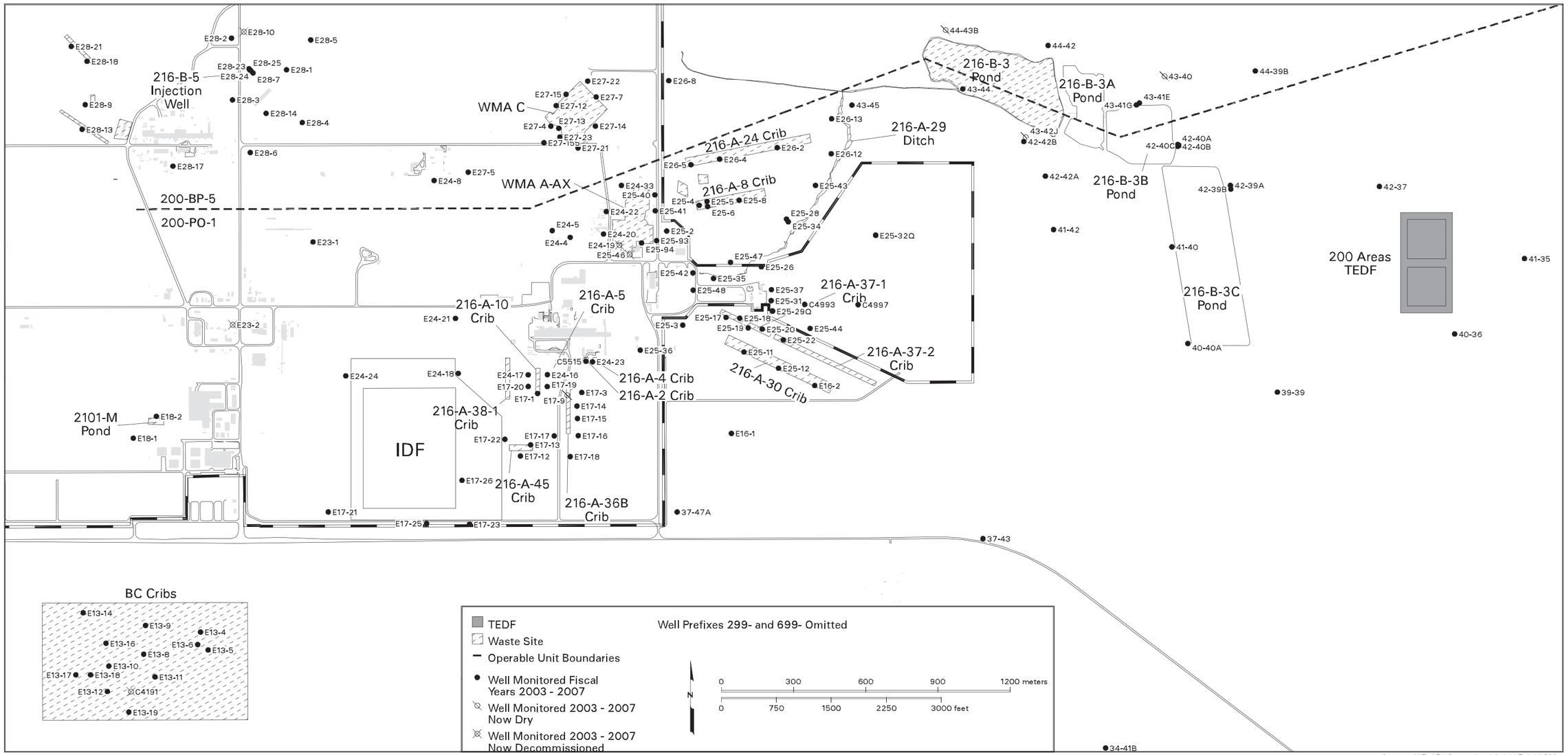


Figure 2.11-1. Facilities and Groundwater Monitoring Wells in North Portion of 200-PO-1 Operable Unit

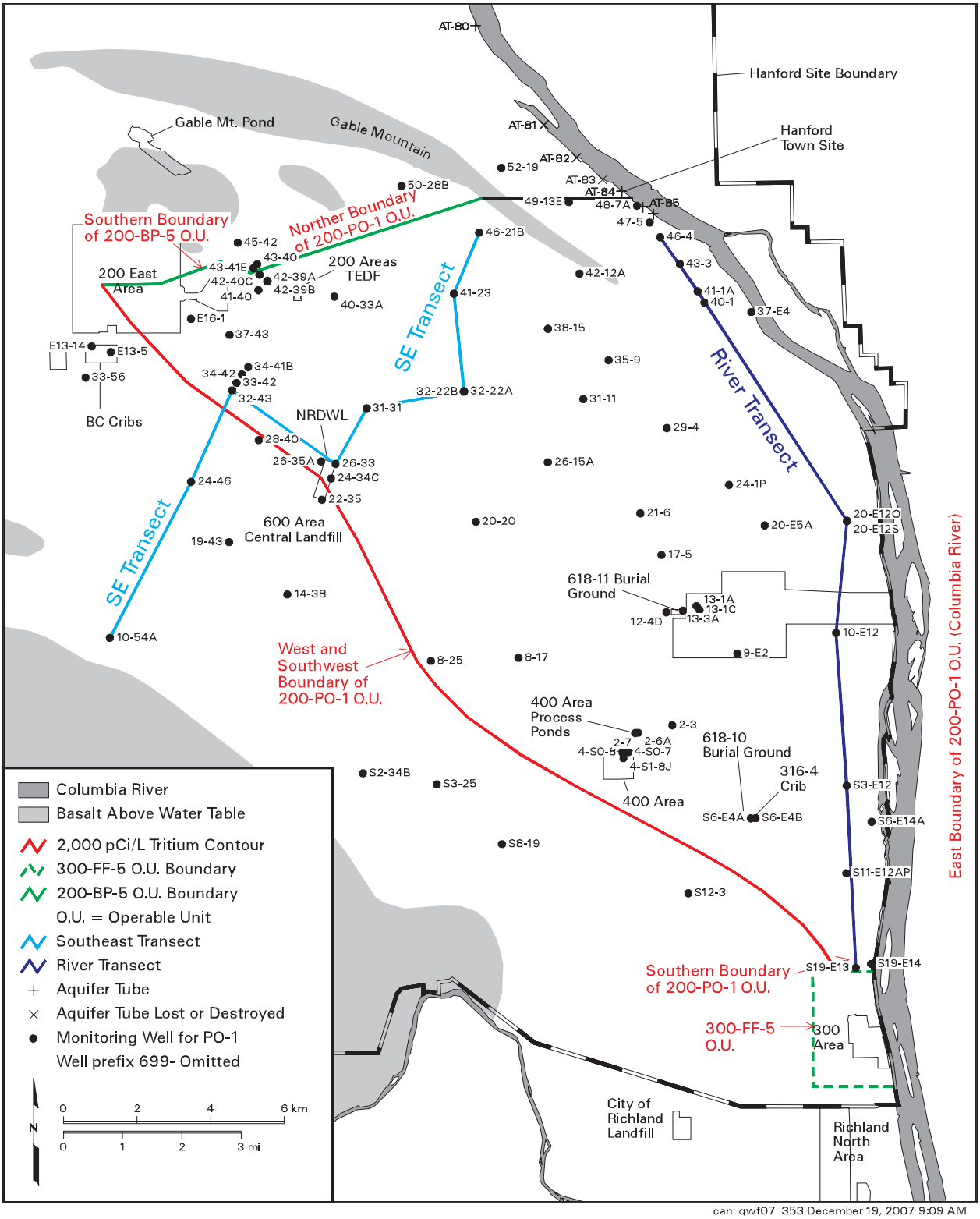


Figure 2.11-2. 200-PO-1 Operable Unit Boundaries, Far-Field Monitoring Wells, and Transects

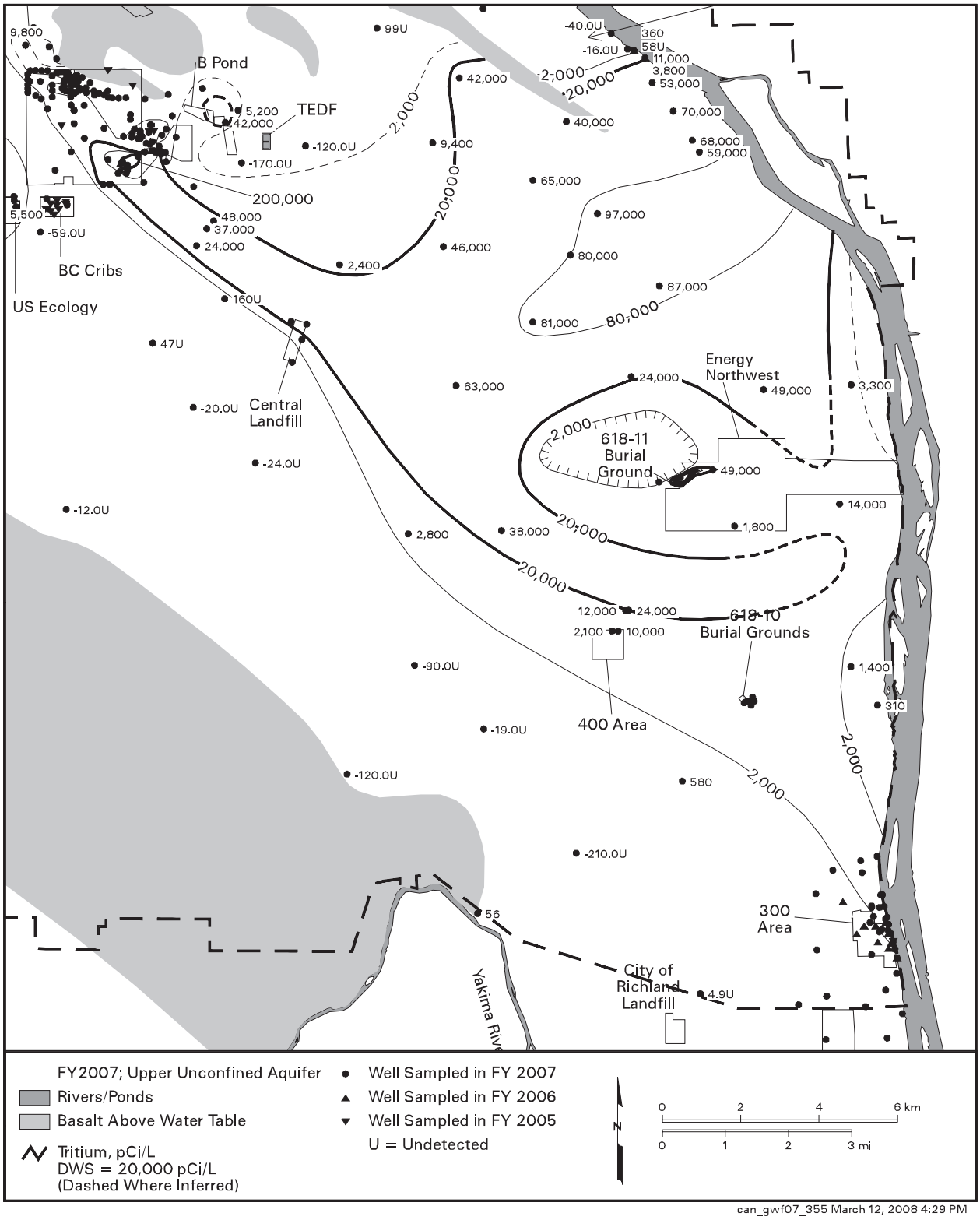


Figure 2.11-3. Tritium Concentrations in 200-PO-1 Operable Unit, Upper Part of Unconfined Aquifer

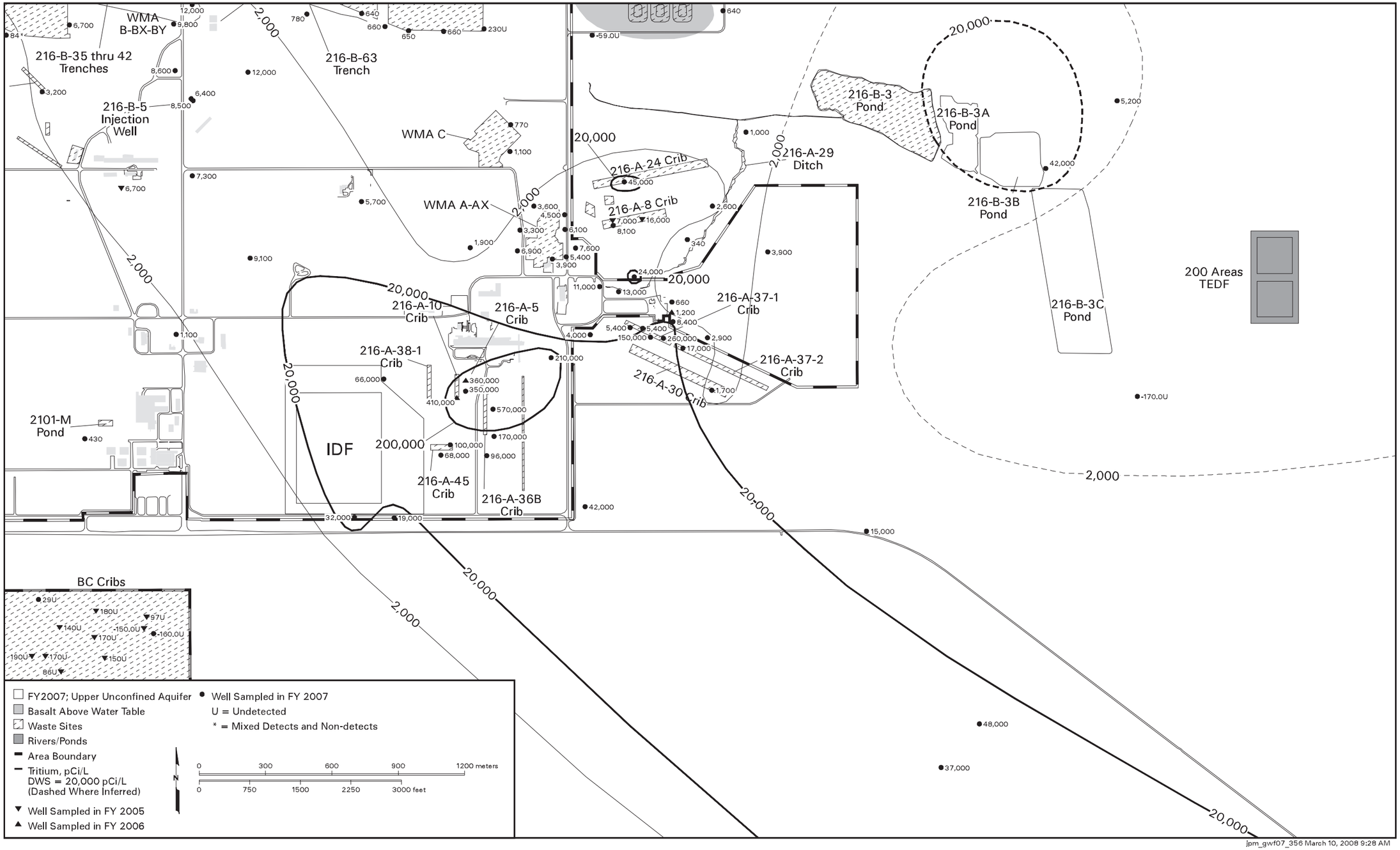


Figure 2.11-4. Average Tritium Concentration in Near-Field Area of 200-PO-1 Operable Unit, Upper Part of Unconfined Aquifer

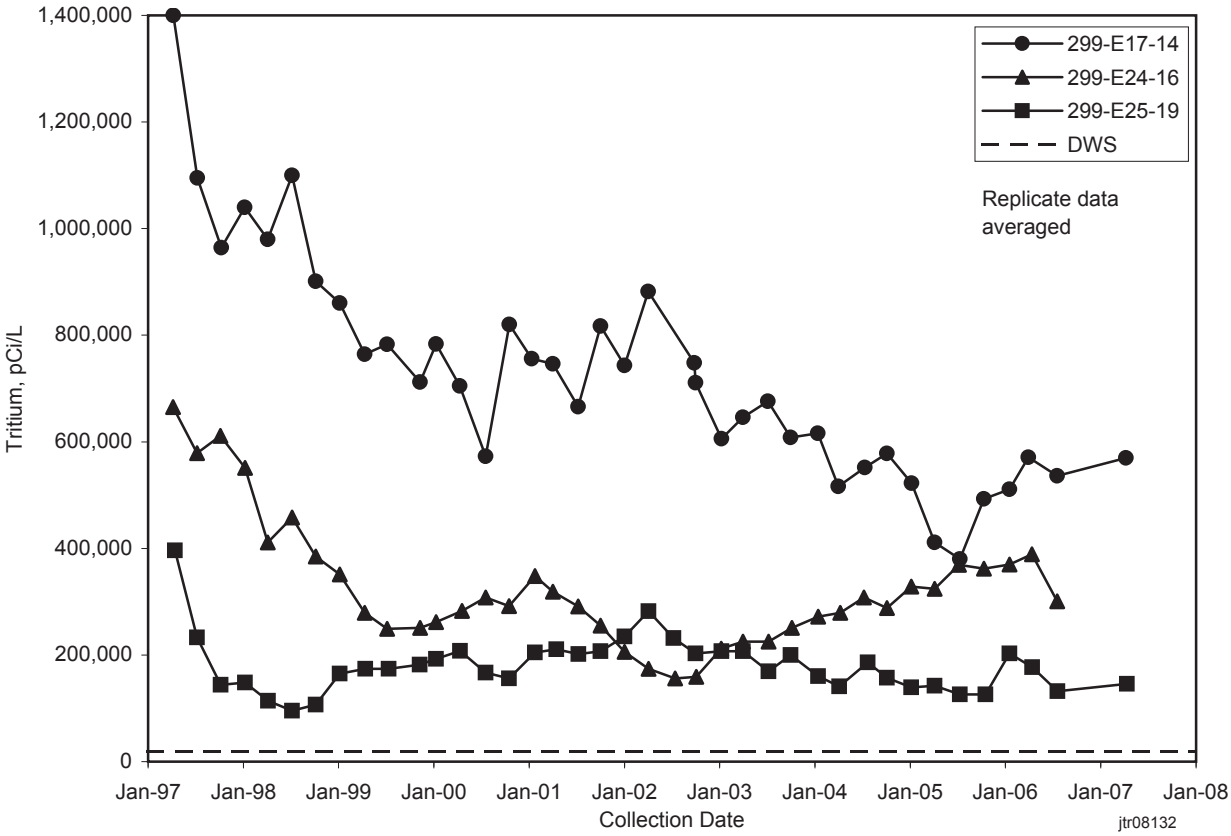


Figure 2.11-5. Tritium Concentrations in Wells Near Three PUREX Cribs

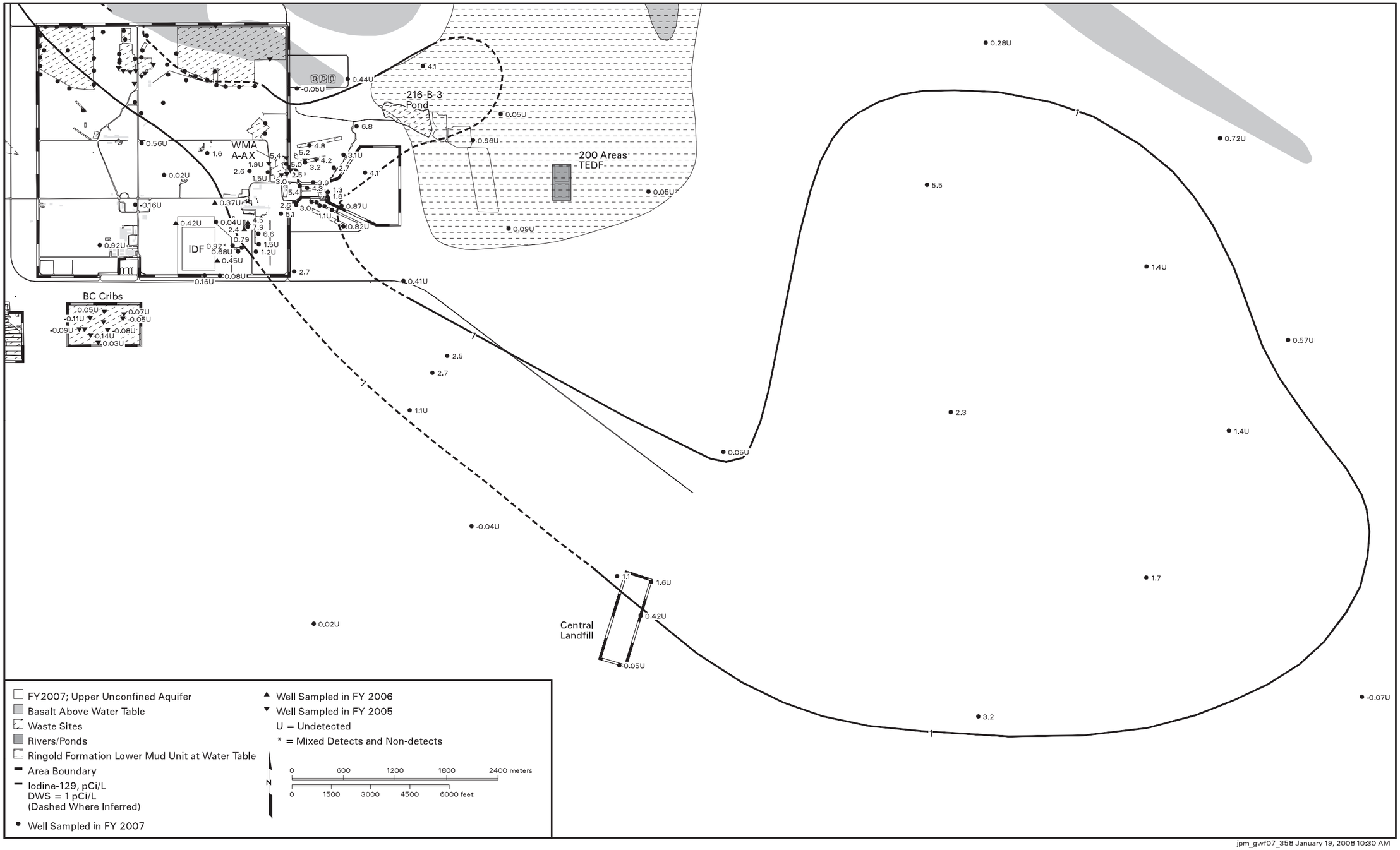


Figure 2.11-6. Iodine-129 Plume Map for 200-PO-1 Operable Unit, Upper Part of Unconfined Aquifer

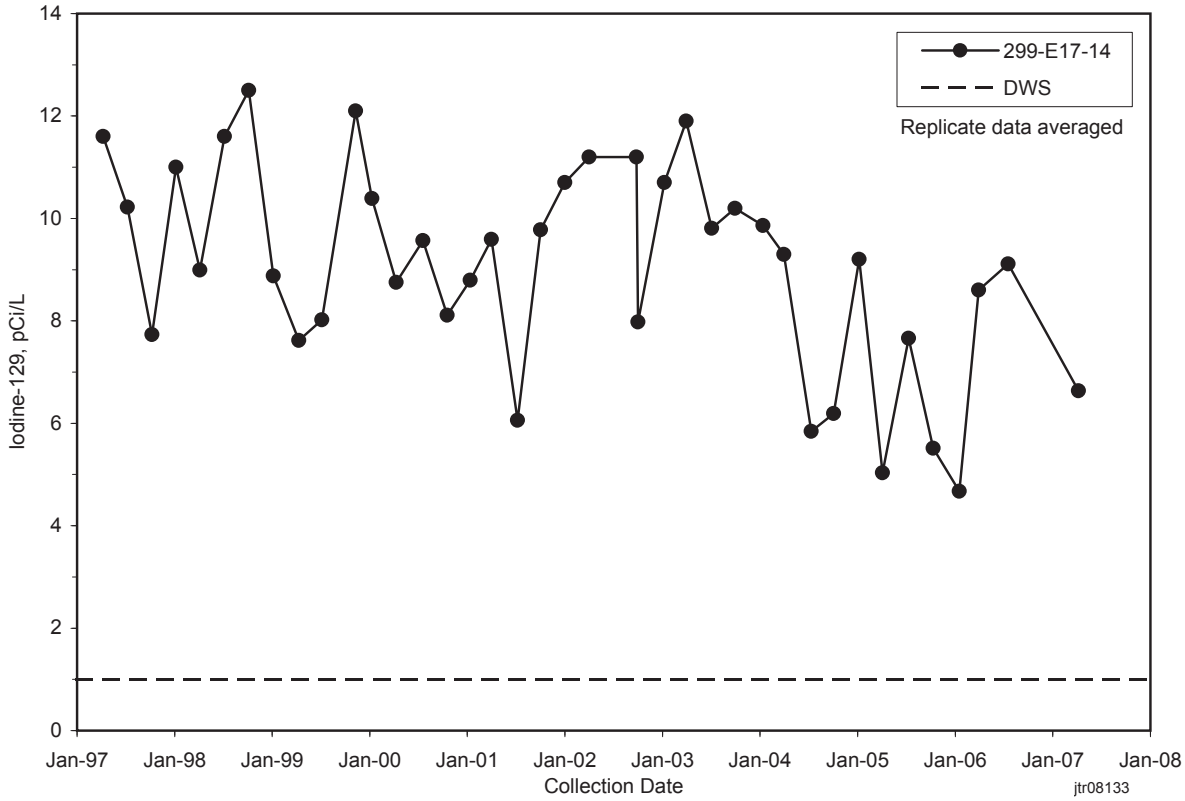


Figure 2.11-7. Iodine-129 Concentrations in Well 299-E17-14 at 216-A-36B Crib

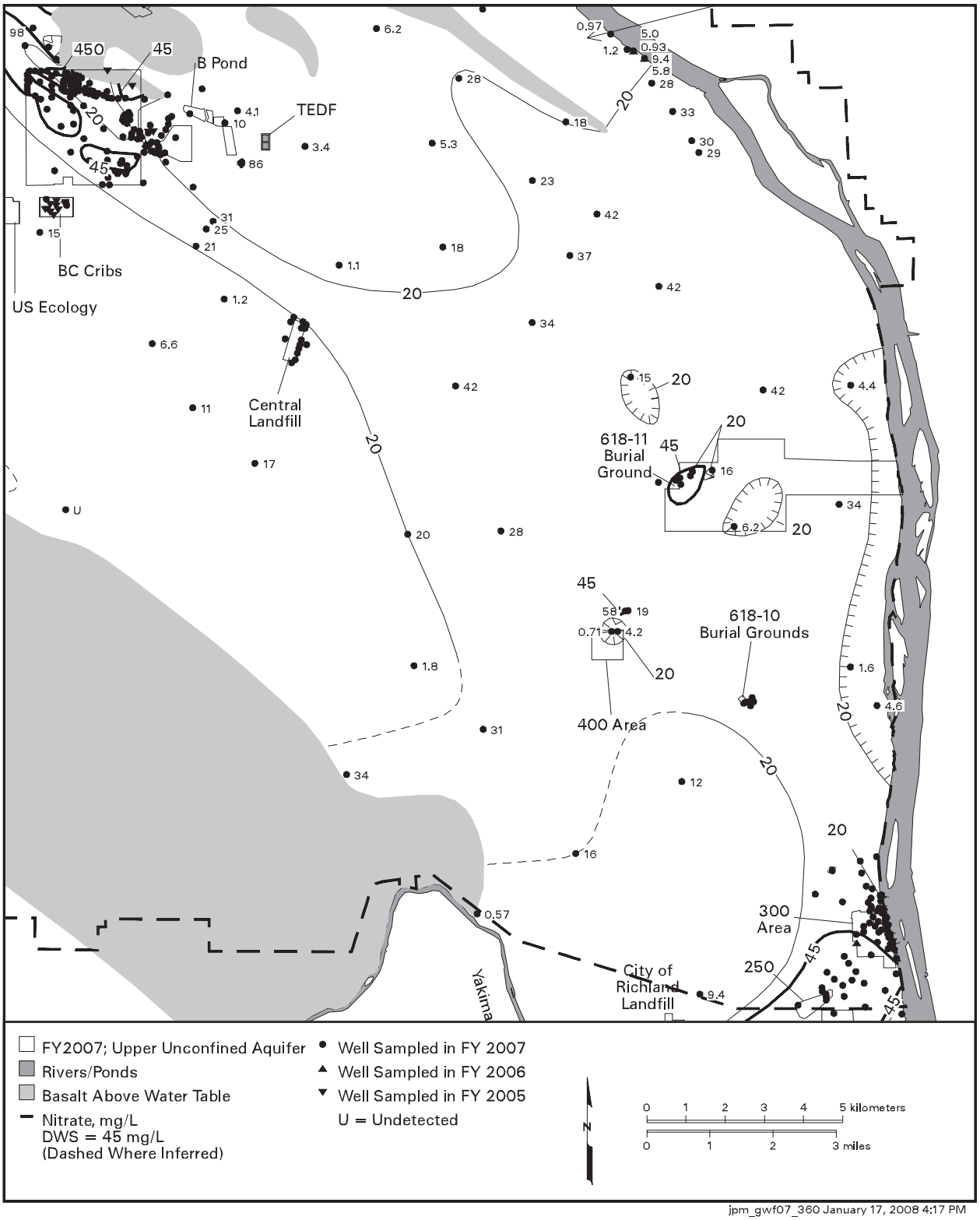


Figure 2.11-8. Nitrate Concentrations in 200-PO-1 Operable Unit, Upper Part of Unconfined Aquifer

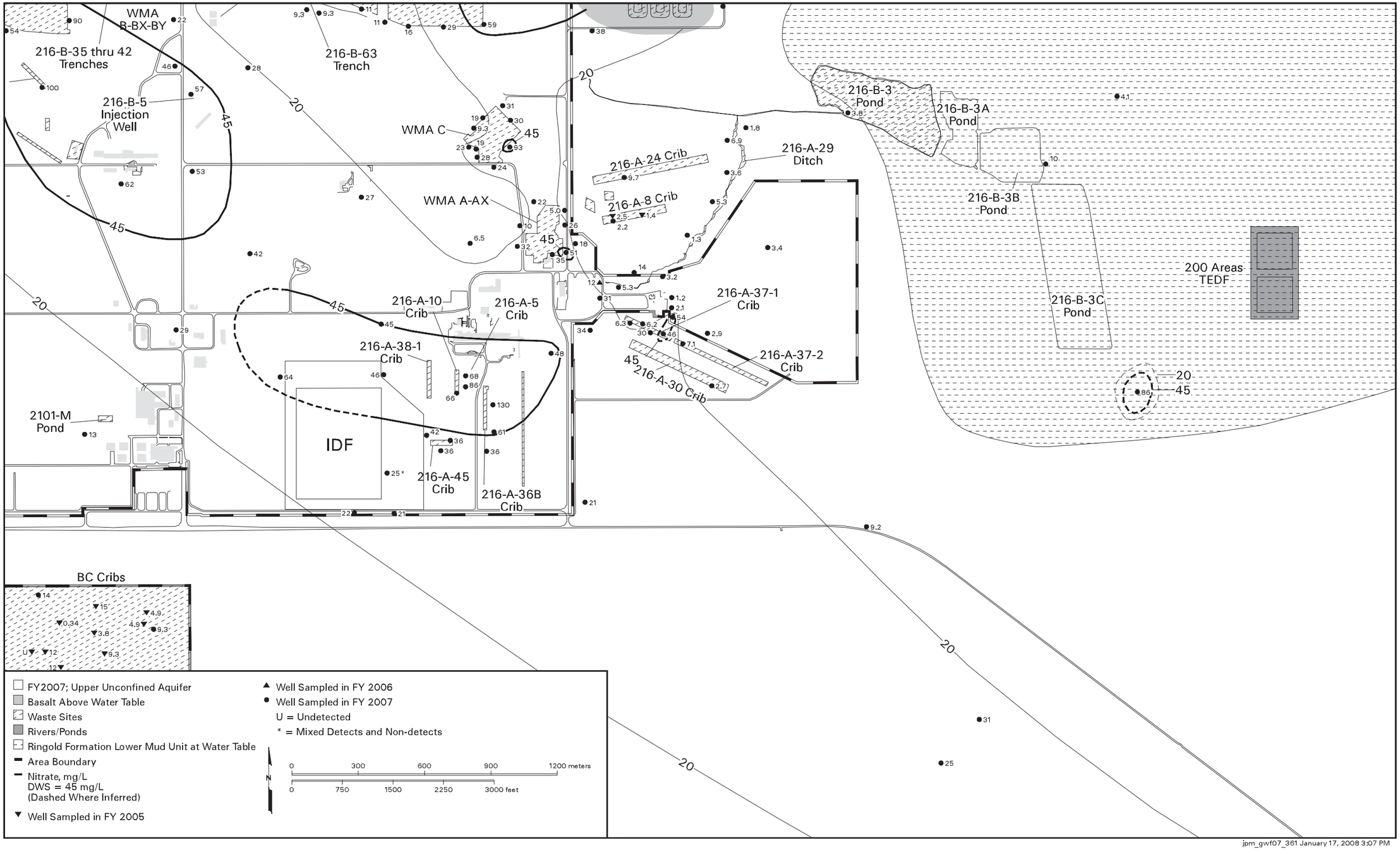


Figure 2.11-9. Nitrate Concentrations in 200-PO-1 Near-Field Area, Upper Part of Unconfined Aquifer

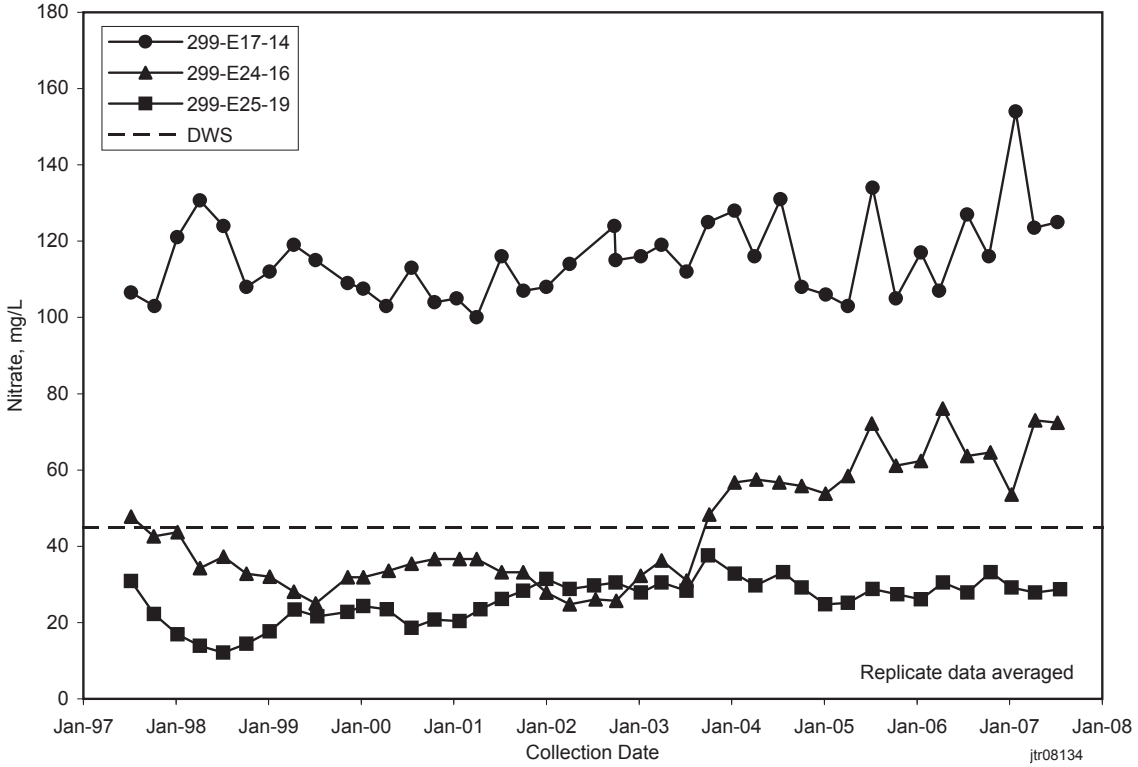


Figure 2.11-10. Nitrate Concentrations in Wells 299-E17-14 at 216-A-36B Crib, 299-E24-16 at 216-A-10 Crib, and 299-E25-19 at 216-A-37A Crib

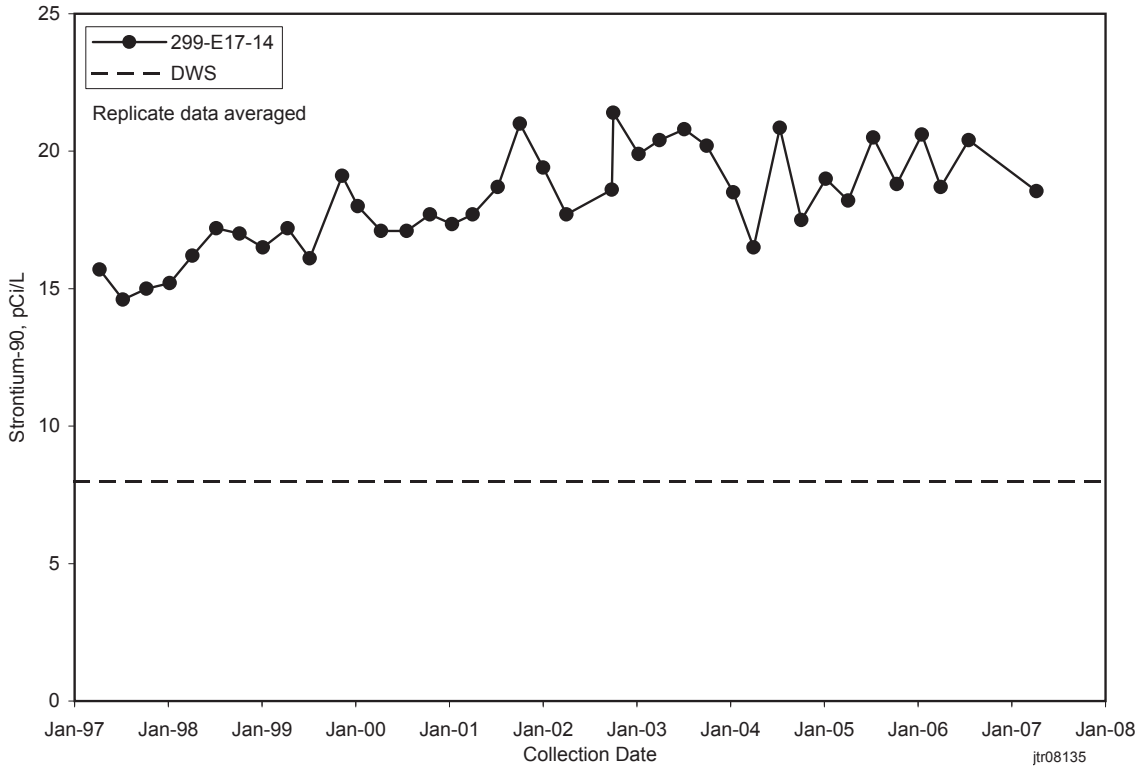


Figure 2.11-11. Strontium-90 Concentrations in Well 299-E17-14 at 216-A-36B Crib

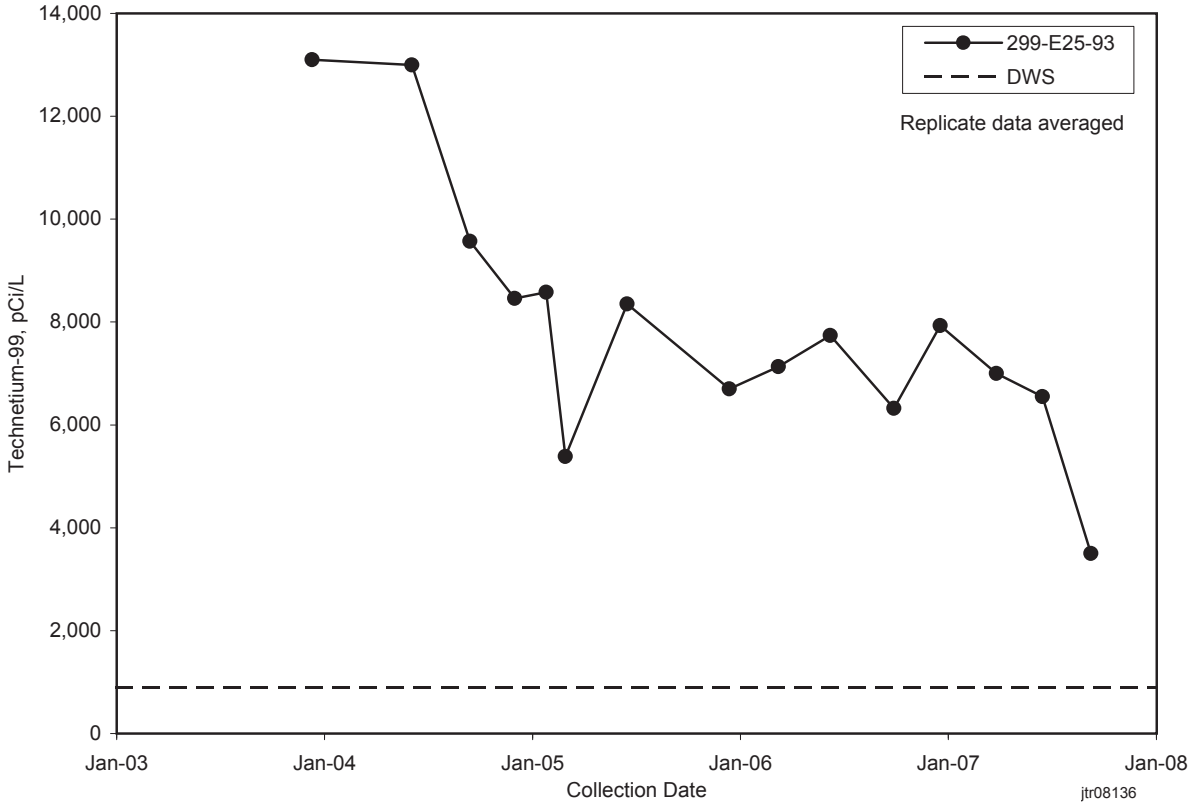


Figure 2.11-12. Technetium-99 Concentrations in Well 299-E25-93 at Waste Management Area A-AX

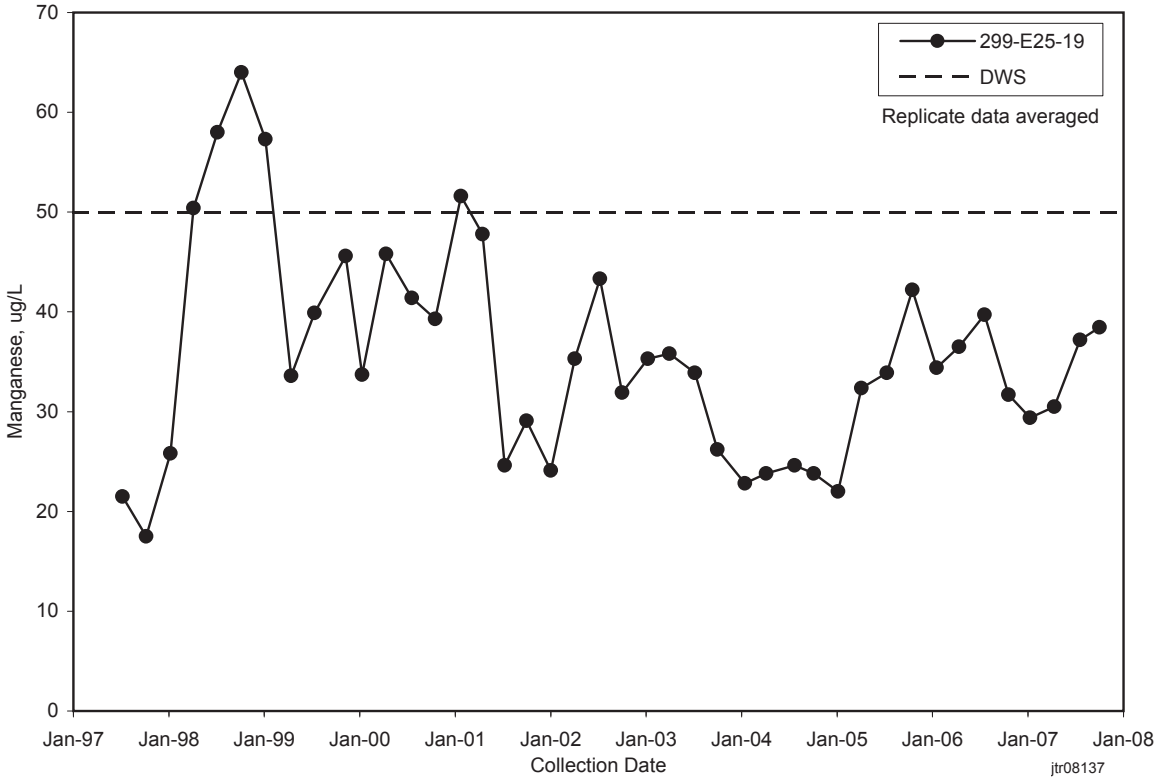


Figure 2.11-13. Manganese Concentrations in Well 299-E25-19 Near 216-A-37-1 Crib

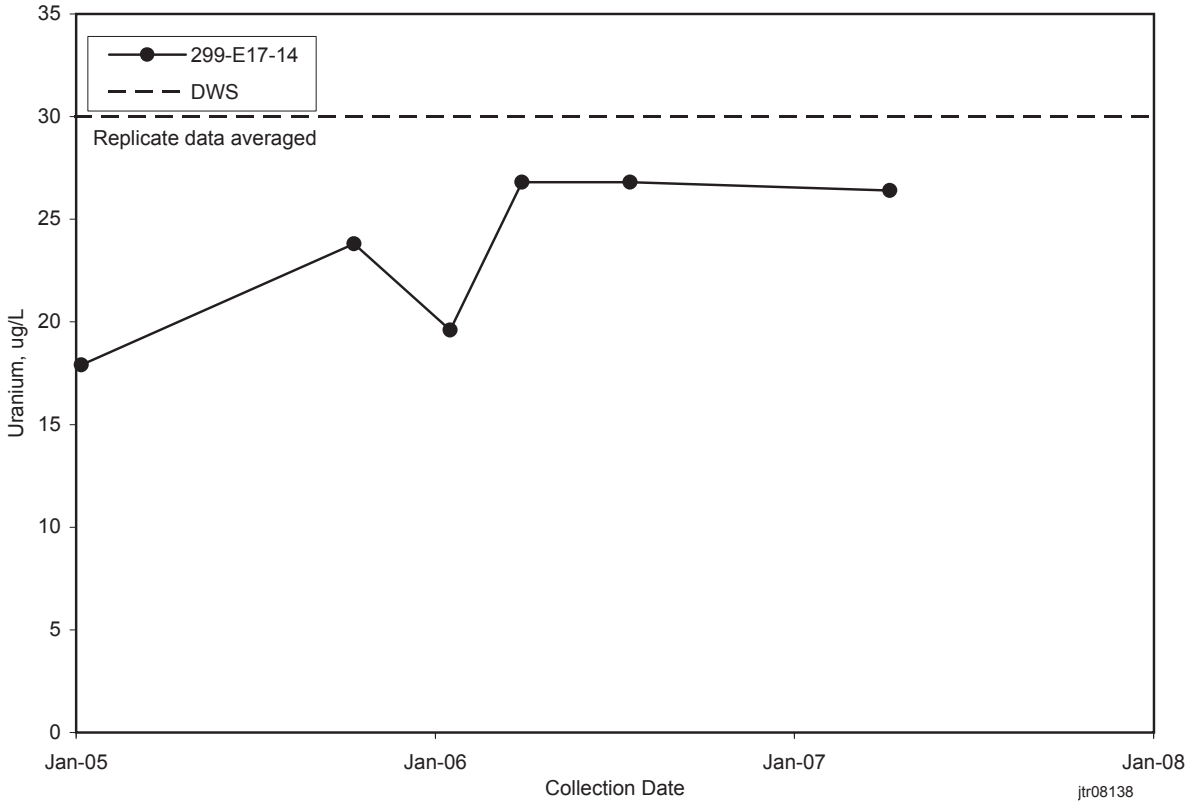


Figure 2.11-14. Uranium Concentrations in Well 299-E17-14 Near 216-A-36B Crib

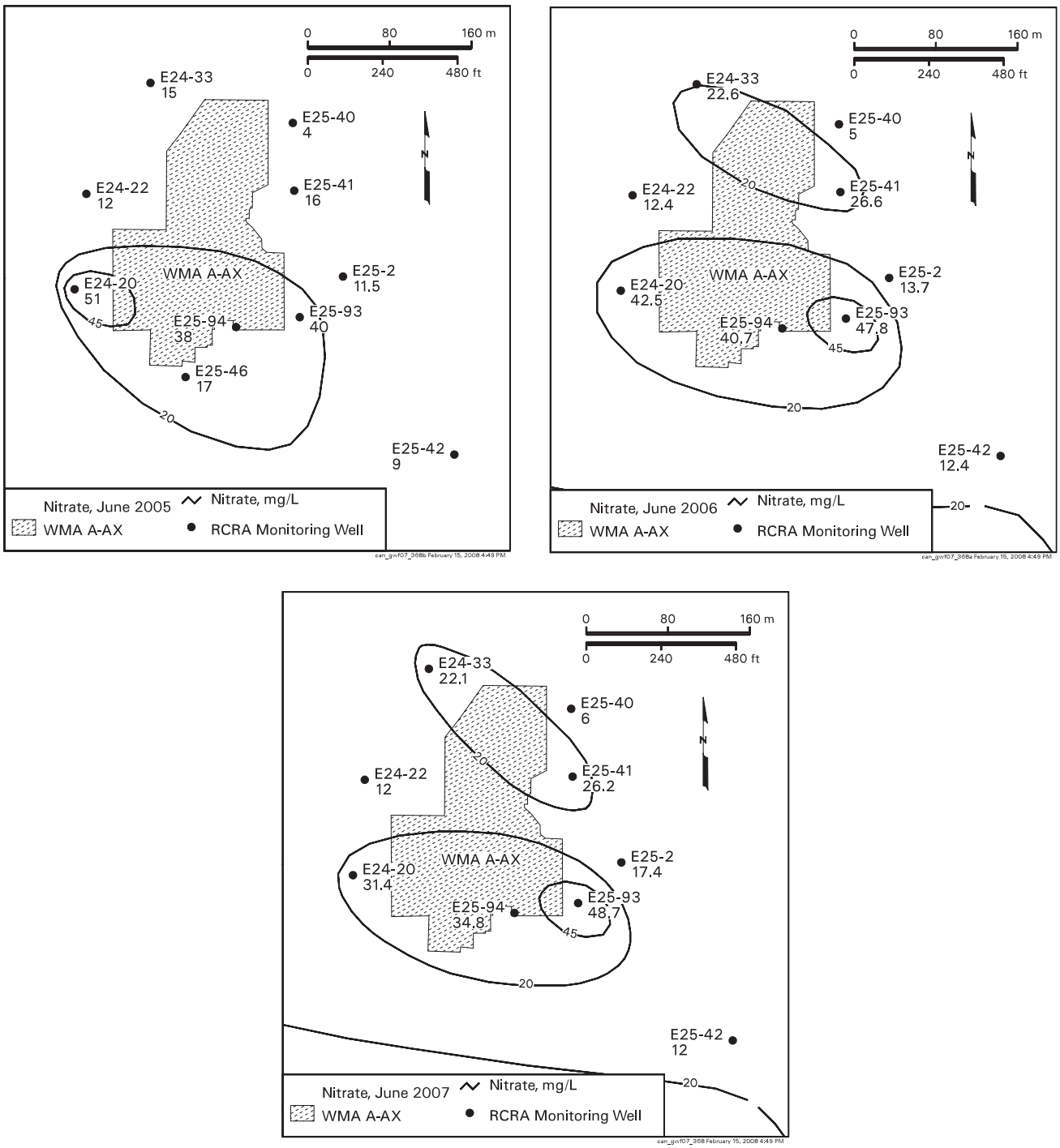
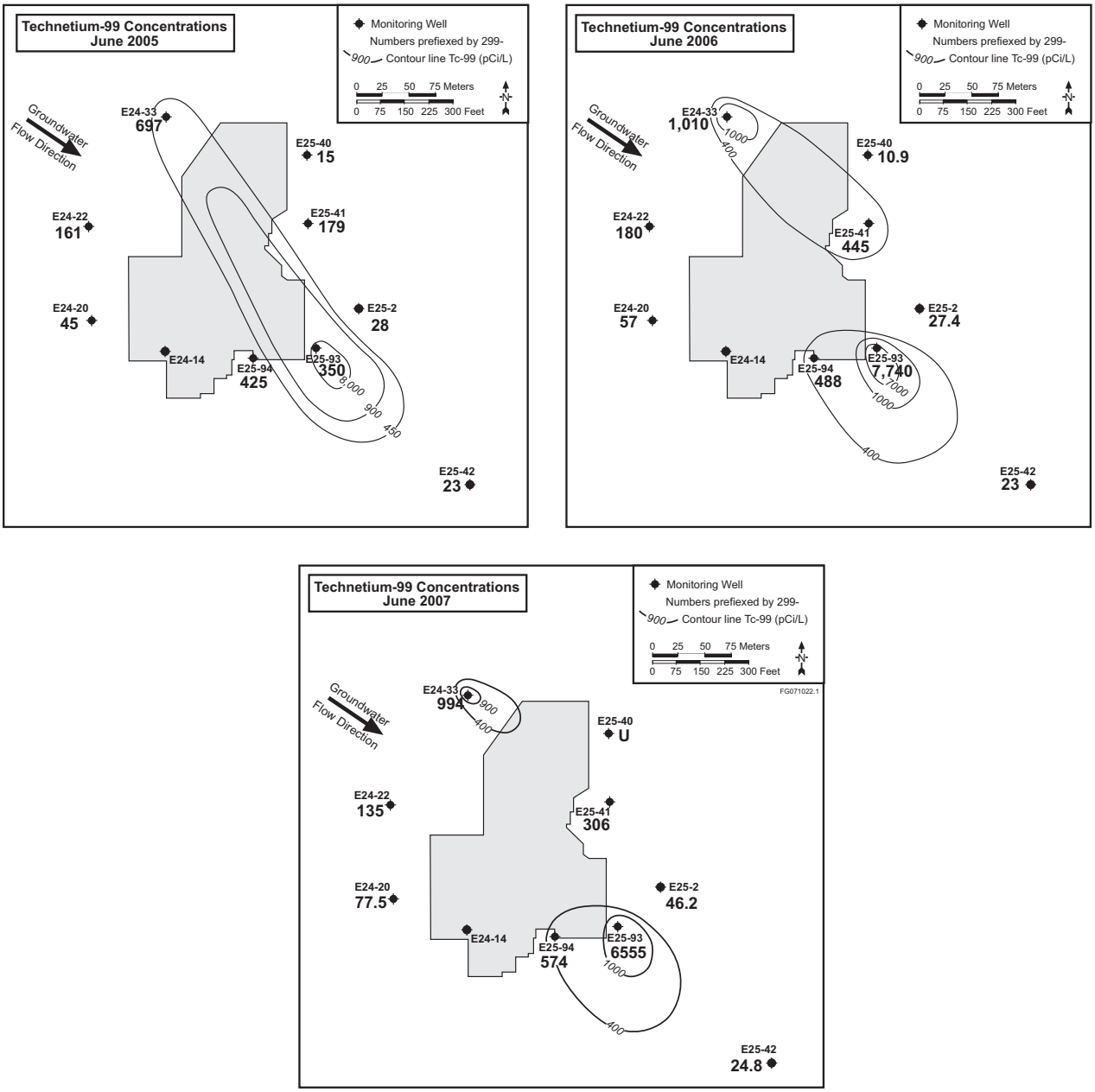


Figure 2.11-15. Nitrate Concentrations at Waste Management Area A-AX, June 2005 to June 2007



FG071022.1

Figure 2.11-16. Technetium-99 Concentrations at Waste Managment Area A-AX, June 2005 to June 2007

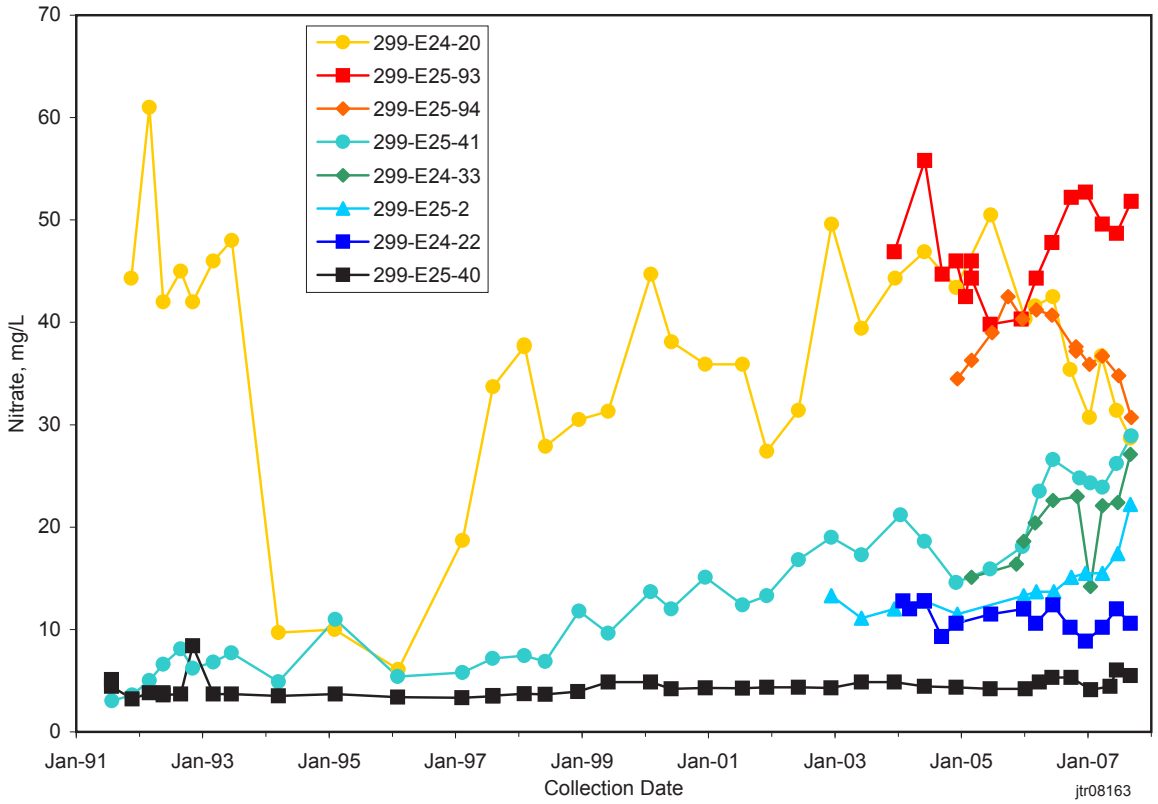


Figure 2.11-17. Nitrate Concentrations in Groundwater at Waste Management Area A-AX

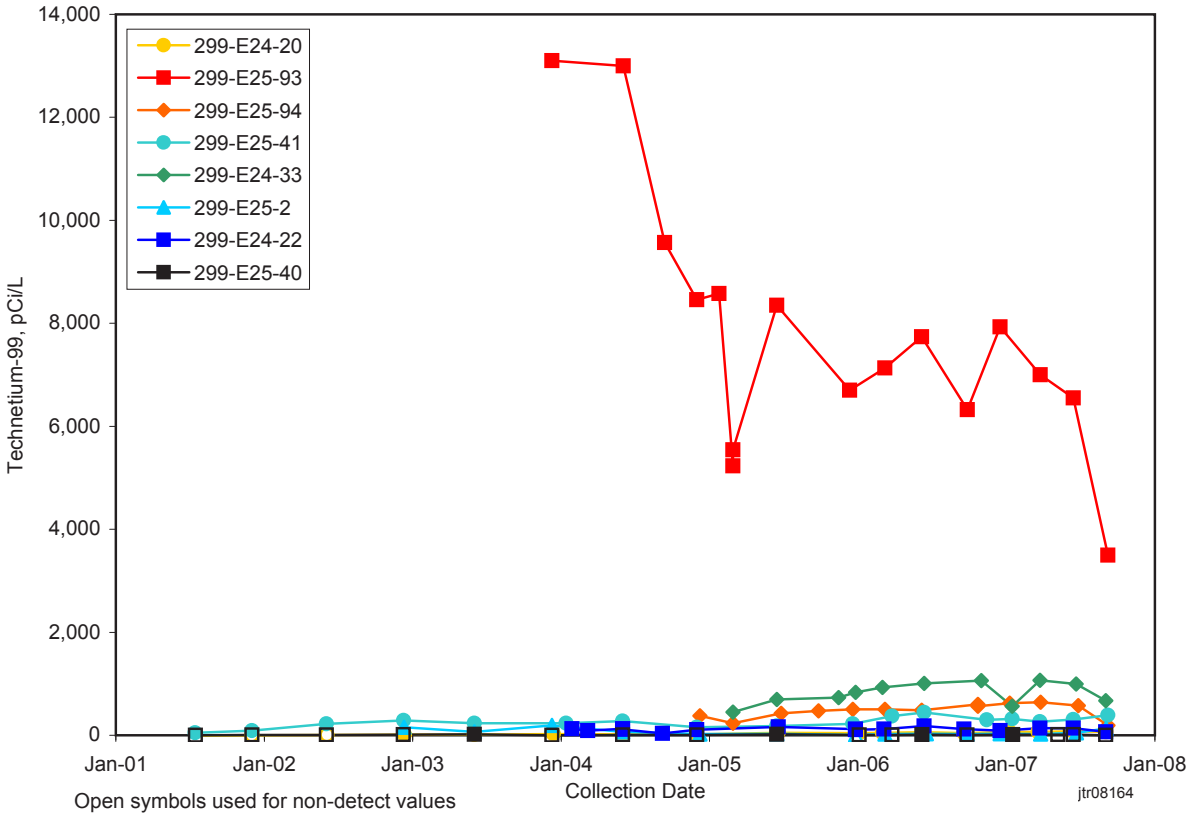


Figure 2.11-18. Technetium-99 Concentrations in Groundwater at Waste Management Area A-AX

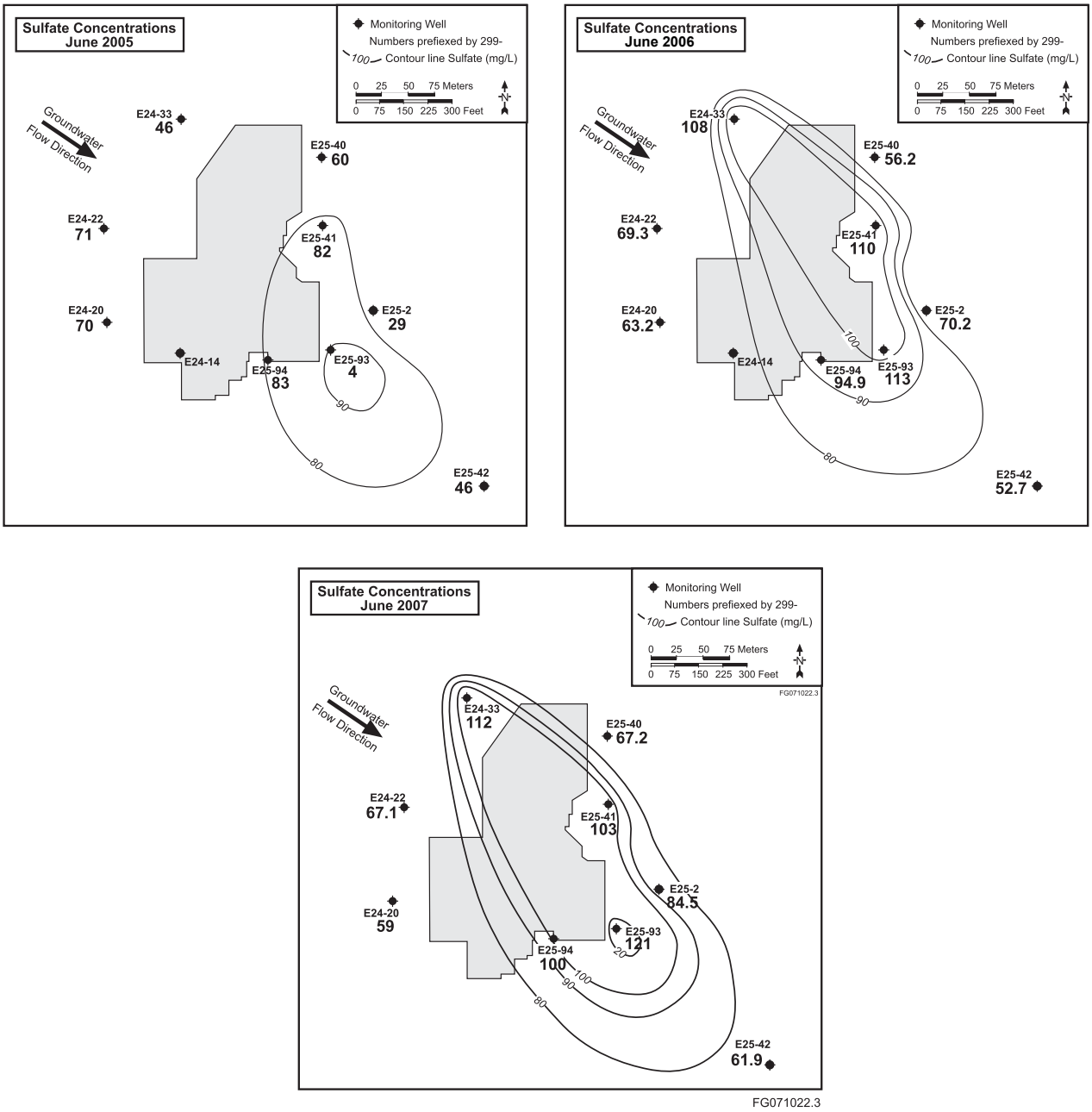


Figure 2.11-19. Sulfate Concentrations at Waste Management Area A-AX, June 2005 to June 2007

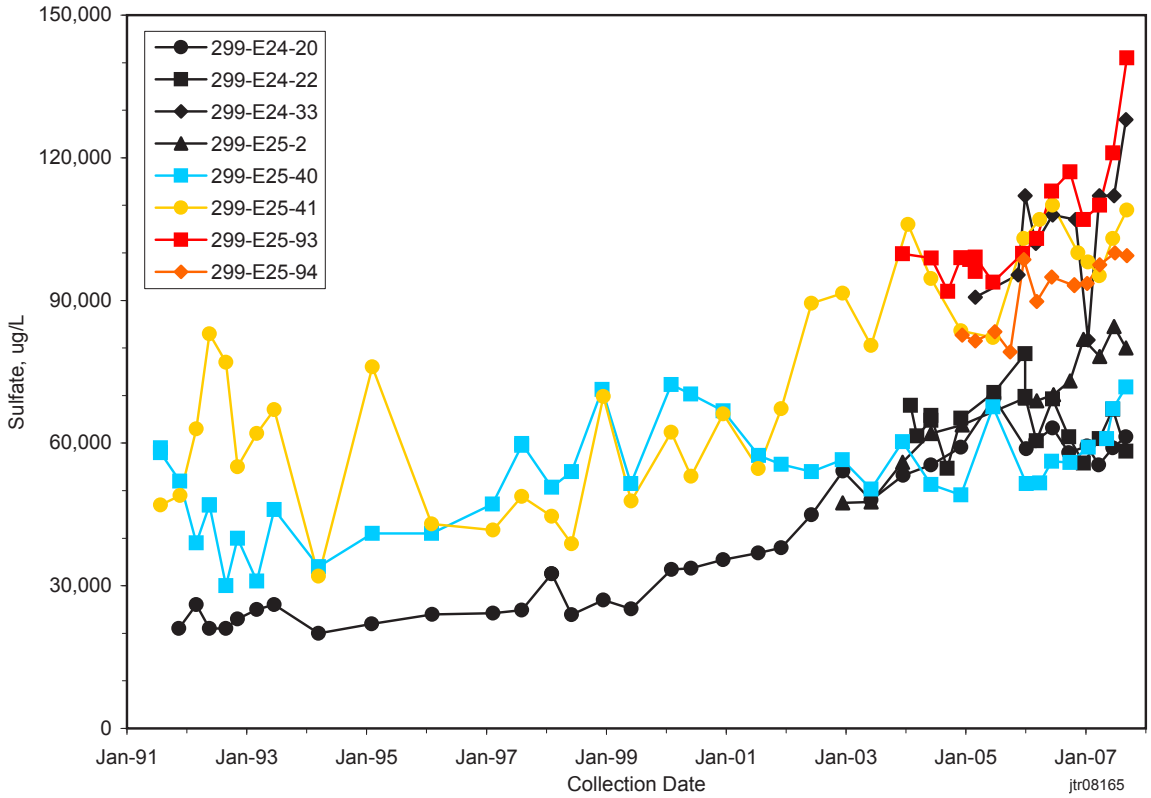


Figure 2.11-20. Sulfate Concentrations in Groundwater at Waste Management Area A-AX

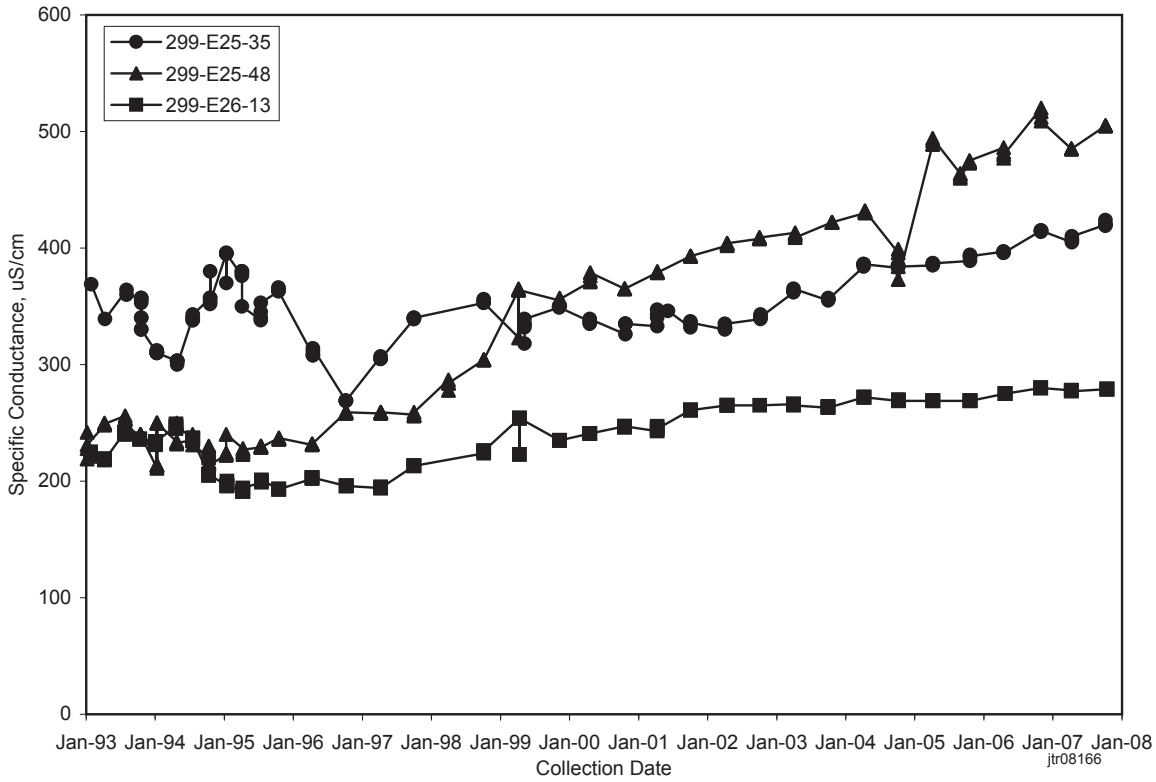


Figure 2.11-21. Specific Conductance in 216-A-29 Ditch Downgradient Wells 299-E25-35, 299-E25-48, and 299-E26-13

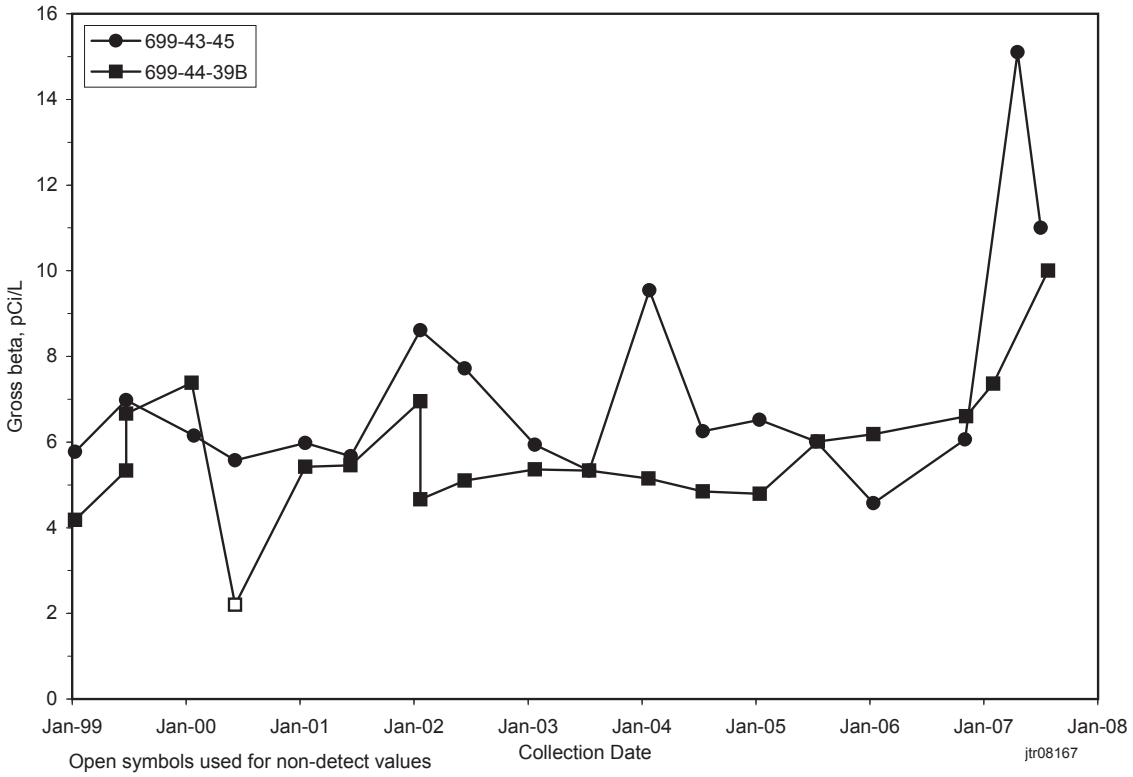


Figure 2.11-22. Gross Beta Concentrations Trends at Upgradient Well 699-44-39B and Downgradient Well 699-43-45, B Pond Facility

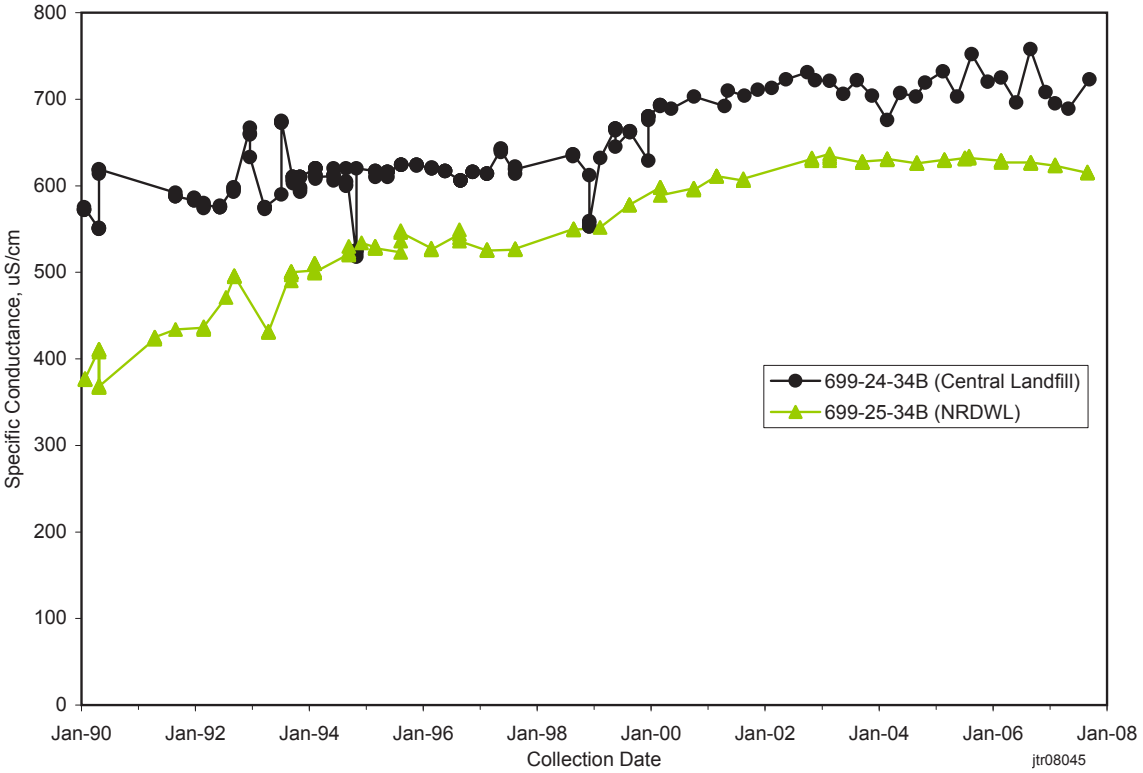


Figure 2.11-23. Specific Conductance at Nonradioactive Dangerous Waste Landfill Wells

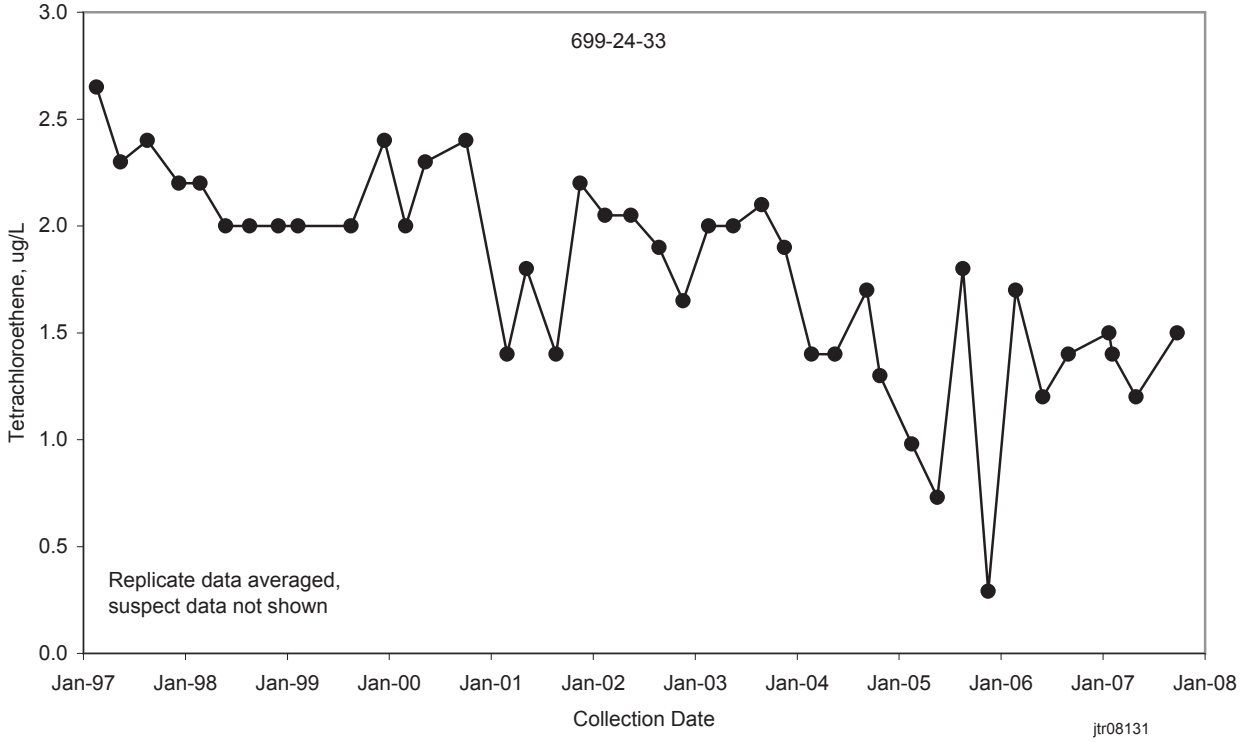


Figure 2.11-24. Tetrachloroethene Concentrations in Well 699-24-33 at the 600 Area Central Landfill

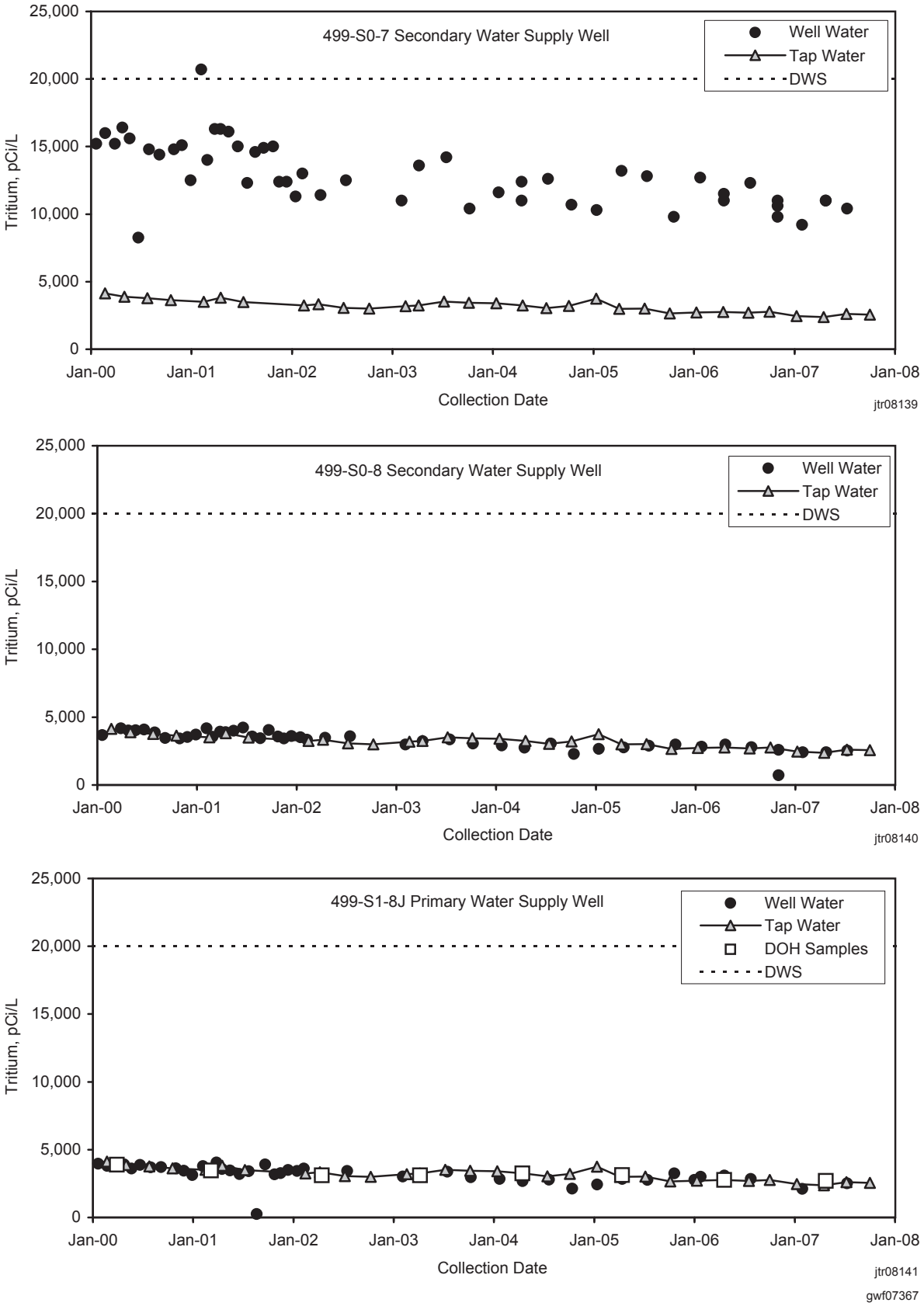


Figure 2.11-25. Tritium Concentrations in 400 Area Water Supply Wells

2.12 300-FF-5 Operable Unit

R. E. Peterson and J. W. Lindberg

The 300-FF-5 Operable Unit is a component of the 300 National Priorities List Site, located in the southeastern portion of the Hanford Site. The operable unit includes groundwater affected by releases from waste sites and facilities associated with the 300-FF-1 and 300-FF-2 Operable Units. The various subregions within the 300-FF-5 Operable Unit and their relationship to the 300-FF-1 and 300-FF-2 Operable Units are shown in Figure 2.12-1. The 300-FF-5 Operable Unit lies within a larger groundwater interest area (see Figure 1.0-1 in Section 1.0), which has been defined informally for scheduling, data evaluation, and interpretation purposes. Remedial investigation activities are underway in the groundwater interest area as part of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) program to (a) track changes in the nature and extent of groundwater contamination, (b) monitor trends in contaminant levels with time, and (c) comply with *Resource Conservation and Recovery Act* (RCRA) requirements associated with the former 300 Area process trenches.

The 300-FF-5 Operable Unit includes groundwater beneath the 300 Area and outlying subregions near the 618-11 and 618-10 burial grounds.

Primary sources for contaminants that have impacted groundwater in the 300-FF-5 Operable Unit are the former liquid waste disposal facilities in the 300 Area, the 618-11 burial ground near the Energy Northwest complex, and the former 316-4 crib, which is located near the 618-10 burial ground. The 300 Area contains former nuclear fuel fabrication facilities, fuels research laboratories, liquid effluent disposal sites, and several solid waste burial grounds. An index map to 300 Area monitoring wells, waste sites, buildings, and shoreline monitoring sites is shown in Figure 2.12-2. The two outlying subregions of the operable unit (i.e., the 618-11 and 618-10 burial grounds) received primarily solid radioactive waste from the 300 Area during the period 1954 to 1967. The former 316-4 cribs, which are located adjacent to the 618-10 burial ground, received uranium-bearing organic liquid waste during the period 1948 to 1956. Index maps to these outlying 300-FF-5 subregions are provided in Figure 2.12-3.

Groundwater in the unconfined aquifer beneath the 300-FF-5 interest area flows generally to the east and southeast (Figure 2.12-4). Flow converges into the

Groundwater monitoring in the 300-FF-5 groundwater interest area includes the following:
Interim Action Monitoring under CERCLA (Appendix A)

- ***Forty-six wells in the 300 Area are sampled quarterly to annually. Three wells were not sampled as scheduled in FY 2007.***
- ***Twelve wells in the north part of the 300-FF-5 Operble Unit are sampled quarterly to semiannually.***
- ***Eight aquifer tube sites near the Columbia River are sampled semiannually.***
- ***Riverbank springs and near-shore river water are sampled annually (coordinated with the Public Safety and Resource Protection Program).***

Facility Monitoring (Appendix B)

- ***Four pairs of wells are sampled eight times per year at the 300 Area Process Trenches.***

300 Area from regions to the northwest, west, and southwest, and ultimately discharges to the Columbia River through the riverbed and to a lesser degree, along the shoreline as riverbank springs. In the northern and central portions of the 300 Area, flow direction is predominantly toward the southeast, while in the southern portion, flow is more eastward, as inferred from water-table elevations recorded during most of any particular year. This flow pattern reflects medium-to-low river stage conditions. As river discharge rises during late May or June, the direction of groundwater flow temporarily shifts to more southward in the northern portion of the 300 Area. The stage of the Columbia River has a profound effect on groundwater flow patterns and rates in the 300 Area. Seasonal changes in river stage are reflected in water levels measured at wells located as far as inland as 360 meters from the Columbia River (PNL-8580).

Groundwater flows toward the east and southeast across the 300-FF-5 interest area and discharges to the Columbia River.

Because of highly transmissive aquifer materials, groundwater flow velocities can be quite high, with a recent tracer test revealing a rate of up to 15 meters/day (PNNL-16571). Other investigations have documented plume migration rates as high as 10 meters/day (PNL-5408, pp. 45-49). However, in spite of high flow velocities, the net rate of discharge to the Columbia River appears to be relatively low. This is a consequence of rapidly changing hydraulic gradients and their orientation, which results from the daily, weekly, and seasonal cycles in river stage. Efforts to more accurately quantify these rates continued during fiscal year (FY) 2007 as part of the 300-FF-5 Phase III Feasibility Study (DOE/RL-2005-41).

Variability in hydraulic gradients and the vertical position the water table influences contaminant concentrations as well as flow rates and patterns. During the Columbia River's spring runoff period when high river stage conditions are present, river water infiltrates the banks and mixes with groundwater, thus diluting the concentrations of contaminants carried by groundwater. The rate at which groundwater discharges to the river is lowest during this period of high river stage because of bank storage effects (e.g., reduced gradients and actual reversal of flow direction near the shoreline). Farther inland, higher water-table elevations may result in groundwater coming in contact with contaminants held in the lower vadose zone, thus remobilizing those contaminants. Consequently, higher concentrations may be observed during the early summer months, particularly in areas beneath former liquid waste disposal sites. These processes are described in detail for the uranium plume beneath the 300 Area (PNNL-17034).

Areas of plumes where the drinking water standard is exceeded in the 300-FF-5 Operable Unit:

****Tritium — 0.22***
Uranium — 0.50
****Excludes tritium from 200-PO-1 Operable Unit.***

The remainder of this section describes contaminant plumes and concentration trends for contaminants of concern or potential concern as listed in sampling and analysis plans associated with CERCLA and RCRA requirements. Following those descriptions, the status of operable unit activities conducted under CERCLA and the facility monitoring under RCRA are discussed.

2.12.1 Groundwater Contaminants

Contaminants of concern, or potential concern, for the 300-FF-5 Operable Unit have been identified in several regulatory decision documents. Under CERCLA, the initial record of decision (ROD 1996b) and subsequent explanation of significant difference (EPA 2000) identify contaminants of concern for each of the three subregions of the groundwater operable unit. Under RCRA, constituents of concern

for corrective action monitoring of groundwater beneath the former 300 Area process trenches are identified in a groundwater monitoring plan (WHC-SD-EN-AP-185, as amended).

The contaminant of greatest significance in groundwater beneath the 300 Area is uranium, which has persisted as a plume long after fuel fabrication activities ceased. Additional contaminants of potential concern from 300 Area sources are the volatile organic compounds cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene. Trichloroethene has been recently discovered at elevated concentrations at depths below those normally monitored. While not specifically listed in the record of decision, strontium-90, gross alpha, and gross beta are also monitored because those radiological contamination indicators have exceeded standards. Contaminants from sources outside of the 300 Area that migrate into the subregion include tritium, nitrate, and trichloroethene.

Uranium is the principal contaminant of concern in the 300-FF-5 Operable Unit, with volatile organic compounds and tritium being contaminants of potential concern.

For the 300-FF-5 outlying subregions, the contaminant of greatest significance is tritium, which has been released from the 618-11 burial ground. The resulting plume is of limited areal extent, but contains tritium concentrations that greatly exceed the drinking water standard of 20,000 pCi/L. This plume lies upgradient of and beneath the Energy Northwest complex. At the 618-10 burial ground and former 316-4 cribs subregion, contaminants of potential concern are uranium and tributyl phosphate. These two contaminants are known to have been disposed to the former 316-4 cribs, and there is some evidence that uranium may also have been released from waste in the 618-10 burial ground. No evidence to date suggests a release of tritium from the 618-10 burial ground, as has occurred at the 618-11 burial ground. Technetium-99, tritium, and nitrate have migrated into the 300-FF-5 outlying subregions from upgradient sources in the 200 East Area.

Most contaminants of potential concern, as identified in regulatory decision documents, show either a decrease or relatively constant concentration trend during the years since the initial remedial investigation for the operable unit was conducted in the early 1990s (PNNL-15127).

2.12.1.1 Uranium

Uranium is a contaminant in groundwater beneath the 300 Area and beneath the 618-10 burial ground/316-4 cribs subregion. In the 300 Area, it was introduced to groundwater by disposal of fuel fabrication effluent to large infiltration ponds and trenches. Disposal of uranium-bearing effluent to waste facilities ended in 1986 (PNNL-13645), although discharge of uncontaminated effluent continued until December 1994. Excavation of contaminated soil at the major liquid waste disposal sites occurred primarily during the period 1997 to 2000, with backfilling at all excavated sites completed by early 2004. At the former 316-4 cribs, uranium was disposed to open-bottomed infiltration cribs along with liquid effluent containing organic compounds. These cribs were removed and the site stabilized in 2004, with some uranium and tributyl phosphate remaining in the soil beneath the excavation (DOE/RL-2006-20, Rev. 1, page 3.8).

At the 300 Area, residual amounts of contaminant uranium remain in the vadose zone and aquifer, with some sorption onto sediment particles. The mobility of uranium within waste sites, the underlying vadose zone, and in the aquifer is highly variable and depends on (a) sediment texture and mineralogy, (b) chemical makeup of the waste effluent, and (c) the subsurface geochemical environment, especially

the bicarbonate content, pH, and surface properties of minerals (PNNL-14022; PNNL-15121; PNNL 17031; PNNL 17034). Uranium in groundwater is typically monitored using chemical analyses for total uranium in an unfiltered sample. In the river environment, uranium in shoreline media and river water is monitored using analyses for specific isotopes. Results for each type of analysis can be converted to the other to provide comparable data sets.

The 300 Area uranium plume has persisted much longer than predicted by the initial remedial investigation in the 1990s. Concentrations in the plume vary seasonally in response to Columbia River conditions.

The U.S. Environmental Protection Agency (EPA) National Primary Drinking Water Standard for uranium is 30 µg/L. The standard is based primarily on uranium's chemical toxicity to humans, which is associated with damage to internal organs. Protection standards for freshwater aquatic organisms have not been established by EPA. A recent literature review regarding the chemical toxicity of uranium to non-human biota describes the relationship between toxicity and water hardness (i.e., the amount of calcium and other cations) for aquatic organisms (Sheppard et al. 2005). The range of predicted no-effect concentrations is from 5 µg/L for freshwater plants and invertebrates (without considering hardness) to 2,800 µg/L for fish (assuming water hardness similar to the Columbia River). Until further regulatory guidance becomes available for the toxicity of uranium to freshwater organisms, the drinking water standard is being used as the level for protection along the 300 Area shoreline where contaminated groundwater discharges to the river.

300 Area Uranium Plume. The uranium plume in the 300 Area has been recently described in detail as part of a continuing feasibility study for remedial action of groundwater (PNNL-17034). Key aspects of the plume include persistence beyond the time predicted by earlier investigations (DOE/RL-94-85), distinct seasonal variability that is associated with the elevation of the water table, and incomplete information as to the source that continues to supply uranium to the plume. Current plume conditions are illustrated in Figures 2.12-5 and 2.12-6, which show conditions during December 2006 and June 2007, respectively, for the upper portion of the unconfined aquifer. The December 2006 period represents typical long-term average conditions for the 300 Area. The June 2007 configuration represents shorter-term conditions during the period of the seasonal high water table. During FY 2007, the seasonal high water table started in late March 2007 and continued into July 2007 (Figure 2.12-7), which is longer than usual, because of warm spring conditions. At the time that June water levels were measured (June 28 and 29), the water table had been elevated for several months and was beginning to decline. During a more typical June, water table conditions in the northern portion of the 300 Area would cause a westerly to southwesterly flow direction, but for 2007, measurements were made as the water table began its decline, and the resulting map closely resembled the December 2006 long-term average condition.

The uranium plume beneath the 300 Area covers approximately 0.5 square kilometers at concentrations above the drinking water standard and contains approximately 45~77 kilograms of dissolved uranium.

The uranium plume in the 300 Area is defined by concentrations exceeding 10 µg/L. Natural background concentrations for uranium in this sub-region are in the range of 3 to 8 µg/L, based on data from wells where groundwater has not been influenced by waste disposal. For the Hanford Site, natural background for uranium in groundwater falls in the range 0.5 to 12.8 µg/L (DOE/RL-96-61). Concentration trends since 2000 within the plume are illustrated in Figure 2.12-8 for three wells located in the vicinity of the former 300 Area process trenches, which is the most recently active liquid waste disposal site. Concentrations in shallow wells during FY 2007 were all less than 200 µg/L.

The area where uranium-contaminated groundwater exceeds the drinking water standard of 30 µg/L is 0.4~0.5 square kilometers. The areal extent remains fairly consistent from year to year, although concentrations within the plume show significant variability during the seasons. Estimates for the mass of dissolved uranium in this area of the plume suggest a value in the range 45 to77 kilograms. These estimates are based on new data that have become available to describe the hydrogeologic framework of the plume (see Section 2.12.3). Seasonal variations in concentrations and distribution patterns within the plume are related to cyclic changes in river stage.

Contaminant concentrations in groundwater near the Columbia River are reduced by infiltrating river water. At inland locations near former waste disposal sites, concentrations typically rise when the water table is elevated.

At locations near the Columbia River, uranium concentrations are reduced by mixing between groundwater and river water that infiltrates the aquifer during high river stage conditions. Also, changes in geochemical conditions caused by the mixing of river water and groundwater may promote adsorption of dissolved uranium onto sediment near the river. The bicarbonate content of river water is lower than that of groundwater, and the lower amount enhances the tendency for adsorption (PNNL-17031; PNNL-17034). Throughout most of the year (i.e., August through April), the river maintains low-to-moderate stage elevation, while during late May and June, the stage is typically high. It is during the seasonal high river stage that dilution of contaminants in groundwater near the river is greatest, and during 2007, this period extended for longer than usual. The dilution effect is illustrated by lowered uranium concentrations at near-river wells during June (compare Figure 2.12-6 with Figure 2.12-5) and by uranium concentration trends at wells 399-1-16A and 399-1-10A (Figure 2.12-9), which are located near the river and within the uranium plume.

At inland locations, the water table beneath the 300 Area responds quickly to changes in river stage because of the highly permeable sediment at the water table. Higher uranium concentrations are frequently observed in some portions of the plume when the water table is elevated above long-term levels, e.g., during the spring high river stage conditions each May and June). These higher concentrations may be the consequence of remobilizing uranium that is sequestered in the lower portion of the vadose zone (PNNL-17034). This is most pronounced beneath liquid waste disposal sites, such as the former 300 Area process trenches (316-5 waste site) and 307 process trenches (316-3 waste site). The increases in uranium concentrations when the water table is elevated are revealed by the uranium concentration trend at well 399-1-11, which is located within the footprint of the former 300 Area process trenches (Figure 2.12-10).

Uranium contamination is contained within the upper portion of the unconfined aquifer, i.e., saturated portion of the Hanford gravel.

The uranium plume maps shown in Figures 2.12-5 and 2.12-6 represent conditions in the upper portion of the unconfined aquifer. Several wells in the 300 Area have open intervals for sampling that are in the lower portion of the unconfined aquifer (e.g., wells with a “B” suffix and well 399-1-8). Uranium concentrations in samples from these wells are typically near background levels, suggesting little to no downward migration of contaminant uranium beyond the extent of saturated Hanford sediment. The highest value observed during FY 2007 was 12.6 µg/L at well 399-1-16B, which is located downgradient from the former 300 Area process trenches where uranium-bearing effluent was most recently released. The range in that well during FY 2007 was 7.2 to 12.6 µg/L, which is very close to the range assumed for natural uranium in saturated Hanford sediment. Many results for samples from other “B” wells are non-detects, suggesting that those wells may be completed in lithologic units with a lower background level of uranium. Also, uranium has not been detected in the fine-

grained subunit of Ringold Formation unit E where elevated levels of trichloroethene have been recently discovered (PNNL-16435; see also Section 2.12.1.2). At depths below the unconfined aquifer (i.e., wells with a "C" suffix), contaminant uranium has not been detected, as corroborated by new information from a recent limited field investigation (PNNL-16435).

Analysis of water samples from aquifer tubes near the Columbia River provides information on the lateral and vertical extent of uranium contamination.

Groundwater is also monitored at eight sites located along the 300 Area shoreline. Aquifer tubes were installed at multiple depths at each of these sites in 2004 and have now been sampled numerous times, with several sampling events conducted during FY 2007: December 2006/January 2007 and again in August 2007. The results of this sampling are shown on Figure 2.12-11, along the results from previous events. The values shown on the map are the highest observed at a tube site for a particular sampling event. The highest uranium value ever recorded for a tube sample is 394 µg/L, although this result is believed to be nonrepresentative of aquifer conditions. A more reasonable maximum value for recent uranium concentrations in groundwater near the river is ~200 µg/L, based on other results from aquifer tubes and from near-river monitoring wells.

Information derived from monitoring at tube sites is reasonably consistent with information based on sampling near-river wells in December 2006. For example, the highest values associated with samples from tubes are generally at sites adjacent to the central core area of the groundwater plume, as shown on Figure 2.12-11, i.e., near sites AT-3-3 and AT-3-4. An exception to this generalization occurs along the northern portion of the plume at the shoreline, where uranium concentrations are frequently higher in samples from tubes at site AT-3-1 than in samples from adjacent wells 399-1-10A and 399-1-1.

Several mechanisms contribute to differences in concentrations observed in samples from tubes and from wells. First, vertical variability in contamination characteristics will likely produce different results in samples collected from screened intervals of various lengths (e.g., 0.15 meter for tubes; 3 to 6 meters for wells). Second, wells may be more influenced than tubes by infiltrating river water, thus diluting the contaminant. Third, lateral variability in a plume causes different concentrations at different locations. In spite of these mechanisms that bias sampling results, data from tubes and wells contribute to defining the lateral extent and concentration range for the contaminant plume. Tube results also provide information on the vertical distribution of the contaminant.

A second representation of uranium results for samples from tubes and near-river wells is shown in Figure 2.12-12, which is a cross section oriented along the 300 Area shoreline. The tube results illustrate the variability in uranium concentrations within the aquifer, much of which is likely to be the result of lateral and vertical variability in concentrations within the plume. The position of near-river monitoring wells has been projected onto this cross section to provide perspective on the representativeness of samples collected from the various types of sampling facilities. Also projected onto the cross section is the contact separating the Hanford gravels from the underlying Ringold Unit E, as identified at the monitoring wells. This figure supports the conclusion that most uranium contamination is contained within the saturated Hanford gravels. The only tubes to be completed in the underlying Ringold Unit E (AT-3-3-D, and possibly AT-3-6-D and AT-3-7-D) show very low uranium concentrations. Finally, the maximum depth of the adjacent river channel is projected onto this cross section, to illustrate that the river channel incises the entire contaminated portion of the aquifer.

Uranium Near 618-10 Burial Ground and 316-4 Cribs. Uranium concentrations are elevated above the natural background level of 5 to 8 µg/L at several wells near the southeast side of the 618-10 burial ground and the former 316-4 cribs. Well 699-S6-E4A, which is located within the excavation footprint for the former cribs, has revealed the highest concentrations in the past, but has shown a steady decline during FY 2007, with September 2007 results well below the 30-µg/L drinking water standard (Figure 2.12-13). The cause for the earlier variability in uranium concentrations at this well is likely related to excavation and backfilling activities. Well 699-S6-E4L, which is located adjacent to the southeast side of the burial ground, also showed elevated uranium concentrations during excavation activities, although since January 2006, concentrations have followed a steady downward trend to values approximately one-half the drinking water standard.

2.12.1.2 Volatile Organic Compounds

Contaminants of concern or potential concern in groundwater beneath the 300 Area include trichloroethene and tetrachloroethene, along with their degradation product cis-1,2-dichloroethene. Although carbon tetrachloride was used in fuel manufacturing process, it has not been detected with certainty in the groundwater beneath the 300 Areas and has not been identified as a contaminant of potential concern. The origins of these volatile organic compounds in groundwater include past disposal to 300 Area facilities and movement into the 300 Area from off-site sources to the southwest. Beneath the 618-10 burial ground and former 316-4 cribs, organic compounds previously identified as of potential concern include tributyl phosphate and petroleum hydrocarbons.

Volatile organic compounds have been present in the upper portion of the 300 Area aquifer at low levels for many years. The sources are local waste disposal during operations and migration into the 300 Area from sources to the southwest.

300 Area Volatile Organic Compounds. During FY 2007, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene continued to be detected in 300 Area groundwater as monitored at wells and aquifer tubes along the river shoreline. In the upper portion of the unconfined aquifer (i.e., near the water table), concentrations of these compounds are lower than the relevant drinking water standard. In the lower portion of the unconfined aquifer, cis-1,2-dichloroethene has persisted at concentrations that exceed the drinking water standard at one well since monitoring began at that well in 1991. During 2006, elevated volatile organic compounds were also discovered at concentrations that exceed the drinking water standard in a sandy subunit of the unconfined aquifer. This discovery is at a depth in the aquifer that is lower than the depths typically covered by the existing monitoring well network.

Trichloroethene is the most widespread of the contaminant volatile organic compounds (Figure 2.12-14); the drinking water standard is 5 µg/L. It was detected at numerous wells within the 300 Area and in wells located to the southwest of the 300 Area, where additional potential sources for trichloroethene are located. The highest concentration observed during FY 2007 in the upper portion of the unconfined aquifer was 4.8 µg/L at well 399-1-7, which is located downgradient from the former 300 Area process trenches, a likely disposal site for volatile organic compounds. Trichloroethene is occasionally detected at wells screened in the lower portion of the unconfined aquifer (i.e., "-B" suffix well names), but at levels below the drinking water standard in recent years. At aquifer tube sites along the rivershore, trichloroethene was generally not detected in shallowest tubes, but was detected at greater depths in the unconfined aquifer, i.e., in the sandy subunit mentioned above. The discovery of volatile organic compounds in the sandy subunit is illustrated in Figure 2.12-15, which shows the concentrations observed in water samples collected

during drilling, and also the concentrations in relatively deep aquifer tubes at the river. (Note: New wells 399-3-21 and 399-3-22 are screened at depths equivalent to the "-B" suffix wells).

Tetrachloroethene was detected at very low concentrations (0.27 to 0.40 µg/L) at three wells during FY 2007; its drinking water standard is also 5 µg/L. Most of the detections are in wells screened at the water table in the central and southern portions of the 300 Area, with no definitive evidence pointing to a specific source. Historically, tetrachloroethene has been observed at concentrations as high as 38 ug/L near the south end of the former 300 Area process trenches, a known source site. However, during FY 2007, results for monitoring in that location are reported with a lab qualifier that indicates non-detection.

Cis-1,2-dichloroethene continues to be at concentrations that exceed the 70-µg/L drinking water standard at one well located along the downgradient flow path from the former 300 Area process trenches. The occurrence is at well 399-1-16B, which is screened in the lower portion of the unconfined aquifer. The concentration at this well rose during initial monitoring in the 1990s, and then remained remarkably constant until increased variability began in 2005 (Figure 2.12-16). The cause for the increased variability has not been identified. The origin for cis-1,2-dichloroethene is presumed to be decomposition of waste trichloroethene and tetrachloroethene. An additional degradation product under certain environmental conditions, vinyl chloride, has not been detected in 300 Area groundwater.

Recent drilling has revealed additional contamination at depth in the unconfined aquifer. High levels of trichloroethene are present in a fine-grained hydrologic unit, which transmits groundwater very slowly.

During the limited field investigation in the 300 Area (Section 2.12.3.2), volatile organic compounds were found in water samples collected in May 2006 during the drilling of four characterization boreholes 399-1-23, 399-3-18, 399-3-19, and 399-3-20 (PNNL-16435; see Figure 2.12-2 for locations). Concentrations found in shallow samples collected during drilling were comparable to those monitored by the routine network. However, at depths below typical screened intervals, some unexpectedly high concentrations were encountered in a fine-grained sandy interval within Ringold Unit E. Trichloroethene concentrations as high as 630 µg/L were encountered at well 399-3-20, which is located adjacent to the southeast corner of the 307 process trench (316-3 waste site). The trichloroethene degradation product cis-1,2-dichloroethene was also present in these samples, as was tetrachloroethene. Samples were collected from aquifer tube sites along the shoreline adjacent to well 399-3-18 have also revealed elevated trichloroethene concentrations (SGW-35028). An August 2007 result from tube AT-3-3-D showed a concentration of 290 µg/L. All of the drilling samples, and likely the sample from tube AT-3-3-D, came from a relatively fine-grained unit within the upper portion of the Ringold Formation (Figure 2.12-16).

The discovery of elevated volatile organic compounds at depth in the unconfined aquifer led to additional drilling to determine the extent of this contamination (SGW-32607). Four characterization boreholes were drilled in the region adjacent to the limited field investigation boreholes 399-2-5, 399-3-21, 399-3-22, and 399-4-14 (see Figure 2.12-2). Boreholes 399-2-5 and 399-4-14 were subsequently completed as water table monitoring wells, while 399-3-21 and 399-3-22 were completed with screens in the lower portion of the unconfined aquifer (equivalent to the earlier "-B" series of wells). Although the Ringold Unit E fine-grained unit was encountered, volatile organic compounds were not generally detected, and where they were detected, the values were < 1 µg/L (preliminary results). This suggests contamination

in a relatively small area that is located near the east end of the 307 process trenches and eastern side of the former South Process Pond. A report describing the results of this investigation is planned for early in 2008.

The travel time for volatile organic compounds to move from the area of discovery through the fine-grained sediment to the river would be long compared to travel times for contaminants in the overlying portion of the aquifer, because of the difference in permeability of these two hydrologic units. Once at the aquifer/river interface, discharge would therefore occur at a relatively low rate, and volatilization in the river flow would occur rapidly, thus reducing the concentrations in river water to negligible levels in a very short distance.

A groundwater plume containing tritium is present near the 618-11 burial ground. The source is presumed to be release of tritium from irradiated material in the burial ground.

Organic Compounds in the Outlying 300-FF-5 Subregions. Tributyl phosphate has been detected in the past in groundwater beneath the former 316-4 cribs (see Figure 2.12-3 for location map). The cribs received liquid waste associated with research conducted at the 321 Separations Laboratory in the 300 Area during the period 1948 to 1954 (BHI-00012). The waste included tributyl phosphate and uranium. Tributyl phosphate concentrations were elevated somewhat in early 2004, along with uranium, during the period when crib removal actions were underway. During FY 2007, estimated concentrations at well 699-S6-E4A, located within the footprint of the 316-4 cribs excavation, have ranged from 2.6 to 6.5 µg/L. The compound was not detected at nearby wells 699-S6-E4K and 699-S6-E4L during FY 2007. The semivolatile compound tends to bind to soil in the vadose zone, where it slowly degrades with time. It is not very soluble in water and, therefore, not widely dispersed via water transport mechanisms. A drinking water standard for tributyl phosphate has not been established.

Petroleum hydrocarbons (both diesel and gasoline) were detected in groundwater during the refurbishment of well 699-S6-E4A in 1995. The source may have been past leaks or spills from a fuel tank associated with operation of the former 316-4 cribs. Monitoring conducted between 1995 and 2005 has shown non-detections at wells in the general vicinity, and analyses for petroleum hydrocarbons are no longer performed.

2.12.1.3 Tritium

Tritium-contaminated groundwater in the 300-FF-5 Operable Unit is associated with two primary sources. One is the site-wide tritium plume that originates in the 200 East Area (see Figure 1.0-2 in Section 1.0 and Section 2.11.1.1) and extends beneath all subregions of the 300-FF-5 Operable Unit. The second source is the 618-11 burial ground, which is located just to the west of the Energy Northwest complex. Concentrations attributed to the site-wide plume as it reaches the 300-FF-5 subregions are shown in Figure 2.12-17 and are generally <20,000 pCi/L, depending on location. In the region just to the north of the 300 Area, concentrations are decreasing with time, as the site-wide plume attenuates by radioactive decay and dispersion (see discussion of 200 East Area tritium plume in Section 2.11.1.1).

Tritium at 618-11 Burial Ground. High concentrations of tritium were detected in early 1999 at well 699-13-3A, which is located immediately to the east of the 618-11 burial ground. Subsequent investigations (PNNL-13675) identified a contaminant plume that extends downgradient as a narrow plume of concentrations much higher than the surrounding site-wide plume from 200 East Area (Figure 2.12-18). Concentrations near the presumed burial ground source have

declined since peak values in 1999 and 2000, with the FY 2007 concentration at well 699-13-3A being the lowest value since monitoring began (Figure 2.12-19). The trend near the burial ground at well 699-13-3A suggests the possibility that an episodic event of unknown nature caused a release of tritium from buried materials and/or mobilization of tritium in the vadose zone. The removal of tritium sources in the 618-11 burial ground is expected to be no later than 2018, per Tri-Party Agreement (Ecology et al. 1989) Milestone M-016-00B. Changes in concentrations at wells farther away from the burial ground reflect migration of the plume, i.e., they include constant or gradually increasing concentrations trends.

The drinking water standard for nitrate is exceeded in groundwater that migrates into the southern portion of the 300 Area from sources to the southwest.

2.12.1.4 Nitrate

300 Area. Nitrate concentrations in groundwater beneath the 300 Area are generally lower than the 45-mg/L drinking water standard, except for the southern portion of the 300 Area (Figure 2.12-20). The relatively higher concentrations in the southern portion currently reflect the migration of nitrate-contaminated groundwater into the 300 Area from sources to the southwest, which possibly include agricultural and industrial activities. Gradually increasing concentrations are observed in wells and at shoreline sites as this nitrate-laden groundwater migrates into the 300 Area. Nitrate also migrates into the 300 Area from the northwest as part of the sitewide plume that originates in the 200 East Area, but at concentrations below the drinking water standard. During earlier periods, additional contributions to groundwater came from disposal of operations-related effluent and sanitary sewer systems. Throughout the 1970s and 1980s, nitrate concentrations in groundwater were somewhat higher than today, but still never greatly exceeded the drinking water standard. Remedial investigation monitoring results indicate a relatively constant level of contamination, but with some variability in concentrations, during the period 1992 to 2004 (PNNL-15127, Table 2.10).

618-11 and 618-10 Burial Ground Subregions. The outlying waste sites in the 300-FF-5 Operable Unit lie within the large contaminant plume that originates in the 200 East Area. Background levels for nitrate upgradient of the 618-11 burial ground are in the range of 20 to 40 mg/L, while in the vicinity of the burial ground concentrations are somewhat higher and exceed the 45-mg/L drinking water standard (Figure 2.12-20). For example, values during FY 2007 at well 699-13-3A were in the range 68 to 78 mg/L and at well 699-12-2C in the range 54 to 83 mg/L. The cause for these higher values near the burial ground is not fully understood; they may reflect some hydrogeologic characteristic that has caused retention of more contaminated groundwater from earlier years (PNNL-13228). Trends for the last several years indicate relatively constant nitrate levels, but with some variability. At the 618-10 burial ground, nitrate concentrations are generally consistent with values expected for the leading edge of the site-wide plume and are lower than the drinking water standard, with the exception of several results at 699-S6-E4L during the year (54 to 66 mg/L). The cause for these somewhat elevated results has not yet been identified.

2.12.1.5 Other Constituents

In addition to the contaminants of concern or potential concern that are formally recognized in decision documents, other constituents of interest are being monitored at various locations in the 300-FF-5 Operable Unit because they either exceed the drinking water standard or are helpful in characterizing contamination in the aquifer. These include radiological constituents gross alpha, gross beta, strontium-90, and tritium.

300 Area. Radiological contamination in the 300 Area, other than uranium, is generally at low levels. Gross alpha, which is associated with uranium, exceeds the drinking water standard of 15 pCi/L at numerous 300 Area wells, as expected because of the uranium plume. Gross beta, a second radiological criteria for drinking water, exceeded the 50-pCi/L standard at two 300 Area wells during FY 2007 and was elevated above background at numerous wells. Potential sources for this activity include daughter isotopes from radiological decay of uranium. Other potential contributors include low levels of technetium-99 and strontium-90 at isolated locations, and background levels from natural sources (e.g., potassium-40).

Radiological contamination indicators such as gross alpha and gross beta are used to monitor groundwater near source remedial action sites.

Strontium-90 has been detected at relatively low levels and as an isolated occurrence at well 399-3-11 in previous years (PNNL-13788). The result for a sample collected in December 2006 from well 399-3-11 was 2.6 pCi/L (the drinking water standard is 8 pCi/L). The well is located in the general vicinity of facilities that had strontium-90 in various waste streams, e.g., the 307 Retention Basins and associated underground transfer lines, which are known to have leaked (WIDS Unplanned Release UPR-300-1).

During the excavation of the 618-2 burial ground in 2006, unexpected occurrences of plutonium and other radiological contamination in the soil were encountered. 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 plutonium was not detected in groundwater samples. Previous measurements at other wells in the vicinity have not revealed plutonium. To further investigate this occurrence, three boreholes were drilled to groundwater at a strategic location within the excavated burial ground. Water samples were collected in December 2006 and analyzed for plutonium, uranium, and gross alpha/gross beta. All results for plutonium isotopes were nondetects. Uranium (total) was detected, but at levels consistent with natural background for the 300 Area. The results of this sampling are in HEIS (boreholes C5387, C5388, and C5399) and in data files attached to this report.

618-11 and 618-10 Burial Ground Subregions. These subregions lie within the large contaminant plume that originates at the 200 East Area. This site-wide plume contains the mobile radiological contaminants tritium, technetium-99, and iodine-129 (see Section 2.11 for description of the site-wide plumes). Tritium and technetium-99 associated with site-wide plumes are at detectable levels at the 300-FF-5 outlying waste sites, although iodine-129 is not. While detectable, the concentrations for site-wide plume contaminants at the two subregions are below drinking water standards.

Groundwater in the 300-FF-5 Operable Unit includes contaminants associated with the sitewide plume that originates in the 200 East Area.

At the 618-11 burial ground, tritium releases from the burial ground are superimposed on the site-wide plume, creating a localized plume that greatly exceeds the drinking water standard. Also, technetium-99 is somewhat elevated relative to expected site-wide plume concentrations in the vicinity of the burial ground, and may be the likely cause for gross beta concentrations that exceed the 50-pCi/L drinking water standard at well 699-12-2C. The concentration trends for technetium-99 and tritium at well 699-13-3A, which is adjacent to the burial ground, are similar, suggesting that small amounts of technetium-99 may have been associated with the release that created the local tritium plume in 1999~2000. At the 618-10 burial ground, gross alpha measurements also exceed the drinking water standard at two wells, presumably as the result of uranium contamination.

2.12.2 Operable Unit Activities

A decision for interim action involving groundwater beneath waste sites in the 300 Area portion of the 300-FF-5 Operable Unit was made in 1996 (ROD 1996b). The geographic extent of the operable unit under this record of decision was subsequently expanded in 2000 to include groundwater potentially impacted by waste sites in two outlying areas north of the 300 Area, i.e., beneath the 618-11 burial ground and 618-10 burial ground/316-4 cribs waste sites (EPA 2000). The interim remedy as stated in the record of decision is:

- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease.
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater contamination.

In 2004, activities were renewed on the operable unit's remedial investigation and feasibility studies. A new Tri-Party Agreement milestone (M-016-68) was developed in early 2005 for a Phase III Feasibility Study report on remedial action alternatives and a draft proposed plan. A work plan was prepared (DOE/RL-2005-41) that describes these additional efforts, which include updated computer simulations of groundwater flow and uranium transport; a limited field investigation involving multiple characterization boreholes; an update to the human health and ecological risk assessment; and an assessment of potential remedial action technologies for the 300 Area uranium plume. Work in all these areas continued during FY 2007 and is summarized in Section 2.12.3.

The remedial action objectives for interim action involving groundwater are:

- ***Protect receptors from exposure to contaminants in the groundwater and control the sources of contamination to minimize future impacts to groundwater.***
- ***Protect the Columbia River such that contaminants in the groundwater or soil after remediation do not result in an impact to the river that would exceed the Washington State surface water quality standards.***
- ***Contaminants of potential concern are identified in the record of decision as cis-1,2-dichloroethene, trichloroethene, and uranium. In 2000, the record of decision was expanded to include groundwater beneath outlying burial grounds, and added tritium and tributyl phosphate to the list of contaminants.***

2.12.2.1 Interim Remedial Action Monitoring

Implementation of the interim remedy specified in the record of decision (ROD 1996b; EPA 2000) is described in the operable unit operations and maintenance plan, as revised in 2002 (DOE/RL-95-73) and a sampling and analysis plan (DOE/RL-2002-11), which was revised in June 2006. The Executive Summary for the operations and maintenance plan describes specific monitoring objectives for the period of interim action:

- Verify that natural attenuation reduces groundwater contamination concentrations to drinking water maximum contaminant levels over a reasonable time period.
- Confirm that contaminant concentrations in the river seeps do not exceed ambient water-quality criteria or established remediation goals (drinking water standards).
- Validate contaminant fate and transport conceptual models.

Progress toward meeting these interim action monitoring objectives has been described in detail previously in an expanded groundwater report for FY 2004 (PNNL-15127). Continued monitoring since that report has produced information

that is generally consistent with historical trends, expectations, and existing conceptual models. The new information has been reported in the annual Hanford Site groundwater monitoring reports, and in an updated description of uranium contamination in the subsurface at the 300 Area (see Section 2.12; PNNL-17034).

Groundwater monitoring during the period of interim remedial action is conducted under an operations and maintenance plan.

For the 300 Area subregion, ~46 monitoring wells were in service during FY 2007 as part of the groundwater monitoring effort, reflecting a slight increase in number as the results of drilling associated with a limited field investigation. In addition, samples were collected from eight aquifer tube sites and two riverbank springs along the shoreline. Groundwater monitoring included semiannual sampling at many of the monitoring wells during December 2006 and June 2007, with the intent of characterizing average seasonal conditions (December) and the spring period of high water-table elevations (June) that are caused by the spring runoff to the Columbia River. The semiannual sampling applies to wells that monitor the upper part of the unconfined aquifer, including the water table. Other wells that monitor deeper horizons are sampled annually. A subset of wells, and all new wells, were sampled quarterly to provide more resolution of seasonal changes and to establish baseline conditions at their locations, respectively. The planned schedule for FY 2007 and comments on its implementation are listed in Appendix A.

At the 618-11 burial ground subregion, six wells are sampled quarterly for key constituents and semiannually for supporting constituents. All of these wells monitor the upper part of the unconfined aquifer. At the 618-10 burial ground/316-4 cribs subregion, six wells are sampled quarterly, semiannually, or annually, depending on proximity to the waste sites. All of the wells used at these two subregions monitor the upper part of the unconfined aquifer.

2.12.2.2 Status of Five-Year Review Action Items

Five-year reviews of the record of decision for 300-FF-5 Operaable Unit reaffirmed the cleanup goals and remedy selection, but call for additional investigation of potential remedial actions for uranium.

Because contamination remains in the 300-FF-5 Operable Unit, the CERCLA process requires a review of the effectiveness of the record of decision every 5 years. The second five-year review of the 300-FF-5 record of decision was conducted during the period summer 2005 through spring 2006. That review was published in November 2006 (DOE/RL-2006-20). One issue and associated action item are listed for the 300-FF-5 Operable Unit:

- **Issue 19**. Predicted attenuation of uranium contaminant concentrations in the groundwater under the 300 Area has not occurred. DOE is currently performing additional characterization and treatability testing in the evaluation of more aggressive remedial alternatives.

  Action 19-1. Complete focused feasibility study for 300-FF-5 Operable Unit to provide better characterization of the uranium contamination, develop a conceptual model, validate ecological consequences, and evaluate treatment alternatives. Concurrently test injection of polyphosphate into the aquifer to immobilize the uranium and reduce the concentration of dissolved uranium. (Due date September 2008).

The status of these activities is described in the following sections.

2.12.2.3 Phase III Feasibility Study

The work plan for the Phase III Feasibility Study for the 300-FF-5 Operable Unit (DOE/RL-2005-41) is focused on uranium contamination in the 300 Area subregion of the operable unit. This contaminant of concern has persisted at elevated levels far longer than predicted by the initial remedial investigation (DOE/RL-94-85).

Therefore, additional evaluation of potential remedial action technologies, i.e., evaluation beyond the information presented in the initial feasibility study report (DOE/RL-93-22), is underway. The objective for the Phase III Feasibility Study is to re-evaluate the remedy for the uranium plume. The ultimate goal for remedial action is to "…select remedial actions that have the potential to (1) restore, to the extent possible, the 300-FF-5 aquifer to its highest and best beneficial use, and (2) reduce risk to human health and the environment" (DOE/RL-2005-41, p. 7).

A feasibility study of remedies for uranium contamination in the 300 Area includes technology screening, additional hydrogeologic characterization, computer simulation of groundwater flow and transport, and updates to the conceptual site model.

The Phase III Feasibility Study includes several major components: Evaluation of potential engineered solutions to reduce the level of uranium contamination in 300 Area groundwater; a limited field investigation in the 300 Area to better define the distribution and geochemical characteristics of uranium; computer simulation of groundwater flow and transport in the 300 Area; updated descriptions of uranium contamination in the subsurface of the 300 Area; and an updated assessment of ecological and human health risks posed by contaminants in the 300-FF-5 Operable Unit groundwater.

Evaluation of Remedial Action Alternatives for 300 Area Uranium. During FY 2007, a report was prepared that describes the screening of potential remedial action technologies to achieve the goal stated above (PNNL-16761). The primary subset of technologies that offers promise are those that use in situ methods to reduce the mobility of uranium in the environment and/or cause permanent sequestration of uranium.

Limited Field Investigation Drilling Project, 300 Area. A limited field investigation was conducted during FY 2006 and FY 2007 in the 300 Area to obtain detailed information on (a) the distribution of uranium in the vadose zone and aquifer, and (b) the mobility characteristics of uranium encountered. The primary purpose for the limited field investigation was to provide information for the selection of potential remedial action technologies to reduce uranium contamination in the aquifer (DOE/RL-2005-47).

A limited field investigation involving four characterization boreholes provides new, detailed information on uranium in the vadose zone and aquifer.

Four characterization boreholes were drilled at locations chosen to be representative of various combinations of proximity to waste sites and the Columbia River. Continuous core was obtained whenever possible throughout the vadose zone and aquifer at each of these boreholes, two of which extended down through the entire unconfined aquifer (399-1-23 and 399-3-18). Water samples were collected at depth-specific intervals in the saturated zone; hydraulic tests were conducted at multiple depth intervals; and geophysical logging, including spectral gamma and neutron moisture logging, was conducted in each borehole to aid in defining stratigraphic contacts. Spectral gamma logging was also run in an attempt to identify contaminant uranium. However, the level of uranium contamination encountered was less than the detection limit for gamma logging. The four boreholes were completed as monitoring wells, with screened intervals placed across the water table (399-1-23, 399-3-18, 399-3-19, and 399-3-20).

Initial laboratory analyses included moisture content and total uranium in sediment samples from select core intervals, and solution chemistry for all groundwater samples. Subsequent laboratory analyses included particle-size distribution and solution chemistry of water extracts from sediment core samples. The results from this lab work have supported several geochemical investigations involving uranium sequestration in the vadose zone (PNNL-17031; PNNL-17034). Hydraulic test

results were evaluated to determine aquifer flow parameters. Geophysical logs were correlated, calibrated, and evaluated to ground truth the spectral gamma logging results with laboratory-derived uranium results.

The drilling and analytical results, along with initial interpretations, are available in a limited field investigation report (PNNL-16435). The limited field investigation provided significant amount of new information that supported an update to the conceptual model for uranium contamination in the subsurface at the 300 Area, including:

- **Updated Hydrogeologic Framework for the 300 Area**. The data associated with the revised framework is managed in EarthVision™ software. Several computer simulation activities draw from this database for input parameters, such as simulation of groundwater flow and transport (Section 2.12.3.3). Limited field investigation data corroborate earlier suggestions that uranium contamination is primarily restricted to sediment of the Hanford formation.
- **More Accurate Information on the Vertical Distribution of Uranium**. Prior to the limited field investigation drilling activity, it was assumed that easily measurable quantities of contaminant uranium would be encountered in the vadose zone at locations near former liquid waste disposal sites. It was also suspected that relatively elevated uranium concentrations are present in the lower vadose zone near the water table throughout the area of the plume.

Computer simulations of groundwater flow and transport have been developed at several scales to support the remedial investigation and various research projects being conducted in the 300 Area subsurface.

However, the results at each of the four characterization "type" locations did not reveal evidence for relatively high levels of contaminant uranium in the vadose zone, nor for an elevated zone of contaminants near the water table. Also, water samples collected from the saturated zone at various depths in the four boreholes revealed uranium concentrations which confirm that contamination is generally confined to the uppermost hydrologic unit (i.e., saturated Hanford gravels). Concentrations in the samples were consistent with those observed during routine groundwater monitoring.

Simulation of Groundwater Flow and Transport. Several groundwater flow and transport models are currently associated with the 300 Area. All rely on the same subsurface spatial data maintained in EarthVision™ software for their hydrostratigraphic framework, which has been updated using the results from the limited field investigation. These models use the computer code Subsurface Transport Over Multiple Phases (STOMP) for simulating flow and transport in the vadose zone and aquifer (PNNL-15782). Computer simulation of groundwater flow in the 300 Area is complicated by heterogeneous aquifer properties, and by frequent and rapid changes in the water-table configuration that are caused by fluctuations in Columbia River flows. Therefore, frequent measurement of water levels (e.g., hourly) are required to provide data for simulating water levels and groundwater flow.

The three-dimensional flow model that supports the Phase III Feasibility Study relies on a comprehensive database of hourly water-level measurements that were obtained during the early 1990s as part of the initial remedial investigation for the operable unit (PNL-9437). This model is being used to provide estimates for groundwater flux into and out of the aquifer beneath the 300 Area, including flux to the Columbia River. Additional detailed groundwater flow and transport simulations were prepared during FY 2007 for a smaller subregion of the 300 Area as part of a treatability test for uranium that involves injection of polyphosphate into the aquifer

(PNNL-16571). The domain of this submodel extends from the southern end of the former 300 Area process trenches (316-5 waste site) to the northern part of the former South Process Ponds (316-1 waste site), and includes the area that extends to the river. This submodel uses data collected from a high-frequency water-level monitoring network established in 2004 by the Remedial Action and Closure Science Project (see Section 2.12.3.4). The development and use to date of the three-dimensional groundwater flow simulations at the 300 Area are described in a report scheduled for release in early 2008.

2.12.2.4 Uranium Treatability Test, 300 Area

A field treatability test to reduce uranium concentrations in groundwater is underway in the 300 Area and involves injecting polyphosphate solution into the aquifer.

A treatability test to immobilize uranium in the aquifer beneath the 300 Area began during FY 2006 and continued during FY 2007 (PNNL-16008). The test initially involved determining the groundwater flow characteristics in the vicinity of the test site, including a bromide tracer test that started in January 2007. This was followed by injection of polyphosphate into the aquifer in June 2007. The site chosen to conduct the test near the south end of the former 300 Area process trenches, where the last waste effluents containing uranium were disposed, and a location where uranium concentrations are typically higher following the seasonally raised water table. The test site is near limited field investigation well 399-1-23 (see Figure 2.12-2). During the latter part of FY 2007, monitoring results following the test injection were being analyzed. A final report on performance of the method is scheduled for May 2008.

2.12.2.5 Research Activities Involving the 300 Area Uranium Plume

The Remediation and Closure Science Project supports the 300-FF-5 Phase III Feasibility Study and associated treatability tests with a comprehensive program of simulation, laboratory, and field research tasks. The project's objective is to develop improved conceptual and transport-simulation models for uranium movement from the vicinity of waste sites, through the vadose zone and aquifer, and into the Columbia River at the 300 Area. The initial results for some of the hydraulic aspects of this modeling are described in PNNL-15125. A more comprehensive description of groundwater flow and uranium transport is described in Yabusaki et al. (2008). The research provides a scientific foundation for topics related to multi-component uranium surface complexation, kinetically controlled uranium mass transfer between mobile and less mobile phases, and spatially and temporally variable transport processes. The research focuses on developing the capability for long-term predictions of uranium migration and fate, which are required for scientifically defensible evaluations of remedial action alternatives .

Laboratory investigations continued during FY 2007 and included mineralogical analyses of sediment collected during the limited field investigation, characterizing uranium geochemistry in sediment samples from above and below the water table, and refining a surface complexation adsorption-desorption model that accounts for the effects of pore water pH, bicarbonate concentration, and sediment texture. Also, laboratory work on uranium exposure and uptake by aquatic organisms has been conducted during FY 2007.

Field investigations included detailed study of the hyporheic zone along the 300 Area shoreline. A report was prepared that describes the results of work conducted between 2004 and 2006, and includes a description of numerous methods to monitor the interface between groundwater and river water, and to help define stratigraphic

contacts (PNNL-16805). The results of this work illustrate the considerable impact that interaction between the groundwater and river hydraulic systems has on the discharge of the uranium plume into the Columbia River (Fritz and Arntzen 2007). Geophysical investigations also continued during FY 2007, during which electrical resistivity and self-potential measurements were used to estimate spatially distributed hydrologic and geochemical properties of the sediment (report being prepared by Pacific Northwest National Laboratory). In time-lapse mode, the data will be used to identify the contributions of recharge, and the mixing of river and groundwater.

The DOE is supporting a variety of applied research activities in the 300 Area, including the geochemistry and mobility of uranium, interaction between the aquifer and river, and methods to remediate uranium contamination.

Conceptual models for the geochemistry of uranium in the subsurface environment have evolved as the result of these laboratory studies and field investigations. The new laboratory results and field observations are being incorporated in computer simulations of uranium transport in the vadose zone and aquifer. These simulations include provisions for the dynamic hydrologic environment created by Columbia River stage fluctuations, which is a necessity for developing accurate predictions of where contaminants are likely to be exposed in the river environment, and at what levels.

Update to the Conceptual Model for Uranium in the 300 Area Subsurface. During FY 2007, an updated description of uranium contamination in the subsurface at the 300 Area was completed, with the results described in PNNL-17034. The update included a detailed description of conditions as revealed by the monitoring program, updates to the hydrogeologic framework as a result of the limited field investigation (PNNL-16435), development of the 3-D computer simulations of groundwater flow, and a detailed discussion of the geochemical controls on uranium inventories and uranium mobility.

The focus for the update to this conceptual model for uranium was to describe where uranium might be sequestered in the environment and the cause for the persistence of the plume in groundwater. The information provided in PNNL-17034 supports the technical basis for selecting a potential remedial action technology (see Section 2.12.3.1) and its implementation if selected as the remedial action alternative. Key elements of the conceptual model are:

- Uranium continues to be supplied to groundwater at rates that approximate the rates at which uranium is lost via discharge to the Columbia River and via a water supply well.
- The vadose zone beneath former liquid waste disposal sites is a likely source area for residual contaminant uranium that continues to feed the groundwater plume.
- A more widespread zone through which the water table rises and falls also influences the rate at which contaminant uranium re-supplies the groundwater plume.
- Bank storage of Columbia River water influences the concentrations, and potentially the sequestration, of uranium carried by groundwater toward the river.

A report is now available that provides an updated description of uranium contamination in the 300 Area subsurface.

The next significant update to this conceptual model is likely to result from uranium transport simulation efforts that are being conducted under the Remediation Science and Technology project (Section 2.12.3.4) and the DOE's Integrated Field-Scale Challenge program, which is using the 300 Area uranium plume as a field research site for uranium mobility investigations (PNNL-17067).

Update to Human Health and Ecological Risk Assessment. An update to the initial qualitative human health and ecological risk assessment for the 300-FF-5 Operable Unit (DOE/RL-93-21) was performed during FY 2006, as part of providing information to support the Phase III Feasibility Study. The three operable unit subregions, i.e., 300 Area, 618-11 subregion, and 618-10/316-4 subregion were considered in the assessment, as was the city of Richland. Impacts were assessed for five current human use scenarios, plus hypothetical direct access to drinking water from the aquifer and Columbia River. The scenarios are residential farmer, child recreation, casual recreation, avid recreation, and industrial. Food product concentrations for human scenarios with food consumption (i.e., residential farmer, and casual and avid recreation) were calculated in the ecological risk assessment. The results for the assessment were published in FY 2007 (PNNL-16454).

The updated ecological assessment models 81 aquatic and riparian species. The 300 Area is assumed to lie within the riparian zone. The upland zone in this assessment is the 618-11 burial ground and the 618-10 burial ground/316-4 cribs waste sites. In these upland subregions, groundwater is at sufficient depth to prevent access by ecological organisms under current conditions. Therefore, no ecological assessment was done for these outlying subregions. The results of this update are consistent with the earlier findings, and also with the recently completed 100/300 Area River Corridor Baseline Risk Assessment (DOE/RL-2007-21). No changes to the list of contaminants of potential concern for the operable unit have been recommended by these risk assessments.

2.12.2.6 Volatile Organic Compounds Investigation

During the limited field investigation for uranium (see Section 2.12.3.2), volatile organic compounds were discovered at elevated levels in groundwater associated with a fine-grained interval within Ringold Unit E (PNNL-13645). This fine-grained interval is located stratigraphically deeper than the majority of well screens used for groundwater monitoring groundwater in the 300 Area. The primary contaminant is trichloroethene and the maximum concentration encountered was 630 µg/L (see Section 2.12.1.2 for further description). The discovery occurred in the vicinity of the east sides of the 307 process trenches and former South Process Ponds, and prompted the need for additional characterization activities.

Four boreholes were drilled to further investigate the discovery of elevated concentrations of volatile organic compounds at depth in the 300 Area aquifer.

A plan for additional characterization drilling at three new locations, and one deep boring at a limited field investigation boring location, was prepared (SGW-32607). The drilling took place in September 2006 and again in May through November 2007. Initial results indicate that the contamination is limited to the fine-grained interval within Ringold Unit E, and to the area east of the 307 process trenches and former South Process Ponds. One aquifer tube (AT-3-3-D) is completed in this fine-grained interval and revealed a trichloroethene concentration of 290 µg/L for a sample collected in September 2007. The three boreholes that have revealed elevated trichloroethene levels in the fine-grained unit are 399-3-18, 399-3-20, and 399-3-21 (see Figure 2.12-for locations).

A report is planned for early 2008 that will describe the results of the additional characterization drilling and a review of historical operations and potential volatile organic compound source locations. A description of the potential area of riverbed where the fine-grained unit is exposed will be included, based on work performed under the Remediation and Closure Science Project (PNNL-SA-56035).

2.12.3 Facility Monitoring: RCRA Compliance at 300 Area Process Trenches

The former 300 Area process trenches (316-5 waste site) received effluent discharges of mixed waste from fuel fabrication and nuclear research laboratories in the 300 Area from 1975 through 1994. The trenches were remediated in 1991 under a CERCLA expedited response action by scraping contaminated soil to the north end of the facility (DOE/RL-92-32). Additional remedial actions were undertaken in 1997 and 1998 by excavating more contaminated soil and ancillary structures (BHI-01164), and final backfilling with clean soil was completed in early 2004 (DOE/RL-2004-74).

In addition to the groundwater monitoring conducted as part of 300-FF-5 Operable Unit activities under CERCLA, this former liquid waste disposal facility has been monitored under the requirements of RCRA for hazardous waste constituents, and under the Atomic Energy Act for uranium. Hazardous constituents and uranium are discussed jointly with respect to RCRA so that a comprehensive description of potential impacts to groundwater associated with this disposal unit is presented. With respect to treatment, storage, or disposal units regulated under RCRA, the DOE has the responsibility and authority to regulate radiological source, special nuclear, and by-product materials at DOE-owned nuclear facilities (see discussion in Section 1.2). Groundwater monitoring required by RCRA is conducted in accordance with WAC 173-303-645(11), "Corrective Action Program," and the Hanford Facility RCRA Permit, Part VI, Chapter 1 (Ecology 1994a). The modified closure plan (DOE/RL-93-73), which is incorporated into the Hanford Facility RCRA Permit, states that groundwater remediation is deferred to the CERCLA 300-FF-5 Operable Unit.

Groundwater near the former 300 Area process trenches continues to be monitored under a RCRA corrective action program.

During FY 2007, RCRA groundwater monitoring for this disposal unit was conducted under a plan that has been in effect since 1997 (WHC-SD-EN-AP-185, as amended). Constituents monitored are uranium (total), cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. (Note: Uranium was included in the monitoring plan for completeness and incorporated by reference into the Hanford Facility RCRA Permit [Ecology 1994b].) The sampling schedule for the RCRA network of eight wells was designed to accommodate two semiannual sampling events, with four time-independent samples collected during each period. This has resulted in a sampling frequency of monthly for 8 months of the year (December, January, February, and March; June, July, August, and September). During FY 2007, this sampling was essentially accomplished as planned (see Appendix B), and reports on the effectiveness of the corrective action monitoring program were prepared semiannually per WAC 173-303-645(11)(g) (PNNL-16492; SQW-35164). The eight wells are situated at four locations: one upgradient (north of the former facility) and three downgradient (east, southeast, and south of the facility). Two wells are present at each location, with one screened near the water table and a second in the lower portion of the unconfined aquifer.

Only two of the four constituents of interest for RCRA monitoring at the former disposal facility continued to exceed their respective drinking water standards during FY 2007, i.e., cis-1,2-dichloroethene and uranium. Cis-1,2-dichloroethene remained at concentrations approximately twice the 70-µg/L drinking water standard at downgradient well 399-1-16B, which monitors conditions in the lower portion of the unconfined aquifer (Figure 2.12-16). Other volatile organic compounds, such as trichloroethene and tetrachloroethene, continue to be detected in wells near the disposal unit, but at levels below their respective drinking water standards. Uranium remained above the 30-µg/L drinking water standard in all three of the downgradient wells screened in the upper portion of the unconfined aquifer (Figure 2.12-8)

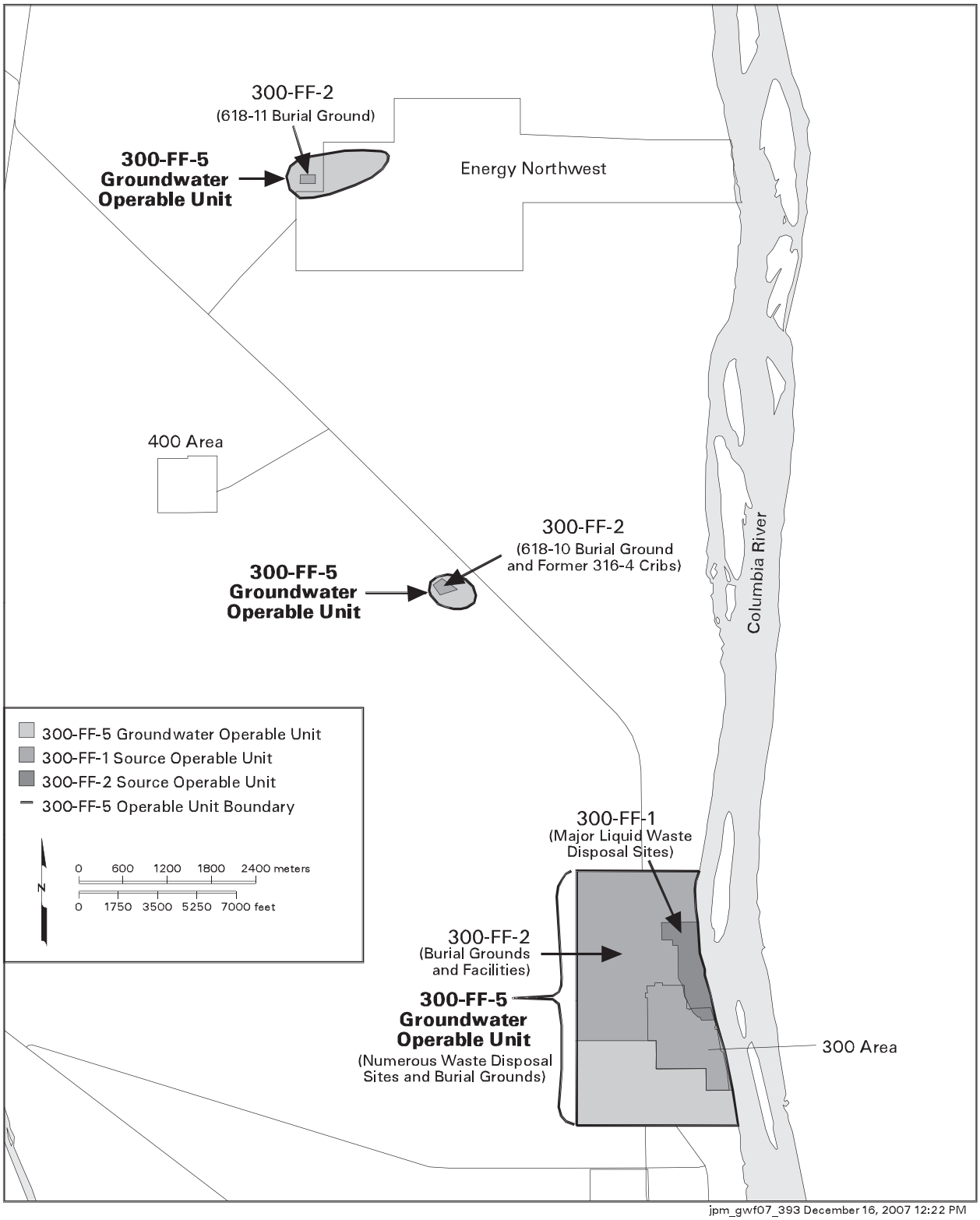


Figure 2.12-1. Operable Units Defined for the 300 National Priorities List Site

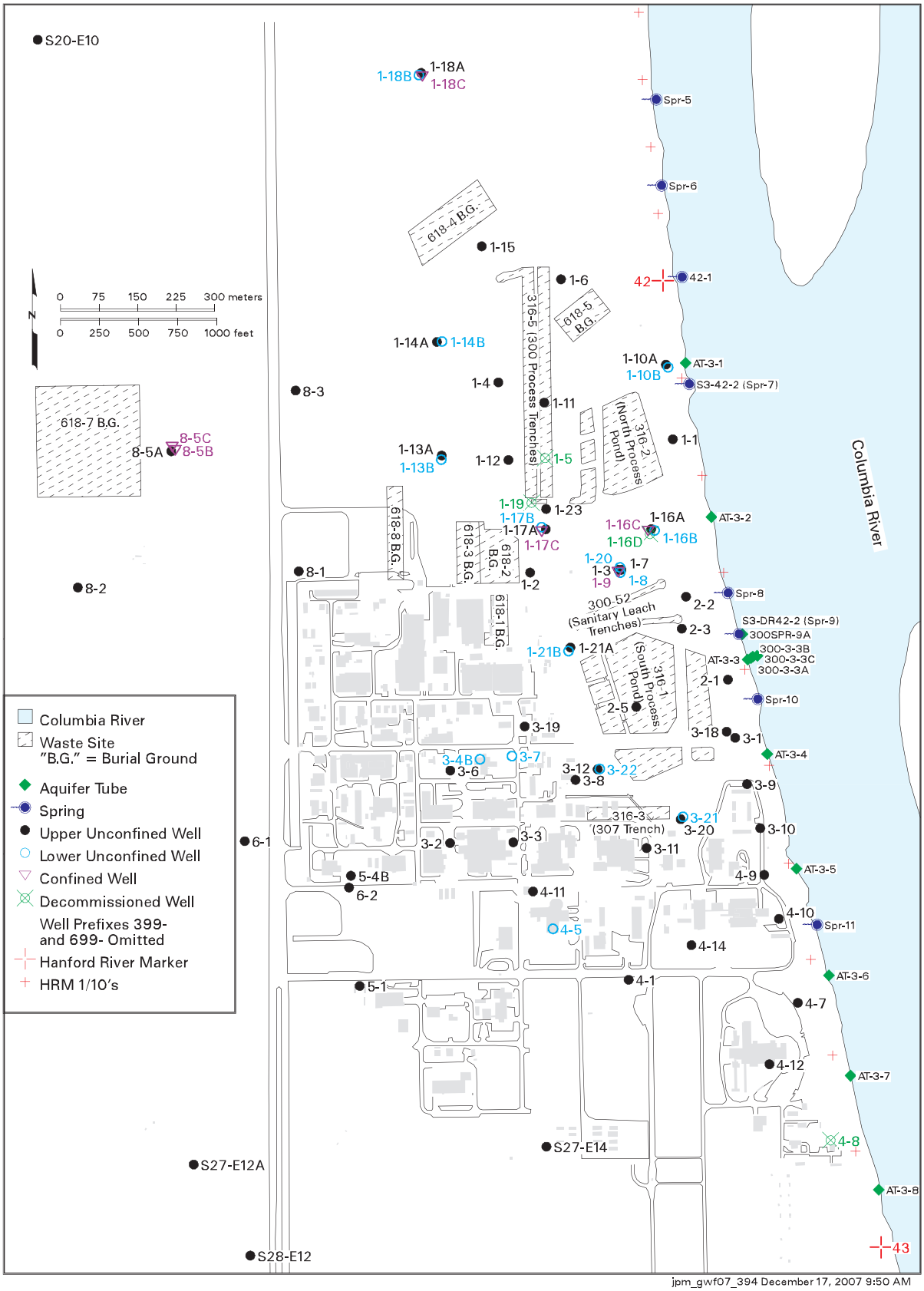
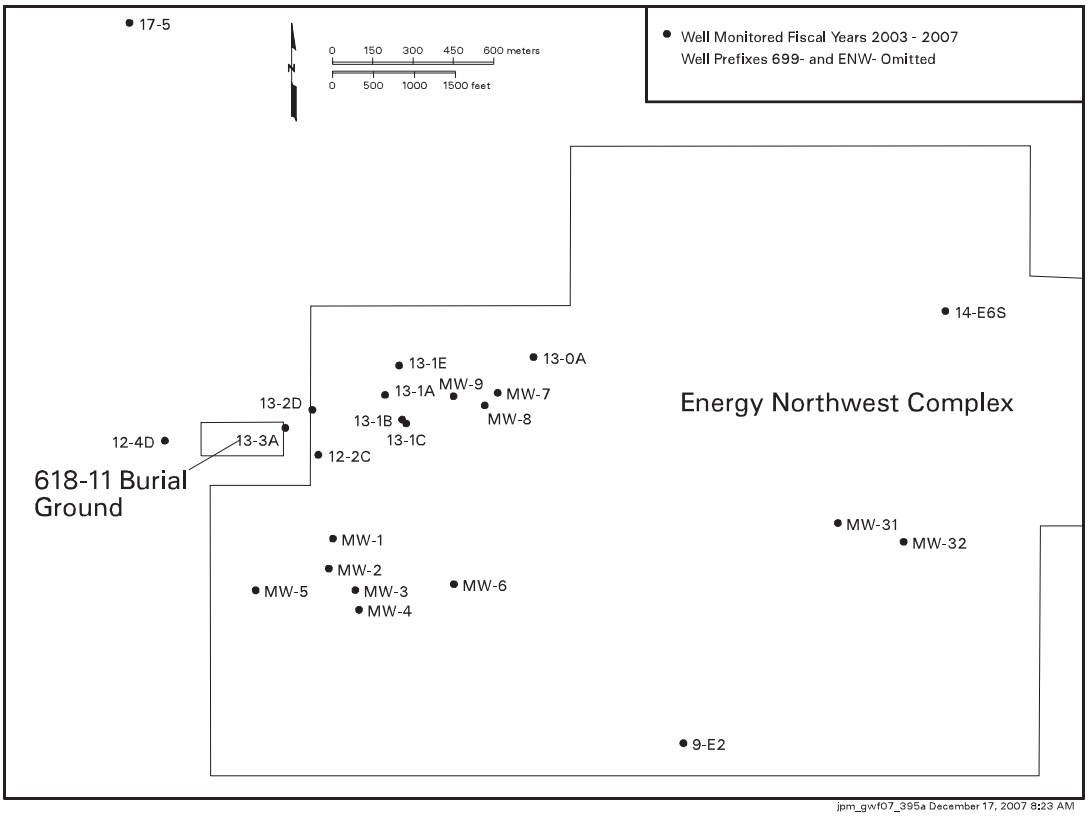


Figure 2.12-2. Groundwater Monitoring Wells in 300 Area



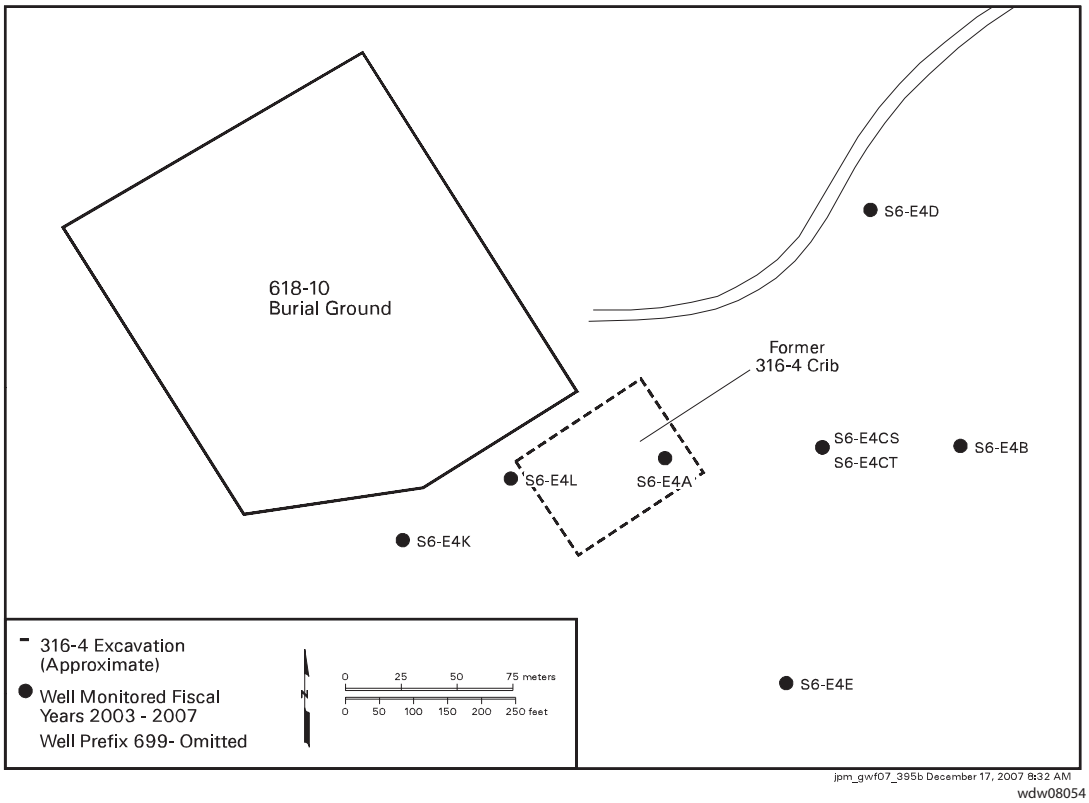


Figure 2.12-3. Groundwater Monitoring Wells in Outlying 300-FF-5 Subregions

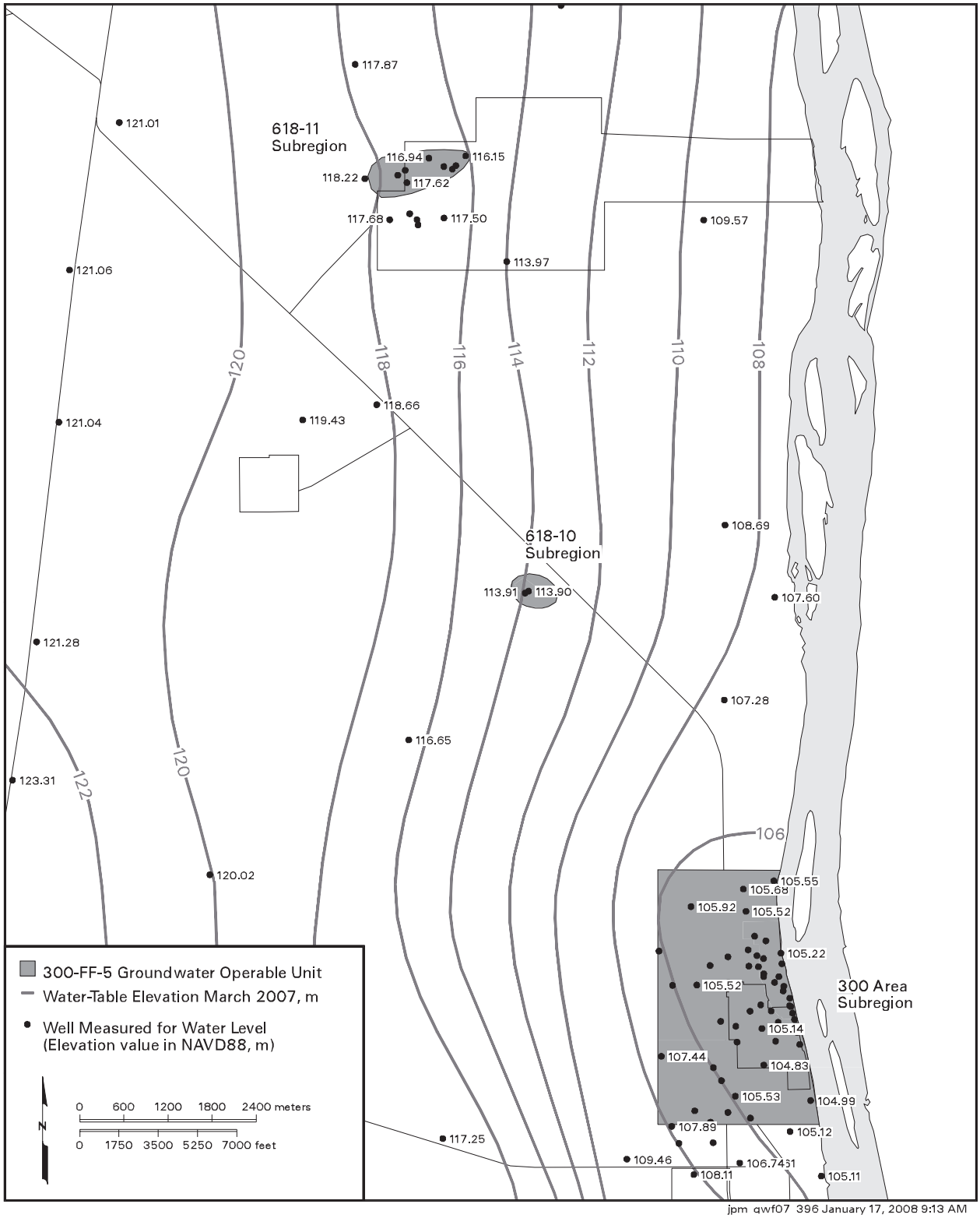


Figure 2.12-4. Water-Table Map for 300-FF-5 Interest Area, March 2007

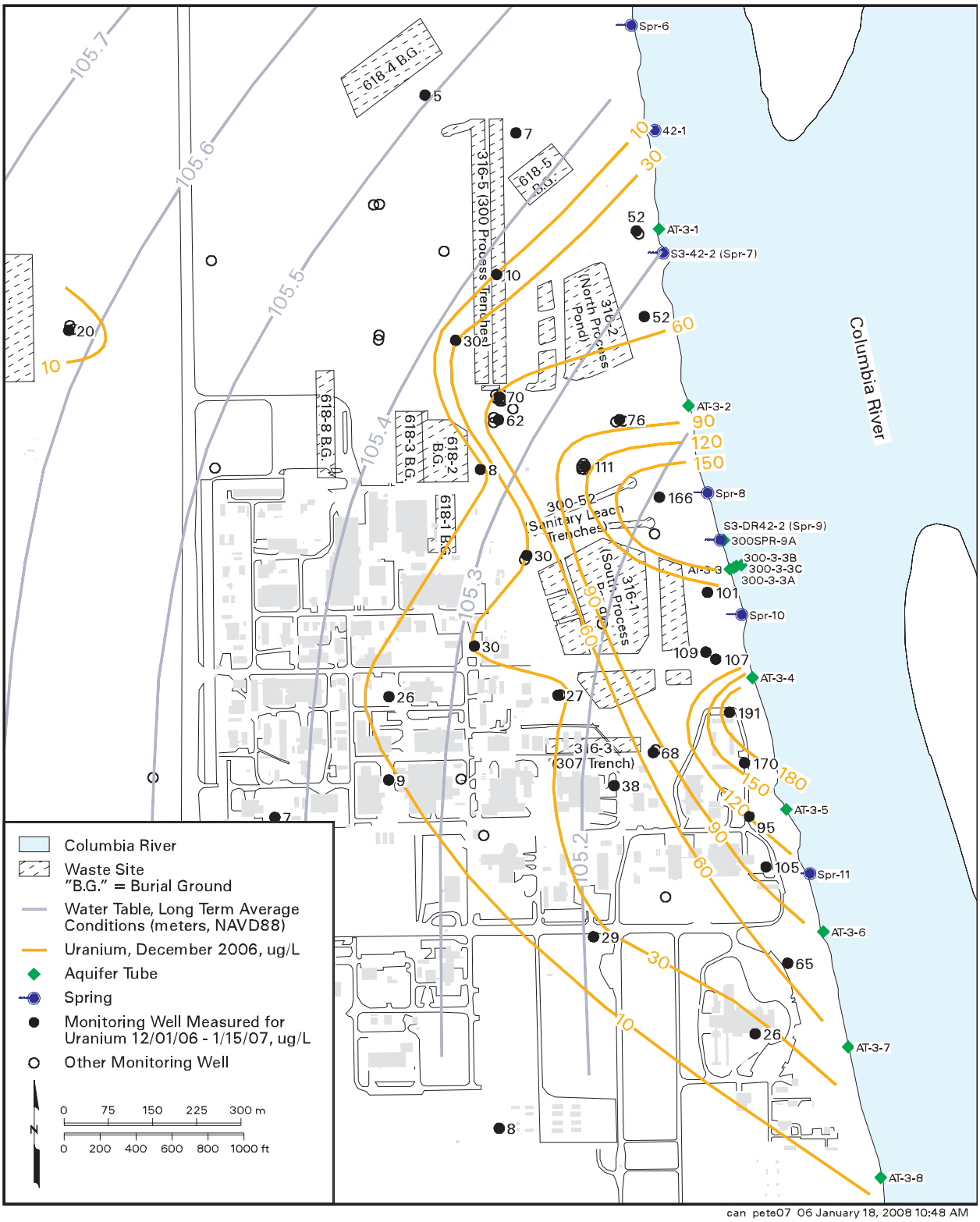


Figure 2.12-5. Uranium Concentrations in Upper Part of Unconfined Aquifer Beneath 300 Area, December 2006

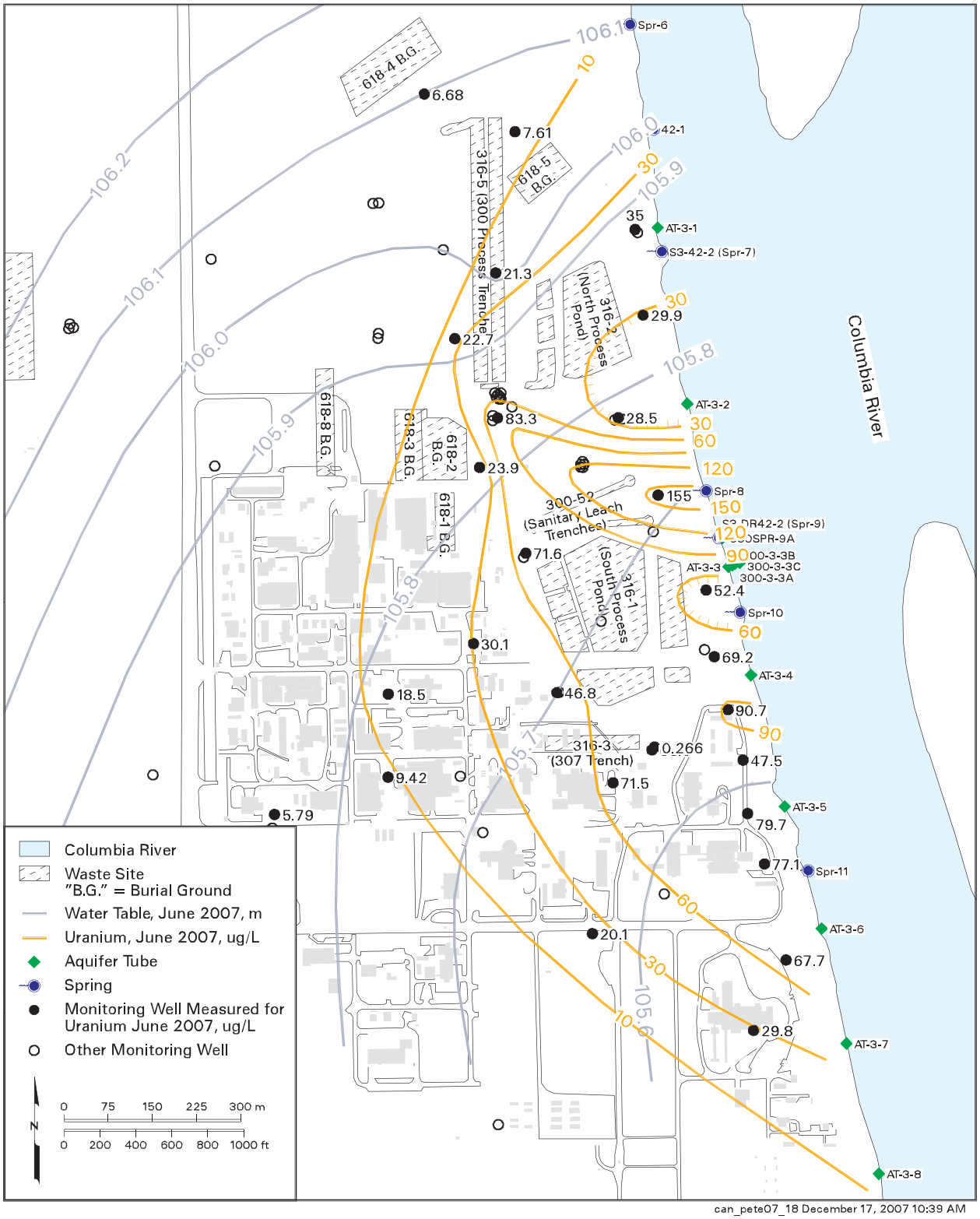
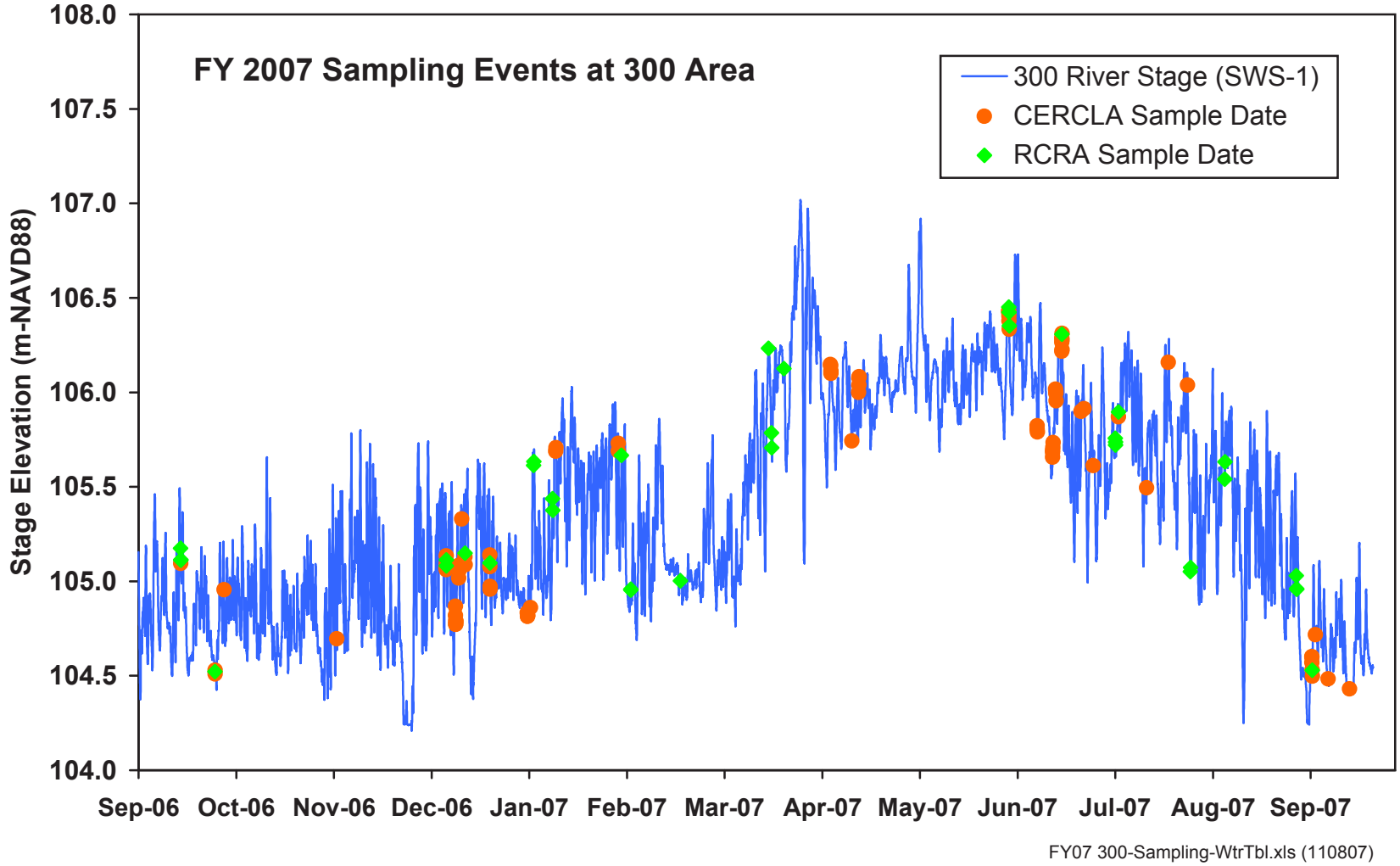


Figure 2.12-6. Uranium Concentrations in Upper Part of Unconfined Aquifer Beneath 300 Area, June 2007



Figures 2.12-7 Columbia River Stage at 300 Area and Groundwater Sampling Dates During FY 2007

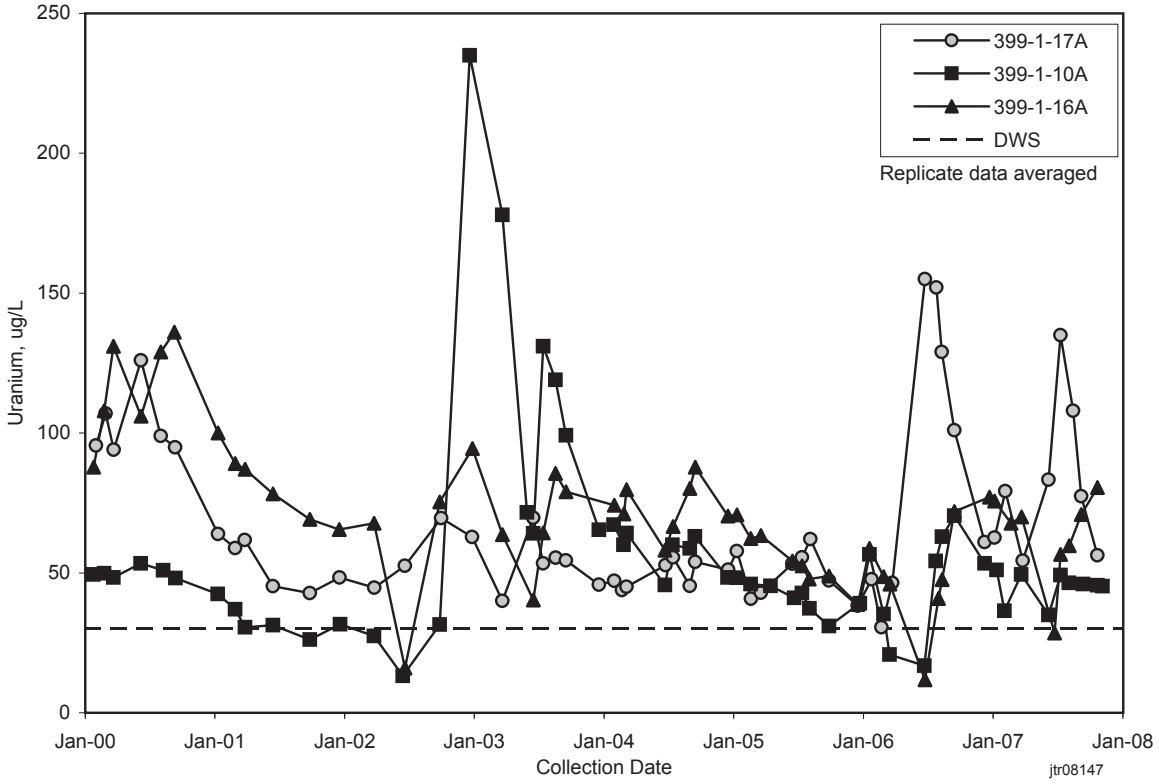


Figure 2.12-8. Uranium Concentrations in RCRA Monitoring Wells Downgradient from Former 300 Area Process Trenches

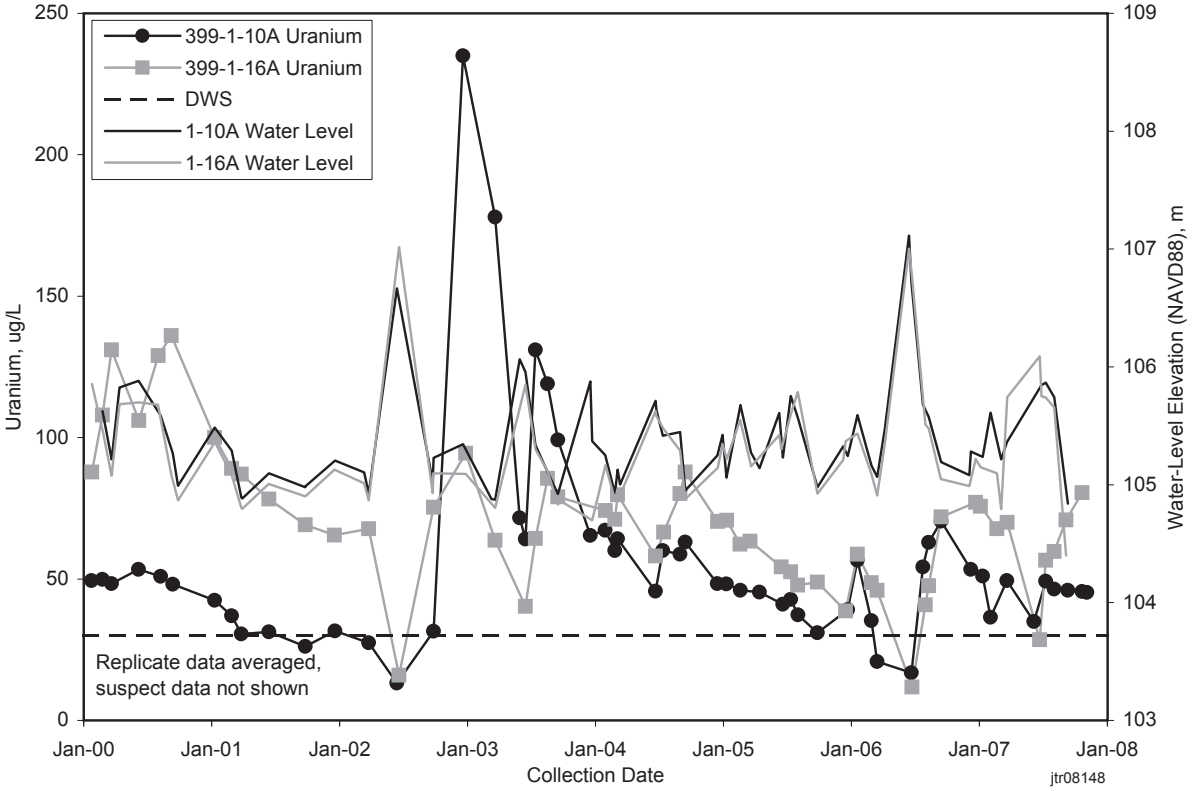
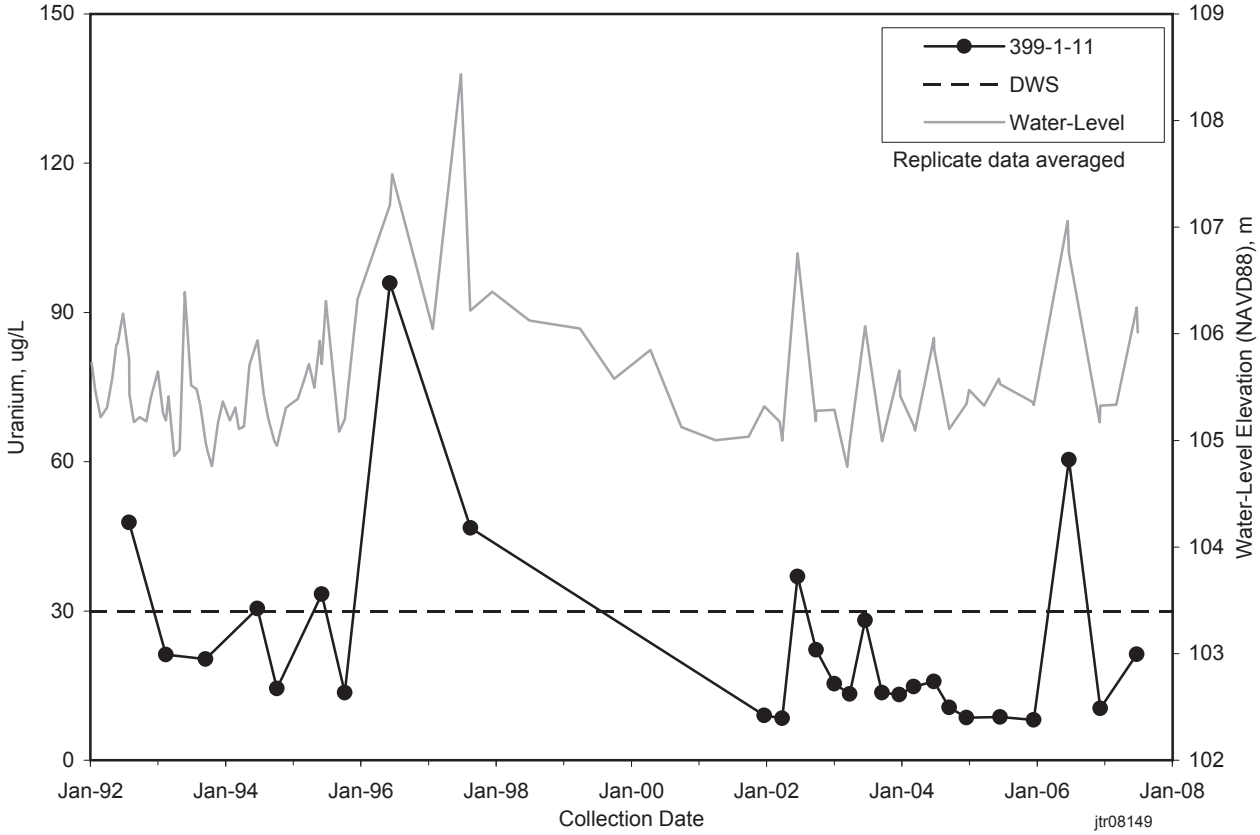


Figure 2.12-9. Correlation Between Uranium Concentrations and Water-Table Elevation at Wells Close to Columbia River



Figures 2.12-10. Correlation Between Uranium Concentrations and Water-Table Elevation at Well Near Waste Site

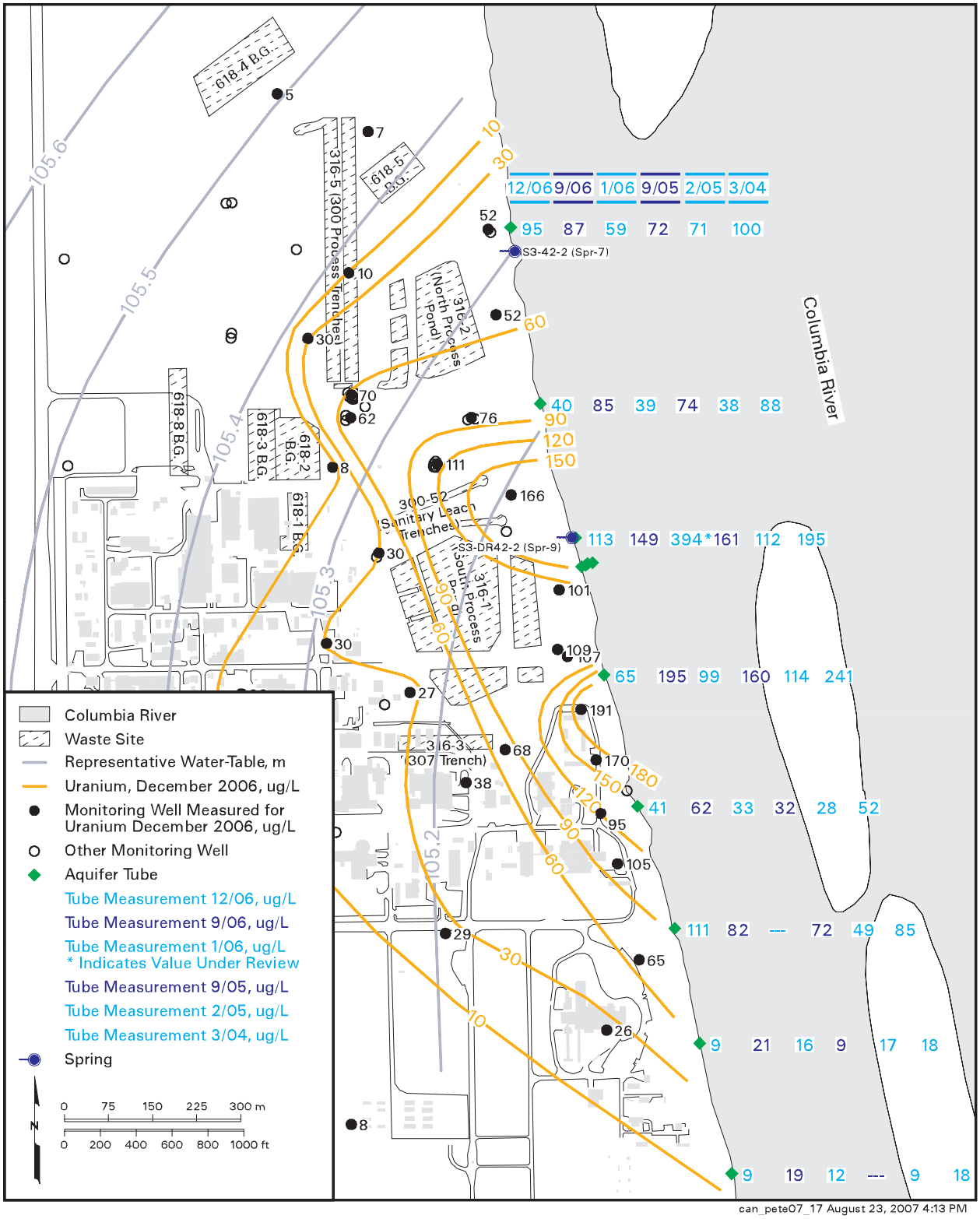
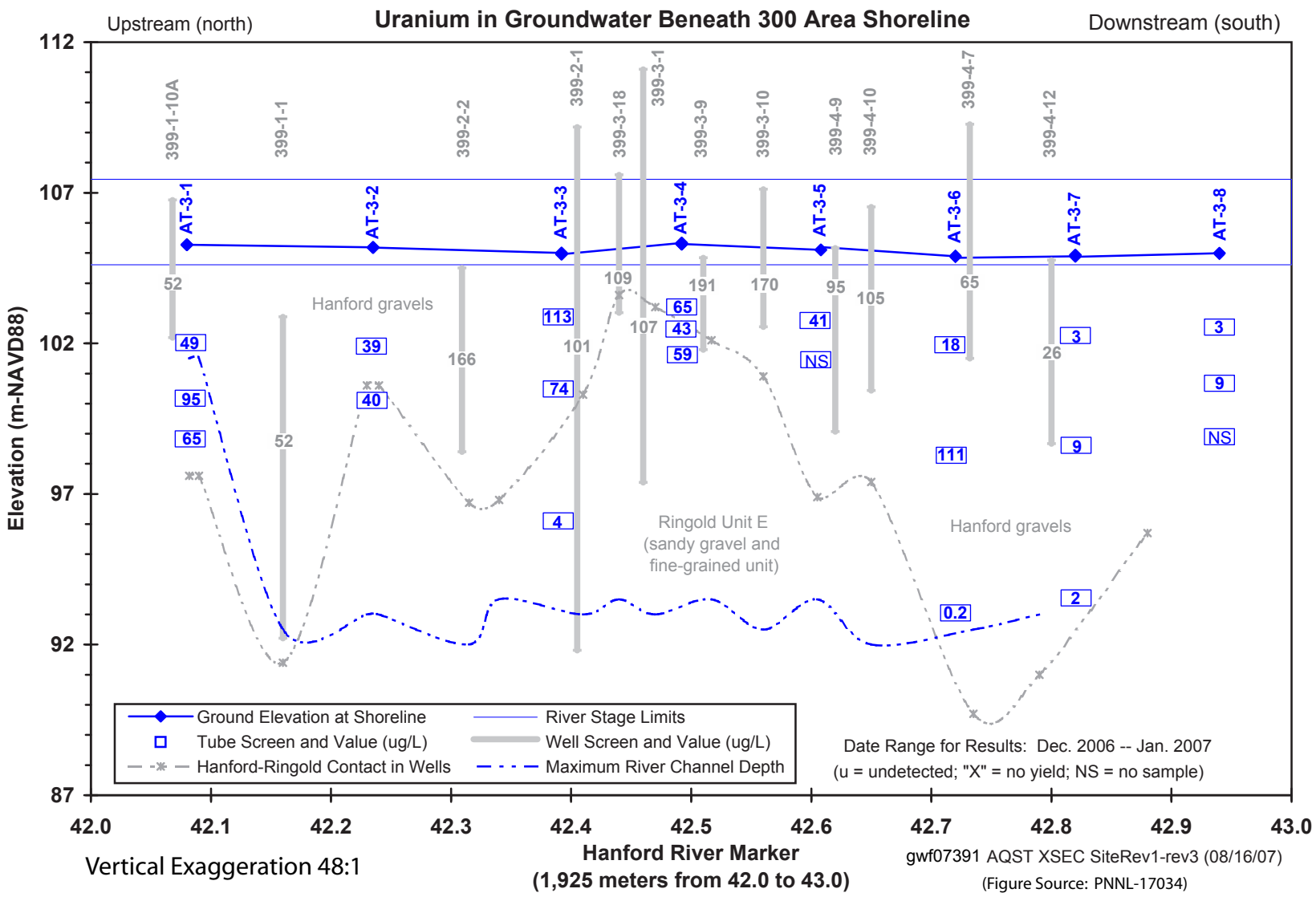
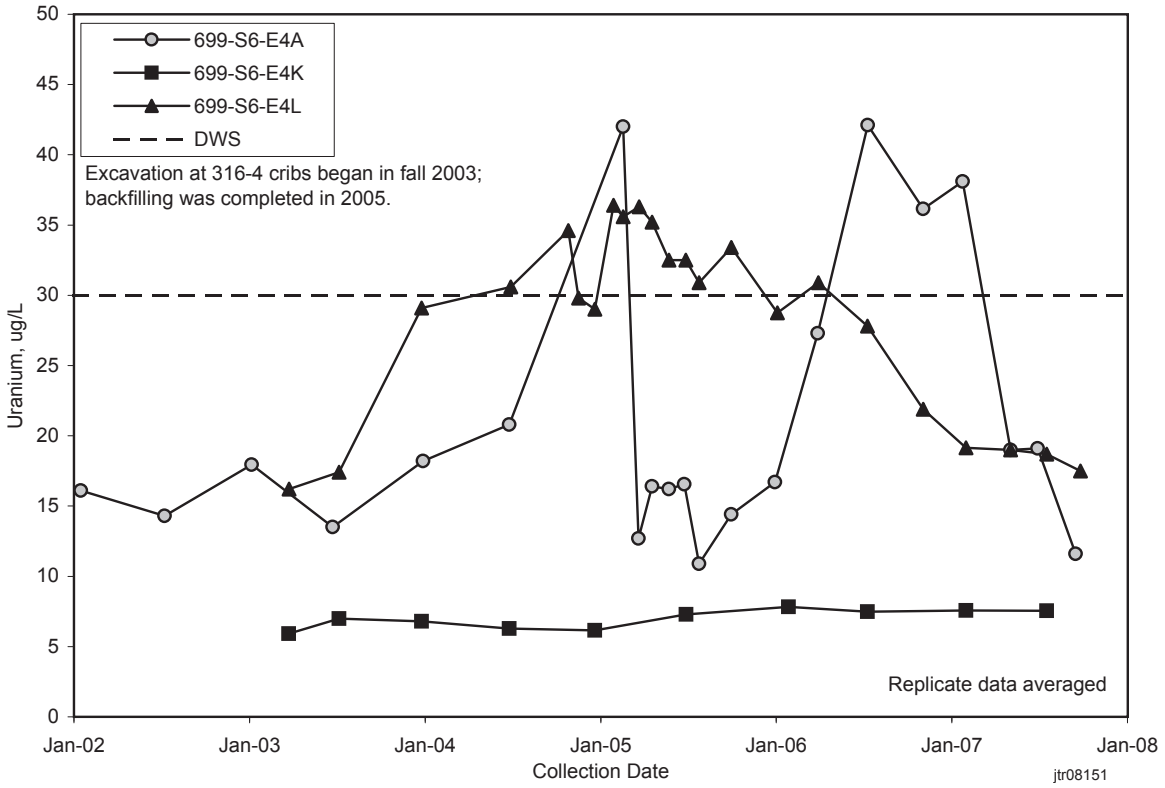


Figure 2.12-11. Uranium Concentrations at Aquifer Tube Sites Along 300 Area Shoreline (from PNNL-17034)



Figures 2.12-12. Cross Section Showing Uranium Concentrations at Multiple Depths in Aquifer Tubes Along 300 Area Shoreline



Figures 2.12-13. Uranium Concentrations at Wells Near 316-4 Cribs Remedial Action Site

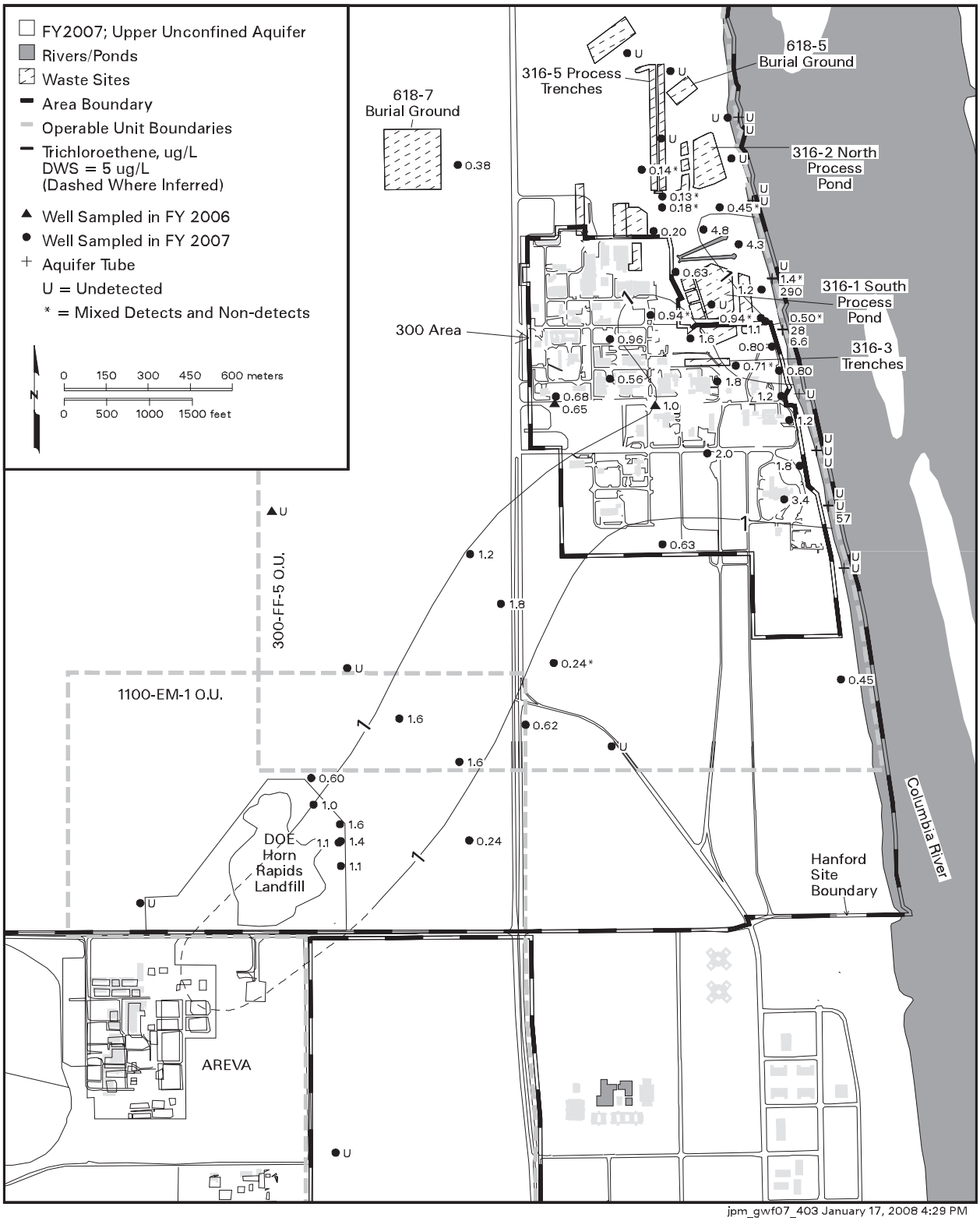


Figure 2.12-14. Average Trichloroethene Concentrations in the Vicinity of 300 Area, Upper Part of Unconfined Aquifer

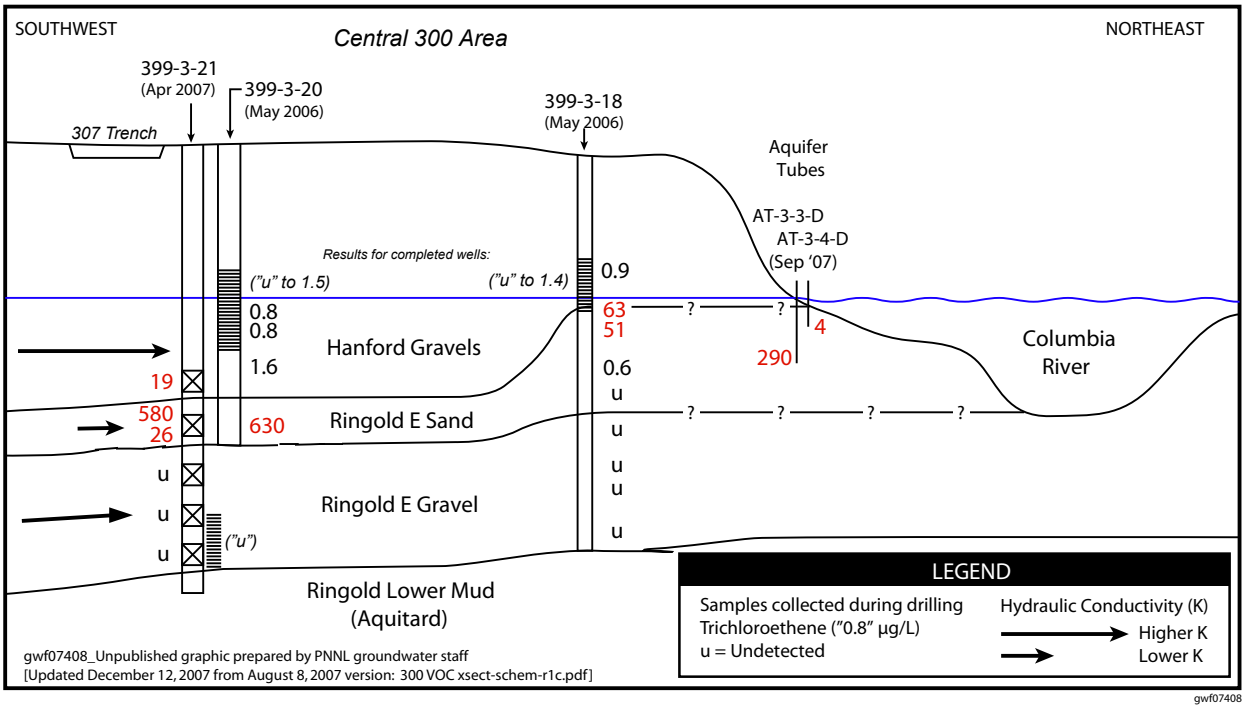


Figure 2.12-15. Trichloroethene in Samples Collected during Limited Field Investigation and Volatile Organic Carbon Investigation Drilling

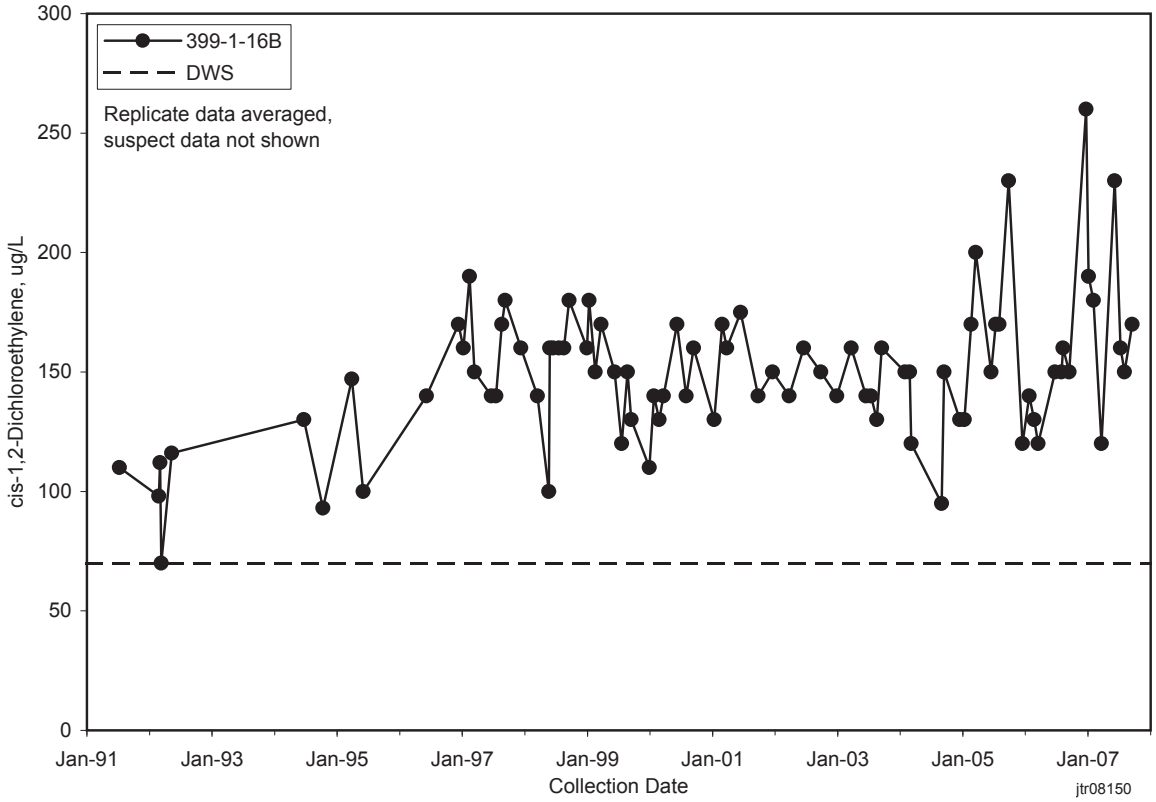


Figure 2.12-16. Concentrations of cis-1,2-Dichloroethene at Well 399-1-16B Near Former 300 Area Process Trenches

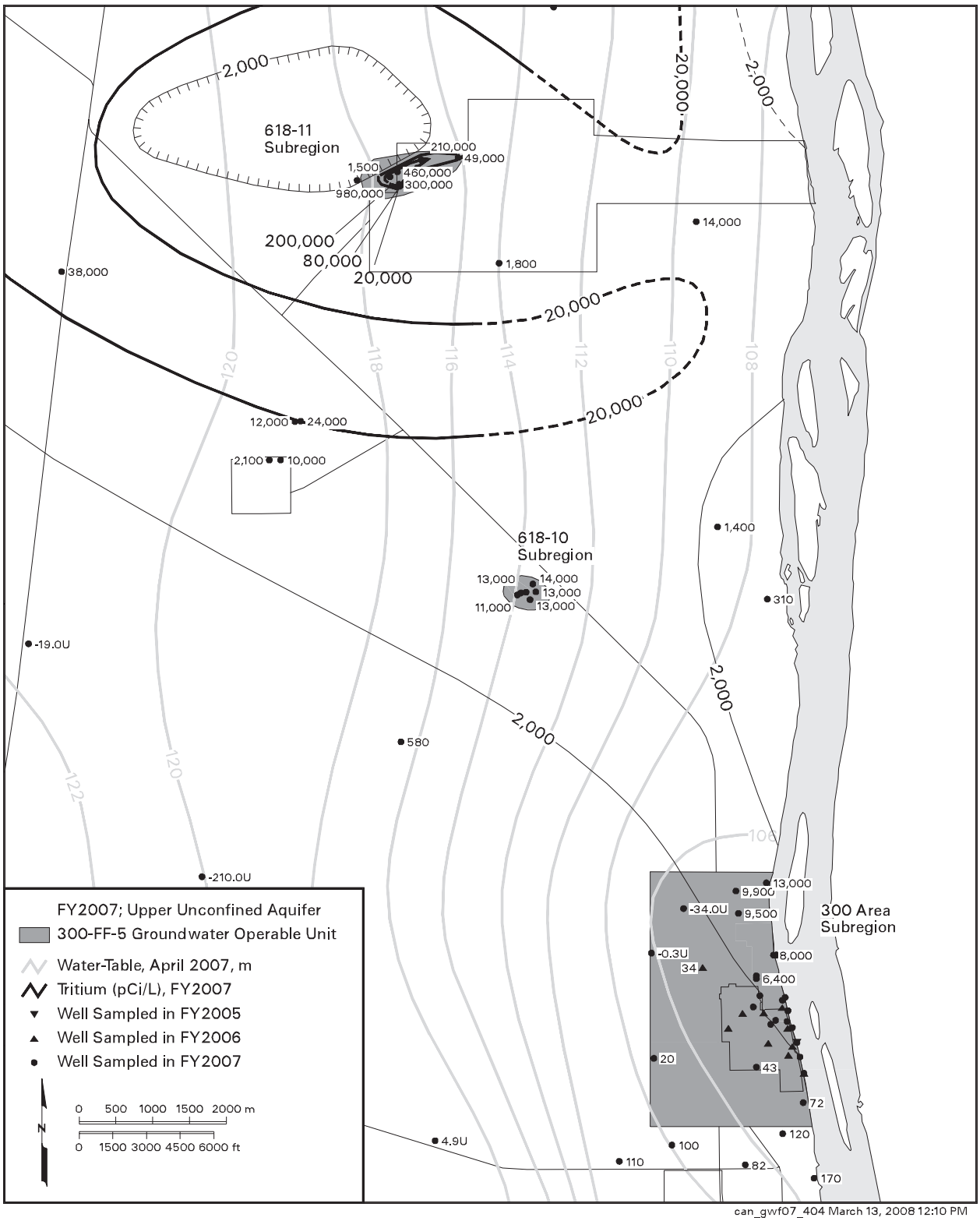


Figure 2.12-17. Average Tritium Concentrations in 300-FF-5 Operable Unit, Upper Part of Unconfined Aquifer

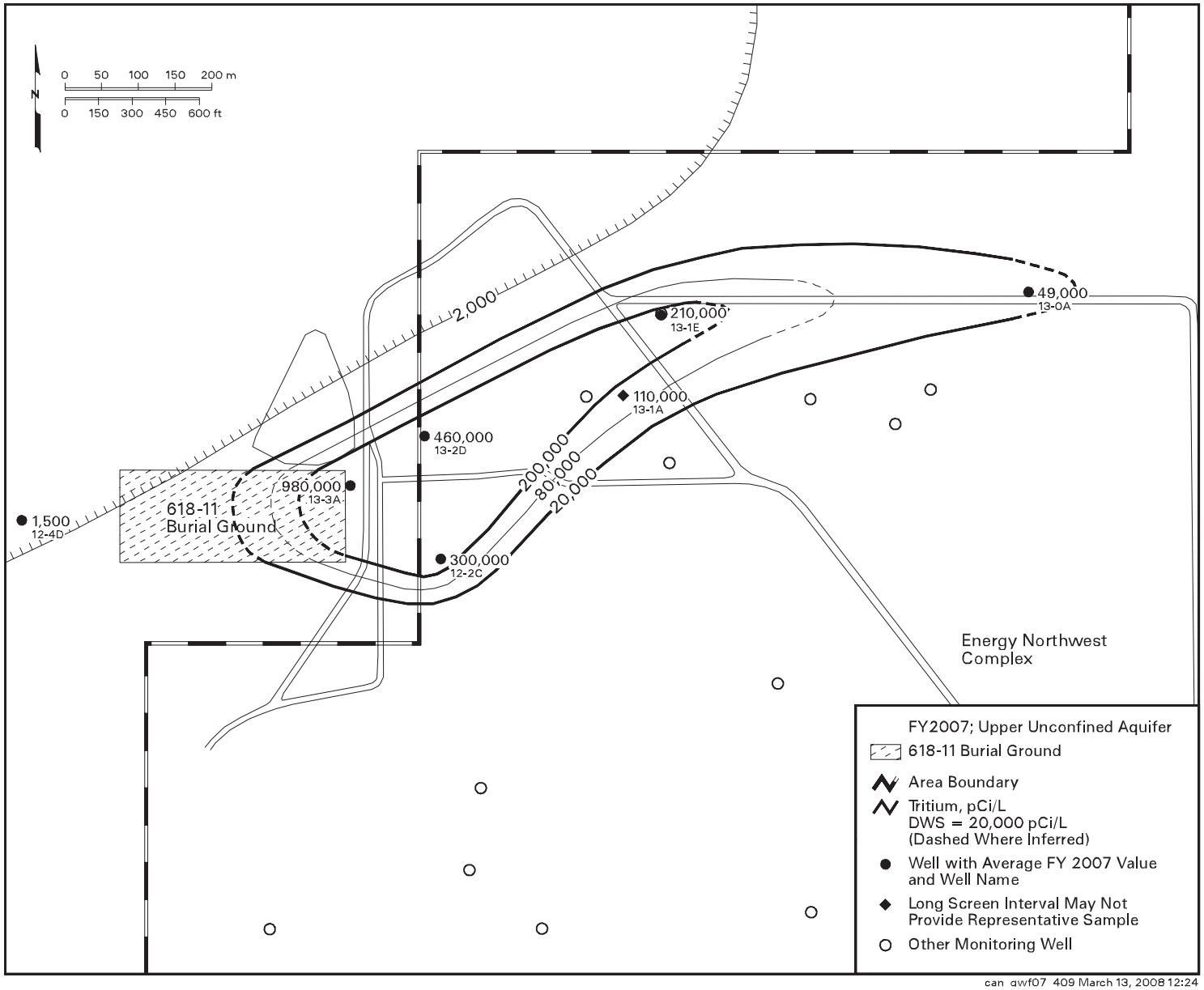


Figure 2.12-18. Average Tritium Concentrations at 618-11 Burial Ground, Upper Part of Unconfined Aquifer

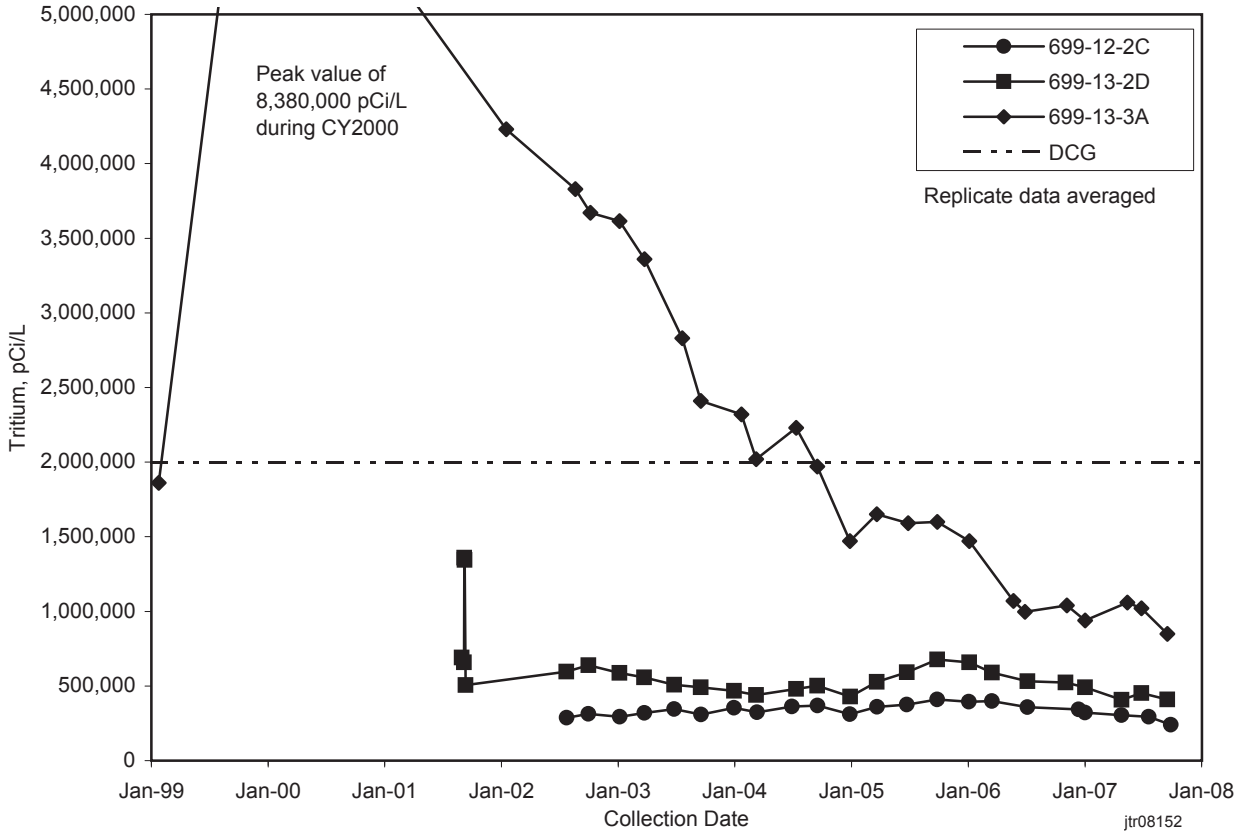


Figure 2.12-19. Tritium Concentration in Wells Near 618-11 Burial Ground

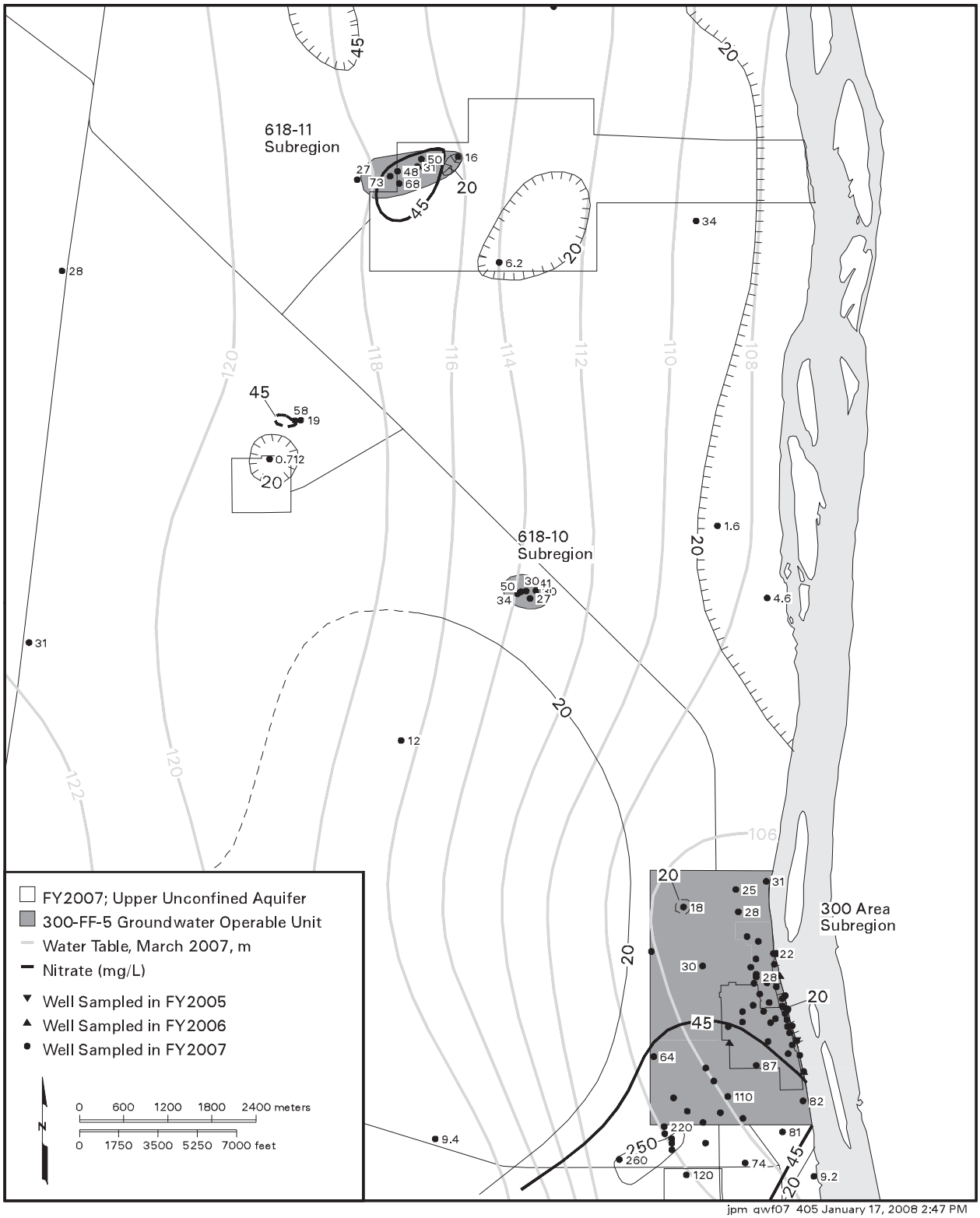


Figure 2.12-20. Average Nitrate Concentrations in 300-FF-5 Operable Unit, Upper Part of Unconfined Aquifer

2.13 1100-EM-1 Operable Unit

S. P. Luttrell and W. D. Webber

The scope of this section is the 1100-EM-1 groundwater interest area, which includes the 1100-EM-1 Operable Unit, a large region in the south portion of the Hanford Site, and the offsite area south of the Hanford Site, including the areas formerly designated as the 1100 and 3000 Areas of the Hanford Site (see Figure 1.0-1 in Section 1.0). The groundwater interest areas are informal designations to aid planning, scheduling, and data interpretation. Figure 2.13-1 shows facilities, wells, and shoreline monitoring sites in this region. The focus of this section is the central and east portions of the 1100-EM-1 groundwater interest area near the south boundary of the Hanford Site. Trichloroethene and nitrate are the contaminants of greatest significance in groundwater. Groundwater is monitored for the 1100-EM-1 Operable Unit to assess the performance of natural attenuation of volatile organic compounds. Groundwater is also evaluated for trichloroethene breakdown products (vinyl chloride and 1,1-dichloroethene) and nitrate.

Nitrate and trichloroethene are the contaminants of greatest significance in groundwater at the 1100-EM-1 Operable Unit.

Figure 2.13-2 shows the March 2007 water-table elevations and corresponding groundwater flow directions for the east portion of the 1100-EM-1 groundwater interest area. Water-table elevation contours in the west portion of Figure 2.13-2, which are consistent with the site-wide water-table map in Figure 2.1-2, are constructed with water-level measurements in wells and by Yakima River stage west of the map area. Groundwater in the 1100-EM-1 groundwater interest area generally flows eastward from the Yakima River (see Figure 2.1-2 in Section 2.1) and discharges to the Columbia River. In the northeast part of the 1100-EM-1 groundwater interest area, groundwater flows northeast and converges with groundwater beneath the 300 Area before discharging to the Columbia River. In the east-central part of the 1100-EM-1 groundwater interest area, groundwater flow from the west is diverted to the northeast and southeast around a recharge mound created by the city of Richland's recharge ponds, located near the North Richland Well Field before discharging to the Columbia River. Agricultural irrigation supplied primarily by the Columbia River, as well as precipitation, recharges the unconfined aquifer between the Yakima and Columbia Rivers.

Groundwater monitoring in the 1100-EM-1 groundwater interest area includes the following monitoring activities:

CERCLA Monitoring (Appendix A)

- ***Fifteen wells are monitored annually; one well was not sampled as scheduled in FY 2007.***
- ***In FY 2007, a change request was approved that reduces monitoring to annual sampling of three wells.***

AEA Monitoring

- ***Wells are sampled annually and semiannually.***

2.13.1 Groundwater Contaminants

This section describes the distribution of groundwater contaminants in the 1100-EM-1 groundwater interest area. Groundwater contaminants discussed are chlorinated hydrocarbons (primarily trichloroethene), tritium, nitrate, uranium, ammonia, gross alpha, gross beta, and technetium-99.

2.13.1.1 Chlorinated Hydrocarbons

Trichloroethene contamination occurs at levels below the 5 µg/L drinking water standard in the 1100-EM-1 groundwater interest area beneath the U.S. Department of Energy's (DOE's) inactive Horn Rapids Landfill and offsite in AREVA wells (Figure 2.13-3). The distribution of trichloroethene in the upper part of the unconfined aquifer shows that the plume has an elongated configuration that reflects the northeast flow direction toward the 300 Area. The thickness of the unconfined aquifer in this area is ~5.6 to 9 meters. Most of the wells used to monitor trichloroethene have screen intervals that penetrate the upper ~4.5 to 7.5 meters of the unconfined aquifer.

Trichloroethene concentrations continue to decrease in all plume areas near DOE's Horn Rapids Landfill.

Trichloroethene sample concentrations continued to be <5 µg/L in all AREVA wells during the first three quarters of fiscal year (FY) 2007 (E06-01-20064Q; E06-01-20071Q; E06-01-20072Q [AREVA 2007]). AREVA data for the fourth quarter of FY 2007 were not published by the time this report was published. The maximum trichloroethene concentration during these first two quarters was 2.9 µg/L immediately downgradient of the process lagoons. The past use of solvent to install and maintain process lagoon liners at AREVA is the only potential source of trichloroethene identified in the eastern portion of the 1100-EM-1 groundwater interest area (DOE/RL-92-67). AREVA also publishes an annual report on the Groundwater Quality Assessment Program for their facility (E06-02-2006).

Trichloroethene concentrations have decreased in all the plume areas near DOE's Horn Rapids Landfill. Trichloroethene concentrations decreased by an order of magnitude in this area since monitoring began in 1990 (Figure 2.13-4). In FY 2007, trichloroethene concentrations were all <5 µg/L, ranging from less than detection to 2.0 µg/L downgradient of the landfill. The decreased concentrations in the majority of wells downgradient of DOE's Horn Rapids Landfill suggest that natural attenuation (e.g., volatilization, passive pumping) has reduced the plume mass. For a discussion of trichloroethene in the 300 Area, see Section 2.12.1.2.

Plume areas (square kilometers) above the drinking water standard at the 1100-EM-1 Operable Unit:
**** Nitrate — 4.54***
**** Primarily from offsite sources.***

Potential breakdown products of trichloroethene, including vinyl chloride and 1,1-dichloroethene, continued to be undetected at their respective minimum detection limits during FY 2007.

The city of Richland monitors groundwater in the upper part of the unconfined aquifer quarterly for chemical constituents at their Horn Rapids Sanitary Landfill (formerly Richland Landfill), located approximately one kilometer south of the Hanford Site boundary (see Figure 2.1-1). Chlorinated hydrocarbons (e.g., tetrachloroethene, trichloroethene, and vinyl chloride) continue to exceed drinking water standards in several monitoring wells. During FY 2007, chlorinated hydrocarbons were below their respective minimum detection limits at onsite well 699-S31-1 (see Figure 2.1-1) just northeast of the city's sanitary landfill.

A confined aquifer found in the Ringold Formation is monitored for trichloroethene downgradient of the inactive DOE Horn Rapids Landfill. Two wells, one upgradient and one downgradient of the landfill, monitor this confined aquifer. This confined aquifer lies below a clay-silt aquitard, but above the basalt surface, at a depth of ~18 to 21 meters below the water table. Trichloroethene has not been detected in this confined aquifer since monitoring began in 1991, which suggests that the trichloroethene plume in the unconfined aquifer did not migrate downward into the underlying confined aquifer.

2.13.1.2 Tritium

The 200 Area tritium plume extends south into the 300 Area, but values less than 300 pCi/L continue to be reported in the 1100-EM-1 groundwater interest area (Figure 2.13-5). Tritium continues to be closely monitored because of its proximity to the city of Richland's North Well Field. The background geometric mean tritium concentration in the upper part of the unconfined aquifer was determined to be 63.9 pCi/L (DOE/RL-96-61). Tritium levels were above this background in several wells near the city of Richland's North Well Field during FY 2007. These levels are far below the drinking water standard (20,000 pCi/L). Trends in tritium concentrations in wells west and north of the city of Richland's North Well Field have fluctuated in the last few years, as shown in Figure 2.13-6.

Monitoring data show that the Richland North Well Field is not contaminated by the Hanford Site tritium plume through the groundwater flow system.

Tritium is not migrating in groundwater from the Hanford Site 200 Areas tritium plume to the city of Richland well field. Factors that limit the migration of the tritium plume into the east portion of the 1100-EM-1 groundwater interest area are:

- Groundwater generally flows from west to east between the Yakima River, a recharge source, and the Columbia River.
- Artificial recharge from agricultural irrigation in the west and central portions of the 1100-EM-1 groundwater interest area south of the Hanford Site contributes to the eastward and northeastward flow.
- Groundwater flow is directed outward from the elevated groundwater levels at the city of Richland's North Well Field because of ponds used to recharge the well field.

These factors produce converging groundwater flow lines in the 300 Area and discharge to the Columbia River (Figure 2.13-2). Figure 2.13-5 shows a region of low tritium concentrations between the 200 Areas tritium plume and the elevated tritium concentrations near the North Richland Well Field and recharge ponds. Thus, no indication exists that the tritium plume is migrating southward to and affecting the city of Richland well field. Tritium in groundwater in the 300 Area is discussed in Section 2.12.

2.13.1.3 Nitrate

The nitrate distribution in the east portion of the 1100-EM-1 groundwater interest area is shown in Figure 2.13-7. Nitrate contamination in this area is likely the result of industrial and agricultural uses off the Hanford Site. Agricultural uses include application of fertilizers onto irrigation circles in the central portion of the 1100-EM-1 groundwater interest area (Figure 2.13-1).

Nitrate contamination in groundwater is the result of industrial and agricultural uses off the Hanford Site.

Nitrate concentrations above the drinking water standard (45 mg/L) are found over much of the east portion of the 1100-EM-1 groundwater interest area and continued to increase in a number of wells in FY 2007 (Figure 2.13-8). Some of the highest nitrate levels occur near an offsite facility (AREVA) and DOE's inactive Horn Rapids Landfill. The highest nitrate concentration in this area was 370 mg/L immediately downgradient of the AREVA facility. Nitrate data for the offsite AREVA wells are reported in E06-01-20064Q, E06-01-20071Q, and E06-01-20072Q.

Nitrate concentrations continued to be elevated in wells downgradient of DOE's inactive Horn Rapids Landfill in FY 2007. The highest nitrate concentration was 274 mg/L. An example of elevated nitrate concentrations immediately downgradient of the landfill are shown for well 699-S31-E10D (Figure 2.13-8). The distribution of nitrate and shape of the nitrate plume (as defined by the 250 mg/L contour) near the AREVA facility and DOE's inactive Horn Rapids Landfill indicates that nitrate in these areas continues to migrate in a northeast direction toward the 300 Area. Groundwater and aquifer tube sample data, shown in Figure 2.13-7, indicates that groundwater with nitrate levels above the drinking water standard has discharged to the Columbia River immediately south of the 300 Area. Nitrate concentration was 49.6 mg/L in the shallow tube at location AT-3-8 in January 2006 (not sampled in FY 2007); the mid-depth tube at this location had a nitrate concentration of 30.1 mg/L in FY 2007.

Uranium contamination is present near DOE's inactive Horn Rapids Landfill, but the source is located offsite.

2.13.1.4 Gross Alpha and Uranium

Elevated levels of gross alpha and uranium occur downgradient of an offsite industrial facility (AREVA) near DOE's inactive Horn Rapids Landfill. Gross alpha data for the offsite AREVA wells are reported in E06-01-20064Q, E06-01-20071Q, and E06-01-20072Q. Several wells downgradient of the AREVA facility showed elevated gross alpha levels, with the highest value of 119 pCi/L during FY 2007 immediately downgradient of the AREVA facility. The gross alpha is likely largely attributed to uranium from industrial uses. If gross alpha is attributed to uranium, then 119 pCi/L gross alpha is equivalent to 172 µg/L uranium, which is above the drinking water standard (30 µg/L) for uranium.

The distribution of uranium near DOE's inactive Horn Rapids Landfill was shown in PNNL-16346. Uranium concentrations in a well downgradient of the Horn Rapids Landfill increased to a maximum of 23.0 µg/L then decreased slightly to 22.6 µg/L (Figure 2.13-9) in FY 2007.

2.13.1.5 Other Constituents

Ammonia – Ammonia was detected in several wells downgradient of the AREVA facility in FY 2007. Concentrations of ammonia in AREVA wells generally remained steady in FY 2007 (E06-01-20064Q, E06-01-20071Q, and E06-01-20072Q). The highest average concentration detected was 12.6 mg/L (as NH_3). Ammonia is typically converted to nitrate by nitrification processes.

Gross Beta – Gross beta continued to be detected in wells (E06-01-20064Q, E06-01-20071Q, and E06-01-20072Q) downgradient of AREVA during FY 2007. The highest average gross beta measurement in FY 2007 was 72.2 pCi/L. The elevated gross beta may be a result of technetium-99 in groundwater.

Technetium-99 – Low levels of technetium-99 are detected near DOE's inactive Horn Rapids Landfill. Results of FY 2007 technetium-99 analyses from well 699-S31-E10B were 36.3 pCi/L in November 2006 and 58.3 pCi/L in August 2007.

2.13.2 Operable Unit Activities

The 1100-EM-1 Operable Unit, which contains DOE's inactive Horn Rapids Landfill, was placed on the National Priorities List in 1989 and de-listed from the National Priorities List in 1996. Results of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) investigation for this operable unit are presented in the final remedial investigation study (DOE/RL-92-67) and the record of decision (ROD 1993). The selected remedy for groundwater is monitored natural attenuation of volatile organic compounds, with institutional controls on drilling of new water supply wells. Monitoring includes analysis of trichloroethene, its breakdown products (e.g., vinyl chloride and 1,1-dichloroethene), and nitrate in wells downgradient of DOE's inactive Horn Rapids Landfill, as recommended in the sampling plan (PNNL-12220). A list of wells and constituents are provided in Appendix A. Fourteen of 15 wells were sampled in FY 2007 (Appendix A).

The remedial action objectives for the 1100-EM-1 Operable Unit (ROD 1993) are:

- ***Attain concentration of <5 µg/L trichloroethene at designated point of compliance.***
- ***Protect environmental receptors in surface waters by reducing groundwater contaminant concentrations in the plume.***

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20) and stated, "The plume mass and concentration have been adequately reduced to be protective of human health and the environment. Groundwater monitoring for the 1100-EM-1 Operable Unit is no longer necessary but continues following an extended period of monitoring that shows contaminant levels are below the maximum contaminant level and continue to show a downward trend." Figure 2.13-10 provides the trend for trichloroethene in the compliance wells.

The CERCLA five-year review action to reduce monitoring requirements was completed and documented in a TPA Change Notice.

The review identified the following action, "Submit a change request to modify groundwater monitoring for the 1100-EM-1 Operable Unit." This action was completed with TPA Change Notice 163, approved in June 2007. Through this approval, groundwater monitoring has been reduced to annual monitoring of three of the original network of wells.

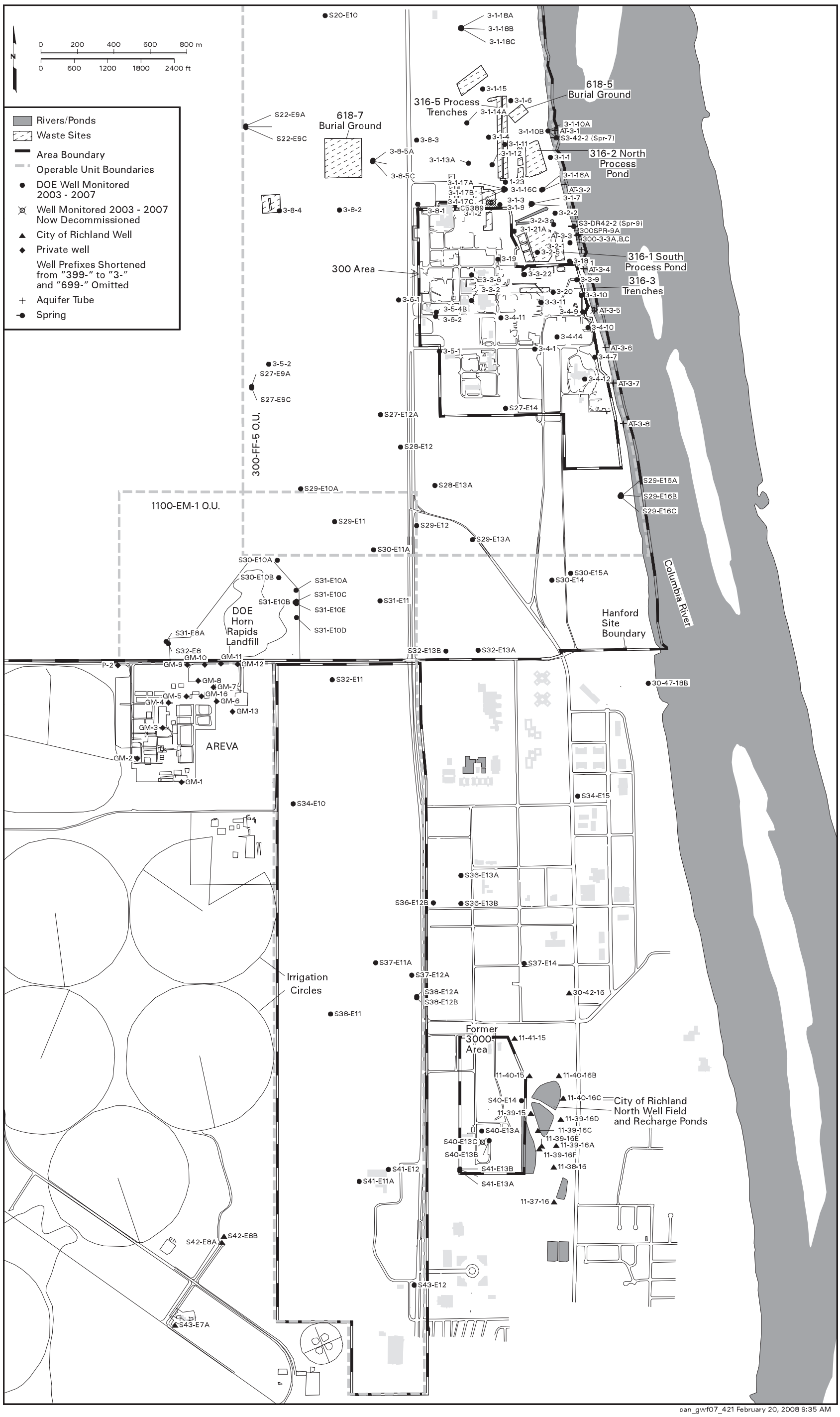


Figure 2.13-1. Groundwater Monitoring Wells and Facilities in 1100-EM-1 and 300 Areas

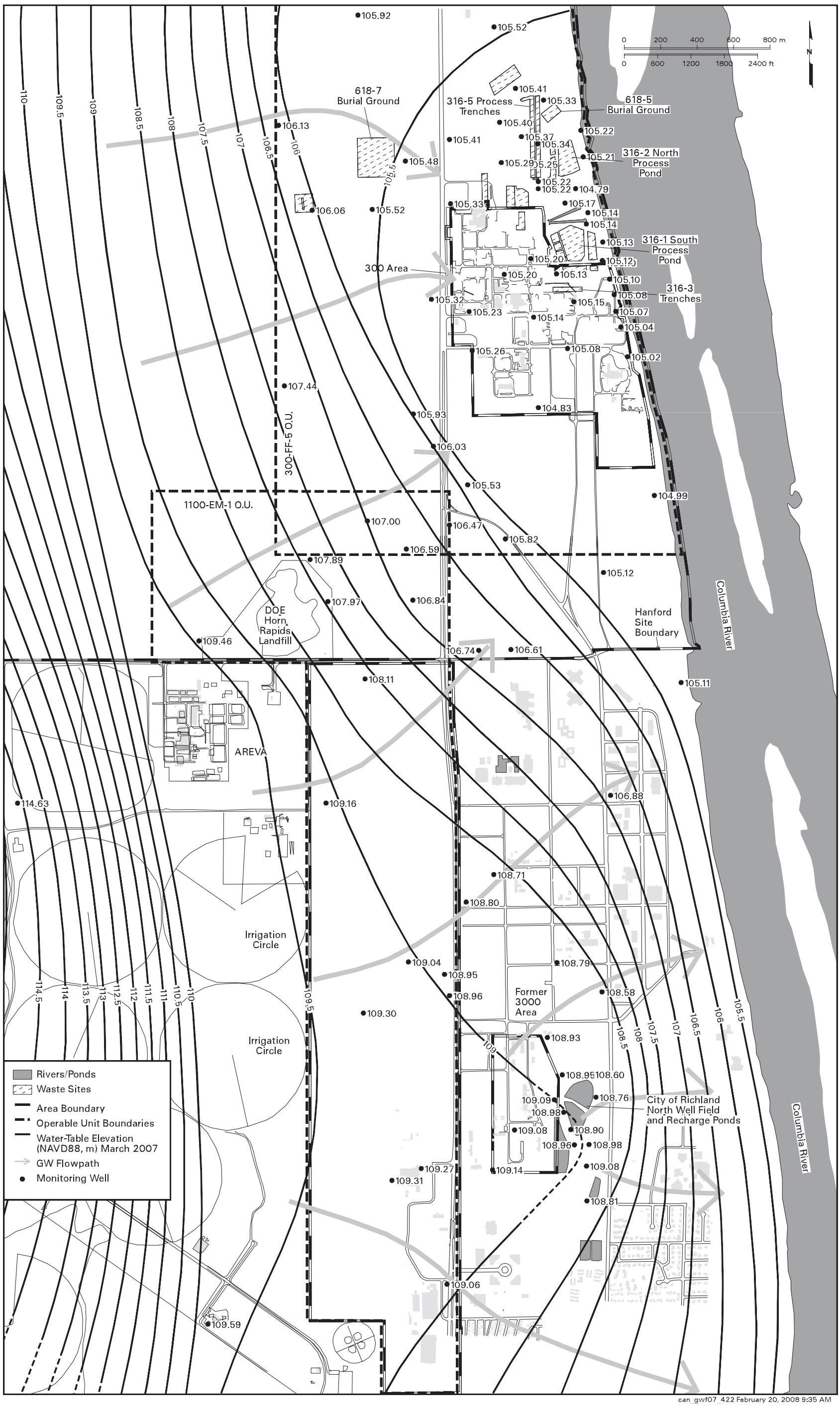


Figure 2.13-2. Water-Table Map for 1100-EM-1 and 300 Areas, March 2007

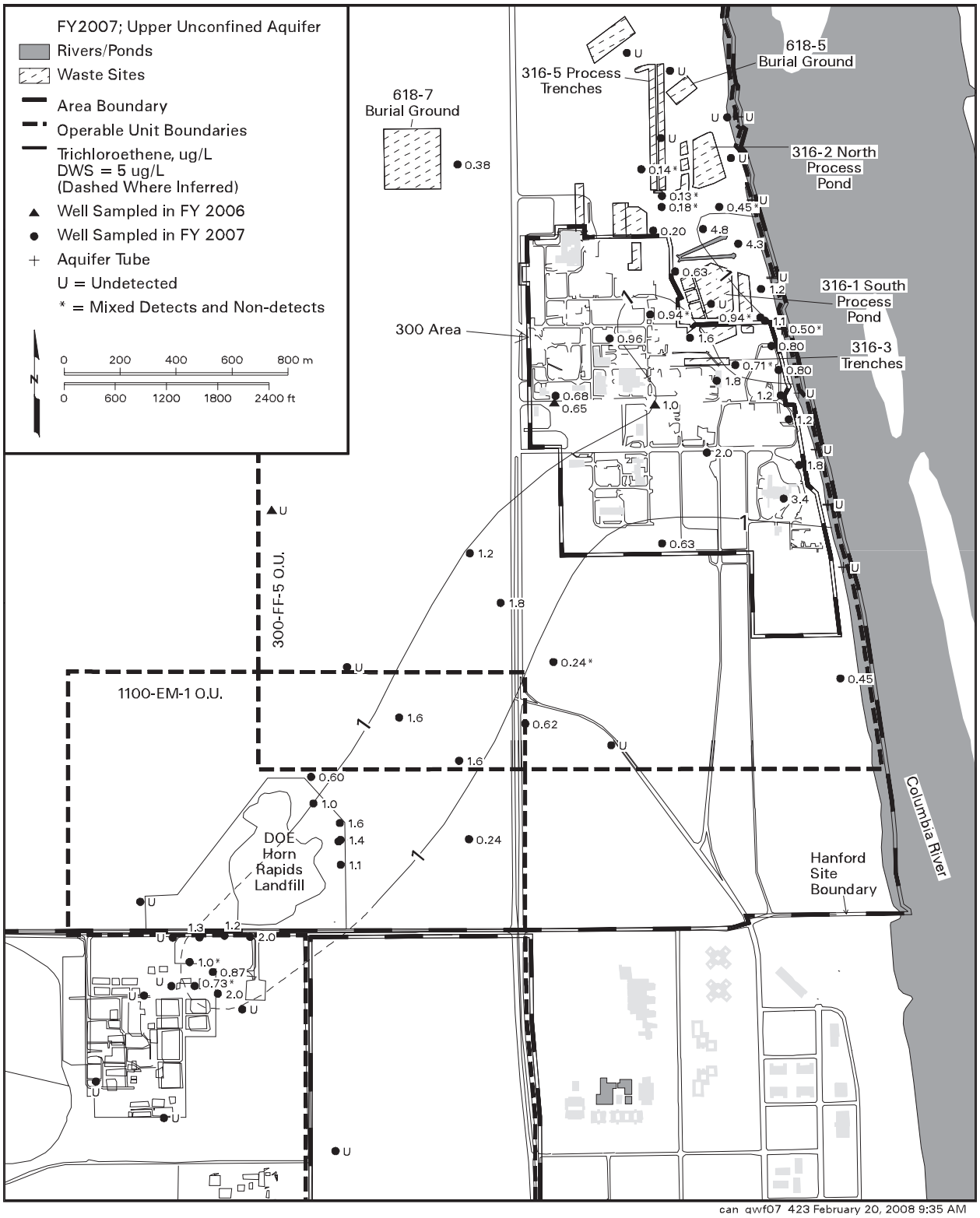


Figure 2.13-3. Average Trichloroethene Concentrations in 300 and 1100-EM-1 Groundwater Interest Areas, Upper Part of Unconfined Aquifer

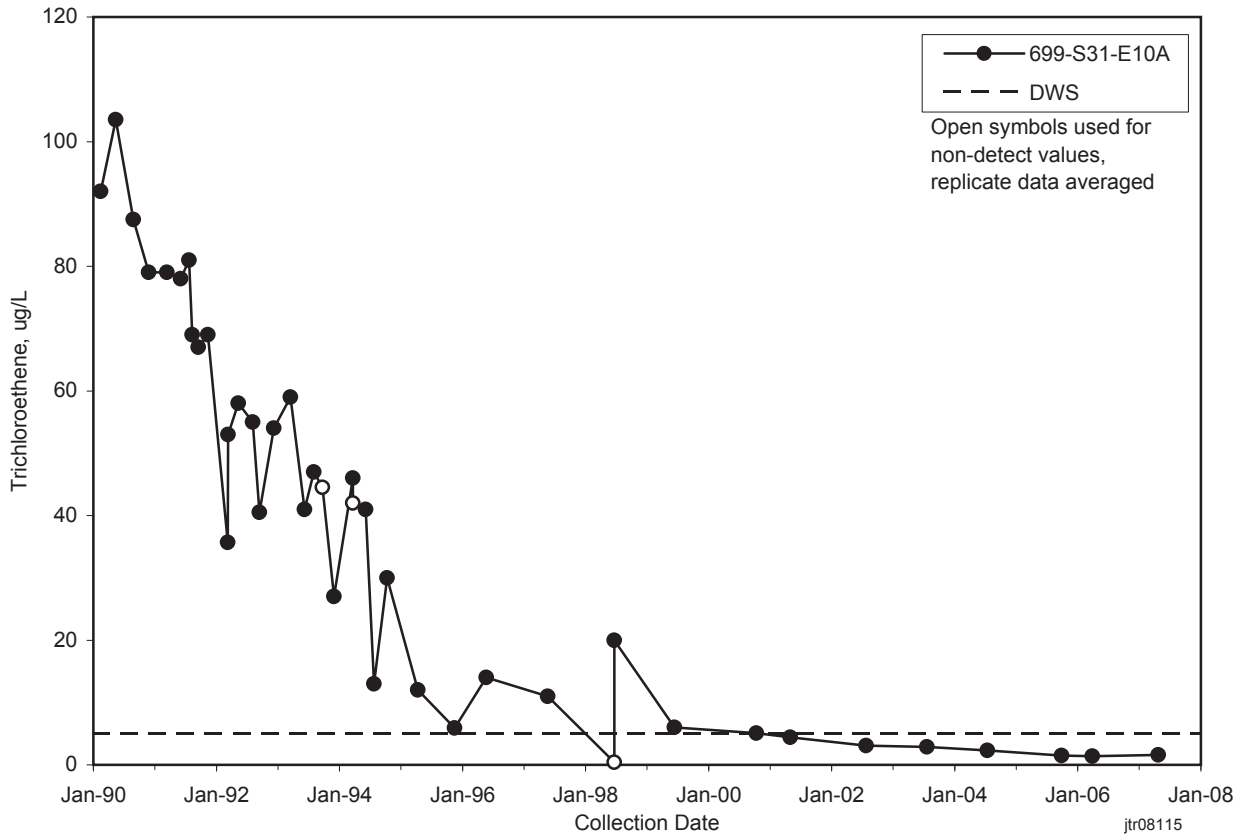


Figure 2.13-4. Trichloroethene Concentrations near the DOE Inactive Horn Rapids Landfill

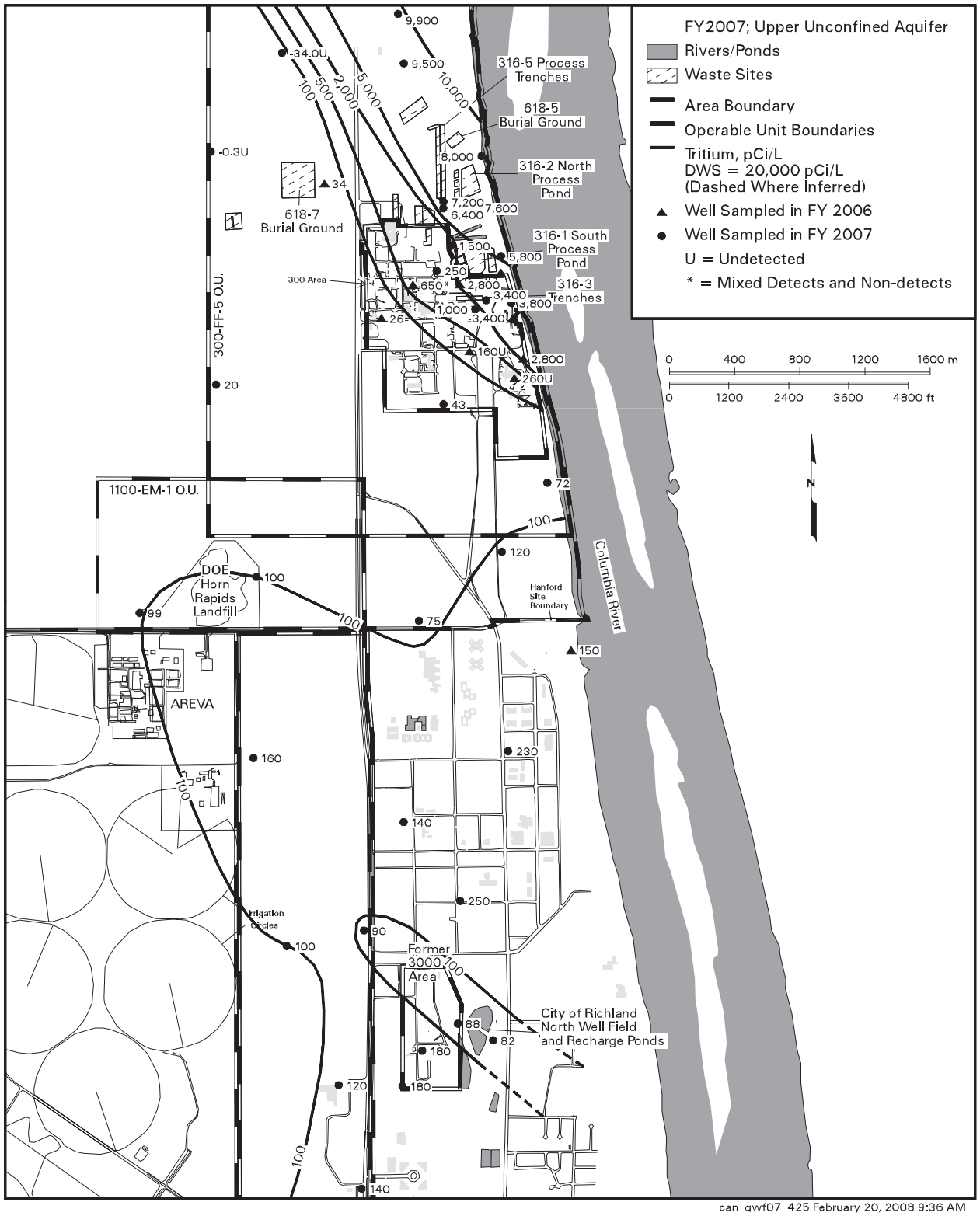


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Figure 2.13-5. Average Tritium Concentrations in 300 and 1100-EM-1 Groundwater Interest Areas, Upper Part of Unconfined Aquifer

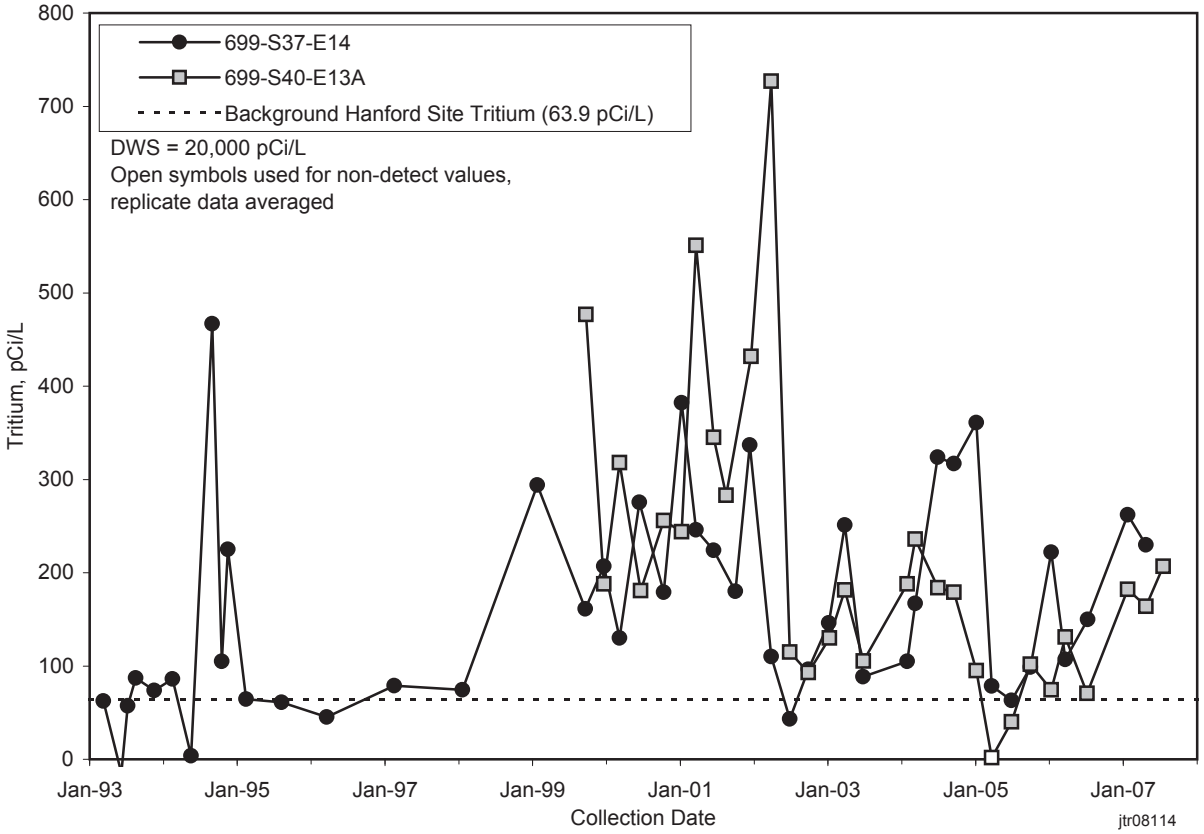

Figure 2.13-6. Tritium Concentrations in Selected Wells in 1100-EM-1 Groundwater Interest Area

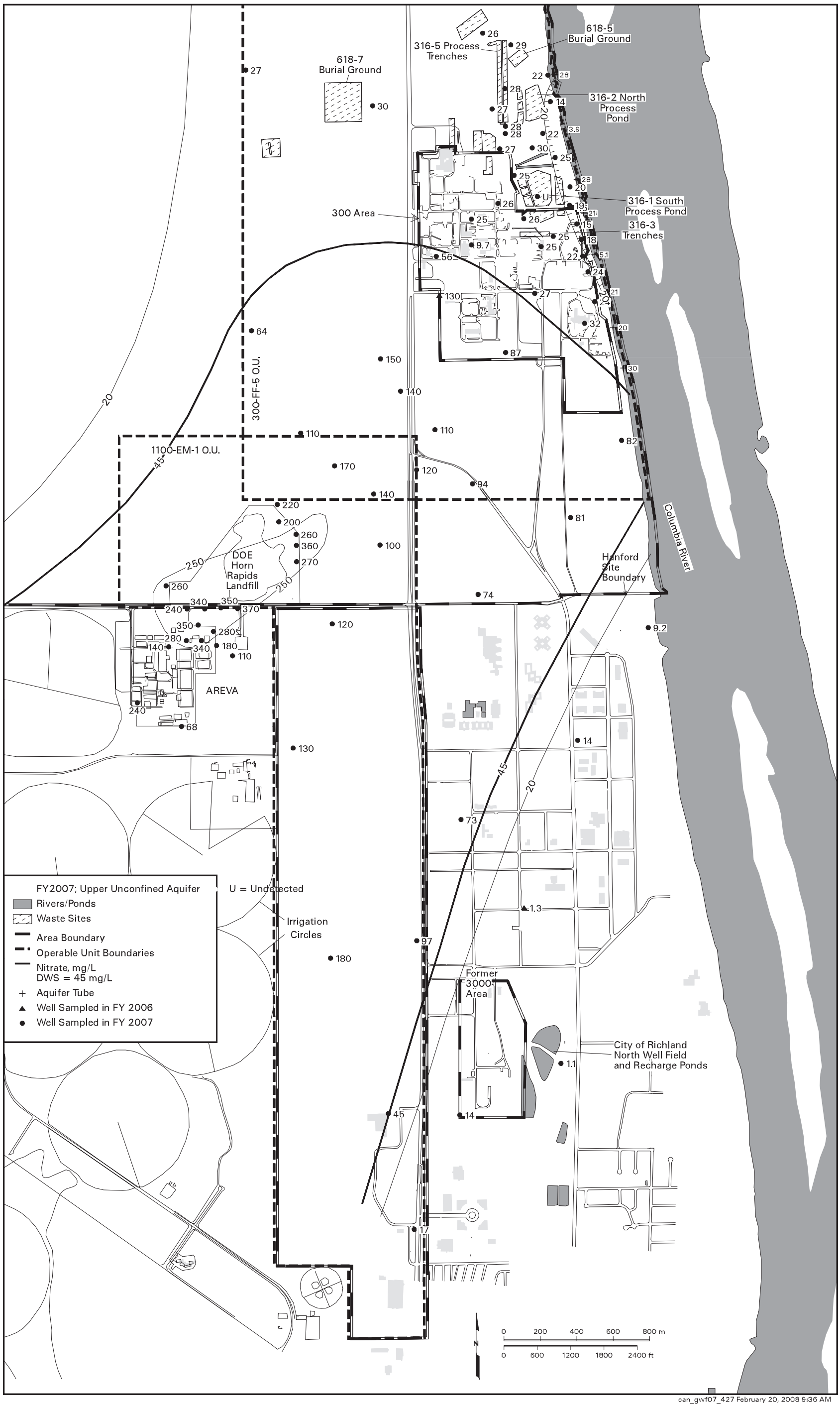

Figure 2.13-7. Average Nitrate Concentrations in 1100-EM-1 Groundwater Interest Area, Upper Part of Unconfined Aquifer

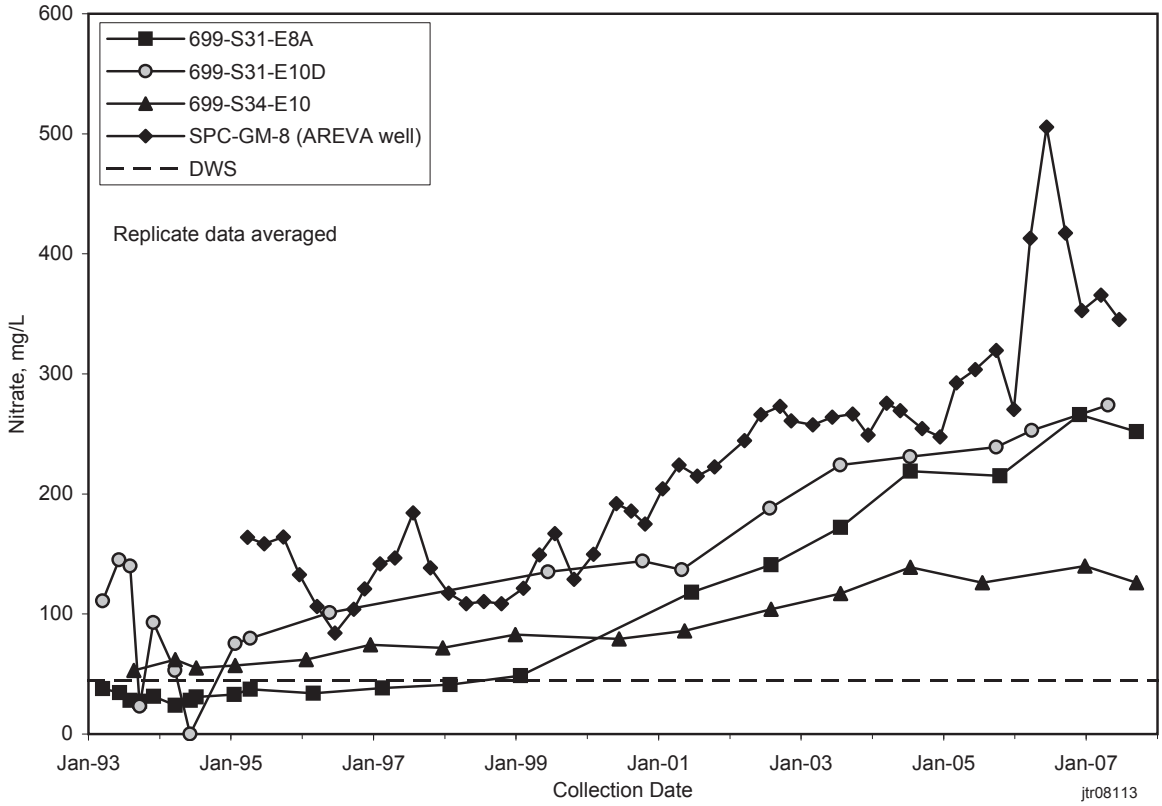

Figure 2.13-8. Nitrate Concentrations in Selected Wells in 1100-EM-1 Groundwater Interest Area

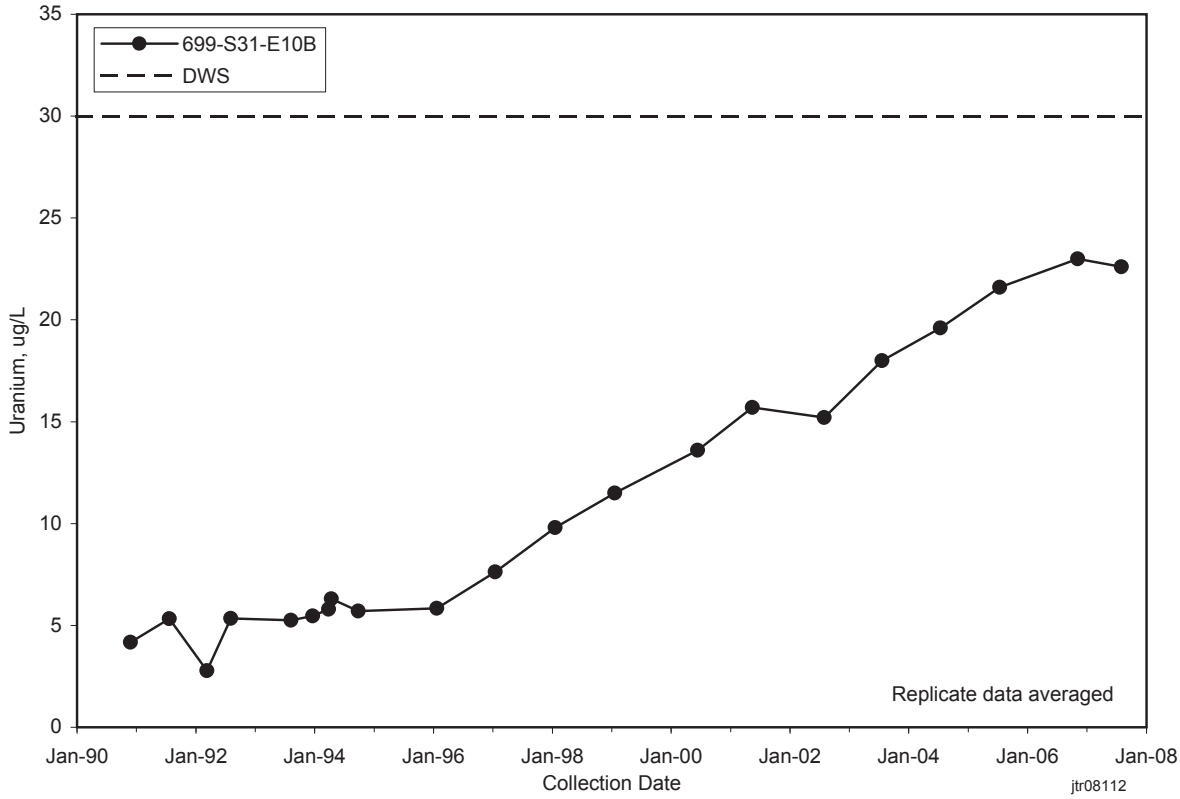

Figure 2.13-9. Uranium Concentrations near DOE Inactive Horn Rapids Landfill

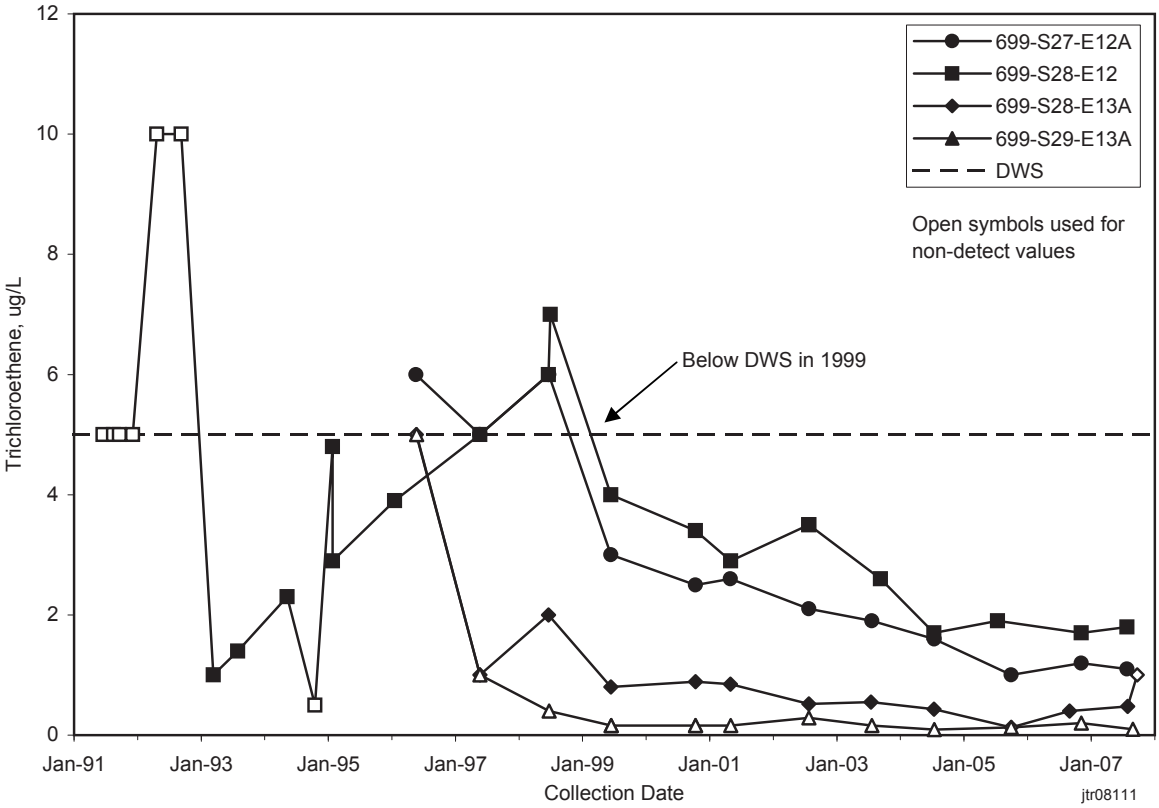

Figure 2.13-10. Trichloroethene Concentrations in 1100-EM-1 Operable Unit Compliance Wells

2.14 Confined Aquifers

W. D. Webber and J. P. McDonald

This section describes groundwater flow and quality within the Ringold Formation and upper basalt-confined aquifers. The Ringold Formation confined aquifer exists beneath much of the Hanford Site including the 100 Areas and 300 Area but is described only for the 200 Areas Central Plateau and the area near the inactive B Pond system because few wells monitor this aquifer. The upper basalt-confined aquifer is described for much of the Hanford Site, primarily the area south of Gable Butte and Gable Mountain.

Intercommunication between the upper basalt-confined aquifer and the overlying sedimentary aquifer system may occur where there is a pathway for the movement of water as well as a difference in hydraulic head between the two systems. The area in the vicinity of the 200 Areas and the inactive B Pond system meets these criteria. Evidence for communication between aquifers in this region is discussed in Section 2.14.2.3.

2.14.1 Ringold Formation Confined Aquifer

Groundwater quality in the Ringold Formation confined aquifer is monitored to evaluate impacts to groundwater and potential future for downward migration of contaminants from the overlying unconfined aquifer.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation (unit 9) shown in Figure 2.14-1. It is confined below by basalt and above by the lower mud unit (unit 8). Where Unit 9 is overlain by fines comprising units, confined conditions generally exist. Where Unit 9 is absent beneath unit 8, limited groundwater flow may occur. Wells completed in the lower portion of unit 8 in regions where unit 9 is absent provide information on the distribution of contaminants in the lower most portion of the sedimentary aquifer system.

Groundwater in the Ringold Formation confined aquifer flows generally west to east in the vicinity of the 200 West Area and west to east along the south boundary of the aquifer.

DOE has begun to investigate groundwater conditions in other portions of the Ringold Formation including the "horn" between the 100-D and 100-H Areas (see Section 2.6).

2.14.1.1 Groundwater Flow in the Ringold Formation Confined Aquifer

Figure 2.14-2 presents the interpreted potentiometric surface for a portion of the Ringold Formation confined aquifer. This map is subject to uncertainty because only a few wells monitor this aquifer. However, generalized flow patterns can be inferred from the available data when the hydrogeologic framework (i.e., extent of the confining unit, presence of basalt subcrops, influence of the May Junction Fault) is taken into account.

Groundwater flow in the Ringold Formation confined aquifer is generally west to east near the 200 West Area and west to east along the south boundary of the aquifer near the Rattlesnake Hills. This flow pattern indicates that recharge occurs west of the 200 West Area in upgradient areas within the Cold Creek Valley, as well as in the Dry Creek Valley and possibly the Rattlesnake Hills. In the vicinity of the 200 East Area, flow in the Ringold Formation confined aquifer converges from the west, south, and east before discharging to the unconfined aquifer where the confining mud

unit (unit 8) is absent (PNNL-12261). This water is thought to flow southeastward over the top of the confining unit (PNNL-15479), although the exact location of the division between northwest and southeast flow within the 200 East Area unconfined aquifer is not known. In the vicinity of the 200 East Area, water-level elevation data from well pair 299-E25-28 and 299-E25-34 that monitor different depths of the unconfined aquifer (Figure 2.14-3), as well as from piezometers 299-E25-32P and 299-E25-32Q also monitoring different depths, suggest a slight upward gradient along the confining unit boundary. This upward gradient is consistent with the discharge of groundwater from the confined aquifer to the overlying unconfined aquifer.

Elevated water levels are present in the Ringold Formation confined aquifer northeast of B Pond as a remnant of past waste water discharges to this facility. This causes southwest flow beneath B Pond to the 200 East Area. Eastward flow away from the region of elevated water levels does not occur; this is attributed to the May Junction Fault, located east of B Pond, which is thought to be a hydrologic barrier preventing flow to the east (PNNL-12261). South of the B Pond area, the flow of water divides with some moving northwest toward the 200 East Area and some moving toward the east or southeast. The location of this flow divide is not accurately known, due partly to a lack of water-level data in this area and because the southward extent of the May Junction Fault is not well defined.

Groundwater quality in the upper basalt-confined aquifer is monitored due to the potential for downward migration of contaminants from the overlying unconfined aquifer.

The potentiometric contours for the Ringold Formation confined aquifer, shown in Figure 2.14-2, are similar to the potentiometric surface contours for the upper basalt-confined aquifer (see Section 2.14.2.1), indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. Basalt bedrock from the topographic low between Gable Butte and Gable Mountain (Gable Gap) in the 200 East Area vicinity was significantly eroded by late Pleistocene catastrophic flooding (RHO-BWI-LD-5), which facilitates intercommunication between the unconfined and confined aquifers (see Section 2.14.3). The 200 East Area vicinity is a discharge area for both of the confined aquifers, which explains the similar flow patterns.

Water levels declined in the Ringold Formation confined aquifer during the period from April/May 2006 to March 2007. The declines in individual wells ranged from 0.01 to 0.18 meter within the aquifer and up to 0.32 meter in the 200 West Area along the boundary between the confined and unconfined aquifers. The potentiometric surface is responding to the curtailment of liquid effluent discharges to ground since the discharge volume peaked in the mid 1980s. The declines were largest in the 200 West Area (up to 0.32 meter) and the 200 East Area (up to 0.15 meter) along the boundary between the confined and unconfined aquifers.

2.14.1.2 Groundwater Quality in the Ringold Formation Confined Aquifer

The 200 Areas Central Plateau and the area near the inactive B Pond system are the two known areas where contamination can migrate from the unconfined aquifer into the Ringold Formation confined aquifer (see Section 2.14.2.3). Groundwater chemistry data for the Ringold Formation confined aquifer are limited to wells near the 200 Area Treated Effluent Disposal Facility and B Pond facilities. During fiscal year (FY) 2007, eighteen wells were sampled that are completed in the Ringold Formation confined aquifer (Figure 2.14-4). Data for potential contaminants of interest are listed in Table 2.14-1. No contaminants were detected above the drinking water standard for wells completed in the Ringold Formation confined aquifer.

2.14.2 Upper Basalt-Confined Aquifer

Groundwater quality in the upper basalt-confined aquifer is monitored because of the potential for downward migration of contaminants from the overlying unconfined aquifer. Contaminants that reach the upper basalt-confined aquifer have the potential to migrate through the aquifer and deeper confined aquifers to areas off the Hanford Site. The upper basalt-confined aquifer is also monitored to assess the potential migration of contaminants onto the Hanford Site from offsite sources. Additional information regarding the potential for contaminants to migrate off the Hanford Site can be found in PNL-10817 and PNNL-14107.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds within the upper Saddle Mountains Basalt (Figure 2.14-1). The thickest and most widespread sedimentary unit in this system is the Rattlesnake Ridge interbed, which is present beneath much of the Hanford Site. Groundwater also occurs within the Levey interbed, which is present only in the south portion of the site. An interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and also may be significant to the lateral transmission of water. This system is confined by the dense, low-permeability, interior portions of basalt flows and in some places by Ringold Formation silt and clay units overlying the basalt.

Groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site toward the Columbia River.

Figure 2.14-4 shows the location of the upper basalt-confined aquifer monitoring wells on the Hanford Site. Most of the wells are completed in the Rattlesnake Ridge interbed near the 200 East Area in the central part of the Hanford Site. A few wells are completed in the Elephant Mountain interflow zone, the Levey interbed, or a composite of one or more interbeds and/or interflow zones within the upper Saddle Mountains Basalt.

2.14.2.1 Groundwater Flow in the Upper Basalt-Confined Aquifer

Figure 2.14-5 presents an approximation of the March 2007 potentiometric surface for the upper basalt-confined aquifer system south of Gable Butte and Gable Mountain. The region to the north of Gable Butte and Gable Mountain was not contoured due to insufficient well control. (See PNL-8869 for a generalized potentiometric surface map of this area.) The upper basalt-confined aquifer is interpreted to not exist in Cold Creek Valley and along the west portion of the Gable Mountain/Gable Butte structural area due to the absence of the Rattlesnake Ridge interbed.

Recharge to the upper basalt-confined aquifer system is believed to occur from upland areas along the margins of the Pasco Basin and results from the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near ground surface. Recharge may also occur from the overlying aquifers (i.e., the unconfined aquifer or confined aquifer in the Ringold Formation) in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge to this aquifer system. The Columbia River represents a discharge area for this aquifer system in the southeastern portion of the Hanford Site but not for the north portion (PNL-8869). Discharge also occurs to the overlying aquifers in areas where the hydraulic gradient is upward. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area may occur through erosional windows in the basalt.

The small amount of contamination detected in the upper basalt-confined aquifer is attributed to areas where confining units of basalt have been partially removed by erosion, are absent, or where wells provided a pathway for migration.

South of Gable Butte and Gable Mountain, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site toward the Columbia River. The May Junction Fault, located east of B Pond and in a north-south trend, acts as a barrier to groundwater flow in the unconfined aquifer and the confined aquifer within the Ringold Formation (PNNL-12261). It may also impede the movement of water in the upper basalt-confined aquifer system by juxtaposing permeable units opposite impermeable units. As with the Ringold Formation confined aquifer, a flow divide is interpreted to exist southeast of the 200 East Area and B Pond in the upper basalt-confined aquifer system, but the exact location of this divide is uncertain due to a lack of well control in the area.

Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated to be between 0.7 and 2.9 meters/year (PNL-10817). This flow rate is considerably slower than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone along with silts and clays, and is less permeable than the sediments in the unconfined aquifer. Also, the magnitude of the hydraulic gradient is generally lower than in the unconfined aquifer.

The vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer varies spatially (Figure 2.14-6). A downward gradient exists in the west portion of the Hanford Site, near the B Pond recharge mound, as well as in the regions north and east of the Columbia River. In the B Pond vicinity, the vertical head gradient between the unconfined aquifer system and the upper basalt-confined aquifer system has diminished in recent years but remains downward. In other areas of the Hanford Site, the hydraulic gradient is upward from the upper basalt-confined aquifer to the overlying aquifer system.

In the 200 East Area vicinity, the potentiometric surface in Figure 2.14-5 is similar to the potentiometric surface for the Ringold Formation confined aquifer (compare with Figure 2.14-2). The basalt in this area was significantly eroded by late Pleistocene catastrophic flooding, which facilitates aquifer intercommunication (RHO-BWI-LD-5). In the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer is upward. Therefore, it is likely the upper basalt-confined aquifer system currently discharges to the overlying aquifer in this region.

Water levels in the upper basalt-confined aquifer declined over most of the Hanford Site from April/May 2006 to March 2007. In the 200 East Area and to the immediate north and east (near B Pond), water-level declines in wells ranged from 0.04 to 0.32 meter. Water-level declines in wells near the 200 West Area ranged from 0.15 to 0.20 meter. The declines are in response to curtailed effluent disposal activities in the 200 Areas and are consistent with water-level declines in the overlying unconfined aquifer and confined aquifer in the Ringold Formation.

Water levels in the upper basalt-confined aquifer along the Columbia River in the east part of the site (i.e., wells 699-13-1C and 699-24-1P) rose from 1990 to 2003 and have subsequently declined but remain above pre-1992 levels (Figure 2.14-7). The long-term increase is interpreted to be the result of offsite irrigation east of the Columbia River (PNL-8869).

2.14.2.2 Groundwater Quality in the Upper Basalt-Confined Aquifer

The upper basalt-confined aquifer is affected by contamination much less than the overlying unconfined aquifer system. Contamination found in the upper basalt-

confined aquifer is most likely attributed to areas where confining units of basalt have been eroded away or were never deposited and where past disposal of large amounts of waste water resulted in downward hydraulic gradients. In some areas, wells penetrating the upper basalt-confined aquifer system constructed prior to implementation of WAC 173-160 lacked an impermeable seal between the well casing and the borehole wall. When recognized, these wells were rehabilitated with the installation of an impermeable seal or were decommissioned by a method that isolated the aquifer. Because of these factors, intercommunication between the aquifers permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer, thereby increasing the potential to spread contamination. A discussion of the communication between the upper basalt-confined aquifer and the overlying aquifers is presented in Section 2.14.2.3.

Wells completed in the upper basalt-confined aquifer system are routinely sampled on the Hanford Site. Most of these wells are sampled every 3 years, and a few are sampled annually. During FY 2005 through 2007, 38 samples were collected from 22 wells and analyzed for chemical and radiological constituents. Many of the samples were analyzed for tritium, iodine-129, and nitrate because these constituents (1) are the most widespread in the overlying unconfined aquifer, (2) are some of the most mobile constituents in groundwater, and (3) provide an early warning for potential contamination in the upper basalt-confined aquifer system. Groundwater samples from the upper basalt-confined aquifer were also analyzed for anions (besides nitrate), cations, cyanide, gross alpha, gross beta, gamma-emitters, strontium-90, technetium-99, tritium, and uranium isotopes. Data for the potential contaminants of interest are listed in Table 2.14-2. A full data set is included in the data files that accompany this report.

Distribution of sample results for selected constituents and wells across the Hanford Site for FY 2005 through 2007 is shown in Figure 2.14-8. Tritium at the Hanford Site ranged from less than the detection limit near the discharge area in the east-southeast portion of the Hanford Site to 4,640 pCi/L in well 699-42-40C, east of the 200 East Area. Concentrations have been decreasing at this location since 1996 (Figure 2.14-9). This elevated tritium is located in the 200 East Area/Gable Mountain region, an area of intercommunication with the overlying contaminated unconfined aquifer. Nearby wells completed in the Ringold Formation (e.g., 699-43-41E) show elevated but declining trends. Near the 618-11 burial ground, where a source of tritium has contaminated the unconfined aquifer at high levels, tritium in the upper basalt-confined aquifer has declined from a concentration of 31.6 pCi/L detected in FY 2004 to less than the detection level in FY 2007. An upward hydraulic gradient exists at this location.

Cyanide, nitrate, and technetium-99 were elevated in one well in the 200 East/ Gable Mountain region, an area of intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer.

In the north part of the 200 East Area, technetium-99 continued to be elevated in the upper basalt-confined aquifer in one well (299-E33-12) (Figure 2.14-8). This well is located in the vicinity of a technetium-99 plume in the overlying unconfined aquifer (Section 2.10.1). The technetium-99 concentration was 1,150 pCi/L in this well (299-E33-12) in 2007. This level, which exceeds the drinking water standard (900 pCi/L), is slightly lower than concentrations observed immediately after a seal which shortened the open interval was placed in the well in 1990 (Figure 2.14-10).

Cyanide and nitrate are also elevated in well 299-E33-12 (Figure 2.14-11). However, these co-contaminants are at levels that do not exceed their respective drinking water standards. Concentrations of cyanide and nitrate have declined slightly at this well since the early 1990s. Cyanide and nitrate are co-contaminants

with much higher concentrations in the unconfined aquifer in the north part of the 200 East Area. Contamination in this well is attributed to migration of high-salt waste down the borehole during construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12 P). A seal was placed in this well to prevent intercommunication between the unconfined and confined aquifers during the 1980s.

Gamma-emitting isotopes were not detected in the upper basalt-confined aquifer on the Hanford Site.

Nitrate levels in the upper basalt-confined aquifer typically range from less than detectable to ~43 mg/L across the Hanford Site. Higher levels indicate intercommunication with the overlying contaminated unconfined aquifer (RHO-BWI-ST-5; RHO-RE-ST-12 P; PNL-10817). The majority of wells with higher nitrate in the upper basalt-confined aquifer occur near Gable Mountain and the 200 East Area (Table 2.14-2).

Some samples collected from upper basalt-confined aquifer wells were analyzed for iodine-129. These wells are located beneath or near the iodine-129 plume contained within the overlying unconfined aquifer. Iodine-129 was not detected in the upper basalt-confined aquifer during FY 2005 through 2007 (Table 2.14-2).

A few samples collected from upper basalt-confined aquifer wells were analyzed for gamma-emitting and uranium isotopes. Gamma-emitting isotopes were not detected in the upper basalt-confined aquifer on the Hanford Site, including the Gable Mountain/200 East Area. Uranium isotopes were not observed above background levels in this aquifer in the eastern part of the Hanford Site during FY 2005 through 2007.

In summary, cyanide, nitrate, and technetium-99 were elevated in an upper basalt-confined aquifer well in the north part of the 200 East Area. Migration of high-salt waste via the well bore during its construction is responsible for this contamination. Tritium was predominantly detected at low levels or was not detected. One elevated tritium concentration near the 200 East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer but was less than the drinking water standard. Iodine-129, strontium-90, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits or background levels in the upper basalt-confined aquifer.

2.14.2.3 Communication Between Aquifers

Intercommunication between the unconfined aquifer and the underlying upper basalt-confined aquifer system is an important consideration for environmental cleanup activities at Hanford. To establish final records of decision for the various groundwater operable units, the nature and extent of contamination in the groundwater must be understood with a reasonable degree of uncertainty. This necessarily includes an assessment of the degree to which the upper basalt-confined aquifer system has been affected by groundwater plumes from the unconfined aquifer. Several studies have been conducted regarding communication between these aquifers, and the following discussion provides a summary of the historical work on this topic.

For aquifer intercommunication to occur, there must be a pathway for the movement of water between the aquifers as well as a difference in hydraulic head between the two systems (i.e., a vertical hydraulic gradient) to provide the driving force for water movement. The uppermost basalt flow at Hanford, the Elephant Mountain Basalt, forms the base of the unconfined aquifer system and serves as the confining unit for the upper basalt-confined aquifer system (i.e., Rattlesnake Ridge interbed beneath most of the Hanford Site). Water may migrate through this unit

along joints and fractures if a sufficiently strong vertical hydraulic gradient exists. The limited areas in which the Elephant Mountain Basalt has been thinned or completely removed by erosion represent the most likely locations where communication may occur.

An area of intercommunication between the unconfined and upper basalt-confined aquifer systems was first identified in the north part of the 200 East Area (RHO-BWI-ST-5; RHO-RE-ST-12 P). Several confined aquifer wells north and east of the 200 East Area have shown evidence of intercommunication with the overlying unconfined aquifer (PNL-10817). Intercommunication between the unconfined and confined aquifers in this region has been attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient that resulted from groundwater mounding associated with past wastewater disposal to the ground. However, this groundwater mounding has diminished in recent years (see Section 2.14.1).

Aquifer intercommunication may occur wherever the basalt has been eroded or where remaining basalt is fractured.

It has been well documented that in the area north of the 200 East Area to Gable Gap, that the Elephant Mountain Basalt has been eroded by the ancestral Columbia River as well as by Pleistocene cataclysmic flooding. In 1982, surface geophysical investigations consisting of magnetic, gravity, and electrical resistivity surveys performed to delineate the basalt surface and identify areas of erosion were reported in RHO-ST-38. It was concluded that both the Elephant Mountain Basalt and the underlying Pomona Basalt had been completed removed from Gable Gap by erosion, and the Elephant Mountain Basalt had been removed from the vicinity of West Lake to the southeast of Gable Gap. These are areas where the unconfined aquifer is in direct communication with the underlying confined aquifer(s). Further, RHO-ST-38 identified "hydrologically significant areas of erosion" of the Elephant Mountain Basalt extending from Gable Gap southeast to the northwest part of the 200 East Area and also at the northeast part of the 200 East Area. It was noted that the Elephant Mountain Basalt is absent from well 699-53-55A and significantly eroded in well 699-47-50. Where the Elephant Mountain member of the Saddle Mountains Basalt has been removed by erosion, the potential for aquifer intercommunication is apparent.

Recent work has demonstrated that the basalt need not be absent for communication to occur. A water-level barometric response analysis in Rattlesnake Ridge interbed well 699-49-57B indicated an unconfined aquifer response, even though the basalt is 16 meters thick at this location. Based on this finding, it was concluded that "… the underlying Rattlesnake Ridge interbed aquifer is unconfined and likely in direct communication with the overlying unconfined aquifer system"[(a)] at this location where remaining basalt is fractured. Thus, aquifer intercommunication may occur wherever the basalt has been eroded or where remaining basalt is fractured.

In 1984, RHO-RE-ST-12 P further delineated areas of erosion in the basalt extending from Gable Gap across the northern part of the 200 East Area to B Pond. The extent of this area, as reported in RHO-RE-ST-12 P, is shown in Figure 2.14-12. It should be noted that this area of erosion does not encompass Gable Mountain Pond but that the western lobed B Pond overlies the area where the Elephant Mountain Basalt has been partially removed by erosion.

(a) Memo from FA Spane (Pacific Northwest National Laboatory) to SP Luttrell (Pacific Northwest National Laboratory), Assessment of the Vertical Hydraulic Gradient and Groundwater-Flow Potential Between the Unconfined Aquifer and Upper-Basalt Confined Aquifer System: Well Site 699-49-57A and B, dated October 23, 2001.

For aquifer intercommunication to occur, there must be a hydraulic head difference between the unconfined and upper basalt-confined aquifers. Downward gradients existed around B Pond and Gable Mountain Pond when these facilities were active (RHO-RE-ST-12 P), and the downward gradient at B Pond persists to the present day (Figure 2.14-12). RHO-RE-ST-12 P further notes that the area of downward gradient may have been larger in the 1960s and 1970s due to a higher water-table elevation. Thus, in the region at and to the northwest of B Pond, a downward gradient occurs within the area of basalt erosion (compare Figures 2.14-6 and 2.14-12), so this area has been deemed the most likely pathway for contaminants to migrate from the unconfined aquifer to the underlying upper basalt-confined aquifer (RHO-ST-38; RHO-RE-ST-12 P). An upward gradient exists elsewhere in the 200 East Area/Gable Gap region, so it is expected that the upper basalt-confined aquifer discharges to the overlying unconfined aquifer, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

Analyses of major cations and anions have also indicated mixing between the two aquifers in the 200 East Area/Gable Mountain region.

The groundwater chemistry of the unconfined and upper basalt-confined aquifers indicates that some intercommunication has actually occurred in the region northwest of B Pond. During the early 1980s, stable isotope ratios for deuterium and oxygen-18 were investigated to determine if mixing between the two systems had occurred (RHO-RE-ST-12 P). The ratio of deuterium (2H) to hydrogen (1H) had values between -139 and -144 parts per thousand (‰) below the mean ratio in sea water for the unconfined aquifer, and between -145 and -156 ‰ for water within the Rattlesnake Ridge interbed flowing into the study area. Within the Rattlesnake Ridge interbed northwest of B Pond, values ranged from -142 to -144 ‰, indicating mixing of the unconfined and upper basalt-confined aquifers. Investigation of the oxygen-18 (18O) to oxygen-16 (16O) ratio resulted in a similar conclusion. Background values for this ratio varied from -16.5 to -17.2 ‰ in the unconfined aquifer, and -17.6 to -18.7 ‰ for the Rattlesnake Ridge interbed. Within the Rattlesnake Ridge interbed northwest of B Pond, values ranged from -16.8 to -17.8 ‰, indicating mixing between the two systems.

Analyses of major cations and anions have also indicated mixing between the two aquifers in the 200 East Area/Gable Mountain region (RHO-RE-ST-12 P; PNL-10817). Water within the unconfined aquifer, as well as near recharge areas within the Rattlesnake Ridge interbed, is a calcium-magnesium-bicarbonate type. With increasing residence time, the water in the Rattlesnake Ridge interbed evolves to a sodium-bicarbonate type. However, a calcium-magnesium-bicarbonate water type occurs within the Rattlesnake Ridge interbed in the 200 East Area/Gable Mountain region, indicating recharge from the unconfined aquifer. Analyses of the trace metal barium in the early 1980s also indicated mixing between the two aquifers northwest of B Pond (RHO-RE-ST-12 P). Barium concentrations ranged from 14.7 to 58.7 µg/L within the unconfined aquifer, and from 105 to 129 µg/L in Rattlesnake Ridge interbed water flowing into the study area. Within the Rattlesnake Ridge interbed northwest of B Pond, barium concentrations ranged from 44.3 to 96.4 µg/L, consistent with mixing of waters between the two aquifers.

Finally, contaminants present in the unconfined aquifer have also been detected in the upper basalt-confined aquifer in the 200 East Area/Gable Mountain region, confirming that communication between the two systems has occurred (RHO-RE-ST-12 P; PNL 10817). Elevated levels of tritium and nitrate have been found in the

Rattlesnake Ridge interbed at B Pond and to the northwest. The highest measured tritium concentration was 8,300 pCi/L in well 699-42-40C at B Pond in 1993, but the highest (on trend) concentration to the northwest of B Pond was only 370 pCi/L in well 699-47-50 in 1986. Concentrations of these constituents in the Rattlesnake Ridge interbed at and northwest of B Pond have never been measured above a drinking water standard (20,000 pCi/L for tritium and 45 mg/L for nitrate).

Communication between the unconfined and upper basalt-confined aquifers has also occurred at well 299-E33-12 in the northwest part of the 200 East Area (see Section 2.14.2.2). This well was drilled in 1953 into the Pomona Basalt underlying the Rattlesnake Ridge interbed, and was uncased from just above the bottom of the unconfined aquifer through the Rattlesnake Ridge interbed (RHO-RE-ST-12 P). High-salt waste is believed to have migrated from the unconfined aquifer down the open borehole by density flow to the Rattlesnake Ridge interbed (RHO-RE-ST-12 P). This well was sealed from the unconfined aquifer in the early 1980s. In 1990, an additional seal was placed in the well that shortened the open interval. Contaminant concentrations rose sharply after the seal was installed. Cyanide, nitrate, technetium-99, and tritium continue to be elevated in this well that monitors the confined aquifer, but only nitrate and technetium-99 have exceeded their respective drinking water standards (45 mg/L for nitrate and 900 pCi/L for technetium-99). The highest historical technetium-99 concentration was 1,800 pCi/L and the highest nitrate concentration was 63 mg/L, both measured in 1991.

Contamination associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer appears to be limited to the northern part of the 200 East Area and vicinity to the north where the Elephant Mountain member of the Saddle Mountains Basalt has been partially or completely removed by erosion.

Table 2.14-1. Potential Contaminants of Interest in Ringold Formation Confined Aquifer, FY 2005 through FY 2007

Well	Sample Date	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (uS/cm)	Tritium (pCi/L)	Uranium (ug/L)
199-H4-15CQ	20-Oct-04		0.438	287		
399-1-9	04-Jan-07		0.0177 U	360		0.0384 U
399-1-16C	04-Jan-05			380	2.58 U	
	24-Jan-06			374	9.16	
	08-Dec-06		0.0177 U	369		0.0246 U
399-1-17C	08-Dec-06		0.0177 U	381		-0.00756 U
699-45-42	20-Jul-07	4.08	3.69	276	7300	
699-S22-E9C	28-Sep-07			372	7.36 U	
699-S27-E9C	28-Aug-07			376	6.51 U	
699-S29-E16C	28-Jun-05			375	2.45 U	
	07-Jul-06			387	6.15	
	03-Jul-07			366	5.06 U	

U = Below detection limit
Empty cells = Not analyzed

Table 2.14-2. Potential Contaminants of Interest in Upper Basalt-Confined Aquifer, FY 2005 through 2007

Well	Sample Date	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (uS/cm)	Sr-90 (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (ug/L)
199-H4-15CP	03-Nov-04						17.3 D	371		1.53 U	-3.56 U	1.61
199-H4-2	17-Jul-06			1.07 U	10.5		0.416	241			7.33	
	03-Jan-07			1.23 U	8.54		4.34 D	254			2.65 U	
299-E16-1	14-Jun-06			0.284 U	9.37	-0.0269 U	0.0177 U	312			-38.2 U	
299-E26-8	14-Jun-06			1.84	14.1	-0.132 U	2.35	288			7.81	
	30-Oct-06			2	8.7	0.192 U	4.03 DN	313			5.54 U	
299-E33-12	18-Apr-06							340		1060		
	26-Jun-07	2.23 U	3.71 U	1.2 U	840	-0.0856 U	43.2 D	352		1150	134	2.8
299-E33-40	26-Jul-07	0.929 U	0.223 U	2.4	10		0.0784 B	265		6.92 U	6.64	3.94
299-E33-50	28-Jun-07	0.96 U	1.69 U				1.25	264		24.1	-64 U	1.91
	09-Sep-07	-0.262 U	0.444 U	2.05	15.7	0.0462 U	1.15 N	268	0.00145 U	24	19 U	2.04 X
399-5-2	29-Jun-07			0.28 U	11		0.0221 U	349			5.74 U	
699-13-1C	13-Dec-06			1.44	7.64		0.0177 UN	317			-31 U	
699-24-1P	28-Oct-05			0.569 U	5.99		0.0443 U	374			11.2 U	
	06-Jul-06			1.33 U	8.91		0.248	357			113 U	
699-32-22B	28-Jun-06			1.27 U	12.5	0.0329 U	0.0177 U	377			-37.8 U	
	07-Nov-06			0.238 U	11	-0.0355 U	0.0531 B	383			5.9	
699-42-40C	02-Nov-06			2.19	10.5	0.171 U	5.31 DN	340			4640	
699-42-E9B	12-Oct-05	1.12 U	0.785 U	0.276 U	10.6	0.0962 U	0.0443 U	428			7.15	
	25-Jul-06	-0.669 U	0.425 U	0.0592 U	13	-0.00338 U	0.0177 U	425			8.04	
		0.253 U	-1.4 U	0.985 U	11.2	0.0222 U	0.124				4.38 U	
699-49-55B	06-Aug-07	0.615 U	1.67 U	2.6	9.6		0.691	274		-3.33 U	1.8 U	4.09
699-49-57B	21-Mar-05	0.423 U	-1.2 U			-0.0396 U	1.06 N	304		1.35 U	14.3 U	
	13-Mar-06	0.651 U	-1.56 U			0.067 U	1.11	300		0.295 U	-63.8 U	
	11-Apr-07	2.48 U	-0.339 U	0.907 U	5.86	0.0399 U	1.06	302		-0.683 U	-1.27 U	2.22 B
699-50-53B	28-Jun-06					0.0167 U	12 D	360		-0.42 U	4.16 U	
	02-Nov-06					-0.161 U	11.5 DN	378		1.84 U	119 U	
699-52-46A	30-Jun-07			3.6	7.6		1.84	326	0.223 U		7.92	

Table 2.14-2. (cont.)

Well	Sample Date	Cesium-137 (pCi/L)	Cobalt-60 (pCi/L)	Gross alpha (pCi/L)	Gross beta (pCi/L)	Iodine-129 (pCi/L)	Nitrate (mg/L)	Specific Conductance (uS/cm)	Sr-90 (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (ug/L)
699-54-34	28-Sep-07			1.8	5.1		20.5	340			6.96 U	
699-54-45B	04-Dec-06						0.416	2036				
699-56-43	07-Jul-06			1.6	5.14		4.87 D	319			0.815 U	
	07-Nov-06			3.1	3.2 U		4.56 D	325			8.06	
				2.01	19		4.38 D					
699-56-53	26-Jan-07			5.81	10.9		1.02 N	360			-59.4 U	
699-S2-34B	31-Mar-05						0.0177 U	604			72.7 U	
	10-Jan-06						0.0443 U	609			-74.2 U	
	30-Jan-07						0.0177 UN	611			-94.7 U	
699-S11-E12AP	01-Feb-05							362			-0.298 U	
	29-Jun-06			-0.216 U	8.54		0.0177 U	360			128 U	
699-S24-19P	28-Sep-07						1.77	306			17.7	

B = Analyte detected at a value less than the contract required detection limit
D = Analyzed at a secondary dilution factor
N = Spike sample recovery is outside control limits
U = Below detection limit
X = Result specific informaton may be in the result comment field
Empty cells = Not analyzed

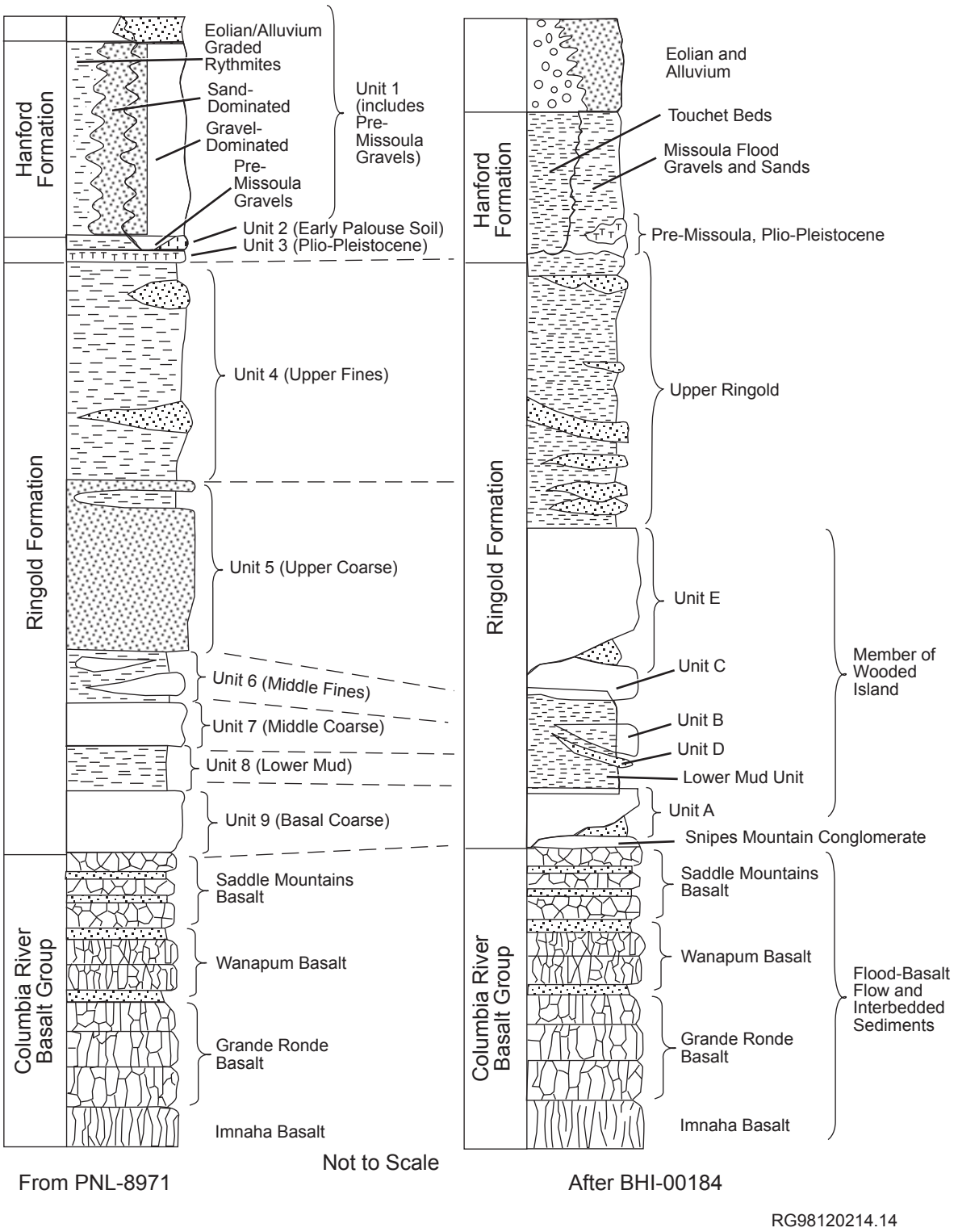

Figure 2.14-1. Hydrostratigraphy of the Hanford Site

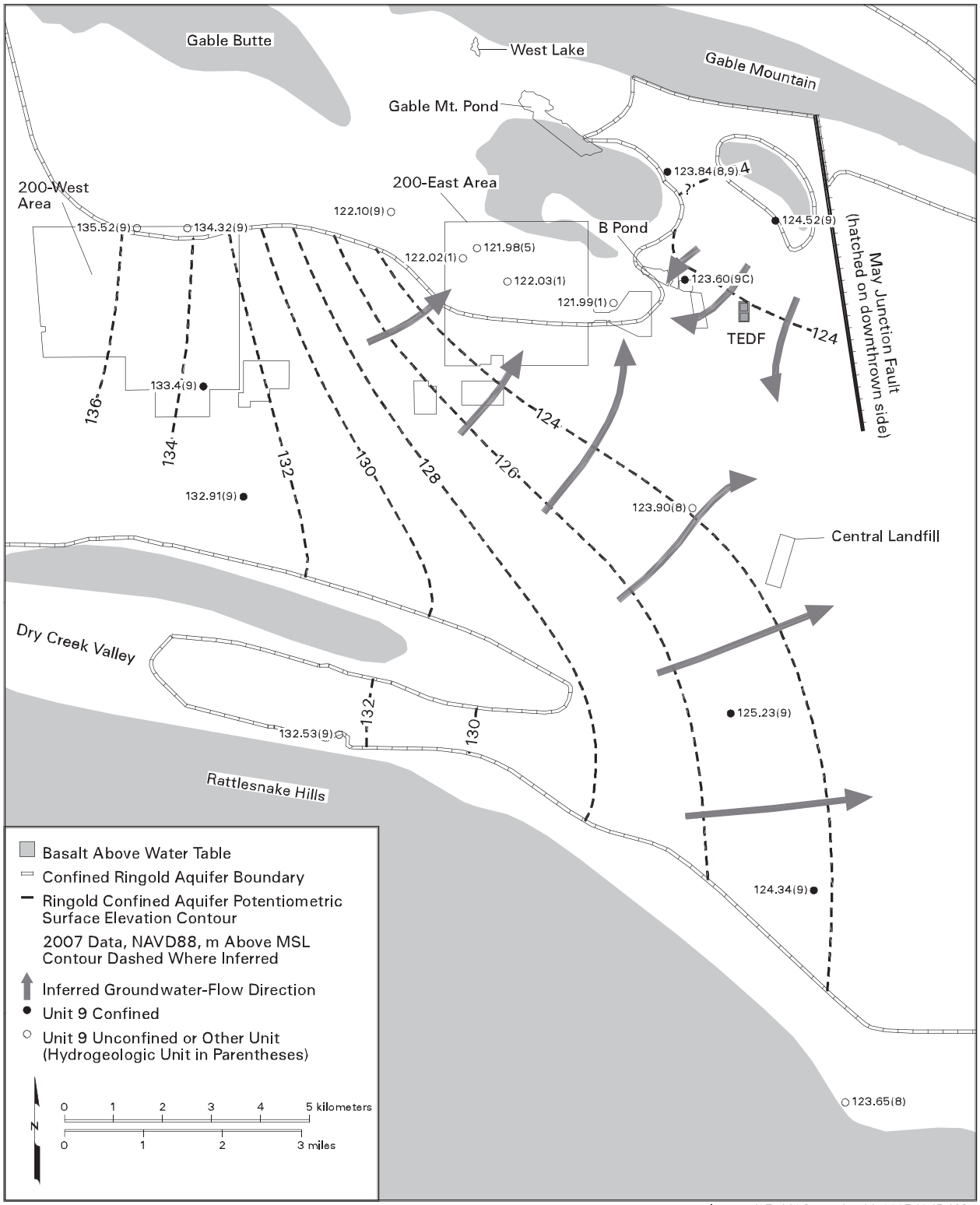

Figure 2.14-2. Potentiometric Surface Map of Ringold Formation Confined Aquifer (Unit 9), Central Hanford Site, March 2007

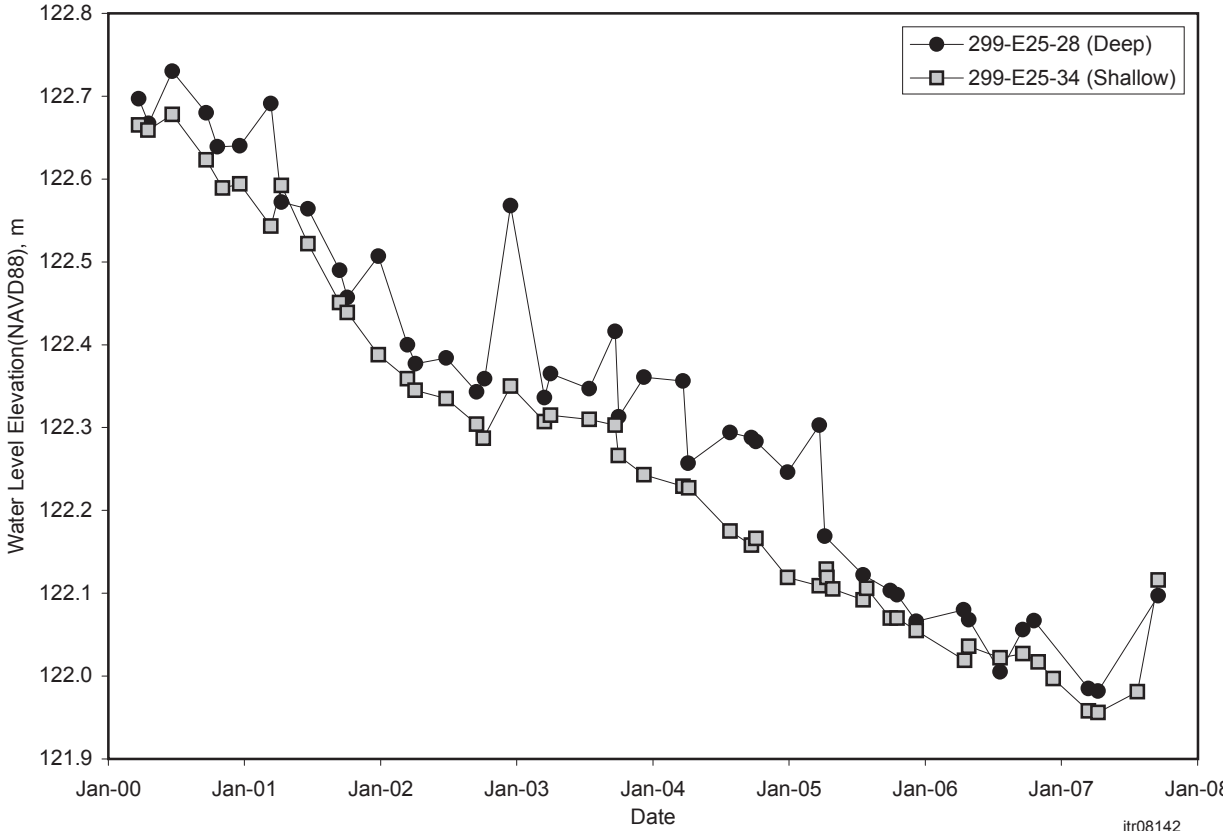

Figure 2.14-3. Water-Level Elevation in Wells Monitoring Different Depths of the Unconfined Aquifer Near 200 East Area

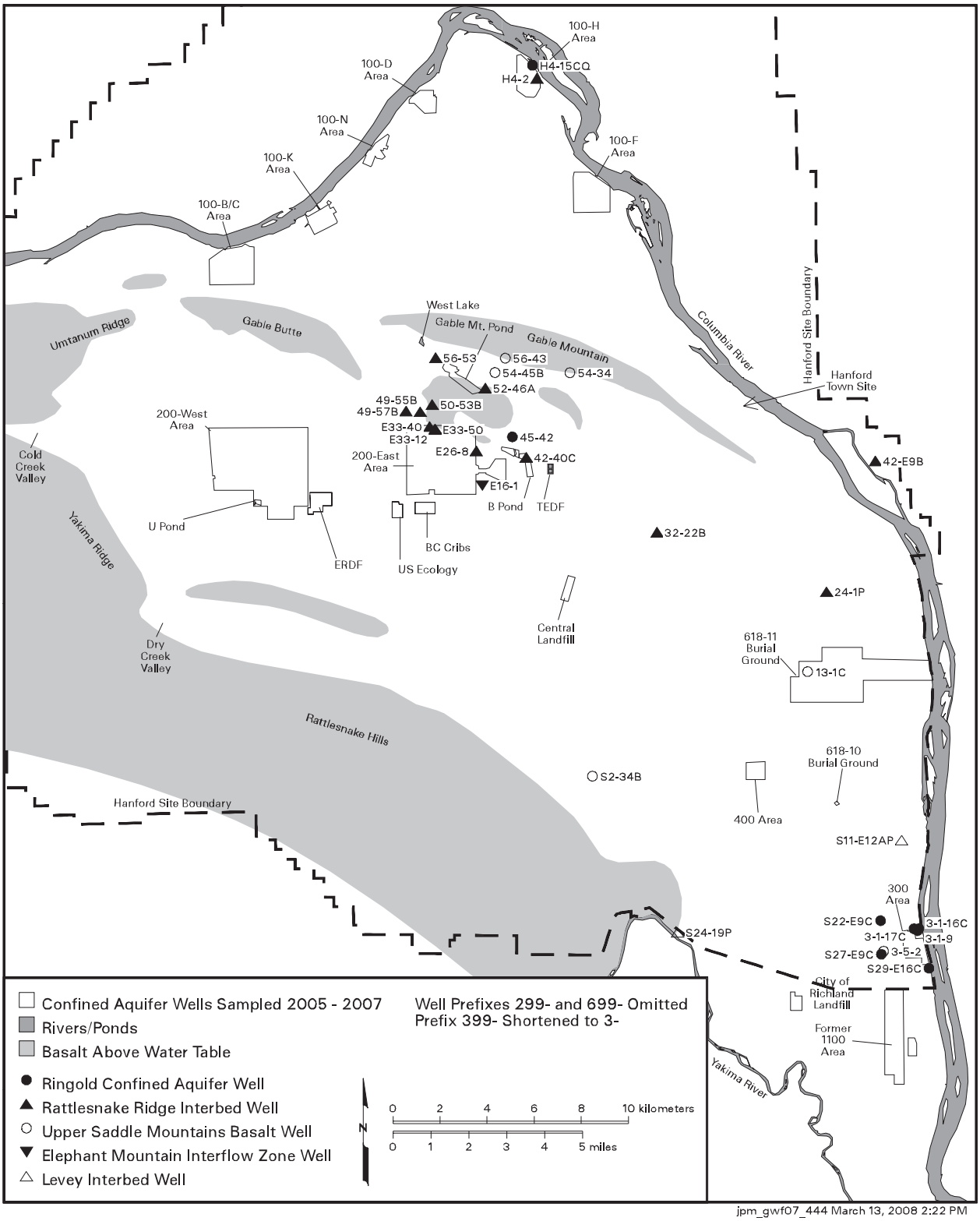

Figure 2.14-4. Groundwater Monitoring Wells Sampled in Ringold Formation Confined and Upper Basalt-Confined Aquifers, FY 2005 through 2007

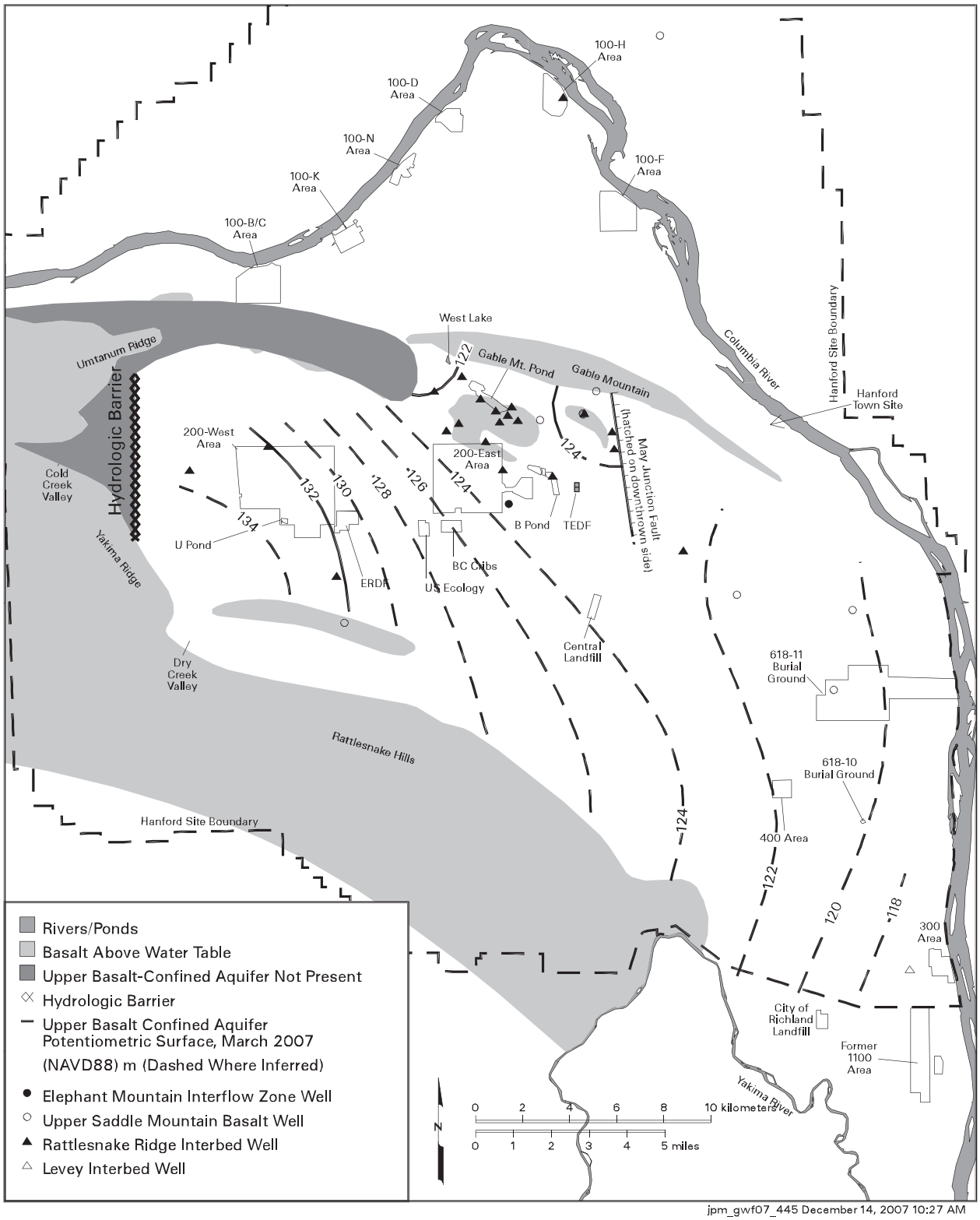

Figure 2.14-5. Potentiometric Surface Map of Upper Basalt-Confined Aquifer System, March 2007

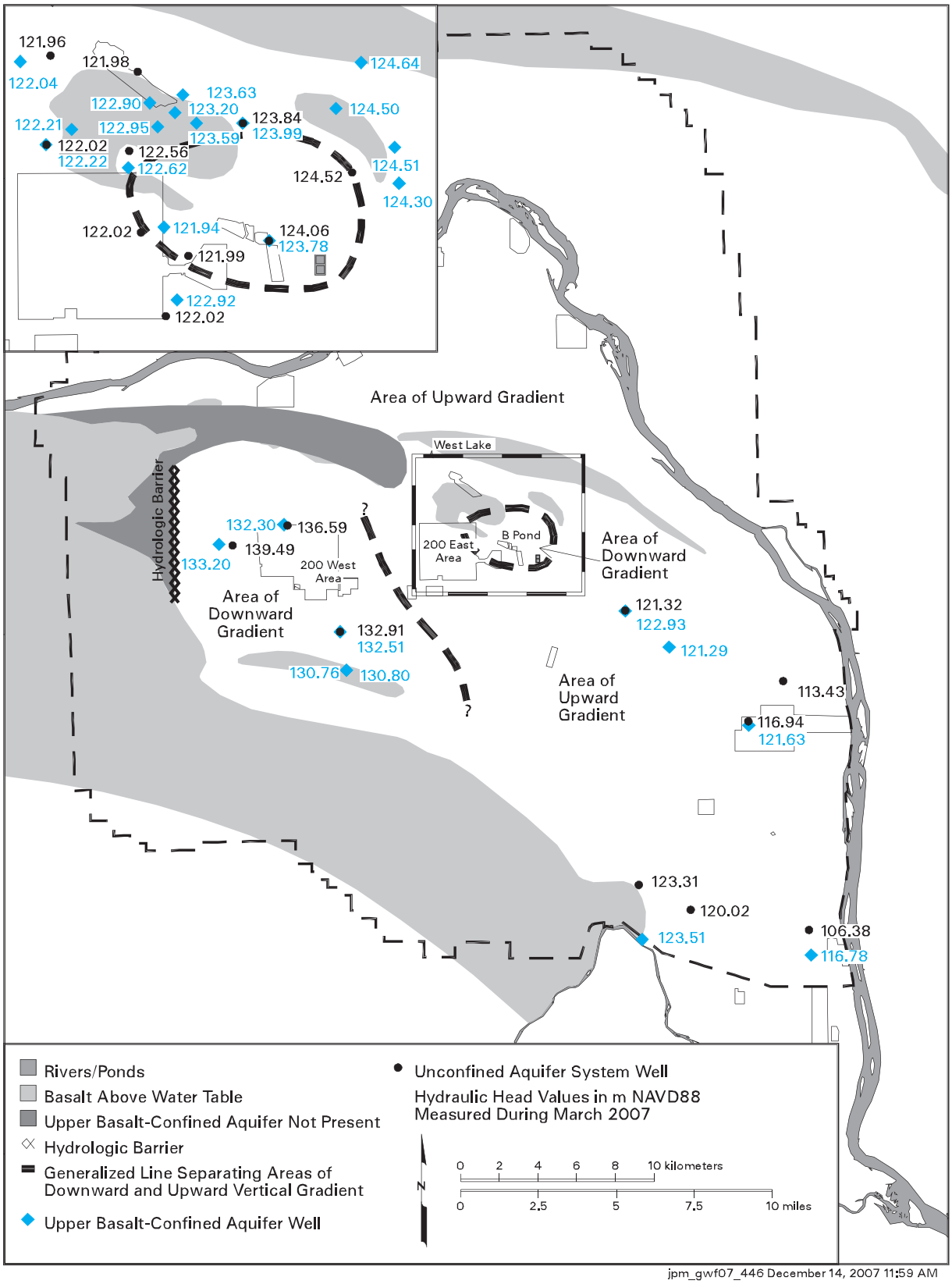

Figure 2.14-6. Comparison of Observed Heads for Upper Basalt-Confined Aquifer and Overlying Unconfined Aquifer

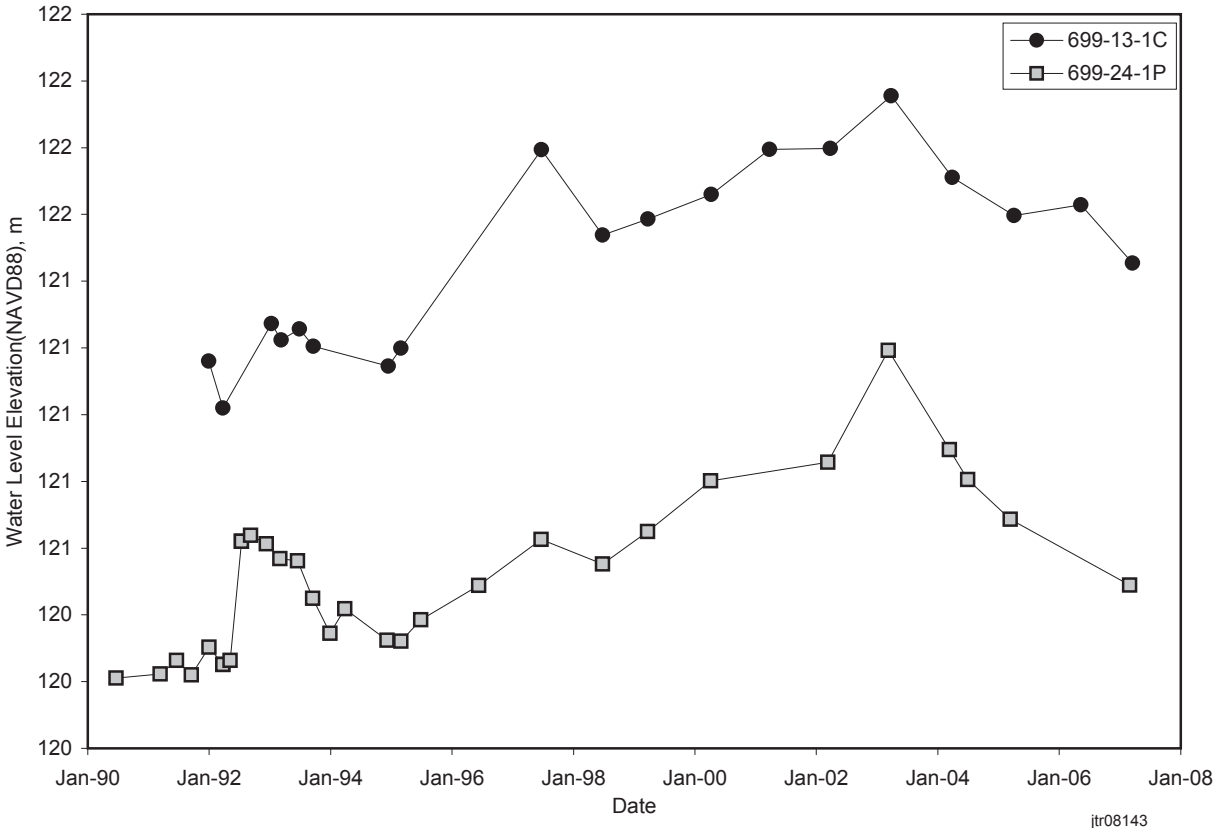

Figure 2.14-7. Water-Level Trends in Upper Basalt-Confined Aquifer Along Columbia River, East Part of Hanford Site

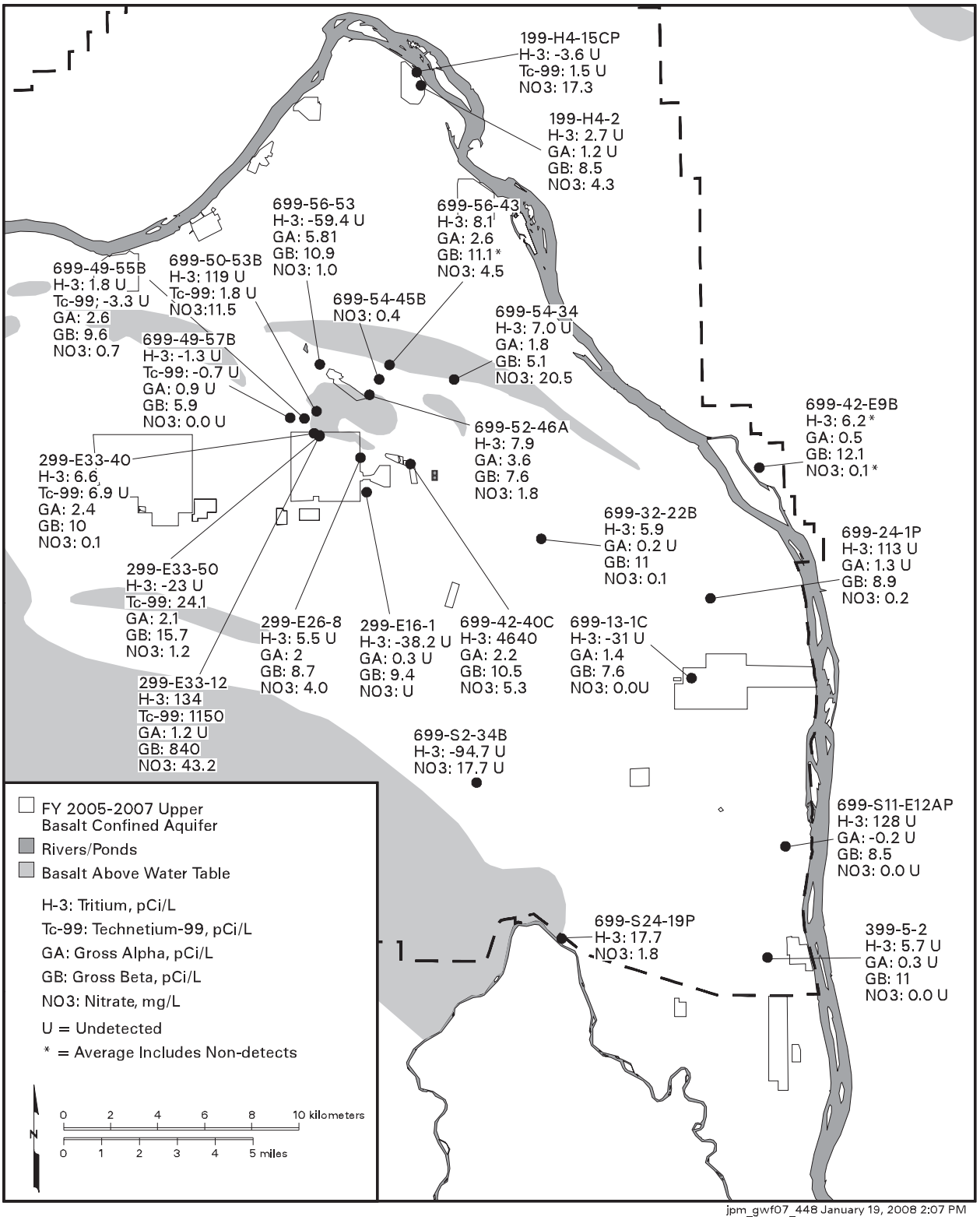

Figure 2.14-8. Distribution of Chemical and Radiological Constituents in Upper Basalt-Confined Aquifer, FY 2005 through 2007

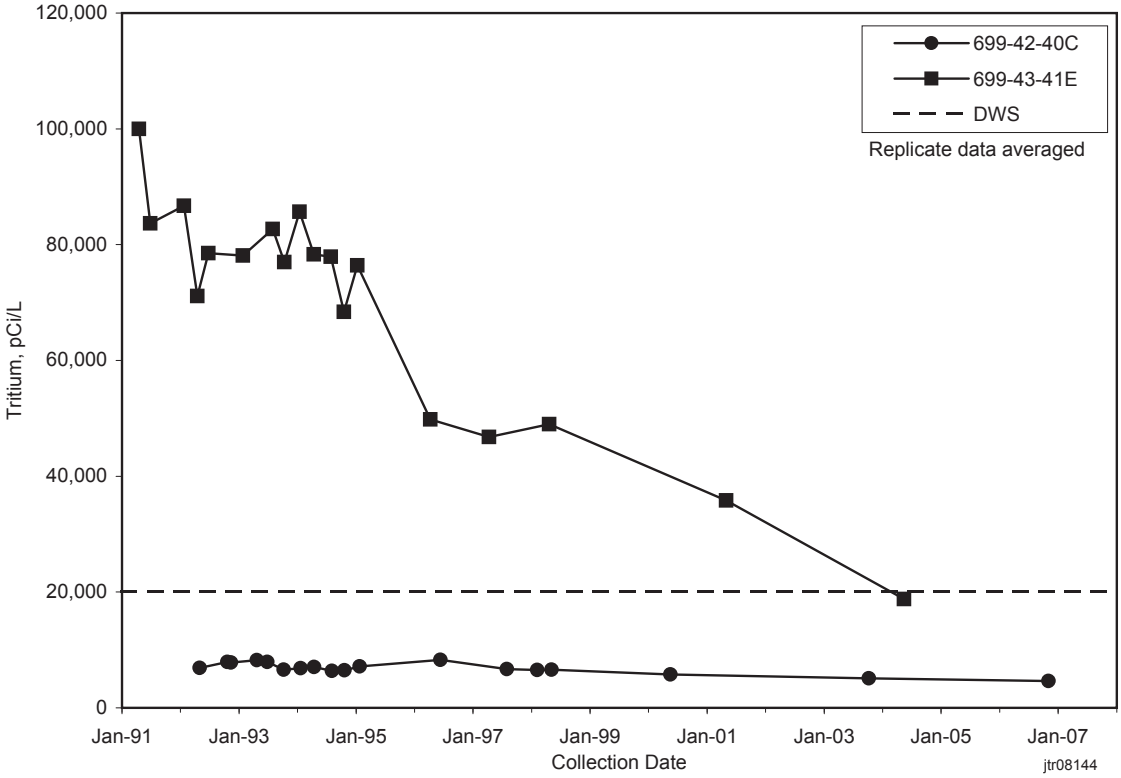

Figure 2.14-9. Tritium Concentrations in Wells 699-42-40C (Upper Basalt-Confined Aquifer) and 699-43-41E (Unconfined Aquifer)

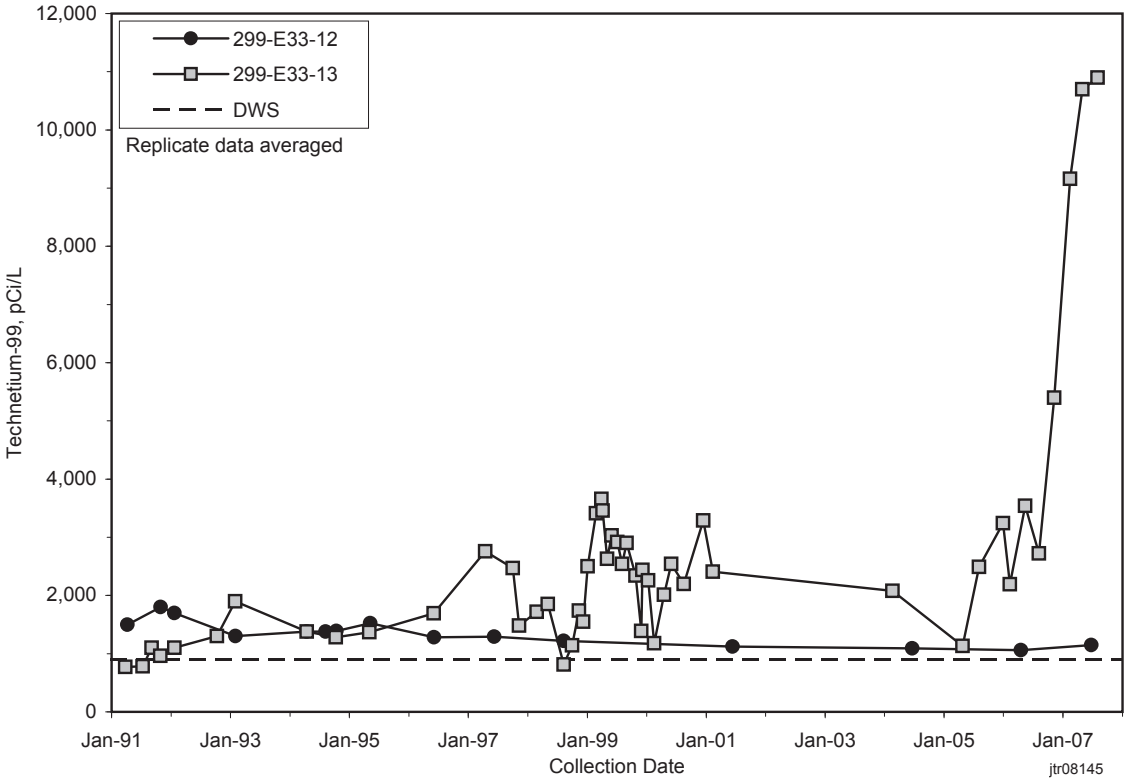

Figure 2.14-10. Technetium-99 Concentrations in Wells 299-E33-12 (Upper Basalt-Confined Aquifer) and 299-E33-13 (Unconfined Aquifer)

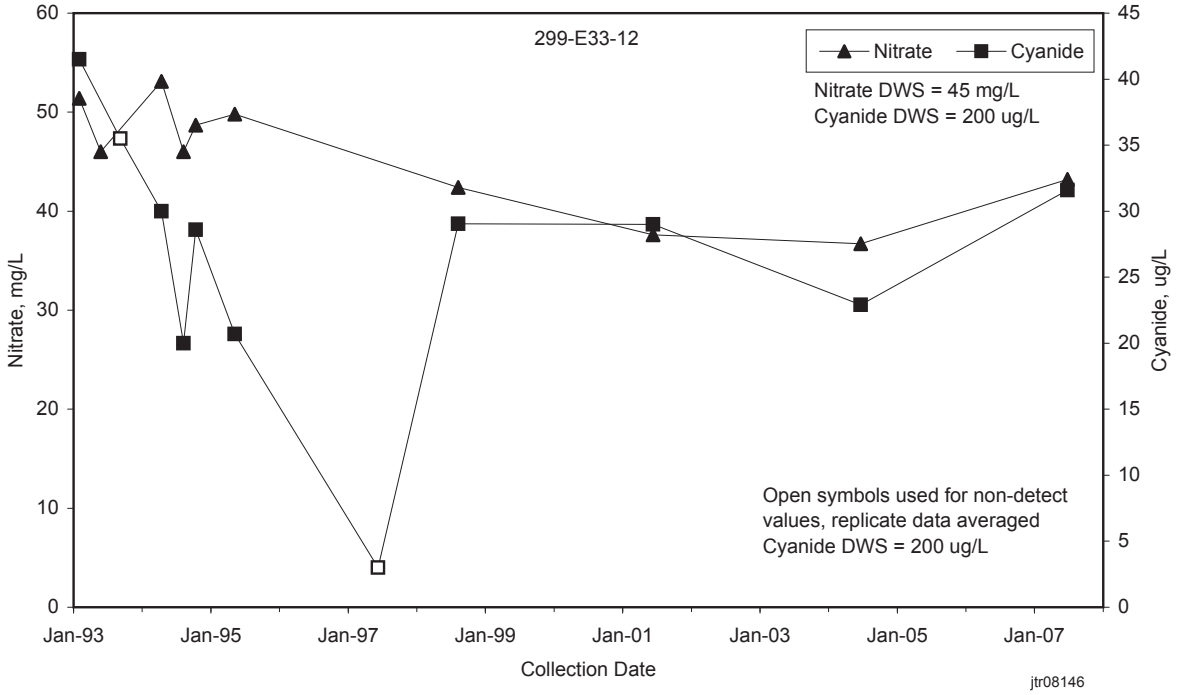

Figure 2.14-11. Cyanide and Nitrate Concentrations in Well 299-E33-12

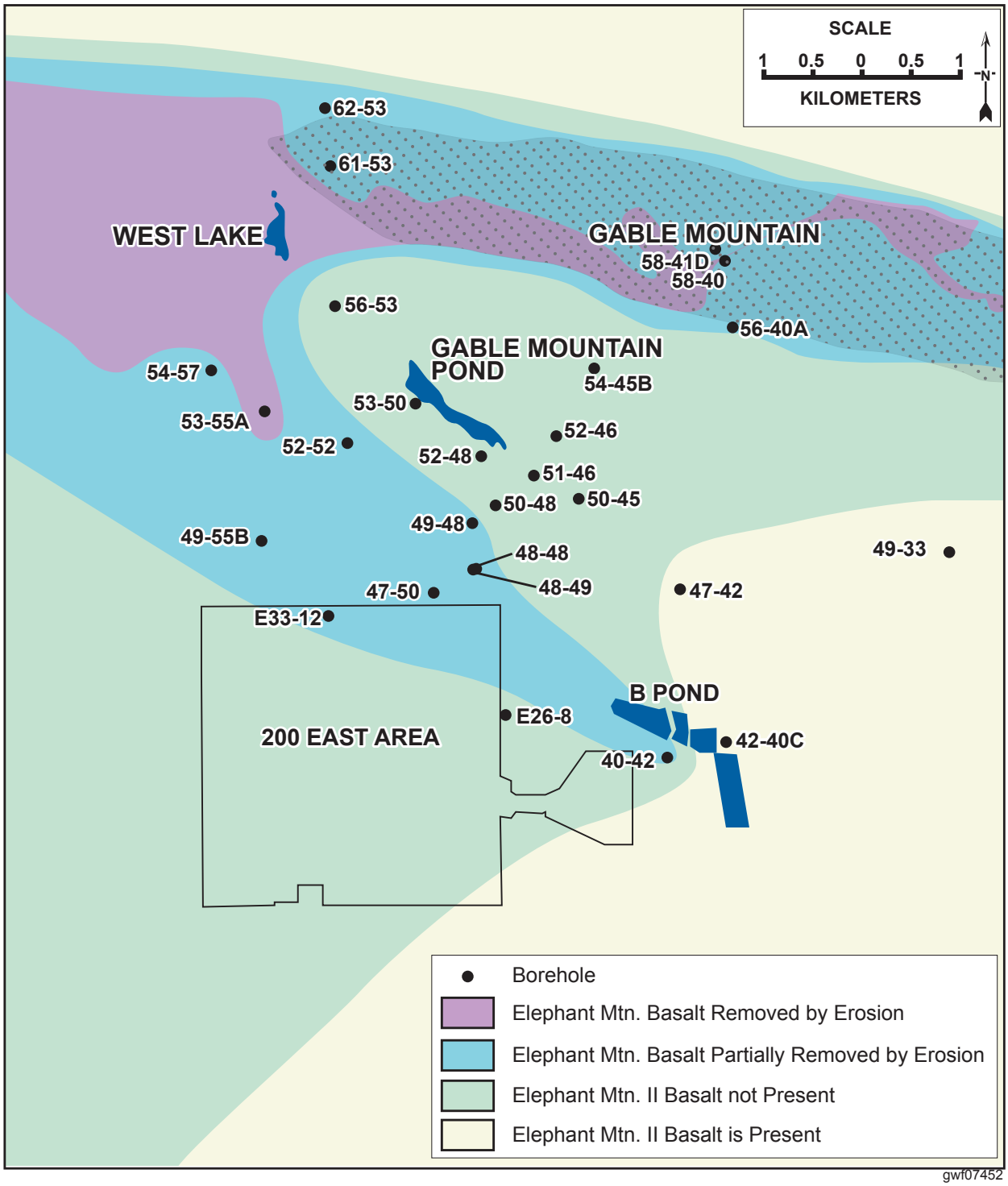

Figure 2.14-12. Extent of Partial or Complete Erosion of the Elephant Mountain Basalt in the 200 East Area/Gable Mountain Region (updated from RHO-RE-ST-12 P)

3.0 Vadose Zone

D. G. Horton

Vadose zone monitoring, using leachate and soil-gas sampling, occurred at three areas on the Hanford Site in fiscal year (FY) 2007. Leachate and soil-gas monitoring continued at the Environmental Restoration Disposal Facility and the Solid Waste Landfill. Also, soil-gas monitoring at the carbon tetrachloride expedited-response-action site continued during FY 2007.

The Tank Farm Vadose Zone Project installed several direct push boreholes in the B, T, and U Tank Farms to support placement of the T-106 Interim Barrier, install electrodes for future geophysical surveys, and investigate unplanned releases. The Tank Farm Vadose Zone Project also completed surface geophysical exploration at Waste Management Area B-BX-BY to map subsurface contaminant distribution. Also, SM Stoller Corporation continued to map vadose zone uranium distribution at Waste Management Area B-BX-BY. Finally, work on a treatability test plan to investigate remediation in the Central Plateau's deep vadose zone began in FY 2007. These monitoring and characterization efforts are summarized in the following sections.

3.1 Leachate Monitoring at the Environmental Restoration Disposal Facility

R. L. Weiss

Washington Closure Hanford, LLC operates the Environmental Restoration Disposal Facility to dispose of radioactive and mixed waste generated during waste management and remediation activities at the Hanford Site. In FY 2007, Washington Closure Hanford, LLC published the results of groundwater and leachate monitoring and sampling at the Environmental Restoration Disposal Facility during the calendar year 2006 (WCH-189). The groundwater results are discussed in Section 2.9; this section summarizes the vadose zone results.

Approximately 525,614 metric tons of remediation waste were placed in the Environmental Restoration Disposal Facility in calendar year 2006

The Environmental Restoration Disposal Facility began operation in July 1996. Located between the 200 East and 200 West Areas (see Figure 2.9-1 in Section 2.9), the facility is currently operating four disposal cells. Throughout calendar year 2006, ~525,614 metric tons of remediation waste were disposed at the facility.

Each disposal cell was constructed with a double liner system to collect leachate resulting from water added as a dust suppressant and natural precipitation. The collected leachate is sent to the Effluent Treatment Facility. The liners deliver the leachate to sumps beneath the cells where it is sampled. A composite sample of leachate was collected in duplicate in June and December 2006 from the sumps associated with the upper liners of cells 1 through 4. The samples were analyzed for selected metals, anions, selected organic compounds, total dissolved solids, gross alpha, gross beta, and selected radionuclides. The purposes of the analyses are to provide data for leachate delisting analyses and to assess whether additional analytes should be added to the routine groundwater monitoring program at the Environmental Restoration Disposal Facility.

The composite leachate samples contained detectable concentration of common metals, anions, and mobile radionuclides. Constituents that were generally increasing

in concentration include chromium, specific conductance, bromide, nitrate, gross alpha, and uranium. The following is a summary (from WHC-189) of those analytes with increasing trends:

- Chromium concentrations that previously were slowly increasing at a stable rate over time appear to have stabilized. The chromium concentration averaged ~29 µg/L in December 2006, down somewhat from 37 µg/L in December 2005.
- Specific conductance appeared to remain stable until December 2004, at which time a fairly significant increase was observed. The June 2006 values (average 2,740 µS/cm) were similar to the previous December 2005 samples, but the values increased to an average of 3,645 µS/cm in December 2006.
- Bromide was not detected in leachate samples until June 2004, and the concentration of bromide increased through June 2005. The June 2006 concentration was 1.1 mg/L.
- Nitrate concentrations had increased at a fairly steady rate through calendar year 2004 but appear to have decreased during 2005. Concentrations remained stable through 2006 at ~ 372 mg/L.
- Uranium concentrations have increased over the past 3 years and reached a new maximum concentration of 1,734 µg/L in December 2006.
- Nickel, which is monitored every 2 years, appears to be increasing. The average nickel concentration was 20.7 µg/L in December 2006.
- Potassium, which is monitored every 2 years, appeared to be increasing through 2004 but stabilized at 27,000 µg/L in December 2006.
- Total dissolved solids appear to be increasing through 2006. The average December 2006 total dissolved solids value was 2,320,000 µg/L.
- Gross alpha concentrations have increased over the past 3 years with an average December concentration of 1,200 pCi/L. The increase in gross alpha parallels the increase in uranium and most of the alpha activity is probably due to uranium.
- Gross beta concentrations have increased over the past 3 years with an average December concentration of 932 pCi/L. Specific beta emitters responsible for the gross beta activity are not known for certain.

Groundwater monitoring data for nickel, gross alpha, gross beta, and uranium were examined to determine whether the leachate from the Environmental Restoration Disposal Facility has affected groundwater. In all cases, groundwater concentrations for these constituents remained stable. Based on this comparison, the data suggest that the Environmental Restoration Disposal Facility leachate has not affected groundwater.

3.2 Leachate and Soil-Gas Monitoring at the 600 Area Central Landfill

Summarized by D. G. Horton

The Solid Waste Landfill is a disposal facility in the center of the Hanford Site (part of the Central Landfill illustrated on Figure 2.1-1 in Section 2.1). The Solid Waste Landfill covers an area of ~26.7 hectares and began operating in 1973 to

receive non-hazardous, nonradioactive sanitary waste generated from Hanford Site operations. The Solid Waste Landfill stopped receiving waste in 1996 and an "interim cover" consisting of 0.6 to 1.2 meters of soil was placed over all trenches. Current monitoring at the 600 Area Central Landfill consists of sampling groundwater, soil gas, and leachate. Recent groundwater monitoring results are discussed in Section 2.11. This section summarizes leachate and soil-gas monitoring results. The results are forwarded annually to Washington State Department of Ecology (Ecology) and the most recent report[(a)] covers the period July 2006 to June 2007.

The 600 Area Central Landfill consists of single trenches and double trenches. One of the double trenches overlies a lined basin lysimeter designed to collect leachate generated by infiltration through the overlying refuse. (All other trenches are unlined.) This lysimeter covers an area of ~88 square meters. A discharge pipe continuously drains leachate by gravity flow from the basin to a nearby collection pump. However, leachate collected from this lysimeter may not be representative of leachate drainage throughout the entire landfill area because the lysimeter only collects leachate from one of the double trenches and is installed under one of the newer trenches built after implementation of regulations that restrict land disposal practices. Still, the lysimeter provides some indication of the rate of infiltration and some of the contaminants that may be released to the vadose zone beneath the site.

Leachate is collected from the 600 Area Central Landfill every 10 to 14 days and tested quarterly.

Leachate is collected from the basin lysimeter every 10 to 14 days. Figure 3.0-1 shows the rate of leachate generated over the past 9 years. Prior to calendar year 2003, the generation rate was consistently between 4 to 8 liters/day. However, during the July 2003 through June 2004 and July 2004 through June 2005 reporting periods, the generation rates increased significantly to ~19 liters/day. This increase mainly was attributed to above average rainfall recorded at the Hanford Site

For the reporting period between July 2006 through June 2007, a total of ~3,165 liters of leachate was generated, for a daily average during the year of 8.7 liters (Figure 3.0-1). This was about a 35% increase in leachate generation from the previous year, when the daily average was ~6.4 liters/day. This increase is attributed mainly to higher than normal precipitation recorded at the Hanford Site during October through December 2006. The Hanford Meteorological Station recorded 8.2 centimeters of precipitation between October and December 2006.

Leachate is sampled and tested quarterly for indicator parameters listed in WAC 173-304-490 and annually for site-specific constituents, which cover a complete range of metals and organics. Concentrations measured during July 2006 through June 2007 are similar to previous concentrations and did not identify any areas of concern. Some of the indicator parameters and some organic constituents and metals in the leachate continued to be above WAC 173-200 groundwater quality criteria and/or drinking water standards established in WAC 246-290-310. See Section 2.11.3.8 for a discussion of groundwater at the 600 Area Central Landfill. Table 3.0-1 shows analytical results for key constituents in the 600 Area Central Landfill leachate.

Soil gas at the 600 Area Central Landfill is monitored to demonstrate that the air quality performance standards are met. Soil-gas monitoring at the Solid Waste Landfill uses eight shallow monitoring stations located around the perimeter of the landfill. Each station consists of two soil-gas probes at depths of ~2.75 and 4.6 meters. Soil gas is monitored quarterly to determine concentrations of carbon

(a) Letter FH-0702400 from CM Murphy (Fluor Hanford, Inc., Richland, Washington) to DA Brockman (U.S. Department of Energy, Richland, Washington), PHMC Section C.4.2 - Submittal of Solid Waste Landfill Annual Monitoring Report, dated September 26, 2007.

dioxide, methane, and several key volatile organic compounds. During the reporting period, between July 2006 and June 2007, results were consistent with results for soil-gas monitoring during previous years. The volatile organic constituents were at or below the detection limits. Methane concentrations remain low or, for the most part, are not detected. Carbon dioxide concentrations continue to be consistent with previous data. Carbon dioxide concentrations are lower when atmospheric pressure is rising and higher when atmospheric pressure is low.

3.3 Carbon Tetrachloride Monitoring and Remediation

V. J. Rohay

Soil-vapor extraction is being used to remove carbon tetrachloride from the vadose zone in the 200 West Area. The U.S. Environmental Protection Agency (EPA) and Washington State Department of (Ecology) authorized DOE to initiate this remediation in 1992 as a *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) expedited response action. The following discussion summarizes fiscal year (FY) 2007 activities associated with the carbon tetrachloride removal. A report containing detailed results of FY 2007 activities will be published in FY 2008. For descriptions of past work, see BHI-00720, WMP-17869, WMP-21327, WMP-26178, WMP-30426, SGW-33746, and Section 3.1.3 in PNNL-16346. SGW-33746 describes the soil-vapor extraction system and the well fields. See Figure 3.0-2 for locations of vapor extraction wells.

The 14.2-cubic-meter/minute soil-vapor extraction system was operated at the 216-Z-9 well field from March 29 through August 7, 2007. The soil-vapor extraction system was operated at the 216-Z-1A well field from August 15 through September 28, 2007. The system was maintained in standby mode from September 30, 2006, through March 29, 2007. The 28.3- and 42.5-cubic-meter/minute soil-vapor extraction systems did not operate and were not maintained during FY 2007. Temporarily suspending soil-vapor extraction operations at each well field allows the carbon tetrachloride concentrations to recharge and be more economically extracted when operations resume.

To track the effectiveness of the remediation effort, soil-vapor concentrations of carbon tetrachloride were monitored at the inlet to the soil-vapor extraction system and at individual online extraction wells during the 6-month operating period. To assess the impact of the soil-vapor extraction system on subsurface concentrations, soil-vapor concentrations of carbon tetrachloride were monitored at off-line wells and probes during the entire fiscal year.

Soil-vapor extraction is being used to remove carbon tetrachloride form the vadose zone in the 200 West Area.

Remediation efforts during FY 2007 also included passive soil-vapor extraction.

3.3.1 Soil-Vapor Extraction

Soil-vapor extraction to remove carbon tetrachloride from the vadose zone resumed March 29, 2007, at the 216-Z-9 well field. Initial extraction was from wells close to the 216-Z-9 trench. As extraction continued, additional wells close to the trench and farther away from the trench were brought online. Extraction wells open near the less-permeable Cold Creek unit, where the highest carbon tetrachloride concentrations have consistently been detected in the past, were selected to optimize mass removal of contaminant. Extraction wells open near the groundwater also were selected. Three narrow-diameter wells (C4937, C4938, C5340) installed using a

direct-push technology on the south side of the 216-Z-9 trench as part of the remedial investigation for the 200-PW-1 Operable Unit, were brought online in June 2007. During the 18 weeks of extraction in FY 2007, the maximum carbon tetrachloride concentration measured at the soil-vapor extraction system inlet was ~94 ppmv on the first day of operation (Figure 3.0-3). This concentration was higher than the maximum concentration (~41 ppmv) measured when the soil-vapor extraction system last operated at this site in 2006. The maximum concentration of carbon tetrachloride measured after the first day of operation was 36 ppmv.

Soil-vapor extraction resumed August 15, 2007, at the 216-Z-1A well field. Online wells were selected within the perimeter of the 216-Z-1A tile field. Extraction wells open near the less-permeable Cold Creek unit, where the highest carbon tetrachloride concentrations have consistently been detected in the past, were selected to optimize mass removal of contaminant. Initial carbon tetrachloride concentrations measured at the soil-vapor extraction inlet during the first week of operation were 0 ppmv, most likely as a result of dilution caused by leaks in the system. Following repairs to the system gaskets, carbon tetrachloride concentrations measured at the soil-vapor extraction inlet during the second week of operation were ~16 ppmv (Figure 3.0-3). This concentration was comparable to the maximum concentration (15 ppmv) measured when the soil-vapor extraction system last operated at this site in 2006.

Approximately 79,200 kilograms of carbon tetrachloride have been removed from the vadose zone since extraction operations started in 1991.

As of September 2007, ~79,200 kilograms of carbon tetrachloride had been removed from the vadose zone since extraction operations started in 1991 (Table 3.0-2). The mass of carbon tetrachloride removed in FY 2007 was 280 kilograms. The performance evaluation report (SGW-33746) provides the amounts of carbon tetrachloride removed per year between 1991 and 2006.

3.3.2 Monitoring at Off-Line Wells and Probes

During FY 2007, soil-vapor concentrations of carbon tetrachloride were monitored near the ground surface, near the Cold Creek unit (~40 meters below ground surface [bgs]), and near groundwater (~66 meters bgs). Soil-vapor concentrations were monitored near the ground surface and groundwater to evaluate whether non-operation of the soil-vapor extraction system negatively affects the atmosphere or groundwater. The maximum concentration detected near the ground surface (between 2 and 10 meters bgs) was 8 ppmv. Near the groundwater (between 53 and 66 meters bgs), the maximum concentration was 16 ppmv.

Soil-vapor concentrations also were monitored above and within the Cold Creek unit to provide an indication of concentrations that could be expected during restart of the soil-vapor extraction system. The maximum concentration detected near the Cold Creek unit (between 25 and 44 meters bgs) was 262 ppmv in soil-vapor probe CPT-28 (27 meters bgs) ~90 meters south of the 216-Z-9 trench. This location may be beyond the zone of influence of the soil-vapor extraction system. Within the 216-Z-9 well field, the maximum carbon tetrachloride concentration detected near the Cold Creek unit was 24 ppmv at two locations: soil-vapor probe CPT-24 and well 299-W15-216 (both 36 meters bgs). North of the 216-Z-9 trench ~200 meters, the maximum carbon tetrachloride concentration detected was 46 ppmv at soil-vapor probe CPT-9A (15 meters bgs).

At the 216-Z-1A well field, the maximum carbon tetrachloride concentration detected near the Cold Creek unit was 131 ppmv at well 299-W18-248 (40 meters bgs).

The maximum carbon tetrachloride concentrations detected in the vadose zone overlying the Cold Creek unit (between 11 and 23 meters bgs) were 193 ppmv at soil-vapor probe CPT-21A, which may be beyond the zone of influence of the soil vapor extraction system, and 191 ppmv at well C4937 (both 20 meters bgs) near the 216-Z-9 trench.

The temporary suspension of soil-vapor extraction in FY 2007 appears to have caused minimal detectable vertical transport of carbon tetrachloride through the soil surface to the atmosphere. This interpretation is supported by data that show carbon tetrachloride concentrations did not increase significantly at the near-surface monitoring probes. In addition, suspending operations of the soil-vapor extraction system appears to have had no negative impact on groundwater quality, because carbon tetrachloride concentrations did not increase significantly near the water table during that time.

3.3.3 Passive Soil-Vapor Extraction

Passive soil-vapor extraction is a remediation technology that uses naturally induced pressure gradients between the subsurface and the ground surface to drive soil vapor to the surface. In general, falling atmospheric pressure causes subsurface vapor to move to the atmosphere through wells, whereas rising atmospheric pressure causes atmospheric air to move into the subsurface. Passive soil-vapor extraction systems are designed to use this phenomenon to remove carbon tetrachloride from the vadose zone.

The temporary suspension of soil-vapor extraction in FY 2007 appears to have caused minimal transport of carbon tetrachloride through the soil to the atmosphere and appears to have had no negative impact on groundwater quality.

Passive soil-vapor extraction systems were installed at the end of FY 1999 at eight boreholes that are open near the vadose-groundwater interface at the 216-Z-1A/216-Z-12/216-Z-18 well field. The passive systems are outfitted with check valves that only allow soil-vapor flow out of the borehole (i.e., one-way movement), and canisters holding granular activated carbon that adsorbs carbon tetrachloride upstream of the check valves before the soil vapor is vented to the atmosphere. The check valve prohibits flow of atmospheric air into the borehole during a reverse barometric pressure gradient, which tends to dilute and spread carbon tetrachloride vapors in the subsurface.

The wells are sampled periodically upstream of the granular activated carbon canisters when atmospheric pressure is falling and the wells are venting. The maximum carbon tetrachloride concentrations measured at the four wells (299-W18-6, 299-W18-7, 299-W18-246, and 299-W18-252) in the vicinity of the 216-Z-1A tile field ranged from 12 to 39 ppmv. The maximum carbon tetrachloride concentrations measured at the four wells (299-W18-10, 299-W18-11, 299-W18-12, and 299-W18-247) in the vicinity of the 216-Z-18 crib ranged from 1 to 14 ppmv.

3.4 Tank Farm Vadose Zone Activities

J. G. Field and D. A. Myers

The Vadose Zone Integration Program is responsible for implementing the Tank Farm RCRA Corrective Action Program through field characterization, laboratory analyses, technical analyzes, risk assessment for past tank leaks, and installation of interim measures that will reduce the threat from contaminants until permanent solutions can be found. In FY 2007, the Vadose Zone Integration Program installed several boreholes for soil sampling and geophysical logging at several tank farms and completed surface geophysical surveys at Waste Management Area B-BX-BY.

3.4.1 Direct Push Boreholes and Sampling

The hydraulic hammer unit was deployed in three tank farms during FY 2007 to evaluate subsurface contamination in the vadose zone. Several pushes were made in the B Tank Farm to investigate unplanned release sites associated with diversion boxes in that farm. The hydraulic hammer unit was deployed in the T Tank Farm to place vadose zone monitoring equipment in support of the T-106 interim barrier placement. In the U Tank Farm, the hydraulic hammer unit was deployed at 10 sites identified from previous investigations as having potentially anomalous distribution of resistivity (RPP-RPT-31557), and from historical records of tank leaks (RPP-15808). Table 3.0-3 provides the locations where direct push was used in single-shell tank farms during FY 2007. The table also shows the number of probe holes, total meters drilled, total meters geophysically logged, the number of samples taken, and the number of electrodes impacted at each site.

A hydraulic hammer is a hydraulic percussion drilling device used for driving steel pipe into the ground to collect samples or place monitoring equipment into the vadose zone.

A relatively new application was made in the U Tank Farm deployment. At this site a multi-level sampler, developed for investigation of the Plutonium Finishing Plant trenches, was used to collect samples of potentially contaminated sediments for laboratory analysis. In addition, the hydraulic hammer unit was used to place deeply buried electrodes at each of the 10 investigated sites. These electrodes will be used during a future full-scale deployment of Surface Geophysical Exploration in the U Tank Farm.

Analyses of the samples collected during the hydraulic hammer unit deployments are being used in the Waste Management Area U Field Investigation Report (to be released as RPP-35845) and the RCRA Field Investigation Report that are scheduled to be published by January 2008.

3.4.2 Surface Geophysical Exploration

Surface geophysical exploration, a combination of surface deployed geophysical techniques, was applied in Waste Management Area B-BX-BY (RPP-RPT-34690) during FY 2007. In addition, reports about the FY 2006 field application of surface geophysical exploration in Waste Management Areas C (RPP-RPT-31558) and U (RPP-RPT-31557) were released during the fiscal year. The primary tool applied through surface geophysical exploration is pole-pole electrical resistivity; other tools include electro-magnetic induction, magnetic gradiometry, and ground-penetrating radar. These latter tools are used to help define the presence and distribution of buried infrastructure, so that those features may be taken into account during the analysis of resistivity data. The depth to which the resistivity measurements interrogate the subsurface is determined by the distance between electrode pairs (the further apart, the deeper the interrogation). Because resistivity is an indirect measure of several subsurface phenomena (e.g., moisture distribution, saline contaminants, or soil texture), the more separated the electrode pairs, the lower the resolution of the analysis. The resistivity data are mathematically analyzed through a process known as inversion to provide a best estimate of the distribution of resistivity anomalies. Surface geophysical exploration provides a means of extrapolating direct measurements taken by sampling, logging, or other means to provide a cost-effective overview of large areas that may have been impacted by a variety of waste management practices.

The analysis of the surface geophysical exploration data is being used to determine the locations of several groundwater monitoring wells that will be drilled during FY 2008 and beyond.

In Waste Management Area B-BX-BY (RPP-RPT-34690), the surface geophysical exploration analyses point to several regions worthy of further characterization using more conventional approaches such as drilling. Figure 3.0-4 provides an isometric, composite view of the waste management area. The figure shows areas of high

conductance (low resistivity) in the vadose zone which probably correspond to areas of high concentrations of nitrate and associated contaminants.

The analysis of the surface geophysical exploration data is being used to direct the locations of several groundwater monitoring wells to be drilled during FY 2008 and beyond. Soil samples collected during the drilling activities will be analyzed and then used to further refine the numerical analysis of the already collected surface geophysical exploration data. Each piece of direct data can be used to further constrain the inversion analysis of the resistivity data, thereby providing an ever increasing resolution to the distribution of subsurface contamination.

3.5 Geophysical Logging

R. McCain

Radiation measurements have been taken in boreholes since the early days of the Hanford Site to detect manmade radionuclides in the subsurface. Logging at the Hanford Site is currently performed by SM Stoller Corporation (Stoller) under subcontract to the Hanford Site contractors.

The original Hanford Geophysical Logging Project was completed in 2000. Currently, boreholes in or near waste sites at the 200 Areas are being logged to gather data that can help well decommissioning, remedial investigations, and groundwater monitoring.

Originally, the objective of the Hanford Geophysical Logging Project was to determine the nature and extent of subsurface contamination in the vicinity of the single-shell tank farms and to provide a baseline against which subsequent measurements could be compared. That effort was completed in 2000. Subsequent to completion of the initial tank farm effort, the Radionuclide Assessment System was developed for use by tank farms personnel, with support from Stoller. Use of the Radionuclide Assessment System in tank farms and comparison of new logs with the baseline logging is presently focused on retrieval support. Radionuclide Assessment System and moisture logging for retrieval is performed at the start and end of retrievals and when significant moisture changes are observed. Drywell logging requirements in support of waste retrieval operations are defined in Tank Waste Retrieval Work Plans and Process Control Plans. Additional tank farm logging will be addressed as part of Tank Farm Corrective Actions and integration between Tank Farm and Central Plateau contractors.

After completion of the original tank farm logging in 2000, the vadose zone characterization project then was established to log existing boreholes in or near waste sites in the Hanford 200 Areas. Stoller provides geophysical logging services in support of well decommissioning, remedial investigation efforts by other contractors, and the groundwater monitoring program. Borehole logs are provided directly to DOE and the Hanford Site contractors. They are also available via the internet at http://www.hanford.gov/cp/gpp/data/gpl.cfm. The logs are incorporated into data sets and reports for individual projects and will not be discussed in this section. This section focuses on logging systems currently in use, detection of manmade uranium, and uranium in the 200-BP-5 Groundwater Operable Unit.

3.5.1 Logging Systems in Use at Hanford

In 2007, the Hanford Geophysical Logging Project operated three logging trucks, with various logging instruments, i.e., sondes. Each combination of a logging truck and sonde is considered a logging system, and each logging system is individually calibrated. Calibrations are performed annually, or after any repairs or modifications to either the equipment or the logging sonde. Currently available logging systems include the following:

- High-resolution spectral gamma logging systems, including the spectral gamma logging system and the high rate logging system. These systems collect high-resolution gamma energy spectra specific to individual gamma emitting radionuclides. The spectral gamma logging system can also be run in total gamma mode, where a shorter count time is used. Energy spectra also are collected and may be analyzed if necessary.
- Neutron moisture logging systems.
- The slim hole logging system, which includes total gamma logs, conventional spectral gamma, and neutron moisture logs - all of which are configured to run in boreholes with inner diameters as small as 4.4 centimeters.
- Passive neutron logging system.

Table 3.0-4 lists currently available logging systems and provides basic analytical performance requirements for typical logging applications.

In addition to the logging systems mentioned above, Stoller has developed and deployed both radionuclide assessment and monitoring systems for use by tank farms personnel. The radionuclide assessment system uses a series of three sodium iodide detectors with limited spectral capability to conduct routine drywell monitoring in the single-shell tank farms. Results are compared against previous logs and baseline data to detect any changes that might indicate a tank leak or contaminant migration. The radionuclide monitoring system uses a neutron moisture log and hybrid gamma detector system (sodium iodide detector and two pairs of Geiger-Mueller detectors) to simultaneously measure moisture content and gross gamma activity in dry wells near tanks undergoing waste retrieval operations.

3.5.2 Detection of Uranium in the Vadose Zone at 200-BP-5 Groundwater Operable Unit

Geophysical logging at Waste Management Area B-BX-BY indicates an increase of uranium in the deep vadose zone.

Wells 299-E33-18, 299-E33-41, and 299-E33-45, located in the source operable units above the 200-BP-5 Groundwater Operable Unit, were originally logged as part of the baseline characterization effort in 2001 to 2002 (see Figure 2.10-1 for location of wells at Waste Management Area B-BX-BY). Uranium-238 logs from these wells were presented and discussed in PNNL-16346. Identification and quantification of manmade uranium is discussed in HGP-LDR-028. Log results identified a plume of manmade uranium, which appeared to be extending downward and to the east-northeast from the general vicinity of tank BX-102, intersecting groundwater in the vicinity of well 299-E33-18. (Sobczyk et al. 2003).

Evaluation of historical log data indicates that uranium-238 plume had arrived at well 299-E33-18 sometime between 1992 and 1997 (Figure 3.0-5), which coincides with the first report of uranium-238 in groundwater samples in early 1993. The 1997 log indicated a maximum uranium-238 concentration of 439 pCi/g at 72.5 meters bgs. The maximum concentration had increased to 1,237 pCi/g in 2006 and to 1,533 pCi/g in 2007 (both at 71.9 meters bgs). This increase is substantially greater than the counting error or error associated with logging system efficiency. Therefore, it is considered to represent a definite increase in uranium-238 in the deep vadose zone at well 299-E33-18. In well 299-E33-41, the maximum uranium concentration in FY 2007 was 715 pCi/g, compared to 777 pCi/g in 2006. In addition to uranium-238, uranium-235 was also detected, although at much lower concentrations. See Sections 2.10.1.6 and 2.10.3.1 for discussions of uranium in groundwater at Waste Management Area B-BX-BY.

3.6 Deep Vadose Zone Treatability Test Plan

S. W. Petersen

Work on a treatability test plan for investigating remediation in the Central Plateau's deep vadose zone began in FY 2007. When submitted, this plan will satisfy the Tri-Party Agreement Milestone M-015-50, "Submit a Treatability Test Work Plan for Deep Vadose Zone Technetium and Uranium to Ecology and EPA." This milestone is due by December 31, 2007. The project team contributing to this plan includes members from the DOE Richland Operation Office and Office of River Protection, Fluor Hanford, Inc., Pacific Northwest National Laboratory, and CH2M HILL Hanford Group, Inc. Fluor Hanford, Inc. is responsible for the overall integration and production of the plan. The activities that will be performed to select a deep vadose zone remedy will satisfy the purposes of both CERCLA and RCRA statutory programs.

The objective of this treatability test plan for technetium-99 and uranium is to provide a strategy to evaluate specific vadose zone technologies for deep vadose zone remediation.

The objective of this treatability test plan for technetium-99 and uranium is to provide a roadmap, including identification of preferred technologies as well as plans and schedules for field testing those technologies. This effort, once implemented, will be used to support remedy selection and post-remedial decision design, deployment, and operation of remediation technologies in the Central Plateau including the following:

- Remediation of contaminated soil and groundwater.
- Closure of tank farms.
- Closure of cribs and trenches.

The treatability test plan framework will include two primary phases. The first phase will focus on conducting laboratory work and numerical modeling to address uncertainties associated with technology functioning and employing the technology in the deep vadose zone. The second phase will involve the large-scale design and implementation of treatability testing in the field at carefully selected locations. These Phase 2 tests will be conducted with one or more technologies depending on the success of Phase 1 testing. A schedule for Phase 2 is in the Treatability Test Plan. The test plan focuses on technetium-99 and uranium as directed by Tri-Party Agreement Milestone M-015-50. These contaminants are mobile in the subsurface environment, have been detected at high concentration deep in the vadose zone, and at some locations have reached groundwater. Testing technologies for remediation of technetium-99 and uranium will also provide information relevant to other contaminants in the vadose zone.

Figure 3.0-1 Analytical Results for Key Constituents in Leachate at the 600 Area Central Landfill

Parameter[a]	Results by Quarter				GWQC[b]	MCL[c]
	3rd 2006	4th 2006	1st 2007	2nd 2007		
Indicator Parameters						
Ammonia as N (mg/L)	0.330	0.340	0.292	NT	NA	NA
Chemical oxygen demand (mg/L)	222	220	208	204	NA	NA
Dissolved iron (μg/L)	87.9	9,850	8,870	6,400	300	300
Dissolved manganese (μg/L)	1,580	1,590	1,540	1,295[d]	50	50
Dissolved zinc (μg/L)	187	40.5	109	155[e]	5,000	5,000
pH	7.35	6.74	6.89	7.32	6.5-8.5	NA
Specific conductance (μS/cm)	1,680	1,860	1,920	2,000	NA	700
Total organic carbon (mg/L)	701	100	76.5	275	NA	NA
Site-Specific Parameters						
1,1,1-Trichloroethane (μg/L)	<1.0	NT	NT	<1.0	200	200
1,1-Dichloroethane (μg/L)	<1.0	NT	NT	<1.0	1.0	NA
1,4-Dichlorobenzene (μg/L)	6.5[f]	NT	NT	4.15[g]	4	NA
1,4-Dioxane (μg/L)	<25.0	NT	NT	<20.0	7	NA
Arsenic (μg/L)	29.3	NT	NT	20.1	0.05	10
Barium (μg/L)	519	NT	NT	452	1,000	2,000
Cadmium (μg/L)	<0.100	NT	NT	<0.100	10	5
Carbon tetrachloride (μg/L)	<1.0	NT	NT	<1.0	0.3	5
Chloride (mg/L)	210	191	192	199	250	25
Chloroform (μg/L)	<1.0	NT	NT	<1.0	7.0	NA
Copper (μg/L)	1.60	NT	NT	1.03	1,000	NA
Fluoride (mg/L)	<0.145	<0.0315	<0.321	0.207	4	4
Methylene chloride (μg/L)	<1.0	NT	NT	1.25[h]	5	NA
Nickel (μg/L)	110	NT	NT	92.9	NA	100
Selenium (μg/L)	2.58	NT	NT	2.15	10	50
Sulfate (mg/L)	5.66	7.67	6.32	7.77	250	25
Tetrachloroethene (μg/L)	<1.0	NT	NT	<1.0	NA	NA
Total dissolved solids (mg/L)	1,460	NT	NT	1,380	500	500[i]
Total organic halides (μg/L)	NT	NT	NT	846	NA	NA
Trichloroethene (μg/L)	<1.0	NT	NT	<1.0	NA	NA

(a) Units as provided in analytical results report.
(b) Groundwater quality criteria from WAC 173-200.
(c) Maximum contaminant levels from WAC 246-290.
(d) Average result from two samples; one sample result was 1,200 μg/L and one sample result was 1,390 μg/L.
(e) Average result from two samples; one sample result was 120 μg/L and one sample result was 190 μg/L.
(f) Average result from two samples; one sample result was <1.0 μg/L and one sample result was 12.0 μg/L.
(g) Average result from two samples; one sample result was <1.0 μg/L and one sample result was 7.3 μg/.L
(h) Average result from two samples; one sample result was <1.0 μg/L and one sample result was 1.50 μg/L.
(i) Required only when specific conductivity exceeds 700 μS/cm.
NA = Not applicable.
NT = Not tested.

Table 3.0-2. Carbon Tetrachloride Inventory Removed by Vaport Extraction from Primary Disposal Sites

Well Field	Estimated Mass Discharged, 1955 to 1973[a] (kg)	Estimated Mass Lost to Atmosphere, 1955 to 1990[b] (kg)	Mass Removed Using Soil-Vapor Extraction, 1991 to September 2007 (kg)
216-Z-1A	270,000	56,700	24,667[c]
216-Z-9	130,000 to 480,000	27,300 to 100,800	54,497
216-Z-18	170,000	35,700	—
Total	**570,000 to 920,000**	**119,700 to 196,800**	**79,164**

(a) Based on DOE/RL-91-32.
(b) Based on WHC-SD-EN-TI-101.
(c) Includes mass removed from 216-Z-18 site; reported as a combined value because the well fields overlap.

Table 3.0-3. Hydraulic Hammer Deployment, FY 2007

Tank Farm	Total days	No. of Probes	Total meters drilled	Total meters logged		No. of Samples	No. of Electrodes
				Gross Gamma	Neutron Moisture		
T	64	23	425	231	66	9	2
B	29	12	153	130	56	4	4
U	107	21	550	313	304	23	10
Totals	224	56	1,138	674	426	36	16

Table 3.0-4. Analytical Performance Requirements for Geopphysical Logging Methods[a]

Parameter	Method	Parameter Reported	Minimum Borehole Inner Diameter	Logging Speed	Target Detection Limit[b]	Precision[c]	Quality Control	Notes
Gamma activity	SGLS[d] (Total gamma)	Counts per second (cps), % dead time	10 cm	0.30480 m/min	Background + 2σ	< 2%	Pre-run and post-run verification; 10% repeat section	Does not identify source radionuclide and may be misleading
	SHLS[e] (NaI[f] & GMs[g])	cps or HGU	4.44 cm	0.60960 m/min		Depends on count time & activity	Verification & 10% repreat section	
^{137}Cs, ^{60}Co	Spectral gamma (NaI)	KUT[h] ^{137}Cs, ^{60}Co	4.44 cm	0.30480-0.60960 m/min	10 - 20 pCi/g	+/- 20%	Verification and 10% repeat section	Energy resolution 30 to 50 keV: unable to resolve gamma lines for many radionuclides
Fission and activation products	SGLS (HPGe[i])	KUT & manmade radionuclides, (pCi/g), total gamma (cps) & dead time (%)	10 cm	2.438 - 9.144 m/hr	< 1 pCi/g	+/- 5-10%	Pre-run and post-run verification	Energy resolution 2-5 keV allows identification of characteristic decay gammas.
	HRLS[j] (HPGe)		10 cm		(depending on radionuclide)		10% repeat section	Minimum Detectable Activity and counting error are also reported.
Manmade uranium	SGLS (HPGe)		10 cm		10-20 pCi/g			
^{234m}Pa								
TRU[k]					10,000 - 50,000 pCi/g			
^{239}Pu, ^{241}Am, ^{241}Pu, ^{237}Np					(1 pCi/g for ^{237}Np)			
^{90}Sr		Qualitative indicator			> 500 - 1000 pCi/g	Qualitative		Bremsstrahlung associated with 2.3 MeV beta from ^{90}Y daughter.
TRU	PNLS[l]	cps	10 cm	0.30480 m/min	Qualitative only		Pre-run and post-run check	Dominant source of neutrons is alpha, n reaction; spontaneous fission is minor component.
	(^{3}He detector)							Possible interference in high gamma activity

Table 3.0-4. (contd)

Parameter	Method	Parameter Reported	Minimum Borehole Inner	Logging Speed	Target Detection Limit[b]	Precision[c]	Quality Control	Notes
Volumetric moisture content	NMLS[m]	cps	4.44 - 10 cm	0.30480 m/min	0.5 to 1 volume %	+/- 10% (of count rate)	Pre-run and post-run verification, 10% repeat section	Calibrations exist for 15.24-cm and 20.32-cm boreholes
	^{241}Am-Be	Volume % moisture						
	(^{3}He detector)							

(a) All logging systems subject to annual calibration and daily source checks.
(b) Target detection limit based on typical logging parameters and minimal interference.
(c) Assuming typical background count rate and borehole environment.
(d) Spectral gamma logging system.
(e) Slim hole logging system.
(f) Sodium iodide (scintillator) detector
(g) Geiger-Mueller detector.
(h) KUT refers to potassium, uranium and thorium as naturally occurring radionuclides.
(i) High-purity germanium (solid state) detector.
(j) High rate logging system: typically run where SGLS dead time exceeds 40%.
(k) Transurranic radionuclides.
(l) Passive neutron logging system.
(m) Neutron moisture logging system.

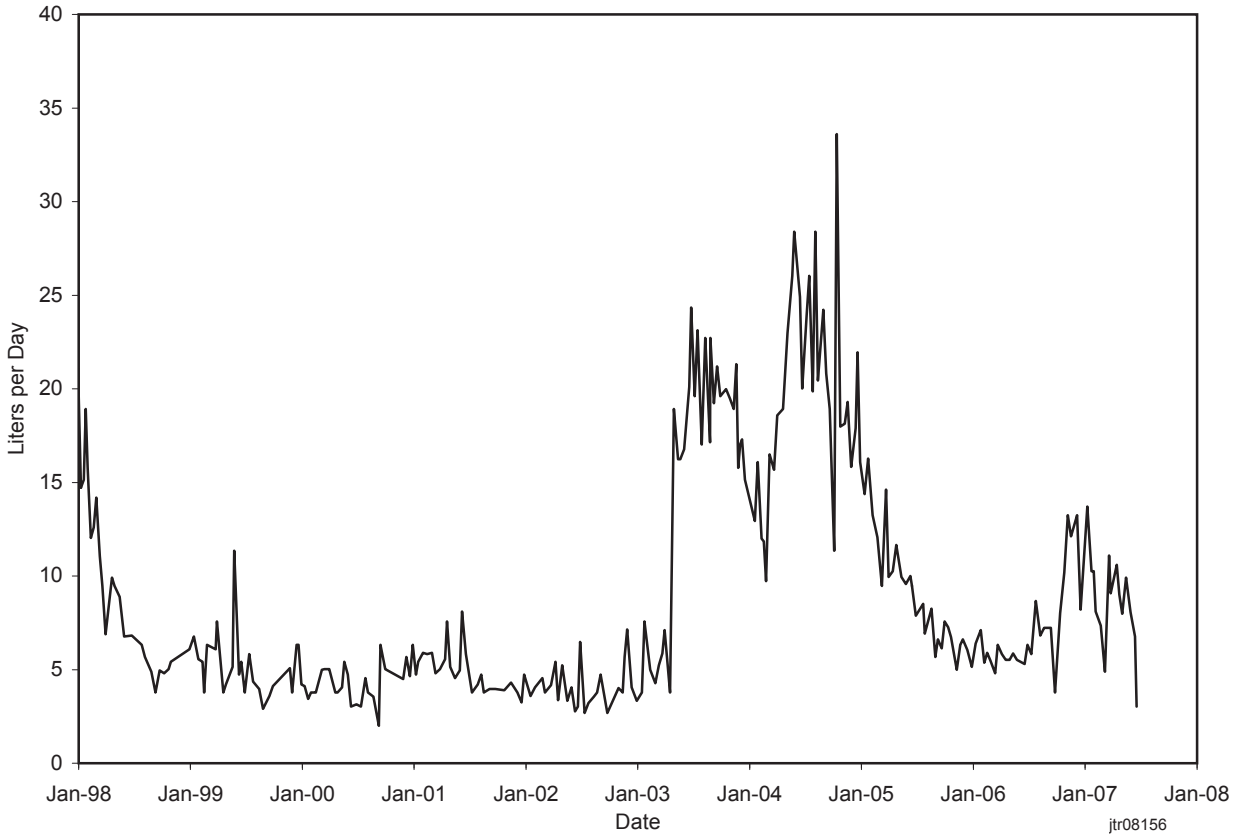

Figure 3.0-1 Leachate Collection Volumes at the 600 Area Central Landfill

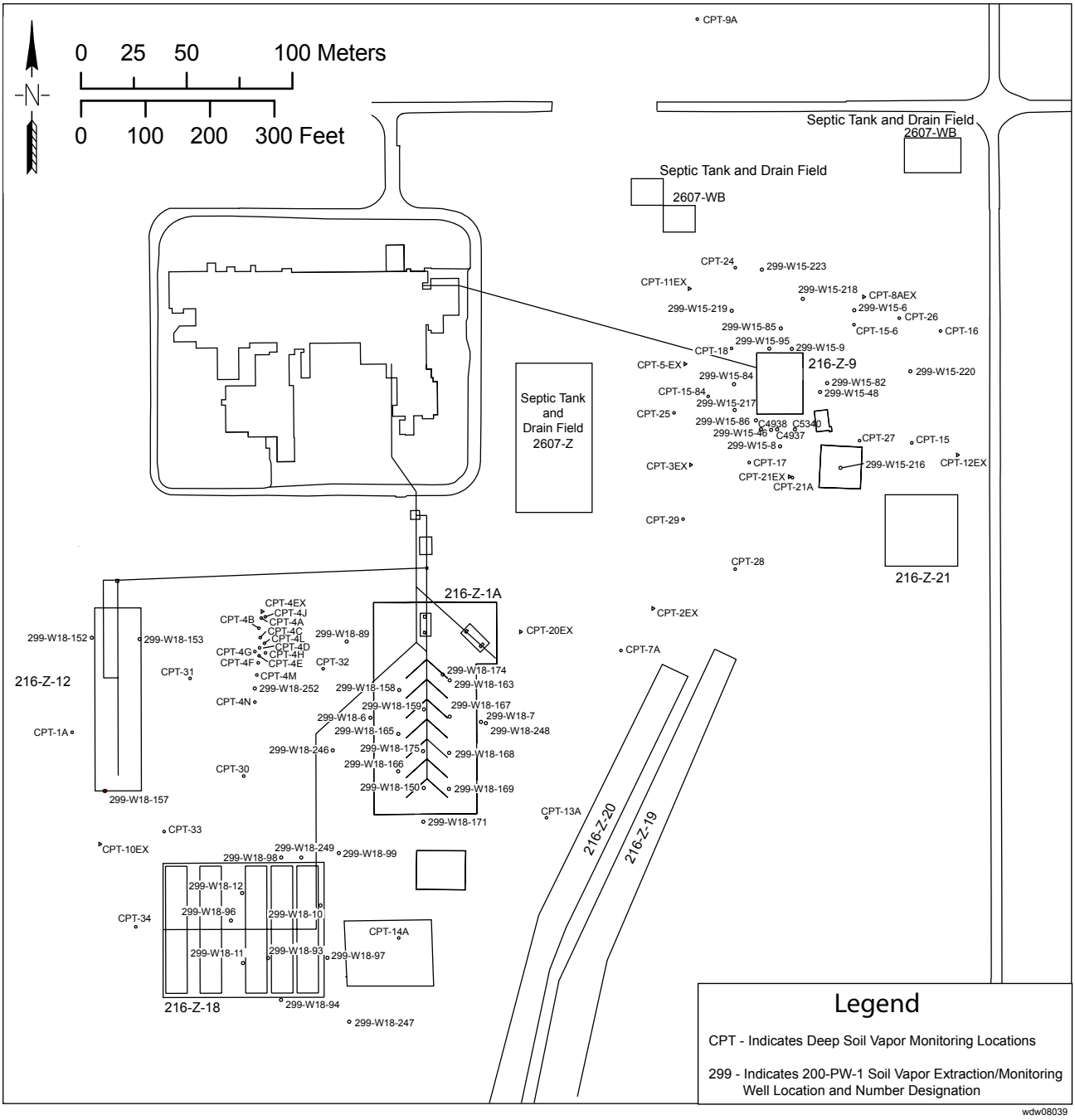

Figure 3.0-2. Locations of Carbon Tetrachloride Vapor-Extraction Wells at 216-Z-1A/216-Z-12/216-Z-18 and 216-Z-9 Well Fields

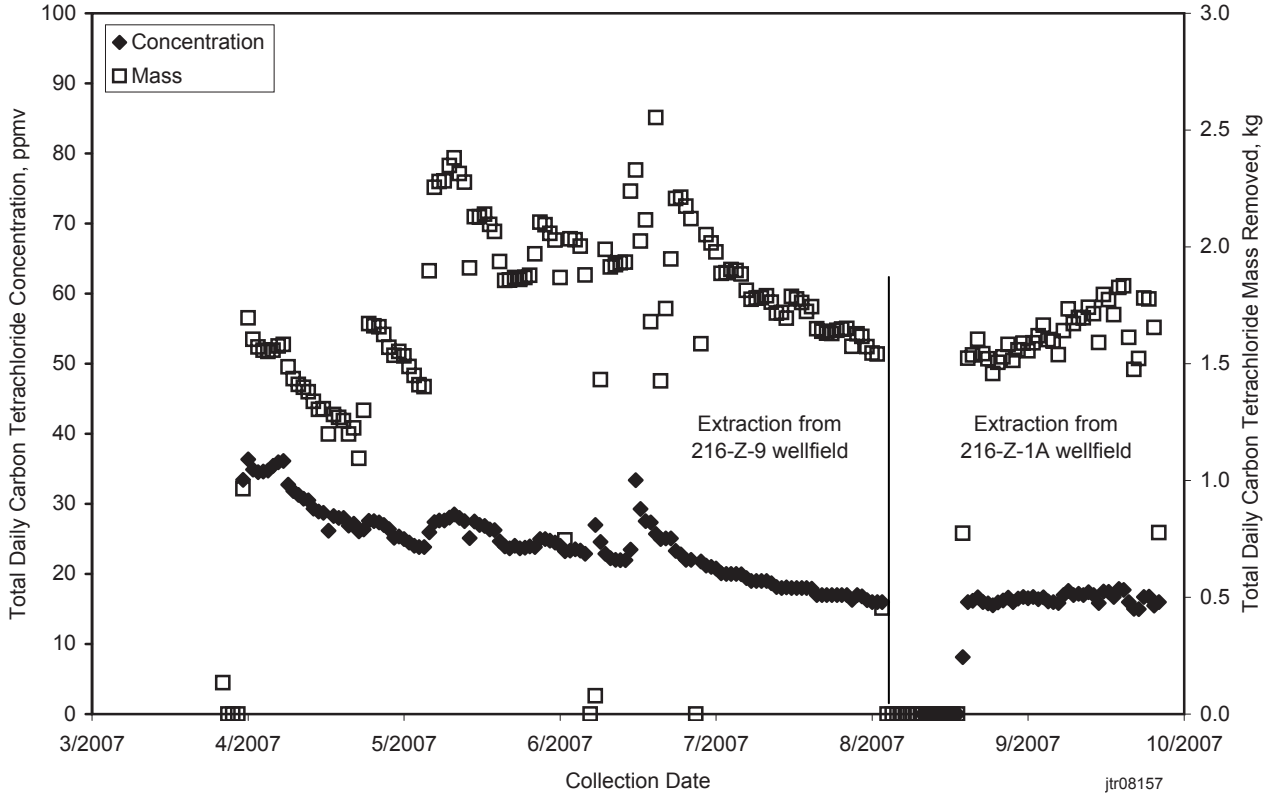

Figure 3.0-3. Time Series Concentrations and Mass of Carbon Tetrachloride in Soil Vapor Extracted from 216-Z-1A/216-Z-12/216-Z-18 and 216-Z-9 Well Fields

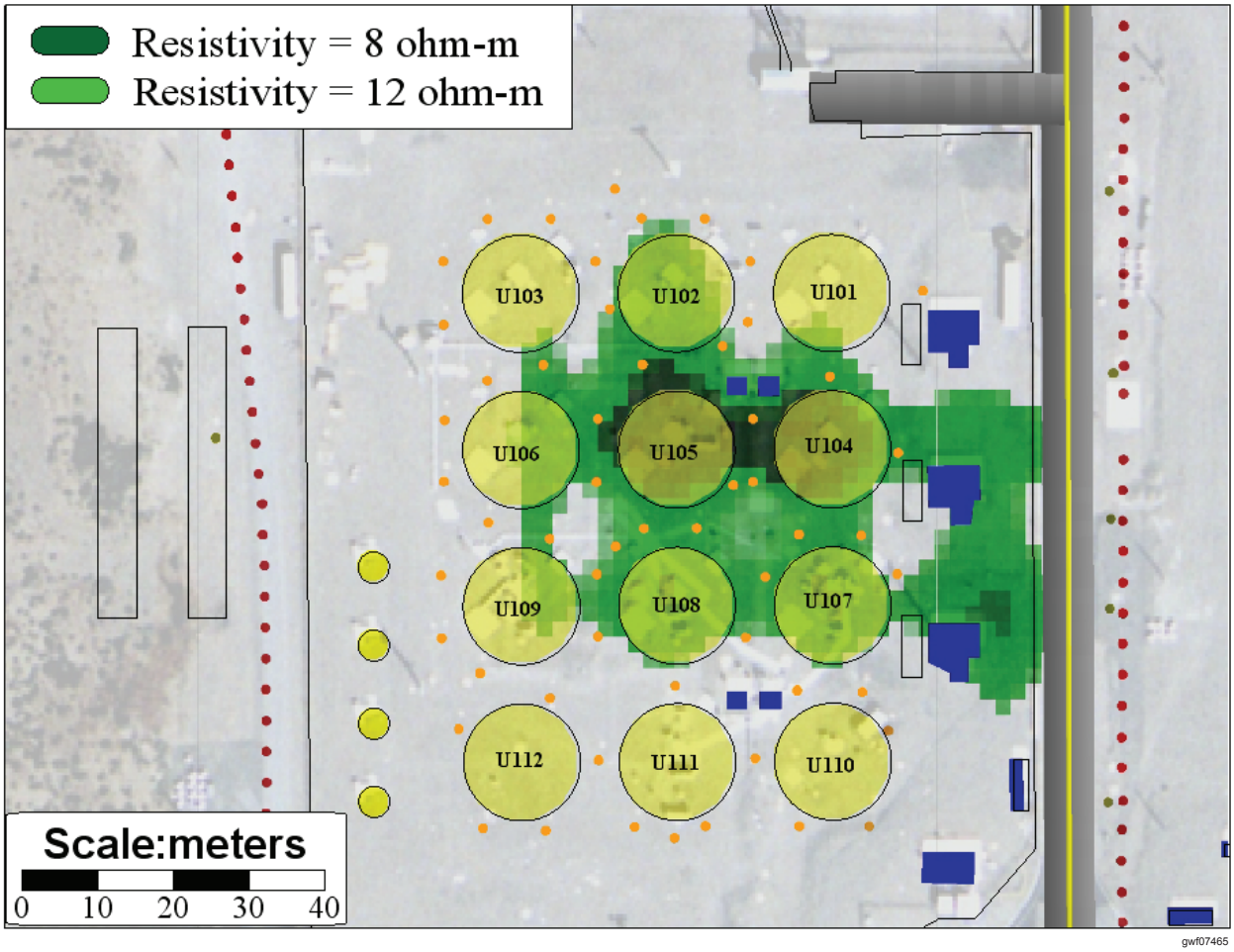

Figure 3.0-4. Resistivity Anomalies Associated with the B Tank Farm Complex

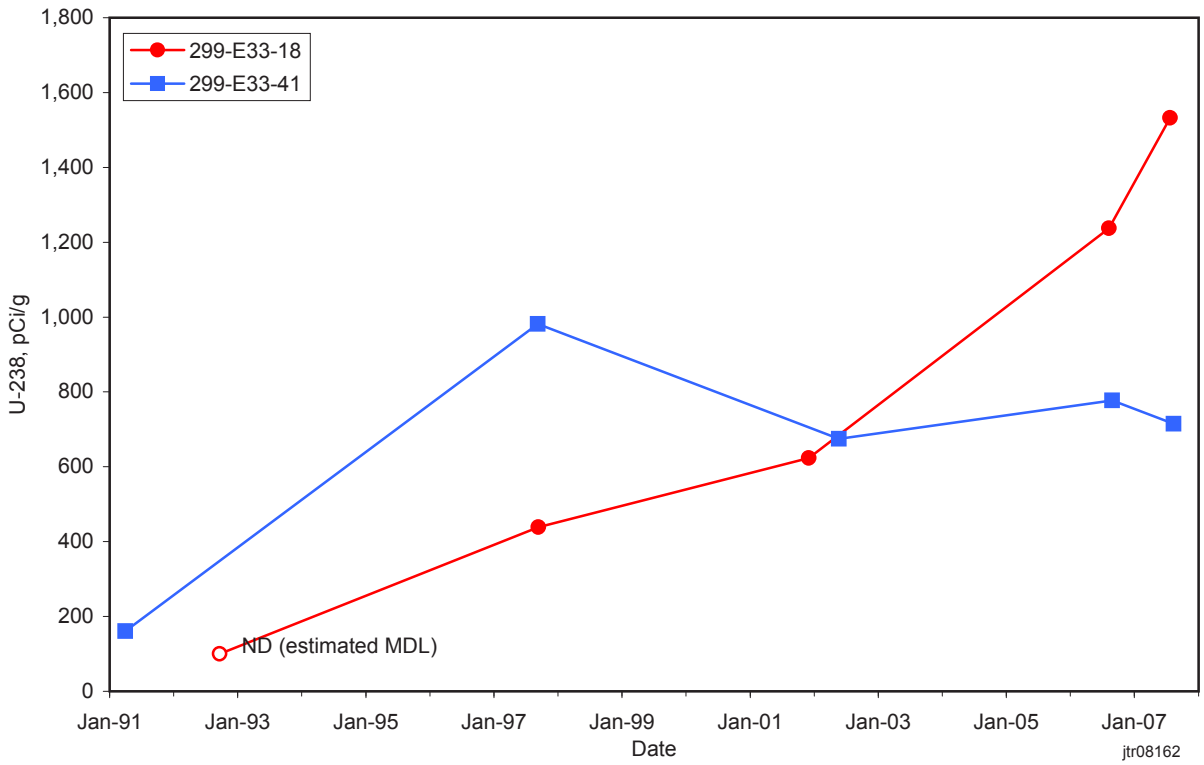

Figure 3.0-5. Deep Vadose Zone Uranium-238 in Wells 299-E33-18 and 299-E33-41 (Construction information for these wells can be found at http://www.hanford.gov/cp/gpp/data/vzcp/data/200East.cfm.)

4.0 Well Installation, Maintenance, and Decommissioning

B. J. Howard, G. G. Kelty, and C. S. Wright

This section describes new well installation, maintenance, and decommissioning activities conducted on the Hanford Site during fiscal year (FY) 2007. In addition, FY 2007 characterization borehole installations (sites where casing was removed and decommissioned after drilling) are summarized.

Approximately 8,836 unique well identification numbers are in use at the Hanford Site. All wells, characterization boreholes, aquifer tubes, soil tubes, piezometers, and other subsurface excavations are required to receive a unique Hanford well identification number. All wells are also required to have a state well identification number that is tracked by the Washington Department of Ecology (Ecology). Figure 4.0-1 presents the categorization of unique well identification numbers from the Hanford Well Information System (HWIS) and their approximate geographic designation. Figure 4.0-2 identifies the geographic designations for the Hanford Site.

Each year the Groundwater Remediation Project reviews the need for new monitoring wells. In FY 2007, 57 new wells were installed.

During FY 2007, a total of 3,085 unique well identification numbers were documented as 'in use' (this number includes 2,310 wells, 129 piezometers within host wells, 354 aquifer tubes, and 292 soil tubes). A total of 57 new monitoring wells were installed during FY 2007. A total of 91 wells were physically decommissioned during FY 2007 and a total of 623 temporary boreholes and subsurface installations were administratively decommissioned by records management.

During review of candidate wells for decommissioning, a records review is conducted to clearly identify the wells location and its attributes by performing (a) a thorough review of the entries for these candidate wells in the Hanford Environmental Information System (HEIS) and HWIS, and (b) a review of records from other contractors. This data is used to define and locate the wells to be decommissioned in the field. The candidate wells that are not found in the field after a reasonable search using field inspections, global positioning system technology, and subsurface magnetometry are considered decommissioned without previous record and are subsequently administratively decommissioned to remove them from the in-use status. A very limited number of new wells are also located during the course of field activities. These wells are added to the Hanford well inventory and assigned a unique well identification number and appropriate status.

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 2007, 57 new wells were installed on the Hanford Site:

- ***Fourteen for CERCLA monitoring (fulfilling Tri-Party Agreement Milestone M-24-57 commitments).***
- ***Forty-three to support groundwater contaminant studies, treatability testing, and ongoing or new groundwater investigations.***

4.1 Well Installation

The Soil and Groundwater Remediation Project, working with the U.S. Department of Energy (DOE) and appropriate regulators, defines the need for new wells at the Hanford Site. Each year, the groundwater project identifies new wells to meet the requirements of the *Resource Conservation and Recovery Act* (RCRA) detection and assessment groundwater monitoring requirements; characterization and monitoring for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA); and long-term monitoring of regional groundwater plumes under DOE Orders based on the *Atomic Energy Ac*t (AEA). These efforts include ongoing RCRA assessment of groundwater contamination, replacement of monitoring wells that go dry because of the declining regional water table, replacement of wells that need to be decommissioned, improvement of spatial coverage for the detection monitoring networks or for plume monitoring, and characterization of subsurface contamination.

The revised Tri-Party Agreement milestone includes a prioritized list and schedule for installation of 60 wells over 4 years.

New RCRA, CERCLA, and AEA well proposals are reviewed, prioritized, and approved annually as defined under the Tri-Party Agreement (Ecology et al. 1989) Milestone M-24. All new wells are constructed or decommissioned in accordance with the provisions of WAC173-160. Well needs are integrated and documented through development of the SGRP budget, discussion with regulators, and monitoring needs. Ecology, U.S. Environmental Protection Agency (EPA), and DOE (the Tri-Parties) annually negotiate an integrated well drilling list that coordinates and prioritizes the requirements of RCRA, CERCLA, and AEA under Tri-Party Agreement Milestone M-24-57.

During FY 2007, a total of 57 new wells were installed at the Hanford Site (Table 4.0-1). These wells were constructed to support activities funded under either M-24 or other project-specific activities. The approximate locations of the new wells are shown on Figure 4.0-3. Detailed maps presenting the location of new wells are shown in the corresponding operable unit sections of this report. Of these 57 wells, the Tri-Party Agreement Milestone M-24-57 approved the installation of 14 wells supporting the FY 2007 and FY 2008 milestones. No wells to support RCRA activities were installed in FY 2007.

The 14 wells supporting the M-24 milestone included three new wells in the 100-D Area within the 100-HR-3 Operable Unit and three wells in the 100-K Area within the 100-KR-4 Operable Unit. Five new wells were constructed in the 200 West Area, four of which were located in the 200-ZP-1 Operable Unit and one in the 200-UP-1 Operable Unit. Three new wells were constructed in the 200-BP-5 Operable Unit; one of these wells is in the 200 East Area and two of them in the 600 Area.

In FY 2006, the United States Congress authorized funding for the Hanford Site to analyze contaminant migration to the Columbia River and to introduce new technology approaches to solve contamination migration issues. These funds are administered through the DOE Office of Environmental Management (specifically through the EM-22 program). After a peer review and selection process, projects were developed to investigate the source and treatment of hexavalent chromium and uranium in the groundwater. The treatment of hexavalent chromium is being evaluated by the injection of a microbial substrate (biostimulation) or the surface treatment of groundwater via an electrocoagulation resin. The treatment of uranium is being evaluated via the injection of polyphosphate. Thirty-five wells were identified for construction to meet

the objectives of the EM-22 program and would be administered under the control of either Pacific Northwest National Laboratory or Fluor Hanford, Inc.

Of the 35 wells identified, 20 wells were constructed in the 100-D Area within the 100-HR-3 Operable Unit. Of these 20 wells, 7 were constructed as chromium source investigation wells. (Note: three of these seven wells were counted toward the M-24 milestone total). The remaining 13 of 20 wells were constructed as chromium treatment wells, 12 of which were installed to evaluate biostimulation and one to support testing of an elecrocoagulation system (Table 4.0-1).

The remaining 15 of 35 wells were constructed in the 300-FF-5 Operable Unit, in the 300 Area, to evaluate the treatment of uranium in the groundwater by injecting polyphosphate.

In conclusion, of the 57 new wells drilled, 11 additional wells were also installed in FY 2007 to support activities beyond the scope of the M-24 milestone and wells supporting DOE Environmental Management EM-22. These included:

- Two wells installed at 100-B/C Area for Washington Closure Hanford to evaluate the presence and extent of hexavalent chromium in the 100-BC-5 Operable Unit.
- Six wells installed to evaluate the vertical and horizontal extent of hexavalent chromium in the 600 Area of the "horn" for the 100-HR-3 Operable Unit as part of a 2-year, 21 well project.
- One well at 100-K Area as an injection well for the 100-KR-4 Operable Unit pump-and-treat.
- One well in the 200 East Area for the 200-PO-1 Operable Unit.
- One well in the 300 Area to evaluate the vertical extent of trichloroethene in the 300-FF-5 Operable Unit.

Twenty-seven new aquifer sampling tubes were installed along the Columbia River.

Water well reports for all newly constructed wells, as required in WAC 173-160, are submitted to Ecology and added to the Ecology well log database. Detailed information about the wells, including the geologic and geophysical descriptions, a listing of characterization activities (i.e., sediment and groundwater sampling, aquifer testing, geophysical logging) and construction records for the new wells are electronically stored in the Integrated Data Management System (IDMS) database. Selected drilling and well construction information (drill depth, screen interval, etc.) are also entered into the HWIS, which is contained within the HEIS database.

Twenty-seven new aquifer sampling tubes were installed along the Columbia River shore during FY 2007. The aquifer tubes are not included in the total count of 57 wells drilled but are tracked in the HWIS database for administrative purposes. Nine of the new aquifer tubes were installed in the 100-N Area shoreline (N Springs) to support either science and technology work or the apatite-barrier treatability test. Eighteen new aquifer sampling tubes were also installed in the "horn" area of the 100-HR-3 Operable Unit to evaluate the extent of hexavalent chromium along the river. The new monitoring points are similar to aquifer tubes monitored elsewhere on the Hanford Site shoreline and range in depth from 0.8 to 5.3 meters.

During FY 2007, a number of temporary characterization boreholes were installed around the Hanford Site to support various projects. Characterization borings are the same as an environmental investigation well (WAC 173-160-410) and are a subclass of resource protection wells. 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 decommissioned. During FY 2007, 109 temporary boreholes (such as cone penetrometer, direct-push technology boreholes, auger, and/or drilled boreholes) were installed. Four borings were drilled to groundwater to collect water samples. Table 4.0-2 provides a summary of the number, program, and general location of these temporary boreholes. The drilling and decommissioning of these temporary characterization boreholes are not included in the count of either new wells or in the decommissioning statistics (physical or administrative). All of the temporary boreholes were decommissioned after data acquisition was completed. Chapter 3 of this report provides more details about vadose characterization studies conducted during FY 2007.

Well maintenance activities include casing repairs, repairing and replacing sampling pumps, pump and equipment retrieval, and tubing replacement.

4.2 Well Maintenance

During FY 2007, non-routine maintenance was completed on 186 wells (219 total maintenance events). A summary of non-routine maintenance activities by regulatory program is presented in Table 4.0-3. Non-routine maintenance tasks, which include both surface and sub-surface aspects, are varied and depend on the specific problem encountered at a well. Surface tasks include conducting field inspections, well labeling, maintenance and replacement of locking well caps, casing repairs, diagnosis and repair of surface electrical wiring, and pump-discharge fitting. Subsurface tasks typically include repairing and replacing sampling pumps, performing camera surveys, pump and equipment retrieval, and tubing replacement.

In the past, the distinction between routine and non-routine maintenance activities was based on a set group of activities and a 5-year cleaning cycle. Currently, any well requiring maintenance to preserve sampling efficiency is repaired under the non-routine maintenance program. This means that if a project scientist determines that a well is losing sampling efficiency, those tasks typically conducted under routine maintenance (identified above) can be conducted under the non-routine tasks. Therefore, while not following a 5-year maintenance schedule, wells are still being maintained as needed to meet specific project and schedule requirements.

4.3 Well Decommissioning

A well becomes a candidate for decommissioning if: (1) its use has been permanently discontinued (i.e., it has gone dry); (2) its condition is so poor that its continued use is impractical; (3) it is in the path of intended remediation, excavation, and construction activities; or (4) it poses an environmental, safety, or public health hazard (e.g., casing corrosion). At this time, decommissioning is generally driven by the long-range environmental restoration schedule (DOE/RL-96-105), available funding, and provisions of WAC 173-160. In addition, the list of candidate wells for decommissioning includes wells identified in HWIS that have no further use. However, all candidate wells must be reviewed and approved for decommissioning by the contractors, DOE, Ecology, EPA, and other potential well users (such as Pacific Northwest National Laboratory) prior to actual decommissioning.

During FY 2007, a total of 91 vadose zone and monitoring well installations were physically decommissioned (Table 4.0-4 and Figure 4.0-4). The 91 wells were identified for decommissioning based on: (1) discontinued use; (2) inadequate construction; (3) location inside or within 15.2 meters of a waste site; and/or (4) posing a potential environmental, safety, or public health hazard due to their location inside the waste sites and would possibly serve as a conduit to transport chemical and radiological hazards deeper into the vadose zone or groundwater.

Decommissioning typically involves backfilling a well with impermeable material to prevent vertical movement of water and/or contaminants. For WAC-compliant wells, decommissioning typically is performed by placing sand across the screen interval and filling the casing with an impermeable material (e.g., bentonite or cement grout). For older, non-compliant wells, the casing(s) is perforated and pressure grouted to create an external seal or the casing is removed. A brass survey marker identifying the well is typically set in grout at the surface and over the well location. Decommissioning activities result in the permanent removal of a well, borehole, or piezometer from service and from the Hanford Site active well inventory. Decommissioning is performed in accordance with WAC 173-160, applicable well variances, and conditions defined in the Hanford Facility RCRA Permit (Ecology 1994a, Condition II.F.2). Characterization boreholes are not included in the decommissioning statistics listed in Table 4.0-4.

Wells are filled with grout if they are in poor condition, interfere with surface construction activities, or are no longer used.

A total of 623 temporary boreholes and subsurface installations were administratively decommissioned by the well management program. DOE follows the requirements of WAC 173-160-460 with regard to well decommissioning. A completed water well report form is required to be transmitted (by the driller) to Ecology when a well is decommissioned. This report provides the details of the well's construction and the steps taken to decommission (plug) the well. When the records available are insufficient to meet the specific requirements of the well decommissioning process, or there is no record of the transmittal, the wells are administratively decommissioned, i.e., all available information is provided to Ecology to demonstrate that the well was never drilled or was drilled and subsequently plugged. Since many hundreds of wells were planned but not drilled, or drilled but subsequently plugged, between the Hanford Site inception in 1943 and 1986, these wells are candidates for administrative decommissioning. In addition, records of some wells that were planned and not drilled, or drilled and plugged after 1986, apparently were inadvertently not transmitted to Ecology as required.

Table 4.0-1. Well Installations, FY 2007

Count	Well ID	Well Name	GW AOI(a)	Construction Date	Well Project	Funding Source	Area
Wells Supporting M-24 Milestone							
1	C5390	199-D5-97	100-HR-3-D	22-Feb-07	100-D Chromium Source Investigation	EM-22 FHI	100D
2	C5391	199-D5-98	100-HR-3-D	02-Apr-07	100-D Chromium Source Investigation	EM-22 FHI	100D
3	C5392	199-D5-99	100-HR-3-D	26-Feb-07	100-D Chromium Source Investigation	EM-22 FHI	100D
4	C5303	199-K-141	100-KR-4	03-Jan-07	100-KR-4 Operable Unit	SGRP	100K
5	C5304	199-K-142	100-KR-4	19-Jan-07	100-KR-4 Operable Unit	SGRP	100K
6	C5305	199-K-143	100-KR-4	20-Dec-06	100-KR-4 Operable Unit	SGRP	100K
7	C5195	299-E33-50	200-BP-5	29-Mar-07	200-BP-5 Operable Unit	SGRP	200E
8	C5855	299-W10-33	200-ZP-1	28-Sep-07	200-ZP-1 Operable Unit	SGRP	200W
9	C5243	299-W11-48	200-ZP-1	02-Jul-07	200-ZP-1 Operable Unit	SGRP	200W
10	C5407	299-W11-87	200-ZP-1	06-Apr-07	200-ZP-1 Operable Unit	SGRP	200W
11	C5102	299-W14-71	200-UP-1	22-Dec-06	200-ZP-1 Operable Unit	SGRP	200W
12	C5103	299-W14-72	200-ZP-1	16-Nov-06	200-ZP-1 Operable Unit	SGRP	200W
13	C5196	699-48-50B	200-BP-5	05-Dec-06	200-BP-5 Operable Unit	SGRP	600
14	C5197	699-50-56	200-BP-5	15-Dec-06	200-BP-5 Operable Unit	SGRP	600
Wells Supporting Environmental Management EM-22							
1	C5394	199-D2-11	100-HR-3-D	07-Mar-07	100-D Chromium Source Investigation	EM-22 FHI	100D
2	C5398	199-D5-102	100-HR-3-D	02-Apr-07	100-D Chromium Source Investigation	EM-22 FHI	100D
3	C5399	199-D5-103	100-HR-3-D	02-Apr-07	100-D Chromium Source Investigation	EM-22 FHI	100D
4	C5400	199-D5-104	100-HR-3-D	02-Apr-07	100-D Chromium Source Investigation	EM-22 FHI	100D
5	C5511	199-D5-106	100-HR-3-D	27-Mar-07	100-HR-3 Treatability Test	EM-22 FHI Electro Coagulation	100D

Table 4.0-1. (contd)

Count	Well ID	Well Name	GW AOI(a)	Construction Date	Well Project	Funding Source	Area
6	C5577	199-D5-107	100-HR-3-D	18-May-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
7	C5578	199-D5-108	100-HR-3-D	08-Jun-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
8	C5579	199-D5-109	100-HR-3-D	16-May-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
9	C5580	199-D5-110	100-HR-3-D	29-May-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
10	C5581	199-D5-111	100-HR-3-D	14-May-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
11	C5582	199-D5-112	100-HR-3-D	31-May-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
12	C5583	199-D5-113	100-HR-3-D	25-May-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
13	C5584	199-D5-114	100-HR-3-D	12-Jun-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
14	C5585	199-D5-115	100-HR-3-D	10-Jul-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
15	C5586	199-D5-116	100-HR-3-D	29-Jun-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
16	C5587	199-D5-117	100-HR-3-D	18-Jun-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
17	C5588	199-D5-118	100-HR-3-D	26-Jun-07	100-D Biostimulation Treatability Test	EM-22 PNNL	100D
18	C5351	399-1-24	300-FF-5	16-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
19	C5352	399-1-25	300-FF-5	17-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
20	C5353	399-1-26	300-FF-5	21-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
21	C5354	399-1-27	300-FF-5	29-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
22	C5355	399-1-28	300-FF-5	30-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
23	C5356	399-1-29	300-FF-5	01-Dec-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
24	C5357	399-1-30	300-FF-5	28-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
25	C5358	399-1-31	300-FF-5	20-Nov-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300

Table 4.0-1. (contd)

Count	Well ID	Well Name	GW AOI(a)	Construction Date	Well Project	Funding Source	Area
26	C5359	399-1-32	300-FF-5	04-Dec-06	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
27	C5626	399-1-33	300-FF-5	01-Jun-07	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
28	C5627	399-1-34	300-FF-5	01-Jun-07	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
29	C5628	399-1-35	300-FF-5	25-May-07	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
30	C5629	399-1-36	300-FF-5	10-May-07	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
31	C5630	399-1-37	300-FF-5	01-Jun-07	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
32	C5631	399-1-38	300-FF-5	01-Jun-07	300-FF-5 Polyphosphate Treatability Test	EM-22 PNNL	300
Wells Non Tri-Party Agreement							
1	C5671	199-B8-7	100-BC-5	15-Aug-07	100-BC-5 Operable Unit/WCH Site Characterization	SGRP	100B
2	C5672	199-B8-8	100-BC-5	14-Aug-07	100-BC-5 Operable Unit/WCH Site Characterization	SGRP	100B
3	C5484	199-K-158	100-KR-4	22-Jan-07	100-KW Pump-and-Treat Injection	SGRP	100K
4	C5301	299-E24-23	200-PO-1	16-Apr-07	200-PO-1 Operable Unit	SGRP	200E
5	C5575	399-3-21	300-FF-5	15-May-07	300-FF-5 Trichloroethene (TCE characterization)	SGRP	300
6	C5665	699-94-41	100-HR-3-H	04-Sep-07	100-HR-3 Operable Unit Horn Investigation	SGRP	100H
7	C5661	699-94-43	100-HR-3-H	28-Sep-07	100-HR-3 Operable Unit Horn Investigation	SGRP	600
8	C5660	699-95-45	100-HR-3-H	18-Sep-07	100-HR-3 Operable Unit Horn Investigation	SGRP	600
9	C5667	699-95-48	100-HR-3-D	21-Sep-07	100-HR-3 Operable Unit Horn Investigation	SGRP	600
10	C5657	699-97-41	100-HR-3-H	29-Aug-07	100-HR-3 Operable Unit Horn Investigation	SGRP	100H
11	C5662	699-97-48B	100-HR-3-D	27-Sep-07	100-HR-3 Operable Unit Horn Investigation	SGRP	600
57	Total Wells Installed in FY07						

(a) = Groundwater area of interest.
SGRP = Soil and Groundwater Remediation Project.

Table 4.0-2. Characterization Boreholes, Soil-Gas Probes, and Push Technology Installation, FY 2007

Well ID and Name	Program	General Location and/or Purpose
C5163	DOE-ORP Tank Farm Vadose	B Tank Farm
C5164	DOE-ORP Tank Farm Vadose	B Tank Farm
C5167	DOE-ORP Tank Farm Vadose	B Tank Farm
C5168	DOE-ORP Tank Farm Vadose	B Tank Farm
C5169	DOE-ORP Tank Farm Vadose	B Tank Farm
C5170	DOE-ORP Tank Farm Vadose	B Tank Farm
C5173	DOE-ORP Tank Farm Vadose	B Tank Farm
C5175	DOE-ORP Tank Farm Vadose	B Tank Farm
C5208	Vista DPT Work	Cold Test site in 200W, Z-9 trench, Z-1A tile field, Z-18 crib
C5210	Vista DPT Work	Cold Test site in 200W, Z-9 trench, Z-1A tile field, Z-18 crib
C5302	RI/FS Activity	Push probe at the 200-E-trench
C5336	Vista DPT Work	Work around 216-Z-9 and 216-Z-1A cribs
C5337	Vista DPT Work	Work around 216-Z-9 and 216-Z-1A cribs
C5338	Vista DPT Work	Work around 216-Z-9 and 216-Z-1A cribs
C5339	Vista DPT Work	Work around 216-Z-9 and 216-Z-1A cribs
C5374	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell Tank T-101.
C5375	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell Tank T-101.
C5377	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell Tank T-101.
C5378	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell tank T-101.
C5379	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell tank T-101.
C5380	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell tank T-101.
C5382	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell tank T-101.
C5383	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell tank T-101.
C5384	DOE-ORP Tank Farm Vadose	Push probes at 241-T Tank Farm near single-shell tank T-101.
C5387	300-Area Plutonium Investigation	Characterization Borings at 618-2 Burial Grounds, 300 Area.
C5388	300-Area Plutonium Investigation	Characterization Borings at 618-2 Burial Grounds, 300 Area.
C5389	300-Area Plutonium Investigation	Characterization Borings at 618-2 Burial Grounds, 300 Area.
C5516	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5517	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5518	RI/FS Activity	BC Controlled Area Geoprobe and Logging.

Table 4.0-2. (contd)

Well ID and Name	Program	General Location and/or Purpose
C5519	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5520	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5521	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5522	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5523	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5524	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5525	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5526	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5527	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5528	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5529	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5530	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5531	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5532	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5533	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5534	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5535	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5536	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5537	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5538	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5539	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5540	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5541	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5542	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5543	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5544	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5545	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5546	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5547	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5548	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5549	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5550	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5551	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5552	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5553	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5554	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5555	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5556	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5557	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5558	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5559	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5560	RI/FS Activity	BC Controlled Area Geoprobe and Logging.

Table 4.0-2. (contd)

Well ID and Name	Program	General Location and/or Purpose
C5561	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5562	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5563	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5564	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5565	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5566	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5567	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5568	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5569	RI/FS Activity	BC Controlled Area Geoprobe and Logging.
C5613	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5614	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5615	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5616	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5617	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5618	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5619	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5620	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5621	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5622	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5623	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5624	RI/FS Activity	BC Controlled Area auger drilling and sampling.
C5670	RI/FS Activity	100-BC Area, 3 characterization borings for WCH.
C5689	DOE-ORP Tank Farm Vadose	T Tank Farm characterization and instrumentation borings.
C5690	DOE-ORP Tank Farm Vadose	T Tank Farm characterization and instrumentation borings.
C5691	DOE-ORP Tank Farm Vadose	T Tank Farm characterization and instrumentation borings.
C5692	DOE-ORP Tank Farm Vadose	T Tank Farm characterization and instrumentation borings.
C5693	DOE-ORP Tank Farm Vadose	T Tank Farm characterization and instrumentation borings.
C5694	DOE-ORP Tank Farm Vadose	T Tank Farm characterization and instrumentation borings.

DPT - Direct push technology.
DOE-ORP = U.S. Department of Energy, Office of River Protection.
RI/FS = Remedial investigation/feasibility study.

Table 4.0-3. Well Maintenance Summary, FY 2007

Well Number	Well ID	Task Number	Program	Well Number	Well ID	Task Number	Program
299-W19-34B	A9513	WMO-NR-2007-1-001	CERCLA	699-67-86	A5313	WMO-NR-2007-2-019	CERCLA
299-E17-12	A4730	WMO-NR-2007-1-005	CERCLA	699-34-42	A5136	WMO-NR-2007-2-020	CERCLA
299-E17-13	A4731	WMO-NR-2007-1-006	CERCLA	699-20-20	A5080	WMO-NR-2007-2-021	CERCLA
299-E17-26	C4648	WMO-NR-2007-1-021	RCRA	699-29-4	A8490	WMO-NR-2007-2-022	CERCLA
299-E25-41	A4790	WMO-NR-2007-1-022	RCRA	699-26-15A	A5100	WMO-NR-2007-2-023	CERCLA
699-35-78A	A5141	WMO-NR-2007-1-023	CERCLA	699-S8-19	A5408	WMO-NR-2007-2-024	CERCLA
699-56-53	A5265	WMO-NR-2007-1-024	AEA	299-W22-48	B8812	WMO-NR-2007-2-025	RCRA
699-56-53	A5265	WMO-NR-2007-1-024	AEA	299-E27-13	A4811	WMO-NR-2007-2-027	CERCLA
199-K-35	A4661	WMO-NR-2007-1-025	CERCLA	299-E27-13	A4811	WMO-NR-2007-2-027	CERCLA
199-K-35	A4661	WMO-NR-2007-1-025	CERCLA	699-S3-25	A5373	WMO-NR-2007-2-028	CERCLA
699-71-30	A5320	WMO-NR-2007-1-026	CERCLA	299-W15-30	B2410	WMO-NR-2007-2-029	CERCLA
699-67-51	A5312	WMO-NR-2007-1-027	CERCLA	699-19-43	A5075	WMO-NR-2007-2-030	CERCLA
699-72-73	A5323	WMO-NR-2007-1-028	CERCLA	699-8-25	A5334	WMO-NR-2007-2-031	CERCLA
699-48-71	A5214	WMO-NR-2007-1-029	CERCLA	699-28-40	A5110	WMO-NR-2007-2-032	CERCLA
299-E33-15	A4842	WMO-NR-2007-1-030	RCRA	699-14-38	A5068	WMO-NR-2007-2-033	CERCLA
199-N-146	C5052	WMO-NR-2007-1-031	CERCLA	199-B2-12	A4550	WMO-NR-2007-2-034	CERCLA
699-53-47B	A5240	WMO-NR-2007-1-032	CERCLA	699-20-E5A	A8428	WMO-NR-2007-2-035	CERCLA
199-H3-2A	A4611	WMO-NR-2007-1-033	CERCLA	699-34-41B	A5135	WMO-NR-2007-2-036	CERCLA
699-60-32	A5279	WMO-NR-2007-1-034	CERCLA	699-40-65	C4235	WMO-NR-2007-2-039	CERCLA
699-54-48	A5252	WMO-NR-2007-1-035	CERCLA	699-48-77A	A8772	WMO-NR-2007-2-040	CERCLA
199-D4-31	B8982	WMO-NR-2007-1-036	CERCLA	699-12-4D	A8252	WMO-NR-2007-2-041	CERCLA
199-D2-8	C3040	WMO-NR-2007-1-037	CERCLA	699-S31-1	A5378	WMO-NR-2007-2-042	OTHER
299-E28-18	A4821	WMO-NR-2007-1-038	CERCLA	699-13-1E	C3798	WMO-NR-2007-2-043	CERCLA
299-E28-21	A6797	WMO-NR-2007-1-040	CERCLA	699-61-62	A5285	WMO-NR-2007-2-044	CERCLA
399-1-7	A5040	WMO-NR-2007-1-041	CERCLA	699-65-50	A5300	WMO-NR-2007-2-045	CERCLA
299-W10-28	C3400	WMO-NR-2007-1-042	RCRA	699-10-54A	A5063	WMO-NR-2007-2-046	CERCLA
199-D5-13	A4570	WMO-NR-2007-1-044	CERCLA	299-E33-16	A6855	WMO-NR-2007-2-047	RCRA
199-D5-13	A4570	WMO-NR-2007-1-044	CERCLA	299-W11-41	C3119	WMO-NR-2007-2-048	RCRA
199-D5-41	B8751	WMO-NR-2007-1-045	CERCLA	299-W10-23	B8545	WMO-NR-2007-2-049	RCRA
399-1-23	C5000	WMO-NR-2007-1-046	CERCLA	699-33-56	A5133	WMO-NR-2007-2-050	CERCLA
299-W18-23	A4935	WMO-NR-2007-1-047	CERCLA	699-35-66A	A5139	WMO-NR-2007-2-051	CERCLA
299-W18-23	A4935	WMO-NR-2007-1-047	CERCLA	699-35-9	A5142	WMO-NR-2007-2-052	CERCLA
299-W18-23	A4935	WMO-NR-2007-1-047	CERCLA	699-36-67	B2733	WMO-NR-2007-2-053	CERCLA
299-W18-31	A4943	WMO-NR-2007-1-048	RCRA	699-37-43	A5146	WMO-NR-2007-2-054	CERCLA
699-62-31	A5287	WMO-NR-2007-1-049	CERCLA	699-37-68	B2732	WMO-NR-2007-2-055	CERCLA
299-W11-47	C4990	WMO-NR-2007-1-050	CERCLA	699-37-E4	A8588	WMO-NR-2007-2-056	CERCLA
699-63-25A	A5289	WMO-NR-2007-1-051	CERCLA	699-38-15	A8594	WMO-NR-2007-2-057	CERCLA
299-W19-34B	A9513	WMO-NR-2007-1-052	CERCLA	699-39-39	A5150	WMO-NR-2007-2-058	CERCLA
299-E28-18	A4821	WMO-NR-2007-1-053	CERCLA	699-49-57B	A5220	WMO-NR-2007-2-059	CERCLA
299-E28-21	A6797	WMO-NR-2007-1-054	CERCLA	699-53-55A	A5244	WMO-NR-2007-2-060	CERCLA
199-D5-37	B8745	WMO-NR-2007-1-055	CERCLA	299-E28-13	A6791	WMO-NR-2007-2-061	CERCLA
299-W11-43	C4694	WMO-NR-2007-1-056	CERCLA	699-61-62	A5285	WMO-NR-2007-2-065	CERCLA
299-W22-86	C4971	WMO-NR-2007-1-057	CERCLA	299-W19-41	B8551	WMO-NR-2007-2-066	RCRA
299-E25-40	A4789	WMO-NR-2007-1-058	RCRA	699-S31-E10D	A5382	WMO-NR-2007-2-067	RCRA
299-W22-48	B8812	WMO-NR-2007-2-001	RCRA	699-53-55C	A5246	WMO-NR-2007-2-068	CERCLA
299-W23-20	C3112	WMO-NR-2007-2-002	RCRA	699-55-57	A5259	WMO-NR-2007-2-069	CERCLA
699-40-1	A5152	WMO-NR-2007-2-005	CERCLA	699-S29-E16A	A5429	WMO-NR-2007-2-070	OTHER
699-42-12A	A5163	WMO-NR-2007-2-006	CERCLA	699-S31-E10A	A5379	WMO-NR-2007-2-071	OTHER
299-E28-28	A4824	WMO-NR-2007-2-008	RCRA	699-S31-E11	A9220	WMO-NR-2007-2-072	RCRA
299-W18-33	A5450	WMO-NR-2007-2-009	CERCLA	699-S32-E13A	A5385	WMO-NR-2007-2-073	OTHER
299-W22-85	C3399	WMO-NR-2007-2-010	RCRA	699-S37-E14	A5394	WMO-NR-2007-2-074	OTHER
299-W22-82	C3124	WMO-NR-2007-2-011	RCRA	699-S40-E13A	A9238	WMO-NR-2007-2-075	OTHER
199-K-131	C4561	WMO-NR-2007-2-014	CERCLA	699-S40-E14	A5398	WMO-NR-2007-2-076	OTHER
699-66-58	A5309	WMO-NR-2007-2-015	CERCLA	699-S41-E12	A5400	WMO-NR-2007-2-077	OTHER
699-40-33A	A5153	WMO-NR-2007-2-016	CERCLA	299-E17-26	C4648	WMO-NR-2007-2-078	RCRA

Table 4.0-3. (contd)

Well Number	Well ID	Task Number	Program	Well Number	Well ID	Task Number	Program
699-48-7A	A5213	WMO-NR-2007-2-017	CERCLA	699-20-E12O	A9613	WMO-NR-2007-2-079	CERCLA
699-71-77	A5322	WMO-NR-2007-2-018	CERCLA	199-D5-13	A4570	WMO-NR-2007-2-080	CERCLA
199-D5-41	B8751	WMO-NR-2007-2-081	CERCLA	699-S22-E9A	A5422	WMO-NR-2007-3-047	CERCLA
199-D4-86	C3318	WMO-NR-2007-2-082	CERCLA	699-S22-E9C	A5424	WMO-NR-2007-3-048	CERCLA
699-51-75	A5232	WMO-NR-2007-2-083	OTHER	699-S27-E9A	A5425	WMO-NR-2007-3-049	CERCLA
299-W15-47	C4184	WMO-NR-2007-2-084	CERCLA	699-S27-E9B	A5426	WMO-NR-2007-3-050	CERCLA
299-E24-8	A4758	WMO-NR-2007-2-086	OTHER	699-S27-E9C	A5427	WMO-NR-2007-3-051	CERCLA
299-E25-37	A4785	WMO-NR-2007-2-088	OTHER	699-S29-E16B	A5430	WMO-NR-2007-3-052	CERCLA
299-E25-43	A4792	WMO-NR-2007-2-089	OTHER	699-S29-E16C	A5431	WMO-NR-2007-3-053	CERCLA
299-E25-44	A5448	WMO-NR-2007-2-090	OTHER	699-S41-E13A	A5401	WMO-NR-2007-3-054	CERCLA
299-E25-47	A4794	WMO-NR-2007-2-091	OTHER	699-S41-E13A	A5401	WMO-NR-2007-3-054	CERCLA
299-E34-5	A4880	WMO-NR-2007-2-092	OTHER	699-S6-E14A	A5405	WMO-NR-2007-3-055	CERCLA
699-19-88	A5077	WMO-NR-2007-2-093	OTHER	299-W19-105	C4968	WMO-NR-2007-3-056	CERCLA
699-21-6	A8438	WMO-NR-2007-2-094	OTHER	699-45-42	A5195	WMO-NR-2007-3-057	CERCLA
699-33-42	A5132	WMO-NR-2007-2-095	OTHER	699-43-3	A8677	WMO-NR-2007-3-058	CERCLA
699-S38-E11	A5395	WMO-NR-2007-2-096	OTHER	699-43-41E	A5174	WMO-NR-2007-3-059	CERCLA
699-S38-E12B	A5397	WMO-NR-2007-2-097	OTHER	699-53-47A	A5239	WMO-NR-2007-3-061	CERCLA
199-D2-8	C3040	WMO-NR-2007-2-098	CERCLA	699-53-48A	A5241	WMO-NR-2007-3-062	CERCLA
299-E27-14	A4812	WMO-NR-2007-2-099	CERCLA	199-D5-41	B8751	WMO-NR-2007-3-063	CERCLA
199-D5-43	B8753	WMO-NR-2007-2-100	CERCLA	199-D2-8	C3040	WMO-NR-2007-3-073	CERCLA
199-D5-38	B8747	WMO-NR-2007-2-101	CERCLA	699-9-E2	A5349	WMO-NR-2007-3-074	CERCLA
299-W23-15	A4984	WMO-NR-2007-2-102	CERCLA	699-47-5	A8744	WMO-NR-2007-3-077	CERCLA
299-E27-13	A4811	WMO-NR-2007-2-103	RCRA	699-54-34	A5248	WMO-NR-2007-4-000	CERCLA
299-E25-40	A4789	WMO-NR-2007-3-001	RCRA	699-36-61A	A5144	WMO-NR-2007-4-001	CERCLA
699-53-55C	A5246	WMO-NR-2007-3-002	CERCLA	299-E25-19	A4765	WMO-NR-2007-4-004	CERCLA
199-D2-11	C5394	WMO-NR-2007-3-003	CERCLA	299-E33-18	A4844	WMO-NR-2007-4-007	CERCLA
199-D5-97	C5390	WMO-NR-2007-3-004	CERCLA	299-E28-2	A6785	WMO-NR-2007-4-008	CERCLA
199-D5-98	C5391	WMO-NR-2007-3-005	CERCLA	299-E33-41	A4867	WMO-NR-2007-4-009	CERCLA
199-D5-99	C5392	WMO-NR-2007-3-006	CERCLA	299-E33-41	A4867	WMO-NR-2007-4-009	CERCLA
199-D5-102	C5398	WMO-NR-2007-3-007	CERCLA	699-2-3	A5078	WMO-NR-2007-4-012	CERCLA
199-D5-103	C5399	WMO-NR-2007-3-008	CERCLA	199-K-131	C4561	WMO-NR-2007-4-014	CERCLA
199-D5-104	C5400	WMO-NR-2007-3-009	CERCLA	199-K-109A	A9828	WMO-NR-2007-4-015	CERCLA
299-W15-36	B2752	WMO-NR-2007-3-010	CERCLA	299-E17-22	C3826	WMO-NR-2007-4-017	CERCLA
199-D2-11	C5394	WMO-NR-2007-3-018	CERCLA	299-E33-1A	A4838	WMO-NR-2007-4-018	CERCLA
199-D2-8	C3040	WMO-NR-2007-3-019	CERCLA	199-D5-33	C4186	WMO-NR-2007-4-019	CERCLA
299-E33-339	C3392	WMO-NR-2007-3-021	RCRA	299-W10-28	C3400	WMO-NR-2007-4-020	CERCLA
699-24-34A	A5090	WMO-NR-2007-3-022	RCRA	299-E33-1A	A4838	WMO-NR-2007-4-021	CERCLA
199-D5-92	C4583	WMO-NR-2007-3-023	CERCLA	299-E33-14	A4841	WMO-NR-2007-4-022	CERCLA
299-E24-8	A4758	WMO-NR-2007-3-024	CERCLA	299-E33-14	A4841	WMO-NR-2007-4-022	CERCLA
199-N-146	C5052	WMO-NR-2007-3-025	CERCLA	299-W11-45	C4948	WMO-NR-2007-4-024	CERCLA
699-33-42	A5132	WMO-NR-2007-3-028	CERCLA	299-W11-46	C4950	WMO-NR-2007-4-025	CERCLA
199-D5-104	C5400	WMO-NR-2007-3-030	CERCLA	199-K-109A	A9828	WMO-NR-2007-4-027	CERCLA
199-D5-97	C5390	WMO-NR-2007-3-031	CERCLA	299-W11-87	C5407	WMO-NR-2007-4-028	CERCLA
299-E23-1	A4747	WMO-NR-2007-3-032	CERCLA	299-W15-2	A5466	WMO-NR-2007-4-030	CERCLA
299-E28-13	A6791	WMO-NR-2007-3-033	CERCLA	299-W22-26	A4968	WMO-NR-2007-4-031	CERCLA
299-E25-42	A4791	WMO-NR-2007-3-034	CERCLA	299-W18-31	A4943	WMO-NR-2007-4-033	CERCLA
299-E28-2	A6785	WMO-NR-2007-3-035	CERCLA	299-W8-1	A5016	WMO-NR-2007-4-034	CERCLA
299-E28-21	A6797	WMO-NR-2007-3-036	CERCLA	699-32-62	A5128	WMO-NR-2007-4-035	CERCLA

Table 4.0-3. (contd)

Well Number	Well ID	Task Number	Program	Well Number	Well ID	Task Number	Program
299-E28-23	A6799	WMO-NR-2007-3-037	CERCLA	699-35-70	A5140	WMO-NR-2007-4-036	CERCLA
299-E28-24	A6800	WMO-NR-2007-3-038	CERCLA	299-W22-26	A4968	WMO-NR-2007-4-037	CERCLA
299-E28-25	A6801	WMO-NR-2007-3-039	CERCLA	299-W22-26	A4968	WMO-NR-2007-4-037	CERCLA
299-E33-12	A4839	WMO-NR-2007-3-040	CERCLA	199-N-3	A4679	WMO-NR-2007-4-038	CERCLA
299-E28-6	A4826	WMO-NR-2007-3-041	CERCLA	299-E33-1A	A4838	WMO-NR-2007-4-039	CERCLA
399-5-2	A8091	WMO-NR-2007-3-042	CERCLA	199-D5-32	C4185	WMO-NR-2008-1-000	CERCLA
699-49-13E	A5215	WMO-NR-2007-3-043	CERCLA	699-50-74	C4697	WMO-NR-2008-1-001	CERCLA
699-52-19	A5233	WMO-NR-2007-3-044	CERCLA	199-D5-34	C4187	WMO-NR-2008-1-004	CERCLA
699-52-19	A5233	WMO-NR-2007-3-044	CERCLA				
699-52-46A	A5234	WMO-NR-2007-3-045	CERCLA				
699-54-34	A5248	WMO-NR-2007-3-046	CERCLA				

AEA = *Atomic Energy Act.*
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act.*
RCRA = *Resource Conservation and Recovery Act*.

Table 4.0-4. Vadose Zone and Groundwater Wells Decommissioned, FY 2007

Count	Well ID	Well Name	Area	GW AOI(a)	Well Type	Count	Well ID	Well Name	Area	GW AOI(a)	Well Type
1	A5873	299-E13-58	200E	200-PO-1	Vadose	47	A7551	299-W18-68	200W	200-ZP-1	Vadose
2	A5874	299-E13-59	200E	200-PO-1	Vadose	48	A7553	299-W18-70	200W	200-ZP-1	Vadose
3	A5875	299-E13-60	200E	200-PO-1	Vadose	49	A7554	299-W18-71	200W	200-ZP-1	Vadose
4	A5876	299-E13-61	200E	200-PO-1	Vadose	50	A7555	299-W18-72	200W	200-ZP-1	Vadose
5	A4748	299-E23-2	200E	200-PO-1	Groundwater	51	A7556	299-W18-73	200W	200-ZP-1	Vadose
6	A9457	299-E23-2O	200E	200-PO-1	Groundwater	52	A7557	299-W18-74	200W	200-ZP-1	Vadose
7	A9458	299-E23-2P	200E	200-PO-1	Groundwater	53	A7559	299-W18-76	200W	200-ZP-1	Vadose
8	A9459	299-E23-2Q	200E	200-PO-1	Groundwater	54	A7560	299-W18-77	200W	200-ZP-1	Vadose
9	A5967	299-E24-112	200E	200-PO-1	Vadose	55	A7561	299-W18-78	200W	200-ZP-1	Vadose
10	A5930	299-E24-75	200E	200-PO-1	Vadose	56	A7562	299-W18-79	200W	200-ZP-1	Vadose
11	A6594	299-E25-184	200E	200-PO-1	Vadose	57	A7563	299-W18-80	200W	200-ZP-1	Vadose
12	A6596	299-E25-190	200E	200-PO-1	Vadose	58	A7564	299-W18-81	200W	200-ZP-1	Vadose
13	A6597	299-E25-191	200E	200-PO-1	Vadose	59	A7566	299-W18-83	200W	200-ZP-1	Vadose
14	A6599	299-E25-193	200E	200-PO-1	Vadose	60	A7567	299-W18-84	200W	200-UP-1	Vadose
15	A6041	299-E25-52	200E	200-PO-1	Vadose	61	A7868	299-W22-61	200W	200-UP-1	Vadose
16	A6658	299-E26-65	200E	200-PO-1	Vadose	62	A7870	299-W22-63	200W	200-UP-1	Vadose
17	A6660	299-E26-67	200E	200-PO-1	Vadose	63	A7899	299-W23-63	200W	200-UP-1	Vadose
18	A6663	299-E26-70	200E	200-PO-1	Vadose	64	A8057	299-W26-1	200W	200-UP-1	Vadose
19	A6753	299-E27-133	200E	200-BP-5	Vadose	65	A8059	299-W26-4	200W	200-UP-1	Vadose
20	A6814	299-E28-63	200E	200-BP-5	Vadose	66	A8060	299-W26-5	200W	200-UP-1	Vadose
21	A6841	299-E28-90	200E	200-BP-5	Vadose	67	A8061	299-W26-51	200W	200-UP-1	Vadose
22	A7083	299-E33-287	200E	200-BP-5	Vadose	68	A8739	699-46-79	200W	200-ZP-1	Vadose
23	A7084	299-E33-288	200E	200-BP-5	Vadose	69	B2469	B2469	200E	200-BP-5	Vadose
24	A7085	299-E33-289	200E	200-BP-5	Vadose	70	B2470	B2470	200E	200-BP-5	Vadose
25	A7086	299-E33-290	200E	200-BP-5	Vadose	71	C3334	C3334	600	200-BP-5	Vadose
26	A6887	299-E33-79	200E	200-BP-5	Vadose	72	C3335	C3335	600	200-BP-5	Vadose
27	A6889	299-E33-81	200E	200-BP-5	Vadose	73	C3448	C3448	600	200-BP-5	Vadose
28	A6890	299-E33-82	200E	200-BP-5	Vadose	74	C3449	C3449	600	200-BP-5	Vadose
29	C4896	299-W11-44	200W	200-ZP-1	Vadose	75	C3450	C3450	600	200-BP-5	Vadose
30	A7324	299-W11-82	200W	200-ZP-1	Vadose	76	C3451	C3451	600	200-BP-5	Vadose
31	A7336	299-W14-52	200W	200-ZP-1	Vadose	77	C3452	C3452	600	200-BP-5	Vadose
32	A7338	299-W14-54	200W	200-ZP-1	Vadose	78	C3538	C3538	600	200-BP-5	Vadose
33	A7339	299-W14-55	200W	200-ZP-1	Vadose	79	C3770	C3770	600	200-BP-5	Vadose
34	A7346	299-W14-62	200W	200-ZP-1	Vadose	80	C3771	C3771	600	200-BP-5	Vadose
35	A7502	299-W15-204	200W	200-ZP-1	Vadose	81	C3772	C3772	600	200-BP-5	Vadose
36	A7638	299-W18-155	200W	200-ZP-1	Vadose	82	C3773	C3773	600	200-BP-5	Vadose
37	A7639	299-W18-156	200W	200-ZP-1	Vadose	83	C3774	C3774	600	200-BP-5	Vadose
38	A7652	299-W18-170	200W	200-ZP-1	Vadose	84	C3775	C3775	600	200-BP-5	Vadose
39	A7655	299-W18-173	200W	200-ZP-1	Vadose	85	C3776	C3776	600	200-BP-5	Vadose
40	A7660	299-W18-178	200W	200-UP-1	Vadose	86	C3777	C3777	600	200-BP-5	Vadose
41	A7662	299-W18-180	200W	200-ZP-1	Vadose	87	C3778	C3778	600	200-BP-5	Vadose
42	A7664	299-W18-182	200W	200-ZP-1	Vadose	88	C3779	C3779	600	200-BP-5	Vadose
43	A7665	299-W18-183	200W	200-ZP-1	Vadose	89	C3780	C3780	600	200-BP-5	Vadose
44	A7666	299-W18-184	200W	200-ZP-1	Vadose	90	C3781	C3781	600	200-BP-5	Vadose
45	A7667	299-W18-185	200W	200-ZP-1	Vadose	91	C3782	C3782	600	200-BP-5	Vadose
46	A7550	299-W18-67	200W	200-ZP-1	Vadose						

(a) Groundwater area of interest.

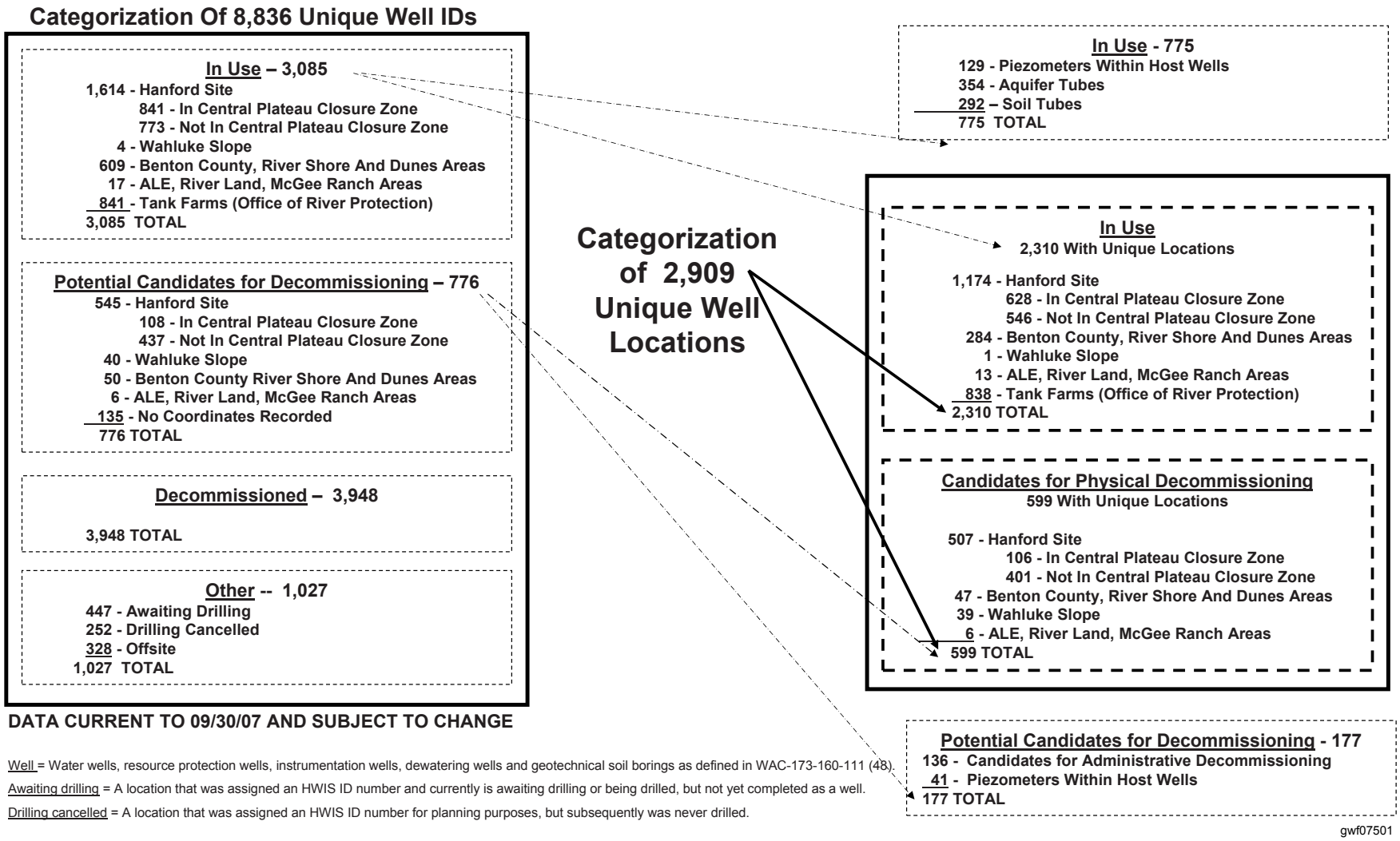

Figure 4.0-1. Categorization of Unique Well Identification Numbers

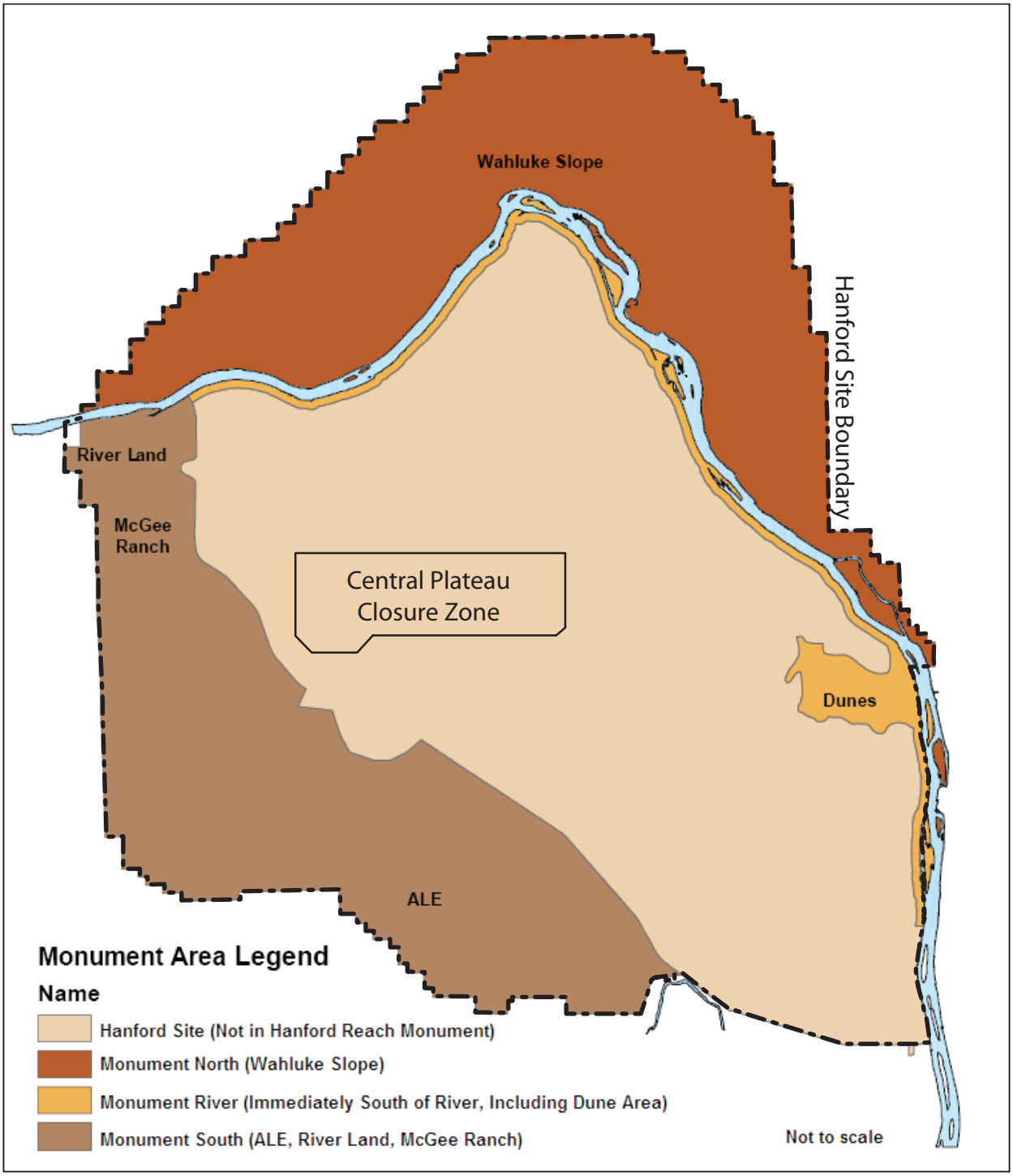

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Figure 4.0-2. Hanford Site and Surrounding Area Depicting Various Geographic Regions, Richland, Washington

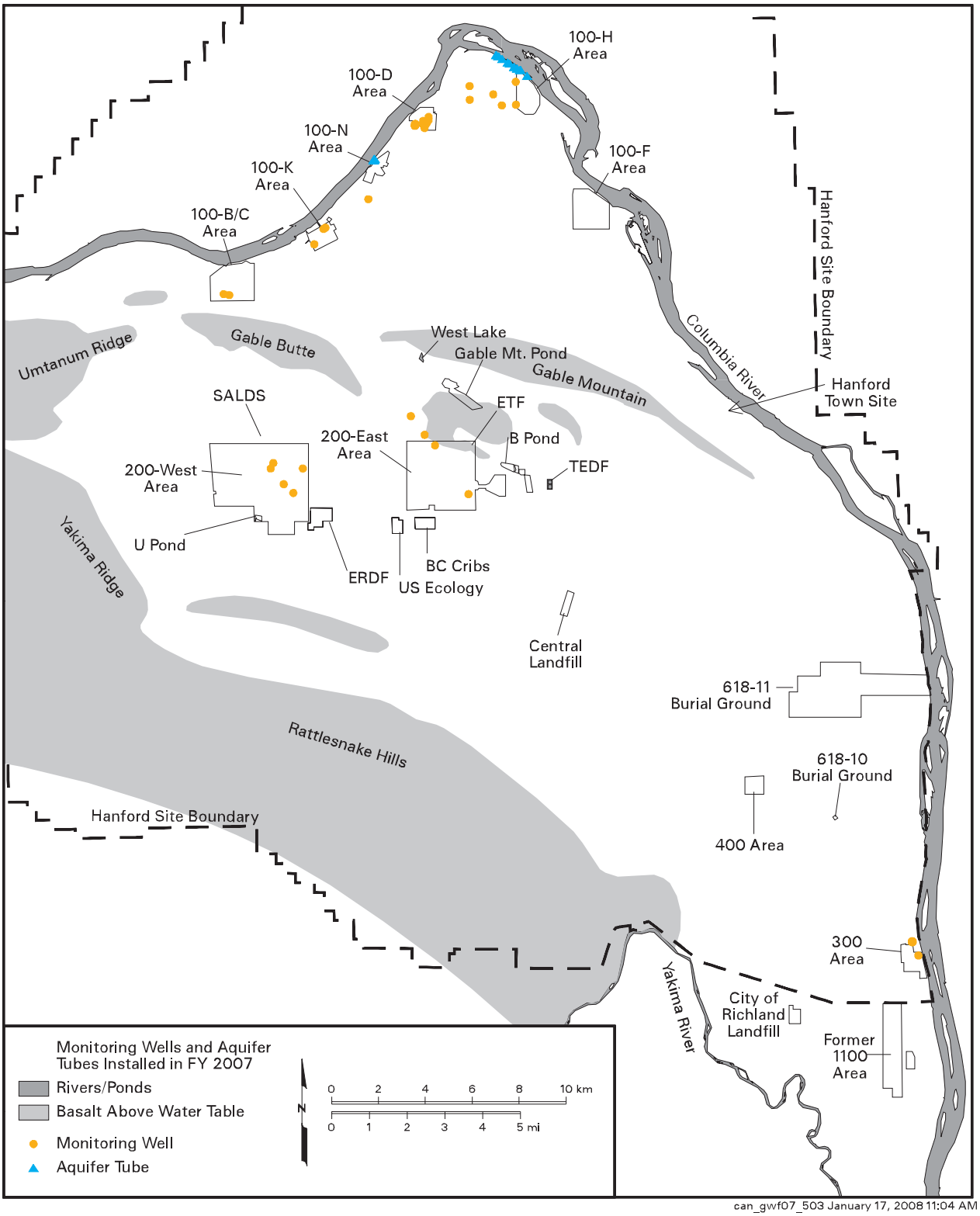

Figure 4.0-3. Groundwater Monitoring Wells and Aquifer Tubes Installed, FY 2007

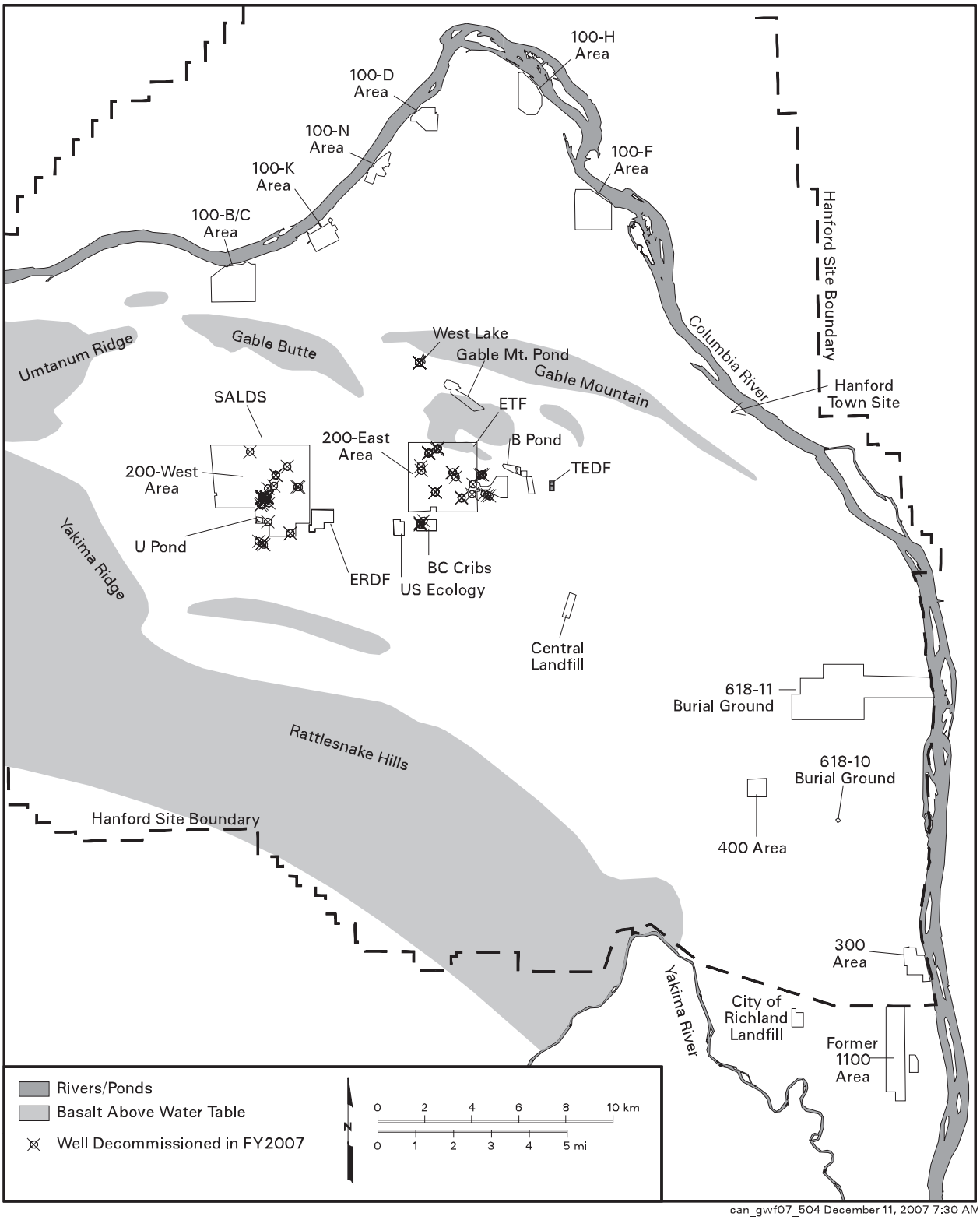

Figure 4.0-4. Vadose Zone and Groundwater Wells Physically Decommissioned, FY 2007

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Appendix A

Supporting Information for CERCLA Groundwater Operable Units

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Appendix - A

Supporting Information for CERCLA Groundwater Operable Units

M. J. Hartman

Under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), the groundwater and vadose zone beneath contaminated portions of the Hanford Site are divided into 11groundwater operable units. Figure 1.0-1 in Section 1.0 of the main text shows the locations of these units and related groundwater interest areas on the Hanford Site. The interest areas are defined informally to aid in planning, scheduling, and data interpretation.

Tables A.1 through A.17 list the constituents, monitoring wells, and the frequency of sampling for each operable units required by sampling and analysis plans or other documentation. The tables also indicate whether the wells were sampled as scheduled during fiscal year 2007.

In many cases, wells are sampled for additional constituents not strictly required by the plans. Those constituents are not listed in the tables of this appendix, but data files accompanying this report include all required and supplemental data.

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Table A.1. Monitoring Wells and Constituents for 100-BC-5 Operable Unit (adapted from DOE/RL-2003-38 and TPA-CN-182)

Well	Alkalinity	Alpha	Anions	Beta	Hexavalent Chromium	Metals	Strontium-90	Tritium	Technetium-99	Sampled as Scheduled in FY 2007
199-B2-12	BO	BO	BO	BO		BO	BO	BO		Yes
199-B2-13	A	BE	A	BE		A	BE	BE		Yes
199-B3-1	A		A		A	A	A	A		Yes
199-B3-46	BO		BO		A	BO	A	A		Yes
199-B3-47	A	A	A	A	A	A	A	A		Yes
199-B4-1	BE	BE	BE	BE	BE	BE	BE	BE		Not scheduled
199-B4-4		BE		BE			BE	BE		Not scheduled
199-B4-5										Water level only
199-B4-6										Water level only
199-B4-7	BO	BO	BO	BO		BO	BO	BO		Yes
199-B4-8	A	BE	A	BE		A	BE	BE		Yes
199-B5-1	A	A	A	A	A	A	BE	A		Yes
199-B5-2		BO		BO	A		BO	A		Yes
199-B8-6	BO	BO	BO	BO		BO	BO	A		Yes
199-B8-7	1	1	1	1	1	1		1		New well - sampled once[(a)]
199-B8-8	1	1	1	1	1	1		1		New well - sampled once[(a)]
199-B9-2		BE		BE			BE	BE		Not scheduled
199-B9-3	BO	BO	BO	BO		BO	BO	BO		Yes
699-63-90	BE	BE	BE	BE		BE		BE		Not scheduled
699-65-72	BE		BE			BE		BE		Not scheduled
699-65-83								BE		Not scheduled
699-66-103								BE		Not scheduled
699-67-86								BO		Yes
699-68-105	BO		BO			BO		BO		Yes
699-71-77	BO		BO			BO		BO	BO	Yes
699-72-73	A		A			A		A	BO	Yes
699-72-92	BO		BO			BO		BO		Yes
AT-01					A			A		Yes
AT-03					A			A		Yes
AT-04			A		A			A		Yes
AT-05		A	A	A	A		A	A		Yes
AT-06		A	A	A	A		A	A		Yes
AT-07		A	A	A	A			A		Yes
AT-11		A		A	A			A	A	Yes
AT-12		A		A	A			A	A	No
AT-B-1					A			A		Yes
AT-B-2					A			A		Yes
AT-B-3		A	A	A	A		A	A		Yes
AT-B-4		A	A	A	A			A		Yes
AT-B-5		A	A	A	A		A	A	A	Yes
AT-B-7		A	A	A	A		A	A		Yes
Seep 037-1		A		A	A			A		Yes
Seep 039-2		A		A	A			A		Yes

(a) Scheduled monthly 9/2007 through 1/2008; quarterly thereafter.
A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.

Table A.2. Monitoring Wells for 100-KR-4 Pump-and-Treat System (adapted from DOE/RL-96-90, DOE/RL-2006-75, and DOE/RL-2006-52, Rev. 1)

Well	Monitoring Purpose	Frequency	Sampled as Scheduled in FY 2007
East Plume Wells			
199-K-18	Compliance	M	Missed 11/2006
199-K-19	Performance	SA	Yes
199-K-20	Compliance	M	Missed 11/2006
199-K-21	Performance	SA	Yes
199-K-22	Performance	SA	Yes
199-K-37	Performance	SA	Yes
199-K-117A	Compliance	M	Missed 11/2006
199-K-130	Planned Extraction/Compliance[(a)]	M	Yes
199-K-131	Planned Extraction/Compliance[(a)]	M	Missed 5/2007
199-K-141	Performance	Q	Wells supporting 100-KR-4 expansion to be added in FY 2008.
199-K-144	Compliance	Q	
199-K-145	Compliance	Q	
199-K-146	Compliance	Q	
199-K-147	Extraction/Compliance	M	
199-K-148	Extraction/Compliance	M	
199-K-149	Extraction/Compliance	M	
199-K-150	Compliance	Q	
199-K-152	Performance	Q	
199-K-153	Performance	Q	
199-K-156	Performance	Q	
199-K-157	Performance	Q	
199-K-161	Extraction/Compliance	S	
199-K-162	Compliance	SA	
KW Wells[(b)]			
199-K-34	Performance	Q	Missed 10/2006
199-K-106A	Performance	Q	Yes
199-K-107A	Performance	Q	Yes
199-K-132	Extraction/Compliance	M	Missed 11/2006
199-K-138	Extraction/Compliance	M	Missed 11/2006
199-K-139	Extraction/Compliance	M	Missed 11 and 12/2006
199-K-140	Extraction/Compliance	M	Missed 11 and 12/2006

(a) Monitored per DOE/RL-96-90 in FY 2007. Will be converted to extaction/compliance wells in FY 2008 per DOE/RL-2006-75.
(b) KW pump-and-treat began operation January 2007.
FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.3. Monitoring Wells for 100-KR-4 Operable Unit Long-Term Monitoring

Well	Frequency	Sampled as Scheduled in FY 2007
199-K-11	BO	Yes
199-K-18	A	Yes
199-K-19	A	Yes
199-K-20	A	Yes
199-K-21	A	Yes
199-K-22	A	Yes
199-K-23	BO	Yes
199-K-27	Q	Yes
199-K-30	Q	Yes
199-K-31	A	Yes
199-K-32A	A	Yes
199-K-32B	A	Yes
199-K-34	BO	Yes
199-K-35	BO	Yes
199-K-36	Q	Yes
199-K-37	A	Yes
199-K-106A	BE	Not scheduled
199-K-107A	Q	Yes
199-K-108A	Q	Yes
199-K-109A	Q	Missed 7/2007
199-K-110A	BE	Not scheduled
199-K-111A	A	Yes
199-K-130	M	Yes
199-K-141	Q	New well, sampled three times
199-K-142	Q	New well, sampled two times
199-K-143	Q	New well, sampled three times
699-70-68	BE	Not scheduled
699-73-61	BE	Not scheduled
699-78-62	A	Yes
SK-057-3	A	No[(a)]
SK-077-1	A	Yes
SK-082-2	A	No[(a)]

(a) Sampling of springs is dependent on flow conditions.
A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.

Table A.4. Monitoring Wells for 100-NR-2 Interim Action

Well	Frequency	Sampled as Scheduled in FY 2007
199-N-2	A	Yes
199-N-3	SA	Yes
199-N-14	SA	Yes
199-N-16	A	Yes
199-N-18	SA	Yes
199-N-21	A	Yes
199-N-27	A	Yes
199-N-32	SA	Yes
199-N-50	A	Yes
199-N-51	A	Yes
199-N-64	A	Yes
199-N-67	SA	Yes
199-N-70	A	Yes
199-N-74	A	Yes
199-N-75	SA	Yes
199-N-76	SA	Yes
199-N-80	A	Yes
199-N-81	A	Yes
199-N-92A	A	Yes
199-N-96A	A	Yes
199-N-99A	A	Yes
199-N-119	A	Yes
199-N-120	A	Yes
199-N-121	A	Yes
199-N-122	M	Sampled seven times[(a)]
199-N-123	M	Sampled five times[(a)]

(a) Access to wells limited by work on the apatite barrier.
A = To be sampled annually.
FY = Fiscal year.
SA = To be sampled semiannually.

Table A.5. Monitoring Wells and Constituents for 100-NR-2 Rebound Monitoring (adapted from PNNL-15798)

Well or Tube Name	Dissolved Oxygen	Beta	Strontium-90	Gamma	Tritium	Alkalinity	Anions	Metals	Citrate	TOC, TPH	Sampled as Scheduled in FY 2007 [(a)]
199-N-2	SA		SA								Yes
199-N-3	SA		SA								Yes
199-N-14	SA		SA								Yes
199-N-46	M	M	Q	Q	Q	Q	Q	Q			Sampled eight times
199-N-67	M	M	Q	Q	Q	Q	Q	Q			Sampled eight times
199-N-75	Q	Q	Q	Q	Q	Q	Q	Q			Yes
199-N-76	SA		SA								Yes
199-N-92A	SA	SA	SA	SA	SA	SA	SA	SA			Yes
199-N-96A	M	M	Q	Q	Q	Q	Q	Q		Q	Sampled ten times
199-N-99A	M	M	Q	Q	Q	Q	Q	Q			Missed 3/2007
199-N-103A	Q	Q	Q	Q	Q	Q	Q	Q			Yes
199-N-105A	Q	Q	Q	Q	Q	Q	Q	Q			Yes
199-N-106A	Q	Q	Q	Q	Q	Q	Q	Q			Yes
199-N-119	M	M	Q	Q	Q	Q	Q	Q			Sampled nine times
199-N-120	SA	SA	SA	SA	SA	SA	SA	SA			Yes
199-N-121	SA	SA	SA	SA	SA	SA	SA	SA			Yes
199-N-122	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled eight times. No citrate.
199-N-123	M	M	Q	Q	Q	Q	Q	Q	Q	Q	Sampled seven times. No citrate.
199-N-146	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled five times. No citrate.
199-N-147	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled eight times. No citrate.
NS-2A-87cm	M	M	Q	Q	Q	Q	Q	Q	Q		Removed from schedule.
NS-4A-138cm	M	M	Q	Q	Q	Q	Q	Q	Q		Removed from schedule.
NVP1-1	Q	Q									Sampled three times.
NVP1-2	Q	Q									Sampled three times.
NVP1-3	Q	Q									Sampled three times.
NVP1-4	Q	Q									Sampled three times.
NVP1-5	Q	Q									Sampled three times.
NVP2-116.3	Q	Q									Sampled three times.
NVP2-116.0	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled three times for beta; once for others. No citrate.
NVP2-115.7	Q	Q									Sampled three times.
NVP2-115.4	Q	Q									Sampled three times.
NVP2-115.1	Q	Q									Sampled three times.
Array-1A	Q	Q	Q	A	A	A	A	A	Q	Q	Sampled three times. No citrate.
Array-2A	Q	Q	Q	A	A	A	A	A	Q	Q	Sampled three times. No citrate.
Array-3A	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled three times. No citrate.
Array-4A	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled three times. No citrate.
Array-6A	M	M	Q	Q	Q	Q	Q	Q	Q		Sampled four times. No citrate.
Array-7A	Q	Q	A	A	A	A	A	A	Q		Sampled three times. No citrate.
Array-8A	Q	Q	A	A	A	A	A	A			Sampled three times.
Array-9A	Q	Q	A	A	A	A	A	A			Sampled three times.
Array-10A	Q	Q	A	A	A	A	A	A			Sampled three times.
Array-11A	Q	Q	A	A	A	A	A	A			Sampled three times.
Array-12A	Q	Q	A	A	A	A	A	A			Sampled three times.
Array-13A	Q	Q	A	A	A	A	A	A			Sampled three times.
Array-14A	Q	Q	A	A	A	A	A	A			Sampled three times.
NS-2	A	A	A	A	A						No
NS-3	A	A	A	A	A						No
NS-4	A	A	A	A	A						No

(a) Access to shoreline wells and aquifer tubes limited by work on the apatite barrier.
A = To be sampled annually.
FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.
SA = To be sampled semiannually.
TOC = Total organic carbon.
TPH = Total petroleum hydrocarbons.

Table A.6. Monitoring Wells for 100-HR-3 Operable Unit In Situ Redox System

Well Name	Frequency	Sampled as Scheduled in FY 2007
199-D2-6	Q	Yes
199-D2-8	Q	Yes
199-D3-2	Q	Yes
199-D4-1	Q	Yes
199-D4-15	M	Yes
199-D4-20	Q	Yes
199-D4-22	Q	Yes
199-D4-23	Q	Yes
199-D4-26	Q	Yes
199-D4-31	Q	Yes
199-D4-32	Q	Yes
199-D4-36	Q	Yes
199-D4-38	Q	Yes
199-D4-39	Q	Yes
199-D4-4	Q	Yes
199-D4-48	Q	Yes
199-D4-5	Q	Yes
199-D4-6	Q	Yes
199-D4-62	Q	Yes
199-D4-7	Q	Yes
199-D4-78	Q	Yes
199-D4-83	Q	Yes
199-D4-84	Q	Yes
199-D4-85	Q	Yes
199-D4-86	Q	Yes
199-D5-36	Q	Yes
199-D5-38	M	Yes
199-D5-39	M	Sampled nine times.
199-D5-43	M	Yes

FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.

Table A.7. Monitoring Wells for 100-HR-3 Pump-and-Treat Systems

Well	Frequency	Sampled as Scheduled in FY 2007
199-D5-37	Q	Yes
199-D5-39	A	Yes
199-D8-54B	SA	Yes
199-D8-69	M	Yes
199-D8-70	M	Yes
199-D8-71	SA	Yes
199-D8-73	M	Yes
199-D8-88	M	Missed 5/2007
199-H3-2A	A	Yes
199-H3-3	Q	Yes
199-H3-4	Q	Yes
199-H3-5	Q	Yes
199-H4-10	SA	Yes
199-H4-11	M	Yes
199-H4-12B	SA	Yes
199-H4-12C	SA	Yes
199-H4-13	SA	Yes
199-H4-15B	SA	Yes
199-H4-15CS	SA	Yes
199-H4-16	SA	Yes
199-H4-45	SA	Yes
199-H4-46	SA	Yes
199-H4-48	SA	Yes
199-H4-49	SA	Yes
199-H4-5	M	Yes
199-H4-6	SA	Yes
199-H4-65	M	Yes
199-H4-8	SA	Yes
199-H5-1A	SA	Yes

FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.8. Monitoring Wells and Constituents for 100-HR-3 Operable Unit Long-Term Monitoring

Well	Frequency	Sampled as Scheduled in FY 2007	Well	Frequency	Sampled as Scheduled in FY 2007
199-D2-6	Q	Yes	199-H4-8	BO	Yes
199-D3-2	Q	Yes	199-H4-9	A	Yes
199-D4-13	Q	Yes	199-H4-10	A	Yes
199-D4-14	Q	Yes	199-H4-12C	A	Yes
199-D4-15	M	Yes	199-H4-13	A	Yes
199-D4-19	Q	Yes	199-H4-16	BO	Yes
199-D4-20	Q	Yes	199-H4-45	A	Yes
199-D4-22	Q	Yes	199-H4-46	BO	Yes
199-D4-23	Q	Yes	199-H4-47	BE	Not scheduled
199-D5-13	Q	Missed 5/2007	199-H4-48	BE	Not scheduled
199-D5-14	Q	Yes	199-H4-49	BE	Not scheduled
199-D5-15	Q	Yes	199-H5-1A	BE	Not scheduled
199-D5-16	Q	Yes	199-H6-1	A	Yes
199-D5-17	A	Yes	699-86-42	A	Yes
199-D5-18	BO	Yes	699-87-42A	A	Yes
199-D5-19	BO	Yes	699-88-41	A	Yes
199-D5-20	A	Yes	699-90-45	A	Yes
199-D5-33	Q	Yes	699-91-46A	BE	Not scheduled
199-D5-34	Q	Yes	699-93-48A	BE	Not scheduled
199-D5-36	Q	Yes	699-96-43	BO	Yes
199-D5-37	Q	Yes	699-96-49	BO	Yes
199-D5-38	M	Yes	699-97-43	BO	Yes
199-D5-39	Q	Missed 8/2007	699-97-51A	A	Yes
199-D5-40	Q	Yes	699-98-49A	A	Yes
199-D5-41	Q	Yes	SD-102-1	A	No[(a)]
199-D5-43	Q	Yes	SD-110-1	A	Yes
199-D5-44	Q	Yes	SD-110-2	A	No[(a)]
199-D8-4	A	Yes	SD-98-1	A	No[(a)]
199-D8-5	A	Yes	SH-144-1	A	No[(a)]
199-D8-54B	A	Yes	SH-145-1	A	Yes
199-D8-55	Q	Yes	SH-150-1	A	No[(a)]
199-H3-2C	BO	Yes	SH-152-2	A	Yes
199-H4-5	A	Yes	SH-153-1	A	No[(a)]
199-H4-6	BO	Yes			

(a) Sampling of springs is dependent on flow conditions.
A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
M = To be sampled monthly.
Q = To be sampled quarterly.

Table A.9. Monitoring Wells, Aquifer Tubes, and Constituents for 100-FR-3 Operable Unit (adapted from DOE/RL-2003-49)

Well	Alkalinity	Alpha	Anions	Hexavalent Chromium	Metals	Strontium-90	Tritium	TCE (VOA)	Uranium	Sampled as Scheduled in FY 2007
199-F1-2	BO		BO		BO					Yes
199-F5-1	A	BE	A		A	BE	BE			Yes
199-F5-4	A	BO	A		A		BO	BO		Yes
199-F5-6	A	BE	A		A	BE	BE			Yes
199-F5-42	BO	BO	BO		BO	BO	BO			Yes
199-F5-43A	BE	BE	BE		BE	BE	BE			Not scheduled
199-F5-43B	BE	BE	BE		BE	BE				Not scheduled
199-F5-44	BE	BE	BE		BE	BE	BE			Not scheduled
199-F5-45	BO	BO	BO		BO	BO	BO	BO	BO	Yes
199-F5-46	BE	A	BE		BE	BE	A	BE	A	Yes
199-F5-47	A	BE	A		A		A	BE	A	Yes
199-F5-48	BO	BO	BO		BO		BO		BO	Yes
199-F6-1	BO	BO	BO		BO	BO	BO			Yes
199-F7-1	BE		BE		BE			BE		Not scheduled
199-F7-2	BE	BE	BE		BE		BE	BE		Not scheduled
199-F7-3	BE	BE	BE		BE		BE	BE		Not scheduled
199-F8-2	BO	BO	BO		BO		BO		BO	Yes
199-F8-3	BO	A	BO		BO		A	BO	A	Yes
199-F8-4	BE	A	BE		BE		BE		A	Yes
699-58-24	BE		BE		BE					Not scheduled
699-60-32	BO		BO		BO					Yes
699-62-31	BO		BO		BO					Yes
699-62-43F	A		A		A		A			Yes
699-63-25A	BO		BO		BO		BO			Yes
699-63-55	BO		BO		BO		A			Yes
699-64-27	BE		BE		BE					Not scheduled
699-66-23	BE		BE		BE		BE			Not scheduled
699-67-51	BO		BO		BO		BO			Yes
699-71-30	BO	BO	BO		BO		BO			Yes
699-74-44	BO		BO		BO			BO		Yes
699-77-36	BE		BE		BE			BE		Not scheduled
699-77-54	BO		BO		BO					Yes
699-81-38	BE		BE		BE					Not scheduled
699-83-47	BE		BE		BE			BE		Not scheduled

Table A.9. (contd)

Well	Alkalinity	Alpha	Anions	Hexavalent Chromium	Metals	Strontium-90	Tritium	TCE (VOA)	Uranium	Sampled as Scheduled in FY 2007
AT-62	A		A	A	A					Yes
AT-63	A		A	A	A					Yes
AT-64	A		A	A	A	A				Yes
AT-65	A		A	A	A	A				Tubes destroyed
AT-66	A		A	A	A	A		A		Yes
AT-67	A		A	A	A					Yes
AT-68	A		A	A	A		A			Yes
AT-72	A		A	A	A		A			Yes
AT-73	A		A	A	A		A			Not found
AT-74	A		A	A	A		A			Yes
AT-75	A		A	A	A		A			Not found in FY 2007; Found in FY 2008
AT-76	A		A	A	A		A			Yes
AT-77	A		A	A	A					Yes
AT-78	A		A	A	A					Not found
AT-80	A		A	A	A					Yes
AT-F-1	A		A	A	A	A				Yes
AT-F-2	A		A	A	A		A	A		Yes
AT-F-3	A		A	A	A		A	A		Yes
AT-F-4	A		A	A	A		A			Yes
SF-187-1	A		A	A	A		A			No[(a)]
SF-190-4	A		A	A	A		A			No[(a)]
SF-207-1	A		A	A	A		A			No alkalinity

(a) Sampling of springs is dependent on flow conditions.
A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
TCE = Trichloroethene.
VOA = Volatile organic analyses.

Table A.10. Monitoring Wells for 200-ZP-1 Operable Unit

Well	Frequency	Sampled as Scheduled in FY 2007	Well	Frequency	Sampled as Scheduled in FY 2007
299-W10-1	A	Yes	299-W15-34	Q	Yes
299-W10-4	SA	Yes	299-W15-35	Q	Yes
299-W10-5	A	Yes	299-W15-36	Q	Yes
299-W10-22	SA	Yes	299-W15-38	A	Yes
299-W10-23	A	Yes	299-W15-39	SA	Yes
299-W10-33	Q	New well; added for FY2008	299-W15-40	Q	Yes
299-W11-3	SA	Yes	299-W15-41	SA	Yes
299-W11-6	SA	Yes	299-W15-41	SA	Yes
299-W11-7	A	Yes	299-W15-42	SA	Yes
299-W11-10	SA	Yes	299-W15-43	Q	Yes
299-W11-13	SA	Yes	299-W15-44	Q	Yes
299-W11-18	A	Yes	299-W15-45	Q	Yes
299-W11-37	SA	Yes	299-W15-46	Q	Sampled three times
299-W11-43	Q	Yes	299-W15-47	Q	Sampled three times
299-W11-45	Q	Yes	299-W15-49	Q	Yes
299-W11-46	Q	Yes	299-W15-50	Q	Yes
299-W11-47	Q	Sampled three times	299-W15-152	Q	Yes
299-W11-48	Q	New well; added for FY2008	299-W15-152	Q	Yes
299-W11-87	Q	Sampled once. New well	299-W15-763	Q	Yes
299-W12-1	A	Yes	299-W15-765	Q	Yes
299-W13-1	Q	Yes	299-W17-1	SA	Yes
299-W14-14	A	Yes	299-W18-16	Q	Yes
299-W14-16	A	Yes	299-W18-23	Q	Sampled three times
299-W14-71	Q	Sampled three times. New well.	299-W7-4	A	Yes
299-W14-72	Q	Sampled three times. New well.	299-W8-1	BE	Not scheduled
299-W15-1	SA	Yes	699-43-89	BO	Delayed until 10/2007
299-W15-2	A	Yes	699-44-64	BO	Yes
299-W15-7	SA	Yes	699-45-69A	BO	Yes
299-W15-11	SA	Yes	699-47-60	BO	Yes
299-W15-15	Q	Yes	699-48-71	SA	Yes
299-W15-17	SA	Yes	699-48-77A	BO	Yes
299-W15-30	SA	Yes	699-50-74	Q	Fourth delayed until 10/2007
299-W15-31A	Q	Fourth delayed until 10/2007	699-55-60A	BO	Delayed until 10/2007
299-W15-35	Q	Yes			

A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.11. Monitoring Wells for 200-UP-1 Operable Unit

Well	Frequency	Sampled as Scheduled in FY 2007	Well	Frequency	Sampled as Scheduled in FY 2007
299-W15-37	A	Yes	299-W22-69	Q	Yes
299-W18-15	SA	Yes	299-W22-72	Q	Yes
299-W18-21	A	Yes	299-W22-83	Q	Yes
299-W18-22	A	Yes	299-W22-86	Q	Yes
299-W18-30	A	Yes	299-W22-87	Q	Yes
299-W19-4	BO	Yes	299-W23-4	SA	Yes
299-W19-18	SA	Yes	299-W23-9	A	Yes
299-W19-101	Q	Yes	299-W23-10	SA	No; dry FY 2006.
299-W19-105	Q	Yes	299-W23-15	SA	Yes
299-W19-107	Q	Yes	299-W23-21	Q	Yes
299-W19-34A	A	Yes	299-W26-13	BO	Yes
299-W19-34B	BE	Not scheduled	299-W26-14	A	Yes
299-W19-35	SA	Yes	699-30-66	SA	Yes
299-W19-36	Q	Yes	699-32-62	BO	Yes
299-W19-37	SA	Yes	699-32-72A	BO	Yes
299-W19-39	SA	Sampled once.	699-35-66A	BO	Yes
299-W19-43	Q	Yes	699-35-70	BO	Yes
299-W19-46	SA	Yes	699-35-78A	A	Yes
299-W19-48	Q	Yes	699-36-61A	A	Yes
299-W19-49	Q	Yes	699-36-70A	A	Yes
299-W21-2	SA	Yes	699-36-70B	Q	Yes
299-W22-9	BO	Yes	699-38-65	A	Yes
299-W22-20	A	Yes	699-38-68A	BO	Yes
299-W22-26	A	No	699-38-70	A	Yes
299-W22-45	A	Yes	699-38-70B	SA	Yes
299-W22-48	SA	Yes	699-38-70C	Q	Yes
299-W22-49	SA	Yes	699-40-62	BO	Yes
299-W22-69	Q	Yes	699-40-65	SA	Yes

A = To be sampled annually.
BE = To be sampled biennially, even fiscal year.
BO = To be sampled biennially, odd fiscal year.
FY = Fiscal year.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.12. Monitoring Wells and Constituents for 200-BP-5 Operable Unit (adapted from DOE/RL-2001-49)

	Contaminants of Concern										Supporting Constituents/Measurements							
Well Name	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	Sampled as Scheduled in FY 2007
299-E24-8		3-07	3-07	3-07		3-07			3-07				3-07	3-07				No arsenic
299-E26-10		A	A	A														Yes
299-E26-11		3-07	3-07	3-07									3-07					Yes
299-E27-10		3-07	3-07	3-07									3-07					Yes
299-E27-14	A	A	A	A														Yes
299-E27-15	A		A								A				A			Yes
299-E27-17		3-07	3-07	3-07									3-07					Yes
299-E27-18		3-07	3-07	3-07									3-07					Yes
299-E27-7	A	A	A	A									A					Yes
299-E28-13		3-07	3-07	3-07			3-07	3-07						3-07				Yes
299-E28-17			A				A	A	A	A								Yes
299-E28-18		A	A	A			A						A	A				Yes
299-E28-2	A	A	A	A				A	A	A	A			A	A			No I-129
299-E28-21							A											Yes
299-E28-23							A	A	A	A		A		A		A		Yes
299-E28-24		A					A	A	A	A		A		A		A		Yes
299-E28-25		A	A	A			A	A	A	A		A	A	A		A		Yes
299-E28-26	A	3-07	A	3-07			A						3-07					Yes
299-E28-27	A	3-07	A	A			A	A	A	A								Yes
299-E28-28		3-07	3-07	3-07														Yes
299-E28-5		3-07	3-07	3-07			A	A	A	A			3-07	3-07				Yes
299-E28-6		3-07	3-07	3-07		A	A	A	A	A			3-07	3-07				Yes
299-E28-8	A						A	A	A	A								Yes
299-E32-10	A	3-07	3-07	3-07	A	A	A						3-07					Yes
299-E32-2		3-07	3-07	3-07														Yes
299-E32-4	A	A	A	A														Yes
299-E32-5		3-07	3-07	3-07			3-07											Yes
299-E32-6	A	3-07	A	3-07			3-07											Yes
299-E32-7		3-07	3-07	3-07														Yes
299-E32-8		3-07	3-07	3-07														Yes
299-E32-9		3-07	A	A	3-07													Yes
299-E33-12	3-07																	Yes

Table A.12. (contd)

Well Name	Contaminants of Concern										Supporting Constituents/Measurements							Sampled as Scheduled in FY 2007
	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	
299-E33-13					A		A											Yes
299-E33-15	A		A															Yes
299-E33-16	A		A	A			A											Yes
299-E33-18	A		A	A			A											Yes
299-E33-26	A	3-07	3-07	3-07	A	A	A							3-07				Yes
299-E33-28	A		A															Yes
299-E33-29	3-07	3-07	3-07	3-07														Yes
299-E33-30	A		A															Yes
299-E33-32	3-07	3-07	3-07	3-07														Yes
299-E33-33		3-07	3-07	3-07			3-07						3-07					Yes
299-E33-334	A		A				A											Yes
299-E33-335	A									A								Yes
299-E33-338	A						A											Yes
299-E33-34	A	A	A	A	A	A	A											Yes
299-E33-35	A	3-07	A	3-07	A	3-07	A		3-07									Yes
299-E33-37		3-07	3-07	3-07														Yes
299-E33-38	A	A	A	A	A	A	A	A		A			A	A				Yes
299-E33-39	A	A	A	A	A		A											Yes
299-E33-40[a]	A	A	A	A	A	A	A		A		A			A	A			No-I-129
299-E33-41	A	3-07	3-07	3-07	3-07	3-07	A		3-07									Yes
299-E33-42	A			A			A											Yes
299-E33-43	A			A			A											Yes
299-E33-44	A					A	A											Yes
299-E33-50[a]	A	A	A		A	A	A		A									Yes; New well
299-E33-7	A	A	A	A	A	A	A		A					A				Yes
299-E34-2		A	A	A														Yes
299-E34-9		3-07	3-07	3-07														Yes
699-44-39B		3-07	3-07	3-07														Yes
699-45-42		3-07	3-07	3-07														Yes
699-47-60	A	A	A	A														Yes
699-48-50B[a]	A	A	A	A	A	A	A		A									Yes; New well
699-49-55A	A	A	A	A	A	A	A	A	A	A				A				Yes
699-49-55B[a]	A	A	A	A	A	A	A		A		A			A	A			No I-129
699-49-57A	A	A	A	A	A	A	A		A				A					Yes
699-49-57B	A	A	A	A	A	A			A									Yes
699-50-56[a]	A	A	A	A	A	A	A		A									Yes; New well
699-50-59	3-06		3-06	3-06		3-06	3-06				3-06				3-06			Yes
699-53-47A		A	A					A						A				Yes
699-53-47B			3-06					3-06										Not scheduled
699-53-48A		A	A	A				A						A	A			Yes

Table A.12. (contd)

Well Name	Contaminants of Concern										Supporting Constituents/Measurements							Sampled as Scheduled in FY 2007
	Technetium-99	Tritium	Nitrate	Iodine-129	Cyanide	Cobalt-60	Uranium	Strontium-90	Cesium-137	Plutonium-239/240	Alkalinity	Americium-241	Arsenic	Gross Alpha/Beta	Metals (filtered)	Neptunium-237	TOC/TOX	
699-53-55A	A	A	A		A	A												Yes
699-53-55B	A	A	A		A	A												Yes
699-53-55C	A	A	A	A	A	A												Yes
699-54-45A			3-06															Not scheduled
699-54-45B			3-06															Not scheduled
699-54-48								3-06										Not scheduled
699-54-49		A	A					A						A				Yes
699-55-50C	A	A	A	A				A										Yes
699-55-57	A	A	A	A	A	A												Yes
699-55-60A	A	A	A	A	A	A												Delayed until 10/2007
699-57-59	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-59-58	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-60-60	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-61-62	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-61-66	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-64-62	A	A	A	A	A	A	A	A	A	A	A			A	A		A	Yes
699-65-50	3-07																	Delayed until 10/2007
699-65-72		3-07																Yes
699-66-58	3-07	3-07																Yes
699-66-64	3-07	3-07																Yes
699-70-68	3-07	3-07																Yes
699-72-73	3-07	3-07	3-07															Yes
699-73-61		3-07																Yes

(a) Well not listed in DOE/RL-2001-49 but added to FY 2007 sampling schedule.

3-xx = To be sampled triennially (every three years); xx indicates the fiscal year of sampling for specified analyte.

A = To be sampled annually.

FY = Fiscal year.

TOC = Total organic carbon.

TOX = Total organic halides.

Table A.13. Monitoring Wells, Aquifer Tubes, and Constituents for 200-PO-1 Operable Unit (adapted from DOE/RL-2003-04[a])

Well or Aquifer Tube Name	Contaminants of Concern							Supporting Constituents				Sampled as Scheduled in FY 2007
	Arsenic	Chromium, Manganese, and Vanadium (filtered)	Iodine-129	Nitrate	Strontium-90	Technetium-99	Tritium	Gross Alpha	Anions[b]	Gross Beta	Metals[c]	
200-PO-1 Near-Field Wells												
299-E16-2	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-12	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-13	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-14	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-16	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-18	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-19	A	A	A	A	A		A	A	A	A	A	Yes
299-E17-23	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E17-25	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E18-1	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E23-1	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E24-18	A	A	A	A	A		A	A	A	A	A	Yes
299-E24-20	A	A	A	A	A	A	A	A	A	A	A	Yes
299-E24-5	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-17	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-18	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-19	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-20	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-22	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-28	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-29P	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-29Q	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-3	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-32P	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-32Q	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-34	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-35	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-36	A	A	A	A	A		A	A	A	A	A	Yes
299-E25-37	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-41	A	A	A	A	A	A	A	A	A	A	A	Yes
299-E25-42	A	A	A	A	A	A	A	A	A	A	A	Yes
299-E25-43	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-44	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-47	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
299-E25-6	A	A	A	A	A		A	A	A	A	A	Yes
299-E26-4	A	A	A	A	A		A	A	A	A	A	Yes
699-37-47A	A	A	A	A	A		A	A	A	A	A	Yes
699-39-39	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
699-42-42B	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	No I-129
699-43-45	3-07	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	Yes
699-44-39B	3-07	3-07	3-07			3-07	3-07	3-07	3-07	3-07	3-07	No Tc-99

Table A.13. (contd)

Well or Aquifer Tube Name	Contaminants of Concern			Supporting Constituents											Sampled as Scheduled in FY 2007
	Iodine-129	Nitrate	Tritium	Gross Alpha	Anions [b]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals [c]	Strontium-90	Technetium-99	Uranium	VOA	
200-PO-1 Far Field Wells															
BC Cribs															
299-E13-14		A	A	A	A	A		A	A	A	A	A	A		Yes
299-E13-5		A	A	A	A	A		A	A	A	A	A	A		Yes
Southeast Transect															
699-10-54A		A	A	A	A	A			A	A	A			A	Yes
699-24-46	A	A	A	A	A	A			A	A	A			A	Yes
699-26-33	A	A	A	A	A	A			A	A	A			A	Yes
699-31-31	A	A	A	A	A	A			A	A	A			A	Yes
699-32-22A	A	A	A	A	A	A			A	A	A			A	Yes
699-32-43	A	A	A	A	A	A			A	A	A			A	Yes
699-41-23	A	A	A	A	A	A			A	A	A			A	Yes
699-46-21B	A	A	A	A	A	A			A	A	A			A	Yes
River Transect															
699-10-E12		A	A	A	A	A			A	A	A			A	Yes
699-20-E12O	A	A	A	A	A	A			A	A	A			A	Yes
699-41-1A	A	A	A	A	A	A			A	A	A			A	Yes
699-46-4	A	A	A	A	A	A			A	A	A			A	Yes
699-S3-E12		A	A	A	A	A			A	A	A			A	Yes
699-S19-E13		A	A	A	A	A			A	A	A			A	Yes
Basalt Confined Aquifer															
299-E16-1	3-06	3-06	3-06	3-06	3-06	3-06				3-06					Not scheduled
699-13-1C		3-06	3-06	3-06	3-06	3-06				3-06					Not scheduled
699-24-1P		3-06	3-06	3-06	3-06	3-06				3-06					Not scheduled
699-32-22B	3-06	3-06	3-06	3-06	3-06	3-06				3-06					Not scheduled
699-42-40C	3-07	3-07	3-07	3-07	3-07	3-07				3-07					Yes
699-S11-E12AP		3-06	3-06	3-06	3-06	3-06				3-06					Not scheduled
Far-Field General															
499-S0-7		3-07	3-07		3-07										Yes
499-S0-8[a]	A	A	A	A	A	A				A					Yes
499-S1-8J[a]	A	A	A	A	A	A			A		A	A	A	A	Yes
699-12-4D	3-07	3-07	3-07		3-07										Yes
699-13-1A	3-07	3-07	3-07		3-07										No I-129
699-13-3A		3-07	3-07		3-07										Yes
699-14-38		3-07	3-07		3-07										Yes
699-17-5	3-07	3-07	3-07		3-07										No; unsuccessful

Table A.13. (contd)

Well or Aquifer Tube Name	Contaminants of Concern			Supporting Constituents											Sampled as Scheduled in FY 2007
	Iodine-129	Nitrate	Tritium	Gross Alpha	Anions [b]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals [c]	Strontium-90	Technetium-99	Uranium	VOA	
699-19-43	3-07	3-07	3-07		3-07										Yes
699-20-20	3-07	3-07	3-07		3-07										Yes
699-20-E12S		3-07	3-07		3-07										Yes
699-20-E5A		3-07	3-07		3-07										Yes
699-21-6	3-07	3-07	3-07		3-07										Yes
699-2-3	3-07	3-07	3-07		3-07										Delayed until 10/2007
699-22-35	3-07	3-07	3-07		3-07										Yes
699-24-34C	3-07	3-07	3-07		3-07										Yes
699-26-15A	3-07	3-07	3-07		3-07										Yes
699-26-33		3-07	3-07		3-07										Yes
699-26-35A	3-07	3-07	3-07		3-07										Yes
699-2-6A		3-07	3-07		3-07										Yes
699-2-7		3-07	3-07		3-07										Yes
699-28-40	3-07	3-07	3-07		3-07										Yes
699-29-4	3-07	3-07	3-07		3-07										Yes
699-31-11	3-07	3-07	3-07		3-07										Yes
699-33-42	3-07	3-07	3-07		3-07										Yes
699-33-56	3-07	3-07	3-07		3-07										No; dry
699-34-41B	3-07	3-07	3-07		3-07										No I-129
699-34-42	3-07	3-07	3-07		3-07										Yes
699-35-9	3-07	3-07	3-07		3-07										Yes
699-37-43	3-07	3-07	3-07		3-07										Yes
699-37-E4	3-07	3-07	3-07		3-07										Yes
699-38-15	3-07	3-07	3-07		3-07										Yes
699-40-1	3-07	3-07	3-07		3-07										Yes
699-40-33A	3-07	3-07	3-07		3-07										Yes
699-41-40	3-07	3-07	3-07		3-07										Yes
699-41-42[a]	3-07	3-07	3-07	3-07	3-07	3-07									No I-129
699-42-12A	3-07	3-07	3-07		3-07										Yes
699-42-39A	3-07	3-07	3-07		3-07										Yes
699-42-39B	3-07	3-07	3-07		3-07										Yes
699-42-40A[a]	3-07	3-07	3-07	3-07	3-07	30-7									Yes
699-43-3	3-07	3-07	3-07		3-07										Yes
699-43-41E	3-07	3-07	3-07		3-07										No; Dry

Table A.13. (contd)

Well or Aquifer Tube Name	Contaminants of Concern			Supporting Constituents											Sampled as Scheduled in FY 2007
	Iodine-129	Nitrate	Tritium	Gross Alpha	Anions [b]	Gross Beta	Hexavalent Chromium	Cyanide	Gamma	Metals [c]	Strontium-90	Technetium-99	Uranium	VOA	
699-45-42	3-07	3-07	3-07		3-07										Yes
699-47-5	3-07	3-07	3-07		3-07										Delayed until 10/2007
699-48-7A		3-07	3-07		3-07										Yes
699-49-13E	3-07	3-07	3-07		3-07										Delayed until 10/2007
699-50-28B	3-07	3-07	3-07		3-07										Yes
699-52-19		3-07	3-07		3-07										Yes
699-8-17	3-07	3-07	3-07		3-07										Yes
699-8-25	3-07	3-07	3-07		3-07										Yes
699-9-E2	3-07	3-07	3-07		3-07										No I-129
699-S12-3		3-07	3-07		3-07										Yes
699-S19-E14		3-07	3-07		3-07										Yes
699-S2-34B	A	A	A		A					A					Yes
699-S3-25		3-07	3-07		3-07										Yes
699-S6-E14A		3-07	3-07		3-07										Yes
699-S6-E4A		3-07	3-07		3-07										Yes
699-S6-E4B		3-07	3-07		3-07										Yes
699-S8-19		3-07	3-07		3-07										Yes
81-D, M, S	A	A	A	A	A	A	A					A			Not found
82-M, S	A	A	A	A	A	A	A					A			Conductivity too low to sample
83-D	A	A	A	A	A	A	A					A			Not found
84-D, M, S	A	A	A	A	A	A	A					A			No Cr6+
85-D, M, S	A	A	A	A	A	A	A					A			No Cr6+
86-D, M, S	A	A	A	A	A	A	A					A			No Cr6+

(a) Some wells added in anticipation of Rev. 2 of DOE/RL-2003-04.
(b) Anions - Analytes include but not limited to nitrate.
(c) Metals - Analytes include but not limited to chromium, manganese, and vanadium.
3-xx = To be sampled triennially (every three years); xx indicates the fiscal year of sampling for specified analyte.
A = To be sampled annually.
ICP = Inductively coupled plasma.
VOA = Volatile organic analyses.

Table A.14. Monitoring Wells, Aquifer Tubes, and Constituents for 300-FF-5 Operable Unit, 300 Area (adapted from DOE/RL-2002-11)

Well or Aquifer Tube Name	Hydrologic Unit Monitored	Contaminants of Concern			Contaminants of Potential Concern				Supporting Measurements						Sampled as Scheduled in FY 2007
		cis-1,2-Dichloroethene	Trichloroethene	Uranium-total	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals (filtered)	Volatile Organic Compounds	Gross Alpha/Beta	Uranium-isotopic	
Near-River Well Grouping															
399-1-1	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-10A	TU	SA	SA	Q	SA		A	Q	Q	Q	SA	SA	SA	A	Yes
399-1-10B	LU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-1-16A	TU	SA	SA	Q	SA		A	Q	Q	Q	SA	SA	SA	A	Yes
399-1-16B	LU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-1-16C	C	A	A	A	A			A	A	A	A	A			Yes
399-2-1	TU	SA	SA	Q	SA		A	Q	Q	Q	SA	SA	SA	A	Yes
399-2-2	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-3-1	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-3-9	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-3-10	TU	SA	SA	Q	SA		A	Q	Q	Q	SA	SA	SA	A	Yes
399-3-18	TU	Q	Q	Q	Q		A	Q	Q	Q	Q	Q	Q	A	Sampled three times
399-4-7	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-4-9	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-4-10	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
Central Region-Uranium Plume Transport Corridor Well Grouping															
399-1-2	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-6	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-7	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Sampled once
399-1-8	LU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-9	C	A	A	A	A			A	A	A	A	A			Yes
399-1-11	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-12	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-17A	TU	SA	SA	Q	SA		A	Q	Q	Q	SA	SA	SA	A	Yes
399-1-17B	LU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-17C	C	A	A	A	A			A	A	A	A	A			Yes
399-1-21A	TU	SA	SA	Q	SA		A	Q	Q	Q	SA	SA	SA	A	Yes
399-1-21B	LU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-23	TU	Q	Q	Q	Q		A	Q	Q	Q	Q	Q	Q	A	Sampled three times
399-2-5	TU	Q	Q	Q	Q		A	Q	Q	Q	Q	Q	Q	A	New well; begin sampling FY 2008
399-3-11	TU	SA	SA	Q	SA	A	A	Q	Q	Q	SA	SA	SA	A	Yes
399-3-12	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-3-20	TU	Q	Q	Q	Q		A	Q	Q	Q	Q	Q	Q	A	Yes
399-3-21	LU	Q	Q	Q	Q		A	Q	Q	Q	Q	Q	Q	A	New well; sampled twice
Northwest Region-Upgradient Conditions Well Group															
399-1-15	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
399-1-18A	TU			SA			SA	SA	SA	SA	SA				Yes
399-1-18B	LU			SA			SA	SA	SA	SA	SA				Yes
399-1-18C	C			A				A	A	A	A				Yes
399-8-5A	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Yes
699-S20-E10	TU			SA			SA	SA	SA	SA	SA				Yes

Table A.14. (contd)

Well or Aquifer Tube Name	Hydrologic Unit Monitored	Contaminants of Concern			Contaminants of Potential Concern				Supporting Measurements						Sampled as Scheduled in FY 2007
		cis-1,2-Dichloroethene	Trichloroethene	Uranium-total	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals (filtered)	Volatile Organic Compounds	Gross Alpha/Beta	Uranium-isotopic	
Southwest Region-Upgradient Conditions Well Group															
399-3-2	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-3-6	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-3-19	TU	Q	Q	Q	Q		A	Q	Q	Q	Q	Q	Q	A	Yes
399-4-1	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-4-12	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
399-5-4B	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA			Yes
699-S27-E14	TU	A	A	A	A			A	A	A	A	A			Yes
Shoreline-Aquifer Tubes															
AT-3-1-D(1)	TU			A											Yes
AT-3-1-M	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		No cis-DCE
AT-3-1-S	TU			A											Yes
AT-3-2-M	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		Sampled once – No cis-DCE
AT-3-2-S	TU			A											Yes
AT-3-3-D	TU			A								SA			Yes
AT-3-3-M	TU			A											Yes
AT-3-3-S	TU	SA	SA	SA	SA			SA	SA	SA	SA	SA	SA		No cis-DCE, alpha, beta; some constituents only once
AT-3-4-D	TU			A								SA			Yes
AT-3-4-M	TU			A											Yes
AT-3-4-S	TU			SA				SA	SA	SA	SA		SA		No cis-DCE, alpha, beta; some constituents only once
AT-3-5-S	TU			SA				SA	SA	SA	SA		SA		Sampled once
AT-3-6-D	TU			A											Yes
AT-3-6-M	TU			A											Yes

Table A.14. (contd)

Well or Aquifer Tube Name	Hydrologic Unit Monitored	Contaminants of Concern			Contaminants of Potential Concern				Supporting Measurements						Sampled as Scheduled in FY 2007
		cis-1,2-Dichloroethene	Trichloroethene	Uranium-total	Tetrachloroethene	Strontium-90	Tritium	Nitrate	Anions	Alkalinity	Metals (filtered)	Volatile Organic Compounds	Gross Alpha/Beta	Uranium-isotopic	
AT-3-6-S	TU			SA				SA	SA	SA	SA		SA		Sampled once – No anions, metals, alpha, beta
AT-3-7-D	TU			A											Yes
AT-3-7-M	TU			SA				SA	SA	SA	SA		SA		Sampled once
AT-3-7-S	TU			A											Yes
AT-3-8-D	TU			A											No
AT-3-8-M	TU			A											Yes
AT-3-8-S	TU			SA				SA	SA	SA	SA		SA		Sampled once – No anions, metals, alpha, beta
Shoreline-Riverbank Springs															
S3-42-2	SW			A				A	A	A	A		A		Yes[a]
S3-DR42-2	SW			A				A	A	A	A		A		Yes[a]
SPRING 10	SW			A				A	A	A	A		A		No[b]
SPRING 11	SW			A				A	A	A	A		A		No[b]

(a) Isotopic uranium instead of total uranium.
(b) Sampling of springs depends on flow conditions.
A = To be sampled annually.
C = Uppermost confined aquifer.
LU = Lower unconfined aquifer.
Q = To be sampled quarterly.
SA = To be sampled semiannually.
SW = Surface water.
TU = Top of unconfined aquifer.

Table A.15. Monitoring Wells and Constituents for 300-FF-5 Operable Unit, 618-11 Subregion (adapted from DOE/RL-2002-11)

Well	Contaminants of Potential Concern						Supporting Measurements			Sampled as Scheduled in FY 2007
	Tritium	Gross Beta	Uranium	Technetium-99	Gross Alpha	Nitrate	Anions	Alkalinity	Metals (filtered)	
Downgradient of 618-11 Burial Ground (Near-Field)										
699-12-2C	Q	Q	SA	SA	Q	SA	SA	SA	SA	Yes
699-13-2D	Q	Q	SA	SA	Q	SA	SA	SA	SA	Yes
699-13-3A	Q	Q	SA	SA	Q	SA	SA	SA	SA	Yes
Upgradient Conditions (Near-Field)										
699-12-4D	A	A	A	A	A	A	A	A	A	Yes
Downgradient of 618-11 Burial Ground (Far-Field)										
699-13-0A	Q	Q			Q	SA	SA	SA	SA	Yes
699-13-1E	Q	Q			Q	SA	SA	SA	SA	Yes

A = To be sampled annually.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.16. Monitoring Wells and Constituents for 300-FF-5 Operable Unit, 618-10/316-4 Subregion (adapted from DOE/RL-2002-11)

Well	Contaminants of Potential Concern					Supporting Measurements						Sampled as Scheduled in FY 2007
	Uranium-total	Tributyl Phosphate	Gross Alpha	Gross Beta	Nitrate	Alkalinity	Metals (filtered)	Volatile Organic Compounds	Tritium	Technetium-99	Uranium-isotopic	
Downgradient of 618-10 Burial Ground (Near-Field)												
699-S6-E4K	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	A	Yes
699-S6-E4L	Q	SA	Q	Q	Q	SA	SA	SA	SA	SA	A	Yes
Downgradient of 618-10 Burial Ground; Within 316-4 Crib Footprint (Near-Field)												
699-S6-E4A	Q	SA	Q	Q	Q	SA	SA	SA	SA	SA	A	Yes
Background: 618-10 Burial Ground/316-4 Cribs												
699-S6-E4D	A		A	A	A	A	A		A	A		Yes
Downgradient of 618-10 Burial Ground/316-4 Crib												
699-S6-E4B	SA		SA	SA	SA	SA	SA		SA			Yes
699-S6-E4E	SA		SA	SA	SA	SA	SA		SA			Yes

Wells completed at the top of the unconfined aquifer.
A = To be sampled annually.
Q = To be sampled quarterly.
SA = To be sampled semiannually.

Table A.17. Monitoring Wells and Constituents for 1100-EM-1 Operable Unit (adapted from PNL-12220)

Well	Anions	Chromium	VOA	Sampled as Scheduled in FY 2007
699-S27-E12A	A		A	Yes
699-S28-E12	A		A	Yes
699-S28-E13A	A		A	Yes
699-S29-E10A	A		A	Yes
699-S29-E11	A		A	Yes
699-S29-E12	A		A	No
699-S29-E13A	A		A	Yes
699-S30-E10A	A		A	Yes
699-S30-E10B	A		A	Yes
699-S30-E11A	A		A	Yes
699-S31-E10A	A		A	Yes
699-S31-E10C	A		A	Yes
699-S31-E10D	A		A	Yes
699-S31-E11	A		A	Yes
699-S41-E12		A		Yes

A = To be sampled annually.
FY = Fiscal year.
VOA = Volatile organic analyses.

Appendix B

Supporting Information for Monitored Facilities

Contents

Supporting Information for Monitoring Facilities B.1

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B.2 Critical Mean Exceedances at 120-N-1 Percolation Pond B.2
B.2.1 History B.2
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Appendix - B
Supporting Information for Monitored Facilities

M. J. Hartman, D. B. Barnett, and J. W. Lindberg

This appendix provides supplemental information for *Resource Conservation and Recovery Act* (RCRA) and other regulated units on the Hanford Site that require groundwater monitoring excluding *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) units (discussed in Appendix A). Site-specific discussions for each facility in Appendix B are found in the body of the document under the respective operable unit in which the facility lies (see Figure 1.0-1 in the main text for operable units).

RCRA groundwater monitoring continued during fiscal year (FY) 2007 at 25 waste management areas (Figure B.1). Estimates of groundwater velocity, hydrologic properties, and associated references are shown in Table B.1 for all RCRA sites. To determine if a waste site has adversely affected groundwater quality under RCRA interim-status regulations (WAC 173-303-400 and by reference, 40 CFR 265.93), concentrations of indicator parameters in downgradient wells are compared to background concentrations. The indicator parameters under interim status are specific conductance, pH, total organic carbon, and total organic halides. The background values to which the indicator parameters are compared are 99% prediction limits, which are calculated for each facility based on samples from upgradient wells. The upper prediction limits also are known as critical mean values.

Critical mean values are recalculated annually or if the number of analyses changes. Annual recalculation accounts for changing background conditions. Changes in the number of analyses are usually the result of changes in monitoring well networks (wells are added or deleted). If changes occur in a monitoring well network, critical mean values for that facility are recalculated for subsequent semiannual sampling events using the new well network.

To reliably indicate potential groundwater effects from a facility, the sample results have to be reasonably precise, or quantifiable. Specific conductance and pH are field measured indicator parameters that are reasonably detectable and quantifiable. The parameters of total organic carbon and total organic halides, however, are much more variable and are often below levels of detection. Significant imprecision and variability occurs when measuring these parameters near detection limits. The variability in laboratory measurements of field blanks are used to estimate laboratory limits of quantitation (LOQ) during the sampling period. The LOQ is defined as ten times the standard deviation of the field blank analyses (see discussion in Section C.7). For detection monitoring the statistical comparison values for total organic carbon and total organic halides are the larger of the critical mean and the LOQ.

Table B.2 lists comparison values (critical mean values and LOQs) used in FY 2007. Additional tables list updated critical mean values for use in FY 2008 for each RCRA unit where these statistics apply. Tables B.3 through B.37 provide supporting information for the RCRA sites and Figures B.2 through B.18 show locations of monitoring wells and regulated units.

This appendix also provides constituent lists, well network configurations, and other ancillary information for regulated facilities that fall outside of RCRA programs except CERCLA units. Some network wells in these facilities are shared with RCRA facilities. Figure B.19 shows the general locations of these facilities. Locations of monitoring wells are shown in Figures B.5, B.15, B.20 and B.21. Tables B.38 through B.44 list the constituents list and/or results summaries for the facilities.

Several RCRA sites continued to have exceedances of critical mean values in FY 2007. Previous assessment studies have shown that the sites have not impacted groundwater with dangerous waste constituents from the facilities. The following sections revisit those conclusions based on recent data.

B.1 Critical Mean Exceedances at 116-N-1 (1301-N) Facility

B.1.1 History

In 1989 downgradient well 199-N-3 exceeded the critical mean value for specific conductance. Assessment studies indicated the exceedance was caused by calcium, sodium, and sulfate that originated at an upgradient facility, the 120-N-1 percolation pond (WHC-SD-EN-EV-003). The site returned to detection monitoring in 1992. To represent groundwater concentrations in the upgradient plume, well 199-N-57 was added to the network. Well 199-N-34 was also monitored as an upgradient well.

B.1.2 FY 2007 Conditions

The high-conductance plume from the 120-N-1 percolation pond is still evident in 100-N Area groundwater. Major ions include sulfate, sodium, calcium, and bicarbonate. The plume has spread to the north over the years (Figure B.22). In the late 1980s and early 1990s, the plume was limited to the area around the 120-N-1 percolation pond and to the north-northwest (see 1990 map in Figure B.22). Groundwater beneath the 116-N-1 and 116-N-3 facilities had very low specific conductance (<200 µS/cm) because the water being discharged to 116-N-3 had low specific conductance. Discharges to the 116-N-3 facility ceased in 1991, and groundwater with higher specific conductance spread northward (see 1996 and 2007 maps in Figure B.22). The core of the high-conductance plume passes to the west of upgradient well 199-N-57, but intersects well 199-N-3. Hence, well 199-N-3 still exceeds the critical mean value that is based on data from wells 199-N-57 and 199-N-34.

Figure B.23 shows trend plots for specific conductance and sulfate in the wells in the 116-N-1 monitoring network. Sulfate is indicative of discharges to the former 120-N-1 percolation pond. As the plume moves downgradient from its source through the aquifer sediments, the groundwater chemistry changes. Sodium and sulfate concentrations drop, while calcium and alkalinity concentrations increase.

B.1.3 Conclusions

The conclusions of the 1992 assessment report (WHC-SD-EN-EV-003) are still valid. The specific conductance exceedances in well 199-N-3 are caused by non-listed constituents including sulfate and sodium from an upgradient facility. There is no evidence that groundwater is adversely impacted by dangerous waste discharges to the 116-N-1 facility. Evidence for these conclusions includes the following:

- ***Effluent Characteristics.*** Discharges to the 116-N-1 facility had low specific conductance. Discharges to the upgradient 120-N-1 percolation pond had high specific conductance and high concentrations of sulfate, sodium, and other ions.
- ***Distribution of Contaminants***. The high-conductance plume from the 120-N-1 percolation pond has spread to the north and the core of the plume intersects well 199-N-3.

The 116-N-1 facility will continue to be monitored under a detection program (PNNL-13914).

B.2 Critical Mean Exceedances at 120-N-1 (1324-NA) Percolation Pond

B.2.1 History

In 1989, all of the downgradient wells monitored for this facility exceeded the critical mean value for specific conductance. Assessment studies indicated the exceedances were caused by non-listed constituents including sodium and sulfate (WHC-SD-EN-EV-003). In 1992 and 1993, total organic halides levels exceeded the critical mean in downgradient wells, and a new assessment program began. That assessment concluded in 1995 and determined that the elevated total organic halides were caused by a nearby facility (WHC-SD-EN-

EV-031). The site returned to detection monitoring. Total organic halides levels are no longer elevated, but specific conductance remains high.

B.2.2 FY 2007 Conditions

All but one of the wells that monitored the 120-N-1 facility in 1989 have gone dry. The remaining well, 199-N-59, and downgradient wells installed in 1991 continue to have elevated specific conductance (Figure B.24). Concentrations of sulfate, sodium, and other ions that were present in the effluent and caused the elevated specific conductance, have declined from their peaks, but remain high.

The high-conductance plume that originated at the 120-N-1 facility is still present beneath the 100-N Area (see Figure B.22).

B.2.3 Conclusions

The conclusions of the 1992 assessment report (WHC-SD-EN-EV-003) are still valid. The exceedances in the downgradient wells are caused by non-listed constituents sulfate and sodium discharged to the site.

The 120-N-1 facility will continue to be monitored under a detection program (PNNL-13914). Groundwater monitoring for the 100-NR-2 Operable Unit continues to monitor the sulfate plume.

B.3 Critical Mean Exceedances at 116-N-3 (1325-N) Facility

B.3.1 History

Samples collected in September 1999 exceeded the revised critical mean value for specific conductance in two downgradient wells (199-N-41 and 199-N-81). A 2000 assessment[(a)] concluded the exceedances did not indicate that the 116-N-3 facility was contaminating groundwater with hazardous constituents. The high specific conductance is caused by non-listed constituents (i.e., sulfate, calcium) from an upgradient source, the 120-N-1 percolation pond. The site returned to detection monitoring in 2000.

B.3.2 FY 2007 Conditions

The high-conductance plume from the former 120-N-1 percolation pond is still evident in 100-N Area groundwater. It has spread toward the north over the years (see Figure B.22). In the late 1980s and early 1990s, the plume was limited to the area around the 120-N-1 percolation pond and to the north-northwest (see 1990 map in Figure B.22). Groundwater beneath the 116-N-1 and 116-N-3 facilities had very low specific conductance (<200 µS/cm) because the water being discharged to 116-N-3 had low specific conductance. Discharges to the 116-N-3 facility ceased in 1991. The groundwater mound beneath the site dissipated, allowing higher conductance groundwater from the former 120-N-1 pond to flow northward (see 1996 and 2007 maps in Figure B.22).

Figure B.25 shows trend plots for specific conductance and sulfate in wells in the 116-N-3 monitoring network. Sulfate is indicative of discharges to the former 120-N-1 percolation pond. As the plume moves downgradient from its source through the aquifer sediments, the groundwater chemistry changes. Sodium and sulfate concentrations drop, while calcium and alkalinity concentrations increase.

All of the wells are affected by the high-conductance plume. The 2007 critical mean value was fairly low because of low variability in specific conductance in the upgradient well. Specific conductance levels in all the downgradient wells are near or above the 2007 critical mean value.

B.3.3 Conclusions

The conclusions of the 2000 assessment[(a)] are still valid. The specific conductance exceedances in the downgradient wells are caused by non-listed constituents (sulfate, sodium, and calcium) from an upgradient

(a) Letter from KM Thompson (U.S. Department of Energy, Richland, Washington) to J Hedges (Washington State Department of Ecology), Results of Assessment at the 1325-N Facility, dated July 22, 2000.

facility. There is no evidence that dangerous waste discharges to the 116-N-3 facility have contaminated groundwater. Evidence for these conclusions includes the following:

- ***Effluent Characteristics***. Discharges to the 116-N-3 facility had low specific conductance. Discharges to the upgradient 120-N-1 percolation pond had high specific conductance and high concentrations of sulfate, sodium, and other ions.
- ***Distribution of Contaminants***. The high-conductance plume from the former 120-N-1 percolation pond has spread to the north and affects all of the monitoring wells for the 116-N-3 facility.

The 116-N-3 facility will continue to be monitored under a detection program (PNNL-13914).

B.4. Critical Mean Exceedances at 216-A-29 Ditch

B.4.1 History

Specific conductance exceedance was first observed in downgradient well 299-E25-35 in 1989 (DOE/RL-94-136). This exceedance and the source were subsequently addressed in a groundwater quality assessment in 1995. The assessment report concluded that sulfate was causing elevated specific conductance, and that sulfuric acid discharges to the 216-A-29 ditch was the probable source of the sulfate (WHC-SD-EN-EV-032). Because sulfate is not a listed constituent, it was determined that the site could revert to detection monitoring. Soon after this determination was made, additional wells (e.g., 299-E25-48 and 299-E26-13) began to reflect higher concentrations of sulfate that tracked with specific conductance (Figure B.26).

B.4.2 FY 2007 Conditions

During FY 2007, specific conductance continued to remain above the critical mean in downgradient wells 299-E25-35, 299-E25-48, and 299-E26-13 (see Figure B.26). Sulfate, nitrate, chloride, and the major cations are also rising in these wells. The reason for the exceedances is two-fold: (1) Migration of groundwater containing the higher concentrations of anions initially identified in well 299-E25-35, particularly sulfate, and (2) A low critical mean calculated from the upgradient well in recent years. Figure B.27 shows the trend in critical mean for specific conductance since 1996. Voluminous discharges of raw water to the B Pond facility up to the late 1990s has depressed concentrations of major ions in the region of the upgradient wells, providing for artificially low critical mean values (PNNL-15479). As such, the upgradient wells (699-43-45 and formerly 699-43-43) used for specific conductance critical mean calculations are not representative of natural background. Nitrate and chloride also show upward trends in all the wells monitoring the 216-A-29 ditch, but most of the maximum concentrations are still well below calculations of natural background for these constituents, and all are below primary and secondary drinking water standards.

B.4.3 Conclusions

Groundwater quality assessment performed in 1995 concluded that exceedance of specific conductance critical mean in well 299-E25-35 was due to the non-listed constituents sulfate and sodium. Based on most recent analytical results from FY 2007, this conclusion is still valid, although exceedances have occurred in two additional wells (299-E25-48 and 299-E26-13). This is partially a result of migration of groundwater containing higher anion concentrations and to lowering of the critical mean during the past 10+ years by using an upgradient well with artificially lowered ionic strength. The critical mean for specific conductance at the 216-A-29 ditch for upgradient/downgradient comparisons is currently calculated at 274 µS/cm. This level is well below statistically derived, natural background for this parameter as presented in WHC-EP-0595 (539µS/cm) and DOE-RL-96-61 (614 µS/cm).

B.5. Critical Mean Exceedances at Low-Level Waste Management Area 1

B.5.1 History

Low-Level Waste Management Area (LLWMA) 1 was placed into assessment in January 1990 when specific conductance exceeded the critical mean for this constituent in well 299-E28-26. At that time, well 299-E28-26 was hydraulically downgradient of the facility, but a declining water table has tentatively placed this well upgradient of the facility. The assessment report (WHC-SD-EN-EV-025) concluded that LLWMA-1 had not contributed to groundwater contamination based on the following observations and conditions:

- LLWMA-1 (218-E-10 burial ground) received primarily dry waste with low potential for reaching groundwater.
- Waste disposal at facilities immediately to the south (cribs 216-B-62 and 216-B-55) of LLWMA-1 was consistent with observed groundwater contamination (primarily nitrate). At the time of the assessment report, groundwater flow was reinterpreted to be toward the northwest, placing the cribs immediately upgradient of LLWM-1.
- Wells located south of LLWMA-1 (then upgradient), with longer records of sampling, indicated high nitrate concentrations (up to 170 mg/L).

B.5.2 FY 2007 Conditions

Water levels have continuously declined from ~1990 through the present in all wells in the LLWMA-1 network, primarily because discharges were discontinued at the B Pond facility. This condition has produced at least two effects in groundwater monitoring. The first effect is to reduce the hydraulic gradient across the facility and make determination of groundwater flow direction increasingly difficult based on head differences (see Section 2.10.3.3). The second effect, which is more problematic, is to produce samples that are higher in concentrations of nitrate, sulfate, chloride, and some cations in several wells in the network. The cause of the second effect is probably a combination of three factors:

1. Movement of regional plumes has changed in response to changing head. Plumes may have migrated to produce multiple episodes of increasing or decreasing concentrations. There are some indications that groundwater drainage from the basalt subcrop to the north-northeast may have affected groundwater quality in the northeast corner of LLWMA-1.
2. Early discharges to 200 East Area facilities migrated through the vadose zone to the lower levels of the aquifer. At that time, the saturated thickness of the aquifer was considerably less than it was when groundwater monitoring began in the late 1980s. Now, as the water table declines, the wells are left with a thinner column of water near the bottom of the screened interval, which is also nearer the bottom of the aquifer. Hence, groundwater samples are collected from an increasingly thinner and deeper water column that contains higher chemical concentrations (Figure B.28).
3. Nitrate and cyanide contamination currently detected in wells on the northern and eastern portions of LLWMA-1 is interpreted as originating from the BY cribs and/or Waste Management Area B-BX-BY (see Section 2.10 of main text). These constituents are still generally increasing in concentration in this region (Figure B.29). Nitrate is above the drinking water standard in all but four wells in the LLWMA-1 monitoring network.

B.5.3 Conclusions

Exceedances of the critical mean for specific conductance in LLWMA-1 wells are due primarily to high concentrations of nitrate originating from cribs and other discharge sites in the 200 East Area. A complex combination of sources and changing groundwater flow directions has allowed several contaminant plumes to

move into the aquifer beneath LLWMA-1. Contamination from LLWMA-1 is not suspected of contributing to these plumes based on:

- LLWMA-1 (218-E-10 burial ground) received primarily dry waste with low potential for reaching groundwater (PNL-6820; RHO-CD-673).
- Other nearby facilities (e.g., the BY, 216-B-62 and 216-B-55 cribs) and Waste Management Area B-BX-BY have documented discharges of contaminants observed beneath and near LLWMA-1 (e.g., DOE/RL-92-05).
- Historical tracking of contaminant plumes (e.g., nitrate and associated waste constituents) and plume geometries indicate sources to the south, east, and northeast of the LLWMA-1 (e.g., see discussion in Section 2.10.1, DOE/RL-94-136; PNNL-13404; PNNL-16346).

B.6. Critical Mean Exceedances at Low-Level Waste Management Area 4

B.6.1 History

DOE has conducted RCRA groundwater monitoring at LLWMA-4 since 1988 (PNL-6852). At that time, groundwater flow direction was to the west and northwest, due to a lingering effect of the decaying U Pond mound. Carbon tetrachloride contamination in groundwater in the vicinity of LLWMA-4 was recognized since the earliest days of monitoring (e.g., PNL-6852). In upgradient well 299-W18-23, carbon tetrachloride displayed its highest observed concentration at the onset of RCRA monitoring in 1988.

In 1996, the 200-ZP-1 pump-and-treat system began to remove carbon tetrachloride and related constituents (e.g., chloroform and trichloroethene) from groundwater in the 200 West Area. Since then, the system has removed ~11,000 kilograms of carbon tetrachloride (see Section 2.8.2.1). This material has been shown to originate mostly from three facilities: 216-Z-1A tile field, 216-Z-18 crib, and 216-Z-9 trench, east of the LLWMA-4. During the operation of U Pond and other discharges, contamination was driven to the water table beneath some of these facilities and spread over a considerable area, including beneath the LLWMA-4 (DOE/RL-2006-20).

In FY 2002, carbon tetrachloride and other volatile organic compounds were detected in vapor samples collected from the trenches and vadose zone within LLWMA-4. A soil-vapor extraction system was operated at the 218-W-4C burial ground from November 2003 through April 2004. The system removed vapors from the burial ground trench and minimized the release of carbon tetrachloride to the environment. The system removed ~11 kilograms of carbon tetrachloride from trench T-04 in the 218-W-4C burial ground during FY 2004. An update to the results of this activity is presented in Section 3.3.

B.6.2 FY 2007 Conditions

During FY 2007, DOE conducted additional soil vapor extraction in burial ground 218-W-4B (trench 7), where waste retrieval is occurring. Initial vapor sampling results indicated high levels of organic vapor in the vicinity of trenches 7 and 8. Section 3.3, in the main text, discusses this activity in greater detail.

Groundwater pump-and-treat activities continued in the 200-ZP-1 Operable Unit, with six injection wells immediately upgradient of LLWMA-4. Injection of clean water near the upgradient monitoring wells at LLWMA-4 undoubtedly dilutes carbon tetrachloride concentrations in the monitoring wells, which are in the direct lines of flow to extraction wells. Concentrations in all wells in LLWMA-4 continued to decline in FY 2007.

Lines of evidence suggesting carbon tetrachloride sources other than LLWMA-4 include:

- The groundwater flow direction in the 1980s and early 1990s was toward the west and northwest. This placed the known sources (216-Z-1A tile field, 216-Z-18 crib, 216-Z-9 trench) immediately upgradient of the LLWMA-4 wells (see DOE/RL-2007-33; PNL-6852).
- Plume maps from 1990 to 2005 (DOE/RL-2006-20) indicate carbon tetrachloride contamination spreading from areas east of LLWMA-4.

- Recent statistical evaluation of carbon tetrachloride distribution in the 200 West Area (PNNL-16509) predicts that a continuing source of carbon tetrachloride beneath burial grounds 218-W-4B and 218-W4-C is unlikely.
- Modeling of carbon tetrachloride as a dense, nonaqueous phase liquid (PNNL-16198) indicates that undocumented releases of carbon tetrachloride (e.g., LLWMA-4) are not likely sources of the contamination of groundwater.
- Widespread migration of carbon tetrachloride in vapor phase from other sources are known to occur in the vadose zone.

B.6.3 Conclusions

Despite detections and extraction of carbon tetrachloride vapors in trenches 218-W-4C and 218-W-4B, LLWMA-4 is not suspected as a source of chlorinated organics in groundwater. Other nearby sources with documented disposal of large quantities of carbon tetrachloride have spread in the subsurface beneath LLWMA-4 and beyond. Minor, incidental disposal of materials contaminated with carbon tetrachloride may have contributed to vapor detected in LLWMA-4 trenches. Alternatively, all of the vapor may have originated from migration (in vapor, aqueous and/or nonaqueous phases) from other sites.

Injection wells for the 200-ZP-1 pump-and-treat system are currently upgradient of LLWMA-4 upgradient monitoring wells. Injecting clean water lowers concentrations of carbon tetrachloride in these background wells, which produces a lower background comparison value for total organic halides. Stratigraphy, changes in hydraulic head, carbon tetrachloride migration behavior, and disposal activities all dictate a source to the east of LLWMA-4. Retrieval activities and results of a media analyses are currently monitored to determine if this conclusion requires re-evaluation.

B.7 Critical Mean Exceedances at Nonradioactive Dangerous Waste Landfill

B.7.1 History

In 2001, downgradient wells 699-25-34A and 699-25-34B exceeded the critical mean value for specific conductance. Assessment studies indicated the exceedance was caused by increases in the concentrations of non-hazardous constituents (such as calcium and magnesium) from the adjacent 600 Area Central Landfill. Specific conductance at the 600 Area Central Landfill was generally higher than at the Nonradioactive Dangerous Waste Landfill, and there is a known mechanism for the rise in specific conductance (i.e., breakdown of sewage causing elevated carbon dioxide in the vadose zone and elevated specific conductance, calcium, and magnesium in the aquifer beneath). Therefore, the exceedance of the critical mean for specific conductance did not indicate that the Nonradioactive Dangerous Waste Landfill was contaminating groundwater with hazardous constituents. DOE submitted a letter report[(b)] that served as both the assessment plan and the assessment report. Since then, detection monitoring has continued.

B.7.2 FY 2007 Conditions

Specific conductance (and calcium and magnesium, which are contributors to elevated specific conductance) remain elevated at both the Nonradioactive Dangerous Waste Landfill and the 600 Area Central Landfill. Three wells (699-25-34A, 699-25-34B, and 699-25-34D) continued to exceed the critical mean for specific conductance (594 µS/cm) during FY 2007. The trend for specific conductance at these three wells has been stable since about 2003 (Figure B.30). Levels of specific conductance, calcium, and magnesium remain higher

(b) Letter 01-GWVZ-025 from JG Morse (U.S. Department of Energy, Richland, Washington) to J Hedges (Washington State Department of Ecology), Results of Assessment at the Non-Radioactive Dangerous Waste Landfill (NRDWL), dated June 7, 2001.

at the 600 Area Central Landfill than at the Nonradioactive Dangerous Waste Landfill (Figures B.31, B.32, and B.33). These figures show the following:

- Trends of specific conductance, calcium, and magnesium at the Nonradioactive Dangerous Waste Landfill continue to closely match the trends at the 600 Area Central Landfill.
- Concentrations remain higher at the 600 Area Central Landfill than at the Non-Radioactive Dangerous Waste Landfill.

B.7.3 Conclusion

The 600 Area Central Landfill continues to be the source of the groundwater constituents that are responsible for the increased specific conductance at the Nonradioactive Dangerous Waste Landfill.

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Table B.1. Estimates of Groundwater Flow Rates at Hanford Site RCRA Facilities

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/d) (source)	Effective Porosity[a]	Gradient[b]	Comments
116-N-1 LWDF	NW	0.03 to 0.58	Darcy	6.1 to 37 (PNL-8335)		0.0016	Gradient calculated between wells 199-N-34 and 199-N-2.
120-N-1 and 120-N-2	NW	0.05 to 0.95	Darcy	6.1 to 37 (PNL-8335)		0.0026	Gradient calculated between wells 199-N-72 and 199-N-26.
116-N-3 LWDF	N	0.02 to 0.37	Darcy	6.1 to 37 (PNL-8335)		0.0010	Gradient calculated between wells 199-N-28 and 199-N-81.
116-H-6 evaporation basins	E	0.21 to 5.9	Darcy	15 to 140 (PNL-6728)		0.0042	Gradient calculated between wells 199-H4-9 and 199-H4-12B.
216-A-29 ditch	SSW	Undetermined		18 (WHC-SD-EN-DP-047)	0.25		Gradient too low to determine flow rate.
216-B-3 pond	WSW to SSE	0.01	Darcy	1.0 (WHC-SD-EN-EV-002; PNL-10195)	0.25	0.002	Gradient calculated between wells 699-44-39B, 699-42-42B and 699-43-44.
216-B-63 trench	Undeter-mined	Undetermined		182 (WHC-MR-0207)			Uncertain of flow direction. Gradient too low to determine flow rate.
216-S-10 pond	ESE	0.075 to 2.25	Darcy	10 (WHC-SD-EN-DP-052) 12 to 150 (BNWL-1709)	0.1 to 0.2	0.0015	Wells are dry. Gradient calculated using regional water-table maps.
216-U-12 crib	ESE	0.027 to 0.05	Darcy	4.2 to 5.4 (PNNL-13378)	0.1 to 0.2	0.001	Gradient calculated from water-table map.
316-5 process trenches	SE	10.7 (PNL-5408)	Movement of PCE spill				
	SE	0.22 to 22	Darcy	150 to 15,000 (PNL-6716)	0.25	0.00036	Gradient calculated from December 2006 water-table map.
IDF	SE	0.002 to 0.0075	Darcy	68 to 75 (PNNL-13652; PNNL-11957)		0.00001	Uncertainty in gradient and rate of flow. Flow direction inferred from plume maps.
LERF	SW	0.24	Darcy	39.8 (PNNL-14804)	0.25	0.0016	Gradient calculated from water-table map.
LLWMA 1	Undeter-mined	Undetermined		2,500 to 7,500 (PNNL-14753)			Uncertain of flow direction. Gradient too low to determine flow rate.

Table B.1. (contd)

Site	Flow Direction	Flow Rate (m/d)	Method	Hydraulic Conductivity (m/d) (source)	Effective Porosity[a]	Gradient[b]	Comments
LLWMA 2	W to SW?	Undetermined		2,500 to 7,500 (PNNL-14753)			Uncertain of flow direction. Gradient too low to determine flow rate.
LLWMA 3	ENE	0.04 to 0.16	Darcy	2.5 to 10 (PNNL-14753)	0.1 (PNNL-14753)	0.0016	Flow direction and gradient from water-table map.
LLWMA 4	E	0.4 to 1.0	Darcy	10 to 25 (PNNL-14753)		0.004	Flow direction is variable due to effects of pump-and-treat system.
NRDWL	SE	0.03 to 0.27	Darcy	518 to 1,524 (WHC-EP-0021)		0.00002	Uncertainty with gradient and rate of flow. Flow direction inferred from plume maps.
PUREX cribs	SE	0.0011 to 0.54	Darcy	18 to 3,000 (PNNL-11523; PNNL-11523-ICN-1)		0.00002	Uncertainty with gradient and rate of flow. Flow direction inferred from plume maps.
WMA A-AX	SE	1.0 to 1.4	Darcy	1,981	0.3 to 0.4	0.0002	Gradient and flow rate calculated between wells 299-E24-20 and 299-E25-93.
WMA B-BX-BY	S	Nearly stagnant	Contaminant migration				
WMA C	SW to SSW	0.09	Contaminant migration				
WMA S-SX	E to ESE	0.07 to 0.14	Contaminant travel time (PNNL-13441)	NA	NA	NA	Based on inferred contaminant travel time between 216-S-25 crib and downgradient wells 299-W23-15 and 299-W22-46, and between wells 299-W22-46 and 299-W22-83.
		0.012 to 0.29	Darcy	1.33 to 14.4 (PNNL-13514 and PNNL-14113)	0.09 to 0.20	0.0018	Gradient determined by trend surface analysis.
WMA T	E	0.002 to 0.25	Darcy	1.04 to 28.1	0.1	0.0002 to 0.0009	Flow direction based on trend surface analysis: PNNL-14113, PNNL-13378.
WMA TX-TY	Variable (see text)	NA	NA	14.2 to 19.9 (PNNL-13378, PNNL-14113, and PNNL-14186	NA	NA	Flow direction and rate influenced by 200-ZP-1 pump-and-treat.
WMA U	E to ENE	0.018 to 0.20	Darcy	1.69 to 9.5 (PNNL-13378)	0.10 to 0.20	0.0021	Gradient determined by trend surface analysis.

(a) Effective porosity assumed to be between 0.1 and 0.3, a representative range for the unconfined aquifer system, unless otherwise noted.
(b) March 2007 unless noted otherwise.
IDF = Integrated Disposal Facility.
LERF = Liquid effluent retention facility.
LLWMA = Low-level waste management area.
LWDF = Liquid waste disposal facility.
NA = Not applicable.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PCE = Tetrachloroethene.
PUREX = Plutonium-Uranium Extraction (Plant).
WMA = Waste management area.

Table B.2. Upgradient/Downgradient Comparison Values[(a)] Used for Statistical Comparisons at RCRA Sites in FY 2007

Quarter	Specific Conductance Critical Mean (µS/cm)	pH Critical Range	TOC Critical Mean[(b)]/LOQ (µg/L)	TOX Critical Mean/LOQ (µg/L)	Comments
116-N-1 (1301-N) Facility					
Jan-Mar 2007	**1,165**	**[6.24, 9.10]**	2,075/**2,320**	**38.3**/13.0	
Jul-Sep 2007	**1,165**	**[6.24, 9.10]**	**2,075**/1,450	**38.3**/22.5	
120-N-1 and 120-N-2 (1324-N/NA) Facilities					
Oct-Dec 2006	**490**	**[7.63, 8.50]**	2,010/**2,070**	**29.6**/22.6	2 downgradient wells
Apr-Jun 2007	**490**	**[7.63, 8.50]**	2,010/**2,070**	**29.6**/22.6	3 downgradient wells
116-N-3 (1325-N) Facility					
Jan-Mar 2007	**401**	**[7.59, 8.53]**	2,090/**2,320**	**27.0**/13.0	
Jul-Sep 2007	**401**	**[7.59, 8.53]**	**2,090**/1,450	**27.0**/22.5	
216-A-29 Ditch					
Oct-Dec 2006	**274**	**[6.99, 9.86]**	**2,360**/2,070	20.0/**22.6**	
Apr-Jun 2007	**274**	**[6.99, 9.86]**	**2,360**/2,070	20.0/**22.6**	
216-B-3 Pond					
Jan-Mar 2007	**338**	**[7.74, 8.55]**	1,190/**2,320**	**27.6**/13.0	
Jul-Sep 2007	**338**	**[7.74, 8.55]**	1,190/**1,450**	**27.6**/22.5	
216-B-63 Ditch					
Oct-Dec 2006	**739**	**[7.51, 8.58]**	1,120/**2,070**	20.4/**22.6**	
Apr-Jun 2007	**739**	**[7.51, 8.58]**	1,120/**2,070**	20.4/**22.6**	
216-S-10 Pond and Ditch					
Oct-Dec 2006	**296**	**[7.49, 8.73]**	1,300/**2,070**	NC/**22.6**	
Apr-Jun 2007	**296**	**[7.49, 8.73]**	1,300/**2,070**	NC/**22.6**	
Low Level Waste Management Area 1					
Oct-Dec 2006	**808**	**[7.44, 8.57]**	**2,770**/2,070	18.5/**22.6**	
Apr-Jun 2007	**808**	**[7.44, 8.57]**	**2,770**/2,070	18.5/**22.6**	
Low Level Waste Management Area 2					
Oct-Dec 2006	**1,397**	**[6.95, 8.48]**	**2,460**/2,070	**62.1**/22.6	
Apr-Jun 2007	**1,397**	**[6.95, 8.48]**	**2,460**/2,070	**62.1**/22.6	
Low Level Waste Management Area 3					
No statistical comparisons until new baseline established					
Low Level Waste Management Area 4					
Jan-Mar 2007	**626**	**[7.34, 8.57]**	1,320/**2,320**	**44.1**/13.0	
Jul-Sep 2007	**626**	**[7.34, 8.57]**	1,320/**1,450**	**44.1**/22.5	
Nonradioactive Dangerous Waste Landfill					
Jan-Mar 2007	**594**	**[6.55, 7.89]**	1,510/**2,320**	**24.3**/13.0	
Jul-Sep 2007	**594**	**[6.55, 7.89]**	**1,510**/1,450	**24.3**/22.5	
Waste Management Area C					
Oct-Dec 2006	**941**	**[7.34, 8.91]**	**2,480**/2,070	**41.2**/22.6	
Apr-Jun 2007	**941**	**[7.34, 8.91]**	**2,480**/2,070	**41.2**/22.6	

(a) Upgradient/Downgradient comparison values **(in bold)** for TOC and TOX are the larger of calculated critical mean value and limit of quantitation for the respective quarter. Starting in April-June 2007, the statistician began to use the LOQ calculated the previous quarter instead of the new one.
(b) Reported values rounded to the nearest 10 ug/L.
LOQ = Limit of quantitation; based on field blanks collected and analyzed in the previous four quarters.
TOC = Total organic carbon.
TOX = Total organic halides.

Table B.3. Monitoring Wells and Constituents for 100-N Area Units (adapted from PNNL-13914)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Parameters				Sampled as Scheduled in FY 2007
			Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Alpha[b]	Anions	Metals (filtered)	
116-N-1 (1301-N) Liquid Waste Disposal Facility											
199-N-105A		C	S	S	S	S	A		A	A	Yes
199-N-2		P	S	S	S	S	A		A	A	Yes
199-N-3		P	S	S	S	S	A		A	A	Yes
199-N-34		P	S	S	S	S	A		A	A	Yes
199-N-57		C	S	S	S	S	A		A	A	Yes
120-N-1 and 120-N-2 (1324-N/NA) Facilities											
199-N-59		C	S	S	S	S	A	A	A	A	Sampled once; insufficient water
199-N-71		C	S	S	S	S	A		A	A	Yes
199-N-72		C	S	S	S	S	A		A	A	Yes
199-N-73		C	S	S	S	S	A		A	A	Yes
199-N-77	Bottom of aquifer; no statistics	C	S	S	S	S	A	S	A	A	Yes
116-N-3 (1325-N) Liquid Waste Disposal Facility											
199-N-28	Information only; no statistics	P	S	S	S	S	A		A	A	Yes
199-N-32		P	S	S	S	S	S		S	S	Missed field quadruplicates once
199-N-41		P	S	S	S	S	A		A	A	Yes
199-N-74		C	S	S	S	S	A		A	A	Yes
199-N-81		C	S	S	S	S	A		A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act* .
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code* .

Table B.4. Critical Means for 116-N-1 Liquid Waste Disposal Facility for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	9	8	5.0413	596.2	138	1,330	1,330
Field pH	9	8	5.6174	7.68	0.261	[6.14, 9.23]	[6.14, 9.23]
Total organic carbon,[b] µg/L	9	8	5.0413	476.1	252.1	1,816	1,816
Total organic halides,[b] µg/L	8[c]	7	5.4079	8.49	4.03	31.6	31.6

(a) Based on semiannual sampling events from March 2006 to September 2007 for upgradient well 199-N-57 and from September 2005 to September 2007 for upgradient well 199-N-34.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Excluded suspected values on samples collected in September 2005 from upgradient well 199-N-34.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 20 comparisons.

Table B.5. Critical Means for 120-N-1 and 120-N-2 Liquid Waste Disposal Facilities for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	7.5287	385.25	23.82	582	582
Field pH	5	4	9.0294	8.093	0.04	[7.70, 8.49]	[7.70, 8.49]
Total organic carbon,[b] µg/L	5[c]	4	7.5287	427.75	164.78	1,787	1,787
Total organic halides,[b] µg/L	5	4	7.5287	7.03	2.34	26.3	26.3

(a) Based on semiannual sampling events from June 2005 to June 2007 for upgradient well 199-N-71; except March 2005 to June 2007 for total organic carbon.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Excluded "R" flagged values on samples collected December 2006.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 12 comparisons

Table B.6. Critical Means for 116-N-3 Liquid Waste Disposal Facility for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	8.1216	376.6	7.72	445	445
Field pH	5	4	9.7291	8.04	0.06	[7.40, 8.67]	[7.40, 8.67]
Total organic carbon,[b] µg/L	5	4	8.1216	318	173.08	1,858	1,858
Total organic halides,[b] µg/L	5	4	8.1216	6.081	2.50	28.3	28.3

(a) Based on semiannual sampling events from September 2005 to September 2007 for upgradient well 199-N-74.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

Table B.7. Monitoring Wells and Constituents for 116-H-6 Evaporation Basins (adapted from PNNL-11573 and 2006 permit modification[a])

Well Number	Comment	WAC Compliant	Permit-Specified				Other Parameters			Sampled as Scheduled in FY 2007
			Hex Cr (filtered)	Nitrate	Technetium-99[b]	Uranium[b]	Alkalinity	Anions	Metals (filtered)	
199-H4-12A	Extraction well	C	A	A	A	A	A	A	A	Yes
199-H4-12C	Mid-depth unconfined	C	A	A	A	A	A	A	A	Yes
199-H4-3	Extraction well	P	A	A	A	A	A	A	A	Yes
199-H4-8		C	A	A	A	A	A	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) Hanford Facility RCRA Permit Modification Notification Form, signed by GP Davis (Ecology), January 10, 2006. 183-H Solar Evaporation Basins, Part VI, Chapter 2, and Attachment 37.
(b) Radionuclides not typically subject to RCRA monitoring, but included in the current Hanford Facility RCRA Permit (Ecology 1994) for this facility.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Hex Cr = Hexavalent chromium.
P = Constructed prior to WAC requirements.
RCRA = *Resource Conservation and Recovery Act*.
WAC = *Washington Administrative Code*.

Table B.8. Monitoring Wells and Constituents for 216-A-29 Ditch (adapted from PNNL-13047)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Parameters				Sampled as Scheduled in FY 2007
			Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Phenols	
299-E25-26	Upper unconfined	C	S	S	S	S	S	S	A	A	Yes
299-E25-28	Deep unconfined; no statistics	C	S	S	S	S	S	S	A	A	TOC and TOX only once[b]
299-E25-32P		C	S	S	S	S	S	S	A	A	Yes
299-E25-34		C	S	S	S	S	S	S	A	A	Yes
299-E25-35		C	S	S	S	S	S	S	A	A	Yes
299-E25-48		C	S	S	S	S	S	S	A	A	Yes
299-E26-12		C	S	S	S	S	S	S	A	A	Yes
299-E26-13		C	S	S	S	S	S	S	A	A	Yes
699-43-45		C	S	S	S	S	S	S	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Not needed for this supplement well.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
TOC = Total organic carbon.
TOX = Total organic halides.
WAC = *Washington Administrative Code* .

Table B.9. Critical Means for 216-A-29 Ditch for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	6	5	7.6037	243.2	3.19	269	269
Field pH	7	6	7.4012	8.39	0.15	[7.24, 9.55]	[7.24, 9.55]
Total organic carbon,[b] µg/L	5[c]	4	9.7291	301.8	73.63	1,086	1,430[d]
Total organic halides,[b] µg/L	6	5	7.6037	4.65	2.61	26.1	26.1

(a) Based on semiannual sampling events from October 2005 to July 2007 (July 2005 to July 2007 for pH) for upgradient well 699-43-45.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Excluded suspected values on samples collected in April 2006.
(d) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 32 comparisons.

Table B.10. Monitoring Wells and Constituents for 216-B-3 Pond (adapted from PNNL-15479)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Parameters						Sampled as Scheduled in FY 2007
			Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Alpha[b]	Anions	Beta[b]	Metals (filtered, unfiltered)	Phenols	
699-42-42B	Bottom of aquifer	C	S	S	S	S	A	S	A	S	A	A	Yes
699-43-44		C	S	S	S	S	A	S	A	S	A	A	Yes
699-43-45		C	S	S	S	S	A	S	A	S	A	A	Yes
699-44-39B		C	S	S	S	S	A	S	A	S	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.11. Critical Means for 216-B-3 Pond for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	6	5	6.5414	255.0	10.26	328	328
Field pH	6	5	7.6037	8.19	0.14	[7.07, 9.30]	[7.07, 9.30]
Total organic carbon,[b] µg/L	5[d]	4	8.1216	297.8	96.65	1,158	1,430[c]
Total organic halides,[b] µg/L	5[d]	4	8.1216	3.27	2.59	26.3	26.3

(a) Based on semiannual sampling events from January 2005 to July 2007 from upgradient well 699-44-39B.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
(d) Excluded rejected total organic carbon values on samples collected February 2007 and anomalously high total organic halides values flagged "F" collected February 2007.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

Table B.12. Monitoring Wells and Constituents for 216-B-63 Trench (adapted from PNNL-14112)

Well Number[a]	WAC Compliant	Contamination Indicator Parameters				Other Parameters						Sampled as Scheduled in FY 2007
		Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Alpha[b]	Anions	Beta[b]	Metals (filtered)	Phenols	
299-E27-8	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-9	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-11	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-16	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-17	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-18	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E27-19	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E33-33	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E33-36	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E33-37	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E34-8	C	S	S	S	S	A	S	A	S	A	A	Yes
299-E34-10	C	S	S	S	S	A	S	A	S	A	A	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act* .
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code* .

Table B.13. Critical Means for 216-B-63 Trench for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	20	19	4.2669	461.6	74.77	789	789
Field pH	20	19	4.5718	8.10	0.13	[7.48, 8.73]	[7.48, 8.73]
Total organic carbon,[b] µg/L	20	19	4.2669	368.0	155.12	1,046	1,430[c]
Total organic halides,[b] µg/L	20	19	4.2669	4.72	3.99	22.2	22.9[c]

(a) Based on semiannual sampling events from October 2005 to April 2007 for upgradient wells 299-E27-8, 299-E27-9, 299-E27-11, and 299-E27-17 and 299-E34-10.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 48 comparisons.

Table B.14. Monitoring Wells and Constituents for 216-S-10 Pond and Ditch (adapted from PNNL-14070 and PNNL-14070-ICN-2)

Well Number	Comment	WAC Compliant	Contamination Indicator Parameters				Other Parameters								Sampled as Scheduled in FY 2007
			Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Carbon Tetrachloride	Chloroform	Hex Cr (filtered)	Metals (filtered)	Phenols	Vanadium (filtered)	
299-W26-13		C	S	S	S	S	S	A	A	A	S	A	A	A	Yes
299-W26-14		C	S	S	S	S	S	A	A	A	S	A	A	A	Yes
299-W27-2	Bottom of aquifer; no statistics	C	S	S	S	S	S	A	A	A	S	A	A	A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Hex Cr = Hexavalent chromium.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code* .

Table B.15. Critical Means for 216-S-10 Pond and Ditch for FY 2008 Comparisons[(a)]

Constituent, unit	N	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	4	3	10.8689	269.8	2.2	296	296
Field pH	4	3	13.745	8.11	0.04	[7.49, 8.73]	[7.49, 8.73]
Total organic carbon,[(b)] µg/L	4	3	10.8689	195.6	90.9	1,300	1,430[(c)]
Total organic halides,[(d)] µg/L	4	3	10.8689	NC	NC	NC	22.9[(c)]

(a) Based on semiannual sampling events from December 2001 to June 2003 for upgradient well 299-W26-7, which went dry in 2003. Background levels will be revised when data from a new upgradient well are available.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
(d) Critical mean cannot be calculated because essentially all measurements are below vendor specified detection limit.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
NC = Not calculated.
t_c = Bonferroni critical t-value for appropriate df and 12 comparisons.

Table B.16. Monitoring Wells and Constituents for 216-U-12 Crib (adapted from PNNL-14301-Rev2-ICN-1)

Well Number[a]	WAC Compliant	Alkalinity	Anions	Arsenic (filtered)	Metals (filtered)	Total Dissolved Solids	Technetium-99[b]	Sampled as Scheduled in FY 2007
299-W21-2	C	A	Q	A	A	A	Q	Yes
299-W22-79	C	A	Q	A	A	A	Q	Yes
299-W22-87	C	A	Q	A	A	A	Q	Yes
699-36-70A	C	A	Q	A	A	A	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
WAC = *Washington Administrative Code*.

Table B.17. Monitoring Wells and Constituents for 316-5 Process Trenches (adapted from WHC-SD-EN-AP-185)

Well Number	Comment	WAC Compliant	cis-1,2-dichloroethene	Tetrachloroethene	Trichloroethene	Uranium[a]	Sampled as Scheduled in FY 2007
399-1-10A		C	S	S	S	S	Yes
399-1-10B	Lower unconfined	C	S	S	S	S	Yes
399-1-16A		C	S	S	S	S	Yes
399-1-16B	Lower unconfined	C	S	S	S	S	Yes
399-1-17A		C	S	S	S	S	Yes
399-1-17B	Lower unconfined	C	S	S	S	S	Yes
399-1-18A		C	S	S	S	S	Yes
399-1-18B	Lower unconfined	C	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) Radionuclides not typically subject to RCRA monitoring, but included in the current Hanford Facility RCRA Permit (Ecology 1994) for this facility.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
RCRA = *Resource Conservation and Recovery Act*.
S = Sampled four consecutive months, twice per year (semiannually).
WAC = *Washington Administrative Code*.

Table B.18. Monitoring Wells and Constituents for Integrated Disposal Facility (adapted from DOE/RL-2003-12 and RPP-PLAN-26534)

Well Number[a]	WAC Compliant	Indicator Parameters					Other Parameters							Sampled as Scheduled in FY 2007
		Chromium (filtered, unfiltered)	Spec. Cond. (field)	pH (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Alpha[b]	Beta[b]	Iodine-129[b]	Technetium-99[b]	
299-E17-22	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	Yes
299-E17-23	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	Tc-99 only once
299-E17-25	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	No Tc-99; I-129, alpha & beta only once
299-E17-26	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	No Tc-99, I-129, alpha or beta
299-E18-1	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	No Tc-99; I-129, alpha & beta only once
299-E24-21	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	No Tc-99, I-129, alpha or beta
299-E24-24	C	S[c]	S[c]	S[c]	S[c]	S[c]	S	S	S	S	S	S	S	No Tc-99, I-129, alpha or beta

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Designated as upgradient well in DOE/RL-2003-12.
(b) Operational parameters monitored for DOE Order 435.1.
(c) Sampled four times semiannually (total of eight times per well per year).
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.19. Monitoring Wells and Constituents for Liquid Effluent Retention Facility (adapted from WHC-SD-EN-AP-024)

Well Number[a]	WAC Compliant	Alkalinity	Alpha[b]	Ammonia	Anions	Beta[b]	Metals (filtered)	Phenols	Volatile Organic Analyses	Sampled as Scheduled in FY 2007
299-E26-10	C	A	S	S	A	S	A	A	S	Ammonia only once
299-E26-11	C	A	S	S	A	S	A	A	S	Ammonia only once

Wells completed at the top of the unconfined aquifer.
Statistical evaluations suspended in 2001 because only one downgradient well is not dry.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for *Atomic Energy Act*.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
WAC = *Washington Administrative Code*.

Table B.20. Monitoring Wells and Constituents for Low-Level Waste Management Area 1 (adapted from PNNL-14859-ICN-1 and DOE/RL-2000-72)

Well Number[a]	WAC Compliant	Contamination Indicator Parameters				Other Chemical Parameters						AEA Parameters[b]				Sampled as Scheduled in FY 2007
		pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Phenols	Iodine-129	Technetium-99	Tritium	Uranium	
299-E28-26	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E28-27	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E28-28	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-2	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-3	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-4	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-5	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-6	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-7	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-8	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-9	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E32-10	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E33-28	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E33-29	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E33-30	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E33-34	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes
299-E33-35	C	S	S	S	S	A	S	S	A	A	A	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for DOE Order 435.1.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.21. Critical Means for Low-Level Waste Management Area 1 for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	28	27	4.1540	511.4	74.99	828	828
Field pH	28	27	4.4137	7.98	0.07	[7.68, 8.29]	[7.68, 8.29]
Total organic carbon,[b] µg/L	29[c]	28	4.1327	586.5	527.95	2,806	2,806
Total organic halides,[b] µg/L	28[c]	27	4.1540	4.82	5.11	26.4	26.4

(a) Based on semiannual sampling events from December 2005 to June 2007 for upgradient wells 299-E28-26, 299-E28-27, 299-E28-28, 299-E32-4, and 299-E33-29; and January 2006 to June 2007 for upgradient wells 299-E33-28 and 299-E33-35.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Excluded "R" flagged total organic carbon data collected January 2007 for 299-E33-28, anomalously high total organic halides value in December 2006 for 299-E28-26, not confirmed by subsequent sampling.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 68 comparisons.

Table B.22. Monitoring Wells and Constituents for Low-Level Waste Management Area 2 (adapted from PNNL-14859-ICN-1 and DOE/RL-2000-72)

Well Number[a]	WAC Compliant	Contamination Indicator Parameters				Other Chemical Parameters							AEA Parameters[b]				Sampled as Scheduled in FY 2007
		pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Polychlorinated Biphenyls	Phenols	Iodine-129	Technetium-99	Tritium	Uranium	
299-E27-8	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E27-9	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E27-10	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E27-11	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E27-17	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E34-2	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E34-9	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E34-10	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-E34-12	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for DOE Order 435.1.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.23. Critical Means for Low-Level Waste Management Area 2 for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	5	4	10.0298	1,004.5	33.46	1,372	1,372
Field pH	5	4	11.9851	7.70	0.04	[7.16, 8.24]	[7.16, 8.24]
Total organic carbon,[b] µg/L	5	4	10.0298	853.3	277.32	3,900	3,900
Total organic halides,[b] µg/L	6	5	7.7981	10.88	6.50	65.7	65.7

(a) Based on semiannual sampling events from April 2005 to April 2007 for upgradient well 299-E27-10.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 36 comparisons.

Table B.24. Monitoring Wells and Constituents for Low-Level Waste Management Area 3 (adapted from PNNL-14859-ICN-1 and DOE/RL-2000-72)

			Contamination Indicator Parameters				Other Chemical Parameters							AEA Parameters[a]				
Well Number	Comment	WAC Compliant	pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Phenols	Volatile Organic Analyses	Iodine-129	Technetium-99	Tritium	Uranium	Sampled as Scheduled in FY 2007
299-W7-3	Deep unconfined; no statistics	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W7-4		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W8-1	Pump lowered 0.762 m 9/2007	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W10-14	Deep unconfined	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W10-29		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	No quadruplicates once
299-W10-30		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W10-31		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	No quadruplicates once

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) Monitored for DOE Order 435.1.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.25. Monitoring Wells and Constituents for Low-Level Waste Management Area 4 (adapted from PNNL-14859-ICN-1 and DOE/RL-2000-72)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Chemical Parameters							AEA Parameters[b]				Sampled as Scheduled in FY 2007
			pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Metals (filtered)	Mercury (filtered)	Lead (filtered)	Phenols	Volatile Organic Analyses	Iodine-129	Technetium-99	Tritium	Uranium	
299-W15-15		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W15-17	Deep unconfined; no statistics	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	I-129 only once
299-W15-30		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W15-83		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	No quadruplicates once
299-W15-94		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	I-129, Tc-99 & tritium only once
299-W15-152		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	No field quadruplicates once
299-W15-224		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	I-129 only once; missed one quadruplicate TOX
299-W18-21		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W18-22	Deep unconfined; no statistics	C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	Yes
299-W18-23		C	S	S	S	S	A	S	S	A	A	A	A	S	S	S	S	I-129 only once; no field quadruplicates once

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) Monitored for DOE Order 435.1.
A = To be sampled annually.
AEA = *Atomic Energy Act* .
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
TOX = Total organic halides.
WAC = *Washington Administrative Code* .

Table B.26. Critical Means for Low-Level Waste Management Area 4 for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	11	10	4.8980	515.3	36.19	700	700
Field pH	11	10	5.3746	8.00	0.14	[7.21, 8.78]	[7.21, 8.78]
Total organic carbon,[b] µg/L	12	11	4.7244	335.3	94.89	802	1,430[c]
Total organic halides,[b] µg/L	12	11	4.7244	3.51	2.02	13.4	22.9[c]

(a) Based on semiannual sampling events from upgradient wells. For wells 299-W15-15 and 299-W18-21: data from January 2005 to July 2007. For well 299-W18-23 specific conductance and pH, data from February 2005 to February 2007. For well 299-W18-23 total organic carbon and total organic halides, data from February 2005 to July 2007.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 32 comparisons.

Table B.27. Monitoring Wells and Constituents for the Nonradioactive Dangerous Waste Landfill (adapted from PNNL-12227 and PNNL-12227-ICN-1)

Well Number[a]	Comment	WAC Compliant	Contamination Indicator Parameters				Other Parameters				Sampled as Scheduled in FY 2007
			pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Anions	Metals (filtered)	Phenols	Volatile Organic Analyses	
699-25-33A	Top of LPU; no statistics	C	S	S	S	S	S	A	A	S	Yes
699-25-34A		C	S	S	S	S	S	A	A	S	Yes
699-25-34B		C	S	S	S	S	S	A	A	S	Yes
699-25-34D		C	S	S	S	S	S	A	A	S	Yes
699-26-33		C	S	S	S	S	S	A	A	S	Yes
699-26-34A		C	S	S	S	S	S	A	A	S	Yes
699-26-34B		C	S	S	S	S	S	A	A	S	Yes
699-26-35A		C	S	S	S	S	S	A	A	S	Yes
699-26-35C	Top of LPU; no statistics	C	S	S	S	S	S	A	A	S	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
LPU = Low-permeability in upper Ringold Formation.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code* .

Table B.28. Critical Means for Nonradioactive Dangerous Waste Landfill for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	8	7	5.7282	546.8	12.05	620	620
Field pH	8	7	6.4295	7.24	0.08	[6.68, 7.81]	[6.68, 7.81]
Total organic carbon,[b] µg/L	6[c]	5	7.3884	374.0	80.79	1,019	1,430[d]
Total organic halides,[b] µg/L	9	8	5.3162	5.53	3.79	26.8	26.8

(a) Based on most recent sampling events from August 2005 to August 2007 for upgradient well 699-26-34A and from August 2005 to September 2007 for well 699-26-35A.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
(c) Excluded suspected total organic carbon values collected in August 2005 from well 699-26-34A and in February 2006 from wells 699-26-34A and 699-26-35A.
(d) Upgradient/downgradient comparison value is the most recently determined limit of quantitation (updated quarterly).
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

Table B.29. Monitoring Wells and Constituents for RCRA PUREX Cribs 216-A-10, 216-A-36B, and 216-A-37-1 (adapted from PNNL-11523, Rev. 1)

Well Number	Comment	WAC Compliant	Primary RCRA Constit.	Supporting Parameters			Sampled as Scheduled in FY 2007
			Nitrate	Anions	Metals (filtered)	Phenols	
299-E17-1	216-A-10	P	S	S	S	A	Yes
299-E17-14	216-A-36B	C	Q	Q	Q	A	Yes
299-E17-16	216-A-36B	C	S	S	S	A	Yes
299-E17-18	216-A-36B	C	S	S	S	A	Yes
299-E17-19	216-A-10	C	S	S	S	A	Yes
299-E24-16	216-A-10	C	Q	Q	Q	A	Yes
299-E24-18	Upgradient	C	S	S	S	A	Yes
299-E25-17	216-A-37-1	P	S	S	S	A	Yes
299-E25-19	216-A-37-1	P	Q	Q	Q	A	Fourth delay until 10/2007
299-E25-31	Upgradient	C	S	S	S	A	Yes
699-37-47A	216-A-37-1	C	S	S	S	A	Yes
124 Wells	Far-field		(a)	(a)			See Appendix A for 200-PO-1

Wells completed at the top of the unconfined aquifer.
(a) Far-field wells sampled annually to triennially in conjunction with 200-PO-1 Operable Unit.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
S = To be sampled simiannually.
WAC = *Washington Administrative Code*.

Table B.30. Monitoring Wells and Constituents for Waste Management Area A-AX (adapted from PNNL-15315)

Well Number[a]	WAC Compliant	Site-Specific Constituents										Sampled as Scheduled in FY 2007
		Nitrate	Sodium (filtered)	Sulfate	Total Organic Carbon	Chromium (filtered)	Lead (filtered)	Alkalinity	Anions	Metals (filtered)	Technetium-99[b]	
299-E24-20	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E24-22	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E24-33	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-2	P	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-40	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-41	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-93	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
299-E25-94	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) *Atomic Energy Act* parameter.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
WAC = *Washington Administrative Code*.

Table B.31. Monitoring Wells and Constituents for Waste Management Area B-BX-BY (adapted from PNNL-13022-ICN-3)

Well Number[(a)]	WAC Compliant	RCRA Parameters				AEA Parameters				Sampled as Scheduled in FY 2007
		Alkalinity	Anions	Cyanide	Metals (filtered)	Gamma	Technetium-99	Tritium	Uranium	
299-E33-9	P	Q	Q	Q	Q	S	Q	Q	Q	Cyanide and uranium twice; gamma once
299-E33-7	P	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-9	P	Q	Q	Q	Q	S	Q	Q	Q	Sampled 3 times
299-E33-15	P	S	S	S	S	S	S	S	S	Yes
299-E33-16	P	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-17	P	A	A	A	A		A	A	A	Yes
299-E33-18[(b)]	P	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-20	P	A	A	A	A		A	A	A	Yes
299-E33-21	P	A	A	A	A		A	A	A	Yes
299-E33-26	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-31	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-32	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-38	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-39	C	Q	Q	Q	Q	S	Q	Q	Q	No gamma
299-E33-41	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-42	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-43	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-44	C	Q	Q	Q	Q	S	Q	Q	Q	Yes
299-E33-47	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-48	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-49	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-334	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-335	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-337	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-338	C	Q	Q	Q	Q		Q	Q	Q	Yes
299-E33-339	C	Q	Q	Q	Q		Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) Bold italic = Upgradient well.
(b) Upgradient of 241-B Tank Farm but downgradient of 241-BY Tank Farm.
A = To be sampled annually.
AEA = *Atomic Energy Act* .
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act* .
S = To be sampled semiannually.
WAC = *Washington Administrative Code* .

Table B.32. Monitoring Wells and Constituents for Waste Management Area C (adapted from PNNL-13024-ICN-4 and RPP-21895)

Well Number[a]	WAC Compliant	Contamination Indicator Parameters				Other Chemical Parameters					AEA Parameters				Sampled as Scheduled in FY 2007
		pH (field)	Spec. Cond. (field)	Total Organic Carbon	Total Organic Halides	Alkalinity	Anions	Cyanide	Metals (filtered)	Phenols	Beta	Gamma	Technetium-99	Uranium	
299-E27-4	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-7	P	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-12	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-13	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-14[b]	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-15	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-21	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-22	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes
299-E27-23	C	Q	Q	S	S	Q	Q	Q	Q	A	Q	Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Well is cross-gradient to the C Tank Farm but downgradient of a waste transfer line.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.33. Critical Means for Waste Management Area C for FY 2008 Comparisons[a]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Specific conductance, µS/cm	8	7	5.7282	660.0	43.11	922	922
Field pH	8	7	6.4295	8.10	0.11	[7.32, 8.87]	[7.32, 8.87]
Total organic carbon,[b] µg/L	8	7	5.7282	707.0	443.91	3,404	3,404
Total organic halides,[b] µg/L	8	7	5.7282	7.13	4.61	35.1	35.1

(a) Based on quarterly/semiannual sampling events from December 2005 to June 2007 for upgradient wells 299-E27-22 and 299-E27-7.
(b) For values reported below laboratory's specified method detection limit, one-half of the method detection limit is used in the critical means calculation.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 28 comparisons.

Table B.34. Monitoring Wells and Constituents for Waste Management Area S-SX (adapted from PNNL-12114-ICN-3)

Well Number[a]	WAC Compliant	RCRA Parameters		Supporting Constituents							Sampled as Scheduled in FY 2007
		Chromium (filtered)	Nitrate	Alkalinity	Anions	Metals (filtered)	Technetium-99[b]	Tritium[b]	Uranium[b]	Gamma[b]	
299-W22-44	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-45	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-47	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-48	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-49	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-50	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-69	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-72	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-80	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-81	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-82	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-83	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-84	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-85	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W22-86	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W23-15	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W23-19	C	Q	Q	Q	Q	Q	Q	A	A	A	Fourth delayed until 10/2007
299-W23-20	C	Q	Q	Q	Q	Q	Q	A	A		Yes
299-W23-21	C	Q	Q	Q	Q	Q	Q	A	A		Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) *Atomic Energy Act* parameter.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
WAC = *Washington Administrative Code*.

Table B.35. Monitoring Wells and Constituents for Waste Management Area T (adapted from PNNL-15301)

Well Number[a]	Comment	WAC Compliant	Constituents of Concern		Constituents of Interest and Supporting Groundwater Quality Constituents									Sampled as Scheduled in FY 2007
			Chromium (total, filtered)	Nitrate	Alkalinity	Anions	Gamma Scan[b]	Gross Alpha[b]	Gross Beta[b]	Iodine-129[b]	Metals (filtered)[b]	Technetium-99[b]	Tritium[b]	
299-W10-1		P	Q	Q	Q	Q		A	A		Q	Q	Q	Yes
299-W10-4		P	Q	Q	Q	Q	A	A	A		Q	Q	Q	Yes
299-W10-8		P	Q	Q	Q	Q		A	A		Q	Q	Q	Yes
299-W10-22		C	S	S	S	S					S	S	S	Yes
299-W10-23		C	Q	Q	Q	Q		A	A		Q	Q	Q	Yes
299-W10-24		C	Q	Q	Q	Q	S	S	S		Q	Q	Q	Yes
299-W10-28		C	Q	Q	Q	Q		A	A		Q	Q	Q	Yes
299-W11-7		P	S	S	S	S					S	S	S	Yes
299-W11-12		P	Q	Q	Q	Q		A	A		Q	Q	Q	Yes
299-W11-39		C	Q	Q	Q	Q	S	S	S		Q	Q	Q	Yes
299-W11-40		C	Q	Q	Q	Q		A	A		Q	Q	Q	Yes
299-W11-41		C	Q	Q	Q	Q	S	S	S	A	Q	Q	Q	Yes
299-W11-42		C	Q	Q	Q	Q	S	S	S		Q	Q	Q	Yes
299-W11-45	Screened 8.5 to 13 m below water table	C	Q	Q	Q	Q	A	A	A		Q	Q	Q	Yes
299-W11-46	Screened 6 to 12 m below water table	C	Q	Q	Q	Q	S	S	S		Q	Q	Q	Yes
299-W11-47	Screened 9.1 to 18.2 m below water table	C	Q	Q	Q	Q	S	S	S	A	Q	Q	Q	Sampled 3 times

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
(b) *Atomic Energy Act* parameter.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
WAC = *Washington Administrative Code* .

Table B.36. Monitoring Wells and Constituents for Waste Management Area TX-TY (adapted from PNNL-16005)

Well Number[(a)]	Comment	WAC Compliant	RCRA Parameters			AEA Parameters							Sampled as Scheduled in FY 2007
			Alkalinity	Anions	Metals (filtered)	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Technetium-99	Tritium	
299-W10-26		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W10-27		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W14-6		P	Q	Q	Q	A	A				Q	Q	Yes
299-W14-11	Screened 11 to 14.6 m below water table	C	Q	Q	Q	S	S	S	Q	A	Q	Q	Yes
299-W14-13		C	Q	Q	Q	S	S	S	Q	A	Q	Q	Yes
299-W14-14		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W14-15		C	Q	Q	Q	A	A	A	Q		Q	Q	Yes
299-W14-16		C	Q	Q	Q				Q		Q	Q	Yes
299-W14-17		C	Q	Q	Q				Q		Q	Q	Yes
299-W14-18		C	Q	Q	Q	A	A	A	Q		Q	Q	Yes
299-W14-19		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W15-40	Extraction well	C	Q	Q	Q	A	A				Q	Q	Yes
299-W15-41		C	Q	Q	Q	A	A	A	S		Q	Q	Yes
299-W15-44	Extraction well	C	Q	Q	Q	A	A	A	S		Q	Q	Yes
299-W15-763		C	Q	Q	Q	A	A	A			Q	Q	Yes
299-W15-765	Extraction well	C	Q	Q	Q	A	A	A	S		Q	Q	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
S = To be sampled semiannually.
WAC = *Washington Administrative Code*.

Table B.37. Monitoring Wells and Constituents for Waste Management Area U (adapted from PNNL-13612-ICN-2)

Well Number[(a)]	WAC Compliant	RCRA Parameters			AEA Parameters				Sampled as Scheduled in FY 2007
		Alkalinity	Anions	Metals (filtered)	Alpha	Beta	Gamma	Technetium-99	
299-W18-30	C	Q	Q	Q	A	A	A	Q	Yes
299-W18-31	C	Q	Q	Q	A	A	A	Q	Sampled three times, then went dry
299-W18-40	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-12	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-41	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-42	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-44	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-45	C	Q	Q	Q	A	A	A	Q	Yes
299-W19-47	C	Q	Q	Q	A	A	A	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
A = To be sampled annually.
AEA = *Atomic Energy Act*.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
RCRA = *Resource Conservation and Recovery Act*.
WAC = *Washington Administrative Code*.

Table B.38. Monitoring Wells and Constituents for the KE and KW Basins (adapted from PNNL-14033)

Well Number	Comment	WAC Compliant	Alpha	Anions	Beta	Carbon-14	Metals (filtered)	Strontium-90	Technetium-99	Tritium	Alkalinity	Uranium (total)	VOA	Sampled as Scheduled in FY 2007
KE Basin														
199-K-27		P	Q/M	Q	Q/M		S	A/S	A/Q	Q/M	0/S	0/S		Yes
199-K-29		P	Q/M	Q	Q/M	A/S	A/S	0/S	0/Q	M	0/S			Missed one tritium
199-K-30		P	Q	Q	Q	A/S	S		0/S	Q	0/S			Yes
199-K-32A		C	Q	Q	Q	A/S	A/S		A/S	Q	0/S			Yes
199-K-109A		C	Q/M	Q	Q/M		S	A	A/Q	Q/M	0/S			Yes
199-K-110A		C	S	S	S		A/S			S	0/S			Yes
199-K-111A		C	Q/M	Q	Q/M	A	A/S		A/S	Q/M	0/S			Yes
199-K-141	New well	C	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q			Sampled twice; no Sr-90
199-K-142	New well	C	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q	0/Q			Sampled twice; no Sr-90
KW Basin														
199-K-31	Not included in monitoring plan	P	0/S	0/S	0/S		0/S		0/A	0/S	0/A			Yes
199-K-34		C	Q	Q	Q	A	S/Q	A	A	Q	0/A	0/A		Yes
199-K-106A		C	Q	Q	Q	A/S	S/Q		0/Q	Q	0/S		0/S	Yes
199-K-107A		C	Q	Q	Q	A	S/Q	A	A	Q	0/A	0/A		Yes
199-K-108A		C	S	S	S	0/S	S			S	0/S			Yes
199-K-132		C	S/Q	S/Q	S/Q	A/S	S/Q		0/S	S/Q	0/S		0/S	Yes

Frequency required under monitoring plan is listed first. Some constituents are sampled more frequently during basin cleanout; those frequencies are listed after the slash. For example, 0/Q means not required under monitoring plan but currently sampled quarterly.

Wells completed at the top of the unconfined aquifer.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
M = To be sampled monthly.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
VOA = Volatile organic analyses.
WAC = *Washington Administrative Code*.

Table B.39. Monitoring Wells, Constituents, and Enforcement Limits for 200 Area Treated Effluent Disposal Facility (adapted from PNNL-13032)

Well[a]	WAC Compliant	Constituents with Enforcement Limits			Other Constituents								Sampled as Scheduled in FY 2007
		pH (6.5 – 8.5)	Cadmium[b] (5 µg/L)	Lead[b] (10 µg/L)	Specific Conductance	Alpha	Anions	Beta	Metals[b]	Total Dissolved Solids	Trace Metals[b]	Tritium	
699-40-36	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A	Yes
699-41-35	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A	Yes
699-42-37	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	A	Yes

All wells completed at the top of the Ringold Formation confined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Filtered and unfiltered samples.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
Q = To be sampled quarterly.
WAC = *Washington Administrative Code*.

Table B.40. Monitoring Wells and Constituents for Environmental Restoration Disposal Facility (adapted from BHI-00873)

Well Number[a]	WAC Compliant	Alkalinity	Alpha	Anions	Beta	Carbon-14	Iodine-129	Metals (filtered, unfiltered)	Radium[b]	Total Dissolved Solids	Technetium-99	Total Organic Halides	Uranium	Volatile Organic Analyses	Sampled as Scheduled in FY 2007
699-35-66A	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-36-67	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-36-70A	P	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes
699-37-68	C	S	S	S	S	S	S	S	S	S	S	S	S	S	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
(b) Total alpha energy emitted from radium
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
S = To be sampled semiannually.
WAC = *Washington Administrative Code*.

Table B.41. Monitoring Wells and Constituents for 600 Area Central Landfill (adapted from PNNL-13014)

Well Number[a]	Comment	WAC Compliant	Required Parameters (WAC 173-304-490)														Other Parameters				Sampled as Scheduled in FY 2007
			Ammonia	Chemical Oxygen Demand	Chloride	Iron (filtered)	Manganese (filtered)	Zinc (filtered)	Nitrate	Nitrite	pH (field)	Spec. Cond. (field)	Sulfate	Temperature (field)	Coliform	Total Organic Carbon	Anions	Metals (filtered)	Arsenic (filtered)	Volatile Organic Analyses	
699-22-35		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-23-34A		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-23-34B		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-33	Information only; no statistics	P	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34A		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34B		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-34C		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-24-35		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-26-35A		C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes

Wells completed at the top of the unconfined aquifer.
(a) ***Bold italic*** = Upgradient well.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
Spec. Cond. = Specific conductance.
WAC = *Washington Administrative Code*.

Table B.42. Analytical Results for Required Constituents[a] at 600 Area Central Landfill

Constituent, unit	Background Threshold Value [b]	Date	Well 699-22-35	Well 699-23-34A	Well 699-23-34B	Well 699-24-33	Well 699-24-34A	Well 699-24-34B	Well 699-24-34C	Well 699-24-35	Well 699-26-35A
Ammonium, ug/L	90 µg/L	Dec. 2006 [c]	13	15.1	<6.69	<6.69	<6.69	34.3	<6.69	<6.69	<6.69
		Feb. 2007	13.1	13.5	9.92	<2.58	8.76	9.79	10	30.5	19.2
		May. 2007	11.9	11.9	13.3	13.5	8.15	11.9	11.9	11.9	12.6
		Sep. 2007	<6.08	<6.08	<6.08	[d]	<6.08	<6.08	<6.08	<6.08	[d]
Chemical oxygen demand, mg/L	10 mg/L	Dec. 2006 [c]	**285** [e]	**13**	**17**	<14.3	**15**	<9.2	**13**	<14.4	**22**
		Feb. 2007	<10	10	<10	<10	<10	<10	<10	<10	<10
		May. 2007	<14.4	<14.4	**27**	<14.4	<14.4	<14.4	**31**	**17**	**62**
		Sep. 2007	<10	<10	<10	[d]	<10	<10	<10	<10	[d]
Chloride, mg/L	7.8 mg/L	Dec. 2006 [c]	7.6	4.7	7.1	**8.4** [e]	7.8	4.7	2.9	7.8	**8.6** [e]
		Feb. 2007	7.7	**9.6** [e]	**9.7** [e]	5.1	**9.1** [e]	7.4	5.1	**9.3** (e)	7.7
		May. 2007	6	5.8	5.3	5.8	6.3	5.9	5.7	5.4	6.3
		Sep. 2007	6.82	7.08	6.71	[d]	6.87	7.2	6.7	6.2	[d]
Coliform Bacteria, col/100ml	1 col/100ml	Dec. 2006 [c]	<1	**345** [e]	<1	<1	<1	<1	<1	<1	<1
		Feb. 2007	<1	<1	<1	<1	<1	<1	<1	<1	<1
		May. 2007	<1	<1	<1	**14.8** [e]	<1	<1	<1	<1	**14.8** [e]
		Sep. 2007	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]
Iron, filtered, ug/L	160 µg/L	Dec. 2006 [c]	34.2	42	34.7	34.1	38.5	32	37	33.1	29.7
		Feb. 2007	39	51.1	51.9	31.2	47	51	43.6	29.6	<25
		May. 2007	43.5	99.6	47.7	29.8	31.7	66.3	43.6	32.8	29
		Sep. 2007	<37.2	<37.2	<37.2	[d]	126	<37.2	72.2	<37.2	d
Manganese, ug/L	11 µg/L	Dec. 2006 [c]	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
		Feb. 2007	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
		May. 2007	<2.5	<2.5	<2.5	<2.5	<2.5	4.1	6.8	<2.5	<2.5
		Sep. 2007	<2.1	<2.1	<2.1	[d]	<2.1	<2.1	<2.1	<2.1	[d]
Nitrate, mg/L	29 mg/L	Dec. 2006 [c]	15.5	16.4	15.1	13.3	12.8	14.2	13.7	12.4	16.4
		Feb. 2007	17.3	17.3	16.4	14.6	14.2	14.6	13.7	12.4	16.8
		May. 2007	17.3	18.1	16.4	13.7	12.8	15.1	12.8	12.4	16.4
		Sep. 2007	17.6	16.9	16.6	[d]	13.9	16.6	13.7	11.6	[d]
Nitrite, ug/L	59 µg/L	Dec. 2006 [c]	<131	<131	<131	<13.1	<131	<131	<131	<13.1	<13.1
		Feb. 2007	**526** [e]	**1150** [e]	**657** [e]	**558** [e]	**558** [e]	**723** [e]	**887** [e]	**526** [e]	**558** [e]
		May. 2007	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1	<13.1
		Sep. 2007	<32.8	<32.8	<32.8	[d]	<32.8	<32.8	<32.8	<32.8	[d]
Field pH	6.68-7.84	Dec. 2006 [c]	6.95	**6.63**	6.7	6.87	6.71	6.71	6.86	6.94	7.27
		Feb. 2007	7.14	6.69	6.76	6.84	6.71	6.71	6.91	6.74	7.21
		May. 2007	6.91	**6.49**	6.68	6.86	6.74	6.7	6.97	6.86	7.2
		Sep. 2007	6.94	6.68	6.73	[d]	6.77	6.73	6.98	6.83	[d]

Table B.42. (contd)

Constituent, unit	Background Threshold Value [b]	Date	Well 699-22-35	Well 699-23-34A	Well 699-23-34B	Well 699-24-33	Well 699-24-34A	Well 699-24-34B	Well 699-24-34C	Well 699-24-35	Well 699-26-35A
Specific conductance, uS/cm	583 µS/cm	Dec. 2006 [c]	**829**	**698**	**762**	**766**	**661**	**708**	**655**	576	545
		Feb. 2007	**826**	**748**	**755**	**755**	**656**	**695**	**725**	565	538
		May. 2007	**809**	**739**	**658**	**744**	**767**	**689**	**730**	560	526
		Sep. 2007	**831**	**619**	**779**	[d]	**678**	**723**	**715**	**591**	[d]
Sulfate, mg/L	47.2 mg/L	Dec. 2006 [c]	42	46.5	42.5	40.8	44.4	46.2	42	41.5	35.1
		Feb. 2007	40	45	42.5	39.9	41.5	44.2	39.6	41.2	35.4
		May. 2007	41.9	47.1	41.1	41.9	45	45.3	39.4	42.3	36.8
		Sep. 2007	42.6	**47.4**	44.9	[d]	44.8	**51.9**	41.7	43.2	[d]
Temperature, °C	20.7 °C	Dec. 2006 [c]	17.8	17.6	17.7	19.4	18.2	17.4	18.2	17.4	19.3
		Feb. 2007	18.2	18.1	17.6	19.2	18.1	18.2	17.7	17.5	19
		May. 2007	18.1	18.7	18.3	19.4	18.5	18.5	18.2	18	19.9
		Sep. 2007	19.4	19.2	**22.2**	[d]	19.7	19.8	19.8	18.7	[d]
Total organic carbon, ug/L	2,700 µg/L	Dec. 2006 [c]	<470	<470	<470	<470	<470	<470	<470	<470	<470
		Feb. 2007	<760	<760	<760	<760	<760	<760	<760	<760	<760
		May. 2007	<470	<760	<760	<760	<760	<760	<760	<760	<760
		Sep. 2007	<470	<760	<760	[d]	<760	<760	<760	<760	[d]
Zinc, ug/L	43.2 µg/L	Dec. 2006 [c]	<9.6	<9.6	<9.6	12.4	<9.6	<9.6	15.6	9.8	<9.6
		Feb. 2007	<5.6	<9.6	<9.6	11.4	<9.6	<9.6	18.3	9.9	<9.6
		May. 2007	<9.6	<9.6	<9.6	13	<9.6	<9.6	14.3	<9.6	<9.6
		Sep. 2007	<19.3	<19.3	<19.3	[d]	<19.3	<19.3	<19.3	<19.3	[d]

(a) WAC 173-304.
(b) Number obtained from Table B.43 of PNNL-16346.
(c) Samples from wells 699-24-33, 699-24-35, and 699-26-35A were collected in January 2007.
(d) Analysis results not yet reported.
(e) Result inconsistent with historical trend. Result under review.
Results in bold exceed background threshold value.

Table B.43. Results of Shapiro and Francia Test for Normality and Background Threshold Values for 600 Area Central Landfill

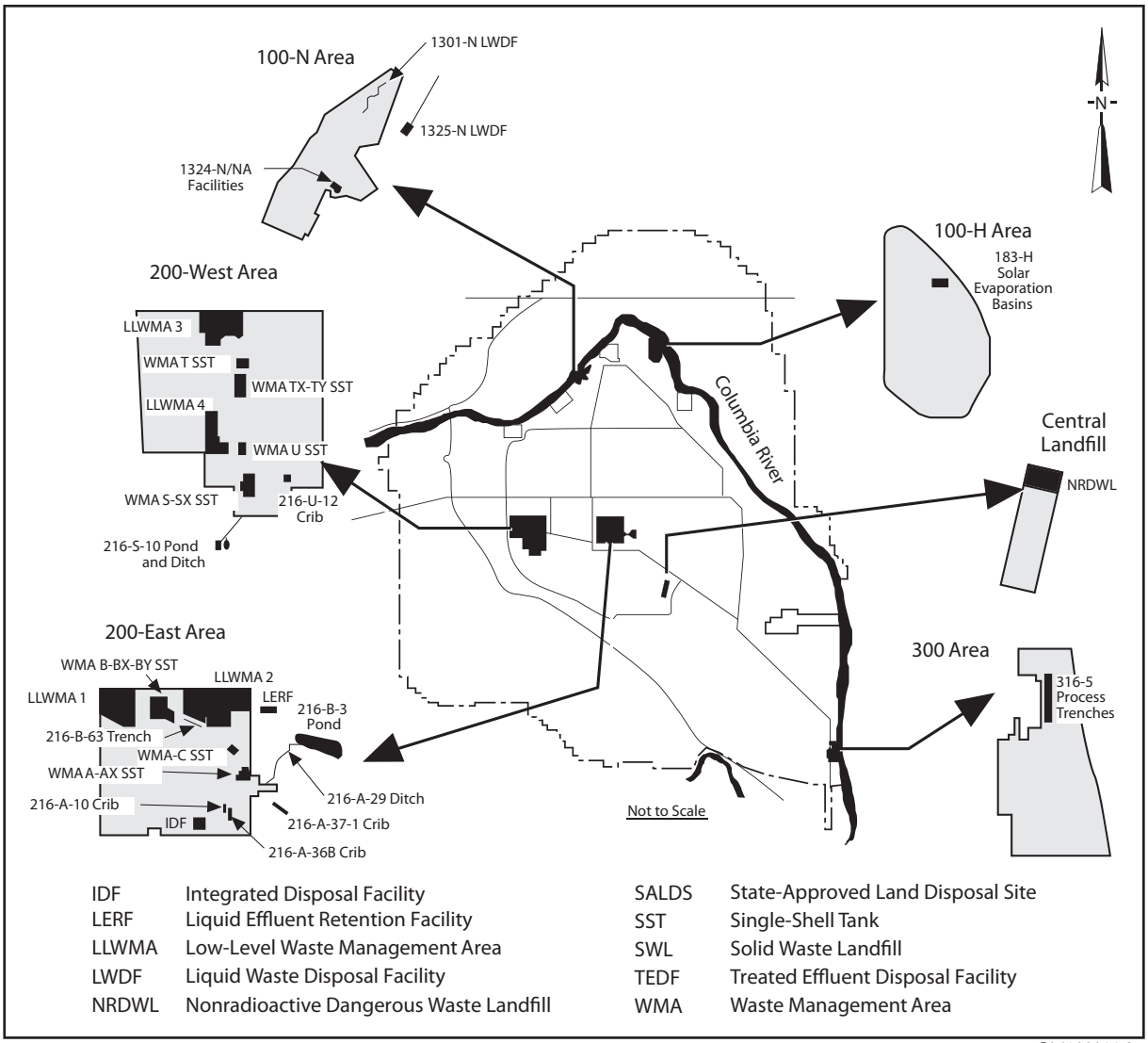
Constituent,[a] unit	W-test Statistic,[b] (log value)	W-test Statistic,[b] (raw data)	W-test[b] Critical Value, Wα[c]	Upper Tolerance Limit	Background Threshold Value
Ammonium (as NH_3^-), µg/L	NC	NC	NC	90[d] 54[e] WSCF 27.5[e] STL	90
Chemical oxygen demand, µg/L	NC	NC	NC	10,000[f]	10,000
Chloride, µg/L	0.954 s	0.962 s	0.963	7,820[d]	7,820
Coliform bacteria, colonies/100 ml	NC	NC	NC	1[f]	1
Field pH	0.988 ns	NA	0.963	[6.68, 7.84][g]	[6.68, 7.84]
Iron, dissolved, µg/L	0.960 s	0.802 s	0.962	160[d] 41[e] WSCF 84[e] STL	160
Manganese, dissolved, µg/L	NC	NC	NC	10[d] 18[e] WSCF 5[e] STL	18
Nitrate (as NO_3^-), µg/L	0.833 s	0.844 s	0.963	29,000[d]	29,000
Nitrite (as NO_2^-), µg/L	NC	NC	NC	148[e] WSCF 72[e] STL	148
Specific conductance, µS/cm	0.978 ns	NA	0.960	583[g]	583
Sulfate, µg/L	0.983 ns	NA	0.963	47,200[g]	47,200
Temperature, °C	0.953 s	0.961 s	0.963	20.7[d]	20.7
Total organic carbon, µg/L	NC	NC	NC	842[d] 1,430[e]	1,430
Zinc, dissolved, µg/L	NC	NC	NC	42.3[d] 18[e] WSCF 43.2[e] STL	43.2

(a) Constituents are specified in WAC 173-304-490(2)(d). Data collected from March 1993 to May 2000 from upgradient wells 699-24-35 and 699-26-35A.
(b) Shapiro and Francia (1972).
(c) Obtained from Table A-9 (Shapiro 1980) for α = 5%.
(d) Maximum value reported.
(e) Based on log-normal distribution.
(f) Based on limit of quantitation determined from field blanks (for total organic carbon) or laboratory blanks.
(g) Based on laboratory lowest detected result.
NA = Not applicable.
NC = Not calculated; insufficient measured values.
ns = Not significant at 0.05 level of significance.
s = Significant at 0.05 level of significance.
STL = Severn Trent Laboratories (St. Louis).
WSCF = Waste Sampling and Characterization Facility.

Table B.44. Monitoring Wells, Constituents, and Enforcement Limits for State-Approved Land Disposal Site (adapted from PNNL-13121)

			Constituents with Enforcement Limits											Other Constituents					
Well	Comment	WAC Compliant	pH (6.5 - 8.5)	Acetone (160 µg/L)	Benzene (5 µg/L)	Cadmium[(a)] (5 µg/L)	Chloroform (6.2 µg/L)	Copper[(a)] (70 µg/L)	Lead[(a)] (10 µg/L)	Mercury[(a)] (2 µg/L)	Sulfate (250 mg/L)	Tetrahydrofuran (100 µg/L)	Total Dissolved Solids (500 mg/L)	Specific Conductance	Alpha	Beta	Strontium-90	Tritium	Sampled as Scheduled in FY 2007
299-W6-6	Bottom of unconfined	C																A	Yes
299-W6-11		C																A	Yes
299-W6-12		C																A	Yes
299-W7-3	Bottom of unconfined	C																S	Yes
299-W8-1		C																A	Yes
699-48-71	Unconfined	P																A	Yes
699-48-77A	Ringold E, upper	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-48-77C	Ringold E, mid to lower	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-48-77D	Ringold E, upper	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Yes
699-49-79		P																A	Yes
699-51-75		P																S	Sampled once; pump failure
699-51-75P	Lower unconfined	P																A	Yes

Wells completed at the top of the unconfined aquifer unless specified otherwise.
(a) Filtered and unfiltered samples.
A = To be sampled annually.
C = Well is constructed as a resource protection well under WAC 173-160.
FY = Fiscal year.
P = Constructed prior to WAC requirements.
Q = To be sampled quarterly.
S = To be sampled semiannually.
WAC = *Washington Administrative Code.*



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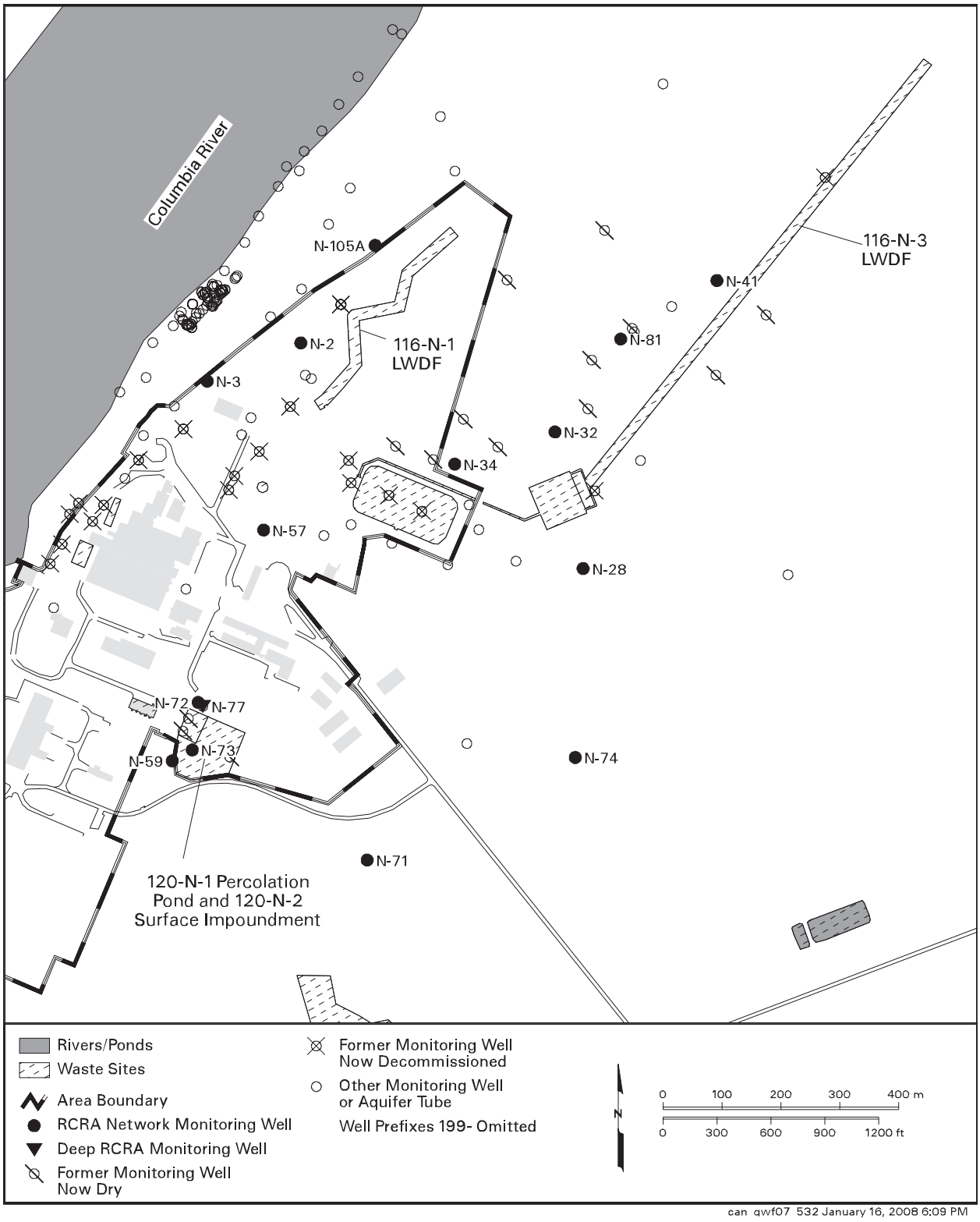

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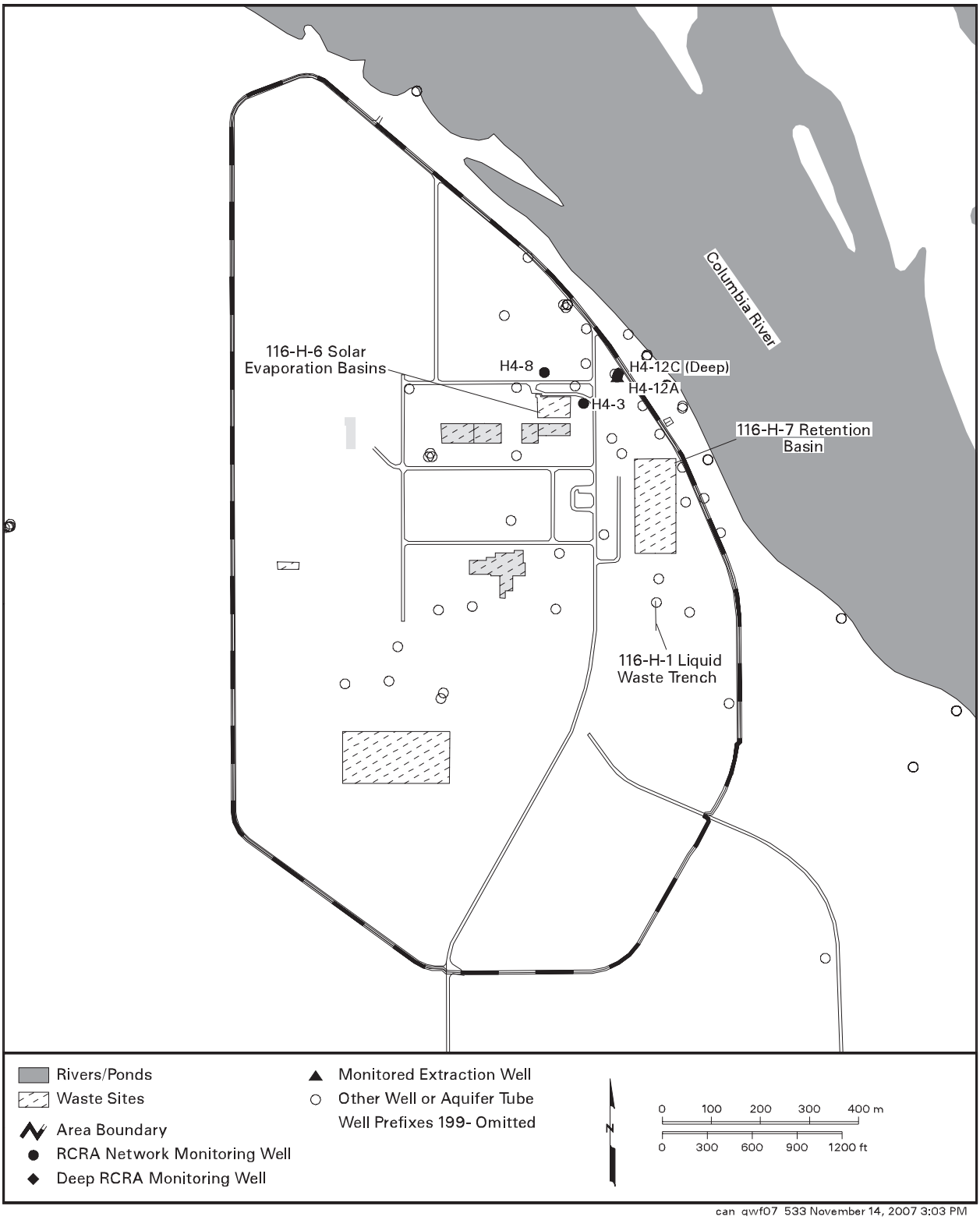

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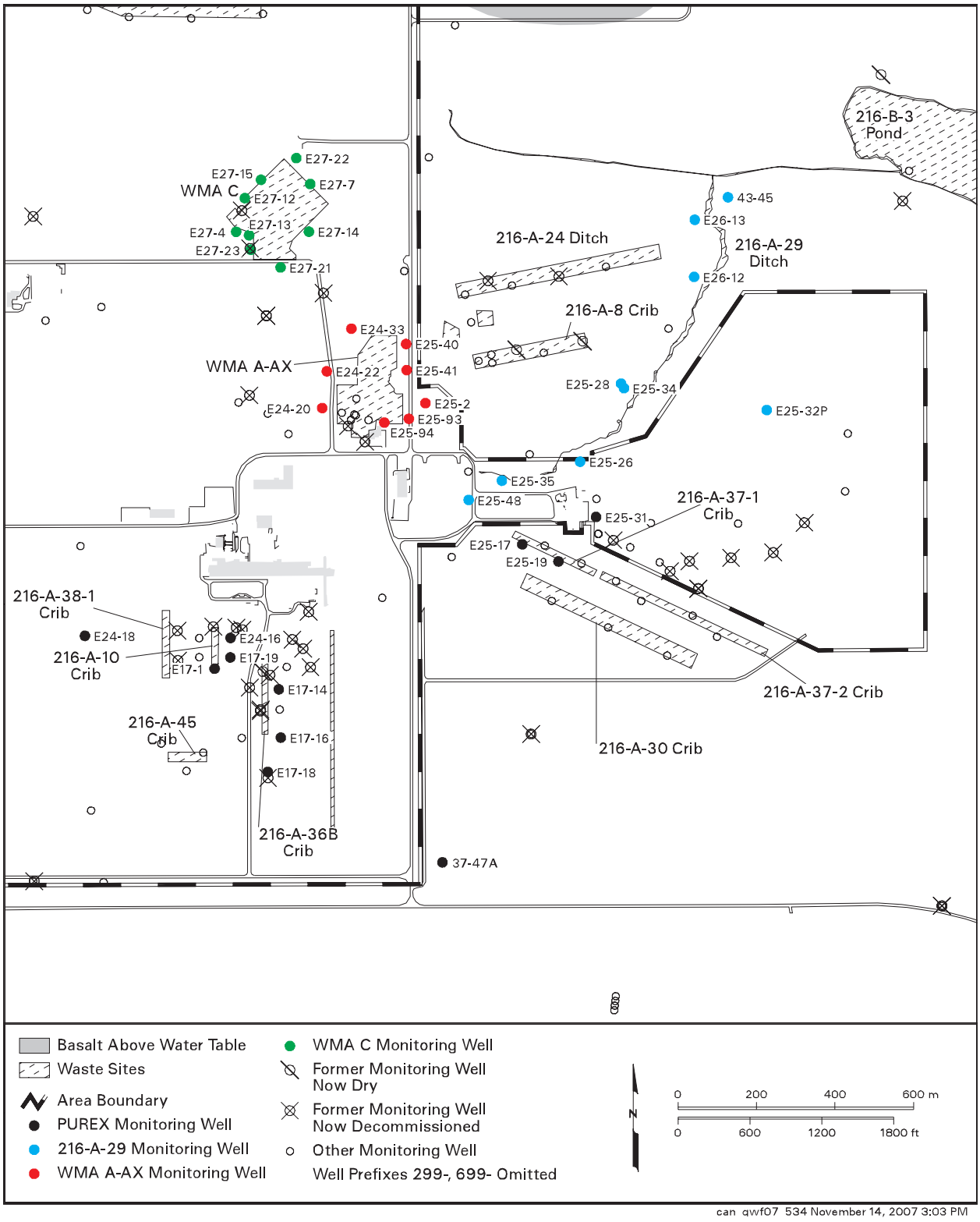

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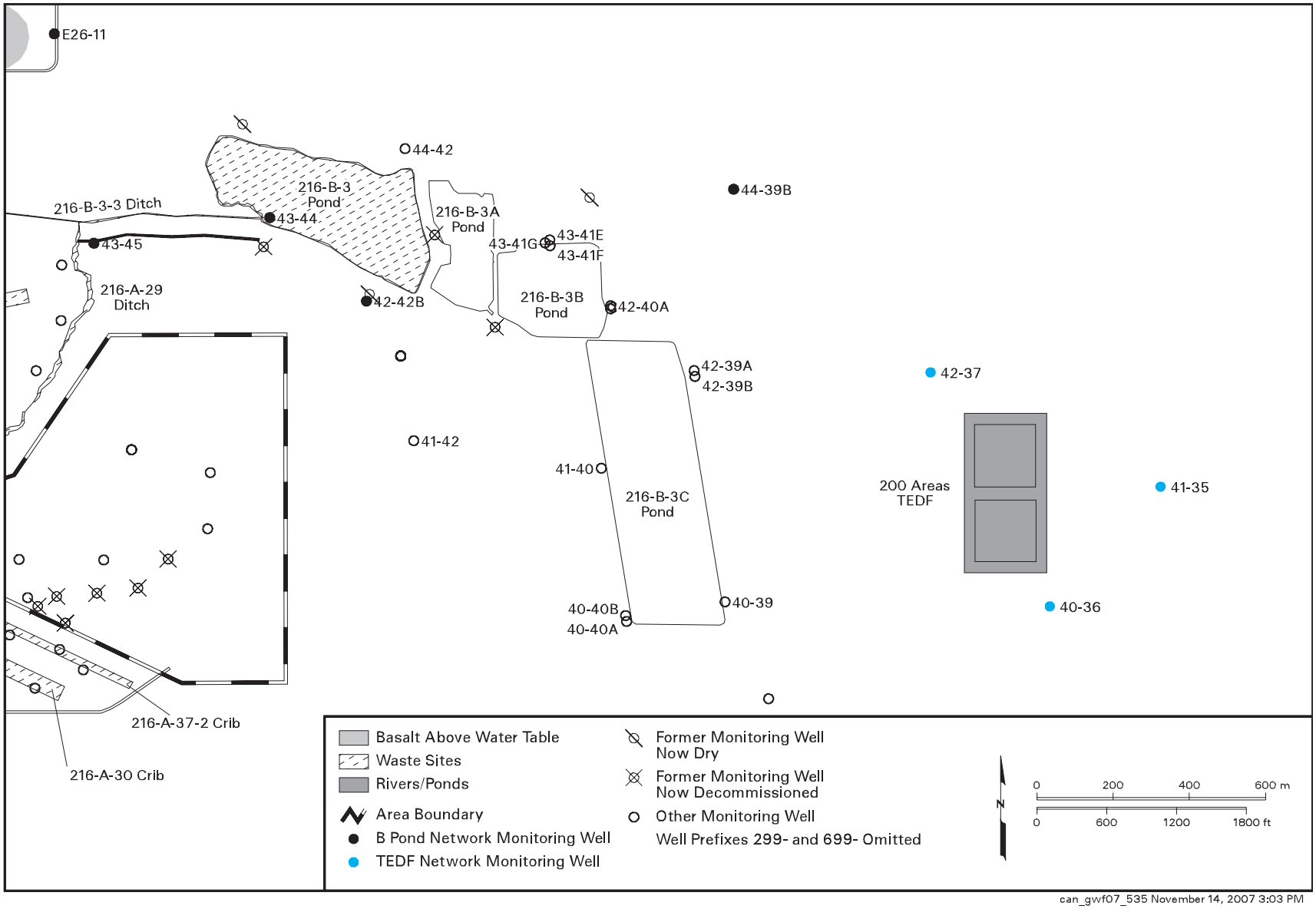

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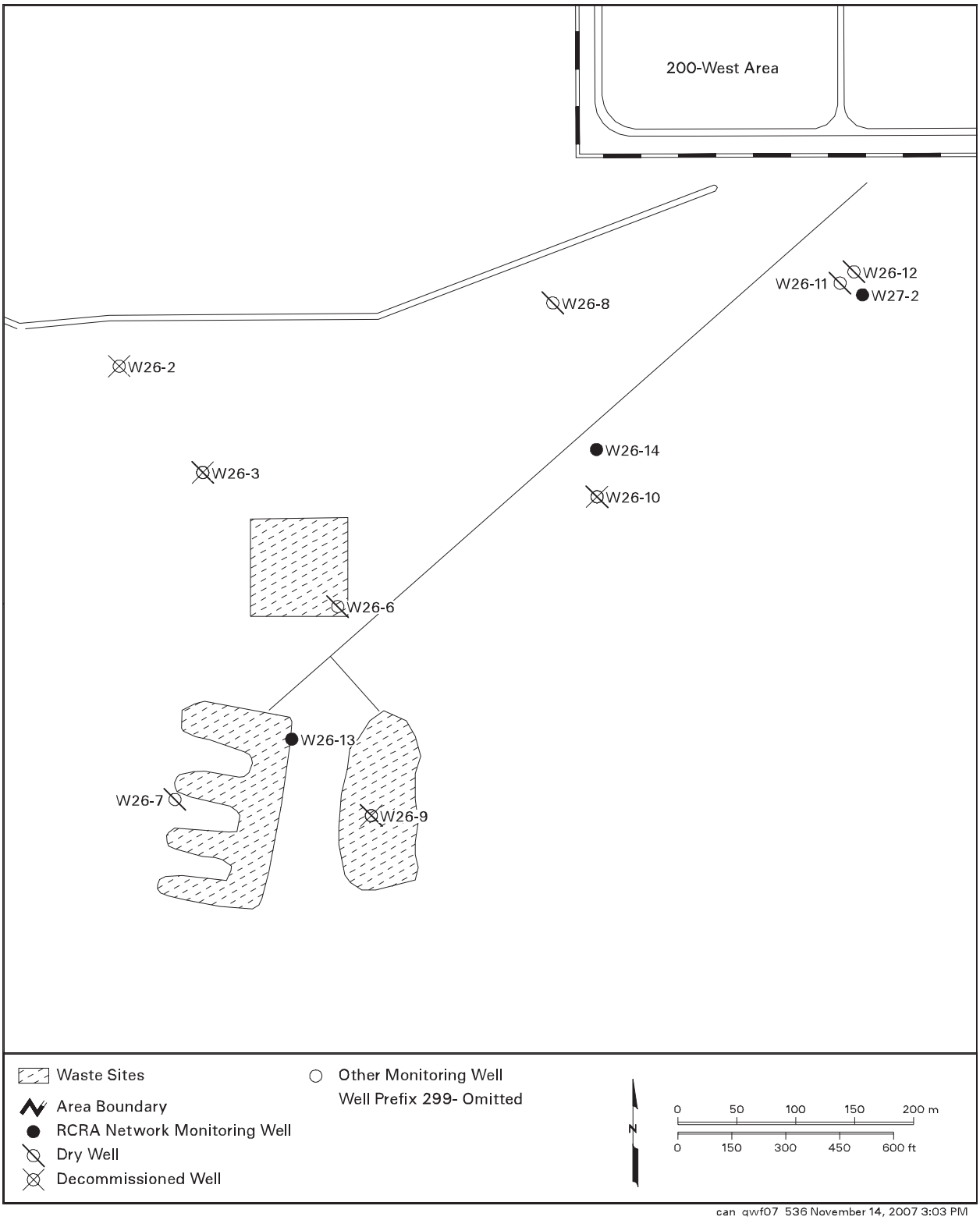

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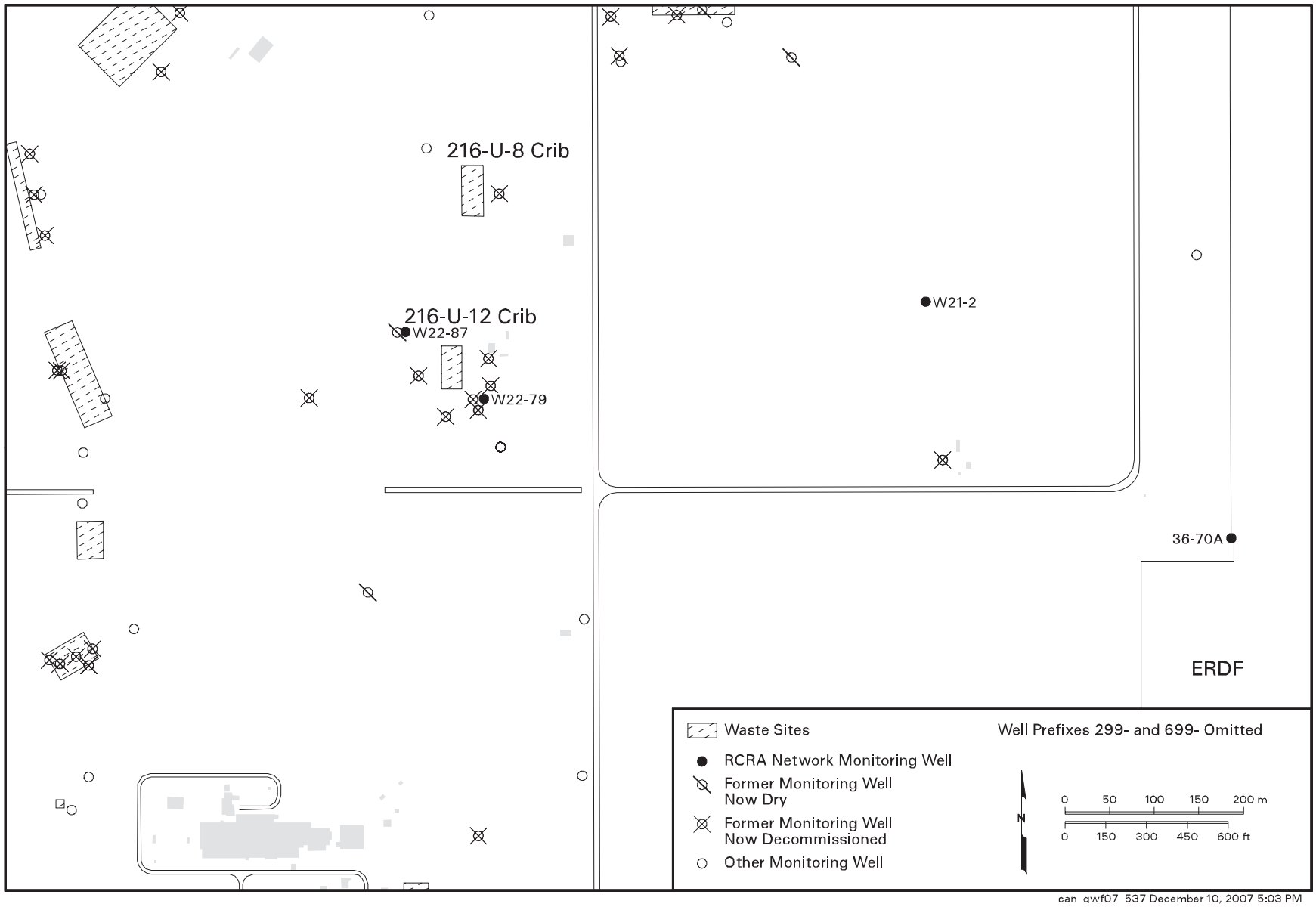

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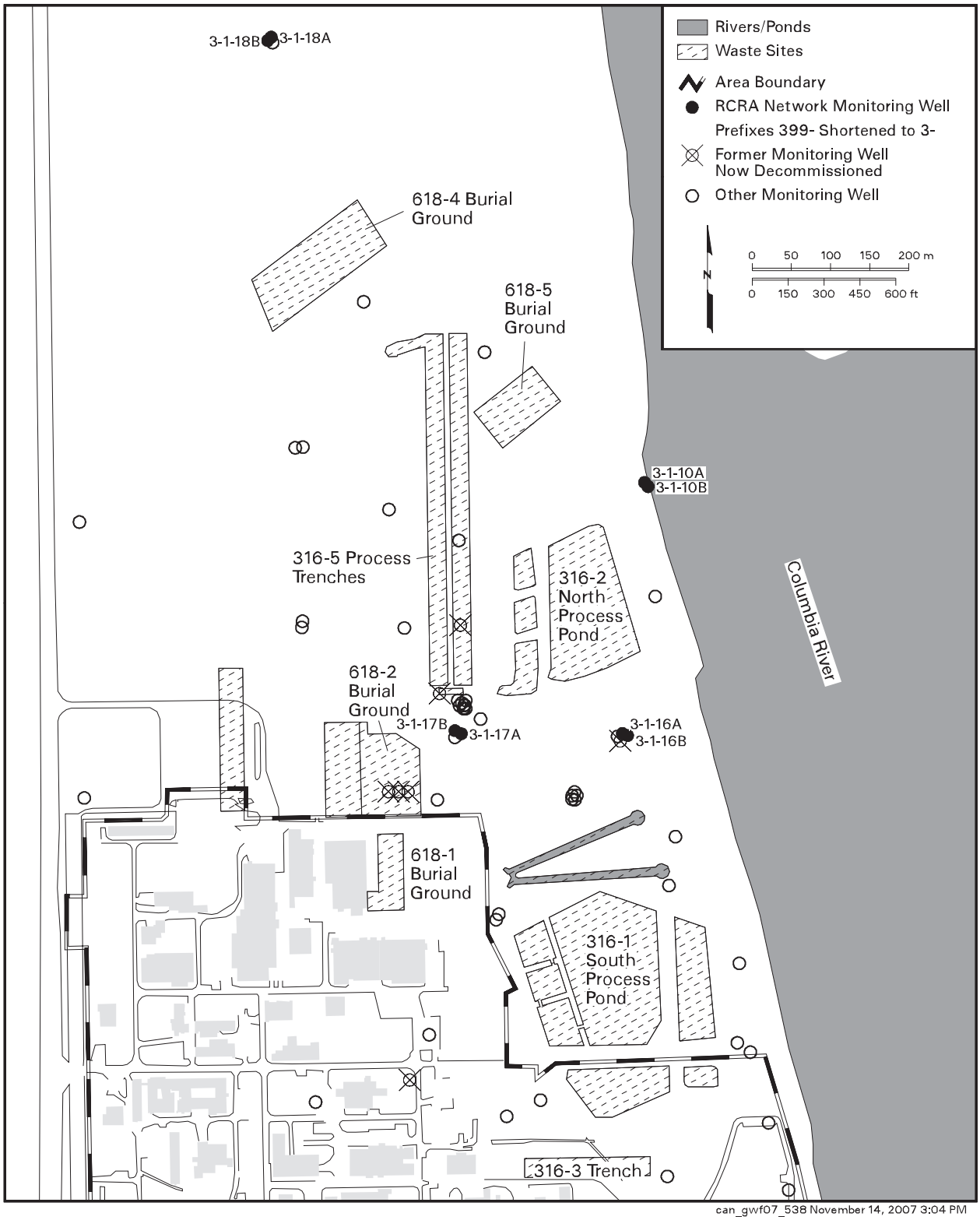

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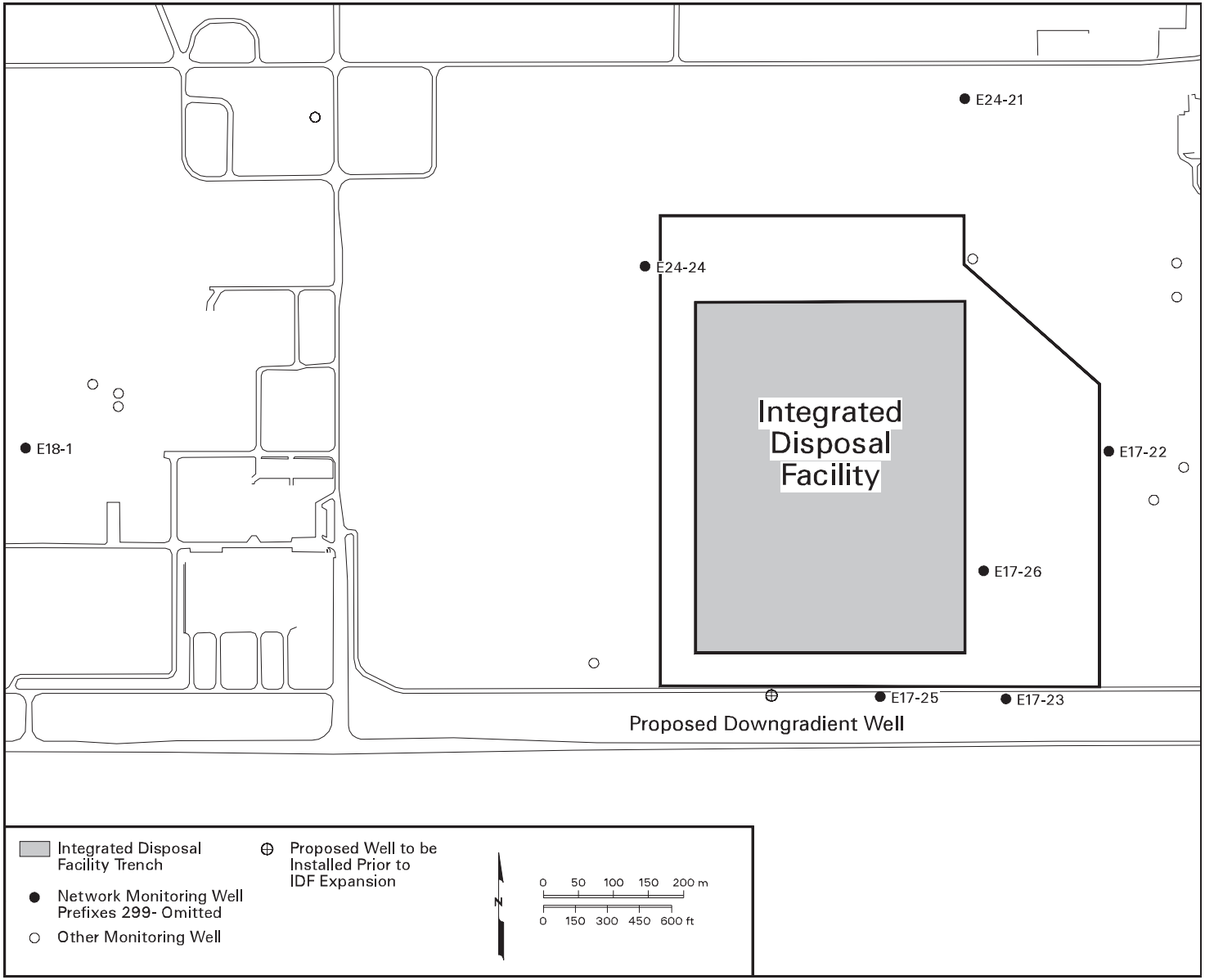

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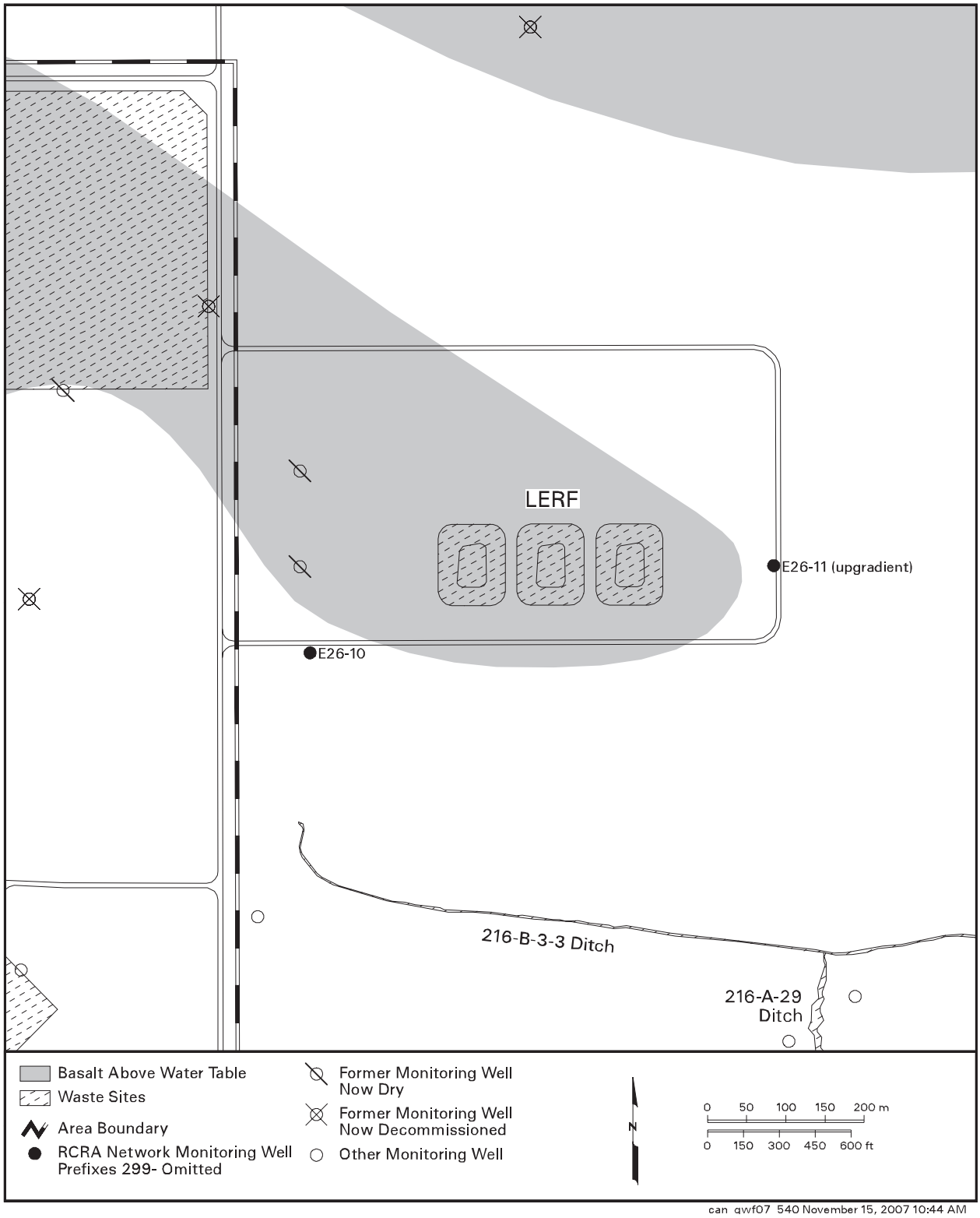
Figure B.9. Groundwater Monitoring Wells at Integrated Disposal Facility



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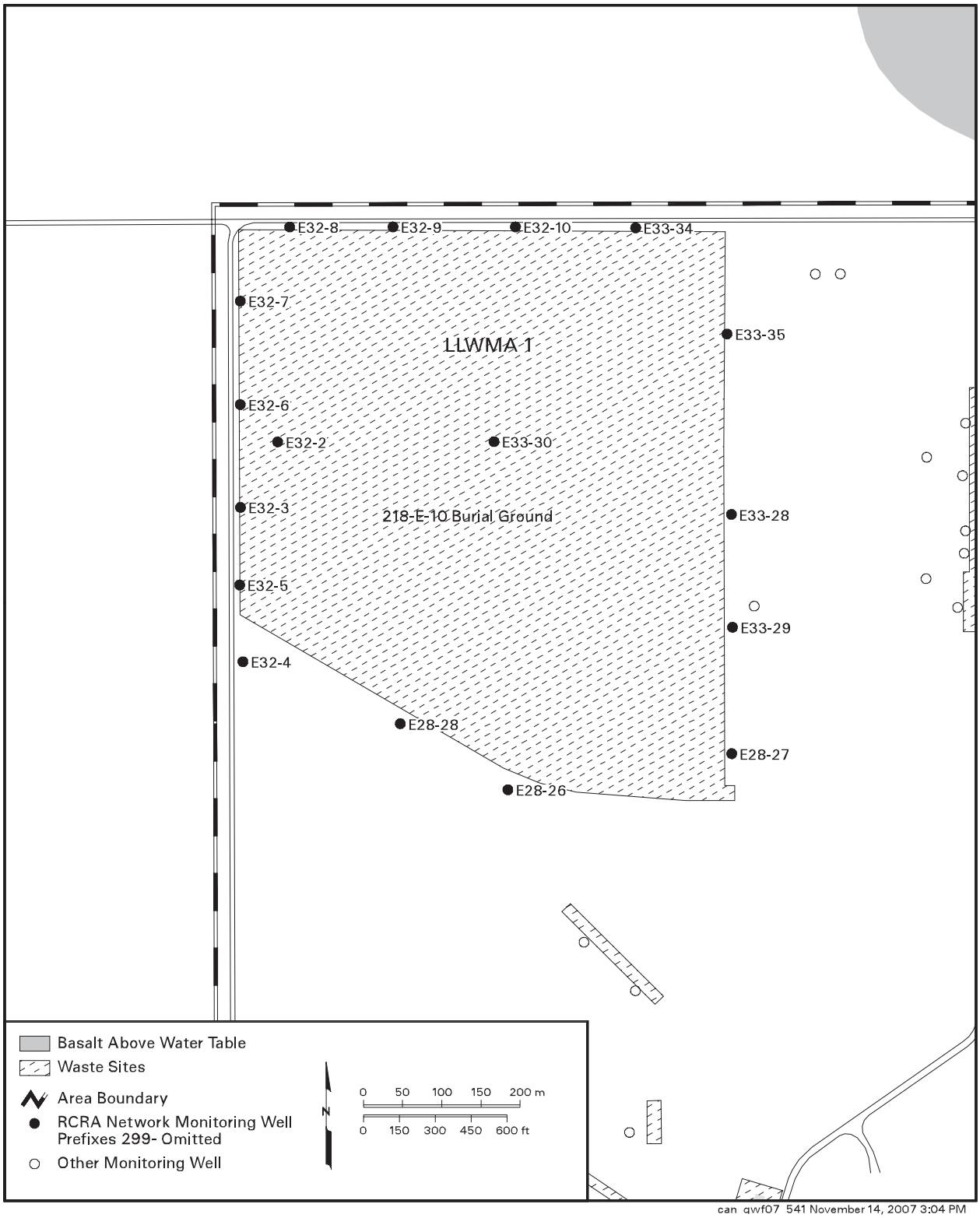
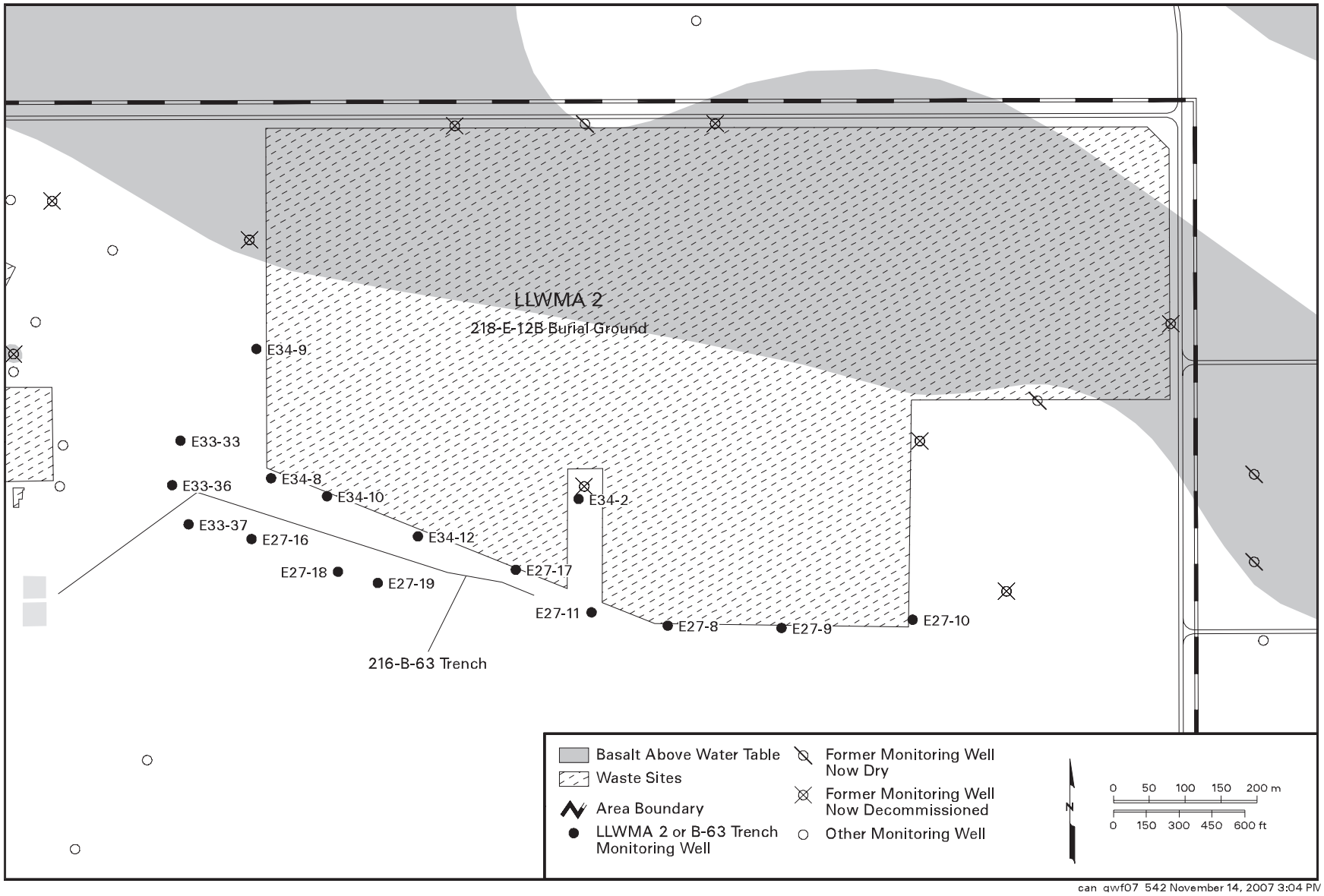


Figure B.11. Groundwater Monitoring Wells at Low-Level Waste Management Area 1



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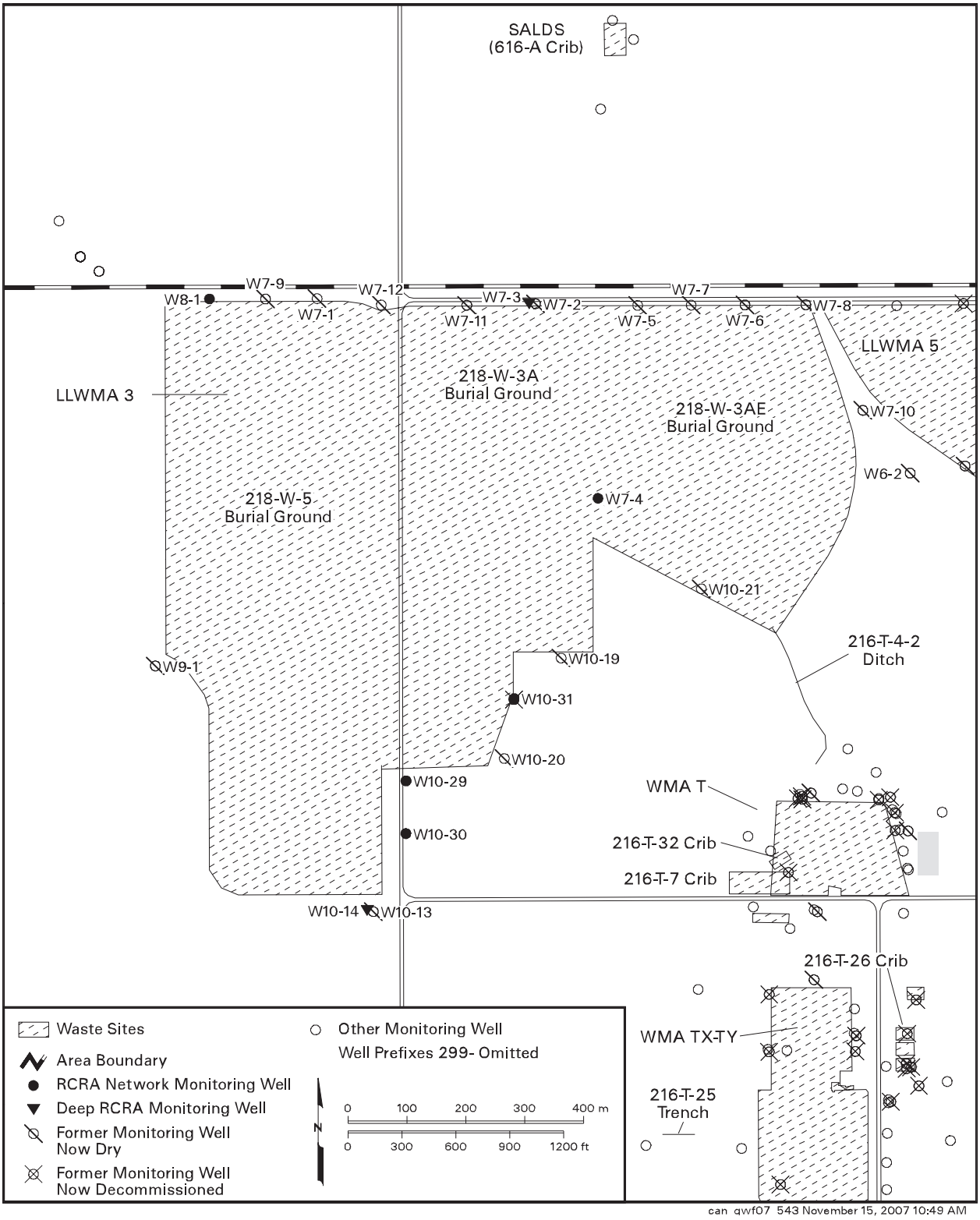
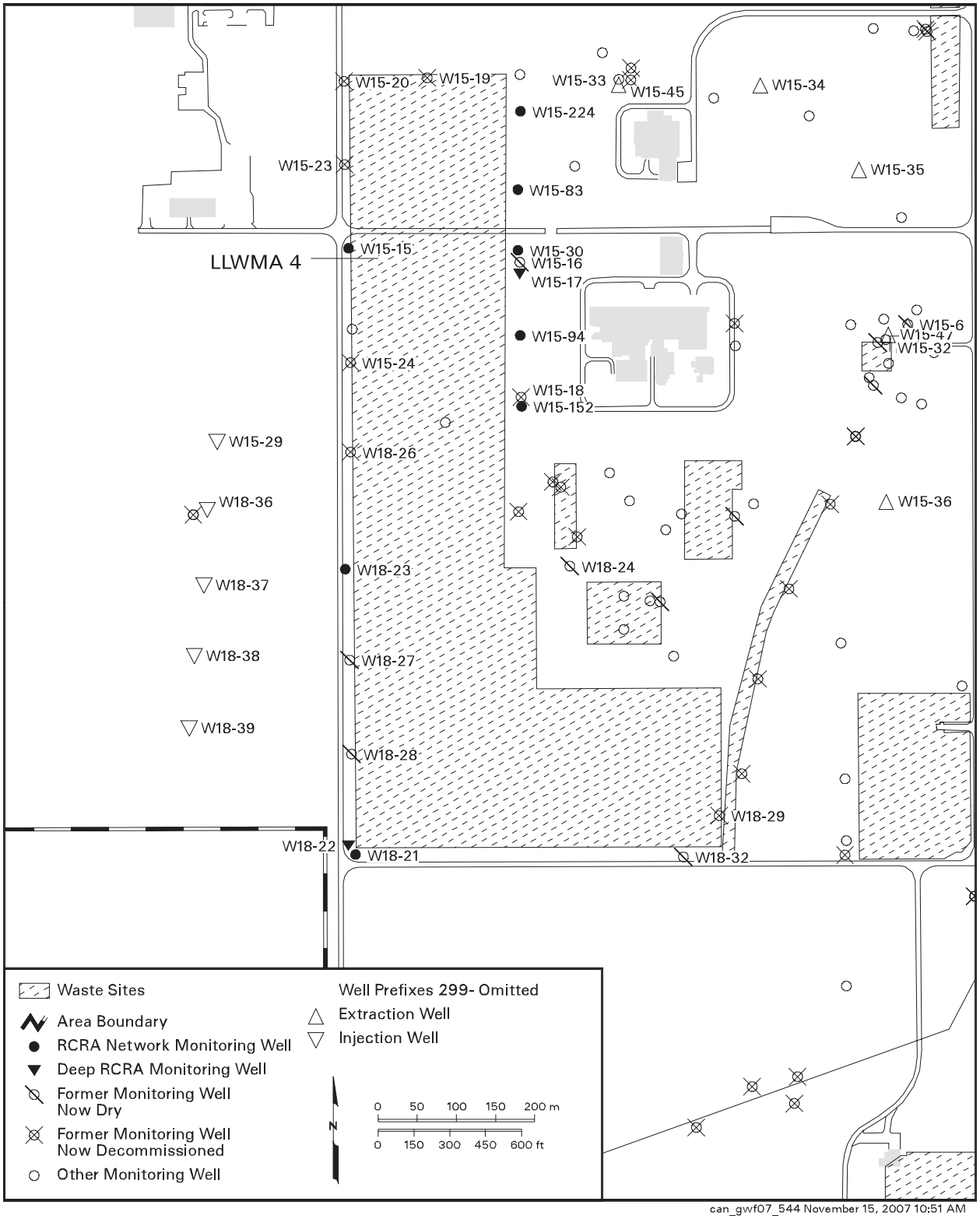


Figure B.13. Groundwater Monitoring Wells at Low-Level Waste Management Area 3



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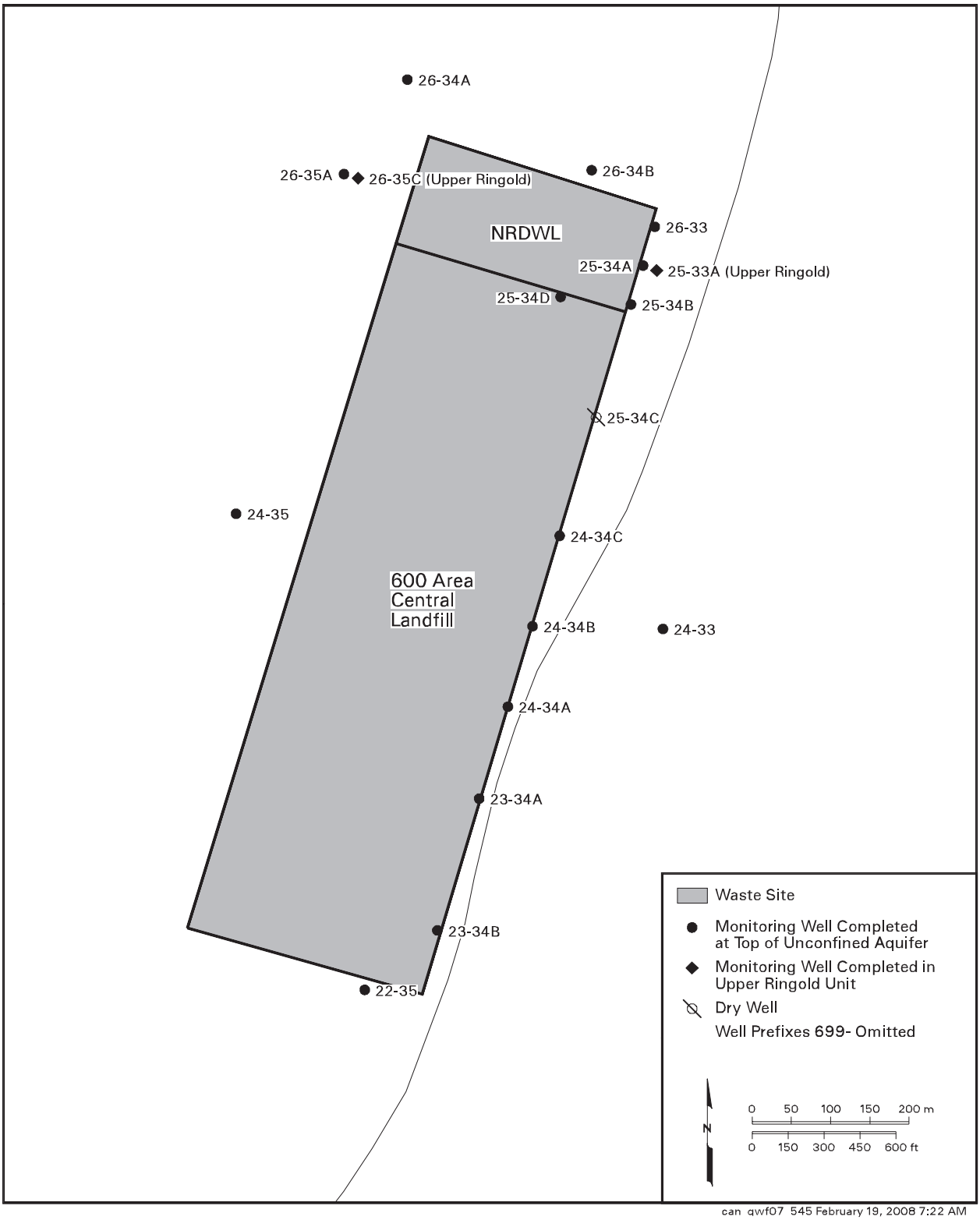

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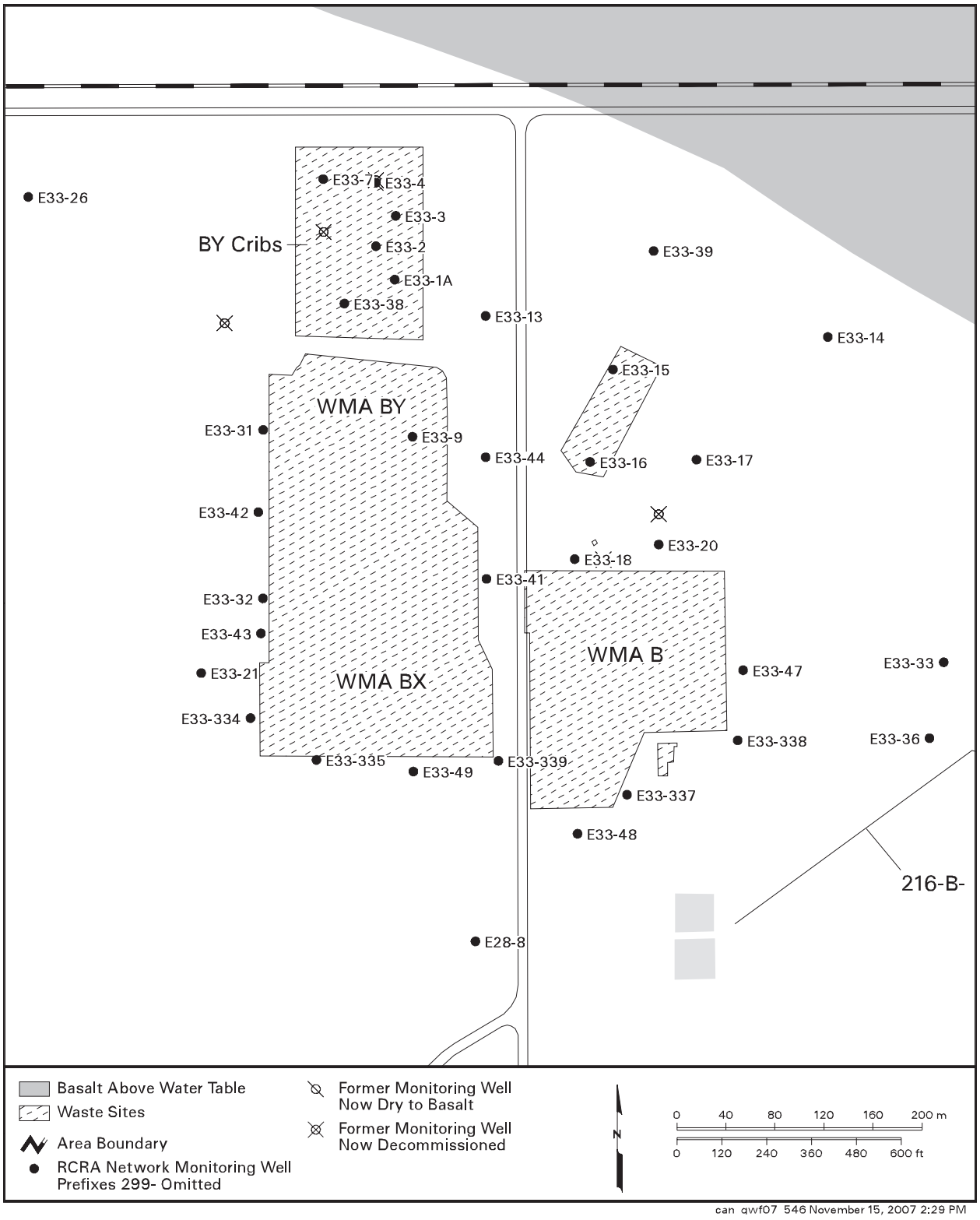


Figure B.16. Groundwater Monitoring Wells at Waste Management Area B-BX-BY

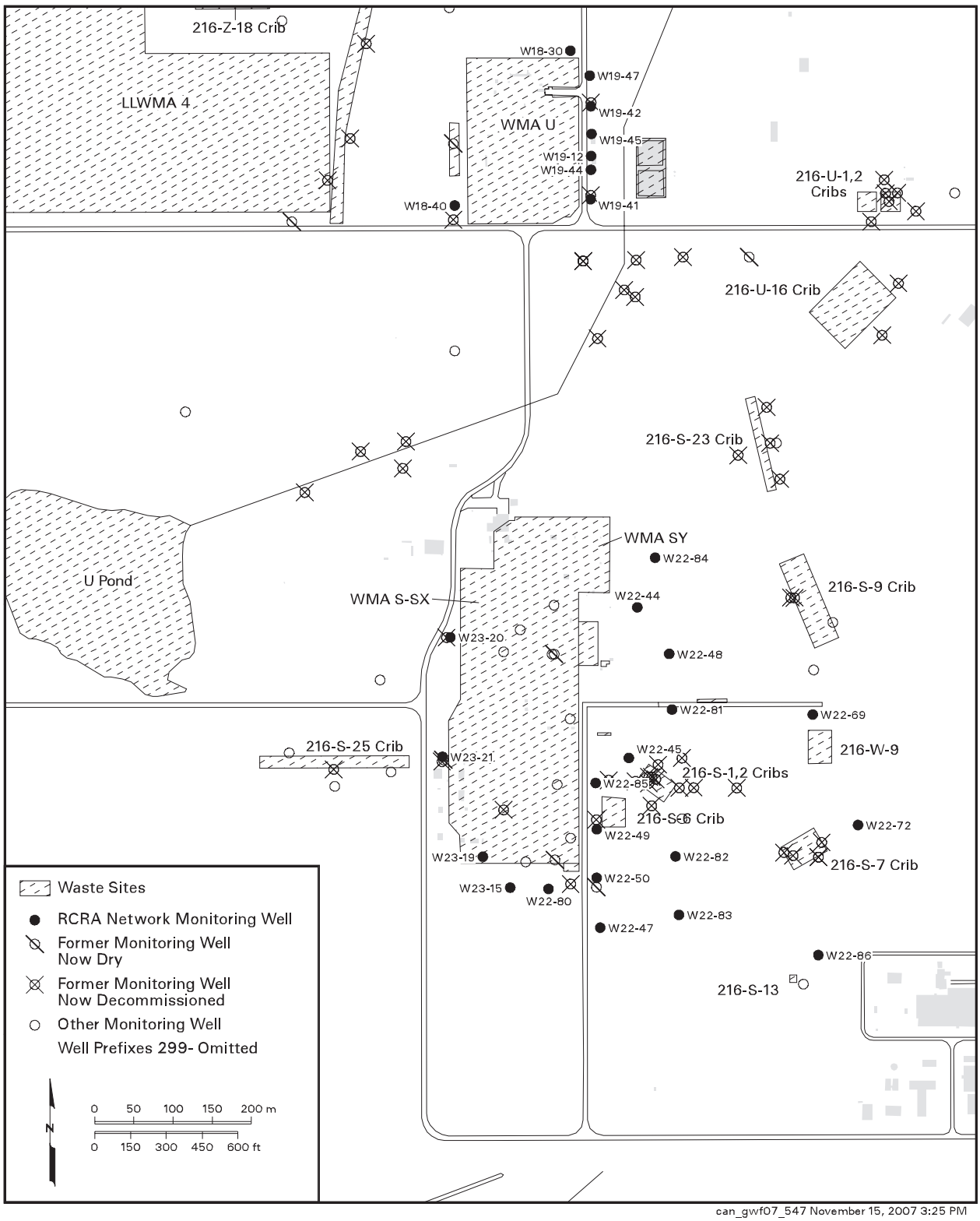
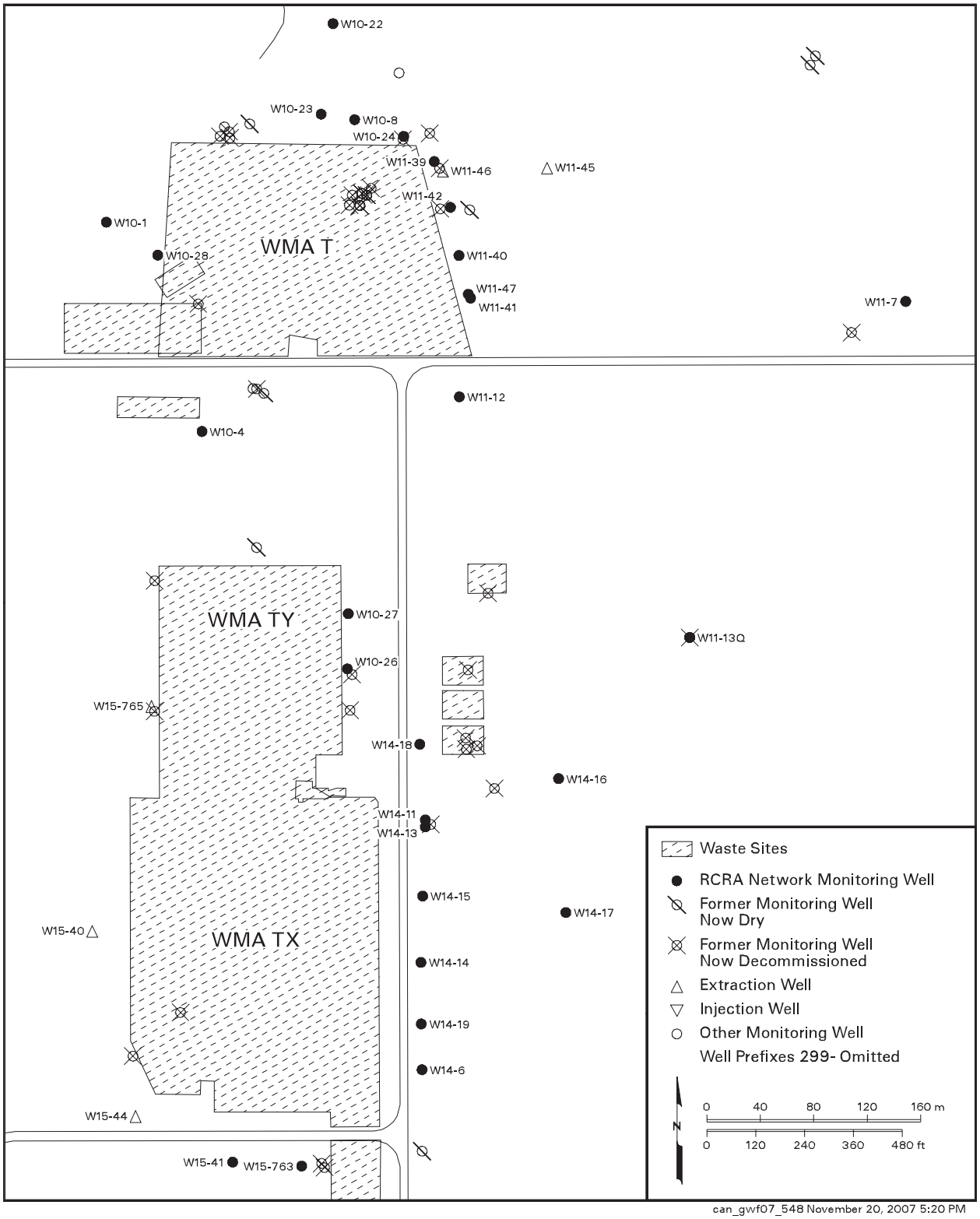


Figure B.17. Groundwater Monitoring Wells at Waste Management Areas S-SX and U



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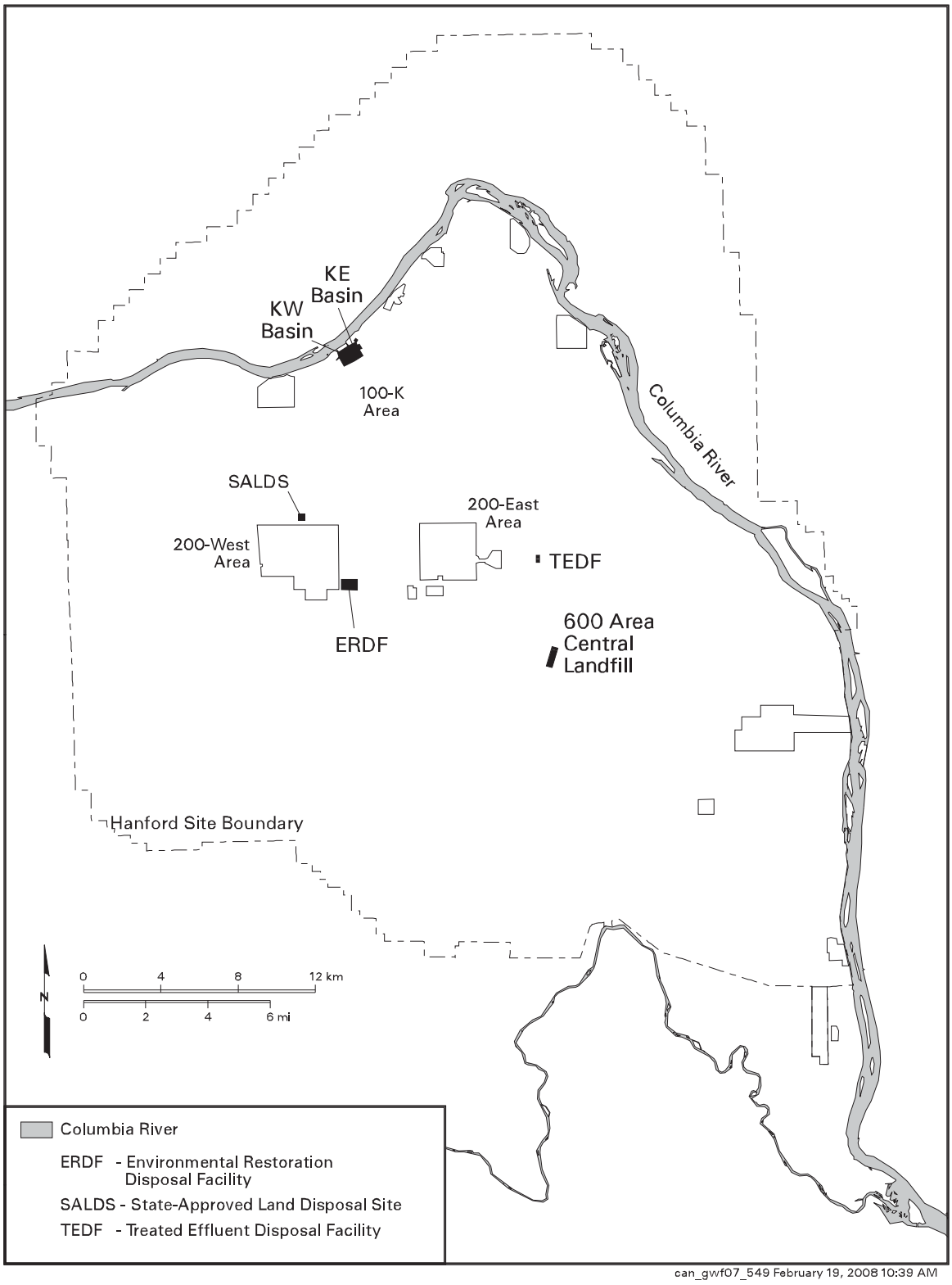
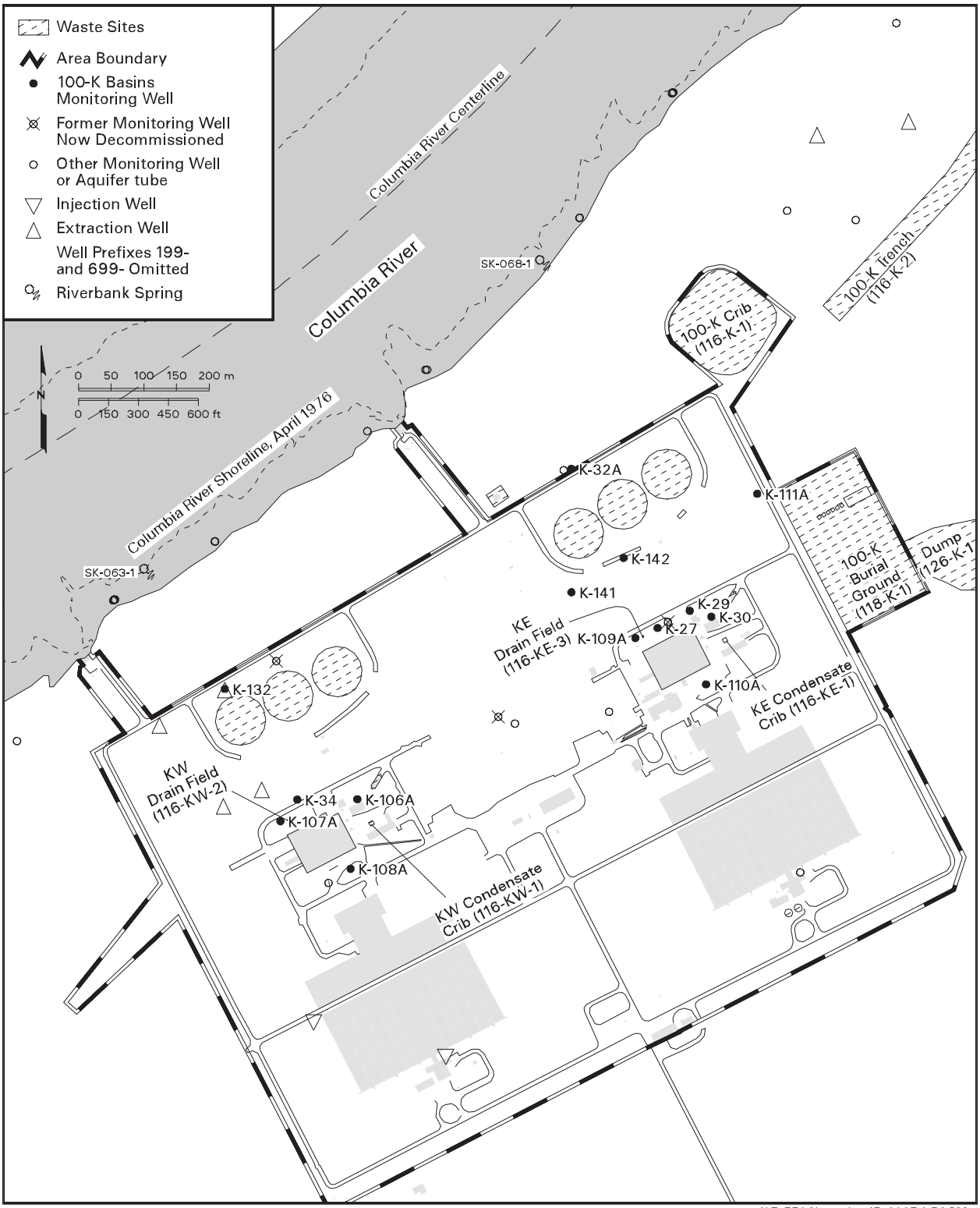


Figure B.19. Regulated Units on the Hanford Site Requiring Groundwater Monitoring



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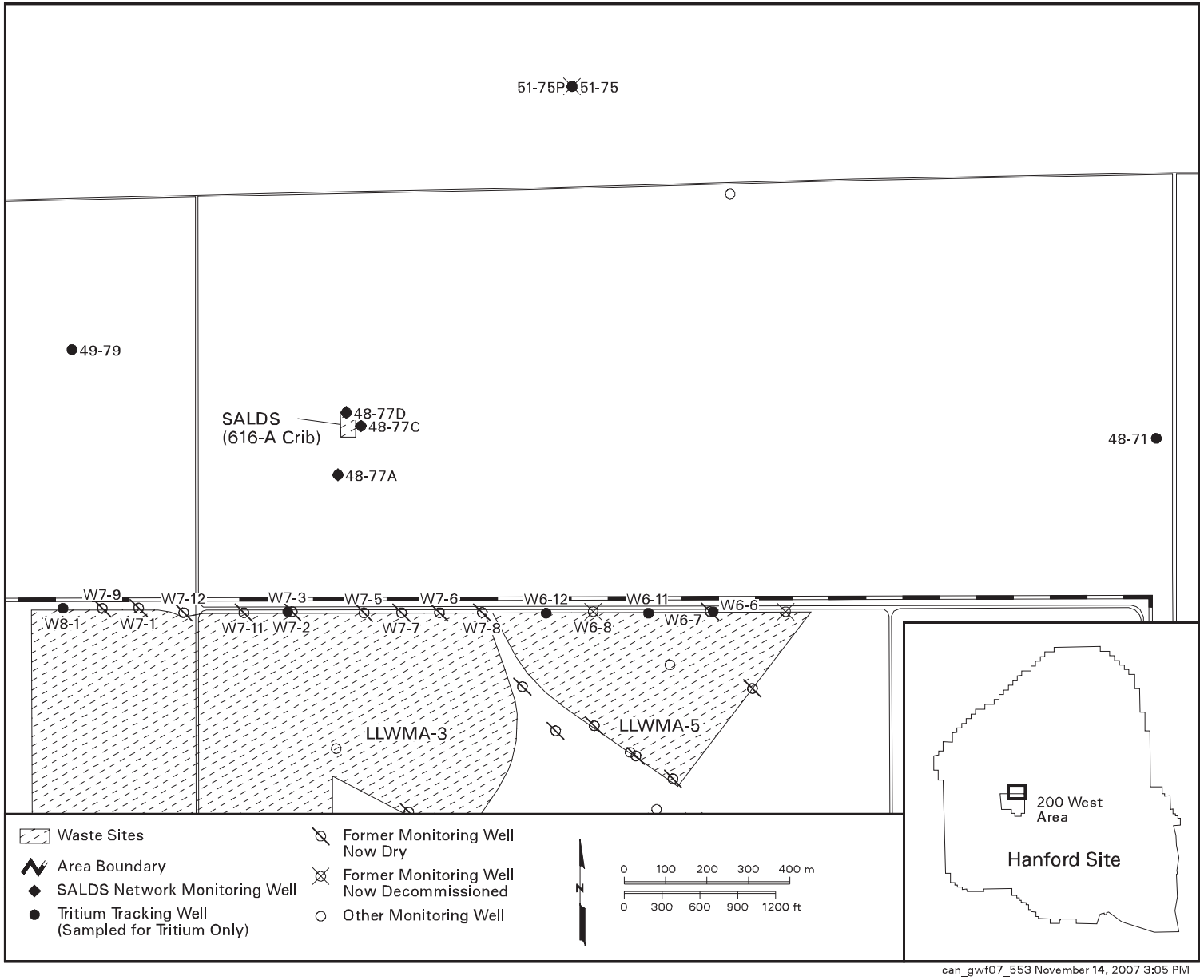

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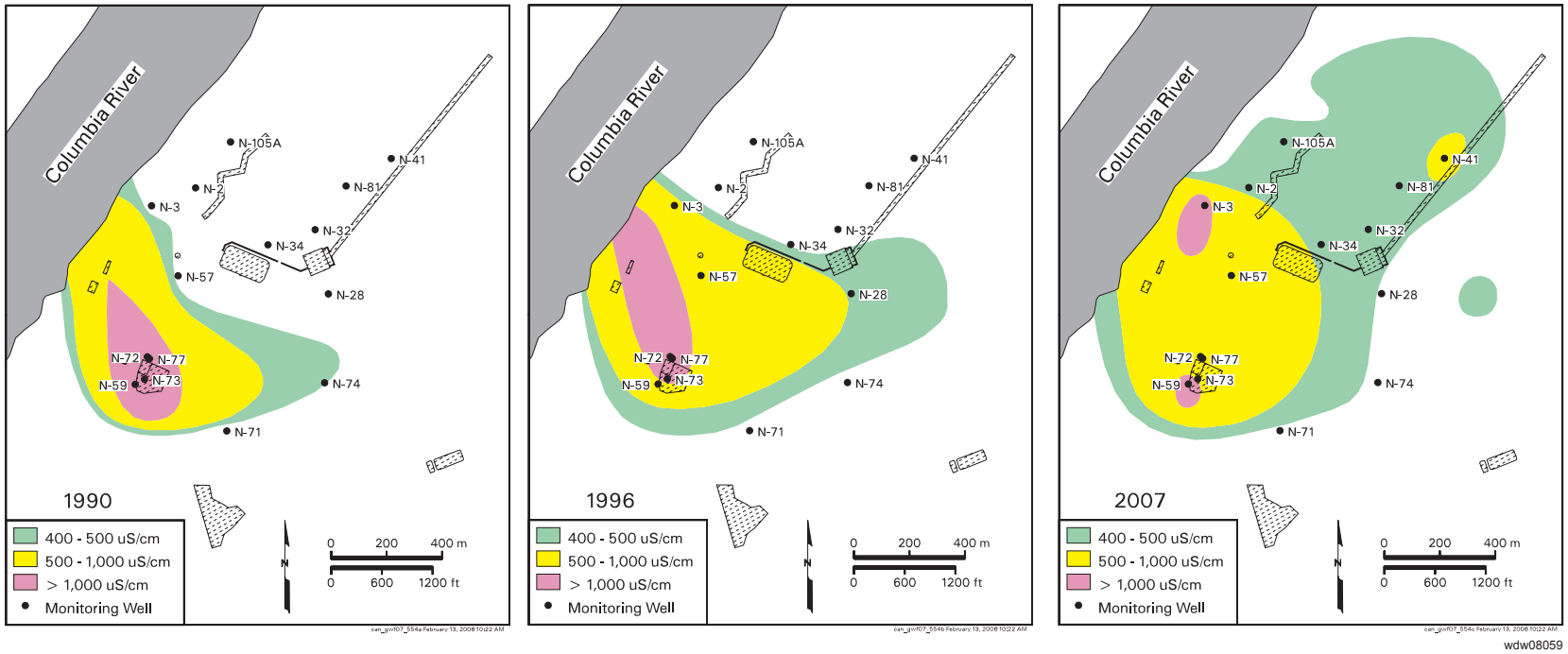

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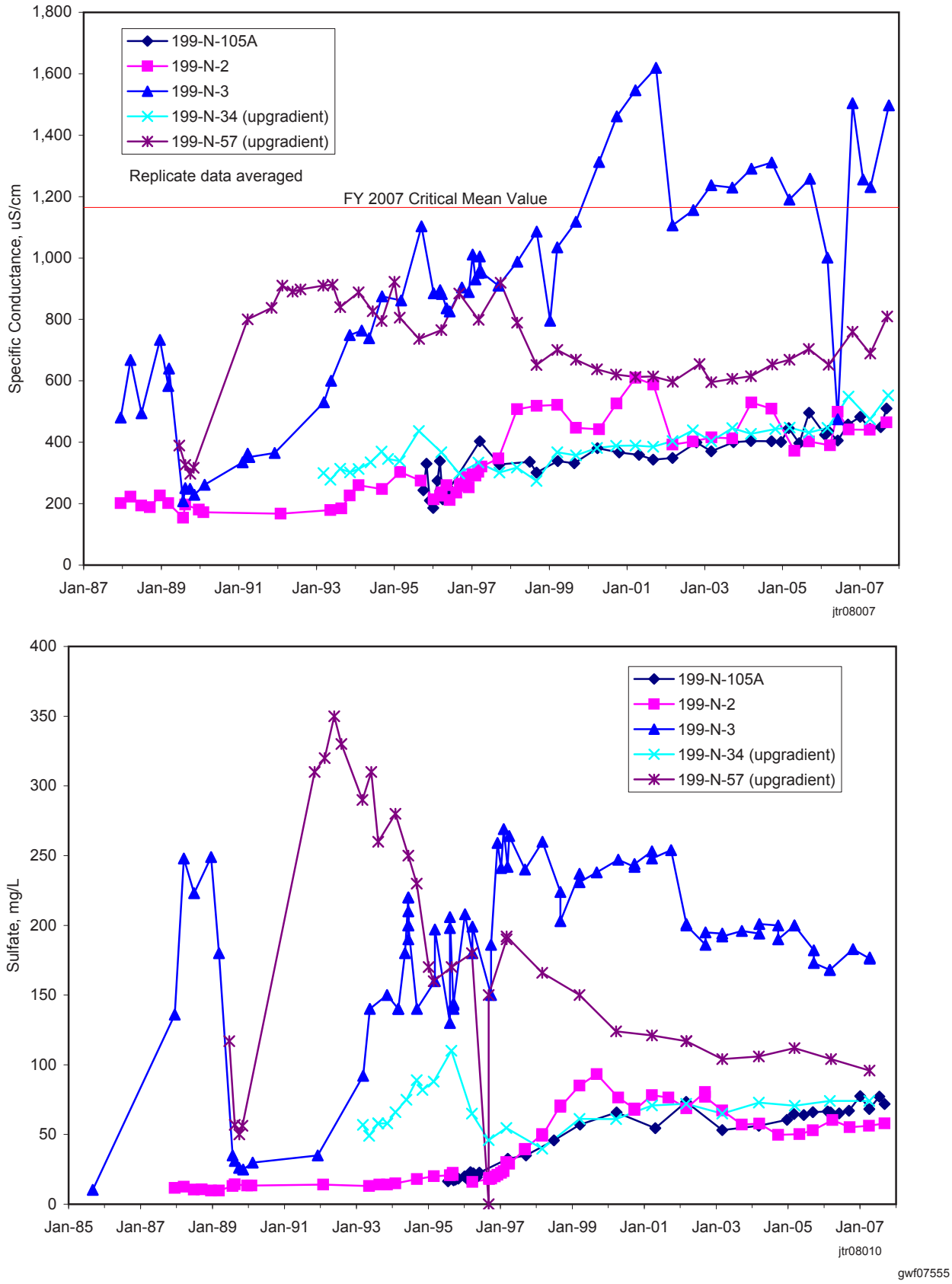
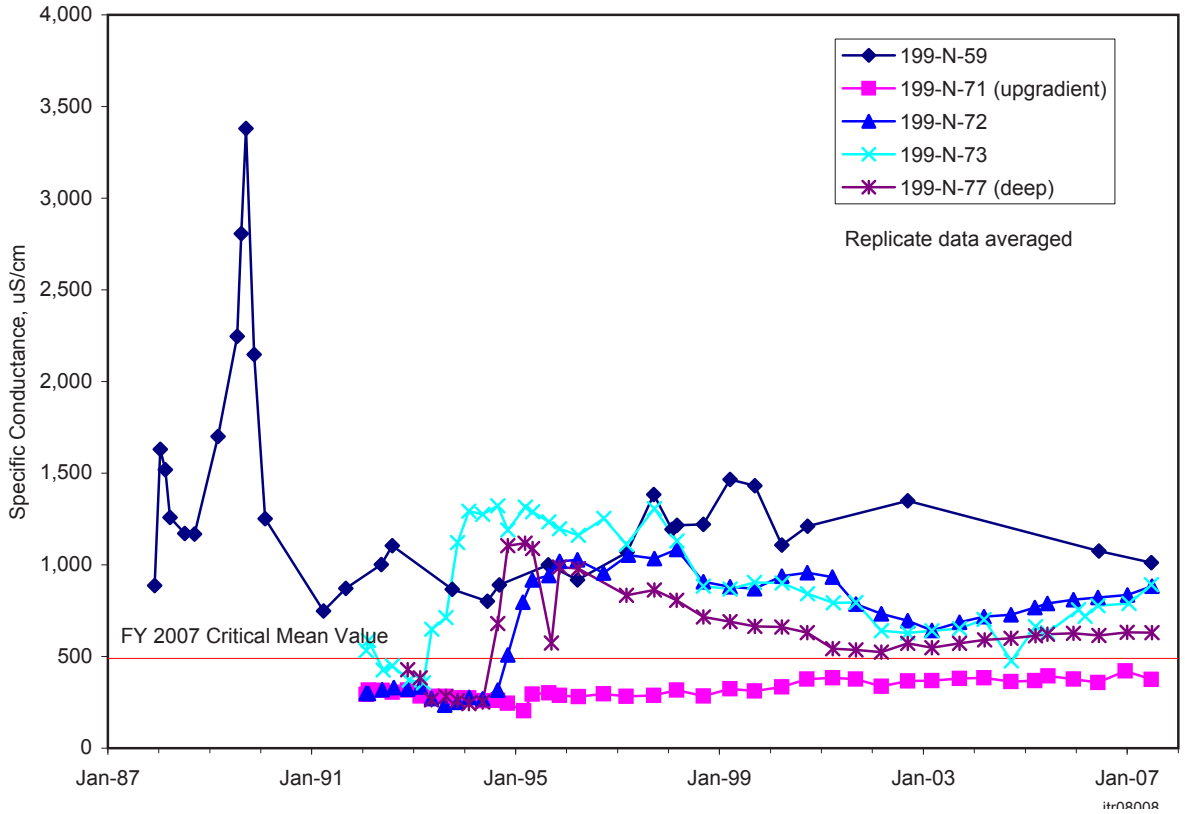


Figure B.23. Specific Conductance and Sulfate in Wells Monitoring 116-N-1 Facility



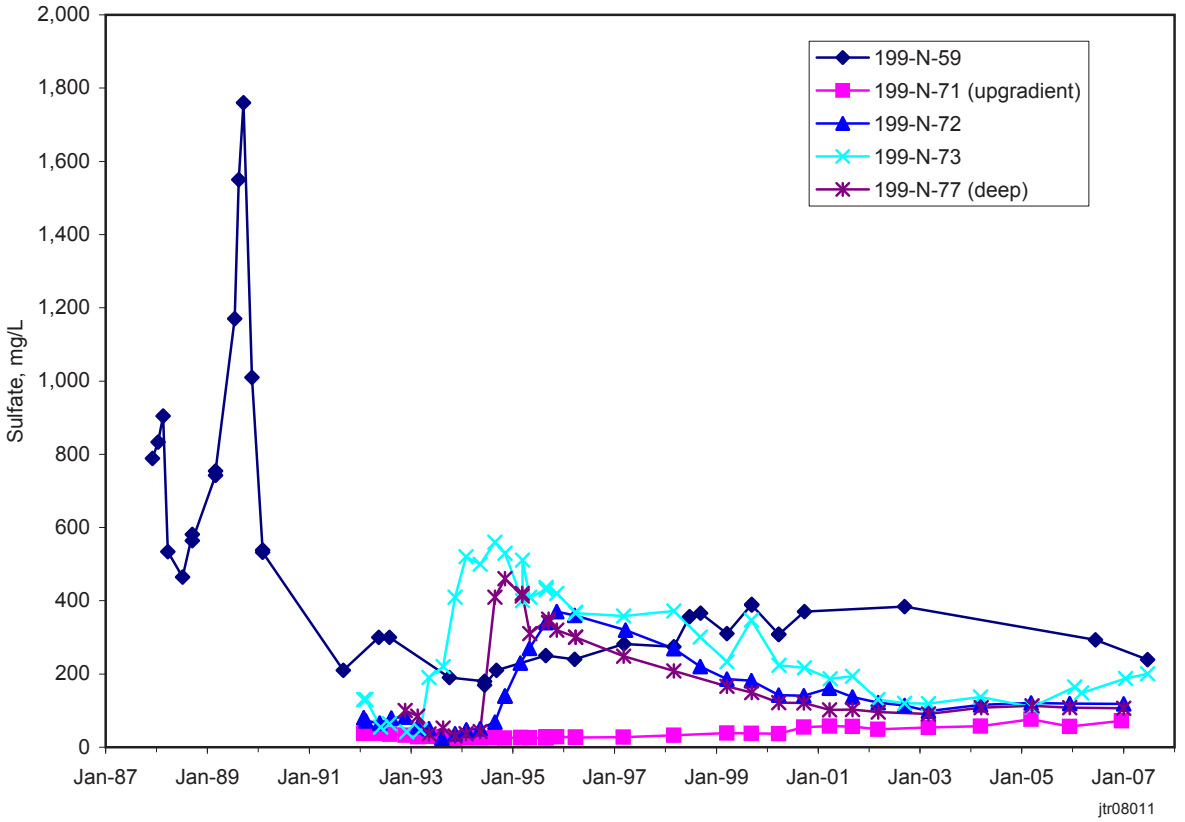


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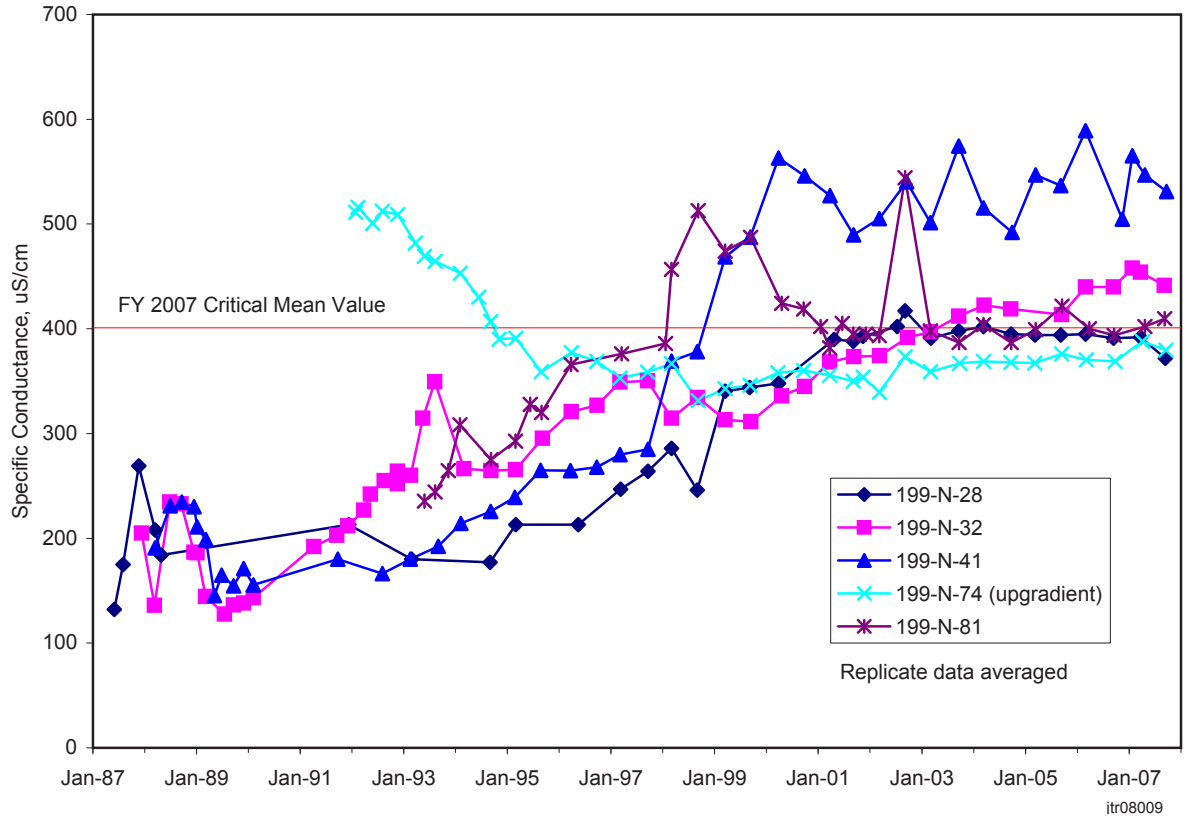
Figure B.24. Specific Conductance and Sulfate in Wells Monitoring 120-N-1 Facility



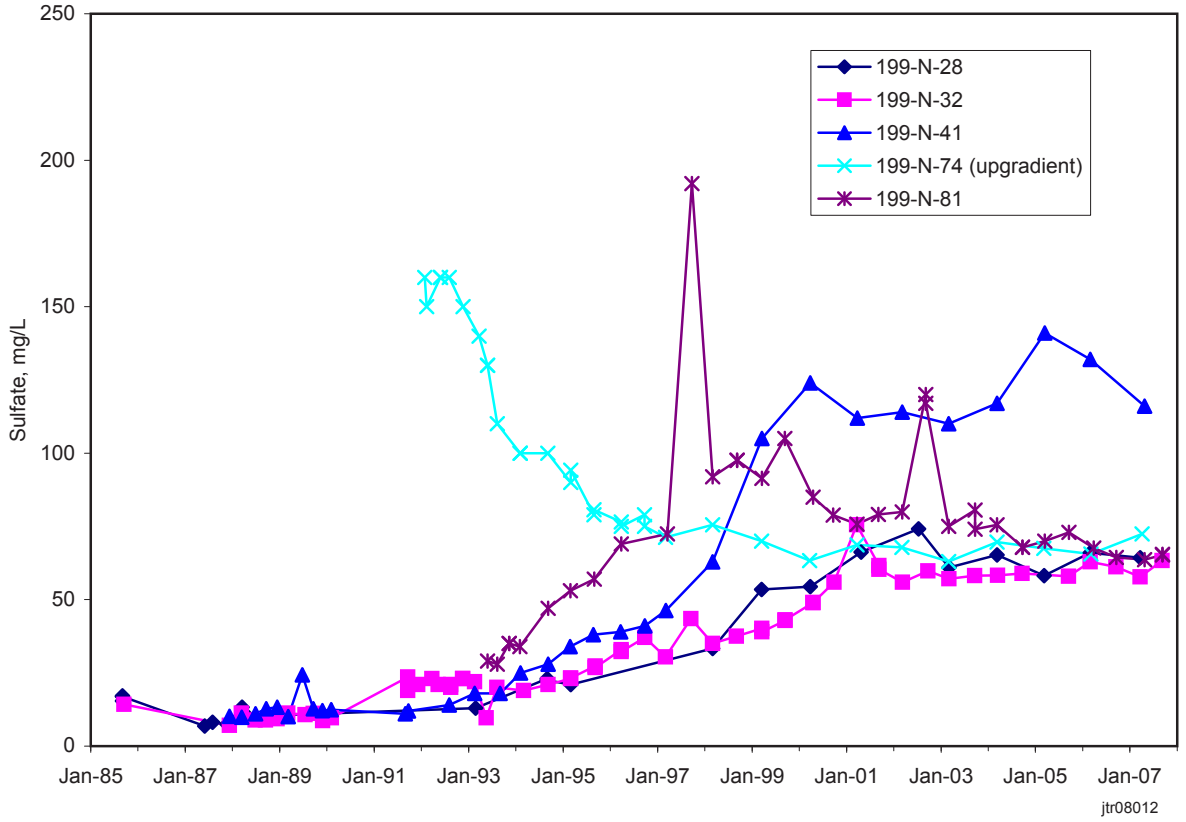


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Figure B.25. Specific Conductance and Sulfate in Wells Monitoring 116-N-3 Facility

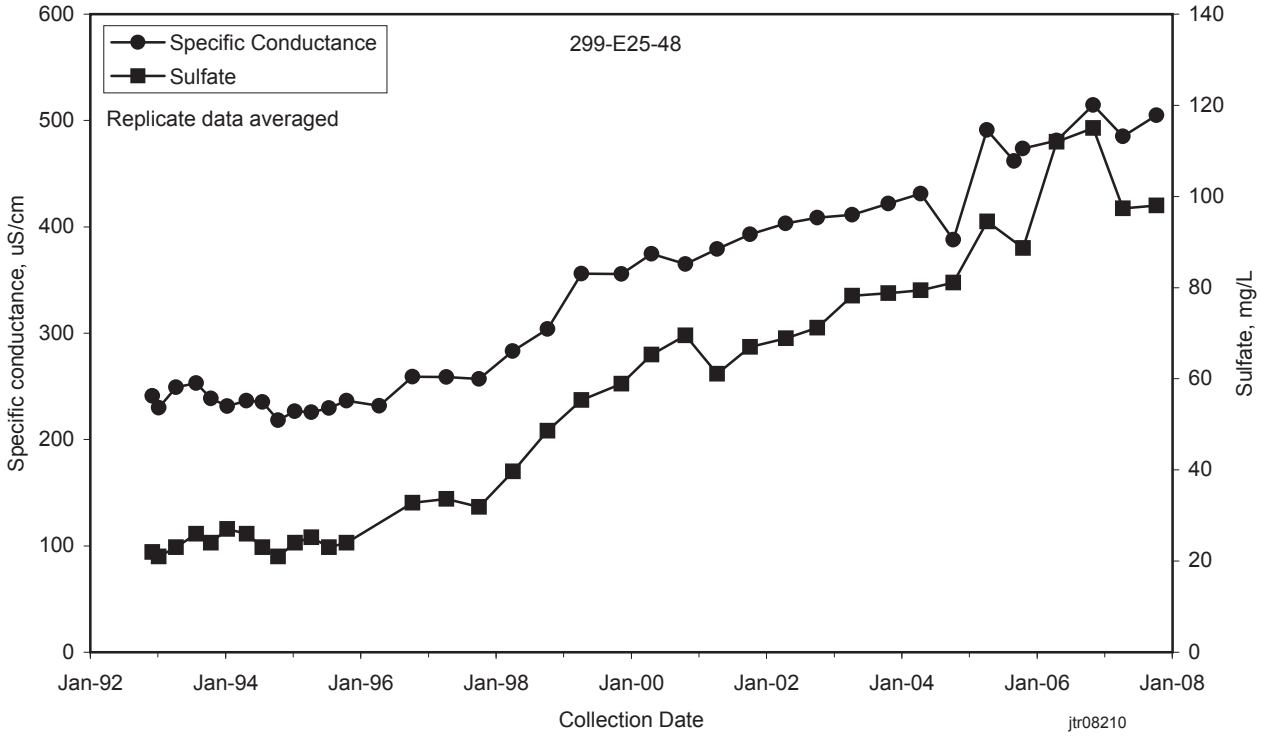
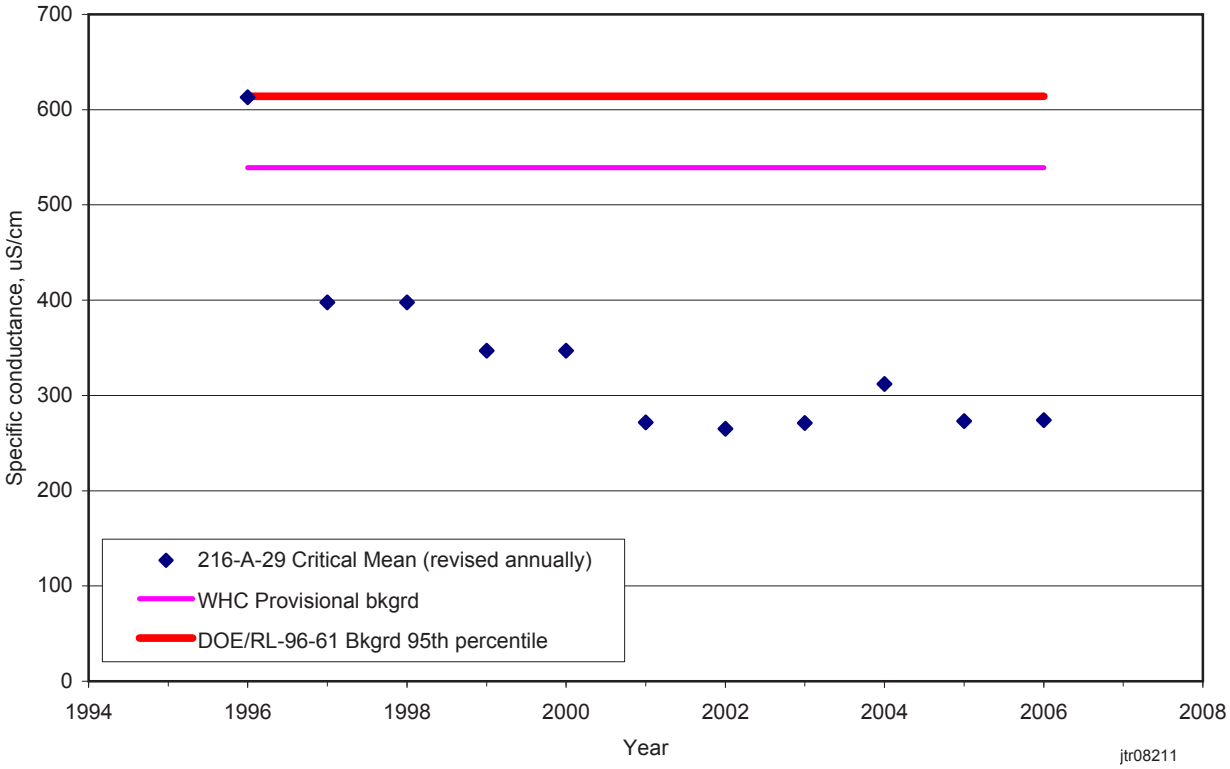


Figure B.26. Specific Conductance and Sulfate in Well 299-E25-48 at the 216-A-29 Ditch



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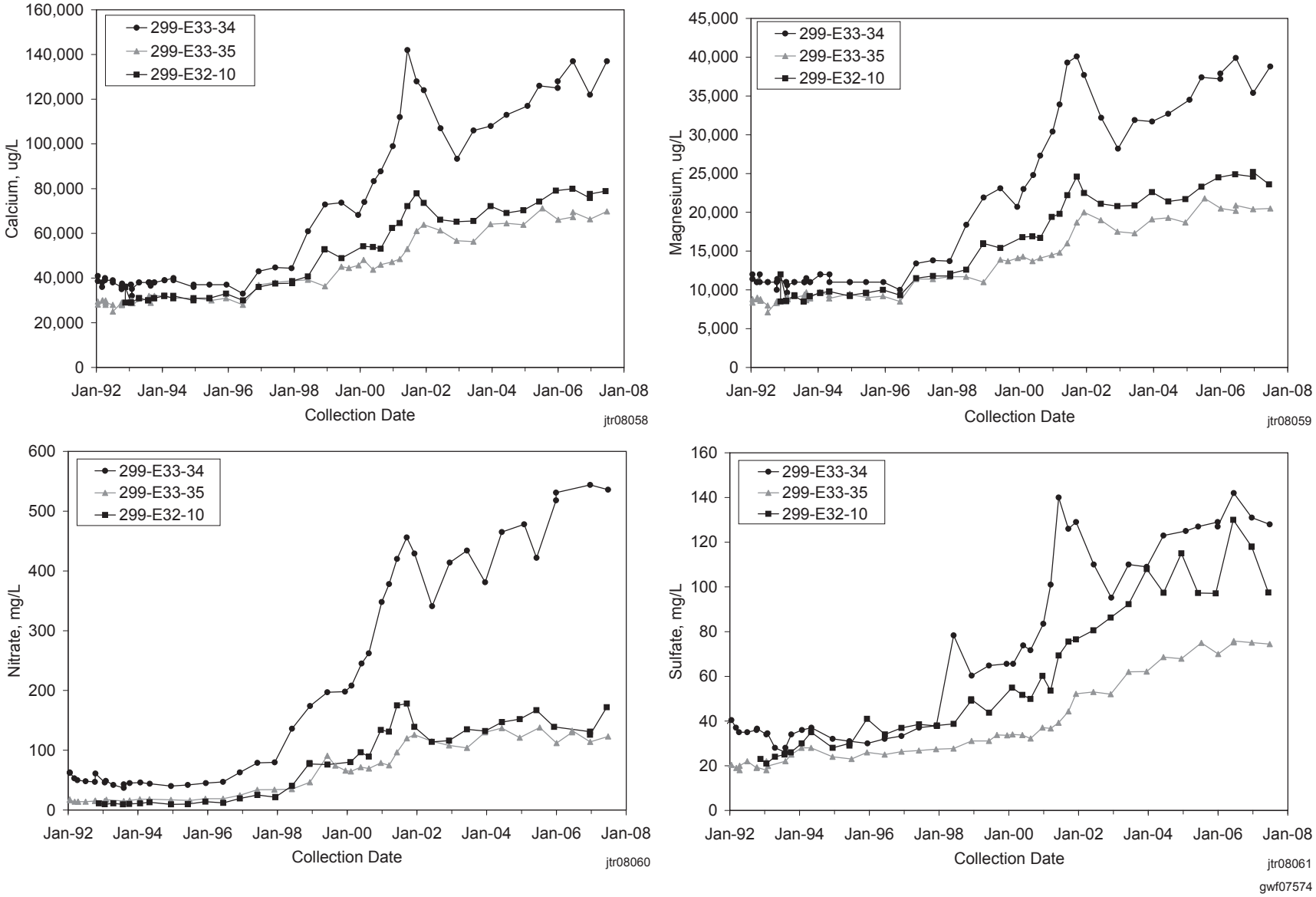

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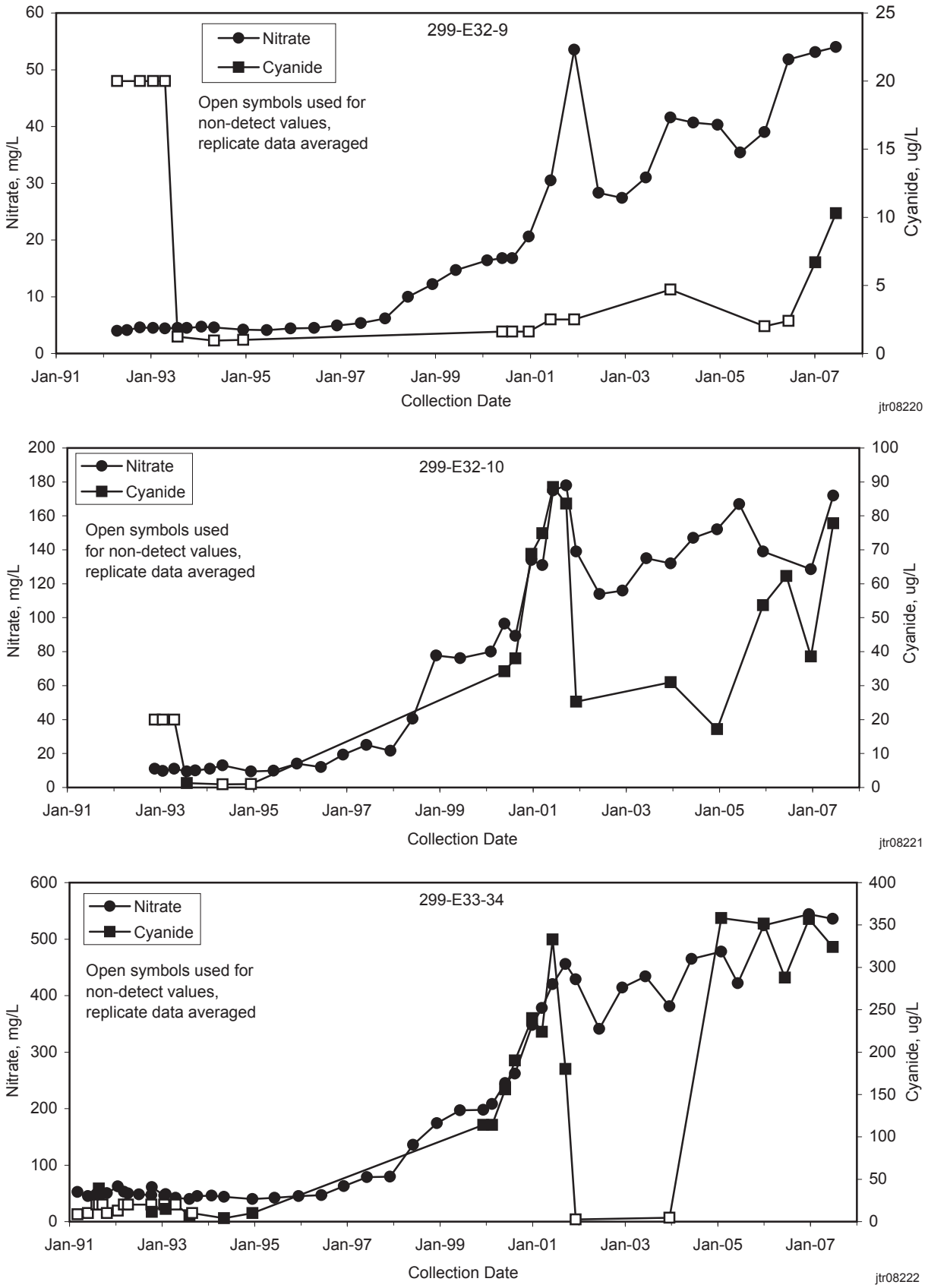

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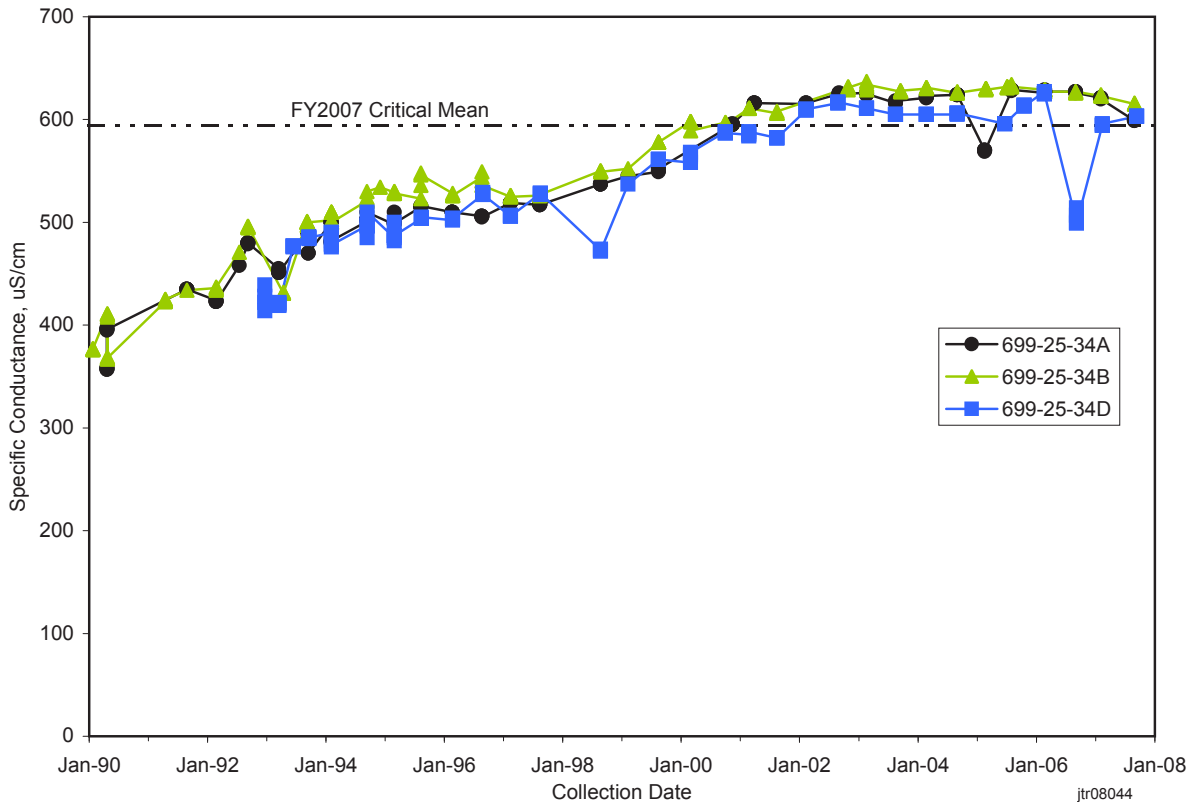


Figure B.30. Specific Conductance at the Nonradioactive Dangerous Waste Landfill

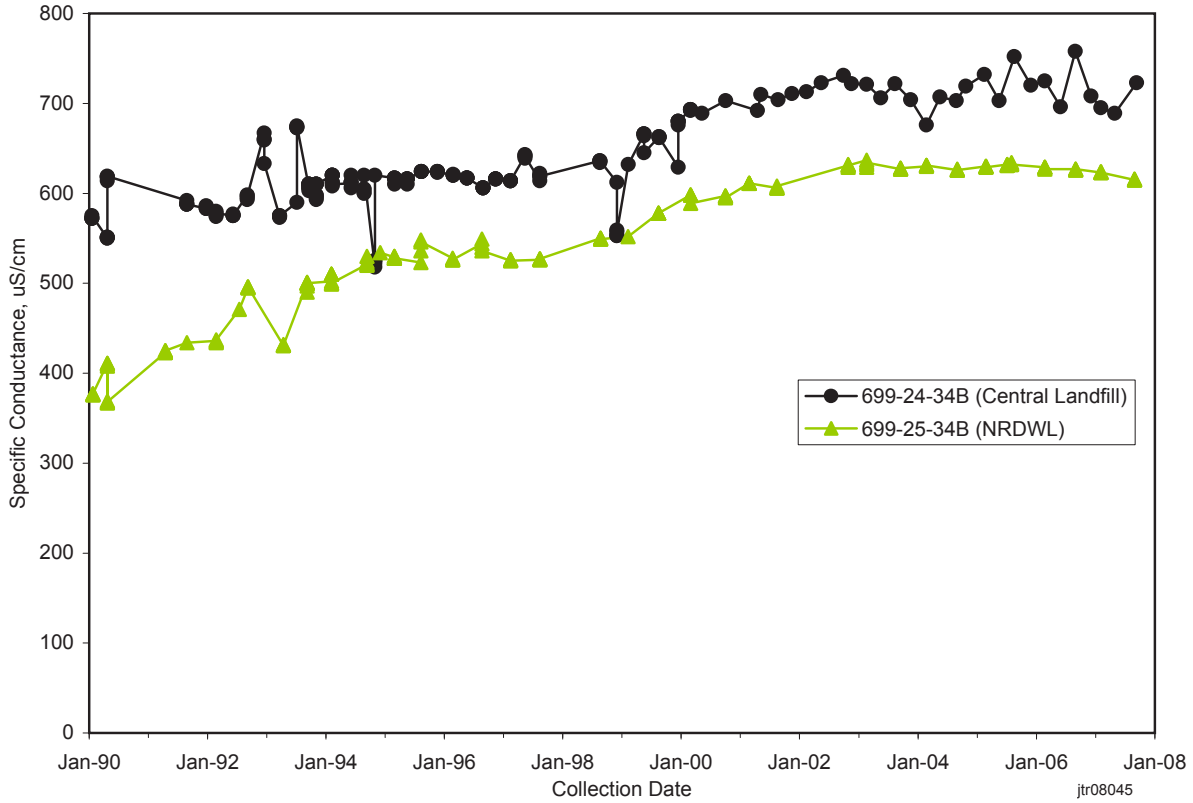
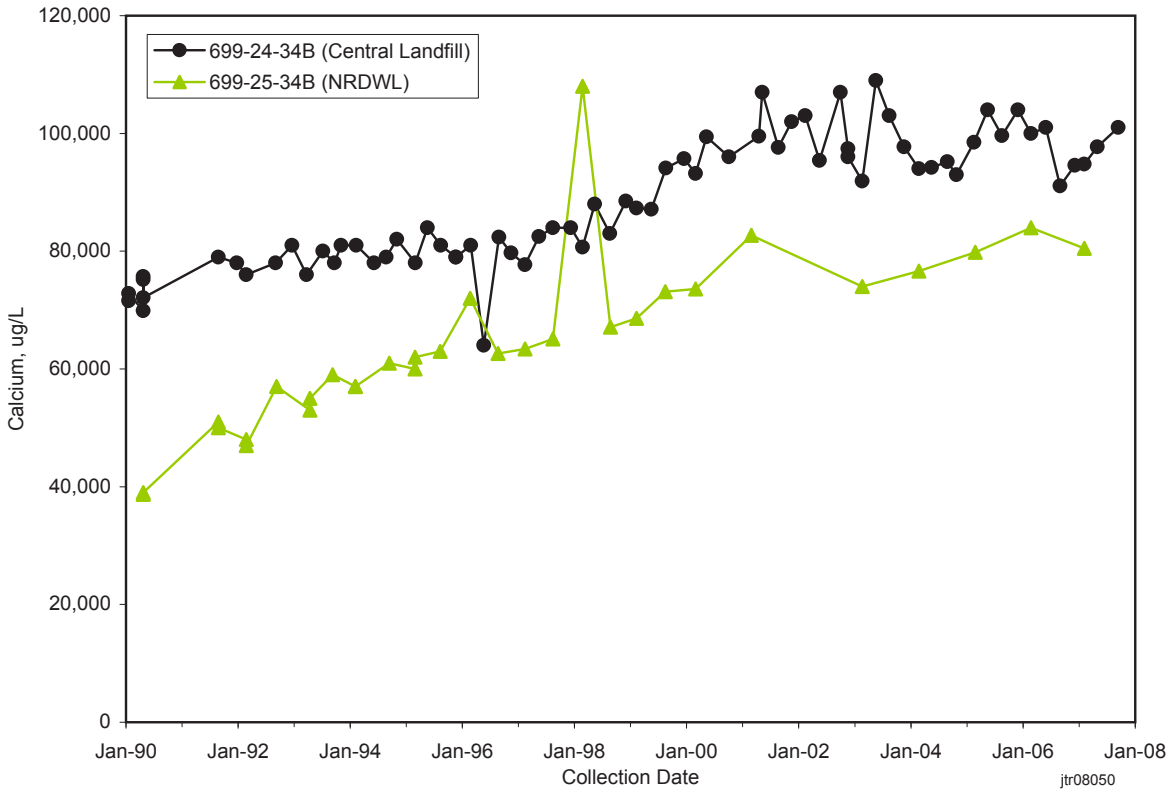


Figure B.31. Comparison of Specific Conductance at 600 Area Central Landfill and Nonradioactive Dangerous Waste Landfill



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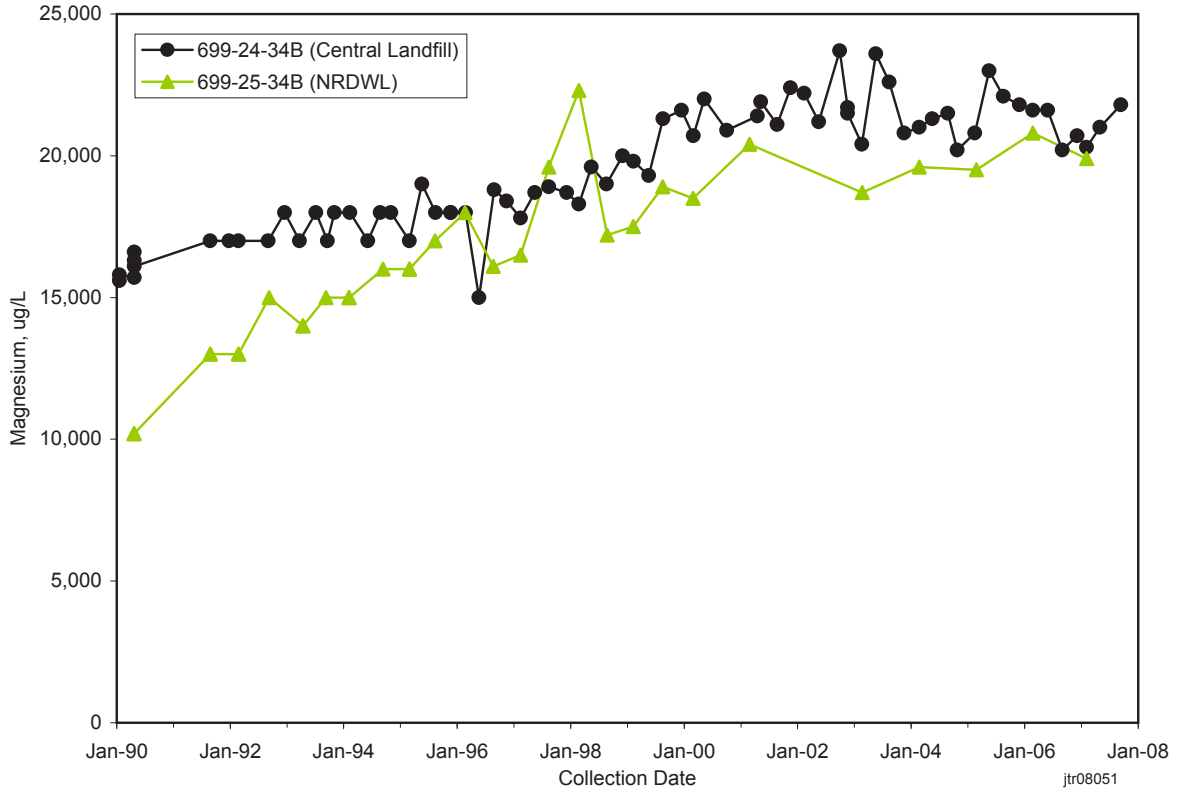

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Appendix C

Quality Assurance and Quality Control

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Appendix C

Quality Assurance and Quality Control

H. L. Anastos and C. J. Thompson

This appendix presents fiscal year (FY) 2007 quality assurance/quality control (QA/QC) information for groundwater monitoring at the Hanford Site. Both long-term and interim action groundwater monitoring are managed by Fluor Hanford, Inc. via the Soil and Groundwater Remediation Project (groundwater project). The phrase "long-term monitoring" refers to monitoring performed to meet the requirements of the *Resource Conservation and Recovery Act* (RCRA) and the *Atomic Energy Act* (AEA). Long-term monitoring also includes monitoring performed at *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) sites with no active groundwater remediation. Interim action monitoring encompasses monitoring at sites with active groundwater remediation under CERCLA. The QA/QC practices used by the groundwater project assess and enhance the reliability and validity of field and laboratory measurements conducted to support these programs. Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Representativeness, completeness, and comparability may also be evaluated for overall quality. These parameters are evaluated through laboratory QC checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and interlaboratory comparisons. Acceptance criteria have been established for each of these parameters. When a parameter is outside the criteria, groundwater project staff review the data, and if appropriate, corrective actions are taken to prevent a future occurrence.

The QA/QC practices for RCRA samples are based on guidance from the U.S. Environmental Protection Agency (EPA) (OSWER-9950.1 and SW-846). U.S. Department of Energy (DOE) Orders and internal requirements provide the guidance for the collection and analysis of samples for other long-term monitoring. The QA/QC practices for the groundwater project are described in the project-specific QA plan (GRP-QA-001, HNF-20635). Guidance for interim action monitoring QA/QC practices is provided in project-specific documents (e.g., DOE/RL-90-08; DOE/RL-91-03; DOE/RL-91-46; DOE/RL-92-76; DOE/RL-96-07; DOE/RL-96-90; DOE/RL-97-36; DOE/RL-2002-10; DOE/RL-2002-17). A glossary of QA/QC terms is provided in PNNL-13080. Additional information about the QA/QC program and FY 2007 data (e.g., results of individual QC samples and/or associated groundwater samples) is available on request.

C.1 Sample Collection and Analysis

H. L. Anastos and C. J. Thompson

Fluor Hanford, Inc. sampling crews collected groundwater samples for FY 2007. Their tasks included bottle preparation, sample set coordination, field measurements, sample collection, sample shipping, well pumping, and coordination of purge water containment and disposal.

During FY 2007, the groundwater project transitioned most of the chemical and radiological analyses from TestAmerica (TA) Laboratories (Richland and St. Louis) to the Waste Sampling and Characterization Facility (WSCF). WSCF is an on-site laboratory managed by Fluor Hanford, Inc. Section C.6.6 provides additional information about the transition.

TestAmerica Laboratories, Inc. was previously known as Severn Trent Laboratories, Incorporated. In June 2007, Severn Trent Laboratories filed a corporate charter amendment and changed their name to TestAmerica

Laboratories, Inc. This was a corporate name change only, and the laboratory is still part of the same legal corporate entity.

TA St. Louis and WSCF performed most of the routine analyses of Hanford groundwater samples for hazardous and non-hazardous chemicals. Lionville Laboratory, Incorporated, Lionville, Pennsylvania (Lionville Laboratory), served as a secondary laboratory for chemical analyses of split samples and blind standards. TA Knoxville, Tennessee (TA Knoxville), performed dioxin analyses. A limited number of hexavalent chromium and volatile organic analyses were performed by an on-site mobile laboratory. The mobile laboratory is also managed by Fluor Hanford, Inc.

TA Richland and the WSCF laboratory performed the majority of radiological analyses on Hanford groundwater samples. Eberline Services, Richmond, California, also analyzed samples for radiological constituents.

Standard methods from EPA and American Society for Testing and Materials (ASTM) were used for the analysis of chemical constituents. Methods employed for radiological constituents were developed by the analyzing laboratories and are recognized as acceptable within the radiochemical industry. Descriptions of the analytical methods used are available upon request.

C.2 Data Review and Validation

H. Hampt and M. J. Hartman

Groundwater project staff review and validate groundwater data according to an established procedure. Validation produces an electronic data set, with suspect or erroneous data corrected or flagged, that is useable by the groundwater project and others. The validation process includes the following activities:

- Review of sampling documents and analytical data verification.
- Quality control evaluation.
- Project scientists' evaluation.
- Statistical evaluation.
- Resolution of data issues that arose during the evaluation.

Sampling documents include the groundwater sampling record, chain-of-custody forms, field logbook pages, and other paperwork associated with sampling and shipping. Project staff review these forms to determine if the documents are filled out completely, signed appropriately, and legible. Staff also verify that analytical data from the laboratories are complete and reported correctly. Moreover, staff review laboratory documents to check the condition of the samples upon receipt at the laboratory and determine if problems arose during analysis that may have affected the data.

A quarterly evaluation of QC data is conducted as part of the validation process. Groundwater project staff assess the laboratories' internal QC practices and submit field QC samples and blind standards to the laboratories on a regular basis. QC results are then summarized for project scientists, DOE, and other data users.

Data management staff generate a series of routine data reports that project scientists review. Among these are biweekly data reports, which are generated twice each month and include analytical data that were loaded into the HEIS database since the previous reporting period. The tables are organized by groundwater interest area, RCRA site, or special project (e.g., confined aquifer data). As soon as practical after receiving a report, the project scientists review the data, typically by viewing trend plots, to determine (1) if there are significant changes in contaminant concentrations or distribution and (2) if there are data points that appear erroneous.

Project scientists also review quarterly compilations of the data. The quarterly review provides a method for project staff to check whether there were problems with sampling, all requested analyses were received, and the data seem to represent actual groundwater quality. Unlike the biweekly reports, the quarterly reports

usually include a full data set (i.e., all the data from the wells sampled during the previous quarter have been received and loaded into HEIS). This review also includes water-level data, preliminary maps of selected analytical data, and a partial listing of sampling comments. When specific questions arise regarding field measurements, analytical results, dates of analysis or sampling, or sample or well numbers, the project scientist requests a formal data review. The process for data reviews is described in Section C.2.1.

C.2.1 Requests for Data Review

Requests for data reviews are the formal mechanism used by the groundwater project to resolve specific issues with data that appear to have problems. When potential anomalies are encountered during a review of analytical data or water-level measurements, the project scientist reviewing the data will initiate a request for data review. Depending on the type of data issue, project staff will then do some or all of the following: request a laboratory recheck, recount, or re-analysis, review hard copy laboratory data, review sampling documents for data-entry errors or other problems, and/or flag the affected data with one of the review codes described in Table C.1.

When a laboratory re-analysis or recount is requested, the laboratory re-analyzes or recounts the original sample and reports the new results. If there is a discrepancy between the original and new results, groundwater staff will determine which results appear to be more representative and assign an appropriate review code to the results that are loaded into HEIS. Laboratory rechecks involve an internal laboratory review of the data. When discrepancies are discovered by the laboratory, the data are re-reported. The re-reported data are loaded into HEIS and flagged appropriately. A review of the sampling documents and/or the hard copy data from the laboratory can sometimes provide an explanation for unusual results (e.g., data entry errors or swapped samples in the field).

Requests for data reviews are most commonly resolved by assigning Y, G, or R review codes to the data in HEIS; however, all of the review codes help define limitations on the data. If a review determines that the result is valid, the result is flagged with a G. If there is clear, documented evidence that a result is erroneous, the result is flagged with an R. The Y code is used when a review did not show if a result was valid or invalid, but the result appears suspect. Data flagged with a Y or R are typically excluded from statistical evaluations, maps, and other interpretations, but are not deleted from HEIS. Occasionally, a request for data review is submitted on data that are not managed by the groundwater project (e.g., data associated with active remediation projects). In those cases, the data owner is notified, but no further action is taken by the groundwater project.

Table C.2 lists the number of analytical and water-level results that were flagged during FY 2007 as a result of the request for data review process. As of December 13, 2007, the resolution of a number of requests is pending, and additional requests may yet be filed on FY 2007 data. Requests for data reviews have been filed on 1,470 out of 69,911 analytical results (~2%), an increase over FY 2006 (1%). Similarly, 5.6% (222 out of 3937) water-level results were associated with requests for data reviews in FY 2007, an increase from FY 2006 (2.8%). In several instances, trends were observed in the requests for data reviews that warranted further evaluation by QC staff. A summary of the steps taken to troubleshoot those issues is found in section C.6.5.

C.3 Data Completeness

C. J. Thompson

Data judged to be complete are data that are not suspect, rejected, associated with a missed holding time, out-of-limit field duplicate or field blank, or qualified to indicate laboratory blank contamination. During FY 2007, 94% of the groundwater data (both long-term and interim action monitoring) were considered complete. The percentages of potentially invalid data were 2.1% for field QC problems, 0.9% for exceeded holding times, 0.5% for rejected results, 0.2% for suspect values, and 3.4% for laboratory blank contamination. These values are similar to the percentages observed in FY 2006.

C.4 Field Quality Control Samples

H. L. Anastos and C. J. Thompson

Field QC samples include field duplicates, split samples, and three types of field blanks. The three types of field blanks are full trip, field transfer, and equipment blanks. Field duplicates are used to assess sampling and measurement precision. Split samples are used to confirm out-of-trend results and for interlaboratory comparisons. Field blanks provide an overall measure of contamination introduced during the sampling and analysis process.

The groundwater project's criteria for evaluating the analytical results of field QC samples are as follows:

- Field Duplicates – Results of field duplicates must have precision within 20%, as measured by the relative percent difference. Only those field duplicates with at least one result greater than five times the method detection limit or minimum detectable activity are evaluated.
- Split Samples – Results must have a relative percent difference <20%. Only those results that are greater than five times the method detection limit or minimum detectable activity at both laboratories are evaluated.
- Field Blanks – For most chemical constituents, results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the method detection limit. Results for metals are flagged if they exceed two times the method detection limit. For radiological data, blank results are flagged if they are greater than two times the total minimum detectable activity.

If a field blank does not meet the established criteria, it is assumed that there are potential problems with the data for all associated samples. For full-trip and field-transfer blanks, an associated sample is one that was collected on the same day and analyzed by the same method as a full-trip or field-transfer blank. For equipment blanks, an associated sample is one that has all of the following in common with an equipment blank:

- Collection date.
- Collection method/sampling equipment.
- Analysis method.

Data associated with out-of-limit field blanks are flagged with a Q in the database to indicate a potential contamination problem. A Q is also applied to both duplicate results when their precision exceeds the QC limits.

The percentages of acceptable field blank (8,246/8,541 = 97%) and duplicate (2,146/2,189 = 98%) results evaluated in FY 2007 were high, indicating little problem with contamination and good precision overall. Due to the laboratory transition, 88 split samples were collected this fiscal year. Approximately 1,100 pairs of data were produced from the split samples, and overall, the laboratories obtained reasonable agreement.

Tables C.3 through C.6 summarize the field blank and field duplicate results that exceeded QC limits. To assist with their evaluation, the tables are divided into the following categories, where applicable: general chemistry parameters, ammonia and anions, metals, volatile organic compounds, semivolatile organic compounds, and radiological parameters. Constituents not listed in the tables had 100% acceptable field blanks and/or field duplicates.

With the exception of semivolatile organic compounds, all classes of constituents had results that were flagged as potentially contaminated because of out-of-limit field blank results. A few constituents such as alkalinity, total organic halides, chloride, nitrogen in nitrate, barium, calcium, chromium, cobalt, copper, iron, magnesium, silver, sodium, vanadium, zinc, carbon disulfide, carbon tetrachloride, methylene chloride, gross

beta, and tritium had several quantifiable field blank results; however, the concentrations were much lower than the levels of these constituents in almost all groundwater samples.

Compared to FY 2006, the number of elevated field blank results for total organic carbon decreased (11% to 0%). The frequency and magnitude of elevated field blanks for other general chemistry parameters remained consistent with FY 2006.

Relative to FY 2006, the number of field blank results for chloride that exceeded the QC limits decreased significantly (54% to 17%). The laboratory method blank detections for chloride also decreased in FY 2007 (from 47.5% to 27.3% for TA and 0% for WSCF). Approximately 81% of the chloride field blank detections were from TA, indicating that many of these results may be due to false positives. However, the results detected were much lower than the levels of chloride typically found in Hanford groundwater.

Eighty-two field blank results for metals exceeded the QC limits, which is higher than the number (27) from last year. Most of the unacceptable results were within a factor of 5 of the detection limits. Relative to FY 2006, the number of elevated field blank results this year increased, for example, chromium (2% to 9%), silver (0% to15%) and zinc (13% to 22%). Several of the metals (i.e., arsenic, barium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, silver, sodium, strontium, vanadium, and zinc) with out-of-limit field blank results had one or more comparable method blank results, suggesting that some of the elevated field blank values were caused by false detections or laboratory contamination.

Concentrations of six volatile organic compounds exceeded the QC limits in one or more field blanks. Methylene chloride was the predominant volatile contaminant, accounting for 86% of the volatile out-of-limit results. Laboratory contamination is the suspected source of this common contaminant, because similar concentrations were also measured in several method blanks. Seven field blanks, however, had concentrations that were more than two times greater than that of the highest laboratory blank. Trace levels of several other volatile organic compounds were also measured in field blanks (Tables C.3 and C.4). In general, the frequencies of detection for these compounds were low (<5%). The overall impact on the data is believed to be minor.

Gross beta, strontium-90, tritium, and uranium were the only radiological constituents with out-of-limit field blank results. Although their field blank concentrations were low, they were greater than levels of these constituents in some of the associated groundwater samples. Gross beta and uranium were also measured in one or more laboratory method blanks at concentrations similar to the field blank values.

Duplicate results were flagged for all constituent classes except semivolatile organic compounds (Table C.6). Overall, the relative number of flagged duplicate results was very low (2%), but the percentages of unacceptable results were high for several constituents based on the number of duplicates that met the evaluation criteria. Most of the associated samples in the radiological parameters category were unfiltered; thus, suspended solids in heterogeneous sample fractions may have caused some of the discrepancies in the results. The majority of the out-of-limit duplicate results appear to be anomalous instances of poor precision based on other QC indicators such as the results from the laboratory duplicates. In several cases, the laboratory was asked to re-analyze or investigate duplicate results with a very high relative percent difference, but the checks did not reveal the source of the problem. Especially poor agreement was observed between pairs of results for nitrite (i.e., non-detect and 2000 µg/L; non-detect and 821 µg/L; non-detect and 460 µg/L; non-detect and, 3940 µg/L). All eleven duplicate failures for nitrite were associated with the TA St. Louis laboratory. Nitrite issues at TA St. Louis are discussed in more detail in Section C.6.5.

In FY 2007, 88 split samples were analyzed for 91 different analytes generating nearly 1,100 field split pairs of data. In general, there was reasonable agreement between laboratories when both data pairs were greater than five times the reporting limit (or minimum detectable activity for radionuclides). Fifty-five of the pairs were outside the acceptance limits of 20% relative percent difference. Chloride, cyanide, fluoride, nitrogen in nitrate, iron, and manganese had several pairs that exceeded the 20% relative percent difference criteria. The results for field splits that exceeded QC limits are summarized in Table C.7.

In addition, the splits data was used to evaluate the performance of the laboratories during the transition of most analyses to the WSCF laboratory. For this review, the data was evaluated even when the result was less than five times the reporting limit. Overall, most of the data from WSCF agree reasonably well with the data generated from the commercial laboratories. A few discrepancies have been identified for metals, anions, gross alpha, gross beta, cyanide and strontium-90.

Several metals, such as iron, potassium and zinc had several splits with poor agreement. The WSCF data does not show a consistent trend (high or low), but generally appears to show more variability than the other laboratories. WSCF is currently troubleshooting their metal analyses and the groundwater project will submit additional blind samples in FY 2008 to investigate further.

The chloride and fluoride anion data generated by WSCF is 20% to 40% lower than the TA data. However, review of the raw data has indicated that the issue is most likely elevation of the TA data due to organic acid interference. Section C.6.5 discusses some of the other current issues associated with TA anion analyses.

Some of the WSCF gross alpha data originally showed a very high bias; however, this was resolved by changing to an alpha discrete analysis technique. Data affected by this bias were either re-analyzed or flagged as not valid in HEIS. See Section C.6.5 for more discussion on the alpha discrete method. Since implementation of the alpha discrete method, the data appear to be consistent with the commercial laboratories and in line with previous trends. WSCF gross beta data continues to show a high bias relative to the commercial laboratories. Additional investigation is underway to determine if this is solely due to method calibration differences (see Section C.6.2).

WSCF cyanide data is consistently 20% to 50% higher than the corresponding TA data. However, all of the recent blind data and performance evaluation data for both laboratories are within acceptable ranges. The cause for the difference in laboratory results is not known at this time. Additional blind samples will be submitted in FY 2008 to continue to investigate this method.

WSCF strontium-90 data also show a high degree of variability relative to the commercial laboratories' data. This may be because WSCF used smaller sample sizes, as is noted in Section C.6.2. The laboratory has been directed to use larger samples sizes for all groundwater samples. Additional blind samples will be submitted in FY 2008 to continue to investigate this method.

C.5 Holding Times

H. Hampt and H. L. Anastos

Holding time is the elapsed time period between sample collection and analysis. Samples should be analyzed within recommended holding times to minimize the possibility of changes in constituent concentrations caused by volatilization, decomposition, or other chemical alterations. Samples are also refrigerated to slow potential chemical reactions within the sample matrix. Maximum recommended holding times for constituents frequently analyzed for the groundwater project are listed in Table C.8. Radiological constituents do not have recommended maximum holding times because these constituents are not typically lost under ambient temperatures when appropriate preservatives are used. Results of radionuclide analysis are corrected for decay from sampling date to analysis date.

During FY 2007, recommended holding times were exceeded for 280 out of 7,651 (3.7%) non-radiological sample analysis requests. This is a decrease compared to FY 2006 (4.9%). Use of the onsite laboratory (WSCF) shortens the shipping time and is expected to decrease the number of missed holding times. In general, the missed holding times should not have a significant impact on the data. Results for samples with missed holding times are flagged with an H in the database. TA St. Louis exceeded the holding times for 235 out of 4,904 (4.8%) sample analysis requests. A sample analysis request is defined as a sample that is submitted for analysis by a particular analytical method.

The constituents with the most missed holding times were alkalinity (25 samples), anions by EPA Method 300.0 (84 samples), total organic carbon (28 samples), cyanide (28 samples) and total organic halides (53 samples). TA Richland exceeded holding times for 2 out of 50 coliform analyses, but all 14 of the laboratory's hexavalent chromium analyses were performed within the recommended holding time. The WSCF laboratory missed holding times on 44 of 2,622 analyses (2%). Sixteen of the missed holding times were due to re-analysis requests on metals samples. The mobile laboratory missed the holding time on 1 of 28 hexavalent chromium samples.

C.6 Laboratory Performance

D. S. Sklarew, H. Hampt, S. J. Trent, and C. J. Thompson

Laboratory performance is measured by several indicators, including national performance evaluation studies, double-blind standard analyses, laboratory audits, and internal laboratory QA/QC programs. This section provides a detailed discussion of the performance indicators for TA St. Louis, TA Richland, and WSCF. Brief summaries of performance measures for Lionville Laboratory and Eberline Services are also presented throughout this section. The majority of the laboratories' results were within the acceptance limits indicating good performance overall.

C.6.1 National Performance Evaluation Studies

During FY 2007, Environmental Resources Associates and DOE conducted national studies to evaluate laboratory performance for chemical and radiological constituents. TA St. Louis, TA Richland, WSCF, and Lionville Laboratory participated in the EPA sanctioned Water Pollution and Water Supply Performance Evaluation studies conducted by Environmental Resources Associates. TA Richland, WSCF, and Eberline participated in the Environmental Resources Associates' InterLaB RadCheM Proficiency Testing Program. All five laboratories took part in DOE's Mixed Analyte Performance Evaluation Program. Results of those studies related to groundwater monitoring at the Hanford Site are described in this section.

C.6.1.1 Water Pollution Studies

The purpose of water pollution studies is to evaluate the performance of laboratories in analyzing selected organic and inorganic compounds. An accredited agency such as Environmental Resource Associates distributes standard water samples to participating laboratories. These samples contain specific organic and inorganic analytes at concentrations unknown to the participating laboratories. After analysis, the laboratories submit results to the accredited agency, which uses regression equations to determine acceptance and warning limits for the study participants. The results of these studies, expressed in this report as a percentage of the results that the accredited agency found acceptable, independently verify the level of laboratory performance. In the event of an unacceptable result, the laboratories may order an ERA QuiK™Response sample to verify successful corrective action. QuiK™Response samples are similar to water pollution/water supply samples, and results are reported in a comparable fashion.

For the two water pollution studies (ERA WP-144 and 150), two water supply studies (ERA WS-123 and 129) and one Quik™Response study (041307A) in which TA St. Louis participated this year, the percentage of results within acceptance limits submitted to the groundwater project ranged from 88% to 95% (Table C.9). Forty-five different constituents had unacceptable results, but only hexachlorobutadiene, benzene in gasoline range organics, and tetrachloroethene were out of limits in two studies in which they were measured. Several nutrients, total organic carbon, total organic halides, trace metals, several volatile organic compounds, and several nitroaromatics were out of limits in one of the studies. The laboratory provided information about possible causes for some of the unacceptable results and suggested corrective actions where appropriate. The

constituents that were out of limits in more than one study last year, fluoride and volatile solids, were also out of limits in one study this year. Fluoride was within limits in a second study (volatile solids was measured in only one study this year). Constituents that were out of limits in only one study during FY 2006 were within limits in FY 2007, except for ammonia as nitrogen; calcium hardness as calcium carbonate; orthophosphate as phosphorus; oil and grease (gravimetric); iron; chloromethane; hexachlorobutadiene; 1,2,3-trichloropropane; total organic halides; and benzene in gasoline range organics. Analyses for calcium hardness, oil and grease, and benzene in gasoline range organics are not performed on Hanford groundwater samples, so these unacceptable results do not impact the interpretation of Hanford groundwater data.

TA Richland participated in one water pollution study this year (ERA WP-144) for total coliforms and hexavalent chromium; both results were acceptable (Table C.9).

For the three water pollution studies (ERA WP-138, 144 and 150) and four Quik™Response studies (091306B, 100506C, 031507A, 090607E) in which WSCF participated this year, the percentage of results within acceptance limits ranged from 97% to 100% (Table C.10). The number of constituents reported in the water pollution studies was considerably fewer than those reported by TA St. Louis, so percentage results are not directly comparable. Six different constituents had unacceptable results in one of the studies, including three metals, total organic carbon, non-filterable residue, and chemical oxygen demand. The laboratory provided information about possible causes for some of the unacceptable results and suggested corrective actions where appropriate. Analyses for non-filterable residue are not performed on Hanford groundwater samples, so this unacceptable result does not impact the interpretation of Hanford groundwater data.

Lionville Laboratory submitted results to the groundwater project for one water pollution study (ERA WP-144) and one water supply study (ERA WS-109) this year. The percentage of results within the acceptance limits ranged from 98% to 100% (Table C.11). The unacceptable results for four organic constituents and orthophosphate as P do not impact the interpretation of Hanford groundwater data since Lionville does not analyze these constituents for the Hanford groundwater program.

C.6.1.2 DOE Mixed Analyte Performance Evaluation Programs

DOE's Mixed Analyte Performance Evaluation Program examines laboratory performance in the analysis of soil and water samples containing metals, volatile and semivolatile organic compounds, and radionuclides. This report considers only water samples. The program is conducted at the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho. DOE evaluates the accuracy of the Mixed Analyte Performance Evaluation Program results for radiological and inorganic samples by determining if they fall within a 30% bias of the reference value.

One study was available for FY 2007 (MAPEP-07-MaW17&OrW17&GrW17). One result for TA St. Louis was unacceptable, viz. tritium (Table C.12). Two results were unacceptable for WSCF, viz., 4-chloroaniline and chrysene; one other result was acceptable with warning (Table C.13). All results were acceptable for TA Richland (Table C.12), Lionville Laboratory, and Eberline Services (Table C.14). The unacceptable results appear to be isolated incidences.

In addition, WSCF reported on results for MAPEP-06-MaW16&OrW16&GrW16; results for the other laboratories were included in last year's annual report. One result was unacceptable for WSCF in this study, viz., di-n-butylphthalate (Table C.13).

C.6.1.3 InterLaB RadCheM Proficiency Testing Program Studies

The purpose of the InterLaB RadCheM Proficiency Testing Program, conducted by Environmental Resources Associates, is to evaluate the performance of laboratories in analyzing selected radionuclides. This program provides blind standards that contain specific amounts of one or more radionuclides in a water matrix to participating laboratories. Environmental Resources Associates standards were prepared for the following radionuclides/parameters: barium-133, cesium-134, cesium-137, cobalt-60, gross alpha, gross beta, iodine-131,

radium-226, radium-228, strontium-89, strontium-90, tritium, uranium (natural), uranium (natural) mass, and zinc-65. After sample analysis, the results were forwarded to Environmental Resources Associates for comparison with known values and with results from other laboratories. Environmental Resources Associates bases its control limits on the EPA's National Standards for Water Proficiency Testing Studies Criteria Document (NERL-Ci-0045).

In the one study in which TA Richland participated this year (RAD-67), a total of 16 constituents were analyzed. All results were acceptable (Table C.12).

WSCF participated in two studies (RAD-68 and 70) and one Quik™Response study (100506D) this year; a total of fifteen constituents were analyzed. The one result for zinc-65 was unacceptable (Table C.13).

Eberline Services participated in two studies (RAD-68 and 70) and one Quik™Response study (022607B) this year; a total of thirty constituents were analyzed. Two of the results, gross alpha and zinc-65, were unacceptable (Table C.14).

C.6.2 Double-Blind Standard Evaluation

During FY 2007, the groundwater project forwarded blind QC standards to TA Richland and St. Louis, WSCF, Lionville Laboratory, and Eberline Services. Blind-spiked standards were generally prepared in triplicate and submitted to the laboratories to check the accuracy and precision of analyses. For most constituents, the standards were prepared in a groundwater matrix from a background well. Standards for specific conductance were commercially prepared in deionized water. In all cases, the standards were submitted to the laboratories in double-blind fashion (i.e., the standards were disguised as regular groundwater samples). After analysis, the laboratory's results were compared with the spiked concentrations, and a set of control limits were used to determine if the data were acceptable. Generally, if a result was out of limits, the data were reviewed for errors. In situations where several results for the same method were unacceptable, the results were discussed with the laboratory, potential problems were investigated, and corrective actions were taken if appropriate.

Tables C.15 through C.17 summarize the number and types of blind standards used in FY 2007 along with the control limits and number of unacceptable results for each constituent. Overall, 88% of the blind spike determinations were acceptable. This was slightly higher than the percentage from FY 2006 (85%). A total of 15 results (~6%) were out of limits for TA Richland and St. Louis. Total organic halides, nitrate as nitrogen, hexavalent chromium, carbon tetrachloride, trichloroethene, and tritium were the constituents with out-of-limit results. The WSCF laboratory had a relatively high percentage of unacceptable results (50/242 = 21%). Groundwater staff are working closely with the laboratory to help improve future performance. Constituents affected included total organic carbon, total organic halides, nitrate as nitrogen, hexavalent chromium, carbon tetrachloride, trichloroethene, gross alpha, gross beta, strontium-90, and tritium. All of the results from Lionville Laboratory and Eberline Services were within the acceptance limits.

Most of this year's total organic carbon results were acceptable, but all four of WSCF's first quarter results were biased high with recoveries of ~175%. As discussed in Section C.6.5, WSCF had a problem with calibration standards that resulted in many low-biased results between November 20 and March 7. However, the standardization problem does not account for the elevated blind-standard results. After implementing several corrective actions to address the bias problem, WSCF demonstrated acceptable performance on two national performance evaluation samples. Moreover, all of WSCF's blind-standard results from the last 3 quarters were within the acceptance limits. TA St. Louis and Lionville Laboratory had 100% acceptable results for total organic carbon.

Two types of blind standards were used to evaluate laboratory performance for total organic halides. The first group was spiked with 2,4,5-trichlorophenol, which is chemically similar to the compound used to calibrate the analyzers. All of TA St. Louis' results for the first group were acceptable. WSCF had three out-of-limit results during the third quarter. However, WSCF's high recoveries (~150%) were not unreasonable, because the third quarter standards were spiked at levels very close to the method detection limit. The second group of standards was spiked with a varying mixture of carbon tetrachloride, chloroform, and trichloroethene

to evaluate performance for volatile analytes. For this group, TA St. Louis had four out-of-limit results (50-70% recoveries) while WSCF had nine unacceptable results (50% to 160% recoveries). The low recoveries are attributed to volatilization or weak retention of the volatile compounds on the charcoal cartridges used in the analysis. Three of WSCF's unacceptable results were biased high, although two of these were for volatile standards that were spiked at concentrations close to the detection limit. Since relatively few (~2%) total organic halides results for regular groundwater samples were flagged as suspect during FY 2007, the problems with the blind standards are believed to be isolated.

In general, TA St. Louis and WSCF performed well on the analysis of anions in blind standards. All of the cyanide results from both labs were within the acceptance limits, and most ion chromatography results were satisfactory. However, WSCF had three unacceptable results for nitrogen in nitrate during the fourth quarter. TA St. Louis also had a high-biased result for nitrogen in nitrate in the fourth quarter. The out-of-limit recoveries were not exceptionally high (most were less than 130%); the data are under investigation at the time of this writing.

One of the weaker performance areas for TA St. Louis and WSCF was on the analysis of volatile organic compounds. The laboratories' percentages of unacceptable results were 17 and 47%, respectively. With one exception (i.e., an elevated TA St. Louis result for trichloroethene), all of the out-of-limit results were biased low; most had recoveries between 65% and 75%. Pacific Northwest National Laboratory (PNNL) analyses of split samples during the first three quarters confirmed that the standards had been spiked close to the expected concentrations. All of the chloroform results for both laboratories were acceptable. Since the water solubility of chloroform is much higher than that of carbon tetrachloride and trichloroethene, the low recoveries may be caused by volatilization of the less-soluble compounds prior to analysis. Additional investigation into this issue is planned during FY 2008.

The majority of the laboratories' results for gross alpha and gross beta were within the QC limits. All of the results from Eberline Services (gross beta only) and TA Richland were satisfactory. WSCF had two unacceptable results for each parameter. One of the out-of-limit results for gross alpha was from the third quarter, when the spiked concentration was within a factor of three of the minimum detectable activity. During the last quarter, two sets of combined gross alpha and gross beta standards were prepared to verify whether WSCF's new discrete alpha method is effective at eliminating interference from beta emitters (Section C.6.5 contains more information about this problem). While one of the corresponding gross alpha results was out of limits (61% recovery), the data indicate that the alpha results were not impacted by relatively high levels of strontium-90 and yttrium-90 (~21,000 pCi/L). Over the entire year, WSCF's gross beta recoveries tended to be ~10-15% higher than those from Eberline Services and TA Richland. This may be partially due to differences in the isotopes used for gross beta calibration: WSCF calibrated with cesium-137, while Eberline Services and TA Richland utilized strontium-90. The gross beta blind standards were spiked with strontium-90.

Initially, four out of six of WSCF's second and third quarter results for strontium-90 were unacceptable. After discussing the problem with laboratory staff, three of the corresponding samples were re-analyzed with larger sample volumes, and the results were improved. Recoveries for two of the April standards dropped from ~1,800% to ~107%. The laboratory has been instructed to ensure that adequate sample volumes are used for the analysis in the future. Six blind standards were submitted to WSCF during the last quarter—three were spiked at 26 pCi/L, and the others were spiked at 2,020 pCi/L. All of the results were acceptable, although the recoveries were high (~122% to 130%) for the standards spiked at the lower concentration. TA Richland's results for strontium-90 were all within the QC limits.

During FY 2007, several of TA Richland's results for regular-level tritium were approximately three times higher than the expected concentrations. Both TA Richland and WSCF had similar results for the first quarter of this year too. An overly concentrated spiking solution was the suspected cause of the elevated results. Beginning with the second quarter of this year, a new tritium spiking standard was used to prepare the blind standards, and most of the subsequent results were significantly improved. WSCF failed to detect tritium in the second quarter standards, but those sample bottles may have been inadvertently filled with the wrong solution

after the standards had been prepared. All of TA Richland's results for samples prepared with the new spiking solution were acceptable. WSCF also had satisfactory recoveries for the third quarter. Low-level tritium results were not affected by the spiking standard; all of TA Richland's low-level results were within the QC limits.

C.6.3 Laboratory Internal QA/QC Programs

TA Richland, TA St. Louis, WSCF, Eberline Services, and Lionville Laboratory maintain internal QA/QC programs that generate data on analytical performance by analyzing method blanks, laboratory control samples, matrix spikes and matrix spike duplicates, matrix duplicates, and surrogates (see PNNL-13080 for definitions of these terms). This information provides a means to assess laboratory performance and the suitability of a method for a particular sample matrix. Laboratory QC data are not currently used for in-house validation of individual sample results unless the laboratory is experiencing unusual performance problems with an analytical method. An assessment of the laboratory QC data for FY 2007 is summarized in this section. TA and WSCF data are discussed in detail. Tables C.18 and C.19 provide a summary of the TA and WSCF QC data, respectively, by listing the percentage of QC results that were out of limits for each analyte category and QC parameter. Additional details are presented in Tables C.20 through C.23. Constituents not listed in these tables did not exceed TA's or WSCF's QC limits. A brief summary of Lionville Laboratory and Eberline Services data is presented at the end of the section.

Most of FY 2007 laboratory QC results were within acceptance limits, suggesting that the analyses were in control and reliable data were generated. Nevertheless, a number of parameters had unacceptable results.

Evaluation of results for method blanks was based on the frequency of detection above the blank QC limits. In general, these limits are two times the method detection limit for chemical constituents and two times the total propagated error for radiochemistry parameters. Because minimum detectable activity levels are not available for radiochemistry components from WSCF, two times the practical quantitation limit was used as the QC limit for WSCF. For common laboratory contaminants such as 2-butanone, acetone, methylene chloride, phthalate esters, and toluene, the QC limit is five times the method detection limit.

Table C.20 summarizes method blank results from TA Richland and St. Louis. The ammonia and anions and general chemistry parameters categories had the greatest percentages of method blank results exceeding the QC limits. The following parameters had >10% of method blank results outside the QC limits: chloride, nitrogen in ammonia, phosphate, lithium, and oil and grease. Table C.21 summarizes method blank results from WSCF. The metals and volatile organic compounds categories had the greatest percentages of method blank results outside the QC limits. The following parameters had >10% of method blank results outside the QC limits: alkalinity, aluminum, magnesium, nickel, silver, vanadium, and zinc. The out-of-limit method blank results for alkalinity, calcium, and magnesium are not a significant problem because the values are typically much lower than the levels measured in Hanford Site groundwater. Similarly, the highest method blank results for chloride (0.47mg/L), sulfate (0.6 mg/L), and sodium (1,540 µg/L) are typically lower than the respective levels measured in Hanford groundwater. For TA, the percentage of out-of-limit method blanks decreased compared to FY 2006 for chloride, sulfate, aluminum, arsenic, barium, calcium, zinc, and methylene chloride, while the percentage increased for alkalinity, total organic halides, nitrogen in ammonia, phosphate, and manganese.

Table C.22 summarizes results for the laboratory control samples from TA Richland and St. Louis. Semivolatile organic compounds and general chemistry parameters had >2% of their measurements outside the QC limits. Both of these categories had an increased percentage of results outside the QC limits compared to FY 2006 results (2% to 6% for semivolatile organics and 0.6% to 2% for general chemistry parameters). Specific compounds with >10% of out-of-limit laboratory control samples included cyanide; phosphate; hexavalent chromium; 1,1,1,2-tetrachloroethane; 2-chloroethyl vinyl ether; bromochloromethane; bromomethane; chloroethane; ethyl acetate; iodomethane; trans-1,4-dichloro-2-butene; vinyl acetate; 2,4,5-trichlorophenol; 4-bromophenylphenyl ether; anthracene; benzo(a)anthracene; benzo(ghi)perylene; bis(2-chloroethoxy)methane; carbazole; dibenz[a,h]anthracene; dimethylphthalate; heptachlor; hexachlorobenzene; indeno(1,2,3-cd)pyrene;

isophorone; nitrobenzene; oil and grease; and uranium-235. In all of these cases except cyanide, phosphate, and 2,4,5-trichlorophenol, the number of QC samples analyzed was limited (<20). Many of these constituents are not routinely monitored in Hanford groundwater. Table C.23 summarizes results for the laboratory control samples from WSCF. None of the compound categories had >1% of their measurements outside the QC limits and none of the constituents had >10% of out-of-limit results.

Table C.24 summarizes results for the matrix spikes and matrix spike duplicates from TA Richland and St. Louis. The ammonia and anions category had the greatest percentage of matrix spikes/spike duplicates exceeding the QC limits. This represents an increase compared to FY 2006 results that were out of limits for the ammonia and anions category (23% to 49%). The metals category also showed an increase in the percentage of results out of limits compared to FY 2006 results (0.7% to 1.6%); the semivolatile organic compounds and radiological parameters categories showed a decrease relative to FY 2006 (2% to 0.8% and 7% to 4%, respectively). The percentage of out-of-limit results increased significantly compared to FY 2006 for chloride; fluoride; nitrogen in nitrate; nitrogen in nitrite, sulfate; sulfide; calcium; iron; magnesium; potassium; sodium; strontium (elemental); 1,1,1,2-tetrachloroethane; 1,2-dibromo-3-chloropropane; 1,2-dichloropropane; 2-chloroethylvinyl ether; 2-methyl-1-propanol; ethyl acetate; styrene; tetrahydrofuran; trichloroethene; and nitrobenzene. Table C.25 summarizes results for the matrix spikes and matrix spike duplicates from WSCF. The general chemistry parameters and radiological parameters categories had the greatest percentage of matrix spikes/spike duplicates exceeding the QC limits. The only compound with >10% of out-of-limit matrix spike results was technetium-99.

For matrix duplicates, only those samples with values five times greater than the method detection limit or the minimum detectable activity (or practical quantitation limit for WSCF) are considered. Quantifiable matrix duplicates are evaluated by comparing the relative percent difference with an acceptable relative percent difference maximum for each constituent. Table C.26 lists the constituents from TA St. Louis and Richland that exceeded the relative percent difference limits. The semivolatile organic compounds, ammonia and anions, and volatile organic compounds categories had the greatest percentage of matrix duplicates exceeding the QC limits. The ammonia and anions and volatile organic compounds categories showed an increase in the percentage of results out of limits compared to FY 2006 results (1% to 4%; 1% to 4%, respectively); the general chemistry parameters and semivolatile organic compounds categories showed a decrease relative to FY 2006 (2% to 0.7% and 13% to 5%, respectively). Table C.27 lists the constituents that exceeded the relative percent difference limits for WSCF. A number of duplicates did not have a relative percent difference reported even though the value was above the method detection limit. The radiological parameters category had the greatest percentage of matrix duplicates exceeding the QC limits; all other categories had less than 1% out of limits. Specific compounds with >10% of out-of-limit duplicates included gross beta and strontium.

Surrogate data from TA St. Louis that were out of limits included six compounds for volatile organics and five for semivolatile organics. For volatile organic compounds, 3% of the surrogate results were outside of QC limits. The semivolatile organic surrogates had 5% of the results out of limits, an increase compared to FY 2006 results (2%). Surrogate data from WSCF that were out of limits included three compounds for volatile organics and one for semivolatile organics.

QC data for Eberline Services and Lionville Laboratory were limited for FY 2007 because these laboratories did not analyze many samples for routine groundwater monitoring. Lionville Laboratory analyzed a limited number (<10 each) of method blanks, laboratory control samples, matrix spikes, and matrix duplicates for total organic carbon, total organic halides, anions by ion chromatography, gasoline range organics, diesel range organics, and metals by inductively coupled plasma-atomic emission spectroscopy. All of the QC data for total organic carbon and total organic halides were within limits. Method blanks for a number of metals (aluminum, barium, calcium, sodium, and zinc) had some results that were out of limits. The levels for the method blanks for calcium and sodium that were out of limits were much lower than the levels measured in the groundwater samples. Two of the duplicates for one metal (zinc) and one matrix spike for one anion (phosphate) were also

out of limits. Eberline Services QC data were limited to gross alpha, gross beta, protactinium-231, radionuclides by gamma spectroscopy, strontium-90, and tritium. All of the QC data were within limits.

C.6.3.1 Issue Resolution

Issue resolution forms are documents used to record and resolve problems encountered with sample receipt, sample analysis, missed holding times, and data reporting (e.g., broken bottles or QC problems). The laboratories generate these forms and forward them to the groundwater project as soon as possible after a potential problem is identified. The forms provide a means for the project to give direction to the laboratory on resolution of the issues. The documentation is intended to identify occurrences, deficiencies, and/or issues that may potentially have an adverse effect on data integrity. During FY 2007, 126 issue resolution forms were submitted by TA Richland, TA St. Louis, and WSCF laboratories. Issue of resolution forms were not received by the secondary or limited use laboratories.

Table C.28 indicates the specific issues identified this year and the number of analytical requests that were impacted. The number of affected analytical requests was small (~500) compared to the total number of analytical requests submitted (~12,000). The number of the issue tracking problems after receipt at the laboratories was greater than FY 2006 in most categories . This increase may be due to better reporting of issues by the laboratories, particularly in cases where the holding time was exceeded. The frequencies of issues prior to receipt at the laboratory were slightly higher than the previous year. Part of this increase may be because a greater number of wells were sampled this year relative to recent years. In addition, there were a number of new personnel collecting samples this year. About 20% of the missed holding time issues were related to shipping delays. Missed holding times at TA St. Louis were generally due to the laboratory reanalyzing samples at different dilution factors out of holding time. At the WSCF laboratory, missed holding times were mostly due to staffing issues. WSCF is not typically staffed after 4:30 p.m. or on weekends; therefore, samples delivered near those times may not meet holding times. Laboratory QC issues were not isolated to any particular methods, but were found infrequently in radiological, wet chemistry, and organic methods.

C.6.3.2 Laboratory Audits and Assessments

Laboratory activities are regularly assessed by surveillance and auditing processes to ensure that quality problems are prevented and/or detected. During FY 2007, six of these audits were conducted on laboratories that routinely analyzed Hanford groundwater samples. Five audits were conducted on commercial analytical service providers. These audits were performed by the DOE Consolidated Audit Program. One assessment was conducted on the WSCF laboratory. This assessment was performed by an integrated contractor assessment team comprised of assessors from Fluor Hanford, Inc.; Washington Closure Hanford; PNNL; Advanced Technologies Laboratory (ATL); and CH2M Hill Hanford.

DOE Consolidated Audit Program Audits. The goal of the DOE Consolidated Audit Program is to design and implement a program to consolidate site audits of commercial and DOE environmental laboratories providing services to DOE Environmental Management. The specific audit objectives of the DOE Consolidated Audit Program were to assess the ability of the laboratories to produce data of acceptable and documented quality through analytical operations that follow approved methods and the handling of DOE samples and associated waste in a manner that protects human health and the environment. All laboratories were evaluated against the requirements of DOE's document *Quality Systems for Analytical Services* , Revision 2.1 (DOECAP 2005).

The DOE Consolidated Audit Program audits were performed at the following laboratories: TA Knoxville, Tennessee, December 11 through 13, 2006; TA St. Louis, Missouri, April 10 through 12, 2007; Eberline Services, Richmond, California, February 27 through March 1, 2007; Lionville Laboratory, Lionville, Pennsylvania, July 24 through 26, 2007; and TA Richland, Washington, June 19 through 21, 2007. The audits at the TA laboratories were initiated prior to the laboratory name change, and therefore, were issued to Severn Trent Laboratories, Incorporated. However, as noted in Section C.1, the name change to TestAmerica Laboratories, Incorporated does not affect the review of the laboratory audits as the laboratories are still part of the same legal corporate entity.

The assessment scope of the DOE Consolidated Audit Program audits included the following specific functional areas:

1. QA management systems and general laboratory practices.
2. Data quality for organic analyses.
3. Data quality for inorganic and wet chemistry analyses.
4. Data quality for radiochemistry analysis.
5. Hazardous and radioactive materials management.
6. Verification of corrective-action implementation from previous audit findings.

A total of 48 findings and 34 observations were noted for the five of the DOE audits. Results of each of these audits are summarized in Table C.29. Of particular note are audit findings associated with the TA St. Louis laboratory. The DOE audit team identified two "Priority I" findings associated with the radiochemistry section of the laboratory. A Priority I finding represents a significant deficiency regarding key management or programmatic control(s), which in and of itself represents a concern of sufficient magnitude to potentially render the audited facility unacceptable to provide services to the DOE if not resolved via immediate and/or expedited corrective action(s). The areas of concern were (1) in the radioactive material tracking and accountability process and (2) an unfilled technical director position in the radiochemistry department of the laboratory. The Priority I audit findings were subsequently closed during a follow-up surveillance conducted by the DOE audit team. Because the groundwater project does not use the TA St. Louis laboratory for radiochemical analyses, these findings did not impact the continued use of the laboratory for chemical analyses.

All other corrective actions have been accepted for all audits, and verification of the corrective actions will be performed in future audits. All laboratories have been qualified to continue to provide analytical services for samples generated at DOE sites.

Integrated Contractor Assessment Team Assessments. An integrated contractor assessment team assessment is performed by Hanford Site contractor personnel on Hanford Site analytical laboratories and is used to verify the implementation of the requirements stated in *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), Volumes 1 and 4 (DOE/RL-96-68). An integrated contractor assessment team assessment of the WSCF laboratory was performed on February 5 through February 8, 2007. The overall results of the assessment indicated that programs and processes reviewed were in place and implemented in accordance with the laboratory QA program plan and DOE/RL-96-68. No issues were noted to indicate concern over the technical adequacy of WSCF to meet the needs of the groundwater project.

A total of six findings and 15 observations were noted during the assessment. Results of this assessment are summarized in Table C.29. Corrective actions have been accepted for all findings and observations, and verification of the corrective actions will be performed in a future assessment.

C.6.4 Filtered and Unfiltered Chromium Comparison

M. J. Hartman

Hanford Site groundwater samples are analyzed for chromium in several ways:

- Total chromium in unfiltered samples
- Total chromium in filtered samples
- Hexavalent chromium in unfiltered samples
- Hexavalent chromium in filtered samples

Hexavalent chromium is soluble while trivalent chromium is not. Dissolved chromium in Hanford Site groundwater is virtually all hexavalent (WHC-SD-EN-TI-302). Hence hexavalent chromium in filtered and

unfiltered samples is assumed to be approximately equal, and total chromium in filtered samples (dissolved chromium) is assumed to be equal to hexavalent chromium. This discussion reviews FY 2007 chromium data from Hanford groundwater samples to test the validity of these assumptions.

C.6.4.1 Methods

The HEIS database was queried for FY 2007 chromium and hexavalent chromium data. The data were extracted in October 2007, when some FY 2007 data had not yet been received from the laboratory (i.e., September data). A total of 3,712 results were extracted. Any replicate samples (e.g., filtered, hexavalent chromium) were averaged.

Many samples are analyzed only for one type of chromium and unfiltered/filtered pairs were not usually collected in FY 2007. A total of 295 data pairs or sets with more than one type of chromium data were identified. Table C.30 lists those data sets.

Filtered and unfiltered results were compared by calculating the signed percent difference (SPD), where the SPD is:

$$SPD = \frac{(x2-x1)}{(x1+x2)/2} \times 100$$

Results where both concentrations were <10 µg/L were excluded. These low values would skew the calculations because of lower analytical precision near detection limits. Small absolute differences in concentrations could have a large effect on percentage difference. Some of the low values also represent detection limits and not measured concentrations.

C.6.4.2 Hexavalent Chromium in Filtered vs. Unfiltered Samples

Few filtered/unfiltered pairs are available for hexavalent chromium results (41 pairs of results; 24 pairs had concentrations >10 µg/L; see Table C.30). The unfiltered samples were, on average, 10% lower than filtered samples. However, this result was affected strongly by an anomalous result from aquifer tubes AT-D-2-M (5 µg/L unfiltered and 18 µg/L filtered). Excluding this result, the percent difference between unfiltered and filtered hexavalent chromium was only 5%. Figure C.1 shows a graph of the filtered/unfiltered pairs analyzed for hexavalent chromium. The graph includes all data pairs, including those with concentrations <10 µg/L. The data define a 1:1 relationship with minimal scatter on either side of the regression line.

C.6.4.3 Total Chromium in Filtered vs. Unfiltered Samples

A total of 152 filtered/unfiltered pairs were analyzed for total chromium (see Table C.30). Of these, 93 pairs had concentrations >10 µg/L. For 62 of the 93 filtered/unfiltered pairs of results (67%), there was not a significant difference in chromium concentrations (signed percent difference between 20% and -20%). For the remaining 31 pairs (33%), unfiltered chromium was significantly higher than filtered. On average, concentrations in unfiltered samples were higher than the filtered samples by 35%.

Figure C.2 plots all of the data pairs and also looks specifically at the results <500 µg/L. The difference between filtered and unfiltered samples is most significant at lower concentrations.

Some wells that typically show unfiltered chromium higher than filtered chromium have erratic unfiltered levels and low filtered levels (e.g., well 699-48-77A, Figure C.3). Iron concentrations follow similar trends, suggesting the presence of particulate matter in the unfiltered samples. Samples from this well occasionally have high turbidity, e.g., up to 16 NTU in FY 2007. However, not all of the high, unfiltered metals are associated with high turbidity.

Figure C.4 shows well 199-K-36, an example of a well with a large difference between unfiltered and filtered chromium results, but the two trend parallel to one another. This well has elevated filtered chromium and hexavalent chromium. All of the recent turbidity readings from this well are low (<5 NTU since 2002). Unfiltered iron concentrations also tend to be high, but do not follow the same trend as chromium.

C.6.4.4. Filtered, Total Chromium vs. Hexavalent Chromium

The signed percent difference between filtered samples analyzed for total chromium and hexavalent chromium in either filtered or unfiltered samples, whichever was available, was calculated (if both were available we used filtered hexavalent results). On average, the total chromium results were 8% lower than the hexavalent results (see Table C.30). If the one outlier (-112% in well 199-K-117A, where the total chromium result was 3.1 µg/L and the hexavalent chromium was 11 µg/L) is excluded, the difference drops to -6.5%. Figure C.5 graphs the results. Overall, filtered, total chromium gives an excellent representation of hexavalent chromium.

C.6.4.5. Conclusions About Filtered vs. Non-Filtered Chromium

The groundwater project's QC program considers duplicate or split samples acceptable if the relative percent difference is <20%. Applying a similar standard to chromium results (signed percent difference is between 20% and -20%), it is concluded that:

- Total chromium results in some wells are significantly affected by whether the samples are filtered or not. Concentrations in unfiltered samples were an average of 35% higher than in filtered samples.
- Hexavalent chromium results from unfiltered (x2) and filtered samples (x1) are essentially equivalent (-5.2% signed percent difference).
- Total chromium in filtered samples is equivalent to hexavalent chromium (-6.5% signed percent difference).

Hexavalent chromium is a contaminant of concern for the 100 Areas. The groundwater project typically averages filtered, total chromium data and all hexavalent chromium data to construct plume maps. This practice is an acceptable way to reflect hexavalent chromium in Hanford's groundwater.

C.6.5 Analytical Troubleshooting

H. L. Anastos and C. J. Thompson

During evaluations of requests for data review submittals, trends may be observed that warrant further investigation by the QC staff. As was noted in Section C.2.1, compared to FY 2006, the number of requests for data review submitted has increased (611 to 1,470). Approximately 57% of the requests for data review were associated with the WSCF laboratory, 30% with TA St. Louis, 10% with the mobile laboratory, and 3% with TA Richland. The high number of requests for data review associated with WSCF is not unexpected, based on the transition of workload from TA Richland and TA St. Louis to WSCF. However, several analytical issues for the laboratories were investigated by QC staff. The issues discussed below account for approximately 60% of the total requests for data review processed in FY2007 to date. The remaining 40% of the total requests appear to be isolated issues.

Nitrite - Approximately 76% of the requests for data review associated with the TA St. Louis laboratory (23% of the total) were for anion analysis by ion chromatography. Elevated nitrite results and apparent false detections were observed in several wells across the site. The problem has been determined to be instrument related, although the exact cause is unknown. The laboratory has made several attempts to resolve the issue, and the number of nitrite detections has decreased. However, a few anomalous results were identified in June and July, suggesting that the problem has not been resolved. Additional information about this problem can be found in Section B-1 of the *Quarterly RCRA Groundwater Monitoring Data for the Period October through December 2006* (SGW-33492). At the time of this writing, WSCF is analyzing most groundwater samples for anions, and the Eberline laboratory is being used as a secondary laboratory. TA St. Louis is continuing to troubleshoot their method.

Total Organic Carbon – Approximately 12% of the requests for data review associated with WSCF (7% of the total) were for total organic carbon. Between November 20, 2006, and March 7, 2007, an improperly

prepared calibration standard was used for analysis, resulting in sample results that were biased low by approximately 35%. Results for 108 samples were corrected by the laboratory, while 26 samples from the same time period were unaffected (non-detects). Groundwater staff agreed to take a conservative approach and reject this data in the HEIS database by applying an "R" flag to all detected results. Corrective actions have been completed and verified. More information about this problem can be found in Section B-1 of the *Quarterly RCRA Groundwater Monitoring Data for the Period January through March 2007* (SGW-34359).

Gross Alpha – Approximately 18% of the requests for data review associated with WSCF (10% of the total) were for gross alpha. Elevated gross alpha results have been identified at several wells across the site. The problem is specific to samples that have significant amounts of technetium-99 and/or strontium-90 (beta emitters). This type of interference is referred to as crosstalk and is largely resolved by adjusting the operating voltage of the detector and measuring gross alpha and gross beta separately (WSCF was performing a simultaneous count). At the groundwater project's request, WSCF implemented an independent alpha counting method in August 2007. Re-analyses by the discrete alpha method confirmed that simultaneous counting was causing high biased results. Future samples are being scheduled for analysis by the new gross alpha procedure. More information about this problem can be found in Section B-1 of the *Quarterly RCRA Groundwater Monitoring Data for the Period April through June 2007* (SGW-35502).

Metals – Approximately 35% of the requests for data review associated with WSCF (20% of the total) were for metals. Thirty-nine of these requests were due to the dilution of samples which resulted in the required detection limit for chromium not being met. The need for dilution was due to an instrument limitation that was quickly resolved. The majority of the requests for data review for metals (258) were associated with elevated, out-of-trend results obtained in the May through August time frame. The problem was tied to specific analytical batches performed at the laboratory on specific days, although the exact cause is unknown. The laboratory is still investigating the issue to determine cause. Re-analysis of the samples yielded in trend results, and the issue does not appear to have recurred. Additional blind samples will be submitted in FY 2008 to further troubleshoot the metals analyses.

C.6.6 Laboratory Transition Overview

C. J. Thompson and H. L. Anastos

As noted in Section C.1, a majority of the analytical services supporting groundwater monitoring were transferred from TA Richland and St. Louis to WSCF during FY 2007. This change was required when Fluor Hanford, Inc. assumed oversight of long-term groundwater monitoring at the site due to a union labor agreement between Fluor Hanford, Inc. and the Hanford Atomic Metal Trades Council. To minimize impacts to the monitoring program, a gradual transition of the sample load to WSCF was implemented. Figure C.6 summarizes the total number of analyses performed by WSCF and the TA laboratories for each month of the fiscal year, and Figure C.7 shows the laboratories' relative percentages by quarter for the most frequently requested analysis methods.

In general, the number of analyses performed by WSCF increased throughout the year. As a result of WSCF's calibration problem with total organic carbon (Section C.6.5), the number of total organic carbon and total organic halides analyses performed by WSCF decreased during the third quarter. Also, the total number of analyses for several methods decreased during the last quarter of the year. This is due to a limited sampling schedule in July and August. Based on past experiences with fire restrictions delaying sampling during these months, the sampling schedule was planned accordingly.

WSCF's performance relative to the commercial laboratories was monitored using split samples and QC blind standards in addition to comparing WSCF results with historical trends at numerous sites. Summaries of the split-sample and blind-standard results are provided in Sections C.4, and C.6.2, respectively. Some additional observations about data comparability are provided below.

Overall, most of the data from WSCF agree reasonably well with historical trends, and the majority of WSCF's blind-standard and split-sample results for the year were acceptable. Trend analysis identified some

discrepancies for several metals, gross alpha, and gross beta at multiple wells. The changes in the data and follow-up investigative actions for metals and gross alpha were summarized in the previous section (C.6.5). Observed differences in the gross beta results were less significant, but many wells showed an increase of 10% to 20% after the analyses were shifted to WSCF. As noted in Section C.6.2, WSCF also obtained higher recoveries on most of the gross beta blind standards. WSCF uses a different isotope for gross beta calibration (cesium-137; TA and Eberline Services use strontium-90), which may partially explain why WSCF's values are higher. During the transition to WSCF, several apparent outliers were also observed for other constituents (e.g., cyanide, carbon tetrachloride, total organic carbon, total organic halides, and strontium-90), but they appeared to be isolated cases. Most of the suspect results have been flagged in the HEIS database.

C.7 Limit of Detection, Limit of Quantitation, and Method Detection Limit

C. A. Newbill, H. Hampt, and D. S. Sklarew

Detection and quantitation limits are essential to evaluate data quality and usefulness because they provide the limits of a method's measurement. The detection limit is the lower limit at which a measurement can be differentiated from background. The quantitation limit is the lower limit where a measurement becomes quantifiably meaningful. The limit of detection, limit of quantitation, and method detection limit are useful for evaluating groundwater data.

The limit of detection is defined as the lowest concentration level statistically different from a blank (Currie 1988). The concentration at which an analyte can be detected depends on the variability of the blank response. For the purpose of this discussion, the blank is taken to be a method blank.

In general, the limit of detection is calculated as the mean concentration in the blank plus three standard deviations of that concentration (EPA/540/P-87/001, OSWER 9355.0-14). The blank-corrected limit of detection is simply three times the blank standard deviation. At three standard deviations from the blank mean, the false-positive and the false-negative error rates are each ~7% (Miller and Miller 1988). A false-positive error is an instance when an analyte is declared present but is, in fact, absent. A false-negative error is an instance when an analyte is declared absent but is, in fact, present.

The limit of detection for a radionuclide is typically computed from the counting error associated with each reported result (e.g., EPA 520/1-80-012) and represents instrumental or background conditions at the time of analysis. In contrast, the limit of detection and limit of quantitation for the radionuclides shown in Table C.31 are based on variabilities that result from both counting errors and uncertainties introduced by sample handling. In the latter case, distilled water, submitted as a sample, is processed as if it were an actual sample. Thus, any random cross contamination of the blank during sample processing will be included in the overall error, and the values shown in Table C.31 are most useful to assess long-term variability in the overall process.

The limit of quantitation is defined as the level above which quantitative results may be obtained with a specified degree of confidence (Keith 1991). The limit of quantitation is calculated as the blank mean plus 10 standard deviations of the blank (EPA/540/P-87/001, OSWER 9355.0-14). The blank-corrected limit of quantitation is simply 10 times the blank standard deviation. The limit of quantitation is most useful for defining the lower limit of the useful range of concentration measurement technology. When the analyte signal is 10 times larger than the standard deviation of the blank measurements, there is a 95% probability that the true concentration of the analyte is within ±25% of the measured concentration.

The method detection limit is defined as the minimum concentration of a substance that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero. The method detection limit is determined from analysis of a sample in a given matrix containing the analyte (Currie 1988). The method detection limit is 3.14 times the standard deviation of the results of seven replicates of a low-level standard. Note that the method detection limit, as defined above, is based on the variability of the response of low-level standards rather than on the variability of the blank response.

For this report, total organic carbon, total organic halides, and radionuclide field blank data are available for limit of detection and limit of quantitation determinations. The field blanks are QC samples that are introduced into a process to monitor the performance of the system. The use of field blanks to calculate the limit of detection and the limit of quantitation is preferred over the use of laboratory blanks because field blanks include error contributions from sample preparation and handling, in addition to analytical uncertainties. Methods to calculate the limit of detection and the limit of quantitation are described in detail in Appendix A of DOE/RL-91-03. The results of the limit of detection and limit of quantitation determinations are listed in Table C.32 for TA and C.33 for WSCF.

Because of the lack of blank data for other constituents of concern, it was necessary to calculate approximate limit of detection and limit of quantitation values by using variability information obtained from low-level standards. The data from the low-level standards are obtained from laboratory method detection limit studies. If low-level standards are used, the variability of the difference between the sample and blank response is increased by a factor of 2 (Currie 1988, p. 84). The formulas are summarized below: where s = standard deviation from the seven replicates of the low-level standard.

The results of limit of detection, limit of quantitation, and method detection limit calculations for most non-radiological constituents of concern (besides total organic carbon and total organic halides) are listed in Tables C.32 and C.33. The values in Table C.32 apply to TA St. Louis and the values in Table C.33 apply to WSCF.

Specific evaluation of detection-limit issues for the interim action groundwater monitoring was not performed for this report. Detection limit issues are primarily assessed as part of site-specific validation activities. No validation activities were performed on interim action groundwater monitoring data in FY 2007.

C.8 Conclusions

H. L. Anastos and C. J. Thompson

Overall, assessments of FY 2007 QA/QC information indicate that groundwater monitoring data are reliable and defensible. Sampling was conducted in accordance with reviewed procedures. Few contamination or other sampling-related problems were encountered that affected data integrity. Likewise, laboratory performance was good in most respects, based on the large percentages of acceptable field and laboratory QC results. Laboratory audits and generally acceptable results in nationally based performance evaluation studies also demonstrated acceptable laboratory performance for the groundwater project. Blind samples, split samples and historical data trend analysis provide confidence that the transition of laboratory services to the WSCF laboratory had no major impact on groundwater data. However, the following areas of concern were identified and should be considered when interpreting groundwater monitoring results:

- A few QC samples were probably swapped in the field or at the laboratory based on a small number of unusually high field-blank results and duplicate results with poor precision. The same problem likely occurred for a small number of groundwater samples. Mismatched results for key constituents are identified during data review and flagged when appropriate.
- Several indicator parameters, anions, metals, volatile organic compounds, and radiological parameters were detected at low levels in field and/or laboratory method blanks. The most significant contaminants were chromium, magnesium, methylene chloride, nitrogen in ammonia, nitrogen in nitrate, silver, tritium, and zinc.
- Maximum recommended holding times were exceeded for ~3.7% of groundwater monitoring samples that were analyzed by non-radiological methods. Anions were primarily affected, though the data impacts are considered minor.
- Laboratory performance on blind standards was good overall: 88% of the results were acceptable. Constituents with out-of-limit results from TA (St. Louis and Richland) were carbon tetrachloride, hexavalent

chromium, nitrogen as nitrate, total organic halides, trichloroethene, and tritium. Constituents with out-of-limit results from WSCF were carbon tetrachloride, chloride, gross alpha, gross beta, hexavalent chromium, nitrogen as nitrate, strontium-90, technetium-99, total organic carbon, total organic halides, trichloroethene, and tritium. All of Lionville Laboratory's and Eberline Services' results were acceptable.

- Several analytical areas have been identified for continued evaluation and follow-up in FY2008. These include anions, gross beta, metals, strontium-90, and volatile organic compounds.

C.9 References

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Table C.1. Data Review Codes

Code	Definition
F	Result is being reviewed as part of the RDR process. This flag is assigned when an RDR is initiated.
G	Result is valid according to further review.
H	Laboratory holding time exceeded before the sample was analyzed.
P	Potential problem. Collection/analysis circumstances make value questionable.
Q	Associated quality control sample is out of limits.
R	Result is not valid according to further review.
Y	Result is suspect. Review had insufficient evidence to show result valid or invalid.
Z	Miscellaneous circumstance exists. See project file.
RDR = Request for data review.	

Table C.2. Requests for Data Review, FY 2007 Data

Flag G	Flag Y	Flag R	Flag P	Notify Owner	Other Action	Pending	Number of Results with an Assigned RDR
Analytical Results							
442	205	367	4	4	19	429	1470
Water-Level Measurements							
18	40	68	--	--	--	94	222
RDR = Requests for data review.							

Table C.3. Full Trip Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
General Chemistry Parameters					
Alkalinity	3	57	5.3	1,700 – 5,000 µg/L	6,000 – 120,000 µg/L
Specific conductance	1	1	100.0	0.98 µS/cm	2.25 µS/cm
Total organic halides	13	61	21.3	4.4 – 10 µg/L	5 – 14.6 µg/L
Ammonia and Anions					
Chloride	12	72	16.7	30 – 64 µg/L	49 – 180 µg/L
Nitrogen in ammonia	1	2	50.0	12.16 µg/L	15.4 µg/L
Nitrogen in Nitrate	5	72	6.9	25.6 – 390 µg/L	36.7 – 278 µg/L
Phosphate	1	3	33.3	20 – 320 µg/L	290 µg/L
Metals					
Arsenic	1	7	14.3	3.2 – 4 µg/L	4.1 µg/L
Barium	3	65	4.6	2 – 20 µg/L	2.2 – 70.8 µg/L
Calcium	7	65	10.8	36 – 400 µg/L	67.6 – 45,800 µg/L
Chromium	6	65	9.2	5 – 28 µg/L	8.5 – 783 µg/L
Cobalt	4	65	6.2	4 – 28 µg/L	8.9 – 10.2 µg/L
Copper	3	65	4.6	3.6 – 28 µg/L	9.9 – 13 µg/L
Iron	4	65	6.2	18 – 132 µg/L	19.4 – 37.4 µg/L
Magnesium	14	65	21.5	12 – 512 µg/L	13.6 – 14,400 µg/L
Manganese	1	65	1.5	1.72 – 12 µg/L	8.8 µg/L
Nickel	1	65	1.5	8 – 20 µg/L	8.4 µg/L
Silver	10	65	15.4	3.4 – 44 µg/L	11.4 – 18.2 µg/L
Sodium	4	65	6.2	54 – 460 µg/L	98.7 – 95,100 µg/L
Strontium	2	65	3.1	1.12 – 8 µg/L	207 – 237 µg/L
Thallium	1	1	100.0	0.64 µg/L	0.66 µg/L
Uranium	1	8	12.5	0.1 µg/L	0.133 µg/L
Vanadium	7	65	10.8	11.8 – 56 µg/L	15.4 – 36.5 µg/L
Zinc	13	65	21.5	4 – 38.6 µg/L	9.5 – 114 µg/L
Volatile Organic Compounds					
Methylene chloride	9	20	45.0	0.5 – 5 µg/L	0.72 – 3.1 µg/L
Radiological Parameters					
Gross beta	3	42	7.1	2.4 – 7.6 pCi/L[b]	3.3 – 8.67 pCi/L
Strontium-90	1	16	6.3	0.836 – 1.214 pCi/L[b]	2.12 pCi/L
Tritium	8	50	16.0	10.18 – 688 pCi/L[b]	40.8 – 105 pCi/L
Uranium	1	26	3.8	0.1508 – 0.42 µg/L	0.133 µg/L

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.
(b) The limit for radiological analyses is determined by the sample-specific total propagated uncertainty.
QC = Quality control.

Table C.4. Field Transfer Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[(a)]	Range of Out-of-Limit Results
Carbon disulfide	4	193	2.1	0.062 – 2 µg/L	0.23 – 0.44 µg/L
Carbon tetrachloride	9	193	4.7	0.078 – 2 µg/L	0.26 – 0.59 µg/L
Chloroform	2	193	1.0	0.096 – 2 µg/L	0.36 – 0.37 µg/L
cis-1,2-Dichloroethene	1	193	0.5	0.096 – 2 µg/L	0.12 µg/L
Methylene chloride	99	192	51.6	0.5 – 5 µg/L	0.59 – 36 µg/L
Trichloroethene	2	193	1.0	0.074 – 2 µg/L	0.11 – 0.31 µg/L

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.
QC = Quality control.

Table C.5. Equipment Blanks Exceeding Quality Control Limits

Constituent	Number Out of Limits	Number of Analyses	Percent Out of Limits	Range of QC Limits[(a)]	Range of Out-of-Limit Results
General Chemistry Parameters					
Total organic halides	8	8	100.0	4.4 – 10 µg/L	23.4 – 36.2 µg/L
Ammonia and Anions					
Chloride	4	6	66.7	30 – 60 µg/L	44.1 – 160 µg/L
Nitrogen in nitrate	5	6	83.3	35.4 – 58.4 µg/L	75.3 – 753 µg/L
Sulfate	2	6	33.3	82 – 140 µg/L	140 – 155 µg/L
Metals					
Calcium	3	4	75.0	68 – 400 µg/L	98 – 529 µg/L
Chromium	1	4	25.0	6.2 – 9.8 µg/L	10.6 µg/L
Copper	1	4	25.0	5.6 – 8 µg/L	11.2 µg/L
Iron	1	4	25.0	18 – 74.4 µg/L	39.7 µg/L
Magnesium	2	4	50.0	12 – 512 µg/L	17.7 – 224 µg/L
Sodium	3	4	75.0	54 – 314 µg/L	340 – 696 µg/L
Strontium	2	4	50.0	1.12 – 8 µg/L	1.5 – 1.6 µg/L
Vanadium	1	4	25.0	11.8 – 24.2 µg/L	17.8 µg/L
Zinc	1	4	25.0	8 – 38.6 µg/L	12.8 µg/L
Volatile Organic Compounds					
Chloroform	2	2	100.0	0.096 µg/L	4.9 – 30 µg/L
Radiological Parameters					
Tritium	3	4	75.0	14.9 – 596 pCi/L	60.5 – 6100 pCi/L

(a) Because method detection limits may change throughout the year, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed.
QC = Quality control.

Table C.6. Field Duplicates Exceeding Quality Control Limits

Constituent	Total Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits	Percent Out of Limits	Range of Out-of-Limit Relative Percent Differences[b]
Ammonia and Anions					
Chloride	52	52	2	3.8	24.5 - 26.0
Cyanide	14	5	2	40.0	36.7 - 60.3
Fluoride	52	45	4	8.9	20.7 - 37.8
Nitrogen in nitrate	52	52	1	1.9	94.3
Nitrogen in nitrite	52	19	11	57.9	35.3 - 197.4
Metals					
Manganese	49	7	1	14.3	95.6
Potassium	49	30	1	3.33	26.7
Volatile Organic Compounds					
Methylene chloride	11	3	3	100.0	160.0 - 180.0
trans-1,2-Dichloroethene	11	1	1	100.0	20.2
Trichloroethene	11	5	3	60.0	168.0 - 187.0
Radiological Parameters					
Cobalt-60	20	5	1	20.00	26.6
Gross alpha	29	8	5	62.50	20.7 - 131.9
Gross beta	38	30	5	16.67	29.6 - 71.9
Iodine-129	12	3	1	33.33	46.6
Technetium-99	34	25	1	4.00	23.9
Tritium	46	38	1	2.63	20.7

(a) Duplicates with both results less than five times the method detection limit or minimum detectable activity were excluded from the evaluation.
(b) In cases where a non-detected result was compared with a measured value, the method detection limit or minimum detectable activity was used for the non-detected concentration.

Table C.7. Field Splits Exceeding Quality Control Limits

Constituent	Total Number of Splits	Number of Splits Evaluated [a]	Number Out of Limits	Percent Out of Limits	Range of Out-of-Limit Relative Percent Differences[b]
Ammonia and Anions					
Chloride	36	36	13	36.1	20.6 - 67.5
Cyanide	19	9	5	55.6	24.7 - 97.7
Fluoride	35	25	14	56.0	21.4 - 178.0
Nitrogen in nitrate	36	30	3	10.0	22.9 - 199.6
Sulfate	36	36	2	5.6	22.0 - 196.0
Metals					
Barium	25	19	1	5.3	76.0
Iron	25	7	5	71.4	22.8 - 132.2
Magnesium	24	24	1	4.2	22.9
Manganese	25	7	4	57.1	48.8 - 108.8
Potassium	25	3	1	33.3	32.2
Sodium	25	25	1	4.0	32.9
Strontium	25	25	1	4.0	23.0
Zinc	25	3	1	33.3	113.0
Radiological Parameters					
Gross beta	17	6	1	16.7	75.4
Strontium-90	14	3	2	66.7	37.5 - 87.4

(a) Splits with both results less than five times the method detection limit or minimum detectable activity were excluded from the evaluation.
(b) In cases where a non-detected result was compared with a measured value, the method detection limit or minimum detectable activity was used for the non-detected concentration..

Table C.8. Hanford Site Groundwater Remediation Project Maximum Recommended Holding Times

Method	Constituent	Holding Time
120.1 (EPA-600/4-81-004)	Conductivity	28 days
160.1 (EPA-600/4-81-004)	Total dissolved solids	7 days
300.0 (EPA-600/4-81-004)	Bromide	28 days
300.0 (EPA-600/4-81-004)	Chloride	28 days
300.0 (EPA-600/4-81-004)	Fluoride	28 days
300.0 (EPA-600/4-81-004)	Nitrate	48 hours
300.0 (EPA-600/4-81-004)	Nitrite	48 hours
300.0 (EPA-600/4-81-004)	Phosphate	48 hours
300.0 (EPA-600/4-81-004)	Sulfate	28 days
310.1 (EPA-600/4-81-004)	Alkalinity	14 days
350.1 (EPA-600/4-81-004)	Ammonia	28 days
410.4 (EPA-600/4-81-004)	Chemical oxygen demand	28 days
6010 (SW-846)	Inductively coupled plasma metals	6 months
6020 (SW-846)	Inductively coupled plasma-mass spectrometry metals	6 months
7060 (SW-846)	Arsenic	6 months
7196 (SW-846)	Hexavalent chromium	24 hours
7421 (SW-846)	Lead	6 months
7470 (SW-846)	Mercury	28 days
8015M (SW-846)	Total petroleum hydrocarbons	14 days
8040 (SW-846)	Phenols	7 days before extraction; 40 days after extraction
8081 (SW-846)	Pesticides	7 days before extraction; 40 days after extraction
8082 (SW-846)	Polychlorinated biphenyls	7 days before extraction; 40 days after extraction
8260 (SW-846)	Volatile organics	14 days
8270 (SW-846)	Semivolatile organics	7 days before extraction; 40 days after extraction
9012 (SW-846)	Cyanide	14 days
9020 (SW-846)	Total organic halides	28 days
9030 (SW-846)	Sulfides	7 days
9060 (SW-846)	Total organic carbon	28 days
9223 (APHA/AWWA/WEF)	Coliform	24 hours

Table C.9. Summary of TestAmerica Water Pollution and Water Supply Performance Evaluation Studies

	TA St. Louis					TA Richland
Accreditation Laboratory, Environmental Resource Associates	WP-144 March 2007	WP-150 September 2007	WS-123 December 2006	WS-129 June 2007	QuiK™ Response 041307A May 2007	WP-144 March 2007
Acceptable Results/Total	504/532[a]	523/548[b]	56/60[c]	53/60[d]	11/12[e]	2/2

(a) Unacceptable results were for total organic carbon, total organic halides, ammonia as N, orthophosphate as P, oil and grease (gravimetric), conductivity at 25ºC, nitrite as N, iron, hexachlorobutadiene, chlordane (technical), 2-(2-methyl-4-chlorophenoxy)propionic acid (MCPP), acenaphthylene, and benzene, ethylbenzene, toluene, and total xylenes in gasoline range organics.
(b) Unacceptable results were for calcium; calcium hardness as $CaCO_3$; chemical oxygen demand; cadmium; fluoride; sulfide; volatile solids; tetrachloroethylene; 4-amino-2,6-dinitrotoluene; 2-amino-4,6-dinitrotoluene; 1,3-dinitrobenzene; 2,4-dinitrotoluene; 2,6-dinitrotoluene; nitrobenzene; 2-nitrotoluene; 3-nitrotoluene; 4-nitrotoluene; RDX; 1,3,5-trinitrobenzene; and 2,4,6-trinitrotoluene.
(c) Unacceptable results were for tetrachloroethene; hexachlorobutadiene; dibromochloropropane; and 1,2,3-trichloropropane.
(d) Unacceptable results were for bromoform; sec-butylbenzene; chloromethane; 4-chlorotoluene; 4-isopropyltoluene; 1,1,1,2-tetrachloroethane; and 1,2,3-trichlorobenzene.
(e) Unacceptable result was for benzene in gasoline range organics.
WP = Water pollution.
WS = Water supply.

Table C.10. Summary of WSCF Water Pollution and Water Supply Performance Evaulation Studies

Accreditation Laboratory, Environmental Resource Associates	WP-138 October 2006	WP-144 March 2007	WP-150 September 2007	QuiK™ Response 091306B October 2006	QuiK™ Response 100506C November 2006	QuiK™ Response 031507A March 2007	QuiK™ Response 090607E September 2007
Acceptable Results/Total	86/89[a]	81/82[b]	82/84[c]	8/8	2/2	1/1	2/2

(a) Unacceptable results were for lead, manganese, and sodium.
(b) Unacceptable result was for total organic carbon.
(c) Unacceptable results were for non-filterable residue and chemical oxygen demand.
WP = Water pollution.

Table C.11. Summary of Lionville Laboratory Water Supply Performance Evaluation Studies

Accreditation Laboratory, Environmental Resource Associates	WP-144 March 2007	WS-126 March 2007
Acceptable Results/Total	471/479[a]	9/9

(a) Unacceptable results were for orthophosphate as P, 1,1-dichloroethane, 1,1-dichloroethylene, ethyl parathion, and diesel range organics.
WP = Water pollution.
WS = Water supply.

Table C.12. Summary of TestAmerica Interlaboratory Water Supply Performance, FY 2007

Constituent	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Mixed Analyte Performance Evaluation Program (MAPEP-07-MaW17&OrW17&GrW17) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-134, cesium-137, cobalt-57, cobalt-60, iron-55, manganese-54, nickel-63, plutonium-238, plutonium-239/240, strontium-90, technetium-99, uranium-234/233, uranium-238, zinc-65, gross alpha, gross beta	2[a,b]	2
Tritium	2[a,b]	1[c]
Antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, thallium, uranium-total, uranium-235, uranium-238, vanadium, zinc	1[b]	1
Aniline; phenol; 2-chlorophenol; 1,3-dichlorobenzene; 1,4-dichlorobenzene; benzyl alcohol; 1,2-dichlorobenzene; hexachloroethane; nitrobenzene; isophorone; 2-nitrophenol; 2,4-dimethylphenol; 2,4-dichlorophenol; 1,2,4-trichlorobenzene; naphthalene; hexachlorobutadiene; 4-chloro-3-methylphenol; 2-methylnaphthalene; 2-methylphenol; hexachlorocyclopentadiene; 3+4-methylphenol; 2,4,6-trichlorophenol; 2,6-dichlorophenol; o-toluidine; 1,4-phenylenediamine; 2-chloronaphthalene; 2-nitroaniline; dimethylphthalate; acenaphthylene; 2,6-dinitrotoluene; 3-nitroaniline; acenaphthene; 2,4-dinitrotoluene; 2,4-dinitrophenol; 4-chloroaniline; dibenzofuran; 4-nitrophenol; 2-naphthylamine; 1,4-naphthoquinone; fluorene; diethylphthalate; 4,6-dinitro-2-methylphenol; 1,2,4,5-tetrachlorobenzene; 2,4,5-trichlorophenol; hexachlorobenzene; 2,3,4,6-tetrachlorophenol; fluoranthene; pyrene; dinoseb; butylbenzylphthalate; benzo(a)anthracene; chrysene; bis(2-ethylhexyl)phthalate; di-n-octylphthalate; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; indeno(1,2,,3-c,d) pyrene; dibenzo(a,h)anthracene; benzo(g,h,i)perylene; alpha-BHC; beta-BHC; gamma-BHC (lindane); delta-BHC; heptachlor; aldrin; heptachlor epoxide; endosulfan I; 4,4'-DDE; dieldrin; endrin; 4,4'-DDD; endosulfan II; 4,4'DDT; endrin aldehyde; endosulfan sulfate; endrin ketone; methoxychlor	1[b]	1
ERA InterLaB RadCheM Proficiency Testing Program (RAD-67) Environmental Resource Associates		
Gross alpha, radium-226	2[a]	2[d]
Barium-133, cesium-134, cesium-137, cobalt-60, gross beta, iodine-131, radium-228, strontium-89, strontium-90, tritium, uranium (natural), zinc-65	1[a]	1[d]

(a) Results from TA Richland.
(b) Results from TA St. Louis.
(c) Result from TA St. Louis was not acceptable.
(d) Control limits from *National Standards for Water Proficiency Testing Studies Criteria Document* (NERL-Ci-0045) and National Environmental Laboratory Accreditation Conference PT Field of Testing list.

Table C.13. Summary of WSCF Interlaboratory Performance, FY 2007

Constituent	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Mixed Analyte Performance Evaluation Program (MAPEP-06-MaW16&OrW16&GrW16 and MAPEP-07-MaW17&OrW17&GrW17) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-134, cesium-137, cobalt-57, cobalt-60, plutonium-238, plutonium-239/240, strontium-90, technetium-99, tritium, uranium-234/233, uranium-238, zinc-65, gross alpha, gross beta	2	2
Manganese-54	1	1
Arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, thallium, uranium-total, vanadium, zinc	2	2
Antimony, silver, technetium-99	1	1[(a)]
Aniline; phenol; 2-chlorophenol; 1,3-dichlorobenzene; 1,4-dichlorobenzene; benzyl alcohol; 1,2-dichlorobenzene; hexachloroethane; nitrobenzene; isophorone; 2-nitrophenol; 2,4-dimethylphenol; 2,4-dichlorophenol; 1,2,4-trichlorobenzene; naphthalene; hexachlorobutadiene; 4-chloro-3-methylphenol; 2-methylnaphthalene; 2-methylphenol; hexachlorocyclopentadiene; 3&4-methylphenol; 2,4,6-trichlorophenol; 2,6-dichlorophenol; o-toluidine; 1,4-phenylenediamine; 2-chloronaphthalene; 2-nitroaniline; dimethylphthalate; acenaphthylene; 2,6-dinitrotoluene; 3-nitroaniline; acenaphthene; 2,4-dinitrotoluene; 2,4-dinitrophenol; dibenzofuran; 4-nitrophenol; 2-naphthylamine; 1,4-naphthoquinone; fluorene; diethylphthalate; 4,6-dinitro-2-methylphenol; 1,2,4,5-tetrachlorobenzene; 2,4,5-trichlorophenol; hexachlorobenzene; pentachlorophenol; 4-nitroaniline; phenanthrene; anthracene; 1,4-dinitrobenzene; 1,3-dinitrobenzene; 1,2-dinitrobenzene; pentachlorobenzene; pentachloronitrobenzene; 2,3,4,6-tetrachlorophenol; fluoranthene; pyrene; dinoseb; butylbenzylphthalate; benzo(a)anthracene; bis(2-ethylhexyl)phthalate; di-n-octylphthalate; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; indeno(1,2,3-c,d)pyrene;	2	2
4-Chloroaniline, di-n-butylphthalate, chrysene	2	1
ERA InterLaB RadCheM Proficiency Testing Program (RAD-68, 70; Quik™Response 100506D) Environmental Resource Associates		
Tritium	3	3[(b)]
Radium-226, radium-228, uranium (natural), uranium (natural) mass	2	2[(b)]
Barium-133, cesium-134, cesium-137, cobalt-60	1	1[(b)]
Zinc-65	1	0[(b)]

(a) One result for antimony was acceptable but outside warning limits.
(b) Control limits from National Standards for Water Proficiency Testing Studies Criteria Document (NERL-Ci-0045) and National Environmental Laboratory Accreditation Conference PT Field of Testing list.

Table C.14. Summary of Eberline Services and Lionville Laboratory Interlaboratory Performance, FY 2007

Constituent	Number of Results Reported for Each	Number Within Acceptable Control Limits
DOE Mixed Analyte Performance Evaluation Program (MAPEP-07-MaW17&OrW17&GrW17) Radiological and Environmental Sciences Laboratory		
Americium-241, cesium-134, cesium-137, cobalt-57, cobalt-60, iron-55, manganese-54, nickel-63, plutonium-238, plutonium-239/240, strontium-90, technetium-99, tritium, uranium-234/233, uranium-238, zinc-65, gross alpha, gross beta	1[(a)]	1
Antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, thallium, uranium-total, vanadium, zinc	1[(b)]	1
Phenol, 2-chlorophenol; 1,3-dichlorobenzene; 1,4-dichlorobenzene; 1,2-dichlorobenzene; hexachloroethane; nitrobenzene; isophorone; 2-nitrophenol; 2,4-dimethylphenol; 2,4-dichlorophenol; 1,2,4-trichlorobenzene; naphthalene; hexachlorobutadiene; 4-chloro-3-methylphenol; 2-methylnaphthalene; 2-methylphenol; hexachlorocyclopentadiene; 3+4-methylphenol; 2,4,6-trichlorophenol; 2-chloronaphthalene; dimethylphthalate; acenaphthylene; 2,6-dinitrotoluene; acenaphthene; 2,4-dinitrotoluene; 2,4-dinitrophenol; dibenzofuran; 4-nitrophenol; fluorene; diethylphthalate; 4,6-dinitro-2-methylphenol; 2,4,5-trichlorophenol; hexachlorobenzene; pentachlorophenol; phenanthrene; anthracene; di-n-butylphthalate; fluoranthene; pyrene; butylbenzylphthalate; benzo(a)anthracene; chrysene; bis(2-ethylhexyl)phthalate; di-n-octylphthalate; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; indeno(1,2,3-c,d)pyrene; dibenzo(a,h)anthracene; benzo(g,h,i)perylene	1[(b)]	1
ERA InterLaB RadCheM Proficiency Testing Program (RAD-68, 70; Quik™Response 022607B) Environmental Resource Associates		
Gross beta	3[(a)]	3[(c)]
Gross alpha	3[(a)]	2[(c)]
Barium-133, cesium-134, cesium-137, cobalt-60, radium-226, radium-228, strontium-89, strontium-90, tritium, uranium(natural), uranium (natural) mass	2[(a)]	2[(c)]
Zinc-65	2[(a)]	1[(d,e)]

(a) Results from Eberline Services.
(b) Results from Lionville Laboratory.
(c) Control limits from *National Standards for Water Proficiency Testing Studies Criteria Document* (NERL-Ci-0045) and from National Environmental Laboratory Accreditation Conference PT Field of Testing list.

Table C.15. Summary of TestAmerica Laboratories Double-Blind Spike Determinations

Constituent	Laboratory	Sample Frequency	Number of Results Reported[a]	Number of Results Outside QC Limits	Control Limits[b] (%)
General Chemical Parameters					
Specific conductance	St. Louis	Quarterly	12	0	±25
Total organic carbon (potassium hydrogen phthalate spike)	St. Louis	Quarterly	16	0	±25
Total organic halides (2,4,5-trichlorophenol spike)	St. Louis	Quarterly	14	0	±25
Total organic halides (carbon tetrachloride, chloroform, and trichloroethene spike)	St. Louis	Quarterly	14	4	±25
Ammonia and Anions					
Chloride	St. Louis	Quarterly	9	0	±25
Cyanide	St. Louis	Quarterly	12	0	±25
Fluoride	St. Louis	Quarterly	12	0	±25
Nitrate as nitrogen	St. Louis	Quarterly	12	1	±25
Nitrite as nitrogen	St. Louis	Annually	3	0	±25
Metals					
Chromium (total)	St. Louis	Semiannually	6	0	±20
Hexavalent chromium	St. Louis	Semiannually	6	1	±20
Volatile Organic Compounds					
Carbon tetrachloride	St. Louis	Quarterly	12	5	±25
Chloroform	St. Louis	Quarterly	12	0	±25
Trichloroethene	St. Louis	Quarterly	12	1	±25
Radiological Parameters					
Gross alpha (plutonium-239 spike)	Richland	Quarterly	12	0	±30
Gross beta (strontium-90 spike)	Richland	Quarterly	12	0	±30
Cesium-137	Richland	Annually	3	0	±30
Cobalt-60	Richland	Annually	3	0	±30
Iodine-129	Richland	Semiannually	3	0	±30
Plutonium-239	Richland	Quarterly	12	0	±30
Strontium-90	Richland	Quarterly	12	0	±30
Technetium-99	Richland	Quarterly	12	0	±30
Tritium	Richland	Quarterly	9	3	±30
Tritium (low level)	Richland	Quarterly	9	0	±30
Uranium-238	Richland	Quarterly	12	0	±30

(a) Blind standards were generally submitted in triplicate or quadruplicate.
(b) Each result must be within the specified percentage of the known value to be acceptable.
QC = Quality control.

Table C.16. Summary of WSCF Double-Blind Spike Determinations

Constituent	Sample Frequency	Number of Results Reported[a]	Number of Results Outside QC Limits	Control Limits[b] (%)
General Chemical Parameters				
Specific conductance	Quarterly	12	0	±25
Total organic carbon (potassium hydrogen phthalate spike)	Quarterly	16	4	±25
Total organic halides (2,4,5-trichlorophenol spike)	Quarterly	14	3	±25
Total organic halides (carbon tetrachloride, chloroform, and trichloroethene spike)	Quarterly	14	9	±25
Ammonia and Anions				
Chloride	Quarterly	9	3	±25
Cyanide	Quarterly	12	0	±25
Fluoride	Quarterly	12	0	±25
Nitrate as nitrogen	Quarterly	12	3	±25
Nitrite as nitrogen	Annually	3	0	±25
Metals				
Chromium (total)	Semiannually	6	0	±20
Hexavalent chromium	Semiannually	6	1	±20
Volatile Organic Compounds				
Carbon tetrachloride	Quarterly	12	7	±25
Chloroform	Quarterly	12	0	±25
Trichloroethene	Quarterly	12	10	±25
Radiological Parameters				
Gross alpha (plutonium-239 spike)	Quarterly	15	2	±30
Gross beta (strontium-90 spike)	Quarterly	15	2	±30
Cesium-137	Annually	3	0	±30
Cobalt-60	Annually	3	0	±30
Plutonium-239	Quarterly	12	0	±30
Strontium-90	Quarterly	12	2	±30
Technetium-99	Quarterly	12	1	±30
Tritium	Quarterly	9	6	±30
Uranium-238	Quarterly	9	0	±30

(a) Blind standards were generally submitted in triplicate or quadruplicate.
(b) Each result must be within the specified percentage of the known value to be acceptable.
QC = Quality control.

Table C.17. Summary of Lionville Laboratory, Inc. and Eberline Services Double-Blind Spike Determinations

Constituent	Laboratory	Sample Frequency	Number of Results Reported[a]	Number of Results Outside QC Limits	Control Limits[b] (%)
General Chemical Parameters					
Total organic carbon (potassium hydrogen phthalate spike)	Lionville	Quarterly	16	0	±25
Radiological Parameters					
Gross beta (strontium-90 spike)	Eberline	Quarterly	12	0	±30

(a) Blind standards were generally submitted in triplicate or quadruplicate.
(b) Each result must be within the specified percentage of the known value to be acceptable.
QC = Quality control.

Table C.18. Percentage of Out-of-Limit Quality Control Results by Category, TestAmerica Laboratories (Richland and St. Louis)

QC Parameter	General Chemistry Parameters	Ammonia and Anions	Metals	VOC	SVOC	Radiological Parameters	Total
Method Blanks	2.7	7.2	1.0	0.5	0.1	0.1	1.2
Lab Control Samples	2.2	1.2	0.3	1.9	6.0	0.7	1.7
Matrix Spikes	5.7	48.9	1.6	2.9	0.8	3.7	5.0
Matrix Duplicates	0.7	3.9	0.8	3.5	4.7	0.7	2.7
Surrogates	—	—	—	2.7	4.5	—	3.1

QC = Quality control.
SVOC = Semivolatile organic compounds.
VOC = Volatile organic compounds.

Table C.19. Percentage of Out-of-Limit Quality Control Results by Category, WSCF

QC Parameter	General Chemistry Parameters	Ammonia and Anions	Metals	VOC	SVOC	Radiological Parameters	Total
Method Blanks	1.3	0.0	8.1	2.3	0.0	0.3	2.0
Lab Control Samples	0.0	0.0	0.1	0.0	0.0	0.6	0.1
Matrix Spikes	4.6	0.9	0.7	0.0	0.0	3.8	0.9
Matrix Duplicates	0.0	0.4	0.6	0.0	1.0	4.4	0.8
Surrogates	—	—	—	0.9	1.2	—	1.0

QC = Quality control.
SVOC = Semivolatile organic compounds.
VOC = Volatile organic compounds.

Table C.20. Method Blank Results, TestAmerica (Richland and St. Louis)

Constituent	Percent Out of Limit[(a)]	Number of Analyses	Concentration Range of Out-of-Limit Results
General Chemistry Parameters			
Total General Chemistry Parameters	2.7	222	—
Alkalinity	7.9	38	2 mg/L
Total organic halides	3.2	94	4.6 – 5.4 µg/L
Ammonia and Anions			
Total Ammonia and Anions	7.2	975	—
Chloride	27.3	176	0.047 – 0.47mg/L
Cyanide	6.3	32	9.8 – 19.5 µg/L
Nitrogen in ammonia	42.1	19	11.1 – 42.2 µg/L
Nitrogen in nitrate	1.1	184	0.011 – 0.013 mg/L
Phosphate	26.1	23	0.21 – 0.73 mg/L
Sulfate	2.2	178	0.17 – 0.6 mg/L
Metals			
Total Metals	1.0	1,894	—
Beryllium	1.0	96	2.3 µg/L
Calcium	6.3	96	72.5 – 1040 µg/L
Copper	1.0	96	8.8 µg/L
Iron	1.0	99	61.5 µg/L
Lithium	12.5	8	17.8 µg/L
Manganese	3.1	96	2.3 – 5.4 µg/L
Sodium	2.1	97	269 – 1,540 µg/L
Strontium (elemental)	2.1	96	2.3 – 2.5 µg/L
Zinc	1.0	96	2.5 µg/L
Volatile Organic Compounds			
Total Volatile Organic Compounds	0.5	3,335	—
Acetone[(b)]	1.0	104	5.6 µg/L
Benzene	1.0	104	0.13 µg/L
Chloroform	1.0	104	0.12 µg/L
Chloromethane	5.6	18	0.1 µg/L
Methylene chloride[(b)]	8.7	104	0.54 – 2.8 µg/L
Toluene[(b)]	1.9	104	0.13 – 0.16 µg/L
Semivolatile Organic Compounds			
Total Semivolatile Organic Compounds	0.1	1,025	—
Oil and grease	14.3	7	1.7 mg/L
Radiological Parameters			
Total Radiochemistry Parameters	0.1	2,104	—
Carbon-14	3.8	26	48.9 pCi/L
Gross beta	1.0	101	4.67 pCi/L
Uranium	1.1	95	3.72 µg/L

(a) Quality control limits are twice the method detection limit.
(b) Quality control limits are five times the method detection limit.

Table C.21. Method Blank Results, WSCF

Constituent	Percent Out of Limit [a]	Number of Analyses	Concentration Range of Out-of-Limit Results
General Chemistry Parameters			
Total General Chemistry Parameters	1.3	76	—
Alkalinity	33.3	3	2.2 mg/L
Ammonia and Anions			
Total Ammonia and Anions	0.0	2,416	—
Metals			
Total Metals	8.1	950	—
Aluminum	14.3	7	709 µg/L
Calcium	6.7	45	72.7 - 390 µg/L
Chromium	6.3	48	12.3 – 15.5 µg/L
Cobalt	6.3	48	9.2 – 10.5 µg/L
Iron	8.9	45	18.4 – 26.2 µg/L
Magnesium	44.4	45	12.4 – 29.1 µg/L
Nickel	10.4	48	9.1 – 15.2 µg/L
Silver	29.2	48	11.5 – 36.8 µg/L
Strontium (elemental)	2.2	45	2.6 µg/L
Vanadium	12.5	48	14.4 – 27.8 µg/L
Zinc	35.4	48	8.3 – 37.7 µg/L
Volatile Organic Compounds			
Total Volatile Organic Compounds	2.3	1,102	—
1,1,1-Trichloroethane	2.4	41	4.7 µg/L
1,1,2-Trichloroethane	2.4	41	5.8 µg/L
1,1-Dichloroethane	2.4	41	5.4 µg/L
1,1- Dichloroethene	2.4	41	5.3 µg/L
1,2-Dichloroethane	2.4	41	5.6 µg/L
2-Butanone[b]	2.4	41	6.2 µg/L
2-Methyl-2-pentanone	4.9	41	5.5 – 5.8 µg/L
Acetone[b]	9.8	41	6.5 – 9.3 µg/L
Benzene	2.4	41	5.7 µg/L
Carbon disulfide	2.4	41	4.2 µg/L
Carbon tetrachloride	2.4	41	4.3 µg/L
Chlorobenzene	2.4	41	7.6 µg/L
cis-1,2-Dichloroethylene	2.4	41	5.1 µg/L
Ethylbenzene	4.9	41	8.3 – 11 µg/L
Methylene chloride[b]	2.4	41	5.9 µg/L
Tetrachloroethene	2.4	41	3.5 µg/L
trans-1,2-Dichloroethylene	2.4	41	4.4 µg/L
Trichloroethene	2.4	41	4.6 µg/L
Vinyl chloride	2.4	41	2.8 µg/L
Xylenes (total)	2.7	37	5.2 µg/L
Semivolatile Organic Compounds			
Total Semivolatile Organic Compounds	0.0	210	—
Radiological Parameters			
Total Radiochemistry Parameters	0.3	379	—
Gross beta	1.3	80	12.9 pCi/L

(a) Quality control limits are twice the method detection limit.
(b) Quality control limits are five times the method detection limit.

Table C.22. Laboratory Control Samples, TestAmerica Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total General Chemistry Parameters	2.2	226
Total organic carbon	7.5	67
Ammonia and Anions		
Total Ammonia and Anions	1.2	1,002
Cyanide	11.1	54
Nitrogen in nitrite	1.7	178
Phosphate	13.0	23
Metals		
Total Metals	0.3	1,892
Hexavalent chromium	11.1	18
Iron	3.0	99
Potassium	1.0	96
Volatile Organic Compounds		
Total Volatile Organic Compounds	1.9	3,248
1,1,1,2-Tetrachloroethane	11.1	18
1,1-Dichloroethane	1.0	104
1,1-Dichloroethene	1.0	104
1,4-Dichlorobenzene	0.8	118
1,4-Dioxane	1.9	103
1-Butanol	1.0	103
2-Butanone	3.8	104
2-Chloroethyl vinyl ether	50.0	2
4-Methyl-2-pentanone	2.9	104
Acetone	4.8	104
Acrolein	5.6	18
Allyl chloride	5.6	18
Benzene	1.0	104
Bromochloromethane	50.0	2

Table C.22. (contd)

Constituent	Percent Out of Limit	Number of Analyses
Bromomethane	16.7	18
Carbon disulfide	5.8	104
Carbon tetrachloride	2.7	112
Chloroethane	11.1	18
Chloroform	2.9	104
cis-1,2-Dichloroethylene	1.0	105
Ethyl acetate	27.3	11
Fluorotrichloromethane	5.6	18
Iodomethane	22.2	18
Methylene chloride	1.9	104
Tetrahydrofuran	1.9	104
Toluene	1.0	104
trans-1,2-Dichloroethylene	1.0	104
trans-1,4-Dichloro-2-butene	11.1	18
Trichloroethene	1.0	104
Vinyl acetate	16.7	18
Semivolatile Organic Compounds		
Total Semivolatile Organic Compounds	6.0	818
2,3,4,6-Tetrachlorophenol	8.0	25
2,4,5-Trichlorophenol	11.1	27
2,4,6-Trichlorophenol	7.4	27
2,4-Dichlorophenol	5.1	39
2,4-Dimethylphenol	7.4	27
2,4-Dinitrophenol	7.4	27
2,6-Dichlorophenol	8.0	25
2-Chlorophenol	7.4	27
2-Methylphenol	5.1	39
2-Nitrophenol	5.1	39
2-secButyl-4,6-dinitrophenol	3.7	27

Table C.22. (contd)

Constituent	Percent Out of Limit	Number of Analyses
3-+4-Methylphenol	5.3	38
4-Bromophenylphenyl ether	50.0	2
4-Chloro-3-methylphenol	7.4	27
4-Nitrophenol	7.4	27
Anthracene	50.0	2
Benzo(a)anthracene	50.0	2
Benzo(g,h,i)perylene	50.0	2
bis(2-Chloroethoxy)methane	50.0	2
Carbazole	100.0	1
Dibenz[a,h]anthracene	50.0	2
Dimethylphthalate	50.0	2
Heptachlor	40.0	5
Hexachlorobenzene	50.0	2
Indeno(1,2,3-cd)pyrene	50.0	2
Isophorone	50.0	2
Naphthalene	6.3	16
Nitrobenzene	50.0	2
Oil and grease	28.6	7
Pentachlorophenol	2.6	39
Phenol	7.0	43
Radiological Parameters		
Total Radiochemistry Parameters	0.7	1,399
Cobalt-60	0.9	110
Iodine-129	1.0	100
Uranium	3.1	191
Uranium-235	50.0	4

Table C.23. Laboraty Control Samples, WSCF

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total General Chemistry Parameters	0.0	162
Ammonia and Anions		
Total Ammonia and Anions	0.0	1,249
Metals		
Total Metals	0.1	951
Antimony	2.1	48
Volatile Organic Compounds		
Total Volatile Organic Compounds	0.0	218
Semivolatile Organic Compounds		
Total Semivolatile Organic Compounds	0.0	106
Radiological Parameters		
Total Radiochemistry Parameters	0.6	330
Tritium	2.9	69

Table C.24. Matrix Spikes and Matrix Spike Duplicates, TestAmerica Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total General Chemistry Parameters	5.7	262
Alkalinity	2.5	40
Chemical oxygen demand	16.7	6
Conductivity	20.0	5
Total organic carbon	6.8	103
Total organic halides	4.7	107
Ammonia and Anions		
Total Ammonia and Anions	48.9	937
Chloride	38.0	171
Cyanide	30.8	39
Fluoride	41.7	168
Nitrogen in ammonia	21.7	23
Nitrogen in nitrate	44.4	169
Nitrogen in nitrite	94.0	168
Phosphate	44.4	18
Sulfate	36.3	171
Sulfide	30.0	10
Metals		
Total Metals	1.6	5,101
Antimony	0.8	264
Barium	0.4	264
Beryllium	0.4	264
Cadmium	0.4	264
Calcium	4.2	264
Chromium	3.0	264
Cobalt	0.4	264
Copper	0.4	262
Iron	4.9	268
Magnesium	1.9	264
Manganese	0.4	264
Mercury	3.2	63
Nickel	0.4	264
Potassium	2.7	264
Silicon	100.0	2
Silver	1.1	264
Sodium	5.4	260
Strontium (elemental)	1.5	260
Vanadium	0.4	260
Zinc	0.4	260
Volatile Organic Compounds		
Total Volatile Organic Compounds	2.9	7,414
1,1,1,2-Tetrachloroethane	9.5	42
1,1,1-Trichloroethane	0.4	235
1,1,2-Trichloroethane	0.9	235
1,1-Dichloroethane	0.4	235
1,1-Dichloroethene	2.6	235
1,2-Dibromo-3-chloropropane	7.1	42
1,2-Dibromoethane	4.8	42
1,2-Dichloroethane	1.3	237

Table C.25. Matrix Spikes and Matrix Spike Duplicates, WSCF

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total General Chemistry Parameters	4.6	194
Total organic carbon	5.4	112
Total organic halides	3.9	76
Ammonia and Anions		
Total Ammonia and Anions	0.9	2,488
Chloride	0.4	484
Nitrogen in nitrate	0.6	482
Nitrogen in nitrite	3.0	474
Phosphorus in Phosphate	4.2	24
Sulfate	0.4	476
Metals		
Total Metals	0.7	1,744
Barium	2.3	88
Iron	1.1	88
Silver	2.3	88
Zinc	9.1	88
Volatile Organic Compounds		
Total Volatile Organic Compounds	0.0	424
Semivolatile Organic Compounds		
Total Semivolatile Organic Compounds	0.0	209
Radiological Parameters		
Total Radiochemistry Parameters	3.8	133
Technetium-99	25.0	20

Table C.26. Matrix Duplicates, TestAmerica Laboratories (Richland and St. Louis)

Constituent	Percent Out of Limit	Number of Analyses
General Chemistry Parameters		
Total General Chemistry Parameters	0.7	458
Total organic halides	2.4	127
Ammonia and Anions		
Total Ammonia and Anions	3.9	1,995
Chloride	4.3	373
Cyanide	9.3	43
Fluoride	4.1	370
Nitrogen in ammonia	2.4	41
Nitrogen in nitrate	1.3	378
Nitrogen in nitrite	8.4	370
Phosphate	5.9	34
Sulfate	0.5	374
Sulfide	9.1	11
Metals		
Total Metals	0.8	2,631
Antimony	0.7	135
Barium	0.7	135
Beryllium	0.7	135
Calcium	0.7	135
Chromium	0.7	135
Cobalt	0.7	135
Copper	0.7	134
Hexavalent chromium	8.1	37
Iron	1.5	137
Magnesium	0.7	135
Manganese	0.7	135
Nickel	0.7	135
Potassium	0.7	135
Silver	0.7	135
Sodium	0.8	133
Strontium (elemental)	0.8	133
Vanadium	0.7	143
Zinc	0.8	133

Table C.26. (contd)

Volatile Organic Compounds		
Total Volatile Organic Compounds	3.5	7,603
1,1,1-Trichloroethane	1.2	254
1,1,2-Trichloroethane	0.8	254
1,1-Dichloroethane	2.0	254
1,1-Dichloroethene	2.0	254
1,2-Dibromo-3-chloropropane	5.7	35
1,2-Dichloroethane	0.8	254
1,4-Dichlorobenzene	1.1	270
1,4-Dioxane	9.9	253
1-Butanol	20.9	253
2-Butanone	13.0	254
2-Hexanone	2.9	35
2-Methyl-1-propanol	11.4	35
4-Methyl-2-pentanone	1.2	254
Acetone	16.1	254
Acetonitrile	11.4	35
Acrolein	11.1	36
Benzene	1.2	254
Bromoform	2.9	35
Bromomethane	2.9	35
Carbon disulfide	3.5	254
Carbon tetrachloride	1.3	232
Chloroform	1.6	252
Chloromethane	2.9	35
cis-1,2-Dichloroethylene	1.6	254
Cyclohexanone	16.7	6
Dichlorodifluoromethane	2.9	35
Ethyl acetate	4.3	23
Ethyl cyanide	1.6	254
Ethyl methacrylate	2.9	35
Ethylbenzene	1.2	254
Iodomethane	11.4	35
Methylene chloride	2.4	254
Tetrachloroethene	2.0	254
Tetrahydrofuran	2.4	254
Toluene	1.6	254
trans-1,2-Dichloroethylene	2.4	254
Trichloroethene	1.2	252
Vinyl chloride	2.8	254

Table C.26. (contd)

Semivolatile Organic Compounds		
Total Semivolatile Organic Compounds	4.7	1,095
2,3,4,6-Tetrachlorophenol	18.4	38
2,4,5-Trichlorophenol	5.0	40
2,4,6-Trichlorophenol	5.0	40
2,4-Dichlorophenol	3.7	54
2,4-Dimethylphenol	5.0	40
2,4-Dinitrophenol	7.5	40
2,6-Dichlorophenol	5.3	38
2-Chlorophenol	5.0	40
2-Methylphenol	3.7	54
2-Nitrophenol	3.7	54
2-secButyl-4,6-dinitrophenol	10.0	40
3-+4-Methylphenol	3.8	53
4,6-Dinitro-2-methylphenol	10.0	40
4-Chloro-3-methylphenol	5.0	40
4-Nitrophenol	15.0	40
Pentachlorophenol	7.4	54
Phenol	3.4	58
TPH Diesel	2.8	36
Radiological Parameters		
Total Radiochemistry Parameters	0.7	2,031
Carbon-14	10.7	28
Cobalt-60	1.8	113
Gross alpha	2.2	91
Gross beta	1.0	99
Iodine-129	2.0	98
Plutonium-239/240	4.0	25
Technetium-99	0.8	125
Tritium	0.7	135
Uranium-235	9.1	11

Table C.27. Matrix Duplicates, WSCF

Constituent	Percent Out of Limit	Number of Analyses[(a)]
General Chemistry Parameters		
Total General Chemistry Parameters	0.0	137
Ammonia and Anions		
Total Ammonia and Anions	0.4	2,312
Fluoride	0.8	476
Nitrogen in nitrate	0.8	484
Nitrogen in nitrite	0.4	476
Metals		
Total Metals	0.6	819
Barium	4.5	44
Iron	2.3	44
Zinc	4.5	44
Volatile Organic Compounds		
Total Volatile Organic Compounds	0.0	213
Semivolatile Organic Compounds		
Total Semivolatile Organic Compounds	1.0	104
Phenol	10.0	10
Radiological Parameters		
Total Radiochemistry Parameters	4.4	383
Gross alpha	6.4	78
Gross beta	11.7	77
Strontium	23.1	13

(a) Relative percent difference values were not reported for 284 duplicates whose value was not below the method detection limit.

Table C.28. Summary of Issue Resolution Forms, FY 2007

Issue Category	Number of Analyses Impacted		
	Prior to Receipt at the Laboratory	After Receipt at the TA Laboratory[(a)]	After Receipt at the WSCF Laboratory
Hold Time Missed	49	200	30
Broken Bottles	9	--	--
Late analysis	--	40	3
Temperature Deviation	25	--	30
pH Variance	--	--	--
Bottle Size/Type (insufficient volume or headspace)	17	--	--
Chain-of-Custody Forms Incomplete/SDG Assignment	1	8	--
Laboratory QC Out of Limits		50	4
Incorrect Preservation of the Sample	9	6	--
Analytical Preparation Deviations	--	7	9
Method Failures/Discontinued Analyses	--	3	--

(a) Includes data from TA St. Louis and TA Richland
QC = Quality control.
SDG = Sample delivery group.
TA = TestAmerica Laboratories, Inc.
WSCF = Waste Sampling and Characterization Facility.

Table C.29. Laboratory Audits and Assessment Results

Laboratory	Findings	Observations	Summary of Results
Severn Trent, Inc. St Louis, MO	21	18	Two "Priority I" audit findings addressing the lack of a technical director for the radiochemistry department and inadequate controls on handling radioactive materials within the facility. Other findings include: No annual review of large percentage of SOPs, no documentation of daily refrigerator temperature checks or calibration of refrigerator thermometers, incorrect interpretation of ion chromatography data, analysis of ICP-MS interference check solutions not always done on a 12-hour basis, linear dynamic range of ICP not verified every 6 months, several problems with radiochemical analysis setup and operations, inadequate documentation of subcontracted work in data packages.
Severn Trent Inc. Richland, WA	0	2	No findings issued.
Eberline Services, Richmond, CA	5	5	Verification of gamma spectrometer software not available for review, no specification on tracer addition during sample preparation, MDL estimation for total uranium by KPA does not follow the QSAS, control limit specification for method blank acceptance does not follow the QSAS, no PE results for GEA, and gross alpha/beta on air filters.
Lionville Laboratory, Inc., Lionville, PA	5	5	Health and Safety retraining not in compliance with SOPs, current version of SOPs do not reference current version of QSAS, no demonstrated lot check for Florisil cartridges, calibration of DO meter not verified after use, no documentation of auditing of waste management facilities.
Severn Trent Inc., Knoxville, TN	2	0	Not all client requirements are well documented, calibration certificates for radiological survey instruments are not kept for the required 5 years.
Waste Sampling and Characterization Facility, Hanford Site	6	15	MDL check samples for ICP not analyzed on quarterly basis, TOX analyst did not meet minimum training requirements, no written SOP for TPH gasoline analysis in soils, ambient temperature for TCLP analyses were out side of temperature tolerance limits, no SOP defining in-house preparation of standards and reagents, SOPs do not define control charting for calibration verification checks for radionuclide analysis.

DO = Dissolved oxygen.
GEA = Gamma energy analysis.
ICP = Inductively coupled plasma.
ICP-MS = Inductively coupled plasma mass spectroscopy.
KPA = Kinetic phosphorescence analysis.
MDL = Method detection limit.
PE = Performance evaluation.
QSAS = Quality Systems for Analytical Services.
SOP = Standard operating procedure.
TCLP = Toxicity characteristics leaching procedure.
TPH = Total petroleum hydrocarbon.
TOX = Total organic halides.

Table C.30. Comparison of FY 2007 Hanford Site Groundwater Chromium Data

C.30. Comparison of FY 2007 Hanford Site Groundwater Chromium Data								
Well	Date	Hexavalent Chromiµm, Filtered (µg/L)	Hexavalent Chromiµm, µnfiltered (µg/L)	Total Chromiµm, Filtered (µg/L)	Total Chromiµm, µnfiltered (µg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
199-B3-1	1/16/2007		28.0	23.8		NA	NA	-16.22%
199-B3-46	1/30/2007		18.0	16.5		NA	NA	-8.70%
199-B3-47	1/16/2007		64.0	55.2		NA	NA	-14.77%
199-B5-1	1/11/2007		12.0	11.4		NA	NA	-5.13%
199-D2-6	11/27/2006	38.5		45.2		NA	NA	15.90%
199-D2-8	1/25/2007	114.0		116.0		NA	NA	1.74%
199-D3-2	11/14/2006	23.0		17.4	18.7	NA	7.20%	-27.72%
199-D4-1	11/14/2006	5.0		3.1		NA	NA	NC
199-D4-13	11/14/2006	5.0		7.0	7.0	NA	NC	NC
199-D4-14	11/14/2006	45.0		45.5	44.1	NA	-3.13%	1.10%
199-D4-15	11/20/2006	1,437.3		1,390.0	1,460.0	NA	4.91%	-3.35%
199-D4-19	11/14/2006	5.0		7.0	7.0	NA	NC	NC
199-D4-20	11/14/2006	186.5		170.0	172.0	NA	1.17%	-9.26%
199-D4-22	11/14/2006	940.0		848.0	862.0	NA	1.64%	-10.29%
199-D4-23	11/14/2006	16.0		11.2	34.6	NA	102.18%	-35.29%
199-D4-26	11/14/2006	553.0		554.0		NA	NA	0.18%
199-D4-31	12/7/2006	583.0		586.0		NA	NA	0.51%
199-D4-32	11/20/2006	80.0		81.4		NA	NA	1.73%
199-D4-36	11/20/2006	289.0		285.0		NA	NA	-1.39%
199-D4-38	11/14/2006	369.0		366.0		NA	NA	-0.82%
199-D4-39	11/14/2006	650.0		665.0		NA	NA	2.28%
199-D4-4	11/20/2006	5.0		3.1		NA	NA	NC
199-D4-5	11/21/2006	5.0		3.1		NA	NA	NC
199-D4-6	11/14/2006	5.0		3.1		NA	NA	NC
199-D4-62	11/14/2006	5.0		3.1		NA	NA	NC
199-D4-7	12/12/2006	86.0		70.4		NA	NA	-19.95%
199-D4-78	11/21/2006	30.0		35.6		NA	NA	17.07%
199-D4-84	11/20/2006	48.0		45.7		NA	NA	-4.91%
199-D4-85	11/20/2006	16.0		14.0		NA	NA	-13.33%
199-D4-86	11/20/2006	16.0		12.1		NA	NA	-27.76%
199-D5-13	11/22/2006	506.0		528.0	563.0	NA	6.42%	4.26%
199-D5-14	11/22/2006	450.0		510.0	500.0	NA	-1.98%	12.50%
199-D5-15	11/22/2006	1,172.0		1,210.0	1,260.0	NA	4.05%	3.19%
199-D5-15	12/7/2006	1,070.0		1,045.0	1,055.0	NA	0.95%	-2.36%
199-D5-16	2/26/2007	94.0		82.6	86.8	NA	4.96%	-12.91%
199-D5-20	11/27/2006	424.5		420.5	413.5	NA	-1.68%	-0.95%
199-D5-32	11/27/2006	429.0		424.5		NA	NA	-1.05%
199-D5-33	11/20/2006	5.5		3.1		NA	NA	NC
199-D5-34	11/20/2006	622.0		641.0		NA	NA	3.01%
199-D5-36	11/27/2006	5.0		7.0		NA	NA	NC
199-D5-37	12/12/2006	46.3		44.7		NA	NA	-3.41%
199-D5-38	11/14/2006	392.0		364.0	358.0	NA	-1.66%	-7.41%
199-D5-39	11/14/2006	1,734.0		1,630.0	1,650.0	NA	1.22%	-6.18%
199-D5-40	11/22/2006			239.0	268.0	NA	11.44%	NA
199-D5-41	11/22/2006	512.0		531.0	539.0	NA	1.50%	3.64%
199-D5-43	11/14/2006	726.0		713.0		NA	NA	-1.81%

Table C.30. (contd)

Well	Date	Hexavalent Chromium, Filtered (µg/L)	Hexavalent Chromium, unfiltered (µg/L)	Total Chromium, Filtered (µg/L)	Total Chromium, unfiltered (µg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
199-D5-43	2/13/2007	702.0		681.0	684.0	NA	0.44%	-3.04%
199-D5-92	11/20/2006	210.0		216.0		NA	NA	2.82%
199-D5-93	1/26/2007	175.0		182.0		NA	NA	3.92%
199-D8-4	11/8/2006			186.0	198.0	NA	6.25%	NA
199-D8-5	11/8/2006			245.0	277.0	NA	12.26%	NA
199-D8-54B	11/8/2006	9.0		7.0	8.9	NA	NC	NC
199-D8-55	11/8/2006	28.0		19.1	20.8	NA	8.52%	-37.79%
199-D8-70	11/8/2006	95.5		88.9		NA	NA	-7.16%
199-D8-73	11/27/2006	208.0		214.0		NA	NA	2.84%
199-D8-88	11/8/2006	78.0		78.6		NA	NA	0.77%
199-H3-2C	11/8/2006			49.8	52.9	NA	6.04%	NA
199-H4-10	11/8/2006	24.0		19.3	18.9	NA	-2.09%	-21.71%
199-H4-12C	11/27/2006	92.0		89.8	90.3	NA	0.56%	-2.42%
199-H4-13	11/8/2006	19.0		13.2	14.0	NA	5.88%	-36.02%
199-H4-16	11/9/2006	9.0		7.0	7.0	NA	NC	NC
199-H4-46	11/21/2006	10.0		7.5	10.6	NA	34.25%	NC
199-H4-48	11/9/2006	18.0		13.2		NA	NA	-30.77%
199-H4-49	11/21/2006	20.0		18.4		NA	NA	-8.33%
199-H4-5	11/9/2006	13.0		7.8		NA	NA	-50.00%
199-H4-6	11/27/2006	11.0		9.7	15.9	NA	48.63%	NC
199-H4-8	11/20/2006	9.0		7.8	24.9	NA	104.59%	NC
199-H4-9	11/27/2006	9.0		7.1	30.7	NA	124.87%	NC
199-H5-1A	11/27/2006	8.0		6.8		NA	NA	NC
199-H6-1	12/20/2006			12.8	14.3	NA	11.46%	NA
199-K-106A	1/18/2007	6.0		4.6		NA	NA	NC
199-K-106A	4/16/2007	8.0		4.0		NA	NA	NC
199-K-106A	8/7/2007	5.0		4.0		NA	NA	NC
199-K-107A	10/12/2006	447.0		441.5	434.0	NA	-1.71%	-1.24%
199-K-107A	1/18/2007	543.0		526.0		NA	NA	-3.18%
199-K-107A	4/16/2007	614.0		610.0		NA	NA	-0.65%
199-K-107A	7/19/2007	409.5		404.0		NA	NA	-1.35%
199-K-108A	10/12/2006	29.6		26.4	29.4	NA	10.75%	-11.26%
199-K-108A	4/27/2007	60.0		61.7		NA	NA	2.79%
199-K-109A	12/20/2006			16.5	15.5	NA	-6.47%	NA
199-K-11	12/22/2006			14.0	14.0	NA	0.00%	NA
199-K-110A	10/31/2006			7.0	21.5	NA	101.75%	NA
199-K-111A	10/16/2006	34.9		33.9	39.4	NA	14.88%	-2.91%
199-K-117A	10/16/2006	11.0		3.1		NA	NA	
199-K-120A	8/13/2007	49.0	51.0			4.00%	NA	NA
199-K-120A	8/13/2007	47.0	51.0			8.16%	NA	NA
199-K-132	1/9/2007	122.0		139.0		NA	NA	13.03%
199-K-132	4/12/2007	112.0		106.0		NA	NA	-5.50%
199-K-132	7/31/2007	82.0		83.2		NA	NA	1.45%
199-K-137	10/24/2006	1,942.0		2,095.0	2,040.0	NA	-2.66%	7.58%
199-K-139	10/31/2006	293.5		283.5	282.0	NA	-0.53%	-3.47%
199-K-140	10/31/2006	161.0		148.0	149.0	NA	0.67%	-8.41%
199-K-143	2/23/2007	22.2		20.2	23.3	NA	14.25%	-9.43%

Table C.30. (contd)

Well	Date	Hexavalent Chromium, Filtered (µg/L)	Hexavalent Chromium, unfiltered (µg/L)	Total Chromium, Filtered (µg/L)	Total Chromium, unfiltered (µg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
199-K-158	1/19/2007		6.5			NA	NA	NA
199-K-18	10/19/2006	145.0		128.0	130.0	NA	1.55%	-12.45%
199-K-19	10/19/2006	58.5		50.0	55.3	NA	10.07%	-15.61%
199-K-20	10/18/2006	21.0		15.6	31.3	NA	66.95%	-29.51%
199-K-21	10/18/2006	11.0		7.0	29.8	NA	123.91%	-44.44%
199-K-22	10/26/2006	120.5	116.0	119.5	117.0	-3.81%	-2.11%	-0.83%
199-K-27	12/1/2006			7.0	12.8	NA	58.59%	NA
199-K-30	10/19/2006			7.0	7.0	NA	NC	NA
199-K-31	10/19/2006			10.8	9.7	NA	-10.73%	NA
199-K-32A	10/19/2006			14.3	43.3	NA	100.69%	NA
199-K-32B	10/19/2006			8.9	47.9	NA	137.32%	NA
199-K-34	10/31/2006			13.7	19.4	NA	34.44%	NA
199-K-34	1/22/2007	22.0		20.6		NA	NA	-6.57%
199-K-34	4/27/2007	32.0		31.2		NA	NA	-2.53%
199-K-34	7/19/2007	21.5		27.6		NA	NA	25.08%
199-K-35	10/19/2006			7.0	42.1	NA	142.97%	NA
199-K-36	10/19/2006	28.0		24.3	89.9	NA	114.89%	-14.15%
199-K-37	10/26/2006	83.0		75.6	79.2	NA	4.65%	-9.33%
299-E17-22	10/13/2006			7.8	8.8	NA	NC	NA
299-E17-22	2/20/2007			7.1	7.7	NA	NC	NA
299-E17-22	3/20/2007			8.0	8.3	NA	NC	NA
299-E17-22	4/23/2007			8.4	8.9	NA	NC	NA
299-E17-23	10/13/2006			29.6	29.8	NA	0.67%	NA
299-E17-23	2/20/2007			29.0	28.2	NA	-2.80%	NA
299-E17-23	3/20/2007			29.7	30.2	NA	1.67%	NA
299-E17-23	4/23/2007			28.4	28.1	NA	-1.06%	NA
299-E17-23	7/5/2007			26.9	26.7	NA	-0.75%	NA
299-E17-25	10/13/2006			24.4	24.5	NA	0.41%	NA
299-E17-25	2/20/2007			21.3	21.0	NA	-1.42%	NA
299-E17-25	3/20/2007			23.4	23.0	NA	-1.72%	NA
299-E17-25	4/23/2007			22.2	22.0	NA	-0.90%	NA
299-E17-25	7/5/2007			20.1	20.6	NA	2.46%	NA
299-E17-26	11/2/2006			10.0	10.2	NA	1.98%	NA
299-E17-26	2/22/2007			11.6	11.9	NA	2.55%	NA
299-E17-26	3/20/2007			13.6	13.5	NA	-0.74%	NA
299-E17-26	4/23/2007			12.6	12.1	NA	-4.05%	NA
299-E17-26	7/5/2007			13.5	13.2	NA	-2.25%	NA
299-E18-1	10/18/2006			7.6	18.3	NA	82.63%	NA
299-E18-1	2/20/2007			14.0	22.0	NA	44.44%	NA
299-E18-1	3/20/2007			23.6	30.4	NA	25.19%	NA
299-E18-1	4/23/2007			10.4	19.8	NA	62.25%	NA
299-E18-1	7/5/2007			11.4	21.7	NA	62.24%	NA
299-E24-21	10/18/2006			3.5	3.7	NA	NC	NA
299-E24-21	2/20/2007			3.4	3.4	NA	NC	NA
299-E24-21	3/20/2007			5.9	13.9	NA	80.81%	NA
299-E24-21	4/23/2007			4.0	3.2	NA	NC	NA
299-E24-21	7/5/2007			4.9	4.9	NA	NC	NA

Table C.30. (contd)

Well	Date	Hexavalent Chromiμm, Filtered (μg/L)	Hexavalent Chromiμm, μnfiltered (μg/L)	Total Chromiμm, Filtered (μg/L)	Total Chromiμm, μnfiltered (μg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
199-K-158	1/19/2007		6.5			NA	NA	NA
199-K-18	10/19/2006	145.0		128.0	130.0	NA	1.55%	-12.45%
199-K-19	10/19/2006	58.5		50.0	55.3	NA	10.07%	-15.61%
199-K-20	10/18/2006	21.0		15.6	31.3	NA	66.95%	-29.51%
199-K-21	10/18/2006	11.0		7.0	29.8	NA	123.91%	-44.44%
199-K-22	10/26/2006	120.5	116.0	119.5	117.0	-3.81%	-2.11%	-0.83%
199-K-27	12/1/2006			7.0	12.8	NA	58.59%	NA
199-K-30	10/19/2006			7.0	7.0	NA	NC	NA
199-K-31	10/19/2006			10.8	9.7	NA	-10.73%	NA
199-K-32A	10/19/2006			14.3	43.3	NA	100.69%	NA
199-K-32B	10/19/2006			8.9	47.9	NA	137.32%	NA
199-K-34	10/31/2006			13.7	19.4	NA	34.44%	NA
199-K-34	1/22/2007	22.0		20.6		NA	NA	-6.57%
199-K-34	4/27/2007	32.0		31.2		NA	NA	-2.53%
199-K-34	7/19/2007	21.5		27.6		NA	NA	25.08%
199-K-35	10/19/2006			7.0	42.1	NA	142.97%	NA
199-K-36	10/19/2006	28.0		24.3	89.9	NA	114.89%	-14.15%
199-K-37	10/26/2006	83.0		75.6	79.2	NA	4.65%	-9.33%
299-E17-22	10/13/2006			7.8	8.8	NA	NC	NA
299-E17-22	2/20/2007			7.1	7.7	NA	NC	NA
299-E17-22	3/20/2007			8.0	8.3	NA	NC	NA
299-E17-22	4/23/2007			8.4	8.9	NA	NC	NA
299-E17-23	10/13/2006			29.6	29.8	NA	0.67%	NA
299-E17-23	2/20/2007			29.0	28.2	NA	-2.80%	NA
299-E17-23	3/20/2007			29.7	30.2	NA	1.67%	NA
299-E17-23	4/23/2007			28.4	28.1	NA	-1.06%	NA
299-E17-23	7/5/2007			26.9	26.7	NA	-0.75%	NA
299-E17-25	10/13/2006			24.4	24.5	NA	0.41%	NA
299-E17-25	2/20/2007			21.3	21.0	NA	-1.42%	NA
299-E17-25	3/20/2007			23.4	23.0	NA	-1.72%	NA
299-E17-25	4/23/2007			22.2	22.0	NA	-0.90%	NA
299-E17-25	7/5/2007			20.1	20.6	NA	2.46%	NA
299-E17-26	11/2/2006			10.0	10.2	NA	1.98%	NA
299-E17-26	2/22/2007			11.6	11.9	NA	2.55%	NA
299-E17-26	3/20/2007			13.6	13.5	NA	-0.74%	NA
299-E17-26	4/23/2007			12.6	12.1	NA	-4.05%	NA
299-E17-26	7/5/2007			13.5	13.2	NA	-2.25%	NA
299-E18-1	10/18/2006			7.6	18.3	NA	82.63%	NA
299-E18-1	2/20/2007			14.0	22.0	NA	44.44%	NA
299-E18-1	3/20/2007			23.6	30.4	NA	25.19%	NA
299-E18-1	4/23/2007			10.4	19.8	NA	62.25%	NA
299-E18-1	7/5/2007			11.4	21.7	NA	62.24%	NA
299-E24-21	10/18/2006			3.5	3.7	NA	NC	NA
299-E24-21	2/20/2007			3.4	3.4	NA	NC	NA
299-E24-21	3/20/2007			5.9	13.9	NA	80.81%	NA
299-E24-21	4/23/2007			4.0	3.2	NA	NC	NA
299-E24-21	7/5/2007			4.9	4.9	NA	NC	NA

Table C.30. (contd)

Well	Date	Hexavalent Chromiμm, Filtered (μg/L)	Hexavalent Chromiμm, μnfiltered (μg/L)	Total Chromiμm, Filtered (μg/L)	Total Chromiμm, μnfiltered (μg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
299-E24-23	4/10/2007		2.0		1.8	NA	NA	NA
299-E24-24	10/18/2006			3.1	3.1	NA	NC	NA
299-E24-24	2/20/2007			3.1	3.1	NA	NC	NA
299-E24-24	3/21/2007			3.1	3.1	NA	NC	NA
299-E24-24	4/9/2007			3.1	3.1	NA	NC	NA
299-E24-24	7/10/2007			4.9	4.9	NA	NC	NA
299-E25-32P	11/1/2006			3.1	20.7	NA	147.90%	NA
299-E27-12	12/22/2006			3.1	8.6	NA	NC	NA
299-E27-22	12/22/2006			3.1	3.1	NA	NC	NA
299-E33-50	3/2/2007		2.0		1.9	NA	NA	NA
299-E33-50	3/6/2007		2.0		2.6	NA	NA	NA
299-E33-50	3/7/2007		2.0		0.5	NA	NA	NA
299-W10-33	7/6/2007		167.0		147.0	NA	NA	NA
299-W10-33	7/10/2007		290.0		262.0	NA	NA	NA
299-W10-33	7/11/2007		91.0		84.1	NA	NA	NA
299-W10-33	7/12/2007		162.0		118.0	NA	NA	NA
299-W10-33	7/16/2007		170.0		86.7	NA	NA	NA
299-W10-33	7/17/2007		46.0		33.5	NA	NA	NA
299-W10-33	7/24/2007		59.0		1.2	NA	NA	NA
299-W11-48	4/6/2007		20.0		19.0	NA	NA	NA
299-W11-48	4/10/2007		28.0		28.1	NA	NA	NA
299-W11-48	4/11/2007		66.0		63.0	NA	NA	NA
299-W11-48	4/13/2007		7.0		0.5	NA	NA	NA
299-W11-48	4/17/2007		95.0		93.1	NA	NA	NA
299-W11-48	4/25/2007		90.5		79.9	NA	NA	NA
299-W11-48	5/3/2007		2.0		0.7	NA	NA	NA
299-W11-48	5/16/2007		4.0		0.8	NA	NA	NA
299-W11-48	5/17/2007		41.0		23.8	NA	NA	NA
299-W11-48	5/21/2007		2.0		2.0	NA	NA	NA
299-W11-48	5/22/2007		142.0		131.0	NA	NA	NA
299-W11-48	5/23/2007		2.0		0.8	NA	NA	NA
299-W11-48	5/29/2007		21.0		21.6	NA	NA	NA
299-W11-48	6/5/2007		9.0		8.2	NA	NA	NA
299-W19-105	10/3/2006	9.0		3.4		NA	NA	NA
299-W19-105	11/29/2006	8.0		3.2		NA	NA	NA
299-W19-105	7/12/2007	3.8		6.0		NA	NA	NA
299-W19-107	12/21/2006	5.0		3.1		NA	NA	NA
299-W22-69	12/14/2006	12.0		11.4		NA	NA	NA
299-W22-69	6/14/2007	10.8		11.5		NA	NA	NA
299-W22-72	1/10/2007	6.0		3.1		NA	NA	NA
299-W22-72	6/14/2007	3.1		2.5		NA	NA	NA
299-W22-86	6/5/2007	32.9		30.6		NA	NA	NA
299-W22-87	6/5/2007	2.0		2.5		NA	NA	NA
299-W26-13	1/29/2007	14.0		21.4		NA	NA	NA
299-W26-14	1/24/2007	5.0		3.1		NA	NA	NA
299-W26-14	6/20/2007	5.0		4.0		NA	NA	NA
299-W27-2	1/29/2007	7.5		4.2		NA	NA	NA

Table C.30. (contd)

Well	Date	Hexavalent Chromiμm, Filtered (μg/L)	Hexavalent Chromiμm, μnfiltered (μg/L)	Total Chromiμm, Filtered (μg/L)	Total Chromiμm, μnfiltered (μg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
299-W7-3	10/26/2006			7.8		NA	NA	NA
299-W7-4	10/26/2006	2.0		3.1		NA	NA	NA
699-19-88	4/4/2007		2.0	3.6		NA	NA	NC
699-19-88	6/14/2007		2.0	5.3		NA	NA	NC
699-40-36	10/9/2006			0.8	1.6	NA	NC	NA
699-40-36	1/17/2007			0.7	5.7	NA	NC	NA
699-40-36	4/3/2007			0.7	1.7	NA	NC	NA
699-40-36	7/23/2007			0.7	1.7	NA	NC	NA
699-41-35	10/9/2006			2.0	4.4	NA	NC	NA
699-41-35	1/17/2007			5.1	7.4	NA	NC	NA
699-41-35	4/3/2007			1.8	5.3	NA	NC	NA
699-41-35	7/23/2007			2.1	4.8	NA	NC	NA
699-42-37	10/9/2006			3.1	6.5	NA	NC	NA
699-42-37	1/17/2007			2.0	4.8	NA	NC	NA
699-42-37	4/3/2007			1.7	4.6	NA	NC	NA
699-42-37	7/23/2007			6.7	12.2	NA	58.75%	NA
699-42-42B	1/29/2007			3.1	5.2	NA	NC	NA
699-43-44	1/29/2007			3.1	55.6	NA	178.88%	NA
699-43-45	11/2/2006			3.1	16.0	NA	135.08%	NA
699-44-39B	2/1/2007			3.7	11.5	NA	102.63%	NA
699-48-50B	12/4/2006		2.0		1.9	NA	NA	NA
699-48-50B	7/31/2007	2.0		4.9		NA	NA	NA
699-48-77A	10/9/2006			4.9	20.6	NA	123.01%	NA
699-48-77A	2/7/2007			5.4	173.0	NA	187.94%	NA
699-48-77A	4/3/2007			4.9	49.1	NA	163.70%	NA
699-48-77A	7/23/2007			10.8	35.6	NA	106.90%	NA
699-48-77C	10/9/2006			1.4	4.9	NA	NC	NA
699-48-77C	1/17/2007			1.6	5.3	NA	NC	NA
699-48-77C	4/3/2007			1.8	6.1	NA	NC	NA
699-48-77C	7/23/2007			1.8	8.2	NA	NC	NA
699-48-77D	10/9/2006			2.1	6.9	NA	NC	NA
699-48-77D	1/17/2007			2.3	6.8	NA	NC	NA
699-48-77D	4/3/2007			4.4	19.6	NA	126.53%	NA
699-48-77D	7/23/2007			5.5	15.7	NA	96.23%	NA
699-50-56	11/28/2006	2.0		0.5		NA	NA	NA
699-78-62	12/5/2006	28.0		24.0	22.7	NA	-5.57%	-15.38%
699-87-55	12/5/2006			22.4		NA	NA	NA
699-96-43	12/27/2006	85.0		82.9	83.8	NA	1.08%	-2.50%
699-96-49	12/6/2006	27.0		26.2	29.3	NA	11.17%	-3.01%
699-97-43	12/5/2006	94.0		113.0	125.0	NA	10.08%	18.36%
699-97-51A	12/27/2006	33.0		30.6	32.7	NA	6.64%	-7.55%
01-M	2/22/2007	7.0	3.0	2.9	6.2	NC	NC	NC
03-D	2/22/2007	6.0	2.0			NC	NA	NA
04-D	2/26/2007	10.0	13.0			26.09%	NA	NA
04-M	2/26/2007	8.0	13.0			47.62%	NA	NA
04-S	2/26/2007		9.5	7.1	7.6	NA	NC	NC
05-D	2/27/2007		18.0		24.8	NA	NA	NA

Table C.30. (contd)

Well	Date	Hexavalent Chromiµm, Filtered (µg/L)	Hexavalent Chromiµm, µnfiltered (µg/L)	Total Chromiµm, Filtered (µg/L)	Total Chromiµm, µnfiltered (µg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
05-D	2/27/2007		45.0	45.2	44.9	NA	-0.67%	0.44%
07-D	2/28/2007		20.5	19.6	19.4	NA	-1.03%	-4.49%
13-S	3/1/2007		4.8		3.9	NA	NA	NA
14-D	1/24/2007	5.0	3.0			NC	NA	NA
17-D	1/23/2007	7.0	4.3	4.1	4.4	NC	NC	NC
18-S	1/22/2007		3.5	1.0	1.2	NA	NC	NC
23-D	2/20/2007	5.0	2.0			NC	NA	NA
36-S	1/9/2007	31.0	29.0			-6.67%	NA	NA
37-S	1/10/2007	5.0	2.0			NC	NA	NA
38-M	1/10/2007	22.0	19.0			-14.63%	NA	NA
43-M	2/20/2007	37.0	32.0			-14.49%	NA	NA
44-D	2/20/2007	13.0	8.0			-47.62%	NA	NA
45-D	2/20/2007	6.0	3.0			NC	NA	NA
47-D	2/6/2007	8.0	8.0			NC	NA	NA
48-M	1/31/2007	8.0	4.0			NC	NA	NA
49-D	1/31/2007	5.0	9.0			NC	NA	NA
50-M	1/31/2007	20.0	14.0			-35.29%	NA	NA
62-M	2/12/2007	7.0	2.0	1.6	2.6	NC	NC	NC
63-S	2/12/2007	8.0	4.0	4.2	4.4	NC	NC	NC
64-D	2/12/2007		4.0	4.3	4.6	NA	NC	NC
66-D	2/1/2007		6.5	4.7	5.0	NA	NC	NC
67-M	2/1/2007		4.3	2.3	2.2	NA	NC	NC
68-D	2/1/2007		2.0		2.0	NA	NA	NA
68-M	2/1/2007		2.0		2.2	NA	NA	NA
72-M	2/13/2007		11.0	8.4		NA	NA	-26.45%
72-M	2/13/2007		8.0		8.6	NA	NA	NA
74-D	2/13/2007		5.0	1.8		NA	NA	NC
74-D	2/13/2007		2.0		1.9	NA	NA	NA
76-D	2/13/2007		6.0	2.8	2.8	NA	NC	NC
77-D	2/15/2007		3.0	3.2	6.4	NA	NC	NC
80-D	2/14/2007		4.0	0.6	0.6	NA	NC	NC
AT-3-1-M	12/11/2006			2.1	2.8	NA	NC	NA
AT-3-2-M	12/11/2006			0.9	1.2	NA	NC	NA
AT-3-3-M	12/11/2006			1.4	1.3	NA	NC	NA
AT-3-4-D	12/12/2006			2.7	1.5	NA	NC	NA
AT-B-3-D	2/28/2007		22.0	22.7	23.5	NA	3.46%	3.13%
AT-B-4-S	2/28/2007	10.0	16.0			46.15%	NA	NA
AT-D-1-D	1/8/2007	8.0	4.0			NC	NA	NA
AT-D-2-M	1/8/2007	18.0	5.0			-113.04%	NA	NA
AT-D-3-D	1/8/2007	50.0	46.0			-8.33%	NA	NA
AT-F-1-D	2/8/2007	9.0	3.5	5.5	6.4	NC	NC	NC
AT-F-2-M	2/8/2007	9.0	3.5		5.3	NC	NC	NA
AT-F-3-M	2/12/2007	8.0	6.0	6.5	6.5	NC	NC	NC
AT-F-4-D	2/15/2007	5.0	2.0	1.1	1.1	NC	NC	NC
AT-H-1-S	2/6/2007	14.0	11.5			-19.61%	NA	NA
AT-H-3-S	2/6/2007	11.0	10.0			-9.52%	NA	NA
AT-K-1-D	1/23/2007		4.0	2.0	3.5	NA	NC	NC

Table C.30. (contd)

Well	Date	Hexavalent Chromiµm, Filtered (µg/L)	Hexavalent Chromiµm, µnfiltered (µg/L)	Total Chromiµm, Filtered (µg/L)	Total Chromiµm, µnfiltered (µg/L)	Hexavalent Chromium Unfiltered/ Filtered SPD	Total Chromium Unfiltered/ Filtered SPD	Total Chromium, Filtered/ Hexavalent Chromium SPD
AT-K-2-D	2/7/2007		2.0	0.8	1.9	NA	NC	NC
AT-K-3-D	2/5/2007	75.0	82.0			8.92%	NA	NA
AT-K-3-M	2/5/2007		62.3		59.0	NA	NA	NA
AT-K-3-S	2/5/2007	14.0	19.0			30.30%	NA	NA
AT-K-5-D	1/11/2007	63.0		59.3		NA	NA	-6.05%
DD-15-3	1/8/2007	18.0	8.0			-76.92%	NA	NA
DD-17-2	1/10/2007	23.0	19.0			-19.05%	NA	NA
DD-39-3	12/6/2006	102.0	100.0		95.1	-1.98%	NA	NA
DD-41-2	12/7/2006	39.0	32.0		29.0	-19.72%	NA	NA
DD-44-4	12/18/2006		64.7	55.2	59.0	NA	6.57%	-15.80%
DK-04-2	1/11/2007		48.5		45.2	NA	N/A	NA
Redox-2-6.0	1/9/2007	27.0	22.5			-18.18%	NA	NA
Redox-3-4.6	12/7/2006	58.0	68.0			15.87%	NA	NA
Redox-4-6.0	12/7/2006	51.0	46.0			-10.31%	NA	NA
AVERAGE						**-9.67%**	**34.69%**	**-6.51%**

NA = Not applicable (both analyses not available)
NC = Not calculated if both valµes <10 µg/L
SPD = Signed percent difference = (x1-x2)/[(x1+x2)/2]
Includes data collected October 2006 through early September 2007. Duplicate samples averaged.

Table C.31. Summary of Analytical Laboratory Detection/Quantitation Limits Determined from Field Blanks Data, Severn Trent Laboratories (Richland and St. Louis) and Waste Sampling and Characterization Facility

Period[a]	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
Constituent: Total Organic Carbon, µg/L					
1/18/06 - 11/7/06	58[b]	265.0	207.0	620[c]	2,070[c]
5/15/06 - 2/20/07	49	250.1	234.3	700	2,340
7/21/06 - 6/28/07	63	119.5	145.3	436	1,450
10/3/06 - 9/12/07	65	113.4	143.3	430	1,430
Summary	65	113.4	143.3	430	1,430
Constituent: Total Organic Halides, µg/L					
1/18/06 - 12/18/06	55[b]	1.53	2.26	6.8[c]	22.6[c]
5/15/06 - 2/13/07	48[b]	0.91	1.30	3.9	13.0
7/21/06 - 6/23/07	59	1.85	2.25	6.8	22.5
10/3/06 - 9/12/07	60[b]	2.23	2.29	6.9	22.9
Summary	60[b]	2.23	2.29	6.9	22.9
Constituent: Cesium-137, pCi/L					
11/17/06 - 11/28/06	3	0.27	1.02	3.06[c]	10.18[c]
1/10/07 - 2/23/07	2	0.7	0.09	0.28	0.94
4/5/07 - 6/23/07	9	0.37	1.08	3.23	10.77
9/7/07 - 9/30/07	4	-0.09	0.41	1.22	4.05
Summary	18	0.28	0.92	2.76	9.2
Constituent: Cobalt-60, pCi/L					
11/17/06 - 11/28/06	3	0.91	1.38	4.13[c]	13.77[c]
1/10/07 - 2/23/07	2	-0.43	0.37	1.10	3.66
4/5/07 - 6/23/07	9	0.05	0.78	2.34	7.8
9/7/07 - 9/30/07	4	0.46	0.34	1.03	3.44
Summary	18	0.23	0.81	2.43	8.08
Constituent: Europium-152, pCi/L					
11/17/06 - 11/28/06	3	-3.67	1.99	5.96[c]	19.86[c]
1/10/07 - 2/23/07	2	-0.94	1.12	3.36	11.21
4/5/07 - 6/23/07	9	-0.13	1.68	5.03	16.77
9/7/07 - 9/30/07	4	-0.63	1.88	5.64	18.81
Summary	18	-0.92	1.74	5.21	17.37
Constituent: Europium-154, pCi/L					
11/17/06 - 11/28/06	3	-1.29	4.20	12.61[c]	42.04[c]
1/10/07 - 2/23/07	2	-0.73	0.99	2.96	9.86
4/5/07 - 6/23/07	9	1.29	4.20	12.60	42.01
9/7/07 - 9/30/07	4	-1.75	1.21	3.62	12.06
Summary	18	-0.04	3.60	10.81	36.04

Table C.31. (contd)

Period[a]	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
Constituent: Europium-155, pCi/L					
11/17/06 - 11/28/06	3	-1.41	3.40	10.21[c]	34.03[c]
1/10/07 - 2/23/07	2	-0.63	0.06	0.17	0.57
4/5/07 - 6/23/07	9	0.24	1.99	5.98	19.92
9/7/07 - 9/30/07	4	-0.07	1.08	3.24	10.80
Summary	18	-0.20	2.04	6.13	20.43
Constituent: Gross Alpha, pCi/L					
10/26/06 - 12/22/06	9	0.01	0.33	0.98[c]	3.26[c]
1/5/07 - 2/23/07	7	0.41	0.39	1.16	3.87
4/19/07 - 6/28/07	13	0.11	0.21	0.64	2.13
9/6/07 - 9/30/07	7	0.19	0.22	0.67	2.25
Summary	36	0.16	0.28	0.85	2.85
Constituent: Gross Beta, pCi/L					
10/26/06 - 12/22/06	9[b]	0.74	0.67	2.02[c]	6.74[c]
1/5/07 - 2/23/07	8	1.14	1.10	3.29	10.96
4/16/07 - 6/28/07	14[b]	0.85	0.94	2.81	9.37
7/10/07 - 9/30/07	8	0.78	0.82	2.46	8.19
Summary	39[b]	0.87	0.90	2.69	8.97
Constituent: Iodine-129, pCi/L					
10/3/06 - 11/17/06	4	-0.02	0.09	0.26[c]	0.87[c]
1/5/07 - 2/23/07	4	-0.02	0.06	0.18	0.61
4/16/07 - 6/22/07	7	0.04	0.11	0.33	1.11
9/12/07 - 9/30/07	2	-0.10	0.14	0.41	1.38
Summary	17	-0.01	0.10	0.30	0.99
Constituent: Strontium-90, pCi/L					
10/12/06 - 12/11/06	5	-0.10	0.14	0.42[c]	1.41[c]
1/9/07 - 1/10/07	2	0.24	0.05	0.15	0.49
4/5/07 - 8/24/07	8[b]	0.10	0.17	0.51	1.69
Summary	15	0.05	0.16	0.48	1.60
Constituent: Technetium-99, pCi/L					
10/3/06 - 11/21/06	9	-0.27	3.31	9.94[c]	33.1[c]
1/5/07 - 3/29/07	10	0.03	1.58	4.73	15.8
4/16/07 - 6/28/07	12	0.81	2.41	7.24	24.1
8/7/07 - 9/16/07	5	-3.19	2.42	7.25	24.2
Summary	36	-0.23	2.49	7.46	24.9

Table C.31. (contd)

Period[a]	Number of Samples	Mean	Standard Deviation	Limit of Detection	Limit of Quantitation
Constituent: Technetium-99, Low-Level Method, pCi/L					
11/10/06 - 9/28/07	4	9.54	9.39	28.2[c]	93.9[c]
Constituent: Tritium, (pCi/L)					
10/3/06 - 12/22/06	10	115.3	88.7	266[c]	887[c]
1/10/07 - 2/23/07	11	63.9	109.7	329	1,097
4/9/07 - 6/22/07	13[b]	40.3	94.2	283	942
8/7/07 - 9/12/07	7	43.9	50.4	151	504
Summary	41	65.5	90.8	272	908
Constituent: Tritium, Low-Level Method, pCi/L					
12/27/06 - 1/12/07	3	99.5	7.1	21.3[c]	70.9[c]
4/25-07 - 6/15/07	2	52.6	16.6	49.9	166.2
9/17/07 - 9/30/07	3	62.7	6.3	18.8	62.6
Summary	8	74.0	9.5	28.6	95.4
Constituent: Uranium, µg/L					
10/3/06 - 12/27/06	11	0.001	0.008	0.026[d]	0.084[d]
1/5/07 - 3/29/07	6	-0.004	0.008	0.019	0.073
4/16/07 - 6/23/07	7	-0.007	0.015	0.038	0.142
8/24/07 - 9/17/07	2	-0.002	0.003	0.006	0.026
Summary	26	-0.002	0.010	0.028	0.100

(a) Time period covered for total organic carbon and total organic halides is a moving average of four quarters.
(b) Excluded outliers.
(c) Limit of detection (blank corrected) equals 3 times the blank standard deviation; limit of quantitation (blank corrected) equals 10 times the blank standard deviation. Numbers are rounded.
(d) Limit of detection equals the mean blank concentration plus 3 standard deviations; limit of quantitation equals the mean blank concentration plus 10 standard deviations. Numbers are rounded.

Table C.32. Summary of Detection and Quantitation Units, TestAmerica Laboratory (St. Louis)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
General Chemical Parameters								
EPA-600/4-81-004, 120.1	Conductivity[b]	0.2	0.3	0.9	03/30/07	0.23	0.3	1.0
EPA-600/4-81-004, 310.1	Alkalinity	2,500	3,376	11,258	04/17/07	850	1148	3828
EPA-600/4-81-004, 410.4	Chemical oxygen demand	9,200	12,423	41,429	01/25/07	14,400	19445	64846
EPA-600/4-81-004, 413.1	Oil and grease	1,800	2,431	8,106	04/06/07	500	675	2252
Ammonia and Anions								
EPA-600/4-81-004, 300.0[c]	Bromide	50	68	225				
EPA-600/4-81-004, 300.0[c]	Chloride	23	31	104	06/15/07	20	27	90
EPA-600/4-81-004, 300.0[c]	Fluoride	20	27	90	06/15/07	25	34	113
EPA-600/4-81-004, 300.0[c]	Nitrate	18	24	81	09/27/07	40	54	180
EPA-600/4-81-004, 300.0[c]	Nitrite	13	18	59	06/15/07	16	22	72
EPA-600/4-81-004, 300.0[c]	Phosphate	100	135	450	06/23/07	160	216	721
EPA-600/4-81-004, 300.0[c]	Sulfate	50	68	225				
EPA-600/4-81-004, 350.1	Ammonia	6.7	9.0	30	04/27/07	6.1	8.2	27.5
EPA-600/4-81-004, 365.2	Phosphate	10	14	45				
SW-846, 9012	Cyanide	2.4	3.2	10.8	07/24/07	2.8	3.8	12.6
SW-846, 9030[c]	Sulfide	310	419	1396	01/10/07	180	243	811
Metals								
SW-846, 6010	Aluminum	94.8	128	427	07/12/07	54.3	73.3	245
SW-846, 6010	Antimony	44.8	60.5	202				
SW-846, 6010	Barium	5	7	23				
SW-846, 6010	Beryllium[d]	0.51	0.69	2.3	08/02/07	1.1	1.5	5.0
SW-846, 6010	Cadmium	2.3	3.1	10	05/21/07	3.5	4.7	16
SW-846, 6010	Calcium[d]	36	49	162	07/10/07	100	135	450
SW-846, 6010	Chromium	3.1	4.2	14	05/31/07	2.5	3.4	11
SW-846, 6010	Cobalt	5	7	23	05/31/07	2	3	9
SW-846, 6010	Copper[d]	2.8	3.8	13	08/09/07	2	3	9
SW-846, 6010	Iron	25	34	113	06/04/07	19	25	84
SW-846, 6010	Lithium	8.7	12	39	07/12/07	10	14	46
SW-846, 6010	Magnesium	108	146	486	05/31/07	128	173	576
SW-846, 6010	Manganese[d]	2.5	3	11	08/09/07	1	1	5
SW-846, 6010	Nickel	7.5	10	34	05/31/07	4.6	6.2	20.7
SW-846, 6010	Potassium	1,500	2025	6755	06/04/07	1,630	2201	7340
SW-846, 6010	Silver	5.2	7.0	23	05/31/07	1.7	2.3	7.7

Table C.32. (contd)

Method	Constituent	Initial MDL[(a)] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[(a)] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 6010	Sodium	110	149	495	06/04/07	78.5	106	354
SW-846, 6010	Strontium (elemental)	0.56	0.76	2.5				
SW-846, 6010	Vanadium	5.9	8.0	27	05/31/07	6.1	8.2	27.5
SW-846, 6010	Zinc	9.6	13	43				
SW-846, 6020	Aluminum	7.9	11	36	08/22/07	9.9	13.4	44.6
SW-846, 6020	Antimony	0.5	0.7	2.3				
SW-846, 6020	Arsenic	2	3	9	06/01/07	1.6	2.2	7.2
SW-846, 6020	Barium	0.25	0.34	1.13				
SW-846, 6020	Beryllim	0.088	0.12	0.40				
SW-846, 6020	Boron	6.7	9.0	30				
SW-846, 6020	Cadmium	0.057	0.077	0.26				
SW-846, 6020	Calcium	21	28	95				
SW-846, 6020	Chromium	2.8	3.8	13				
SW-846, 6020	Cobalt	0.31	0.42	1.40				
SW-846, 6020	Copper	0.25	0.34	1.13				
SW-846, 6020	Iron	9.4	13	42				
SW-846, 6020	Lead	0.49	0.66	2.21				
SW-846, 6020	Magnesium	6.4	8.6	29				
SW-846, 6020	Manganese	0.34	0.46	1.53				
SW-846, 6020	Molybdenum	0.5	0.7	2.3				
SW-846, 6020	Nickel	0.52	0.70	2.34				
SW-846, 6020	Potassium	10	14	45				
SW-846, 6020	Selenium	1	1	5				
SW-846, 6020	Silicon	100	135	450				
SW-846, 6020	Silver	0.2	0.3	0.9				
SW-846, 6020	Sodium	11	15	50				
SW-846, 6020	Strontium (elemental)	0.53	0.72	2.39				
SW-846, 6020	Thallium	0.32	0.43	1.44	08/22/07	0.6	0.8	2.7
SW-846, 6020	Tin	0.2	0.3	0.9				
SW-846, 6020	Titanium	0.39	0.53	1.76				
SW-846, 6020	Vanadium	1.6	2.2	7.2				
SW-846, 6020	Zinc	1	1	5				
SW-846, 7470	Mercury	0.093	0.13	0.42				

Table C.32. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
Volatile Organic Compounds								
SW-846, 8260	1,1,1,2-Tetrachloroethane[d]	0.15	0.20	0.68	08/27/07	0.1	0.1	0.5
SW-846, 8260	1,1,1-Trichloroethane[d]	0.15	0.20	0.68	06/28/07	0.1	0.1	0.5
SW-846, 8260	1,1,2,2-Tetrachloroethane	0.28	0.38	1.26	01/25/07	0.14	0.19	0.63
SW-846, 8260	1,1,2-Trichloroethane	0.23	0.31	1.04	01/25/07	0.092	0.12	0.41
SW-846, 8260	1,1-Dichloroethane	0.16	0.22	0.72	01/25/07	0.046	0.06	0.21
SW-846, 8260	1,1-Dichloroethylene	0.21	0.28	0.95	01/25/07	0.045	0.06	0.20
SW-846, 8260	1,2,3-Trichloropropane	0.27	0.36	1.22	01/25/07	0.24	0.32	1.08
SW-846, 8260	1,2-Dibromo-3-chloropropane	0.38	0.51	1.71	01/25/07	0.55	0.74	2.48
SW-846, 8260	1,2-Dibromoethane	0.23	0.31	1.04	01/25/07	0.13	0.18	0.59
SW-846, 8260	1,2-Dichloroethane	0.21	0.28	0.95	01/25/07	0.11	0.15	0.50
SW-846, 8260	1,2-Dichloroethene (total)	0.35	0.47	1.58	08/27/07	0.1	0.1	0.5
SW-846, 8260	1,2-Dichloropropane	0.16	0.22	0.72	01/25/07	0.077	0.10	0.35
SW-846, 8260	1,4-Dichlorobenzene[d]	0.2	0.3	0.9	06/28/07	0.1	0.1	0.5
SW-846, 8260	1,4-Dioxane	12	16	54				
SW-846, 8260	1-Butanol	2.6	3.5	11.7	01/25/07	14	19	63
SW-846, 8260	2-Butanone	0.56	0.76	2.52	01/25/07	1.8	2.4	8.1
SW-846, 8260	2-Chloro-1,3-butadiene	0.2	0.3	0.9	08/27/07	0.1	0.1	0.5
SW-846, 8260	2-Hexanone	0.19	0.26	0.86	01/25/07	1	1	5
SW-846, 8260	2-Methyl-1-propanol	5.7	7.7	25.7	01/25/07	29	39	131
SW-846, 8260	4-Methyl-2-pentanone	0.53	0.7	2.4	01/25/07	0.21	0.28	0.95
SW-846, 8260	Acetone	0.8	1.1	3.6				
SW-846, 8260	Acetonitrile	3.5	4.7	15.8	01/25/07	1.5	2.0	6.8
SW-846, 8260	Acrolein	1.4	1.9	6.3	01/25/07	0.44	0.59	1.98
SW-846, 8260	Acrylonitrile	0.78	1.05	3.51	01/25/07	0.57	0.77	2.57
SW-846, 8260	Allyl chloride	0.27	0.36	1.22	01/25/07	0.047	0.06	0.21
SW-846, 8260	Benzene[d]	0.17	0.23	0.77	06/28/07	0.1	0.1	0.5
SW-846, 8260	Bromodichloromethane	0.14	0.19	0.63	01/25/07	0.064	0.086	0.29
SW-846, 8260	Bromoform	0.21	0.28	0.95	01/25/07	0.12	0.16	0.54
SW-846, 8260	Bromomethane	0.28	0.38	1.26	01/25/07	0.085	0.11	0.38
SW-846, 8260	Carbon disulfide[d]	0.16	0.22	0.72	06/28/07	0.1	0.1	0.5
SW-846, 8260	Carbon tetrachloride[d]	0.15	0.20	0.68	06/23/07	0.1	0.1	0.5
SW-846, 8260	Chlorobenzene[d]	0.2	0.3	0.9	08/16/07	0.1	0.1	0.5
SW-846, 8260	Chloroethane[d]	0.16	0.22	0.72	08/16/07	0.1	0.1	0.5

Table C.32. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8260	Chloroform[d]	0.19	0.26	0.86	06/29/07	0.1	0.1	0.5
SW-846, 8260	Chloromethane[d]	0.2	0.3	0.9	08/27/07	0.1	0.1	0.5
SW-846, 8260	cis-1,2-Dichloroethene	0.19	0.26	0.86	01/25/07	0.048	0.06	0.22
SW-846, 8260	cis-1,3-Dichloropropene	0.2	0.3	0.9	01/25/07	0.05	0.1	0.2
SW-846, 8260	Dibromochloromethane	0.27	0.36	1.22	01/25/07	0.11	0.15	0.50
SW-846, 8260	Dibromomethane	0.23	0.31	1.04	01/25/07	0.12	0.16	0.54
SW-846, 8260	Dichlorodifluoromethane	0.27	0.36	1.22	01/25/07	0.045	0.06	0.20
SW-846, 8260	Ethyl acetate	0.23	0.31	1.04				
SW-846, 8260	Ethyl cyanide	1.7	2.3	7.7				
SW-846, 8260	Ethyl methacrylate	0.66	0.89	2.97	01/25/07	0.19	0.26	0.86
SW-846, 8260	Ethylbenzene	0.22	0.30	0.99	01/25/07	0.064	0.086	0.29
SW-846, 8260	Fluorotrichloromethane[d]	0.19	0.26	0.86	08/27/07	0.1	0.1	0.5
SW-846, 8260	Iodomethane	0.19	0.26	0.86	01/25/07	0.13	0.18	0.59
SW-846, 8260	Methacrylonitrile	2.1	2.8	9.5	01/25/07	0.3	0.4	1.4
SW-846, 8260	Methyl methacrylate	0.6	0.8	2.7	01/25/07	0.84	1.13	3.78
SW-846, 8260	Methylene chloride	0.1	0.1	0.5	01/25/07	0.6	0.8	2.7
SW-846, 8260	Styrene	0.28	0.38	1.26	08/27/07	0.1	0.1	0.5
SW-846, 8260	Tetrachloroethene	0.19	0.26	0.86	01/23/07	0.17	0.23	0.77
SW-846, 8260	Tetrahydrofuran	2.9	3.9	13.1	01/23/07	1.2	1.6	5.4
SW-846, 8260	Toluene[d]	0.2	0.3	0.9	06/28/07	0.1	0.1	0.5
SW-846, 8260	trans-1,2-Dichloroethylene[d]	0.16	0.22	0.72	06/28/07	0.1	0.1	0.5
SW-846, 8260	trans-1,3-Dichloropropene	0.23	0.31	1.04	01/25/07	0.085	0.11	0.38
SW-846, 8260	trans-1,4-Dichloro-2-butene	0.56	0.76	2.52	01/25/07	0.43	0.58	1.94
SW-846, 8260	Trichloroethene[d]	0.2	0.3	0.9	06/28/07	0.1	0.1	0.5
SW-846, 8260	Vinyl acetate	0.46	0.62	2.07	01/25/07	0.72	0.97	3.24
SW-846, 8260	Vinyl chloride	0.23	0.31	1.04	12/15/05	0.044	0.06	0.20
SW-846, 8260	Xylenes (total)[d]	0.58	0.78	2.61	06/28/07	0.3	0.4	1.4
SW-846, 8015	TPH, gasoline fraction	7.9	10.7	35.6	02/15/07	9.5	12.8	42.8
Semivolatile Organic Compounds								
SW-846, 8015	TPH, diesel fraction	50	68	225	08/02/07	33	45	149
SW-846, 8015	TPH, kerosene fraction	50	68	225	08/24/07	36	49	162
SW-846, 8040	2,3,4,6-Tetrachlorophenol	2	3	9				
SW-846, 8040	2,4,5-Trichlorophenol	2.2	3.0	9.9				
SW-846, 8040	2,4,6-Trichlorophenol	2.2	3.0	9.9				

Table C.32. (contd)

Method	Constituent	Initial MDL[(a)] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[(a)] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8040	2,4-Dichlorophenol	2.1	2.8	9.5				
SW-846, 8040	2,4-Dimethylphenol	2.1	2.8	9.5				
SW-846, 8040	2,4-Dinitrophenol	2.4	3.2	10.8				
SW-846, 8040	2,6-Dichlorophenol	2.1	2.8	9.5				
SW-846, 8040	2-Chlorophenol	2.2	3.0	9.9				
SW-846, 8040	2-Methylphenol (cresol, o-)	2.2	3.0	9.9				
SW-846, 8040	2-Nitrophenol	2.3	3.1	10.4				
SW-846, 8040	2-secButyl-4,6-dinitrophenol(DNBP)	2.4	3.2	10.8				
SW-846, 8040	3- + 4-Methylphenol	2.2	3.0	9.9				
SW-846, 8040	4,6-Dinitro-2-methyl phenol	2.2	3.0	9.9				
SW-846, 8040	4-Chloro-3-methylphenol	2.4	3.2	10.8				
SW-846, 8040	4-Nitrophenol	2.2	3.0	9.9				
SW-846, 8040	Pentachlorophenol	2.4	3.2	10.8				
SW-846, 8040	Phenol	2.3	3.1	10.4				
SW-846, 8081	4,4'-DDD	0.004	0.005	0.018	04/25/07	0.0031	0.0042	0.0140
SW-846, 8081	4,4'-DDE	0.0082	0.011	0.037	04/25/07	0.0059	0.0080	0.0266
SW-846, 8081	4,4'-DDT	0.032	0.043	0.144	04/25/07	0.0098	0.013	0.044
SW-846, 8081	Aldrin	0.0052	0.0070	0.023	04/25/07	0.0047	0.0063	0.0212
SW-846, 8081	alpha-BHC	0.018	0.024	0.081	04/25/07	0.0044	0.0059	0.0198
SW-846, 8081	beta-BHC	0.0072	0.010	0.032	04/25/07	0.0065	0.0088	0.0293
SW-846, 8081	Chlordane	0.044	0.059	0.198	04/25/07	0.032	0.043	0.144
SW-846, 8081	delta-BHC	0.0034	0.005	0.015	04/25/07	0.0032	0.0043	0.0144
SW-846, 8081	Dieldrin	0.011	0.015	0.050	04/25/07	0.0036	0.0049	0.0162
SW-846, 8081	Endosulfan I	0.0061	0.0082	0.027	04/25/07	0.0031	0.0042	0.0140
SW-846, 8081	Endosulfan II	0.0035	0.005	0.016	04/25/07	0.0032	0.0043	0.0144
SW-846, 8081	Endosulfan sulfate	0.017	0.023	0.077	04/25/07	0.0082	0.011	0.037
SW-846, 8081	Endrin	0.0079	0.011	0.036	04/25/07	0.0067	0.0090	0.0302
SW-846, 8081	Endrin aldehyde	0.0048	0.0065	0.022	04/25/07	0.0027	0.0036	0.0122
SW-846, 8081	gamma-BHC (lindane)	0.0067	0.0090	0.030	04/25/07	0.0029	0.0039	0.0131
SW-846, 8081	Heptachlor	0.0036	0.0049	0.016	04/25/07	0.0052	0.0070	0.0234
SW-846, 8081	Heptachlor epoxide	0.0048	0.0065	0.022	04/25/07	0.0041	0.0055	0.0185
SW-846, 8081	Methoxychlor	0.0081	0.011	0.036				

Table C.32. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8081	Toxaphene	0.22	0.30	0.99	04/25/07	0.19	0.26	0.86
SW-846, 8082	Aroclor-1016[d]	0.31	0.42	1.40	01/31/07	0.27	0.36	1.22
SW-846, 8082	Aroclor-1221[d]	0.31	0.42	1.40	01/31/07	0.27	0.36	1.22
SW-846, 8082	Aroclor-1232[d]	0.31	0.42	1.40	01/31/07	0.27	0.36	1.22
SW-846, 8082	Aroclor-1242[d]	0.31	0.42	1.40	01/31/07	0.27	0.36	1.22
SW-846, 8082	Aroclor-1248[d]	0.31	0.42	1.40	01/31/07	0.27	0.36	1.22
SW-846, 8082	Aroclor-1254[d]	0.28	0.38	1.26	01/31/07	0.21	0.28	0.95
SW-846, 8082	Aroclor-1260[d]	0.28	0.38	1.26	01/31/07	0.21	0.28	0.95
SW-846, 8151	2,4,5-T	0.17	0.23	0.77				
SW-846, 8151	2,4,5-TP (silvex)	0.15	0.20	0.68				
SW-846, 8151	2,4-D	1.3	1.8	5.9				
SW-846, 8151	2-secButyl-4,6-dinitrophenol(DNBP)	0.6	0.8	2.7				
SW-846, 8270	1,2,4,5-Tetrachlorobenzene	1	1	5				
SW-846, 8270	1,2,4-Trichlorobenzene	1	1	5				
SW-846, 8270	1,2-Dichlorobenzene	1	1	5				
SW-846, 8270	1,3-Dichlorobenzene	1	1	5				
SW-846, 8270	1,4-Dichlorobenzene	1	1	5				
SW-846, 8270	1,4-Naphthoquinone	0.95	1.3	4.3				
SW-846, 8270	1-Naphthylamine	1	1	5				
SW-846, 8270	2,2'-Oxybis(1-chloropropane)	1	1	5				
SW-846, 8270	2,3,4,6-Tetrachlorophenol	1	1	5				
SW-846, 8270	2,4,5-Trichlorophenol	2	3	9				
SW-846, 8270	2,4,6-Trichlorophenol	2	3	9				
SW-846, 8270	2,4-Dichlorophenol	1	1	5				
SW-846, 8270	2,4-Dimethylphenol	1	1	5				
SW-846, 8270	2,4-Dinitrophenol	10	14	45				
SW-846, 8270	2,4-Dinitrotoluene	1.1	1.5	5.0				
SW-846, 8270	2.6-Dichlorophenol	1	1	5				
SW-846, 8270	2,6-Dinitrotoluene	1.1	1.5	5.0				

Table C.32. (contd)

Method	Constituent	Initial MDL[(a)] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[(a)] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	2-Acetylaminofluorene	1	1	5				
SW-846, 8270	2-Chloronaphthalene	1	1	5				
SW-846, 8270	2-Chlorophenol	1	1	5				
SW-846, 8270	2-Methylnaphthalene	1	1	5				
SW-846, 8270	2-Methylphenol (cresol, o-)	2	3	9				
SW-846, 8270	2-Naphthylamine	1	1	5				
SW-846, 8270	2-Nitroaniline	2	3	9				
SW-846, 8270	2-Nitrophenol	1	1	5				
SW-846, 8270	2-Picoline	5.5	7.4	24.8				
SW-846, 8270	2-secButyl-4,6-dinitrophenol(DNBP)	2	3	9				
SW-846, 8270	3,3'-Dichlorobenzidine	1	1	5				
SW-846, 8270	3,3'-Dimehtylbenzidine	10	14	45				
SW-846, 8270	3- + 4-Methylphenol	1.2	1.6	5.4				
SW-846, 8270	3-Methylcholanthrene	1	1	5				
SW-846, 8270	3-Nitroaniline	1.1	1.5	5.0				
SW-846, 8270	4,6-Dinitro-2-methyl phenol	5	7	23				
SW-846, 8270	4-Aminobiphenyl	1	1	5				
SW-846, 8270	4-Bromophenylphenyl ether	1	1	5				
SW-846, 8270	4-Chloro-3-methylphenol	1	1	5				
SW-846, 8270	4-Chloroaniline	1	1	5				
SW-846, 8270	4-Chlorophenylphenyl ether	1	1	5				
SW-846, 8270	4-Methylphenol (cresol, p-)	1	1	5				
SW-846, 8270	4-Nitroaniline	1.3	1.8	5.9				
SW-846, 8270	4-Nitrophenol	5	7	23				
SW-846, 8270	4-Nitroquinoline-1-oxide	5	7	23				
SW-846, 8270	5-Nitro-o-toluidine	1	1	5				
SW-846, 8270	7,12-Dimethylbenz[a]anthracene	1	1	5				
SW-846, 8270	Acenaphthene	1	1	5				
SW-846, 8270	Acenaphthylene	1	1	5				
SW-846, 8270	Acetophenone	1	1	5				

Table C.32. (contd)

Method	Constituent	Initial MDL[(a)] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[(a)] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	alpha,alpha-Dimethylphenethylamine	20	27	90				
SW-846, 8270	Aniline	1	1	5				
SW-846, 8270	Anthracene	1.1	1.5	5.0				
SW-846, 8270	Aramite	5	7	23				
SW-846, 8270	Azobenzene	1	1	5				
SW-846, 8270	Benzo(a)anthracene	1	1	5				
SW-846, 8270	Benzo(a)pyrene	1	1	5				
SW-846, 8270	Benzo(b)fluoranthene	1	1	5				
SW-846, 8270	Benzo(ghi)perylene	1	1	5				
SW-846, 8270	Benzo(k)fluoranthene	1	1	5				
SW-846, 8270	Benzothiazole	1	1	5				
SW-846, 8270	Benzyl alcohol	1	1	5				
SW-846, 8270	Bis(2-Chloroethoxy)methane	1	1	5				
SW-846, 8270	Bis(2-chloroethyl) ether	1	1	5				
SW-846, 8270	Bis(2-ethylhexyl) phthalate	1	1	5				
SW-846, 8270	Butylbenzylphthalate	1	1	5				
SW-846, 8270	Chlorobenzilate	1	1	5				
SW-846, 8270	Chrysene	1	1	5				
SW-846, 8270	Diallate	2	3	9				
SW-846, 8270	Di-n-butylphthalate	1	1	5				
SW-846, 8270	Di-n-octylphthalate	5	7	23				
SW-846, 8270	Dibenz[a,h]anthracene	1	1	5				
SW-846, 8270	Dibenzofuran	1	1	5				
SW-846, 8270	Diethylphthalate	1	1	5				
SW-846, 8270	Dimethoate	1.1	1.5	5.0				
SW-846, 8270	Dimethyl phthalate	1	1	5				
SW-846, 8270	Disulfoton	1	1	5				
SW-846, 8270	Ethyl methanesulfonate	1	1	5				
SW-846, 8270	Famphur	50	68	225				
SW-846, 8270	Fluoranthene	1	1	5				

Table C.32. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	Fluorene	1	1	5				
SW-846, 8270	Hexachlorobenzene	1	1	5				
SW-846, 8270	Hexachlorobutadiene	1	1	5				
SW-846, 8270	Hexachlorocyclopentadiene	2.5	3.4	11.3				
SW-846, 8270	Hexachloroethane	1	1	5				
SW-846, 8270	Hexachlorophene	10	14	45				
SW-846, 8270	Hexachloropropene	2.5	3.4	11.3				
SW-846, 8270	Indeno(1,2,3-cd)pyrene	1	1	5				
SW-846, 8270	Isodrin	1	1	5				
SW-846, 8270	Isophorone	1	1	5				
SW-846, 8270	Isosafrole	5.7	7.7	25.7				
SW-846, 8270	Kepone	20	27	90				
SW-846, 8270	m-Dinitrobenzene	1	1	5				
SW-846, 8270	Methapyrilene	14	19	63				
SW-846, 8270	Methyl methanesulfonate	5	7	23				
SW-846, 8270	Methyl parathion	1	1	5				
SW-846, 8270	Naphthalene	1	1	5				
SW-846, 8270	Nitrobenzene	1	1	5				
SW-846, 8270	Nitrosopyrrolidine	1	1	5				
SW-846, 8270	N-Nitrosodiethylamine	1	1	5				
SW-846, 8270	N-Nitrosodimethylamine	2	3	9				
SW-846, 8270	N-Nitroso-di-n-butylamine	1	1	5				
SW-846, 8270	N-Nitroso-di-n-propylamine	1	1	5				
SW-846, 8270	N-Nitrosodiphenylamine	1	1	5				
SW-846, 8270	N-Nitrosomethylethylamine	1	1	5				
SW-846, 8270	N-Nitrosomorpholine	0.96	1.3	4.3				
SW-846, 8270	N-Nitrosopiperidine	1	1	5				
SW-846, 8270	O,O,O-Triethyl phosphorothioate	1	1	5				
SW-846, 8270	O,O-Diethyl0-2-pyrazinyl phospho	0.99	1.3	4.5				
SW-846, 8270	o-Toluidine	1	1.4	4.5				
SW-846, 8270	Parathion	1	1.4	4.5				
SW-846, 8270	p-Dimethylaminoazobenzene	1	1.4	4.5				

Table C.32. (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
SW-846, 8270	Pentachlorobenzene	2.7	3.6	12.2				
SW-846, 8270	Pentachloroethane	1	1	5				
SW-846, 8270	Pentachloronitrobenzene (PCNB)	1.1	1.5	5.0				
SW-846, 8270	Pentachlorophenol	2	3	9				
SW-846, 8270	Phanacetin	0.94	1.3	4.2				
SW-846, 8270	Phenanthrene	1	1	5				
SW-846, 8270	Phenol	4	5	18				
SW-846, 8270	Phorate	2.9	3.9	13.1				
SW-846, 8270	p-Phenylenediamine	1	1	5				
SW-846, 8270	Pronamide	1	1	5				
SW-846, 8270	Pyrene	1	1	5				
SW-846, 8270	Pyridine	5	7	23				
SW-846, 8270	Safrol	1	1	5				
SW-846, 8270	sym-Trinitrobenzene	5	7	23				
SW-846, 8270	Tetraethyl dithiopyrophosphate	1	1	5				
SW-846, 8270	Tributyl phosphate	1.1	1.5	5.0				
SW-846, 8270	tris-2-Chloroethyl phosphate	1.2	1.6	5.4				

(a) MDLs for many constituents changed during the fiscal year. For these constituents, the initial MDL, LOD, and LOQ were in effect until the date the values were updated (ending values, effective date). In cases where the MDL did not change, no ending values are listed.
(b) µMhos/cm.
(c) Units for this method are mg/L.
(d) Additional MDLs were used briefly during the year for these compounds.
LOD = Limit of detection.
LOQ = Limit of quantitation.
MDL = Method detection limit.

Table C.33 Summary of Detection and Quantitation Limits, WSCF

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
General Chemical Parameters								
EPA-600/4-81-004, 120.1	Conductivity[b]	0.49	0.66	2.21				
EPA-600/4-81-004, 160.1	Total dissolved solids	9	12	41				
EPA-600/4-81-004, 310.1	Alkalinity	1000	1350	4503				
EPA-600/4-81-004, 410.4	Chemical Oxygen Demand	10,000	13503	45032				
Ammonia and Anions								
EPA-600/4-81-004, 300.0[d]	Bromide[c]	36	49	162				
EPA-600/4-81-004, 300.0[d]	Chloride[c]	36	49	162	2/7/2007	30	41	135
EPA-600/4-81-004, 300.0[d]	Fluoride[c]	6.4	9	29	6/26/2007	6	8	27
EPA-600/4-81-004, 300.0[d]	Nitrate[c]	42.1	57	190	6/26/2007	22.1	30	100
EPA-600/4-81-004, 300.0[d]	Nitrite[c]	75.5	102	340	11/29/2006	32.8	44	148
EPA-600/4-81-004, 300.0[d]	Phosphate[c]	135	182	608	10/31/2006	123	166	554
EPA-600/4-81-004, 300.0[d]	Sulfate[c]	63	85	284	4/23/2007	70	95	315
EPA-600/4-81-004, 300.7	Ammonium	2.58	3.5	11.6	4/27/2007	12	16.2	54.0
EPA-600/4-81-004	Cyanide	4	5.4	18.0				
Metals								
SW-846, 6010	Aluminum[c]	37	50.0	166.6	1/29/2007	30	41	135
SW-846, 6010	Antimony[c]	72	97	324	1/29/2007	32.0	43.2	144.1
SW-846, 6010	Barium[c]	1	1.4	4.5	1/29/2007	4	5.4	18.0
SW-846, 6010	Beryllium[c]	1	1.35	4.50	1/29/2007	4	5.40	18.01
SW-846, 6010	Cadmium[c]	3	4	14	1/30/2007	4	5.4	18.0
SW-846, 6010	Calcium[c]	31	42	140	1/29/2007	34	46	153
SW-846, 6010	Chromium[c]	7	9	32	1/30/2007	4	5.4	18.0
SW-846, 6010	Cobalt[c]	7	9	32	1/29/2007	4	5.4	18.0
SW-846, 6010	Copper[c]	7	9.5	31.5	1/30/2007	4	5.4	18.0
SW-846, 6010	Iron[c]	33	44.6	148.6	1/29/2007	9	12	41
SW-846, 6010	Magnesium[c]	15	20	68	1/29/2007	6	8	27
SW-846, 6010	Manganese[c]	3	4.1	13.5	1/29/2007	4	5	18
SW-846, 6010	Nickel[c]	5	7	23	1/29/2007	4	5.4	18.0
SW-846, 6010	Potassium[c]	220	297	991	1/29/2007	45	61	203
SW-846, 6010	Silver[c]	11	15	50	1/29/2007	5	6.8	22.5
SW-846, 6010	Sodium[c]	120	162	540	1/29/2007	27	36	122
SW-846, 6010	Strontium (elemental)[c]	1	1.4	4.5	1/30/2007	4	5.40	18.01
SW-846, 6010	Vanadium	14	18.9	63.0	1/29/2007	7	9.5	31.5
SW-846, 6010	Zinc[c]	2	2.7	9.0	1/29/2007	4	5.4	18.0

Table C.33 (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
Volatile Organic Compounds								
SW-846, 8260	1,1,1-Trichloroethane	1	1.35	4.50				
SW-846, 8260	1,1,2-Trichloroethane	1	1.35	4.50				
SW-846, 8260	1,1-Dichloroethane	1	1.4	4.5				
SW-846, 8260	1,1-Dichloroethene	1	1.35	4.50				
SW-846, 8260	1,2-Dichloroethane	1	1.4	4.5				
SW-846, 8260	1,4-Dichlorobenzene	1	1.35	4.50				
SW-846, 8260	1-Butanol	1	1.35	4.50				
SW-846, 8260	2-Butanone	1	1.35	4.50				
SW-846, 8260	2-Petanone, 4-Methyl	1	1.35	4.50				
SW-846, 8260	Acetone	1	1.35	4.50				
SW-846, 8260	Benzene	1	1.35	4.50				
SW-846, 8260	Carbon disulfide	1	1.35	4.50				
SW-846, 8260	Carbon tetrachloride	1	1.35	4.50				
SW-846, 8260	Chlorobenzene	1	1.4	4.5				
SW-846, 8260	Chloroform	1	1.35	4.50				
SW-846, 8260	cis-1,2-Dichloroethene	1	1.35	4.50				
SW-846, 8260	Ethyl cyanide	1	1.4	4.5				
SW-846, 8260	Ethylbenzene	1	1.35	4.50				
SW-846, 8260	Methylene chloride	1	1.4	4.5				
SW-846, 8260	Tetrachloroethene	1	1.35	4.50				
SW-846, 8260	Tetrahydrofuran	2	2.70	9.01				
SW-846, 8260	Toluene	1	1.35	4.50				
SW-846, 8260	trans-1,2-Dichloroethene	1	1.35	4.50				
SW-846, 8260	Trichloroethene	1	1.35	4.50				
SW-846, 8260	Vinyl chloride	1	1.35	4.50				
SW-846, 8260	Xylenes (total)	1	1.35	4.50				
SW-846, 8015	TPH, gasoline fraction	50	67.52	225.16				

Table C.33 (contd)

Method	Constituent	Initial MDL[a] (µg/L)	Initial LOD (µg/L)	Initial LOQ (µg/L)	Ending Values, Effective Date	Ending MDL[a] (µg/L)	Ending LOD (µg/L)	Ending LOQ (µg/L)
Semivolatile Organic Compounds								
SW-846, 8015	TPH, diesel fraction	120	162	540	9/13/2007	71	95.9	319.7
SW-846, 8082	Aroclor-1016	0.1	0.14	0.45	9/27/2007	0.11	0.15	0.50
SW-846, 8082	Aroclor-1221	0.2	0.27	0.90	9/27/2007	0.21	0.28	0.95
SW-846, 8082	Aroclor-1232	0.1	0.14	0.45	9/27/2007	0.11	0.15	0.50
SW-846, 8082	Aroclor-1242	0.1	0.14	0.45	9/27/2007	0.11	0.1	0.5
SW-846, 8082	Aroclor-1248	0.1	0.14	0.45	9/27/2007	0.11	0.15	0.50
SW-846, 8082	Aroclor-1254	0.1	0.14	0.45	9/27/2007	0.11	0.15	0.50
SW-846, 8082	Aroclor-1260	0.1	0.14	0.45	9/27/2007	0.11	0.15	0.50
SW-846, 8270	1,4-Dichlorobenzene[c]	1.5	2.03	6.75				
SW-846, 8270	2,4-Dichlorophenol[c]	0.48	0.6	2.2				
SW-846, 8270	2-Methylphenol (cresol, o-)[c]	0.48	0.6	2.2				
SW-846, 8270	2-Nitrophenol	0.48	0.6	2.2				
SW-846, 8270	2-Picoline [c]	4.8	6.5	21.6				
SW-846, 8270	3+4-Methylphenol (cresol, m+p)[c]	0.48	0.6	2.2				
SW-846, 8270	Benzothiazole [c]	0.67	0.9	3.0				
SW-846, 8270	Bis(2-ethylhexyl) phthalate[c]	0.52	0.7	2.3				
SW-846, 8270	Naphthalene[c]	1.9	3	9				
SW-846, 8270	Pentachlorophenol[c]	0.95	1.3	4.3				
SW-846, 8270	Phenol[c]	0.48	0.65	2.16				
SW-846, 8270	Total cresols[c]	0.62	0.84	2.79				
SW-846, 8270	Tributyl phosphate[c]	0.48	0.65	2.16				
SW-846, 8270	Tris-2-chloroethyl phosphate [c]	0.5	0.7	2.3				

(b) MDLs for many constituents changed during the fiscal year. For these constituents, the initial MDL, LOD, and LOQ were in effect until the date the values were updated (ending values, effective date). In cases where the MDL did not change, no ending values are listed.
(b) µMhos/cm.
(c) Additional MDLs were used during the year for these compounds.
(d) Units for this method are mg/L.
LOD = Limit of detection.
LOQ = Limit of quantitation.
MDL = Method detection limit.

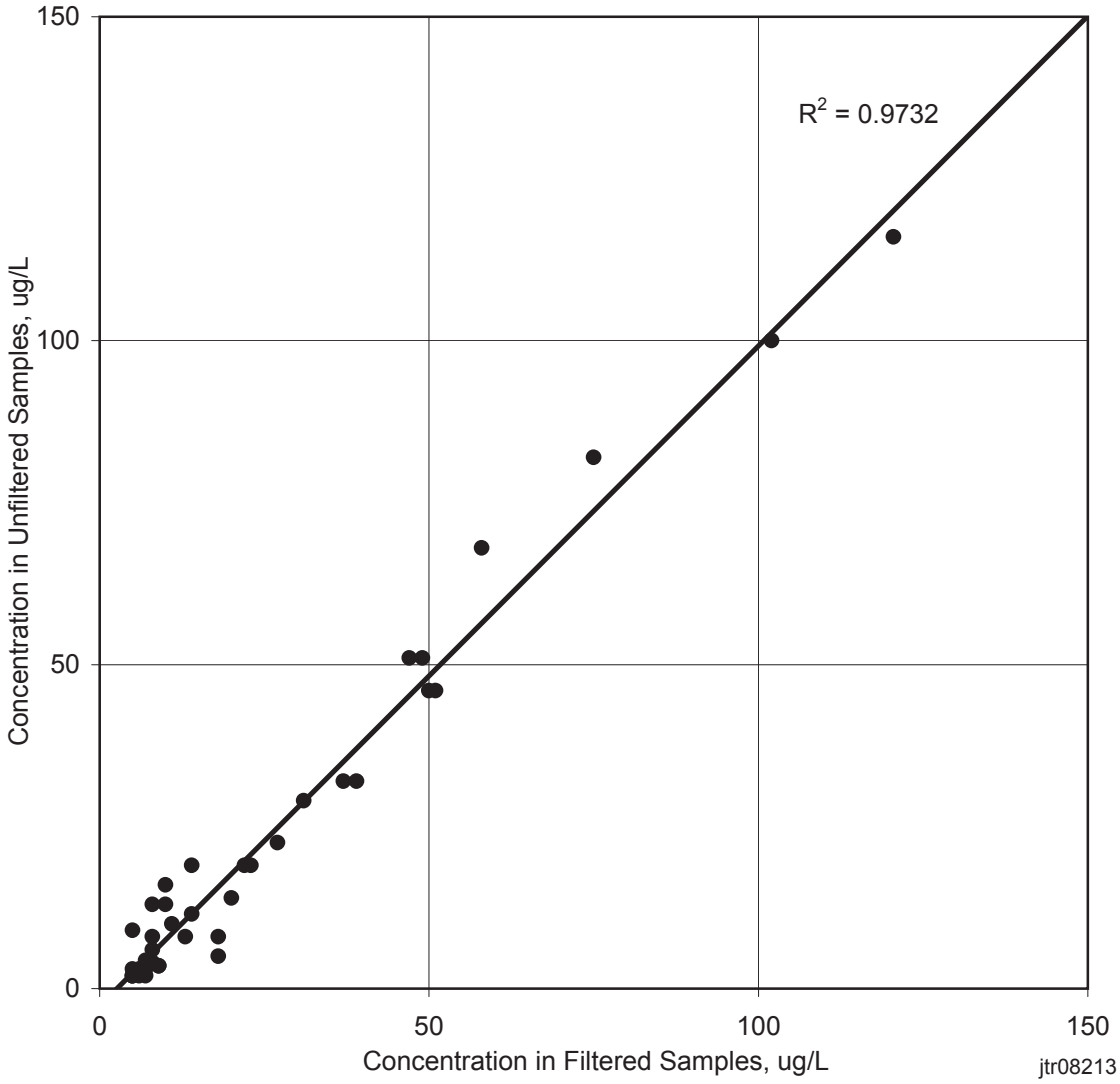
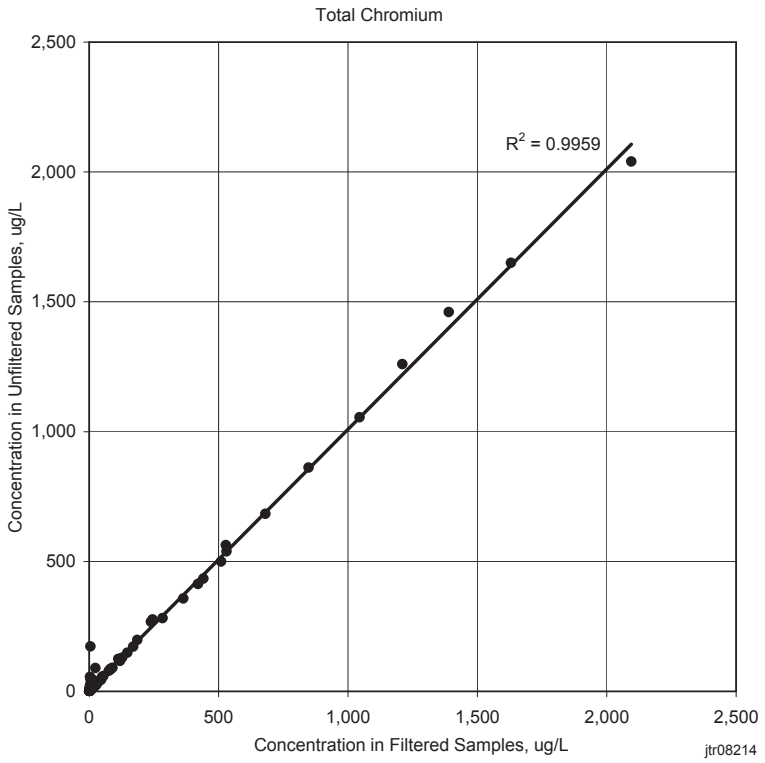


Figure C.1. Hexavalent Chromium in Filtered/Unfiltered Pairs



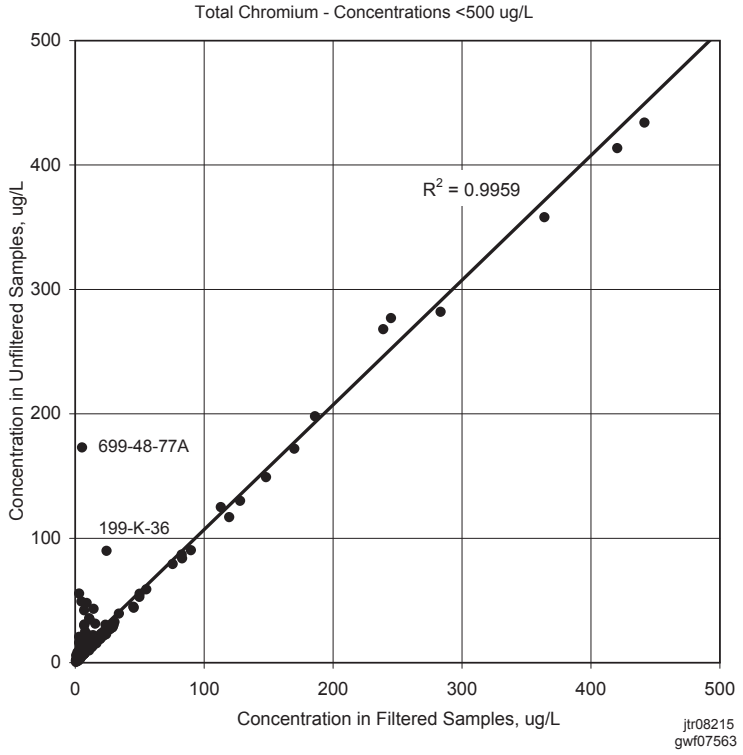


Figure C.2. Total Chromium in Filtered/Unfiltered Pairs (Bottom panel zooms on concentrations <500 µg/L.)

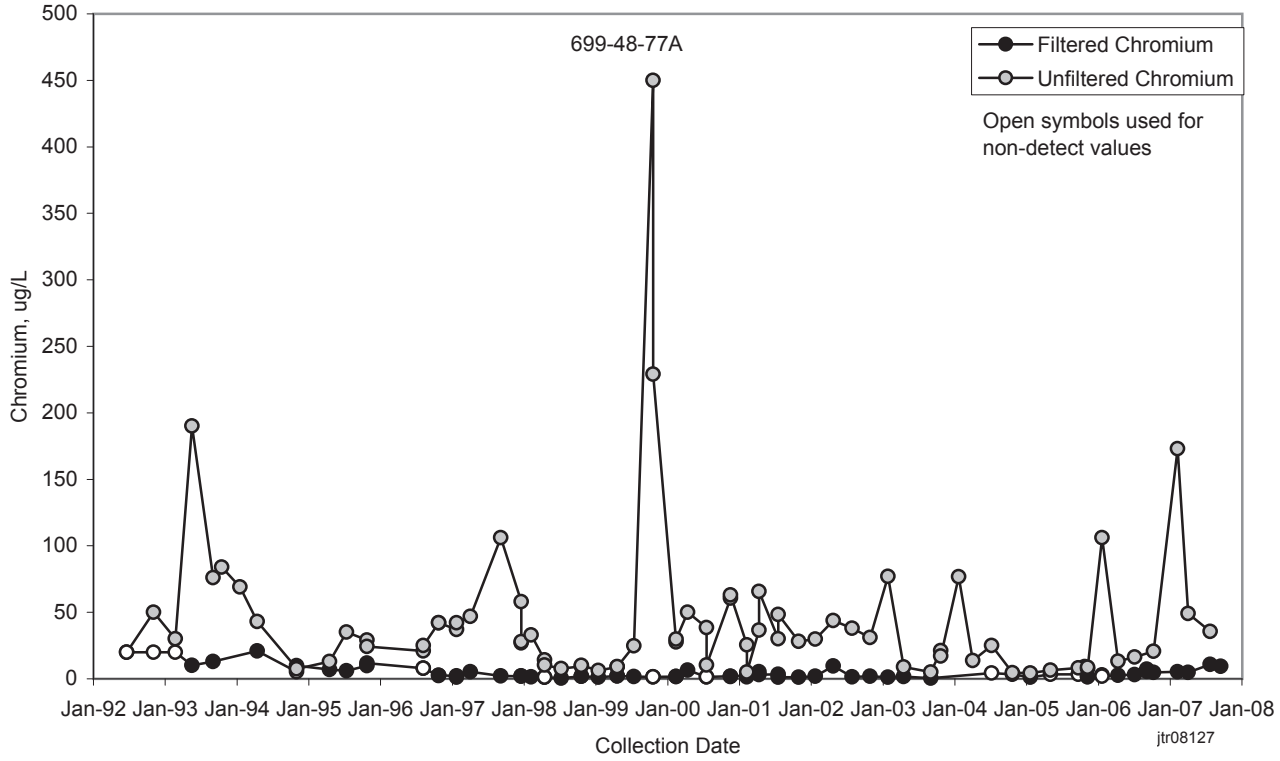


Figure C.3. Filtered and Unfiltered Total Chromium, Well 699-48-77A

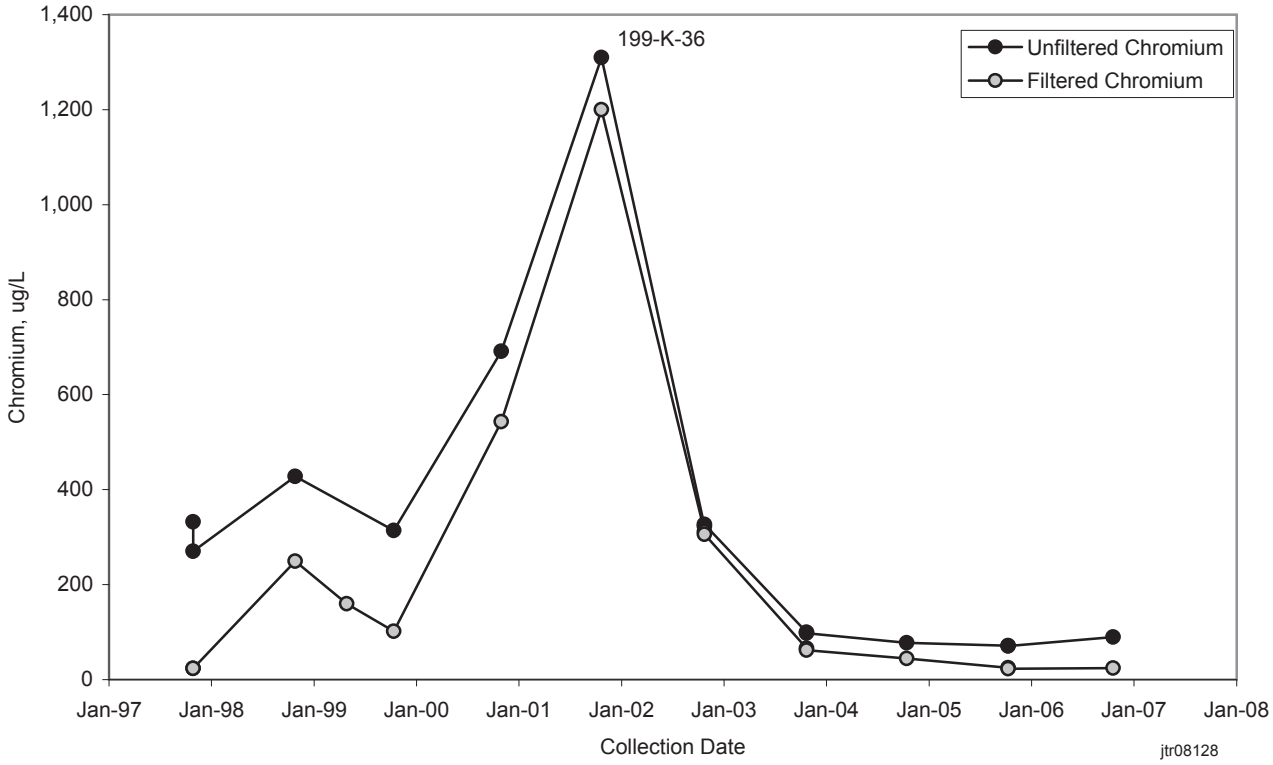


Figure C.4. Filtered and Unfiltered Total Chromium, Well 199-K-36

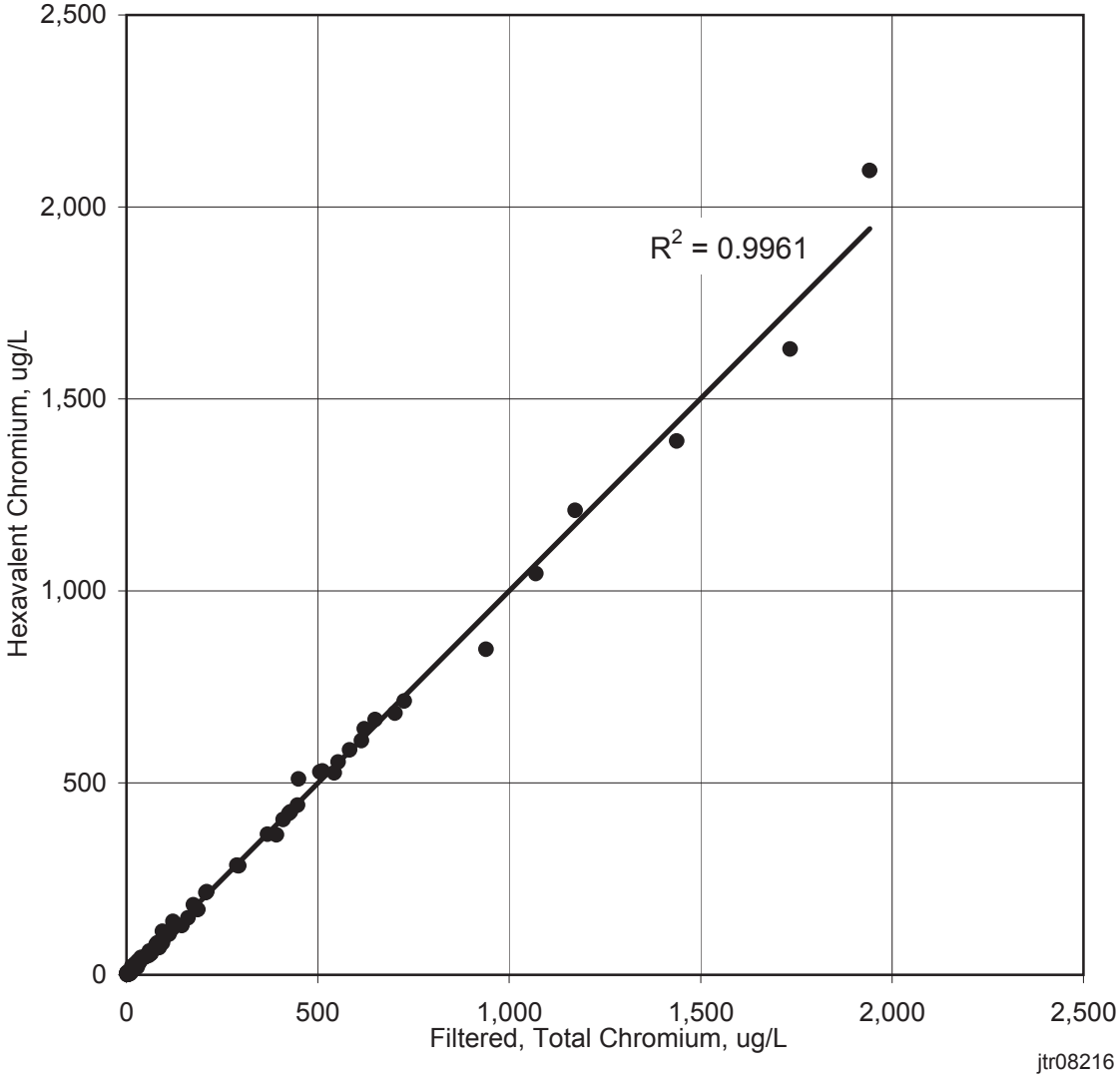


Figure C.5. Hexavalent Chromium and Filtered, Total Chromium

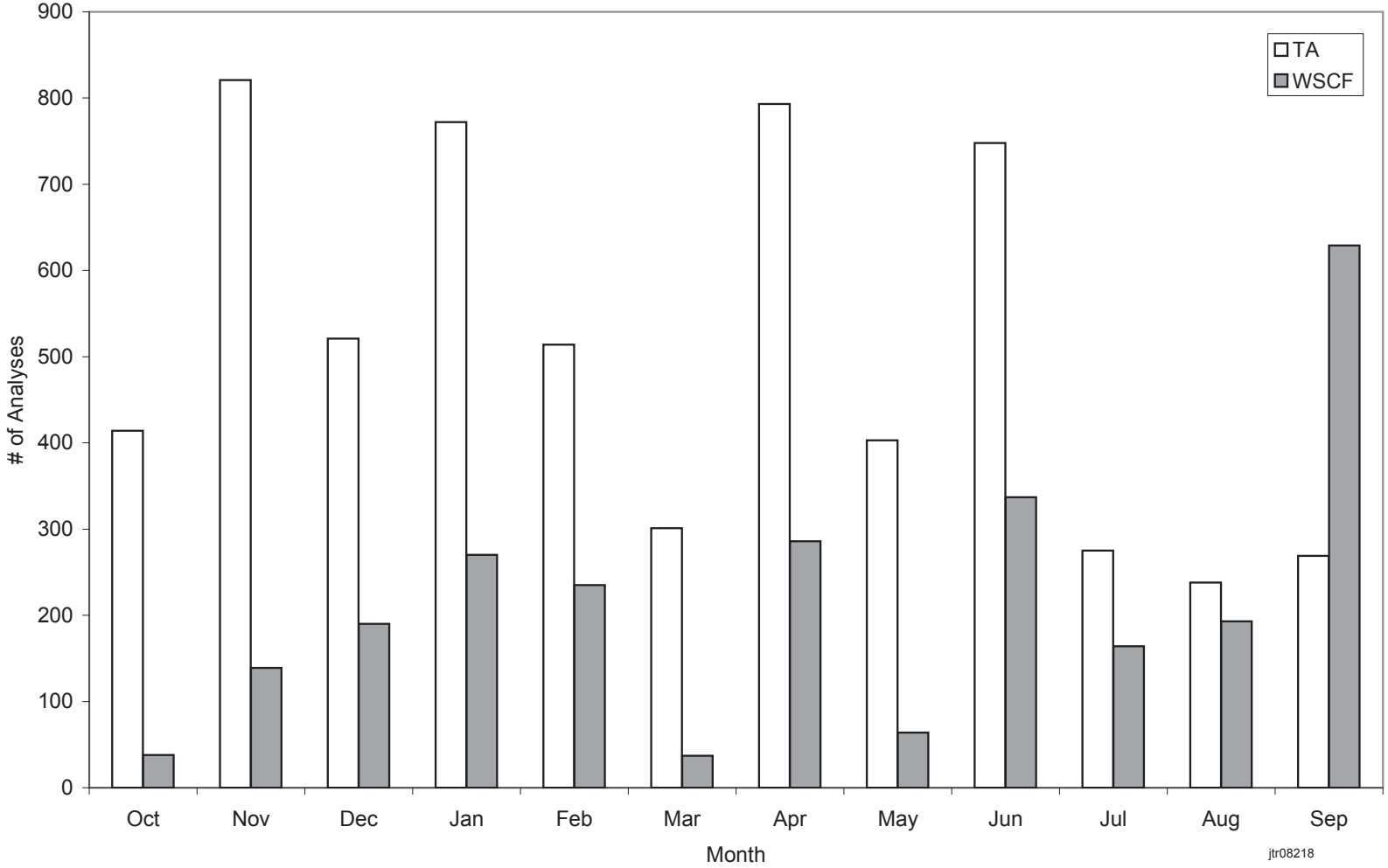


Figure C.6. Number of Analyses by Laboratory, FY 2007

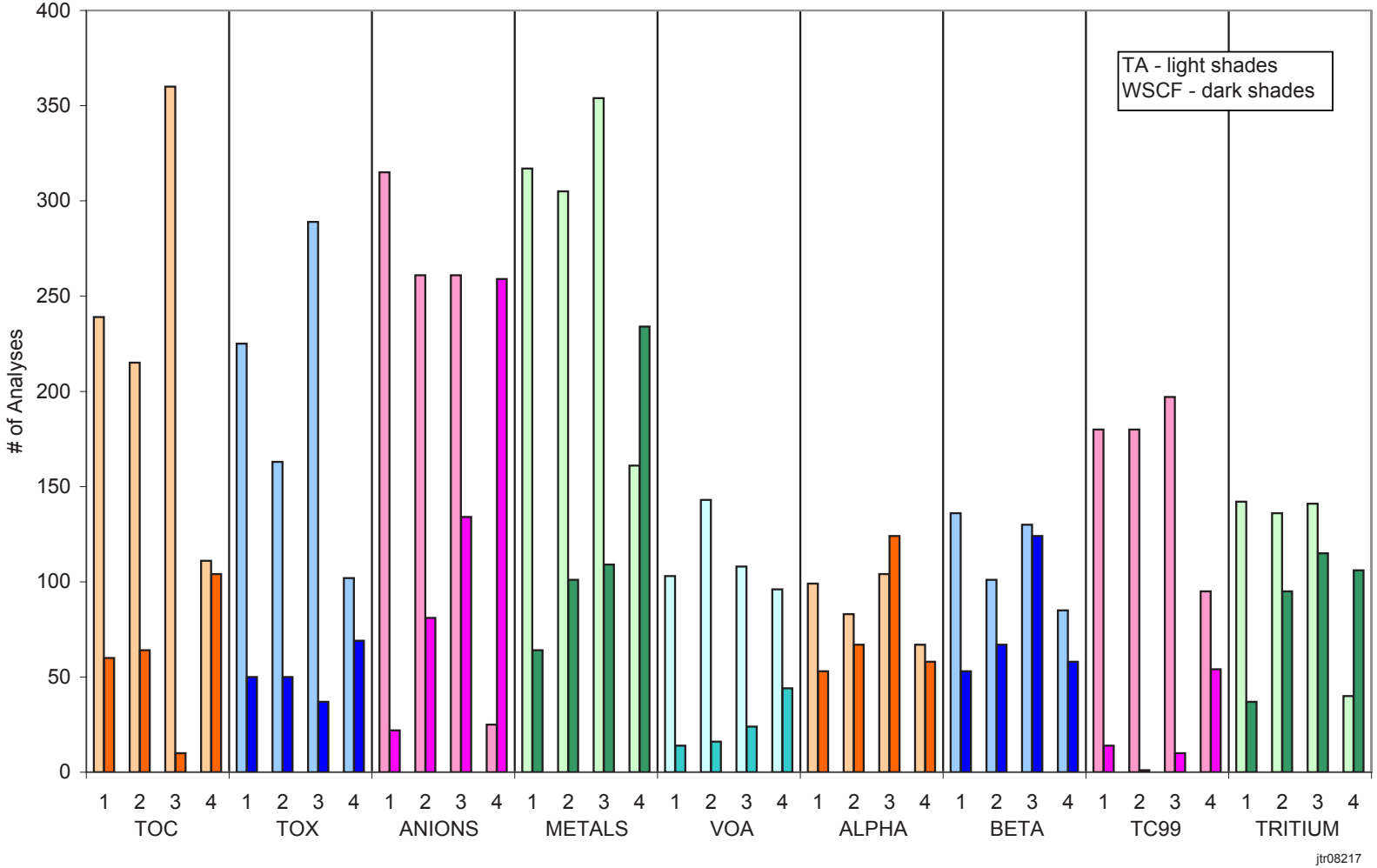


Figure C.7. Number of Analyses by Quarter, FY 2007

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