2.6 100-HR-3-H Operable Unit

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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 2.1-1 in Section 2.1). The Groundwater Performance Assessment Project (groundwater project) defined the "interest areas" informally to facilitate scheduling, data review, and interpretation. Figure 2.6-1 shows facilities, wells, and shoreline monitoring sites in this region. Chromium is the contaminant of greatest significance 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 groundwater contaminant of greatest 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, toward 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 groundwater remediation (Section 2.6.2), and discusses groundwater monitoring of individual facilities (Section 2.6.3). Section 2.6.4 summarizes recent bioremediation research at the 100-H Area.

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, 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. Results for filtered samples analyzed for total chromium represent hexavalent chromium, which is more soluble than trivalent chromium. Many groundwater samples also are analyzed specifically for hexavalent chromium.

Dissolved chromium continued to exceed the remedial action goal of 22 µg/L beneath a portion of the 100-H Area (Figure 2.6-3), but concentrations are decreasing and the

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

CERCLA and AEA Monitoring

- ***Wells are sampled monthly to biennially for chromium and co-contaminants.***
- ***Aquifer tubes are sampled annually for chromium and co-contaminants.***
- ***In FY 2004, one well was not sampled as scheduled (see text and Appendix A).***

Facility Monitoring – 116-H-6 Evaporation Basins

- ***Four downgradient wells are sampled annually for chromium, nitrate, technetium-99, and uranium for requirements of RCRA and AEA.***
- ***Sampling is coordinated with CERCLA to avoid duplication.***
- ***In FY 2004, all wells were sampled as scheduled.***

region with concentrations >22 µg/L at the top of the aquifer shrank between fiscal years (FY) 2003 and 2004. The plume had various sources, but the highest concentrations in FY 2004 continued to be near the former 116-H-6 evaporation basins, where the maximum concentrations ranged from 65 to 81 µg/L. Chromium concentrations in this area decreased more than an order of magnitude since the 1980s and have remained level since 2002 (Figure 2.6-4).

Four wells were monitored monthly as compliance wells for the 100-HR-3 pump-and-treat system (Figure 2.6-5; Section 2.6.2). Wells 199-H4-5 and 199-H4-64 are located northeast of the former 116-H-6 evaporation basins. Well 199-H4-4 is located within the plume east of the former 116-H-6 evaporation basins. Well 199-H4-63 is located farther south between the former 116-H-7 retention basin and the Columbia River. Concentrations in these wells varied inversely with river stage and continued to exceed the remedial action goal of 22 µg/L during most of FY 2004.

Chromium concentrations at 100-H Area vary with river stage but are declining overall.

Chromium concentrations in most of the aquifer tubes along the shoreline of the 100-HR-3 interest area exceeded the 10-µg/L aquatic standard, and three tube sites exceeded the 22-µg/L remediation goal. The highest concentrations were north and south of the main 100-H Area. The northern tubes, 43-D and 44-D, had concentrations of 48 and 50 µg/L respectively, levels that have been typical of these tube sites (Figure 2.6-6). This contamination is believed to be connected to an upgradient plume seen in well 699-97-43 and is discussed below. South of the main 100-H Area, the maximum chromium concentration at tube site 51 was also ~50 µg/L (Figure 2.6-6). This contamination could have moved south along the shoreline from 100-H Area sources. Chromium was lower in tubes monitoring the shoreline downgradient of the 100-H Area pump-and-treat system (~11 to 20 µg/L; Figure 2.6-7).

Chromium concentrations in deeper wells 199-H4-12C and 199-H4-15CS continued to exceed the 100-µg/L drinking water standard (maximum 132 µg/L), but are declining. Co-contaminants nitrate, technetium-99, and uranium are low in the deeper well. The source of this deeper chromium is unknown.

Wells upgradient of the 100-H Area continued to have chromium concentrations above the drinking water standard (104 µg/L in well 699-97-43). The source of this contamination is probably an old plume that originated in the 100-D Area when a water-table mound was present there (WHC-SD-EN-TI-023).

2.6.1.2 Strontium-90

Strontium-90 concentrations continued to exceed the 8-pCi/L drinking water standard 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. The highest concentrations in FY 2003 and 2004 were ~20 to 25 pCi/L. Concentrations are somewhat variable but are neither increasing nor decreasing overall. Strontium-90 was not analyzed in aquifer tubes near the 100-H Area in FY 2004, but has exceeded the drinking water standard at tube site 47 in the past.

2.6.1.3 Technetium-99 and Uranium

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

Chromium — 0.11
Nitrate — 0.24
Strontium-90 — 0.18
Uranium — 0.01

Technetium-99 is elevated in groundwater downgradient of the former 116-H-6 evaporation basins, but levels were below the 900-pCi/L drinking water standard in FY 2004. Well 199-H4-3, immediately downgradient of the basins, historically has shown the highest technetium-99 concentrations and detected 485 pCi/L in FY 2004 (Figure 2.6-8). Concentrations have declined two orders of magnitude since the mid-1990s, but increased gradually during the past 2 years. Nearby well 199-H4-9 had high technetium-99 in FY 2003 (986 pCi/L), but the concentration decreased to 326 pCi/L in May 2004 (Figure 2.6-8).

Uranium also is elevated in groundwater downgradient of the former 116-H-6 evaporation basins and exceeded the 30-µg/L drinking water standard only in

well 199-H4-3 (54.3 µg/L in December 2003). Uranium in well 199-H4-9 decreased from FY 2003 (54.5 µg/L) to 19.3 µg/L in May 2004.

Technetium-99 and uranium were analyzed in three new aquifer tubes in FY 2004. The new tubes are located directly downgradient of the former 116-H-6 basins. Technetium-99 was undetected and the maximum uranium concentration was 1.65 µg/L.

2.6.1.4 Tritium

Tritium concentrations are generally below 5,000 pCi/L beneath the 100-H Area. Concentrations vary seasonally in wells near the river and are declining in most inland wells. Concentrations are slightly higher in upgradient wells (5,000 to 6,000 pCi/L) but are declining.

2.6.1.5 Nitrate

Nitrate concentrations continued to exceed the 45-mg/L drinking water standard in numerous wells near the former 116-H-6 evaporation basins and in several wells in the southeast 100-H Area (Figure 2.6-9).

The maximum nitrate concentration in FY 2004 was 192 mg/L in well 199-H4-3. Trends in that area vary seasonally, but the peaks have diminished over the years, and concentrations are declining overall. The nitrate concentrations in well 199-H4-9, northeast of the basins, increased sharply in FY 2003 (474 mg/L) but decreased to 60.6 mg/L in November 2003.

A second nitrate plume in the southeast 100-H Area is detected at levels above the drinking water standard in wells surrounding the 116-H-1 trench. New data from aquifer tube sites 48 through 51, which had not been sampled for nitrate in the past 3 fiscal years, exceeded the drinking water standard (46 to 49 mg/L). The plume map in Figure 2.6-9, which incorporates the new data, shows a larger nitrate plume in this region than in previous years.

Nitrate concentrations exceed drinking water standards near the former 116-H-6 evaporation basins and in southeast 100-H Area.

2.6.2 Interim Groundwater Remediation for Chromium

A pump-and-treat system operates in the 100-H Area as part of a CERCLA interim action for the 100-HR-3-H Operable Unit (ROD 1996a). Interim remedial action monitoring is described in DOE/RL-96-90. Figure 2.6-1 displays locations of extraction and injection wells and Appendix A lists sampling frequencies and constituents. In FY 2004, well 199-H4-45 was not sampled as scheduled. Wasps had built nests in the area around the well with radiologically contaminated mud. The well cannot be sampled until workers clean up the nests.

Eight new aquifer tubes at three sites were installed in the 100-H Area shoreline. Tube sites AT-H-1, AT-H-2, and AT-H-3 are located downgradient of the former 116-H-6 evaporation basins. Together with older aquifer tube sites, the new sites monitor the shoreline downgradient of the extraction wells. Pertinent results from aquifer tube sampling were discussed in Section 2.6.1.

2.6.2.1 Progress During FY 2004

The 100-H Area pump-and-treat system is reducing overall contamination in the operable unit by removing contaminant mass. During FY 2004, the pump-and-treat system extracted ~161.9 million liters of groundwater from the 100-H Area, removing ~4.1 kilograms of hexavalent chromium.

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. EPA specified enhancements needed to the system in their 5-year review (EPA 2001).

The pump-and-treat system has removed ~37.3 kilograms of hexavalent chromium from the 100-H Area groundwater since startup in July 1997. This represents a large fraction of the ~42 kilograms of chromium estimated in the plume in 1992 (WHC-SA-1674-VA). That estimate did not include chromium from upgradient nor in the vadose zone.

During FY 2004, the pump-and-treat system at 100-H Area extracted ~161.9 million liters of groundwater, removing ~4.1 kilograms of hexavalent chromium.

2.6.2.2 Influence on Aquifer Conditions

Chromium concentrations in 100-H Area groundwater have declined, and the size of the plume at the top of the aquifer has shrunk since the pump-and-treat system began to operate in 1997. These changes are likely due to a combination of natural processes (e.g., dispersion) and the effects of the pump-and-treat system. Because the size of the plume is smaller and concentrations of hexavalent chromium have declined below the remedial action goal of 22 µg/L in some extraction wells, the system is being changed to enhance and accelerate cleanup. In October 2004, Washington State Department of Ecology (Ecology) approved the following modifications to the 100-H extraction and injection well network:

- 199-H3-2A will be converted from an extraction to an injection well.
- 199-H4-18 will be converted from a monitoring to an injection well.
- 199-H4-64 and 199-H4-4 will be converted from compliance wells to extraction wells.
- 199-H4-7 will be converted from an extraction to a monitoring well.
- Only one of the three previous injection wells (199-H3-3, 199-H3-4, and 199-H3-5) will continue to be used.

Current extraction wells 199-H4-11, 199-H4-12A, and 199-H4-15A will remain extraction wells.

Hexavalent chromium concentrations in compliance wells vary inversely with river stage. The ranges of concentration observed in FY 2004 were similar to those observed the last 2 years. Figure 2.6-5 shows chromium trends for the compliance wells. Chromium declined beneath the remedial action goal (22 µg/L) in wells 199-H4-4 and 199-H4-16 in the summer, but exceeded that level for the rest of the year. In the other two compliance wells, 199-H4-5 and 199-H4-64, chromium concentrations were above the goal throughout the year with no clear upward or downward trend over the last 3 years.

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 2003 can be found in DOE/RL-2004-21. Results for 2004 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 site is monitored during the post-closure period under corrective action monitoring requirements of WAC 173-303-645(11)(g). The objective of monitoring is to track contaminant trends during the operation of the CERCLA interim action for chromium. Lists of wells and constituents monitored and a well location map are included in Appendix B.

The unit was incorporated into the Hanford Facility RCRA Permit (Ecology 1994a). Groundwater remediation is integrated with the 100-HR-3 Operable Unit, where remediation for chromium is underway. While the 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). The objective of monitoring during the operation of the pump-and-treat system is to determine whether concentrations of the contaminants of concern are decreasing. The U.S. Department of Energy (DOE) proposed a change to the monitoring requirements with a permit modification in FY 2004. The proposed change would bring the site under a post-closure monitoring program that is integrated with the CERCLA monitoring program, as allowed under Section II.K.7 of the Hanford Facility RCRA Permit (Ecology 1994a).

The four wells in the RCRA network were sampled as scheduled in FY 2004 for the constituents of interest listed in the groundwater monitoring plan. 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.

Two semiannual letter reports[(a)] that document the effectiveness of the corrective action program were submitted to Ecology during FY 2004. The current monitoring network was designed to accommodate groundwater flow imposed by the pump-and-treat system, and no changes are planned for FY 2005.

2.6.4 Bioremediation Research

DOE's Natural and Accelerated Bioremediation Research (NABIR) Program conducted field tests near the 100-H Area in FY 2003 and 2004 to demonstrate the feasibility of a remediation technology to immobilize hexavalent chromium in the aquifer (Hazen et al. 2004). The goal of the NABIR Program is to provide the fundamental science to serve as the basis for the development of cost-effective bioremediation of radionuclides and metals in the subsurface at DOE sites. Scientists from Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory, and Regenesis Ltd. performed the 100-H Area investigations. Additional details about the test are available at http://esd.lbl.gov/ERT/hanford100h.

Bioremediation is the process by which living organisms break down or transform hazardous contaminants to environmentally safe levels in soil, water, or other materials.

The test site was west of the 100-H Area where researchers installed two wells near existing well 699-96-43 (Figure 2.6-1). Researchers identified several types of bacteria in the sediment, including species that are known to reduce or sorb hexavalent chromium. The natural microbial population is likely insufficient for direct chromium reduction, but the population was successfully stimulated during the field tests.

To assess the background hydraulic properties of the Hanford formation and to design the test, researchers performed three bromide tracer tests and two pumping tests (concurrent with the bromide tracer tests). Geophysicists also collected cross-borehole measurements.

In August 2004, staff conducted pilot field-scale biostimulation by injecting Hydrogen Release Compound®[(b)] (HRC) and a bromide tracer in one of the wells, then pumped the observation well for 27 days. HRC is a polylactate ester that is specifically designed to slowly release lactic acid when contacted with water. Microbial cell counts reached their maximum 13 to 17 days after the injection. The injection resulted in highly reducing conditions: dissolved oxygen dropped from 8.2 to 0.35 mg/L, redox potential from 240 to -130 mV, and pH from 8.9 to 6.5. Geophysical cross-borehole tomography confirmed the distribution of the HRC plume in the subsurface between the injection and pumping wells. After pumping ceased, background microbial conditions began to recover under natural groundwater flow. Additional work is planned for summer 2005.

(a) Letter report 04-AMCP-0278 from KA Klein, U.S. Department of Energy Richland Operations Office, to JA Hedges, Washington State Department of Ecology, *Resource Conservation and Recovery Act (RCRA) Final Status Corrective Action Semiannual Reports for July through December 2003*, dated June 23, 2004.

Letter report 05-AMCP-0027 from MS McCormick, DOE/RL, to JA Hedges, Washington State Department of Ecology, *Resource Conservation and Recovery Act (RCRA) Final Status Corrective Action Semiannual Reports for January through June 2004*, dated October 26, 2004.

(b) HRC is a registered trademark of Regenesis, San Clemente, California.

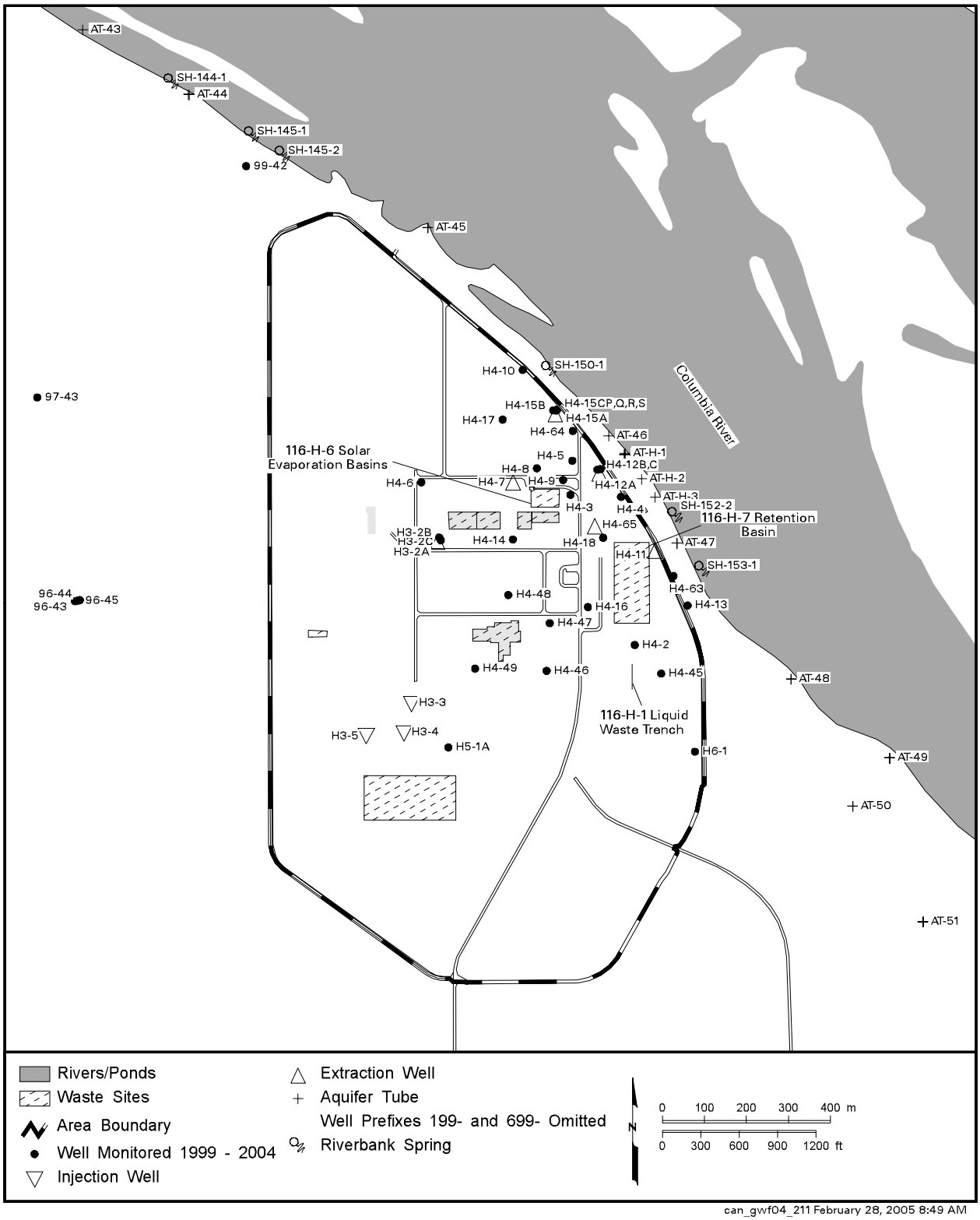


Figure 2.6-1. Groundwater Monitoring Wells in the 100-H Area

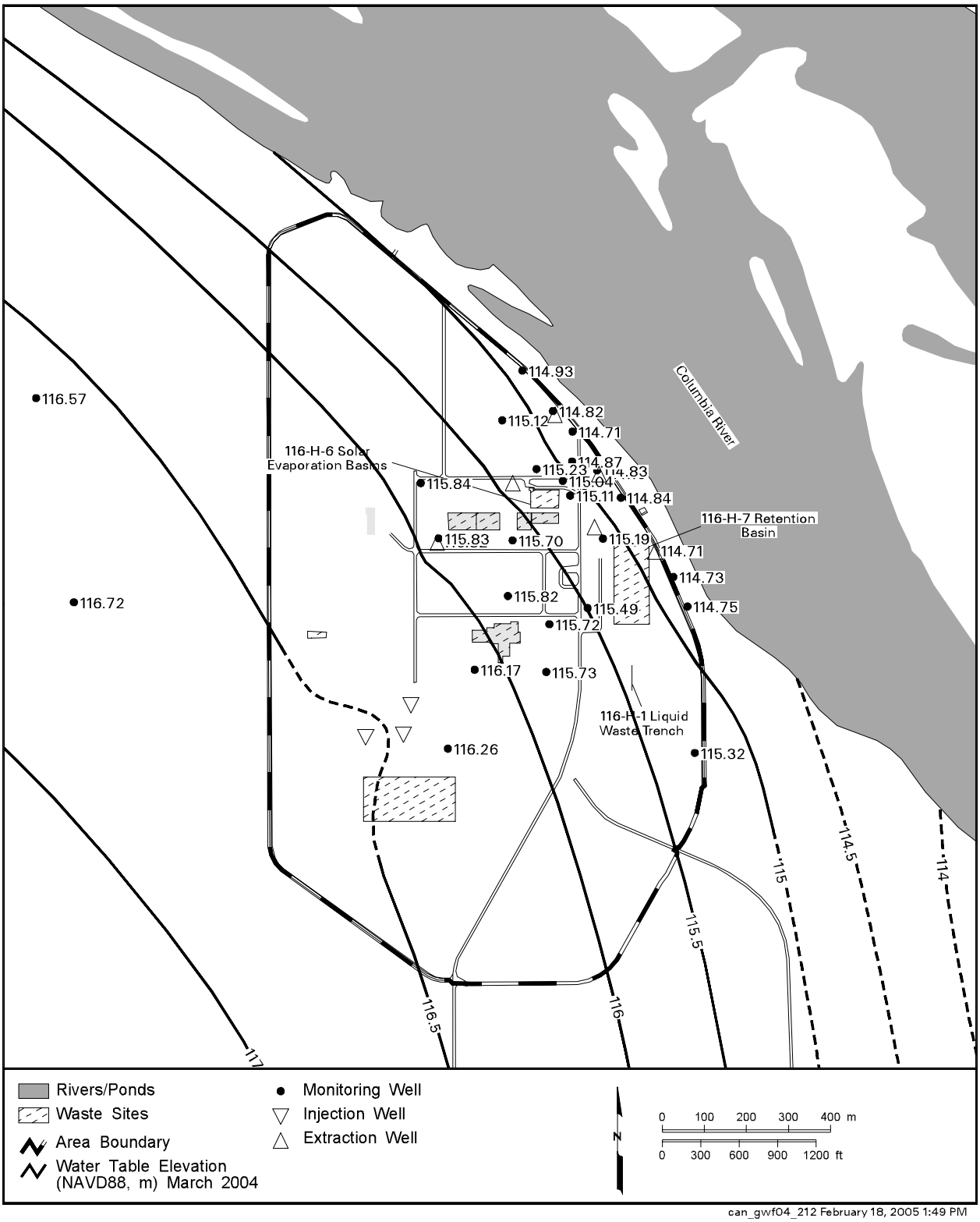


Figure 2.6-2. 100-H Area Water-Table Map, March 2004

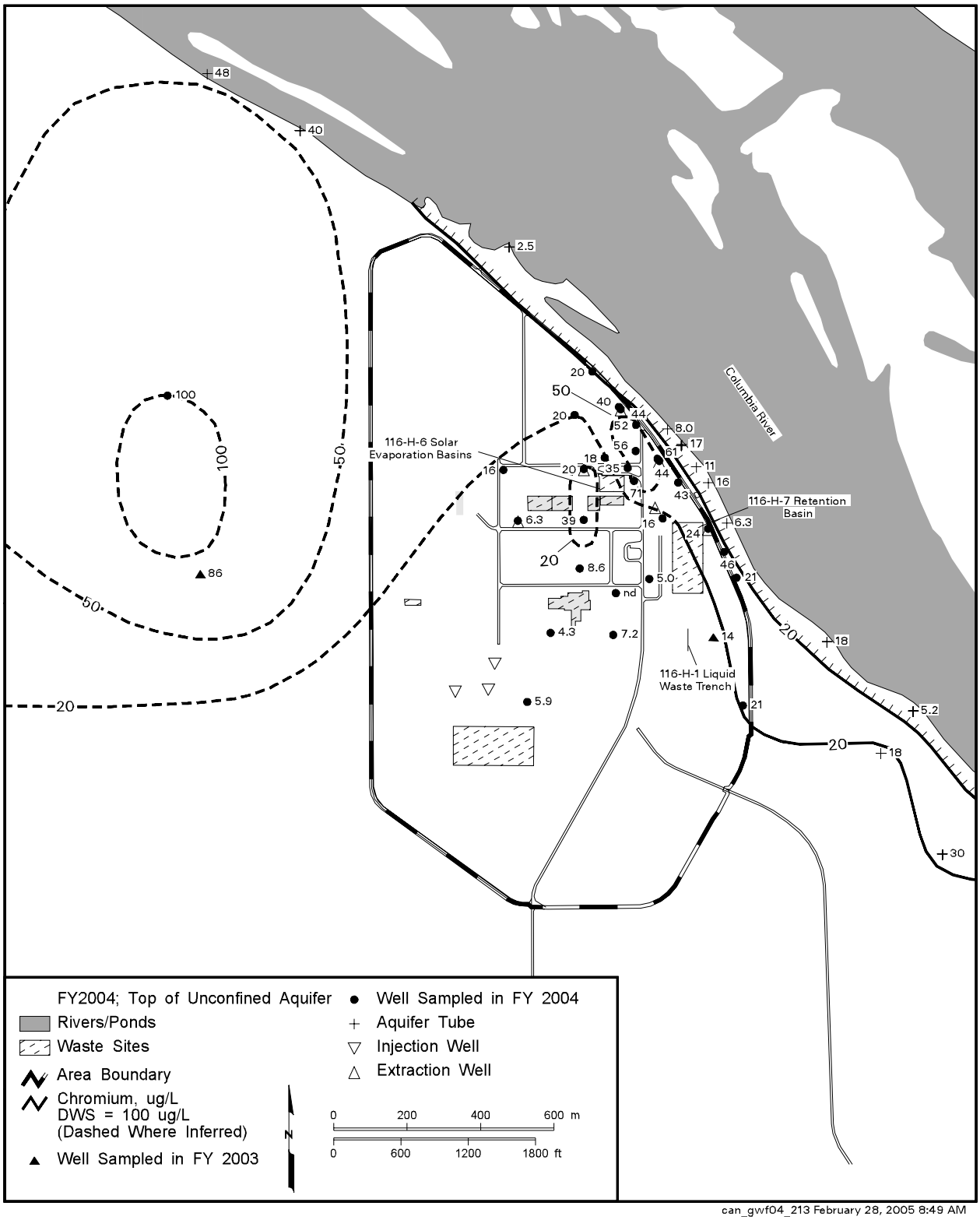


Figure 2.6-3. Average Chromium Concentrations in the 100-H Area, Top of Unconfined Aquifer

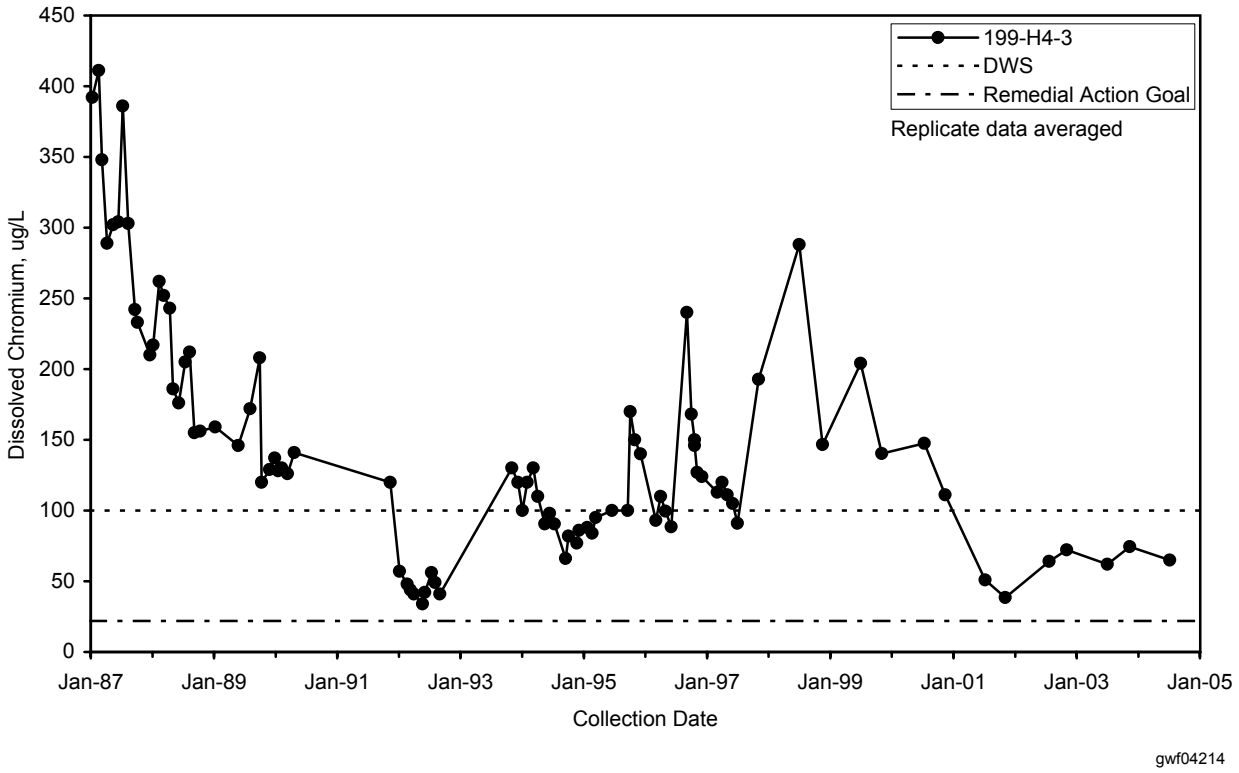
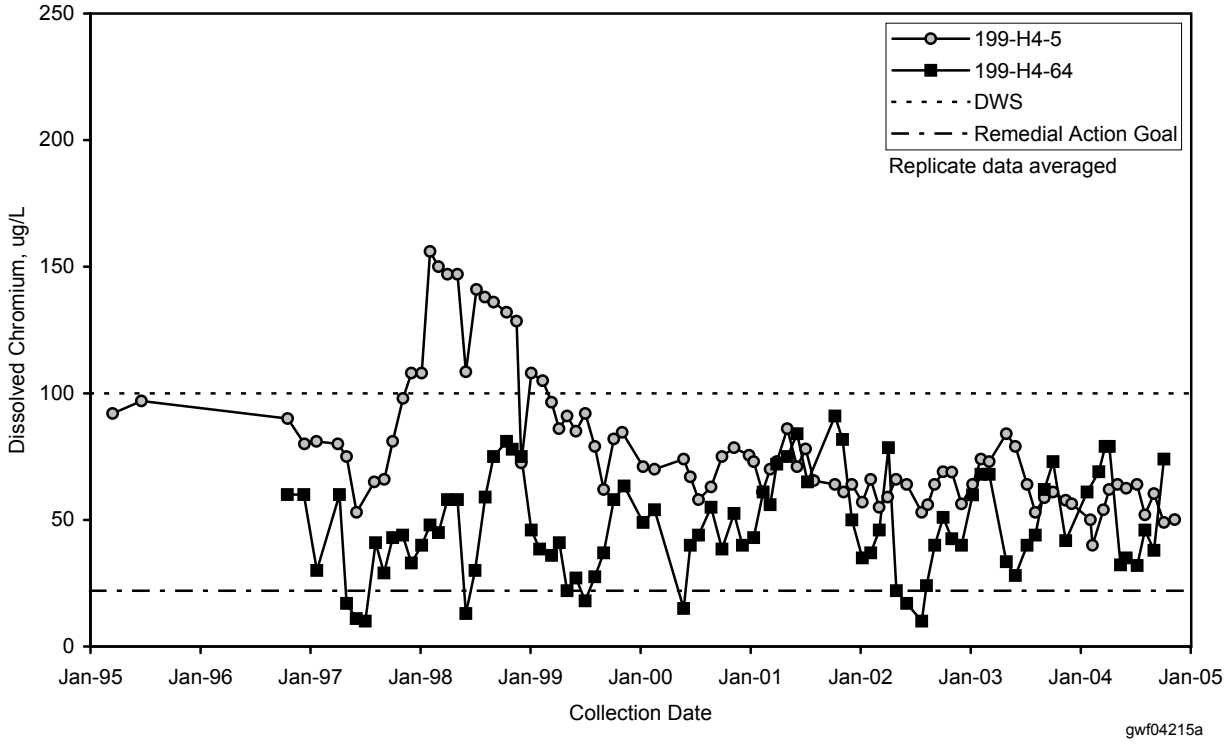


Figure 2.6-4. Chromium Concentrations Downgradient of 116-H-6 Evaporation Basins



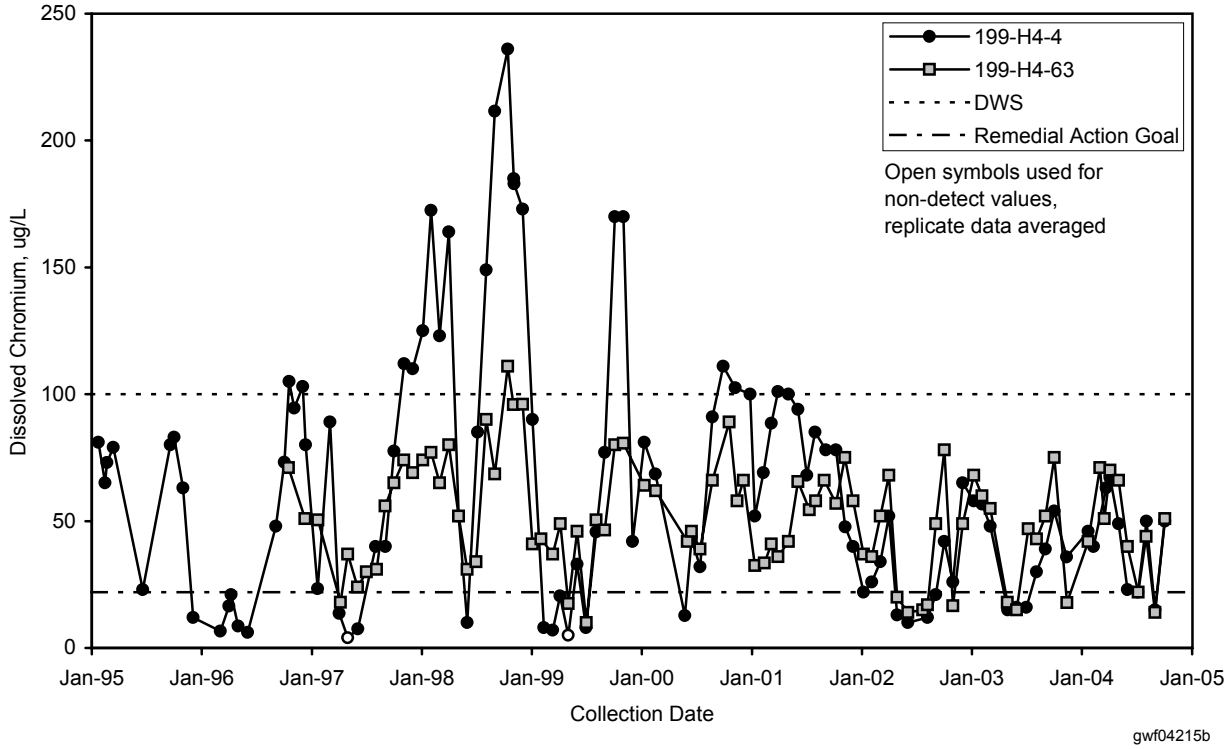


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Figure 2.6-5. Chromium Concentrations in Compliance Wells for the 100-HR-3 Pump-and-Treat System at 100-H Area

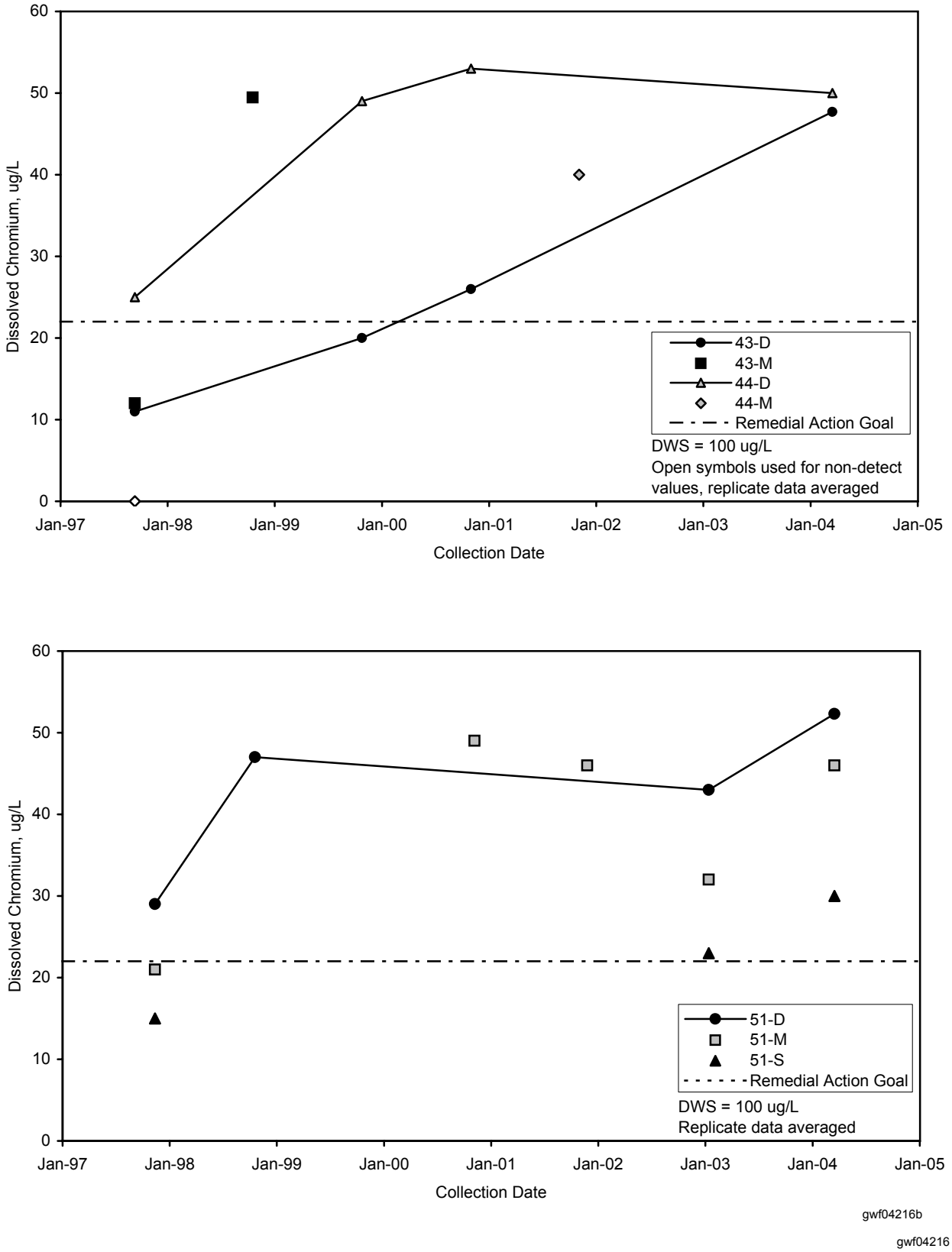

Figure 2.6-6. Chromium Concentrations in Aquifer Tubes North (top panel) and South (bottom panel) of the Main 100-H Area

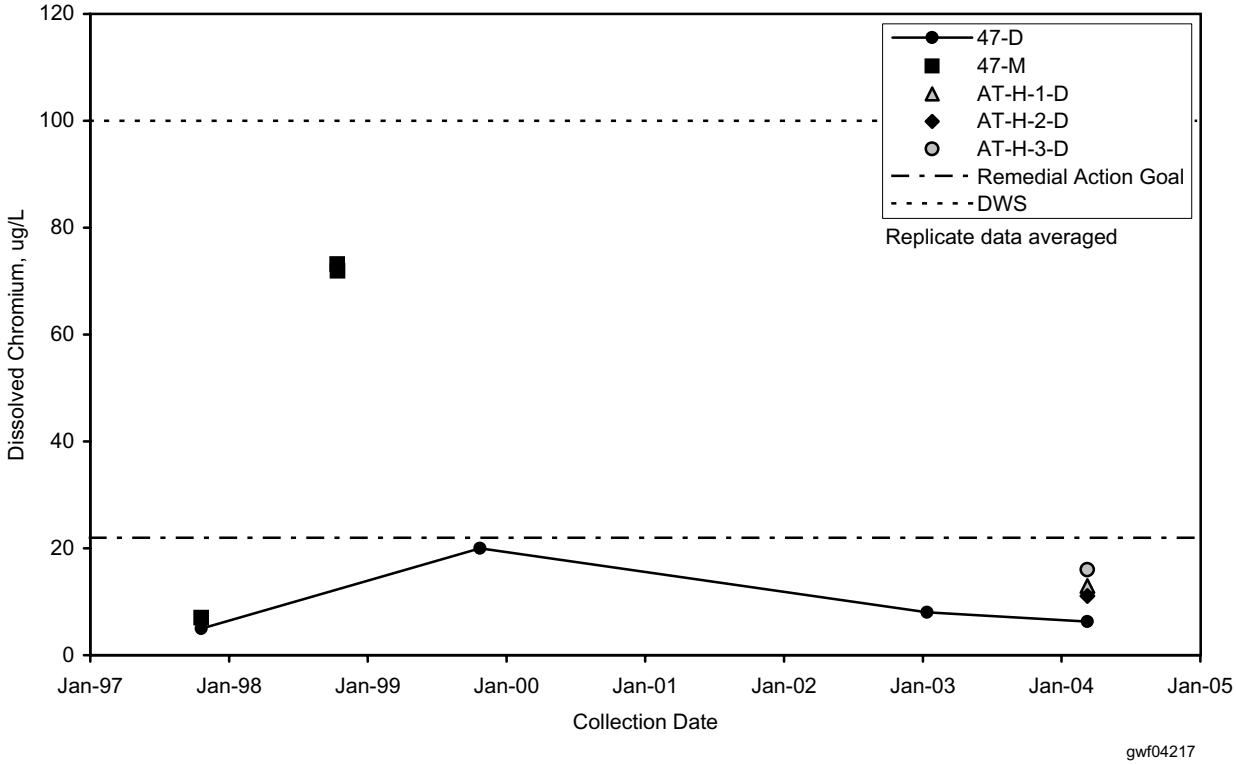

Figure 2.6-7. Chromium Concentrations in Aquifer Tubes Downgradient of 100-H Pump-and-Treat System

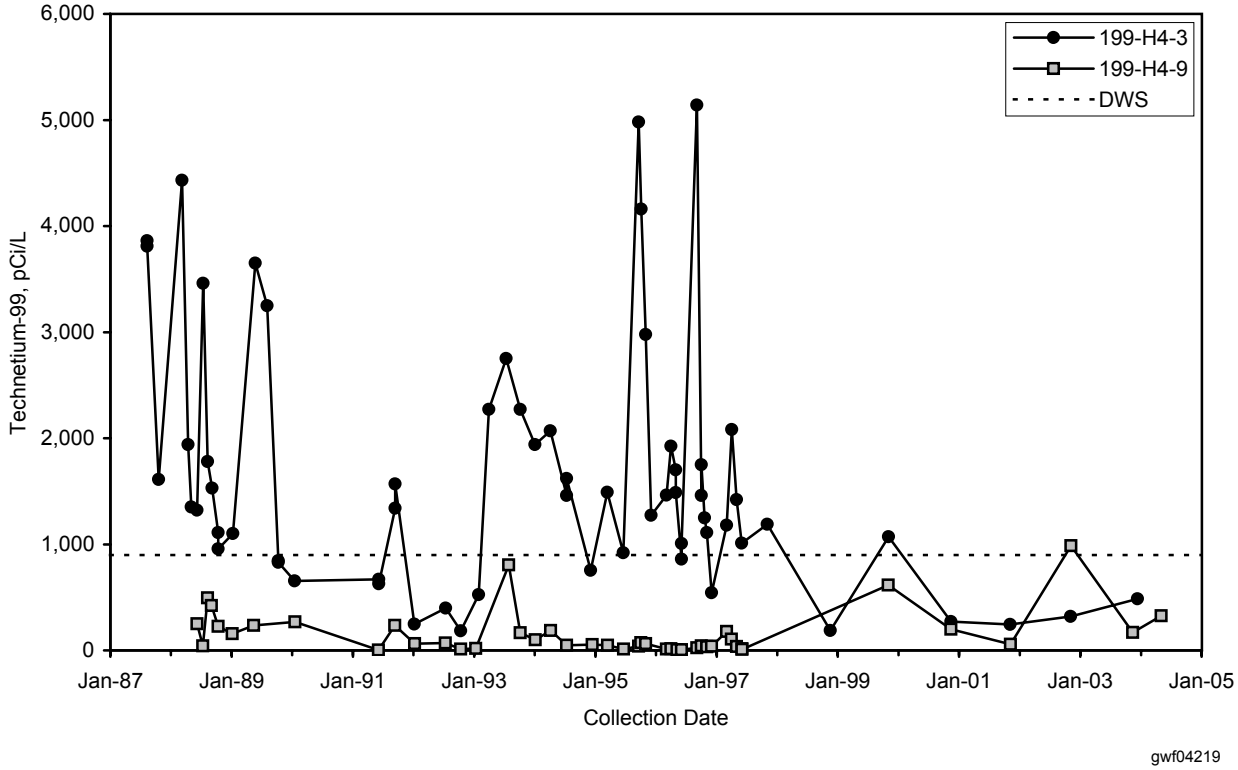

Figure 2.6-8. Technetium-99 Concentrations in Wells Near the 116-H-6 Evaporation Basins

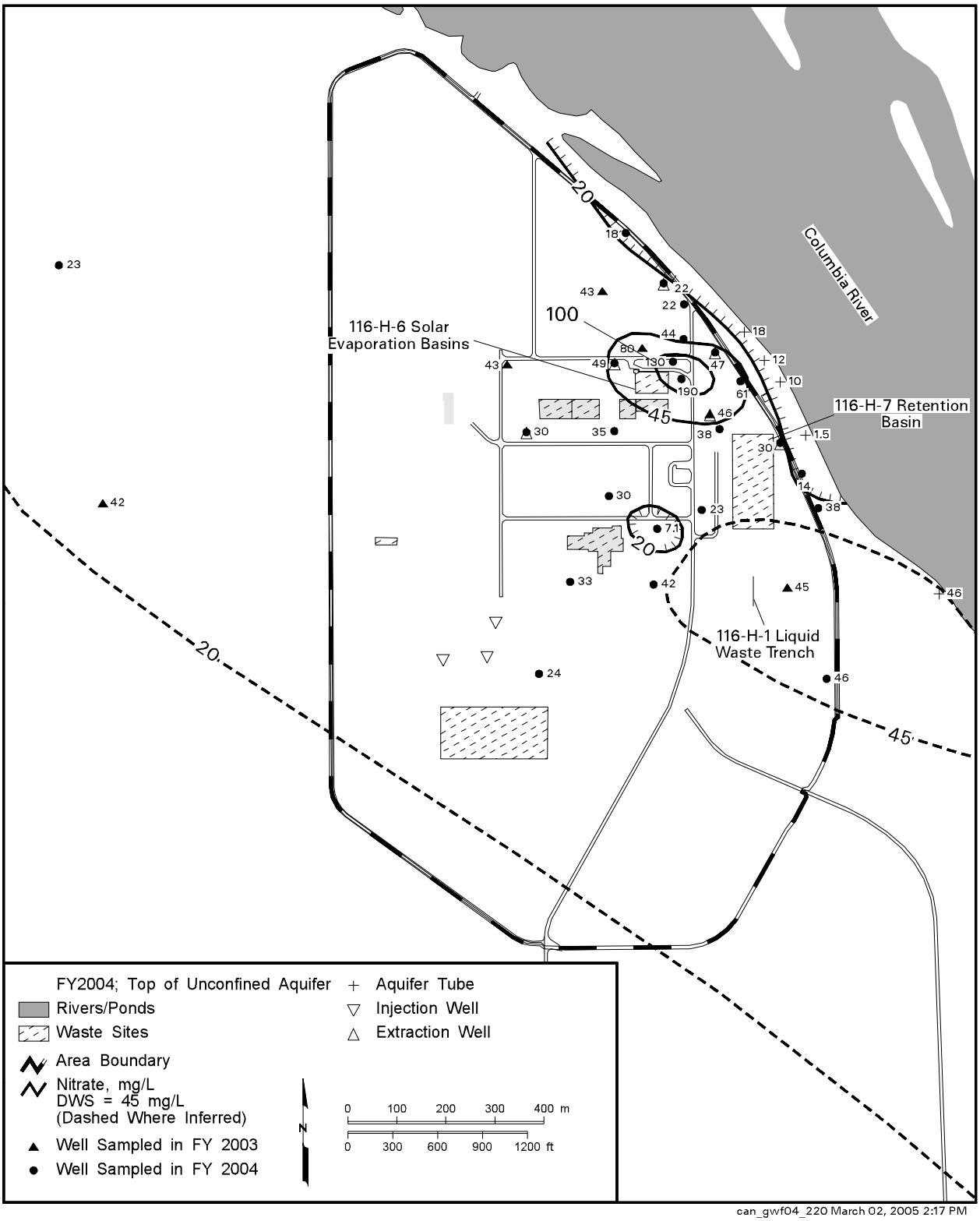

Figure 2.6-9. Average Nitrate Concentrations in the 100-H Area, Top of Unconfined Aquifer