2.1 Overview of Hanford Site Groundwater

M. J. Hartman, J. P. McDonald, and C. J. Thompson

This section provides a broad picture of groundwater flow and contaminant distribution beneath the Hanford Site. Table 2.1-1 summarizes fiscal year (FY) 2004 highlights or changes for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) groundwater operable units, *Resource Conservation and Recovery Act* (RCRA) sites, and other regulated units and indicates where to find additional information in this report. Details for specific locations are included in Sections 2.2 through 2.14. Supporting tables and figures for sites monitored under CERCLA are compiled in Appendix A. Appendix B includes tables and figures for facilities monitored under RCRA or other regulations. Appendix C describes results of the quality control program.

Groundwater monitoring objectives of RCRA, CERCLA, and the *Atomic Energy Act of 1954* (AEA) often differ slightly, and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on non-radioactive 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 U.S. Department of Energy (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 or other RCRA regulatory requirements.

DOE monitors groundwater quality across the Hanford Site to know what contaminants are present and how they are moving.

The uppermost aquifer beneath most of the Hanford Site is unconfined and is composed of unconsolidated to semiconsolidated sediment of the Hanford and Ringold Formations, which was deposited on the basalt bedrock. In some areas, deeper parts of the aquifer are confined locally by layers of silt and clay. Confined aquifers occur within the underlying basalt and associated sedimentary interbeds.

For site characterization and cleanup, waste sites are grouped into source operable units, and the groundwater beneath the sites is divided into groundwater operable units. The formal, groundwater operable units do not include the entire Hanford Site, and in the case of the 200 Areas operable units, comprise just a single boundary line. Therefore, to provide scheduling, data review, and interpretation for the entire Hanford Site, the Groundwater Performance Assessment Project (groundwater project) has informally defined "groundwater interest areas" that generally correspond to the groundwater operable units. Figure 2.1-1 illustrates these interest areas and the operable unit boundaries.

Well location maps for each geographic region are included in Sections 2.2 through 2.14. Wells in the 600 Area (i.e., portions of the Hanford Site other than the former operational areas) are shown in Figure 2.1-2.

Groundwater is the water that fills the pores or cracks between grains in a layer of sediment or rock. Monitoring the groundwater helps determine what contamination exists beneath the Hanford Site. This information will help regulatory agencies and DOE make cleanup decisions based on scientific information and technical capabilities.

DOE monitors groundwater on the Hanford Site to help determine what chemical and radiological contaminants have made their way to groundwater and how they have migrated. Groundwater monitoring is a part of the cleanup mission and will remain a component of long-term stewardship after remediation is completed.

Monitoring points near the river, called aquifer tubes, provide additional information on water quality near the Columbia River. The aquifer tubes are located in the 100 Areas, the Hanford town site, and in FY 2004, in the 300-FF-5 Operable Unit. Their locations are shown on well location maps in applicable sections of this report.

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

2.1.1 Groundwater Flow

During March and early April 2004, 869 water-level measurements were collected from the unconfined aquifer system and the underlying confined aquifers beneath the Hanford Site. These data are 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 compute groundwater flow velocities; (3) support groundwater model calibration; 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. Flow in the confined aquifer in the lower Ringold Formation and the upper basalt-confined aquifer is discussed in Section 2.14. For more information regarding water-level monitoring activities, see PNNL-13021.

2.1.1.1 March 2004 Water Table

Figure 2.1-3 presents the March 2004 water-table map for the Hanford Site. Groundwater in the unconfined aquifer generally flows from west to east and discharges to 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 southeast between Gable Butte and Gable Mountain (Gable Gap), and through the 200 East Area into the central portion of the Hanford 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 gradient areas are associated with the highly permeable sand and gravel of the Hanford formation.

North of Gable Butte and Gable Mountain, groundwater generally flows from west to east and discharges to the Columbia River. Groundwater enters this region from the Columbia River west of the 100-B/C Area, through Gable Gap, and through the gap between Umtanum Ridge and Gable Butte. An apparent groundwater mound exists ~2 kilometers north of Gable Mountain, and is associated with low conductivity Ringold Formation muds at the water table. This mound is contoured as if it were part of the unconfined aquifer, but it could also represent a perched zone above the regional water table. There is insufficient information to distinguish between these possibilities.

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.

Past effluent discharges at U Pond and other facilities caused a groundwater mound to form beneath the 200 West Area. These discharges had 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 ~12 meters above the estimated pre-Hanford water table.[(a)] Scientists predict that when equilibrium conditions are established, the water table may be ~5 to 7 meters higher than the pre-Hanford water table because of artificial recharge from offsite irrigation (PNNL-11801). The water table beneath the 200 West Area is locally perturbed by discharges associated with the State-Approved Land Disposal Site, as well as by operation of two groundwater remediation pump-and-treat systems (at the 200-UP-1 and 200-ZP-1 Operable Units).

(a) Based on the February 2004 water-level elevation in well 299-W18-15 (137.1 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).

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 relatively flat because of the presence of highly permeable sediment of the Hanford formation at the water table. Uncertainty in the hydraulic head measurements is larger than the magnitude of the hydraulic gradient, which makes hydraulic gradient determinations problematic in this area. Groundwater flow in this region also is significantly affected by the presence of low permeability sediment of the Ringold Formation at the water table east and northeast of the 200 East Area, as well as basalt above the water table. The extent of the basalt units above the water table continues to increase due to the declining water table, resulting in an even greater effect on groundwater flow in this area. The mapped extent of these units was revised for the March 2004 water-table map, to take into account further declines in the water table. The water table beneath the 200 East Area is ~2.4 meters higher than pre-Hanford conditions.[b] Scientists estimate that when equilibrium conditions are established in the 200 East Area, the water table will be near its pre-Hanford elevation (PNNL-11801).

From the 200 East Area, groundwater flows toward the southeast and east, where it enters the Columbia River. In the south part of the site, flow converges on the 300 Area from the northwest, west, and southwest.

In addition to the Hanford Site water table, Figure 2.1-3 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 2000. The offsite water table is heavily influenced by irrigation practices, and the configuration of the water table is significantly controlled by topography. Many of the contour flexures and mounds represent valleys and higher plateau areas. Hydraulic head 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.

2.1.1.2 Water-Table Changes from FY 2003

During FY 2004, staff sampled 730 wells and 134 aquifer tubes for radiological and chemical constituents.

In the 200 East Area, the elevation of the water table declined by an average of 0.09 meter from March 2003 to March 2004. This is greater than the previous annual decline (0.04 meter from March 2002 to March 2003, PNNL-14548), but is still less than the normal decline seen in earlier years (e.g., 0.19 meter from March 2001 to March 2002, PNNL-14187). The region affected by this smaller than normal decline extends from Gable Gap through the 200 East Area to the Central Landfill, i.e., in the highly conductive sediment of the Hanford formation. This fluctuation in the rate of water-table decline is demonstrated by the hydrograph for well 299-E32-8 in the northwest part of the 200 East Area (Figure 2.1-4). Possible explanations for this perturbation of the water table continue to be investigated.

In the 100-D Area, the water-table elevation increased in the vicinity of the 182-D reservoir due to water leaking from this facility. The resulting groundwater mound is evident from the shape of the 118-meter water-level contour in Figure 2.5-3 of Section 2.5. Section 2.5 provides additional information regarding this leak.

Over much of the rest of the Hanford Site, the long-term decline in the water-table elevation continued, although increases did occur in some areas. The water-table elevation increased in many areas along the Columbia River north of Gable Butte and Gable Mountain as well as in the 300 Area. These increases are attributed to changes in river stage. In the

(b) Based on the average water-level elevation measured in 15 wells within the 200 East Area during March 2004, which have been corrected for deviations of the borehole from vertical (122.3 meters NAVD88), and the pre-Hanford water-table elevation for the 200 East Area estimated from BNWL-B-360 (~119.9 meters NAVD88).

200 West Area, the water table declined by an average of 0.21 meter (in those areas not influenced by pump-and-treat remediation systems).

2.1.2 Groundwater Contaminants

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

During FY 2004, Hanford Site staff sampled 730 wells and 134 aquifer tubes for radiological and chemical constituents. Many of the wells were sampled multiple times, for a total of 2,026 sampling trips.

Chromium (total or hexavalent) was the most frequently analyzed constituent, analyzed 1,768 times. Anions, tritium, iodine-129, metals, technetium-99, strontium-90, and volatile organic compounds were other commonly analyzed constituents (Table 2.1-2). The data from many wells on the Hanford Site are used to meet the objectives of multiple regulations, including AEA, CERCLA, and RCRA. Sampling and analysis are coordinated to avoid unnecessary costs.

Monitoring water quality along the river is accomplished by collecting samples from (a) aquifer tubes having sample ports at several depths beneath the shoreline, (b) riverbank springs, and (c) near-shore river water. Use of aquifer tubes at riverbank springs is included in CERCLA monitoring plans for groundwater operable units in the 100 and 300 Areas. 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). DOE installed 108 new aquifer tubes in FY 2004 to improve coverage in the 100 Areas and to monitor the 300 Area shoreline for the first time.

Tritium, nitrate, and iodine-129 are the most widespread contaminants associated with past Hanford Site operations. Their distribution in the unconfined aquifer is shown in Figures 2.1-5, 2.1-6, and 2.1-7. 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. Other contaminant plumes on the Hanford Site are listed below:

Although some contaminants exceed drinking water standards in groundwater samples, the concentrations measured in river water remained far below standards.

- Carbon tetrachloride and associated trichloroethene in the 200 West Area.
- Chromium in the 100 Areas.
- Chromium in the 200 West Area and in the 600 Area south of the 200 Areas.
- Strontium-90 in the 100 Areas.
- Technetium-99 and uranium that extend eastward from the 200 West Area.
- Technetium-99 and uranium with minor amounts of cyanide and cobalt-60 in the northwest 200 East Area.
- Uranium in the 300 Area.

The distribution of hexavalent chromium in aquifer tubes along the 100 Areas is illustrated in Figure 2.1-8. The highest concentrations are detected along the south 100-D Area shoreline.

Table 2.1-3 lists contaminants and refers to the sections in this report where they are discussed. The table highlights contaminants that exceed water quality standards. Analytical results including FY 2004 and historical data are included in the data files accompanying this report.

With the exception of carbon tetrachloride, the highest concentrations of contaminants on the Hanford Site remain near the water table. Relatively few wells are completed deeper in the aquifer, but in most cases, these detect lower levels of contamination than their shallow counterparts. A confined aquifer in the Ringold sediment east of the 200 East Area is contaminated with tritium at levels near those in the unconfined aquifer. However, tritium levels drop sharply a short distance downgradient, as discussed in Section 2.14. Deeper still,

in the upper basalt-confined aquifer ~25 meters below the water table, contamination has been detected in only two wells, both near the 200 East Area (see Section 2.14).

Carbon tetrachloride data have been collected from various depths within the unconfined aquifer in recent years. In some cases, concentrations are higher near the bottom of the aquifer than near the water table. Section 2.8 discusses the vertical distribution of carbon tetrachloride.

The discharge of the Columbia River along the Hanford Reach is controlled by releases from the Priest Rapids Dam, located upstream of the Hanford Site. Daily discharge cycles can cause river elevation changes of up to several meters along the reactor areas. These fluctuations create a bank storage zone containing highly variable water movement patterns. The influx of river water may dilute contamination carried toward the river by groundwater, prior to its discharge through the riverbed sediment and river bank springs. Seasonal discharge cycles also influence the release of groundwater into the river environment.

2.1.3 Groundwater Remediation

DOE is working to clean up groundwater contamination that may pose a risk to human health or the environment. Decision-making efforts are organized by groundwater operable unit. The text below summarizes the status of remediation in each operable unit and Table 2.1-4 lists the volume of water treated and amount of contaminant removed. Additional details are provided elsewhere in Chapter 2.

DOE is working to clean up groundwater contamination that may pose a risk to human health or the environment. Interim remedial actions reduce the movement of contaminants until final cleanup decisions are made.

DOE, EPA, and Ecology have created records of decision for seven groundwater operable units:

- **100-HR-3 (100-D and 100-H Areas) and 100-KR-4 (100-K Area)** – Chromium may pose a threat to aquatic organisms in the Columbia River. In the 100-K, 100-D, and 100-H Areas, interim action pump-and-treat systems reduce the amount of chromium reaching the river. A second system began to operate in the 100-D Area in FY 2004. Also in the 100-D Area, an innovative treatment method immobilizes chromium in the aquifer. In FY 2004, chromium concentrations at all these interim action sites remained above remediation goals (ROD 1996a, 1999a).
- **100-NR-2 (100-N Area)** – Strontium-90 concentrations remained much higher than the drinking water standard in wells at the river shore in FY 2004. DOE has operated a pump-and-treat system for strontium-90 as an interim action since 1995 and is investigating alternative remediation methods (phytoremediation and apatite sequestration; ROD 1999b).
- **200-UP-1 (200 West Area)** – DOE has operated an interim action pump-and-treat system for technetium-99 and uranium since 1995. In FY 2004, all concentrations in the extraction and monitoring wells were below the remediation goals (ROD 1997). A new extraction well was put online in FY 2004.
- **200-ZP-1 (200 West Area)** – DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride from spreading since 1994 (ROD 1995a). More recently, carbon tetrachloride concentrations have been detected above the remedial action goal north of the Plutonium Finishing Plant, just west of the TX-TY Tank Farm. Because of these changes, plans are now underway to expand the pump-and-treat system by adding additional extraction wells.
- **300-FF-5 (300 Area and satellite areas to the north)** – The interim action involves natural attenuation of the cis-1,2-dichloroethene, trichloroethene, and uranium plumes in the 300 Area. In FY 2004, concentrations of the organic contaminants were low, but uranium remained elevated (ROD 1996b). DOE and EPA are investigating alternative forms of remediation via a remedial investigation/feasibility study process.

- **1100-EM-1 (Richland North Area)** – DOE and regulatory agencies have determined that the final cleanup action will be monitored natural attenuation of the contaminant plumes (ROD 1993).

At the 100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1 operable units, monitoring indicates there is no imminent threat to human health or the environment, so no interim remedial actions are occurring. Remedial investigations and feasibility studies will be conducted to support final remediation decisions for these operable units. Meanwhile, waste sites and plumes will continue to be monitored.

2.1.4 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 2004 are reliable and defensible. Details of the quality control program for FY 2004 are included in Appendix C. Highlights include the following:

Evaluation of the groundwater project quality assurance program indicates that the data for FY 2004 are reliable and defensible.

- During FY 2004, 87% of the groundwater monitoring data was considered complete. The groundwater project is attempting to improve completeness by working with the laboratories to reduce laboratory blank contamination.
- Analytical services are performed by four offsite contract laboratories. All four laboratories participated in two or more national performance evaluation studies. Overall, the percentage of acceptable results for FY 2004 was 95%; the percentages for the individual laboratories ranged from 91% 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 95% of field blank and field duplicate results for FY 2004 were acceptable, indicating little problem with contamination and good precision overall. A limited number of split samples were collected during the year; the analyzing laboratories demonstrated reasonable agreement.
- Recommended holding times were met for 95% 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 very good overall – 90% of the results were acceptable.
- Approximately 97% of the laboratory quality control results for FY 2004 were within the acceptance limits, suggesting that the analyses were in control and reliable data were generated. Specifically, 99% of the method blanks, 98% of the laboratory control samples, 95% of the matrix spikes, 96% of the matrix duplicates, and 95% of the surrogates were within the acceptance limits.
- Seven audits of the commercial laboratories were conducted by DOE and its contractors. Several minor findings and observations were identified along with a number of proficiencies. Corrective actions have been accepted for all of the audits.

Table 2.1-1. Groundwater Operable Units and Regulated Units on the Hanford Site

Site or Operable Unit	Type of Monitoring Program	Text Section	FY 2004 Highlights
CERCLA Groundwater Operable Units (well/constituent tables in Appendix A)			
100-BC-5	Long-term monitoring	2.2	Revised sampling and analysis plan
100-FR-3	Long-term monitoring	2.7	Revised sampling and analysis plan
100-HR-3 (D pump and treat)	IRA; interim ROD	2.5	Chromium > remediation goal; second system added; three wells installed
100-HR-3 (D redox site)	IRA; interim ROD	2.5	Chromium > remediation goal
100-HR-3 (H pump and treat)	IRA; interim ROD	2.6	Chromium > remediation goal
100-KR-4 (pump and treat)	IRA; interim ROD	2.3	Chromium > remediation goal; two wells installed
100-NR-2 (pump and treat)	IRA; interim ROD	2.4	No decrease in plume size; investigating alternatives; baseline monitoring to support planned rebound study; three wells installed
200-BP-5	Long-term monitoring	2.10	Revised sampling and analysis plan
200-PO-1	Long-term monitoring	2.11	New sampling and analysis plan
200-UP-1 (pump and treat)	Interim action ROD	2.9	Technetium-99 and uranium < remediation goal; rebound study planned; seven wells installed
200-ZP-1 (pump and treat)	Interim action ROD	2.8	System to be expanded; four wells installed
300-FF-5 (300 Area)	Natural attenuation; interim ROD	2.12	Average TCE <5 µg/L; uranium remains elevated; RI/FS began
300-FF-5 (north)	Operations and Maintenance plan	2.12	Tritium levels decreasing
1100-EM-1	Natural attenuation; final ROD	2.13	Average TCE <5 µg/L since FY 2001
Regulated Units (well location maps, well/constituent tables, statistics tables, and flow rates in Appendix B)			
100-K basins	AEA	2.3.3	No leaks detected
116-N-1 (1301-N) facility	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.4.3.1	Continued detection[(a)]
116-N-3 (1325-N) facility	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.4.3.3	Continued detection[(a)]
120-N-1, 120-N-2 (1324-N/NA) facilities	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.4.3.2	Continued detection[(a)]
116-H-6 (183-H) evaporation basins	WAC 173-303-645(11)(g)	2.6.3	Monitoring during IRA; chromium, nitrate, technetium-99, uranium
200 Area TEDF	WAC 173-216	2.11.3.8	No influence in upper aquifer
216-A-29 ditch	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.3	Continued detection[(a)]
216-B-3 pond	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.5	Reverted to conventional statistics
216-B-63 trench	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.2	Continued detection[(a)]
216-S-10 pond and ditch	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.9.3.3	Continued detection;[(a)] two shallow and one deep downgradient wells remain
216-U-12 crib	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.9.3.4	Continued assessment; two downgradient wells remain
316-5 process trenches	WAC 173-303-645(11)(g)	2.12.3	Monitoring during natural attenuation IRA
ERDF	CERCLA	2.9.3.5	No impact on groundwater
LERF	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.5	Insufficient wells; no statistical comparisons

Table 2.1-1. (contd)

Site or Operable Unit	Type of Monitoring Program	Text	FY 2004 Highlights
Regulated Units (well location maps, well/constituent tables, statistics tables, and flow rates in Appendix B)			
LLWMA 1	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.3	Continued detection[(a)]
LLWMA 2	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.4	Continued detection;[(a)] north wells dry; no unconfined aquifer in north
LLWMA 3	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.8.3.1	Continued detection;[(a)] three wells went dry
LLWMA 4	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.8.3.2	Continued detection until last shallow downgradient well went dry
NRDWL	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.6	Continued detection[(a)]
PUREX cribs	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.11.3.1	Continued assessment; iodine-129, nitrate, and tritium
SALDS	WAC 173-216	2.8.3.5	No permit limits exceeded; two dry wells
SST WMA A-AX	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.11.3.2	Continued detection;[(a)] two corroded wells decommissioned; two new wells installed
SST WMA B-BX-BY	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.10.3.1	Continued assessment; nitrate, nitrite, technetium-99, uranium; three wells installed
SST WMA C	WAC 173-303-400; 40 CFR 265.93(b); AEA	2.10.3.6	Temporarily ceased CIP comparisons
SST WMA S-SX	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.9.3.2	Continued assessment; chromium, technetium-99; new well planned
SST WMA T	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.8.3.3	Continued assessment; technetium-99; new wells planned
SST WMA TX-TY	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.8.3.4	Continued assessment; chromium, technetium-99; new well planned
SST WMA U	WAC 173-303-400; 40 CFR 265.93(d); AEA	2.9.3.1	Continued assessment; nitrate, technetium-99; one well installed
SWL	WAC 173-304	2.11.3.7	Five constituents exceeded background or standards; low levels of organics

(a) Analysis of RCRA CIP provided no evidence of groundwater contamination with hazardous constituents from the unit.

AEA = *Atomic Energy Act of 1954*.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*.
CFR = Code of Federal Regulations.
CIP = Contamination indicator parameters.
ERDF = Environmental Restoration Disposal Facility.
FY = Fiscal year.
IRA = Interim remedial action.
LERF = Liquid Effluent Retention Facility.
LLWMA = Low-level waste management area.
NRDWL = Nonradioactive Dangerous Waste Landfill.
PUREX = Plutonium-Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act*.
RI/FS = Remedial investigation/feasibility study.
ROD = Record of decision.
SALDS = State-Approved Land Disposal Site.
SST = Single-shell tank.
SWL = Solid Waste Landfill.
TCE = Trichloroethene.
TEDF = Treated Effluent Disposal Facility.
WAC = Washington Administrative Code.
WMA = Waste management area.

Table 2.1-2. Number of Groundwater Analyses by Groundwater Interest Area,[a] FY 2004

Constituent	Site Total	100-BC-5	100-KR-4	100-NR-2	100-HR-3-D	100-HR-3-H	100-FR-3	200-ZP-1	200-UP-1	200-BP-5	200-PO-1	300-FF-5	1100-EM-1
Carbon tetrachloride	585	4	1	0	0	0	25	214	103	7	59	136	36
Chromium (total and hexavalent)	1,768	42	203	72	421	177	58	181	179	229	159	36	11
Iodine-129	382	0	0	0	0	0	0	79	72	95	120	13	3
Nitrate (anions)	1,367	19	72	77	87	52	44	234	197	233	225	78	49
Plutonium-239/240	31	4	0	0	0	0	0	6	0	20	0	1	0
Strontium-90	346	20	54	66	17	23	11	22	25	40	62	6	0
Technetium-99	702	9	18	0	10	28	1	185	192	210	36	10	3
Trichloroethene (VOA)	584	4	1	0	0	0	25	213	103	7	59	136	36
Tritium	1,054	30	96	66	49	32	24	194	70	201	150	87	55
Uranium	644	4	0	8	41	28	0	48	151	173	12	163	16

FY = Fiscal year.
VOA = Volatile organic analysis.
(a) Groundwater interest areas are shown on Figure 2.1-1.

Table 2.1-3. Maximum Concentrations of Selected Groundwater Contaminants in FY 2004 in Groundwater Interest Areas (see Figure 2.1-1)

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	
		Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes	Wells	Aquifer Tubes
Antimony (filtered), µg/L[b]	6			**31.1**		**57.4**							
Arsenic (filtered), µg/L	10							8.5					
Carbon tetrachloride, µg/L	5												
Carbon-14, pCi/L	2,000 [70,000]			**15,300**	181								
Cesium-137, pCi/L	200 [3,000]												
Chloroform, µg/L	100			0.2								0.6	0.2
Chromium (dissolved), µg/L	100	19.1	28.1	**565**	72.2	**170**	36.3	**3,830**	**363**	**132**	52.3	97.8	13.9
cis-1,2-dichloroethene, µg/L	70												
Cobalt-60, pCi/L	100 [5,000]												
Cyanide, µg/L	200												
Fluoride, mg/L	4	0.4	0.2	0.5	0.4	0.9	0.3	0.5		0.5	0.2	0.9	0.2
Gross alpha, pCi/L	15	2.4		7.6		5.2		8.0		**36.8**		13.6	
Gross beta, pCi/L	50	45.8		**3,860**	3.7	**16,900**	**7,710**	**375**		**134**		45	
Iodine-129, pCi/L	1 [500]												
Nitrate, mg/L	45	27.4	28.8	**132**	41.2	**270**	6.8	**74.4**	40.3	**192**	**491**	**166**	**52.7**
Nitrite, mg/L	3.3		0.72	0.49		1.68	0.12	**4.60**	0.17				0.19
Plutonium-239/240, pCi/L[c]	NA [30]												
Strontium-90, pCi/L	8 [1,000]	**39.0**	0.6	**2,380**	1.4	**7,390**	**3,830**	**8.2**		**29.6**	**2.4**	**22.6**	**1.2**
Technetium-99, pCi/L	900 [100,000]	109	124	117						485		150	
Trichloroethene, µg/L	5			**10.0**								**19.0**	
Tritium, pCi/L	20,000 [2,000,000]	**41,000**	**20,100**	**636,000**	11,900	**28,600**	5,240	**25,200**	**31,900**	5,750		8,240	798
Uranium, µg/L	30							7.6		**54.3**	1.7		

Table 2.1.3. (contd)

Contaminant, units (alphabetical order)	DWS [DCG][a]	200-ZP-1 Wells	200-UP-1 Wells	200-BP-5 Wells	200-PO-1 Wells	300-FF-5 Wells	300-FF-5 Aquifer Tubes	1100-EM-1 Wells	AREVA[d]	Richland Landfill[e]
Antimony (filtered), µg/L[b]	6	**46.2**	**41.0**							1.8
Arsenic (filtered), µg/L	10	10.0	6.7	**11.7**	**12.4**					10
Carbon tetrachloride, µg/L	5	**9,700**	**650**			0.5				<1
Carbon-14, pCi/L	2,000 [70,000]	8.7								
Cesium-137, pCi/L	200 [3,000]			**1,150**						
Chloroform, µg/L	100	**150**	19.0		0.6	4.0		0.3		5.6
Chromium (dissolved), µg/L	100	**733**	**558**	56.8	73.7	8.8	0.4			31
cis-1,2-Dichloroethene, µg/L	70	0.1	0.3		0.2	**150**	0.2			**70**
Cobalt-60, pCi/L	100 [5,000]	9.6		**109**						
Cyanide, µg/L	200	12.3	25.1	**357**	10.0					
Fluoride, mg/L	4	**4.6**	0.6	0.8	**7.6**	0.7	0.6	1.4	**4.19**	
Gross alpha, pCi/L	15	10.1	**16.6**	**323**	**16.9**	**66.1**		8.5	**119**	
Gross beta, pCi/L	50	**6,050**	**18,100**	**13,400**	**4,290**	**82.6**		10.2	49	
Iodine-129, pCi/L	1 [500]	**24.8**	**13.6**	**5.8**	**10.2**					
Nitrate, mg/L	45	**3,430**	**522**	**1,070**	**132**	**101**	**67.3**	**239**[f]	**282**	**53.1**
Nitrite, mg/L	3.3	0.361	**11.7**	1.28	1.05	0.28				
Plutonium-239/240, pCi/L[c]	NA [30]			**66.2**						
Strontium-90, pCi/L	8 [1,000]	1.4	**35.0**	**6,360**	**21.1**	3.8				
Technetium-99, pCi/L	900 [100,000]	**21,400**	**46,100**	**11,100**	**13,100**	30.1		24.4		
Trichloroethene, µg/L	5	**26.0**	**7.1**		0.8	**5.4**	**6.8**	2.3	4.6	**28**
Tritium, pCi/L	20,000 [2,000,000]	**1,830,000**	**339,000**	**39,100**	**616,000**	***2,320,000***		394		
Uranium, µg/L	30	**250**	**599**	**590**	2.8	**127**	**241**	19.6		

Note: Table lists highest concentration for FY 2004 in each groundwater interest area. Concentrations in **bold** exceed drinking water standards. Concentrations in **bold italic** exceed DOE derived concentration guides. Blank space indicates the constituent was undetected or not analyzed.

(a) DWS = Drinking water standard; DCG = DOE derived concentration guide. See Tables 1.1-2 and 1.1-3 in Section 1.0 for more information on these standards.
(b) Detection limit is higher than DWS. Not a known contaminant of interest on the Hanford Site.
(c) There is no drinking water standard for plutonium-239/240.
(d) AREVA (formerly Framatome ANP) data from October 2003 to March 2004 (EMF-1865, Addenda 35 and 37).
(e) City of Richland data from October 2003 to June 2004 (City of Richland 2004a, 2004b, 2004c).
(f) From offsite contaminant sources.
DOE = U.S. Department of Energy.
FY = Fiscal year.

Table 2.1-4. Hanford Site Groundwater and Vadose Zone Remediation

Remediation Site	Year Initiated	Contaminant	Average Concentration in FY 2004		Volume of Water Treated (million liters)		Amount of Contaminant Removed	
			Influent	Effluent	FY 2004	Since Startup	FY 2004	Since Startup
Pump-and-Treat Systems								
100-KR-4	1997	Hexavalent chromium	64 µg/L	4 µg/L	518.9	2,590	31.5 kg	244.3 kg
100-NR-2	1995	Strontium-90	2,027 pCi/L	431 pCi/L	116.2	986	0.2 Ci	1.6 Ci
100-HR-3 North 100-D	1997	Hexavalent chromium	188 µg/L	6 µg/L	172.8	1,090	30.9 kg	192.2 kg
100-HR-3 Central 100-D	2004	Hexavalent chromium	950 µg/L	<5 µg/L	7.9	7,900	6.4 kg	6.4 kg
100-HR-3, 100-H	1997	Hexavalent chromium	26 µg/L	6 µg/L	161.9	1,100	4.1 kg	37.3 kg
200-UP-1	1994	Uranium	251.2 µg/L	undetected	93.8	801.2	23.5 kg	5,207 kg
		Technetium-99	2,207 pCi/L	undetected			12 g (0.2 Ci)	114.1 g (2.39 Ci)
		Carbon tetrachloride	58.2 µg/L	undetected			5.4 kg	31.2 kg
		Nitrate	55.5 mg/L	undetected			5,207 kg	32,550 kg
WMA S-SX (299-W23-19)[a]	2003	Technetium-99	43,263 pCi/L	--	0.01169	0.0277	0.043 g (0.00073 Ci)	0.11 g (0.0019 Ci)
200-ZP-1	1994	Carbon tetrachloride	3,079 µg/L	<5 µg/L	274.5	2,420	840.4 kg	8,508 kg
Other Remediation								
100-HR-3, South 100-D	1999	Hexavalent chromium	Permeable barrier, in situ redox manipulation. Concentrations in most compliance wells downgradient of barrier have decreased, but chromium rebounding in some barrier wells.					
200-ZP-1	1992	Carbon tetrachloride	Soil-vapor extraction (256 kg removed in FY 2004; 78,300 kg removed since startup).					
300-FF-5	1996	TCE cis-1,2-DCE Uranium	Natural attenuation selected as interim action. TCE and cis-1,2-DCE have declined below remedial action goals. Uranium is not attenuating at an acceptable rate and alternative forms of remediation are being investigated.					
1100-EM-1	1993	TCE	Natural attenuation selected as final remedy. Concentrations remain below remedial action goals.					

DCE = Dichloroethene.
FY = Fiscal year.
TCE = Trichloroethene.
WMA = Waste management area.
(a) Well is pumped to remove 3,785 liters after each sampling event.

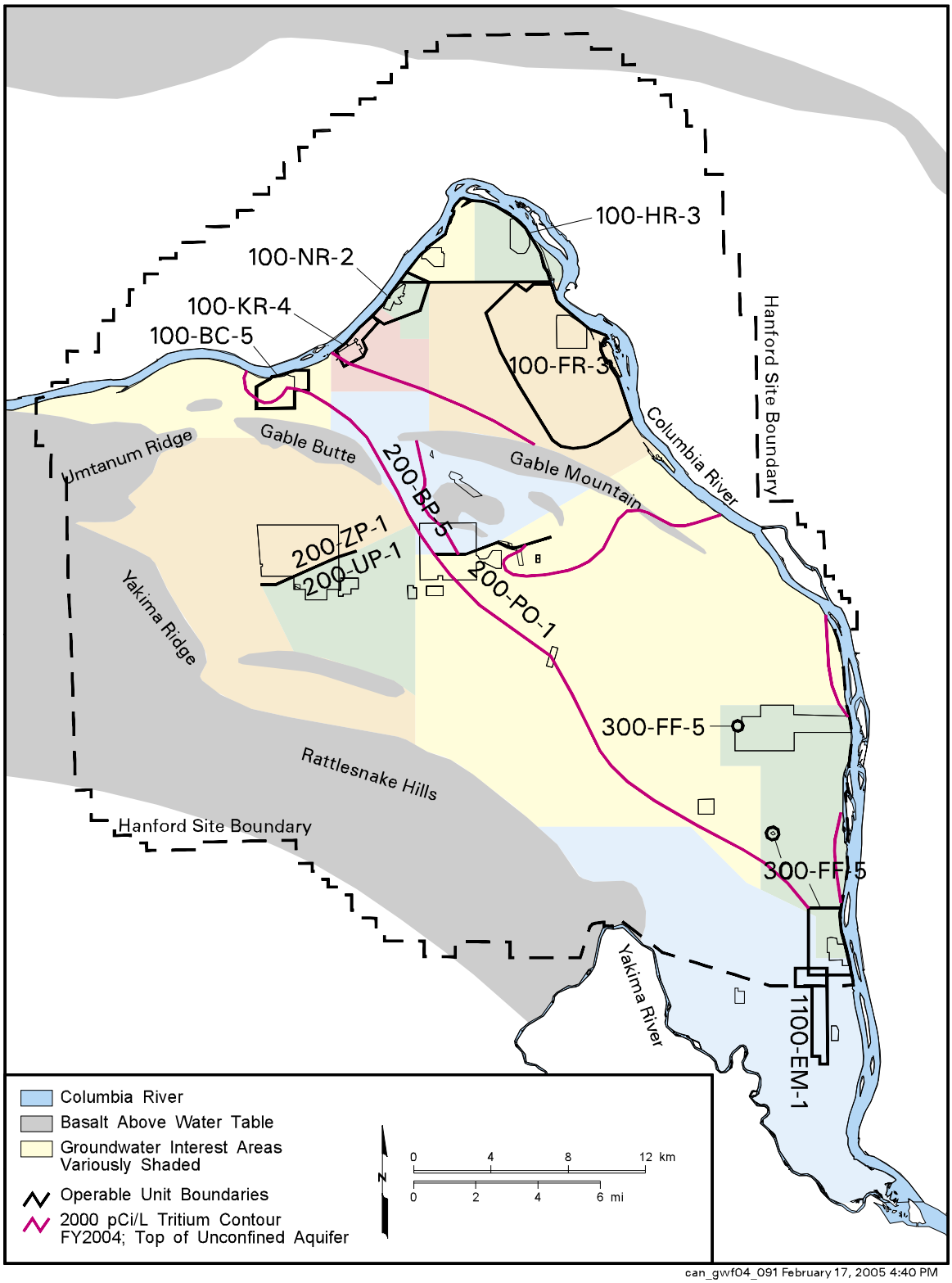

Figure 2.1-1. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site

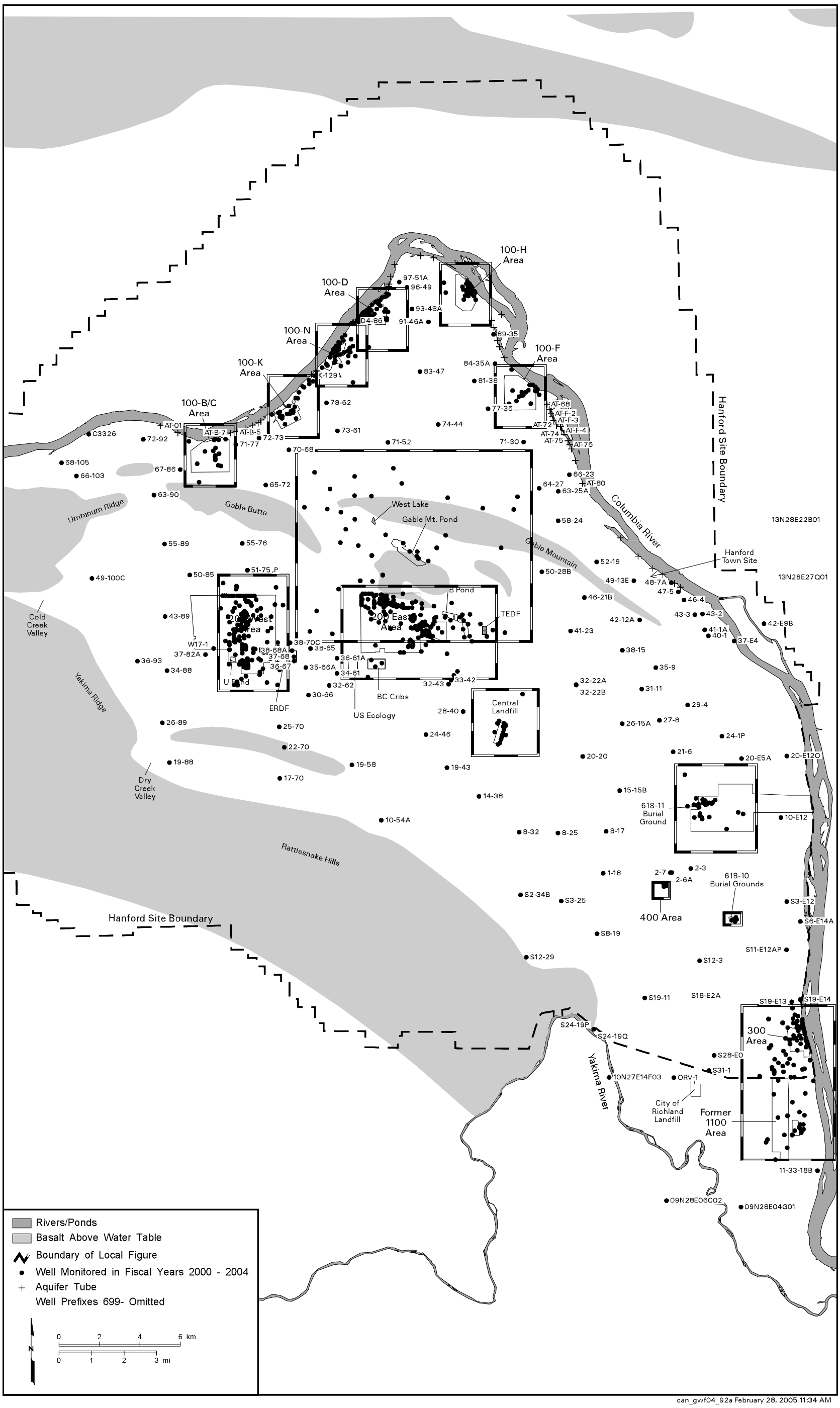

Figure 2.1-2. Groundwater Monitoring Wells in the 600 Area

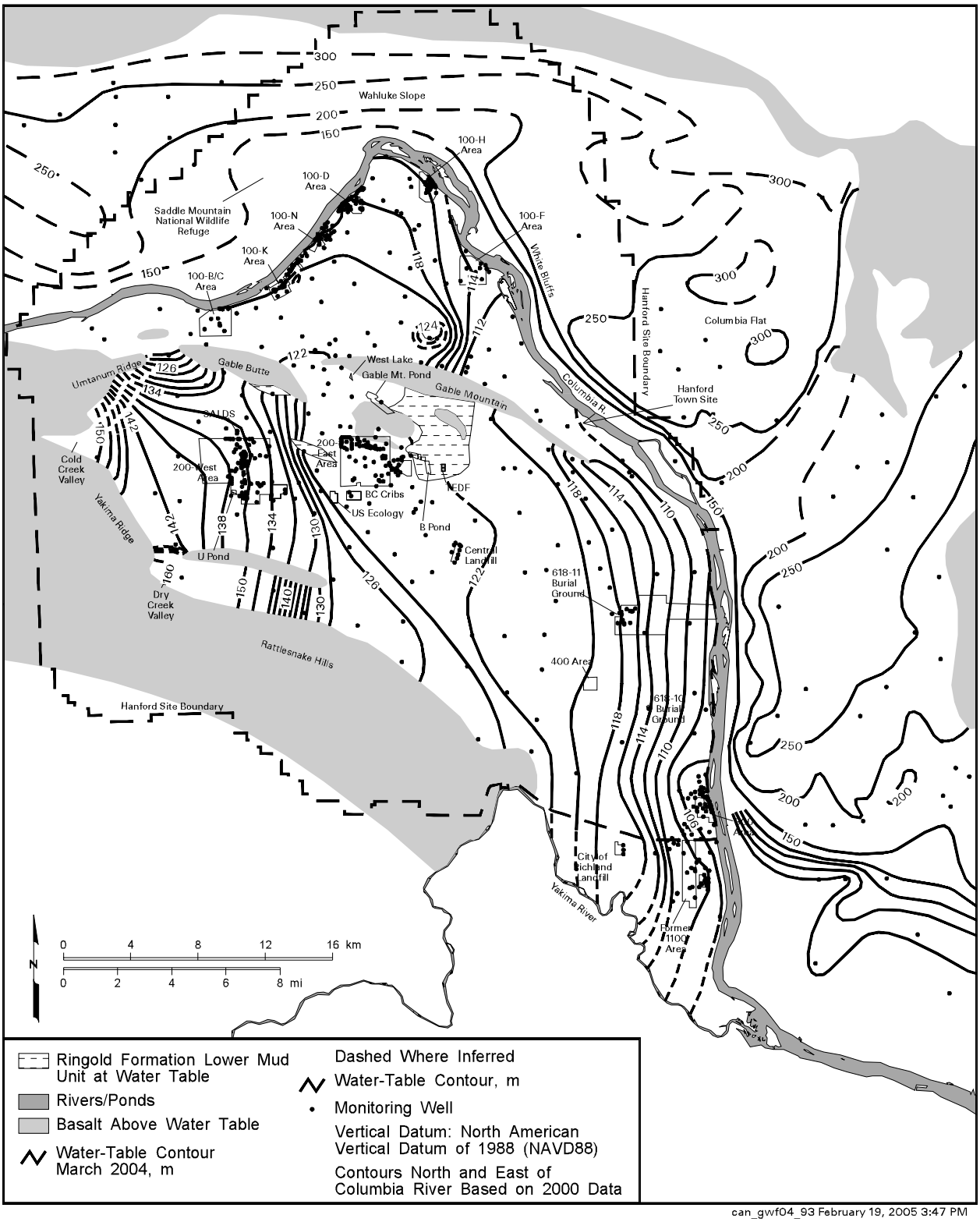

Figure 2.1-3. Hanford Site and Outlying Areas Water-Table Map, March 2004

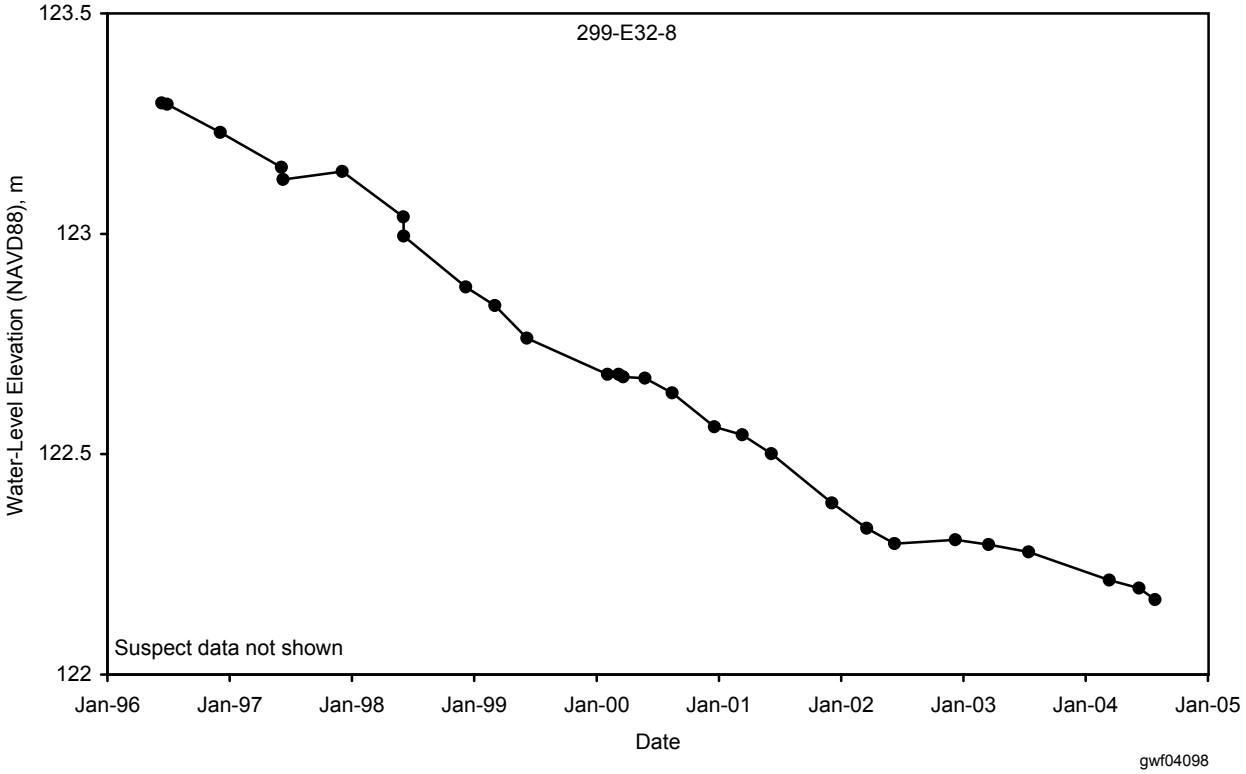

Figure 2.1-4. Water Level in Well 299-E32-8, Northwest 200 East Area

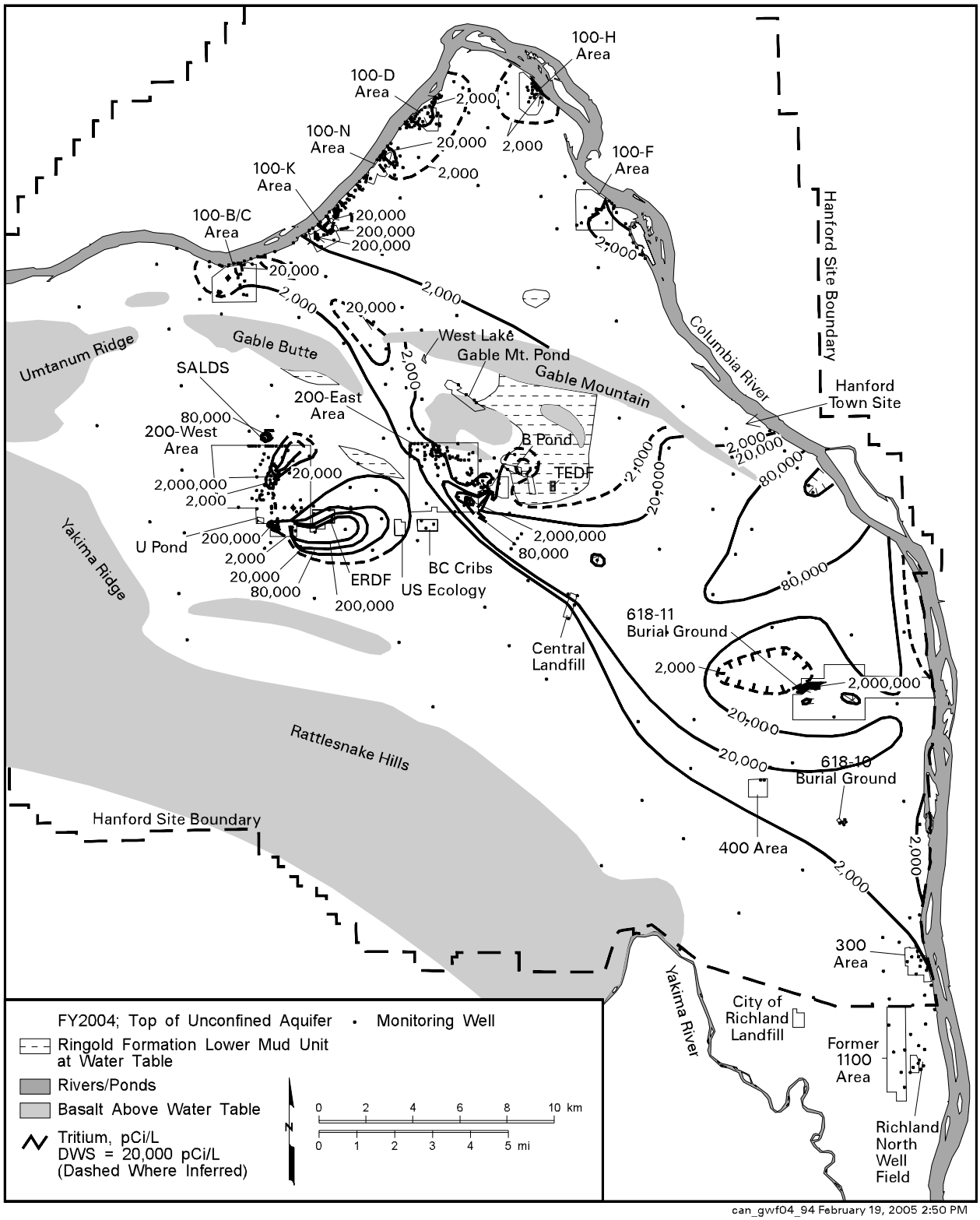

Figure 2.1-5. Average FY 2004 Tritium Concentrations on the Hanford Site, Top of Unconfined Aquifer

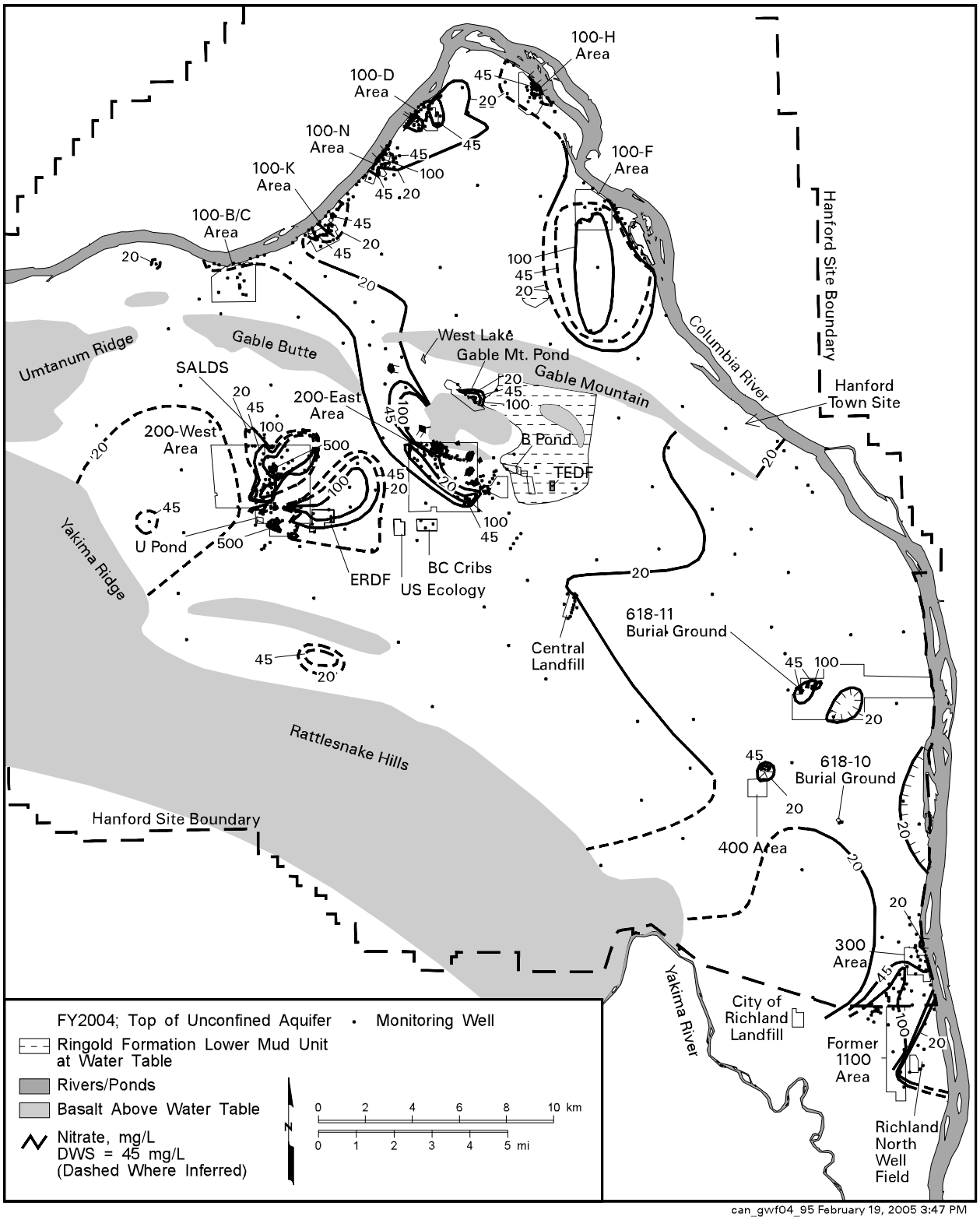

Figure 2.1-6. Average FY 2004 Nitrate Concentrations on the Hanford Site, Top of Unconfined Aquifer

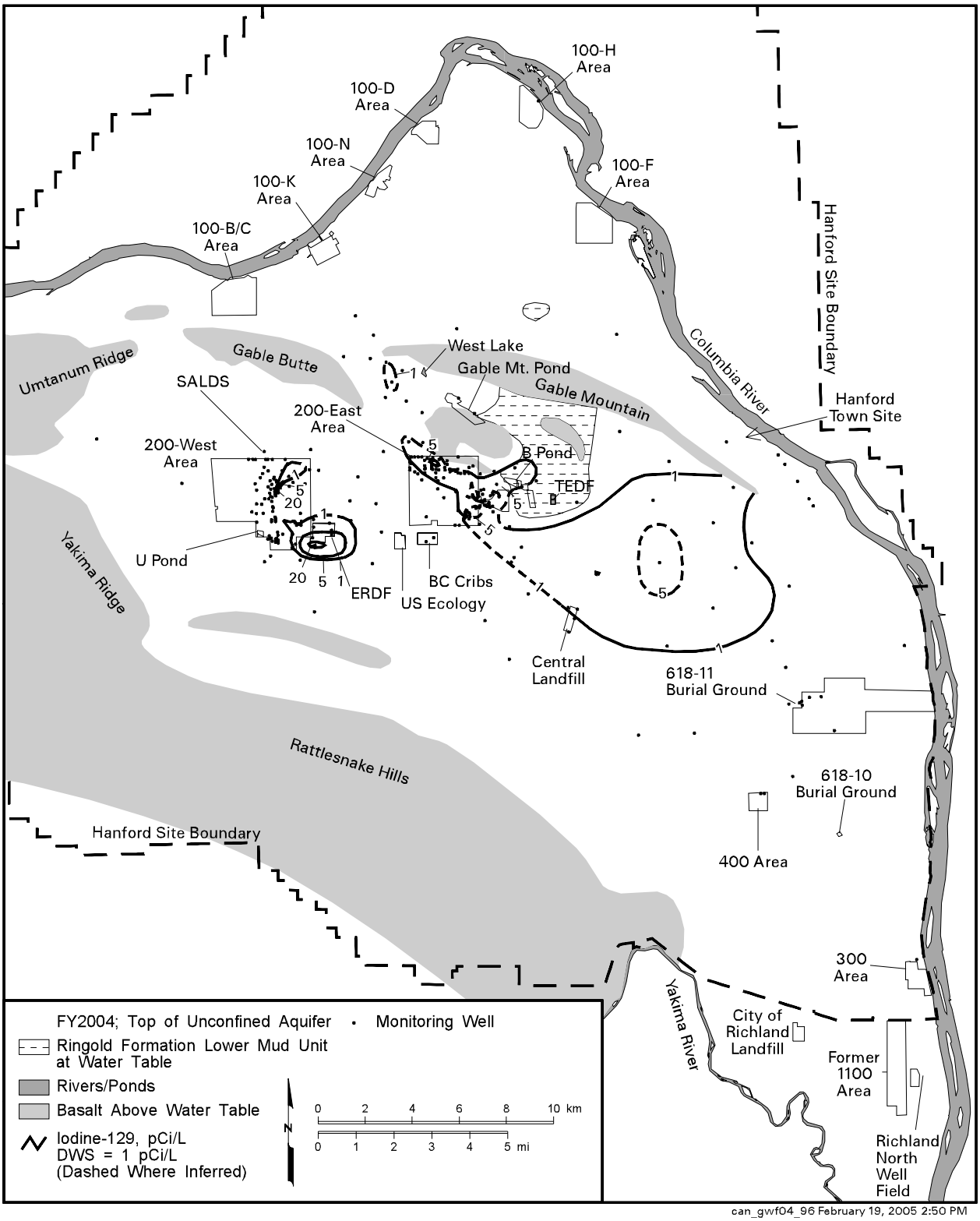

Figure 2.1-7. Average FY 2004 Iodine-129 Concentrations on the Hanford Site, Top of Unconfined Aquifer

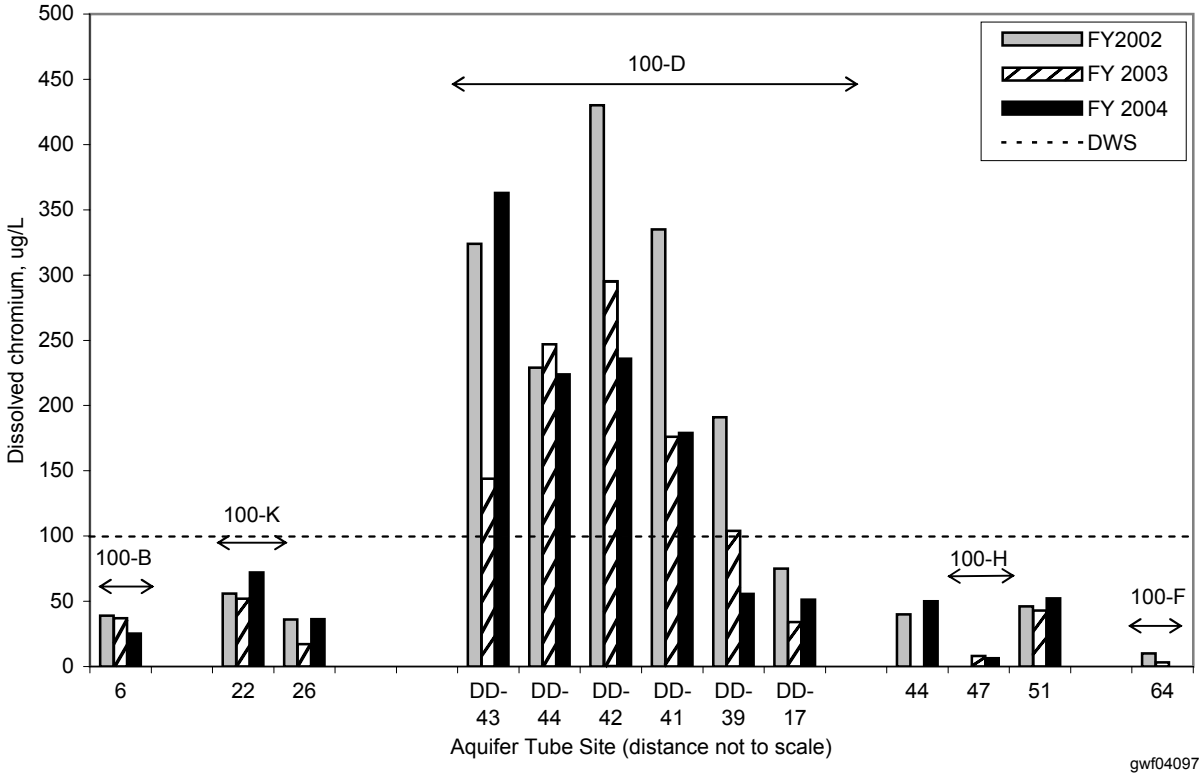

Figure 2.1-8. Dissolved Chromium at Selected Aquifer Tube Sites, 100 Areas