2.12 300-FF-5 Operable Unit

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The 300-FF-5 Operable Unit is located in the southeastern portion of the Hanford Site and includes groundwater affected by releases from waste sites and facilities associated with the 300-FF-1 and 300-FF-2 Operable Units. The operable unit lies within a larger 300-FF-5 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (Figure 1.0-1). Figure 2.12-1 shows the subregions within the 300-FF-5 Operable Unit and their relationship to the 300-FF-1 and 300-FF-2 Operable Units.

The 300-FF-5 Operable Unit includes groundwater beneath the 300 Area and outlying subregions near the 618-11 and 618-10 Burial Grounds.

Groundwater in the unconfined aquifer beneath the 300-FF-5 groundwater interest area flows generally to the east and southeast (Figure 2.12-2). Flow converges into the 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. This flow pattern reflects medium-to-low river stage conditions. As river stage rises during late May or June, the direction of groundwater flow shifts to more southward over much of the 300 Area. The daily, weekly, seasonal, and multiyear cycles of the Columbia River stage have a profound effect on groundwater flow patterns and rates in the 300 Area. Recent computer 3-dimensional simulation of groundwater flow has provided new insight on how contamination is dispersed beneath the 300 Area (PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area, Hanford Site, Washington State*). Routine seasonal changes in river stage are reflected in water levels measured at wells located as much as 360 m inland from the Columbia River and even farther inland during unusually high river discharge conditions (e.g., during 1996 and 1997).

The cyclic variability in Columbia River stage, which causes the rapid changes in hydraulic gradients and their orientation, also causes changes in water quality conditions in the aquifer near the river. During the river's spring runoff period when high stage conditions are present, river water intrudes into the aquifer near the channel and layers and/or mixes with groundwater, thus reducing contaminant concentrations observed in samples from wells and riverbank springs. Also, the rate at which groundwater discharges to the river is lowest during this period of high river stage because of reduced gradients and actual reversal of flow direction near the shoreline. Farther inland, high stage conditions result in higher water table elevations, with the water table fluctuating through a vertical range up to several meters. A high water table may result in groundwater encountering contamination potentially sequestered in the lower vadose zone, providing a remobilization mechanism for those contaminants. Consequently, higher concentrations may be observed during the summer months, particularly in the vicinity of former liquid waste disposal sites. These processes are described in detail as part of the conceptual model for uranium contamination in the subsurface at the 300 Area (PNNL-17034, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*).

Groundwater in the unconfined aquifer 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 in the upper portion of the unconfined aquifer, groundwater flow velocities can be high, with a recent tracer

test indicating a rate of 15 m/d (PNNL-16571, *Treatability Test Plan for 300 Area Uranium Stabilization through Polyphosphate Injection*). Other investigations also have documented plume migration rates as high as 10 m/d (PNL-5408, *Ground-Water Monitoring at the Hanford Site, January-December1984*). In spite of high flow velocities, the net rate of groundwater discharge to the Columbia River appears to be relatively low. This is likely a consequence of rapidly changing hydraulic gradients and their orientation, which may result in a reversal of flow (i.e., directed inland). Efforts to more accurately quantify discharge rates continued during fiscal year (FY) 2008 (PNNL-17708). Vertical hydraulic gradients in the upper aquifers beneath the 300 Area are directed upward, and this is presumed true for all of the 300-FF-5 Operable Unit.

Principal sources for contaminants known to have impacted groundwater in the 300 Area portion of the operable unit are the former liquid waste disposal facilities associated with nuclear fuels fabrication and research activities. Figure 2.12-3 shows 300 Area monitoring wells, waste sites, buildings, and shoreline monitoring sites. Liquid effluent also was disposed to the former 316-4 Cribs (located approximately 3 km northwest of the 300 Area) and releases from the 618-11 Burial Ground (located on the west side of the Energy Northwest complex) have impacted groundwater. Figure 2.12-4 shows monitoring wells at these outlying subregions. Groundwater in the operable unit has been influenced by releases from the 200 East Area, which is the origin for the sitewide plume addressed by the 200-PO-1 Operable Unit (Section 2.11). Finally, some contamination migrates into the operable unit from various sources to the southwest of the 300 Area.

Some of the main concepts associated with the 300-FF-5 Operable Unit include the following.

- Principal sources of groundwater contamination in the 300 Area included former liquid waste sites (300 Area process ponds and trenches). Contaminated soil was excavated at these former waste sites, but some contamination is known to remain in sediment.
- Uranium is the principal contaminant of concern in groundwater beneath the 300 Area. The plume area has remained relatively constant for the past ten years. Residual contamination in the vadose zone is a candidate for resupplying the plume.
- Organic contaminants (trichloroethene and cis-1,2-dichloroethene) are also present in 300 Area groundwater at levels exceeding drinking water standards.
- Tritium is a contaminant of concern at the 618-11 Burial Ground where it forms a small but high-concentration plume. Concentrations are declining near the burial ground.
- Wells screened at different depths in the unconfined aquifer beneath the 300 Area show that uranium is found in the shallow, coarse-gained portion of the aquifer and organics are found locally in deeper, finer-grained sediment.
- Most groundwater contamination appears to be dissipating as a result of natural processes. An exception is an increase in uranium concentrations near a large burial ground just west of the 300 Area, which has recently been excavated and backfilled.

- An interim remedial action involved monitoring the natural attenuation of the uranium and hydrocarbon contamination. However, the predicted attenuation of the uranium plume has not occurred. A new remedial investigation/ feasibility study work plan is under development for the 300 Area Decision Unit, with completion scheduled for October 2009.
- The U.S. Department of Energy (DOE) is investigating uranium mobility in the subsurface at a test site in the 300 Area. Results will support the CERCLA feasibility study.
- One *Resource Conservation and Recovery Act of 1976* (RCRA) site, the former 300 Area Process Trenches, is located in the 300 Area. Monitoring continued under the previously-established compliance program.

Remedial investigation activities and treatability tests are being conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). These activities track changes in the nature and extent of groundwater contamination, monitor trends in contaminant levels with time, and investigate potential methods for treating uranium contamination in the subsurface at the 300 Area. Groundwater monitoring also is being conducted to comply with RCRA requirements associated with the former 300 Area Process Trenches. Section 2.12.1 describes contaminant plumes and concentrations. Section 2.12.2 summarizes operable unit activities, which include interim action groundwater monitoring, the Phase III feasibility study, and testing technologies for uranium remediation and treatment. Section 2.12.3 describes groundwater monitoring under RCRA for the former 300 Area Process Trenches.

2.12.1 Groundwater Contaminants

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Wells in the 300-FF-5 Operable Unit are sampled to monitor constituents identified in an operations and maintenance plan (DOE/RL-95-73, *Operation and Maintenance Plan for the 300-FF-5 Operable Unit)* and its implementing sampling and analysis plan (DOE/RL-2002-11, *300-FF-5 Operable Unit Sampling and Analysis Plan*). Contaminants of concern or potential concern are identified in EPA/ROD/R10-96/143, *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington* and a subsequent explanation of significant differences (EPA/ESD/R10-00/524, *EPA Superfund Explanation of Significant Differences: Hanford 300-Area (USDOE)*). For the 300 Area subregion, contaminants of concern under CERCLA are identified as uranium, trichloroethene, and cis-1,2-dichloroethene. At the 618-11 Burial Ground, tritium is identified as a contaminant of potential concern. At the 618-10 Burial Ground/ 316-4 Cribs subregion, uranium and tributyl phosphate have been identified as contaminants to be monitored. Wells in the vicinity of the former 300 Area Process Trenches are also sampled to meet requirements for RCRA corrective action monitoring (WHC-SD-EN-AP-185, *Groundwater Monitoring Plan for the 300 Area Process Trenches*). Uranium in 300 Area groundwater is the contaminant of concern that has received the most attention because of the persistence of the plume at

Plume Areas (square kilometers) in the 300-FF-5 Operable Unit:
Tritium — 0.22
Uranium — 0.53
Excludes tritium from 200-PO-1 Operable Unit.

concentrations that exceed the drinking water standard and the proximity of the plume to the Columbia River.

Most contaminants of potential concern, as identified in the 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, *Contaminants of Potential Concern in the 300-FF-5 Operable Unit: Expanded Annual Groundwater Report for Fiscal Year 2004*). Table 1.0-4 summarizes contamination indicator concentrations and regulatory standard exceedances.

Uranium is identified as the principal contaminant of concern in the 300-FF-5 Operable Unit, with volatile organic compounds and tritium being contaminants of potential concern.

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. Disposal of uranium-bearing effluent to 300 Area waste facilities ended in 1986 (PNNL-13645, *300 Area Process Trenches Groundwater Monitoring Plan*), although discharge of uncontaminated effluent continued until December 1994. Excavation of contaminated soil at the major liquid waste disposal sites in the 300 Area occurred primarily during the period 1997 to 2000, with backfilling at all excavated sites completed by February 2004. At the former 316-4 Cribs, uranium was disposed to open-bottomed infiltration cribs along with liquid effluent containing organic compounds during the period 1948 to 1956. 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).

The mobility characteristics of uranium remaining within waste sites, the underlying vadose zone, and in the aquifer are highly variable. Mobility is influenced by sediment texture and mineralogy, chemical makeup of the original waste effluent, and the subsurface geochemical environment, especially the bicarbonate content, pH, and surface properties of minerals (PNNL-14022; PNNL-15121; PNNL-17031; PNNL-17034). Uranium concentrations from wells are typically measured as total uranium in an unfiltered sample. 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 the EPA. For the Hanford Site, natural background for uranium in groundwater in the unconfined aquifer has an estimated range of 0.5 to 12.8 µg/L (DOE/RL-96-61).

The 300 Area uranium plume in groundwater has persisted longer than expected, with concentrations that vary seasonally in response to Columbia River conditions.

300 Area. The uranium plume in 300 Area groundwater is described in detail in several reports released during the past two years (PNNL-17034; PNNL-17793; Yabusaki et al., 2008). Key aspects of the conceptual model for the plume include persistence beyond the time predicted by the earlier remedial investigation (i.e., DOE/RL-94-85, *Remedial Investigation/Feasibility Study Report for the 300-FF-5 Operable Unit*), distinct seasonal variability associated with the elevation of the water table, and incomplete information to identify the source that continues to supply uranium to the plume. Residual amounts of contaminant uranium are known to remain in the vadose zone, the zone through which the water table fluctuates, and the upper portion of the unconfined aquifer (PNNL-17793). For characterization purposes, the uranium plume in the 300 Area is defined by concentrations exceeding 10 µg/L, with natural background concentrations for uranium in the hydrologic unit containing uranium contamination falling in an estimated range of 3 to 8 µg/L,

based on data from wells where groundwater was unlikely to have been influenced by waste disposal.

Figures 2.12-5 and 2.12-6 show the groundwater plume at the 300 Area during December 2007 and June 2008, respectively. December 2007 represents typical long-term average conditions for the 300 Area, while June 2008 represents shorter-term conditions during the period of the seasonal high water table. The seasonal high water table started in mid-May 2008 and continued into mid-July, which is a fairly typical seasonal pattern. Figure 2.12-7 shows a hydrograph for the river at the 300 Area, along with an indication of groundwater sample collection dates. Most of the summer season samples were collected as the high water table started returning to its long-term average elevation.

The uranium plume beneath the 300 Area covers an area between 0.4 and 0.5 km^2 at concentrations exceeding the drinking water standard. Estimates for the mass of uranium in the plume have ranged from 41 to 83 kg for the period 2002 to 2008.

Table 2.12-1 summarizes parameters used to describe the uranium plume and its changes in recent years. The area where uranium-contaminated groundwater exceeds the drinking water standard (30 µg/L) is estimated at 0.4 to 0.5 km^2. The areal extent appears consistent from year to year, although concentrations within the plume show significant variability with the different seasons. Estimates for the mass of dissolved uranium in this area of the plume since June 2002 suggest values ranging from 41 to 83 kg.

Figure 2.12-8 illustrates concentration trends since 2002 within the plume for (a) two wells located near former liquid waste disposal sites and inland from the Columbia River, and (b) two wells located downgradient from waste sites and near the Columbia River. 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 shown in Figure 2.12-8). The higher concentrations may be caused by remobilizing uranium that is sequestered in the lower portion of the vadose zone (PNNL-17034; PNNL-17793). This is most pronounced in the vicinity of former liquid waste disposal sites, such as the 300 Area Process Trenches and 307 Process Trenches.

At locations near the Columbia River, uranium concentrations observed in samples from wells are reduced because of the intrusion of river water into the aquifer. Intrusion is especially pronounced during high river stage conditions, and may be manifested as layering of river water over groundwater and/or mixing with groundwater; either or both processes may cause a reduction in uranium concentrations as measured in samples from wells. A reduction in concentrations also may occur because of changes in geochemical conditions caused by the intrusion of river water, which could promote adsorption of dissolved uranium onto sediment near the river. The lower bicarbonate content of river water compared to groundwater enhances the tendency for adsorption, although the significance of this process has not yet been quantified (PNNL-17031; PNNL-17034; Yabusaki et al., 2008).

Contaminant concentrations in groundwater at inland locations near former waste disposal sites typically increase when the water table is elevated. At near-river locations, they decrease.

A recent change in the uranium distribution pattern is occurring in the area immediately downgradient from the former 618-7 Burial Ground, where remediation activities have been underway since December 2007. Higher than expected uranium concentrations were observed at well 399-8-5A in January 2008 and have remained elevated, with a maximum concentration of 225 µg/L observed during September 2008 (Figure 2.12-9).

The uranium plume maps (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, well 399-1-8, and recently installed wells 399-3-21 and 399-3-22). Uranium concentrations in samples from these wells are typically near background levels, suggesting little or no downward migration of contaminant uranium beyond the extent of saturated Hanford formation sediment. Uranium has not been detected in a finer-grained interval within Ringold Formation Unit E sediment, which forms the lower portion of the unconfined aquifer. (Note: Elevated trichloroethene concentrations were observed in March 2006 in that interval; see 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 a limited field investigation in 2006 (PNNL-16435, *Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington*).

Uranium concentrations in groundwater near the 618-7 Burial Ground have increased during FY 2008.

Near the Columbia River, the uranium plume is monitored using aquifer tubes at twelve sites along the 300 Area shoreline. Aquifer tubes were installed at multiple depths at each of these sites in February 2004, with four additional sites being equipped during March 2008. During FY 2008, the tubes were sampled in November 2007 and March 2008. Figure 2.12-10 presents concentrations from the November sampling. It is expected that the highest concentrations of uranium in groundwater beneath the shoreline should appear during the fall months, following addition of uranium to the plume during the summer high water table conditions. Information derived from monitoring at tube sites generally is consistent with information based on sampling near-river wells in December 2007. However, several causes could explain differences between concentrations measured in tube samples and well samples. First, vertical variability in contaminant concentrations likely will produce different results in samples collected from screened intervals of various lengths (e.g., 0.15 m for tubes; 3 to 6 m for wells). Second, because of their longer screens, wells may be more influenced than tubes by the intrusion of river water into the aquifer, diluting the contaminated groundwater. 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. An analysis of the proportion of river water in samples from aquifer tubes suggested that for most tubes, the samples represented approximately 60% groundwater and 40% river water (PNNL-17034, pp. 3.12 to 3.15).

Uranium contamination appears to be contained within the upper portion of the unconfined aquifer, in the saturated portion of the Hanford gravel.

The cross section shown in Figure 2.12-10 is oriented north-south along the 300 Area shoreline. The screens of near-river monitoring wells have been projected onto this cross section to provide perspective on the representativeness of samples collected from the various types of sampling facilities, with uranium concentrations in wells that represent the December 2007 sampling event (Figure 2.12-5). 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.

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 southeastern portion of the 618-10 Burial Ground and the former 316-4 Cribs. All wells in this 300-FF-5 Operable Unit subregion monitor the upper portion of the unconfined aquifer. Well 699-S6-E4A (located within the excavation footprint for the former cribs) has revealed the highest concentrations in the past, but has shown a steady decline during recent years, with the fall 2007 and summer 2008 results remaining below the 30 µg/L drinking water standard (Figure 2.12-11). The cause for the earlier variability in uranium concentrations at this well likely is related to excavation and backfilling activities. Variability associated with a fluctuating water table does not occur in this subregion, as water table elevation remains fairly constant. Well 699-S6-E4L (located adjacent to the southeastern portion of the burial ground) also showed elevated uranium concentrations during excavation activities; however, 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

Volatile organic compounds that are contaminants of concern or potential concern in groundwater beneath the 300-FF-5 Operable Unit include trichloroethene and tetrachloroethene, which were used in substantial quantities during the fuels fabrication process (BHI-00012; EMO-1026; WHC-MR-0388). Carbon tetrachloride also was used in small quantities for testing fuel element integrity. Cis-1,2-dichloroethene is present in the aquifer beneath the 300 Area, apparently as a degradation product of trichloroethene and tetrachloroethene. The origins of these volatile organic compounds in groundwater include past disposal to 300 Area facilities and movement into the 300 Area from offsite sources to the southwest. At the outlying subregions of the 300-FF-5 Operable Unit, organic compounds associated with fuels fabrication waste include the semivolatile tributyl phosphate in the vicinity of the former 316-4 Cribs.

300 Area. During FY 2008, trichloroethene and tetrachloroethene, along with the degradation product cis-1,2-dichloroethene, continued to be detected in 300 Area groundwater. In the upper portion of the unconfined aquifer (i.e., near the water table), concentrations of these compounds are lower than their respective drinking water standards. In the lower portion of the unconfined aquifer, cis-1,2-dichloroethene concentrations continue to exceed the 70 µg/L drinking water standard at well 399-1-16B.

Drilling has revealed additional contamination in the unconfined aquifer. High concentrations of trichloroethene are present in a finer-grained interval with Ringold Formation sediment, which transmits groundwater very slowly.

Additional investigation of volatile organic compounds beneath the 300 Area were undertaken during FY 2008, prompted by an earlier discovery of contamination during a limited field investigation for uranium (PNNL-16435). Contamination was discovered in groundwater associated with a relatively finer-grained interval within Ringold Unit E sediment. The primary contaminant is trichloroethene and the maximum concentration encountered during drilling was 630 µg/L. The contamination appears to be limited to the area immediately east of the 307 Process Trenches and former South Process Ponds. The finer-grained interval of sediment is not intercepted by existing well screens, and current knowledge of conditions in the interval is based on samples collected during drilling. The finer-grained interval has

a very low yield and groundwater moves very slowly through this hydrologic unit; however, the unit is incised by the river channel. PNNL-17666, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington* describes the results of the additional investigation, along with a review of historical operations and potential source locations for volatile organic compounds. While a full explanation for the source and method of emplacement in the finer-grained interval is not yet available, no evidence to date as been uncovered suggesting the presence today of a dense, nonaqueous phase liquid contaminant.

Trichloroethene has been detected in the upper portion of the unconfined aquifer at numerous wells within the 300 Area, but typically at concentrations much lower than the 5 µg/L drinking water standard. During FY 2008, the method detection limit was raised from 0.2 to 1.0 µg/L. Where previous years' reports have described detections, albeit at less than 1.0 µg/L, many results for FY 2008 show as undetected because of the change in detection limit. The highest concentration observed during FY 2008 in the upper portion of the unconfined aquifer was 4.2 µg/L at well 399-2-2, which is located downgradient from the former 300 Area Process Trenches and North Process Pond, each of which were likely disposal sites for volatile organic compounds. At aquifer tube sites along the rivershore, trichloroethene was generally undetected in tubes that monitor Hanford gravels sediment.

Volatile organic compounds have been present in the upper portion of the 300 Area aquifer at levels below the drinking water standard for many years. Sources include local waste disposal of fuels fabrication waste effluents operations and migration into the 300 Area from sources to the southwest.

Trichloroethene is occasionally detected at wells screened in the lower portion of the unconfined aquifer (i.e., wells 399-1-8 and 399-1-16B), but at levels below the drinking water standard in recent years. It also was detected at relatively high concentrations in an aquifer tube that monitors the finer-grained interval within Ringold Formation sediment. The maximum concentration observed during FY 2008 in that interval was 542 µg/L in samples from tube AT-3-3-D (PNNL-17666).

Tetrachloroethene results for FY 2008 are qualified as undetected, indicating concentrations less than 1.0 µg/L (the drinking water standard is 5 µg/L). Historically, tetrachloroethene has been observed occasionally at higher concentrations near and downgradient of the southern end of the former 300 Area Process Trenches and North Process Pond, which are known source waste sites.

Cis-1,2-dichloroethene concentrations at well 399-1-16B remain above the 70 µg/L drinking water standard, with a maximum concentration of 190 µg/L during FY 2008 (Figure 2.12-12). The well is located along the downgradient flow path from the former 300 Area Process Trenches and North Process Pond, and is screened in the lower portion of the unconfined aquifer. The origin for cis-1,2-dichloroethene is likely from decomposition of trichloroethene and tetrachloroethene disposed to the former 300 Area Process Trenches and North Process Pond (PNNL-17666). An additional degradation product under certain environmental conditions, vinyl chloride, has not been detected in 300 Area groundwater.

Although carbon tetrachloride was used in relatively small quantities during the fuels manufacturing process (WHC-MR-0388), that compound has not been identified as a contaminant of potential concern in groundwater. Carbon tetrachloride is occasionally detected, but at levels below the 5 µg/L drinking water standard and typically at concentrations of less than 1 µg/L.

Outlying 300-FF-5 Subregions. Tributyl phosphate has been detected in the past in groundwater beneath the former 316-4 Cribs. The cribs received liquid waste associated with research conducted at the 321 Separations Laboratory in the 300 Area from 1948 to 1954 (BHI-00012). The waste included tributyl phosphate and uranium. Tributyl phosphate concentrations were elevated slightly in early 2004,

along with uranium, when crib removal actions were occurring. During FY 2008, the concentration at well 699-S6-E4A, located within the footprint of the 316-4 Cribs excavation, was 5.6 µg/L, which is consistent with the recent historical trend at the well. The compound was undetected at nearby wells 699-S6-E4K and 699-S6-E4L during FY 2008. Tributyl phosphate 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.

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 originating in the 200 East Area (200-PO-1 Operable Unit) and extending beneath all subregions of the 300-FF-5 Operable Unit. Concentrations attributed to the site-wide plume as it reaches the 300-FF-5 Operable Unit subregions are generally less than 20,000 pCi/L, depending on location (Figure 2.11-3). The second source is the 618-11 Burial Ground, located just west of the Energy Northwest complex.

A groundwater plume containing tritium is present near the 618-11 Burial Ground. The source is presumed to be an unplanned release of tritium associated with irradiated material in the burial ground.

Tritium at 618-11 Burial Ground. High concentrations of tritium were detected in early 1999 at well 699-13-3A, which is located at the eastern fence line of the 618-11 Burial Ground. Subsequent investigations (PNNL-13675, *Measurement of Helium-3/Helium-4 Ratios in Soil Gas at the 618-11 Burial Ground*) 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 2.12-13). Concentrations near the presumed burial ground source have declined since peak values in 1999 and 2000, with the FY 2008 concentrations at well 699-13-3A ranging between 610,000 and 818,000 pCi/L (Figure 2.12-14). The trend at well 699-13-3A indicates a possible episodic event of unknown nature that caused a release of tritium from buried materials and/or mobilization of tritium in the vadose zone. 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) (PNNL-15293, *Evaluation of the Fate and Transport of Tritium Contaminated Groundwater from the 618-11 Burial Ground*).

2.12.1.4 Nitrate

300 Area. Nitrate concentrations in groundwater beneath the 300 Area are lower than the 45 mg/L drinking water standard, except for the southern portion of the 300 Area (Figure 2.11-7). 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. For example, the concentration at well 699-S28-E12, located near the southwestern corner of the 300 Area boundary, was 159 mg/L during FY 2008. 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 site-wide plume that originates in the 200 East Area, but at concentrations lower than the drinking water standard.

The drinking water standard for nitrate is exceeded in groundwater migrating into the southern portion of the 300 Area from sources to the southwest.

During the earlier operational period, nitrate contributions to 300 Area groundwater came from disposal of fuels fabrication effluent and sanitary sewer systems. Throughout the 1970s and 1980s, nitrate concentrations in groundwater were somewhat higher than today, but still have not greatly exceeded the drinking water

standard. Remedial investigation monitoring results indicate a relatively constant level of contamination, but with some variability in concentrations between 1992 and 2004 (PNNL-15127).

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 2.11-7). For example, values during FY 2008 at well 699-13-3A ranged from 83 to 98 mg/L and at well 699-12-2C ranged from 41 to 52 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, *Evaluation of Elevated Tritium Levels in Groundwater Downgradient from the 618-11 Burial Ground Phase I Investigations*). Trends for the last several years indicate relatively constant nitrate levels, but with some variability. At the 618-10 Burial Ground, nitrate concentrations generally are consistent with values expected for the leading edge of the site-wide plume and are lower than the drinking water standard. The maximum concentration observed during FY 2008 was at well 699-S6-E4L (42 mg/L). The cause of the elevated concentration has not yet been identified.

Radiological contamination indicators such as gross alpha and gross beta are used to monitor groundwater near former waste disposal facilities and during source remedial actions.

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 technetium-99. Chromium was added to the list for FY 2008 because of a new occurrence near a remedial action site.

300 Area. Radiological contamination in the 300 Area, other than uranium, is generally at low levels. Gross alpha, which is associated with uranium, is elevated at numerous 300 Area wells. Gross beta, a second radiological criteria for drinking water, exceeded the 50 pCi/L standard at four 300 Area wells during FY 2008 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 and natural uranium).

Chromium concentrations in groundwater near the 618-7 Burial Ground have increased during FY 2008, along with other contamination indicators.

Changes in chemical contaminants in groundwater include the appearance of chromium at well 399-8-5A, which is adjacent to the 618-7 Burial Ground on its eastern side. Concentrations measured as total chromium in filtered and unfiltered samples were higher in March 2008 than the background level of ~8 µg/L and reached ~90 µg/L in September 2008; the trend is concurrent with increasing uranium concentrations (Figure 2.12-9). Other constituents that show a recent increase include calcium, chloride, gross alpha, gross beta, nitrate, and sodium. Remediation activities were underway during FY 2008 at this burial ground and the changes in groundwater conditions may be related to those activities.

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, and the chemical contaminant nitrate (Section 2.11). While detectable, the concentrations for contaminants associated with site-wide plume sources at the two subregions are typically below drinking water standards.

At the 618-11 Burial Ground, technetium-99 is elevated at several hundred pCi/L, well below the 900 pCi/L drinking water standard but higher than expected. Technetium-99 may be the likely cause for gross beta concentrations that exceeded the 50 pCi/L drinking water standard during FY 2008 at wells 699-12-2C and 699-13-2D, although recent changes in laboratory calibration for gross beta also may be a factor. The concentration trends for technetium-99 and tritium at well 699-13-3A, which is adjacent to the burial ground, are similar, indicating that small amounts of technetium-99 may have been associated with the release that created the local tritium plume in 1999.

At the 618-10 Burial Ground, gross alpha measurements have exceeded the drinking water standard at two wells in the past, presumably as the result of uranium contamination. During FY 2008, neither gross alpha nor gross beta exceeded their respective regulatory standards in groundwater.

2.12.2 Operable Unit Activities

R. E. Peterson

This section summarizes interim remedial actions for the 300-FF-5 Operable Unit and provides the status of CERCLA five-year review action items.

Interim remedial action under CERCLA initially targeted groundwater beneath waste sites in the 300 Area portion of the 300-FF-5 Operable Unit (EPA/ROD/R10-96/143, *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units*). The geographic extent of the operable unit was subsequently expanded in June 2000 to include groundwater potentially impacted by waste sites in two outlying areas north of the 300 Area (EPA/ESD/R10-00/524, *EPA Superfund Explanation of Significant Differences: Hanford 300-Area (USDOE)*). The outlying areas contain the 618-11 Burial Ground, the 618-10 Burial Ground, and the 316-4 Cribs waste sites. The interim remedy, as stated in EPA/ROD/R10-96/143, is as follows:

- 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.

The remedial action objectives for interim action involving groundwater are as follows.

- ***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.***

In FY 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 for uranium and a draft proposed plan. A work plan was prepared (DOE/RL-2005-41, *Work Plan for Phase III Feasibility Study 300-FF-5 Operable Unit*) that describes these additional efforts, including updated computer simulations of groundwater flow and uranium transport, a limited field investigation of uranium 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. Many of these additional activities essentially were completed during FY 2008. Continuing work includes interim action monitoring and characterization activities, and systematic planning that will lead to a new work plan for additional remedial investigation and feasibility study activities. These activities are intended to develop information that will lead to a proposed plan for final remediation efforts.

Five-year reviews of the record of decision for the 300-FF-5 Operable Unit reaffirmed the cleanup goals and remedy selection, but call for additional investigation of potential remedial actions for uranium.

2.12.2.1 Five-Year Review Action Items

The second five-year review of the CERCLA record of decision was published in November 2006 (DOE/RL-2006-20). The review identified one issue and one action pertaining to the 300-FF-5 Operable Unit.

- **Issue 19**. Predicted attenuation of uranium contaminant concentrations in the groundwater under the 300 Area has not occurred. The 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 (September 2008).

2.12.2.2 Interim Remedial Action Monitoring

Implementation of the interim remedy specified in the record of decision (EPA/ROD/R10-96/143) is described in the operable unit operations and maintenance plan (DOE/RL-95-73; revised May 2002) and a sampling and analysis plan (DOE/RL-2002-11, *300-FF-5 Operable Unit Sampling and Analysis Plan*; under revision during FY 2008). As described in the operations and maintenance plan, the following are the 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 in PNNL-15127. Continued monitoring has produced information generally consistent with historical trends, expectations, and existing conceptual models. The new data have been reported in the annual Hanford Site groundwater monitoring reports, and for uranium, in updated descriptions of the features and

processes associated with uranium contamination in the subsurface at the 300 Area (PNNL-17034; PNNL-17793; Yabusaki et al., 2008).

For the 300 Area subregion, 46 monitoring wells were in service during FY 2008 as part of the groundwater monitoring effort, including 3 new wells. In addition, samples were collected at twelve aquifer tube sites and three riverbank springs along the shoreline. Groundwater monitoring included semiannual sampling at many of the monitoring wells during December 2007 and June 2008. The samples helped characterize typical conditions experienced during most of the year (December) and the seasonal high water-table conditions (June), the latter typically revealing the maximum uranium concentrations in groundwater. 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 newly installed wells, were sampled quarterly to provide greater resolution of seasonal changes and to establish baseline conditions at their locations, respectively. Four wells were sampled monthly, to monitor the changes induced by the fluctuating water table and seasonal river stage conditions. Appendix A lists the planned schedule for FY 2008 and comments on actual implementation. Well 399-1-7 was sampled only once because it was in use to supply water for a treatability test. One quarterly sample from well 399-1-23 was not collected, pending electrical repair of the pump. Well 399-2-5 was added to the network in FY 2008 and was sampled three times. One quarterly sample was missed in well 399-3-11 because of access limitations, and the fourth quarterly sampling event was delayed until early FY 2009. Two quarterly samples were missed in wells 399-3-19 and 399-3-20 because of electrical problems. Four aquifer tubes that should be sampled semiannually under the sampling and analysis plan were only sampled once, because of a scheduling error. Some of the supporting constituents required under the sampling and analysis plan were not scheduled for analysis in FY 2009. A revised plan will be implemented in FY 2009.

Groundwater monitoring during the period of interim remedial action has produced new information that will support future remediation decisions.

For 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. Two wells were sampled only once because of electrical problems with the pumps. 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. A quarterly sample was missed in well 699-S6-E4L because of a scheduling conflict. A quarterly sample was missed in well 699-S6-E4A because of an electrical problem with the pump. The fourth quarter's samples from wells 699-S6-E4A and 699-S6-E4E were delayed until FY 2009. All of the wells used at these two subregions monitor the upper part of the unconfined aquifer.

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) focused on uranium contamination in the 300 Area subregion of the operable unit. Uranium has persisted at elevated levels far longer than predicted by the initial remedial investigation (DOE/RL-94-85). Additional evaluation of potential remedial action technologies was initiated (i.e., evaluation beyond the information presented in the initial feasibility study report (DOE/RL-93-22, *Phase I and II Feasibility Study Report for the 300-FF-5 Operable Unit*). The objective for the Phase III Feasibility Study as originally defined was to re-evaluate the remedy for the uranium plume. DOE/RL-2005-41 (p. 7) provides the following ultimate goal

for remedial action, "…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."

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
- An updated assessment of ecological and human health risks posed by contaminants in the 300-FF-5 Operable Unit groundwater.

Several reports were released during FY 2008 regarding uranium contamination in the 300 Area, including updates to the conceptual model and a remediation strategy for reducing concentrations in groundwater.

Evaluation of Remedial Action Alternatives for 300 Area Uranium. DOE/RL-2008-36, *Remediation Strategy for Uranium in Groundwater at the 300 Area 300-FF-5 Operable Unit*, describes a remediation strategy for uranium in groundwater beneath the 300 Area. This report expands on PNNL-16761, *Evaluation and Screening of Remedial Technologies for Uranium at the 300-FF-5 Operable Unit, Hanford Site, Washington*, which described the screening of potential remedial action technologies to achieve the remedial action goals. 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 the distribution of uranium in the vadose zone and aquifer, and 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, *300-FF-5 Operable Unit Limited Field Investigation Plan*).

Further study of potential remedies for uranium contamination in the 300 Area included technology screening, additional hydrogeologic characterization, computer simulation of groundwater flow and transport, and updates to the conceptual model.

The drilling and analytical results, along with initial interpretations, are available in a limited field investigation report (PNNL-16435). The limited field investigation provided new information on uranium contamination in the subsurface at the 300 Area, along with the unexpected discovery of volatile organic compounds in a finer-grained interval of Ringold Formation sediment in the unconfined aquifer. Results at each of the four types of characterization locations chosen for drilling did not reveal evidence for relatively high levels of contaminant uranium in the vadose zone, nor for a zone of significantly elevated inventories of contaminants near the water table. Also, water samples collected from the saturated zone at various depths in the four boreholes revealed uranium concentrations that 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 software for their hydrostratigraphic framework, which has been updated using the results from the limited field investigation and a subsequent investigation of volatile organic compounds. These models use the computer code

Subsurface Transport Over Multiple Phases for simulating flow and transport in the vadose zone and aquifer (PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases*). 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 caused by fluctuations in Columbia River flows. The status and results of all groundwater simulation activities to date are described in a report prepared during FY 2008 (PNNL-17708).

An updated description of the conceptual model for uranium contamination in the subsurface at the 300 Area is presented in PNNL-17034. Refinements to the conceptual model include a detailed description of current conditions based on the monitoring program, updates to the hydrogeologic framework as a result of the limited field investigation (PNNL-16435), development of the three-dimensional computer simulations of groundwater flow, and a detailed discussion of (a) potential uranium inventories in subsurface compartments and (b) the geochemical controls on uranium mobility. The focus for refining the conceptual model was on 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 and a subsequent report on uranium associated with sediment (PNNL-17793) supports the technical basis for selecting a remediation alternative and evaluating potential remedial action technologies. Key elements of the conceptual model are as follows.

Computer simulations of groundwater flow and uranium transport have been developed to support the remedial investigation and various research projects being conducted in the 300 Area.

- 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 remains a candidate repository for 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.

The conceptual model for uranium is likely to evolve as new information from research activities on uranium transport becomes available (Section 2.12.2.5).

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, *Phase I Remedial Investigation Report for the 300-FF-5 Operable Unit*) was performed during FY 2006 and a report describing the results of the assessment published in FY 2007 (PNNL-16454, *Current Conditions Risk Assessment for the 300-FF-5 Groundwater Operable Unit*). The three operable unit subregions (i.e., 300 Area, 618-11 Subregion, and 618-10/316-4 Subregion) were considered in the assessment, along with the city of Richland. The results of this update are consistent with the earlier findings, and with the initial results for the 100/300 Area River Corridor Baseline Risk Assessment (DOE/RL-2007-21). No changes to the list of contaminants of potential concern for the 300-FF-5 Operable Unit, as defined in earlier reports (Section 2.12.1) were indicated by this risk assessment.

2.12.2.4 Uranium Treatability Test, 300 Area

A field treatability test involving the injection of polyphosphate into the aquifer was conducted during FY 2008 to investigate the viability of this technology to reduce uranium concentrations in groundwater.

A treatability test to immobilize uranium in the aquifer beneath the 300 Area was conducted during FY 2006 and FY 2007 (PNNL-16008, *Site Characterization Plan: Uranium Stabilization Through Polyphosphate Injection*), with subsequent monitoring of the test's effects continuing during FY 2008. The effort is being conducted under DOE's Office of Environmental Management as an applied research activity. The test initially involved determining the groundwater flow characteristics in the vicinity of the test site and included 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 is near the south end of the former 300 Area Process Trenches, where uranium concentrations are typically higher following the seasonally raised water table. Monitoring during FY 2008 has revealed that the method has not performed as well as hoped in permanently sequestering uranium on aquifer solids, thus reducing the amount and concentration of uranium dissolved in groundwater (PNNL-17480, *Challenges Associated with Apatite Remediation of Uranium in the 300 Area Aquifer*). The heterogeneity in aquifer sediment and the dynamic nature of hydrologic conditions present significant challenges to implementing the polyphosphate technology and other potential in situ remedies. Additional laboratory testing of polyphosphate technology continued during FY 2008, and field-scale tests involving vadose zone applications will be conducted during FY 2009.

2.12.2.5 Research Activities Involving the 300 Area Uranium Contamination

Numerous research activities have been underway at the 300 Area during the past several years, with many focused on uranium contamination in the subsurface. DOE-supported projects include direct support to environmental restoration activities and basic research involving uranium in the environment.

The DOE is supporting a variety of applied research activities in the 300 Area, including investigating the geochemistry and mobility of uranium, the interaction between the aquifer and river, and various methods to remediate uranium contamination.

The Hanford Site Remediation and Closure Science Project. This project has supported the 300-FF-5 Operable Unit 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 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, *Flow and Transport in the Hanford 300 Area Vadose Zone-Aquifer-River System*, with a more comprehensive description of groundwater flow and uranium transport described in Yabusaki et al., 2008. The research focuses on developing the capability for long-term predictions of uranium migration and fate.

Field research that has focused on the hyporheic zone along the 300 Area shoreline was concluded during FY 2008. A comprehensive report describes the results of work conducted between FY 2004 and FY 2007 (PNNL-16805, *Investigation of the Hyporheic Zone at the 300 Area, Hanford Site*). That report includes descriptions of numerous methods to monitor the interface between groundwater and river water, and to help define stratigraphic contacts. 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; PNNL-17034). A final report on results associated with this field research was published during FY 2008 (PNNL-17836, *Methods for Assessing the Relative*

Amounts of Groundwater Discharge into the Columbia River and Measurement of Columbia River Gradient at the Hanford Site's 300 Area).

Integrated Field-Scale Research Challenge. This DOE Office of Science research project has focused on the geochemistry and mobility characteristics of uranium in the vadose zone at the 300 Area during FY 2008 (PNNL-17067, *300 Area Integrated Field-Scale Subsurface Research Challenge (IFRC) Field Site Management Plan*). Initial field activities include drilling 35 characterization boreholes at a location centered on the southwest corner of the former South Process Pond (Figure 2.12-3). This location is where discharge from the process sewer system initially entered the pond during the period of fuel fabrication activities. The location offers relatively good potential of encountering residual contaminant uranium in the vadose zone. Geophysical investigations associated with this project also continued during FY 2008. Electrical resistivity and self-potential measurements are being used to estimate spatially distributed hydrologic and geochemical properties of the sediment. In time-lapse mode, the data will be used to help describe recharge of the unconfined aquifer and the interaction between river and groundwater. Additional work was started in FY 2008 to identify areas of groundwater discharge through the riverbed adjacent to the 300 Area. One of the methods involves measuring temperature variations along kilometer-long fiber optics cables laid parallel to the shoreline.

2.12.3 Facility Monitoring: RCRA Compliance at 300 Area Process Trenches

M. J. Hartman

The former 300 Area Process Trenches received effluent discharges of mixed waste from fuel fabrication and nuclear research laboratories in the 300 Area from 1975 through 1985, followed by continued discharge of clean effluent until 1994. The trenches were remediated in 1991 under a CERCLA expedited response action by scraping contaminated soil to the north end of the facility, and additional remedial actions were undertaken in 1997 and 1998.

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 of 1954* 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), and the Hanford Facility RCRA Permit, Part VI, Chapter 1 (WA7890008967). The modified closure plan (DOE/RL-93-73, *300 Area Process Trenches Modified Closure Postclosure Plan*), which is incorporated into the Hanford Facility RCRA Permit, states that groundwater remediation is deferred to the CERCLA 300-FF-5 Operable Unit. Groundwater flows generally toward the south-southeast beneath the 300 Area Process Trenches. The estimated flow rate in March 2008 varied from 0.18 to 18 m/d (Appendix B).

Groundwater near the former 300 Area Process Trenches continues to be monitored under a RCRA corrective action program.

During FY 2008, RCRA groundwater monitoring for this disposal unit was conducted under a plan that has been in effect since 1997 (WHC-SD-EN-AP-185). Waste indicator constituents monitored are uranium (total, unfiltered samples), cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. 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 sampling during 8 months of the year (December, January, February, and March; June, July, August, and September). In FY 2008, this sampling was accomplished as planned (Appendix B), and reports on the effectiveness of the corrective action monitoring program were prepared semiannually per WAC 173-303-645(11)(g) (SGW-38473; SGW-39299). 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). The most distant downgradient location is approximately 200 m to the southeast, along the dominant groundwater flow path from 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 cis-1,2-dichloroethene and uranium continued to exceed their respective drinking water standards during FY 2008. 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 2.12-12). Concentrations of trichloroethene and tetrachloroethene were all below the 1 µg/L detection limit during FY 2008.

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. Concentrations at wells 399-1-10A and 399-1-16A, near the Columbia River, dropped below the drinking water standard in early July when the river stage was high, a consequence of dilution by the intrusion of river water into the aquifer. The concentration increased during the same period in well 399-1-17A (Figure 2.12-8). This well is located near the waste site, where contamination apparently remains in the lower portion of the vadose zone, to be mobilized by high water table conditions during the early summer months.

Groundwater monitoring in the 300-FF-5 groundwater interest area includes the following.

CERCLA Monitoring (Appendix A)

- ***Forty-six wells are scheduled for quarterly to annual sampling in the 300 Area. Six wells were sampled less frequently than planned in FY 2008.***
- ***Twelve wells are scheduled for quarterly to semiannual sampling in the northern part of the 300-FF-5 Operable Unit. Three wells were sampled less frequently than planned in FY 2008.***
- ***The DOE installed 35 wells to support research and three wells to investigate trichloroethene distribution.***

Facility Monitoring (Appendix B)

- ***Four pairs of wells are scheduled to be sampled eight times per year at the 300 Area Process Trenches. All were sampled as planned.***

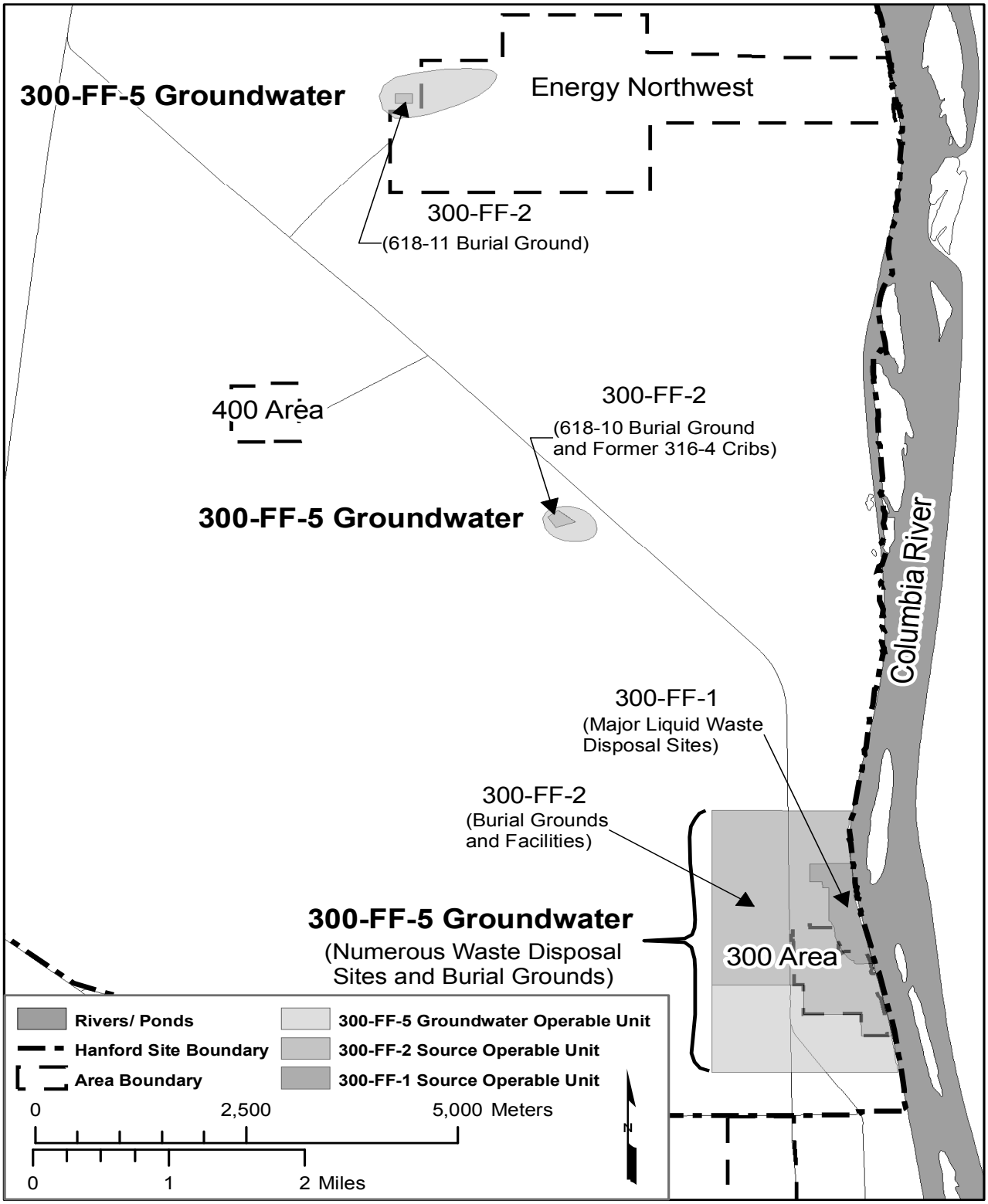
Table 2.12-1. Attributes of 300 Area Uranium Plume in Groundwater.

Time Period Represented	>30 mg/L Portion of Plume:			>10 mg/L Portion of Plume:		
	Area of Plume (km^2)	Volume of Water (m^3)	Mass of Uranium (kg)	Area of Plume (km^2)	Volume of Water (m^3)	Mass of Uranium (kg)
June 2002	0.42	1,060,626	54.4	1.01	2,580,241	84.8
December 2002	0.43	901,216	78.0	0.86	1,794,192	95.8
June 2003	0.42	1,067,334	54.9	0.87	2,211,604	77.8
December 2003	0.32	673,342	40.7	0.87	1,808,715	63.4
June 2004	0.40	1,008,386	60.8	0.85	2,170,544	84.0
December 2004	0.40	836,520	52.3	0.95	1,979,449	75.2
June 2005	0.42	1,061,158	76.2	1.12	2,852,401	112.0
December 2005	0.41	846,596	63.0	0.96	1,988,448	85.9
June 2006	0.40	1,025,135	76.9	1.12	2,850,525	113.4
December 2006	0.48	1,003,316	78.8	0.74	1,536,019	89.4
June 2007	0.50	1,263,458	82.9	0.83	2,119,758	100.1
December 2007	0.41	853,008	55.1	1.03	2,137,160	80.8
June 2008	0.51	1,298,280	62.5	1.25	3,196,142	100.5

Assumptions:
1. Contaminated thickness: 9.8 m (June) and 8.0 m (December).
2. Total porosity of 26%.
3. Mass is estimated using mid-point concentration between map contours.

Table Source: Based on PNNL-17034, Table 3.3, with updates for FY 2008.

Figure 2.12-1. Operable Units Defined for the 300 Area National Priorities List Site.



gwf08_411

Figure 2.12-2. 300-FF-5 Groundwater Interest Area Water-Table Map, March 2008.

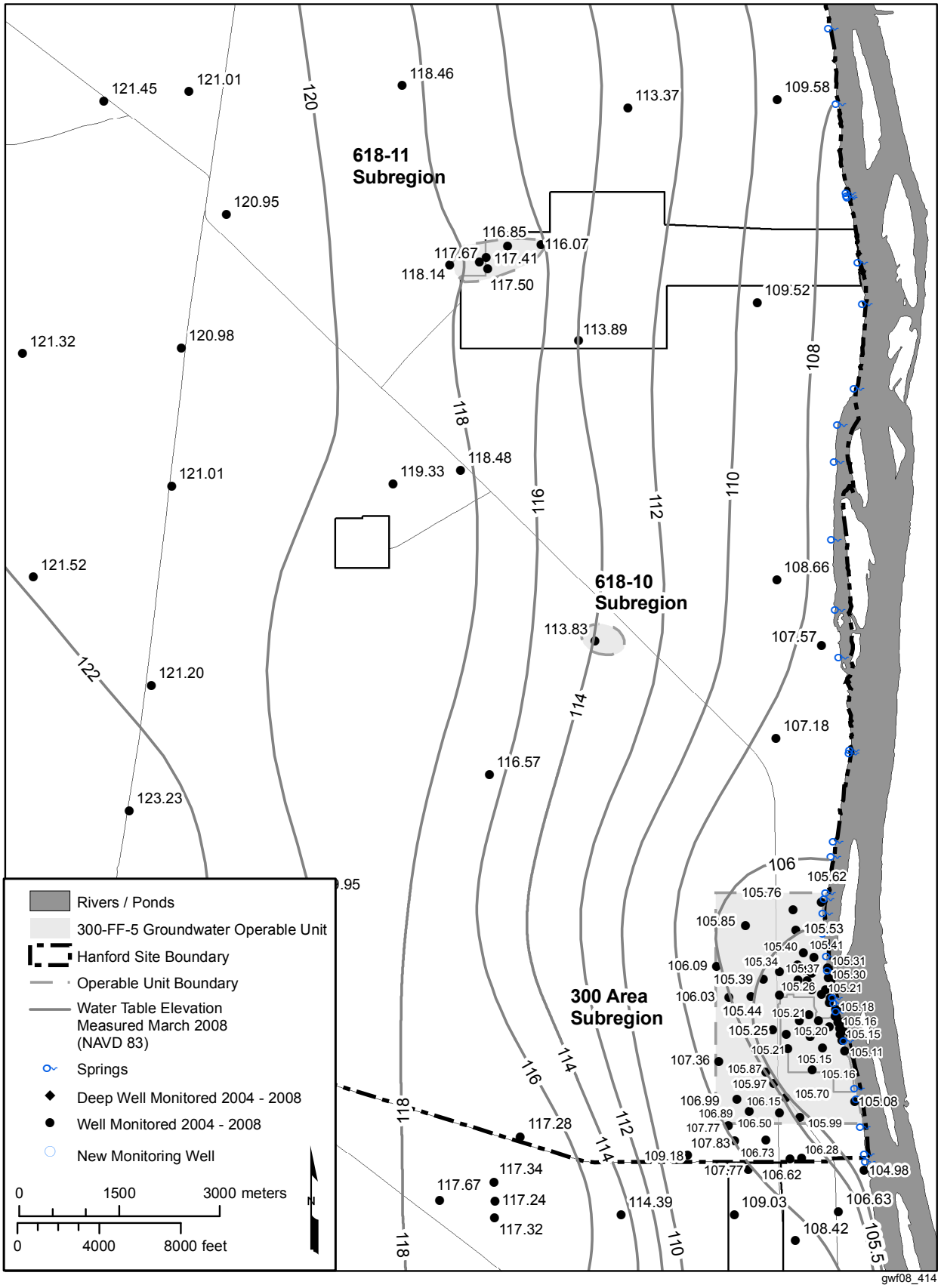


Figure 2.12-3. Facilities and Groundwater Monitoring Wells in the 300 Area.

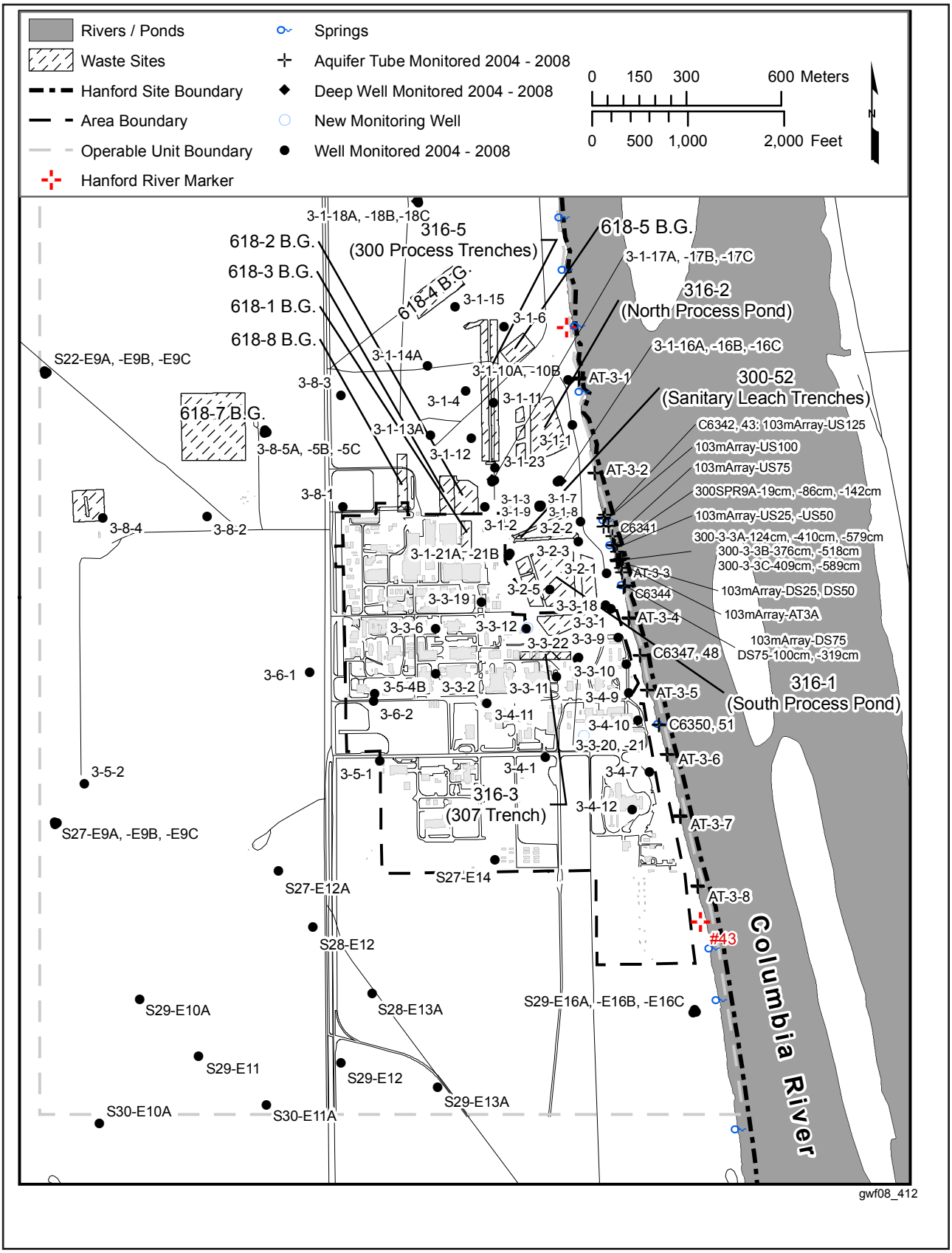
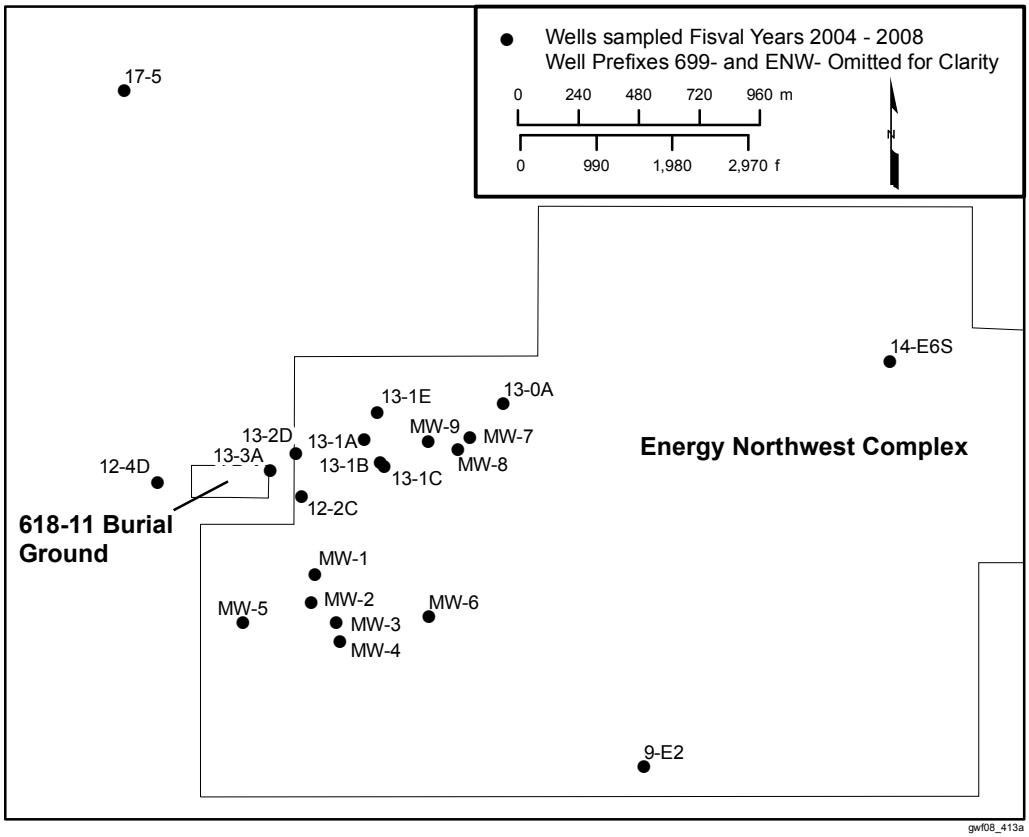


Figure 2.12-4. Groundwater Monitoring Wells in Outlying 300-FF-5 Operable Unit Subregions.



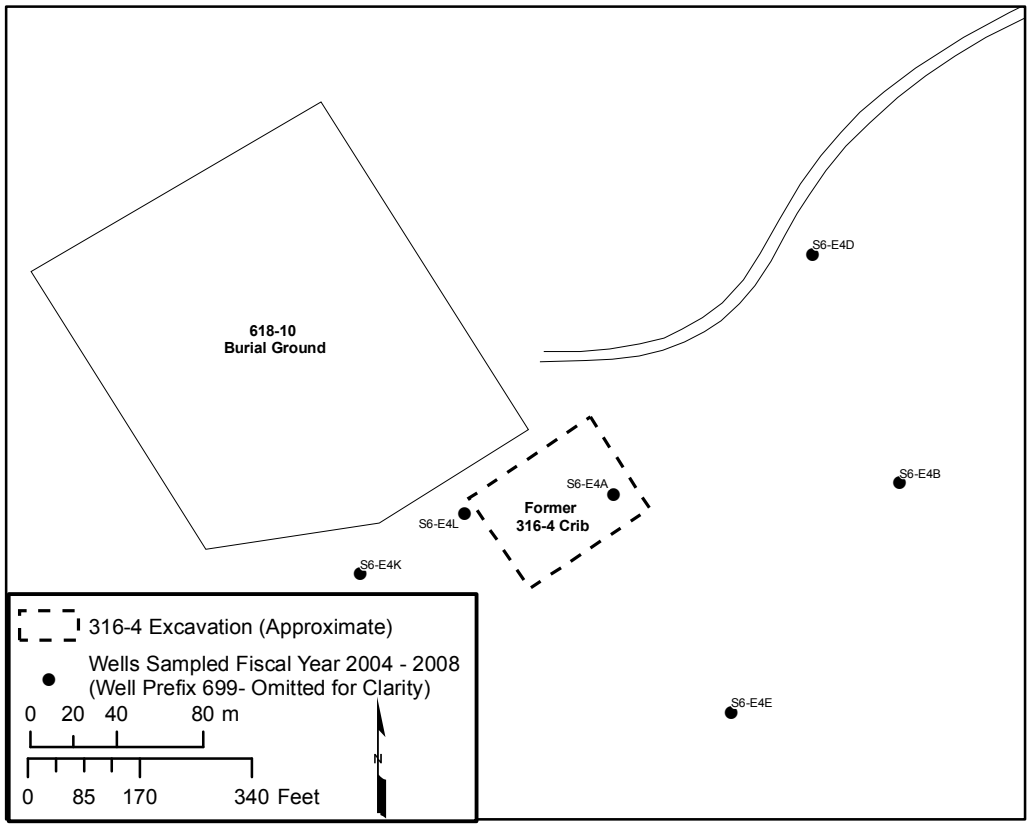


Figure 2.12-5. Uranium Concentrations Beneath the 300 Area, Upper Part of Unconfined Aquifer, December 2007.

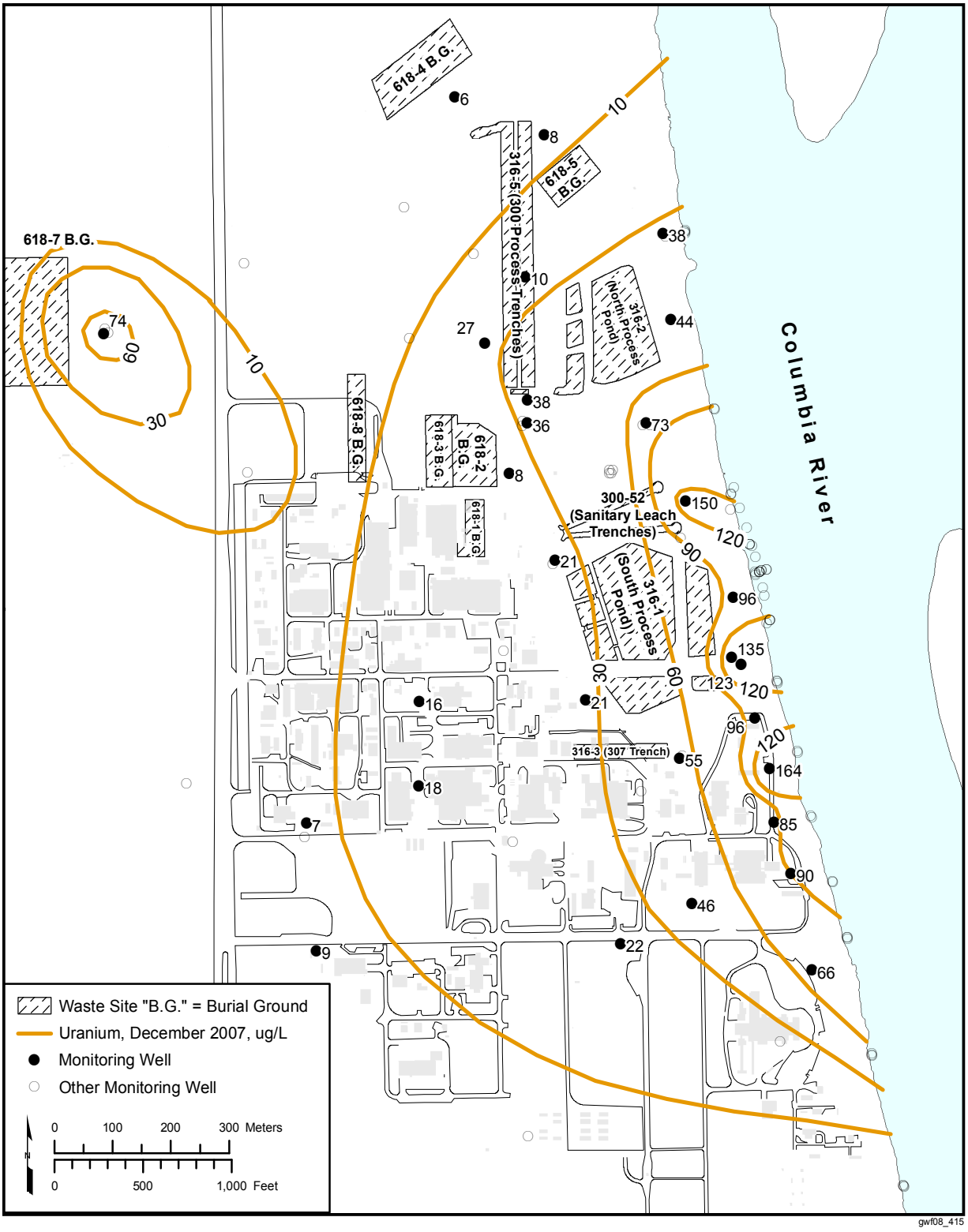


Figure 2.12-6. Uranium Concentrations Beneath the 300 Area, Upper Part of Unconfined Aquifer, June 2008.

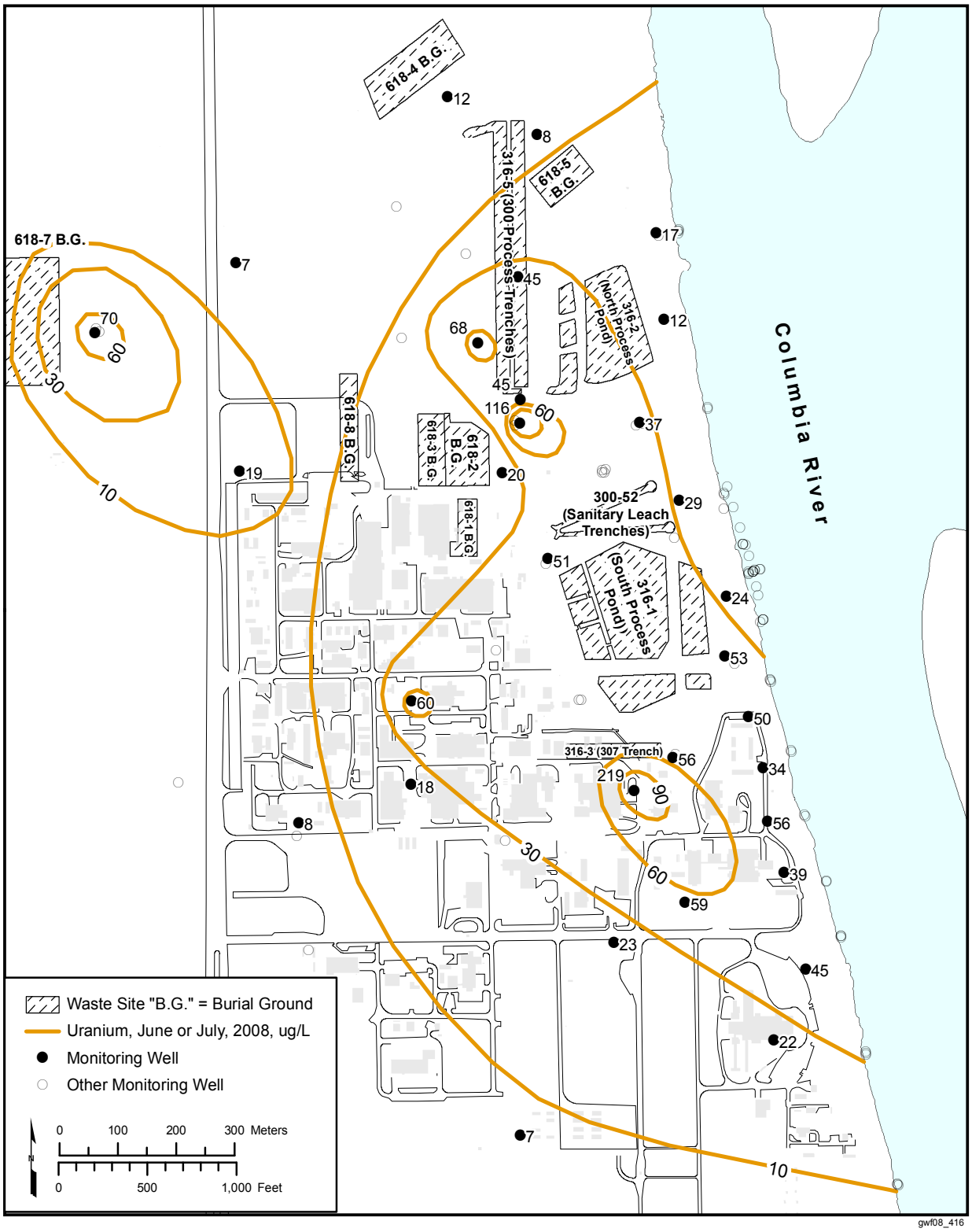


Figure 2.12-7. Columbia River Stage in the 300 Area and Groundwater Sampling Dates, FY 2008.

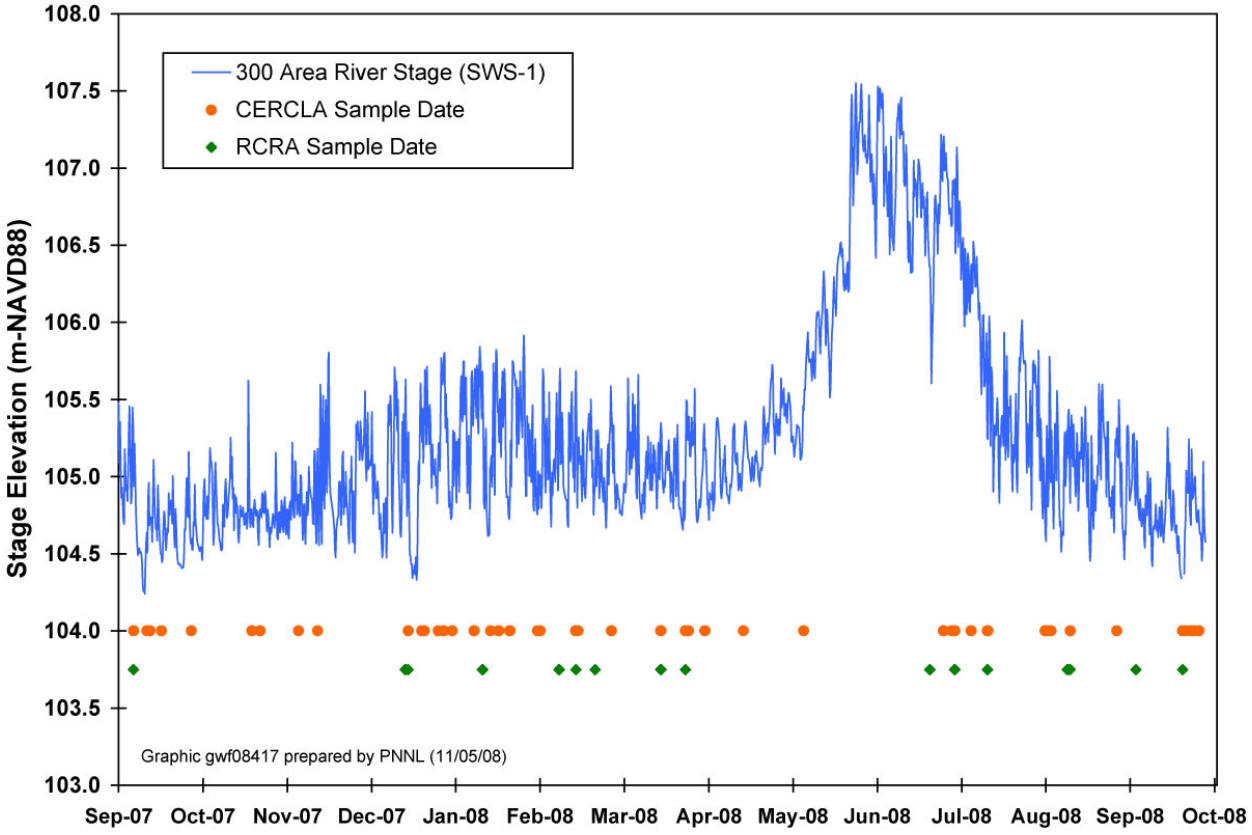


Figure 2.12-8. Uranium Concentrations and Water Levels at (A) Inland Wells and (B) Near-River Wells.

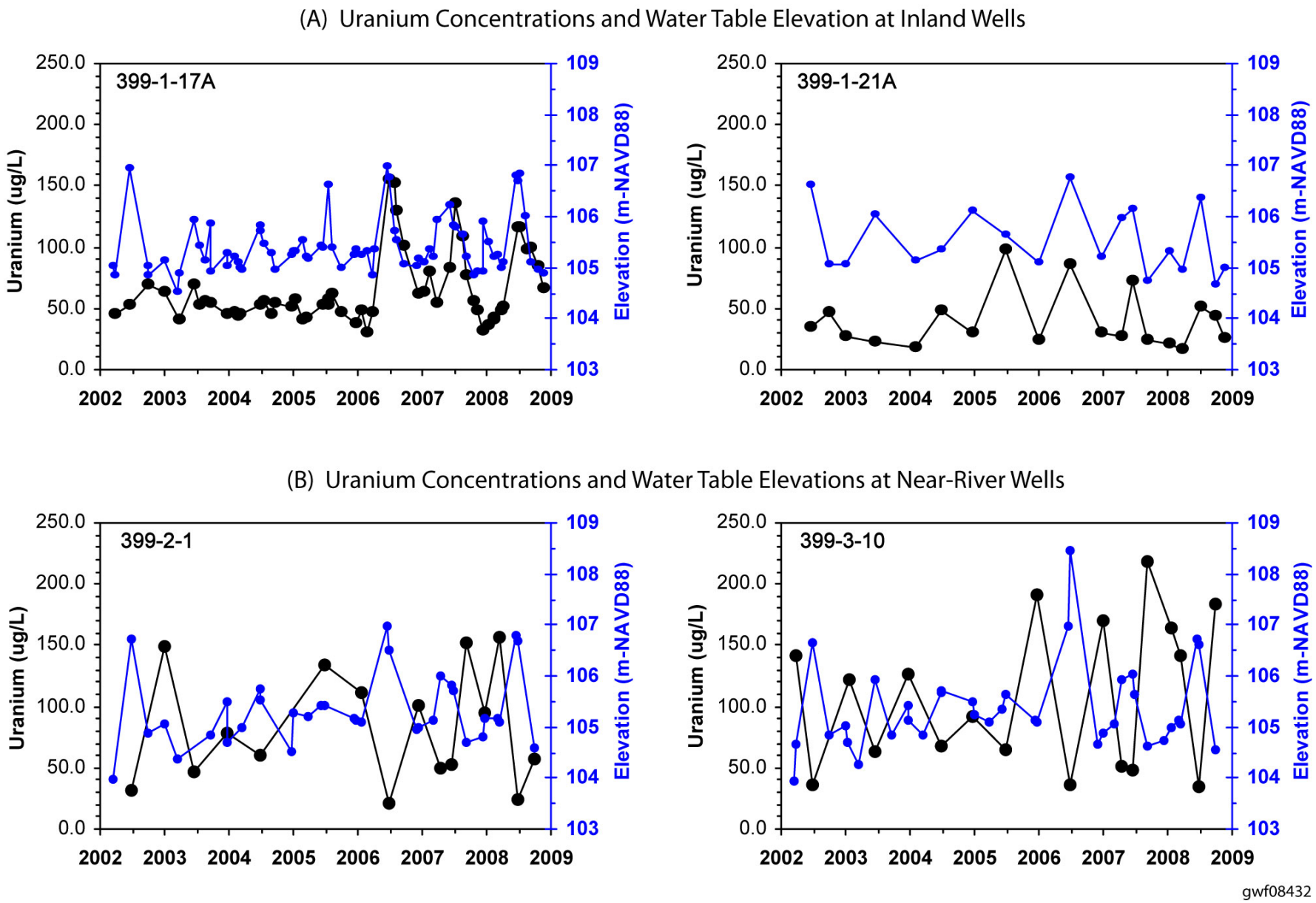


Figure 2.12-9. Uranium Concentrations in Wells Downgradient from the 618-7 Burial Ground.

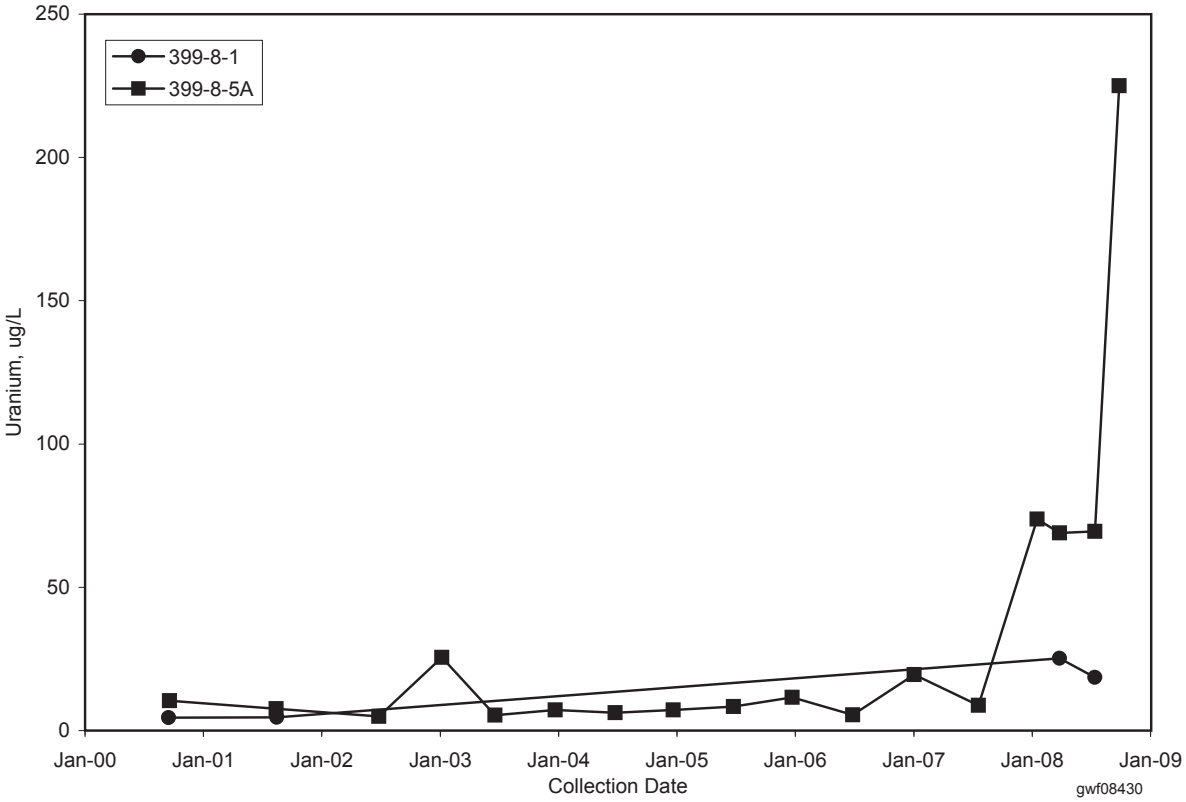


Figure 2.12-10. Cross Section of Uranium Concentrations in Aquifer Tubes Along the 300 Area Shoreline.

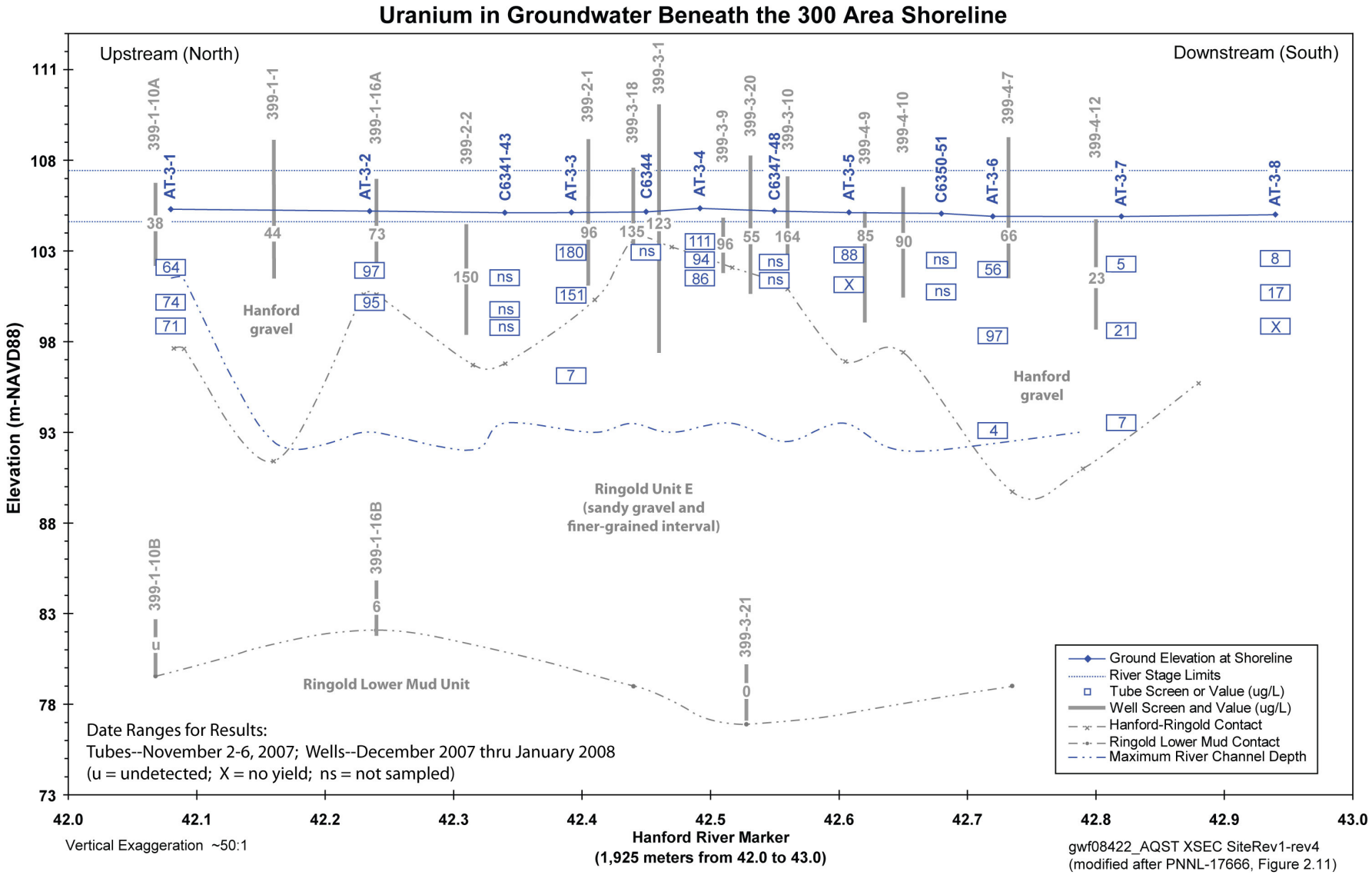


Figure 2.12-11. Uranium Concentrations at Wells near the 316-4 Cribs Remedial Action Site.

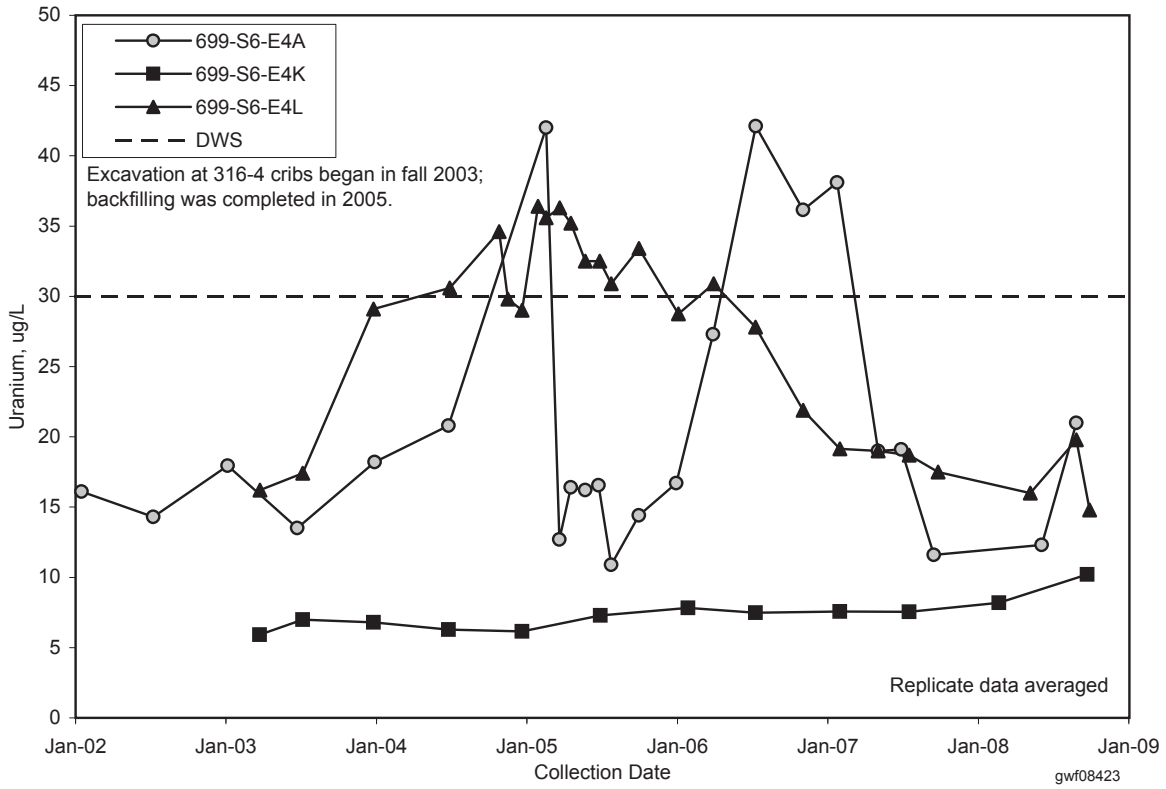


Figure 2.12-12. Concentrations of cis-1,2-Dichloroethene in Well 399-1-16B.

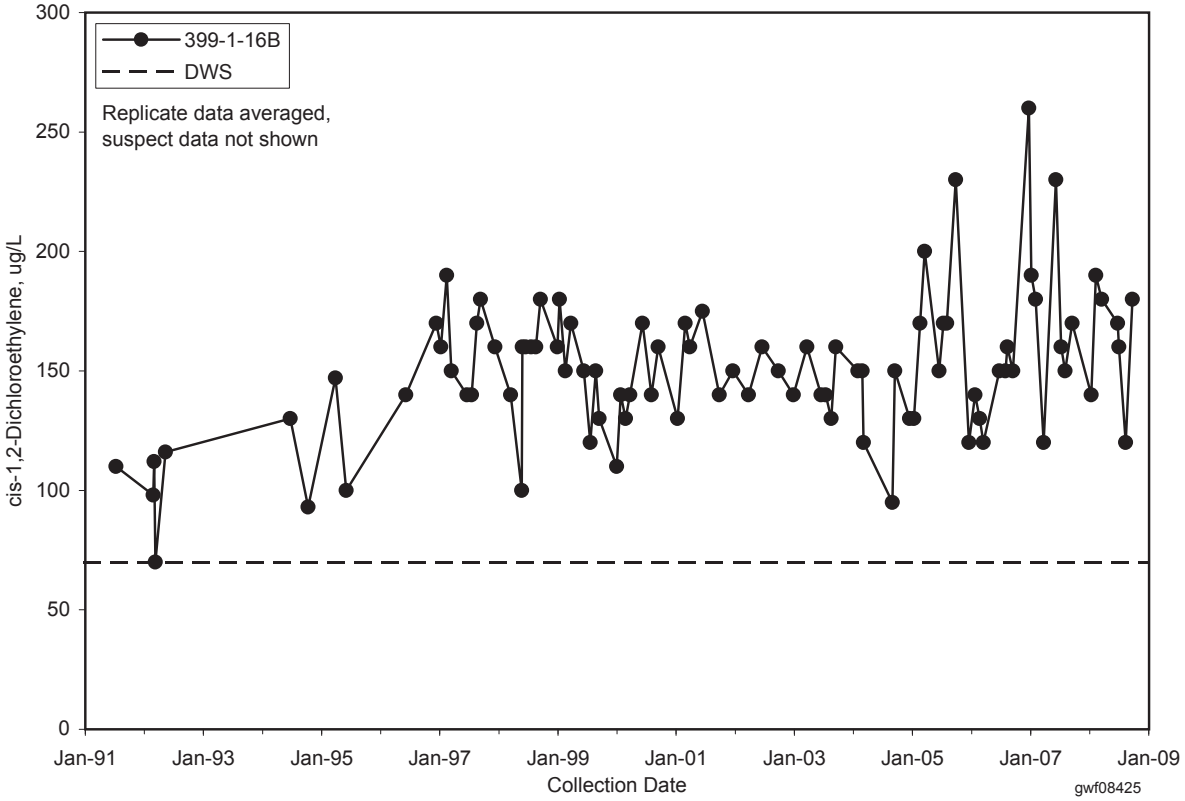


Figure 2.12-13. Average Tritium Concentrations in the 618-11 Burial Ground, Upper Part of Unconfined Aquifer.

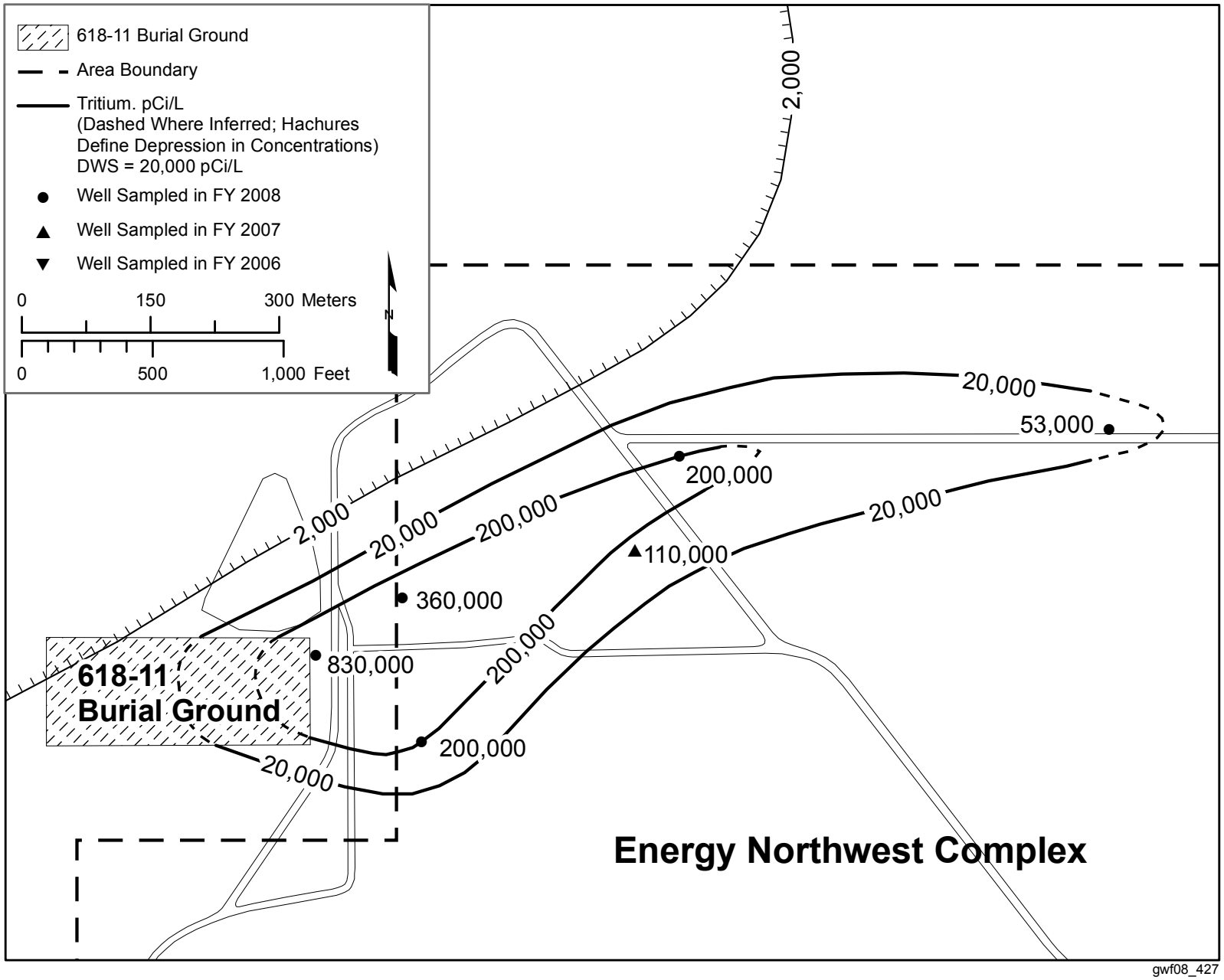
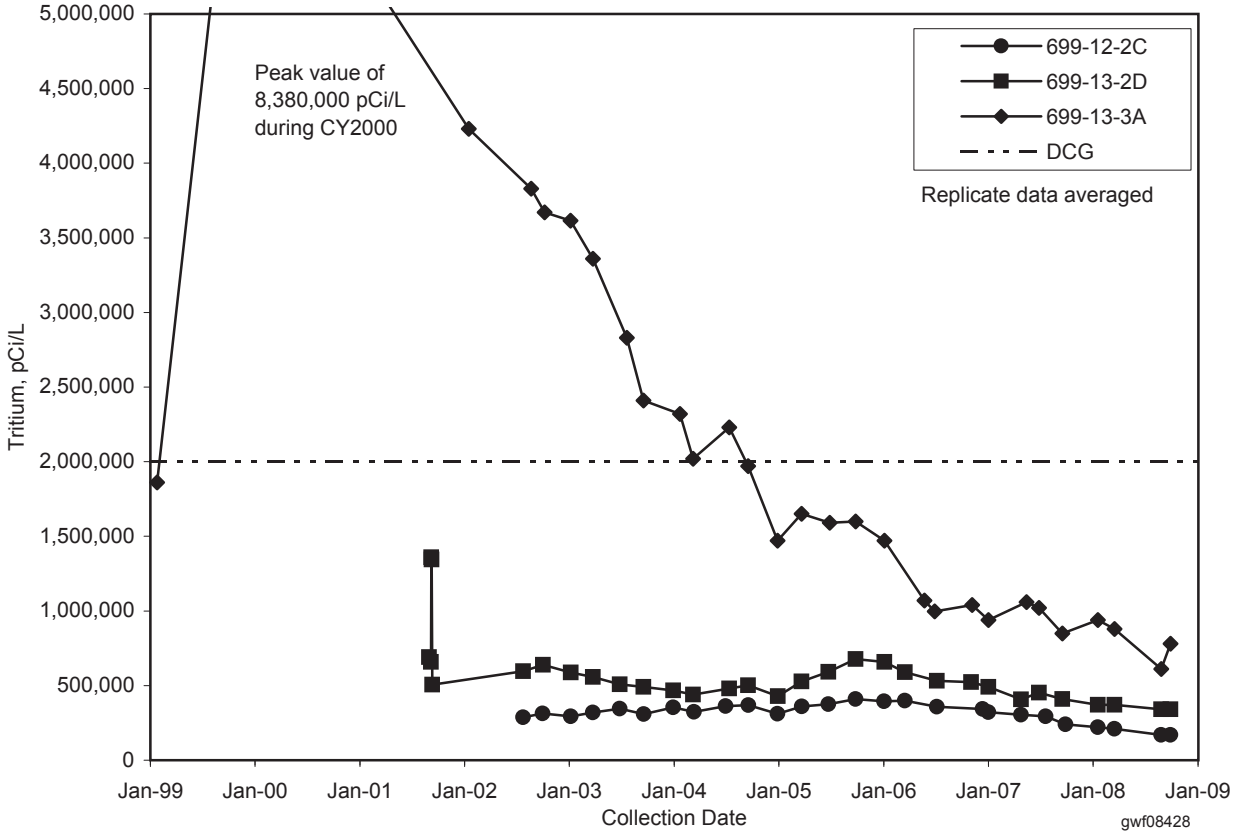



Figure 2.12-14. Tritium Concentration in Wells near the 618-11 Burial Ground.