

## 13.0 300-FF-5 Operable Unit

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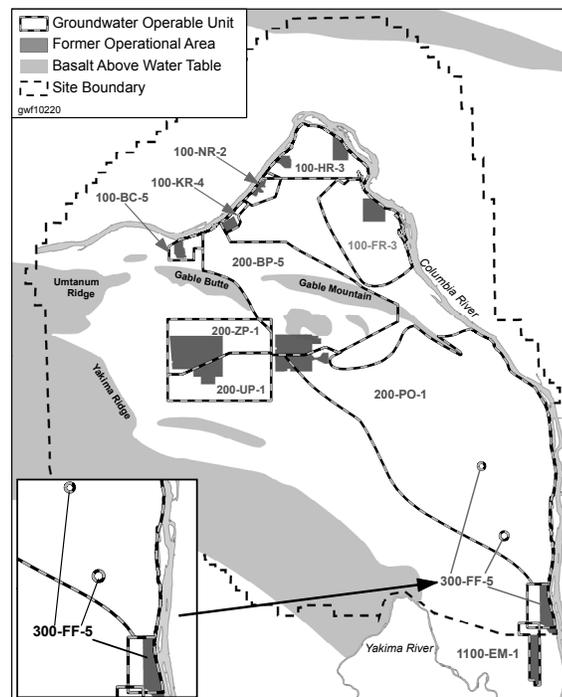
The 300-FF-5 Operable Unit (OU) is defined as groundwater that has been impacted by waste disposal or unplanned releases associated with the 300-FF-1 and 300-FF-2 OUs. The OU consists of several areas of contaminated groundwater beneath the southeastern portion of the Hanford Site, with subregions designated for the 300 Area, 618-11 Burial Ground, and 618-10 Burial Ground/316-4 Cribs (Figure 13-1). In addition to releases from 300-FF-1 and 300-FF-2, contaminated groundwater also migrates to this portion of the Hanford Site from waste sites not associated with those OUs and from sources not involving Hanford Site activities. The latter contamination is described as part of the 200-PO-1 OU (Chapter 10.0) and the 1100-EM-1 groundwater interest area (Chapter 14.0), respectively.

The principal origin for contamination currently observed in groundwater beneath the 300 Area involves historical routine disposal of liquid effluent associated with (1) fabrication of nuclear fuel assemblies, and (2) research involving the processing of irradiated fuel. The liquid wastes produced were discharged to ponds and trenches designed for infiltration to the underlying soil. Periodic spills and accidental releases from various facilities also occurred. Because nearly all of the principal liquid waste disposal facilities have been out of service for decades and most have been remediated by removing contaminated soil (DOE/RL-2004-74, *300-FF-1 Operable Unit Remedial Action Report*), the contamination remaining in the underlying vadose zone and aquifer can be characterized as residual.

Potential sources for groundwater contamination beneath the 300 Area that have not yet been remediated include the process sewer system and the 307 Process Trenches. Some release and/or remobilization of contamination may have occurred in more recent years because of continuing operations, excavation activities, removal of buildings, and processes potentially still active at some of the unremediated burial grounds (e.g., formation of a tritium plume in groundwater at the outlying 618-11 subregion). At the outlying subregions, intrusive investigative activities began at the 618-10 Burial Ground in August 2010, with excavation and removal activities planned to begin in March 2011. Remediation activities have not yet started at the 618-11 Burial Ground, but intrusive investigative work is underway.

The subregion of 300-FF-5 with the most significant groundwater issues is the 300 Area, where manufacturing and research activities associated with nuclear fuel were conducted during the Hanford Site's operational period. Large volumes of liquid effluent containing hazardous constituents were disposed to ponds and trenches designed for infiltration, with some contamination retained within the underlying vadose zone and a large portion reaching groundwater, followed by discharge to the Columbia River. Most of the contaminated sediment associated with these facilities has been removed and disposed at the Environmental Restoration Disposal Facility. The key issues for the 300 Area subregion are as follows:

- Persistent uranium contamination in the upper portion of the unconfined aquifer beneath most of the 300 Area. Evidence gathered during the interim action reveals



***Groundwater in the 300-FF-5 OU has been affected by liquid waste disposal and unplanned releases in the 300 Area and two outlying subregions.***

***Contaminants in groundwater beneath the 300 Area reflect past waste disposal associated with the fabrication of nuclear fuel for the plutonium-production reactors and research related to processing irradiated fuel.***

areas where contamination from the vadose zone may continue to resupply the groundwater plume.

- Persistent contamination by dichloroethene at one well, which monitors the lower portion of the unconfined aquifer. This volatile organic compound (VOC) is a degradation product of trichloroethene and tetrachloroethene, which were used extensively during the period of nuclear fuel manufacturing.
- Trichloroethene contamination of limited geographic extent, contained in a relatively finer grained sediment interval within the unconfined aquifer. Because of low groundwater yield, monitoring wells are not screened in this interval. The potential for further dispersal via the interval is limited because of the low permeability of the sediment. The source(s) for the compound and mechanisms by which it contaminated the finer grained interval are not clearly known.

One inactive treatment, storage, and disposal (TSD) facility regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA) is located in the 300 Area. The former 300 Area Process Trenches were used between 1975 and 1994 for disposal of hazardous liquid waste. The trenches were initially remediated under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) in 1991, followed by additional remediation during July 1997 through February 1998, with final backfilling early in 2004. The site continues to be monitored under CERCLA, as well as post-corrective action monitoring under RCRA. Figure 13-2 shows the principal waste sites responsible for contamination in the subsurface environment; outlines for facilities still in use at the 300 Area are also shown on the map.

At the two outlying subregions of the 300-FF-5 OU, groundwater is monitored near two solid waste burial grounds and a former liquid waste disposal crib. The quantity of tritium released from material buried at the 618-11 Burial Ground created a plume in groundwater, with concentrations greatly exceeding the federal drinking water standard (DWS). The plume extends eastward beneath the northern portion of the Energy Northwest generating station complex. The key issues for this subregion are as follows:

- The potential for additional release of radiological contamination from the burial ground in sufficient quantities to impact groundwater is not fully understood. The existing groundwater plume appears to have developed as a consequence of a single event, although the exact processes are largely unknown and uncertainty remains.
- Migration of the tritium plume to locations where groundwater may be withdrawn for beneficial use.

A similar impact to groundwater has not been observed at the older 618-10 Burial Ground, where historical disposal activities also included radiological material but apparently not material that releases tritium. Remedial action at this waste site began in 2010, and the use of dust-control water and soil fixatives increases the potential for any uncontained, mobile contaminants to be transported downward to the groundwater. The same is true for residual contamination remaining in the soil beneath the former 316-4 Cribs, which were adjacent to the 618-10 Burial Ground. The key issue for this subregion is as follows:

- Mobilization of contamination that may be present in the vadose zone underlying these two waste disposal sites. The frequency of groundwater monitoring has been increased during the period of remedial actions at the burial ground.

***Release of tritium from materials in the 618-11 Burial Ground has resulted in a groundwater plume with very high tritium concentrations that migrates to the east.***

Figures 13-3 and 13-4 provide index maps showing the locations of the waste sites and monitoring wells for the 618-11 and 618-10/316-4 subregions, respectively.

Groundwater in the uppermost aquifer beneath the southeastern portion of the Hanford Site generally flows in an easterly direction toward the Columbia River, as indicated by the water table elevation contours shown in Figure 13-5. (Note that flow direction is inferred as being perpendicular to contours.) Beneath the 300 Area, flow tends to converge, with groundwater migrating in from the northwest, west, and southwest. Flow patterns throughout the region are complicated by the variable permeability of sediment in the upper portion of the unconfined aquifer and, near the Columbia River, by the influence river-stage fluctuations, which are related to the operation of dams upstream and downstream from the Hanford Reach. River-stage fluctuations produce significant seasonal variations in groundwater conditions beneath the 300 Area.

Cross sections shown in Figure 13-7 depict the geologic and hydrologic units that are relevant to CERCLA information needs (an index map to the cross sections is provided in Figure 13-6). Although this figure is based on conditions beneath the 300 Area, similar hydrogeologic features are present at the outlying subregions. Contamination is generally contained within the upper portion of the unconfined aquifer (i.e., the interval of Hanford formation gravelly sediment that lies below the water table). The thickness of the contaminated portion of the unconfined aquifer is variable because of the undulating contact surface between stratigraphic units and, at the 300 Area, significant seasonal fluctuations in water table elevation (PNNL-17034, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*).

Beneath the 300 Area, the undulating contact between the bottom of the saturated Hanford formation interval and the underlying Ringold unit E sediment reveals paleochannels that act as preferential pathways for groundwater flow. Saturated Hanford formation sediment is much more permeable than the underlying sediment intervals, with tracer tests and tracking of unplanned releases suggesting plume movement velocities as high as 15 meters per day in the Hanford formation (PNNL-18529, *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report*; PNNL-17666, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington*). The high velocities suggest that contamination introduced to groundwater may be transported to the river environment as quickly as several weeks to months, depending on the input location and the mobility characteristics of the contaminant.

Near the Columbia River, the contaminant discharge rate to the river is influenced by daily and seasonal river-stage fluctuations (PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area, Hanford Site, Washington State*). Effects include temporary reversal of flow direction, dilution of contamination by the intrusion of clean river water, and possible influences on contaminant mobility because of changes in the geochemical environment. Contaminant discharge to the river occurs via riverbank springs that flow across the beach region (riparian zone) during periods of low river stage, as well as by upward movement through the riverbed.

Beneath the river shoreline region, a complex hydrologic and geochemical environment is formed as the result of river water interacting with Hanford Site groundwater. An understanding of this dynamic environment is necessary to (1) evaluate potential impact to ecological receptors caused by discharge of contaminated groundwater, and (2) conduct a feasibility study (FS) for selecting

***Significant impact to groundwater has not been observed near the 618-10 Burial Ground, where remediation work started in 2010.***

***Contaminants in groundwater beneath the 300 Area are mainly contained within Hanford formation gravel, through which groundwater flows rapidly.***

***The rise and fall of the Columbia River results in a dynamic zone of interaction between groundwater and river water, causing distinct changes in contaminant plume characteristics.***

a remedial action alternative. Simulating groundwater flow patterns and contaminant transport through the zone of interaction is challenging because of rapidly changing hydraulic gradients and variable geochemistry (“Building Conceptual Models of Field-Scale Uranium Reactive Transport in a Dynamic Vadose Zone-Aquifer-River System” [Yabusaki et al., 2008]). Results from a recent research project involving computer simulation of uranium transport through the saturated zone provide additional insight into the migration of uranium via the groundwater pathway beneath the 300 Area (“Field-Scale Modeling for the Natural Attenuation of Uranium at the Hanford 300 Area Using High Performance Computing” [Hammond and Lichtner, 2010]; “Stochastic Simulation of Uranium Migration at the Hanford 300 Area” [Hammond et al., 2010]).

The conceptual model describing the features, processes, and events associated with groundwater contamination of Hanford Site origin provides a technical basis for future remediation decisions. If a remedial action technology is warranted, additional site-specific details for the conceptual model may be required to design and implement the remedy. The *Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2 and 300-FF-5 Operable Units* (DOE/RL-2009-30) describes the activities necessary to complete the remedial investigation (RI) process and to conduct a FS that evaluates alternatives for final remedial actions. A report describing the results of the RI and FS activities will be prepared during 2011 for public release by December 31, 2011, in accordance with *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) Milestone M-015-72-T01.

### **13.1 Groundwater Contaminants**

***Plume Areas (square kilometers) in the 300-FF-5 Operable Unit:***

***Tritium\*, 20,000 pCi/L — 0.064***

***Uranium, 30 µg/L — 0.55***

***\* Excludes tritium from 200-PO-1 Operable Unit.***

Contaminants of potential concern (COPCs) in 300 Area groundwater were identified during the initial evaluation of risk posed by contamination remaining in the vadose zone and unconfined aquifer in the early phase of the RI for the 300-FF-5 OU (DOE/RL-94-85, *Remedial Investigation/Feasibility Study Report for the 300-FF-5 Operable Unit*). Based on the initial evaluation, uranium, cis-1,2-dichloroethene, and trichloroethene were identified in 1996 by the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the U.S. Department of Energy (DOE) as contaminants of concern (COCs) for interim action (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*). In 2000, groundwater affected by releases from the 618-11 Burial Ground and the 618-10 Burial Ground/316-4 Cribs was added to the 300-FF-5 OU (EPA/ESD/R10-00/524, *EPA Superfund Explanation of Significant Differences: Hanford 300-Area [USDOE]*). A risk assessment at those sites was not conducted, so the COPCs were not formally identified. However, waste indicators were identified for those sites, which included tritium near the 618-11 Burial Ground, as well as uranium and tributyl phosphate near the 618-10 Burial Ground and 316-4 Cribs.

In 2004, an updated, comprehensive description of groundwater contamination in the 300-FF-5 OU was prepared to show the changes in COC trends since the initial RI in the early 1990s. No major changes were recommended for the list of waste indicator constituents to be monitored (PNNL-15127, *Contaminants of Potential Concern in the 300-FF-5 Operable Unit: Expanded Annual Groundwater Report for Fiscal Year 2004*). Following that effort, an update to the initial qualitative risk

assessment for the 300-FF-5 OU was completed in 2007 (PNNL-16454, *Current Conditions Risk Assessment for the 300-FF-5 Groundwater Operable Unit*). The assessment concluded that conditions with regard to risk remained consistent with the earlier conclusions from 1994. Other constituents in groundwater may exceed the federal DWS but have not been explicitly identified in regulatory decision documents as COCs or COPCs for the purpose of evaluating human health and ecological risk.

The work plan for renewed RI activities for 300 Area OUs presents an updated list of groundwater COPCs (DOE/RL-2009-30, Section 4.5). The list is more comprehensive than previously identified in earlier regulatory decision documents and is being used to guide new risk assessment activities. Also, new information from the ongoing River Corridor Baseline Risk Assessment (DOE/RL-2004-37, *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the RCBRA*) and investigation of contaminant releases to the Columbia River (DOE/RL-2008-11, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River*) may result in the identification of new COPCs or possibly delisting some previously identified COPCs.

The following subsections discuss various constituents in groundwater that are either formally listed as COPCs in regulatory decision documents or are monitored under the 300-FF-5 OU operation and maintenance plan (DOE/RL-95-73, *Operation and Maintenance Plan for the 300-FF-5 Operable Unit*) and its sampling and analysis plan (DOE/RL-2002-11, *300-FF-5 Operable Unit Sampling and Analysis Plan*) as indicators of hazardous waste in the environment. The constituents of greatest interest for monitoring are uranium, VOCs, tritium, and nitrate. Descriptions include the origins, geographic extent, concentration trends, and other aspects of the particular constituent that are relevant to the ongoing RI.

### 13.1.1 Uranium

Uranium is a contaminant found in subsurface environmental pathways beneath the 300 Area and, to a much lesser degree, beneath the 618-10 Burial Ground/316-4 Cribs subregion. In the 300 Area, a groundwater plume has persisted far longer than predicted by the early phase of the RI. The persistence of the uranium plume is related to geochemistry and environmental conditions. The complex exchange processes involving uranium dissolved in groundwater, and various geochemical complexes associated with solids in the lower vadose zone and aquifer, provide a significant challenge for simulating behavior of the plume, as well as for developing a remediation technology that would lower concentrations in groundwater. Uncertainties in the conceptual model involve contamination remaining in (1) the vadose zone, (2) the periodically rewetted zone (i.e., water table zone), and (3) the unconfined aquifer. The most vexing uncertainties relate to the mobility characteristics of the various forms of uranium in those subsurface pathways, and also to the availability of a medium (e.g., infiltrating moisture) to transport any uranium that becomes remobilized.

The potential for uranium remaining at unremediated waste sites, the underlying vadose zone, and the aquifer to be mobilized is 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. Additional information on mobility characteristics is provided in the following reports, which describe the results of numerous investigations involving uranium in subsurface pathways beneath the 300 Area:

- PNNL-14022, *300 Area Uranium Leach and Adsorption Project*

***The list of groundwater constituents identified as COPCs has evolved during the interim action, with an updated list being developed in 2010 as part of the renewed RI.***

***For monitoring 300-FF-5 OU groundwater quality, the focus is on uranium, VOCs, tritium, and nitrate.***

***Numerous investigations have been conducted at the 300 Area to better understand uranium contamination in the subsurface and the potential for the uranium to migrate via environmental pathways.***

- PNNL-15121, *Uranium Geochemistry in Vadose Zone and Aquifer Sediments from the 300 Area Uranium Plume*
- PNNL-17031, *A Site-Wide Perspective on Uranium Geochemistry at the Hanford Site*
- PNNL-17034, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*
- PNNL-17793, *Uranium Contamination in the 300 Area: Emergent Data and Their Impact on the Source Term Conceptual Model*
- “Geochemical Controls on Contaminant Uranium in Vadose Hanford Formation Sediments at the 200 Area and 300 Area, Hanford Site, Washington” (McKinley et al., 2007)
- “Building Conceptual Models of Field-Scale Uranium Reactive Transport in a Dynamic Vadose Zone-Aquifer-River System” (Yabusaki et al., 2008).

Uranium contamination in groundwater is typically monitored by measuring total uranium in an unfiltered water sample. The DWS for uranium is 30 µg/L, and the standard is based primarily on uranium’s chemical toxicity to humans, which is associated with damage to internal organs. Radiological dose rates are also monitored by measuring the activity concentrations of various isotopes, although for human health, the risk from chemical toxicity occurs at lower mass concentrations than the risk associated with radioactivity. As of 2010, protection standards for freshwater aquatic organisms had not been established by the EPA or Washington State. For the Hanford Site, natural background for uranium in groundwater in the unconfined aquifer is estimated to range between 0.5 and 12.8 µg/L (DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*).

#### **13.1.1.1 300 Area**

Disposal of uranium-bearing effluent to the last operational infiltration site, the 300 Area Process Trenches, ended in 1986; however, discharge of uncontaminated effluent continued until December 1994 (PNNL-13645, *300 Area Process Trenches Groundwater Monitoring Plan*). Contaminated soil was removed from the site in 1991, with additional excavation of contaminated soil at this site and other major liquid waste disposal sites in the 300 Area occurring primarily from 1997 through 2000. These excavations remained open until backfilling was completed at all excavated sites during early 2004. Figure 13-8 illustrates the historical trend of uranium impact to groundwater near the former 300 Area Process Trenches. The figure includes the chronology for various remedial action activities and more recent treatability testing. The positive correlation between water table elevation and uranium concentrations at this location is also illustrated, where uranium is likely to remain in the lower portion of the vadose zone and to be remobilized during periods of high water table conditions.

The uranium plume has persisted well beyond the 3- to 10-year period after late 1993 that was predicted by the initial phase of the RI (DOE/RL-94-85). Concentration patterns reveal distinct seasonal variability correlated to the elevation of the water table, which is in turn related to Columbia River flow. Incomplete information is available on the contaminant source(s) that continue to supply uranium to the plume (DOE/RL-2009-30). Residual amounts of uranium are known to remain in (1) the vadose zone beneath or immediately adjacent to remediated waste disposal sites, (2) the widespread zone through which the water table fluctuates, and (3) the upper portion of the unconfined aquifer (PNNL-16435, *Limited Field Investigation Report*

for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington; PNNL-17793).

The uranium plume in groundwater beneath the 300 Area is defined by concentrations exceeding 10 µg/L, with natural background concentrations in the contaminated hydrologic unit estimated between 3 and 8 µg/L based on data from 300 Area wells where groundwater was unlikely to have been influenced by waste disposal (PNNL-17034, Section 3.1). Figure 13-9 shows the groundwater plume during June 2010. Maps prepared using the June monitoring results illustrate the conditions that develop during the period when the water table is elevated due to high river stage.

Typical characteristics of the plume during seasonal high water table conditions include (1) lowered concentrations along some portions of the Columbia River shoreline, and (2) increased concentrations at some locations farther inland, near former waste disposal facilities and potential sites of unplanned releases. Figure 13-10 shows the uranium concentration trends at locations representative of near-river and inland conditions. Beneath the shoreline, river water intrudes into the aquifer during high river-stage conditions and lowers contaminant concentrations by dilution. Further inland, increased concentrations are apparently the consequence of contamination in the lower vadose zone being mobilized by temporarily saturated conditions while the water table is elevated, which facilitates downward transport of contamination to groundwater.

During other months of the seasonal cycle, the highest concentrations in the plume are often observed near the river. Uranium introduced during the preceding period of high water table conditions has migrated downgradient to the shoreline, and dilution by river water in the zone beneath the shoreline is lessened due to lower river-stage conditions. A more comprehensive description of features and processes associated with uranium in environmental pathways beneath the 300 Area is available in PNNL-17034.

A relatively new area of uranium contamination in groundwater developed in early 2008 immediately downgradient from the former 618-7 Burial Ground. The contaminant plume is related to remediation activities conducted during 2007 and 2008 at the burial ground. Higher-than-expected uranium concentrations were first observed in January 2008, along with increased concentrations of chromium and constituents associated with soil fixative material (calcium and chloride). The impact to groundwater is likely the result of infiltration of dust-control water and soil fixatives during remedial action at the burial ground. By the end of 2010, concentrations at nearby downgradient wells continued to decrease, indicating passage of the contaminant plume (Figure 13-11). New monitoring wells 399-6-3 and 399-6-5, which were installed during late 2010, will provide increased coverage of the downgradient migration of this plume.

The uranium plume map in Figure 13-9 represents conditions in the upper portion of the unconfined aquifer, where uranium contamination is contained within saturated Hanford formation gravel sediment. Several wells in the 300 Area have open intervals for sampling that are in the lower portion of the unconfined aquifer. These include wells with a "B" suffix, well 399-1-8, and recently installed wells 399-3-21 and 399-3-22. Screens for these wells are positioned in Ringold unit E gravelly sediment. Uranium concentrations in samples from these wells are typical of natural background levels, suggesting little or no downward migration of contaminant uranium beyond the extent of saturated Hanford formation sediment. Hydrographs for wells screened

***Uranium contamination in groundwater beneath the 300 Area has persisted far longer than initially predicted.***

***Concentration patterns in the uranium plume vary seasonally as a consequence of changes in water table elevation and infiltrating river water.***

***Remediation activities at the former 618-7 Burial Ground apparently mobilized uranium, impacting the groundwater.***

in either saturated Hanford formation sediment or Ringold Formation unit E sediment are virtually identical, indicating no significant vertical gradients. Contamination has not been detected in the few wells that monitor the uppermost confined aquifer, which is a somewhat permeable interval within the Ringold lower mud unit (e.g., wells with a “C” suffix and well 399-1-9). Hydrographs for these wells show a distinct upward hydraulic gradient, with a head difference of approximately 9 meters.

As suggested by the rapid changes in groundwater concentrations that likely result from changes in water table elevation and river stage, it is apparent that the timing of groundwater sample collection plays a significant role in determining the uranium concentration for the sample. Thus, concentration patterns shown in groundwater plume maps contain bias in regard to representing aquifer conditions. Bias is also introduced by the different construction features of the various monitoring wells and aquifer tubes that make up the groundwater monitoring network. This bias was evident in recent monitoring results at the polyphosphate treatability test site, which is located at the southern end of the former 300 Area Process Trenches. Significantly higher concentrations of uranium were measured in samples from wells with 0.6-meter screens located in the uppermost portion of the aquifer than in samples from wells with typical 5-meter screens (“River-Induced Wellbore Flow Dynamics in Long-Screen Wells and Their Impact on Aqueous Sampling Results” [Vermeul et al., 2010]). An understanding of bias in monitoring data is important when (1) describing uncertainties associated with the conceptual site model, and (2) establishing criteria for remedial action performance evaluation and subsequent compliance monitoring.

The previous description focuses on the concentration of uranium dissolved in groundwater, which is information used to determine compliance with various regulatory standards and applicable or relevant and appropriate requirements. For screening, design, and implementation of remedial action technologies, additional parameters are needed, such as the spatial distribution and the mass of contaminant (DOE/RL-2008-36, *Remediation Strategy for Uranium in Groundwater at the Hanford Site 300 Area 300-FF-5 Operable Unit*). An analysis of some of those additional parameters for the 300 Area uranium plume is presented in PNNL-17034, from which the following estimates are extracted.

The areal extent of uranium-contaminated groundwater that exceeds the DWS is ~0.5 square kilometers. The length of Columbia River shoreline impacted by the plume is ~1,900 meters. Various estimates for the mass of uranium dissolved in the plume during recent years suggest approximate values between 40 and 80 kilograms. One method for estimating the areal extent and mass of dissolved uranium in the plume since 2002 indicates fairly constant values, although concentration patterns vary significantly with the seasons. An analysis of the inventory of contaminant uranium stored in various subsurface “compartments” indicated that ~4,000 kilograms of uranium may remain in sediment and moisture associated with the vadose zone, as well as an additional 180 kilograms associated with aquifer sediment and groundwater. Under current conditions, the flux of uranium to the Columbia River via groundwater discharge may be several tens of kilograms per year, with an additional 10 kilograms removed from the aquifer via a well providing water for the aquariums in PNNL’s 331 Life Sciences Building (well 399-4-12).

Uranium contamination in groundwater near the Columbia River is monitored by sampling near-river wells, aquifer tubes at twelve sites along the shoreline, and, to a lesser extent, riverbank springs. At locations near the river, uranium concentrations are frequently lowered by the intrusion of river water into the aquifer. Intrusion is

***Several thousand kilograms of contaminant uranium may remain in the vadose zone and aquifer beneath the 300 Area.***

especially pronounced during high river-stage conditions and may occur as layering of river water over groundwater and/or mixing with groundwater. An analysis of samples from aquifer tubes, using specific conductance values as an indicator of river water, suggested approximate proportions of 60% groundwater and 40% river water in samples from the Hanford formation gravels hydrologic unit beneath the shoreline (PNNL-17034). A lowering of concentrations may also occur due to 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; Yabusaki et al., 2008).

Figure 13-12 shows the uranium concentrations observed in samples from aquifer tubes collected from March 10-17, 2010. Concentrations in tube samples represent more discrete intervals in the aquifer than the concentrations determined for samples from traditional monitoring wells because of different lengths for screened openings (15-centimeter screen length for tubes and typically 5 meters for a monitoring well). Contamination may become more evenly distributed vertically in the aquifer near the river because of mixing during transport from source areas to the river, and the values from tubes at multiple depths at a site support this idea. The cross section shown in Figure 13-12 also includes information on near-river wells with their screen positions projected onto the section, as well as the stratigraphic contacts that are relevant to groundwater movement. The cross section supports the conclusion that most uranium contamination is contained within the saturated Hanford formation gravelly sediment. The only aquifer tube that is clearly installed in the underlying Ringold unit E is tube AT-3-3-D, and concentrations are consistent with natural background uranium levels.

#### **13.1.1.2 618-10 Burial Ground and 316-4 Cribs**

From 1948 to 1956, uranium was included in liquid waste disposed to the former 316-4 Cribs, which are adjacent to the easternmost corner of the 618-10 Burial Ground (BHI-00012, *300-FF-2 Operable Unit Technical Baseline Report*). The cribs were vertical culverts, open at their bottoms, into which VOCs contaminated by uranium were discharged. The liquid effluent included compounds such as methyl isobutyl ketone (hexone) and tributyl phosphate. The cribs and some of the contaminated adjacent soil were removed in 2004 and the site was partially backfilled. However, some uranium and tributyl phosphate contamination was known to remain in the soil beneath the excavated site (DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site*). Uranium concentrations in groundwater have remained below the DWS since 2008.

Uranium concentrations in groundwater were previously elevated above the DWS at several wells near the southeastern fence line of the 618-10 Burial Ground and within the footprint of the former 316-4 Cribs, although concentrations in that area have remained below the DWS since approximately 2007 (Figure 13-13). The cause for the earlier variability in uranium concentrations at wells 699-S6-E4A and 699-S6-E4L was likely related to the 316-4 Cribs excavation and backfilling activities in 2004. All wells in the vicinity monitor the upper portion of the unconfined aquifer, and the water table elevation at this subregion remains fairly constant. In August 2010, the first intrusive work at the burial ground began as part of preparing for more extensive removal actions, which include removing additional contaminated soil from beneath the 316-4 Cribs site. These removal actions are scheduled to begin in March 2011.

***The mass of uranium in the groundwater plume is roughly the same amount as the mass that leaves the plume each year via groundwater discharge to the Columbia River and withdrawal at a water supply well, suggesting continued resupply of the plume from the vadose zone.***

***Uranium was included in waste disposed to the 316-4 Cribs and 618-10 Burial Ground, but the impact to groundwater has been minimal.***

### 13.1.2 Volatile Organic Compounds

The VOCs trichloroethene and tetrachloroethene were used in substantial quantities in the 300 Area during the fuels fabrication process (BHI-00012; EMO-1026, *Addendum to Data Compilation Task Report for the Source Investigation of the 300-FF-1 Operable Unit Phase I Remedial Investigations*; WHC-MR-0388, *Past Practices Technical Characterization Study – 300 Area – Hanford Site*). Trichloroethene was the primary degreaser used until the 1970s, followed by tetrachloroethene in the 1970s and 1980s. Carbon tetrachloride was also used in small quantities for testing fuel element integrity and is occasionally detected, but at levels below the DWS.

Cis-1,2-dichloroethene is present in the aquifer beneath the 300 Area, apparently as a degradation product of trichloroethene and tetrachloroethene. Vinyl chloride, a potential degradation product, is not detected in 300 Area groundwater. At the outlying subregions of the 300-FF-5 OU, volatile and semivolatile organic compounds (SVOCs) associated with fuels fabrication were included in waste disposed to burial grounds and cribs, but these compounds are only occasionally detected today in the groundwater.

#### 13.1.2.1 300 Area

Trichloroethene and tetrachloroethene continue to be detected in the upper portion of the unconfined aquifer at 300 Area wells but at concentrations below the 5 µg/L DWS. The detection limit for these compounds increased from 0.2 to 1.0 µg/L in late 2007, so the results for recent samples from many wells where the compounds were previously listed as detected are now listed as nondetected. Trichloroethene and/or tetrachloroethene are occasionally detected at wells screened in the lower portion of the unconfined aquifer (e.g., 399-1-8 and 399-1-16B), but detections have been below the DWS in recent years. 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 both waste disposal sites where releases of tetrachloroethene have occurred (a summary of the historical releases is presented in PNNL-17666). Some trichloroethene continues to migrate into the 300 Area from sources to the southwest (see Chapter 14.0).

Trichloroethene was detected in March 2010 samples from some aquifer tubes positioned in Hanford formation gravels sediment along the river, however the concentrations were lower than the DWS (Figure 13-14). One explanation for this occurrence is the release of trichloroethene from a contaminated, finer grained interval of Ringold Formation sediment located just below the Hanford formation gravels. Uncertainty exists regarding this explanation because of a lack of information relating to potential source(s) and transport processes leading to contamination of this interval of sediment. Only one aquifer tube (AT-3-3-D) is clearly positioned within this interval, with a concentration of 430 µg/L for a sample collected in March 2010. This level of contamination is consistent with concentrations observed during characterization drilling through the finer grained interval in 2006 and 2007 (PNNL-17666).

In the lower portion of the unconfined aquifer, cis-1,2-dichloroethene concentrations continue to exceed the DWS at one well located near the former North Process Pond. Concentrations at well 399-1-16B remain above the 70 µg/L DWS, with a maximum concentration of 170 µg/L during 2010 (Figure 13-15). Well 399-1-16B is located along the downgradient flow path from the former 300 Area Process Trenches and

*Volatile organic compounds were used extensively as degreasers during fuels manufacturing in the 300 Area.*

*Concentrations of trichloroethene and tetrachloroethene near the water table are below the DWS.*

North Process Pond; it is screened in Ringold Formation gravelly sediment in the lower portion of the unconfined aquifer. The origin for cis-1,2-dichloroethene is likely degradation of trichloroethene and/or tetrachloroethene disposed to the former 300 Area Process Trenches and/or North Process Pond (PNNL-17666). This degradation product is also detected at well 399-1-17B, which is also near the two disposal sites but at concentrations much lower than the DWS.

During a limited field investigation for uranium (PNNL-16435), VOC contamination was encountered in groundwater associated with a finer grained interval of sediment within Ringold unit E. The interval is a subunit within the unconfined aquifer system and is not laterally continuous beneath the 300 Area. The primary contaminant discovered was trichloroethene, with the maximum concentration encountered during drilling at 630 µg/L. Additional drilling was conducted during 2007 to further characterize this occurrence. The results of this investigation, as well as a review of historical operations and potential source locations for VOCs, are presented in PNNL-17666.

The contamination initially appeared to be limited to the area immediately east of the former 307 Process Trenches and South Process Pond. However, 300 Area RI/FS drilling in 2010 indicated that the contamination extends further north and includes the area east of the former sanitary leach trenches. Figure 13-16 provides an updated cross section that shows the results from groundwater samples collected during the various drilling campaigns, including those available in 2010 from the most recent drilling activities. The finer grained interval of sediment is not intercepted by existing well screens, so current knowledge of conditions in the interval is based on samples collected during drilling. The finer grained interval has a very low permeability and does not readily yield groundwater. Groundwater moves very slowly through this hydrologic unit; however, the unit is incised by the river channel, so at least some potential exists for exposure at the riverbed.

#### 13.1.2.2 Outlying 300-FF-5 Operable Unit Subregions

Tributyl phosphate has been detected in groundwater beneath the former 316-4 Cribs, although at low levels, and recent sampling has indicated nondetects. The cribs received liquid waste associated with research conducted at the 321 Separations Laboratory in the 300 Area from 1948 to 1954 (BHI-00012), which included tributyl phosphate and uranium. Tributyl phosphate concentrations, along with uranium, were elevated in early 2004 at well 699-S6-E4A (located within the footprint of the remedial action excavation) during crib removal activities. Tributyl phosphate, an SVOC, tends to bind to soil in the vadose zone, where it slowly degrades over time; it is not particularly soluble in water and, therefore, not widely dispersed via water transport mechanisms. A DWS for tributyl phosphate has not been established.

#### 13.1.3 Tritium

Tritium released from the 618-11 Burial Ground, which is a 300-FF-2 OU waste site, has contaminated groundwater in the vicinity of the Energy Northwest complex. High concentrations of tritium in groundwater were detected in early 1999 at well 699-13-3A, located next to the eastern fence line of the burial ground. The contamination was unexpected, and concentrations greatly exceeded the 20,000 pCi/L DWS, with peak concentrations reaching 8 million pCi/L. Subsequent investigations revealed a narrow plume that extends downgradient (east) of the burial ground, with concentrations that are much higher than the surrounding site-wide plume from the 200 East Area (PNNL-13675, *Measurement of Helium-3/Helium-4*

*Cis-1,2-dichloroethene, a degradation product of tetrachloroethene and trichloroethene, is detected at one well that monitors the lower portion of the unconfined aquifer.*

*Elevated concentrations of trichloroethene are present in a layer of finer grained sediment below the water table, but only in a limited area.*

***Tritium released from materials in the 618-11 Burial Ground has resulted in a groundwater plume with concentrations well above the drinking water standard.***

*Ratios in Soil Gas at the 618-11 Burial Ground*). Concentrations in the plume during 2010 are shown in Figure 13-17.

Concentrations near the burial ground have declined since peak values in 1999 and 2000. The trend in groundwater at well 699-13-3A (Figure 13-18) suggests that a possible episodic event of unknown nature caused tritium released from buried materials to contaminate groundwater. At wells farther away from the burial ground, concentration trends reflect migration of the plume. The conceptual model for the plume, including a simulation of plume evolution over time, suggests that concentrations will be below the DWS when the plume reaches the Columbia River (PNNL-15293, *Evaluation of the Fate and Transport of Tritium-Contaminated Groundwater from the 618-11 Burial Ground*). Groundwater monitoring wells in use by Energy Northwest do not show evidence of this plume, nor is tritium detected in Energy Northwest water supply wells, which tap deep aquifers.

#### **13.1.4 Nitrate**

Some groundwater contamination by nitrate occurred because of disposal at 300-FF-1 and 300-FF-2 OU waste sites during the active years of fuels production and research, and also while a sanitary sewer system was in use at the 300 Area. Throughout the 1970s and 1980s, nitrate concentrations in groundwater were somewhat higher than today but never greatly exceeded the DWS. Evaluation of concentration trends from 1992 through 2004 revealed a relatively constant level of contamination, but with some variability (PNNL-15127). Trends since 2004 are similar, although concentrations exceeding the DWS continue in the southern portion of the 300 Area and near the 618-11 Burial Ground subregion. Nitrate contamination is also associated with the widespread site-wide contaminant plume.

***Nitrate exceeds the DWS in groundwater, with sources including past disposal to 300 Area waste sites, 200 East Area waste sites, and non-Hanford Site activities.***

##### **13.1.4.1 300 Area**

Nitrate concentrations in groundwater beneath the 300 Area are lower than the 45 mg/L DWS (i.e., 10 mg/L measured as nitrogen in nitrate), except for the southern portion of the 300 Area where groundwater has been impacted by agricultural and industrial activities not associated with the Hanford Site (see Chapter 14.0 for discussion of sources). 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. Gradually increasing concentrations are observed in wells and at shoreline sites as the nitrate-laden groundwater migrates into the 300 Area. For example, the concentration at well 699-S28-E12 (located near the southwestern corner of the 300 Area boundary) was 157 mg/L in June 2010, and the concentration was 84 mg/L at nearby well 699-S27-E14 in May 2010. Nitrate also migrates into the 300 Area from the northwest as part of the site-wide plume that originates in the 200 East Area, with concentrations typically ranging from 25 to 30 mg/L (Chapter 10.0 includes further discussion of the site-wide plume).

##### **13.1.4.2 618-11 Burial Ground Subregion**

Nitrate concentrations near of the 618-11 Burial Ground have remained elevated above the DWS for many years. Concentrations at well 699-13-3A, which is adjacent to the burial ground, have been gradually increasing and reached 136 mg/L during 2010. The origin for nitrate observed in this area is enigmatic; waste acids, such as nitric acid, are not known to have been placed in the burial ground. Septic systems associated with Energy Northwest are not located in the vicinity of this contamination. One explanation suggests that waste disposal at the 200 East Area sites may be implicated (i.e., the contamination is part of the site-wide groundwater plume assigned to the 200-PO-1 OU). The relatively higher concentrations currently observed near

the burial ground may be explained by the local occurrence of lower permeability aquifer sediment that has sequestered higher levels of contamination from earlier periods, and those sediments are continuing to slowly release the contamination (PNNL-13228, *Evaluation of Elevated Tritium Levels in Groundwater Downgradient from the 618-11 Burial Ground Phase I Investigations*).

#### 13.1.4.3 618-10 Burial Ground Subregion

Nitrate in groundwater near the 618-10 Burial Ground primarily reflects the site-wide groundwater plume (200-PO-1 OU), with concentrations in the range of 25 to 30 mg/L. For a brief period that included 2005, concentrations at well 699-S6-E4L, adjacent to the burial ground, were elevated just above the 45 mg/L DWS. Concentrations at the well have subsequently followed a gradual decrease but with occasional, sporadic, higher values. The cause for the temporarily elevated concentrations at the well is not known.

#### 13.1.5 Other Constituents

In addition to the COCs or COPCs that are formally recognized in regulatory decision documents, other constituents of interest are being monitored at various locations in the 300-FF-5 OU because the constituents either exceed their respective DWS or are helpful in characterizing contamination in the aquifer. These include the radiological constituents gross alpha, gross beta, strontium-90, and technetium-99. Chromium has been added to the discussion list because of an occurrence near the 618-7 Burial Ground remedial action site.

##### 13.1.5.1 300 Area

During 2010, radiological contamination in the 300 Area (other than uranium) continued to be at low levels. Gross alpha, which is associated with uranium, exceeds the 15 pCi/L DWS at numerous 300 Area wells. Gross beta periodically exceeds the 50 pCi/L DWS at several 300 Area wells and is elevated above background at many other wells. Sources for the gross beta activity include daughter isotopes from radiological decay of uranium. Other potential contributors to gross beta include low levels of technetium-99 and strontium-90 at isolated locations, including the area near the former 340/307 complex retention basins, trenches, and associated underground piping. While groundwater impacts have not yet been identified, recent discoveries at the 324 Building warranted an increase in radiological monitoring at downgradient wells during 2010. Background radiation from natural sources (e.g., potassium-40 and uranium) also contributes to gross beta levels.

Chromium appeared as part of the plume associated with remedial action at the 618-7 Burial Ground. At well 399-8-5A, which is adjacent to the eastern fence line of the former burial ground, concentrations measured as total chromium in filtered and unfiltered samples during late 2008 and 2009 had a high value of 105 µg/L in July 2009. Since then, concentrations have continued to decline (Figure 13-11). The source for the chromium is unknown but may be related to release of material from the burial ground during remedial action excavation activities or to corrosion of the stainless-steel well screen in well 399-8-5A, which may have occurred due to the elevated chloride level. Other constituents showing a concurrent increase at this well include calcium, chloride, gross alpha, gross beta, nitrate, and sodium. Remediation activities were underway during 2007 and completed late in 2008 at this burial ground.

*Other waste indicators monitored in groundwater include radiological constituents gross alpha, gross beta, strontium-90, and technetium-99, and various chemical constituents included in analyses for major anions and cations (i.e., metals).*

### 13.1.5.2 618-11 and 618-10 Burial Grounds Subregions

These subregions lie within the large groundwater plume that originates in the 200 East Area, which contains the mobile radiological contaminants tritium, technetium-99, and iodine-129, as well as the chemical contaminant nitrate (see Chapter 10.0). The concentrations of contaminants from 200 East Area sources at the two subregions are typically below their respective DWS.

Near the 618-11 Burial Ground, technetium-99 is detected at ~200 pCi/L, which is well below the 900 pCi/L DWS but is higher than expected. Technetium-99 may be the likely cause for elevated gross beta activity in the area, with well 699-12-2C showing the highest values. A recent change in laboratory calibration for gross beta analysis appears to be the cause for significant trend changes that began abruptly in August 2008 at wells 699-12-2C and 699-13-2D. At least some of the technetium-99 contamination observed near this burial ground is associated with the site-wide plume, with sources in the 200 East Area. However, historical concentration trends for technetium-99 and tritium at well 699-13-3A (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 DWS at two wells in the past, which is likely a consequence of uranium contamination. During late 2008 and 2009, a slightly increasing trend in both parameters at this site is suggested, although neither gross alpha nor gross beta exceeded their respective regulatory standards in groundwater. Site preparation activities are underway at this subregion, so increased disturbance of the ground surface and application of water for dust control are anticipated in the coming year, which may impact groundwater.

## 13.2 CERCLA Groundwater Activities

This section discusses the RI/FS process under CERCLA for the 300-FF-5 OU. The process began in the late 1980s with work planning (DOE/RL-89-14, *Remedial Investigation/Feasibility Study Work Plan for 300-FF-5 Operable Unit, Hanford Site, Richland, Washington*). Several RI and/or FS reports were issued as a result of phasing the process:

- A Phase I RI report was published in July 1993 (Vol. 1) and January 1994 (Vol. 2) (DOE/RL-93-21, *Phase I Remedial Investigation Report for the 300-FF-5 Operable Unit*).
- A Phase I and II FS report published in January 1994 (DOE/RL-93-22, *Phase I and II Feasibility Study Report for the 300-FF-5 Operable Unit*)
- A combined RI/FS report for the OU was published in May 1995 (DOE/RL-94-85) and provided the basis for a Record of Decision (ROD) for interim remedial action. Part of the rationale for an interim action rather than final action was the continuing nature of remedial actions for waste sites and facilities in the 300-FF-1 and 300-FF-2 OUs, which contain waste sites that could potentially impact groundwater.

Interim remedial action under CERCLA initially targeted groundwater beneath waste sites in the 300 Area portion of the 300-FF-5 OU (EPA/ROD/R10-96/143). The geographic extent of the OU 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). The interim remedy, as stated in EPA/ROD/R10-96/143, is as follows:

*Interim action for the 300-FF-5 OU is appropriate while extensive remediation of waste disposal sites and removal of decommissioned facilities continues.*

- Continued monitoring of groundwater 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.

Because an engineered remedial action was not part of the interim action ROD, an operation and maintenance plan for the 300-FF-5 OU was prepared in 1996 (DOE/RL-95-73, Rev. 0). The purpose of the plan was to identify monitoring tasks and administrative requirements. The EPA's data quality objectives process was followed in defining monitoring requirements, which led to preparation of a sampling and analysis plan (DOE/RL-2002-11, Rev. 0). The operation and maintenance plan and the sampling and analysis plan have been subsequently revised based on interpretation of the monitoring results and new information obtained from remedial actions at the waste sites and facilities.

As of 2010, two 5-year reviews of the 1996 ROD have been conducted, and a third review is in progress. The first review was performed in 2000 and concluded that the selected remedy and remedial action objectives for the period of interim action were still appropriate (*USDOE Hanford Site First Five-Year Review Report* [EPA, 2001]). However, an action item required the update and expansion of the initial operation and maintenance plan. The second review was completed in 2006 and also concluded that continuation of the interim action remained appropriate, until completion of activities related to the River Corridor Baseline Risk Assessment; waste site remediation; the facility's deactivation, decontamination, decommissioning, and demolition activities; treatability testing for uranium contamination; and FS activities (DOE/RL-2006-20). Action 19-1 specified the completion of a focused FS for uranium and concurrent field testing of polyphosphate injections to immobilize uranium (see Section 13.2.1).

During 2009, new milestones and target completion dates were developed under the Tri-Party Agreement (Ecology et al., 1989). Those that apply to the 300-FF-5 OU are as follows:

- Milestone M-015-00D: The DOE shall complete the RI/FS process through the submittal of a proposed plan for all 100 and 300 Area OUs (December 31, 2012).
- Milestone M-015-71: Submit CERCLA RI/FS work plan for the 300-FF-2 and 300-FF-5 OUs for groundwater and soil (October 31, 2009; completed).
- Milestone M-015-72-T01: Submit CERCLA RI/FS report and proposed plan for the 300-FF-2 and 300-FF-5 OUs for groundwater and soil (target date December 31, 2011).
- Milestone M-016-110-T05: The DOE will have a remedy in place designed to meet federal DWSs for uranium throughout the groundwater plume in the 300-FF-5 OU unless otherwise specified in a CERCLA decision document (target date December 31, 2015).

### 13.2.1 Remedial Investigation/Feasibility Study

In 2004, activities were renewed for a FS focused on uranium at the 300 Area. Additional efforts included updating computer simulations of groundwater flow and uranium transport; conducting a limited field investigation for uranium, which involved drilling four characterization boreholes; updating the initial qualitative human health and ecological risk assessment; and assessing potential remedial action technologies for the 300 Area uranium plume. The limited field investigation revealed previously undetected contamination by VOCs in one area, and four additional characterization boreholes were drilled that expanded the uranium investigation.

*Several 5-year reviews of the 1996 Record of Decision for interim action at the 300-FF-5 OU concluded that continued monitoring of groundwater and restrictions on groundwater use remained appropriate.*

*A proposed plan for final remedial action at waste sites and environmental pathways in the 300 Area and outlying subregions is due by December 31, 2012.*

Tri-Party Agreement Milestone M-016-68 was developed in early 2005 for some of this work and required the completion of two reports by March 31, 2005:

- DOE/RL-2005-41, *Work Plan for Phase III Feasibility Study, 300-FF-5 Operable Unit*
- PNNL-15127, *Contaminants of Potential Concern in the 300-FF-5 Operable Unit: Expanded Annual Groundwater Report for Fiscal Year 2004.*

Many of the other renewed RI/FS activities were essentially complete by 2008 and are described in the following documents (listed in chronological order):

- PNNL-16435, *Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington*
- PNNL-16454, *Current Conditions Risk Assessment for the 300-FF-5 Groundwater Operable Unit*
- PNNL-16761, *Evaluation and Screening of Remedial Technologies for Uranium at the 300-FF-5 Operable Unit, Hanford Site, Washington*
- DOE/RL-2008-36, *Remediation Strategy for Uranium in Groundwater at the Hanford Site 300 Area, 300-FF-5 Operable Unit*
- PNNL-17666, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington*
- PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington*
- PNNL-17793, *Uranium Contamination in the 300 Area: Emergent Data and Their Impact on the Source Term Conceptual Model.*

In September 2008, a new Hanford Site planning effort was launched for RI/FS activities that would lead to a proposed plan for final remedial actions for the remaining 300 Area National Priorities List OUs (i.e., 300-FF-2, and 300-FF-5 OUs; remedial actions are considered complete for the 300-FF-1 OU). A work plan was prepared (DOE/RL-2009-30, Rev. 0) for activities that complement those already underway or planned under existing source OU work plans and the groundwater OU operation and maintenance plan. The new work plan activities will fill the data needs deemed necessary to support selection of alternatives for final remedial actions throughout the 300 Area RI/FS interest area.

***The RI for  
300 Area OUs during  
2010 focused on  
activities to support  
decisions involving  
final remedial actions.***

For the 300-FF-5 OU, a primary work plan activity during 2010 and 2011 is drilling at eleven locations in the 300 Area, each chosen to represent a different combination of subsurface conditions. Figure 13-19 shows the locations of earlier limited field investigation/VOC investigation characterization drilling and the current drilling campaign. The drilling strategy includes comprehensive characterization of subsurface conditions as drilling proceeds, with extensive collection of sediment and water samples. Analysis of sediment samples is focused on identifying the amounts and the mobility characteristics of contaminants that have the potential to degrade groundwater quality. New stratigraphic data are being used to update the three-dimensional model of subsurface pathways for contamination, which will improve computer simulations of groundwater flow and contaminant transport. Each drilling location is subsequently completed as a groundwater monitoring well.

Other key activities that began in 2010 included (1) more widespread hourly monitoring of the elevation of the water table, which provides data for improving the simulation of groundwater movement; and (2) efforts to simulate transport of uranium through the vadose zone and aquifer. The latter effort is difficult because

of the dynamic nature of groundwater flow beneath the 300 Area, particularly near the Columbia River, and also because of the complex geochemical interactions of uranium between dissolved forms and forms associated with sediment (Yabusaki et al., 2008; Hammond and Lichtner, 2010). However, some insight on future conditions is possible based on modeling efforts, which will be helpful during the remedial action alternative evaluation process.

### 13.2.2 Interim Remedial Action Monitoring

Groundwater monitoring required under the 1996 ROD is implemented via a sampling and analysis plan (DOE/RL-2002-11), which has been modified several times. Samples are collected from wells, and in the 300 Area, samples are collected from aquifer tubes beneath the shoreline. Comprehensive sampling events occur semiannually, with more frequent sampling occurring when conditions change rapidly and/or major excavation activities are underway. Most monitoring wells have screens positioned to include the zone occupied by the water table. Several wells are screened in the lower portion of the unconfined aquifer, and a few wells are screened in the uppermost confined aquifer.

During the latter part of 2010, wells and aquifer tubes were not sampled as planned between late September and the end of the year due to a work shutdown related to safety issues. Additional minor exceptions to planned monitoring occurred due to maintenance issues and scheduling compromises. Lists of wells and aquifer tubes used for monitoring and the laboratory analyses conducted on groundwater samples are presented in Appendix A.

Additional environmental monitoring along the 300 Area shoreline, as described in the 300-FF-5 OU operation and maintenance plan, is conducted under the Surface Environmental Surveillance Project (SESP), which is part of DOE's Public Safety and Resource Protection Program (DOE/RL-91-50, *Environmental Monitoring Plan*). The SESP monitors potential contamination in riverbank springs (water and sediment), near-shore river water, and the free-flowing stream of the Columbia River; the project also performs limited biota sampling. The schedule and locations for SESP monitoring for calendar year 2011 will be described in an upcoming PNNL environmental monitoring report.

### 13.2.3 Treatability Tests for Uranium Contamination in the Subsurface

The DOE's remedial action objective for 300 Area groundwater is to reduce the concentration of dissolved uranium to less than the DWS. One strategy is to transform dissolved uranium to a less mobile form that is sequestered in aquifer sediment. A second strategy involves transforming contaminant uranium remaining in the vadose zone to even less mobile forms, thus reducing the downward flux to groundwater.

Bench-scale testing using polyphosphate solutions to immobilize uranium in the subsurface began in 2006 under DOE's Environmental Management program. The process involves introducing polyphosphate and calcium chloride to groundwater contaminated by uranium. Minerals are formed that cause the dissolved uranium to be sequestered in solid form as part of the new minerals crystal structure, thus reducing the potential for further migration along environmental pathways. Following successful bench-scale testing, field testing involving the injection of polyphosphate into the aquifer at a site near the south end of the former 300 Area Process Trenches was performed in 2007 (see Figure 13-19 for the location of testing). While the chemical reactions worked well in the laboratory, application in the field proved more challenging because of heterogeneous sediment and geochemical conditions

*Groundwater monitoring includes use of wells screened at various depths in the contaminated aquifer and aquifer tubes along the 300 Area shoreline.*

*Application of polyphosphate solutions is being tested for reducing concentrations of uranium dissolved in groundwater.*

*The DOE supports several basic and applied research activities that focus on uranium contamination beneath the 300 Area, including the IFRC test site.*

(PNNL-17480, *Challenges Associated with Apatite Remediation of Uranium in the 300 Area Aquifer*). A final report on the aquifer injection test conducted in 2007 is presented in *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report* (PNNL-18529). Additional treatability testing using polyphosphate solutions began in 2009 and continued into 2010 at a second test site, focusing on immobilizing uranium in the vadose zone (DOE/RL-2009-16, *300-AF-5 Groundwater Operable Unit Infiltration Test Sampling and Analysis Plan*).

#### **13.2.4 Research Activities**

The DOE's Office of Science, Biological and Environmental Research, is supporting field research involving the mobility of uranium in the environment under a program referred to as the Integrated Field-Scale Research Challenge (IFRC). The focus of the research is multi-scale, mass-transfer processes that control the sequestration and mobility of uranium contamination in the subsurface, including the vadose zone and groundwater. The Hanford Site 300 Area is one of three DOE sites where field and laboratory research activities are being performed. The activities at the Hanford Site are described in the *300 Area Integrated Field-Scale Subsurface Research Challenge (IFRC) Field Site Management Plan* (PNNL-17067). A detailed description of the 300 Area IFRC site's network of boreholes for experiments and the hydrogeologic setting is presented in *Borehole Completion and Conceptual Hydrogeologic Model for the IFRC Well Field, 300 Area, Hanford Site* (PNNL-18340). The location of the IFRC is shown in Figure 13-19.

Other DOE Office of Science projects include geophysical investigations of the aquifer beneath the 300 Area and the connection of the aquifer to the river channel. This investigation uses a variety of near-surface geophysical methods to characterize preferential pathways for groundwater movement and discharge to the river channel. One of the methods uses fiber optic cables on the riverbed, which record temperature at 1-meter increments along the length of the approximately 1-kilometer-long cable. The results and interpretations are presented in "Use of Electrical Imaging and Distributed Temperature Sensing Methods to Characterize Surface-Water/Groundwater Exchange Regulating Uranium Transport at the Hanford 300 Area, Washington" (Slater et al., 2010).

The DOE has also funded a groundwater flow and uranium transport modeling project for the 300 Area via the Scientific Discovery Through Advanced Computing Program. This project involves massively parallel, high-speed computing and conducts calculations that would otherwise require exceedingly long computing times with conventional computer equipment. Initial project results are presented in "Field-Scale Modeling for the Natural Attenuation of Uranium at the Hanford 300 Area Using High Performance Computing" (Hammond and Lichtner, 2010) and "Stochastic Simulation of Uranium Migration at the Hanford 300 Area" (Hammond et al., 2010).

### **13.3 Facility Monitoring: 300 Area Process Trenches**

#### **D.C. Weekes**

The former 300 Area Process Trenches (waste site 316-5) 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 December 1994. During this period of operation the trenches were used as a TSD facility, therefore the trenches are regulated under RCRA. A comprehensive

description of the facility and its history of operations is provided in *300 Area Process Trenches Groundwater Monitoring Plan* (PNNL-13645). The trenches were remediated in 1991 under a CERCLA expedited response action by scraping contaminated soil to the north end of the facility (DOE/RL-92-32, *Expedited Response Action Assessment for 316-5 Process Trenches*). Additional removal actions were performed in 1997 and 1998, followed by backfilling and surface restoration in 2004 (DOE/RL-2004-74).

### 13.3.1 Network Evaluation and Compliance Status

Groundwater is monitored under the requirements of the RCRA for hazardous waste constituents and under the *Atomic Energy Act of 1954* for uranium. Groundwater monitoring required by RCRA is conducted in accordance with WAC 173-303-645(11) (“Dangerous Waste Regulations,” “Releases from Regulated Units”) and the *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste, 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 300-FF-5 OU under CERCLA.

Post-corrective action monitoring under RCRA uses wells 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 meters to the southeast, along the dominant groundwater flow path from the facility. Groundwater flows generally toward the south-southeast beneath the former trenches. Estimates for flow rates in March 2009 ranged from 0.20 to 20 meters per day (Appendix B, Table B-1).

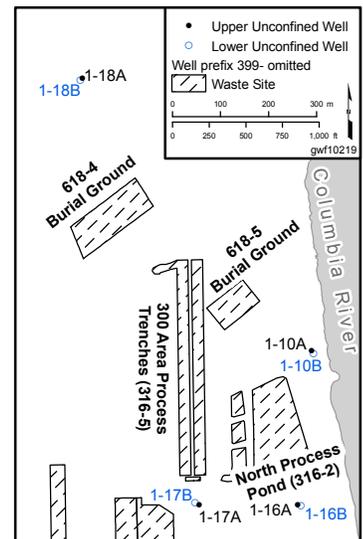
Two wells are present at each of the four locations, with one well screened near the water table and the second well screened in the lower portion of the unconfined aquifer. The sampling schedule for the eight wells is designed to accommodate two semiannual sampling events, with four time-independent samples collected during each period to provide data amenable to statistical analysis. The schedule results in sampling during 8 months of the year: the first sampling event covers December, January, February, and March, and the second sampling event covers June, July, August, and September. The intervening months at the water table wells are sampled under the CERCLA program, thus obtaining a continuous record of monthly measurements.

During 2010, sampling was performed as planned, except as noted in wells 399-1-10B, 399-1-16B, and 399-1-17A (Appendix B, Table B-16). Reports on the effectiveness of the corrective action monitoring program were prepared semiannually in accordance with WAC 173-303-645(11)(g). The results for 2010 are provided in *Results of Groundwater Monitoring for the 183-H Solar Evaporation Basins and 300 Area Process Trenches, January – June 2010* (SGW-47971) and *Results of Groundwater Monitoring for the 183-H Solar Evaporation Basins and 300 Area Process Trenches, July – December 2010* (SGW-49268).

### 13.3.2 Groundwater Contaminants

Groundwater monitoring to meet RCRA requirements is conducted based on the *Groundwater Monitoring Plan for the 300 Area Process Trenches* (WHC-SD-EN-AP-185), which has been in effect since 1997. The dangerous waste constituents monitored under this plan include trichloroethene and tetrachloroethene, as well as their potential environmental degradation products cis-1,2-dichloroethene

***The former 300 Area Process Trenches have been remediated. Groundwater impacted by past disposal to the trenches continues to be monitored under RCRA and CERCLA requirements.***



and vinyl chloride. Uranium is regulated under the *Atomic Energy Act of 1954*; it is also monitored in samples collected under RCRA and is measured as the total amount in an unfiltered sample. Uranium contamination beneath the 300 Area is also monitored under an extensive CERCLA program (total and periodic isotopic measurements) and in the adjacent river environment under the DOE Public Safety and Resource Protection program (isotopic uranium). Table 13-1 presents a summary of the maximum values observed at each of the eight wells for the four dangerous waste constituents monitored under the RCRA program and uranium monitored under the AEA for the period from 2008 through 2010.

Analytical results for trichloroethene were all below the detection limit of 1 µg/L during 2010, with the exception of two detections in samples from well 399-1-16B (1.4 and 1.1 µg/L) and one detection at well 399-1-17A (0.31 µg/L). Analytical results for tetrachloroethene were all below the 1 µg/L detection limit (the DWS for trichloroethene and tetrachloroethene is 5 µg/L). At well 399-1-16B, which monitors conditions in the lower portion of the unconfined aquifer, cis-1,2-dichloroethene remains at concentrations approximately twice the 70 µg/L DWS, with values ranging from 130 to 170 µg/L during 2010. Concentrations of this compound in other RCRA network monitoring wells ranged from nondetect to 4.8 µg/L. Additional information on the characteristics of VOCs in groundwater beneath the 300 Area is provided in Section 13.1.2.1.

***Cis-1,2-dichloroethene and uranium continue to exceed their respective DWSs at RCRA network wells.***

Uranium concentrations in groundwater during 2010 remained above the 30 µg/L DWS at each of the three downgradient wells screened in the upper portion of the unconfined aquifer, with values ranging from 19.9 to 89 µg/L. Concentrations at wells 399-1-10A and 399-1-16A, which are near the Columbia River, declined in spring and early summer when the river stage was high as a consequence of dilution by river water intruding into the aquifer. Concentrations at upgradient well 399-1-18A are consistent with background levels for saturated Hanford formation sediment and were in the range of 5 to 7 µg/L during 2010. Concentrations in the lower portion of the unconfined aquifer are typically below detection levels, with the exception of detections at well 399-1-16B that were less than 15 µg/L. Additional information on the characteristics of uranium in groundwater beneath the 300 Area is provided in Section 13.1.1.1.

## **13.4 Conclusions and Recommendations**

### **13.4.1 Conclusions**

Uranium in the subsurface at the 300 Area remains the principal COC for the 300-FF-5 OU because concentrations in groundwater exceed the 30 µg/L DWS and the plume has persisted longer than predicted in the early 1990s by the initial RI. Uranium contamination in the vadose zone and unconfined aquifer beneath the 300 Area is the focus of numerous activities described in the work plan for continuing the RI/FS process (DOE/RL-2009-30). Testing of technologies to reduce concentrations in groundwater, as well as research activities to better understand the mobility potential for uranium in the subsurface, continued during 2010.

Tritium in groundwater near the 618-11 Burial Ground is of concern because the concentrations greatly exceed the 20,000 pCi/L DWS and the proximity of the plume to areas of potential withdrawal of groundwater for beneficial use. The processes by which tritium released from materials contained within the 618-11 Burial Ground resulted in a groundwater plume remain uncertain, as does the potential for additional future impacts to groundwater. Computer simulation of this plume indicates that

***The primary groundwater issue for the 300-FF-5 OU RI/FS involves uranium in groundwater beneath the 300 Area.***

concentrations will be below the DWS when the affected groundwater reaches the Columbia River, because of natural attenuation by radioactive decay and dispersion.

Other groundwater contaminants identified during the initial qualitative risk assessment (e.g., nitrate, tritium, and VOCs) for the 300-FF-5 OU have shown relatively constant or decreasing concentration trends or are not associated with waste sites in the 300-FF-1 and 300-FF-2 OUs. Characterization of these contaminants through monitoring and computer simulation will continue to provide information to assist in the selection of final remedial action alternatives.

Contaminant characterization activities in the Columbia River environment adjacent to the 300 Area may provide new information on COPCs with regard to human health and ecological risk. The new information will be factored into conclusions and recommendations presented in the RI/FS report for 300 Area National Priorities List OUs, which has a Tri-Party Agreement target date of December 31, 2011 (Milestone M-015-72-T01).

Groundwater monitoring in the 300-FF-5 OU during 2010 included sampling at monitoring wells (Appendix A, Tables A-17, A-18, and A-19) and aquifer tubes (Appendix C, Table C-9) under CERCLA and RCRA programs, and at several research sites where activities involve groundwater:

- Fifty monitoring wells in use at monthly to annual frequencies in the 300 Area
- Twenty-nine aquifer tubes at multiple depths beneath the shoreline (Appendix C)
- Corrective action monitoring under RCRA at eight wells near the former 300 Area Process Trenches (Appendix B, Table B-16)
- Two research test sites that include groundwater monitoring: (1) the polyphosphate treatability test site near the southern end of the former 300 Area Process Trenches, and (2) the IFRC site at the southwest corner of the former South Process Pond.

### 13.4.2 Recommendations

The path forward for groundwater monitoring in the 300-FF-5 OU will continue to follow the strategies presented in the operation and maintenance plan (DOE/RL-95-73) and its sampling and analysis plan (DOE/RL-2002-11). These plans will be revised based on monitoring results, new insight from research activities and treatability testing, and remedial investigation activities associated with satisfying data needs as presented in the RI/FS work plan (DOE/RL-2009-30).

The third 5-year review of the 1996 ROD for the 300-FF-5 OU will be conducted during 2010 and 2011. The review will be supported by monitoring data gathered during nearly 22 years of sampling since the CERCLA process began. The data will be used to illustrate COPC trends as established under the influence of natural attenuation processes and in response to the remediation of contaminated waste disposal sites, unplanned release locations, and now defunct facilities. Conclusions from the review will complement interpretations being developed as part of the RI/FS and will focus the path forward, which will be presented in a proposed plan (Tri-Party Agreement Milestone M-015-00D), with a due date of December 31, 2012.

The plan for RCRA-regulated, post-corrective action groundwater monitoring near the former 300 Area Process Trenches is out of date. New monitoring wells have been installed in the area under the CERCLA program that may be better located to provide information on conditions near the remediated waste disposal trenches. Extensive historical data indicate that trends are well established, suggesting that a decrease in sampling frequency may be appropriate. With the exception of cis-1,2-dichloroethene at well 399-1-16B, little evidence exists of contaminants potentially associated

***Other COPCs in the 300-FF-5 OU are monitored to establish long-term trends and potential risk to natural resources.***

***The third 5-year review of the 1996 ROD will be conducted during 2010 and 2011 and will be available in 2011.***

***The need for post-corrective action monitoring under RCRA near the former 300 Area Process Trenches should be re-evaluated to avoid duplication with similar activities being conducted under CERCLA.***

with the former trenches having migrated downward to the lower portion of the unconfined aquifer. Also, the origin for the cis-1,2-dichloroethene is not clearly known, with trichloroethene (and later tetrachloroethene) used extensively in the fuels manufacturing process. However, large volumes of waste effluent associated with fuels manufacturing were routinely disposed to the North and South Process Ponds, with the volume decreasing following shutdown of the last production reactors in 1971. Reducing uncertainties regarding the origin and extent of the contamination observed at well 399-1-16B is included as part of the renewed RI under CERCLA.

**Table 13-1. Maximum Observed Concentrations for 300 Area Process Trenches  
Waste Indicators in Groundwater, 2008 Through 2010**

Well Names (RCRA Network)	Tetrachloroethene (µg/L)	Trichloroethene (µg/L)	cis-1,2-Dichloro- ethene (µg/L)	Vinyl Chloride	Uranium, Total (µg/L)
<b>Upper Confined Aquifer (water table, saturated Hanford gravels)</b>					
399-1-10A	U	U	U	U	54*
399-1-16A	U	U	U	U	85*
399-1-17A	U	0.3	0.2	U	116*
399-1-18A	U	U	U	U	7
<b>Lower Portion of Unconfined Aquifer (Ringold unit E gravelly sediment)</b>					
399-1-10B	U	U	4.5	U	0
399-1-16B	U	1.4	190.0*	U	16
399-1-17B	U	U	5.7	U	U
399-1-18B	U	U	U	U	0

Notes: Data in this table were obtained via query of the Hanford Environmental Information System database for the period January 1, 2008, through December 31, 2010, using the Data View and Evaluator (DaVE) interface. Maximum values are shown, when detected.

\* Exceeds the EPA drinking water standard.

U = not detected in sample

Figure 13-1. Index Map Showing 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units

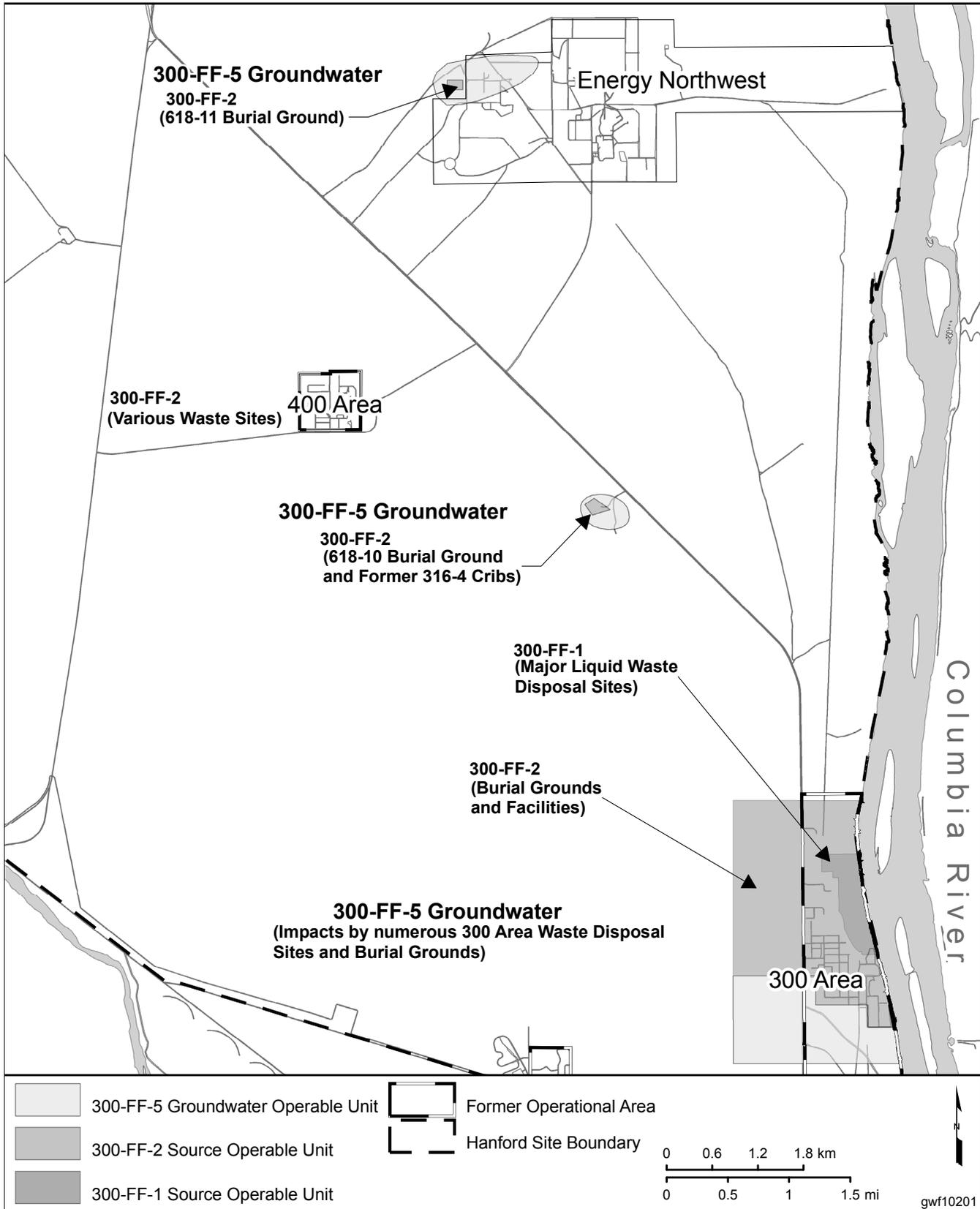




Figure 13-3. Monitoring Wells Near 618-11 Burial Ground

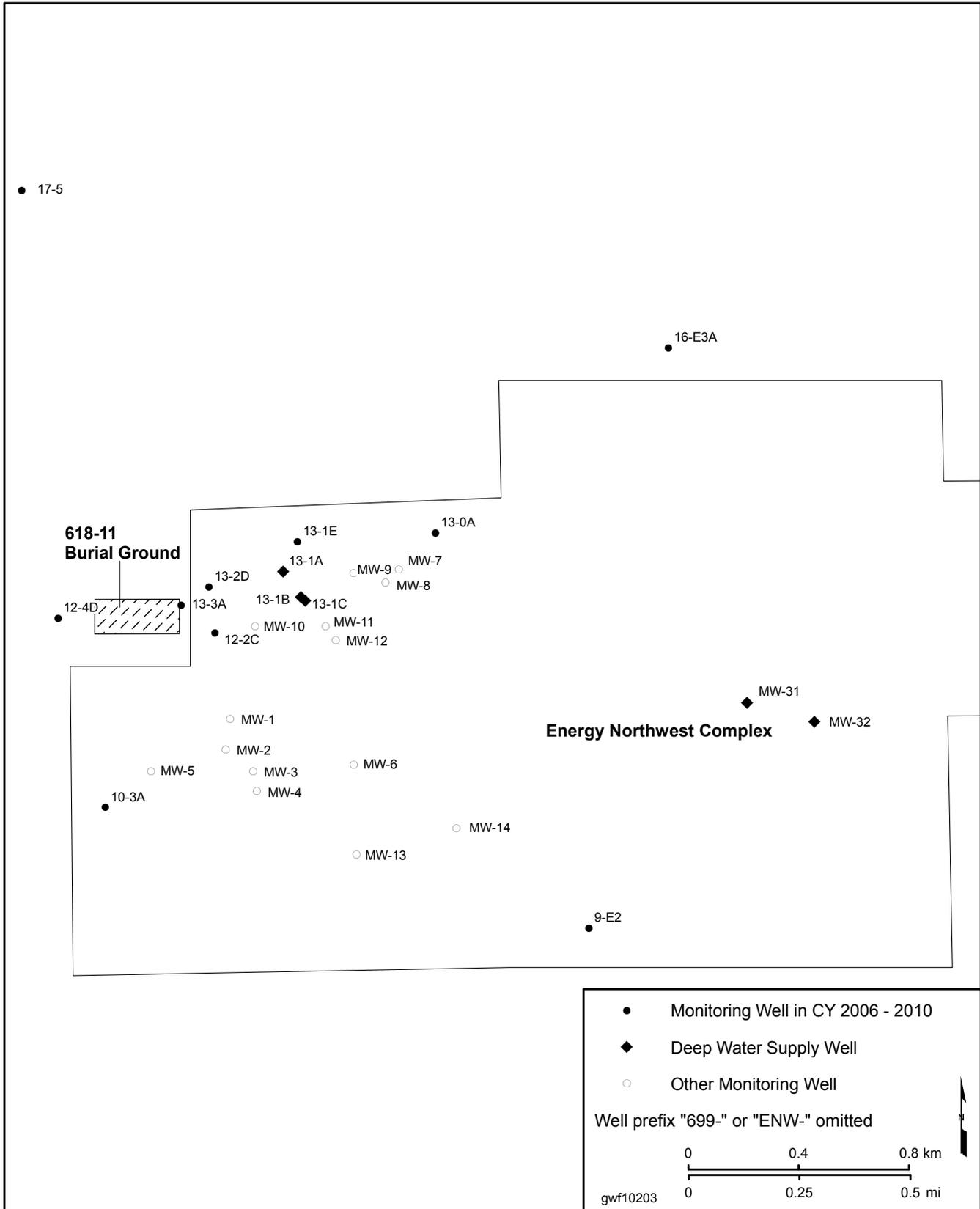


Figure 13-4. Monitoring Wells Near 618-10 Burial Ground

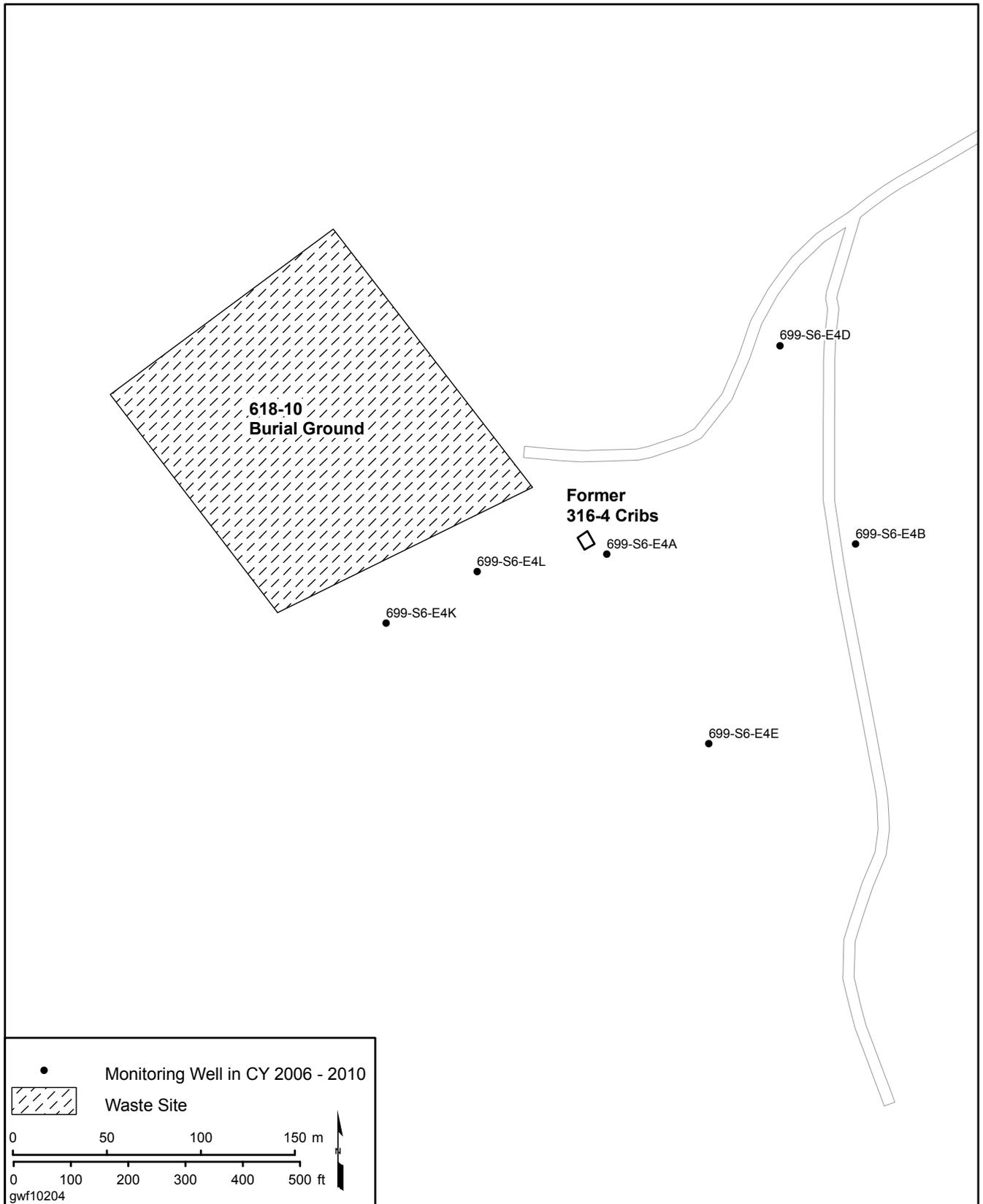


Figure 13-5. Water Table Elevation Map for Region Containing the 300-FF-5 Operable Unit

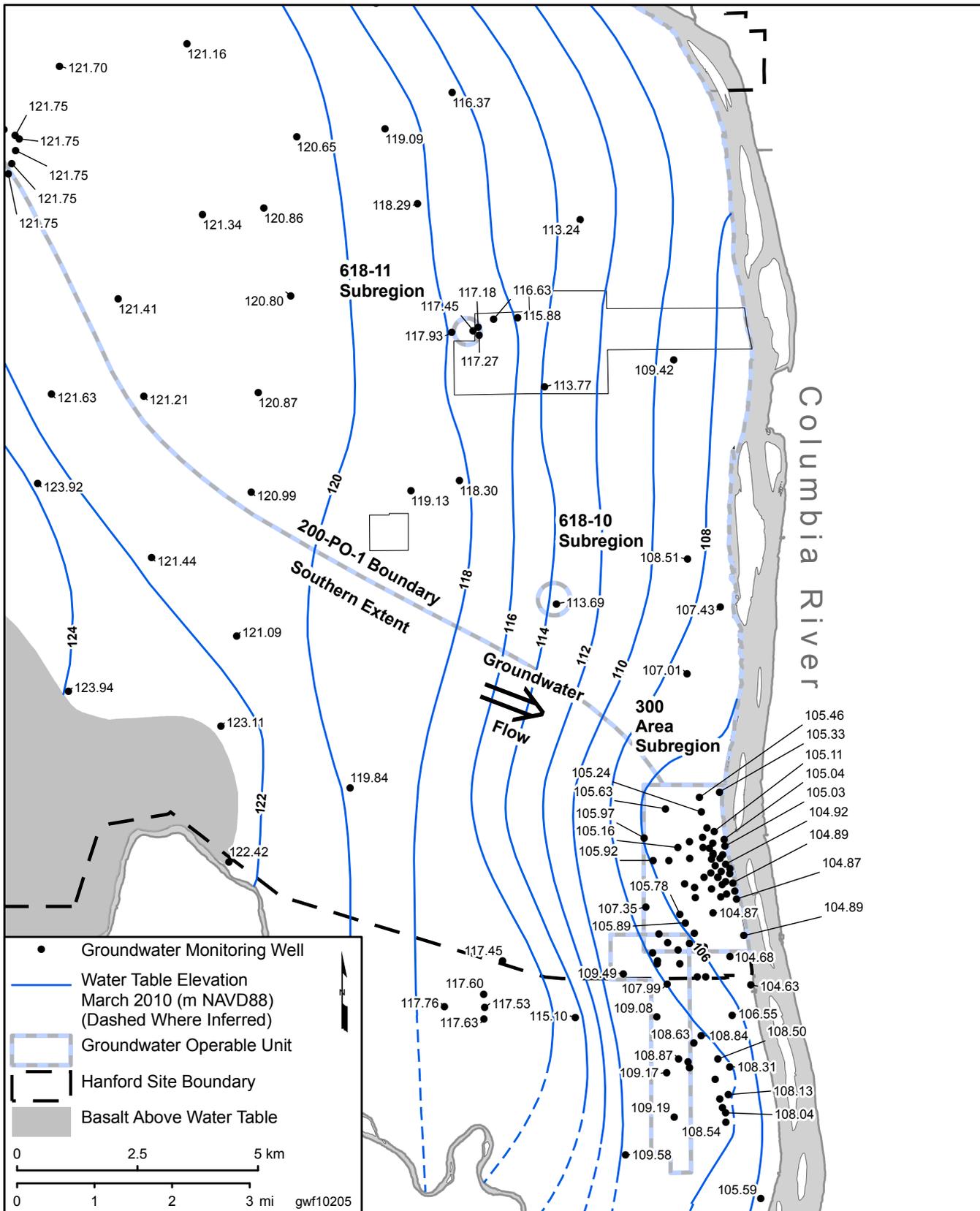


Figure 13-6. Index Map to the Hydrogeologic Cross Sections Illustrating Aquifer Beneath the 300 Area

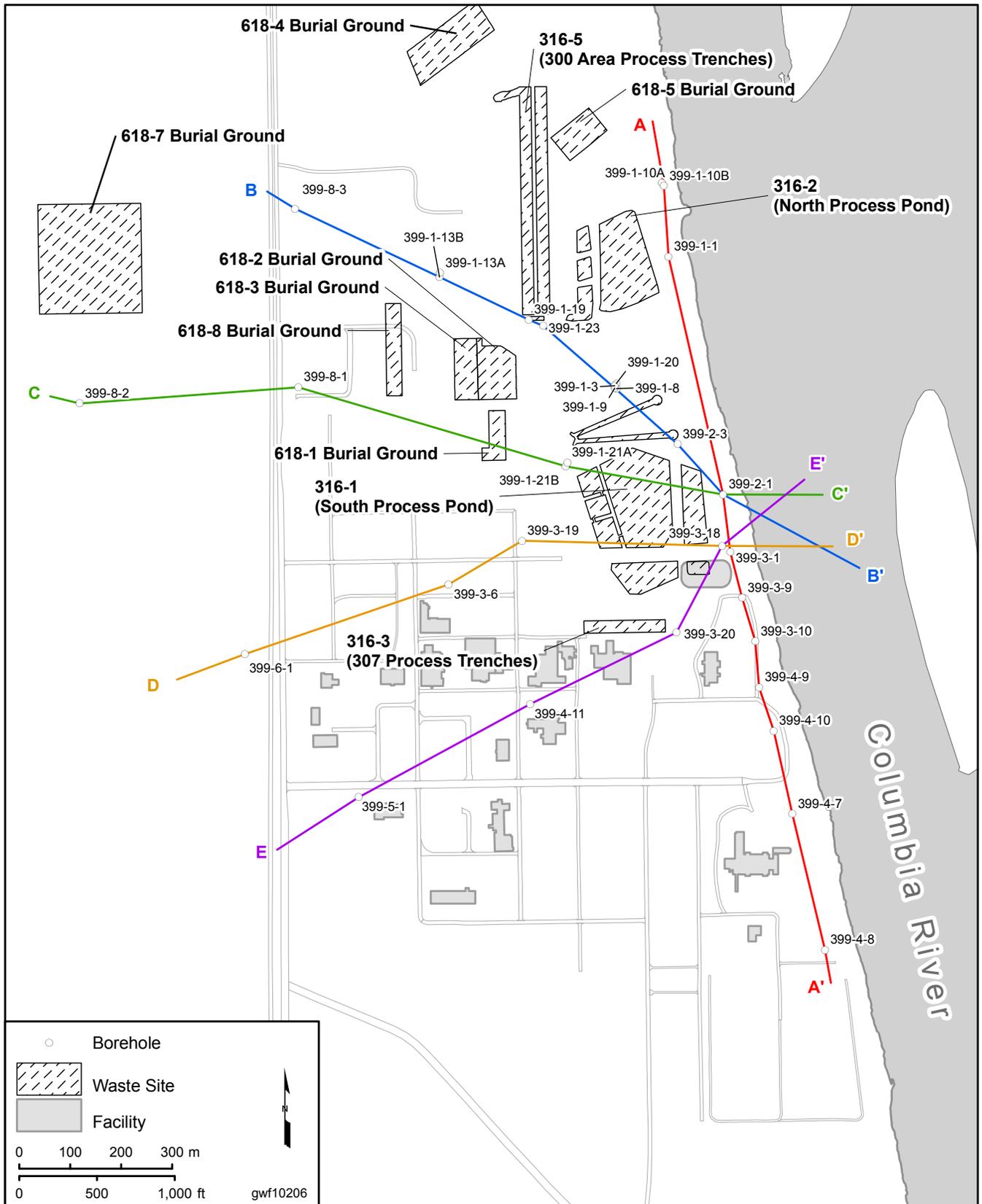
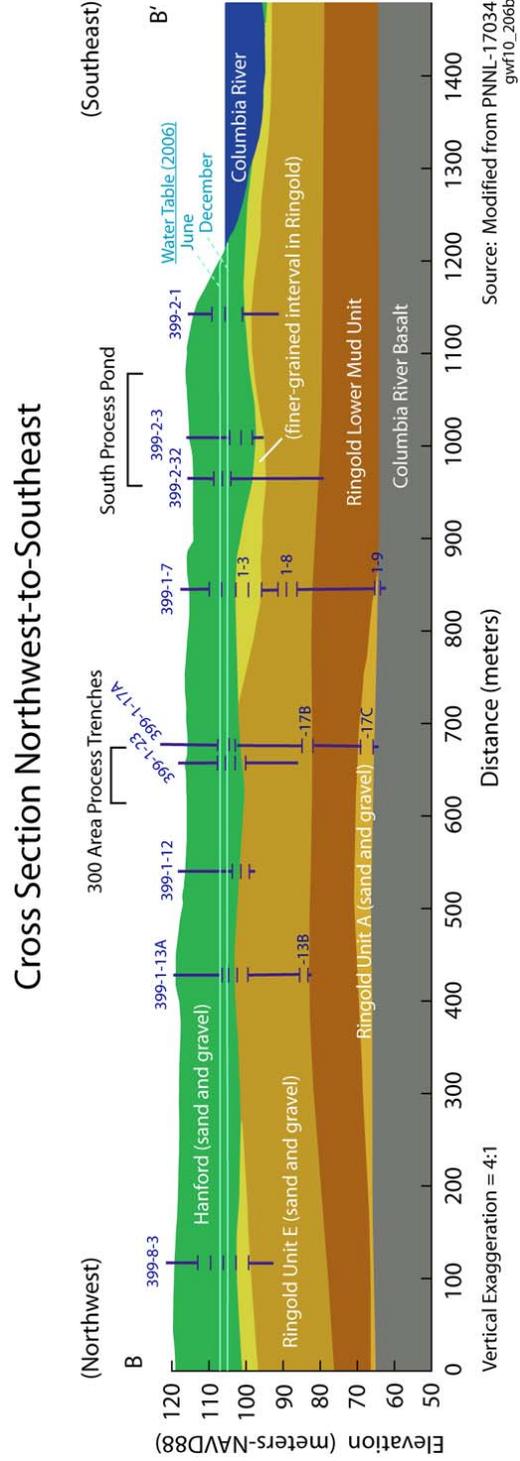
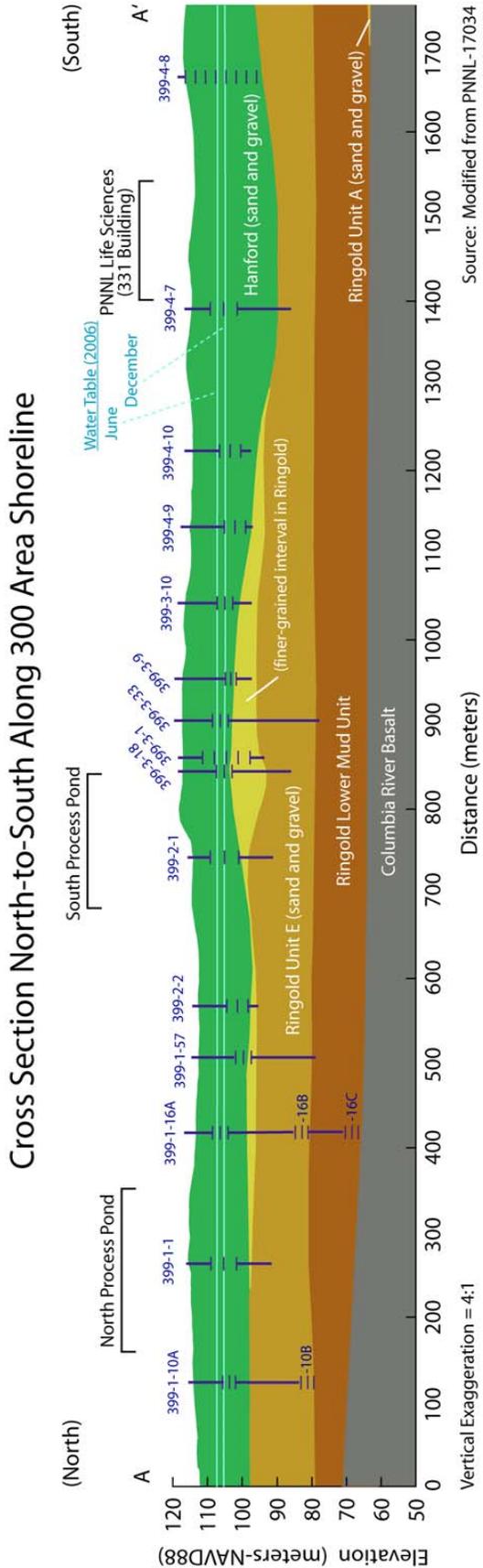


Figure 13-7a and b. Hydrogeologic Cross Sections Illustrating Aquifer Beneath the 300 Area



**Figure 13-8. Uranium Concentrations in Groundwater Near Former 300 Area Process Trenches**

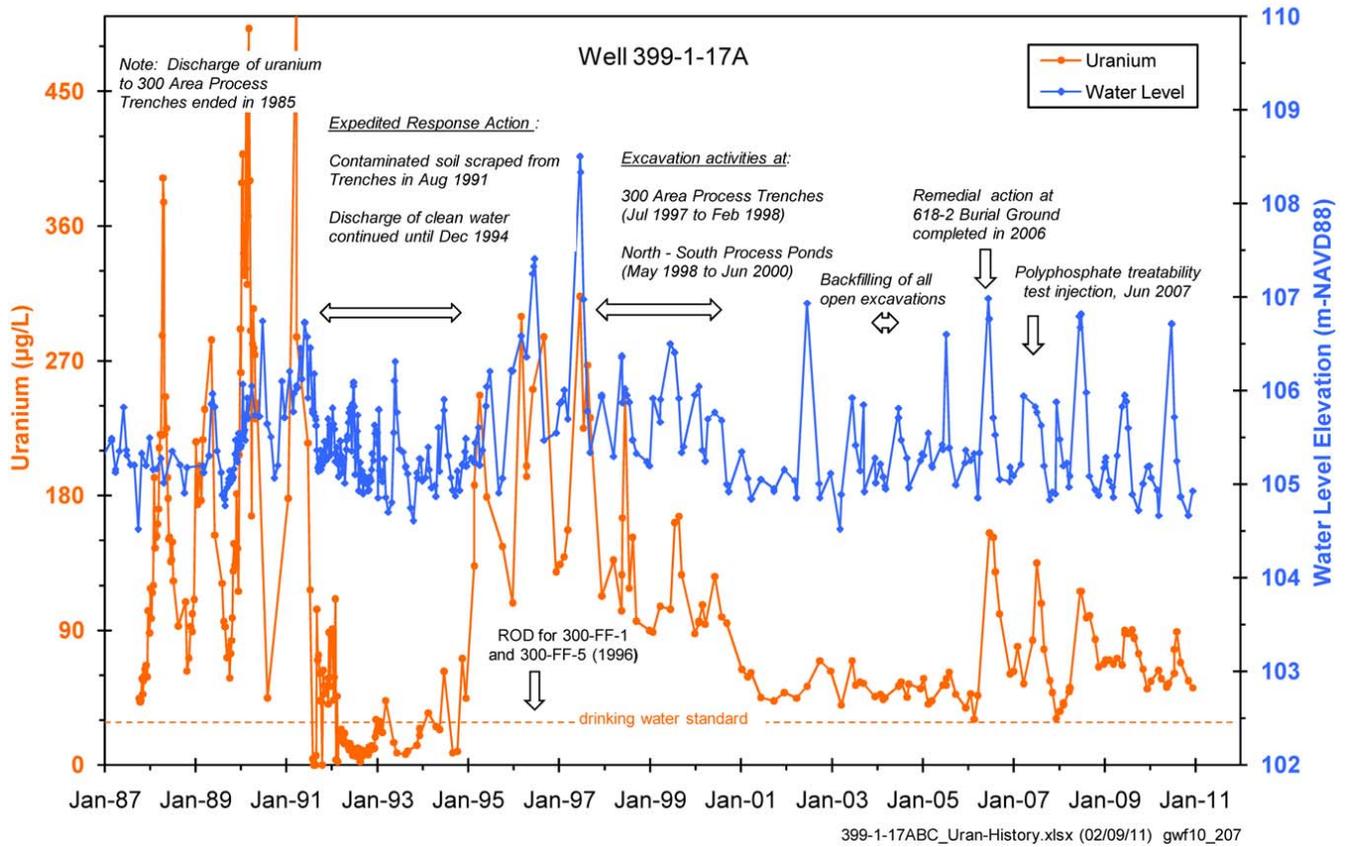


Figure 13-9. Uranium Plume in Groundwater Beneath 300 Area, June 2010

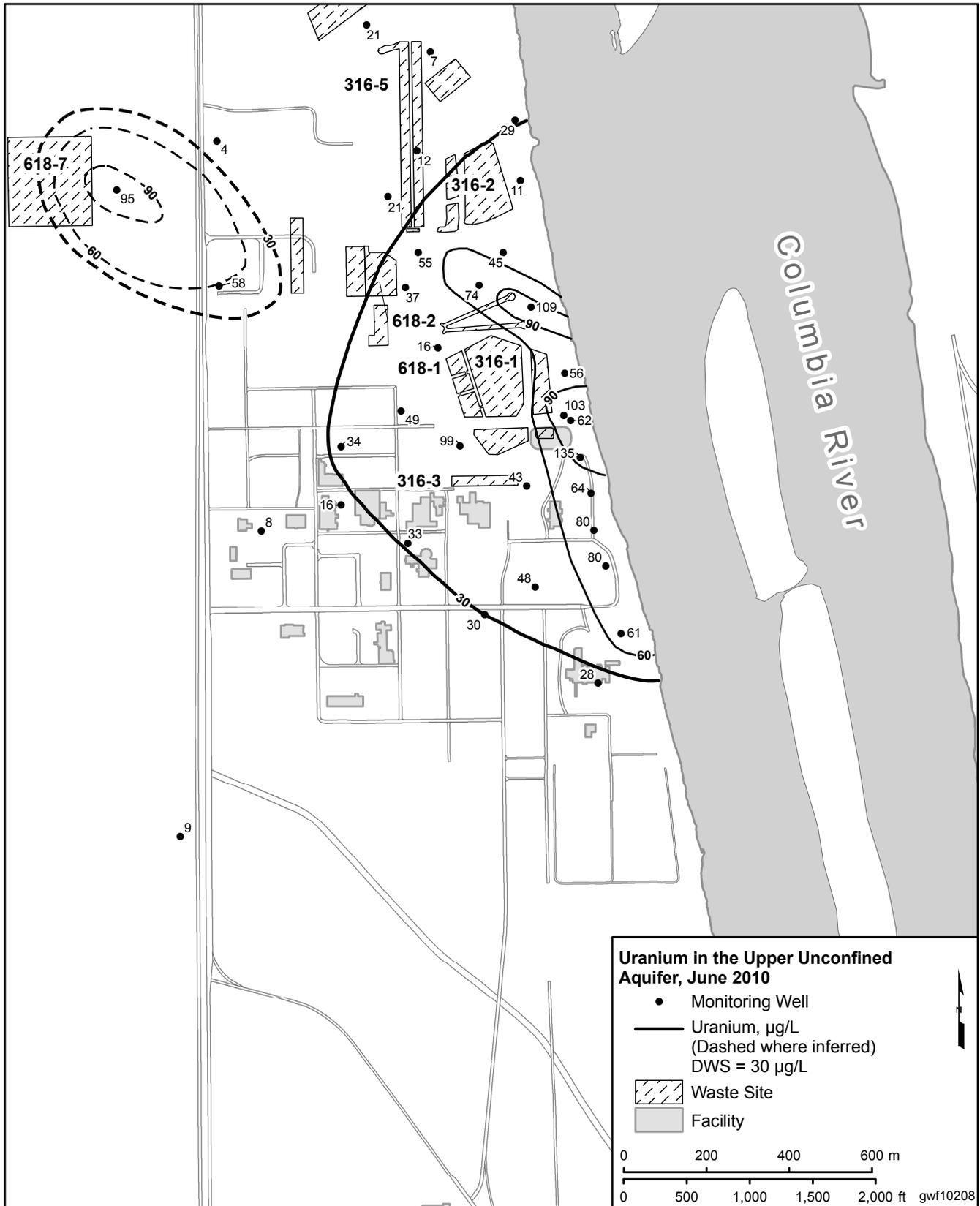
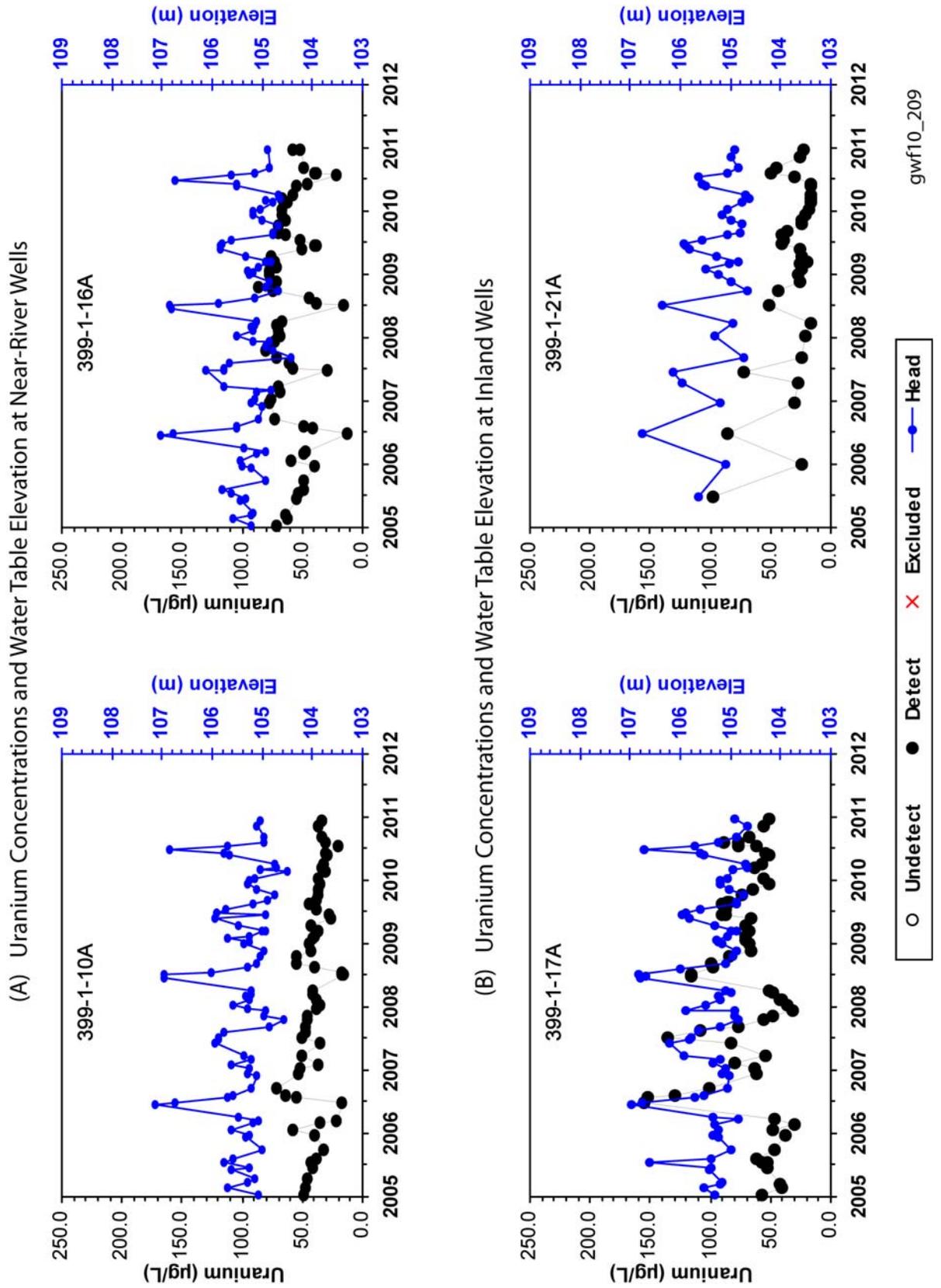


Figure 13-10. Uranium Concentration Trends and Water Levels at (A) Near-River Wells and (B) Inland Wells, 300 Area Groundwater



**Figure 13-11. Uranium and Chromium Concentration Trends in Groundwater Downgradient from Former 618-7 Burial Ground**

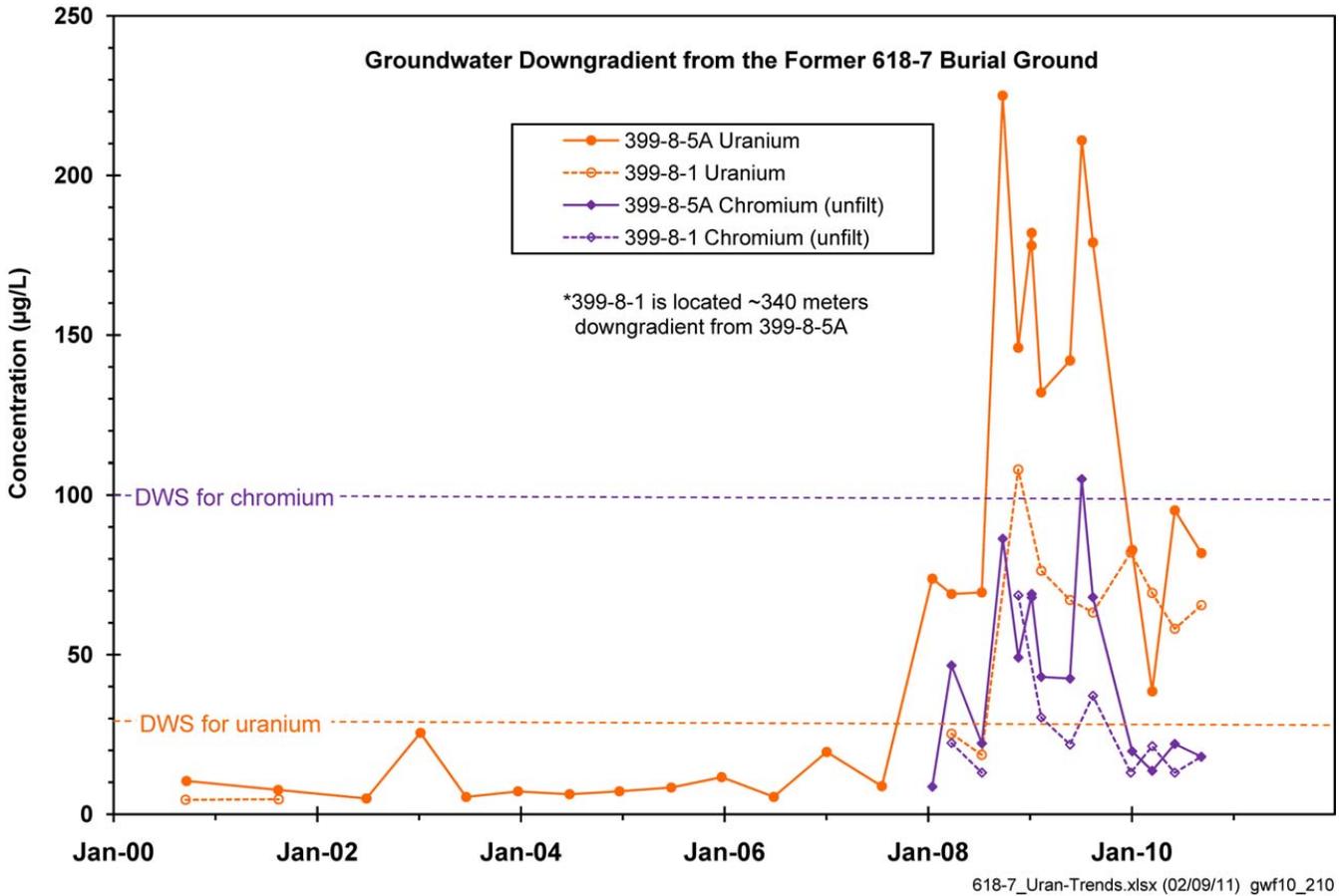
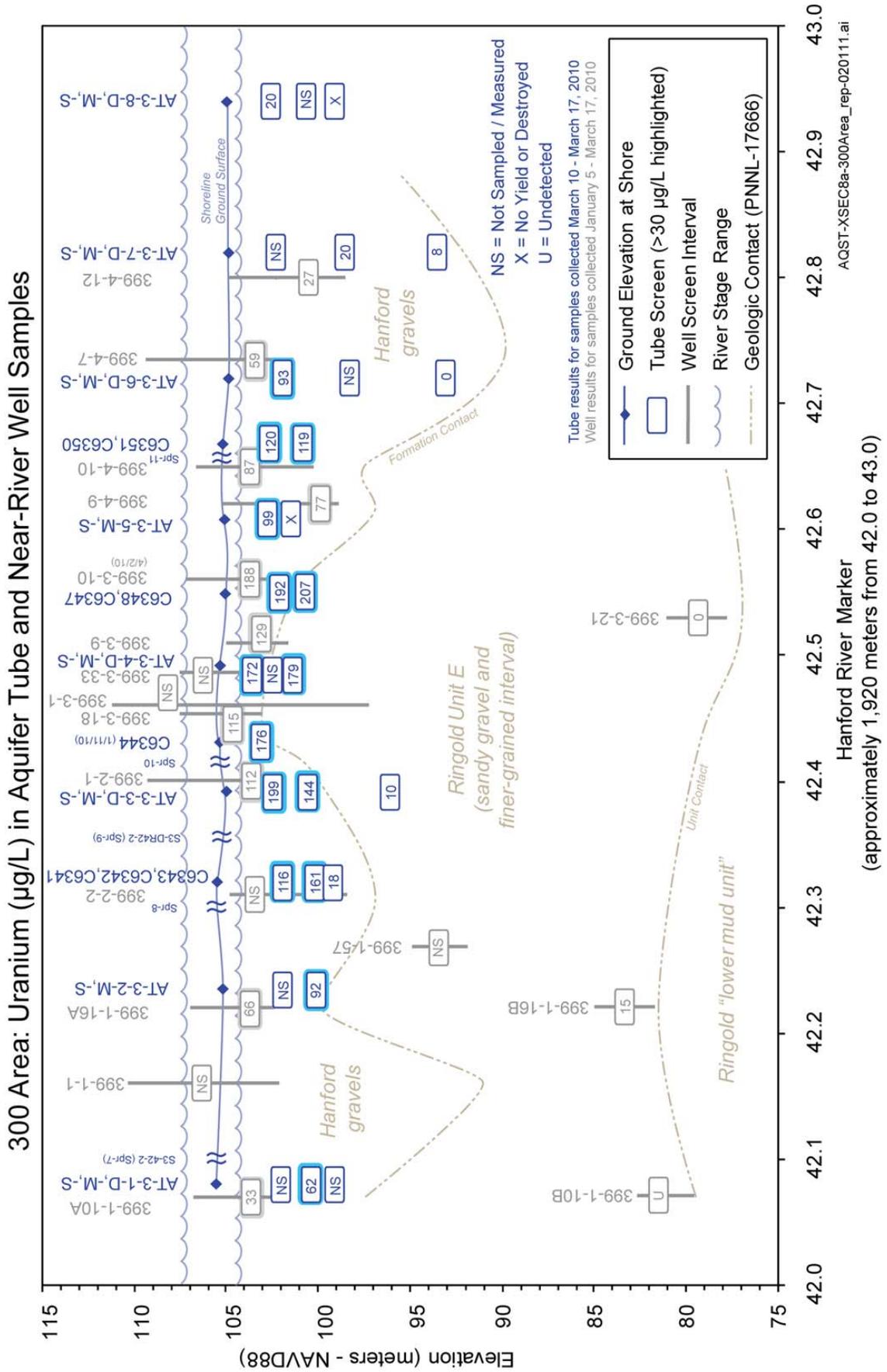


Figure 13-12. Uranium Distribution in Groundwater Beneath 300 Area Shoreline



**Figure 13-13. Uranium Concentration Trends at Wells Adjacent to 618-10 Burial Ground**

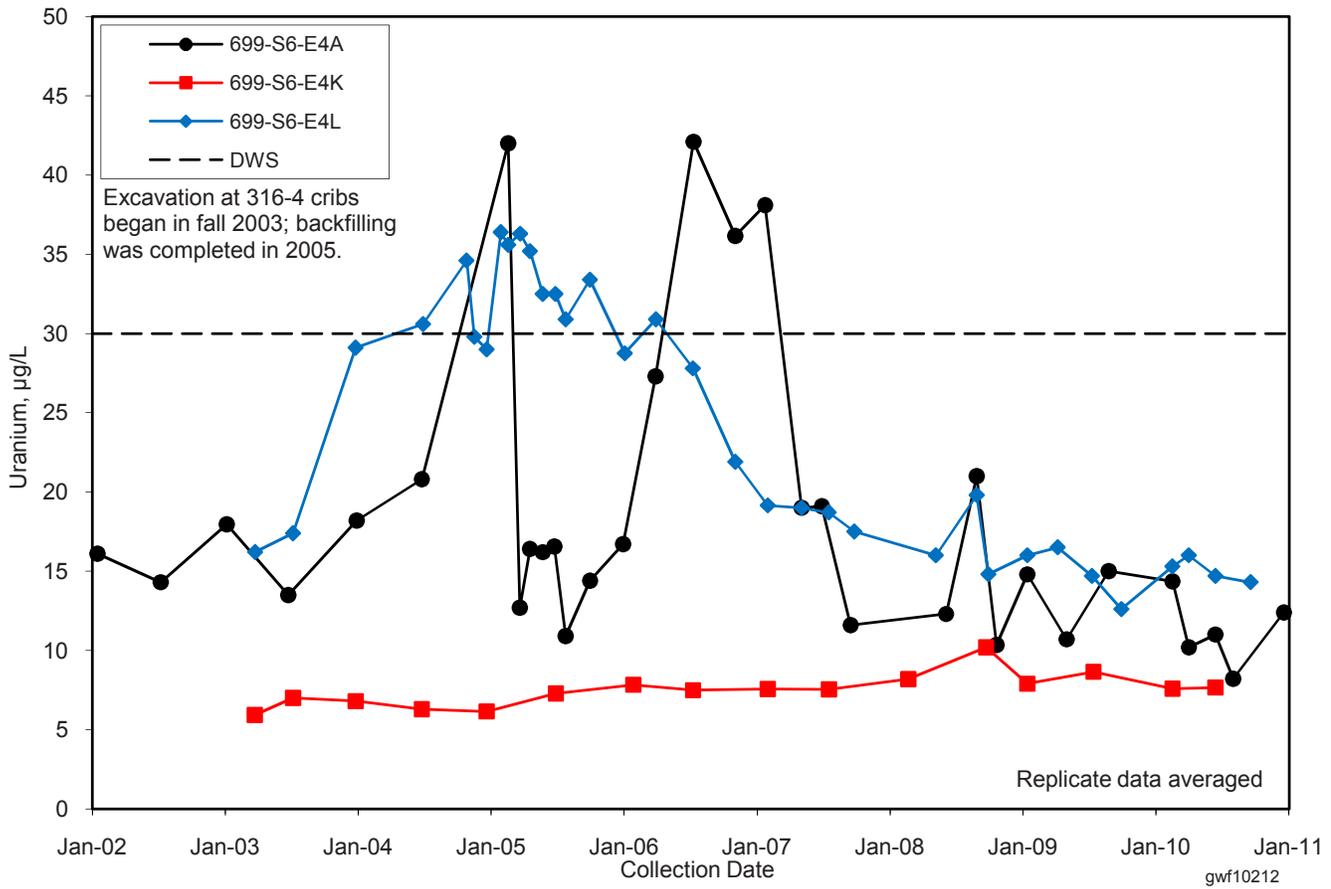
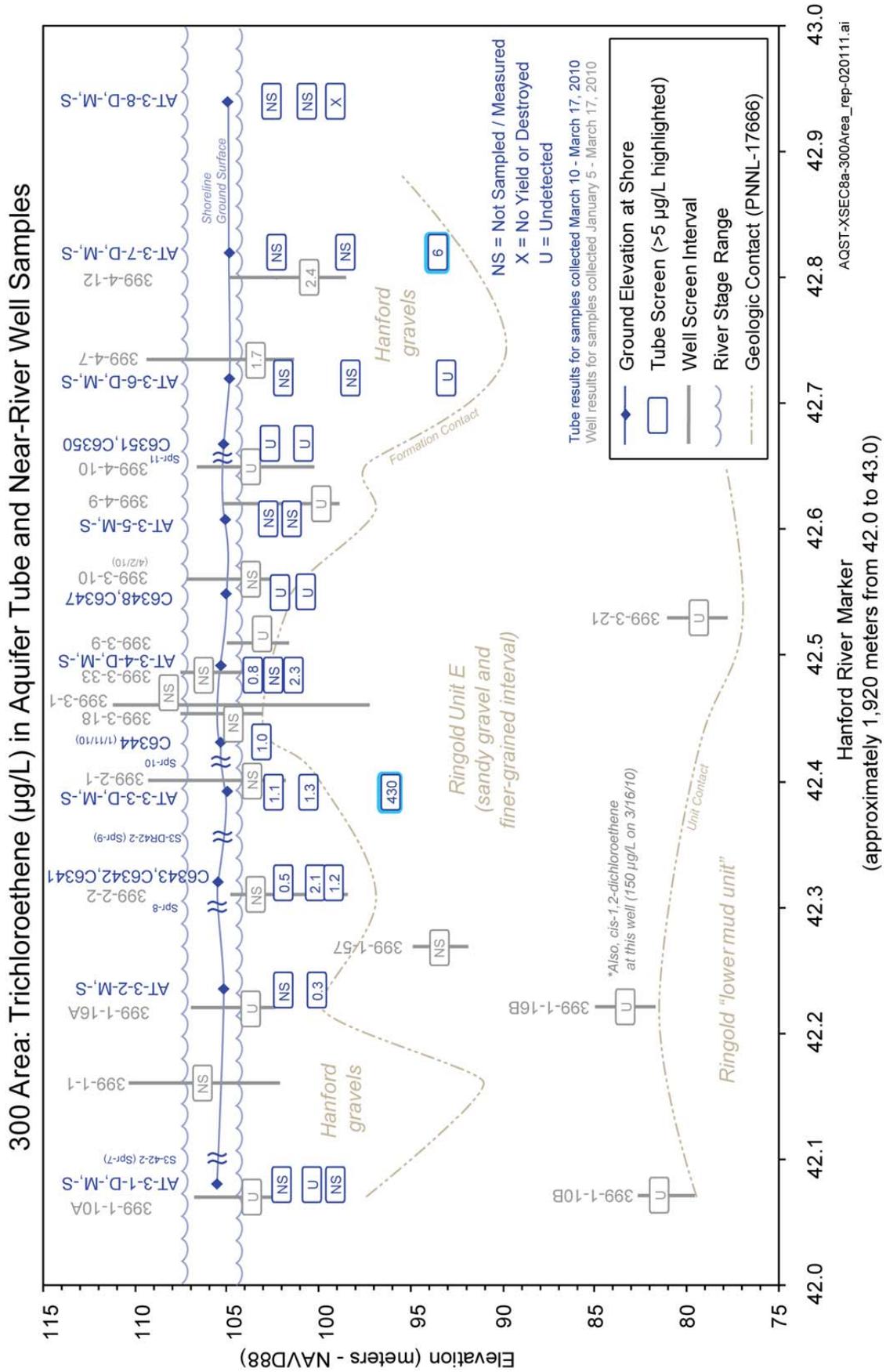


Figure 13-14. Trichloroethene Concentrations in Groundwater Beneath 300 Area Shoreline



**Figure 13-15. Volatile Organic Compound Concentrations in Lower Portion of Unconfined Aquifer at Well 399-1-16B, 300 Area**

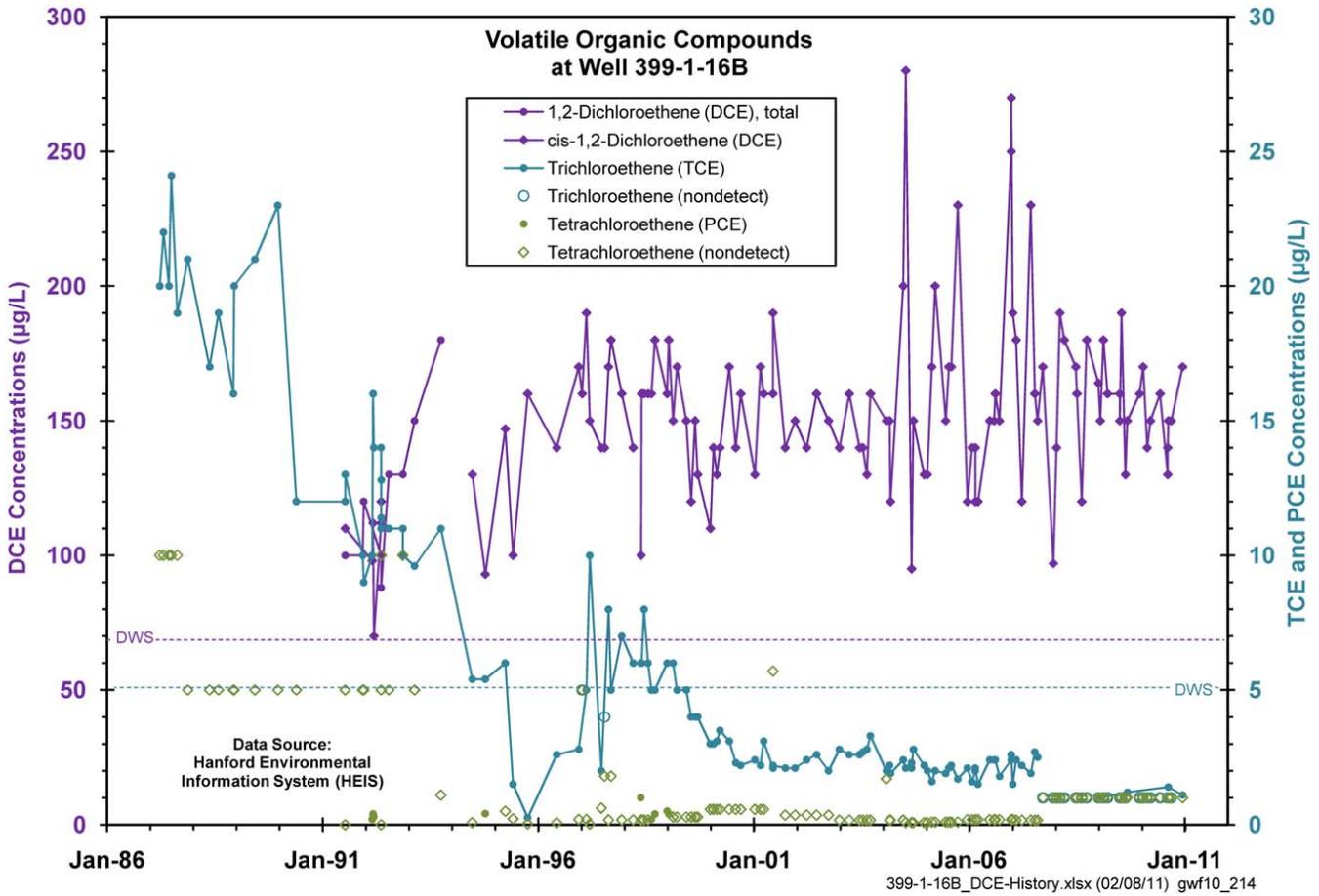
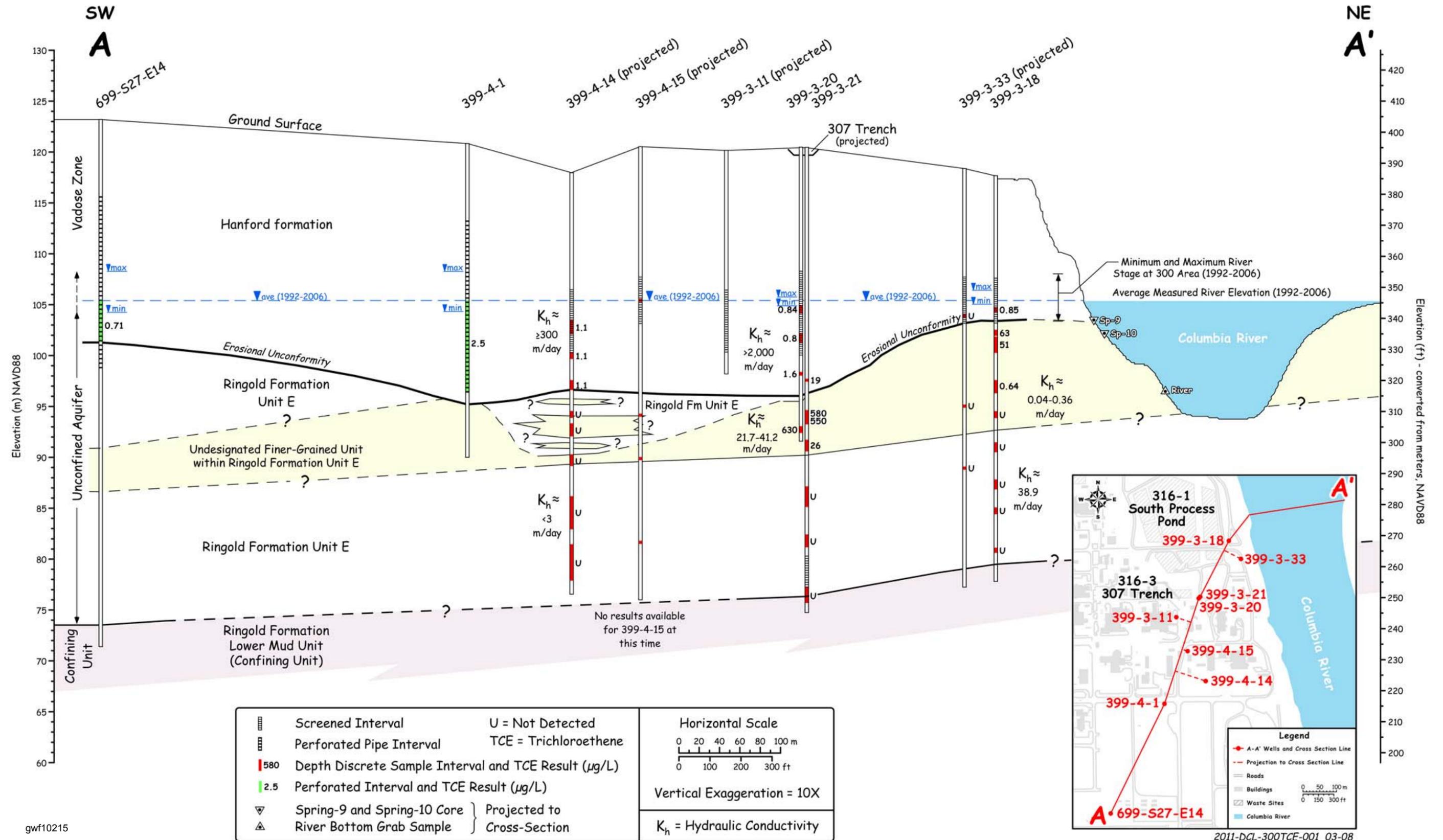


Figure 13-16. Cross Section Showing Volatile Organic Compounds Encountered During Drilling, 300 Area



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Figure 13-17. Tritium Plume in Groundwater Near 618-11 Burial Ground

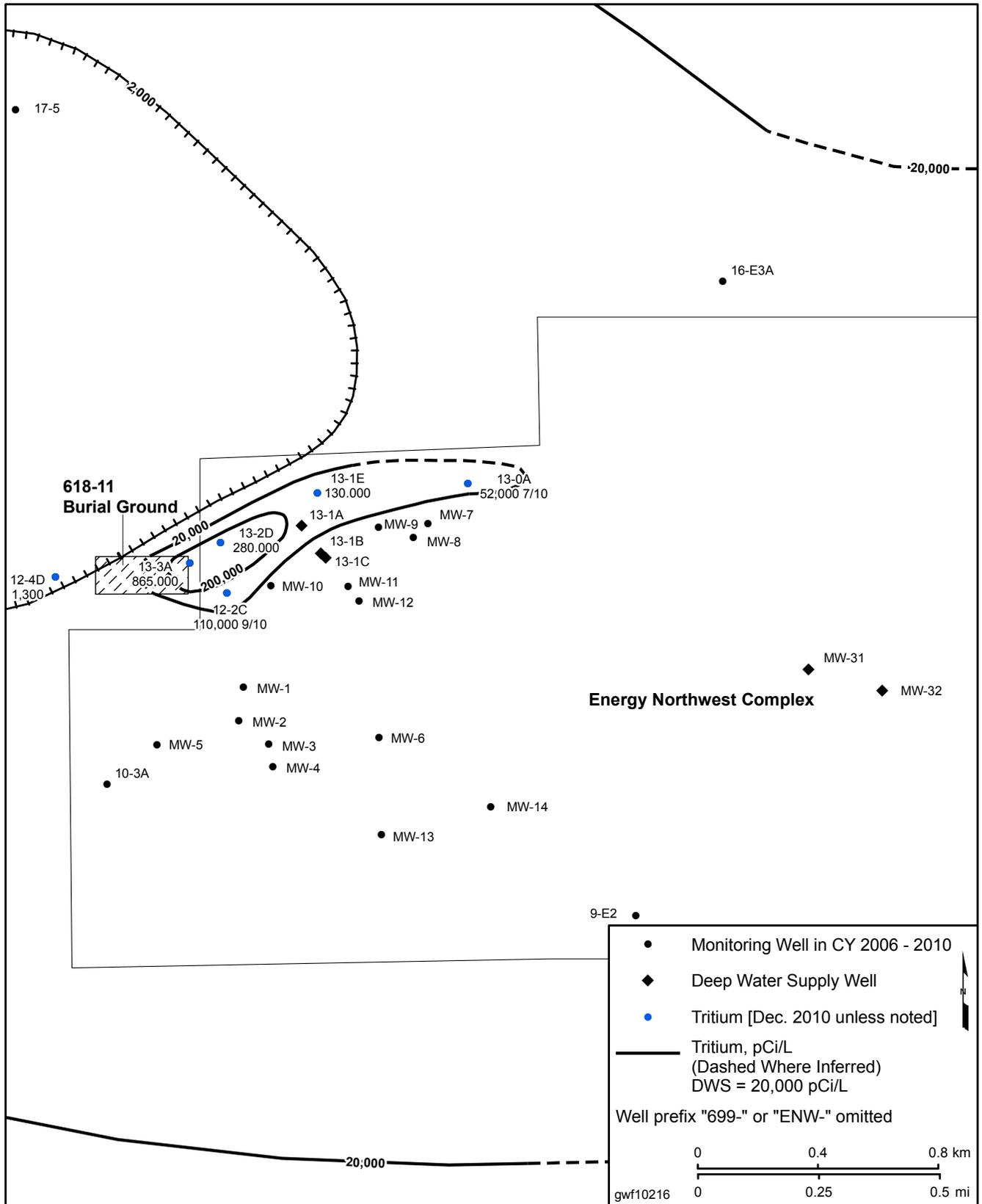
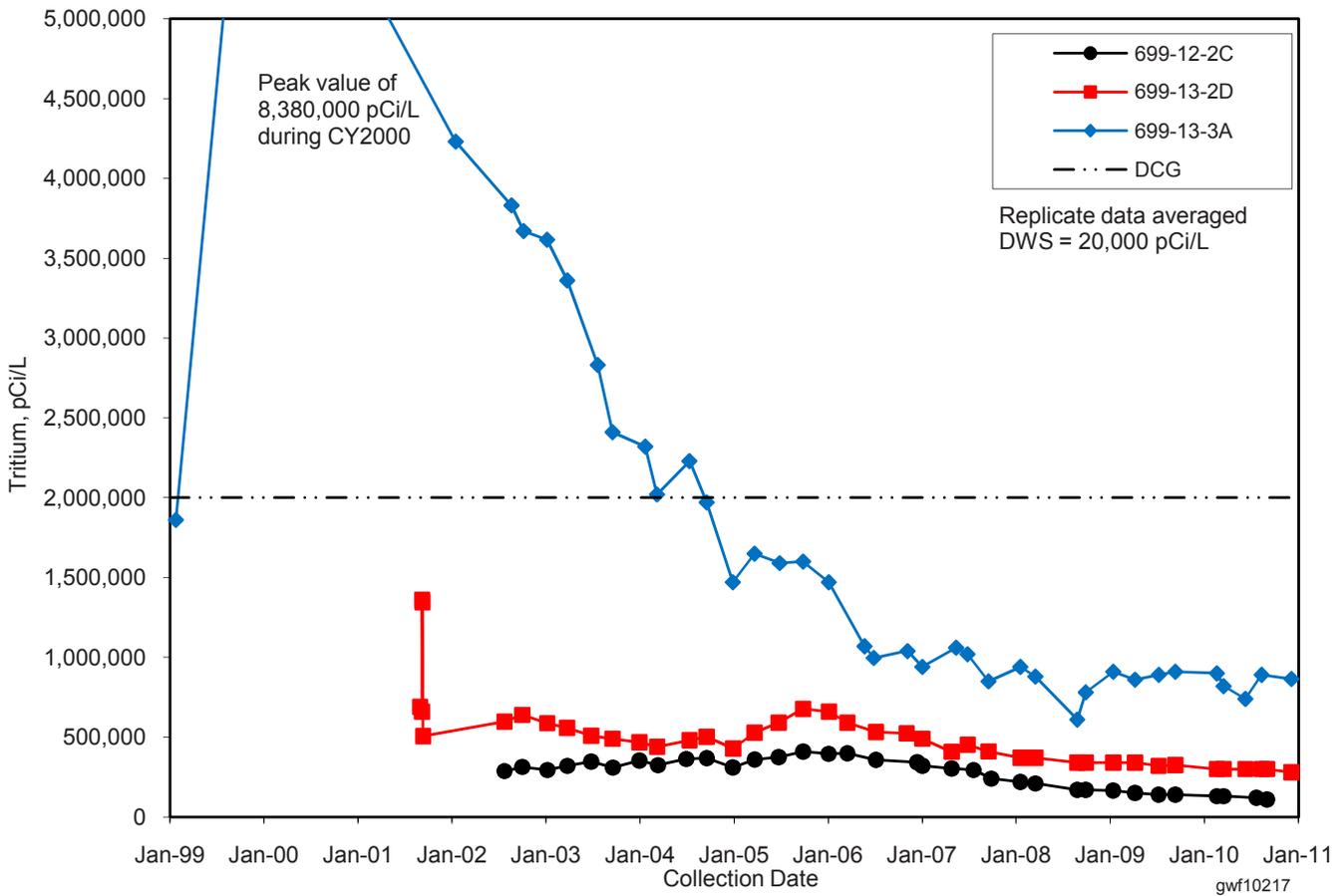
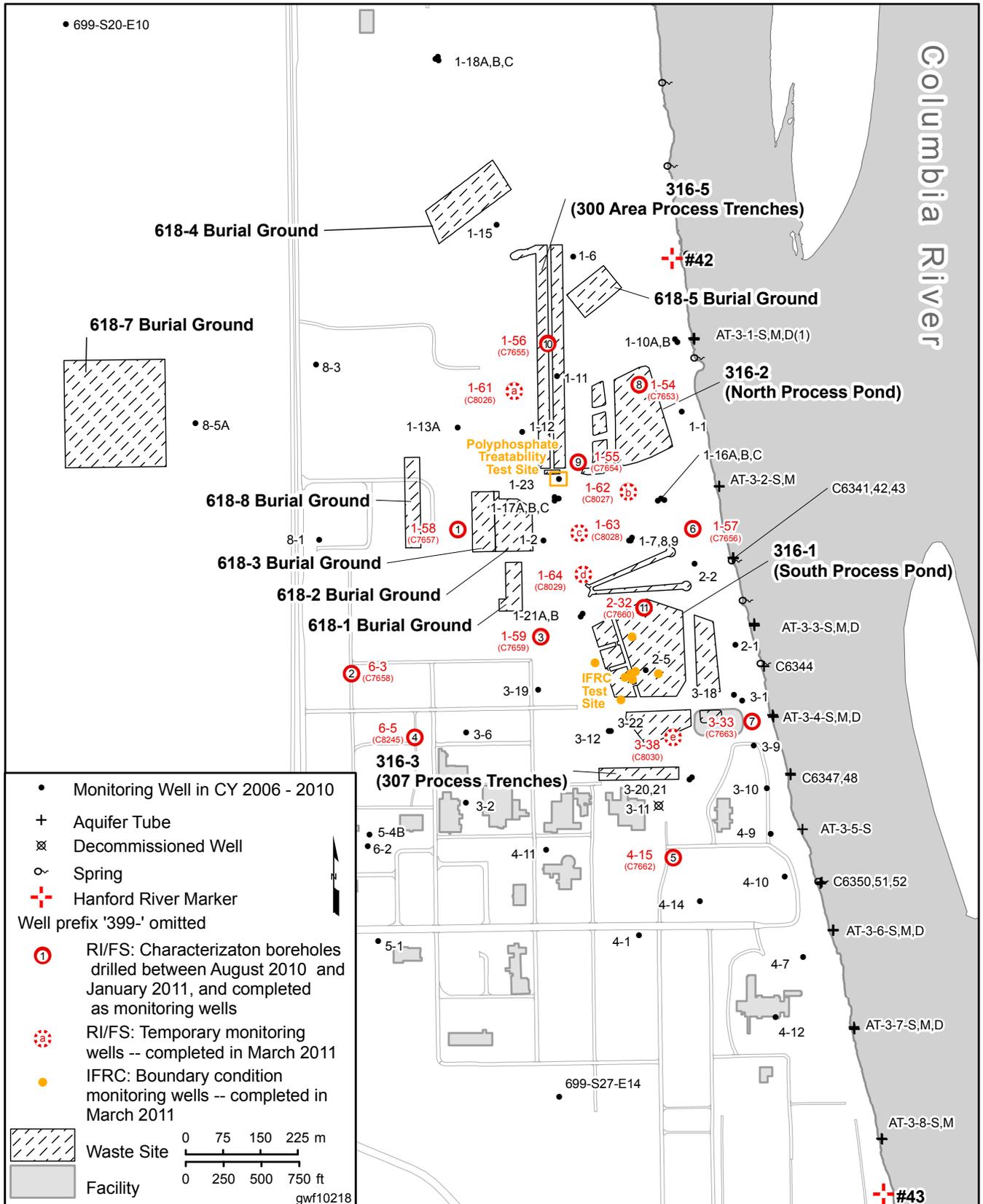


Figure 13-18. Tritium Concentration Trends at Wells Near 618-11 Burial Ground



**Figure 13-19. 300 Area Index Map Showing Remedial Investigation Drilling Locations, Treatability Test Site, and IFRC Site**



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