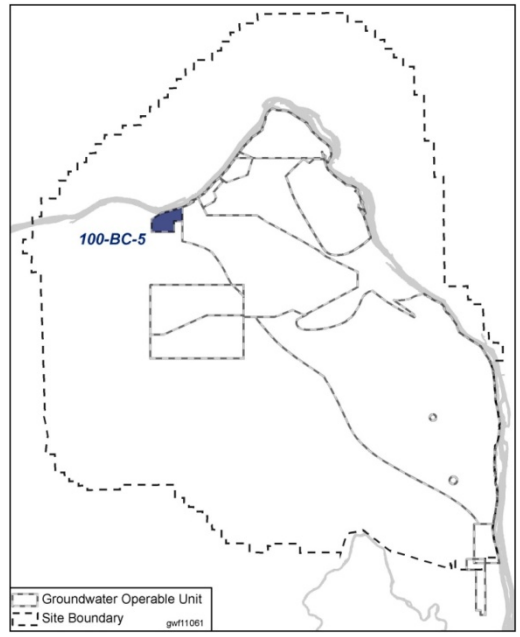
2.2 100-BC-5

M.J. Hartman

This section describes groundwater flow and contaminant distribution in the vicinity of the 100-BC Area, which is known as 100-BC-5. Figure 2.2-1 shows facilities, wells, and aquifer tubes. Groundwater monitoring for the AEA is integrated fully with CERCLA monitoring. No active waste disposal facilities or RCRA sites are in 100-BC-5. Previous assessments have not resulted in any interim remedial measures for groundwater. The area is currently undergoing a CERCLA RI/FS process, which will provide data to support final cleanup decisions. Additional details about 100-BC-5 history and waste sites are provided in Chapters 2 and 3 of DOE/RL-2008-46-ADD3, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 3: 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units*.



Most of the waste sites in the 100-BC Area have been remediated or are classified as not requiring remediation. In 2011, workers continued to excavate the 100-C-7 and 100-C-7:1 waste sites, removing sediment contaminated with hexavalent chromium. These excavations are very large and extend to depths of approximately 24 meters, nearly to the water table (Figure 2.2-2). During excavation, water was sprayed on the excavation to control dust for the protection of workers. Much of this water was subsequently removed from the site during excavation. However, when the holes reached total depth in late 2011, the application of dust-control water had the potential to move remaining contamination into the underlying aquifer.

100-BC-5 at a Glance

Reactor Operations: B 1944–1968; C 1952–1969				
2011 Groundwater Monitoring				
Contaminant	**Drinking Water Standard**	**Maximum Concentration**	**Plume Area[a] (km^2)**	**Shoreline Impact (m)**
Hexavalent Chromium	10/48[b] µg/L	53.5 µg/L	2.4[c]	1,400[c]
Strontium-90	8 pCi/L	36 pCi/L	0.41	280
Tritium	20,000 pCi/L	28,000 pCi/L	0.16	0
Remediation				
Waste Sites (interim action): >90% complete[d].				
Groundwater (interim action): None.				
Final Record of Decision anticipated in 2013.				

a. Estimated area above listed water quality standard.

b. 10 µg/L aquatic standard; 48 µg/L groundwater cleanup standard.

c. At the 10 µg/L level.

d. Waste sites with status of closed, interim closed, no action, not accepted, or rejected.

The vadose zone in 100-BC-5 comprises Hanford formation sand and gravel. The water table is in the lower part of the Hanford formation or in the Ringold Formation unit E. The unconfined aquifer is 32 to 48 meters thick, and the base of the aquifer is the Ringold upper mud unit (Chapter 3 of DOE/RL-2010-96, *Remedial Investigation/Feasibility Study for 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units*, in progress).

Groundwater enters 100-BC-5 from upgradient areas along the Columbia River and the gaps between Umtanum Ridge, Gable Butte, and

Gable Mountain. Groundwater flows primarily to the north-northeast and discharges to the Columbia River (Figure 2.2-3). The water table is very flat in southern 100-BC-5. Effects of recharge from the 182-B Reservoir (used to store river water for the Site-wide water supply), or dust-control water at the 100-C-7 waste site, are not evident in the existing monitoring network. The changing river stage affects groundwater flow seasonally. The river stage was high in June 2011, causing water to flow from the river into the aquifer and the water table to slope toward the south-southwest.

Water levels in monitoring wells vary by as much as 4 meters near the river, and less than 1 meter in the southern part of 100-BC-5, approximately 1 kilometer inland. The changing river stage affects concentrations in near-river wells, but the effects are local and short-lived. Spring and fall 2010 plume maps showed little difference (Chapter 4 of DOE/RL-2011-01).

Routine groundwater monitoring requirements are described in *100-BC-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-38). Wells are sampled for the contaminants of concern selected using the data quality objectives process (PNNL-14287, *Data Quality Objectives Summary Report – Designing a Groundwater Monitoring and Assessment Network for the 100-BC-5 and 100-FR-3 Operable Units*). The contaminants of concern for routine monitoring are strontium-90, tritium, and hexavalent chromium. Most of the wells are sampled once per year or once every other year (Appendix A). Plume maps in this section are based on 2011 average concentrations. Ten wells installed from 2009 through 2011 for the RI/FS are not yet formally incorporated into the groundwater sampling and analysis plan. The wells were sampled annually to quarterly during 2011 (Appendix A).

A subset of 100-BC-5 aquifer tubes is scheduled for annual sampling in the fall of each year. Fall 2011 sampling was partially completed in December 2011. Some tubes could not be sampled because they were submerged or frozen, and sampling was delayed into 2012. Some 100-BC-5 tubes were also sampled in early 2011, delayed from the event scheduled in fall 2010. Appendix D lists sampling dates for the aquifer tubes.

Figure 2.2-4 shows how the sizes of the hexavalent chromium, strontium-90, and tritium plumes have changed since 2003. Some of the apparent changes in plume area were the result of new sampling locations and not an actual change in size. These changes are discussed in the following sections.

2.2.1 Hexavalent Chromium

Sources of hexavalent chromium included cribs near the reactor buildings, trenches, and retention basins near the Columbia River (e.g., 116-B-1, 116-B-11, 116-C-1, and 116-C-5), and pipelines from the reactor buildings to these near-river facilities. During remediation activities in recent years, additional chromium sources were identified in the 100-BC Area: the 100-C-7 and 100-C-7:1 sites and associated pipelines in the south, and the 100-B-27 sodium dichromate spill site in the northwest.

Figure 2.2-5 illustrates the portion of the plume with concentrations greater than 10 µg/L, based on 2011 average concentrations in wells screened in the upper portion of the unconfined aquifer. Hexavalent chromium concentrations are much lower than in the 100-K or 100-D Areas; concentrations typically exceed the 48 µg/L groundwater cleanup standard only in well 199-B3-47 (although the 2011 average concentration in that well was 44 µg/L, below the standard). The area of the plume above 10 µg/L is slightly smaller than in 2010, based on trends of declining concentrations in wells in western and southern 100-BC-5. Figure 2.2-4 shows the change in the size of the chromium plume over time. The apparent increase between 2006 and 2010 was primarily a result of the installation of new wells, which revealed that the plume in western 100-BC-5 was more extensive than previously thought. The increase between 2010 and 2011 was an artifact of the way the plume map was constructed (computer contouring in 2011 and manual contouring in 2010).

The western extent of the 100-BC-5 chromium plume is not well defined. Concentrations in well 199-B5-5 (screened in the lower part of the aquifer and not shown on the plume map) averaged 38 µg/L in 2011, about the same as in 2010. Concentrations at the top of the aquifer at this location, based

on characterization samples collected in 2009, are >20 µg/L. The only well farther west is 199-B2-13, where concentrations were less than 10 µg/L in 2010 (the well was not scheduled for sampling in 2011). Hexavalent chromium concentrations in aquifer tubes along the western shoreline of 100-BC-5 continued to be below 10 µg/L in 2011.

Two wells in southern 100-BC-5 showed sharp increases in hexavalent chromium concentrations in 2011 and early 2012. These changes may be caused by remediation activities at the 100-C-7 and 100-C-7:1 waste sites. The plume contours of Figure 2.2-5 have been adjusted to account for the apparent contamination beneath these waste sites. Concentrations in downgradient well 199-B4-14, a water-table well, rose to 40 µg/L in October 2011 and 144 µg/L in February 2012 (Figure 2.2-6). East of the waste sites, concentrations temporarily rose to approximately 50 µg/L in well 199-B8-9 in June 2011 (Figure 2.2-7). If these changes were caused by mobilization of hexavalent chromium from the vadose zone during remediation, then it took 1 year or less for the contamination to travel through the vadose zone and aquifer to well 199-B8-9, and no more than 20 months to reach well 199-B4-14. These travel times are shorter than expected, indicating the hydraulic conductivity of the shallow aquifer (Hanford formation) is higher than previously thought. The hydraulic gradient also may have increased because of artificial recharge by dust-control water. However, this effect is not evident in water level data from surrounding wells.

After remediation of the 100-C-7 and 100-C-7:1 sites is completed in 2012, no additional contamination will migrate into groundwater. DOE has increased the frequency of monitoring at well 199-B4-14 and adjacent deep well 199-B5-6 to determine the persistence and magnitude of the effects of remediation.

Two wells in southern 100-BC-5 showed sharp increases in hexavalent chromium concentrations in 2011 and early 2012. These changes may have been caused by remediation activities at the 100-C-7 or 100-C-7:1 waste sites.

The unconfined aquifer in 100-BC-5 is 32 to 48 meters thick, and contaminants are not evenly distributed with depth. Characterization data collected during drilling of the RI wells show that hexavalent chromium concentrations decrease with depth in eastern 100-BC-5 (for example, well 199-B3-51). Monitoring data confirm the characterization results. Shallow well 199-B3-47 typically has the highest chromium concentrations in 100-BC-5 (Figure 2.2-8), while adjacent well 199-B3-51, screened at the bottom of the aquifer, has concentrations near or below detection limits. The sharp dip in chromium concentrations in 199-B3-47 in mid-2011 was caused by inflowing river water when the river stage was high in late June. In western 100-BC-5 (at the locations of 199-B5-5 and 199-B5-6), hexavalent chromium concentrations are highest at the top and bottom of the aquifer and lower in between (Chapter 3 of DOE/RL-2010-96, in progress). The distribution is likely a result of different periods of contaminant release.

Hexavalent chromium contamination appears to be limited to the unconfined aquifer. Deep monitoring wells 199-B2-12 and 199-B2-15 are screened in a water-bearing unit within or beneath the Ringold Formation upper mud unit. Hexavalent chromium concentrations are near or below detection limits in that unit.

Hexavalent chromium concentrations in 100-BC-5 aquifer tubes range from less than detection limits to 35 µg/L and are generally declining. Sampling of Columbia River pore water[1] in 2009 showed

[1] Pore water samples were collected from the riverbed at depths of 30 to 40 centimeters. Aquifer tube depths range from 6 to 25 meters in 100-BC-5.

hexavalent chromium concentrations ranging from less than 2 to 112 µg/L. Two subsequent rounds of pore water sampling did not find such high concentrations, indicating no ongoing, highly-concentrated plume in pore water. Results are described in *Columbia River Pore Water Sampling in 100-BC Area, November 2010* (SGW-49368).

2.2.2 Strontium-90

Liquid effluent containing strontium-90 was disposed to cribs near the reactor buildings, and to cribs, trenches, and retention basins in northeastern 100-BC-5. Figure 2.2-9 shows an interpretation of the plume based on 2011 data. The plume split into two parts in 2011 as strontium-90 concentrations in central 100-BC-5 declined (Figure 2.2-10). Most of the 2011 data from wells near the former B Reactor were below the drinking water standard in 2011, but characterization borehole data from 2010 had higher concentrations. Strontium-90 concentrations in some aquifer tubes adjacent to the plume are near or above the drinking water standard.

Figure 2.2-4 shows how the plume has changed in size. The apparent decrease in size in 2006 reflects a change in interpretation, benefitting from new data. The declines in size in 2010 and 2011 were the result of falling concentrations in central 100-BC-5.

Strontium-90 concentrations in 100-BC-5 groundwater declined between 2009 and 2011, and the plume has decreased in size.

Figure 2.2-11 shows the strontium-90 trends in northern 100-BC-5 near some of the former contaminant sources: 199-B3-47 near the 116-B-11 Retention Basin and 116-B-14 Trench; 199-B3-1 near the 116-B-1 Trench; and 199-B3-46 near the 116-C-1 Trench. These sites have been remediated, although a borehole near the 116-B-14 Trench detected low levels of strontium-90 in the vadose zone (Section 4.2 of DOE/RL-2010-96, in progress). The highest concentrations in groundwater are approximately four times the drinking water standard, and concentrations have declined.

Groundwater samples collected during drilling indicate that strontium-90 contamination in 100-BC-5 groundwater is limited to the upper portion of the unconfined aquifer. Strontium-90 concentrations in well 199-B3-51, screened at the bottom of the aquifer, are below detection limits, while adjacent well 199-B3-47 has concentrations above the drinking water standard.

2.2.3 Tritium

Tritium was present in effluent discharged to former cribs near the B Reactor (for example, 116-B-5 Crib) and near the Columbia River. The former 118-B-1 Burial Ground in the southwestern 100-BC-5 was another source of contamination. All of these waste sites have been remediated. The unconfined aquifer beneath 100-BC-5 is contaminated with tritium at concentrations exceeding the drinking water standard in three areas (Figure 2.2-12). The plume decreased in size between 2010 and 2011 (Figure 2.2-4).

In northern 100-BC-5, tritium distribution formerly was interpreted as one narrow, continuous plume extending from central 100-BC Area to the Columbia River. The 2011 plume map (Figure 2.2-12) depicts tritium in two separate, small plumes because of lower concentrations in intermediate wells.

Tritium concentrations in northern 100-BC-5 have varied widely over the past two decades, but the peaks are declining (Figure 2.2-13). Some of the changes in the 1990s may have been caused by nearby waste site remediation that mobilized contamination, but that does not explain recent spikes. The tritium concentration declined sharply between 2010 and 2011 in 199-B5-2. The sharp decline in the tritium concentration in 199-B3-47 in late June 2011 was caused by an unusually high river stage. The well had not been sampled during the high river stage in previous years. Inflow of river water into the aquifer diluted the groundwater, as evidenced by the low specific conductance of the sample. Tritium

concentrations in aquifer tube 06-M have exceeded the drinking water standard several times in the past, but were below the standard when sampled in March 2011.

In northern 100-BC-5, tritium concentrations have varied widely over the past two decades, but the peak concentrations have declined.

Tritium concentrations in a portion of southern 100-BC-5 are interpreted as exceeding the drinking water standard (Figure 2.2-12), although no 2011 averages from this region exceeded the standard. Wells 199-B8-7 and 199-B8-8 had tritium concentrations above the drinking water standard before the wells were decommissioned in 2010. The tritium concentration in 199-B8-6, located near the 118-B-1 Burial Ground, was above the drinking water standard in the past, but below the standard in 2010 and 2011 (Figure 2.2-14). Tritium concentrations were elevated but below the drinking water standard in deep well 199-B5-6 and its shallow partner 199-B4-14. In well 199-B8-9, farther east, tritium concentrations rose to a level above the drinking water standard in October 2011 (Figure 2.2-14). The pattern of concentration changes in southern 100-BC-5 indicates the plume is gradually migrating toward the east.

Vertical characterization data from recently drilled wells indicate that tritium concentrations decrease with depth in the aquifer in most locations (Section 4.3 of DOE/RL-2010-96, in progress).

2.2.4 Other Contaminants

The 100-BC RI/FS work plan (DOE/RL-2008-46-ADD3) identified an extensive list of groundwater contaminants of potential concern. Evaluation of the RI data concluded that only hexavalent chromium, strontium-90, and tritium remain contaminants of concern (Chapter 6 of DOE/RL-2010-96, in progress).

Nitrate concentrations in most 100-BC-5 wells are below approximately 20 mg/L. Concentrations are higher in well 199-B3-47 in northeastern 100-BC-5, ranging from 29 to 44 mg/L in 2010, which was the last time this well was sampled for nitrate.

In 2010, low concentrations (below 5 µg/L) of trichloroethene and chloroform were detected in 100-BC-5 wells (Section 4.1.5 of DOE/RL-2011-01). Few wells were sampled for organic contaminants in 2011. Chloroform concentrations were all below the 1 µg/L detection limit. Trichloroethene was detected in upgradient well 199-B5-8 at 2.2 µg/L and in 199-B8-9 at 1.1 µg/L. The results are flagged as estimates because they are near the detection limit. The risk evaluation determined that trichloroethene and chloroform were not contaminants of concern (Chapter 6 of DOE/RL-2010-96, in progress).

2.2.5 CERCLA Groundwater Activities

In 2011, CERCLA activities associated with groundwater included continued RI studies and routine groundwater monitoring.

Routine groundwater sampling requirements are defined in DOE/RL-2003-38, as modified by Change Notice for Modifying Approved Documents/Workplans in Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records, 100-BC-5 Operable Unit Sampling and Analysis Plan, DOE/RL-2003-38 Rev 1 (as modified by TPA-CN-240, 12/08/08) (TPA-CN-293). With one exception, well sampling occurred as planned in 2011 (Appendix A). One quarterly sample from new well 199-B2-16 was missed because of restrictions related to electrical work, coupled with dry weeds causing fire danger. The well was successfully sampled the next quarter.

The new wells installed for the RI/FS have been sampled quarterly for one year and will be sampled annually to quarterly, depending on monitoring objectives, in 2012. The routine sampling and analysis plan does not yet include new wells installed for the RI/FS and should be updated.

An RI was performed in 2010 and early 2011 (DOE/RL-2008-46-ADD3). The last two RI monitoring wells (199-B3-51 and 199-B5-8) were drilled and installed in 2011. A draft RI/FS report (DOE/RL-2010-96, in progress) is being prepared, which will lead to the selection of alternatives for site cleanup. The draft report will undergo review by regulatory agencies and the public.

Figure 2.2-1. Facilities and Groundwater Monitoring Wells in 100-BC-5

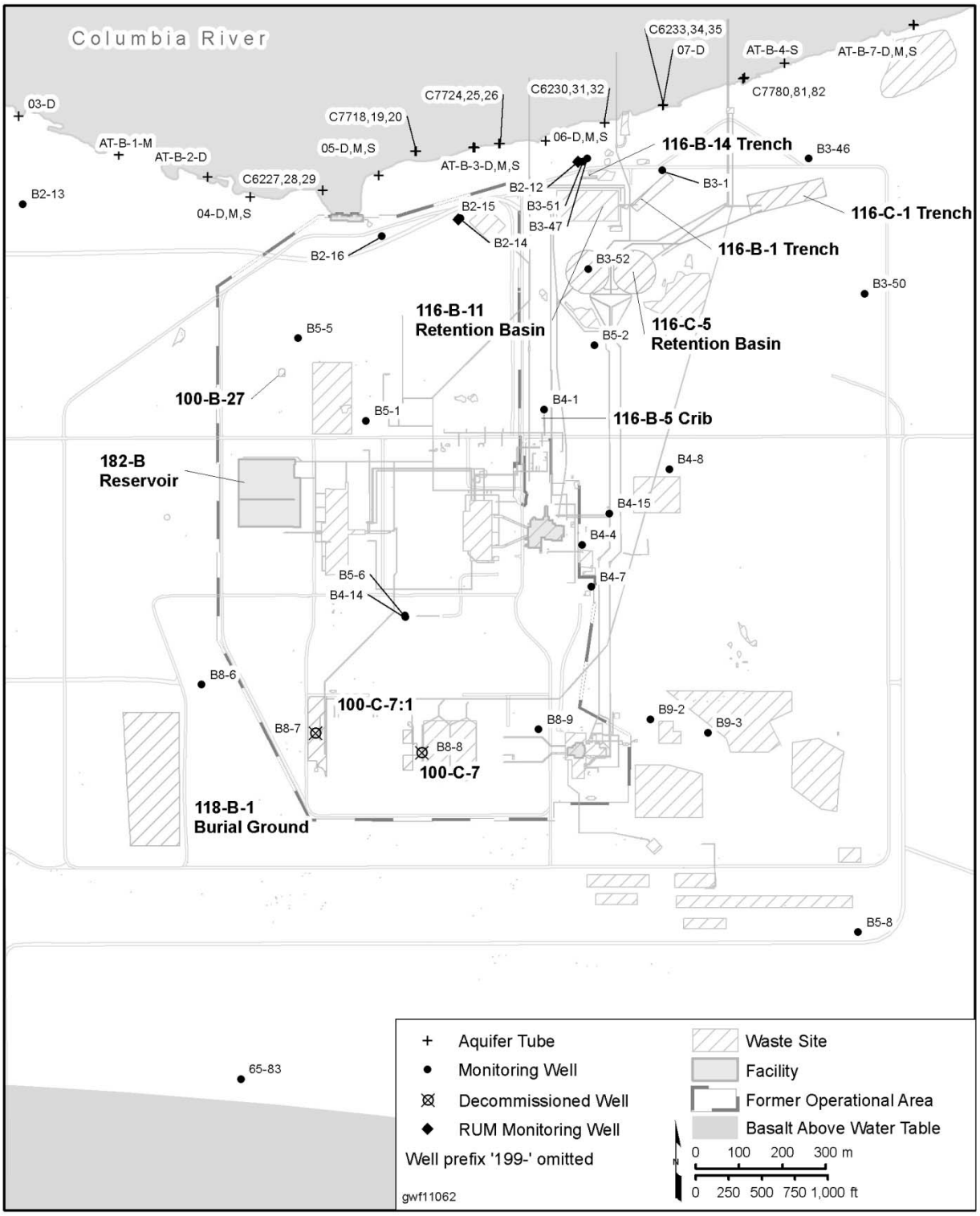


Figure 2.2-2. Aerial Photograph of Excavations at 100-C-7:1 (left) and 100-C-7 (right) Waste Sites, Early 2012

Figure 2.2-3. 100-BC-5 Water Table, March 2011

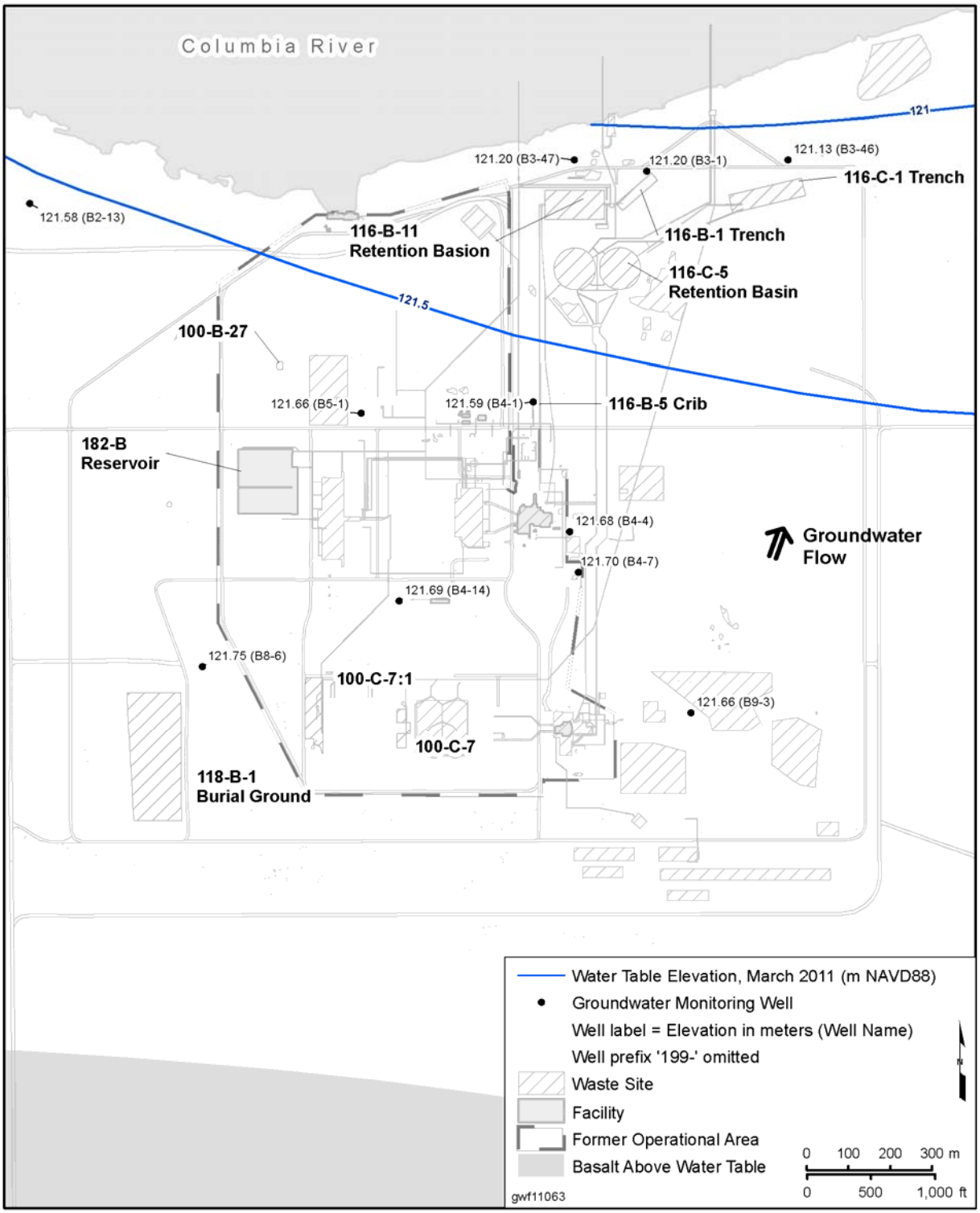


Figure 2.2.4. Changes in 100-BC-5 Plume Areas with Time

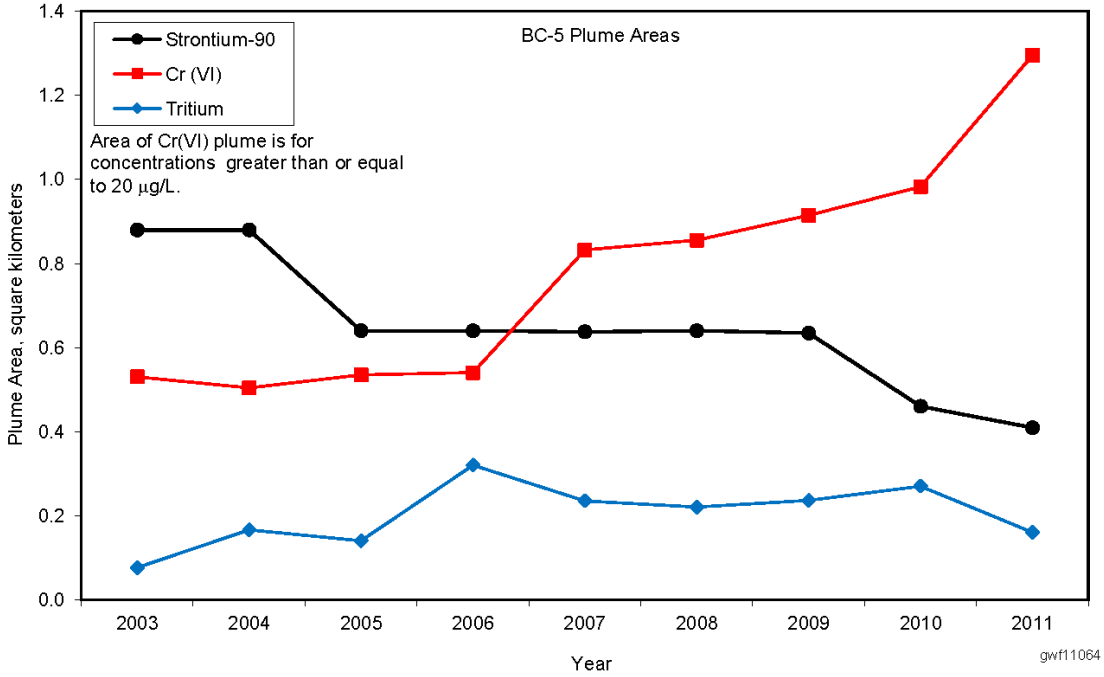


Figure 2.2-5. Average Chromium Concentrations in 100-BC-5 Upper Part of Unconfined Aquifer, 2011

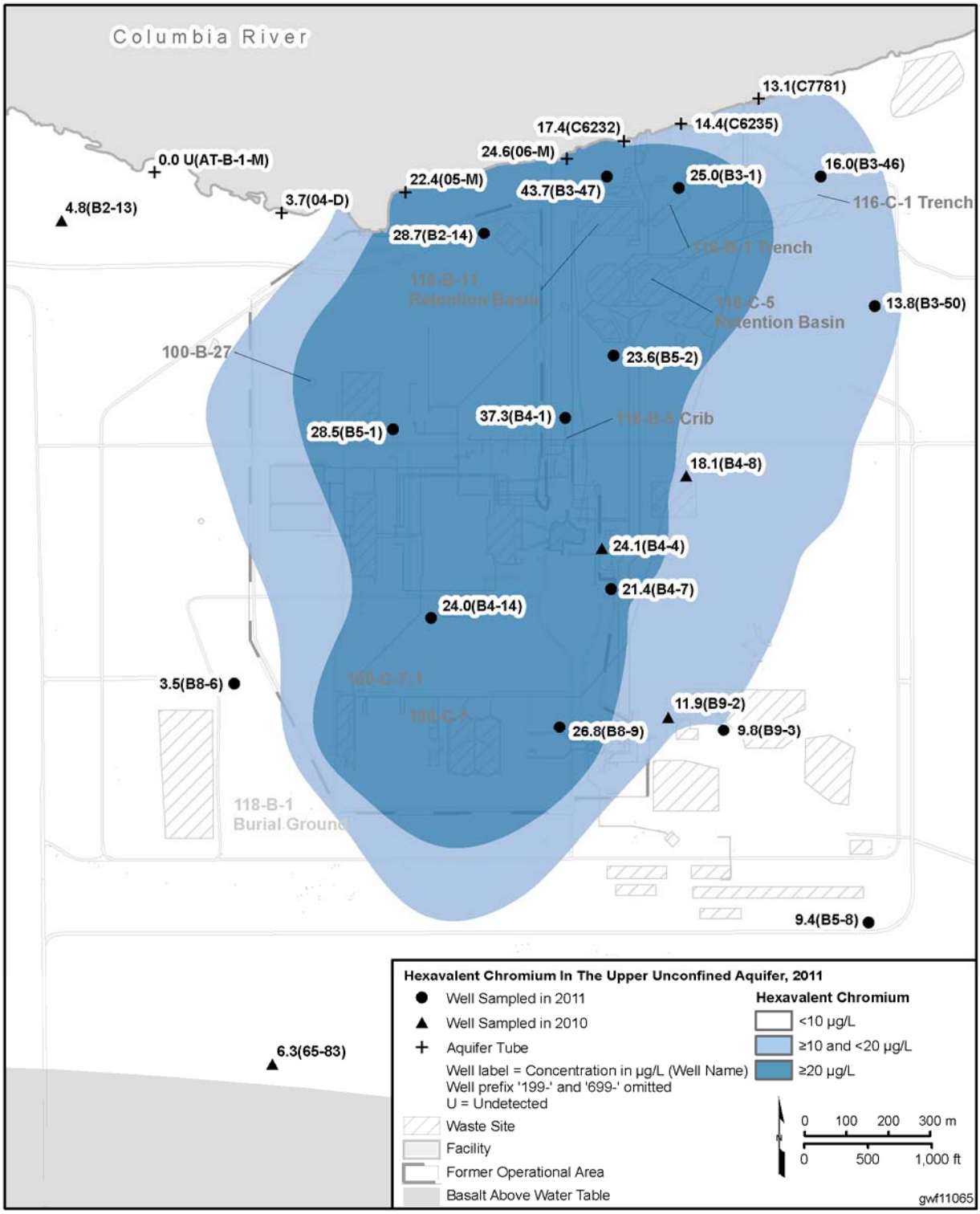


Figure 2.2-6. Hexavalent Chromium Trends in Shallow/Deep Well Pair, Central 100-BC-5

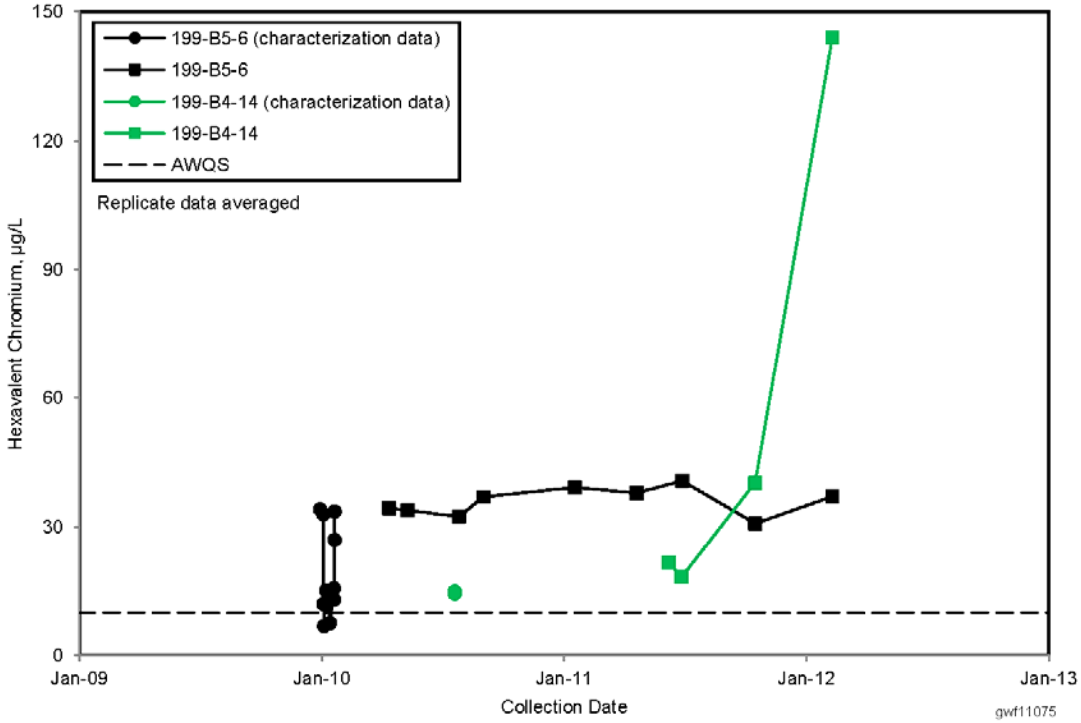


Figure 2.2-7. Hexavalent Chromium Trend in Well 199-B8-9, Southern 100-BC-5

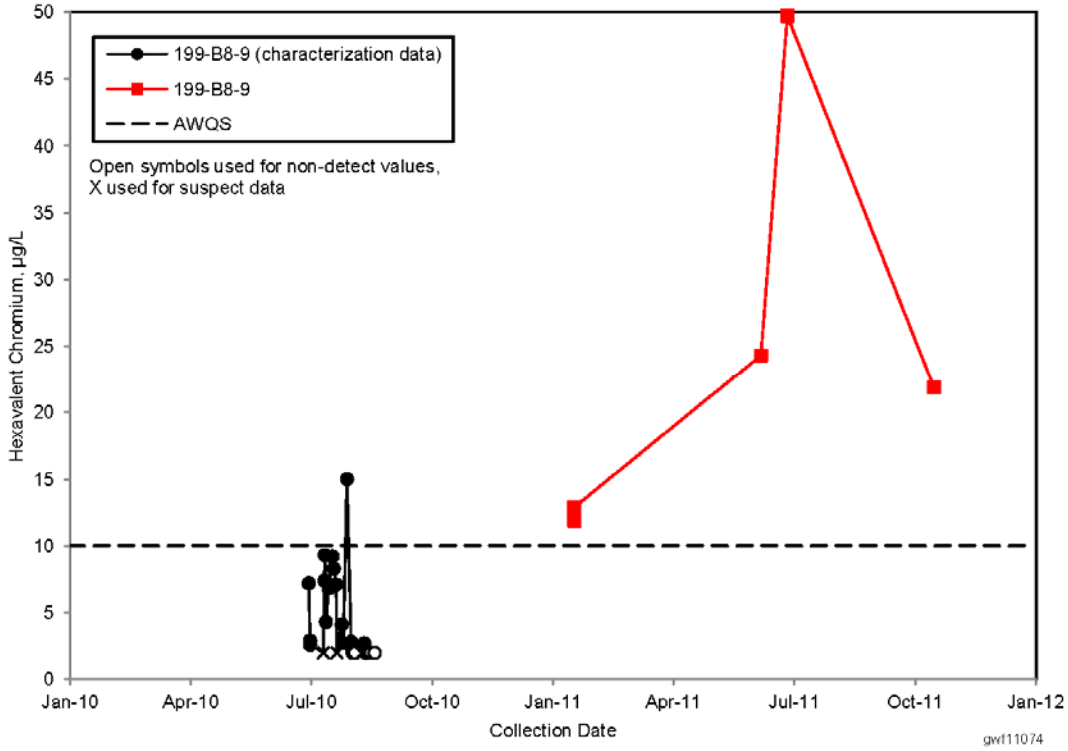


Figure 2.2-8. Dissolved Chromium Trends in Shallow/Deep Well Pair, Northern 100-BC-5

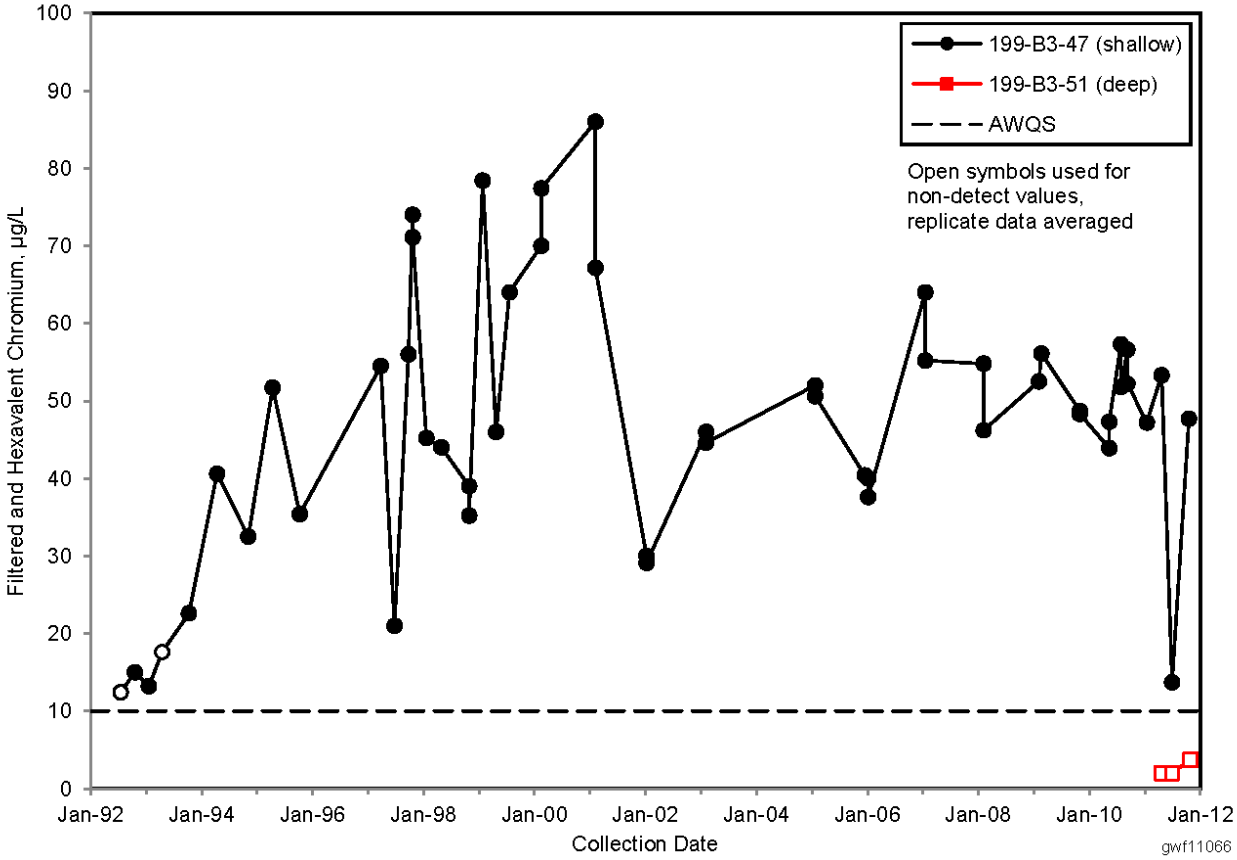


Figure 2.2-9. Average Strontium-90 Concentrations in 100-BC-5, Upper Part of Unconfined Aquifer, 2011

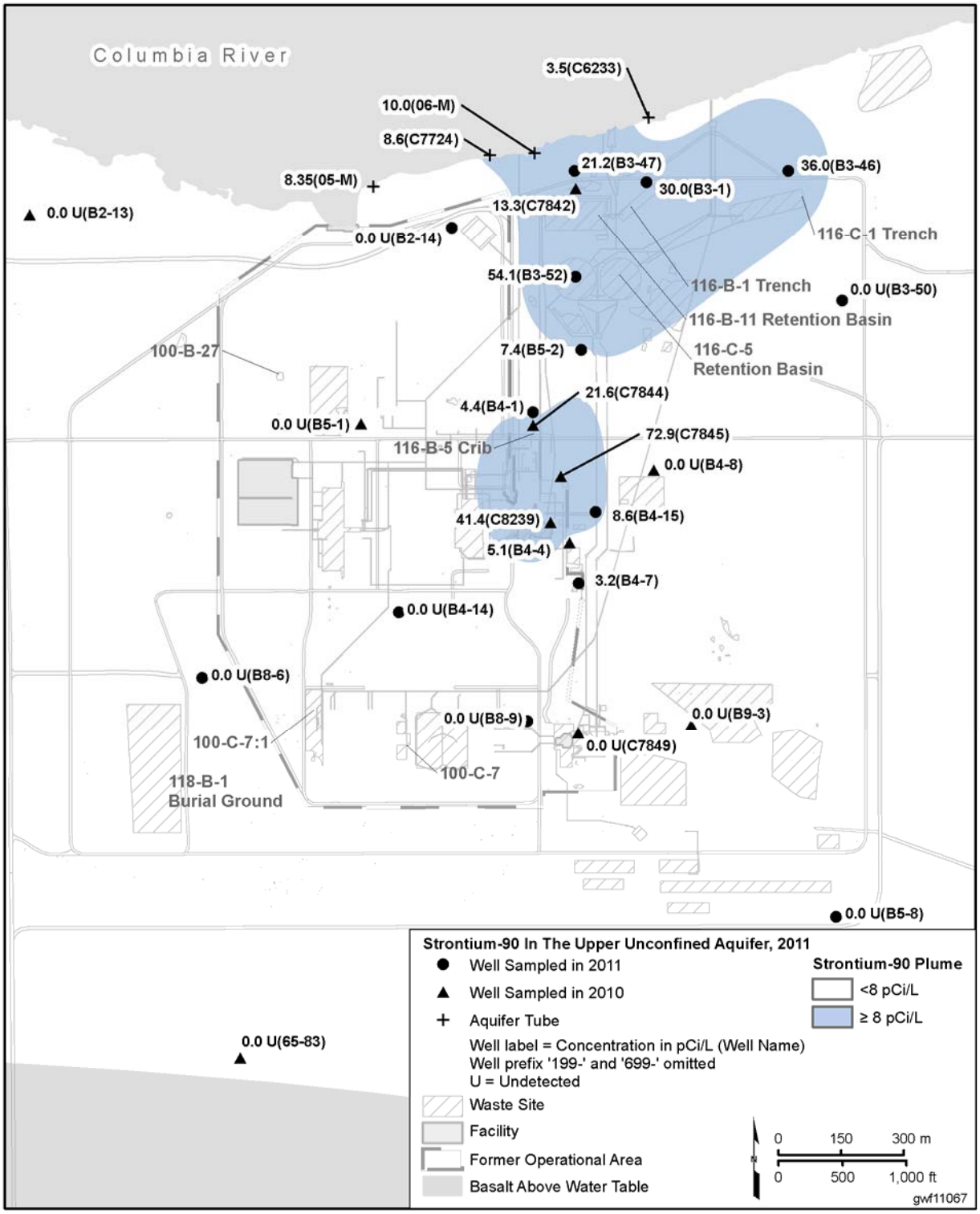


Figure 2.2-10. Strontium-90 Trends in Wells in Central 100-BC-5

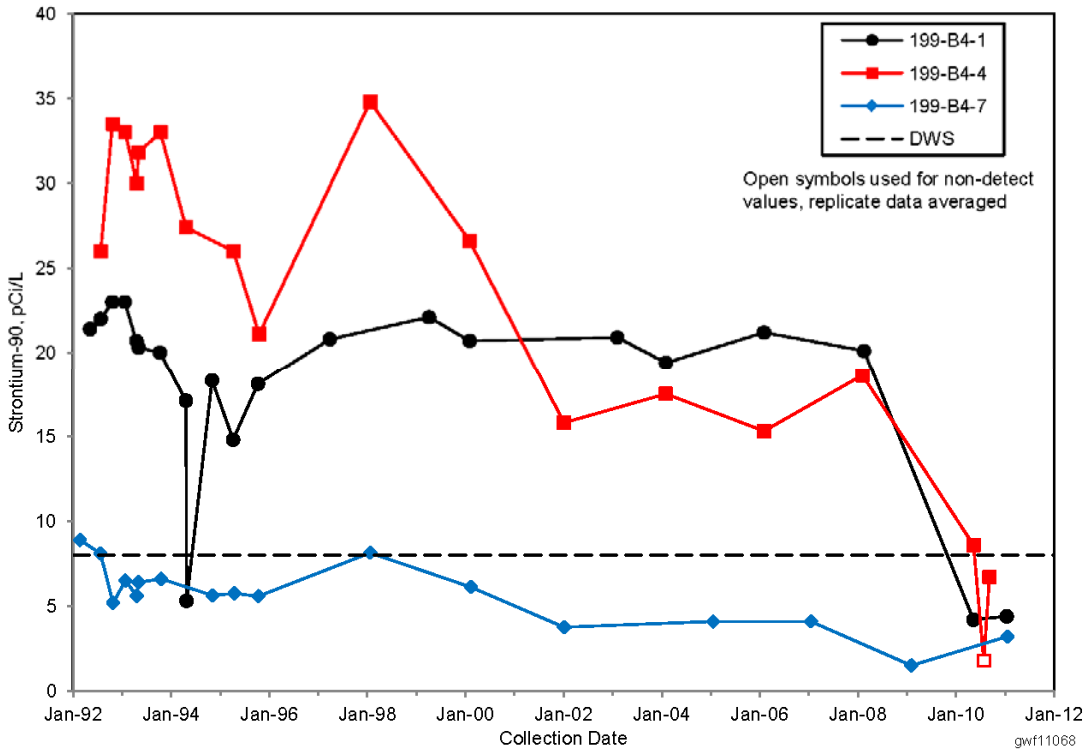


Figure 2.2-11. Strontium-90 Trends in Wells in Northern 100-BC-5

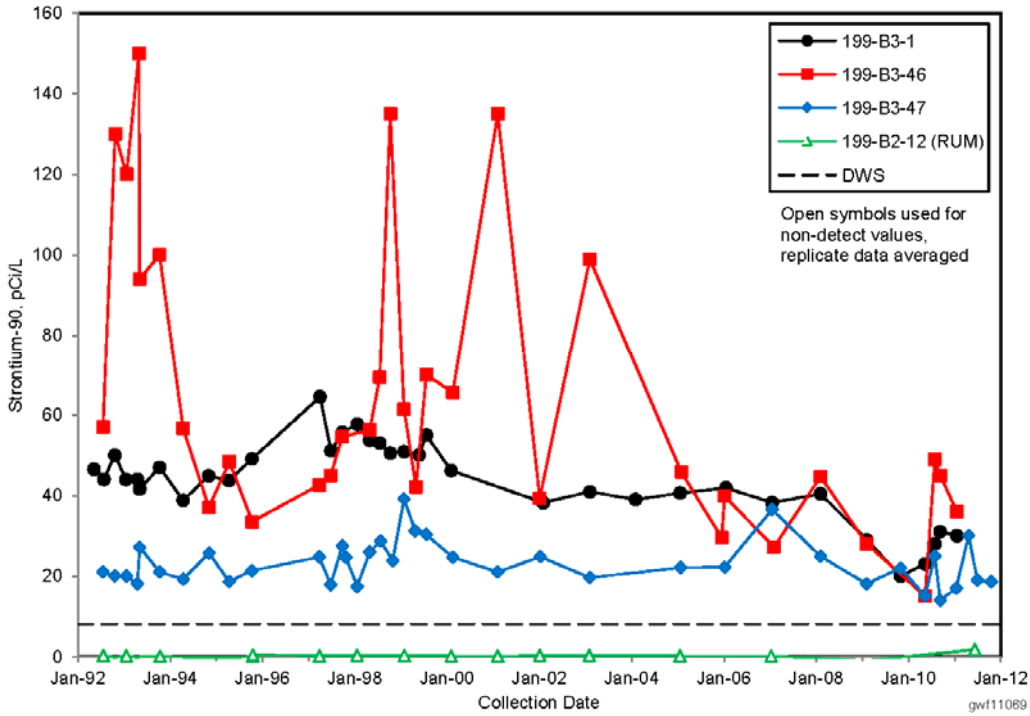


Figure 2.2-12. Average Tritium Concentrations in 100-BC-5, Upper Part of Unconfined Aquifer, 2011

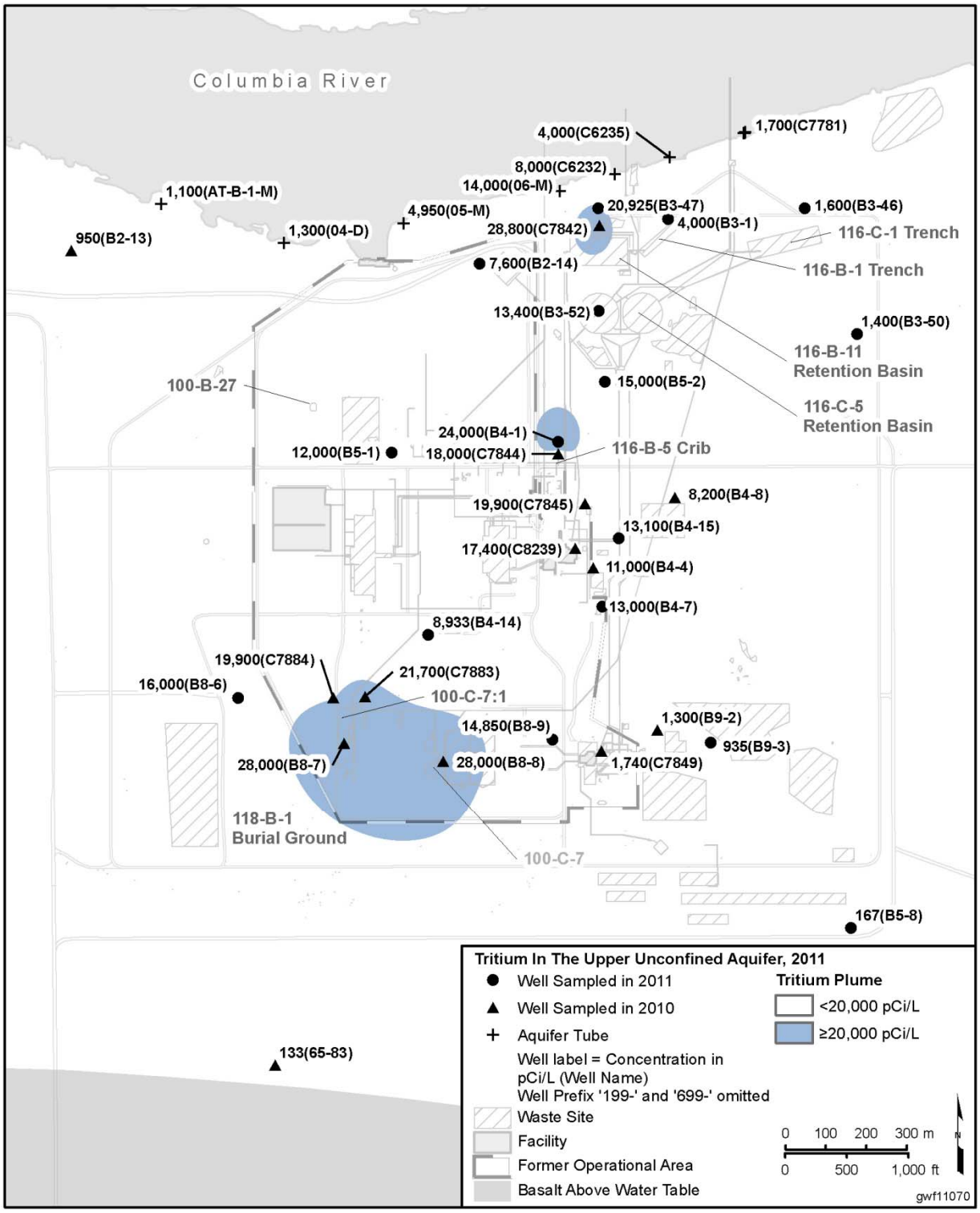


Figure 2.2-13. Tritium Trends in Wells in Northern 100-BC-5

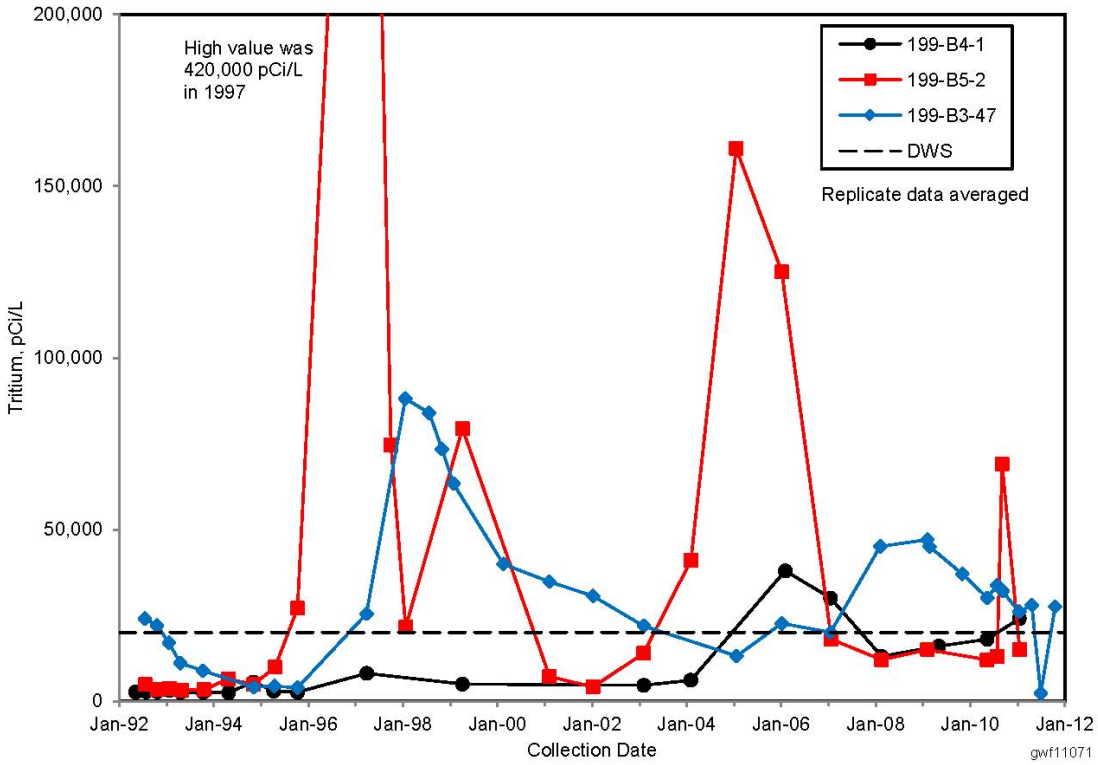
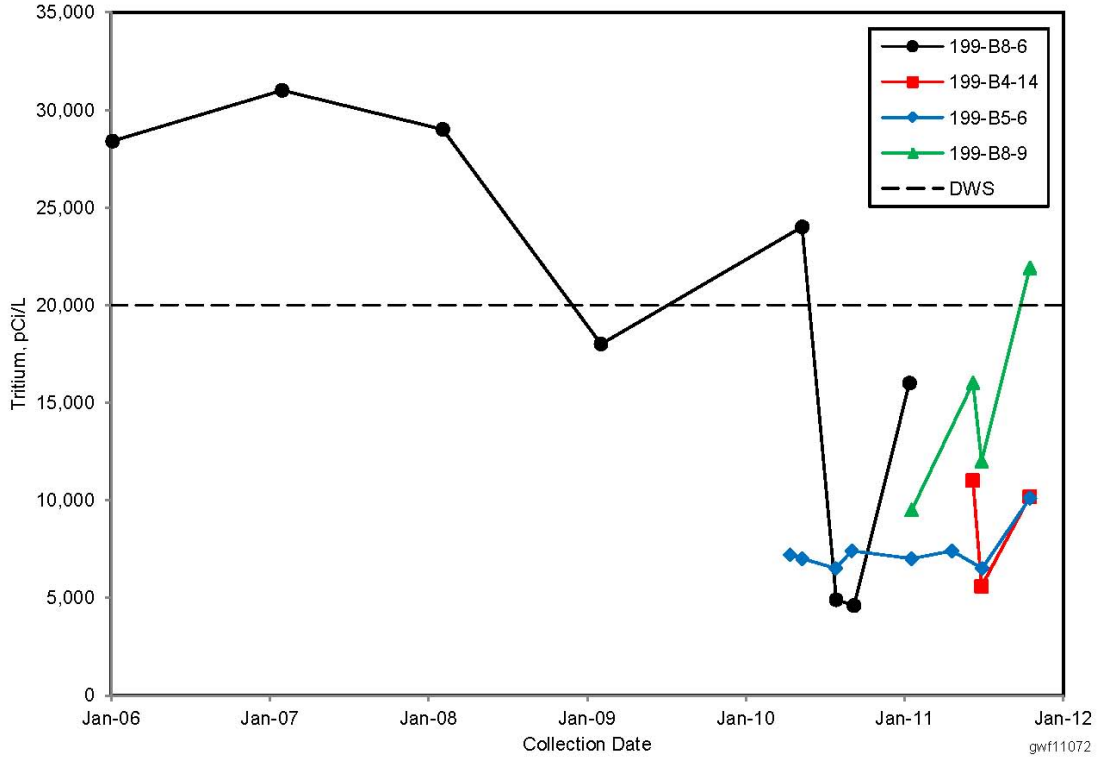


Figure 2.2-14. Tritium Trends in Wells in Southern 100-BC-5



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