

200-UP

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200-UP Overview

The 200-UP groundwater interest area includes the 200-UP-1 groundwater operable unit (OU) in the southern portion of the 200 West Area, and adjacent portions of the surrounding 600 Area. With the exception of the Environmental Restoration Disposal Facility (ERDF), the facilities and waste sites within 200-UP are associated with early operation of the Reduction-Oxidation (REDOX) Plant (plutonium and uranium separation) and U Plant (uranium recovery). U.S. Department of Energy (DOE) conducts groundwater monitoring in 200-UP under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) for the 200-UP-1 OU and the ERDF; and under the *Resource Conservation and Recovery Act of 1976* (RCRA) for Waste Management Area (WMA) S-SX, WMA U, and the 216-S-10 Pond and Ditch. Monitoring of radionuclides is also performed to meet the *Atomic Energy Act of 1954* (AEA) requirements.

Groundwater monitoring within the 200-UP-1 OU is performed under a sampling schedule incorporated into the Remedial Design/Remedial Action (RD/RA) work plan ([DOE/RL-2013-07](#)). Technetium-99, uranium, tritium, iodine-129, nitrate, chromium, and carbon tetrachloride form extensive groundwater plumes in the area. These contaminants originated from operations in this area except for carbon tetrachloride which has migrated into 200-UP from 200-ZP. The contaminants chloroform, 1,4-dioxane, strontium-90, selenium-79, and trichloroethene (TCE) have been found in groundwater to a limited extent and are routinely sampled in selected wells. Table UP.1 lists key facts about 200-UP.

Within 200-UP, groundwater occurs as an unconfined aquifer and as confined aquifers beneath the Ringold lower mud unit and between the basalt flows. The unconfined aquifer is the aquifer directly impacted by past waste disposal operations. The unconfined aquifer occurs within Ringold unit E; its base is the fine-grained Ringold lower mud unit (Figure UP.1).

Depths from land surface to the water table range from 64 to 106 meters, with the largest depths occurring in the northeastern portion of the OU. The thickness of the unconfined aquifer varies from 70 meters in the western portion of the OU to near zero north of the OU boundary where the top of the lower mud unit has been extrapolated to occur above the water table. The water table elevation in 200 West Area and resultant groundwater gradients have been historically affected by large volume waste water discharges ([DOE/RL-2008-01](#); [PNNL-13080](#)).

Groundwater flow in the unconfined aquifer is toward the east within the southern 200 West Area and toward the east-northeast in the eastern portion of the interest area (Figure UP.2).

Table UP.1 200-UP at a Glance

REDOX Plant Operations: 1952 to 1967 (plutonium separation)			
U Plant Operations: 1952 to 1957 (uranium recovery)			
2013 Groundwater Monitoring			
Groundwater Contaminant	Cleanup Level ^a	Maximum Concentration	Plume Area ^b (km ²)
Carbon tetrachloride	3.4 µg/L	700 µg/L (299-W14-71)	13.3 ^c
Chromium	48 ^d /100 ^e µg/L	907 µg/L (299-W23-19)	3.86/0.37
Nitrate	45 mg/L	3,210 mg/L (288-W19-43)	5.8
Iodine-129	1 pCi/L	9.14 pCi/L (299-W22-88)	3.1
Technetium-99	900 pCi/L	62,000 pCi/L (299-W23-19)	0.29
Tritium	20,000 pCi/L	310,000 pCi/L (699-36-66B)	5.5
Uranium	30 µg/L	298 µg/L (299-W19-43)	0.34
Remediation			
U Plant pump-and-treat (interim action from 1994 to 2011):			
<ul style="list-style-type: none"> • Removed 220.5 kg uranium • Removed 2.17 Ci technetium-99 			
S-SX Tank Farms Groundwater Extraction System (interim action):			
<ul style="list-style-type: none"> • Began operating during July 2012 • Removed 1.03 Ci technetium-99 since startup • Removed 17.9 kg chromium since startup • Removed 9,560 kg nitrate since startup • Removed 121 kg carbon tetrachloride since startup 			
Interim action record of decision approved in September 2012.			
Remedial Design/Remedial Action Work Plan released September 2013.			

- a. From Table 14 in the interim ROD (EPA et al., 2012).
- b. Estimated area above the cleanup level unless otherwise noted.
- c. Represents the entire extent of the plume (includes the 200-ZP).
- d. "Model Toxics Control Act—Cleanup" (WAC 173-340) Method B groundwater cleanup level for hexavalent chromium.
- e. Federal drinking water standard for total chromium.

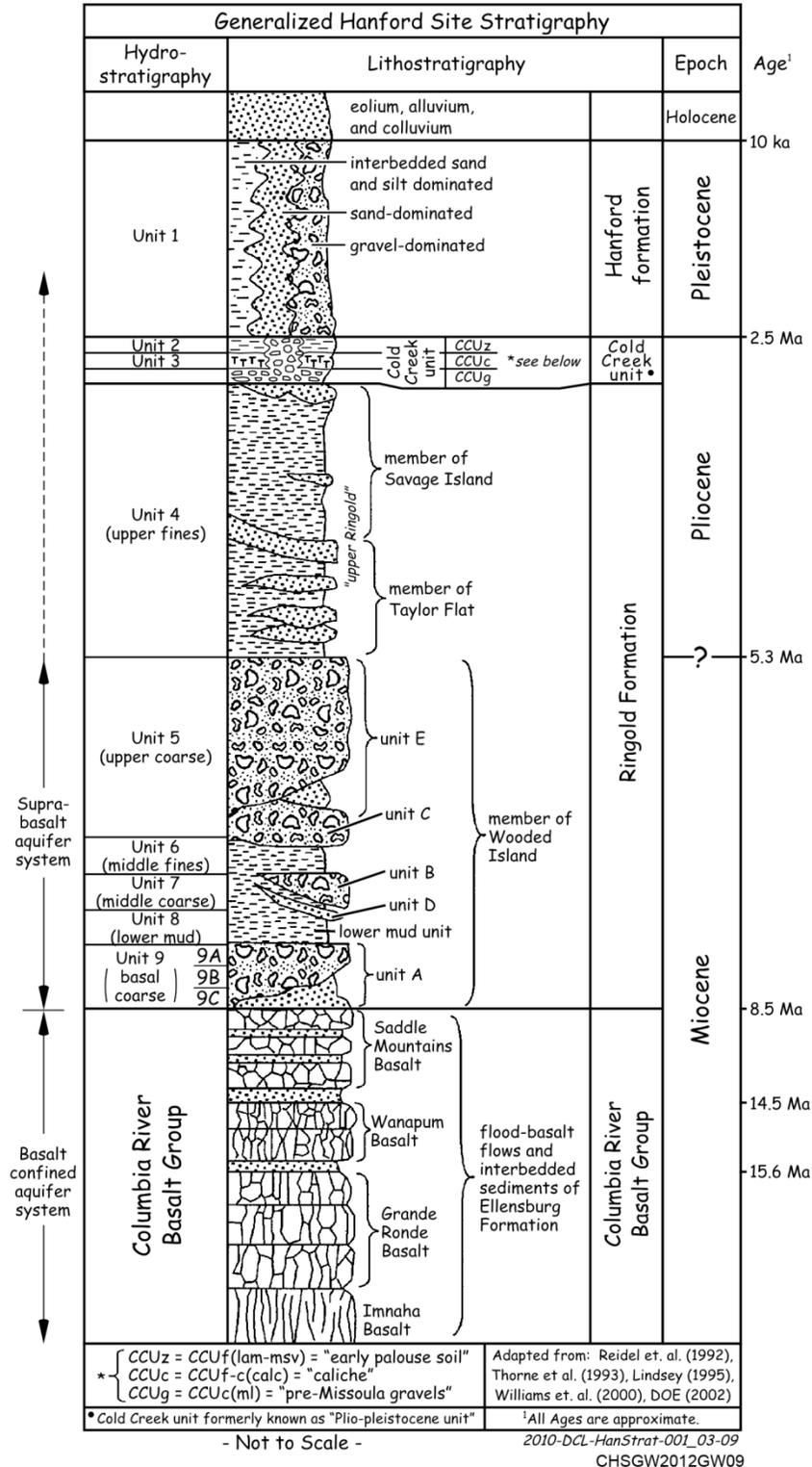


Figure UP.1 Generalized Stratigraphy of the Hanford Site

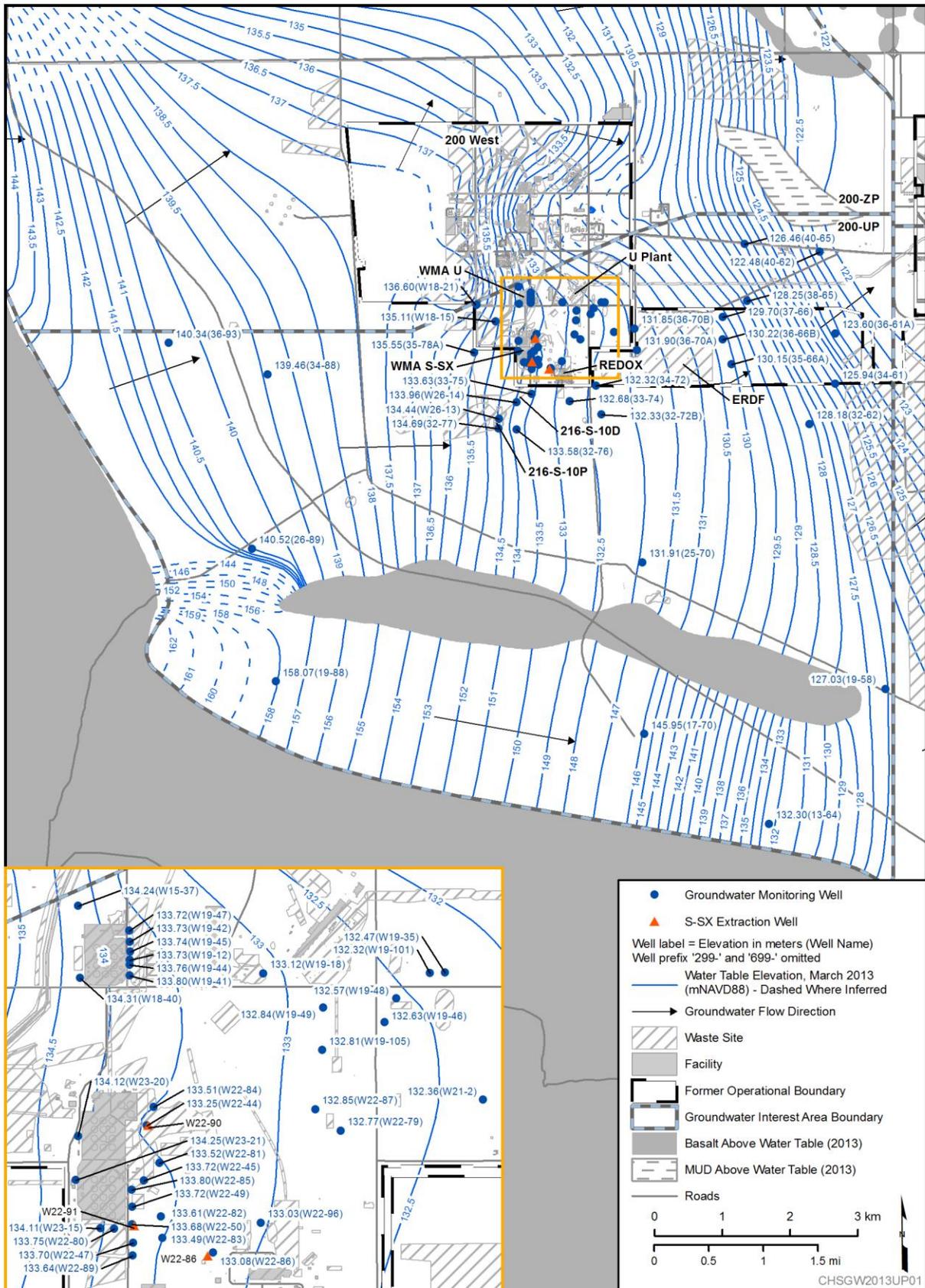


Figure UP.2 200-UP Water Table Map, March 2013

200-UP CERCLA Activities

An interim action Record of Decision (ROD) addressing all of the major contaminant plumes within the 200-UP-1 OU was published during September 2012 ([EPA et al., 2012](#)). This ROD superseded the prior interim action ROD issued in 1997 ([EPA/ROD/R10-97/048](#)). The selected remedy in the 2012 ROD consists of a combination of the following:

- Groundwater extraction and treatment for technetium-99, uranium, and chromium
- A combination of pump and treat (P&T) and monitored natural attenuation (MNA) for nitrate and carbon tetrachloride
- MNA for tritium
- Hydraulic containment for iodine-129 while treatment technologies are investigated
- Institutional Controls (ICs)

CERCLA activities during 2013 included continued groundwater monitoring (sample locations shown in Figure UP.3), continued operation of a groundwater extraction system downgradient from the S-SX Tank Farms, and publication of an RD/RA work plan ([DOE/RL-2013-07](#)). Table A-15 in Appendix A lists the monitoring network and sampling status for 2013. The third CERCLA 5-year review ([DOE/RL-2011-56](#)) identified no issues pertaining to 200-UP-1. Changes in plume areas over time for major contaminant plumes within 200-UP are shown in Figure UP.4.

Remedial Design/Remedial Action Work Plan. The RD/RA work plan ([DOE/RL-2013-07](#)) was released during September 2013. The plan addresses several topics, which include the following:

- The approach to be used to design P&T systems for uranium and technetium-99 near U Plant (expected to consist of 2 extraction wells and 2 injection wells), a P&T system for the chromium plume southeast of 200 West Area (expected to consist of 2 extraction wells and 2 injection wells), and an injection well system for hydraulic control of the iodine-129 plume while treatment technologies are investigated (expected to consist of 3 injection wells)
- Continued operation of the groundwater extraction system at the S-SX Tank Farms
- Modifications to the 200 West P&T to accommodate the additional water and treatment needs for the 200-UP-1 remedies

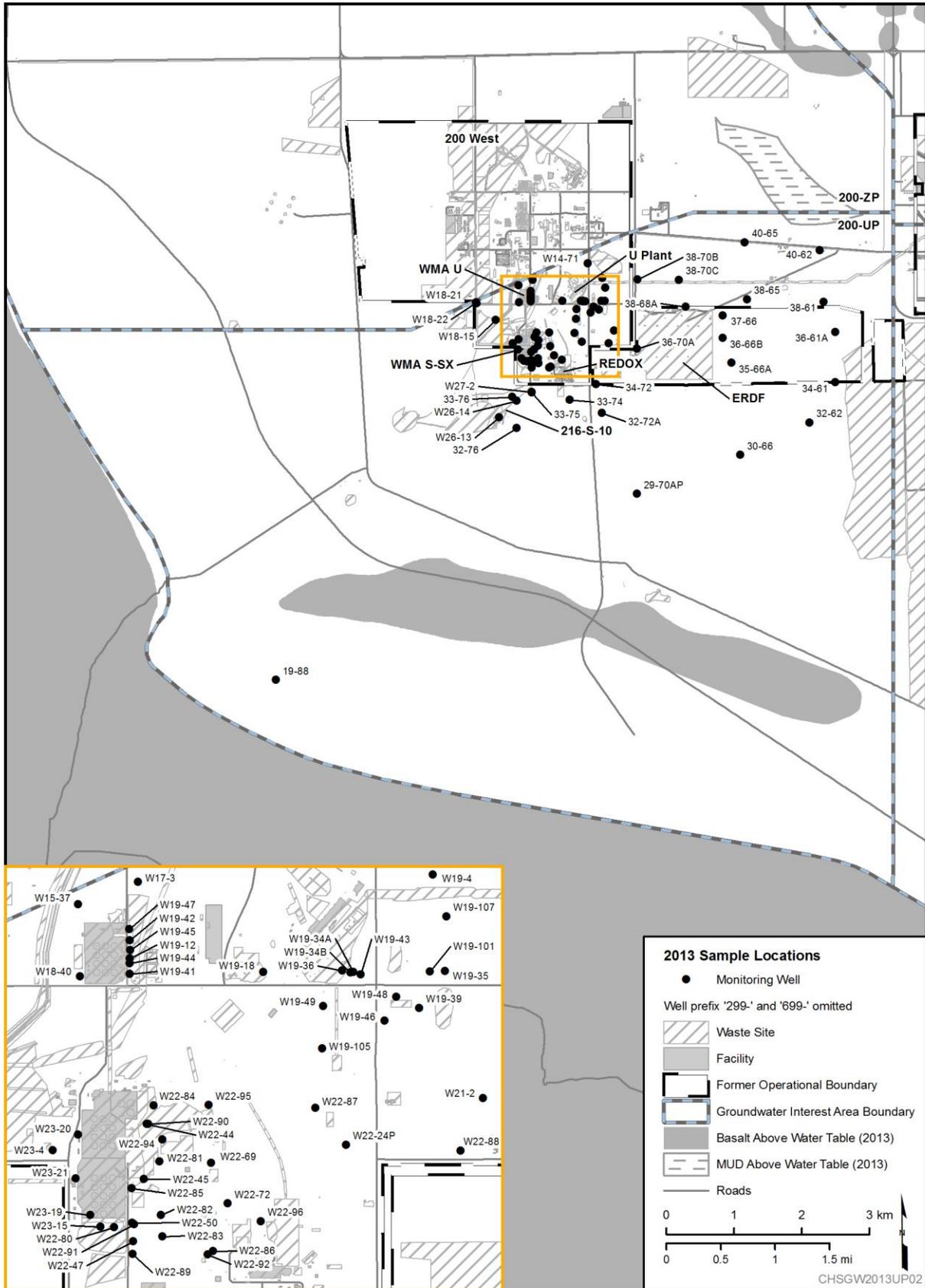


Figure UP.3 200-UP 2013 Sampling Locations

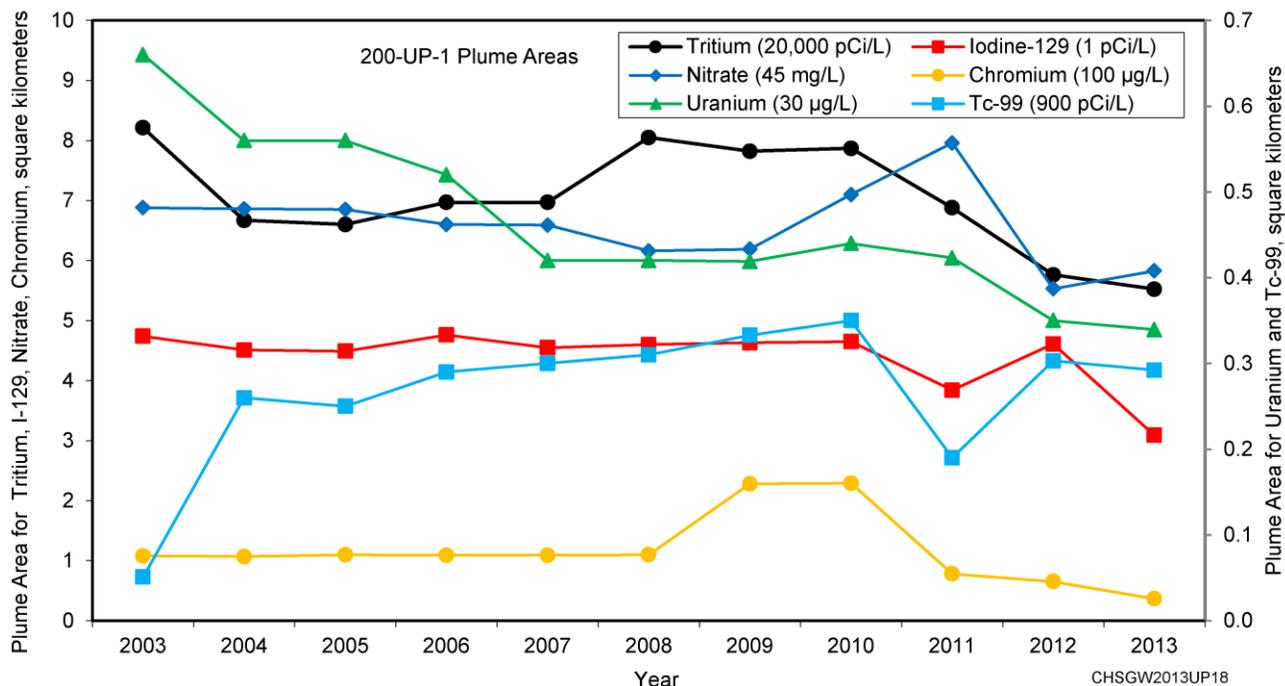


Figure UP.4 200-UP Plume Areas

200-UP Technetium-99

Technetium-99 concentrations occur above the 900 pCi/L cleanup level downgradient of WMA S-SX, downgradient from the 216-U-1 and 216-U-2 Cribs (near U Plant), and downgradient of WMA U (Figure UP.5).

WMA S-SX. Technetium-99 plumes occur downgradient of both the S and SX Tank Farms. At well 299-W23-19 (located inside the SX fence line), concentrations declined during the year from 62,000 pCi/L during March 2013 to 20,000 pCi/L during December 2013 (Figure UP.6). The decline is attributed to a groundwater extraction system which began operating during July 2012. The nearest extraction well, 299-W22-91, is located 155 meters east-southeast of 299-W23-19 (Figure UP.3). Concentrations in many of the downgradient wells from the SX Tank Farm are near steady-state conditions (e.g., 299-W22-83 in Figure UP.7), although some are being affected by the groundwater extraction system (e.g., 299-W22-86 in Figure UP.7). This plume is attributed primarily to a 190,000 liter leak from tank SX-115 that occurred during 1965 (Section 4.5 of [RPP-ENV-39658](#)). Depth-discrete sample results within this plume indicate it occurs within the upper 2.5 meters (66 feet) of the aquifer at concentrations above the cleanup level ([DOE/RL-2009-122](#)).

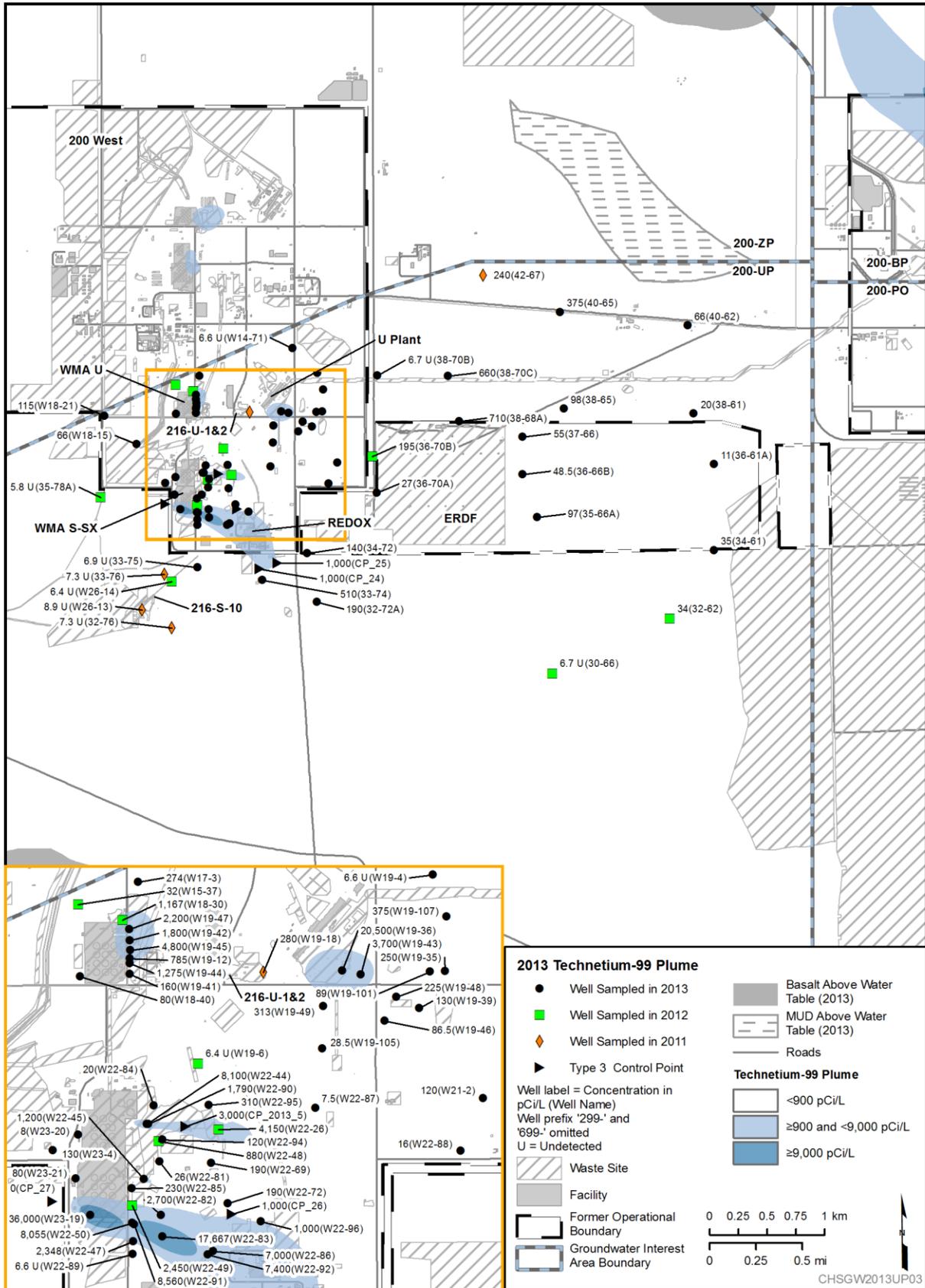


Figure UP.5 200-UP 2013 Technetium-99 Plume Map

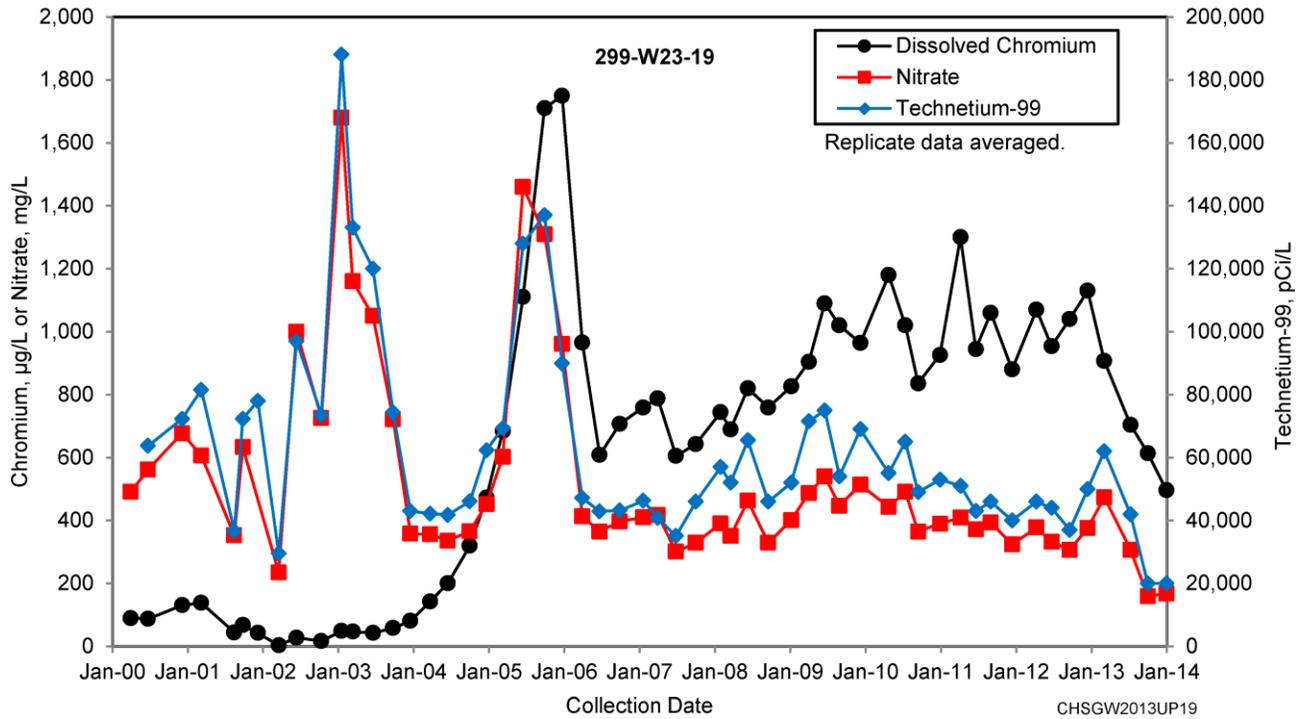


Figure UP.6 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W23-19 at WMA S-SX

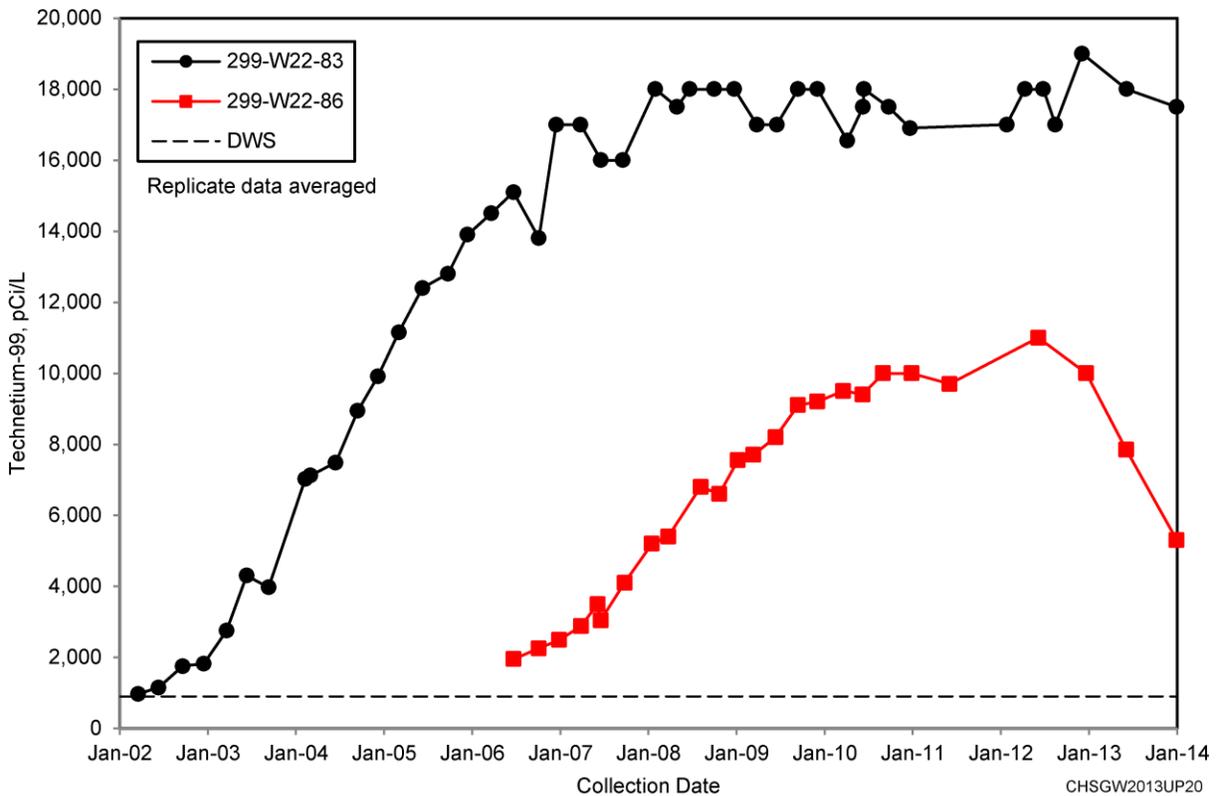


Figure UP.7 200-UP Technetium-99 Data for Wells 299-W22-83 and 299-W23-86 East of WMA S-SX

Between 1966 and 1970, an estimated 91,000 liters of waste was released from tank S-104 (S Tank Farm) in an overfill event. A geophysical survey indicated the vadose zone plume has reached groundwater (Sections 3.7.2 and 4.6 in RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*). At 299-W22-44, the nearest downgradient well at S Tank Farm, the technetium-99 concentration began increasing in 2006, peaked in 2009 at 20,000 pCi/L, and declined to 8,000 pCi/L by March 2013 (Figure UP.8). A similar trend occurred at far-downgradient well 299-W22-26, where concentrations began increasing in 2006, peaked at 6,000 pCi/L in December 2010, and declined to 4,200 pCi/L by July 2012 (Figure UP.9). The peak concentrations in these wells are attributed to separate episodes of contaminant migration from the vadose zone into the aquifer beneath the S Tank Farm. Both wells 299-W22-44 and 299-W22-26 are now dry. Well 299-W22-95 was drilled during 2013 as a replacement for 299-W22-26. The new well is located north of 299-W22-26 because groundwater flow modeling indicates the flow direction will change in the future to be toward the northeast in response to operation of the large 200 West P&T system in 200-ZP. A replacement well for 299-W22-44 has not been drilled, but this well is located adjacent to extraction well 299-W22-90 which is being sampled quarterly. Depth-discrete sample results during drilling of extraction well 299-W22-90 indicate this technetium-99 plume extends to a depth of 10 meters (33 feet) below the water table at concentrations above the cleanup level ([DOE/RL-2011-118](#)).

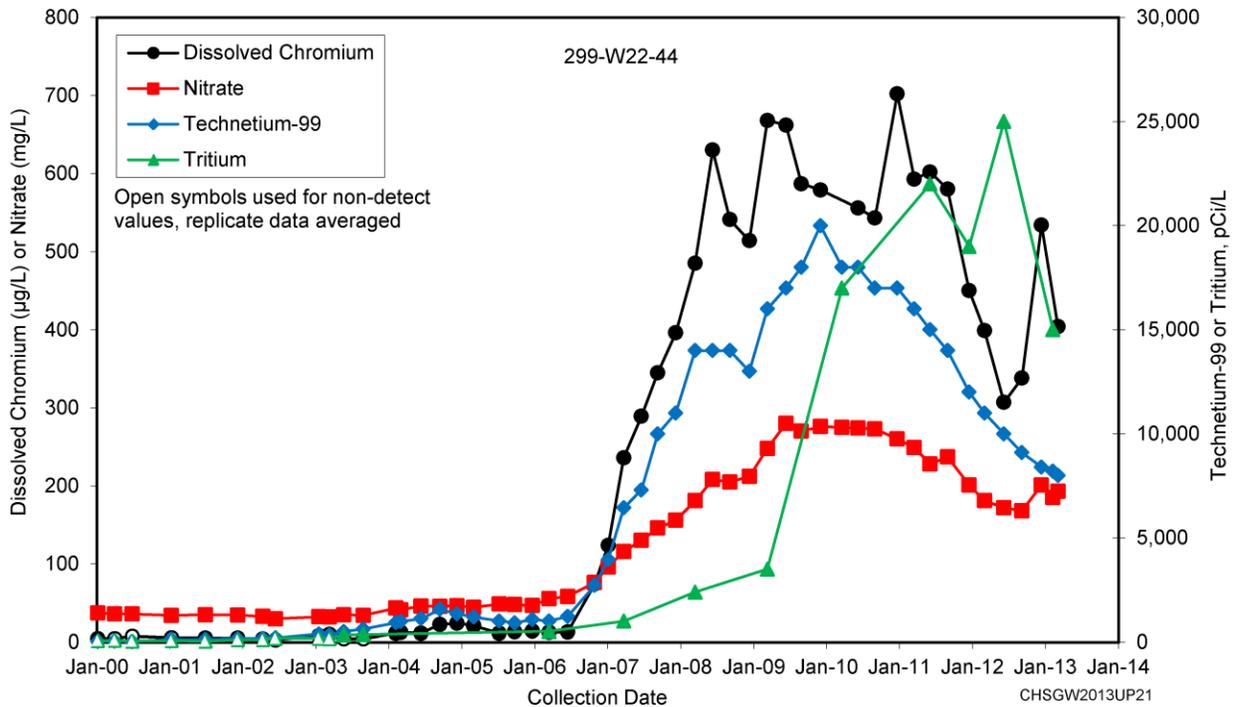


Figure UP.8 200-UP Chromium, Nitrate, Technetium-99, and Tritium Data for Well 299-W22-44 at WMA S-SX

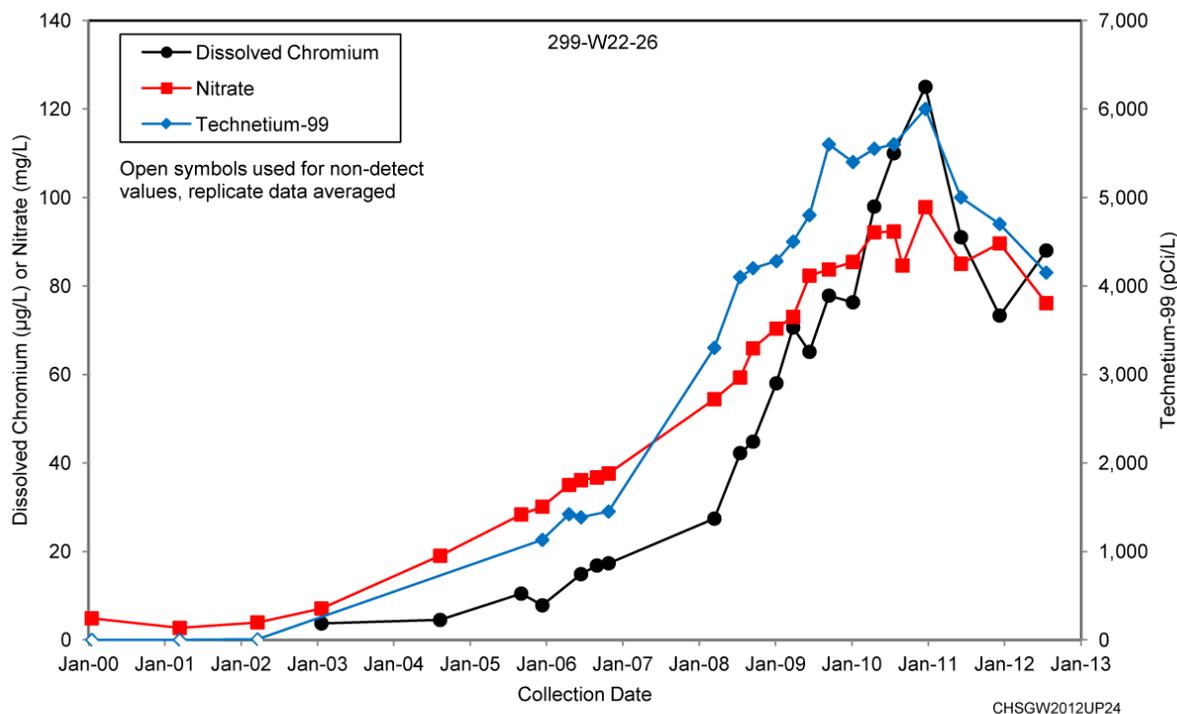


Figure UP.9 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W22-26 at WMA S-SX

216-U-1 and 216-U-2 Cribs. A technetium-99 plume originated from these cribs near U Plant, which were active in the 1950s and 1960s. The initial U Plant P&T system operated in this plume from 1994 until the system was shut down during March 2011. This P&T system was effective at reducing technetium-99 concentrations in the aquifer. The technetium-99 concentration has rebounded substantially at former extraction well 299-W19-36 (from 6,300 pCi/L during June 2010 to 20,500 pCi/L during September 2013) (Figure UP.10). Concentrations also increased at 299-W19-43 during 2013 (Figure UP.11). The groundwater flow direction in this area has changed due to operation of the 200 West P&T system. Formerly, the flow direction was toward the east, but the flow direction during 2013 was north-northeast toward the extraction wells (see Figure UP.2). This may be a factor in the concentration increase at 299-W19-43. Further remediation in this area is addressed by the 2012 interim ROD ([EPA et al., 2012](#)) and a groundwater extraction system is in the planning stage.

WMA U. The WMA U area is a source of technetium-99 groundwater contamination ([PNNL-13282](#)). In previous years, technetium-99 concentrations in many of the downgradient wells were stable or increasing slowly, but concentrations in well 299-W19-45 began to increase significantly during 2011 (Figure UP.11). This trend continued during 2013. Between July 2012 and July 2013, technetium-99 increased in this well from 3,400 to 5,400 pCi/L. Technetium-99 concentrations also were greater than the cleanup level in three other wells during 2013, including 299-W19-44 in which concentrations increased to above the cleanup level during the year (Figure UP.11). Well 299-W18-30 on the northeast corner of the tank farm also had concentrations above the cleanup level, but this well became dry during 2012. The groundwater contamination is believed to result from multiple sources within WMA-U ([HNF-EP-0182](#)). The contamination is within the capture zone of the 200 West P&T extraction well network.

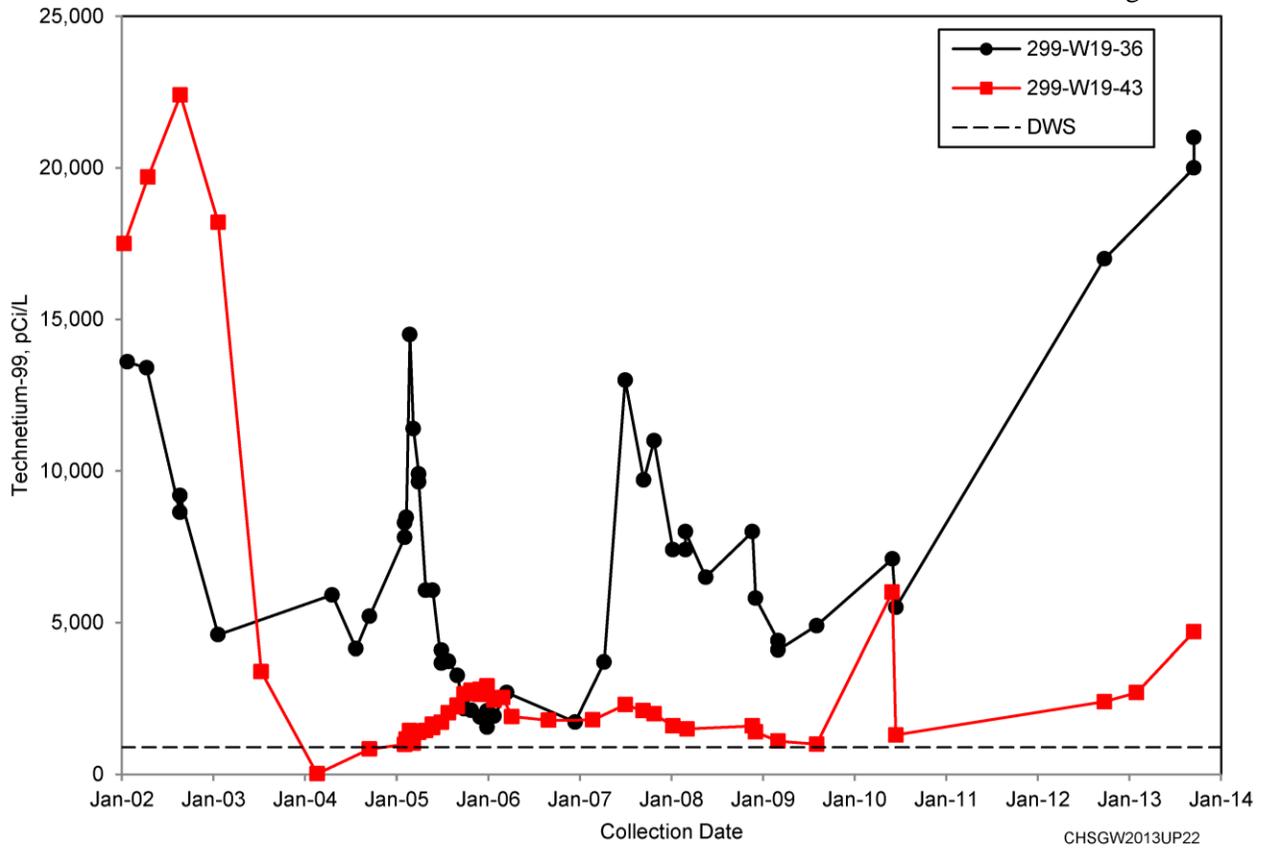


Figure UP.10 200-UP Technetium-99 Data for Wells 299-W19-36 and 299-W19-43 near U Plant

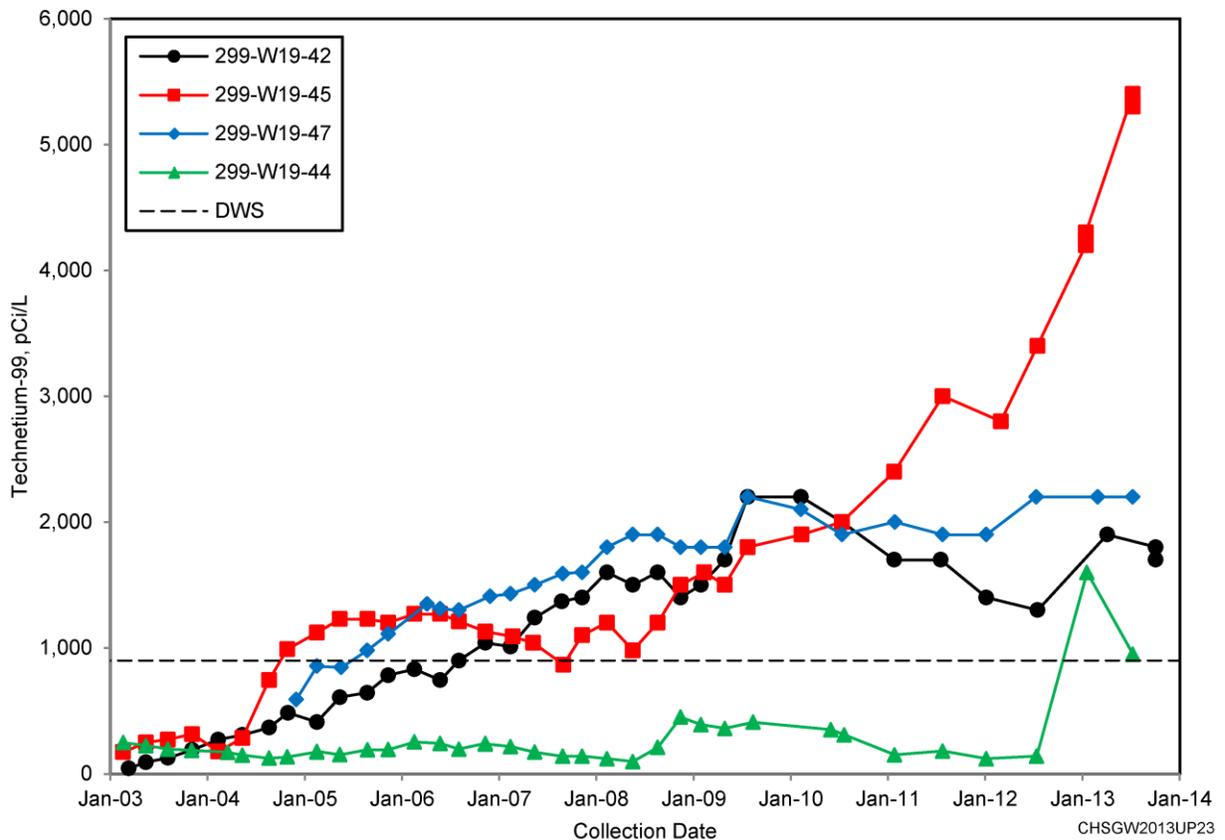


Figure UP.11 200-UP Technetium-99 Data for Selected Wells at WMA U

200-UP Uranium

Uranium occurs at concentrations above the 30 µg/L cleanup level within two regions of 200-UP, downgradient of the 216-U-1 and 216-U-2 Cribs and near the 216-U-10 Pond (U Pond).

216-U-1 and 216-U-2 Crib Plume. These cribs were the source of a uranium plume that is interpreted to extend 1.5 kilometers to the east at levels above the 30 µg/L cleanup level (Figure UP.12). The former U Plant P&T system operated in the central portion near these cribs from 1994 until the system was shut down in March 2011. Throughout 2013, uranium sample results were below the former 300 µg/L remedial action objective at all wells within the area targeted for remediation, but concentrations at most wells were above the current 30 µg/L cleanup level. The maximum concentration was 298 µg/L in 299-W19-43. This plume is limited to the upper 20 meters of the aquifer (Figure 11-13 of [DOE/RL-2011-01](#)).

The groundwater flow direction in this area has changed due to operation of the 200 West P&T system. Formerly, the flow direction was toward the east, but the flow direction during 2013 was north-northeast toward the extraction wells (Figure UP.2). The change in flow direction has caused changes in the uranium concentration trends in some wells. The most notable change was in 299-W19-49 in which the uranium concentration increased from 56 to 264 µg/L between June 2012 and January 2013 (Figure UP.13). The concentration declined in 299-W19-105 from 72 µg/L in January 2013 to 27 µg/L in September 2013, below the cleanup level. Further remediation of this plume is addressed by the interim ROD issued in September 2012 ([EPA et al., 2012](#)), and a groundwater extraction system is currently being designed.

Near the cribs, uranium has remained elevated in 299-W19-18. A sample collected in January 2013 yielded a result of 313 µg/L, but this result is flagged as rejected because the well was not fully purged during sampling. The March 2011 sample result was 374 µg/L, which is believed to be more representative of the concentration in the aquifer. The persistence of elevated concentrations in this well may be caused by an ongoing source of uranium to the aquifer. Possible sources include continued leaching from the vadose zone beneath the cribs and/or desorption of uranium from aquifer sediment. However, the uranium concentration may also result from the slower migration of this constituent compared to technetium-99.

U Pond. Uranium concentrations exceed the cleanup level in one well near U Pond, 299-W23-4 (near the 216-S-21 Crib), which had a concentration of 44.2 µg/L during January 2013. Concentrations have been increasing very slowly in this well since 2000. Two other wells in this area have had concentrations above the cleanup level: 299-W18-21 (during the period between 2001 and 2004) and 299-W18-15 (before 2002 and in 2006). Uranium is interpreted to be leaching from the vadose zone beneath U Pond. The pond received an estimated 2,100 kilograms of uranium (Section 4.2.2 of [DOE/RL-2009-122](#); Appendix C of RPP-26744, *Hanford Soil Inventory Model, Rev. 1: SIM Production Output Files*). The wells installed around this area are older and were all completed to monitor the water table, therefore, no vertical groundwater profile data is available.

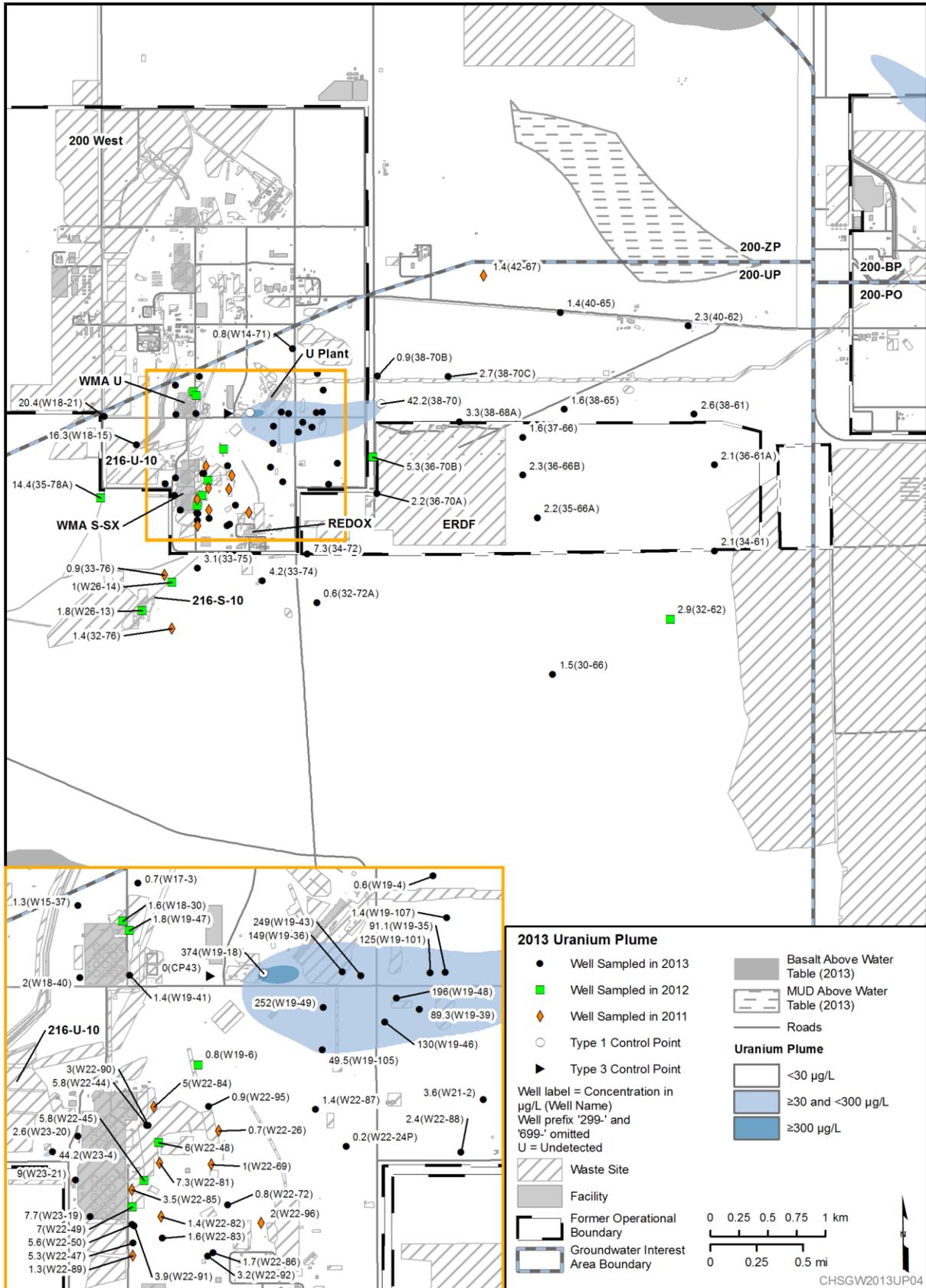


Figure UP.12 200-UP 2013 Uranium Plume

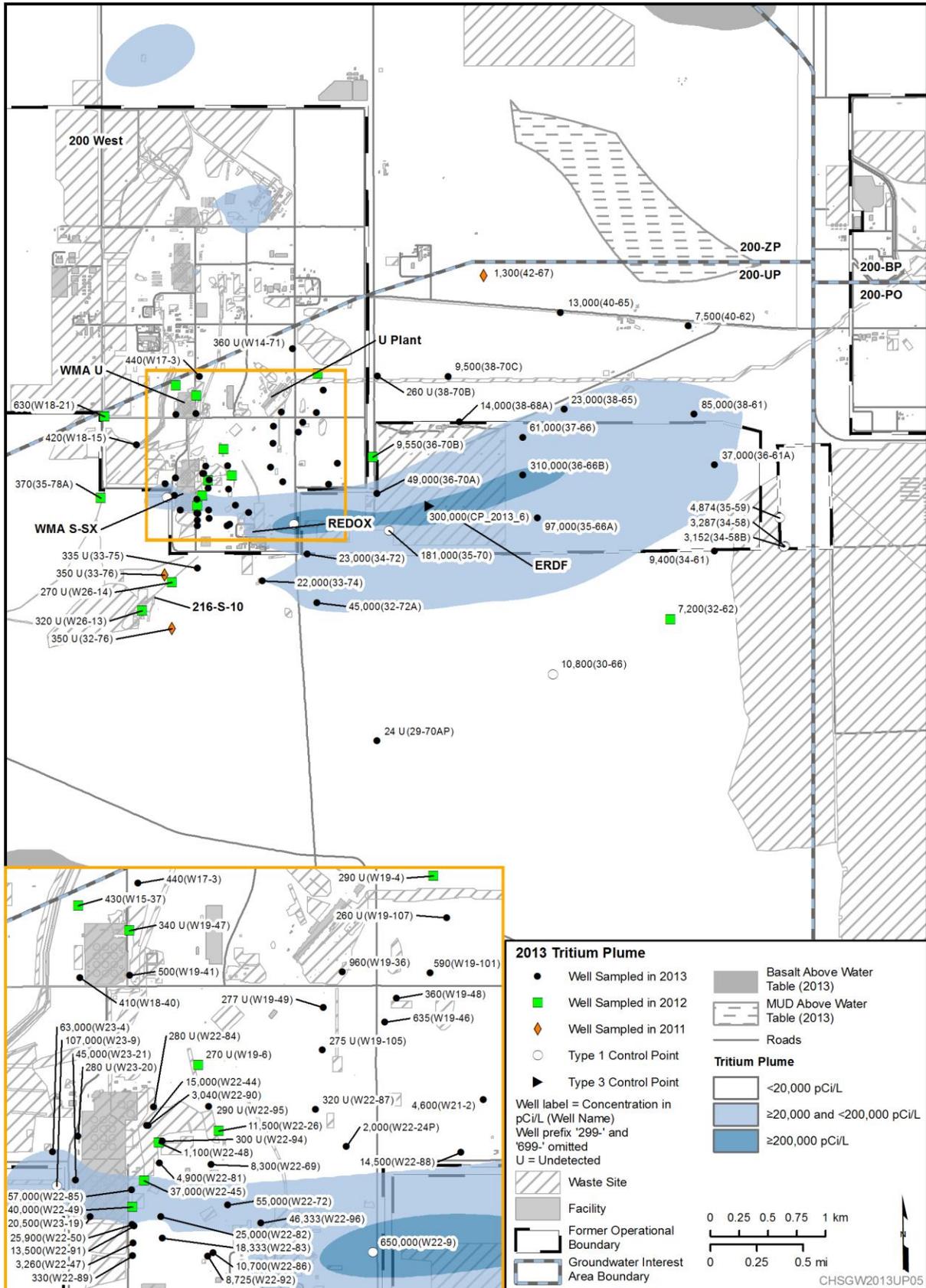


Figure UP.14 200-UP 2013 Tritium Plume

216-S-25 Crib. Tritium occurs above the cleanup level in wells downgradient of the 216-S-25 Crib. The maximum tritium concentration in this area during 2013 was 57,000 pCi/L in well 299-W22-85 located east of the SX Tank Farm and 250 meters downgradient from the crib. Radioactive liquid effluent was disposed of to the 216-S-25 Crib from 1973 through 1980, and effluent from a P&T system at the 216-U-1 and 216-U-2 Crib was disposed of to 216-S-25 for 6 months during 1985. The crib received an estimated 3,600 curies of tritium (Appendix C in RPP-26744).

216-S-3 Crib. The tritium concentration in S Tank Farm downgradient well 299-W22-44 increased to above the cleanup level during June 2011. The concentration peaked during June 2012 at 25,000 pCi/L and then declined to 15,000 pCi/L during February 2013 (Figure UP.8). This well became dry during 2013 because it is located adjacent to extraction well 299-W22-90 which began operating during July 2012. The concentration in the extraction well declined to 1,800 pCi/L during November 2013 due to operation of the groundwater extraction system. Because the tritium trend in well 299-W22-44 lagged behind the trends of the tank waste constituents chromium, nitrate, and technetium-99, the tritium is interpreted to have originated from the 216-S-3 Crib located along the east side of the tank farm. This crib received an estimated 122 curies of tritium between 1953 and 1956 (Appendix C in RPP-26744).

216-S-21 Crib. The tritium concentration in 299-W23-4 near the 216-S-21 Crib (west of WMA S-SX) had been increasing since 2003, but the trend reversed during 2012. The concentration peaked during February 2012 at 77,000 pCi/L, but declined to 63,000 pCi/L in January 2013 (Figure UP.15). The crib received an estimated 2,500 curies of tritium between 1954 and 1969 (Appendix C in RPP-26744). To put the current contamination levels into perspective, the maximum tritium concentration in 299-W23-4 occurred in 1963 and 1964 at 110 million pCi/L.

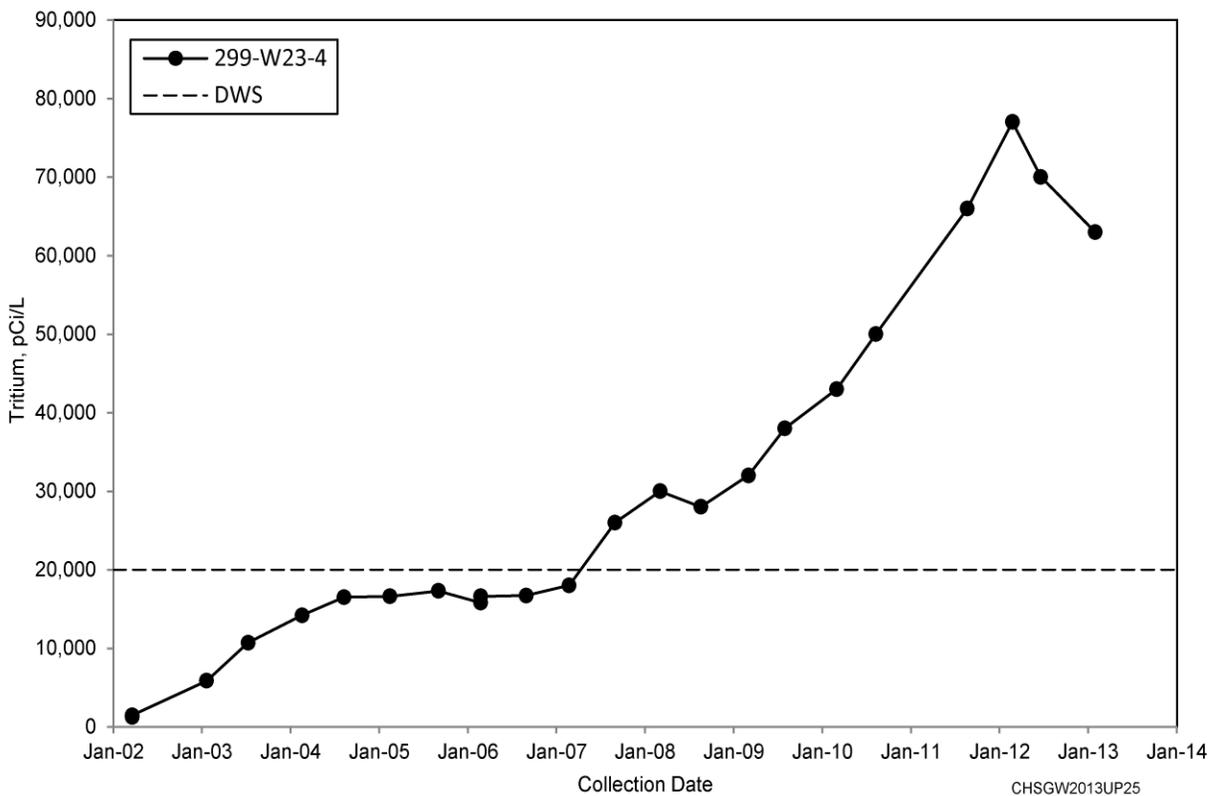


Figure UP.15 200-UP Tritium Data for Well 299-W23-4 at the 216-S-21 Crib

200-UP Iodine-129

Iodine-129 plumes in 200-UP originated from U Plant and REDOX Plant waste sites, although the latter were the primary sources (Figure UP.16). Iodine-129 occurs as two plumes, one from the 216-U-1 and 216-U-2 cribs near U Plant and a second from the REDOX Plant waste sites in the southern portion of the 200 West Area. These plumes merge downgradient and become indistinguishable.

The boundary of the iodine-129 plume had been extended eastward during 2012 based on sample results from well 699-38-61 located 2.8 kilometers east of the 200 West Area boundary. The February 2012 sample result from this well was 2.0 pCi/L (above the 1 pCi/L cleanup level), but this result was not confirmed by sampling during 2013. This well was sampled during May and November with results of 0.61 and 0.74 pCi/L, respectively. Based on these values, the eastward extent of the plume was revised again to be consistent with plume depictions in previous years.

REDOX Waste Sites. The highest concentrations of iodine-129 within 200-UP, greater than 10 times the 1 pCi/L cleanup level, originate from the REDOX Plant waste sites and occur in a region extending 2 kilometers east into the 600 Area from the southeastern 200 West Area (Figure UP.16). The maximum sample result in this plume during 2013 was 9.1 pCi/L in well 299-W22-88. High concentrations in this area occurred at 699-35-70, where the iodine-129 concentration was 37 pCi/L in March 2008. This well is now dry. High concentrations also occurred in 299-W22-9 located along the eastern boundary of the 200 West Area. This well became dry during 2006; the iodine-129 concentration was 30 pCi/L when this well was last sampled in 2005. It is recommended that dry wells 699-35-70 and 299-W22-9 be replaced and that depth-discrete sampling be performed during drilling to characterize the vertical profile of the plume.

SX Tank Farm. A small iodine-129 plume is interpreted to occur beneath the SX Tank Farm (Figure UP.16). In a sample collected during December 2011 from 299-W23-19, located within the tank farm, the iodine-129 concentration was reported to be 2.0 pCi/L. Concentrations have declined since startup of groundwater extraction in the area during July 2012. In December 2013, the concentration was down to 1.0 pCi/L. Iodine-129 is not detected in upgradient well 299-W23-21, so the SX Tank Farm is likely the source of this small plume. No other wells in the WMA S-SX vicinity have concentrations above the 1 pCi/L cleanup level. Iodine-129 was detected above the cleanup level at 299-W22-26 downgradient from the S Tank Farm before this well became dry (2.8 pCi/L in 2011), but the source is the 216-S-9 Crib.

216-U-1 and 216-U-2 Cribs. The maximum iodine-129 sample result downgradient from these cribs during 2013 was 2.6 pCi/L in well 299-W19-49. This plume occurs at a shallow depth near the source, but deepens as the plume extends eastward. The plume is fully mixed vertically throughout the aquifer at well 699-38-70C, located 1.8 kilometers east of the cribs (see the plume cross section in [DOE/RL-2011-01](#), Figure 11-16). Full mixing of the plume is attributed to vertical dispersion.

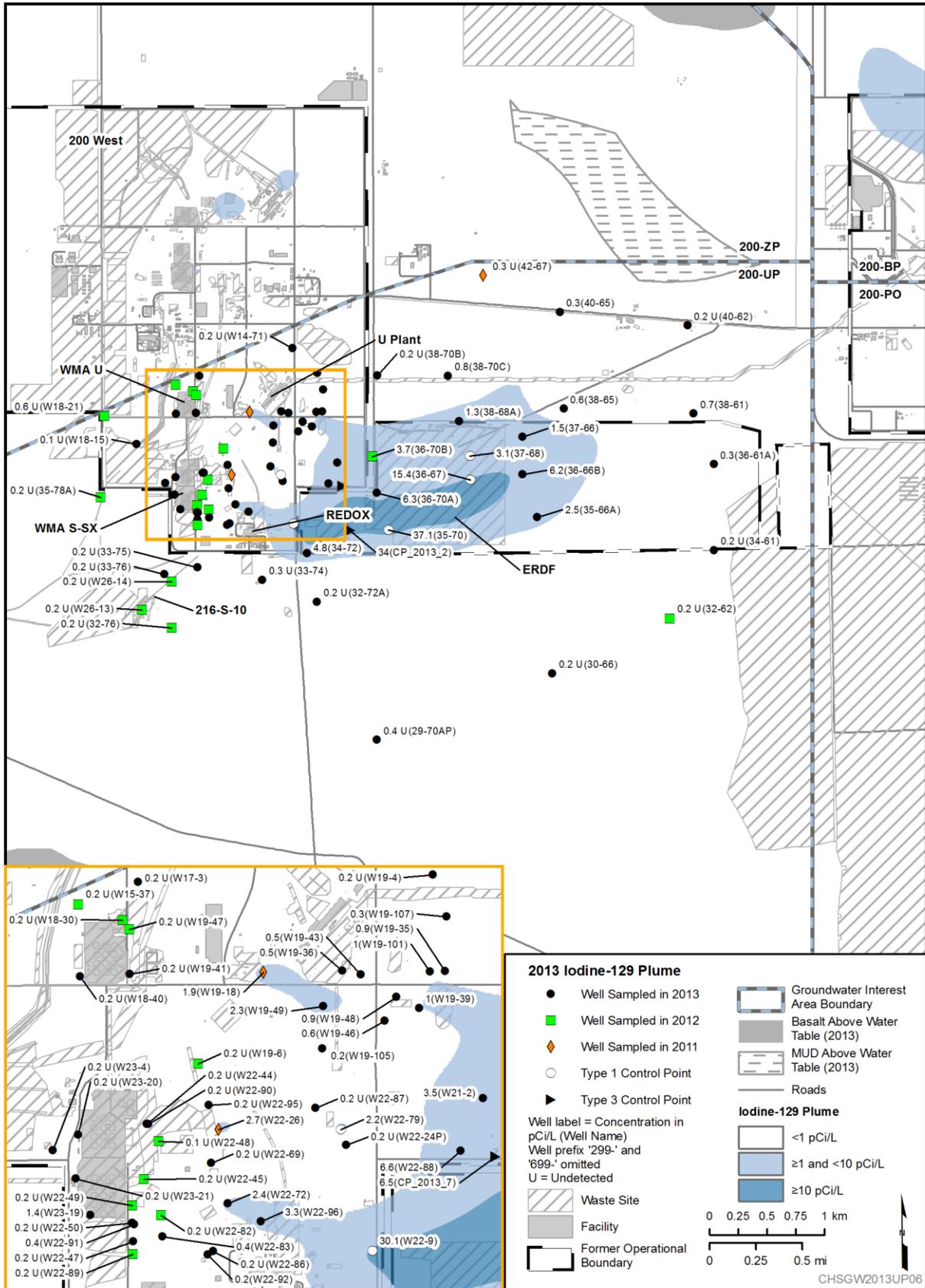


Figure UP.16 200-UP 2013 Iodine-129 Plume

200-UP Nitrate

Nitrate plumes in 200-UP originated from U Plant and REDOX Plant disposal facilities, although U Plant sources were more substantial (Appendix C in RPP-26744, *Hanford Soil Inventory Model, Rev 1: SIM Production Output Files*) (Figure UP.17).

U Plant Crib Sources. In the U Plant area, nitrate concentrations have been highest in the two former extraction wells, 299-W19-36 and 299-W19-43. The 2013 sample result at 299-W19-36 was 314 mg/L, an increase from 256 mg/L in 2012. The result from 299-W19-43 was 3,210 mg/L, similar to the concentration in 2012 (Figure UP.18). Concentrations at 299-W19-43 are much higher than concentrations measured at the 216-U-1 and 216-U-2 Cribs in the 1970s and 1980s (approximately 100 mg/L to approximately 300 mg/L). This suggests a local source of nitrate near 299-W19-43. The highest concentration east of the 200 West Area during 2013 was 210 mg/L in wells 699-38-68A and 699-40-65.

WMA U. During 2013, nitrate concentrations were greater than the 45 mg/L cleanup level in six of the seven monitoring wells at the U Tank Farm, including the upgradient well, 299-W18-40. The upgradient source is interpreted to be the injection wells formerly used for the 200-ZP interim action P&T system (Section 3.3.5 of [DOE/RL-2011-118](#)). Because concentrations in some of the downgradient wells are higher than in the upgradient well, it is likely that WMA U is also a source of nitrate to the groundwater. At downgradient well, 299-W19-44, the nitrate concentration had increased rapidly during 2012 from 37 mg/L in April to 75 mg/L in October. The concentration peaked during January 2013 at 97 mg/L, and then declined to 71 mg/L in July 2013 (Figure UP.19). A fluctuation in the nitrate trend also occurred at 299-W19-41 (Figure UP.19). These trend changes could be explained by a pulse of contamination entering the aquifer from beneath the tank farm. However, the trend changes began shortly after startup of the nearby 200 West P&T system, which began operating during July 2012 and the perturbation of the groundwater flow system may also be the cause. The groundwater beneath this tank farm is within the capture zone of the nearby extraction well 299-W17-3.

WMA S-SX/216-S-25 Crib. A nitrate plume originates from the 216-S-25 Crib and merges with a nitrate plume from the SX Tank Farm. At 299-W23-19 within the SX Tank Farm, the nitrate concentration declined during 2013 from 474 mg/L in March to 159 mg/L during October (Figure UP.6). This decline is attributed to operation of the WMA S-SX groundwater extraction system. Nitrate from the WMA has been attributed primarily to a 190,000 liter leak from tank SX-115 that occurred during 1965 (Section 4.5 of [RPP-ENV-39658](#)).

A nitrate plume also originates from the S Tank Farm. The maximum concentration in this plume during 2013 was 193 mg/L measured at 299-W22-44 in March. Nitrate in this well began increasing in 2006, peaked during 2010, and has generally decreased thereafter (Figure UP.8), and remains below the peak concentration observed in 2010. This plume originates from an overfill event at tank S-104 between 1966 to 1970. At 299-W22-26, located 250 meters downgradient from 299-W22-44, nitrate concentrations peaked in 2010 and declined thereafter (Figure UP.9). The nitrate in this well is from an earlier release from the vadose zone to the aquifer beneath the tank farm.

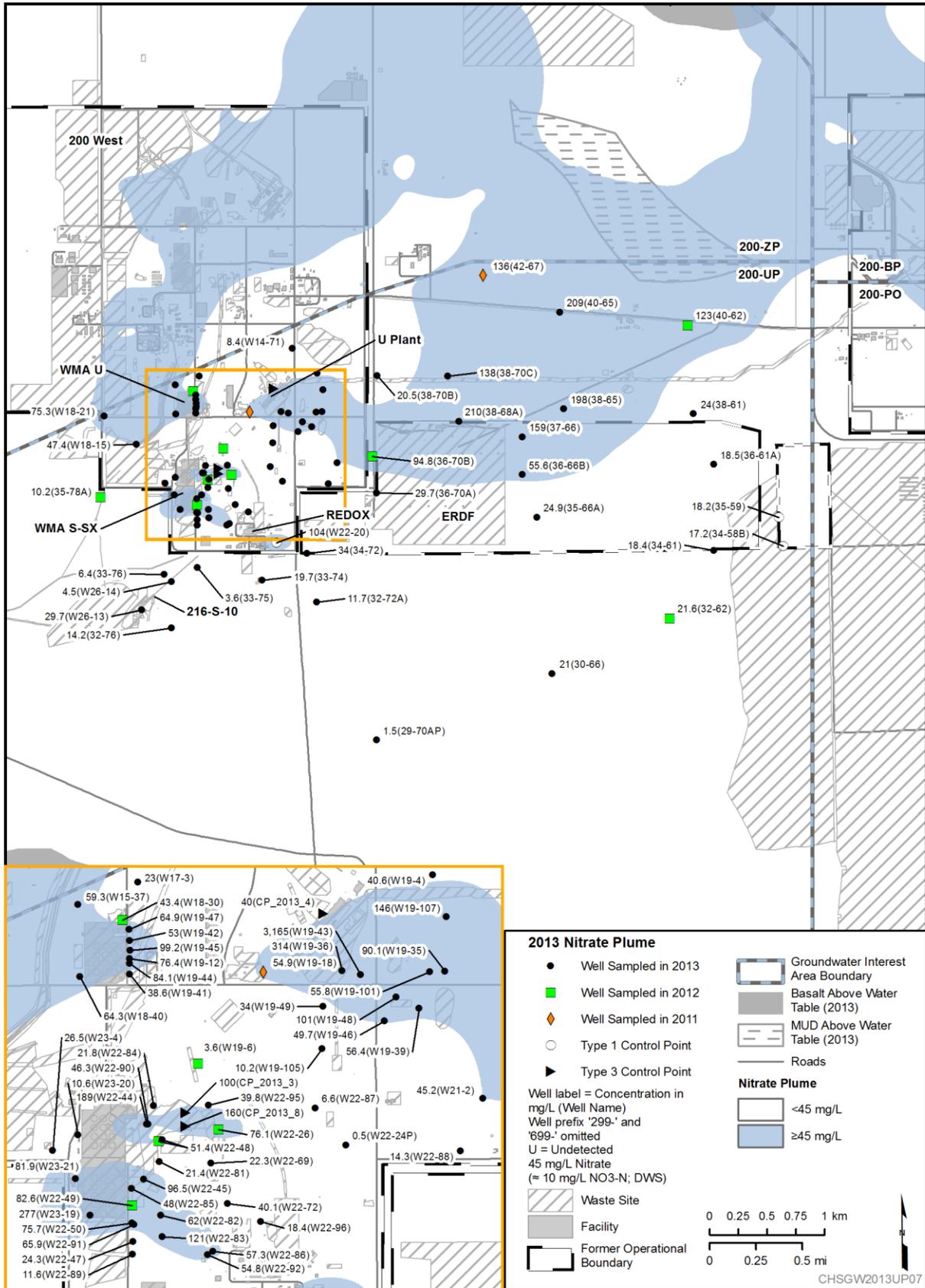


Figure UP.17 200-UP 2013 Nitrate Plume

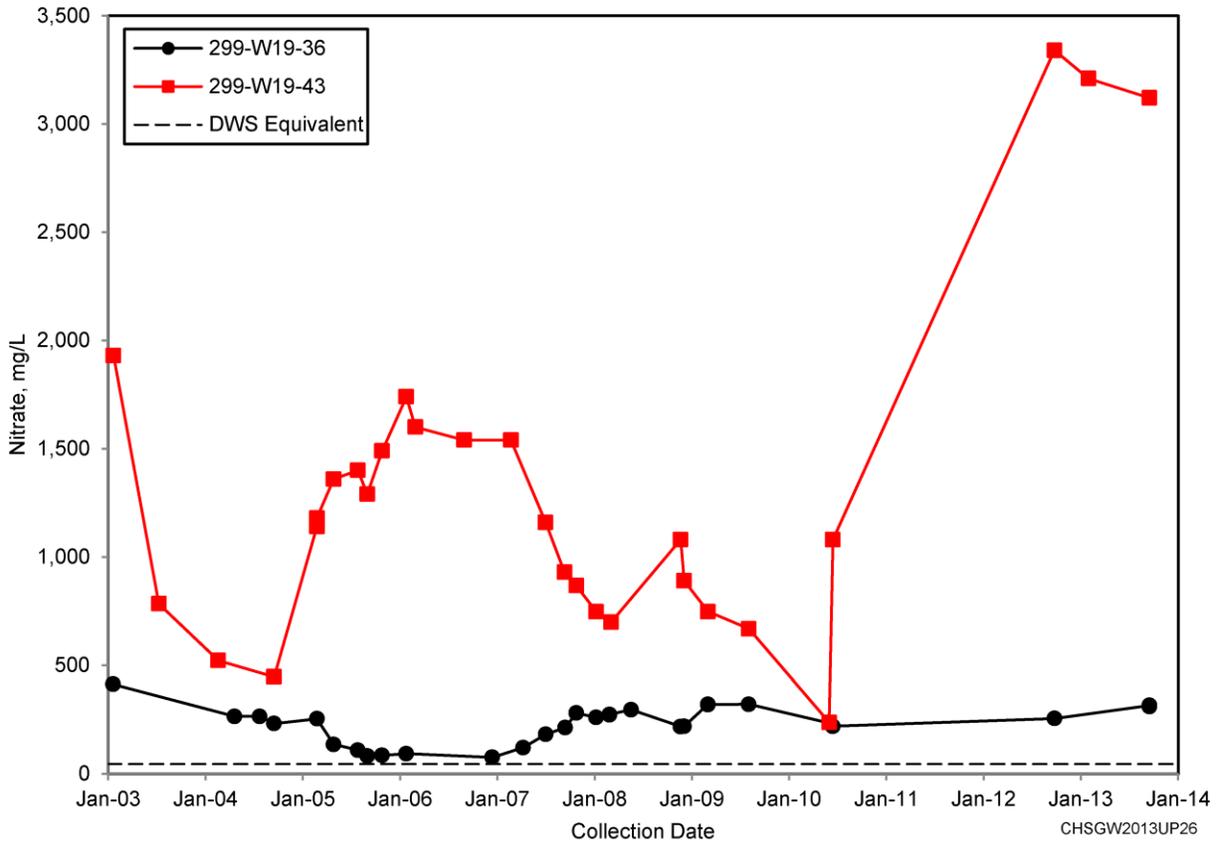


Figure UP.18 200-UP Nitrate Data for Wells 299-W19-36 and 299-W19-43 near U Plant

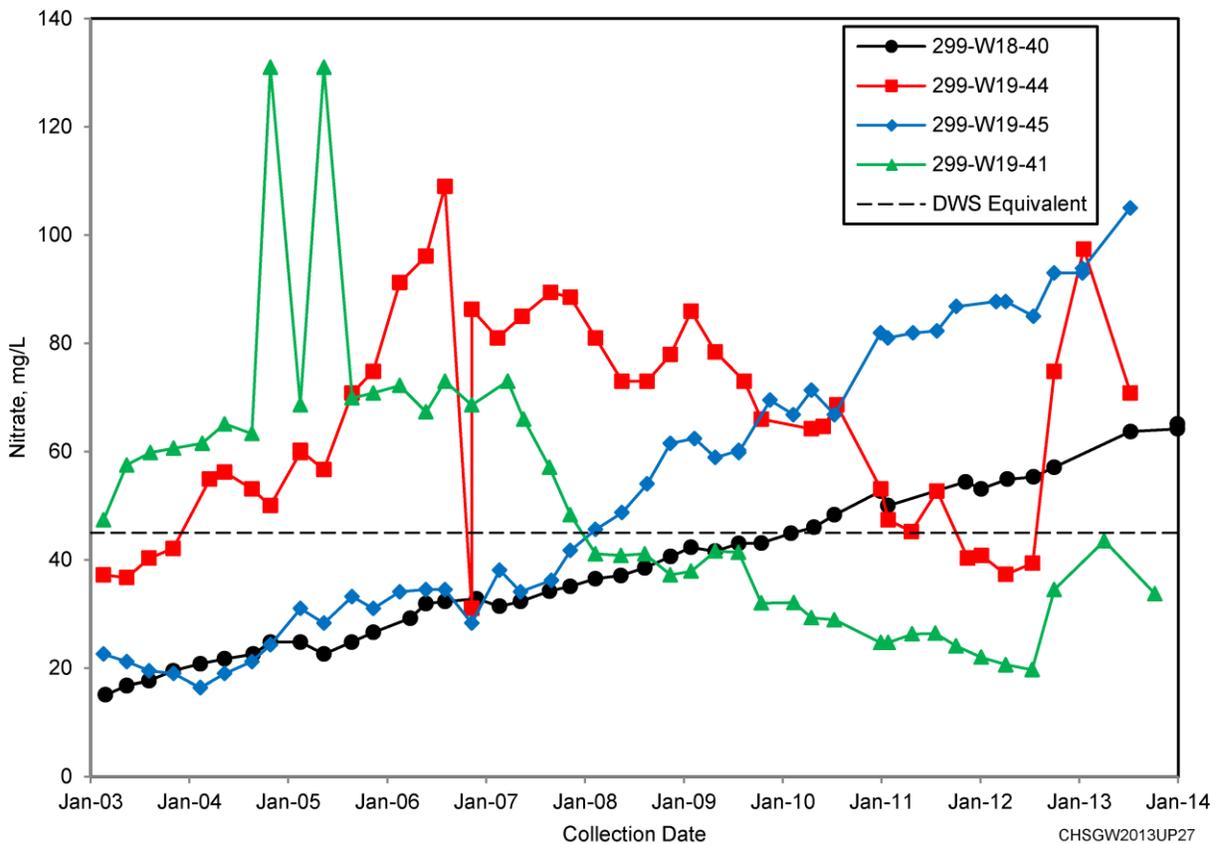


Figure UP.19 200-UP Nitrate Data for Selected Wells at WMA U

200-UP Chromium

Substantial chromium plumes are found in two regions of 200-UP: in two plumes at WMA S SX and another, larger plume in the 600 Area east and southeast of the 200 West Area (Figure UP.20). Concentrations above the 48 µg/L cleanup level also occur near the 216-S-20 Crib and 216-S-10 Pond and Ditch, the sources of the 600 Area chromium plume.

WMA S-SX. Chromium concentrations in seven wells at WMA S-SX exceeded the 48 µg/L cleanup level in at least one sample during 2013. The highest concentrations occurred at 299-W23-19, where sample results declined during the year from 906 µg/L in March to 484 µg/L in December (Figure UP.6). The decline is attributed to operation of the WMA S-SX groundwater extraction system.

A second chromium plume occurs downgradient from the S Tank Farm. This plume originated from tank S-104 (an overflow event from 1966 to 1970). At near-field downgradient well 299-W22-44, the chromium concentration was 404 µg/L in a filtered sample collected during March (the unfiltered result was 641 µg/L but was affected by high turbidity) (Figure UP.8). This well is now dry. Concentrations at nearby extraction well 299-W22-90 declined during 2013 from 120 µg/L in April to 76 µg/L in November (both unfiltered). The extraction well captures the portion of the chromium plume near the source.

Southeast Plume. Within the chromium plume east-southeast of the 200 West Area, concentrations in 699-32-62 have slowly declined from 254 to 134 µg/L since this constituent was first measured in 1992 (Figure UP.21) (this well is sampled for chromium every other year). The gradual reduction in concentration at this location likely results from the continued downgradient migration of the dissolved chromium plume. Chromium is also elevated at well 699-30-66 (results between 112 and 121 µg/L during 2013), which is completed deep in the aquifer just above the Ringold lower mud unit (Figure UP.21). These data indicate chromium is present throughout the aquifer thickness in this region because of dispersion as the plume migrated east from the source sites (see the cross section on Figure 11-20 in [DOE/RL-2011-01](#)).

An interim ROD addressing the remediation of this plume was issued in September 2012. This plume originated primarily from effluent disposal to the 216-S-20 Crib during the 1950s, although the REDOX Plant ponds and ditches south of the 200 West Area were also sources (Section 4.2.4 of [DOE/RL-2009-122](#)). An estimated 5,900 kilograms of chromium were disposed to the 216-S-20 Crib, and an estimated 3,000 kilograms were disposed to 216-S-10 Pond and Ditch (Appendix C in RPP-26744, *Hanford Soil Inventory Model, Rev 1: SIM Production Output Files*). Chromium concentrations continue to be observed in groundwater near both of these source locations. In well 699-34-72, downgradient from the 216-S-20 Crib, total chromium was detected at 34 µg/L in a filtered sample collected during January 2013 (50 µg/L in the unfiltered sample). In well 299-W26-13 at the 216-S-10 Pond and Ditch, chromium averaged 103 µg/L during 2013 (hexavalent chromium and total chromium results combined) and the trend has been generally increasing (Figure UP.22). Chromium is also above background in well 699-32-76, located 300 meters farther downgradient (Figure UP.22).

The RD/RA work plan ([DOE/RL-2013-07](#)) released during September 2013, describes additional characterization activities to better define the vertical and horizontal extent of the southeast plume. The additional characterization will refine the plume geometry of the southeast regional chromium plume to focus and optimize the remedial design. Wells will be drilled and sampled in the area of the southeast chromium plume to collect the necessary data.

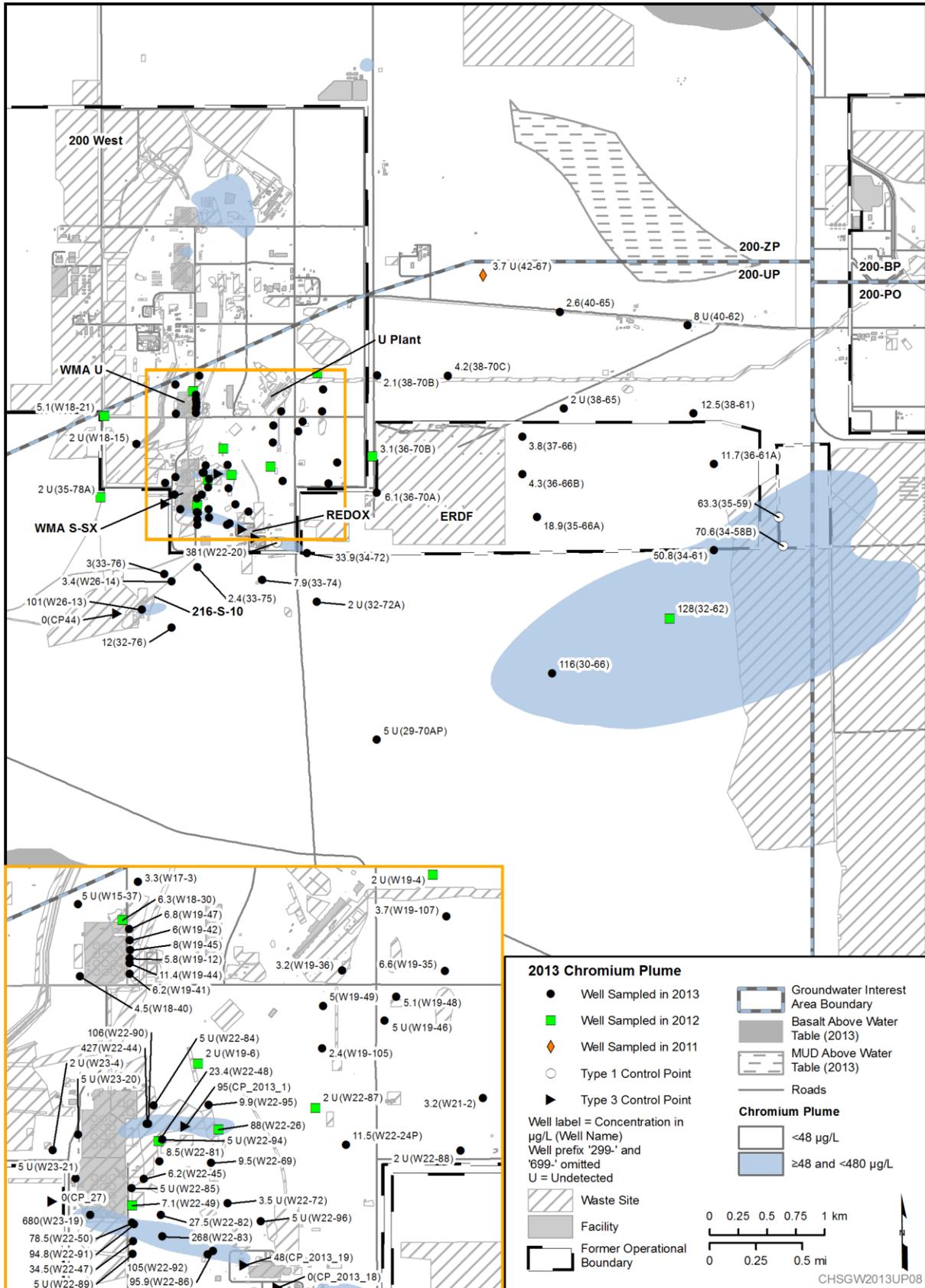


Figure UP.20 200-UP 2013 Chromium Plume

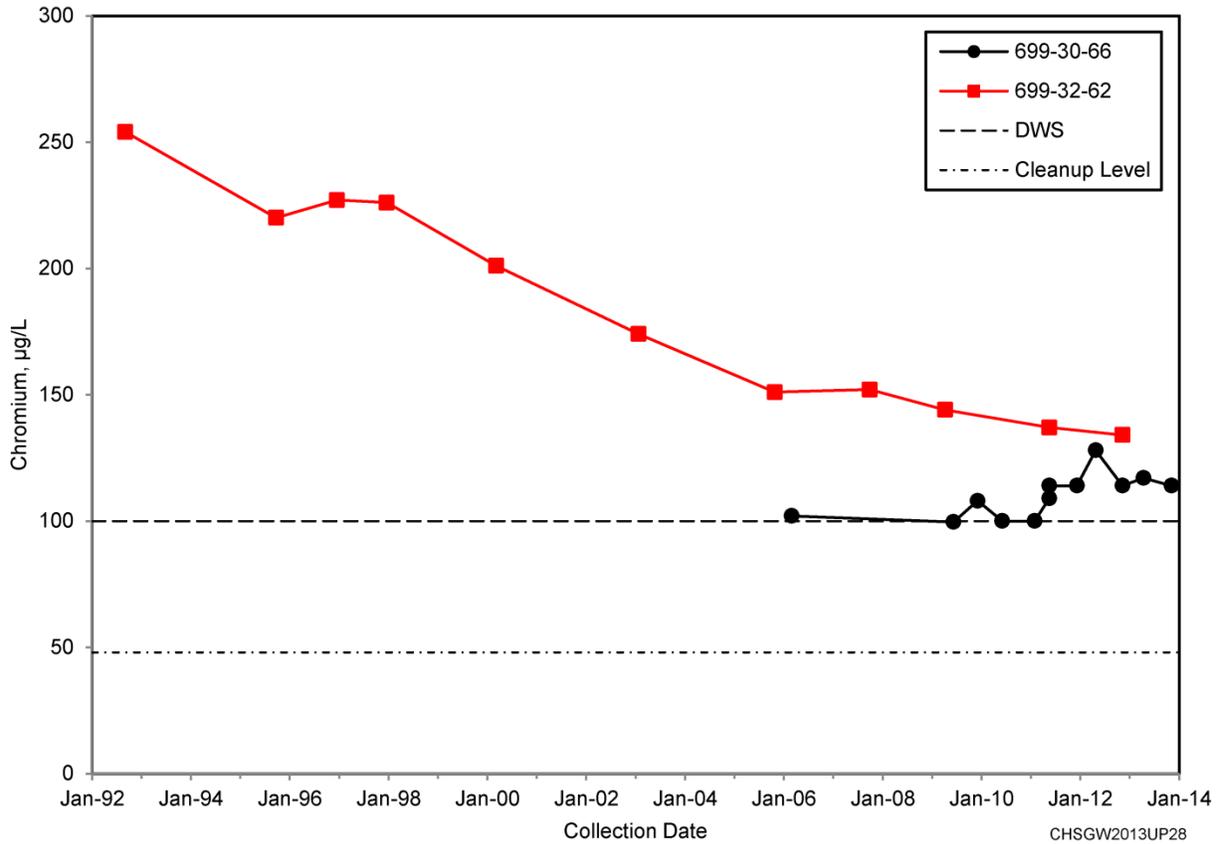


Figure UP.21 200-UP Chromium Data for Wells 699-30-66 and 699-32-62 Southeast of the 200 West Area

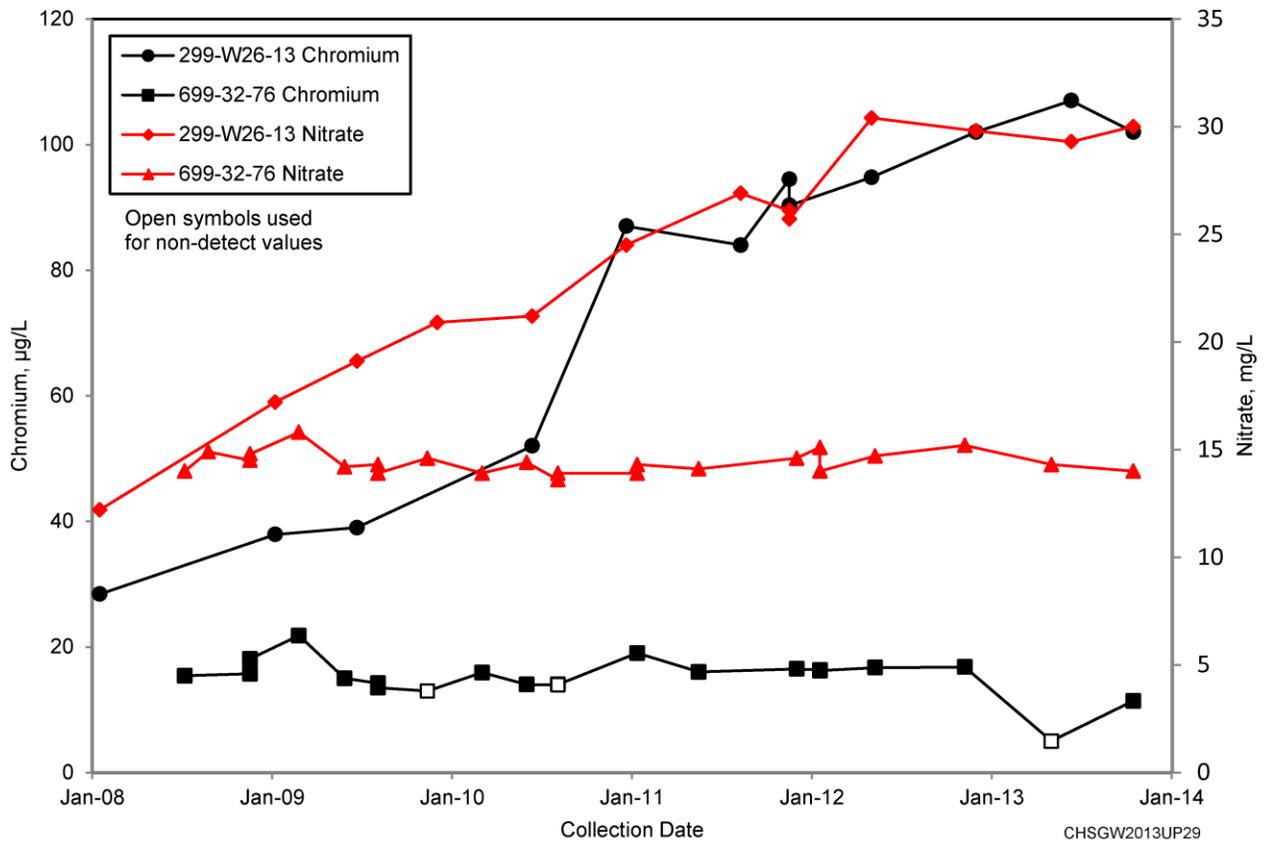


Figure UP.22 200-UP Chromium and Nitrate Data for Wells 299-W26-13 and 699-32-76 at the 216-S-10 Pond and Ditch

200-UP Carbon Tetrachloride

Carbon tetrachloride at concentrations above the 3.4 µg/L cleanup level is widespread within 200-UP. Concentrations were greater than 10 times the cleanup level in 32 wells during 2013. Concentrations were above the cleanup level in 44 of the 61 wells sampled for carbon tetrachloride within 200-UP in 2013. In the southern portion of the 200 West Area, the plume extends as much as 1.2 kilometers east into the 600 Area (Figure UP.23). The plume originated from waste disposal sites associated with the Plutonium Finishing Plant (PFP) in 200-ZP. In the eastern portion of the plume, concentrations increase with depth (see the plume cross section in Figure 11-21 in [DOE/RL-2011-01](#)). For instance, the highest carbon tetrachloride concentration measured within 200-UP during 2013 was 700 µg/L at 299-W14-71 (Figure UP.24), which is screened at the bottom of the unconfined aquifer. Also, concentrations at 299-W19-34A during 2013 averaged 101 µg/L, less than half the concentration of 220 µg/L in the adjacent well 299-W19-34B, which is completed near the bottom of the aquifer. The 200-ZP section provides additional information regarding carbon tetrachloride in 200 West.

Chloroform, a degradation product of carbon tetrachloride, tends to occur in the same wells as carbon tetrachloride. Thus, natural degradation of carbon tetrachloride is occurring, although chloroform was also introduced to the aquifer from the 2607-Z Tile Field (Section 3.2.8 in [DOE/RL-2011-01](#)). During 2013, 104 chloroform analyses were performed on samples from 61 wells within 200-UP; no exceedances of the drinking water standard (DWS) (80 µg/L for total trihalomethanes) were found. The maximum concentration was 9 µg/L at well 299-W19-34B. Depth-discrete sampling during new well installation indicates that chloroform concentrations tend to increase with depth, similar to carbon tetrachloride.

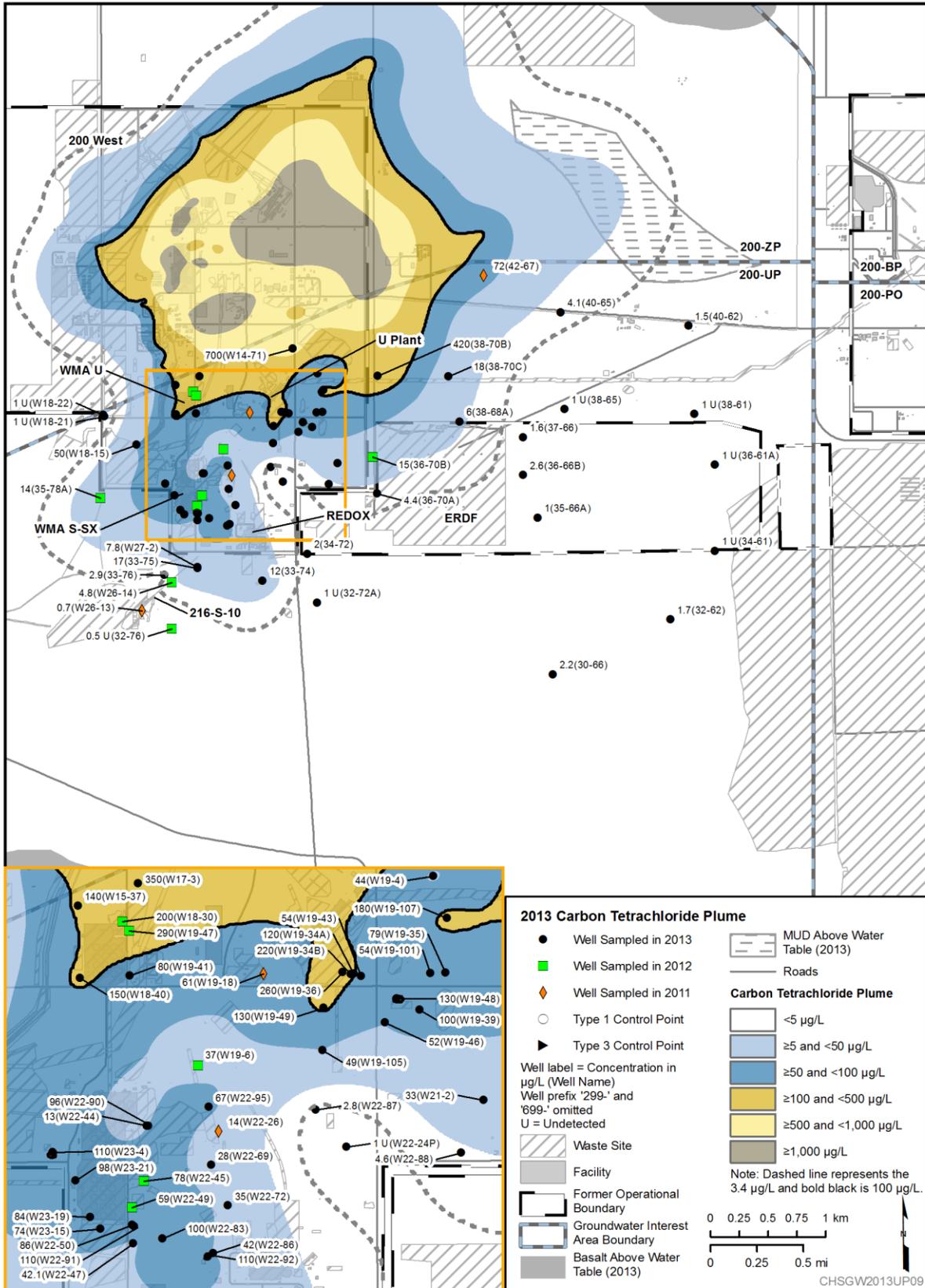


Figure UP.23 200-UP 2013 Carbon Tetrachloride Plume

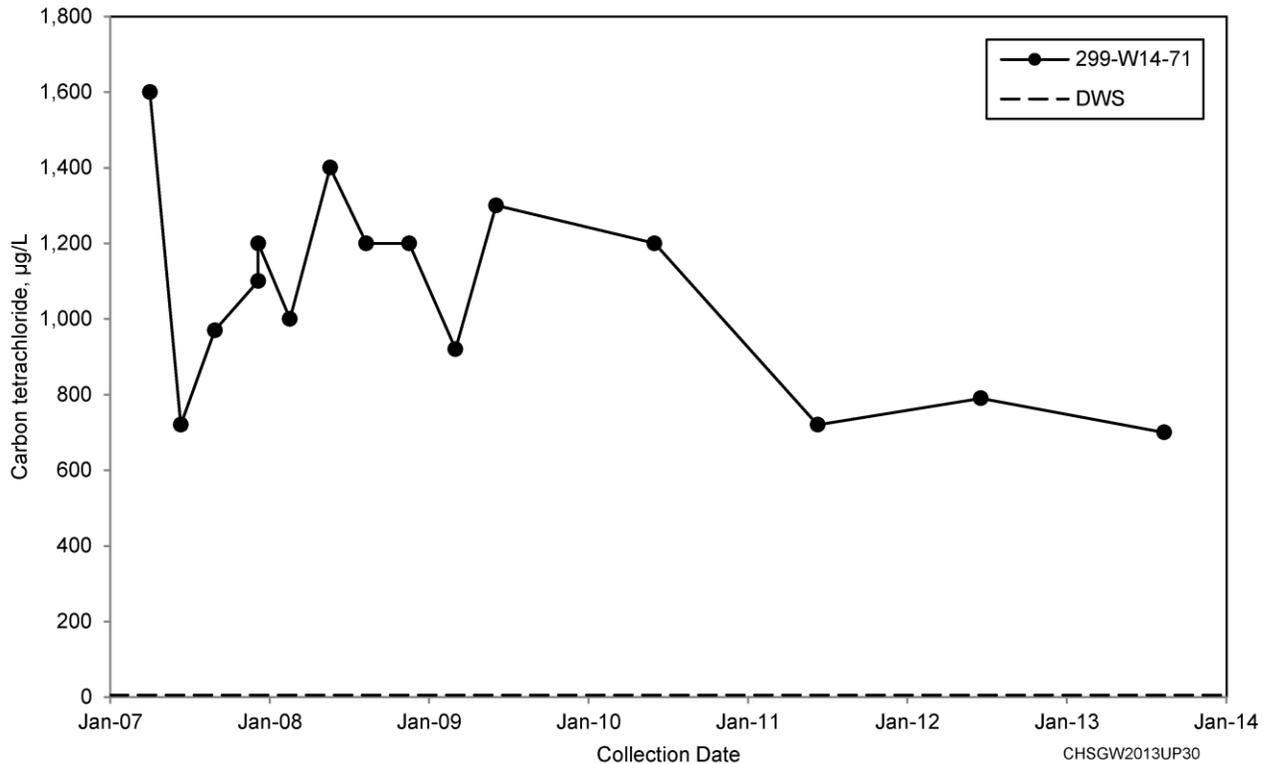


Figure UP.24 200-UP Carbon Tetrachloride Data for Well 299-W14-71 North of U Plant

200-UP Trichloroethene (TCE)

During 2013, TCE was found in groundwater in the northern portion of 200-UP (Figure UP.25). Depth-discrete samples during well drilling show that TCE concentrations increase with depth, similar to carbon tetrachloride and chloroform.

During 2013, 104 TCE analyses were performed on samples from 61 wells within 200-UP. TCE was detected in 11 wells, but the DWS (5 µg/L) was exceeded only at 299-W14-71 (7.2 µg/L), 699-38-70B (6.3 µg/L) and 299-W19-107 (5.4 µg/L). Three of the four TCE degradation products, 1,1-dichloroethene, 1,2-dichloroethene (cis- and trans-), and chloroethene (i.e., vinyl chloride), were also analyzed for, but no detections occurred during 2013.

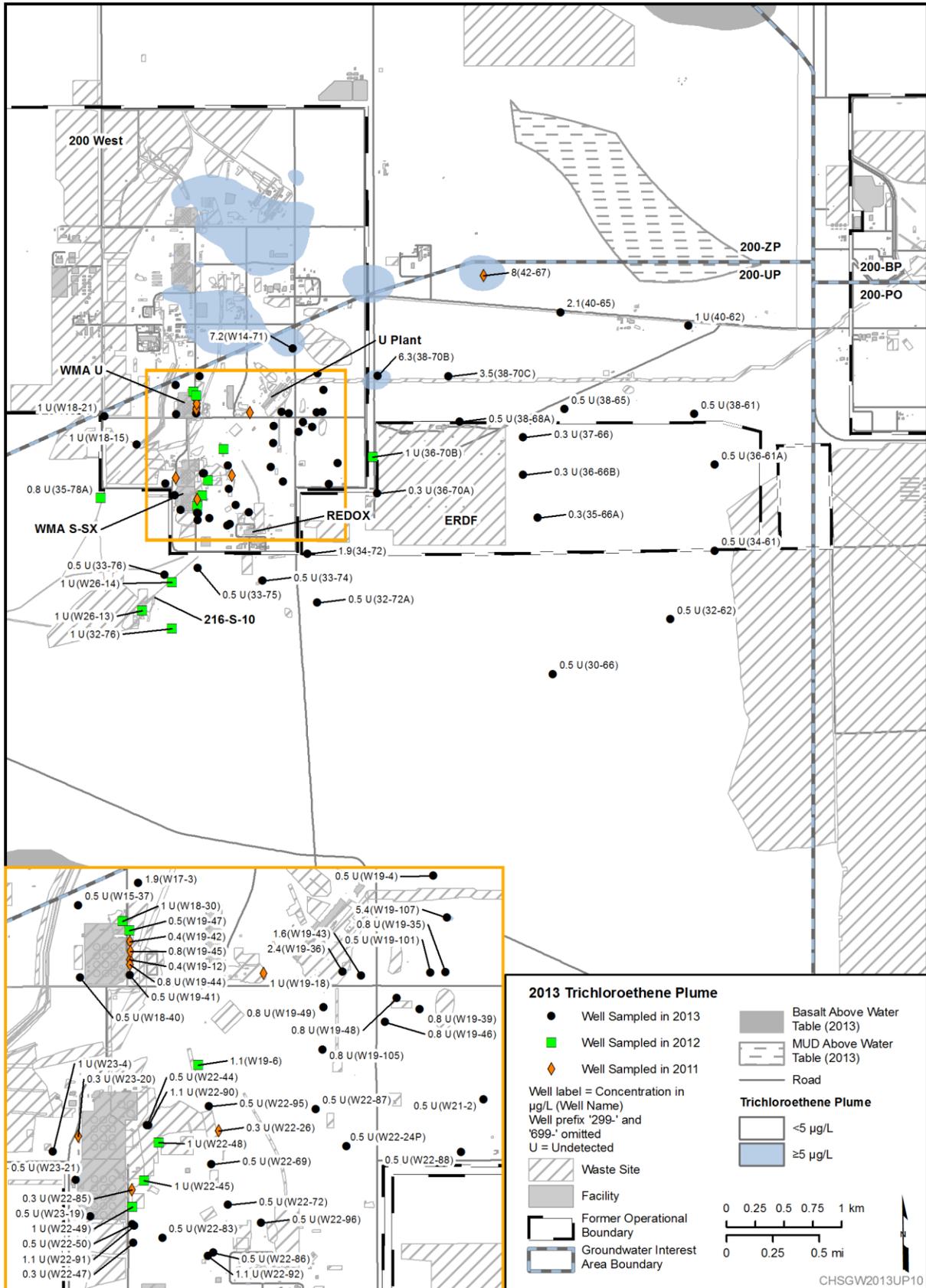


Figure UP.25 200-UP 2013 Trichloroethene (TCE) Plume

200-UP ERDF

The ERDF is a low-level radioactive mixed waste facility used for disposal of waste from surface remedial actions on the Hanford Site. The facility consists of ten disposal cells, six of which were active during 2013. Each disposal cell was constructed with a double-liner system to collect leachate from natural precipitation and water added as a dust suppressant. Leachate collects in sumps beneath the cells and is pumped to two holding tanks before being sent to the Effluent Treatment Facility (ETF) for treatment. During 2013, 975,560 metric tons (19,506 Ci of radioactivity) of remediation waste were disposed of at the facility.

Groundwater monitoring at the ERDF is regulated under a CERCLA ROD ([EPA/ROD/R10-95/100](#)), which states that groundwater monitoring will be conducted in accordance with RCRA regulations. The site was designed to meet RCRA standards, although it is not actually permitted as a RCRA facility.

Leachate Monitoring. Periodic sampling and analyses of the ERDF leachate is performed to ensure the leachate meets the ETF waste acceptance criteria and to assess whether additional analytes should be added to the routine groundwater monitoring program. The ERDF leachate was delisted as a hazardous waste in 1999, allowing the leachate to be managed as a nonhazardous waste for transfer to the ETF for treatment. To maintain the delisting status, concentrations of certain constituents in the leachate must remain below the delisting levels. These constituents (all nonradionuclides), their delisting levels, and criteria to maintain delisting status are specified in [WCH-173](#).

Samples are collected from the holding tanks and represent composite samples of all the leachate collected. Leachate samples are normally collected during March and September of each year, but the September 2013 sampling was delayed until February 2014 due to procedural and accessibility issues. No exceedances of a delisting level occurred during this time frame and no new detections were noted. Only nitrate was noted at detected concentrations greater than 1/10th of the delisting value (all nitrate values to date have exceeded 1/10th of the delisting values). Nitrate values rebounded somewhat from the near minimum values seen in 2012, but remained below historical averages. Results of the leachate sampling indicated that no analytes need to be added to the groundwater monitoring program.

Groundwater Sampling. Groundwater monitoring at the ERDF is performed under the [WCH-198](#). The groundwater flow direction beneath the ERDF is toward the east-northeast. One upgradient well (699-36-70A) and three downgradient wells (699-37-66, 699-36-66B, and 699-35-66A) are sampled semiannually (Figure UP.26), typically in March and September. To detect impacts to groundwater quality, sample results are compared to baseline conditions established when monitoring began in 1996 using a tolerance interval approach ([WCH-198](#)). All monitoring wells were sampled successfully during 2013.

The results of groundwater monitoring at the ERDF continued to indicate that the facility has not affected groundwater quality. Several constituents (tritium, iodine-129, nitrate, and carbon tetrachloride) are present in the groundwater near or above the 200-UP-1 cleanup levels, but these constituents are elevated in both the upgradient and downgradient wells. These plumes originated in the 200 West Area and have migrated toward ERDF.

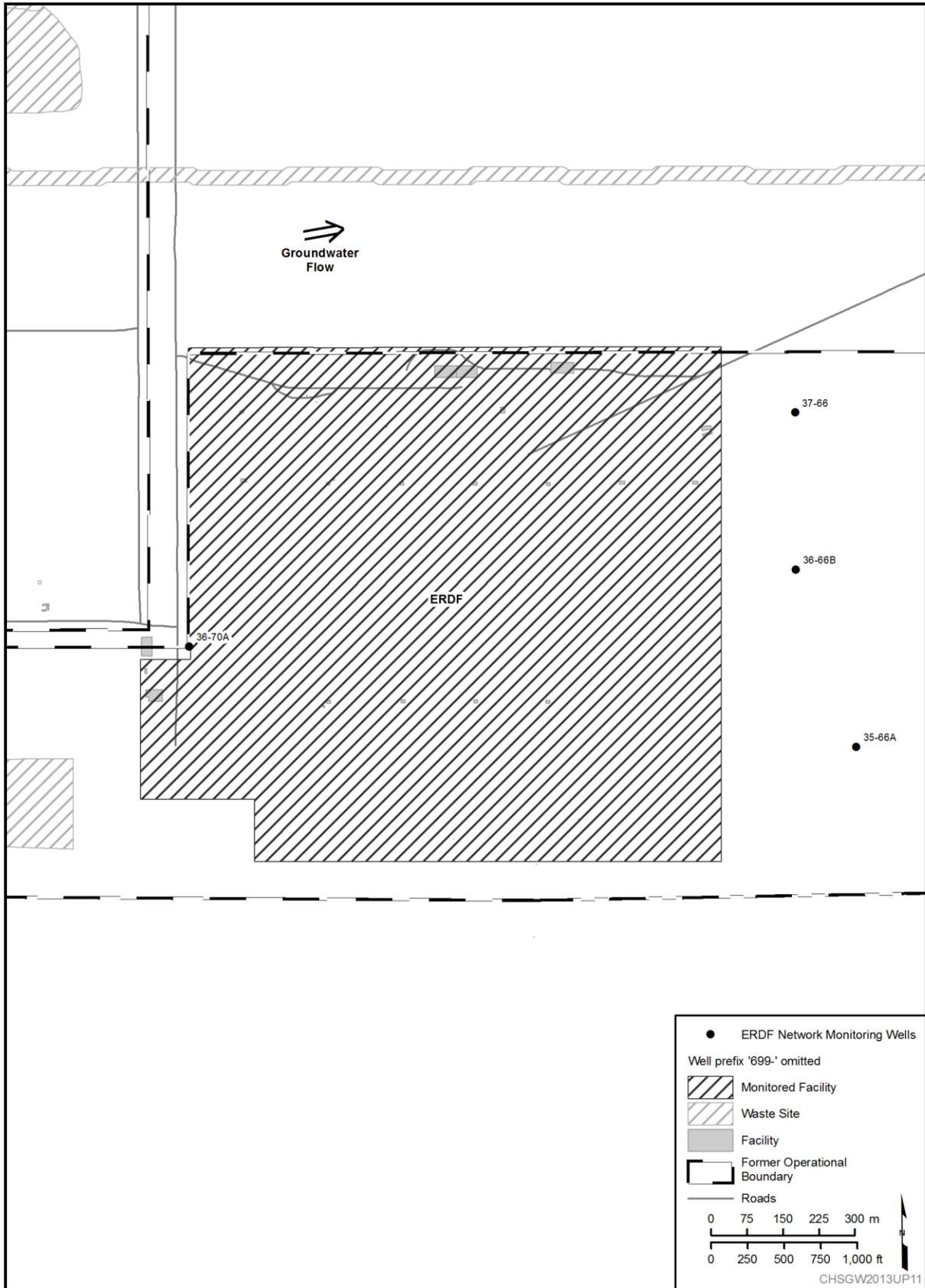


Figure UP.26 200-UP ERDF Monitoring Well Locations

The uranium concentrations at all wells are consistent with Hanford Site background levels. Both technetium-99 and gross beta are trending downward in upgradient well 699-36-70A and downgradient wells 699-37-66 and 699-36-66B. Technetium-99 and gross beta (affected by technetium-99) in downgradient well 699-35-66A dropped in 2013 from the maximum seen in 2012. Additional sampling will be needed to determine if these constituents are now trending downward similar to the other wells. The maximum technetium-99 results remain approximately 15 percent of the 200-UP cleanup level. Nitrate levels appear to be stabilizing in all wells. Fluoride results for all wells appear to have stabilized near historic levels below the spikes noted in 2012. Vanadium results in all wells continue to decline from the maximum seen in the March 2010 sampling and have returned to or near the pre-March 2010 values.

Chromium sample results have increased slightly in all wells, with upgradient well 699-36-70A showing the largest increase in the fall 2013 sampling. While chromium is present as a contaminant in some areas of the Hanford Site, low-levels of chromium have also been associated with corrosion of the stainless steel well screens. Nickel and manganese (both components of 304/316 stainless steel) are slightly elevated at 699-36-70A, consistent with corrosion of the screen. Lead results routinely are below detection limits for all wells. Periodically, low levels of lead are detected, typically in all wells during a given sampling event. Lead detections were noted in both 2013 sampling events with some values from September 2013 being the highest since 1999. The highest concentration of lead detected in 2013 was 13.1 µg/L from an unfiltered sampling from downgradient well 699-37-66. There are currently insufficient data to determine if these are trends or essentially random analytical variations. These specific items will continue to be monitored.

200-UP Remedy – S-SX Pump-and-Treat

During 2013, one groundwater remediation measure operated within 200-UP: the WMA S-SX groundwater extraction system. This system began operating during July 2012. The implementation plan for the WMA S-SX groundwater extraction system is contained in [DOE/RL-97-36](#), issued in 2010. The system was designed and began operating under the interim action ROD issued in 1997 ([EPA/ROD/R10-97/048](#)) as modified by the explanation of significant differences ([EPA et al., 2009b](#)). A new RD/RA work plan ([DOE/RL-2013-07](#)) was issued during 2013 to implement the new ROD issued in September 2012. This section provides a summary of this system for 2013. More details can be found in the 2013 annual P&T system report (DOE/RL-2014-26, In Press).

The WMA S-SX groundwater extraction system consists of three extraction wells: 299-W22-90, 299-W22-91, and 299-W22-92 (Figure UP.27). Extracted water is pumped to the 200 West P&T. The extraction wells began operating during July 2012. During 2013, the combined flow rate from the extraction wells averaged 258 liters per minute. During 2013, 135.5 million liters were pumped, and 0.81 curie of technetium-99, 7,550 kilograms of nitrate, 13.5 kilograms of chromium, and 119 kilograms of carbon tetrachloride were removed from the aquifer (Table UP.2).

The system is operating with the goal of reducing concentrations to below the 9,000 pCi/L cleanup level ([DOE/RL-2013-07](#)). As shown by the hydraulic capture zones on Figure UP.28, it is expected that extraction wells will capture almost all of the plume above 9,000 pCi/L near the sources in the S and SX Tank Farms (Figure UP.28). Each concentric circle on Figure UP.28 represents approximately one year of modeled capture. For example, the 9,000 pCi/L portion of southernmost plume will be captured by well 299-W22-92 in approximately 10 years. Groundwater modeling will be performed to assess if MNA will reduce the remaining portion of the plume to below the cleanup level.

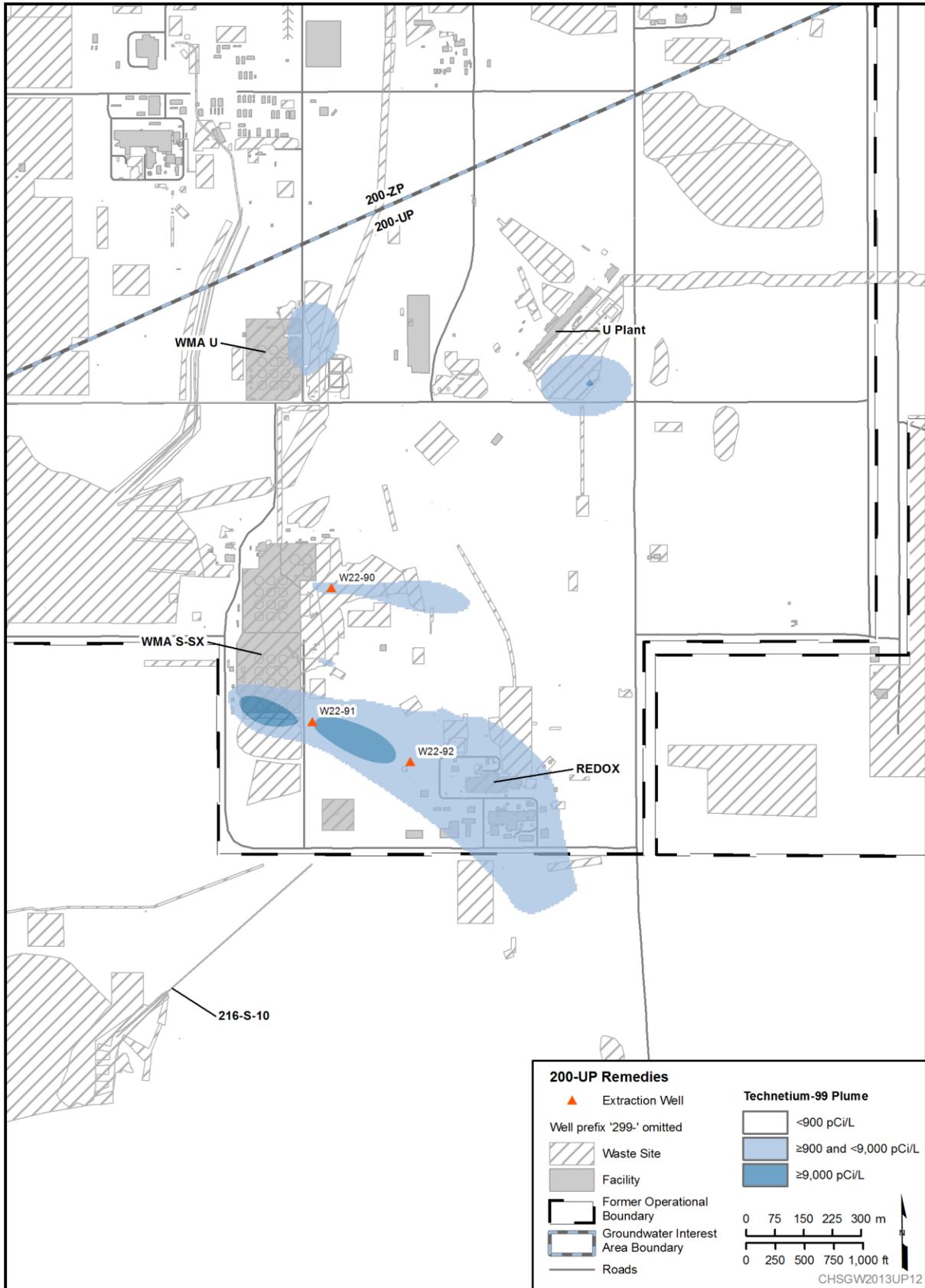


Figure UP.27 200-UP Remedy Locations

Table UP.2 S-SX Tank Farms Groundwater Extraction System Summary		
Parameter	2013	Since Startup
Total groundwater processed, millions of liters	135.5	161.6
Mass of chromium removed, kg	13.5	17.9
Mass of nitrate removed, kg	7,550	9,560
Mass (activity) of technetium-99 removed, g (Ci)	47.8 (0.811)	60.8 (1.03)
Mass of carbon tetrachloride removed, kg	119	121
System availability during 2013	89%	n/a

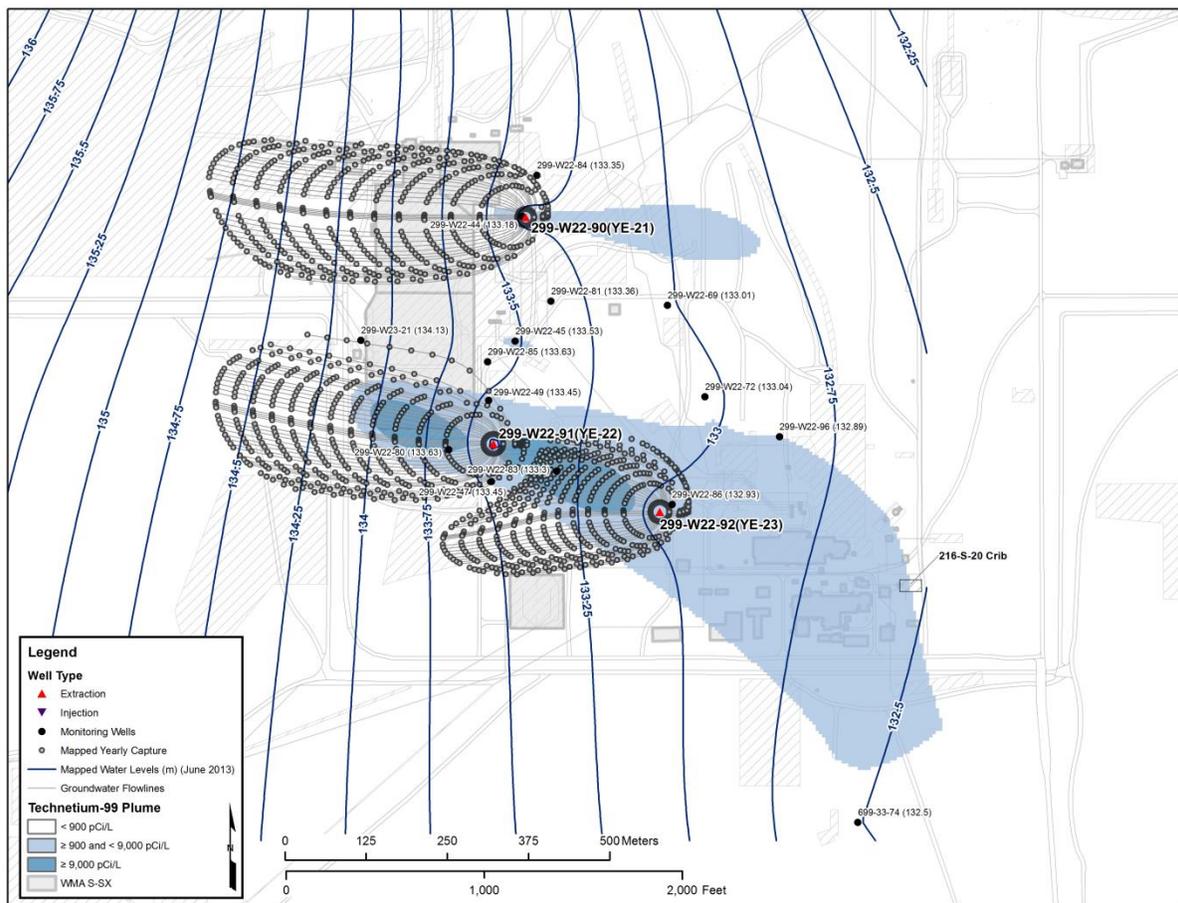


Figure UP.28 200-UP Modeled Groundwater Capture Zones at WMA S-SX

As expected, concentrations of chromium, nitrate, and technetium-99 in the extraction wells have exhibited declining trends since pumping began (Figures UP.29, UP.30, and UP.31). The declines are attributed to growth of the capture zones either into portions of the plumes with different concentrations or outside of the plumes entirely (vertically and laterally). Concentrations of carbon tetrachloride either increased (299-W22-90) or were unchanged (299-W22-91 and 299-W22-92) (Figure UP.32), consistent with the widespread occurrence of this constituent in the aquifer.

Operation of the extraction wells has changed contaminant concentration trends in some nearby monitoring wells, particularly 299-W22-47. By the end of 2013, chromium and nitrate concentrations in this well had declined to below their respective cleanup levels, and technetium-99 was only slightly above the cleanup level at 1,100 pCi/L (Figure UP.33). The rapid concentration declines indicate higher permeability sediments between this well and extraction well 299-W22-91.

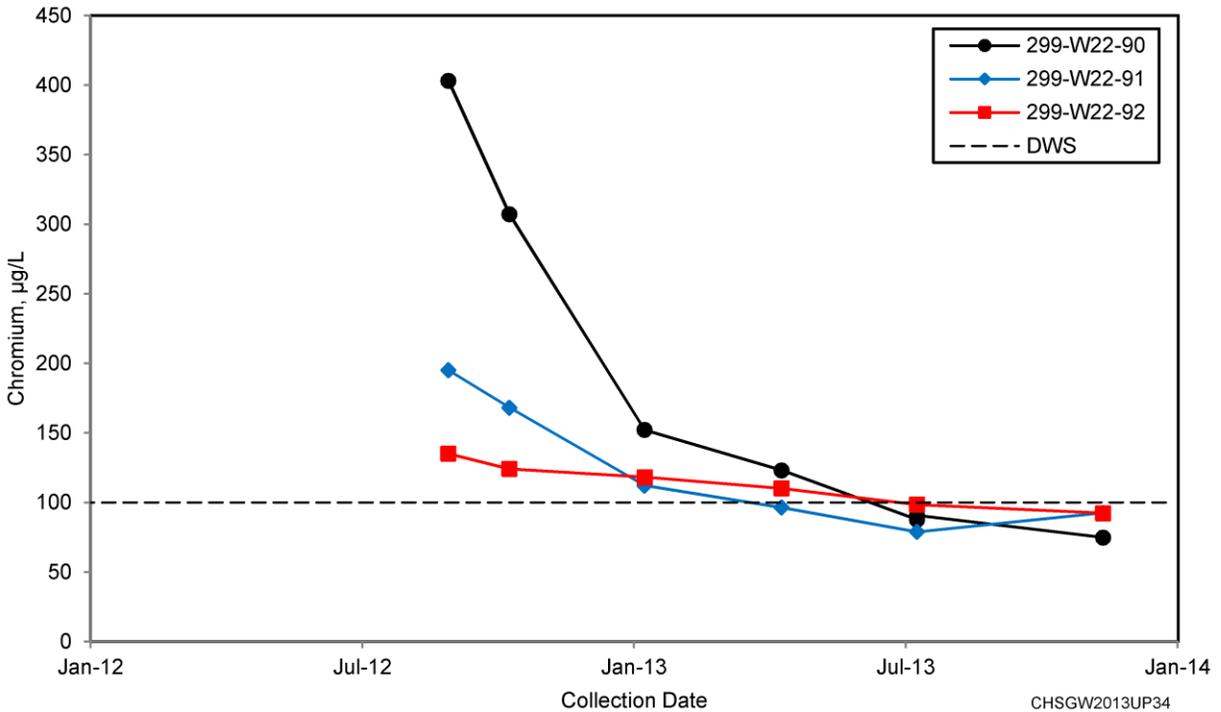


Figure UP.29 200-UP Chromium Data for WMA S-SX Extraction Wells

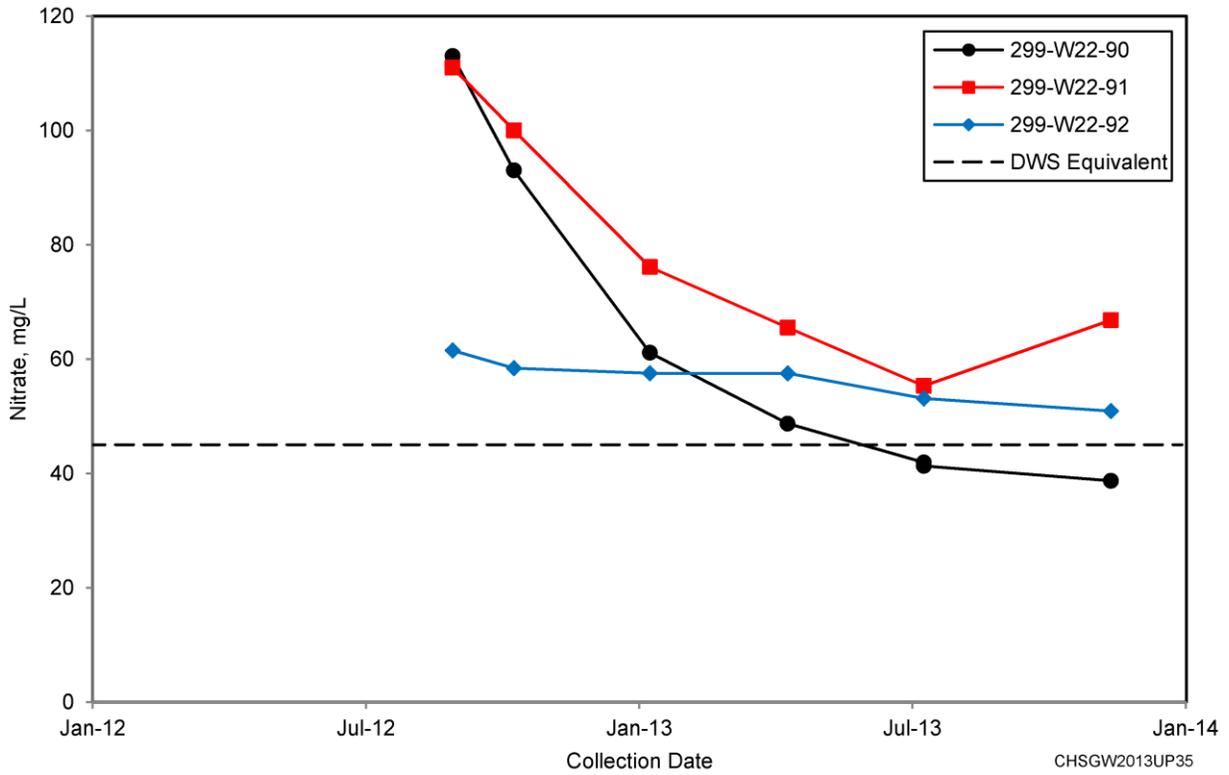


Figure UP.30 200-UP Nitrate Data for WMA S-SX Extraction Wells

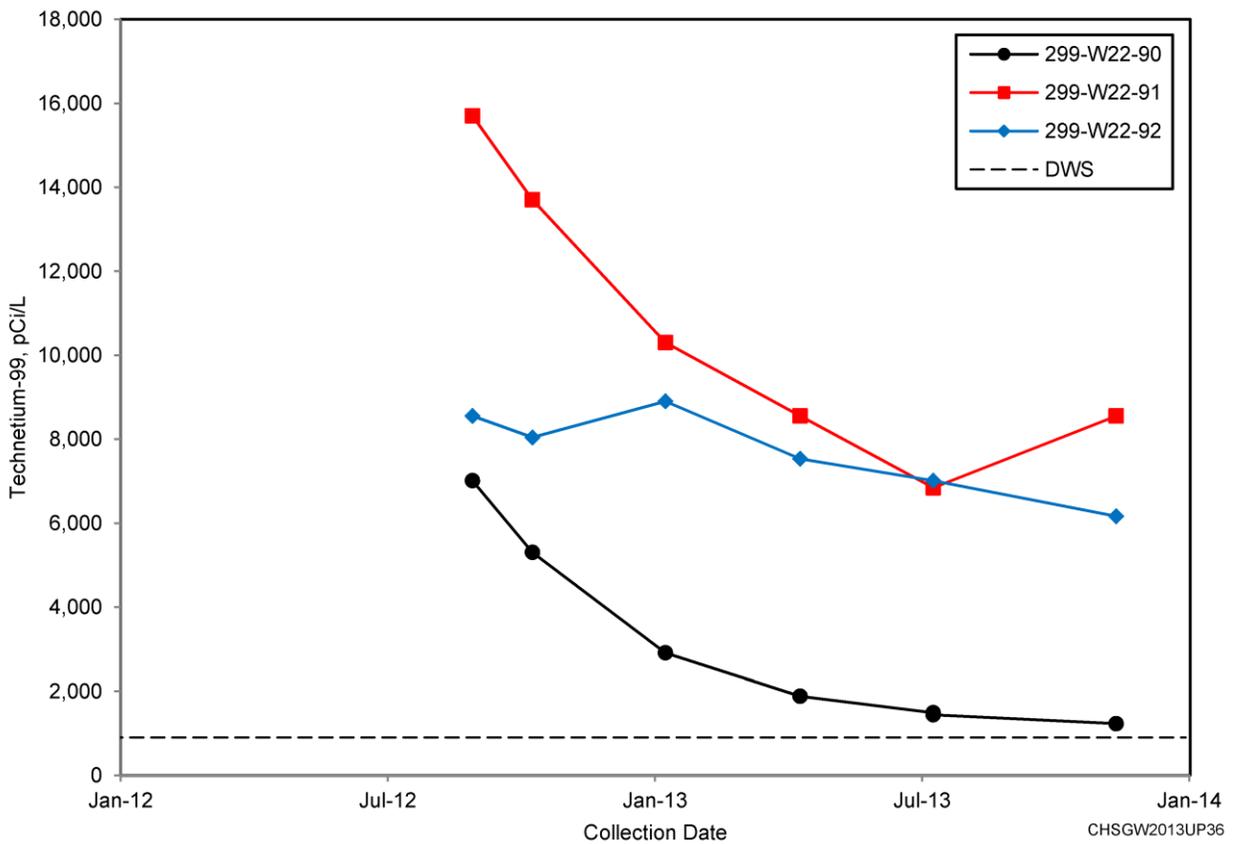


Figure UP.31 200-UP Technetium-99 Data for WMA S-SX Extraction Wells

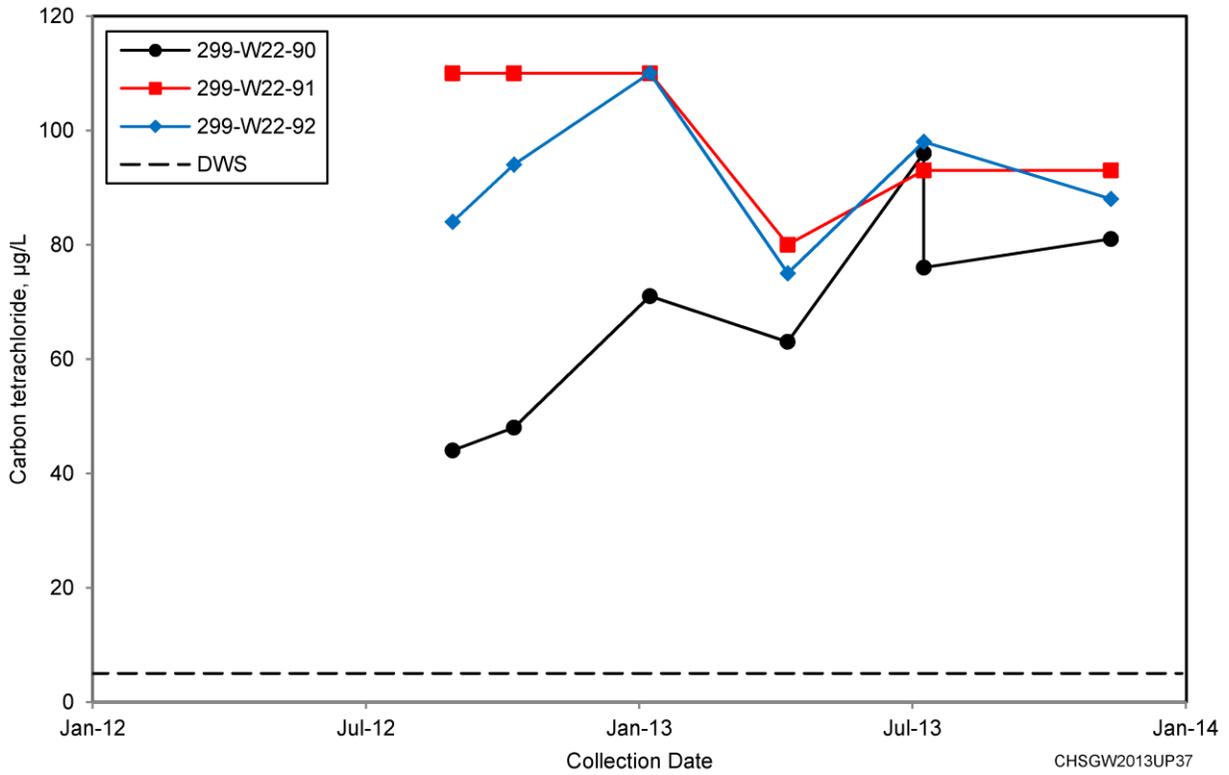


Figure UP.32 200-UP Carbon Tetrachloride Data for WMA S-SX Extraction Wells

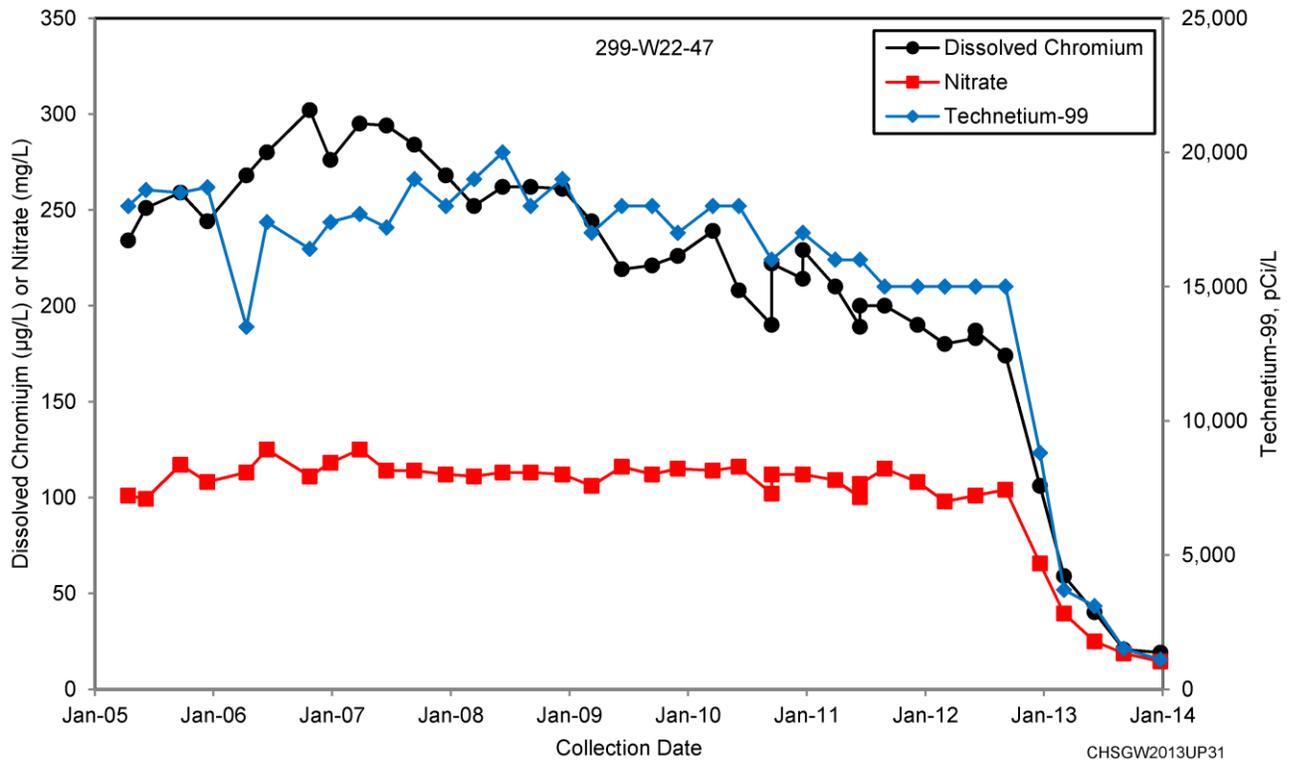


Figure UP.33 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W22-47 at WMA S-SX

200-UP RCRA – Introduction

The following sections describe the results of monitoring in accordance with RCRA regulations at three individual waste management/disposal facilities within 200-UP. Interim status groundwater quality assessment monitoring is conducted at WMA S-SX and WMA U ([40 CFR 265.93](#)[d], as referenced by [WAC 173-303-400](#)). Interim status detection monitoring for indicator parameter evaluation is conducted at the 216-S-10 Pond and Ditch ([40 CFR 265.92](#) and [40 CFR 265.93](#)[b], as referenced by [WAC 173-303-400](#)). Locations of the RCRA sites within the 200-UP groundwater interest area are shown on Figure UP.3

Groundwater data are available in the Hanford Environmental Information System (HEIS) database and in the appendices accompanying this report. The database is available at: <http://environet.hanford.gov/eda/>. Appendix B includes additional information (including well and constituent lists, groundwater flow rates, and statistical tables). Site analytical data can also be obtained from the PHOENIX system (<http://phoenix.pnnl.gov/>).

200-UP RCRA – WMA S-SX

WMA S-SX consists of the S Tank Farm and the SX Tank Farm. The S Tank Farm contains twelve tanks, each with a capacity of 2.9 million liters. The SX Tank Farm contains fifteen tanks, each with a capacity of 3.8 million liters (Section 1.2 of [RPP-7884](#)). The WMA also includes ancillary equipment consisting of three catch tanks, one receiver tank, six diversion boxes, and associated piping, valve pits, and pumps (Section 1.2 of [RPP-7884](#)). Both tank farms received waste generated from REDOX Plant in the 1950s and 1960s. To minimize the probability and severity of future leaks, all drainable liquid in each tank has been removed and transferred to double-shell tanks. Monitoring wells are shown in Figure UP.34.

In 1996, at Ecology's direction, WMA S-SX was placed into assessment status because of elevated specific conductance in downgradient monitoring wells. The first determination assessment found that multiple sources within the WMA had affected groundwater quality with elevated concentrations of nitrate and chromium (Section 5.0 of [PNNL-11810](#)). Groundwater is currently monitored under [DOE/RL-2009-73](#). The current objective of RCRA monitoring at WMA S-SX is to assess the extent and concentrations of dangerous waste constituents in the groundwater and determine their rate of movement. Table B.75 of Appendix B provides a list of the wells and constituents monitored for WMA S-SX. All required sampling was performed successfully during 2013, with the following exceptions:

- Well 299-W22-26 was determined to be dry during early 2013. A replacement well (299-W22-95) was drilled during the year and sampling began during December.
- Well 299-W22-44 was sampled successfully in March, but became dry by June. A replacement well has been staked in the field but is a low priority for drilling because samples continue to be collected quarterly from the adjacent extraction well, 299-W22-90.
- The June scheduled sampling of 299-W22-45 was not successful due to a pump problem. The problem was not fixed until November, so the June sampling was cancelled. This well was sampled successfully in December.
- The June scheduled sampling of 299-W22-49 was not successful because this well is nearly dry. Attempts to install a different pump were not successful. The June sampling was cancelled and the December scheduled sampling was completed in early January 2014 using a bailer. A replacement well is planned to be drilled during 2014.

In addition to the replacement well for 299-W22-26, a replacement well was also drilled for 299-W22-48 which had become dry during 2012. The new well is 299-W22-94 and sampling began during December 2013.

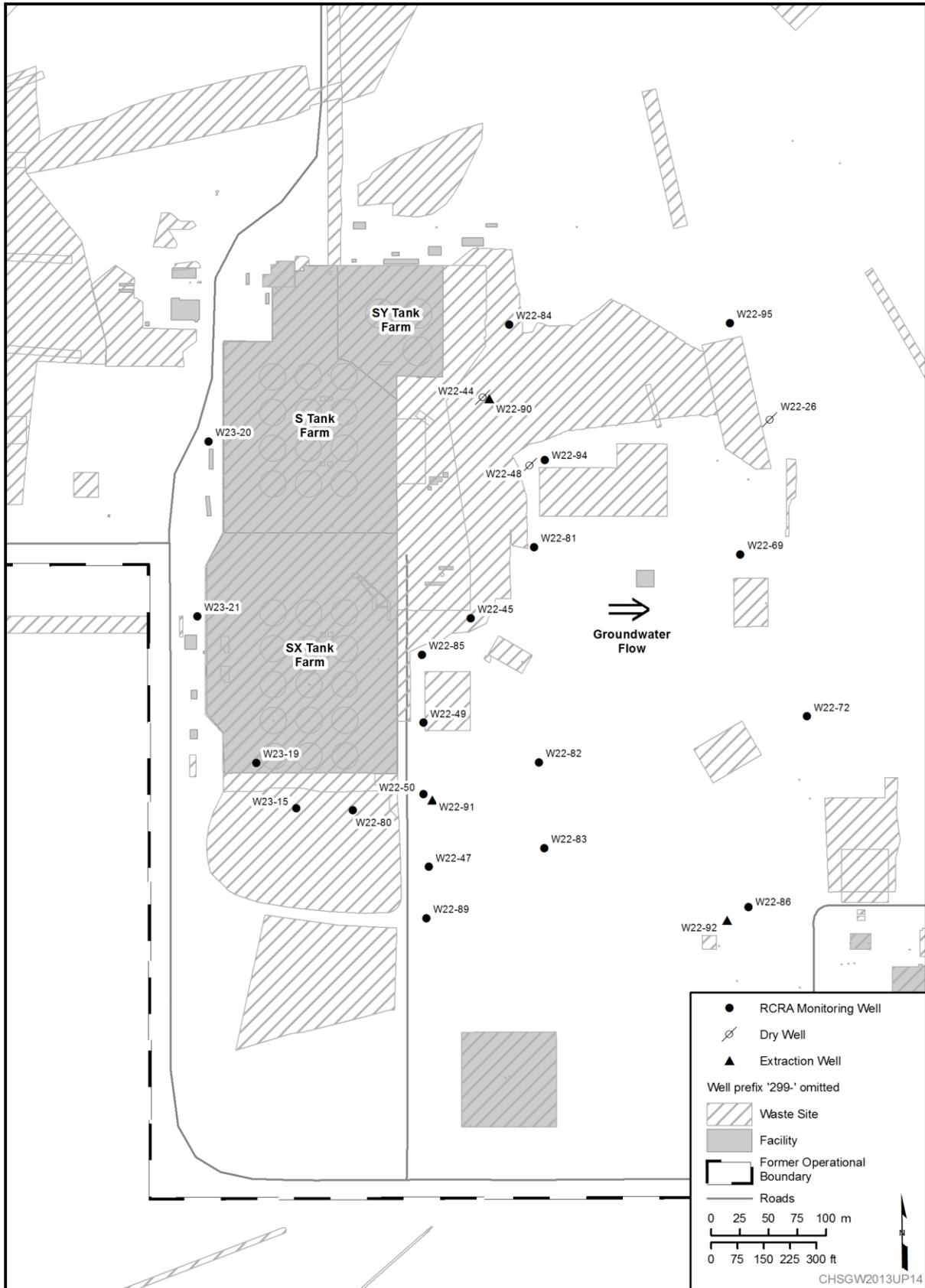


Figure UP.34 200-UP RCRA Facility WMA S-SX Monitoring Well Locations

Water-Level and Well Network Evaluation. The water table elevation declined an average of 0.55 meters in the monitoring wells between April 2012 and March 2013. This is larger than the long-term rate of decline between 2007 and 2011 of 0.25 meters per year. The larger decline is caused by operation of the WMA S-SX groundwater extraction system. Trend-surface analyses were performed on three sets of water-level data collected during 2013, and the average result was a hydraulic gradient of 2.4×10^{-3} meters per meter nearly due east (88 degrees azimuth), and the groundwater flow rate (i.e., average linear velocity) ranged from 0.016 to 0.39 meters per day (6 to 141 meters per year), depending on the hydraulic conductivity and effective porosity selected. Using values of 6.1 meters per day for the hydraulic conductivity and 0.12 for the effective porosity (average values from multiple constant-rate pumping tests in wells at the WMA [[PNNL-13514](#); [PNNL-14113](#); [PNNL-14186](#)]), the groundwater flow rate most representative for this site is 0.12 meters per day (45 meters per year). This is higher than the average for 2012 of 0.012 to 0.30 meters per day (5 to 109 meters per year) with a best value of 0.094 meters per day (34 meters per year). The higher average flow velocity for 2013 is caused by an increase in the hydraulic gradient toward the extraction wells (for comparison, the average hydraulic gradient magnitude for 2012 was 1.9×10^{-3} meters per meter).

Based on the distribution of the monitoring wells compared to the extent of contamination, DOE believes the current well network is capable of monitoring the distribution of contamination at this WMA. The WMA S-SX will remain in interim status groundwater quality assessment monitoring for 2014.

Assessment Results. Groundwater beneath WMA S-SX is contaminated with the dangerous waste constituent chromium and supporting constituent nitrate. This contamination is attributed to two primary sources within the WMA: an overflow event of 91,000 liters from tank S-104 in the S Tank Farm (Sections 3.7.2 and 4.6 in RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*), and a 190,000 liter leak from tank SX-115 during 1965 in the SX Tank Farm (Section 4.5 of [RPP-ENV-39658](#)). Because chromium and nitrate are highly mobile in the aquifer, these constituents migrate at an average rate (toward the east) equal to the calculated average groundwater flow rate of 0.12 meters per day (45 meters per year). The extent of the nitrate plume is shown on Figure UP.17 and the chromium plume extent is shown on Figure UP.20. Assessment data are summarized in Table B-77 of Appendix B.

Three groundwater extraction wells (299-W22-90, 299-W22-91, and 299-W22-92) located within the WMA S-SX plumes began pumping during July 2012. Operation of these wells is beginning to alter the migration of the chromium and nitrate plumes. Instead of continuing toward the east, some of the chromium and nitrate contamination is being drawn into the extraction wells. During 2013, 13.5 kilograms of chromium and 7,550 kilograms of nitrate were removed from the aquifer.

Operation of the groundwater extraction system has also changed some of the concentration trends in the monitoring wells. Concentrations at 299-W23-19, located inside the SX Tank Farm, declined during 2013 (Figure UP.6). Chromium declined from 906 $\mu\text{g/L}$ in March to 484 $\mu\text{g/L}$ in December, and nitrate declined from 474 mg/L in March to 159 mg/L during October. This well has the maximum nitrate and chromium concentrations at the WMA.

Contaminant concentrations have declined rapidly at 299-W22-47 (Figure UP.33). Chromium has declined from 180 $\mu\text{g/L}$ in June 2012 to 19 $\mu\text{g/L}$ in December 2013, below the 48 $\mu\text{g/L}$ cleanup level. Nitrate has declined from 101 to 14 mg/L during the same time, below the 45 mg/L cleanup level. These declines indicate that higher permeability sediments exist between 299-W22-47 and extraction well 299-W22-91 allowing for the rapid movement of water north toward the extraction well.

Two new wells were drilled on the edges of the S Tank Farm plume during 2013: 299-W22-94 (replacement for dry well 299-W22-48) and 299-W22-95 (replacement for dry well 299-W22-26). Depth discrete groundwater samples were collected during drilling of these wells. The results indicate that nitrate concentrations are highest in the upper part of the aquifer at both locations (Figure UP.35), consistent with the sample results from drilling of extraction well 299-W22-90 in 2011 (Table 3.3-1 in

[DOE/RL-2011-118](#)). All sample results were below the 45 mg/L cleanup level in both wells. The wells were also sampled for chromium, but the results of samples collected during and shortly after drilling may not be reliable because the drilling process is known to produce reducing conditions that can affect hexavalent chromium concentrations. After well construction and development, samples collected for chromium analysis are typically representative. The uppermost sample results at each well were the highest at 6.06 and 4.9 µg/L for total chromium and hexavalent chromium, respectively, in 299-W22-95, and 5.8 µg/L for hexavalent chromium at 299-W22-94.

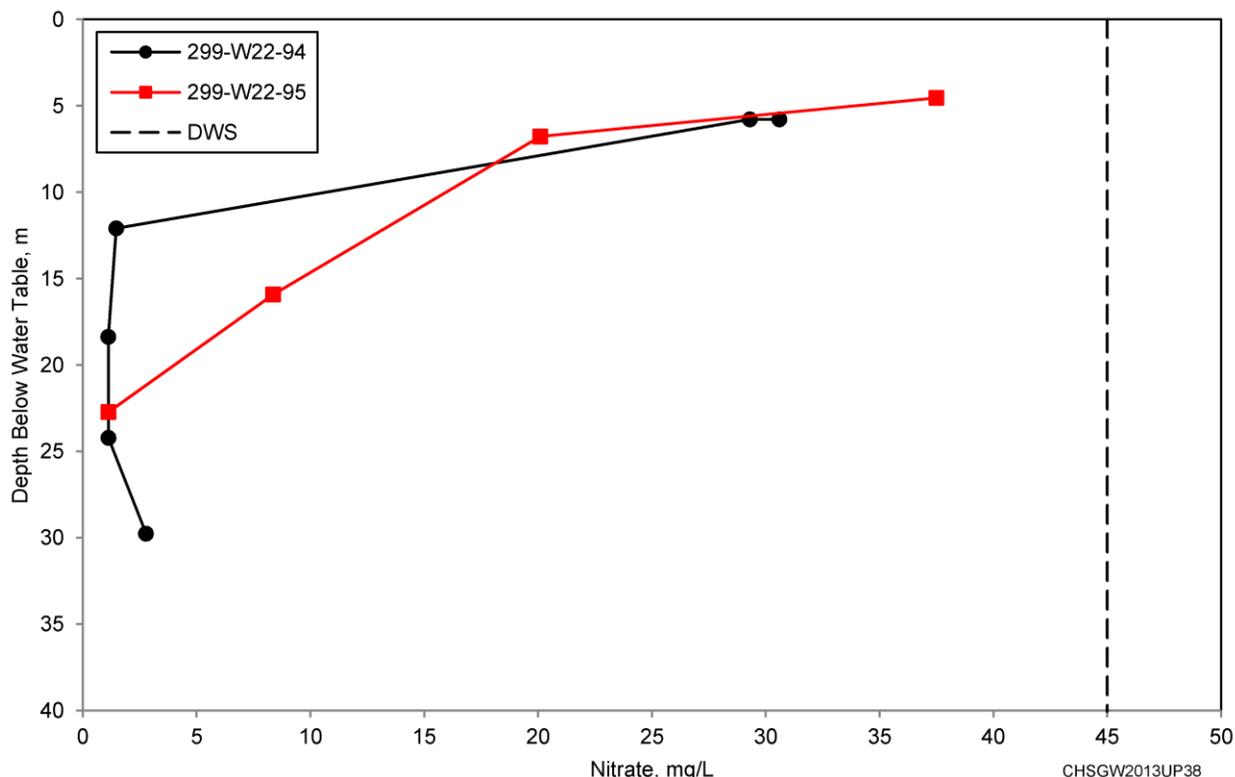


Figure UP.35 200-UP Nitrate Depth Profiles for Wells 299-W22-94 and 299-W22-95 at WMA S-SX

200-UP RCRA – WMA U

The WMA U contains 16 underground single-shell tanks constructed between 1943 and 1944. Twelve of the single-shell tanks have capacities of 2 million liters and four have capacities of 210,000 liters (Section 1.2 of RPP-35485). The WMA also contains a variety of ancillary equipment used to manage tank waste during operations, including six diversion boxes, the 271-UR control house, the 244-UR process vault, the 244-U double-contained receiver tank, and waste transfer lines, pits, and junction boxes. Monitoring wells are shown in Figure UP.36.

The tank farm received waste from the bismuth-phosphate process between 1946 and 1948, and from the REDOX process between 1954 and 1957 ([WHC-MR-0132](#)). In 1952, some waste was retrieved and pumped to the 242-T Evaporator, and between 1952 and 1957, the metal waste stored in nine of the 2-million-liter-capacity tanks was transferred to U Plant for uranium recovery. To minimize the probability and severity of future leaks, all drainable liquid in each tank has been removed and transferred to double-shell tanks.

WMA U was placed into assessment status in 2000 when specific conductance in groundwater monitoring wells downgradient of the WMA exceeded upgradient levels (Section 1.1 of [PNNL-13185](#)). An assessment of that finding determined that the WMA had affected groundwater quality, based on elevated concentrations of nitrate and possibly chromium in downgradient wells (Section 6.0 of [PNNL-13282](#)). Contaminant concentrations did not exceed their respective DWS, and the affected area was limited to the southeastern corner of the WMA at that time.

Groundwater at WMA U is currently monitored under [DOE/RL-2009-74](#). This plan was revised during 2012 to make the monitoring program more efficient. The frequency of sampling the downgradient wells was changed from quarterly to semi-annual in alternating quarters, and the frequency of sampling the upgradient well was reduced to annual ([DOE/RL-2013-22](#)). The reduced sample frequency was implemented during 2013. The objective of RCRA monitoring at WMA U is to assess the extent and concentrations of dangerous waste constituents in the groundwater and determine their rate of movement. See the 200-UP technetium-99 section and RPP-35485 for a discussion of vadose zone conditions beneath the WMA. Table B-84 of Appendix B provides a list of wells and constituents monitored for WMA U. Well 299-W18-30 became dry during the year. A replacement well is planned to be drilled during 2014. All other required sampling was performed successfully during 2013.

Water-Level and Well Network Evaluation. Groundwater flow beneath WMA U is being affected by the 200 West P&T system. Trend surface analyses were performed on three sets of water-level measurements at WMA U during 2013 and the average hydraulic gradient magnitude was 3.6×10^{-3} meters per meter, an increase from the average of 2.0×10^{-3} meters per meter during 2012. An extraction well, 299-W17-3, is located 150 meters north-northeast of the WMA (Figure UP.36). Drawdown around this well accounts for the increased gradient magnitude at WMA U. In response to pumping in this well, the groundwater flow direction beneath the WMA is expected to turn toward the northeast. However, the average direction during 2013 was similar to previous years: east-northeast at 80 degrees azimuth.

The average hydraulic gradient for 2013, 3.6×10^{-3} meters per meter, was used to estimate the flow rate beneath the WMA. The groundwater flow rate (i.e., average linear velocity) ranged from 0.030 to 0.34 meters per day (11 to 124 meters per year), depending on the hydraulic conductivity and effective porosity selected. Using values believed to be most representative, 6.12 meters per day for the hydraulic conductivity and 0.17 for the effective porosity from a constant-rate pumping test conducted in 299-W19-42 (Section 7.4 of [PNNL-13378](#)), the groundwater flow rate most representative for this site is 0.13 meters per day (47 meters per year). This is an increase from the estimated best value of 0.071 meters per day (26 meters per year) for 2012.

Water levels in the monitoring wells declined an average of 0.51 meter between April 2012 and March 2013. This is larger than the long-term average decline of 0.27 meter between 2006 and 2011. The larger decline is due to rebound of the water table following shut down of an interim-action pump-and-treat system during March 2012 causing increased water levels during April 2012, and startup of the final remedy P&T system in July 2012 causing lower water levels.

Based on the distribution of wells at the WMA and the groundwater flow direction, DOE believes the well network (with a replacement well for dry well 299-W18-30) is currently capable of monitoring the distribution of contamination from the WMA. Table B-85 in Appendix B summarizes water-level data for WMA U. The WMA U will remain in interim status groundwater quality assessment monitoring for 2014.

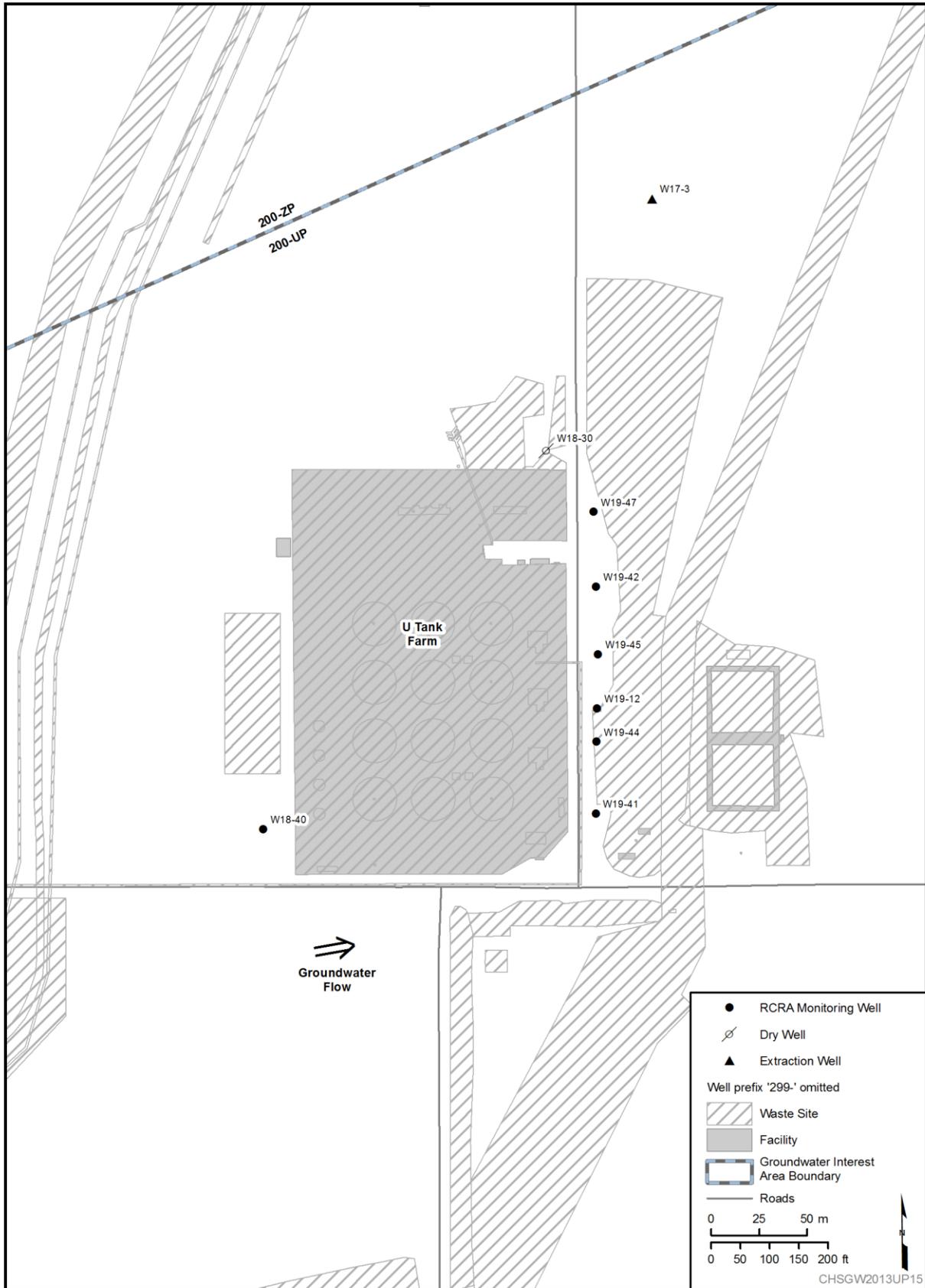


Figure UP.36 200-UP RCRA Facility WMA U Monitoring Well Locations

Assessment Results. WMA U has been identified as the source of groundwater contamination limited to the downgradient (east) side of the tank farm (Section 6.0 of [PNNL-13282](#)). The dangerous waste constituent chromium and supporting constituent nitrate are present in the groundwater (Table B-86 in Appendix B). During 2013, chromium was detected in several downgradient wells at concentrations ranging from 5.7 to 15 µg/L. Concentrations in upgradient well 299-W18-40 averaged 4.2 µg/L. These concentrations are below the 48 µg/L cleanup level for hexavalent chromium in 200-UP.

While chromium is highly mobile in the aquifer, it can migrate more slowly than nitrate in the vadose zone beneath the tank farms, at least initially. This has been attributed to a reduction process where tank fluids dissolve iron(II) minerals in the sediment. The iron then reacts with the soluble chromium(VI) reducing it to chromium(III), which precipitates as an insoluble iron-chromium hydroxide ([Zachara et al., 2007](#), "Geochemical Processes Controlling Migration of Tank Wastes in Hanford's Vadose Zone").

This vadose zone reaction may explain the present low concentrations of chromium in the groundwater.

During 2013, nitrate concentrations were greater than the 45 mg/L cleanup level in six of the seven monitoring wells at the U Tank Farm, including the upgradient well, 299-W18-40. The source of the nitrate from upgradient was the former 200-ZP interim action P&T system injection wells (Section 3.3.5 of [DOE/RL-2011-118](#)). The maximum 2013 nitrate sample result was 105 mg/L in 299-W19-45 during July.

As stated in the "200-UP Nitrate" section, the nitrate concentration at 299-W19-44 (a downgradient well on the south side of the tank farm) increased rapidly during the second half of 2012, and the concentration remained elevated during 2013 with a maximum of 97 mg/L during January 2013 and declining thereafter (Figure UP.37). A similar trend is noted for nitrate in 299-W19-41 (Figure UP.37). Chromium in 299-W19-44 also increased, reaching a peak value of 15 µg/L in January 2013 and then declining. These results could be explained by a pulse of contamination entering the aquifer from beneath the tank farm. However, the trend changes began shortly after startup of the nearby 200 West P&T system which began operating during July 2012 and the perturbation of the groundwater flow system may also be the cause. The groundwater beneath this tank farm is within the capture zone of the nearby extraction well 299-W17-3. Chromium and nitrate are mobile in the aquifer; thus, their rate of migration (toward the east-northeast) is equal to the calculated groundwater flow rate of 0.13 meters per day (47 meters per year).

Well 299-W19-41 exhibited an increasing pH trend between 2004 and 2011, but values had declined during 2012. The trend was generally stable during 2013 with results of 8.45 in April and 8.28 in October. The pH trend does not correlate with trends in contaminant concentrations, major anions, or cations. The cause of the formerly increasing pH trend in this well is not known.

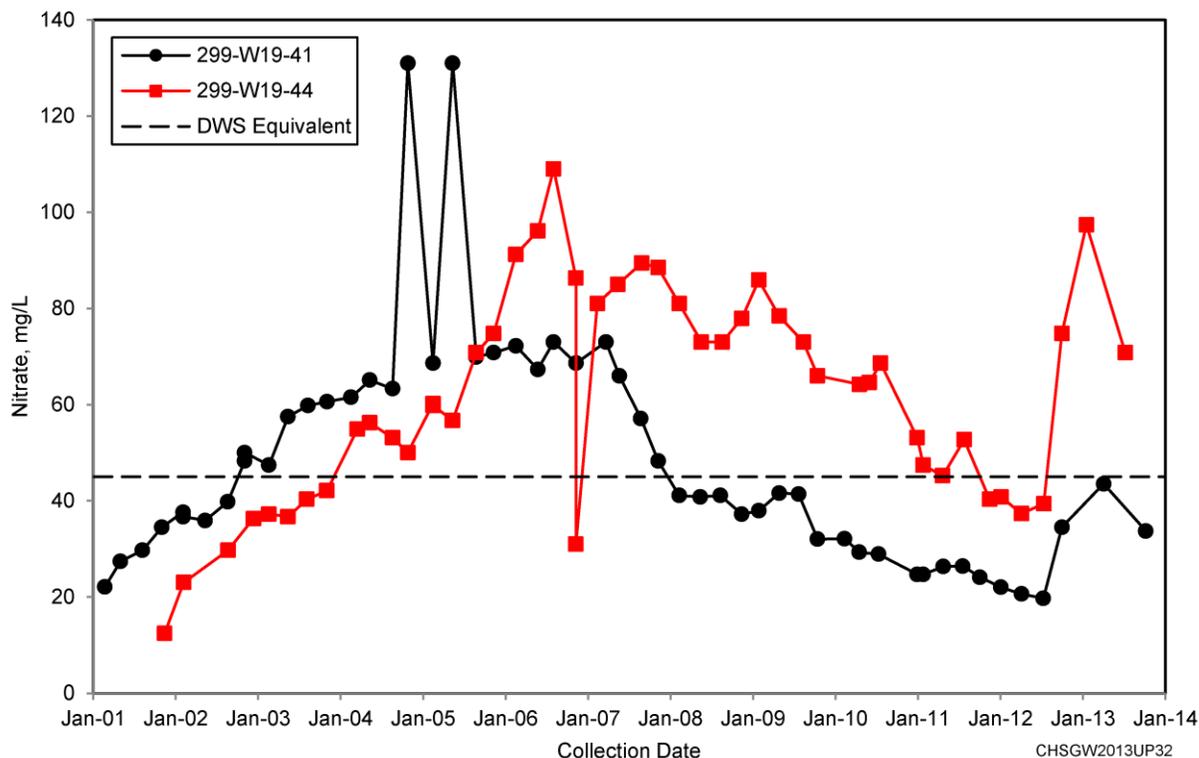


Figure UP.37 200-UP Nitrate Data for Wells at WMA U

200-UP RCRA – 216-S-10 Pond and Ditch

The 216-S-10 Pond and Ditch, located outside the southwestern corner of the 200 West Area, consisted of an unlined ditch, 1.2 meters wide at its base and 686 meters long, connected to a pond covering 0.02 square kilometers (0.008 square miles). The pond was shaped like a backwards “E” with an extra leg, where each leg was a separate leaching trench. The ditch was also connected to the 216-S-11 Pond, which was an overflow pond to accommodate excess discharges. During its active life from 1951 through 1991, the site received 6.6×10^9 liters of effluent, primarily from the REDOX Plant chemical sewer. Monitoring wells are shown in Figure UP.38.

The groundwater beneath 216-S-10 is monitored under interim status regulations to determine whether dangerous waste constituents have affected groundwater ([DOE/RL-2008-61](#)). The monitoring well network consists of one upgradient well (699-33-76), four downgradient wells screened in the upper part of the aquifer at the water table (299-W26-13, 299-W26-14, 699-32-76, and 699-33-75), and one downgradient well screened 50 meters below the water table (299-W27-2). Table B.34 of Appendix B includes a list of wells and constituents sampled for the 216-S-10 unit.

During 2013, all groundwater samples required by the monitoring plan ([DOE/RL-2008-61](#)) were collected as scheduled.

Water-Level and Well Network Evaluation. The hydraulic gradient beneath 216-S-10 was determined by trend-surface analysis using water-level measurements collected during March and May 2013 from six wells: 299-W26-13, 299-W26-14, 699-32-76, 699-32-77 (March only), 699-33-75, and 699-33-76. The average direction of groundwater flow was calculated to be east-southeast (108 degrees azimuth) with a hydraulic gradient magnitude of 2.7×10^{-3} meters per meter. Using a hydraulic conductivity range of 2 to 42.7 meters per day (range of 14 hydraulic test results in the upper part of the aquifer at 216-S-10, excluding the high and low values) and an assumed effective porosity range of 0.1 to 0.2, the average

linear velocity was estimated to range from 0.026 to 1.1 meters per day (10 to 410 meters per year). Using a best hydraulic conductivity value of 10.4 meters per day (constant-rate-discharge test at 299-W27-2 performed within a temporary open interval near the water table [[WHC-SD-EN-DP-052](#)]) and an assumed effective porosity of 0.15, the best estimate average linear velocity is 0.18 meters per day (67 meters per year). Water levels in the network wells have been declining at a long-term average rate of 0.22 meters per year from 2009 to 2013.

Based on the calculated groundwater flow direction, DOE believes the monitoring well network remains capable of detecting constituents migrating from the S-10 unit into the uppermost aquifer. Table B.36 in Appendix B summarizes water-level data for 2013.

Sampling Results. No exceedances of an indicator parameter critical means occurred during 2013. Specific conductance is near the critical mean (364 $\mu\text{S}/\text{cm}$) in downgradient well 699-32-76, but the trend was stable (average value of 347 $\mu\text{S}/\text{cm}$ during 2013; Figure UP.39). Between 2007 and 2012, specific conductance generally trended upward in 299-W26-13 from annual average values of 270 to 310 $\mu\text{S}/\text{cm}$. The increasing trend correlated to increasing chromium and nitrate concentrations (Figure UP.39). During 2012 and 2013, specific conductance was stable to declining consistent with the chromium and nitrate trends. The chromium concentration remained above the 100 $\mu\text{g}/\text{L}$ total chromium DWS during 2013 (average value of 107 $\mu\text{g}/\text{L}$). The 216-S-10 Pond and Ditch is probably the source of this chromium, because there are no other substantial chromium sources in the area (according to Appendix C of RPP-26744). Remediation of the groundwater is addressed by the 200-UP-1 ROD ([EPA et al., 2012](#)). The monitored natural attenuation component of the selected remedy is applicable to this small plume. Table B.37 in Appendix B summarizes 2013 water quality parameters.

Elevated total organic halides continue to occur in downgradient well 699-33-75, but no exceedance of the critical mean (36.7 $\mu\text{g}/\text{L}$) occurred. The average concentration was 7.7 $\mu\text{g}/\text{L}$ during 2013. Elevated total organic halides in this well have been attributed to carbon tetrachloride, which has been detected in several wells within the 216-S-10 monitoring network. Well 699-33-75 has the highest concentrations in the network with an average of 13.5 $\mu\text{g}/\text{L}$ during 2013. This is above the 3.4 $\mu\text{g}/\text{L}$ cleanup level. Carbon tetrachloride is also detected in upgradient well 699-33-76 (2.9 $\mu\text{g}/\text{L}$ in 2013). This constituent does not originate from 216-S-10. It is widespread in the groundwater beneath and near the 200 West Area and originates from waste disposal sites at PFP.

Chromium, iron, and nickel continue to be elevated in 299-W27-2, which is screened 50 meters below the water table. These constituents are stainless steel corrosion products and this well is constructed of stainless steel components. Corrosion of the well screen has been confirmed by a downhole camera survey confirming this is the source of the elevated metals.

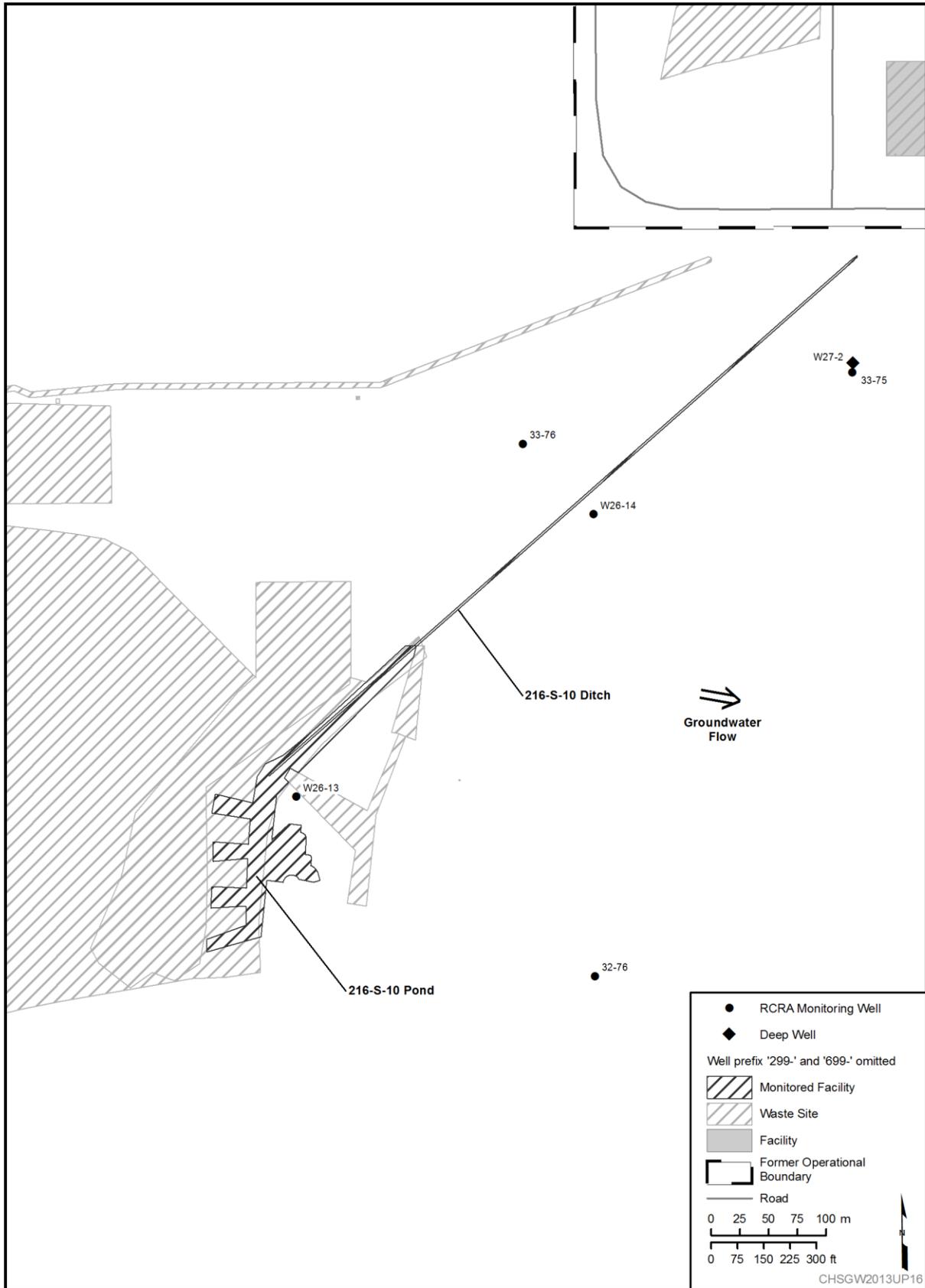


Figure UP.38 200-UP RCRA Facility 216-S-10 Monitoring Well Locations

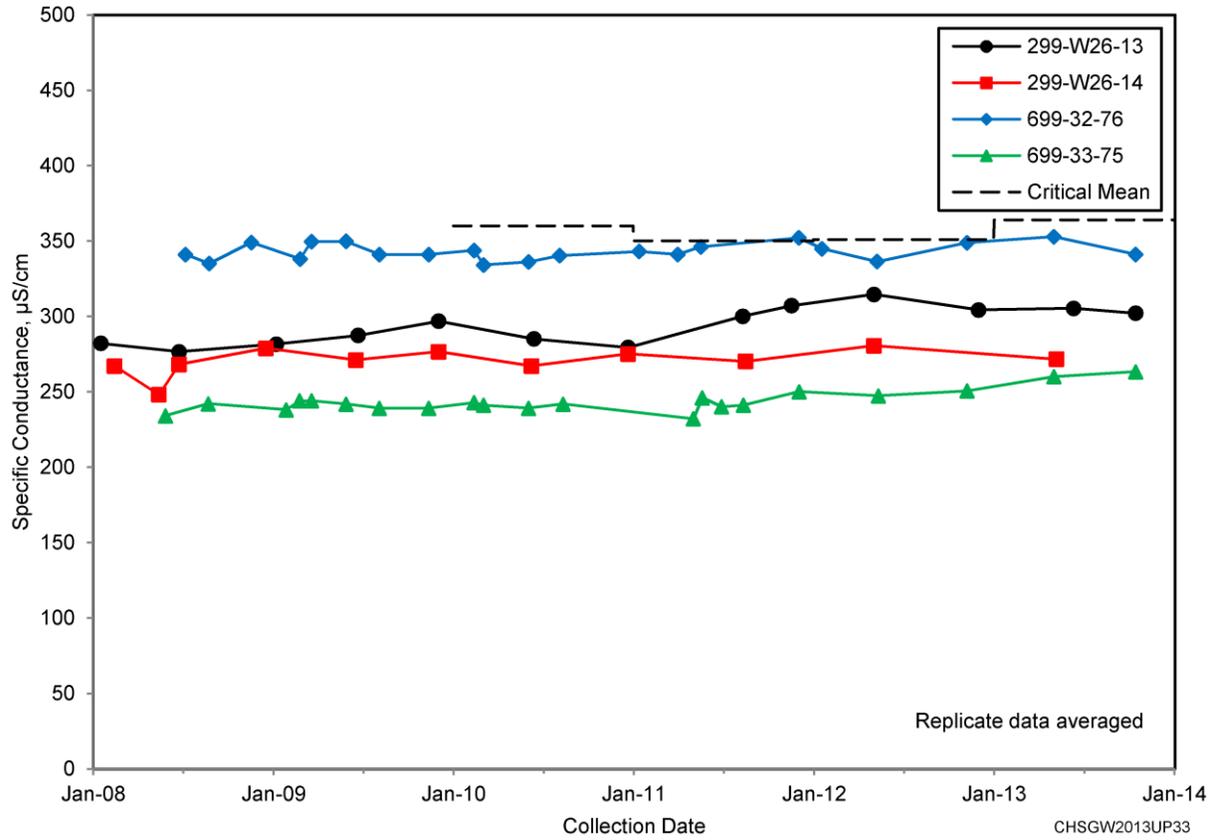


Figure UP.39 200-UP Specific Conductance Data for Monitoring Wells at 216-S-10