11 200-UP

11.1 Overview

The 200-UP groundwater interest area includes the 200-UP-1 Groundwater OU in the southern portion of the 200 West Area and adjacent portions of the surrounding 600 Area. With the exception of the ERDF, the facilities and waste sites within 200-UP are associated with early operation of the REDOX Plant (plutonium and uranium separation) and U Plant (uranium recovery). Currently there are no liquid waste disposal sites active within the OU. The only active solid waste disposal site is the ERDF which receives waste from surface remedial actions at the Hanford Site. The single-shell waste tanks in the OU have been interim stabilized in that all drainable liquid from each tank has been transferred to double-shell tanks.

DOE conducts groundwater monitoring in 200-UP under CERCLA for the 200-UP-1 OU and the ERDF; and under RCRA for WMA S-SX, WMA U, and the 216-S-10 Pond and Ditch. Monitoring of radionuclides is also performed to meet AEA requirements.

Groundwater monitoring within the 200-UP-1 OU is performed under a sampling schedule incorporated into the 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 mostly migrated into 200-UP from 200-ZP, although some carbon tetrachloride may have come from the U Pond. The contaminants chloroform, 1,4-dioxane, strontium-90, selenium-79, and TCE have been found in groundwater to a limited extent and are routinely sampled in selected wells. Table 11-1 lists key facts about 200-UP. Section 1.3 of the Introduction provides plume mapping details, including descriptions of terms in figure legends (e.g., Type 1 Control Point).

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 within the OU. The unconfined aquifer occurs within Ringold unit E; its base is the fine-grained Ringold lower mud unit (Figure 11-1). There is some contamination (carbon tetrachloride) of the confined aquifer beneath the Ringold Lower Mud unit in the northern portion of the OU which originates from the 200-ZP-1 OU. Appendix A of DOE/RL-2013-07 contains a set of geologic cross sections with vertical contaminant distribution in 200-UP.

Depths from land surface to the water table range from 64 to 106 m (210 to 348 ft), with the largest depths occurring in the northeastern portion of the OU. The thickness of the unconfined aquifer varies from 70 m (230 ft) 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 wastewater 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 11-2).

Table 11-1. 200-UP at a Glance

REDOX Plant operations: 1952 to 1967 (plutonium separation) **U Plant operations:** 1952 to 1957 (uranium recovery)			
2014 Groundwater Monitoring			
Contaminant	**Cleanup Level[a]**	**Maximum Concentration**	**Plume Area[b] (km^2)**
Carbon tetrachloride	3.4 µg/L	680 µg/L (299-W14-71)	17.9[c]
Chromium	48[d]/100[e] µg/L	497 µg/L (299-W23-19)	4.7/0.4
Nitrate	45 mg/L	2,270 mg/L (288-W19-43)	5.8
Iodine-129	1 pCi/L	11.0 pCi/L (699-36-70A)	3.2
Technetium-99	900 pCi/L	86,500 pCi/L (299-W19-36)	0.3
Tritium	20,000 pCi/L	280,000 pCi/L (699-36-66B)	5.6
Uranium	30 µg/L	734 µg/L (299-W19-18)	0.3
Remediation			
U Plant P&T (interim action from 1994 to 2011): • Removed 220.5 kg uranium • Removed 2.17 Ci technetium-99 S-SX Tank Farms groundwater extraction system (interim action): • Began operating during July 2012 • Removed 1.66 Ci technetium-99 since startup • Removed 28.1 kg chromium since startup • Removed 16,280 kg nitrate since startup • Removed 250 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.

P&T - pump and treat

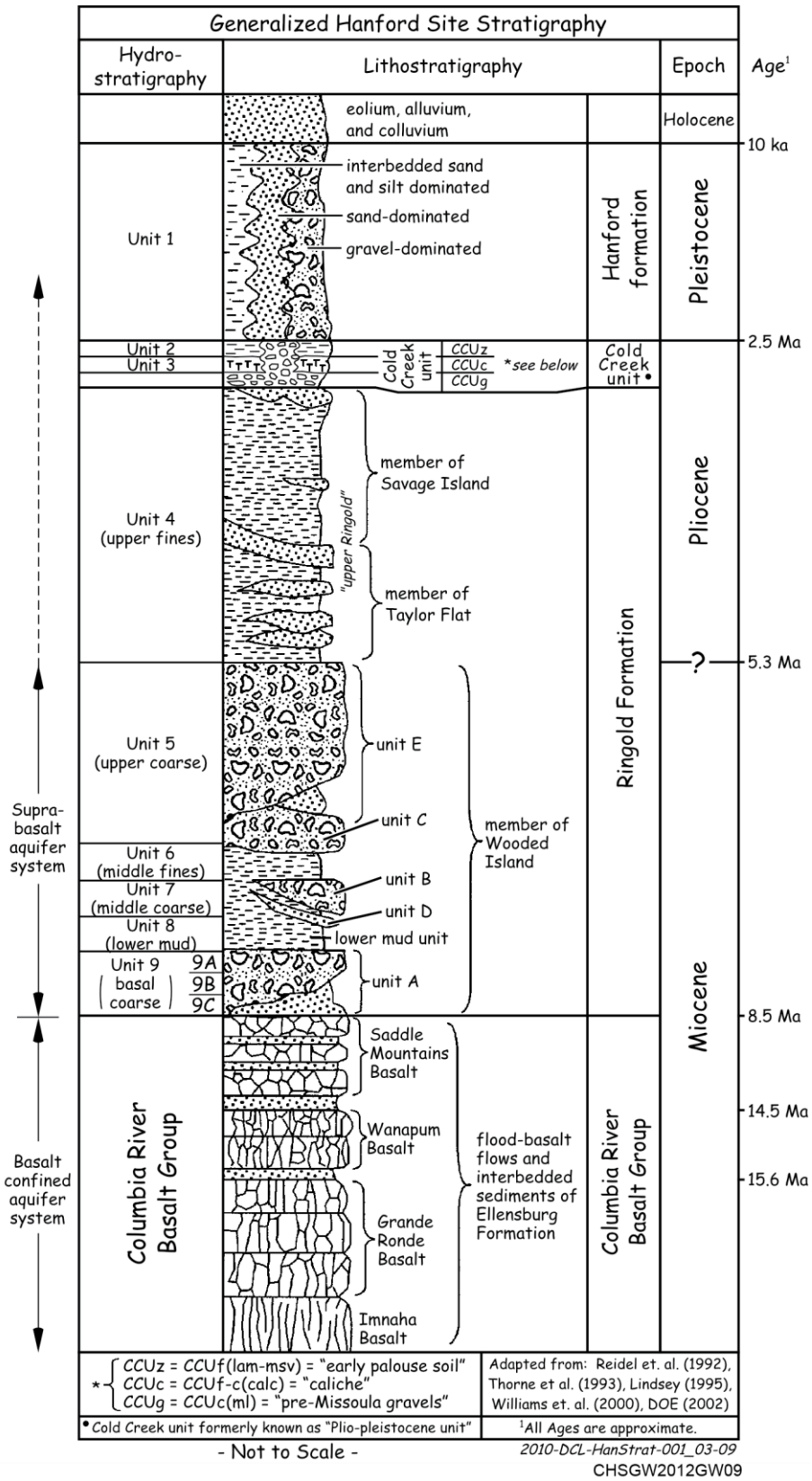

Figure 11-1. Generalized Stratigraphy of the Hanford Site Central Plateau

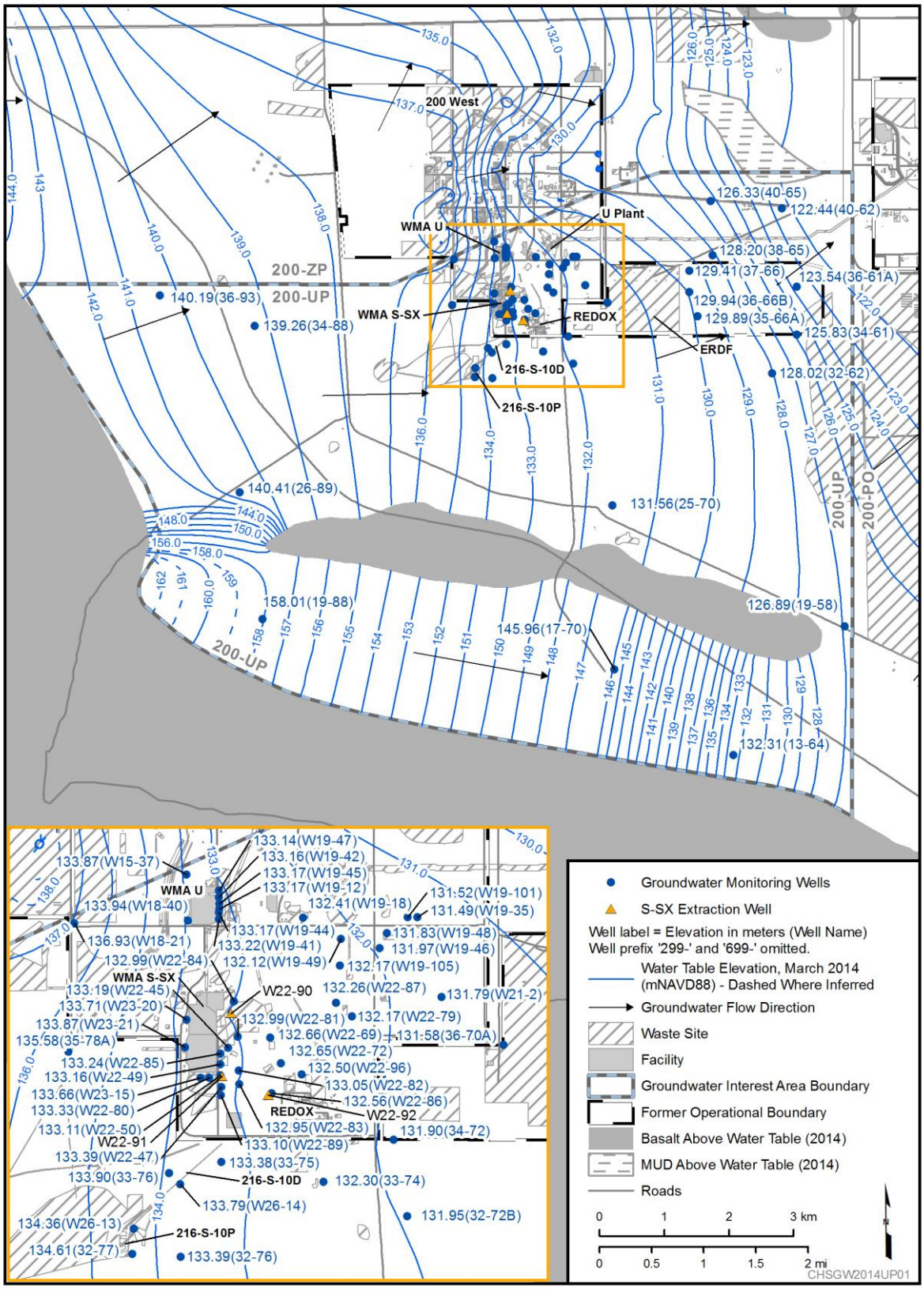

Figure 11-2. 200-UP Water Table Map, March 2014

11.2 CERCLA Activities

An interim action ROD addressing all of the major contaminant plumes within the 200-UP-1 OU was published during September 2012 (EPA et al., 2012). The selected remedy in the ROD consists of a combination of the following:

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

Implementation of the ROD is addressed by the *200-UP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2013-07). The plan addresses several topics, including the following:

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

Implementation of the RD/RA work plan began during 2014 with the following activities:

- A SAP was published to support drilling of two extraction wells for the uranium plume remedy near U Plant (DOE/RL-2014-27, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*)
- The 90 percent remedial design for the uranium plume remedy was completed
- Construction of the uranium plume remedy was initiated, including drilling of the two extraction wells (299-W19-113 and 299-W19-114); the wells will be completed in 2015
- Design of the iodine-129 hydraulic containment system was initiated, and locations for the injection wells were selected

Additional activities during 2014 included continued groundwater monitoring (sample locations shown in Figure 11-3) and continued operation of a groundwater extraction system downgradient from the S-SX Tank Farms.

Table A-14 in Appendix A lists the monitoring network and sampling status for 2014. 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 11-4.

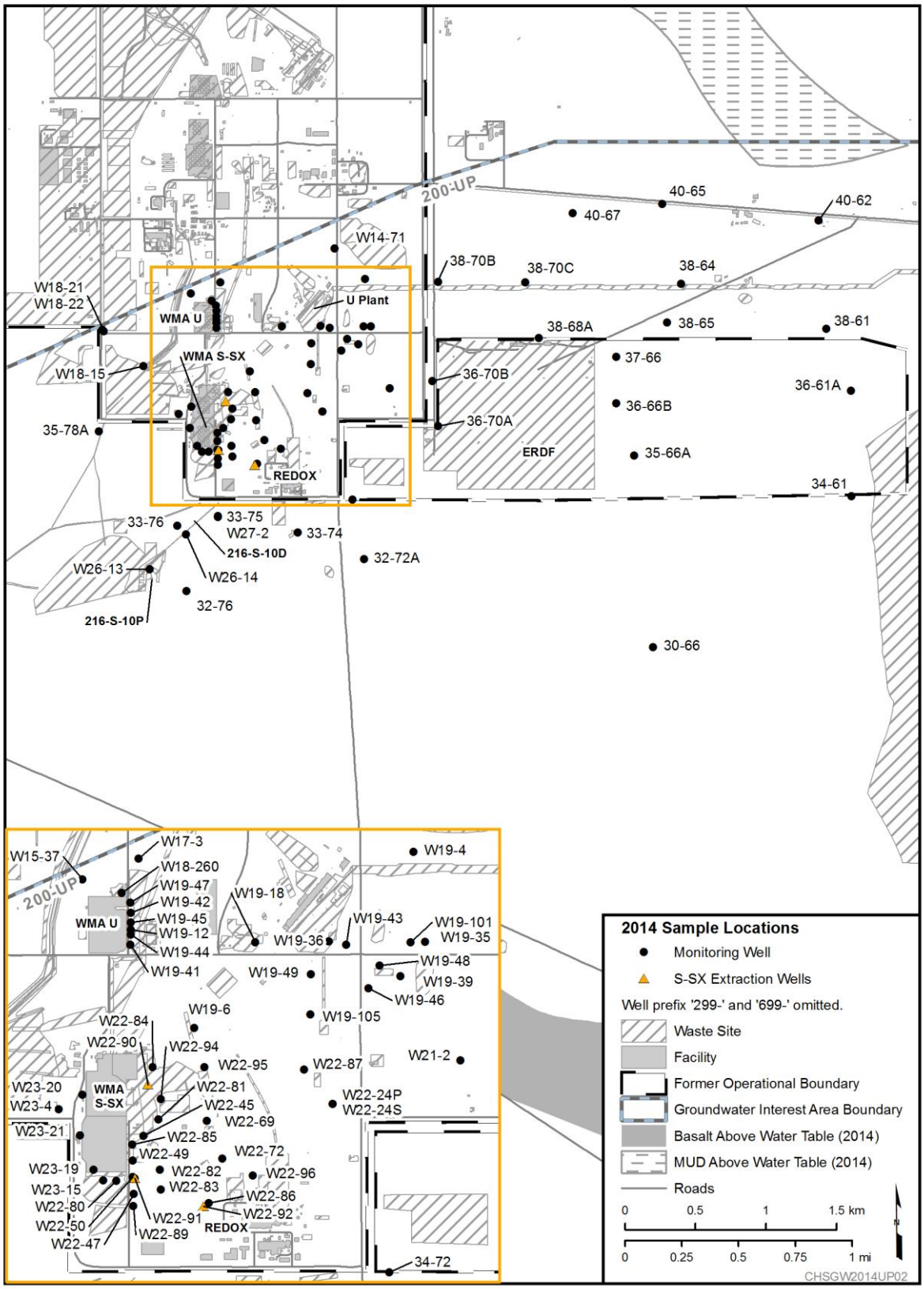

Figure 11-3. 200-UP Sampling Locations, 2014

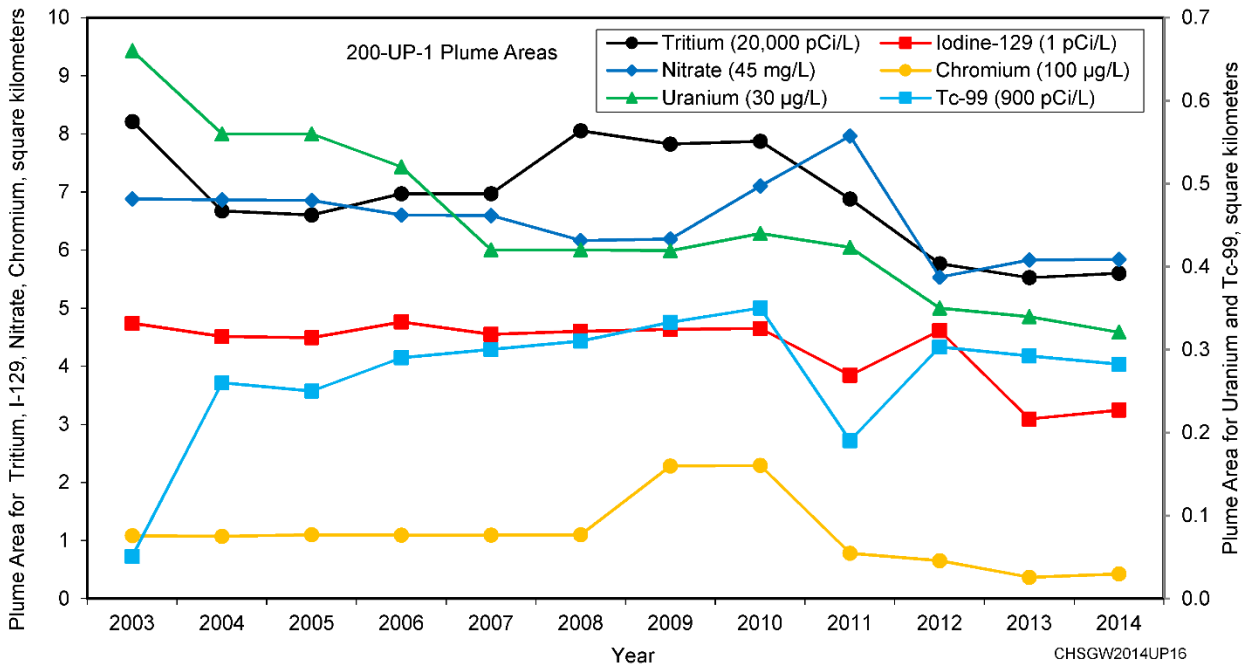

Figure 11-4. 200-UP Plume Areas

11.3 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 11-5).

11.3.1 Waste Management Area S-SX

Technetium-99 plumes occur downgradient of both the S and SX Tank Farms. At Well 299-W23-19 (located next to Tank SX-115 inside the SX fence line), concentrations declined slightly during the year from 22,000 pCi/L in April to 16,600 pCi/L in December (Figure 11-6). These concentrations are substantially lower than the maximum during 2013 of 62,000 pCi/L. 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 m (509 ft) east-southeast of Well 299-W23-19 (Figure 11-3). Concentrations in many wells downgradient of the SX Tank Farm are declining due to operation of the groundwater extraction system (Figure 11-7). During the year, the technetium-99 concentration in Well 299-W22-47 declined to below the cleanup level. Concentrations are above the cleanup level in seven other monitoring wells within the plume. This plume is attributed primarily to a 190,000 L (51,000 gal) leak from Tank SX-115 that occurred during 1965 (Section 4.3 of RPP-ENV-39658). Depth-discrete sample results within this plume indicate it occurs within the upper 20 m (66 ft) of the aquifer at concentrations above the cleanup level (DOE/RL-2009-122).

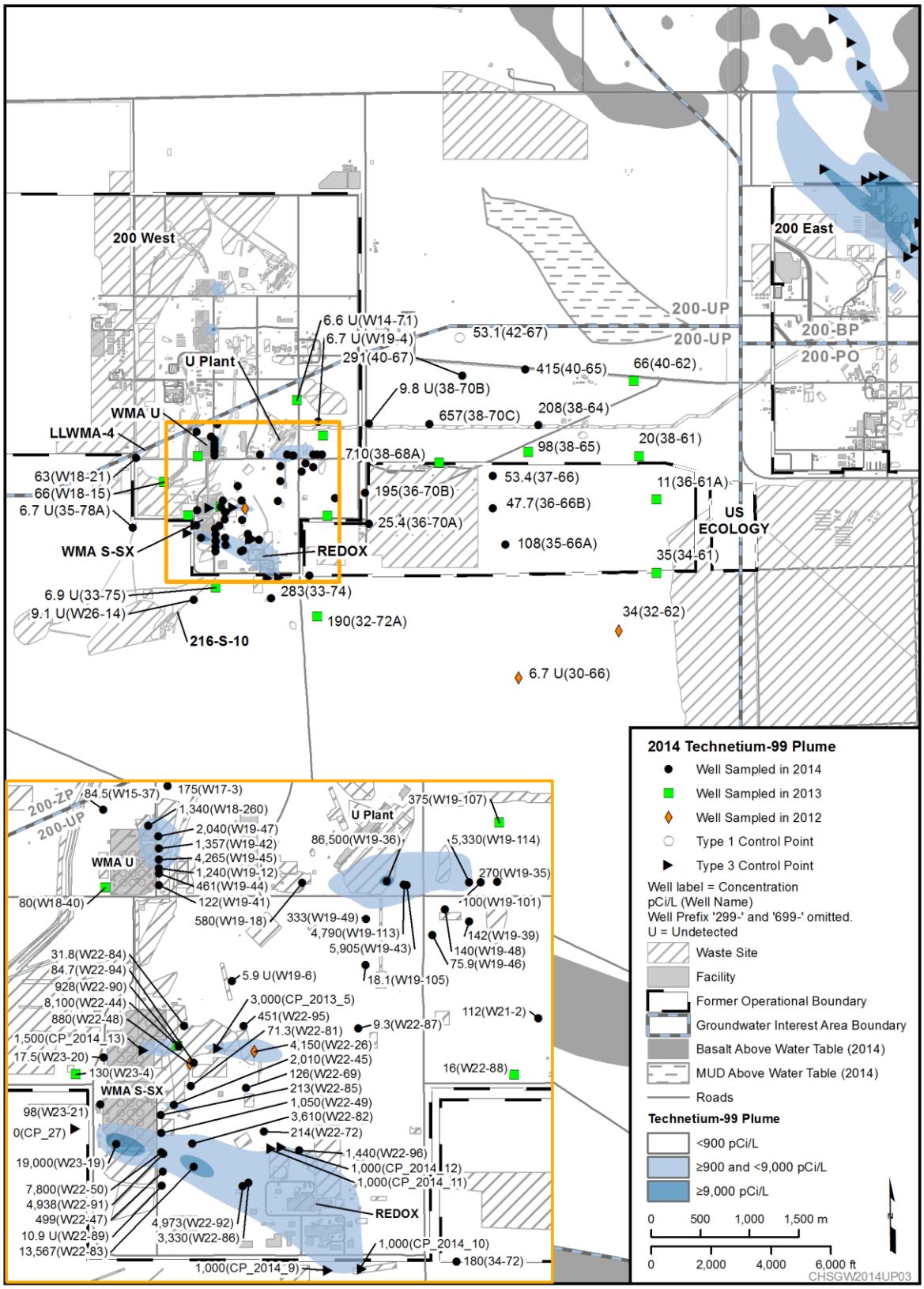

Figure 11-5. 200-UP Technetium-99 Plume Map, 2014

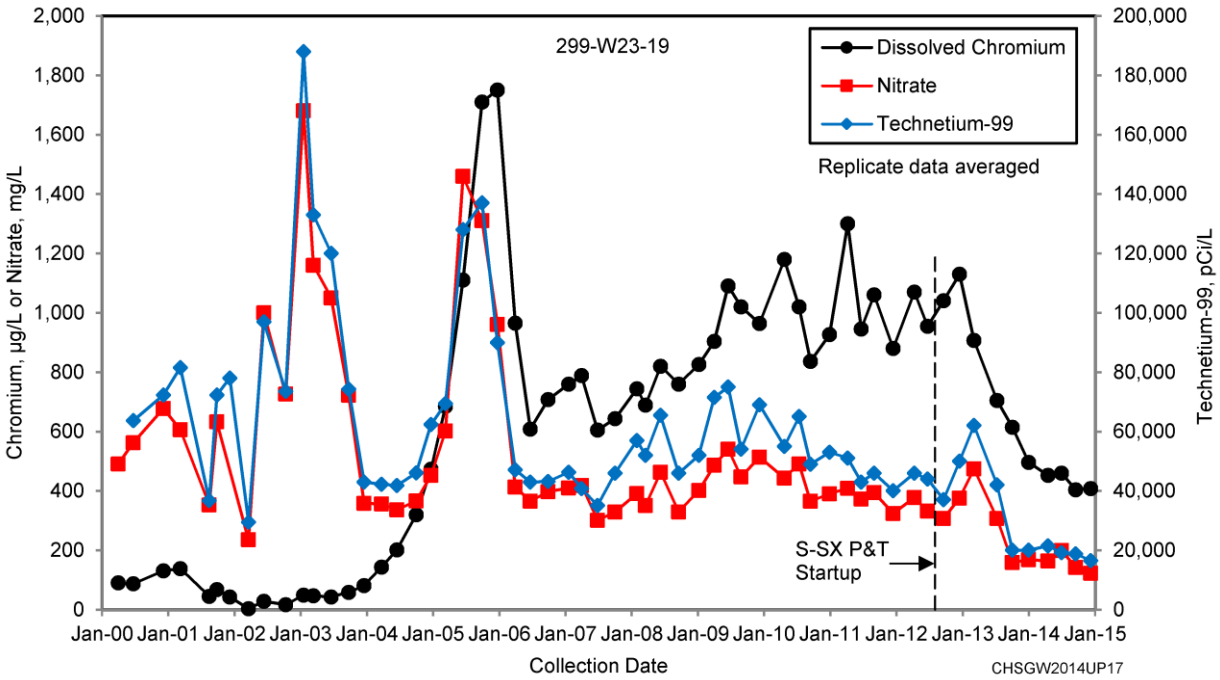

Figure 11-6. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W23-19 at WMA S-SX

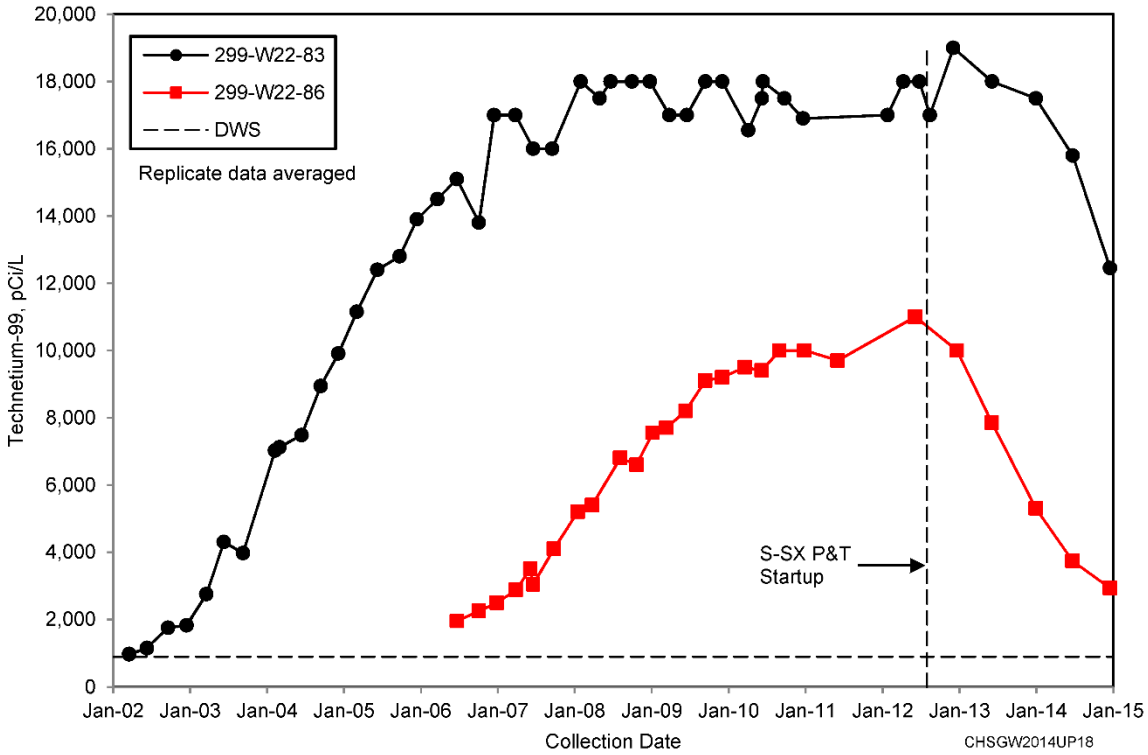

Figure 11-7. 200-UP Technetium-99 Data for Wells 299-W22-83 and 299-W23-86 East of WMA S-SX

Between 1966 and 1970, an estimated 91,000 L (24,000 gal) of waste were 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*). This is the source of the plume downgradient from the S Tank Farm. This plume has been defined by two wells, 299-W22-44 (the nearest downgradient well at S Tank Farm) and 299-W22-26 (located farther downgradient at the 216-S-9 Crib). Peak concentrations in these wells were 20,000 pCi/L in Well 299-W22-44 (January 2009) and 6,000 pCi/L in Well 299-W22-26 (December 2010). Both of these wells are now dry. Well 299-W22-95 was drilled during 2013 as a replacement for Well 299-W22-26. The new well is located north of Well 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 Well 299-W22-44 has not yet been drilled, but this well is located adjacent to extraction Well 299-W22-90 which is being sampled quarterly. The maximum concentration in the extraction well during 2014 was 976 pCi/L. Depth-discrete sample results during drilling of this well indicate the technetium-99 plume extends to a depth of 10 m (33 ft) below the water table at concentrations above the cleanup level (Section 3.3 of DOE/RL-2011-118).

11.3.2 216-U-1 and 216-U-2 Cribs

The technetium-99 plume near U Plant originated from these cribs, which were active in the 1950s and 1960s. A P&T system operated in this plume from 1994 until March 2011, and the system was effective at reducing technetium-99 concentrations in the aquifer. Recently, however, the technetium-99 concentration has rebounded at former extraction Well 299-W19-36. The concentration was 20,500 pCi/L in 2013, an increase from 6,300 pCi/L during 2010. The concentration increased still further during 2014 to 86,500 pCi/L (Figure 11-8). Concentrations have increased also at former extraction Well 299-W19-43 from 3,650 pCi/L during 2010 to 5,900 pCi/L during 2014 (Figure 11-8).

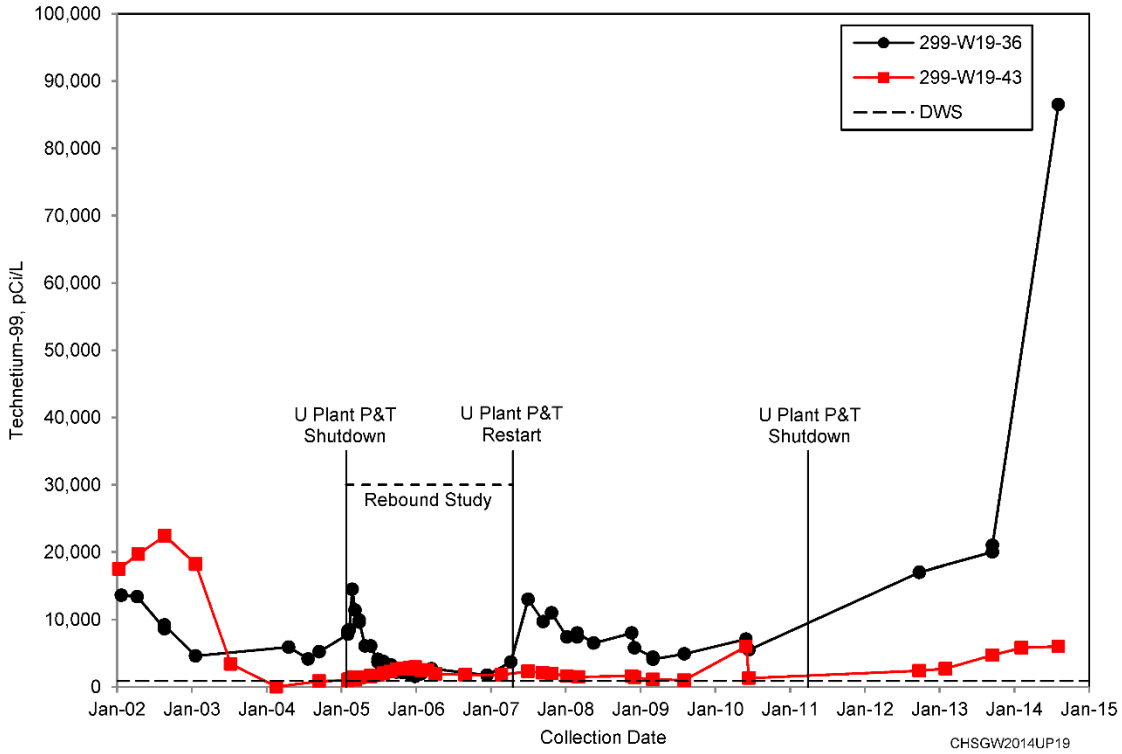

Figure 11-8. 200-UP Technetium-99 Data for Wells 299-W19-36 and 299-W19-43 near U Plant

Further remediation of this plume is addressed by the 2012 interim ROD (EPA et al., 2012) and a new groundwater extraction system is being installed. The system will consist of two extraction wells (299-W19-113 and 299-W19-114) (Figure 11-3) with treatment at the 200 West Groundwater Treatment Facility. Both wells were drilled to total depth during 2014 but due to a drilling problem; Well 299-W19-113 became partly filled in and had to be redrilled to total depth in early 2015. Vertical profile sampling was performed in the aquifer during drilling. The results show technetium-99 concentrations above the cleanup level from the water table to a depth of 10 m (33 ft) at Well 299-W19-113 (Figure 11-9). The plume is deeper at Well 299-W19-114, where concentrations were above the cleanup level between 9 and 27 m (28 and 89 ft) below the water table (Figure 11-10).

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 since 2013 has been toward the north-northeast (see Figure 11-2). This is causing the technetium-99 plume to move toward the north-northeast. This was demonstrated by the technetium-99 concentrations in Well 299-W19-107 to the north of the plume, which have increased from 91 pCi/L in June 2012 to 410 pCi/L in December 2013.

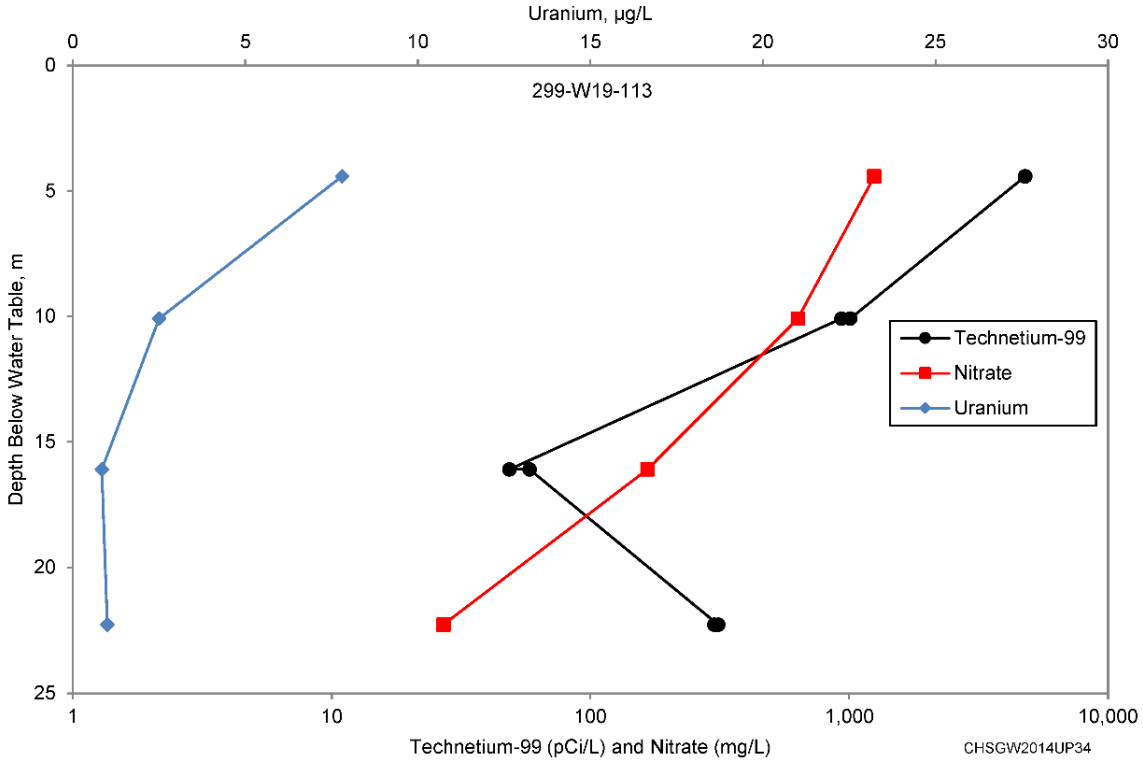

Figure 11-9. 200-UP Vertical Profile Sampling Results for Well 299-W19-113 near U Plant

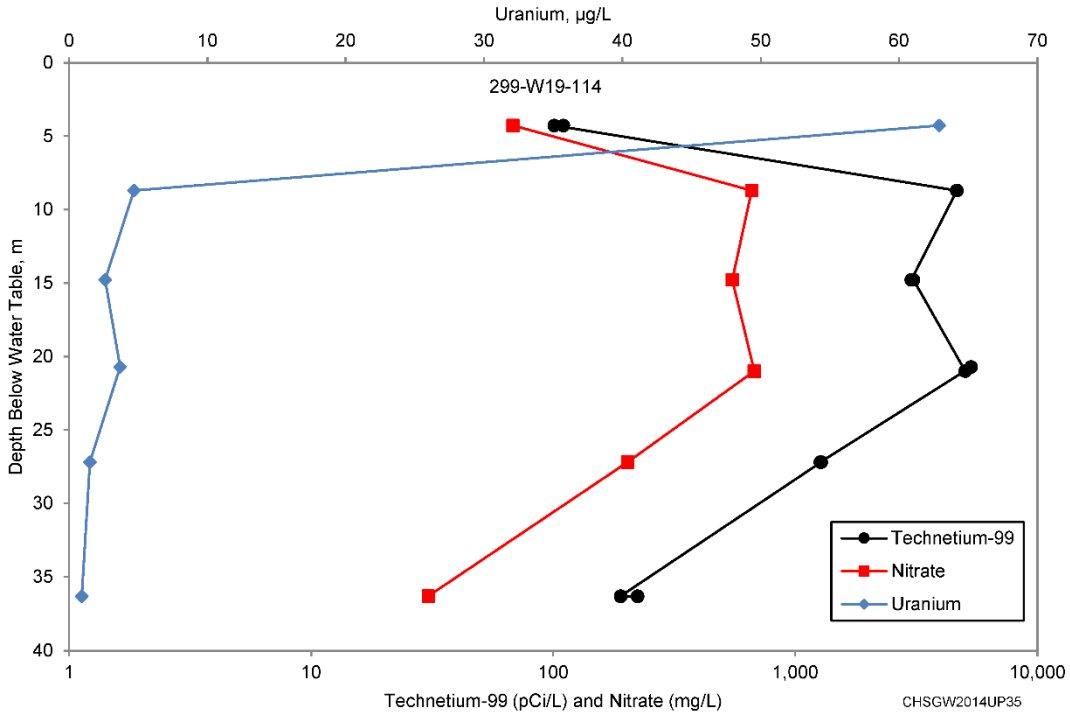

Figure 11-10. 200-UP Vertical Profile Sampling Results for Well 299-W19-114 near U Plant

11.3.3 Waste Management Area U

The WMA U area is a source of technetium-99 groundwater contamination (PNNL-13282). Concentrations in many of the downgradient wells are stable or slowly increasing, with the exception of Well 299-W19-45 in which concentrations have increased substantially since 2011 (Figure 11-11). Concentrations declined slightly in this well during 2014, from 5,400 pCi/L in July 2013 to 4,430 pCi/L in July 2014. Technetium-99 concentrations were also greater than the cleanup level in four other wells during 2014: 299-W19-12, 299-W19-42, 299-W19-47, and 299-W18-260. Well 299-W18-260 was drilled during 2014 as a replacement for dry Well 299-W18-30. Results of vertical profile sampling during drilling are shown in Table 11-2 and Figure 11-12. Technetium-99 occurs at concentrations above the cleanup level only in the upper part of the aquifer from the water table to a depth of 8 m (28 ft) below the water table. The groundwater contamination at WMA U is believed to result from multiple sources within the WMA (HNF-EP-0182). The contamination is within the capture zone of the 200 West P&T extraction well network (see Chapter 12, Figure 12-21).

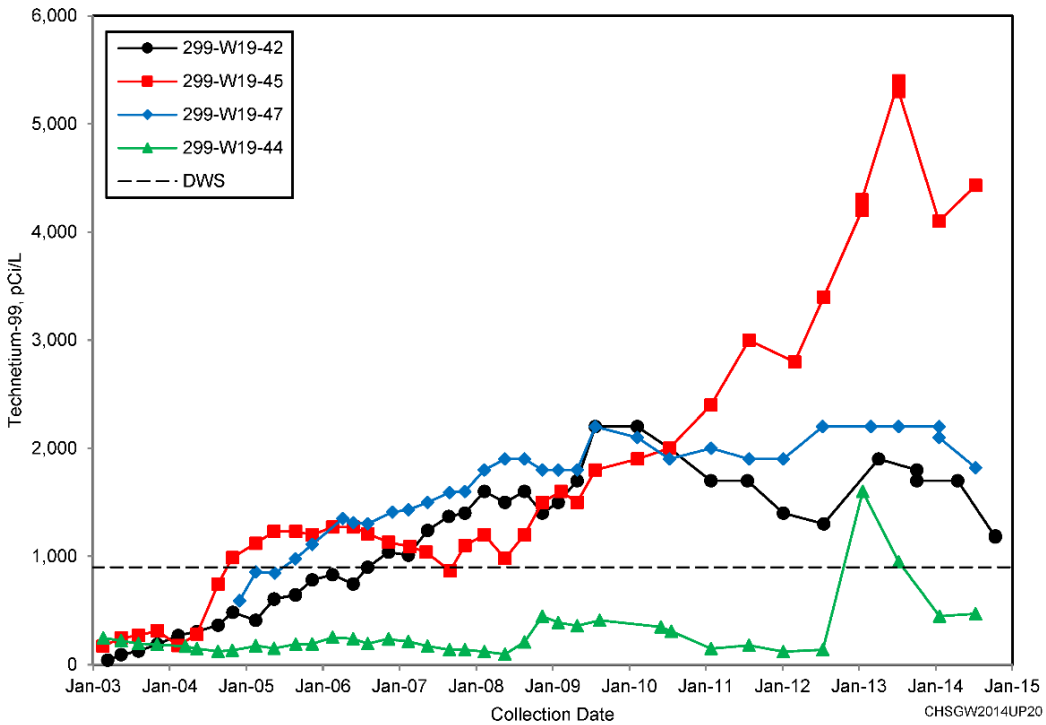

Figure 11-11. 200-UP Technetium-99 Data for Selected Wells at WMA U

Table 11-2. Depth Profile Sample Results for 299-W18-260

Depth (ft below water table)	Carbon Tetrachloride (µg/L)	Nitrate (mg/L)	Technetium-99 (pCi/L)
10	72.4	57.1	1,340
28	195	53.1	1,060
48	250	43.4	43.5
67	272	35.3	28.1
87	271	4.4	Not detected

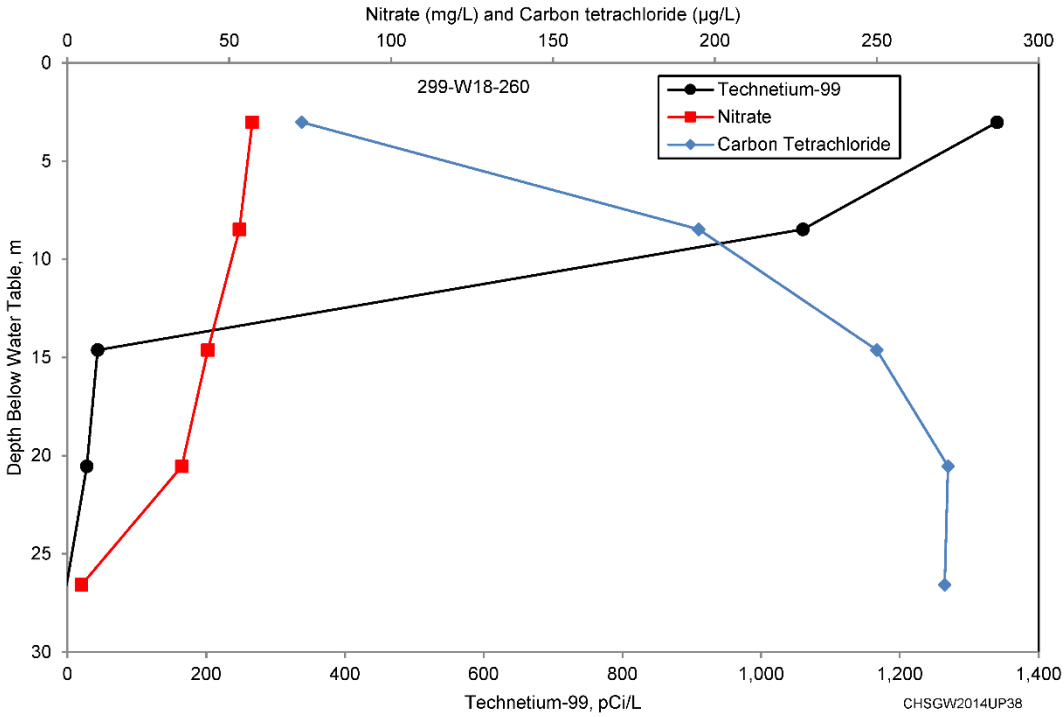

Figure 11-12. 200-UP Vertical Profile Sampling Results for Well 299-W18-260 at WMA U

11.4 Uranium

Uranium occurs at concentrations above the 30 µg/L cleanup level in 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).

11.4.1 216-U-1 and 216-U-2 Cribs Plume

These cribs were the source of a uranium plume that is interpreted to extend 1.5 km (0.9 mi) to the east at levels above the 30 µg/L cleanup level (Figure 11-13). A P&T system operated in this plume from 1994 until March 2011. The system was effective at reducing uranium concentrations below the 300 µg/L former remedial action objective in the area targeted for remediation, but concentrations at most wells remained above the current cleanup level of 30 µg/L. This plume is limited to the upper 20 m (66 ft) of the aquifer (Figure 11-13 of DOE/RL-2011-01).

Further remediation of this plume is addressed by the 2012 interim ROD (EPA et al., 2012) and a new groundwater extraction system is being installed. The system will consist of two extraction wells (299-W19-113 and 299-W19-114) (Figure 11-2) with treatment at the 200 West Groundwater Treatment Facility. Both wells were drilled to total depth during 2014 but due to a drilling problem, Well 299-W19-113 became partly filled in and had to be redrilled to total depth in early 2015. Vertical profile sampling was performed in the aquifer during drilling. The uranium concentration at Well 299-W19-114 was 62.9 µg/L in the uppermost sample at 4 m (14 ft) below the water table, but was below the cleanup level for all deeper samples (Figure 11-10). Uranium was not detected above the cleanup level at Well 299-W19-113 (Figure 11-9). The maximum concentration was 7.8 µg/L at 4 m (14 ft) below the water table.

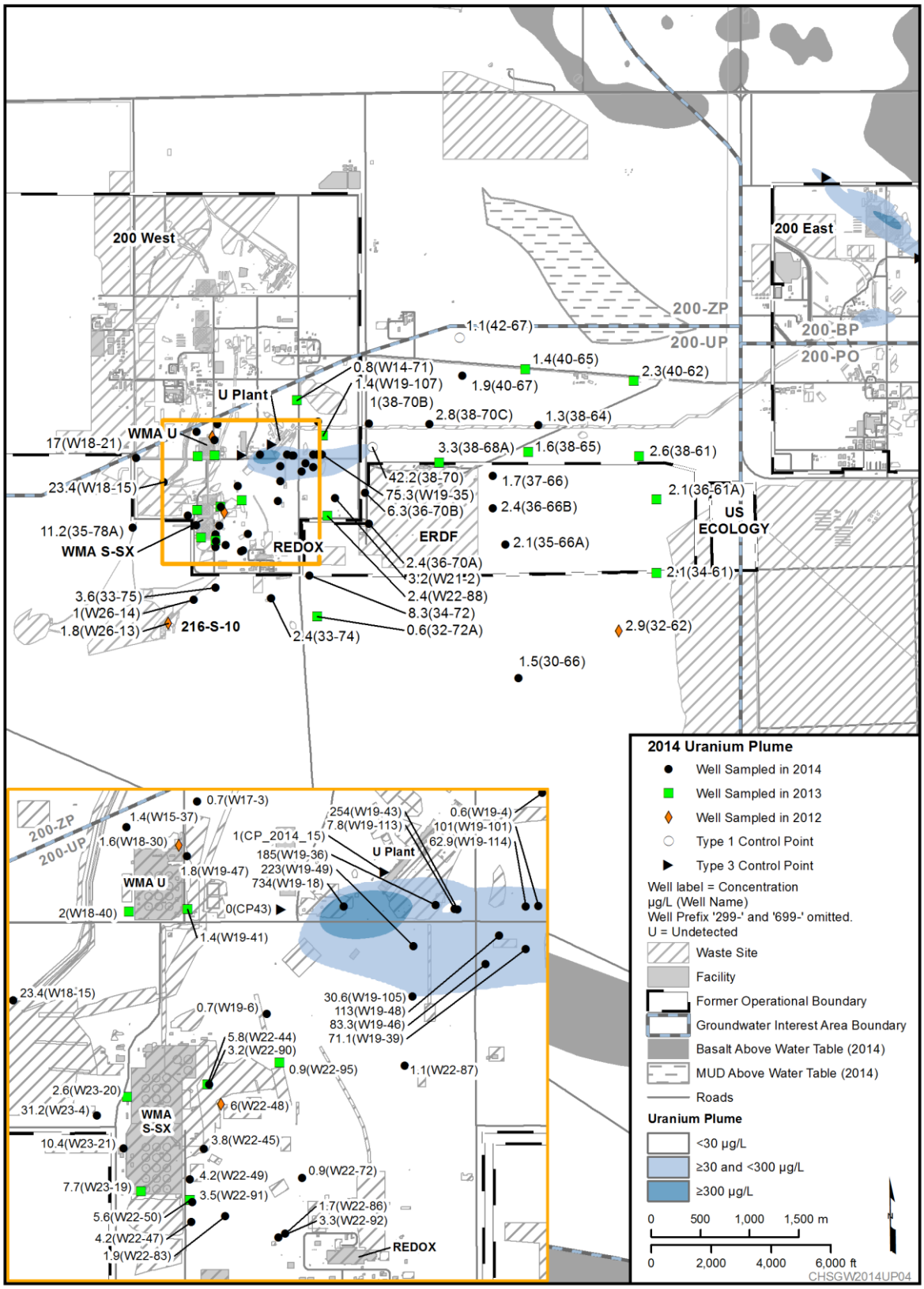

Figure 11-13. 200-UP 2014 Uranium Plume

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 direction since 2013 has been north-northeast toward the 200-ZP-1 extraction wells (Figure 11-2). The change in flow direction caused changes in the uranium concentration trends in some wells. The most notable change was in Well 299-W19-49 in which the uranium concentration increased from 56 to 264 µg/L between June 2012 and January 2013 (Figure 11-14). Concentrations in this well have declined slightly since then (218 µg/L in August 2014). The concentration declined in Well 299-W19-48 from 220 µg/L in January 2013 to 119 µg/L in August 2014.

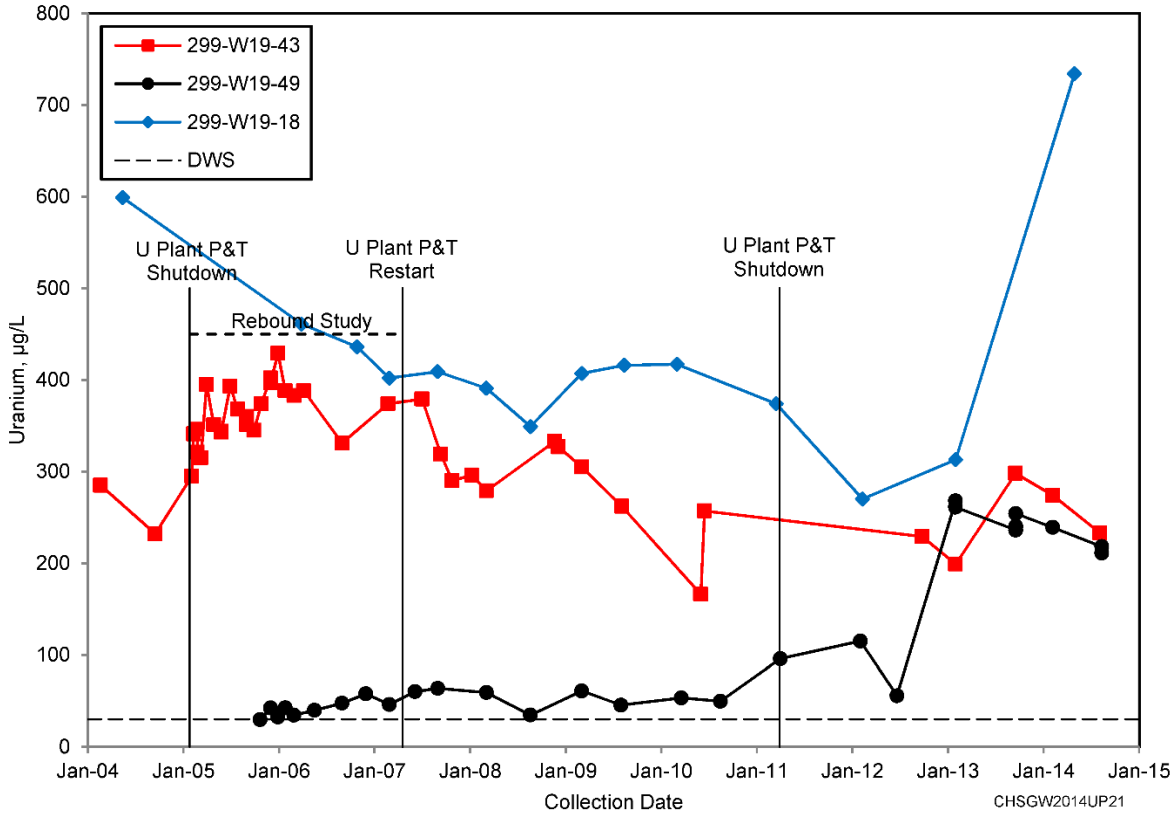

Figure 11-14. 200-UP Uranium Data for Wells 299-W19-18, 299-W19-49, and 299-W19-43 near U Plant

Near the cribs, uranium has remained elevated in Well 299-W19-18. The 2014 sample result was 734 µg/L, a substantial increase from 374 µg/L in 2011 (Figure 11-14). 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.

11.4.2 U Pond

Uranium concentrations exceed the cleanup level in one well near U Pond, Well 299-W23-4 (near the 216-S-21 Crib), which had a concentration of 31.2 µg/L during 2014. Concentrations have been increasing very slowly in this well since 2000. Two other wells in this area have had concentrations above the cleanup level: Wells 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 kg 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.

11.5 Tritium

Disposal facilities associated with the REDOX Plant, which operated from 1952 until 1967, were the primary sources of tritium in 200-UP. A large tritium plume from the REDOX Plant cribs extends 5 km (3.1 mi) toward the east and northeast at concentrations above the 20,000 pCi/L cleanup level (Figure 11-15).

11.5.1 Eastern High-Concentration Area

The highest concentration measured during 2014 within the tritium plume was 280,000 pCi/L in Well 699-36-66B, a decline from 310,000 pCi/L during 2013. High tritium concentrations historically occurred at now-dry Wells 699-35-70 and 299-W22-9. The concentration was 240,000 pCi/L in Well 699-35-70 when it was last sampled in 2008; the concentration was 1,020,000 pCi/L in Well 299-W22-9 when it was last sampled in 2005. Together, these three wells define a high-concentration portion of this plume (i.e., greater than 200,000 pCi/L) that extends 2.5 km (1.6 mi) east and northeast from the southern 200 West Area. Dry Wells 699-35-70 and 299-W22-9 are scheduled to be replaced and depth-discrete sampling will be performed during drilling to characterize the vertical extent of the tritium plume in this area (DOE/RL-2014-27, Rev. 1, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit*). Concentration trends are declining in eight of the nine wells (not currently dry) within the 20,000 pCi/L contour (i.e., the cleanup level), consistent with attenuation of the plume by dispersion and radiological decay. At Well 299-W22-96, the tritium concentration has declined from 96,000 pCi/L in July 2012 to 17,000 pCi/L (below the cleanup level) in June 2014. This is consistent with the eastward migration of the high-concentration portion of this plume, although operation of extraction Well 299-W22-92 located 220 m (700 ft) southwest of Well 299-W22-96 may also be a factor.

11.5.2 216-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 2014 was 69,400 pCi/L in Well 299-W22-49 located east of the SX Tank Farm and 260 m (850 ft) downgradient from the crib. Radioactive liquid effluent was discharged 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 Cribs was discharged to 216-S-25 for 6 months during 1985. The crib received an estimated 3,600 Ci of tritium (Appendix C in RPP-26744).

11.5.3 216-S-21 Crib

The tritium concentration in 299-W23-4 near the 216-S-21 Crib (west of WMA S-SX and north of the 216-S-25 Crib) had been increasing since 2003. The trend reversed during 2012 and the declining trend continued during 2014. The February sample result was 37,000 pCi/L, a decline from 63,000 pCi/L in January 2013 (Figure 11-16). The crib received an estimated 2,500 Ci of tritium between 1954 and 1969 (Appendix C in RPP-26744). To put the current contamination levels into perspective, the maximum tritium concentration in Well 299-W23-4 occurred in 1963 and 1964 at 110 million pCi/L.

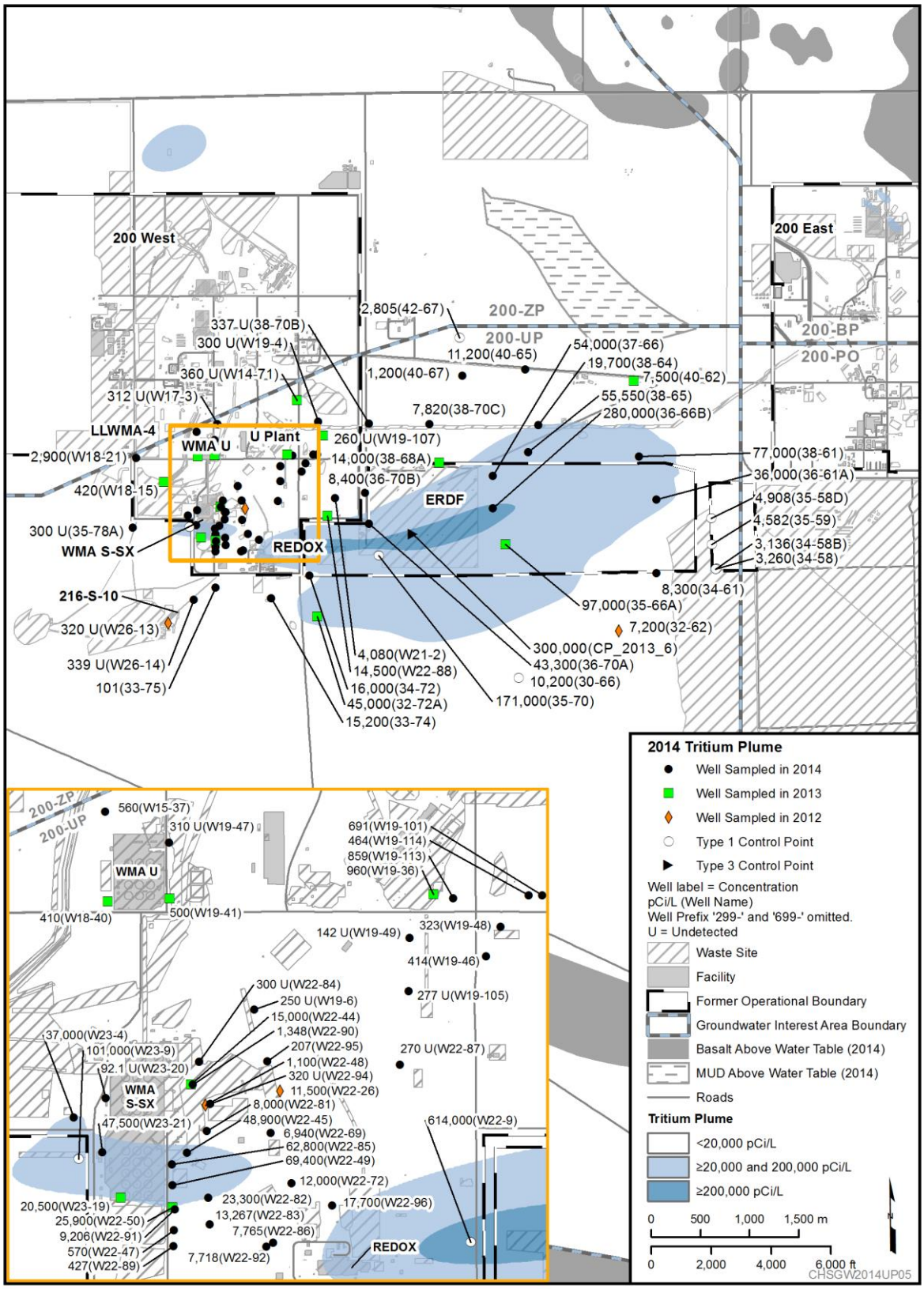

Figure 11-15. 200-UP Tritium Plume, 2014

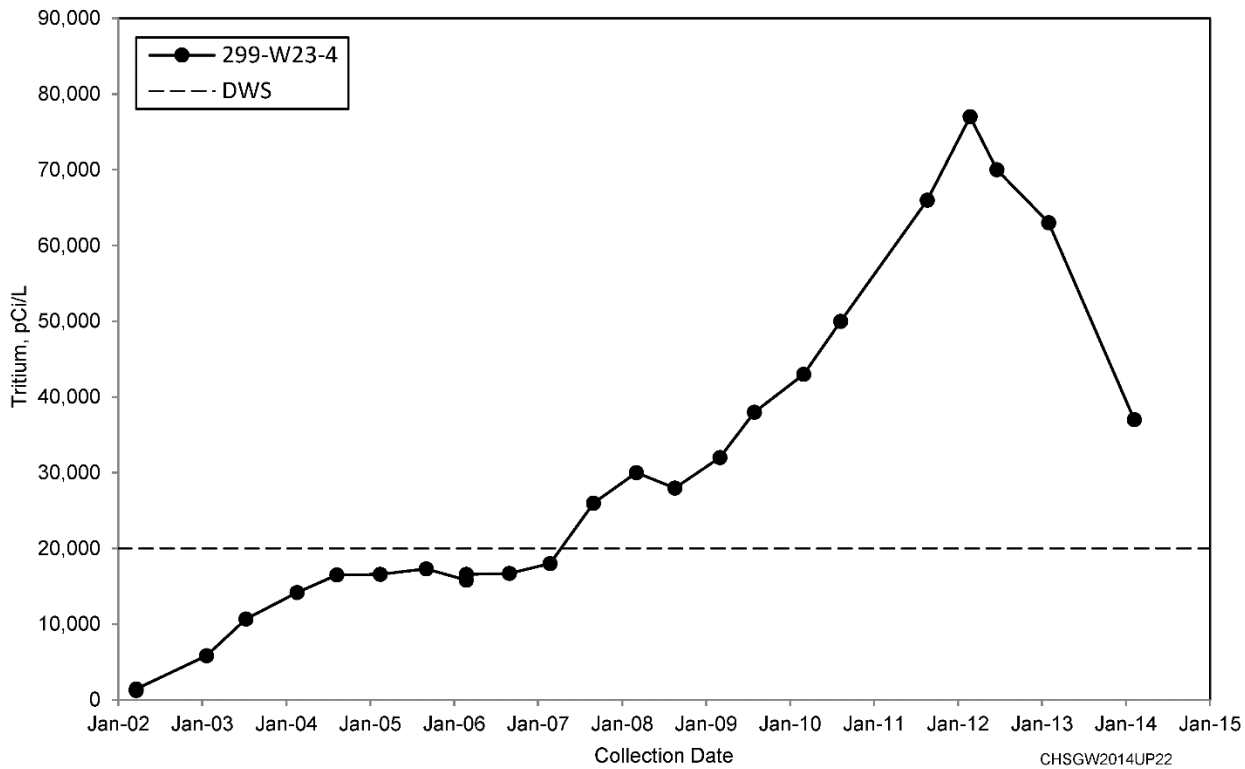

Figure 11-16. 200-UP Tritium Data for Well 299-W23-4 at the 216-S-21 Crib

11.6 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 11-17). 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. East of the 200 West Area, these plumes have merged and become indistinguishable.

11.6.1 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 2.5 km (1.6 mi) east into the 600 Area from the southeastern 200 West Area (Figure 11-17). Although short-term variability in sample results can cause substantial concentration changes from year to year in some wells, long-term concentration trends in this plume tend to be stable to slightly declining (Figure 11-18). The maximum sample result during 2014 was 11 pCi/L in Well 699-36-70A. The highest concentrations recently in this plume occurred at Well 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 Well 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. Wells 699-35-70 and 299-W22-9 are scheduled to be replaced and depth-discrete sampling will be performed during drilling to characterize the vertical profile of the plume (DOE/RL-2014-27, Rev. 1).

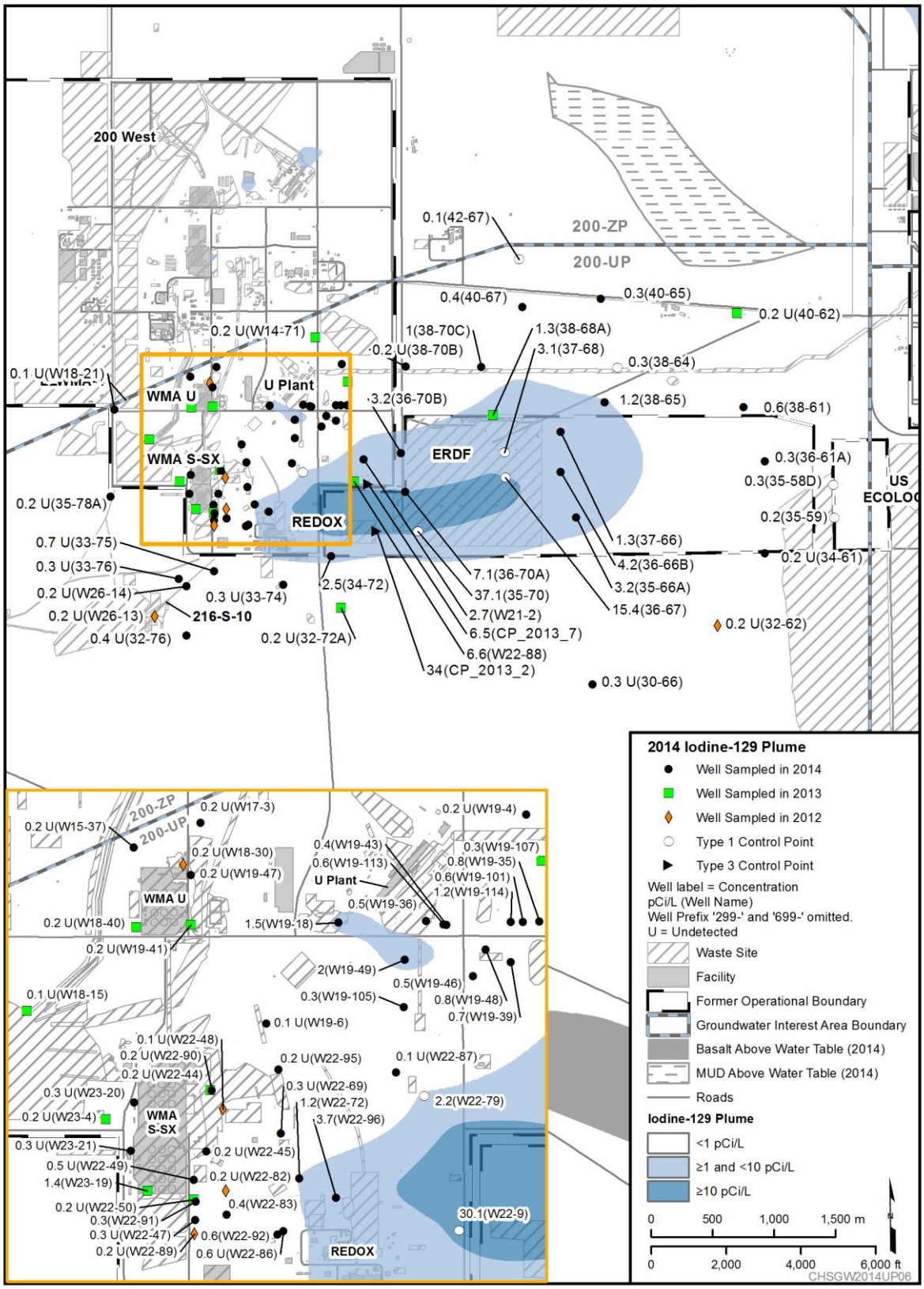

Figure 11-17. 200-UP Iodine-129 Plume, 2014

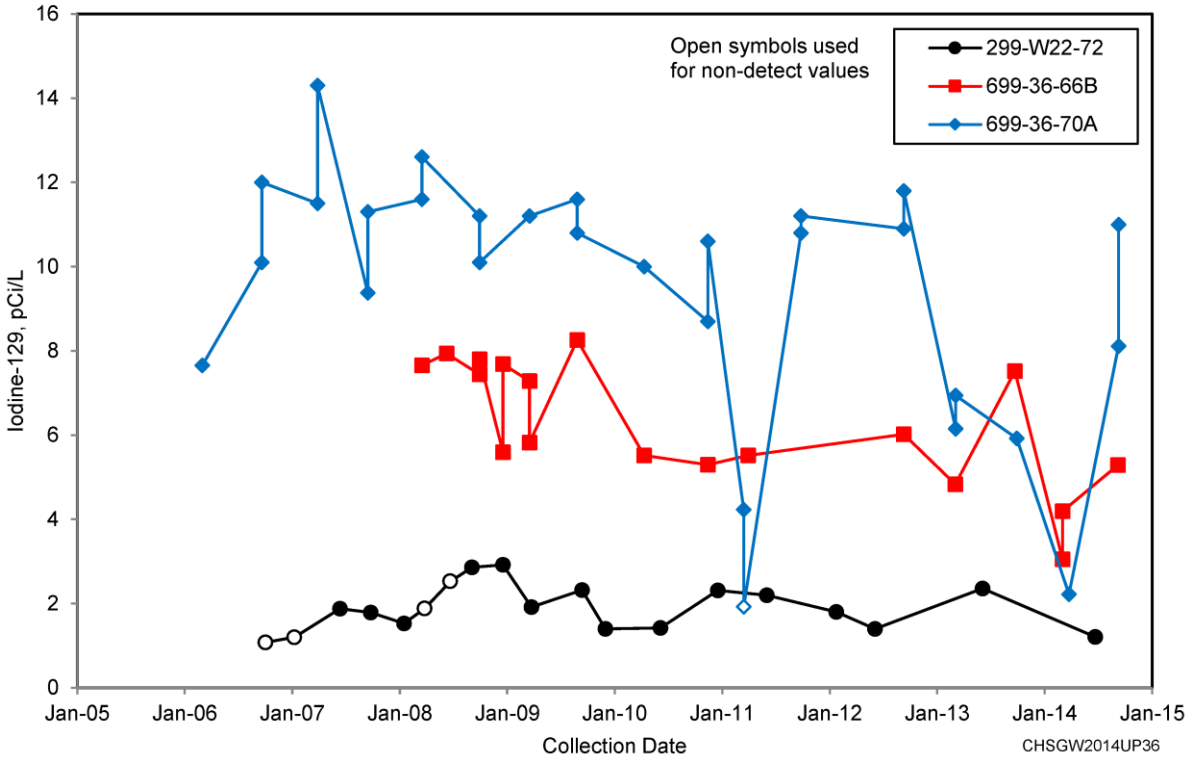

Figure 11-18. 200-UP Iodine-129 Concentrations for Wells 299-W22-72, 699-36-66B, and 699-36-70A

11.6.2 SX Tank Farm

Iodine-129 is interpreted to occur beneath the SX Tank Farm at concentrations slightly above the 1 pCi/L cleanup level (Figure 11-17). In a sample collected during December 2011 from Well 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 Well 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.

11.6.3 216-U-1 and 216-U-2 Cribs

The maximum iodine-129 sample result downgradient from these cribs during 2014 was 2.8 pCi/L in Well 299-W19-49. Concentrations are low in this area. The only other well with concentrations above the 1 pCi/L cleanup level is Well 299-W19-18, which had a result of 1.53 pCi/L during April. 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 km (1.1 mi) 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.

11.7 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 11-19).

11.7.1 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 2014 sample result at Well 299-W19-36 was 1,010 mg/L, a substantial increase from 316 mg/L in 2013. The result from Well 299-W19-43 was 2,270 mg/L, a decline from 3,210 mg/L in 2013 (Figure 11-20). Because these concentrations are higher than historical nitrate concentrations in groundwater near the 216-U-1 and 216-U-2 Cribs (approximately 100 to 300 mg/L in the 1970s and 1980s), the nitrate at Wells 299-W19-36 and 299-W19-43 was thought to originate from a local source. However, efforts to identify a local source were not successful. The source is now interpreted to be the 216-U-1 and 216-U-2 Cribs which may have had effluent nitrate concentrations up to approximately 15,000 mg/L (based on the mean mass loading and effluent volumes reported in Appendix C of RPP-26744). The highest nitrate concentration in groundwater east of the 200 West Area during 2014 was 214 mg/L in Well 699-40-65.

Remediation of the region of high nitrate concentrations near former extraction Wells 299-W19-36 and 299-W19-43 is addressed by the 2012 interim ROD (EPA et al., 2012). A P&T system is being constructed and extraction Wells 299-W19-113 and 299-W19-114 were drilled to total depth in the U Plant area during 2014 but due to a drilling problem, Well 299-W19-113 became partly filled in and had to be redrilled to total depth in early 2015. Vertical profile sample results during drilling are shown in Figures 11-9 and 11-10. Nitrate concentrations were above the 45 mg/L cleanup level to a depth of 16 m (53 ft) below the water table in Well 299-W19-113 and to a depth of 29 m (89 ft) below the water table in Well 299-W19-114. The maximum concentrations were 1,250 mg/L in 299-W19-113 and 677 mg/L in Well 299-W19-114.

11.7.2 Waste Management Area U

Nitrate concentrations are greater than the 45 mg/L cleanup level in all of the monitoring wells at the U Tank Farm, except for the southernmost downgradient well, 299-W19-41. The concentration in the upgradient well, 299-W18-40, was 65.1 mg/L (December 2013). The upgradient source is interpreted to be the injection wells formerly used for the 200-ZP-1 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 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 has declined since to 68 mg/L in July 2014 (Figure 11-21). This trend change could be explained by a pulse of contamination entering the aquifer from beneath the tank farm. However, the trend change 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 200-ZP-1 remedy extraction Well 299-W17-3 (see Chapter 12, Figure 12-21).

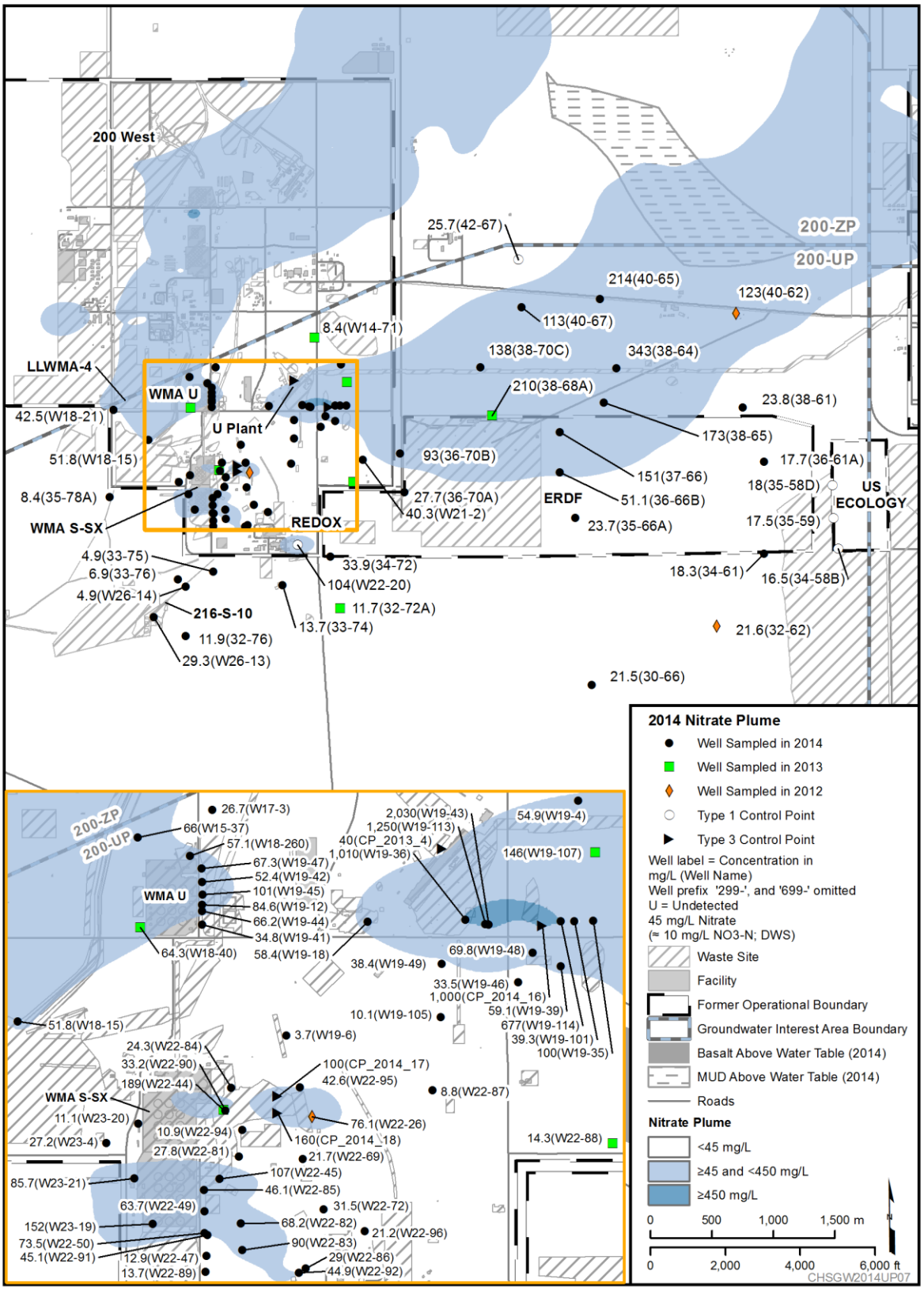

Figure 11-19. 200-UP Nitrate Plume, 2014

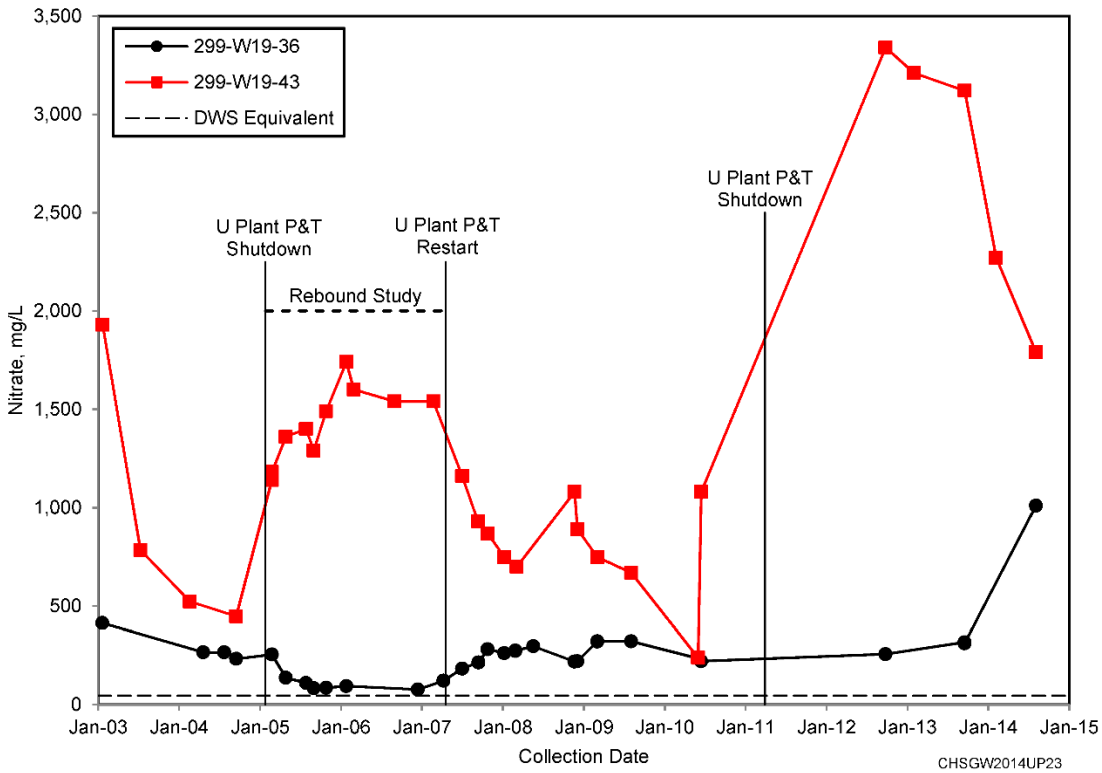

Figure 11-20. 200-UP Nitrate Data for Wells 299-W19-36 and 299-W19-43 near U Plant

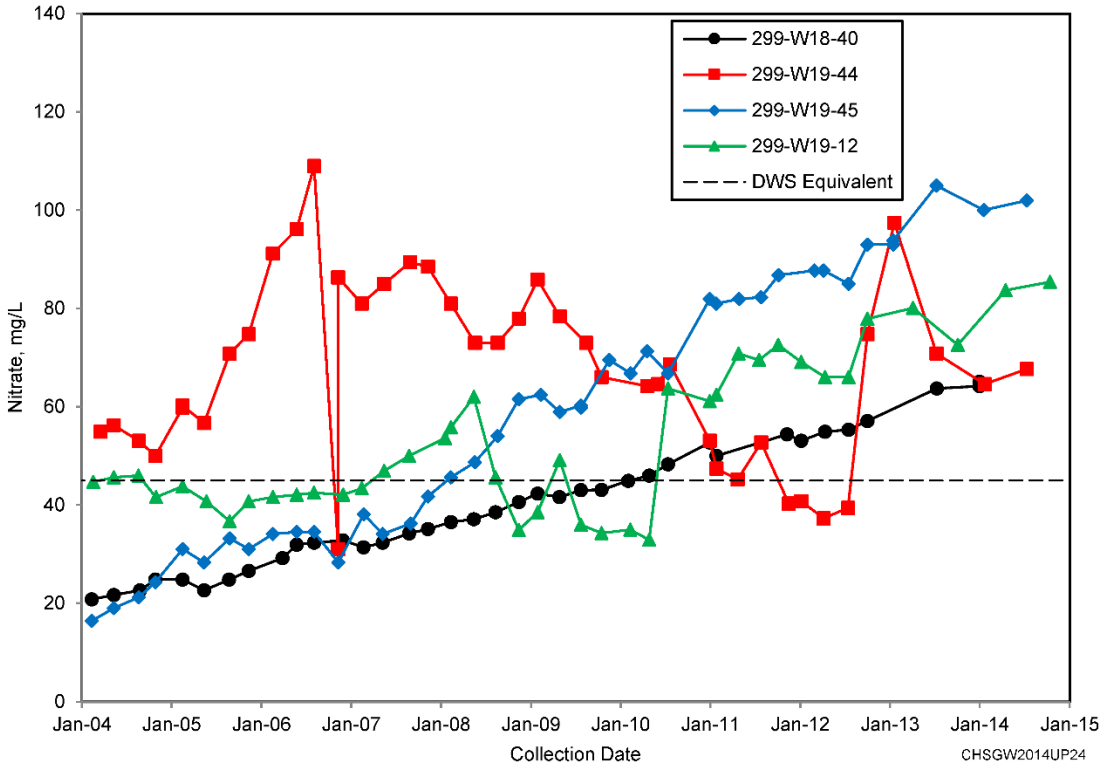

Figure 11-21. 200-UP Nitrate Data for Selected Wells at WMA U

11.7.3 Waste Management Area 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. Nitrate concentrations are highest in Well 299-W23-19 within the SX Tank Farm. Concentrations in this well declined during 2014 from 170 mg/L in April to 121 mg/L in December (Figure 11-6). 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 L (51,000 gal) leak from Tank SX-115 that occurred during 1965 (Section 4.3 of RPP-ENV-39658). The contamination is gradually migrating into the unconfined aquifer.

A nitrate plume also originates from the S Tank Farm. The maximum concentration in this plume during 2013 was 193 mg/L measured at Well 299-W22-44. This well became dry during 2013 and a replacement well is scheduled for drilling. This plume originates from an overfill event at Tank S-104 between 1966 and 1970.

11.8 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 11-22). 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.

11.8.1 Waste Management Area S-SX

Chromium concentrations in four wells at WMA S-SX exceeded the 48 µg/L cleanup level in at least one sample during 2014. The highest concentrations occurred at Well 299-W23-19, where sample results declined during the year from 497 µg/L in April to 413 µg/L in December (Figure 11-6). The decline is attributed to operation of the WMA S-SX groundwater extraction system. Concentrations in two wells declined to below the cleanup level during 2014, 299-W22-47 (near extraction Well 299-W22-91) and 299-W22-86 (near extraction Well 299-W22-92).

A second chromium plume occurs downgradient from the S Tank Farm. This plume originated from Tank S-104 (an overfill 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 2013 (the unfiltered result was 641 µg/L but was affected by high turbidity). This well is now dry, but a replacement well is scheduled for drilling. Concentrations at nearby extraction Well 299-W22-90 ranged between 58.5 and 78.7 µg/L during 2014. The extraction well captures the portion of the chromium plume near the source (Section 11.12).

11.8.2 Southeast Plume

Within the chromium plume east southeast of the 200 West Area, concentrations in Well 699-32-62 have slowly declined from 254 to 134 µg/L since this constituent was first measured in 1992 (Figure 11-23). 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 117 and 127 µg/L during 2014), which is completed deep in the aquifer just above the Ringold lower mud unit (Figure 11-22). 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).

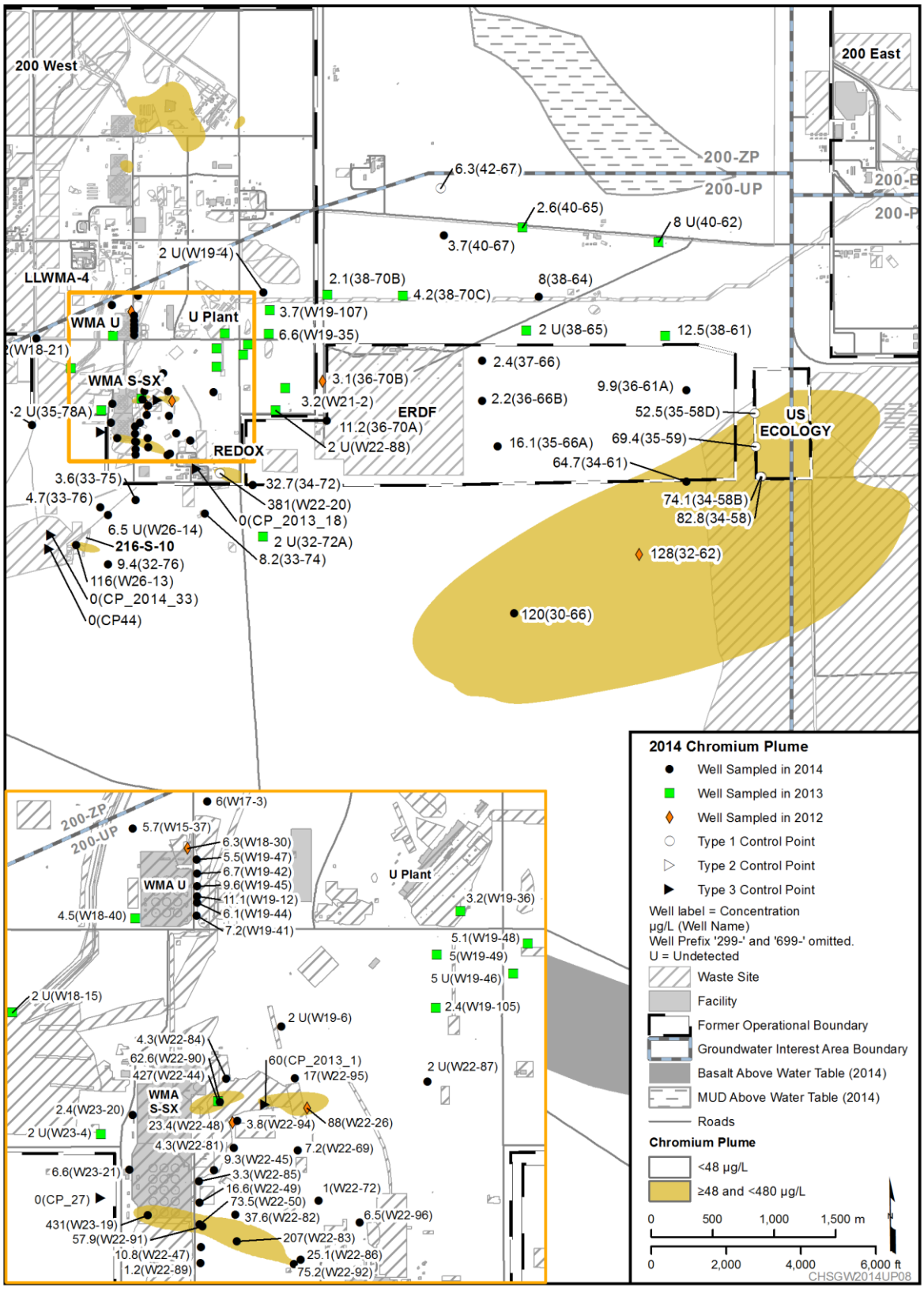

Figure 11-22. 200-UP Chromium Plume, 2014

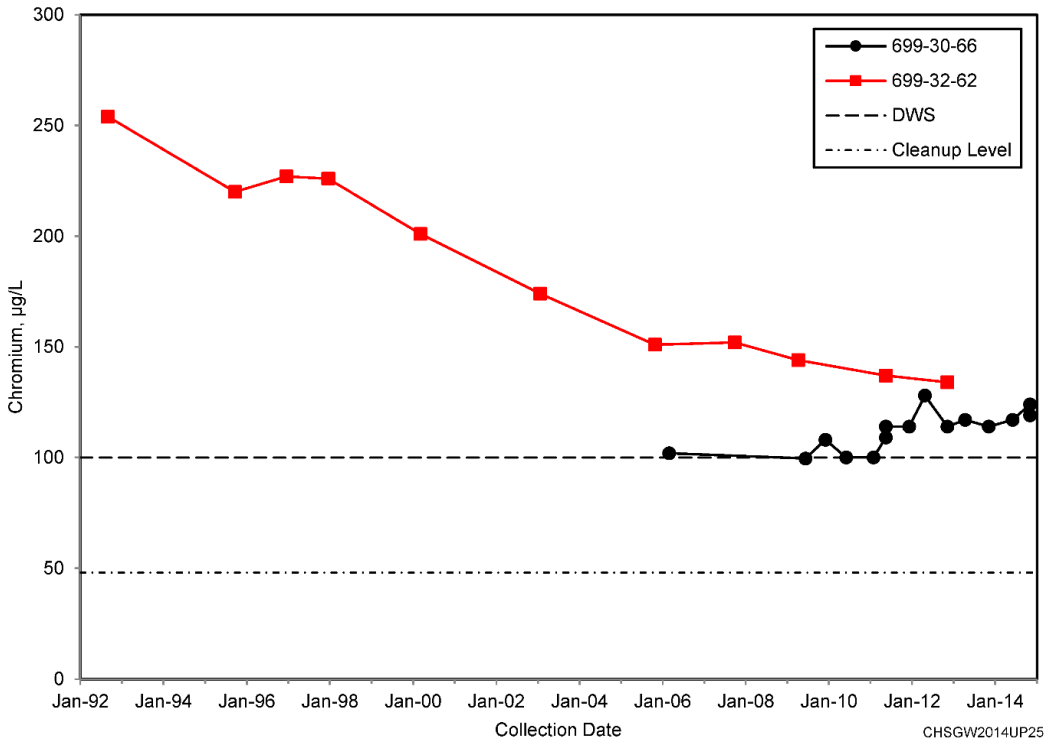

Figure 11-23. 200-UP Chromium Data for Wells 699-30-66 and 699-32-62 Southeast of the 200 West Area

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 kg of chromium were disposed to the 216-S-20 Crib, and an estimated 3,000 kg 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 33 µg/L in a filtered sample collected during February 2014 (42 µg/L in the unfiltered sample). In Well 299-W26-13 at the 216-S-10 Pond and Ditch, chromium averaged 116 µg/L during 2014 (hexavalent chromium and total chromium results combined) and the trend has been generally increasing (Figure 11-24). Chromium is also above background in Well 699-32-76, located 300 m (1,000 ft) farther downgradient (Figure 11-24).

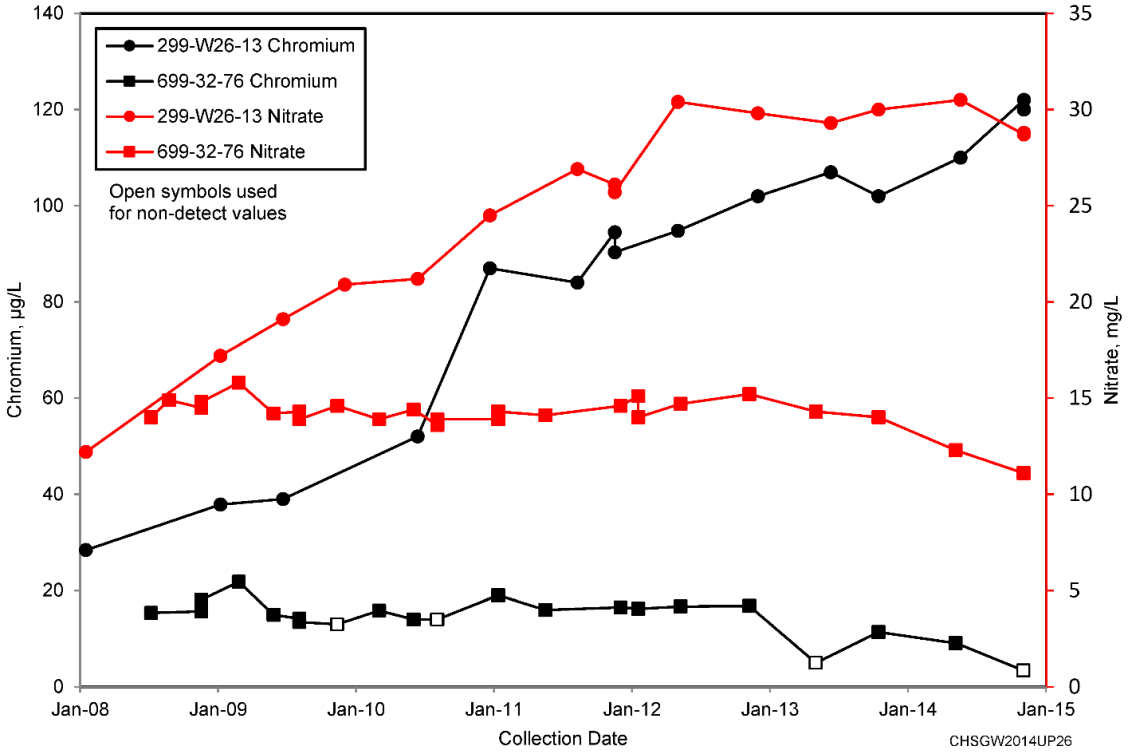

Figure 11-24. 200-UP Chromium and Nitrate Data for Wells 299-W26-13 and 699-32-76 at the 216-S-10 Pond and Ditch

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 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 (DOE/RL-2014-27, Rev. 1).

11.9 Carbon Tetrachloride

The occurrence of 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 27 wells during 2014. Concentrations were above the cleanup level in 48 of the 64 wells sampled for carbon tetrachloride within 200-UP in 2014. In the southern portion of the 200 West Area, the plume extends as much as 1.2 km (0.7 mi) east into the 600 Area (Figure 11-25). The plume originated from waste disposal sites associated with the 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 2014 was 680 µg/L at Well 299-W14-71 (Figure 11-26), which is screened at the bottom of the unconfined aquifer. The second highest concentrations occur in Well 699-38-70B (390 µg/L) which is also screened at the bottom of the unconfined aquifer. Also, concentrations at Well 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.

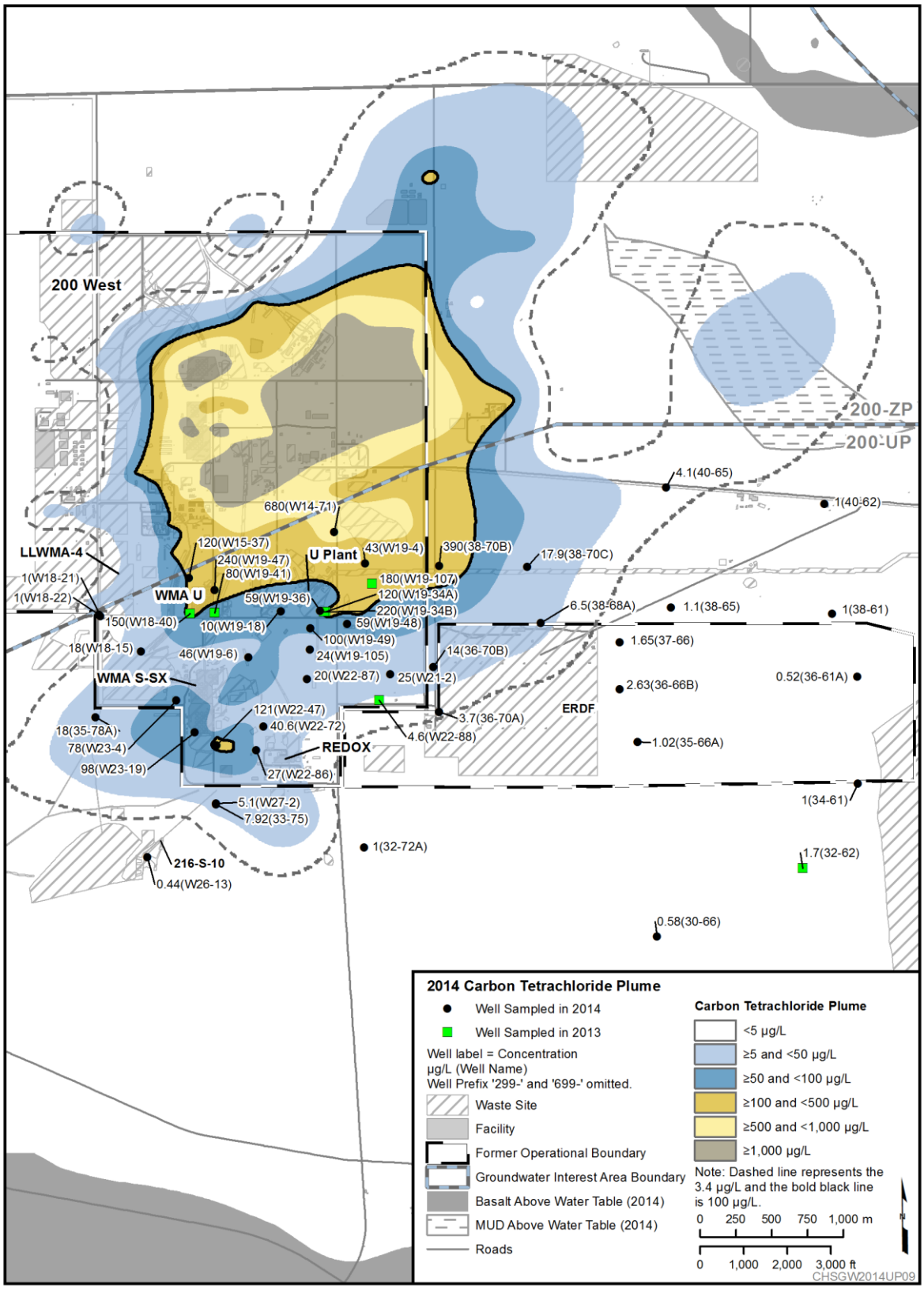

Figure 11-25. 200-UP Carbon Tetrachloride Plume, 2014

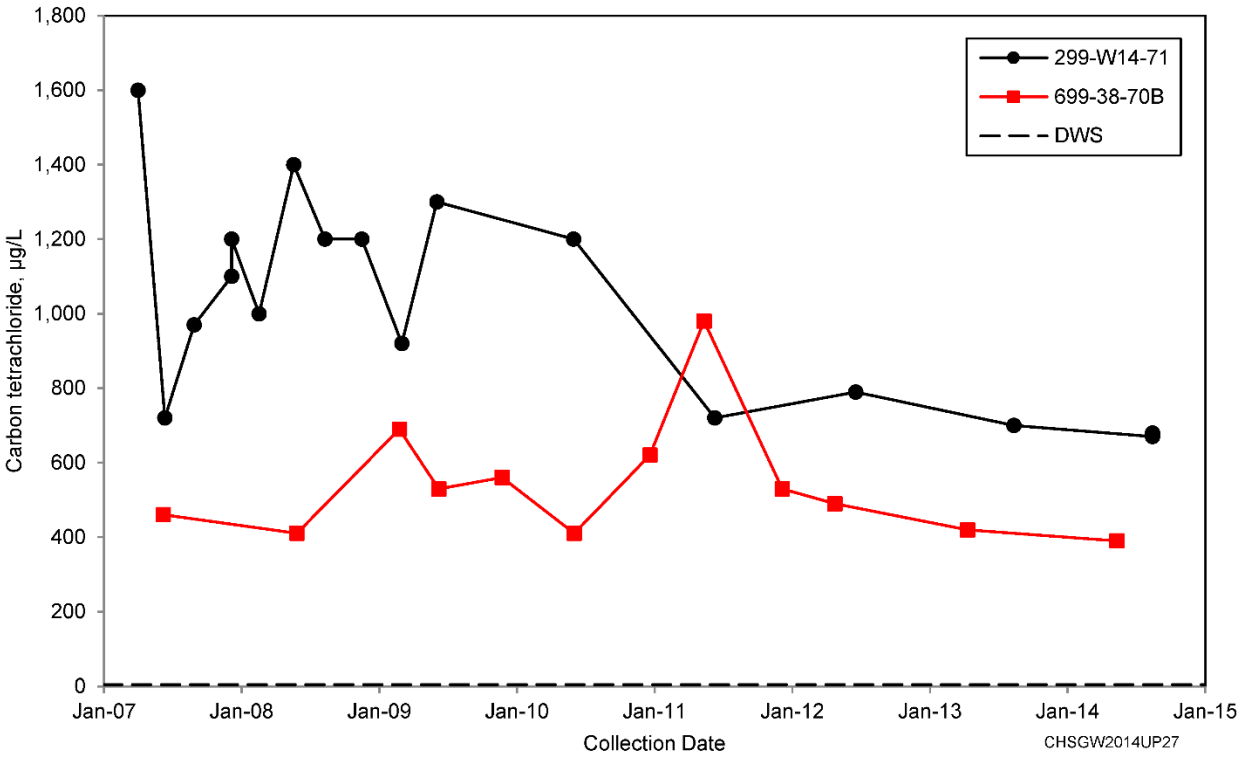

Figure 11-26. 200-UP Carbon Tetrachloride Data for Wells 299-W14-71 North of U Plant and 699-38-70B East of U Plant

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 2014, 104 chloroform analyses were performed on samples from 63 wells within 200-UP; no exceedances of the DWS (80 µg/L for total trihalomethanes) were found. The maximum concentration was 10 µg/L in Well 299-W19-47. Depth-discrete sampling during new well installation indicates that chloroform concentrations tend to increase with depth, similar to carbon tetrachloride.

11.10 Trichloroethene

TCE is found in groundwater in the northern portion of 200-UP (Figure 11-27). Depth-discrete samples during well drilling show that TCE concentrations increase with depth, similar to carbon tetrachloride and chloroform. During 2014, 114 TCE analyses were performed on samples from 65 wells within 200-UP. TCE was detected in 14 wells, but the DWS (5 µg/L) was exceeded only at Well 299-W14-71 (8.7 µg/L) and in a single sample from Well 299-W19-114 collected during drilling (7.5 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 2014.

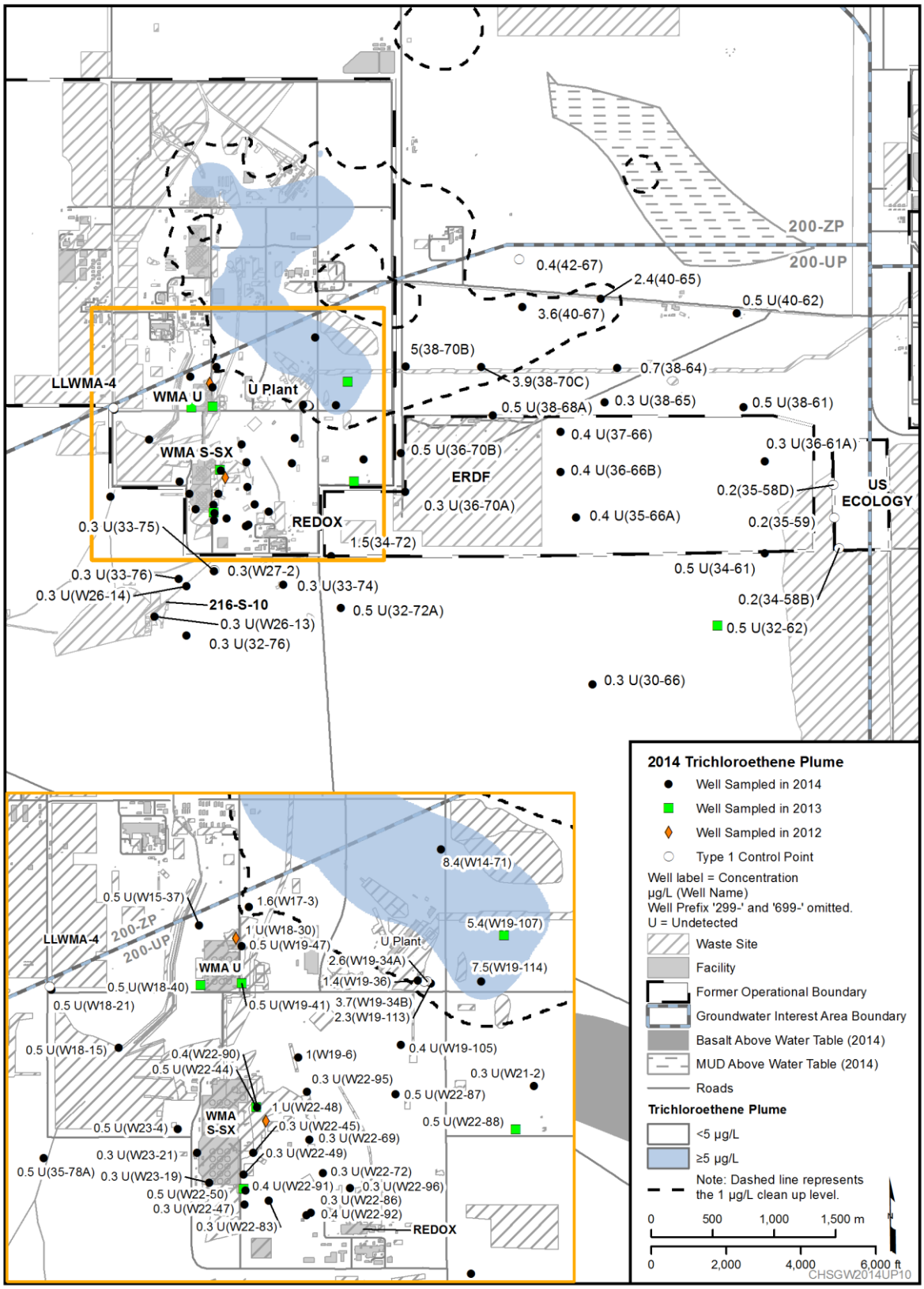

Figure 11-27. 200-UP TCE Plume, 2013

11.11 Environmental Restoration Disposal Facility

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 10 disposal cells, 6 of which were active during 2014. 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 2014, 1,409,000 metric tons (1,553,000 tons) (9,400 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.

11.11.1 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. Due to procedural and accessibility issues, the September 2013 sampling was delayed until February 2014. Leachate samples are normally collected during March and September of each year. Routine calendar year 2014 sampling of the leachate occurred on March 18, 2014, and November 11, 2014. The November sampling was for the biennial “long list” for over 300 chemical and radionuclide analytes. No exceedances of a delisting level occurred during this time frame. Seven organic compounds were reported as detected for the November sampling, all near analytical detection limits. The number of low-level organic detects was comparable to previous long list analyses. One organic, 1,2-diphenylhydrazine, was detected (0.25 µg/L) in one sample (replicate result was nondetected) just above the detection limit and just above 1/10th of the assigned delisting value (2.5 µg/L) The only other analyte detected at concentrations greater than 1/10th of the delisting value was nitrate. This compound will be monitored in the 2015 sampling for inclusion in the routine analysis list. All nitrate values to date have exceeded 1/10th of the delisting values. Nitrate values have continued to rebound 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.

11.11.2 Groundwater Sampling

Groundwater monitoring at the ERDF is performed in accordance with 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 11-28), 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 2014.

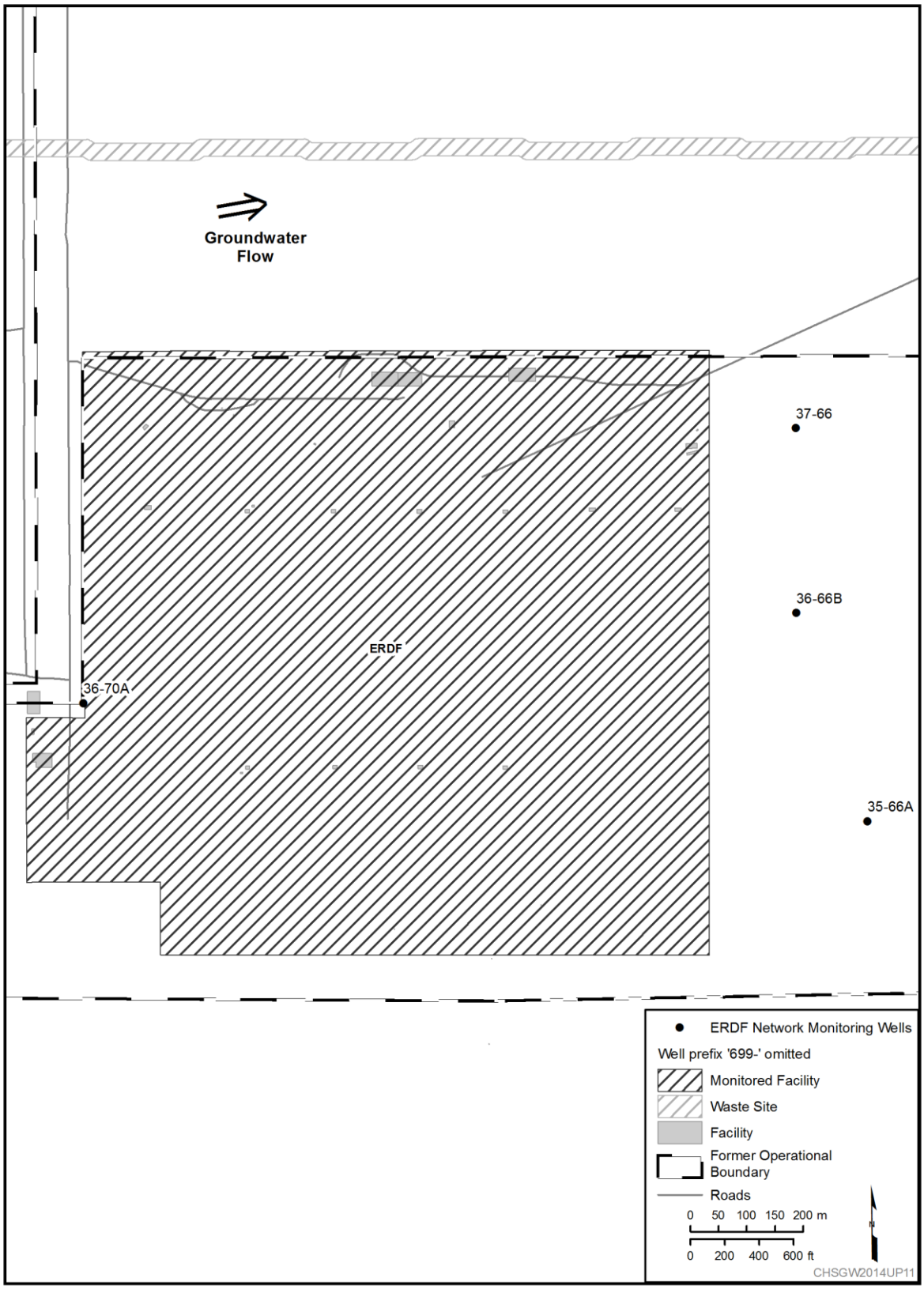

Figure 11-28. 200-UP ERDF Monitoring Well Locations

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.

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 in downgradient Wells 699-37-66 and 699-36-66B. Technetium-99 and gross beta (affected by technetium-99) in downgradient Well 699-35-66A remained below the maximum seen in 2012 but have rebounded some from the 2013 results. 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-1 cleanup level.

Nitrate levels appear to be stabilizing in all wells with indications of a slight downward trend. Fluoride results for all wells appear to have stabilized near historical levels below the spikes noted in 2012. Fluoride concentrations in upgradient Well 699-36-70A remain slightly elevated from historical levels.

Vanadium results in all wells appear to be stabilizing at historical levels, down from the maximum seen in the March 2010 sampling. Chromium sample results appear to have stabilized in the downgradient wells. Upgradient Well 699-36-70A has elevated levels of chromium. While chromium is present as a contaminant in some areas of the Hanford Site, chromium has also been associated with corrosion of the stainless-steel well screens. Nickel and manganese (both components of 304/316 stainless steel) remain elevated at Well 699-36-70A, consistent with corrosion of the screen. 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. Lead values for the 2014 sampling returned to nondetect levels. These specific items will continue to be monitored.

11.12 S-SX Pump-and-Treat

During 2014, 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 operates under the interim action ROD issued in 2012 (EPA et al., 2012). This section provides a summary of this system for 2014. More details can be found in the 2014 annual P&T system report (DOE/RL-2015-06, 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 11-29). Extracted water is pumped to the 200 West P&T. The extraction wells began operating during July 2012. During 2014, the combined flow rate from the extraction wells averaged 315 L/min (83 gpm). A total of 165.7 million L (43.8 million gal) were pumped during the year, and 0.63 Ci of technetium-99, 6,720 kg of nitrate, 10.2 kg of chromium, and 129 kg of carbon tetrachloride were removed from the aquifer (Table 11-3). Since startup, the system has extracted 327.3 million L (86.5 million gal) and removed 1.66 Ci of technetium-99, 16,280 kg of nitrate, 28.1 kg of chromium, and 250 kg of carbon tetrachloride.

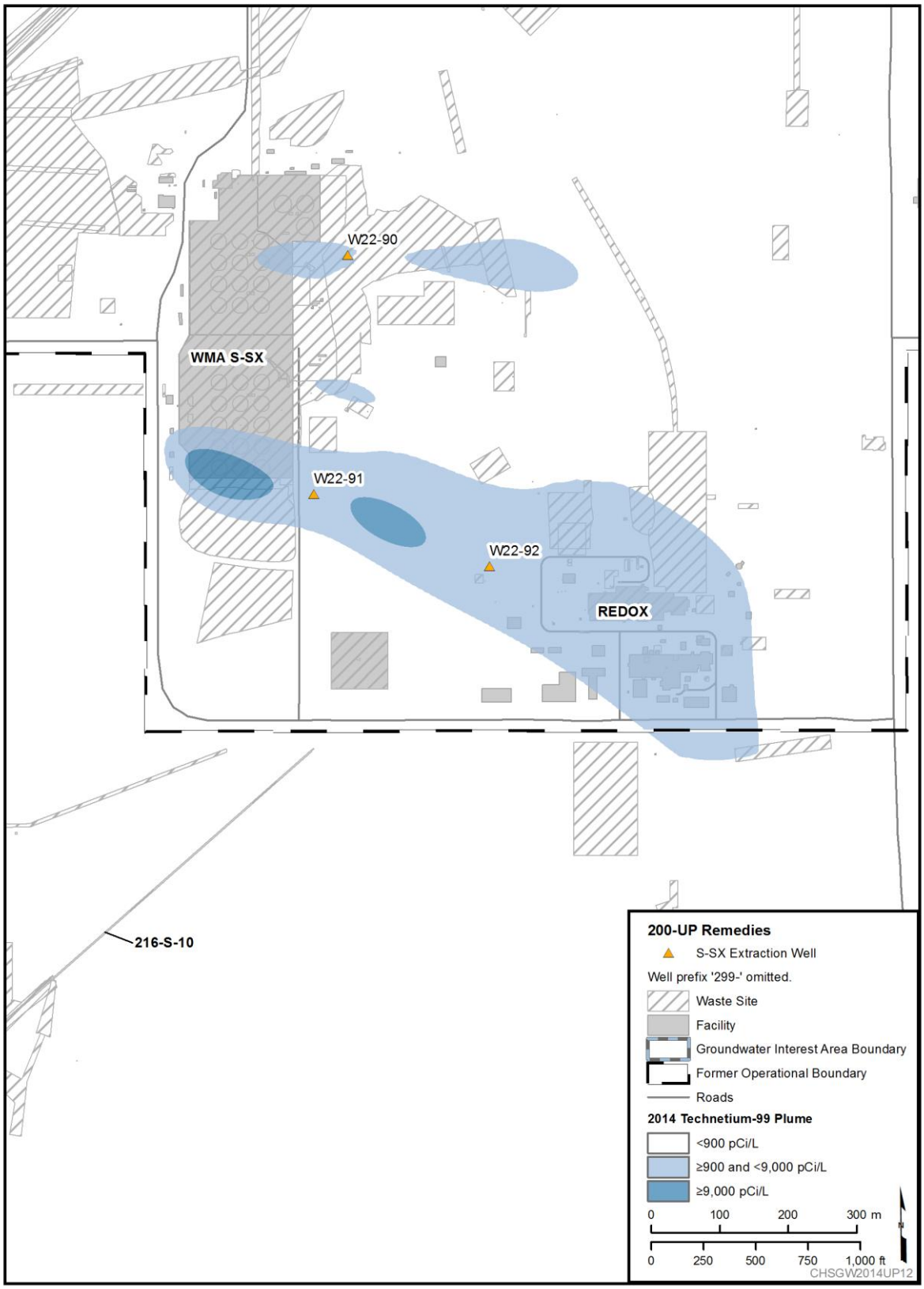

Figure 11-29. 200-UP Remedy Locations

Table 11-3. S-SX Tank Farms Groundwater Extraction System Summary

Parameter	2014	Since Startup
Total groundwater processed, millions of L	165.7	327.3
Mass of chromium removed, kg	10.2	28.1
Mass of nitrate removed, kg	6,720	16,280
Mass (activity) of technetium-99 removed, g (Ci)	37.2 (0.631)	98.0 (1.66)
Mass of carbon tetrachloride removed, kg	129	250
System availability during 2014	>90%	N/A

The system was specifically designed to capture the high-concentration portions of the technetium-99 plume. As shown by the hydraulic capture zones on Figure 11-30, it is expected that the extraction wells will capture almost all of the plume above 9,000 pCi/L near the sources in the S and SX Tank Farms. Previous analyses indicated that the capture zone at Well 299-W22-90 was substantially larger than the width of the technetium-99 plume. During 2014, the flow rate in this well was reduced from an average of 86 L/min (23 gpm) to 62 L/min (16 gpm) resulting in the smaller capture zone shown in Figure 11-30. The flow rate in Well 299-W22-92, where the technetium-99 plume has a larger width, was increased from 90 L/min (24 gpm) to 128 L/min (34 gpm) to increase the mass recovery at this location.

As expected, concentrations of chromium, nitrate, and technetium-99 in the extraction wells have exhibited generally declining trends since pumping began (Figures 11-31, 11-32, and 11-33). The declines are a combination of the removal of contaminant mass/activity from the aquifer and the growth of the capture zones either into portions of the plumes with different concentrations or outside of the plumes entirely (vertically and laterally). The chromium concentration at Well 299-W22-91 was below the 48 µg/L cleanup level during the April and July 2014 sample events but increased to above the cleanup level by October (Figure 11-29). By the end of the year, nitrate concentrations were below the 45 mg/L cleanup level in all three extraction wells. Concentrations of carbon tetrachloride are variable. Extraction Well 299-W22-90 has a generally increasing trend, but the other extraction wells show a slightly declining trend (Figure 11-34). The slow concentration change in these wells is consistent with the widespread occurrence of this constituent in the aquifer.

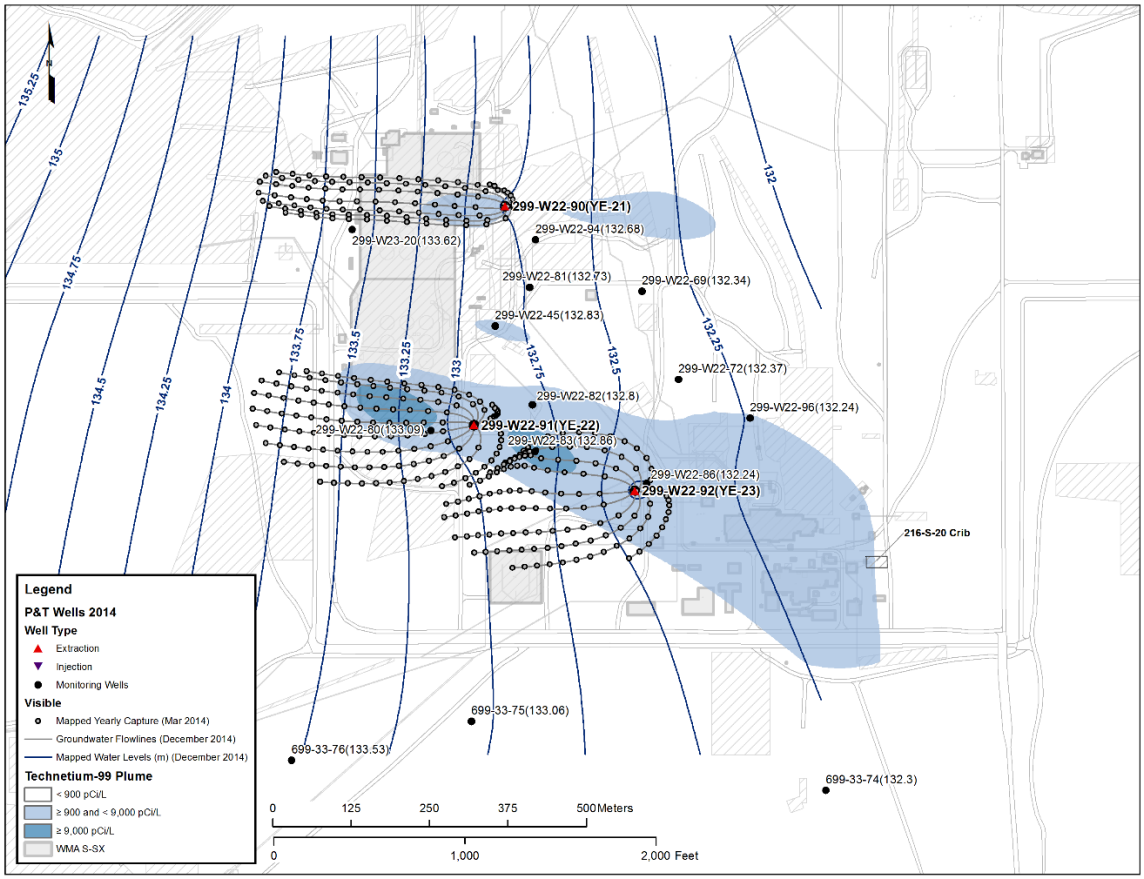

Figure 11-30. 200-UP Groundwater Capture Zones at WMA S-SX

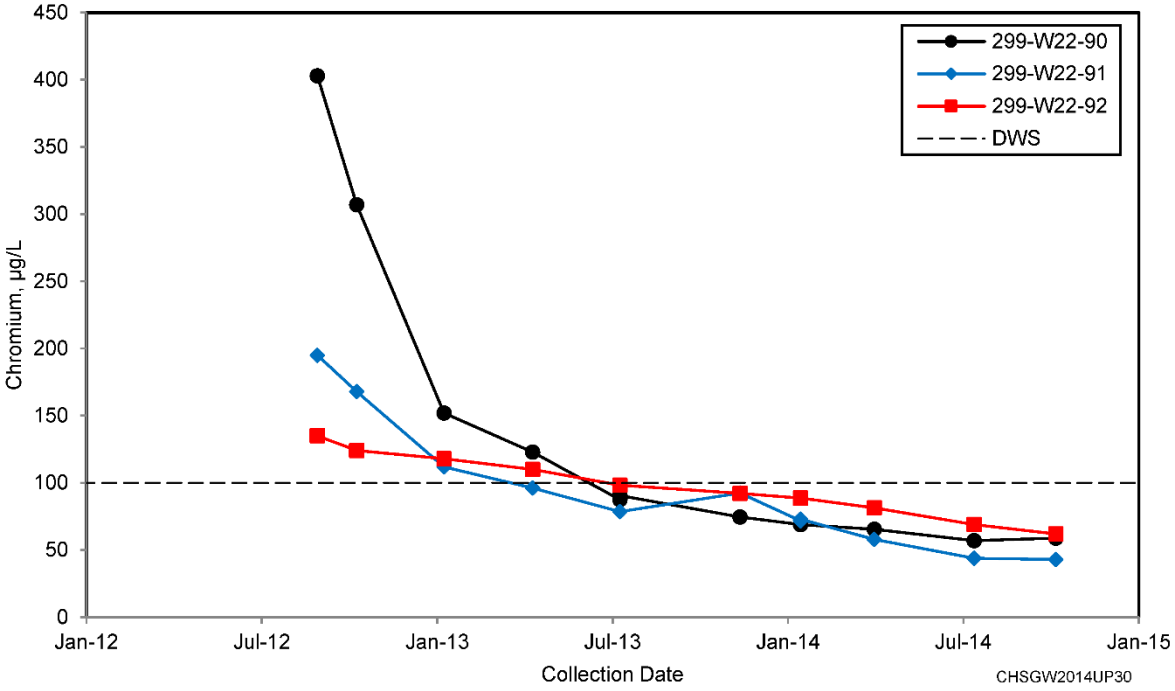

Figure 11-31. 200-UP Chromium Data for WMA S-SX Extraction Wells

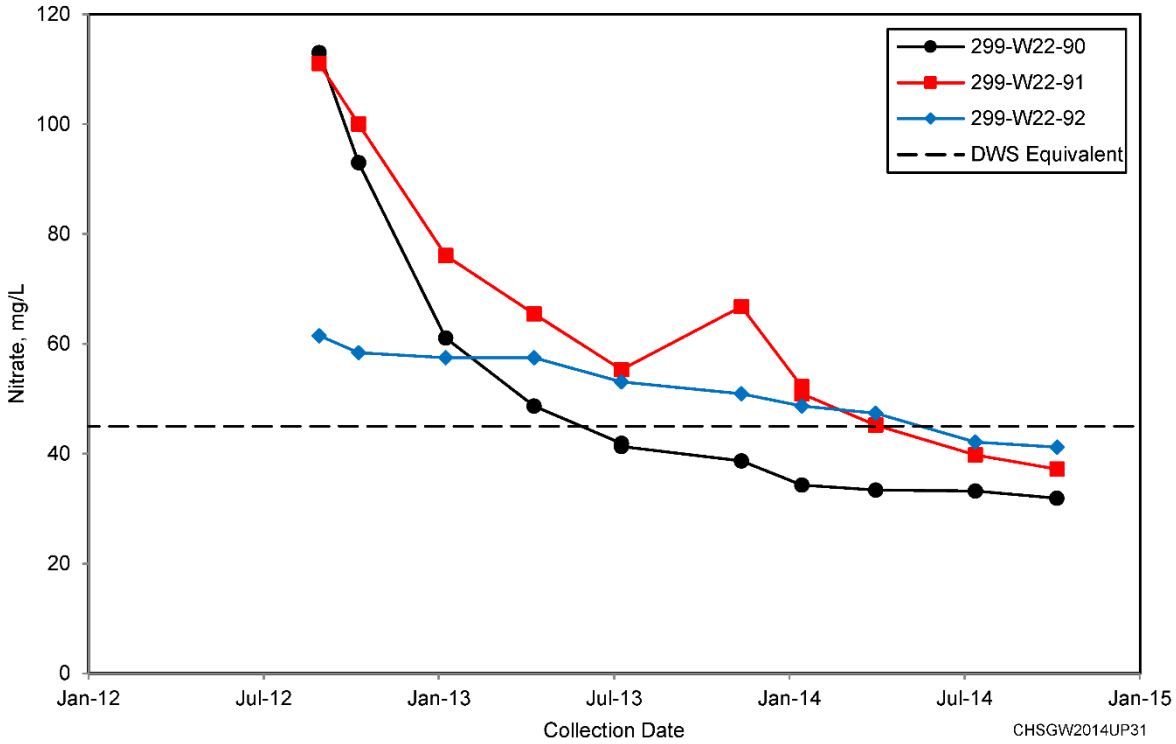

Figure 11-32. 200-UP Nitrate Data for WMA S-SX Extraction Wells

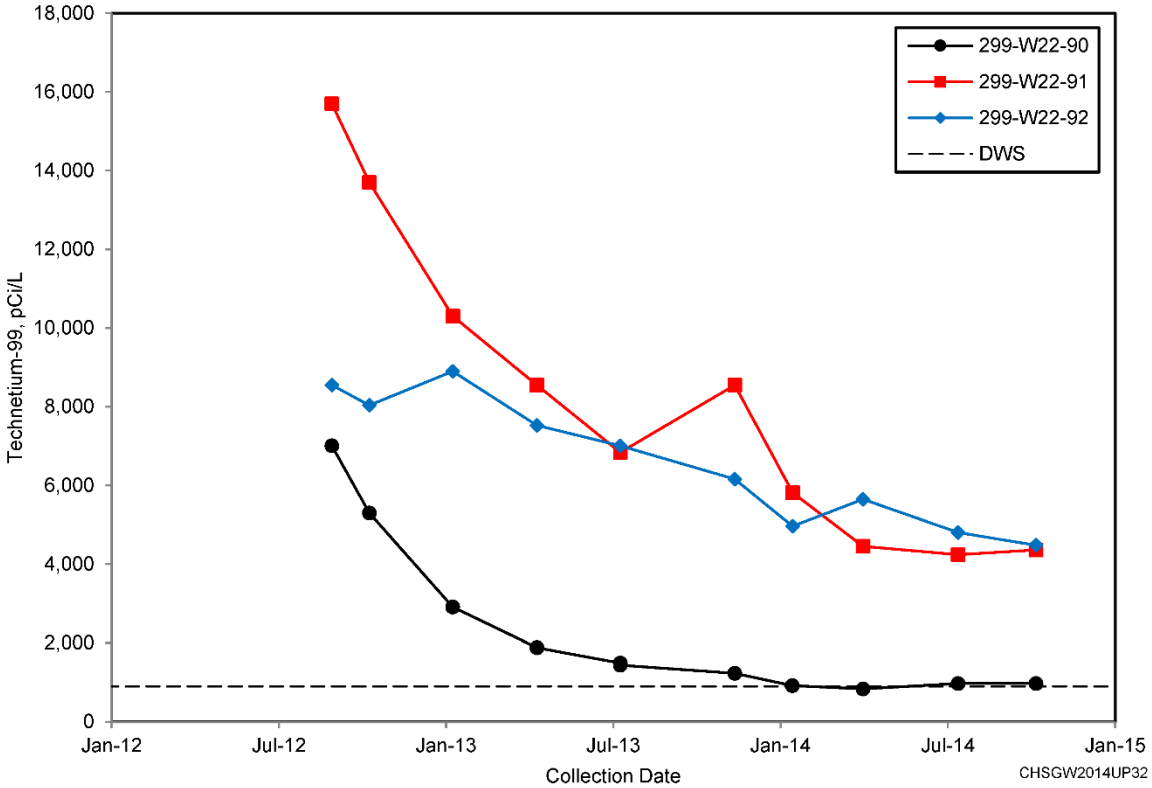

Figure 11-33. 200-UP Technetium-99 Data for WMA S-SX Extraction Wells

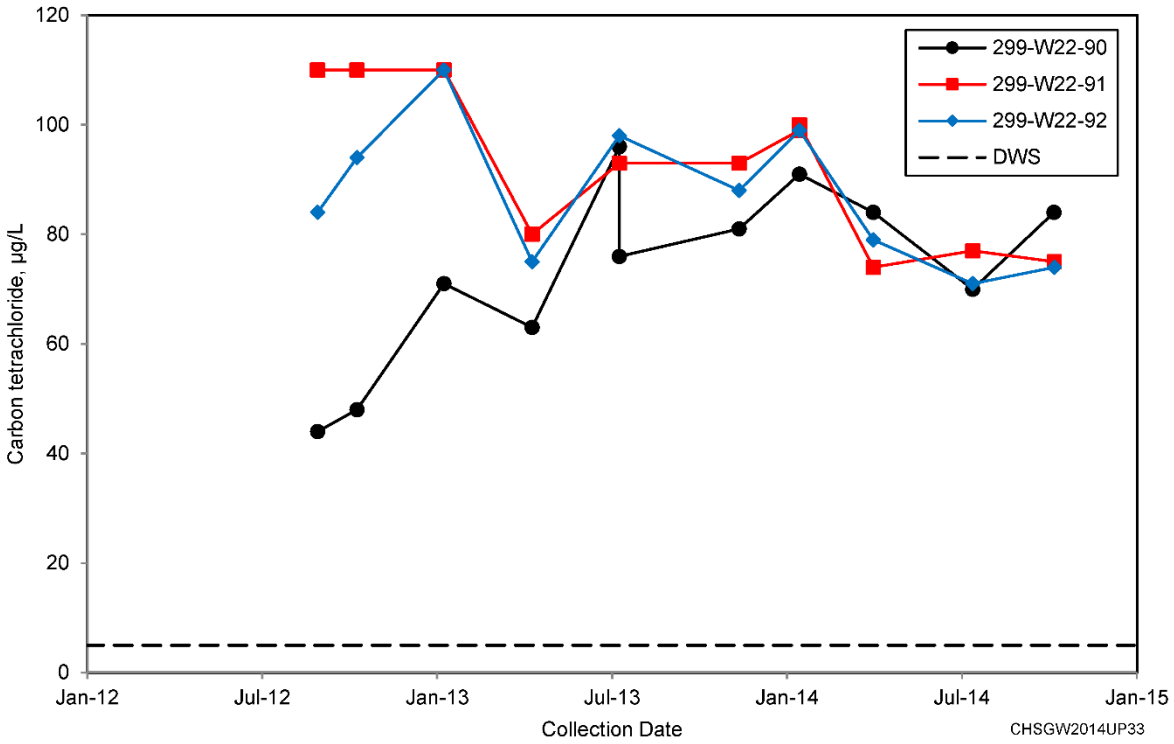

Figure 11-34. 200-UP Carbon Tetrachloride Data for WMA S-SX Extraction Wells

The groundwater extraction system has reduced the chromium, nitrate, and technetium-99 concentrations in many of the network monitoring wells. Considering those wells that had baseline concentrations above a cleanup level, chromium concentrations have declined in 3 of 6 wells, nitrate concentrations have declined in 7 of 11 wells, and technetium-99 concentrations have declined in 5 of 8 wells. The largest percentage declines have occurred in Well 299-W22-47 located south of extraction Well 299-W22-91. The chromium concentration in this well declined to 5.48 µg/L, a 97 percent reduction from the baseline of 183 µg/L. Nitrate has declined by 89 percent from 99.4 to 11.2 mg/L, and technetium-99 has declined by 99 percent from 15,000 to 139 pCi/L (Figure 11-35). During 2014, chromium and nitrate declined to below their cleanup levels in Well 299-W22-86, and nitrate declined to below its cleanup level in Well 299-W22-85.

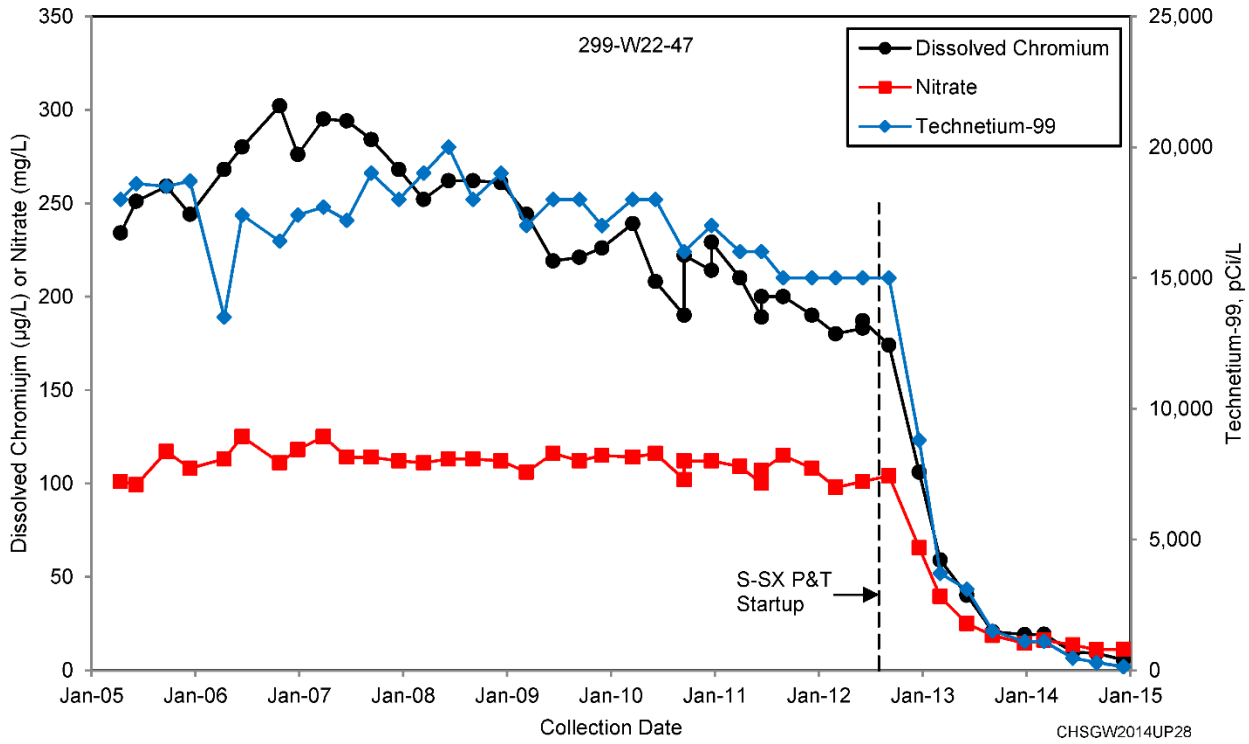

Figure 11-35. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W22-47 at WMA S-SX

11.13 RCRA Monitoring

The following sections describe the results of monitoring in accordance with RCRA regulations at three individual waste management/disposal facilities (WMA S-SX, WMA-U, and the 216-S-10 Pond and Ditch) 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 11-3.

Groundwater data are available in the HEIS database, which is available at: https://ehs.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/).

11.13.1 Waste Management Area S-SX

WMA S-SX consists of the S Tank Farm and the SX Tank Farm. The S Tank Farm contains 12 tanks, each with a capacity of 2.9 million L (758,000 gal). The SX Tank Farm contains 15 tanks, each with a capacity of 3.8 million L (1,000,000 gal) (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 11-36.

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-77 in Appendix B provides a list of the wells and constituents monitored for WMA S-SX. All required sampling was performed successfully during 2014, with the following exceptions:

- No attempts were made to sample Well 299-W22-44 during 2014 because this well became dry during June 2013. A location for a replacement well has been staked in the field, but the well has been a low priority for drilling because samples continue to be collected quarterly from the adjacent extraction well, 299-W22-90. Drilling of the replacement well is planned for 2015.
- Well 299-W22-50 was sampled successfully in March, but was found to be dry during June. Drilling of a replacement well has been a low priority because samples continue to be collected quarterly from the adjacent extraction well, 299-W22-91. Drilling of the replacement well is planned for 2015.
- Well 299-W22-113 is a replacement well completed late in 2014. It replaced Well 299-W22-49, which is nearly dry. Well 299-W22-49 was scheduled for sampling in June and December. It was removed from the sample schedule, and Well 299-W22-113 was added to the schedule in its place for the December sampling. No sampling event at this location was missed, but the December sampling of Well 299-W22-113 was delayed until early January 2015 for installation of the sample pump.
- The December sampling of Well 299-W22-95 was delayed until early January 2015 due to maintenance being performed on the well cap.

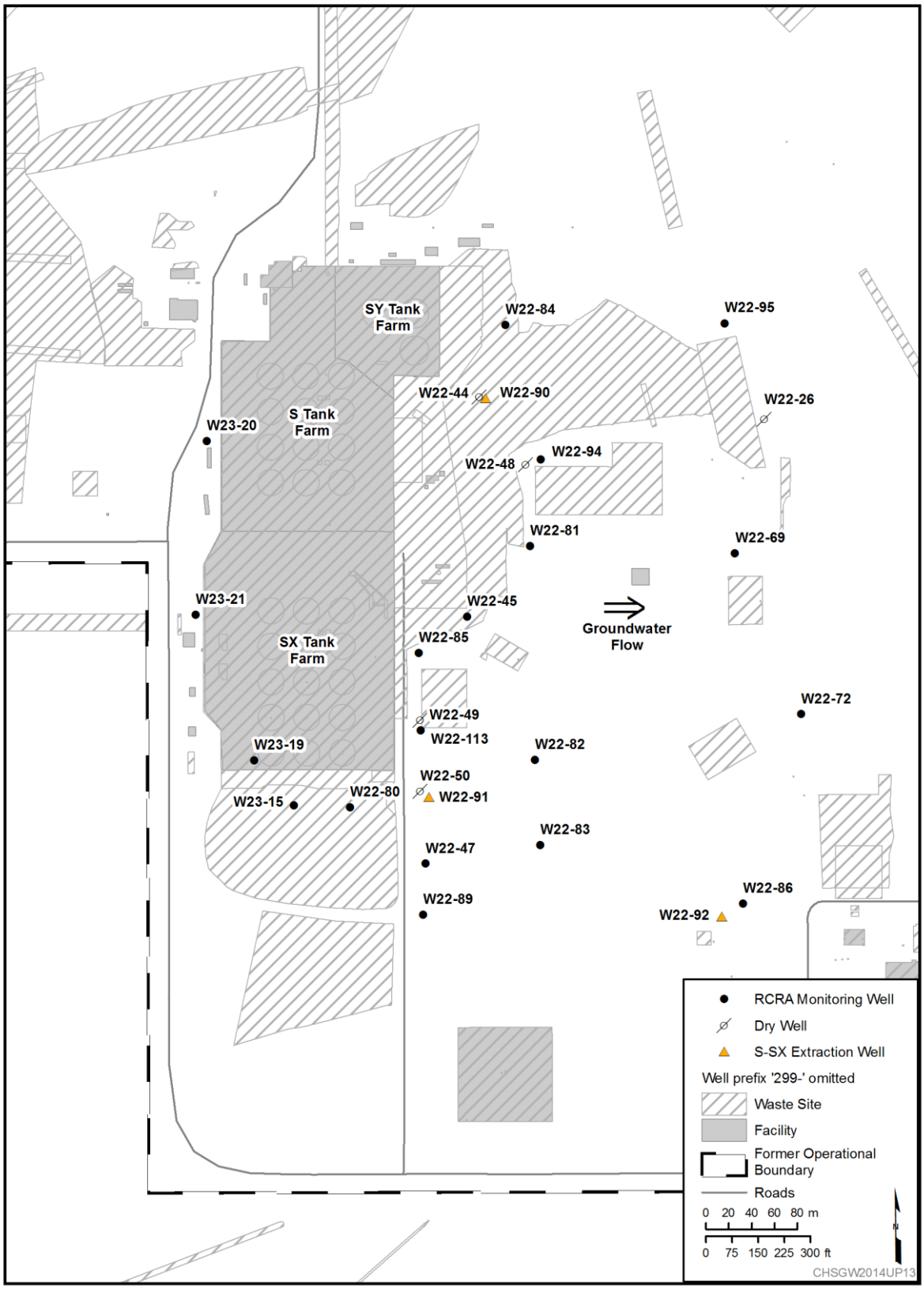

Figure 11-36. 200-UP RCRA Facility WMA S-SX Monitoring Well Locations

11.13.1.1 Water-Level and Well Network Evaluation

The water table elevation declined an average of 0.49 m (1.61 ft) in the monitoring wells between March 2013 and March 2014. This is larger than the long-term rate of decline between 2007 and 2011 of 0.25 m/yr (0.82 ft/yr). The larger decline is caused by the WMA S-SX groundwater extraction system, which began operating in 2012. Trend surface analyses were performed on four sets of water-level data collected during 2014. The average result was a hydraulic gradient of 2.8×10^{-3} m/m due east (90 degrees azimuth) and the groundwater flow rate (i.e., average linear velocity) ranged from 0.018 to 0.44 m/d (0.059 to 1.44 ft/d), depending on the hydraulic conductivity and effective porosity selected. Using values of 6.1 m/d (20 ft/d) 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 0.14 m/d (0.46 ft/d). This is slightly higher than the average for 2013 of 0.016 to 0.39 m/d (0.053 to 1.3 ft/d), with a best value of 0.12 m/d (0.39 ft/d). The higher average flow velocity for 2014 is caused by further drawdown of the water table near the extraction wells and the resulting increase in the average hydraulic gradient (for comparison, the average hydraulic gradient magnitude for 2013 was 2.4×10^{-3} m/m).

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 2015.

11.13.1.2 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 overfill event of 91,000 L (24,000 gal) 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 L (51,000 gal) leak from Tank SX-115 during 1965 in the SX Tank Farm (Section 4.3 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 0.14 m/d (0.46 ft/d). The extent of the nitrate plume is shown on Figure 11-19 and the chromium plume extent is shown on Figure 11-22. Assessment data are summarized in Table B-79 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 has altered 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 2014, 10.2 kg of chromium and 6,720 kg of nitrate were removed from the aquifer.

Operation of the groundwater extraction system has caused contaminant concentrations to decline in several of the network monitoring wells. In wells that had baseline chromium concentrations above the 48 µg/L cleanup level prior to operation of the groundwater extraction system, concentrations have decreased in four wells and are unchanged in four wells. In those wells with a baseline nitrate concentration above the 45 mg/L cleanup level, the concentration has decreased in seven wells, is unchanged in three wells, and has increased in one well. The nitrate concentration is trending upward in Well 299-W22-45, changing from 96.5 mg/L in December 2013 to 105 mg/L in December 2014. At Well 299-W23-19, located inside the SX Tank Farm, the chromium concentration declined from 484 µg/L in December 2013 to 413 µg/L in December 2014 (Figure 11-6). Nitrate also declined in this well from 168 mg/L in December 2013 to 122 mg/L in December 2014. This well has the maximum nitrate and chromium concentrations at the WMA because it is located in the source area. Both the chromium and nitrate concentrations declined to below their respective cleanup levels in Well 299-W22-86 (Figure 11-37) located near extraction Well 299-W22-92.

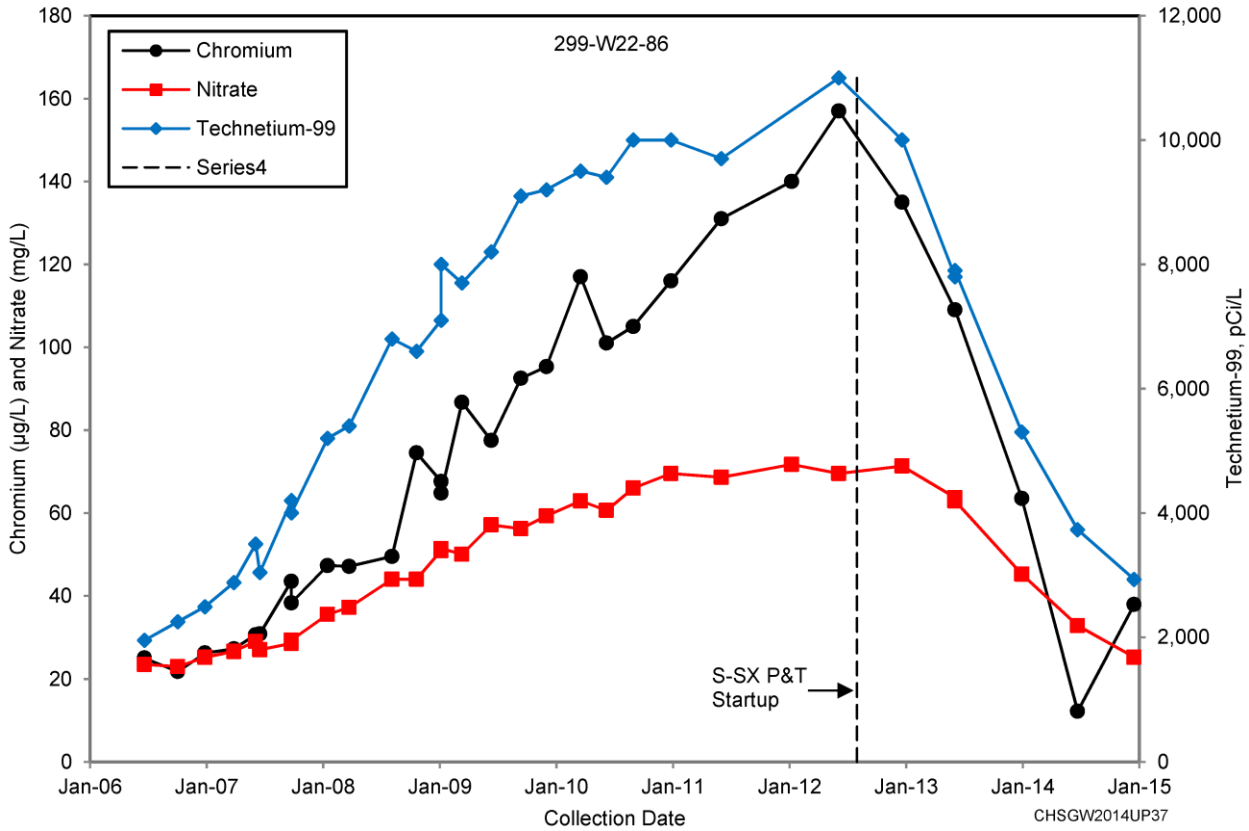

Figure 11-37. 200-UP Chromium, Nitrate, and Technetium-99 Concentrations in Well 299-W22-86 Downgradient from WMA S-SX

11.13.2 Waste Management Area 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 L (535,000 gal) and four have capacities of 210,000 L (55,000 gal) (Section 1.2 of RP-35485, *Field Investigation Report for Waste Management Area U*). 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 11-38.

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, *A History of the 200 Area Tank Farms*). 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 L (535,000 gal) 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.

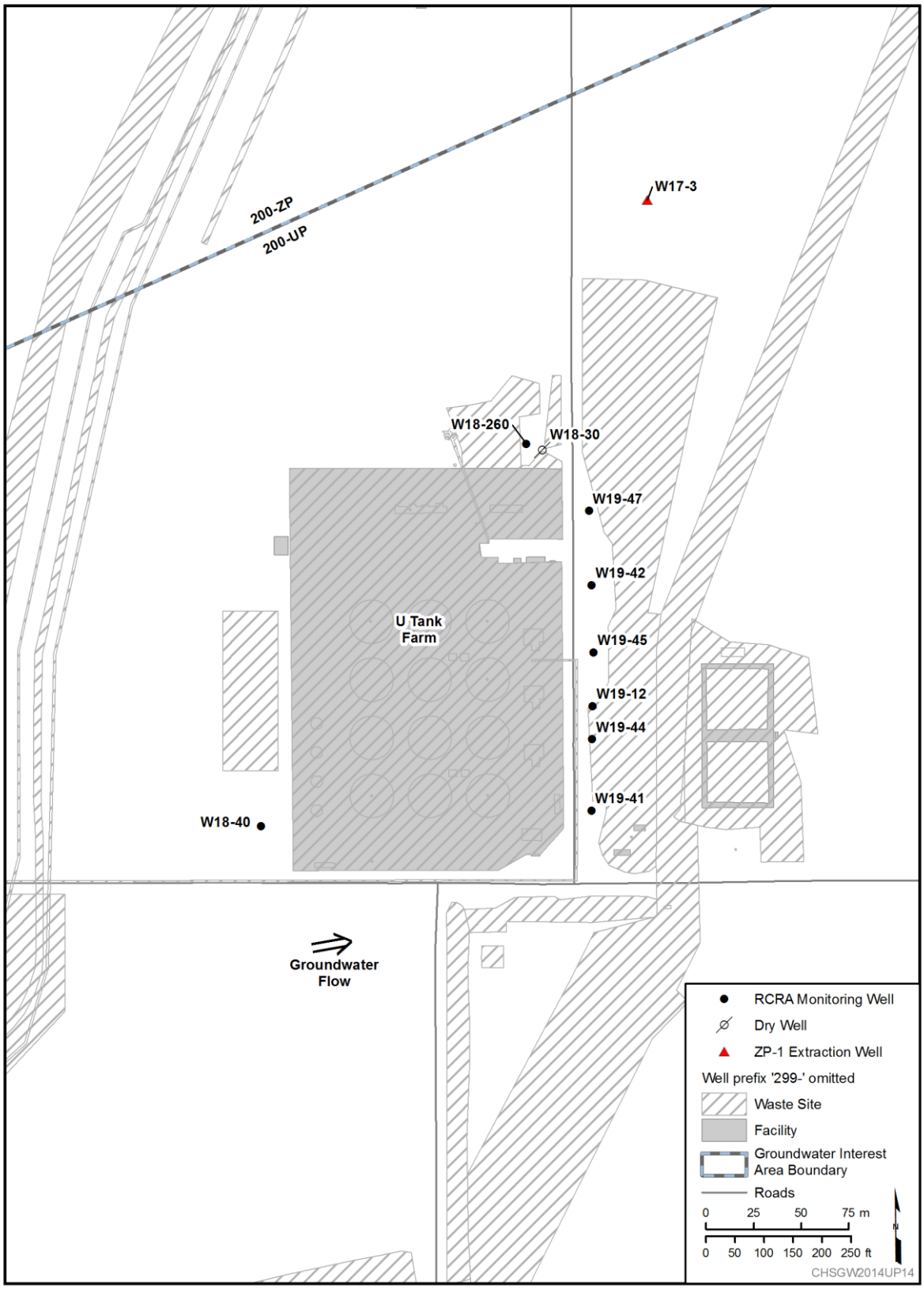

Figure 11-38. 200-UP RCRA Facility WMA U Monitoring Well Locations

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. 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 RPP-35485 for a discussion of vadose zone conditions beneath the WMA, and see the 200-UP technetium-99 section of this report for a discussion of the technetium-99 plume. Table B-86 of Appendix B provides a list of wells and constituents monitored for WMA U. Well 299-W18-30 became dry during 2013, so it was not sampled during 2014. A replacement well, 299-W18-260, was drilled during 2014 and will be sampled beginning in 2015. All other required sampling was performed successfully during 2014.

11.13.2.1 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 five sets of water-level measurements at WMA U during 2014, and the average hydraulic gradient magnitude was 4.1×10^{-3} m/m, an increase from the average of 3.6×10^{-3} m/m during 2013. An extraction well, 299-W17-3, is located 150 m (490 ft) north-northeast of the WMA (Figure 11-38). 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 was expected to turn toward the northeast. However, the average direction during 2014 was similar to previous years: east-northeast at 82 degrees azimuth.

The average hydraulic gradient for 2014, 4.1×10^{-3} m/m, was used to estimate the flow rate beneath the WMA. The groundwater flow rate (i.e., average linear velocity) ranged from 0.035 to 0.39 m/d (0.11 to 1.3 ft/d), depending on the hydraulic conductivity and effective porosity selected. Using values believed to be most representative, 6.12 m/d (20.1 ft/d) for the hydraulic conductivity and 0.17 for the effective porosity from a constant rate pumping test conducted in Well 299-W19-42 (Section 7.4 of PNNL-13378), the groundwater flow rate most representative for this site is 0.15 m/d (0.49 ft/d). This is an increase from the estimated best value of 0.13 m/d (0.43 ft/d) for 2013.

Water levels in the monitoring wells declined an average of 0.54 m (1.77 ft) between March 2013 and March 2014. This is larger than the long-term average decline of 0.27 m (0.89 ft) between 2006 and 2011. The larger decline is due to drawdown associated with the 200 West P&T system, particularly operation of nearby extraction Well 299-W17-3 (which is operated for the 200-ZP-1 groundwater remedy).

Based on the distribution of wells at the WMA and the groundwater flow direction, DOE believes the well network is currently capable of monitoring the distribution of contamination from the WMA. Table B-87 in Appendix B summarizes water-level data for WMA U. The WMA U will remain in interim status groundwater quality assessment monitoring for 2015.

11.13.2.2 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-88 in Appendix B). During 2014, chromium was detected in several downgradient wells at concentrations ranging from 5.2 to 21 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-1. 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 divalent iron minerals in the sediment. The iron then reacts with the soluble hexavalent chromium, reducing it to trivalent chromium, 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 2014, 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 2014 nitrate sample result was 102 mg/L in Well 299-W19-45 during July.

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 0.15 m/d (0.49 ft/d).

Water samples were collected during drilling of replacement monitoring Well 299-W18-260. The results showed that the contamination is present in the upper part of the aquifer (Table 11-2; Figure 11-12). Nitrate concentrations were above the 45 mg/L cleanup level at the uppermost two sample depths (3 and 8.4 m [10 and 28 ft] below the water table), and were below the cleanup level at the deeper sample depths. The maximum concentration was 57.1 mg/L at 3 m (10 ft) below the water table.

11.13.3 216-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 m (3.9 ft) wide at its base and 686 m (2,250 ft) long, connected to a pond covering 0.02 km^2 (0.008 mi^2). 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 L (1.7 billion gal) of effluent from the REDOX Plant chemical sewer. Monitoring wells are shown in Figure 11-39.

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 m (164 ft) below the water table (299-W27-2). Table B-35 of Appendix B includes a list of wells and constituents sampled for the 216-S-10 unit.

During 2014, all groundwater samples required by the monitoring plan (DOE/RL-2008-61) were collected as scheduled.

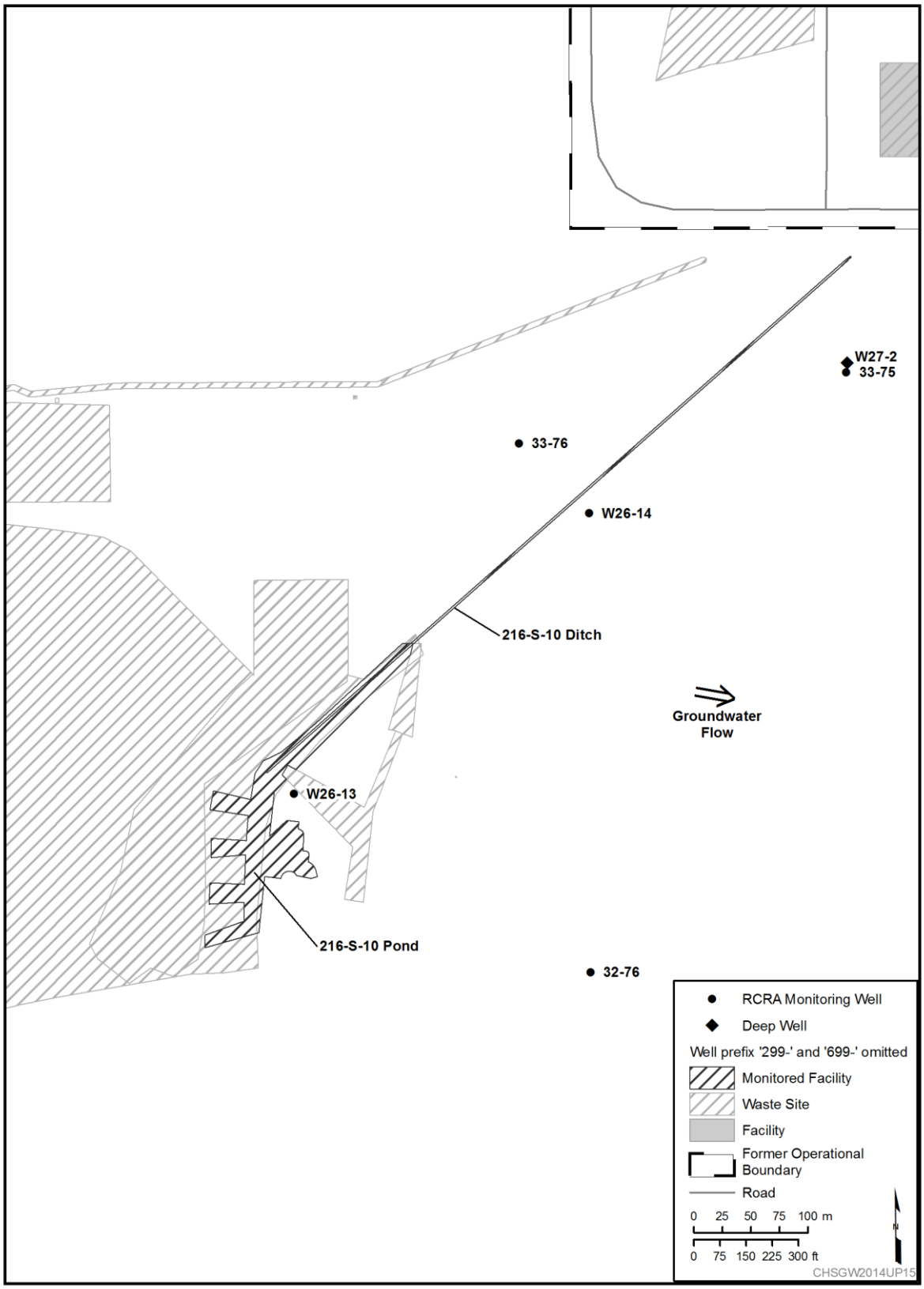

Figure 11-39. 200-UP RCRA Facility 216-S-10 Monitoring Well Locations

11.13.3.1 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 2014 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 (104 degrees azimuth) with a hydraulic gradient magnitude of 2.9×10^{-3} m/m. Using a hydraulic conductivity range of 2 to 42.7 m/d (7 to 140 ft/d) (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 0.029 to 1.2 m/d (0.095 to 3.9 ft/d). Using a best hydraulic conductivity value of 10.4 m/d (34.1 ft/d) (constant rate discharge test at Well 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 0.20 m/d (0.66 ft/d). Water levels in the network wells have been declining at a long term average rate of 0.23 m/yr (0.75 ft/yr) from 2010 to 2014.

Based on the calculated groundwater flow direction, DOE believes the monitoring well network remains capable of detecting constituents migrating from the 216-S-10 unit into the uppermost aquifer. Table B-37 in Appendix B summarizes water-level data for 2014.

11.13.3.2 Sampling Results

No exceedances of an indicator parameter critical mean occurred during 2014. Specific conductance is near the critical mean (363 µS/cm) in downgradient Well 699-32-76 (average value of 331 µS/cm during 2014), but the trend declined slightly during 2014 (Figure 11-40). Between 2007 and 2012, specific conductance generally trended upward in Well 299-W26-13 from annual average values of 270 to 310 µS/cm (Figure 11-40). The increasing trend correlated to increasing chromium and nitrate concentrations (Figure 11-24). From 2012 through 2014, specific conductance has been relatively stable, consistent with the nitrate trends. However, the chromium concentration has continued to increase and is above the 100 µg/L total chromium DWS (average value of 122 µg/L in November 2014). 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 plume. Table B-38 in Appendix B summarizes 2014 water quality parameters.

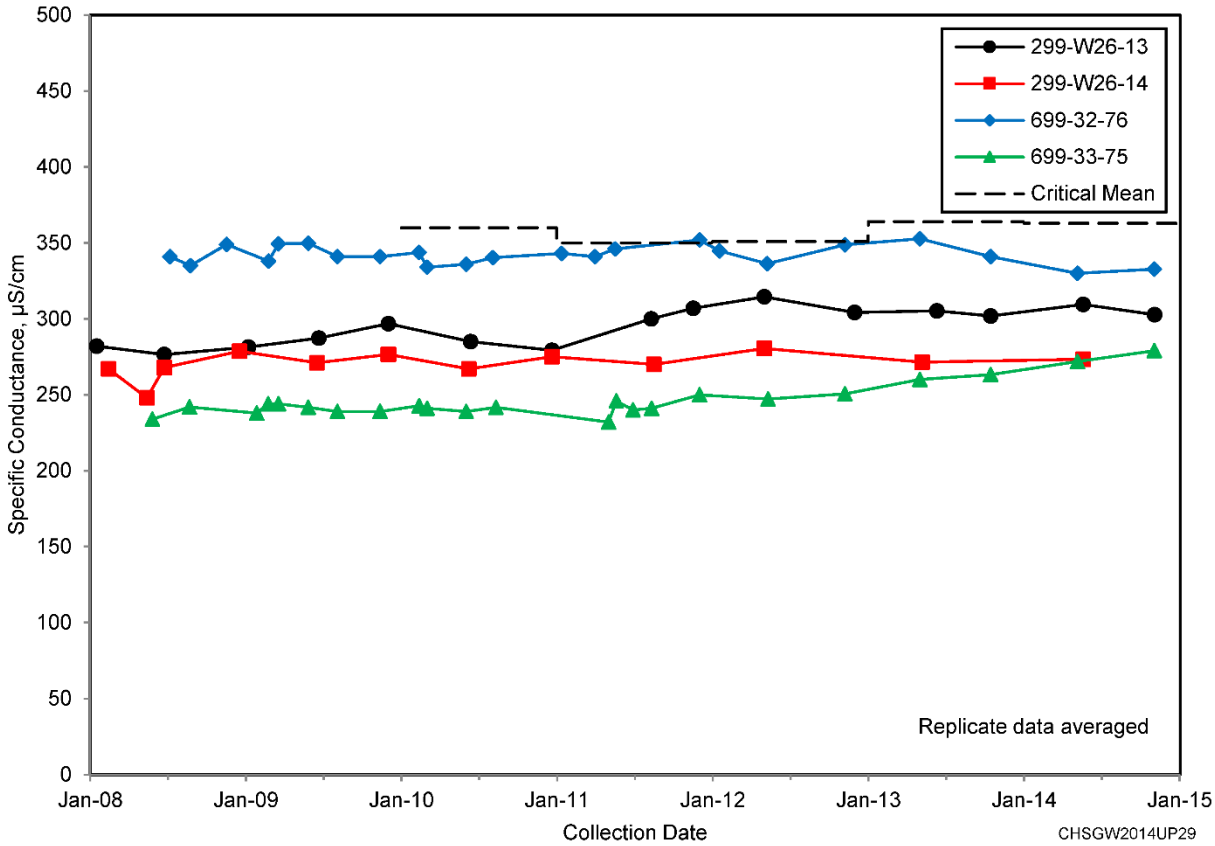

Figure 11-40. 200-UP Specific Conductance Data for Monitoring Wells at 216-S-10

Elevated levels of total organic halides formerly were detected in downgradient Well 699-33-75, but concentrations were near or below detection limits in 2014, far below the critical mean (49.82 µg/L). The average concentration was 4.7 µg/L during 2014, a decline from an average of 7.7 µg/L during 2013. Elevated total organic halides in this well was 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 7.2 µg/L during 2014. This is above the 3.4 µg/L cleanup level. Concentrations of carbon tetrachloride and total organic halides are trending downward in Well 699-33-75. Carbon tetrachloride is also detected in upgradient Well 699-33-76 (3.7 µg/L in 2014). 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.

Concentrations of chromium (unfiltered), iron (unfiltered), and nickel (filtered and unfiltered) continue to be elevated in Well 299-W27-2, which is screened 50 m (164 ft) 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 observed by a downhole camera survey confirming that the source of the elevated metals is corrosion.