DOE/RL-2017-66
Revision 0

Hanford Site Groundwater Monitoring Report for 2017

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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APPROVED
By Julia Raymer at 1:43 pm, Aug 30, 2018

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Executive Summary

Chemical and radioactive wastes contaminated the soil and groundwater beneath portions of the U.S. Department of Energy (DOE) Hanford Site. Figure ES-1 shows the location and extent of the iodine-129, nitrate, and tritium contaminant plumes in the Hanford Site groundwater interest areas. The majority of the contamination is found in the 200 East Area, 200 West Area, 300 Area, and 100 Area. Note that wells outside mapped contour levels are not necessarily free of contamination, and the contaminant plumes may be more extensive at lower concentrations. Maps in the main body of this report show all of the data, whether above or below contour levels.

DOE operates an extensive groundwater monitoring program on the Hanford Site. Groundwater is monitored for *Resource Conservation and Recovery Act of 1976* (RCRA)[1] units; for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)[2] groundwater operable units; for other Washington State-required programs; and for the *Atomic Energy Act of 1954* (AEA),[3] as required by DOE orders. Tritium, iodine-129, and nitrate comprise the largest contaminant plumes in Hanford Site groundwater. Figure ES-1 shows the extent of these plumes in 2017, and Figure ES-2 shows how the sizes of the three largest plumes have changed over the years.

River Corridor

The 100 and 300 Areas comprise the River Corridor of the Hanford Site. About 94% of the waste sites in this region have been remediated or were determined not to require remediation, reducing the possibility of continued contaminant migration to groundwater. Remedial action decisions for the remaining 6% of the waste sites are in progress. Groundwater in this region migrates slowly through the aquifer and into the Columbia River. Figure ES-3 illustrates River Corridor contaminant plumes in 2017, and Table ES-1 compares the maximum concentration measured in 2017 and 2016 for the contaminants in each of the River Corridor groundwater interest areas.

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[1] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Pub. L. 94-580, 90 Stat. 2795. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

[2] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: https://www.csu.edu/cerc/researchreports/documents/CERCLASummary1980.pdf.

[3] *Atomic Energy Act of 1954*, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919, as amended. Available at: https://science.energy.gov/~/media/bes/pdf/nureg_0980_v1_no7_june2005.pdf.

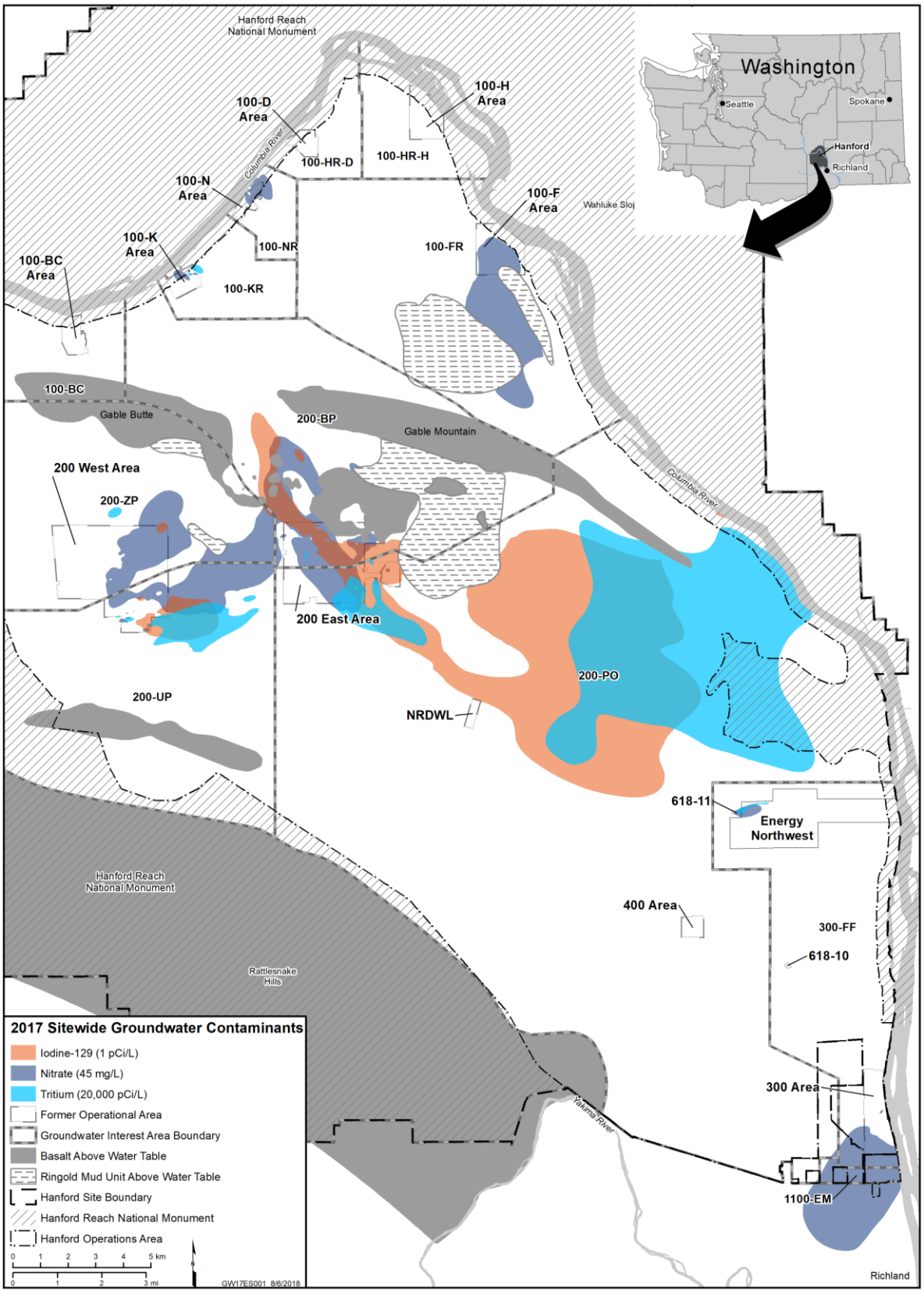

Figure ES-1. Major Groundwater Contaminant Plumes and Regions of the Hanford Site

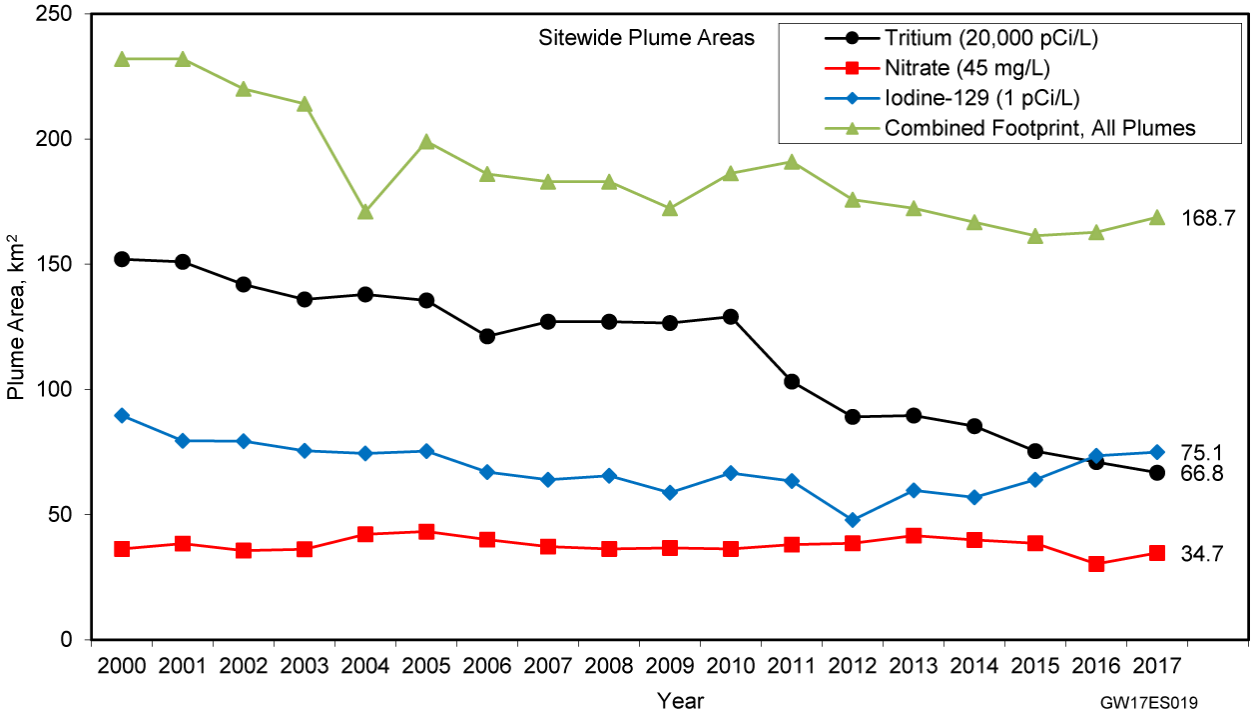

Figure ES-2. Hanford Site Plume Areas

River Corridor groundwater is being remediated under various CERCLA decision documents (Table ES-2). The size of the Cr(VI) and nitrate plumes have decreased markedly since 2002 due to groundwater remediation and natural attenuation (Figure ES-4). Other contaminants are attenuating naturally or as a result of influences from pump-and-treat (P&T) systems. Decreases in the sizes of the tritium and trichloroethene (TCE) plumes are evident in Figure ES-4, whereas the uranium and strontium-90 plumes are attenuating more slowly.

Maximum concentrations of hexavalent chromium (Cr(VI)), nitrate, and TCE in the River Corridor have decreased over time (Figure ES-5). The detected maximum concentrations of some other contaminants increased in recent years because new wells were intentionally installed in areas near suspected contaminant sources. Data from these characterization wells are used to develop and select alternatives for remediation.

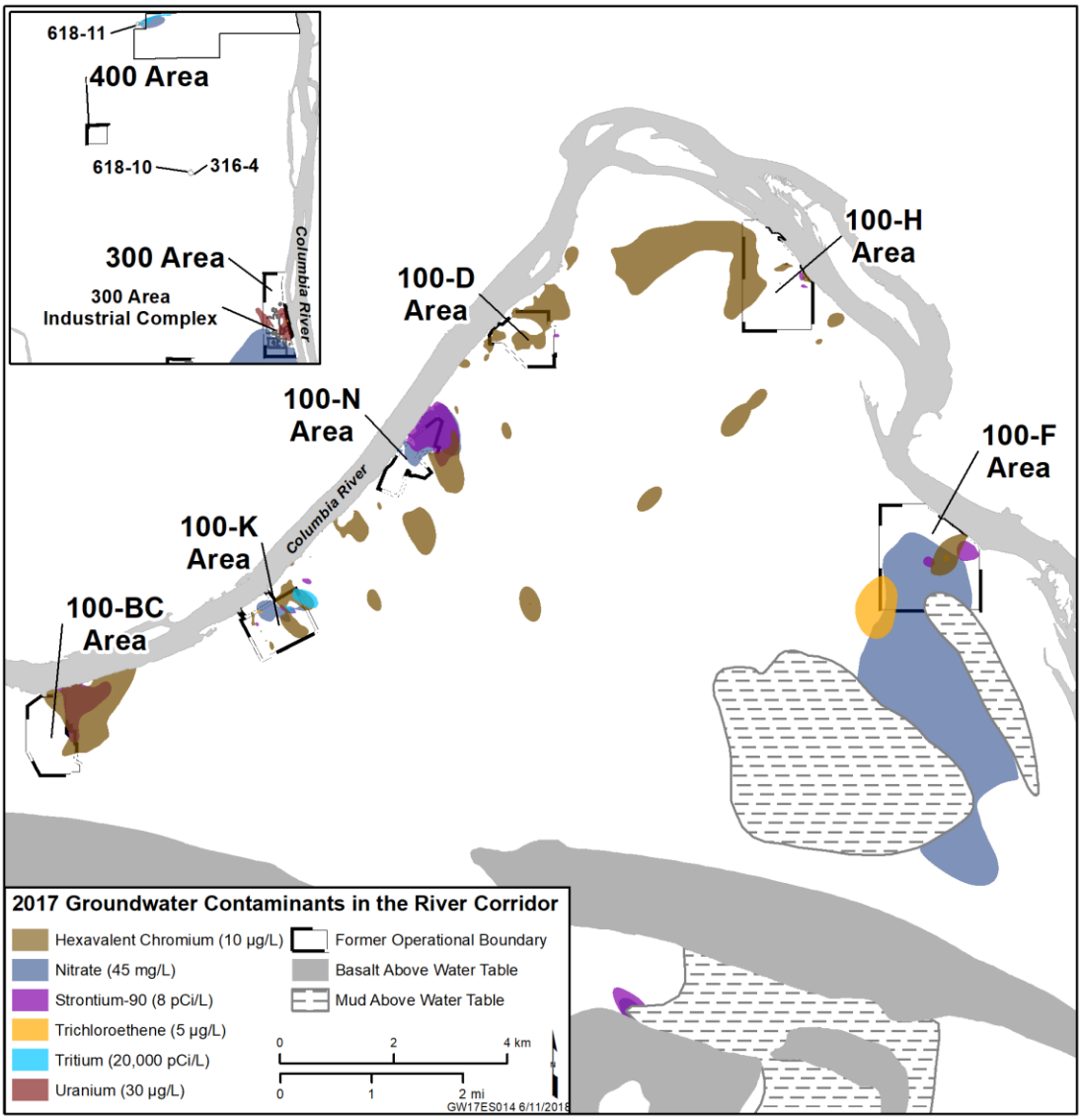

Figure ES-3. Groundwater Contaminant Plumes in the River Corridor

DOE has established derived concentration standards for use in conducting radiological environmental protection programs. The standards represent the concentration of a given radionuclide in water or air that would result in a person receiving a 100 mrem total effective dose following continuous exposure for one year. Figure ES-6 illustrates the total effective dose that would occur if a person consumed River Corridor groundwater for one year. The dose in wells with values greater than 100 mrem/yr is primarily from strontium-90 in the 100-K and 100-N Areas.

Table ES-1. River Corridor Groundwater Contaminants, 2016 and 2017

Ground-water Interest Area	Maximum Concentrations							
	Year	C-14 (pCi/L)	Cr(VI) (µg/L)	Nitrate (mg/L)	Sr-90 (pCi/L)	TCE (µg/L)	Tritium (pCi/L)	Uranium (µg/L)
100-BC	2017	N	50	21.9	43.6	5.49	11,900	5.4
	2016	N	58	19.9	49.7	6.69	15,600	5.5
100-FR	2017	N	42	342	120	13	3030	14
	2016	N	70	124	126	15	3,300	12.5
100-HR	2017	N	730	217	27.8	N	9440	142
	2016	N	640	66.4	30.1	N	10,600	50
100-KR	2017	28,500	840	115	15,600	8.1	3,810,000	13.8
	2016	40,100	360	75.3	164	9.48	730,000	27
100-NR	2017	325	130	319	14,200	0.3	282,000	8.9
	2016	357	117	443	12,600	0.18	373,000	9.45
300-FF	2017	N	10	186	N	1.99	570,000	5,460
	2016	N	12.5	181	N	2.09	799,000	1,180
1100-EM	2017	N	N	150[a]	N	N	N	34.5[a]
	2016	N	N	155[a]	N	0.47	N	40.9[a]
Standard[b]		2,000	10	45	8	5	20,000	30
Half-life		5,730 yr	N/A	N/A	28.8 yr	N/A	12 yr	>159,000 yr
Mobility		High	High to moderate	High	Slight	Moderate	High	Moderate

Colors and listed values indicate maximum concentration, as follows:

- ≥Standard and <10 × standard
- ≥10 × standard and <100 × standard
- ≥100 × standard and <1,000 × standard
- ≥1,000 × standard

a. Originate from offsite sources.

b. Drinking water standards for all but Cr(VI) (aquatic standard).

Cr(VI) = hexavalent chromium
MNA = monitored natural attenuation
N = not detected or not analyzed
N/A = not applicable
TCE = trichloroethene

Table ES-2. Summary of CERCLA Groundwater Remediation in the River Corridor

Groundwater Operable Unit	CERCLA Decision Status	Groundwater Contaminants of (Potential) Concern*	Current Groundwater Remediation	Mass Removed
100-BC-5	Draft A RI/FS report and proposed plan released 2017	Cr(VI), strontium-90, TCE, tritium	No interim action required; final action pending	Not applicable
100-FR-3	ROD for final action signed 2014	Cr(VI), nitrate strontium-90, TCE	Monitored natural attenuation	Not applicable
100-HR-3	Interim ROD; RI/FS and proposed plan completed; ROD in progress	Cr(VI), total chromium, nitrate, strontium-90, tritium	Interim action P&T for Cr(VI) 1997-2017; interim action permeable reactive barrier emplaced but no longer maintained	2017: 56.3 kg Total: 2,460 kg
100-KR-4	Interim ROD; Draft A RI/FS report in revision	Cr(VI), total chromium, carbon-14, nitrate, strontium-90, TCE, tritium	Interim action P&T for Cr(VI) 1997-2017	2017: 36.7 kg Total: 904 kg
100-NR-2	Draft B RI/FS report in progress	Strontium-90, TPH-D, nitrate, Cr(VI), total chromium, tritium	Interim action permeable reactive barrier for strontium-90; removal of TPH-D	Strontium-90: not applicable TPH-D: 1.5 kg in 2017; 17 kg total
300-FF-5	ROD for final action signed 2013	Uranium, gross alpha, *cis*-1,2-dichloroethene, TCE, nitrate, tritium	Enhanced attenuation for uranium; monitored natural attenuation for others	Not applicable
1100-EM-1	ROD signed 1993	TCE	No longer required; remedial action objectives achieved	Not applicable

*Contaminants of concern are listed for operable units with RODs for final action. The primary contaminants of potential concern are listed for the other operable units.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Cr(VI) = hexavalent chromium
P&T = pump and treat
RI/FS = remedial investigation/feasibility study
ROD = Record of Decision
TCE = trichloroethene
TPH-D = total petroleum hydrocarbons-diesel range

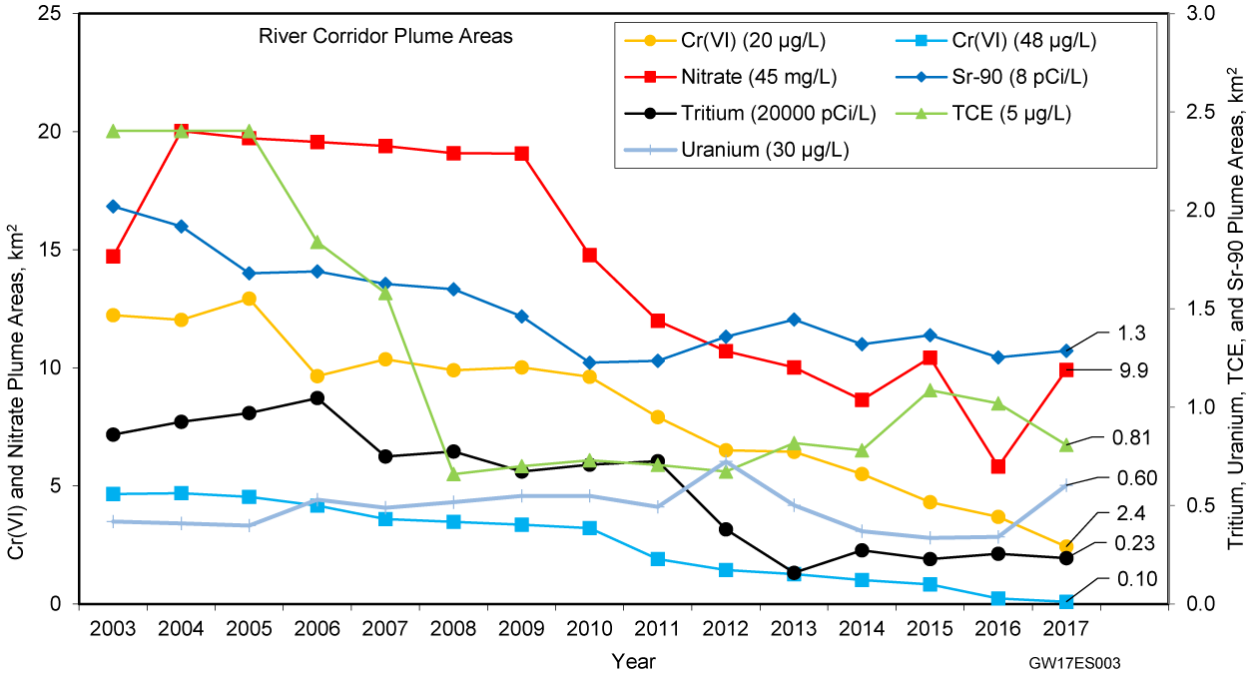

Figure ES-4. River Corridor Plume Areas

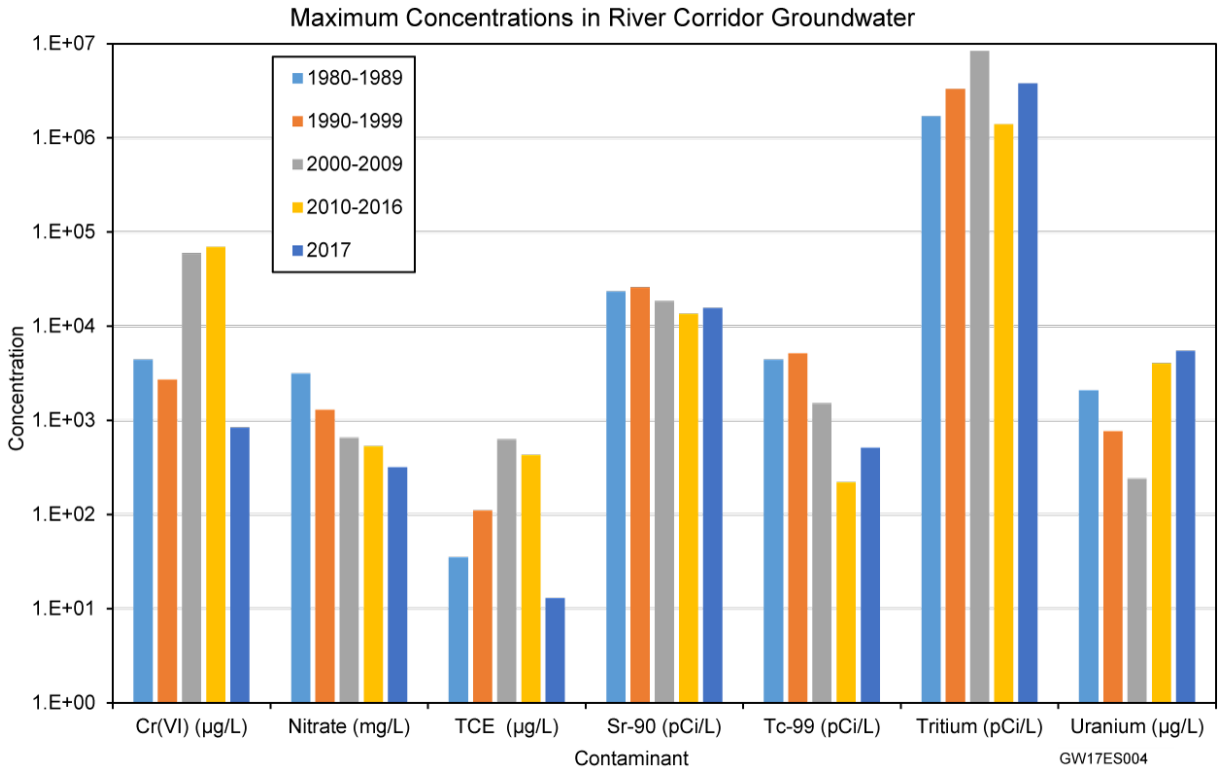

Figure ES-5. Maximum Concentrations of River Corridor Contaminants over Time

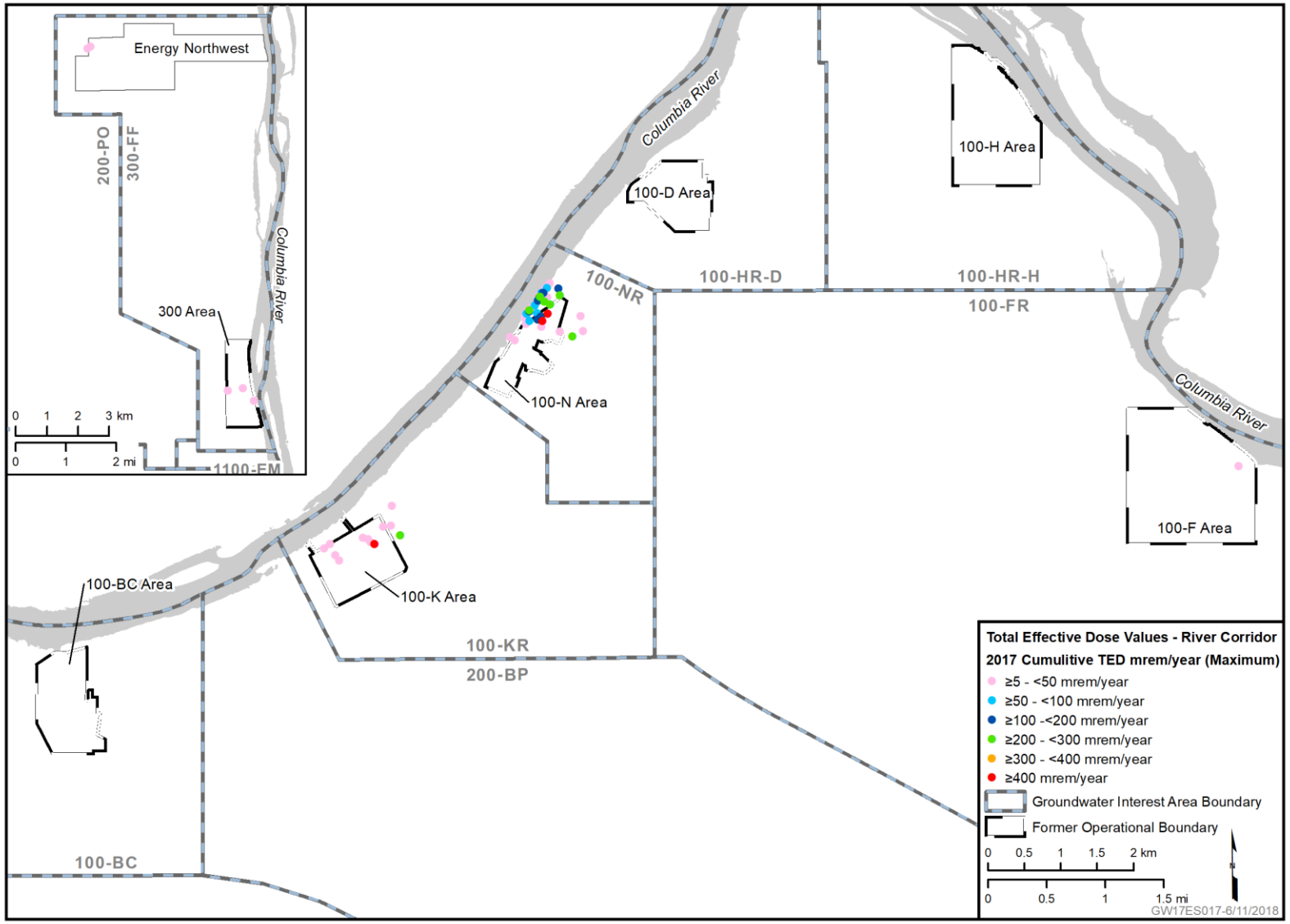

Figure ES-6. Groundwater Dose Calculation for the River Corridor

The following activities or changes occurred in the River Corridor in 2017:

- **100-BC:** Cr(VI) concentrations continued to decline, and the 2017 plume area was smaller than 2016, particularly at concentrations above 20 µg/L.
- **100-FR:** Nitrate concentrations increased to 342 mg/L in a well in the central 100-F Area, which is the highest ever observed in 100-FR groundwater. Nitrate concentrations also increased in two wells in the southern part of the interest area, causing the plume interpretation to change. The causes of the increases are not yet known. The concentrations of other contaminants declined in 2017.
- **100-HR:**
  - The Cr(VI) plumes in the 100-D Area continued to shrink in 2017 due to groundwater remediation, and concentrations declined. Concentrations of Cr(VI) and uranium increased temporarily in a small region in 100-H Area wells during a period of high water levels in 2017.
  - In the 100-H Area, DOE installed three extraction wells screened in the unconfined aquifer and three wells to characterize and remediate the Ringold Formation upper mud unit semiconfined aquifer. Hydraulic testing concluded that the aquifer and the overlying unconfined aquifer are connected through a leaky confining layer, and there is some connection to the Columbia River. High levels of Cr(VI), technetium-99, and nitrate were identified in one of the new Ringold upper mud unit wells.
- **100-KR:**
  - DOE installed four new wells for monitoring and potential groundwater extraction. One depth-discrete groundwater characterization sample from one of the wells had a tritium concentration of 3.8 million pCi/L, much higher than other results in recent years. Concentrations were much lower in other characterization samples and in samples from the completed well.

  - In 2017, DOE completed a one-year rebound study at the K West P&T. During the rebound period, concentrations of Cr(VI) and other contaminants increased in wells near the former contaminant sources, indicating residual contamination in the vadose zone. The P&T restarted in April 2017, and concentrations in groundwater declined.

- **100-NR:** Concentrations of strontium-90 and total petroleum hydrocarbons increased temporarily in some wells during a period of high river stage in 2017. Plume areas did not change significantly between 2016 and 2017.

- **300-FF:**
  - DOE installed 48 injection wells and 19 monitoring wells to support Stage B of the uranium sequestration remedy, which is planned for 2018.
  - Uranium concentrations increased in some 300 Area wells, and the interpreted plume area increased between 2016 and 2017.

- **RCRA:** Ecology approved modifications to the Hanford RCRA Permit,[4] adding a clean closure option for the 1301-N and 1325-N Liquid Waste Disposal Facilities (100-NR), and revising groundwater monitoring requirements for the 183-H Solar Evaporation Basins (100-HR) and the 300 Area Process Trenches (300-FF).

- **New wells:** Table ES-3 lists wells installed or decommissioned in the River Corridor in 2017.

[4] WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology. Available at: https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html.

Table ES-3. Summary of River Corridor Wells or Boreholes Drilled or Decommissioned in 2017

Groundwater Interest Area	Wells or Instrument Boreholes Completed	Wells or Boreholes Decommissioned	Comment
100-BC	0	0	
100-FR	0	0	
100-HR	6	0	Pump-and-treat extraction wells.
100-KR	4	1	Dual-purpose monitoring and extraction wells installed.
100-NR	0	0	
300-FF	67	0	Uranium sequestration injection and monitoring wells.
1100-EM	0	0	
Total	**77**	**1**	

Central Plateau

The Central Plateau, located in the middle of the Hanford Site, includes the 200 West and 200 East Areas. Ponds, cribs, and ditches used for liquid waste disposal were primary sources of groundwater contamination. There are also seven single-shell tank waste management areas in the 200 Areas. Contamination is still present at some locations in the thick Central Plateau vadose zone and may continue to migrate into the groundwater. DOE is beginning to characterize and remediate these sites.

Figure ES-7 shows the Central Plateau groundwater contaminant plumes in 2017, and Table ES-4 compares the maximum contaminant concentrations measured in 2017 and 2016 in the Central Plateau groundwater interest areas.

Groundwater beneath portions of the Central Plateau is being remediated under CERCLA decision documents. Table ES-5 summarizes the status of CERCLA remediation for Central Plateau groundwater and deep vadose zone operable units. P&T systems continued to remove carbon tetrachloride, nitrate, technetium-99, uranium, and other contaminants from groundwater in 2017.

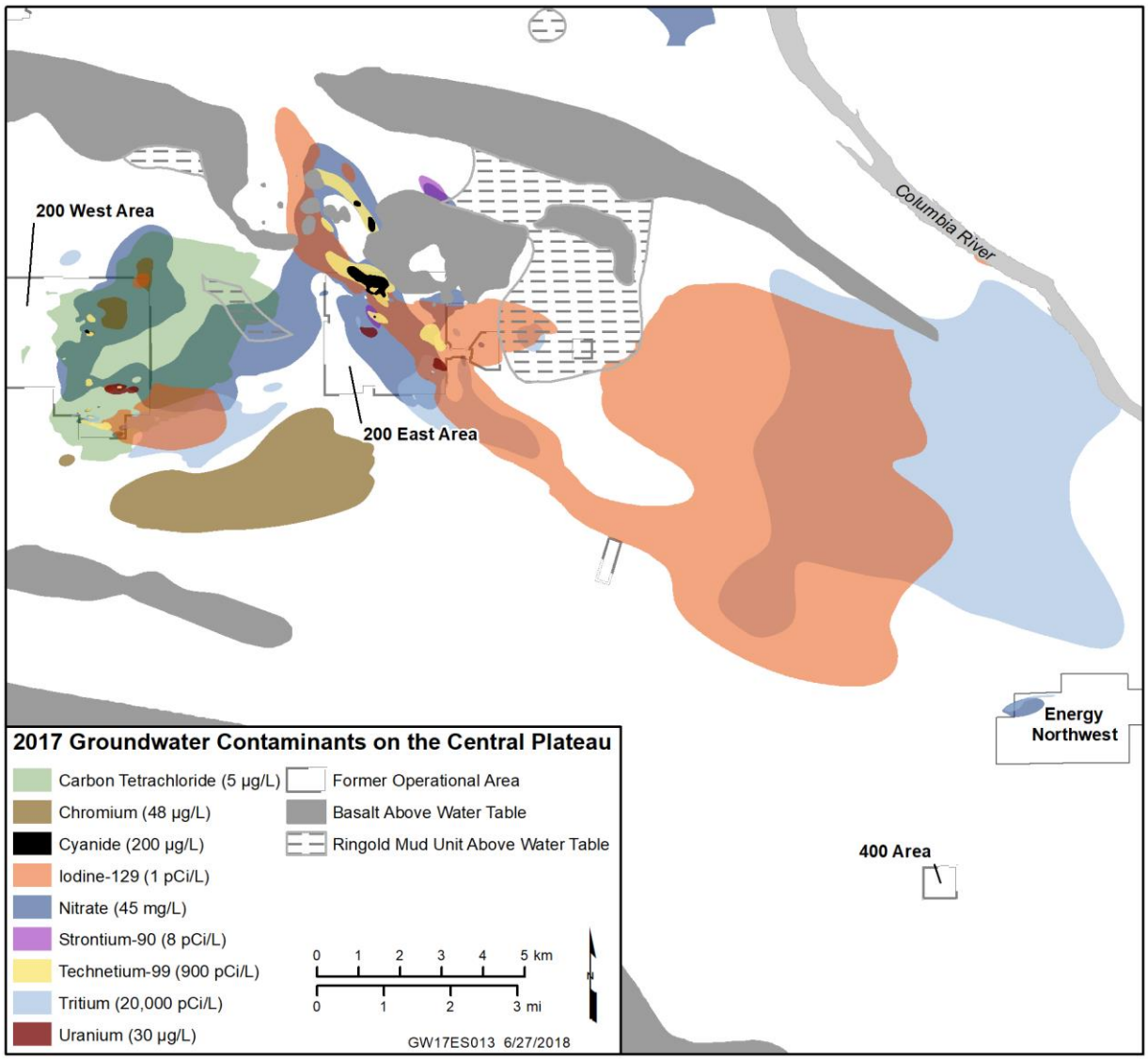

Figure ES-7. Groundwater Contaminant Plumes in the Central Plateau

The size of the Central Plateau tritium plume continued to decline in 2017 due to natural attenuation, which includes radioactive decay (Figure ES-8). The size of the carbon tetrachloride plume appears to have increased in recent years, partly due to better characterization (new wells) and partly due to migration of the distal lobes of the plume, which the P&T remedy is not designed to capture. The estimated extent of Cr(VI) contamination increased in 2017 because new wells were installed to characterize and monitor contamination in the southeastern part of the 200-UP interest area. The area of other Central Plateau plumes remained about the same in 2017.

Table ES-4.Central Plateau Groundwater Contaminants, 2016 and 2017

Ground-water Interest Area	Year	Maximum Concentrations							
		Carbon Tetra-chloride (µg/L)	Chromium (µg/L)	I-129 (pCi/L)	Nitrate (mg/L)	Sr-90 (pCi/L)	Tc-99 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)
200-BP	2017	N	37.5	9.67	1,590	511	36,000	53,700	2,970
	2016	N	50.2	5.27	1,510	4,470	32,700	61,400	3,790
200-PO	2017	N	110	10.9	120	13.3	5,360	133,000	61
	2016	0.17	85	8.91	146	13.7	1,950	418,000	23.9
200-UP	2017	412	224	22.8	221	19.1	13,700	218,000	5,000
	2016	801	460	20.2	531	15.3	39,000	250,000	2,400
200-ZP	2017	1,960	160	1.46	620	2.12	11,100	60,300	4.3
	2016	2,320	180	1.2	708	N	10,700	58,800	6.5
Regulatory standard		5	48	1	45	8	900	20,000	30
Half-life (years)		N/A	N/A	1.6E+07	N/A	28.8	212,000	12.3	>159,000
Mobility		Multi-phase	High to moderate	High	High	Slight	High	High	Moderate

Colors and listed values indicate maximum concentration, as follows:

- ≥ Standard and <10 × standard
- ≥10 × standard and <100 × standard
- ≥100 × standard and <1,000 × standard

N = not detected or not analyzed
N/A = not applicable

Maximum concentrations of most Central Plateau groundwater contaminants have decreased over time (Figure ES-9) due to remediation, migration, dispersion, and, in some cases, radioactive decay.

Figure ES-10 illustrates the total effective dose from hypothetical exposure of members of the public by drinking Central Plateau groundwater. Radionuclides contributing to doses greater then 100 mrem/yr include iodine-129, strontium-90, technetium-99, tritium, and uranium.

Table ES-5.Summary of CERCLA Groundwater Remediation on the Central Plateau

Operable Unit	CERCLA Decision Status	Groundwater Contaminants of (Potential) Concern[a]	Current Groundwater Remediation	Mass Removed in 2017 (and Since Startup)
200-BP-5	Implemented action memorandum (2016); submitted draft RI report (2015)	Cyanide, iodine-129, nitrate, strontium-90, technetium-99, tritium, uranium	Removal action: Groundwater extraction (2015–2017)	Cyanide: 44 kg (102 kg) Nitrate: 17,071 kg (87,261 kg) Technetium-99: 95.1 g (171 g) Uranium: 123 kg (137 kg)
200-PO-1	Submitted RI report (2012) and RI addendum (2015)	Iodine-129, tritium, nitrate, strontium-90, technetium-99, uranium	None required	Not applicable
200-UP-1	ROD for interim remedial action signed (2012)	Technetium-99, uranium, carbon tetrachloride, Cr(VI), total chromium, iodine-129, nitrate, tritium	Interim actions: P&T near U Plant (2015–2017) P&T at WMA S-SX (2012–2017) Hydraulic containment for iodine-129 (2015–2017) Monitored natural attenuation	Nitrate: 31,716 kg (179,523 kg[b]) Technetium-99: 33.8 g (351 g[b]) Uranium: 17.9 kg (937 kg[b])
200-ZP-1	ROD for final remedial action signed (2008)	Carbon tetrachloride, Cr(VI), total chromium, iodine-129, nitrate, technetium-99, trichloroethene, tritium	P&T and monitored natural attenuation	Carbon tetrachloride: 1,906 kg (26,802 kg[b]) Chromium: 89.4 kg (409 kg) Nitrate: 349,770 kg (1,524,760 kg)
200-DV-1[c]	Implemented action memorandum (2016); characterization of the deep vadose zone in progress	Nitrate, technetium-99, uranium (perched water)	Removal action: Perched water extraction (2011–2017)	Nitrate: 1,324 kg (2,102 kg) Technetium-99: 2.7 g (5.2 g) Uranium: 78 kg (157 kg)

a. Contaminants of concern are listed for operable units with RODs for final action. The primary contaminants of potential concern are listed for the other operable units.

b. Totals includes mass from P&T system under earlier RODs for interim action.

c. Deep vadose zone operable unit

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Cr(VI) = hexavalent chromium
P&T = pump and treat
RI = remedial investigation
ROD = Record of Decision
WMA = waste management area

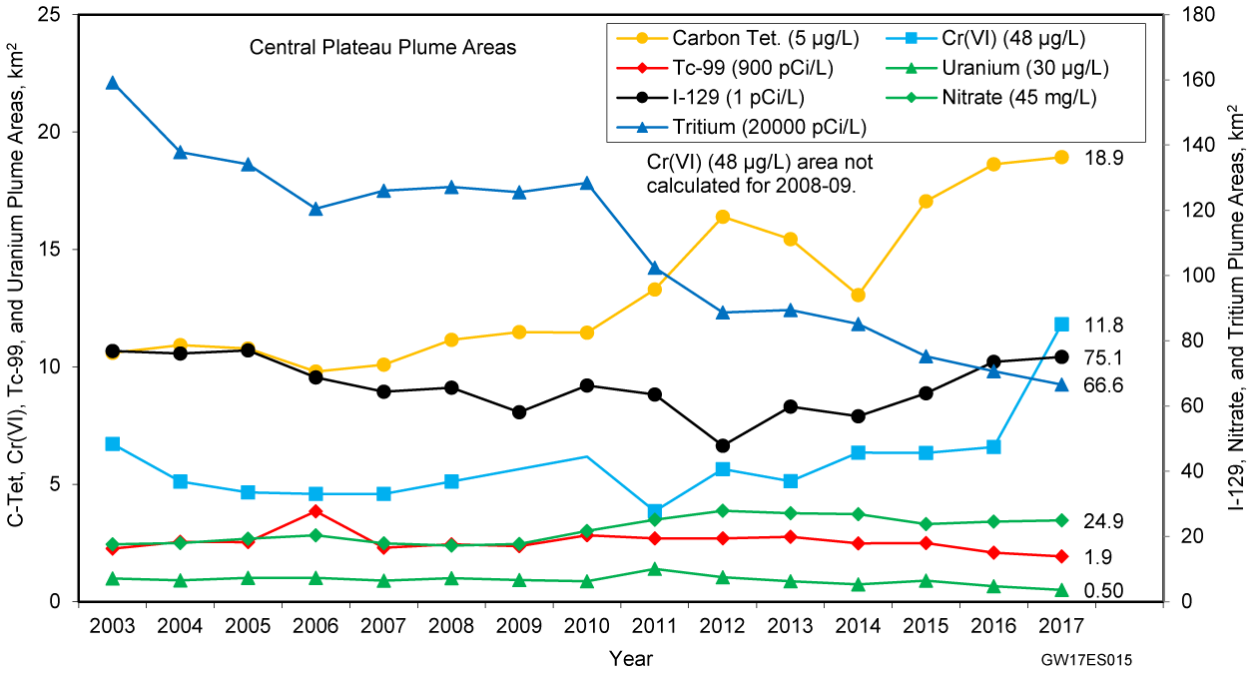

Figure ES-8. Central Plateau Plume Areas

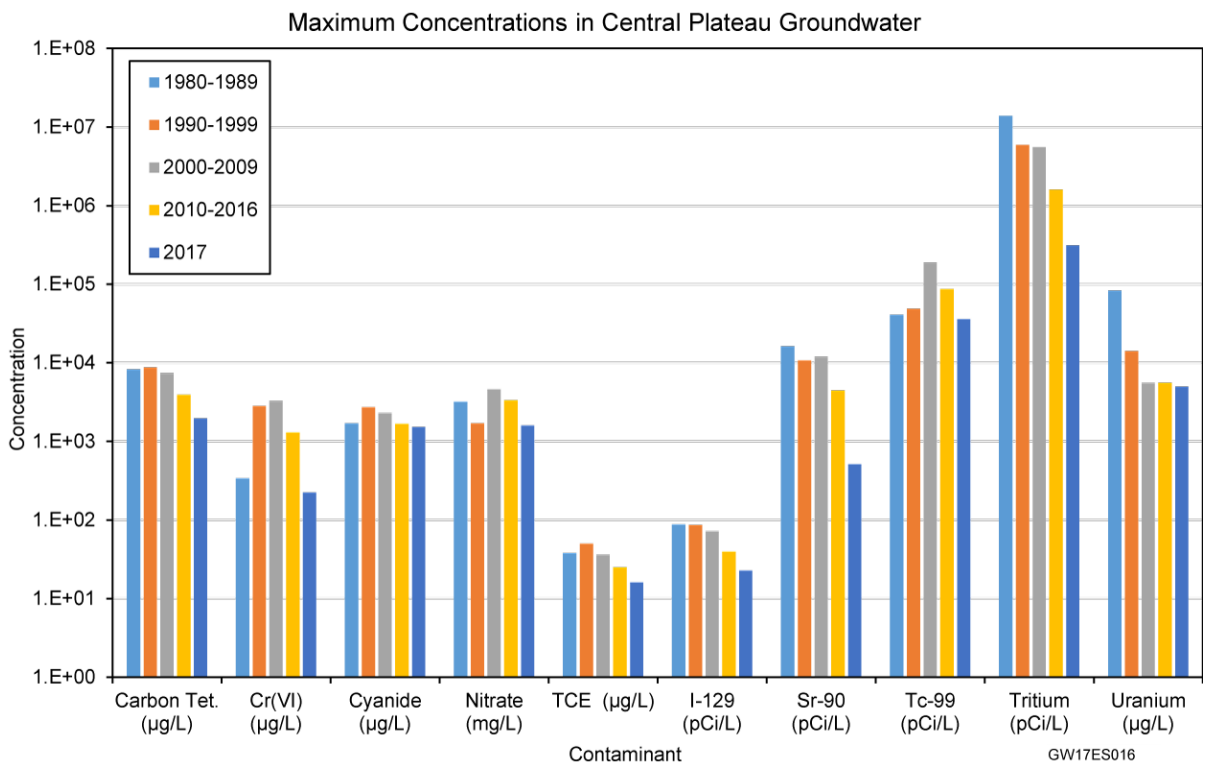

Figure ES-9. Maximum Concentrations of Central Plateau Contaminants over Time

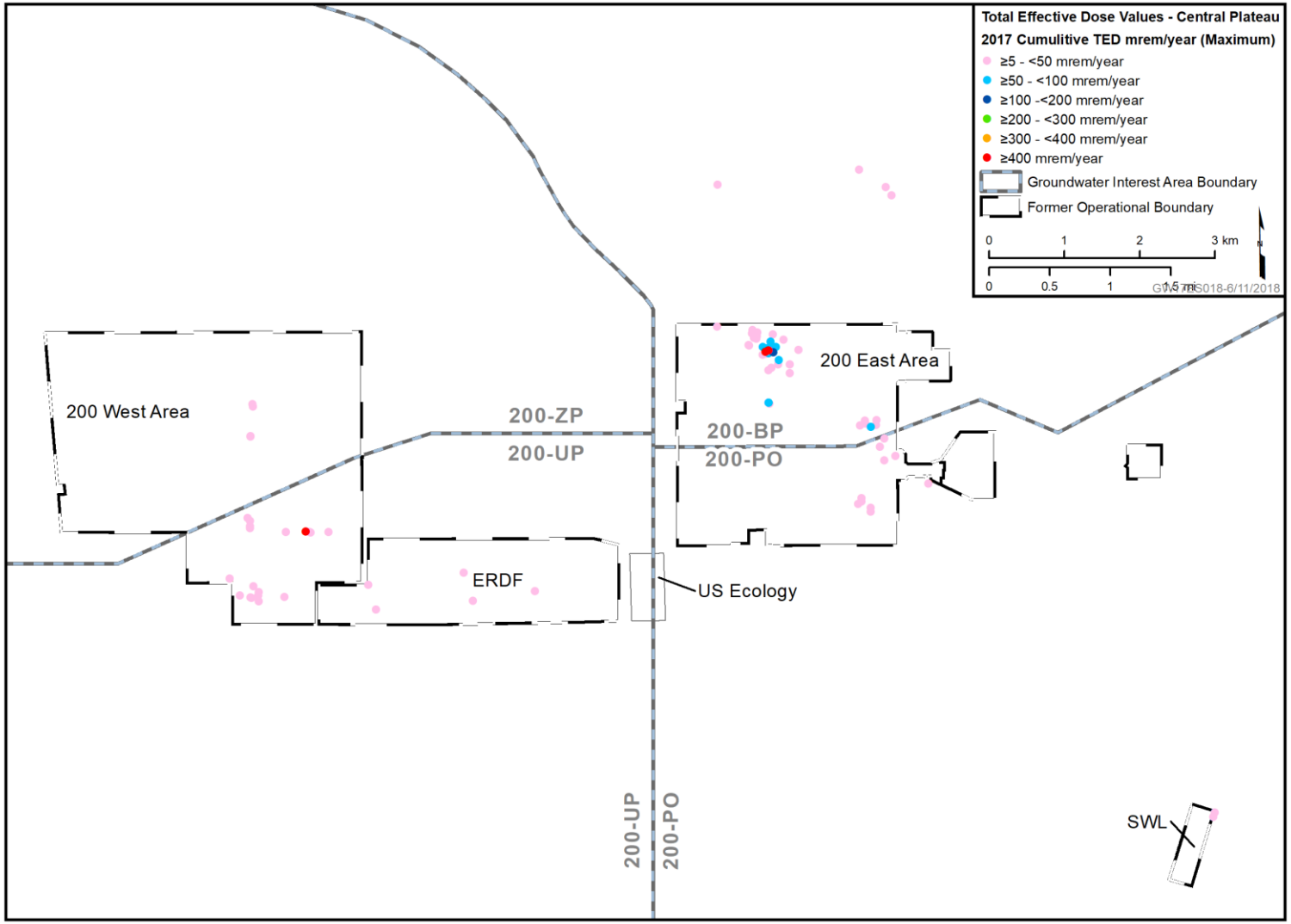

Figure ES-10. Groundwater Dose Calculation for the Central Plateau

The following activities or changes occurred in the Central Plateau in 2017:

- **200-BP:** New groundwater extraction well 299-E33-360 became active in 2017 as a part of a groundwater removal action. Concentrations of technetium-99, uranium, and other contaminants in nearby monitoring wells declined as a result of remedial actions. The part of the uranium plume with concentrations greater than 300 µg/L shrunk by about 60% between 2016 and 2017.
- **200-PO:** The large tritium plume originating from sources in the 200 East Area continued to shrink in 2017 due to dispersion and radioactive decay.
- **200-UP:**
  - Six dual-purpose monitoring-extraction wells were installed for the P&T system, and five monitoring wells were installed to characterize the southeast chromium plume.
  - The size of the uranium plume near U Plant declined between 2016 and 2017 as a result of groundwater remediation. Groundwater extraction near Waste Management Area S-SX caused chromium and technetium-99 concentrations to decline.
- **200-ZP:**
  - As a result of remediation by the 200 West P&T, carbon tetrachloride concentrations are declining in locations where the highest levels were formerly present. The interpreted extent of the plume at lower concentrations (3.4 µg/L cleanup level) expanded between 2016 and 2017 based on the monitoring data and a computer simulation. These parts of the plume are not captured by the P&T system and will attenuate naturally over time, as described in the 200-ZP-1 ROD.[5]
  - Four new injection wells were installed for the P&T system; two of these began operating in 2017.

[5] EPA, Ecology, and DOE, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington,* U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=00098825.

- **RCRA:**
  - New monitoring wells were installed for 216-A-37-1 Crib (one well), 216-A-29 Ditch (three wells), and 216-B-3 Pond (one well).
  - The Nonradioactive Dangerous Waste Landfill began groundwater quality assessment in 2017 as a result of a new critical mean exceedance.
  - New monitoring requirements for the Liquid Effluent Retention Facility were implemented through a revision to the Hanford RCRA Permit[4] in 2017. New interim status groundwater monitoring plans were implemented for the 216-A-37-1, 216-B-3, and 216-S-10 Pond and Ditch.
- **New wells:** Table ES-6 lists wells installed or decommissioned at the Central Plateau in 2017.

Table ES-6. Summary of Central Plateau Wells or Boreholes Drilled or Decommissioned in 2017

Groundwater Interest Area	Wells or Boreholes Drilled	Wells or Instrument Boreholes Completed	Wells or Boreholes Decommissioned	Comment
200-BP	2	1	2	Included one boring for the 200-DV-1 OU.
200-PO	6	6	1	
200-UP	15	14	1	Included one boring for the 200-DV-1 OU and five pilot test wells for the 200-WA-1 OU.
200-ZP	7	4	3	Included three borings for the 200-DV-1 OU.
Total	**30**	**25**	**7**	

OU = operable unit

Additional Information

The monitoring data presented in this report and information on monitoring well locations, construction details, and screened intervals can be found through the DOE Environmental Dashboard Application at https://ehs.hanford.gov/eda/, in the interactive version of this document at https://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports, or on the Pacific Northwest National Laboratory PHOENIX website at https://phoenix.pnnl.gov.

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Terms

AEA	*Atomic Energy Act of 1954*
AWLN	automated water level network
AWQC	ambient water quality criteria
bgs	below ground surface
BTV	background threshold value
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
cis-1,2-DCE	*cis*-1,2-dichloroethene
COC	contaminant of concern
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
CSM	conceptual site model
DCE	dichloroethene
DOE	U.S. Department of Energy
DST	double-shell tank
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EDA	Environmental Dashboard Application
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FS	feasibility study
FSB	fuel storage basin
GEL	GEL Laboratory
HEIS	Hanford Environmental Information System
HSP	hyporheic sampling point
IDF	Integrated Disposal Facility
IC	institutional control

ISRM	in situ redox manipulation
IX	ion exchange
LERF	Liquid Effluent Retention Facility
LLBG	low-level burial ground
LLWMA	low-level waste management area
LOQ	limit of quantitation
LWDF	Liquid Waste Disposal Facility
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limit
MNA	monitored natural attenuation
MSA	Mission Support Alliance
MTCA	Model Toxics Control Act
NPL	National Priorities List
NRDWL	Nonradioactive Dangerous Waste Landfill
OU	operable unit
P&T	pump and treat
PCE	tetrachloroethene
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
PRB	permeable reactive barrier
PUREX	Plutonium-Uranium Extraction (Plant)
QA	quality assurance
QC	quality control
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RAWP	remedial design/remedial action work plan
RDR	request for data review
REDOX	Reduction-Oxidation (Plant)

RI	remedial investigation
RLM	Ringold lower mud unit
ROD	Record of Decision
RUM	Ringold upper mud unit
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SST	single-shell tank
SWL	Solid Waste Landfill
TASL	Test America–St. Louis
TCE	trichloroethene
TED	total effective dose
TEDF	Treated Effluent Disposal Facility
TOC	total organic carbon
TOX	total organic halides
TPH	total petroleum hydrocarbon
TPH-D	total petroleum hydrocarbon–diesel
Tri-Parties	Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UCL	upper confidence limit
UPR	unplanned release
VOA	volatile organic analyte
VOC	volatile organic compound
WMA	waste management area

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Glossary[6]

Aquifer: An underground geological formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring. The top of an unconfined aquifer is known as the *water table*.

Confined aquifer: An *aquifer* having defined, relatively impermeable upper and lower boundaries and the pressure of which is significantly greater than atmospheric.

Crib: An underground structure designed to receive liquid waste that could percolate into the soil directly or after travelling through a connected tile field. Numerous cribs were used in the 100, 200, and 300 Areas.

Feasibility study: A study performed by an agency to develop and evaluate options for *remedial action* that emphasizes data analysis and is generally performed concurrently with the *remedial investigation*.

Groundwater: Water that fills the spaces between soil, sand, rock, and gravel particles beneath the earth's surface.

Half-life: The length of time in which any radioactive substance will lose one-half of its radioactivity. The half-lives of some Hanford Site radionuclides are listed below:

Radionuclide	Half-Life
Carbon-14	5,730 years
Iodine-129	16 million years
Plutonium (various isotopes)	88 to 24,000 years
Strontium-90	28.8 years
Technetium-99	212,000 years
Tritium	12 years
Uranium (various isotopes)	160,000 to 4.5 billion years

Hanford Reach: The segment of the Columbia River that extends 85 km (51 mi) downstream from Priest Rapids Dam to the head of the McNary Pool near the city of Richland, Washington. The Hanford Reach National Monument, which the U.S. government established in 2000, includes the River Corridor and other undisturbed portions of the Hanford Site.

Hydraulic conductivity: A property of an *aquifer* or *vadose zone* material that describes the ease at which water can move through pores or cracks. It is related to *permeability*.

Hydraulic gradient: The difference in water-level elevations divided by the distance between the points; the "slope" of the water table. *Groundwater* flows from higher to lower gradient, in a direction generally perpendicular to the contour lines of a *water table* map.

[6] Terminology shown in italics indicates cross reference to another term defined in this glossary.

Hyporheic zone: The region of sediment beneath and adjacent to a stream or lake where *groundwater* and surface water mix.

Mobility: Ability of a contaminant to move through the subsurface. The distance that contaminants migrate from waste sites depends on the properties of the contaminant, the volume of effluent, and subsequent *recharge*.

Low-mobility contaminants:	Many metals and radionuclides adhere to sediment grains in the vadose zone. When little or no liquid effluent was discharged, contamination remains in the shallow sediment within the waste site. Disposal of high volumes of liquid waste may spread low-mobility contaminants deeper in the soil. Natural and artificial recharge also can increase contaminant migration.
Slightly mobile contaminants:	Some contaminants such as strontium-90 can migrate in the subsurface but at a much slower rate than water. Strontium-90 was present in numerous Hanford Site waste sites. Where large volumes of liquid effluent were discharged, contaminants migrated through the vadose zone and moved a limited distance vertically and horizontally in groundwater.
Mobile contaminants:	Mobile contaminants migrate at the same or nearly the same rate as water. Common mobile contaminants in Hanford Site groundwater include tritium, iodine-129, technetium-99, nitrate, and hexavalent chromium. Large groundwater mounds developed when high-volume discharge sites were active, spreading mobile contaminants.

Monitored natural attenuation: Remediation that relies on natural processes to decrease or "attenuate" concentrations of contaminants in soil and groundwater. Scientists monitor these conditions to ensure that natural attenuation is working.

Operable unit: A discrete portion of the Hanford Site, as identified in Section 3.3 of the Tri-Party Agreement Action Plan; a group of land disposal sites placed together for the purposes of cleanup actions. The primary criteria for placement of a site into an operable unit includes geographic proximity, similarity of waste characteristics and site type, and the possibility for economies of scale.

Permeability: Ability of sediment or rocks to allow the passage of a liquid such as water. Permeable materials such as gravel and sand allow water to move quickly through them, whereas impermeable materials such as clay or solid basalt do not allow water to flow freely.

Plume: Volume of air, soil, or water containing contaminants. Groundwater plumes are usually depicted as two-dimensional maps but are present in three dimensions in an *aquifer*. Plume maps use contour lines or shading to illustrate areas of similar concentration.

Porosity: The ratio, usually expressed as a percentage, of the total volume of pores in a geologic unit to the total volume of the unit. Effective porosity reflects how many of the pores are connected and able to transmit water.

Pump and treat: A common method for remediating contaminated groundwater by pumping water from wells to an above-ground treatment system that removes the contaminants.

Radionuclide (radioisotope): Any naturally occurring or artificially produced radioactive element or isotope. An atom that has excess nuclear energy, making it unstable. As the excess energy is emitted, the radionuclide is said to undergo radioactive decay. Also see *half-life*.

Recharge: Water added to an *aquifer* from natural processes such as precipitation or artificial sources such as irrigation or effluent disposal to the ground.

Record of Decision: The CERCLA document used to select the method of *remedial action* to be implemented at a site after the *feasibility study* and proposed plan have been completed.

Remedial action: An action taken under CERCLA authority to permanently resolve a hazardous substance release or to significantly reduce the potential for a release from a unit or group of units.

Remedial investigation: The CERCLA process for determining the extent of contamination and, as appropriate, conducting treatability investigations, performed in conjunction with a *feasibility study*.

Seep: An area on the river bank where *groundwater* flows out of the *aquifer* into a river or lake; also known as a spring.

Sodium dichromate: A chemical added to reactor cooling water as an anticorrosion agent. Typical sodium dichromate concentrations in the cooling water during the early years of Hanford Site operations were 2,000 µg/L (700 µg/L as hexavalent chromium). Concentrations decreased to 1,000 µg/L in the mid-1960s, and then to 500 µg/L (170 µg/L as hexavalent chromium) in the final stages of operations.

Trench: A narrow ditch dug in the soil, formerly used to dispose solid and liquid waste from Hanford Site operations.

Vadose zone: The unsaturated region of soil between the ground surface and the *water table*.

Waste management area: A grouping of waste sources regulated as one unit under RCRA (e.g., a group of underground storage tanks and associated pipelines).

Water table: Top of an unconfined *aquifer*; top of the saturated sediment or rock. The water table can have high and low points similar to the topography of the land surface. Also see *hydraulic gradient*.

Well: An excavation or structure created in the ground by drilling, digging, or driving to access *groundwater*. The following well types are present on the Hanford Site:

Aquifer tube:	A groundwater monitoring point installed where the water table is very shallow, such as along the river shoreline. Generally consists of a small-diameter tube and screen installed using push technology.
Boring:	A borehole that was decommissioned immediately after drilling. Decommissioning is generally performed before the drill rig is removed from the site.
Groundwater well:	A well with the open interval extending below the water table. Most Hanford Site groundwater wells are used for monitoring or groundwater remediation (e.g., pump and treat).
Hosted piezometer:	Small-diameter groundwater well inside a host well, often part of a group monitoring different depths.
Independent piezometer:	Small-diameter groundwater well not constructed inside a host well.

Lysimeter: Generally, an in situ open bottom cylindrical core where the top is coincident with the ground surface and with walls that prevent horizontal movement of moisture. A lysimeter is used to measure moisture or contaminant changes through time over a specific depth interval.

Piezometer host: A well with one or more piezometers constructed inside of it.

Soil tube: Vadose zone monitoring site consisting of a small-diameter tube and possibly a screen left in place after drilling is completed for sampling.

Vadose well: A vadose zone monitoring site where casing is left in place after drilling activities are completed. May have a screen, open bottom, or may be closed.

Glossary Sources

Definitions in this glossary were adapted from the following sources (complete citations are provided in Chapter 13):

DOE/EH-413/9713, *Glossary of Terms Related to CERCLA, EPCRA, PPA, RCRA and TSCA:* https://public.ornl.gov/sesa/environment/guidance/cercla/gloss97.pdf

EPA 542-F-12-014, *A Citizen's Guide to Monitored Natural Attenuation:* https://clu-in.org/download/Citizens/a_citizens_guide_to_monitored_natural_attenuation.pdf.

EPA 542-F-12-017, *A Citizen's Guide to Pump and Treat:* https://clu-in.org/download/Citizens/a_citizens_guide_to_pump_and_treat.pdf.

PNNL-14187-SUM, *Summary of Hanford Site Groundwater Monitoring for Fiscal Year 2002:* http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14187SUM.pdf.

Tri-Party Agreement (Appendix A of the Action Plan): https://www.hanford.gov/files.cfm/ap-App-A.pdf.

USGS Glossary of Hydrologic Terms: https://or.water.usgs.gov/projs_dir/willgw/glossary.html.

1 Introduction

The Hanford Site, part of the U.S. Department of Energy (DOE) nuclear weapons complex, encompasses an area of about 1,505 km^2 (581 mi^2) northwest of the city of Richland along the Columbia River in southeastern Washington State (Figure 1-1). In 1943, as part of the top-secret Manhattan Project, the federal government took possession of the Hanford Site to build the world's first large-scale plutonium-production reactor. Between 1943 and 1963, nine nuclear reactors were built, mainly to produce weapons-grade plutonium. During reactor operations (the last reactor operated through 1987), large amounts of chemical and radioactive wastes were released into the environment that have contaminated the soil and groundwater beneath portions of the Hanford Site. Groundwater at the Hanford Site flows toward the Columbia River, the primary exposure route for contaminants to reach human and ecological receptors.

DOE monitors and remediates Hanford Site groundwater to protect workers, the public, and the environment. This report presents the results of monitoring during 2017 and summarizes the progress of groundwater remediation.

DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed a comprehensive cleanup and compliance agreement in 1989. The Tri-Party Agreement (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*) is an agreement for achieving compliance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and *Resource Conservation and Recovery Act of 1976* (RCRA). The Tri-Party Agreement (1) defines and ranks CERCLA and RCRA cleanup commitments, (2) establishes responsibilities, (3) provides a basis for budgeting, and (4) reflects a concerted goal of achieving full regulatory compliance and remediation with enforceable milestones.

The Tri-Party Agreement is legally binding and consists of two main documents:

- The "Agreement" (Ecology et al., 1989a) describes the agency roles, responsibilities and authority regarding the compliance and permitting processes. It also establishes dispute resolution processes and describes how the agreement will be enforced.
- The "Action Plan" (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*) includes milestones for initiating and completing specific work and describes procedures the three agencies will follow.

Additionally, an associated Public Involvement Plan (DOE et al., 2017, *Hanford Federal Facility Agreement and Consent Order Hanford Public Involvement Plan*) describes how the public will be informed and involved throughout the cleanup process.

The key elements associated with managing Hanford Site groundwater and vadose zone contamination are (1) to protect the Columbia River and groundwater from further contamination, (2) to develop a cleanup decision process, and (3) to restore groundwater to its highest beneficial use. DOE has already taken many actions to protect the Columbia River and groundwater, including the following:

- Cease discharge of all unpermitted liquid effluents
- Remediate waste sites near the Columbia River to reduce the potential for future groundwater contamination
- Contain groundwater plumes and reduce the mass of contaminants through remedial actions such as pump and treat (P&T)

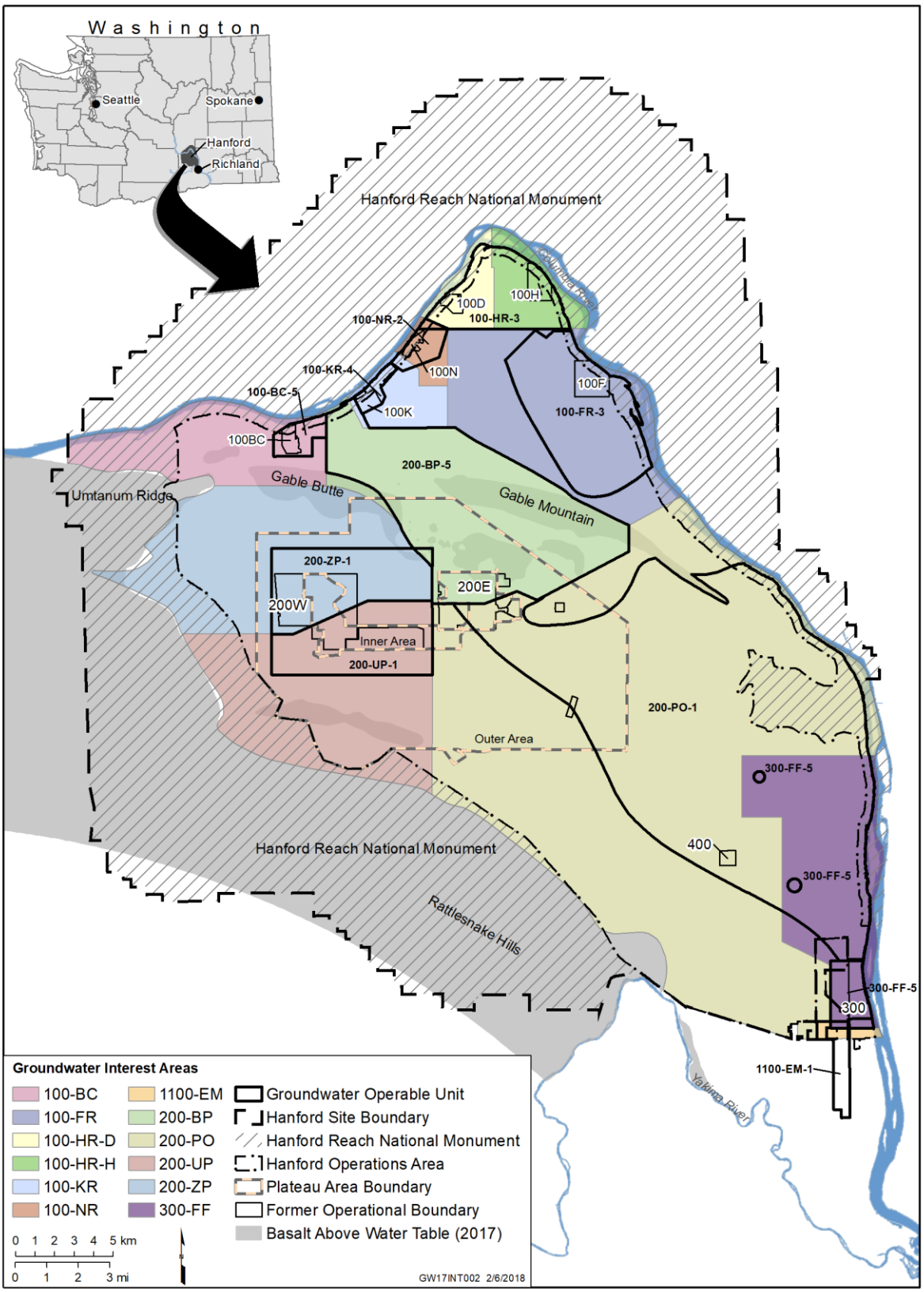


Figure 1-1. DOE Hanford Site, Groundwater Interest Areas, and Operable Units

1.1 Purpose and Scope

This report presents the 2017 results for Hanford Site groundwater monitoring in accordance with the requirements for CERCLA groundwater operable units (OUs) and the *Atomic Energy Act of 1954* (AEA), as required by DOE orders (Table 1-1). A separate groundwater annual report for the RCRA treatment, storage, and disposal (TSD) units (DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*) was previously published, and that information is included in this report. Separate CERCLA reports are being published for OUs with ongoing groundwater remediation. This report also provides information about two facilities regulated under the *Washington Administrative Code* (Table 1-1). Appendices A, B, and C provide supporting information on CERCLA, RCRA, and the AEA, respectively. Appendix D summarizes confined aquifer monitoring results, and Appendix E summarizes the results of a data usability assessment.

Table 1-1. Reporting Requirements for Groundwater Monitoring

Operable Unit or Facility	Formal Report	Supplemental Report or Summaries
CERCLA		
100-BC-5, 200-BP-5, and 200-PO-1	This report	Unit managers' meeting presentations
100-KR-4, 100-NR-2, 100-HR-3, 200-UP-1, and 200-ZP-1	DOE/RL-2017-67; DOE/RL-2017-68	Unit managers' meeting presentations; this report
300-FF-5 and 100-FR-3	Periodic performance evaluation reports	Unit managers' meeting presentations; this report
ERDF	Separate annual report	This report
RCRA		
Operating RCRA units (IDF, LERF, and LLBG)	DOE/RL-2017-65	This report
Closure RCRA units (116-N-1 and 116-N-3; 120-N-1 and 120-N-2)	DOE/RL-2017-65	This report
Post-closure RCRA units (116-H-6 and 316-5)	Semiannual reports to Ecology; DOE/RL-2017-65	This report
Interim status groundwater quality assessment RCRA sites (216-A-29; NRDWL; WMAs A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U)	DOE/RL-2017-65	This report
Interim status indicator evaluation RCRA sites (216-A-36B, 216-A-37-1, 216-B-3, 216-B-63, and 216-S-10 Pond)	DOE/RL-2017-65	This report
Other Facilities		
AEA sites (K Basins; LLBG, IDF, Richland North, 400 Area water supply wells, and confined aquifers)	This report	Unit managers' meeting presentations
SALDS (WAC 173-216)	Quarterly discharge monitoring reports; annual report (e.g., RPP-RPT-60453)	This report

Table 1-1. Reporting Requirements for Groundwater Monitoring

Operable Unit or Facility	Formal Report	Supplemental Report or Summaries
SWL (WAC 173-350)	This report	Fiscal year report (DOE/RL-2015-21)

Note: Complete reference citations are provided in Chapter 13.

References: DOE/RL-2015-21, *Hanford Site Solid Waste Landfill Annual Monitoring Report October 2016 through September 2017*.

DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*.

DOE/RL-2017-67, *Calendar Year 2017 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*.

DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*.

RPP-RPT-60453, *Results of the Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2016*.

WAC 173-216, "State Waste Discharge Permit Program."

WAC 173-350, "Solid Waste Handling Standards."

AEA	=	*Atomic Energy Act of 1954*	NRDWL	=	Nonradioactive Dangerous Waste Landfill
CERCLA	=	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*	RCRA	=	*Resource Conservation and Recovery Act of 1976*
Ecology	=	Washington State Department of Ecology	SALDS	=	State-Approved Land Disposal Site
ERDF	=	Environmental Restoration Disposal Facility	SWL	=	Solid Waste Landfill
IDF	=	Integrated Disposal Facility	WMA	=	waste management area
LERF	=	Liquid Effluent Retention Facility			
LLBG	=	low-level burial ground			

This report focuses on 2017 groundwater monitoring results and changes from the previous year. Details of previous studies (e.g., remedial investigations [RIs]) are published in separate reports that are cited in applicable chapters of this report. Readers are referred to other documents for details regarding hydrogeology, characterization results, detailed conceptual site models (CSMs), and descriptions of waste sites and the shallow vadose zone.

The groundwater monitoring objectives of RCRA, CERCLA, and AEA differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated units, monitoring focuses on nonradioactive dangerous waste constituents. While radionuclides (source, special nuclear, and byproduct materials) may be monitored in some wells associated with RCRA units to support objectives of monitoring under the AEA and/or CERCLA, they are not subject to RCRA regulation. Pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are instead regulated by DOE, acting pursuant to its AEA authority.

The Hanford Site is broadly divided into the River Corridor and Central Plateau regions. The River Corridor is located along the Columbia River, and the Central Plateau is in the middle of the Hanford Site. Within these broad regions, this report is organized by groundwater interest areas and groundwater OUs (Figure 1-1).

- CERCLA groundwater OUs include groundwater beneath one or more source OUs (i.e., sites that received waste from the same or similar sources) and may include larger regions where contaminated groundwater has migrated.

- The formal groundwater OUs do not cover the entire Hanford Site. DOE has defined informal groundwater interest areas, which include the groundwater OUs and the intervening regions, to provide scheduling, data review, and data interpretation for the entire Hanford Site.

The following geographic divisions are sometimes used to describe aspects of the Hanford Site:

- The Hanford Site's former operational areas were given alphanumeric names (Figure 1-1). These include the 100-BC, 100-K, 100-N, 100-D, 100-H, and 100-F Areas, which housed the nuclear reactors; and the 200 West and 200 East Areas, where chemical separation occurred. The 300 Area was home to the fuel manufacturing operations, as well as experimental and laboratory facilities, and the 400 Area housed a research nuclear reactor.
- For purposes of remediation under CERCLA, waste sites have been sorted into source OUs. The source OUs focus on contamination in the vadose zone.

1.2 Groundwater Monitoring

DOE coordinates groundwater sampling for the RCRA, CERCLA, *Washington Administrative Code*, and AEA programs to avoid duplication. Specific groundwater monitoring plans and sampling and analysis plans (SAPs) define which wells to sample, how often to sample, and what constituents to analyze. The sampling objectives are based on the data needs, such as interpreting the extent of contamination, evaluating vertical contaminant distribution, refining geologic models, complying with regulations, evaluating the performance of remediation activities, defining concentration trends, or identifying emerging contaminants.

During 2017, DOE sampled 1,063 wells (Table 1-2). Many wells were sampled numerous times, for a total of 3,920 successful well sampling trips. During the year, 199 aquifer tubes were sampled, and many were sampled more than once, for a total of 247 sampling trips.

1.2.1 CERCLA Remediation and Monitoring

Executive Order 12580, *Superfund Implementation*, assigns DOE the responsibility and authority (under CERCLA Section 104, "Response Authorities") to clean up soil and groundwater contaminated by waste sites. CERCLA Section 120, "Federal Facilities," gives EPA an oversight role at the Hanford Site and other federal facilities on the CERCLA National Priorities List (NPL) (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List"). Cleanup decisions are based on the results of environmental investigations that include the vadose zone and groundwater.

CERCLA groundwater activities at the Hanford Site include defining the nature and extent of contamination, implementing remedial actions such as P&T systems, and evaluating the effectiveness of remedial actions. DOE publishes separate groundwater annual reports for CERCLA OUs with remedial actions (DOE/RL-2017-67, *Calendar Year 2017 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*; DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*).

Table 1-2. 2017 Groundwater Sampling Trips

Interest Area	Number of Wells Sampled	Number of Successful Well Trips	Number of Aquifer Tubes Sampled	Number of Successful Aquifer Tube Trips
100-BC	33	39	21	21
100-FR	40	69	8	8
100-HR-D	124	849	20	20
100-HR-H	101	647	21	22
100-KR	107	670	55	57
100-NR	103	202	41	86
300-FF	80	226	14	14
1100-EM and offsite	11	17	0	0
200-BP	144	333	4	4
200-PO	123	306	15	15
200-UP	103	264	0	0
200-ZP	94	298	0	0
Total	**1,063**	**3,920**	**199**	**247**

Note: A successful sampling trip is determined by the presence of data in the Hanford Environmental Information System database. A trip may consist of routine sampling, characterization sampling, or sampling conducted to support groundwater remediation systems.

1.2.2 RCRA and Other Monitored Units

RCRA regulates the management of solid waste, hazardous waste, and certain underground storage tanks. It applies to active or recently active TSD dangerous waste management units. DOE reported the 2017 RCRA groundwater monitoring results to Ecology in DOE/RL-2017-65. The contents of that report are repeated in this report for convenience and completeness.

Monitoring is required at some RCRA units to determine if they are affecting groundwater quality in the uppermost aquifer (Table 1-3). Groundwater monitoring requirements for the Hanford Site's RCRA units fall into one of two broad categories: interim status or final status. Final status units have been incorporated into WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereinafter referred to as the Hanford RCRA Permit). A permitted RCRA unit requires final status monitoring, as specified in WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." The RCRA units not currently incorporated into a permit require interim status monitoring under WAC 173-303-400, "Interim Status Facility Standards," as implemented by 40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring."

Table 1-3. RCRA Monitoring Status, 2017

RCRA Unit	Section	Status	Engineering Evaluation[a]
1301-N LWDF	6.8.1	Continued indicator evaluation monitoring;[b] in 2017 Ecology approved a request for a Class 2 modification, which adds a clean closure option	No
1324-N and 1324-NA Ponds	6.8.3	Continued indicator evaluation monitoring[b]	No
1325-N LWDF	6.8.2	Continued indicator evaluation monitoring;[b] in 2017 Ecology approved a request for a Class 2 modification, which adds a clean closure option	No
183-H Evaporation Basins	4.11	Corrective action monitoring program during interim remedial action; monitoring plan revised in Hanford RCRA Permit in 2017	No
300 Area Process Trenches	7.7	Corrective action monitoring program during interim remedial action; monitoring plan revised in Hanford RCRA Permit in 2017	No
216-A-29 Ditch	10.10.4	Assessment monitoring (elevated specific conductance); assessment plan revised in 2017	Yes (to be prepared in 2018)
216-A-36B Crib	10.10.2	Continued indicator evaluation monitoring[b]	Yes (to be prepared in 2018)
216-A-37-1 Crib	10.10.3	Continued indicator evaluation monitoring;[b] monitoring plan revised in 2017	Yes (to be prepared in 2018)
216-B-3 Pond	10.10.5	Continued indicator evaluation monitoring;[b] monitoring plan revised in 2017	Yes (to be prepared in 2018)
216-B-63 Trench	9.10.3	Continued indicator evaluation monitoring[b]	Yes (to be prepared in 2018)
216-S-10 Pond and Ditch	11.12.3	Continued indicator evaluation monitoring;[b] monitoring plan revised in 2017	Yes (draft in review)
IDF	10.10.6	Not yet in use; monitoring results added to baseline data set	Yes (to be prepared in 2018)
LERF	9.10.4	Detection monitoring; monitoring plan revised in 2017 and incorporated into the Hanford RCRA Permit	Yes (SGW-41072)
LLWMA-1	9.10.5	Continued indicator evaluation monitoring[b]	Yes (to be prepared in 2018)

Table 1-3. RCRA Monitoring Status, 2017

RCRA Unit	Section	Status	Engineering Evaluation[a]
LLWMA-2 (Trench 94)	9.10.6	Continued indicator evaluation monitoring[b]	Note c
LLWMA-3[d]	12.11.3	Continued indicator evaluation monitoring[b]	SGW-60583
LLWMA-4	12.1.4	Continued indicator evaluation monitoring[b]	SGW-60584
NRDWL	10.10.7	Began assessment monitoring (specific conductance exceedance)	Yes (to be prepared in 2018)
SST WMA A-AX	10.10.1	Continued assessment monitoring (elevated specific conductance)	Yes (to be prepared in 2018)
SST WMA B-BX-BY	9.10.1	Continued assessment monitoring (cyanide[e])	Yes (to be prepared in 2018)
SST WMA C	9.10.2	Continued assessment monitoring (cyanide[e])	Yes (to be prepared in 2018)
SST WMA S-SX	11.12.1	Continued assessment monitoring (chromium[e])	SGW-60577
SST WMA T	12.11.1	Continued assessment monitoring (chromium[e])	SGW-60575
SST WMA TX-TY	12.11.2	Continued assessment monitoring (chromium[e])	SGW-60576
SST WMA U	11.12.2	Continued assessment monitoring (chromium[e])	SGW-60598

Note: Complete reference citations are provided in Chapter 13.

a. Engineering evaluations to determine needs for new or replacement monitoring wells for these units.

b. Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with dangerous waste or dangerous waste constituents from the unit.

c. Applicability waiver sought under WAC 173-303-645(1)(b), "Dangerous Waste Regulations," "Releases from Regulated Units."

d. Trenches 31 and 34 will be included in modification C of the RCRA Permit (SGW-59564).

e. Primary RCRA constituent at this unit.

IDF = Integrated Disposal Facility
LERF = Liquid Effluent Retention Facility
LLWMA = Low-Level Waste Management Area
LWDF = Liquid Waste Disposal Facility
NRDWL = Nonradioactive Dangerous Waste Landfill
RCRA = *Resource Conservation and Recovery Act of 1976*
SST = single-shell tank
WMA = waste management area

RCRA groundwater monitoring is conducted under one of three types of programs: (1) contaminant indicator evaluation (or detection) monitoring, (2) groundwater quality assessment (or compliance) monitoring, or (3) corrective action monitoring. Prior to closure of these units, monitoring may move between these types of programs as groundwater circumstances dictate. In the interim status contaminant indicator evaluation monitoring, four indicator parameters (pH, specific conductance, total organic carbon [TOC], and total organic halides [TOX]) are monitored and evaluated against statistically derived threshold values calculated from upgradient wells. In final status detection monitoring, site-specific

indicators are evaluated using statistical methods identified in the respective permit. Groundwater quality assessment (interim status) or compliance (final status) monitoring occurs when a facility appears to have impacted groundwater quality. The objective of the monitoring program shifts from detection to assessing the nature and extent of the problem. If contaminant concentrations in groundwater have exceeded a permit concentration limit, groundwater remediation is required and corrective action monitoring is initiated. The goal of a corrective action groundwater monitoring program is to determine if the corrective action is effective.

The adequacy of RCRA groundwater monitoring networks may be affected by natural or anthropogenic changes (e.g., P&T systems). DOE is working with Ecology to review the monitoring networks and is evaluating the need for additional wells through the Hanford RCRA Permit (Revision 9) working group. DOE is preparing RCRA engineering evaluation reports and related final status monitoring plans (Table 1-3), which will be added to the Hanford RCRA Permit through Revision 9.

1.2.3 Washington Administrative Code Units

Two Hanford Site facilities require groundwater monitoring under the *Washington Administrative Code*: the Solid Waste Landfill (SWL) (under WAC 173-350, "Solid Waste Handling Standards") and the State-Approved Land Disposal Site (SALDS), associated with the Effluent Treatment Facility (ETF) (WAC 173-216, "State Waste Discharge Permit Program"). Chapters 10 and 12 of this report summarize the 2017 monitoring results for these facilities.

1.2.4 Atomic Energy Act Monitoring

The AEA was promulgated to ensure the proper management of radioactive materials. Through the AEA, DOE regulates the control of radioactive materials under its authority. Accordingly, DOE promulgated a series of regulations and directives to protect human health and the environment from potential risks associated with radioactive materials. Sections of the AEA authorize DOE to establish radiation protection standards for itself and its contractors through DOE orders and contractor requirements documents.

Requirements for groundwater monitoring associated with environmental surveillance under the AEA are implemented through DOE O 458.1, *Radiation Protection of the Public and the Environment*; DOE O 436.1, *Departmental Sustainability*; and DOE O 435.1, *Radioactive Waste Management* (primarily applied in DOE M 435.1-1, *Radioactive Waste Management Manual*). These DOE orders and their associated manuals, standards, guidance, and contractor requirements documents implement AEA requirements across the DOE complex and include groundwater monitoring to detect, characterize, and respond to releases of radionuclides. DOE has not relinquished this responsibility under the Tri-Party Agreement (Ecology et al., 1989a); rather, DOE conducts activities in accordance with both the Tri-Party Agreement and DOE orders.

DOE/RL-2015-56, *Hanford Atomic Energy Act Sitewide Groundwater Monitoring Plan*, describes AEA monitoring requirements. Chapters 2 through 12 of this report summarize the results of AEA monitoring, and Appendix C provides supporting information.

The objectives of AEA monitoring are to determine the location and movement of radionuclide contamination in Hanford Site groundwater and to estimate impacts to human health and the environment in terms of the total effective dose (TED) received by potential receptors. The analytical results were used to estimate the TED from hypothetical exposure of members of the public by drinking radiologically contaminated groundwater. The TED at each groundwater well was calculated as the cumulative dose from all radionuclides detected in groundwater samples from that well in 2017, including samples

collected for CERCLA and RCRA. The doses were calculated separately for each sampling event if more than one sampling event occurred in 2017.

The TED was calculated under AEA standards in accordance with DOE O 458.1. DOE-STD-1196-2011, *Derived Concentration Technical Standard*, was released in 2011 to support determining compliance with DOE O 458.1. This standard establishes derived concentration standards on a radionuclide- and pathway-specific basis, reflecting the current state of knowledge and practice in radiation protection. These derived concentration standards are used to calculate doses from exposure to groundwater and represent the activity concentration of a given radionuclide in groundwater that results in a member of the public receiving a 100 mrem TED from drinking groundwater for one year. The cumulative dose from all radionuclides detected at a monitoring location is calculated and compared to the 100 mrem/yr TED criterion.

Although groundwater at the Hanford Site is not used as a source of drinking water, remedial actions have focused on restoring groundwater quality to its highest use, which is considered to be as a source of drinking water. To this end, the radionuclide concentrations in groundwater were also used to evaluate whether contaminated Hanford Site groundwater would exceed drinking water standards (DWSs) under a hypothetical drinking water exposure scenario. The cumulative drinking water dose was calculated under the EPA DWSs in accordance with 40 CFR 141, "National Primary Drinking Water Regulations," and the process described in EPA 816-F-00-002, *Implementation Guidance for Radionuclides*. The DWSs establish a maximum contaminant level (MCL) for beta and photon emitters at 4 mrem/yr cumulative dose from all beta and photon emitters present in the water supply. The dose is calculated using a sum-of-fractions approach to determine the cumulative dose to the whole body or any critical organ from beta- and photon-emitting radionuclides and compared to the 4 mrem/yr beta/photon DWS. The DWS is calculated using a defined set of radionuclide-specific dose factors that differs from those established by DOE in DOE-STD-1196-2011. The numerical activity concentration values frequently used for comparison of individual beta- or photon-emitting radionuclide concentrations (e.g., 1 pCi/L iodine-129, 8 pCi/L strontium-90, 900 pCi/L technetium-99, and 20,000 pCi/L tritium) are actually not the DWS for those radionuclides. These values are the individual single-nuclide, MCL-equivalent derived activity concentrations. If a single nuclide is present in drinking water at the corresponding derived concentration (e.g., 8 pCi/L strontium-90), then the corresponding dose would be 4 mrem/yr, which exceeds the DWS. If more than one nuclide is present in drinking water, then the cumulative dose effects must be calculated using the sum of fractions to determine the actual drinking water dose for comparison to the 4 mrem/yr DWS.

Activity concentrations of the alpha-emitting radionuclides were summed to derive the cumulative alpha-emitter activity concentration, which is compared to the 15 pCi/L alpha-emitter DWS (EPA 816-F-00-002). This calculation excludes uranium and radium-226 (which are regulated under separate standards). Uranium may be measured as mass (total uranium, reported in µg/L) or as activity (isotopic uranium, reported in pCi/L). Total uranium concentrations are compared to the 30 µg/L DWS. If only isotopic uranium is measured, the activity concentrations are converted to mass and summed for comparison to the DWS.

The calculations of cumulative TED, beta/photon-emitter dose, alpha-emitter activity, and uranium mass concentration are provided in ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Although the compliance aspects of AEA monitoring are associated with radioactivity, historical AEA sampling has included contaminants such as nitrate as an indicator of contaminant migration and to

characterize potential non-DOE contamination sources. The current AEA monitoring plan (DOE/RL-2015-56) continues to include nitrate.

1.3 Water Levels

DOE measures water levels in monitoring wells to discern the direction of groundwater flow. Water levels are measured manually and with an automated system. Water levels are used to determine rates of contaminant migration, adequacy of monitoring networks, and radial influence of remedial actions.

In March of each year, field crews measure water levels from an extensive network of wells. In many areas of the Hanford Site, water levels are measured more frequently to evaluate seasonal changes. SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*, describes the collection and analysis of manual water-level measurements at the Hanford Site. ECF-Hanford-17-0120, *Preparation of the March 2017 Hanford Site Water Table and Potentiometric Surface Maps*, describes how the water table map was constructed. Groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge areas along the Columbia River (Figure 1-2).

The automated water-level network (AWLN) is an array of remote monitoring stations connected by a telemetry network to a central base station (SGW-53543, *Automated Water Level Network Functional Requirements Document*). Each monitoring station consists of a pressure transducer connected to a data collection telemetry unit. Pressure data from the AWLN are used to calculate water levels, which are used to estimate the level of hydraulic containment achieved by P&T systems, determine hydraulic gradients in areas with variable conditions, and measure changes in the stage of the Columbia River in the 100 and 300 Areas.

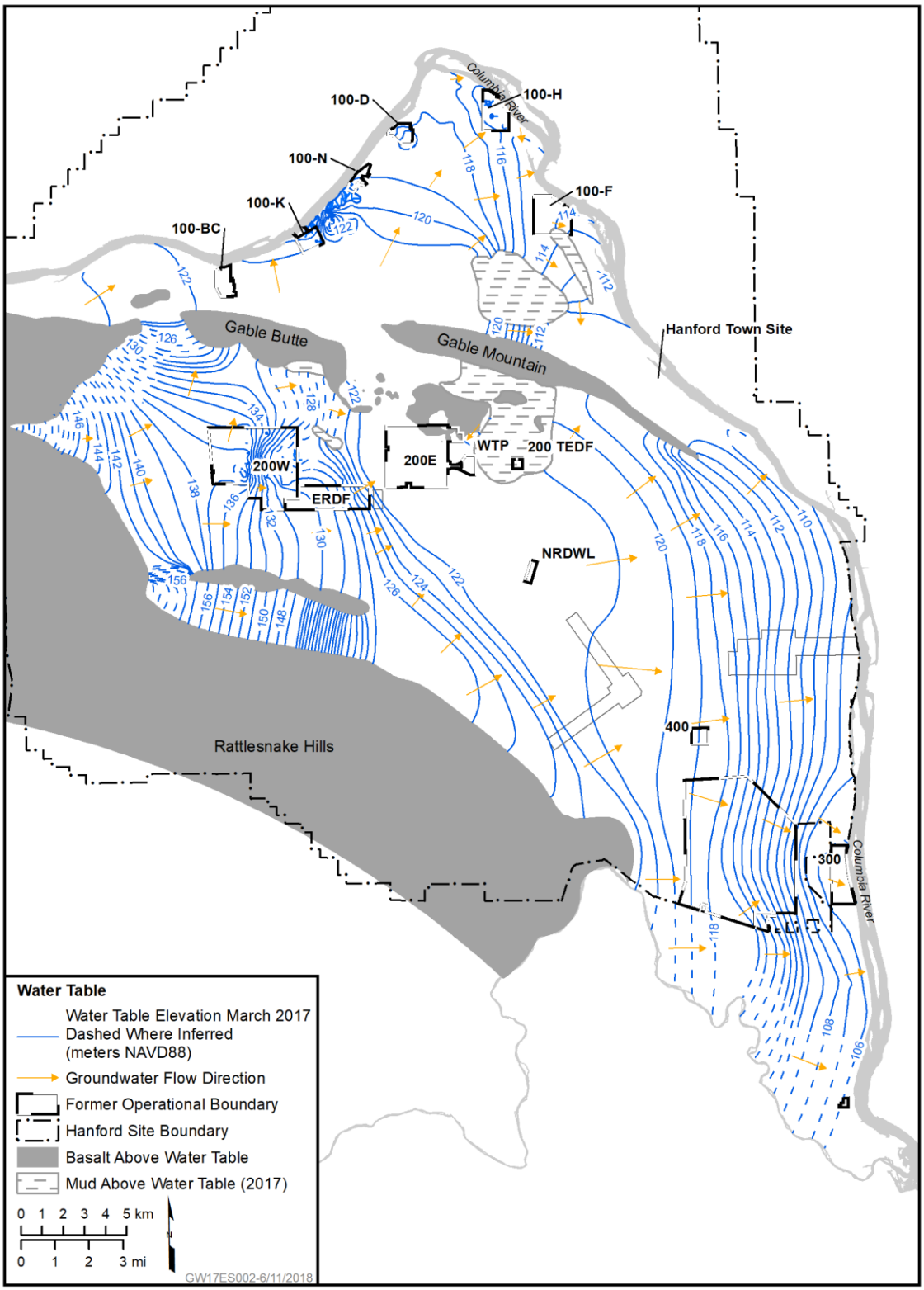
By the end of December 2017, there were 196 AWLN stations on the Hanford Site, including 7 new stations in the 100-BC Area, 7 new stations in 100-H Area, and 5 new stations in 100-D Area. Two stations were moved in 100-K Area, two stations were turned off for future moves, and one station (199-N-189) was turned off for conversion to an extraction well.

1.4 Well Installation, Maintenance, and Decommissioning

Over the lifetime of the Hanford Site, DOE has installed and maintained thousands of wells to monitor and remediate groundwater and provide geologic data. When wells are no longer useful or are in poor condition, they are decommissioned. Figure 1-3 presents the categories of unique well identification numbers and their geographic designations.

DOE works with the appropriate regulatory agencies to define the need for new wells. Each year, DOE proposes new wells to meet the requirements of RCRA, CERCLA, or other regulations. These efforts may include new or ongoing RCRA assessment of groundwater contamination, replacement of monitoring wells that go dry because of the declining regional water table, replacement of wells that need to be decommissioned, improvement of spatial coverage for different monitoring networks and plume monitoring, and characterization of subsurface contamination.

New monitoring well proposals are reviewed, prioritized, and approved annually in accordance with Tri-Party Agreement Milestone M-024. All new wells are constructed as either resource protection wells or water supply wells in accordance with WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells.” Well requirements are integrated, prioritized, and documented through the budget development process, discussions between DOE and the regulatory agencies, and specific monitoring and characterization requirements.



NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

Figure 1-2. Hanford Site Water Table and Directions of Groundwater Flow, 2017

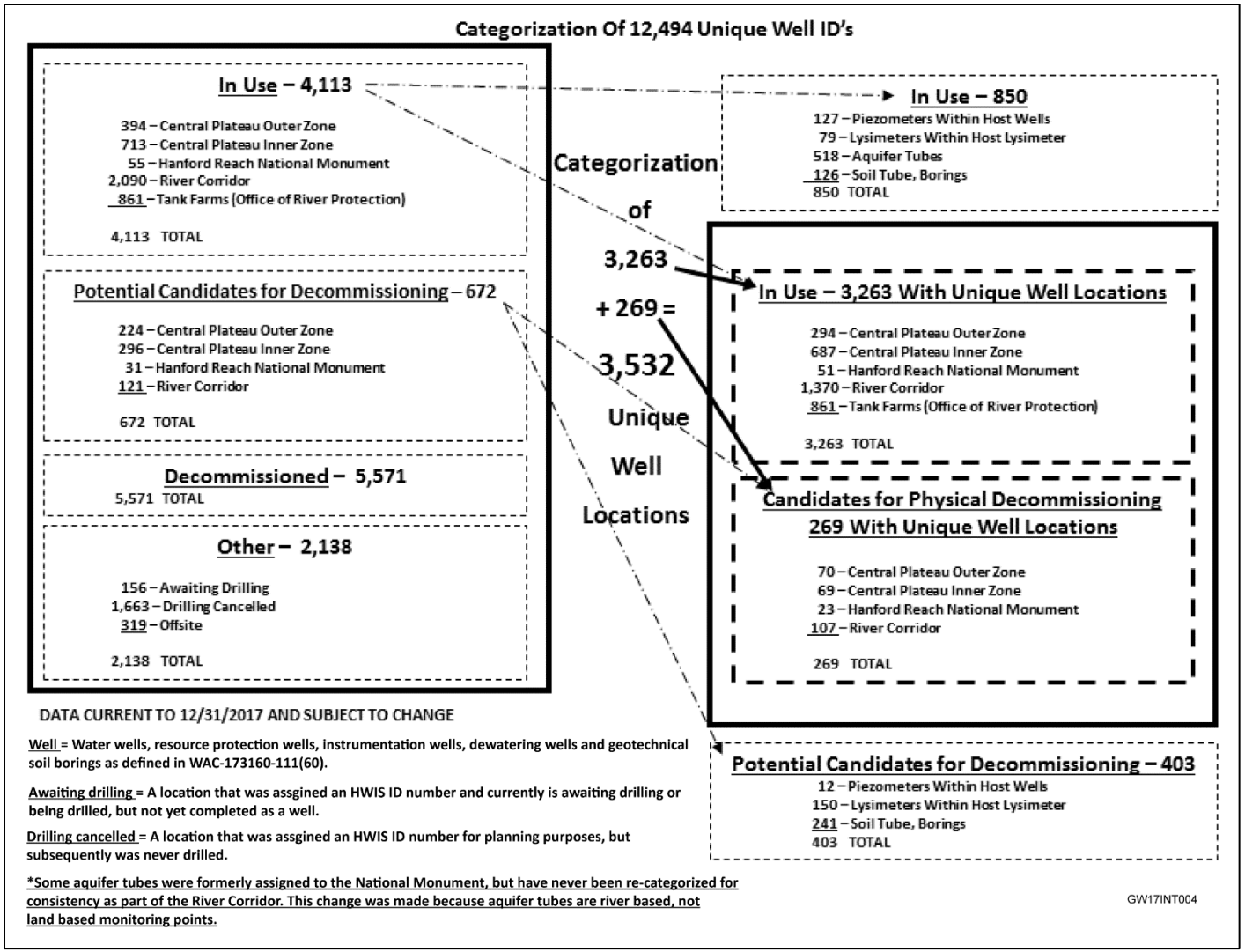


Figure 1-3. Categories of Unique Well Identification Numbers

1.5 Conventions Used in This Report

This section describes conventions for creating maps and trend plots and for depicting groundwater contaminant concentrations.

Contaminant plume maps illustrate the extent of groundwater contamination at concentrations above certain thresholds and are developed by interpolating sample data using computer software and professional interpretation. Details regarding the development of the groundwater plume maps for 2017 are provided in ECF-Hanford-18-0013, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2017 Hanford Site Groundwater Monitoring Report*. The following general rules were applied to select representative data sets:

- Use data collected during 2017 (or a specific portion of 2017 [e.g., low river-stage months]) from monitoring wells, injection wells, extraction wells, and aquifer tubes.
- If more than one data point was available for a well in 2017, use the average value. In cases where concentrations are variable because of seasonal effects or remedial actions, shorter time periods are selected (see Chapters 4 and 5 of this report).
- If data were not collected from a well in 2017, use data from 2016 or 2015 and denote on the maps.
- Exclude data flagged as “R” (rejected).
- Display and interpret nondetect data at the method detection limit (MDL) (chemical constituents) or minimum detectable activity (MDA) (radionuclides).

In some instances, older measurements or data based on other site-specific information were included to improve the plume interpretations. These supplemental data (control points) are shown on the plume maps as Type 1, Type 2, and Type 3 data, which the computer software uses in the same way as measured data. A brief description of each type of data follows:

- **Type 1 data:** Point values based on contaminant concentration measurements that are outside of the data selection rules described above. Examples include P&T effluent concentrations (at injection wells), contaminant measurements outside the 2015 through 2017 data period, and data from non-Hanford Site sources (e.g., US Ecology).
- **Type 2 data:** Point values determined by geology. Examples include “zero” concentrations in locations where basalt above the water table is a barrier to contaminant migration, and estimated concentrations in locations where zones of higher hydraulic conductivity may be conduits of contaminant migration.
- **Type 3 data:** Point values based on site-specific or historical information. Examples include estimated concentrations based on knowledge of plume sources and disposal history, calculations of inferred plume migration, and radioactive decay calculations from wells that are no longer available for sampling.

The highest concentrations of most Hanford Site groundwater contaminants are found in the upper part of the unconfined aquifer, and most monitoring wells are screened accordingly. However, some contaminants have more variable concentrations with depth and are monitored by wells that are deeper or have longer screens. Most of the plume maps in this report are based on the well with the highest concentration in the unconfined aquifer, no matter what depth, thus depicting the full plume footprint.

ECF-Hanford-18-0013 provides details on which wells were included and excluded for each contaminant in each groundwater interest area.

The areal extent of contaminant plumes is calculated from the plume maps for comparisons over time. Plumes are three-dimensional so the volume of contaminated groundwater would provide a more complete comparison. However, because the thickness of contamination is not well defined in many areas (fewer wells are screened in deeper parts of the aquifer), volume calculations would have a high uncertainty.

Groundwater remediation goals (cleanup levels), set as part of the CERCLA process, are often based on water quality standards such as those listed in Table 1-4. However, cleanup levels vary among the groundwater OUs. For consistency in plume maps, contour levels are chosen as follows:

- DWSs and multiples of 10 (e.g., 8, 80, and 800 pCi/L for strontium-90)
- Intermediate levels to help define plumes (e.g., 100 µg/L for carbon tetrachloride)
- Additional contour levels for hexavalent chromium (Cr(VI))
  - Aquatic standard (10 µg/L near the Columbia River)
  - WAC 173-340, "Model Toxics Control Act—Cleanup" (MTCA) (48 µg/L)
- Other cleanup levels established through Records of Decision (RODs) (e.g., 3.4 µg/L for carbon tetrachloride in the 200-ZP-1 OU, and 4 µg/L for trichloroethene [TCE] in the 100-FR-3 OU)

Wells outside these mapped contour levels are not necessarily free of contamination. The contaminant plumes may be more extensive at lower concentrations. Maps in the main body of this report show all of the data, whether above or below contour levels.

Table 1-4. Water Quality Criteria and Background for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	MTCA[a]	Ambient Surface Water Quality Criteria[b]	Background[c]
Chemical Constituents					
Aluminum	µg/L	50 to 200[d]	16,000	—	7.11
Antimony	µg/L	6	6.4	—	55.1
Arsenic	µg/L	10	0.058	190	7.85
Barium	µg/L	2,000	3,200	—	105
Cadmium	µg/L	5	8.0	Hardness dependent	0.916
Carbon tetrachloride	µg/L	5	0.63	—	NC
Chloride	mg/L	250[d]	—	230	15.63
Chloroform[e]	µg/L	80	1.41	--	NC
Chromium	µg/L	100[f]	24,000/48[f,g]	10[g]	2.4[f]
cis-1,2-Dichloroethene	µg/L	70	16	—	NC

Table 1-4. Water Quality Criteria and Background for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	MTCA[a]	Ambient Surface Water Quality Criteria[b]	Background[c]
Copper	µg/L	1,300[h] 1,000[d]	640	Hardness dependent	0.81
Cyanide (free)	µg/L	200	4.8	5.2	NC
Fluoride	mg/L	4	960	—	1.047
		2[d]	—	—	
Iron	µg/L	300[d]	11,200	—	570
Lead	µg/L	15[h]	—	Hardness dependent	0.917
Manganese	µg/L	50[d]	384	—	38.5
Mercury (inorganic)	µg/L	2	4.8	0.012	0.003
Methylene chloride (dichloromethane)	µg/L	5	22	—	NC
Nitrate, as NO_3-	mg/L	45[i]	114	—	26.871
Nitrite, as NO_2-	mg/L	3.31[j]	4.8	—	0.0937
pH	--	6.5 to 8.5[d]	—	6.5 to 8.5	8.23
Selenium	µg/L	50	80	5.0	10.5
Silver	µg/L	100[d]	80	—	5.28
Sulfate	mg/L	250[d]	—	—	47.014
Tetrachloroethene	µg/L	5	21	—	NC
Thallium	µg/L	2	0.16	—	1.67
Total dissolved solids	mg/L	500[d]	—	—	258
1,1,1-Trichloroethane	µg/L	200	16,000	—	NC
Trichloroethene	µg/L	5	0.54	—	NC
Uranium (total)	µg/L	30	48	—	9.85
Zinc	µg/L	5,000[d]	4,800	Hardness dependent	21.8
Radionuclides[k, l]					
Antimony-125 (β^- emitter)	pCi/L	300	—	—	0.00695
Beta particle and photon activity	pCi/L	4 mrem/yr[l]	—	—	8.08
Carbon-14 (β^- emitter)	pCi/L	2,000	—	—	NC
Cesium-137 (β^- emitter)	pCi/L	200	—	—	0.00843

Table 1-4. Water Quality Criteria and Background for Hanford Site Groundwater Contaminants

Constituent	Unit	DWS	MTCA[a]	Ambient Surface Water Quality Criteria[b]	Background[c]
Cobalt-60 (β^- emitter)	pCi/L	100	—	—	0.0225
Iodine-129 (β^- emitter)	pCi/L	1	—	—	0.0000939
Ruthenium-106 (β^- emitter)	pCi/L	30	—	—	0.00368
Strontium-90 (β^- emitter)	pCi/L	8	—	—	0.0146
Technetium-99 (β^- emitter)	pCi/L	900	—	—	0.83
Total alpha (excluding uranium and radium)	pCi/L	15	—	—	2.70
Tritium (β^- emitter)	pCi/L	20,000	—	—	119

a. MTCA; individual risk based concentration levels as derived from WAC 173-340-720, "Groundwater Cleanup Standards."

b. Criteria for chronic exposure in fresh water, WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington," "Toxic Substances," Table 240(3).

c. DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*. 90th percentile, as corrected.

d. Secondary standards are not associated with health effects, but associated with taste, odor, staining, or other aesthetic qualities.

e. Standard is for total trihalomethanes.

f. Total chromium.

g. Hexavalent chromium.

h. Action level.

i. 45 mg/L as NO_3^- is equivalent to 10 mg/L of nitrate as nitrogen.

j. 3.3 mg/L as NO_2- is equivalent to 1 mg/L of nitrite as nitrogen.

k. The DWS for beta/photon emitters is a cumulative dose of 4 mrem/yr. The activity concentrations shown are the single-nuclide-derived concentrations equivalent to a 4 mrem/yr dose from each radionuclide.

l. Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose greater than 4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr.

—	=	no criterion
β^- emitter	=	radionuclide is a beta-emitting isotope and contributes to sum-of-fractions dose for comparison to the 4 mrem/yr DWS
DWS	=	drinking water standards
MTCA	=	Model Toxics Control Act (WAC 173-340, "Model Toxics Control Act—Cleanup")
NC	=	not calculated in DOE/RL-96-61

In addition to DWSs (Table 1-4), radionuclide concentrations may also be compared with DOE-derived concentration standards and risk-based protectiveness values for human health and the environment (Table 1-5).

Unless otherwise specified, maps showing chromium include total chromium in filtered samples and Cr(VI) in filtered or unfiltered samples. Dissolved chromium in Hanford Site groundwater is nearly all hexavalent (Chapter 7 of WHC-SD-EN-TI-302, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*; Appendix C of DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*), so filtered total chromium data effectively represent Cr(VI) concentrations.

Table 1-5. Derived Concentration Standards, 4 mrem Effective Dose Equivalent Concentrations, and Risk-Based Concentrations for Hanford Site Radionuclides

Radionuclide	100 mrem/yr Derived Concentration Standard[a] (pCi/L)	4 mrem Effective Dose Equivalent[b] (pCi/L)	Risk-Based Concentration[c] (pCi/L)	
			10^{-6} Risk	10^{-4} Risk
Antimony-125	27,000	1,100	10	1,000
Carbon-14	62,000	2,500	0.72	71.7
Cesium-137	3,000	120	1.71	171
Cobalt-60	7,200	290	3.32	332
Iodine-129	330	13	0.346	34.6
Plutonium-239/240	140	6	0.0603	0.603
Ruthenium-106	4,100	160	727,000	7,270,000
Selenium-79	8,500	340	7.55	755
Strontium-90	1,100	44	0.707	70.7
Technetium-99	44,000	1,800	19.0	1,900
Tritium	1,900,000	76,000	14.5	1,450
Uranium-234	680	27	0.016	1.67
Uranium-235	720	29	0.071	7.14
Uranium-238	750	30	0.016	1.58

a. Concentration of a specific radionuclide in water that could be continuously consumed at average annual rates and not exceed an effective dose equivalent of 100 mrem/yr. From Table 5 of DOE-STD-2011, *Derived Concentration Technical Standard*.

b. Concentration of a specific radionuclide in water that would produce an effective dose equivalent of 4 mrem/yr if consumed at average annual rates. The EPA DWSs for radionuclides listed in Table 1-4 were derived based on a 4 mrem/yr dose standard using maximum permissible concentrations in water specified in NBS Handbook 69, *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure*. The 4 mrem/yr dose standard listed in this table was calculated using a more recent dosimetry system adopted by the U.S. Department of Energy (see footnote a). The values shown in this column are not comparable to DWS and should not be used for that purpose.

c. From EPA, 2012, *Preliminary Remediation Goals for Radionuclides (PRG)* website (November 2014 update). These values represent the concentration of each radionuclide that an individual could consume over a lifetime that would not result in one additional cancer in a population of 1,000,000 and a population of 10,000, respectively. Potentially complete exposure pathways for all radionuclides include ingestion and immersion. Concentrations of tritium and carbon-14 also includes inhalation; the inhalation pathway is incomplete for all other radionuclides.

Nitrate concentrations in this document are expressed as the NO_3^- ion. The federal and state DWS for nitrate is 10 mg/L expressed as NO_3-N. Converting NO_3-N values to nitrate as the NO_3^- ion requires multiplying the NO_3-N value by 4.43. Nitrate data provided in this report are the converted values and, as such, the DWS is equivalent to approximately 45 mg/L as NO_3^-. Similarly, nitrite is expressed as the NO_2^- ion.

The time-series plots presented in this report use open symbols to show values below laboratory detection limits. These results are typically plotted as values that represent the detection limit for chemical parameters and reported values for radiological parameters (negative values are converted to zero). Discussion of increasing or decreasing trends is generally based on qualitative observations, not statistical evaluations.

When potential anomalies are encountered during reviews of analytical data or water-level measurements, a formal request for data review (RDR) process is initiated. Resolution of the RDR may involve a laboratory recheck, sample reanalysis, review of sampling documents, or other actions. Data are corrected (and flagged as "G") if possible; otherwise, the data are flagged as "Y" (suspect), "R" (reject), or with another flag, as appropriate. The "R"-flagged data are excluded from plume maps in this report. The "Y"-flagged data are excluded from plume maps or trend plots if they create an unsupported interpretation of the data. Data excluded from plume maps are listed in ECF-Hanford-18-0013. All of the data with appropriate data quality flags are included in the data available through the interactive online version of this report and are available in the Hanford Environmental Information System (HEIS) database via the Environmental Dashboard Application (EDA).

1.6 River Corridor

The Columbia River flows through the northern Hanford Site before turning south toward the city of Richland. The region along the shoreline is known as the River Corridor, where former operations included nine nuclear reactors in the 100-BC, 100-K, 100-N, 100-D, 100-H, and 100-F Areas. Fabrication of nuclear fuel assemblies, related research, and maintenance services were located in the 300 and 1100 Areas. Six groundwater OUs (Table 1-6) and 15 source OUs are associated with the River Corridor.

Contaminant sources in the 100 Area included cooling water conditioning and handling facilities, underground pipe leaks, liquid and solid waste disposal sites, and unplanned releases (UPRs) (surface spills). During reactor operation, large volumes of effluent were discharged in the 100 Area, transporting contamination into the aquifer, creating large groundwater mounds, and modifying groundwater flow. Sources of 300 Area groundwater contamination included routine disposal of liquid effluent associated with nuclear fuel assembly fabrication prior to the 1980s and research involving irradiated fuel processing. The 1100-EM groundwater interest area and the adjacent region include a variety of onsite and neighboring offsite land uses. Numerous municipal, industrial, and agricultural activities affect groundwater quality in this area.

DOE has focused efforts on remediating River Corridor waste sites to protect the river and reduce the active cleanup footprint to 120 km^2 (75 mi^2) in the center of the Hanford Site (Section 1.5 of DOE/RL-2009-10, *Hanford Site Cleanup Completion Framework*). By the end of 2017, 94% of the waste sites in the River Corridor had been remediated or classified as not requiring remediation.

The 1100-EM-1, 100-FR-3, and 300-FF-5 Groundwater OUs have RODs for final action. The CERCLA decision process is under way to develop RODs for final remedial action at the other groundwater OUs (Table 1-6).

Table 1-6. River Corridor at a Glance

	100 Area	300 Area and Outlying Regions	Former 1100 Area
Groundwater Operable Units	100-BC-5, 100-KR-4, 100-NR-2, 100-HR-3[a], and 100-FR-3	300-FF-5 (includes 300 Area Industrial Complex, 618-10/316-4 and 618-11 facilities)	Formerly 1100-EM-1
Type of Operations	Nine former nuclear reactors and associated facilities	Historically used for nuclear fuel fabrication and research	Historically used for vehicle maintenance and solid waste disposal
Types of Waste Sites	Inactive liquid waste cribs, ditches, trenches, retention basins, pipelines, and spills; four RCRA sites	Inactive liquid waste cribs, trenches, ponds, pipelines, and spills; one RCRA site	Former waste sites remediated
Waste Site Remediation	93% complete overall[b]	96% complete overall[b]	100% complete
Groundwater Remediation	Final action in progress in 100-FR-3; interim actions in progress in 100-KR-4, 100-HR-3, and 100-NR-2	Final action in progress	Complete
CERCLA Status	ROD for final remedial action signed in 2014 for 100-FR-3; RI/FS underway for others	ROD for final remedial action signed in 2013	ROD for final remedial action signed in 1993; remedial action goals met
Fast Facts	There is a total of 82 km (51 mi) of Columbia River shoreline. River stage is controlled by Priest Rapids Dam. The Hanford Reach National Monument was established in 2000.		

a. The 100-HR-3 Operable Unit includes the 100-D and 100-H Areas.

b. Percent of sites that have been interim or final remediated or classified as not requiring remediation.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

RCRA = *Resource Conservation and Recovery Act of 1976*

RI/FS = remedial investigation/feasibility study

ROD = Record of Decision

1.6.1 River Corridor Hydrogeology

Figure 1-4 illustrates the general stratigraphy and hydrogeologic units of the 100 Area. The vadose zone comprises the sand and gravel of the Hanford formation and, in some locations, a portion of Ringold Formation unit E. The vadose zone can be less than 1 m (3 ft) thick near the Columbia River and up to 30 m (100 ft) thick beneath inland portions of the River Corridor.

The unconfined aquifer consists of the saturated sand and gravel of Ringold unit E and portions of the Hanford formation. This aquifer is thickest in the western portion of the region (up to 50 m [160 ft] in 100-BC) and thinnest near the 100-H and 100-F Areas, where in some places it is less than 2 m (6 ft) thick. The base of the unconfined aquifer is one of a number of fine-grained layers of the Ringold Formation (informally called the Ringold upper mud unit [RUM]), which contains numerous distinct layers of sand and gravel. These layers typically contain water and act as local confined or semiconfined aquifers. A series of confined aquifers within and beneath the RUM is present through most of the 100 Area. Basalt aquitards and basalt-confined aquifers are present beneath the Ringold Formation.

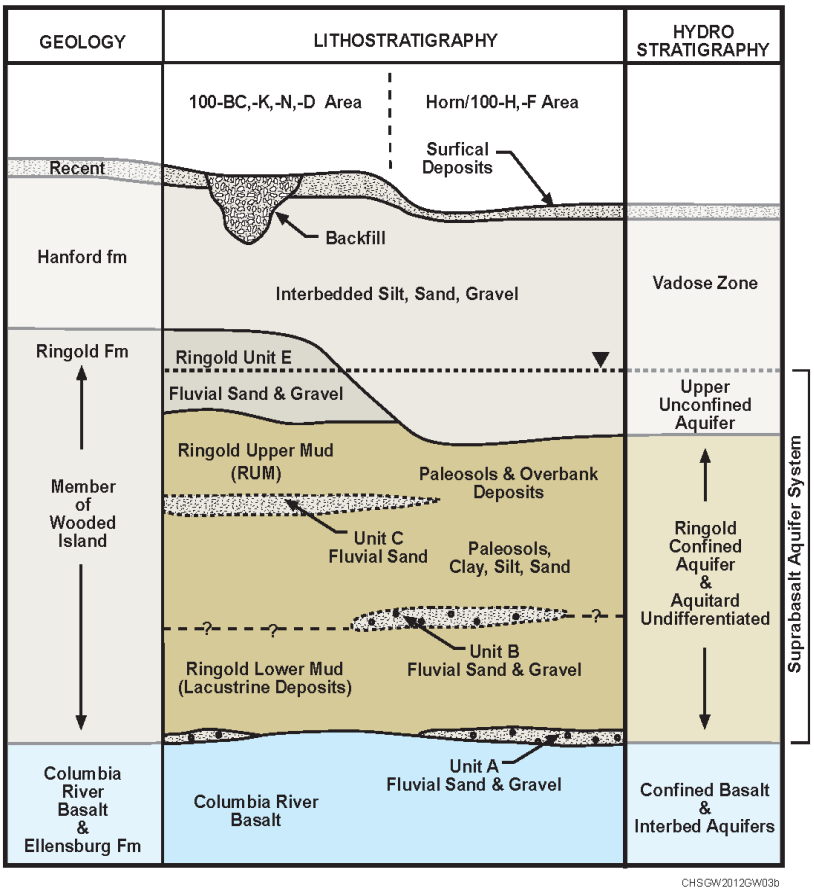


Figure 1-4. River Corridor Geology

Beneath the 300 Area and 1100-EM, the vadose zone is entirely within the gravel and sand of the Hanford formation, and the unconfined aquifer includes the lower portion of the Hanford formation. Beneath the 300 Area, the undulating contact between the bottom of the saturated Hanford formation and the underlying Ringold unit E sediment reveals paleochannels that act as preferential groundwater flow paths. Saturated Hanford formation sediment is much more permeable than the underlying Ringold sediment. The Ringold lower mud unit underlies Ringold unit E. Coarse-grained sediments of Ringold unit A underlie the lower mud in some areas; elsewhere, the mud overlies basalt.

Groundwater in the unconfined aquifer generally flows from upland areas in the west toward the regional discharge area north and east along the Columbia River. In the 100 Area, the local groundwater flow is generally toward the Columbia River, although groundwater P&T systems in 100-KR and 100-HR alter this flow pattern locally to capture contaminants.

1.6.2 River Corridor Groundwater Contamination

The predominant contaminants in River Corridor groundwater include Cr(VI), nitrate, and strontium-90. Table 1-7 lists maximum concentrations detected in River Corridor wells and aquifer tubes during 2017. The 2017 data did not result in any major reinterpretations of the nature and extent of groundwater contamination. The Executive Summary of this report provides general plume maps, and Chapters 2 through 8 provide details.

In 2017, DOE continued to remediate groundwater in the River Corridor. Cleanup actions included P&T systems for Cr(VI) in the 100-HR-3 and 100-KR-4 OUs, a permeable reactive barrier (PRB) for strontium-90 in the 100-NR-2 OU, enhanced attenuation of uranium in the 300-FF-5 OU, and monitored natural attenuation (MNA) in the 100-FR-3 OU.

As defined in the current interim action RODs, the remedial action target concentration for Cr(VI) in 100-KR and 100-HR groundwater is 20 µg/L in compliance wells. The surface water quality standard is 10 µg/L. The remedial action goal was based on an estimated 1:1 mixing of groundwater (and the associated Cr(VI)) with river water at the Columbia River discharge boundary. Based on further assessment during development of RI/feasibility studies (FSs) for RODs for final remedial action, it has been determined that the 1:1 mixing ratio cannot be universally applied. In the RODs for final remedial action, there will be no assumption of dilution, and the cleanup level for Cr(VI) entering surface water will be 10 µg/L.

1.6.3 Shoreline Monitoring

Groundwater is a potential pathway for contaminants to enter the Columbia River. Groundwater flows into the river from seeps located above the water line and through areas of upwelling in the river bed. Hydrologists estimate that groundwater currently flows from the Hanford unconfined aquifer to the Columbia River at a rate of approximately 0.000012 m^3/s (0.00042 ft^3/s) (Section 4.1 of PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River*). For comparison, the average flow of the Columbia River is approximately 3,400 m^3/s (120,000 ft^3/s).

The rise and fall of the Columbia River creates a zone of interaction of surface water and groundwater. River stage varies over short (e.g., hourly) and long (e.g., seasonal) intervals in response to natural influences and the operation of dams on the Columbia River system. High river stage during 2017 was generally from April to early July, with a maximum at the river gauge station below Priest Rapids Dam occurring on June 22, 2017. River stage at the Hanford Site remained high for a longer period of time than typical, as illustrated by the river gauge at the 100-D Area shown in Figure 1-5. Low river stage in 2017 occurred in September and October, which is typical.

During the high river-stage period, the groundwater elevation increases in response to the change in boundary condition, and the gradient toward the river decreases. Transport of river water into the aquifer during high river stage can affect contaminant concentrations. As would be expected, longer-term changes in the river stage produce more extensive and longer-lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. These relationships are most evident in wells located closest to the Columbia River, although apparent relationships are also evident in water levels and sample data obtained from wells hundreds of meters inland of the shoreline.

DOE samples water near the Columbia River shoreline via near-shore monitoring wells, natural seeps, and aquifer tubes. Aquifer tubes are small-diameter, flexible tubes that are screened on one end. Most aquifer tube sites include two or three individual tubes monitoring at different depths, from about 1 to 8 m (3 to 26 ft) below ground surface (bgs). They are not constructed as resource protection wells (as specified in WAC 173-160) and are not used as compliance points for groundwater decisions. The results of aquifer tube sampling for 2017 are included with groundwater results in Chapters 2 through 8 and Chapter 10 of this report.

Table 1-7. Maximum Concentrations of Selected Constituents in Hanford Site Groundwater, 2017

Contaminant	Water Quality Standard	100-BC		100-FR		100-HR-D		100-HR-H		100-KR		100-NR		300-FF		1100-EM and Offsite	200-BP		200-PO		200-UP	200-ZP
		Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs		Wells	ATs	Wells	ATs	Wells	Wells
Radionuclides (pCi/L)																						
Carbon-14	2,000									28,500	141	325	58.9				185		44.2		38.8	
Cesium-137	200							2.31									766					
Gross alpha	15					13.2		14.6		103	2.95	61.8	5.11	168	1.78		27.1		27.2	3.05	51.6	4.98
Gross beta	50					83.8		264		30,800	10.3	24,200	5,220	22.9	7.36		15,500	23.3 Q	1,580 A	30.2	1,460	2,470
Iodine-129	1																9.67		10.9	1.13	22.8	1.46
Plutonium-239/240	6																14.4					
Strontium-90	8	43.6 Q	18.3	120	7.03 Q	27.8	4.51	25.8	7.98 B	15,600	5.19	14,200	2,390				511		13.3		19.1	2.12
Technetium-99	900						113	506		510	27.5	42.4		105			36,000		5,360 A	82.2	13,700 Q	11,100
Tritium	20,000	11,900	8,450	3,030		9,440	2,470	2,770		3,810,000	5,980	282,000	157,000	570,000	588		53,700	2,330	311,000	23,400	218,000	60,300
Metals (µg/L)																						
Antimony (filtered)	6			0.47 B		0.83 B		2 BDC		2.1 BD	0.71 B	5.06 B	9.6 B	6 BC			5.14 B	0.81 B	7.17 B		5.1 B	
Antimony	6			0.14 B		0.86 B		4.7 BDC		3.56 B	0.77 B	7.7 B	4.1 B	2.1 BDC			8.52 B	0.63 BC	9.25 B		5.8 B	0.58 B
Arsenic (filtered)	10			5.1		4.35 CB		9.08		6 B	4.1 B	29.8	25.6	13.5 B			22	4.28 B	11.9 B		14	4.83 B
Arsenic	10			4.9 B		4.32 CB		8.64		8 B	4.1 B	30	28.5	11 C			23	4.36 B	14.6 B		11	18.3 B
Chromium (filtered)	100			34		181		150 D		641	28 CQ	127 D	9.39	10.2			37.5	8.7	108		224	46
Chromium	100			62.4 D		192		1,970 D		678	34 CQ	128 D	8.74	14.9			1,550 D	10.8 A	296 D		216	463
Chromium, hexavalent (filtered)	48	50	39	44	4.5	730	21	140	30	840	29	130	1.9				8	8.8	87	3.2 B	201	
Chromium, hexavalent	48	49	39	42	5.3	720	21	140	29	840	35	120					30	8.8	110	3 B	180	160
Selenium (filtered)	50			3.8 B		2.4 BD		5.3 B		5.6 BA	0.5 B	3.73 B		4.5 B			23.4	2 B	14.9		12	7.07
Selenium	50			4.8 BD		2.62 B		4.01 B		2.47 B	0.34 B	3.83 B	0.24 B	4.6 BD			114	2.02 B	15.5		12	7.59
Uranium (filtered)	30			14	0.662	4.4 D		119 D		13.8	5.8	7.5 D		1,200			1,220 D	2.1	63 N		69	2.2 D
Uranium	30	5.4	3.6 D	14		4.6 D	1.28	142 D		13.2	6	8.86	5.93	8,450 D	175 DQ	34.5	2,970 D	2.1	61 N		5,000 D	4.3 D
Anions																						
Cyanide (total) (µg/L)	None									6.5							1,520 D		5.9 C		3.9 BC	688
Cyanide (free) (µg/L)	200																66					66*
Cyanide (amenable) (µg/L)	200																380					348*
Fluoride (µg/L)	4,000	236 B	64.8 B	808	217 B	370 D	78 BD	710 D	160 D	420 D	226 B	1,200 D	800 D	3,400 D	250 D	1,640	1,300 D	308 B	9,200 D	230 D	684 D	5,000 D
Nitrate (mg/L)	45	16.4 D	21.9 D	204 D	23.7 D	40.7 ZDH	21.2 D	217 D	20.4 D	102 D	26.6 D	319 DA	70.8 D	186 DQ	48.7 D	150 D	1,590 D	12.6	120 D	35.9 D	221 D	620 D
Nitrite (µg/L)	3,300			1,280		558 D		394 D		591 BD	187 BD	2,170 D	282 D	680 B			6,900 ZNDH		591 BD	164 BDN	427 BD	2,100 BDZH

Table 1-7. Maximum Concentrations of Selected Constituents in Hanford Site Groundwater, 2017

Contaminant	Water Quality Standard	100-BC		100-FR		100-HR-D		100-HR-H		100-KR		100-NR		300-FF		1100-EM and Offsite	200-BP		200-PO		200-UP	200-ZP
		Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs	Wells	ATs		Wells	ATs	Wells	ATs	Wells	Wells
Volatile Organic Compounds (µg/L)																						
Carbon tetrachloride	5																				412	1,960 DT
cis-1,2-Dichloroethylene	70													191 D								
Trichloroethene	5	5.49		13						8.1	2.2	0.3 J		1.99 J		0.46 J			1.73		15	16 D

Notes: Table lists the highest values for 2017 for each groundwater interest area, excluding data flagged as suspect ("Y"), under review ("F"), or rejected ("R"), and data from perched zones.

Blank cells indicate not detected or not analyzed.

Blue-shaded cells indicate that the contaminant exceeded the listed water quality standards. Orange-shaded cells indicate that the contaminant exceeded the derived concentration standard for that isotope (Table 1-5).

*Inconsistent with other cyanide data.

AT = aquifer tube

TCE = trichloroethene

Laboratory and review qualifiers:

A = discrepancy in chain-of-custody paperwork

B (inorganics, anions) = analyte was detected at less than the quantitation limit

B (organics, radionuclides) = analyte was detected in both the sample and the quality control blank

C = analyte was detected in both the sample and the quality control blank

D = analyte was reported at a secondary dilution factor

E = reported value is estimated because of interference

H = laboratory holding time exceeded before the sample was analyzed

J (organics) = estimated value; analyte was detected at less than the quantitation limit

N = spike and/or spike duplicate recovery is out of limits

Q = associated quality control sample is out of limits

Z = miscellaneous circumstances exist; additional information available in database comment fields

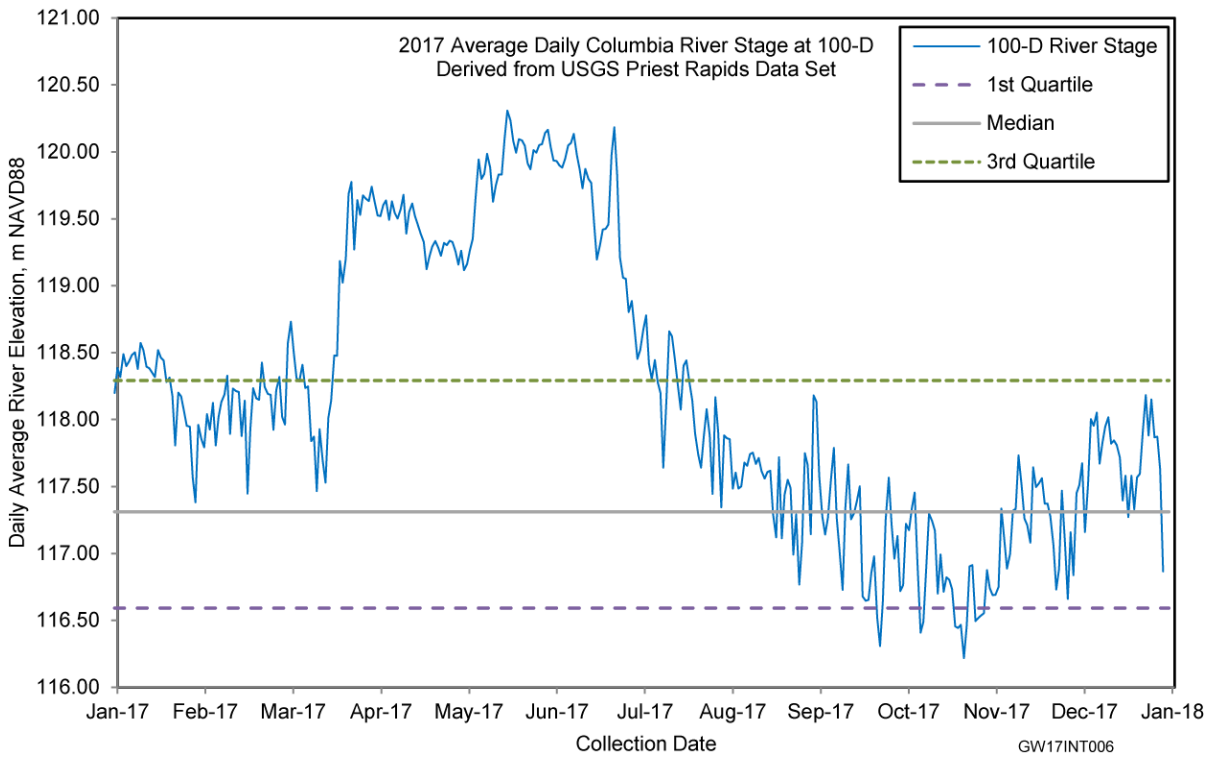


Figure 1-5. Daily Average River Stage at the 100-D Area, 2017

Seeps represent groundwater leaving the aquifer in areas where the groundwater elevation remains higher than the river elevation for some period of time. DOE collects samples from seeps in the fall when the river stage is low. Table 1-8 lists the concentrations of contaminants of interest in seeps along each shoreline segment sampled in fall 2017. Strontium-90 was detected above the DWS in one seep in the 100-N Area, and uranium exceeded the DWS in a 300 Area seep. Cr(VI) exceeded the aquatic standard in the 100-BC and 100-D Areas.

DOE monitors Columbia River water by collecting samples along several cross-river transects and at near-shore river locations adjacent to groundwater plumes where humans and aquatic biota are potentially exposed to contaminants. The surveillance data provide a historical record of radionuclides and chemicals in the environment. The results of water quality monitoring along the shoreline and in the river are presented annually in the Hanford Site environmental report (DOE/RL-2017-24, *Hanford Site Environmental Report for Calendar Year 2016*). Publication of the 2017 environmental report follows the publication of this groundwater report, so the 2016 results are summarized here. Table 1-9 lists the results of composite samples collected upstream and downstream of the Hanford Site. Except for tritium and uranium isotopes, radionuclides were undetected in upstream and downstream samples. The maximum tritium activity downstream of the Hanford Site (near the city of Richland) was 49.2 pCi/L compared to 26.8 pCi/L upstream of the Hanford Site. No other radionuclides were statistically higher in downstream samples in 2016. Chromium was undetected in river transect samples on the Hanford Site.

Table 1-8. Hanford Site Contaminants in Columbia River Seeps, 2017

Seep[a]	Sample Date	Cr(VI) (µg/L)		Nitrate (mg/L)		Sr-90 (pCi/L)		Tritium (pCi/L)		Uranium (Unfiltered) (µg/L)	
300 Seep 42-2	9/21/2017	1.5	U	22.5		—		4,590		48.7[b]	
B Seep 38-3	11/6/2017	4.7		6.06		0.0498	U	210	U	1.65	
B Seep 39-2	11/2/2017	12		4.05		1.86		1,920		2.77	
D Seep 110-1	9/19/2017	12		21.3		2.24		2,100		3.09	
F Seep 187-1	10/4/2017	1.9	B	2.79	D	—		—		—	
F Seep 207-1	9/26/2017	3.7	B	12.8	D	0.0131	U	351		2.65	
F Seep 211-1	11/14/2017	2.2	B	11.2		0.034	U	37.2	U	2.28	
H Seep 144-1	10/12/2017	1.5	U	—		—		—		—	
H Seep 152-2	11/2/2017	2.9	B	7.88		3.67		134	U	2.7	
K Seep 077-1	10/11/2017	1.5	U	0.575	D	-0.108	U	-6.47	U	—	
K Seep 63-1	9/21/2017	7.4		12.5		0.858	U	623		2.1	
K Seep 63-1	9/27/2017	2	B	3.96		0.0037	U	182	U	0.579	
K Seep 68-1	9/21/2017	1.5	U	1.24		0.383	U	-101	U	0.486	
K Seep 82-2	10/16/2017	1.5	U	0.899	B	0.644	U	103	U	—	
N Seep 89-1	11/6/2017	1.5	U	3.3		22.5		78.2	U	0.086	B
Hanford Townsite Seep 28-2	11/7/2017	1.5	U	13.6		—		15,900		—	

Notes: If more than one result is available, the maximum value is listed here.

Yellow shading indicates concentrations greater than a water quality standard.

a. Unofficial common names are listed here. Seep designations in the Hanford Environmental Information System database vary.

b. Approximation of total uranium is based on sum of isotopic results.

Cr(VI) = hexavalent chromium

Data qualifiers:

— = no data

B = less than required detection limit but greater than method detection limit (inorganics)

D = analyte was reported at a secondary dilution factor

U = less than detection limit

Table 1-9. Comparison of Contaminant Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site, 2016

Constituent	Upstream of Hanford Site (Priest Rapids Dam)			Downstream of Hanford Site (Richland)		
	Number of Samples	Number of Detections	Maximum Concentration (pCi/L)	Number of Samples	Number of Detections	Maximum Concentration (pCi/L)
Strontium-90	14	0	0.036 ± 0.035	14	0	0.0304 ± 0.0254
Technetium-99	14	0	0.454 ± 0.467	14	0	0.401 ± 0.322
Tritium	14	12	26.8 ± 72.6	14	14	***49.2 ± 11.5***
Uranium-234	14	14	0.336 ± 0.0649	14	14	0.335 ± 0.0607
Uranium-235	14	4	0.0707 ± 0.0569	14	3	0.0341 ± 0.0236
Uranium-238	14	14	0.273 ± 0.104	14	14	0.253 ± 0.0553
Total of uranium isotopes	—	—	0.68	—	—	0.62

Reference: Tables C-6 and C-7 of DOE/RL-2017-24, *Hanford Site Environmental Report for Calendar Year 2016*.

Note: Concentrations shown in bold/italic are higher downstream of the Hanford Site than upstream of the Hanford Site.

1.7 Central Plateau

Four groundwater OUs, numerous source OUs, and one vadose zone OU are associated with the Central Plateau (Table 1-10). The groundwater OUs encompass groundwater contamination from the 200 East and 200 West Areas and regions where this contamination has migrated beyond the Central Plateau.

When the Hanford Site was operational, spent fuel reprocessing, isotope recovery operations, and associated waste management activities occurred in the 200 East and 200 West Areas. Each chemical processing facility generated multiple waste streams and used multiple locations for waste management and disposal. This has resulted in a complex mixture of soil and groundwater contamination that complicates linking specific contaminant sources to specific groundwater contaminant plumes. Waste disposal was associated with the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, and Hot Semiworks Facility in the 200 East Area; and the Reduction-Oxidation (REDOX) Plant, T Plant, U Plant, and Plutonium Finishing Plant (PFP) in the 200 West Area. Additional liquid waste and wastewater was released to ground from ancillary facilities such as the 200 East and West Area steam plants, high-level waste evaporators, and waste processing activities conducted in the single-shell tank (SST) farms.

Table 1-10. Central Plateau Groundwater and Source OUs

OU	OU Type	Description
200-UP-1	Groundwater	Groundwater contamination in the southern 200 West Area and surrounding 600 Area primarily originating from U Plant and REDOX Plant waste sites.
200-ZP-1	Groundwater	Groundwater contamination in the northern 200 West Area and surrounding 600 Area primarily originating from T Plant and Plutonium Finishing Plant waste sites.
200-BP-5	Groundwater	Groundwater contamination in the northern 200 East Area and surrounding 600 Area primarily originating from B Plant and the Hot Semiworks Facility.
200-PO-1	Groundwater	Groundwater contamination in the southern 200 East Area and surrounding 600 Area primarily originating from PUREX Plant.
200-DV-1	Vadose zone	Addresses selected waste sites with deep vadose zone contamination posing a threat to groundwater quality and for which standard surface-based remedies cannot be used. It currently consists of waste sites in the vicinity of WMA B-BX-BY in the 200 East Area and WMA T, WMA TX-TY, and WMA S-SX in the 200 West Area, although other waste sites may be added in the future.
200-PW-1, -3, and -6 200-CW-5	Source	Waste sites in the Inner Area contaminated primarily with plutonium and/or cesium.
200-WA-1 200-BC-1	Source	Majority of the waste sites in the 200 West Inner Area and the BC Cribs and Trenches.
200-EA-1 200-IS-1	Source	Majority of the waste sites in the 200 East Inner Area and pipelines in the Inner Area.
200-SW-1	Source	Central landfill (nonradioactive).
200-SW-2	Source	Burial grounds and landfills located in the Inner Area.
200-CB-1	Source	B Plant canyon and associated waste sites.
200-CP-1	Source	PUREX Plant canyon and associated waste sites.
200-CR-1	Source	REDOX Plant canyon and associated waste sites.
200-CU-1	Source	U Plant canyon and associated waste sites.
200-OA-1 200-CW-1 and -3	Source	Waste sites located in the Outer Area.

OU = operable unit
PUREX = Plutonium-Uranium Extraction (Plant)
REDOX = Reduction-Oxidation (Plant)
WMA = waste management area

The 200 Areas contain seven SST waste management areas (WMAs): A-AX, B-BX-BY, and C within the 200 East Area; and S-SX, T, TX-TY, and U within the 200 West Area. The UPRs (e.g., leaks or overfill events) associated with some of the tanks have contaminated the vadose zone, and some of this contamination has migrated to groundwater (e.g., PNNL-11810, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site*).

DOE has finished remediating most of the River Corridor waste sites and is now shifting its focus to the Central Plateau. In 2016 and 2017, DOE drilled characterization boreholes to study deep vadose zone contamination in the 200 East and 200 West Areas. Groundwater and deep vadose zone remediation on the Central Plateau include the 200 West P&T, U Plant and S-SX extraction systems, a deep vadose zone removal action in the B Complex, and a removal action for the 200-BP-5 Groundwater OU in the B Complex.

1.7.1 Central Plateau Hydrogeology

The stratigraphic units beneath the Central Plateau consist of (in ascending sequence) bedrock of the Saddle Mountains Basalt, semiconsolidated sand and gravel of Ringold unit A, silt and clay of the Ringold lower mud unit, semiconsolidated sand and gravel of Ringold unit E, fine- to coarse-grained Cold Creek unit (CCU), and unconsolidated sand and gravel of the Hanford formation (Figure 1-6). Section 2.1 of DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010*, describes these units in detail. The unconfined aquifer is mostly within the Hanford formation and Ringold unit E. The low-permeability lower mud unit forms the base of the unconfined aquifer in most areas. The thickness of the unconfined aquifer varies substantially within the Central Plateau, from over 200 m (656 ft) southeast of the 200 East Area to zero where the aquifer pinches out against mud units and basalt above the water table. The water table is up to 106 m (348 ft) bgs beneath the Central Plateau.

Groundwater beneath the Central Plateau flows generally from west to east, although local conditions may vary. Natural recharge to the unconfined aquifer comes from the Cold Creek Valley, Dry Creek Valley, Rattlesnake Hills, and infiltrating precipitation.

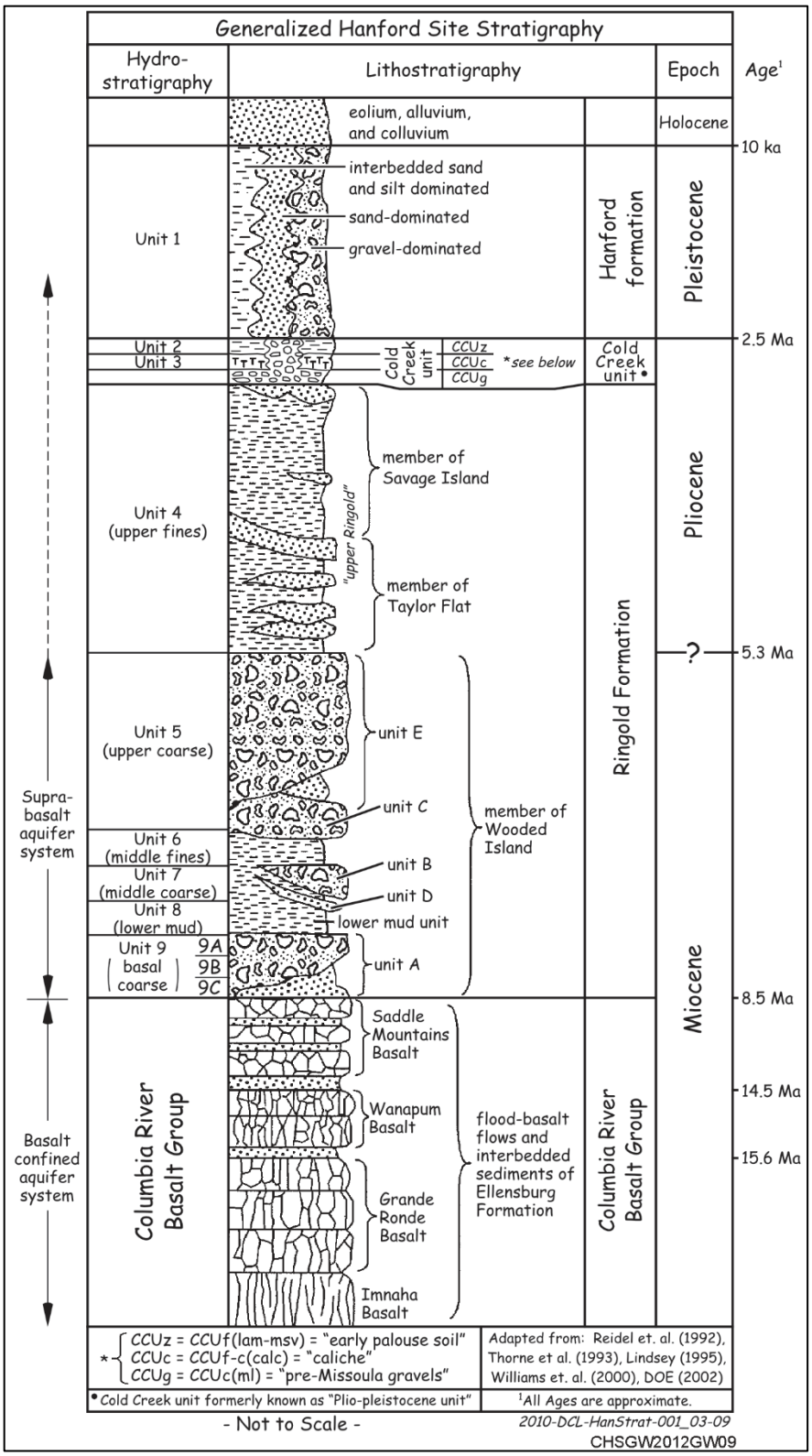
1.7.2 Central Plateau Groundwater Contamination

Central Plateau groundwater contaminants include tritium, iodine-129, nitrate, technetium-99, uranium, Cr(VI), cyanide, strontium-90, and carbon tetrachloride. Liquid effluent facilities such as cribs, ponds, and ditches were past sources of the most widespread contamination. In some cases, contaminants from the SST farms form local groundwater plumes with increasing concentrations, indicating that contaminants continue to enter groundwater from the vadose zone. This situation is being addressed, in part, by P&T systems. To minimize the probability of future leaks, all of the SSTs have been interim stabilized, with the pumpable liquid in each tank being transferred to double-shell tanks (DSTs).

Table 1-7 lists the maximum concentrations of groundwater contaminants in the Central Plateau interest areas in 2017. The Executive Summary of this report provides general plume maps, and Chapters 9 through 12 provide details.

1.8 CERCLA 5-Year Review

Whenever contaminants remain in the environment above levels that would allow for unrestricted use, CERCLA regulations require the regulatory agency to conduct a review of the decision at least every 5 years. DOE issued the most recent report (DOE/RL-2016-01, *Hanford Site Fourth CERCLA Five-Year Review Report*) in 2017. The review covered the period from 2011 through 2015 and includes technical assessments of remedy implementation and performance for Hanford Site OUs engaged in cleanup in the River Corridor and on the Central Plateau.



Note: Complete reference citations are provided in Chapter 13.

Figure 1-6. Central Plateau Geology

1.9 Quality Control

Groundwater data quality is assessed and enhanced by a multifaceted quality assurance (QA)/quality control (QC) program. Appendix E presents a detailed description of the data usability assessment for 2017. This assessment evaluated routine groundwater samples collected during 2017 from wells, aquifer tubes, and seeps and is based on three QA components:

- Field QC samples consist of field blanks, sample replicates (replicate samples sent to the same laboratory), and sample splits (replicate samples sent to different laboratories). Field blanks provide a measure of possible sample contamination during field sampling, transportation, and laboratory operations. Sample replicates provide a measure of precision for field sampling and laboratory analysis. Sample splits provide an interlaboratory comparison of analytical results.
- Laboratory QC samples consist of method blanks, sample duplicates, laboratory control samples/laboratory control sample duplicates, matrix spikes/matrix spike duplicates, and surrogates/surrogate duplicates. Method blanks provide a measure of possible sample contamination during laboratory analysis. Laboratory control samples, matrix spikes, and surrogates provide a measure of analytical accuracy. The various duplicate samples provide a measure of analytical precision.
- Laboratory performance measures consist of groundwater monitoring program blind standards and commercial performance evaluation samples. Both the blind standards and performance evaluation samples provide a measure of laboratory analytical accuracy and bias; the blind standards also provide a measure of laboratory analytical precision.

Based on the results of the data usability assessment, sample results appear to accurately represent target analyte concentrations in Hanford Site groundwater, and the analytical data are sufficient in quantity and quality to be usable for the groundwater monitoring program. The percentage of usable data for the 2017 groundwater monitoring data set is 95.3%, which exceeds the groundwater monitoring requirement of 85% data usability (DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*). Furthermore, 96.9% of the laboratory QC samples met QC requirements. This high rate of acceptable laboratory QC results indicates that laboratory accuracy, precision, and contamination control during sample preparation and analysis support the use of the data set for the groundwater monitoring program. Field QC samples were collected and laboratory QC samples were analyzed at the frequencies required.

The data usability assessment raised some concerns about the analytical results for TOX, nitrite, sulfide, 2-propanol, polychlorodibenzo-p-dioxins and polychlorodibenzofurans, and gross alpha. The assessment also examined the usability of the 2017 cyanide results and concluded that the total cyanide results are generally reliable. The results for cyanide amenable to chlorination are much less reliable.

1.10 Sources of Additional Information

All of the groundwater data presented in this report are available via the internet through the DOE EDA available at https://ehs.hanford.gov/eda/.

The documents referenced in this report are generally available at the DOE Public Reading Rooms around Washington State. Many documents are also available online as part of the Administrative Record, available at http://pdw.hanford.gov/arpir/, or other online libraries. Requests for documents can also be made through interlibrary loan directly to DOE. References to documents in this report are provided as a direct electronic link when possible. If reports are not accessible through the internet, the document number (if applicable) and full title are provided.

Other reports and databases relating to Hanford Site groundwater are cited or summarized in this report as needed, including the following:

- The HEIS database is the main environmental database for the Hanford Site. The database is used to store groundwater chemistry data and other environmental data (e.g., soil and surface water chemistry, soil physical properties, and survey data). HEIS data are available through the DOE EDA.
- Previous Hanford Site groundwater monitoring reports are accessible at the following location: http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.
- Hanford Site environmental reports present the results of monitoring, including groundwater, riverbank seeps, river water, sediment, air, and biota. The reports also describe environmental management performance and report the status of compliance with environmental regulations. These reports are available through the Mission Support Alliance (MSA) website at http://msa.hanford.gov/page.cfm/EnviroReports.
- Tank monitoring and groundwater data, and other information are available from the Pacific Northwest National Laboratory (PNNL) PHOENIX dashboard available at http://phoenix.pnnl.gov/.
- Quarterly RCRA summaries are informal reports or presentations to Ecology after groundwater data associated with RCRA have been verified and evaluated. These reports/presentations describe the status of RCRA sampling and analysis, statistical analysis results, and changes or highlights from the quarter.
- Groundwater remediation reports describe the progress of groundwater remediation systems at the Hanford Site. The annual reports discuss the removal and treatment efficiencies during the year, as well as any operational issues for the groundwater remediation systems. Previous groundwater remediation reports are accessible at the following location: http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.
- DOE recently released RI/FS documents for all of the River Corridor. These documents provide the results of RI studies and make recommendations for remediating the vadose zone and groundwater beneath the River Corridor.

2 100-BC

The 100-BC groundwater interest area includes the 100-BC-5 OU and surrounding region (Figure 1-1). DOE has remediated 93% of the waste sites in 100-BC, and groundwater contaminant concentrations are declining.

2.1 Overview

Two nuclear reactors formerly operated in 100-BC. The B Reactor was the first of its kind and operated from 1944 to 1968. The C Reactor operated from 1952 to 1969.

Groundwater contamination in 100-BC is mainly associated with waste produced by the reactors and related processes. Table 2-1 summarizes key facts about 100-BC; details are provided in DOE/RL-2010-96, Draft A, *Remedial Investigation/Feasibility Study for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units*. Figure 2-1 shows the locations of groundwater monitoring wells and aquifer sampling tubes. Data from monitoring seeps and springs are shown on each of the plume figures presented but were not used for plume development due to their transient nature. Plume mapping details, including descriptions of terms (e.g., Type 1 control point) used in the figure legends, are provided in Section 1.5.

DOE monitors 100-BC groundwater to meet CERCLA and AEA requirements. Previous assessments have not resulted in any interim remedial measures for groundwater. DOE has identified Cr(VI), strontium-90, TCE, and tritium as groundwater contaminants of concern (COCs). Figure 2-2 shows the change in estimated plume areas (in the upper portion of the unconfined aquifer) since 2003. The TCE contamination is limited to a single well screened in the lower part of the unconfined aquifer.

The vadose zone in 100-BC is primarily Hanford formation sand and gravel (Figure 2-3). The water table is at a depth of 18 to 24 m (59 to 79 ft). The upper portion of the unconfined aquifer beneath most of 100-BC is in the highly permeable sediments of the Hanford formation. The lower portion of the unconfined aquifer and the entire aquifer near the Columbia River is present in Ringold unit E sands and gravels. The unconfined aquifer is 32 to 48 m (105 to 158 ft) thick, and the base of the aquifer is a silt/clay-rich unit commonly called the RUM (Chapter 3 of DOE/RL-2010-96, Draft A). Water-bearing RUM units in 100-BC are not contaminated.

Figure 2-4 illustrates the water table contours based on data collected in early March 2017, when the river stage was near average for the year. In the northern 100-BC Area, groundwater flowed to the north and northeast, discharging to the Columbia River. In the southern 100-BC Area, the hydraulic gradient is very low because the water table is in the highly permeable Hanford formation. Groundwater flow varied from east to north-northeast. The average direction of groundwater flow in the southern 100-BC Area is interpreted to be to the northeast based on water-level data and movement of the Cr(VI) plume (Section 3.6.3 of DOE/RL-2010-96, Draft A).

A high river stage in spring and early summer 2017 reversed the hydraulic gradient. Groundwater flowed toward the southeast, and near the shore there was the potential for river water to flow into the unconfined aquifer and mix with groundwater.

Water levels in wells screened in the lower part of the unconfined aquifer, near the bottom of Ringold unit E, define a potentiometric surface that determines a northward flow direction in the deep part of the aquifer. This potentiometric surface is different from the water table (top of the unconfined aquifer), with a more uniform gradient across 100-BC.

Table 2-1. 100-BC Groundwater Conditions at a Glance

Reactor operations: B Reactor, 1944 to 1968; C Reactor: 1952 to 1969				
Groundwater Monitoring				
Contaminant, Water Quality Standard, Units	**Year**	**Maximum Concentration (Well)**	**Plume Area[a] (km^2)**	**Shoreline Impact (m)**
Hexavalent chromium, 48 µg/L/ 10 µg/L[b]	2017	50 (199-B3-47)	0.04/1.3	0/1,546
	2016	58 (aquifer tube C6230)	0.05/1.6	162/1,838
Strontium-90, 8 pCi/L	2017	43.6 (199-B3-52)	0.50	443
	2016	49.7 (199-B3-52)	0.45	251
Trichloroethene, 5 µg/L	2017	5.49 (199-B5-11)	Not calculated[c]	Not calculated[c]
	2016	6.69 (199-B5-11)		
Tritium, 20,000 pCi/L	2017	11,900 (199-B5-2)	0	0
	2016	15,600 (199-B5-2)	0	0
Remediation				
Waste sites: 93% complete.[d] **Groundwater:** No interim actions. Record of Decision for final remedial action is anticipated in 2019.				

a. Estimated area at a concentration greater than the listed water quality standard in the upper part of the unconfined aquifer.

b. 48 µg/L in the upland area (WAC 173-340, "Model Toxics Control Act—Cleanup") and 10 µg/L where groundwater discharges to surface water (WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington").

c. Single well exceeded water quality standard; no plume defined.

d. Sites with status of closed, interim closed, final closed, no action, not accepted, or rejected as of December 31, 2017.

Within the unconfined aquifer, the vertical hydraulic gradient in the southern 100-BC is generally downward, particularly when the water table is dropping in late summer and fall. The vertical gradient in the northern 100-BC is upward, indicative of a groundwater discharge area.

Estimates of average linear velocity of groundwater in the Hanford formation at 100-BC (based on the migration of Cr(VI) peaks) range from 0.77 to 1.2 m/d (2.5 to 3.9 ft/d) (ECF-100BC5-15-0123, *Estimating Chromium Migration Rate by Correlating Concentration Peaks*).

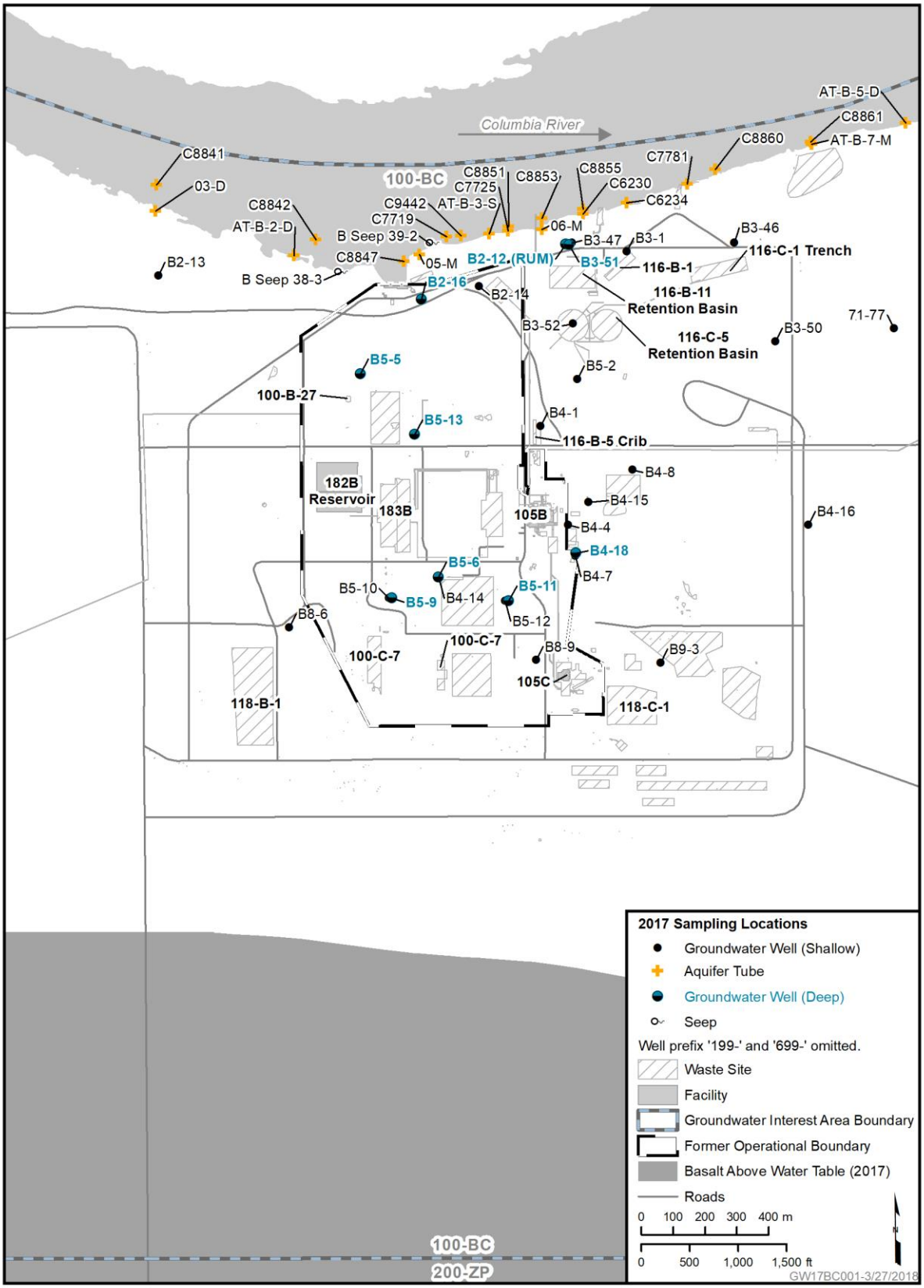


Figure 2-1. 100-BC Sampling Locations, 2017

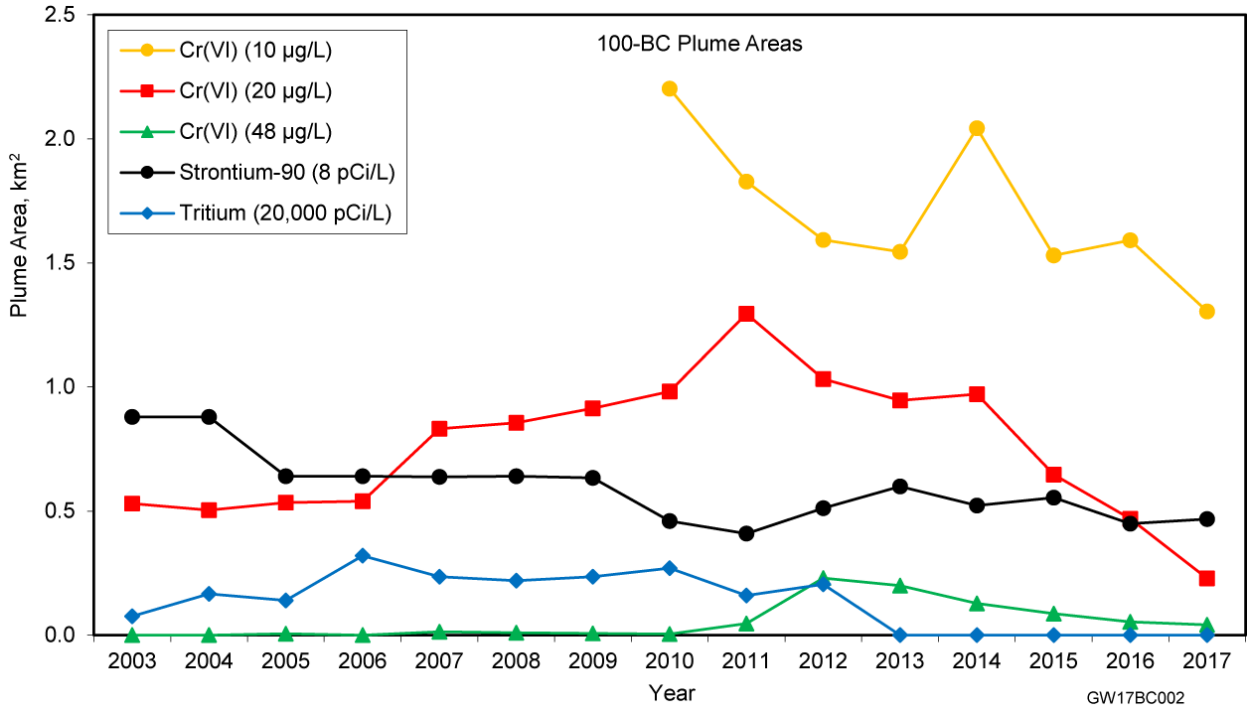


Figure 2-2. 100-BC Plume Areas

2.2 Hexavalent Chromium

Sources of Cr(VI) included cribs near the reactor buildings, trenches and retention basins near the Columbia River, and pipelines from the reactor buildings to the near-river facilities. Other Cr(VI) sources were the sodium dichromate spills at the 100-C-7 and 100-C-7:1 sites in the southern 100-BC and the 100-B-27 sodium dichromate spill site in the northwest.

Movement of Cr(VI) in 100-BC groundwater is influenced by differences in permeability in the Hanford formation and the underlying Ringold unit E. In most of 100-BC, the top of the aquifer includes 1 to 15 m (3 to 49 ft) of the Hanford formation. The Cr(VI) plume moves rapidly through these highly permeable sediments. In the northern 100-BC, the Hanford formation is unsaturated, and the aquifer is entirely within Ringold unit E. Cr(VI) concentrations in the upper part of the aquifer in the northern 100-BC are more stable than in the upper part of the aquifer in the southern 100-BC.

The Cr(VI) plume exceeding the 10 µg/L surface water standard covers a large area at relatively low concentrations (Figure 2-5). The areal extent of the plume in the upper part of the aquifer decreased between 2016 and 2017 at the 10 and 20 µg/L levels. The most notable changes were in the southern part of the plume.

The Cr(VI) trends in 100-BC wells (Figure 2-6) illustrate the migration of the plume. Well 199-B4-14 is located in the southern 100-BC, near the former Cr(VI) source at the 100-C-7:1 site (remediated in 2011 and 2012). The Cr(VI) peak in 2012 was caused by activities related to waste site remediation. The subsequent lower peaks are related to seasonal variations in vertical groundwater flow. Concentrations were below 10 µg/L during both 2017 sampling events. The increase and decrease of concentrations in downgradient wells 199-B4-7 (central 100-BC) and 199-B5-2 (farther north) illustrate downgradient migration of the 100-C-7:1 contaminant plume.

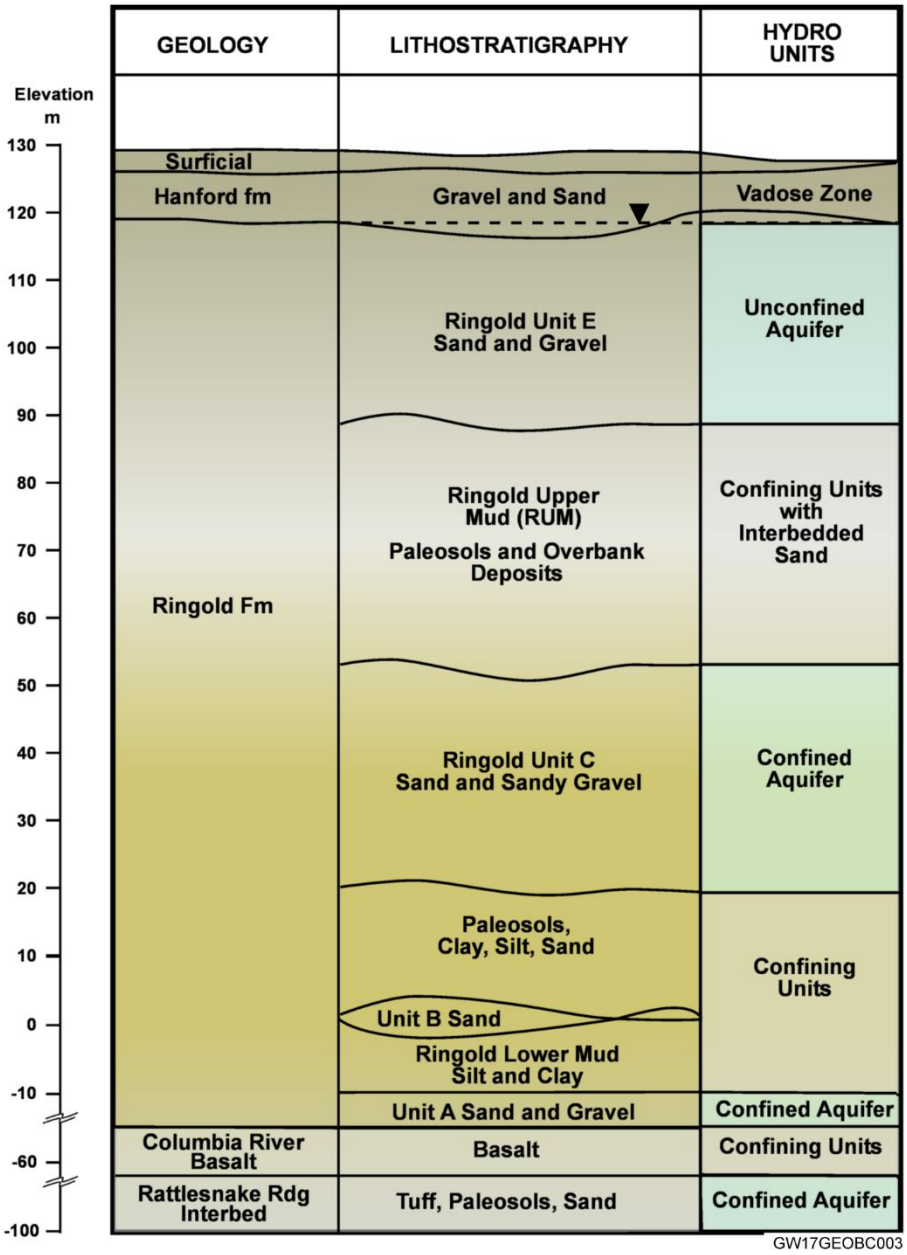
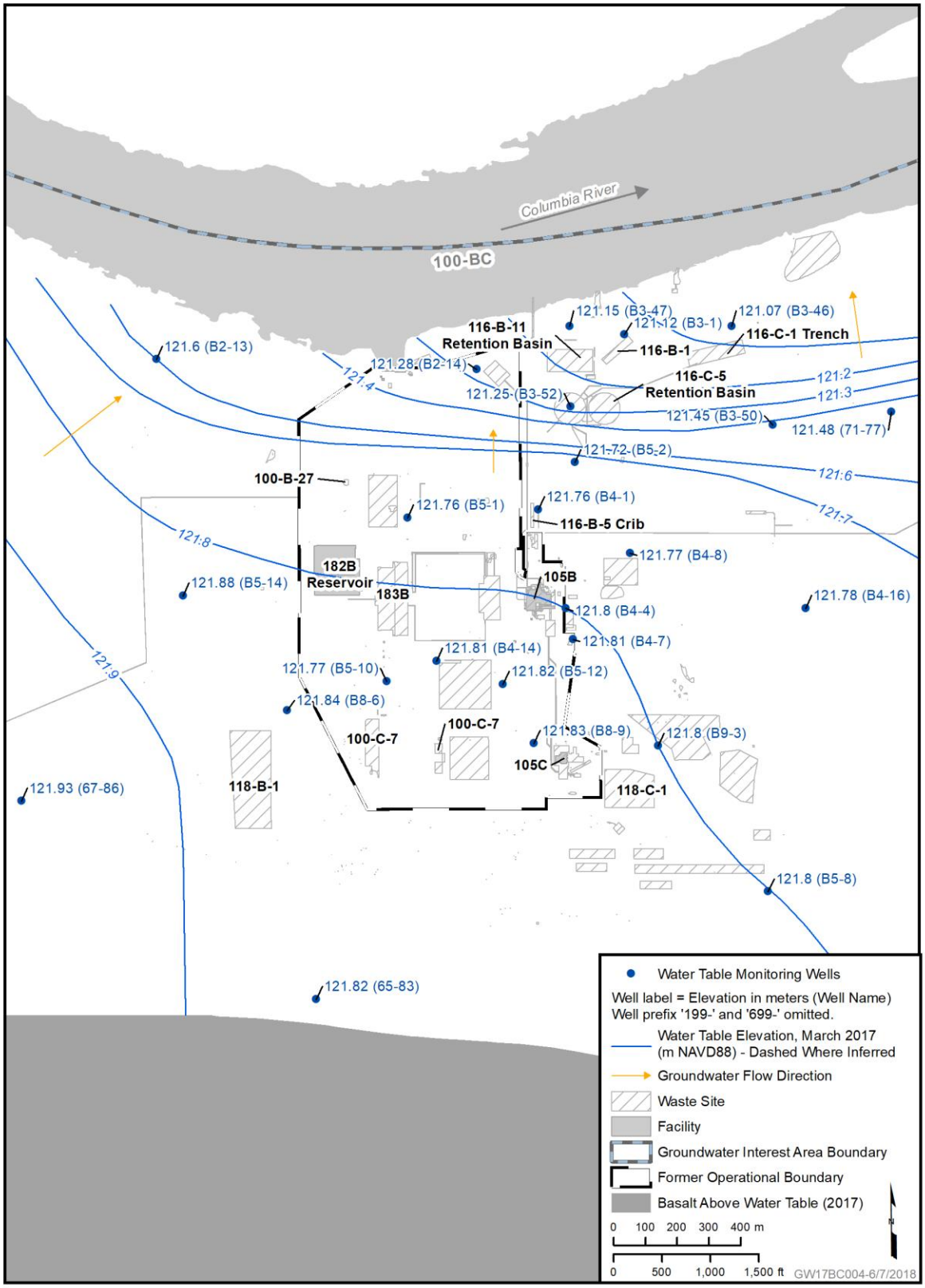


Figure 2-3. 100-BC Geology

The eastern boundary of the Cr(VI) plume at 10 and 20 µg/L reached its maximum extent in 2014 and then began to contract as concentrations declined. In 2017, concentrations continued to decline in well 199-B4-16 and stabilized in well 199-B3-50 (Figure 2-6). Concentrations increased in well 199-B3-46 in June and declined in October. This direct relationship with the water table may suggest some residual contamination in the lower part of the vadose zone near the well.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 2-4. 100-BC Water Table, March 2017

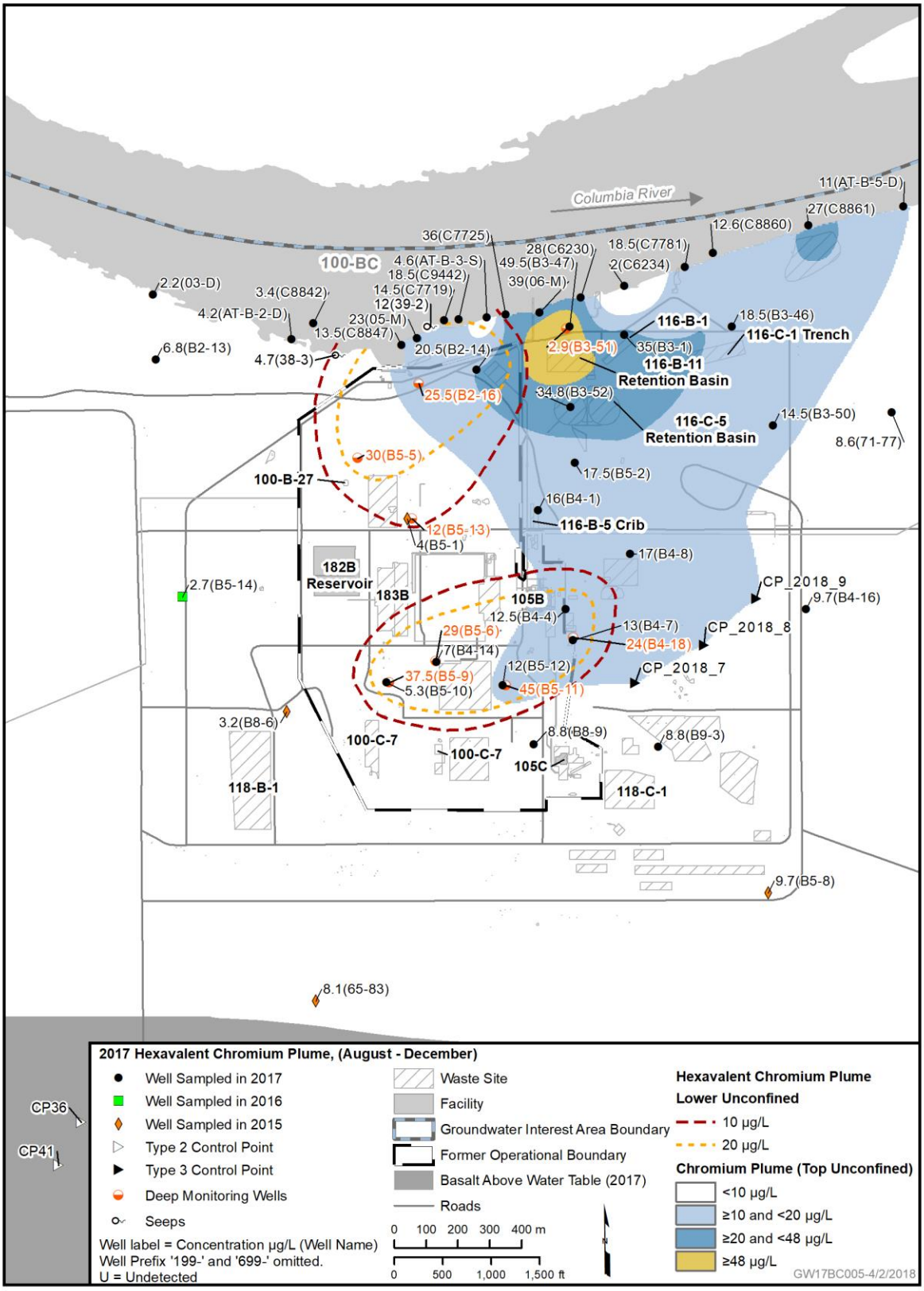


Figure 2-5. 100-BC Cr(VI) Plumes in Upper and Lower Parts of the Unconfined Aquifer, 2017

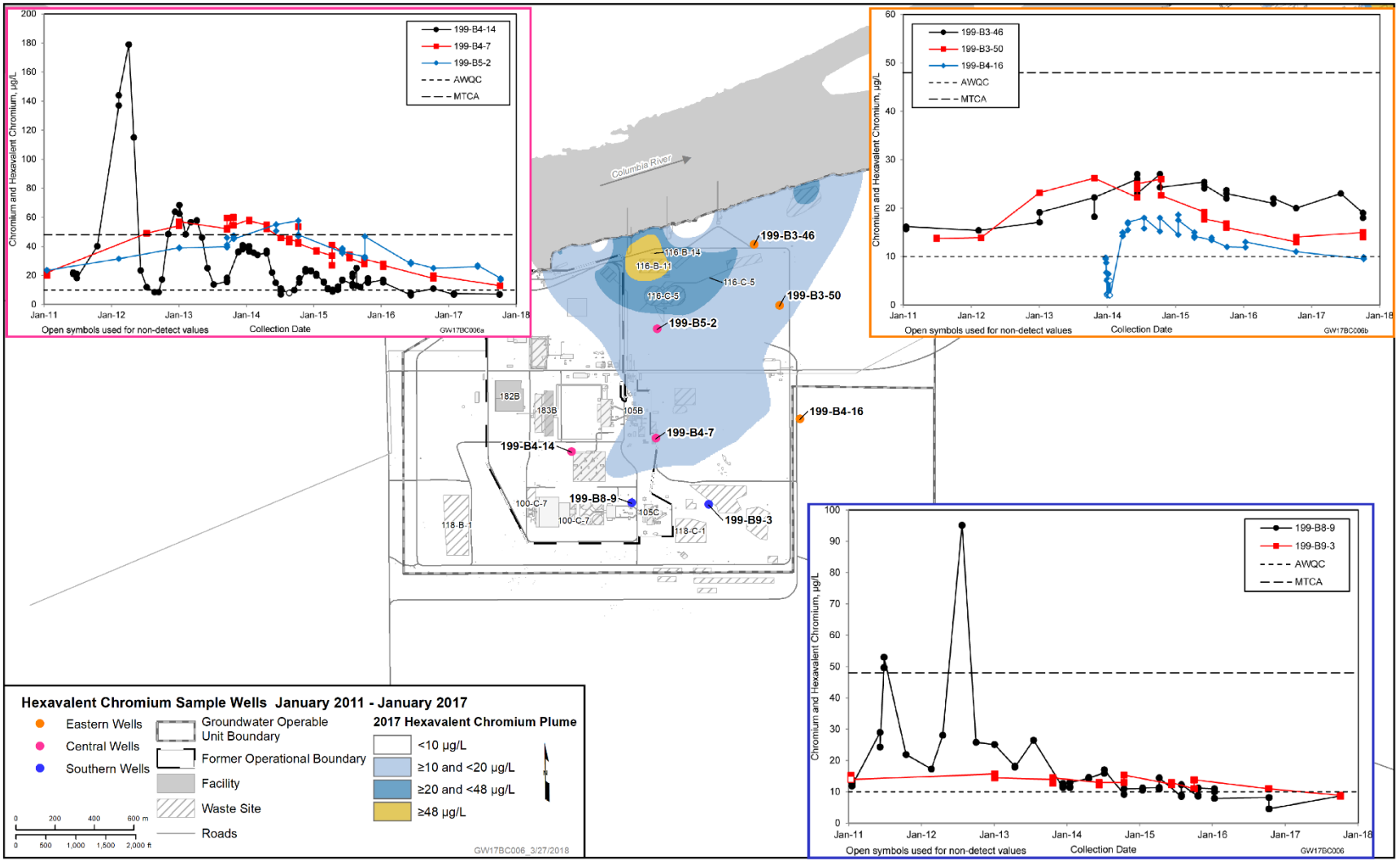


Figure 2-6. 100-BC Cr(VI) Trends in Selected Wells

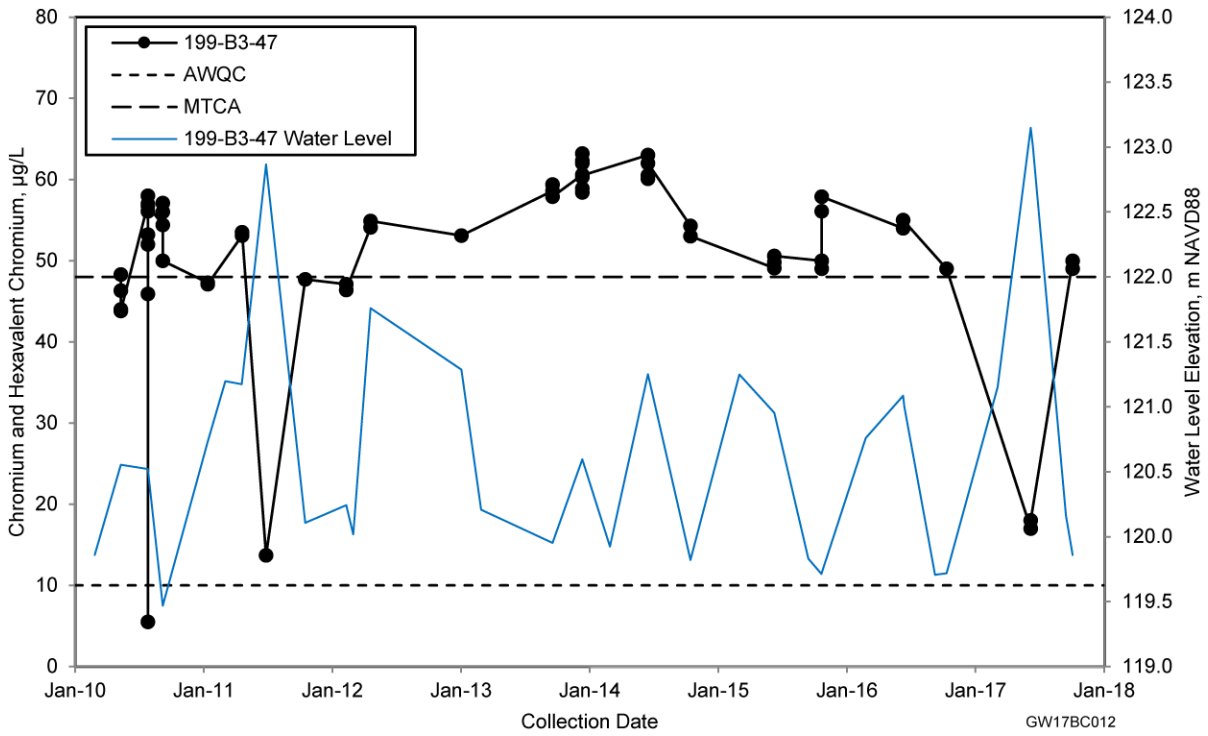


Figure 2-7. 100-BC Cr(VI) and Water Levels in Well 199-B3-47

One well (199-B3-47, screened at the water table and located near the Columbia River) had Cr(VI) concentrations above 48 µg/L in fall 2017 (Figure 2-7). In June 2017, when the river stage was high, the Cr(VI) concentration and specific conductance dropped sharply, indicating mixing with river water. Except when influenced by high river stage, concentrations have remained generally stable in well 199-B3-47 since 2003. Remediation of nearby Cr(VI) waste sites was completed in the late 1990s, and the persistence of Cr(VI) in groundwater may suggest that residual sources remain in the deep vadose zone.

Figure 2-8 illustrates Cr(VI) concentrations in selected wells screened in the lower part of the aquifer in Ringold unit E. Concentrations increased in 2016 and 2017 in well 199-B5-11, reaching a maximum of 45 µg/L. The Cr(VI) distribution in the lower part of the unconfined aquifer (illustrated by dashed lines in Figure 2-5) did not change significantly between 2016 and 2017. The vertical distribution of Cr(VI) in the western 100-BC is attributed to contaminant releases of different ages.

The Cr(VI) exceeds the surface water standard in groundwater approaching the Columbia River but not in the river itself. The highest Cr(VI) concentration in a 100-BC aquifer tube in 2017 was 39 µg/L in tube 06-M. The concentration in tube C6230, which had the highest concentration in 2016 (58 µg/L), was 30 µg/L in 2017. Water samples from the river had Cr(VI) concentrations below the surface water standard (Chapter 4 of DOE/RL-2010-96, Draft A).

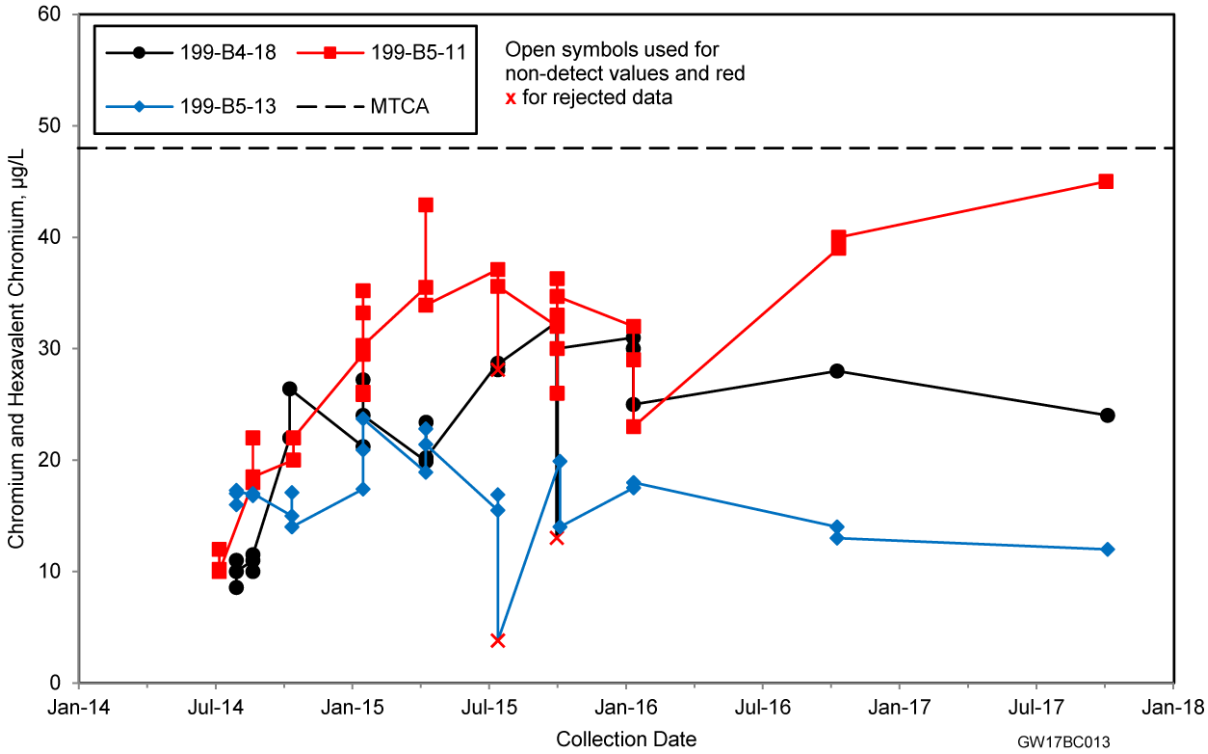


Figure 2-8. 100-BC Cr(VI) in Wells Screened in the Lower Part of the Unconfined Aquifer

2.3 Strontium-90

Liquid effluent containing strontium-90 was disposed to cribs near the reactor buildings and to cribs, trenches, and retention basins in the northeastern 100-BC Area. Figure 2-9 shows an interpretation of the plume based on 2017 data; there was no significant change from 2016.

Strontium-90 contamination in 100-BC groundwater is limited to the upper portion of the unconfined aquifer. Strontium-90 concentrations in well 199-B3-51 (screened at the bottom of the aquifer) are below detection limits, whereas adjacent well 199-B3-47 (screened at the water table) has concentrations above the DWS.

Strontium-90 concentrations in some wells have not declined at the rate expected from radioactive decay and downgradient migration, which may suggest the presence of some residual source in the vadose zone, but the amount appears to be minor. If a significant mass of contamination remained in the lower vadose zone, concentrations would increase when the water table rose (e.g., 100-N [see Section 6.2]). However, during June 2017, when the water table was high, strontium-90 concentrations in 100-BC wells did not increase, indicating that the residual contamination is minor. Figure 2-10 shows the strontium-90 trends in the northern 100-BC Area near some of the remediated waste sites: well 199-B3-46 near the 116-C-1 Trench, well 199-B3-47 near the 116-B-11 Retention Basin and 116-B-14 Trench, and well 199-B3-52 near the 116-C-5 Retention Basin.

Strontium-90 concentrations in several 100-BC aquifer tubes continued to exceed the DWS in 2017 (Figure 2-9), with a maximum of 18.3 pCi/L in tube C6230. Concentrations are typically lower in deeper tubes, reflecting the distribution in the aquifer. This contamination does not extend to the shallow hyporheic zone; strontium-90 was near or below detection limits in 100-BC hyporheic sampling points (HSPs) in 2017.

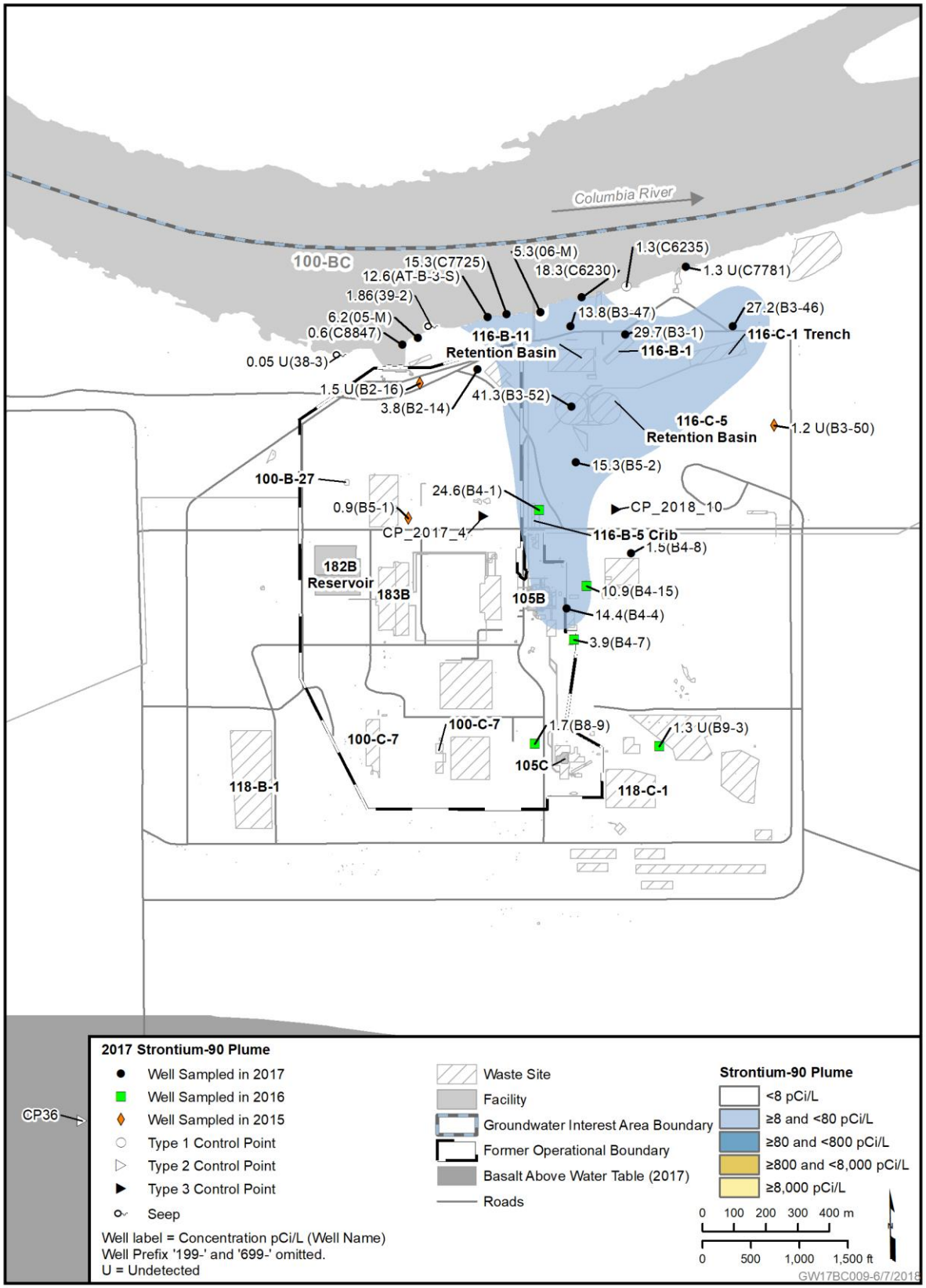


Figure 2-9. 100-BC Strontium-90 Plume, Fall 2017

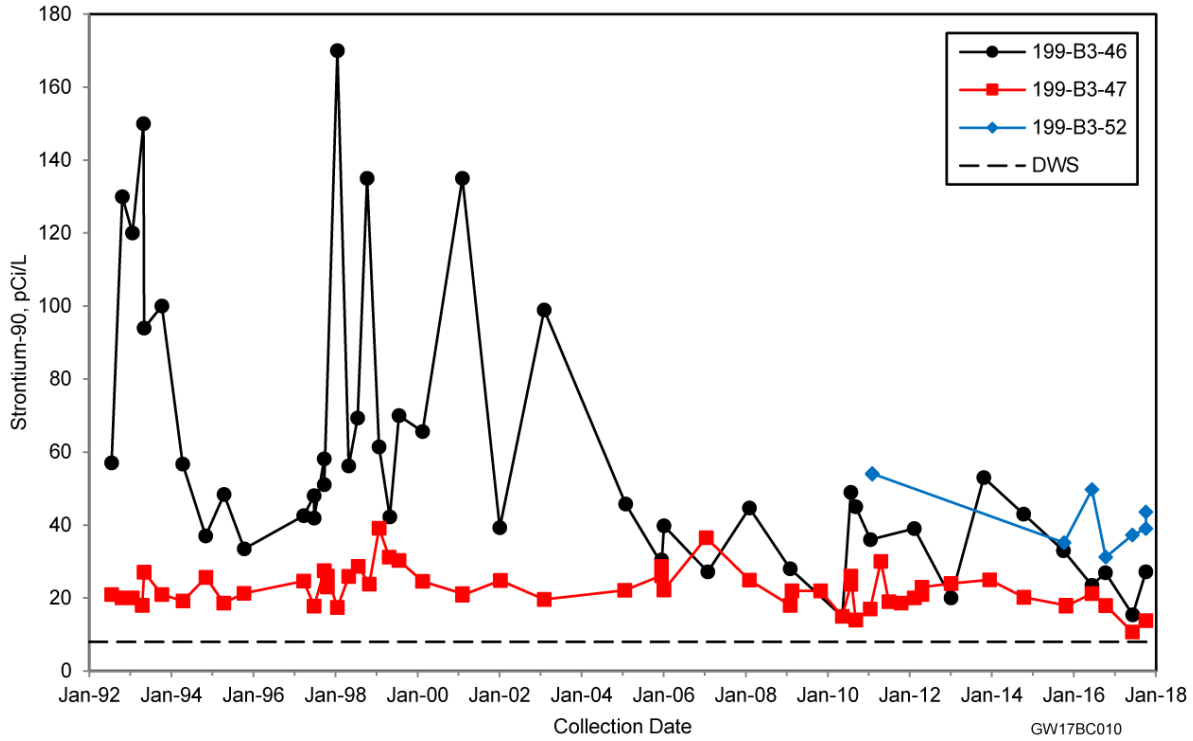


Figure 2-10. 100-BC Strontium-90 Data in Selected Wells

2.4 Tritium

Tritium was present in effluent discharged to former cribs near B Reactor and near the Columbia River. The former 118-B-1 Burial Ground in the southwestern 100-BC was another source of tritium. All of these waste sites have been remediated, although some tritium remains in the vadose zone beneath the 118-B-1 Burial Ground (Section 4.2.4.7 of DOE/RL-2010-96, Draft A).

Tritium concentrations in 100-BC monitoring wells and aquifer tubes have been below the 20,000 pCi/L DWS since 2013 and continued to decline in 2017. The highest concentration was 11,900 pCi/L in well 199-B5-2, located in the northern 100-BC. Downgradient of the 118-B-1 Burial Ground, tritium was undetected in well 199-B8-6.

Vertical characterization data from wells drilled in 2009, 2010, and 2013 indicate that tritium concentrations were generally highest near the top or middle of the unconfined aquifer, and concentrations were lower at the bottom of the aquifer.

2.5 Trichloroethene

During RI characterization drilling in 2010 and 2011, low concentrations of TCE were detected in groundwater samples, with the most persistent detections in the lower part of the unconfined aquifer. The source of this contamination is not known, and its presence in the lower part of the aquifer suggests that it is related to older releases during operational periods when the hydraulic gradient was downward. Only well 199-B5-11 had concentrations above the 5 µg/L DWS (Figure 2-11), at a concentration of 5.49 µg/L in 2017.

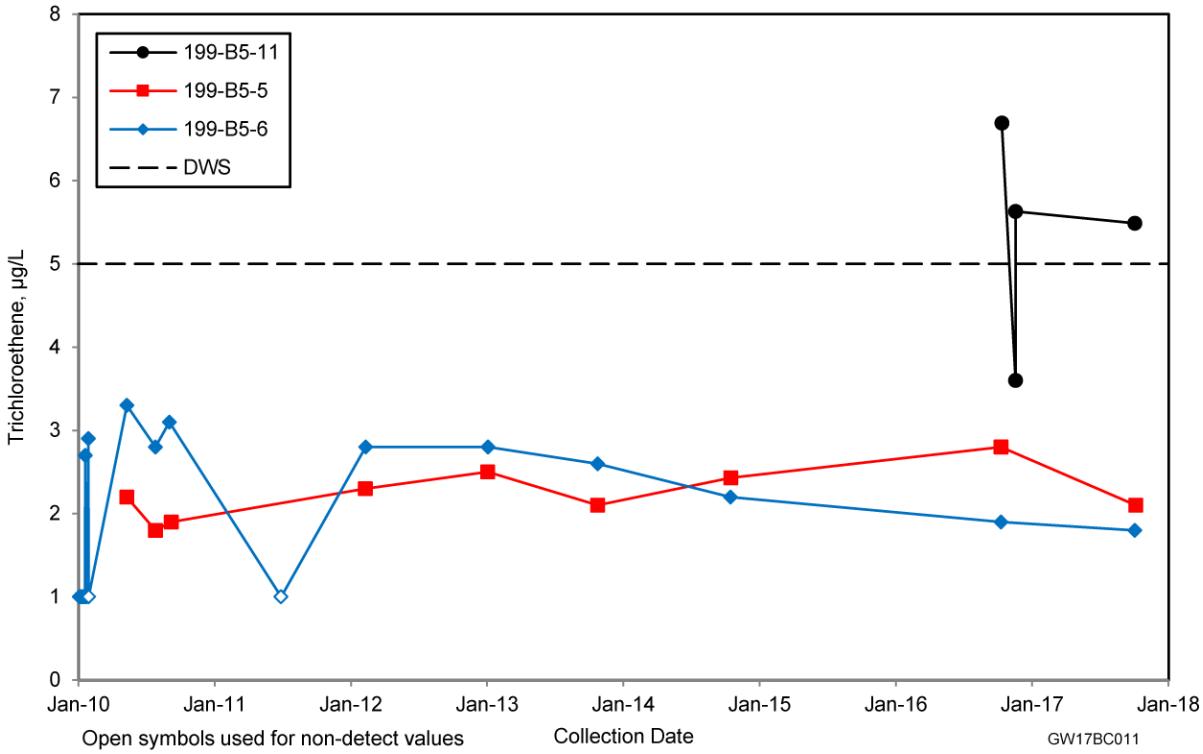


Figure 2-11. 100-BC TCE Data in Selected Deep Wells

2.6 CERCLA Remediation and Monitoring

In 2017, CERCLA activities for 100-BC included routine groundwater monitoring and continued progress on an RI/FS report and proposed plan.

Routine groundwater monitoring was performed in accordance with the SAP (DOE/RL-2003-38, *100-BC-5 Operable Unit Sampling and Analysis Plan*), as modified by TPA-CN-0734, *Tri-Party Agreement Change Notice Form: DOE/RL-2003-38, Rev 2, 100-BC-5 Operable Unit Sampling and Analysis Plan*. The SAP was designed to meet sampling objectives during the period of time after the conclusion of RI studies until a groundwater remediation method is selected and implemented under an upcoming ROD. Wells and aquifer tubes were sampled successfully in 2017.

In 2017, EPA reviewed the Draft A RI/FS report (DOE/RL-2010-96) and proposed plan (DOE/RL-2016-43, *Proposed Plan for Remediation of the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units*). DOE is revising the documents, which will undergo public review in 2018. These documents propose MNA as the preferred remedy for groundwater. A ROD is expected in 2019.

2.7 Atomic Energy Act Monitoring

AEA groundwater monitoring was conducted at 22 groundwater wells and aquifer tubes in the 100-BC groundwater interest area in accordance with the SAP (DOE/RL-2015-56). The primary AEA constituents for 100-BC are strontium-90 and tritium. Wells were sampled in accordance with SAP requirements in 2017.

Concentrations of radionuclides detected in groundwater samples from 23[1] wells and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard in 100-BC. The DWSs for cumulative alpha emitters and uranium mass were not exceeded. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 10 locations in this interest area (Table 2-2). Some of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of institutional controls (ICs) that restrict access to groundwater. CERCLA remedial action decisions will provide longer term protection of the public and the environment.

Table 2-2. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-BC in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr	
	Minimum	Maximum
06-M	4.39	4.39
199-B3-1	12.13	16.3
199-B3-46	7.7	14.41
199-B3-47	5.71	8.83
199-B3-52	18.65	23.53
199-B4-4	8.02	8.02
199-B5-2	10.03	10.03
AT-B-3-S	6.67	6.67
C6230	9.15	9.15
C7725	8.76	8.76

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Note: None of the wells in 100-BC had total effective dose ≥100 mrem/yr, cumulative alpha activity ≥15 pCi/L, or uranium mass concentration ≥30 µg/L.

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

3 100-FR

This chapter presents information for the 100-FR groundwater interest area (Figure 1-1), which includes the former 100-F operational area, the 100-FR-3 OU, and surrounding region (Figures 1-1 and 3-1).

3.1 Overview

One nuclear reactor operated at 100-FR between 1945 and 1965. Groundwater contamination originated from waste sources related to reactor operations and biological experiments that continued until 1976. Table 3-1 summarizes key facts about 100-FR, and additional details about 100-FR history and waste sites are provided in Chapter 1 of DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*. Waste site remediation in 100-FR is 100% complete.

EPA signed a CERCLA ROD in September 2014 (EPA et al., 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*). The selected remedy for groundwater is MNA. The groundwater COCs are nitrate, TCE, Cr(VI), and strontium-90.

DOE monitors 100-FR groundwater to meet CERCLA and AEA requirements. Figure 3-1 shows the locations of groundwater monitoring wells and aquifer sampling tubes. Figure 3-2 depicts how the plume areas have changed over the years.

The vadose zone and the unconfined aquifer in 100-FR comprise mostly Hanford formation sand and gravel (Figure 3-3). Ringold unit E is largely absent in this region, but a remnant of Ringold unit E is interpreted to exist in the southwestern 100-F Area and smaller remnants in the central and eastern 100-F Area. In two locations, Ringold unit E extends above the water table, comprising the entire aquifer thickness.

The base of the unconfined aquifer in 100-FR is the RUM. In two regions south of the 100-F Area, the RUM extends above the regional water table and the unconfined aquifer is absent (Figure 3-1). SGW-61298, *Evaluation of 100-FR-3 Groundwater Monitoring Results from Phase 1 Wells*, contains an updated geologic map and cross sections.

As stated above, the unconfined aquifer is not present in some locations. Where present, the unconfined aquifer may be as thick as 8 m (26 ft), as in the eastern portions of 100-FR. Most of the 100-FR monitoring wells are screened across all (or nearly all) of the aquifer. Two wells are screened in water-bearing units of the RUM, contamination has not been detected in these wells, and the wells are no longer sampled.

Figure 3-4 illustrates the water table in late February 2017, when the Columbia River was at a moderate stage. In the 100-F Area, the gradient was nearly flat, and groundwater flowed generally to the east or southeast. Farther south, groundwater flow is constrained by the areas where the RUM is above the water table. East of the RUM ridge near the river, water flowed out of the river into the aquifer, then toward the southeast. West of the RUM ridge, groundwater flows toward the southeast.

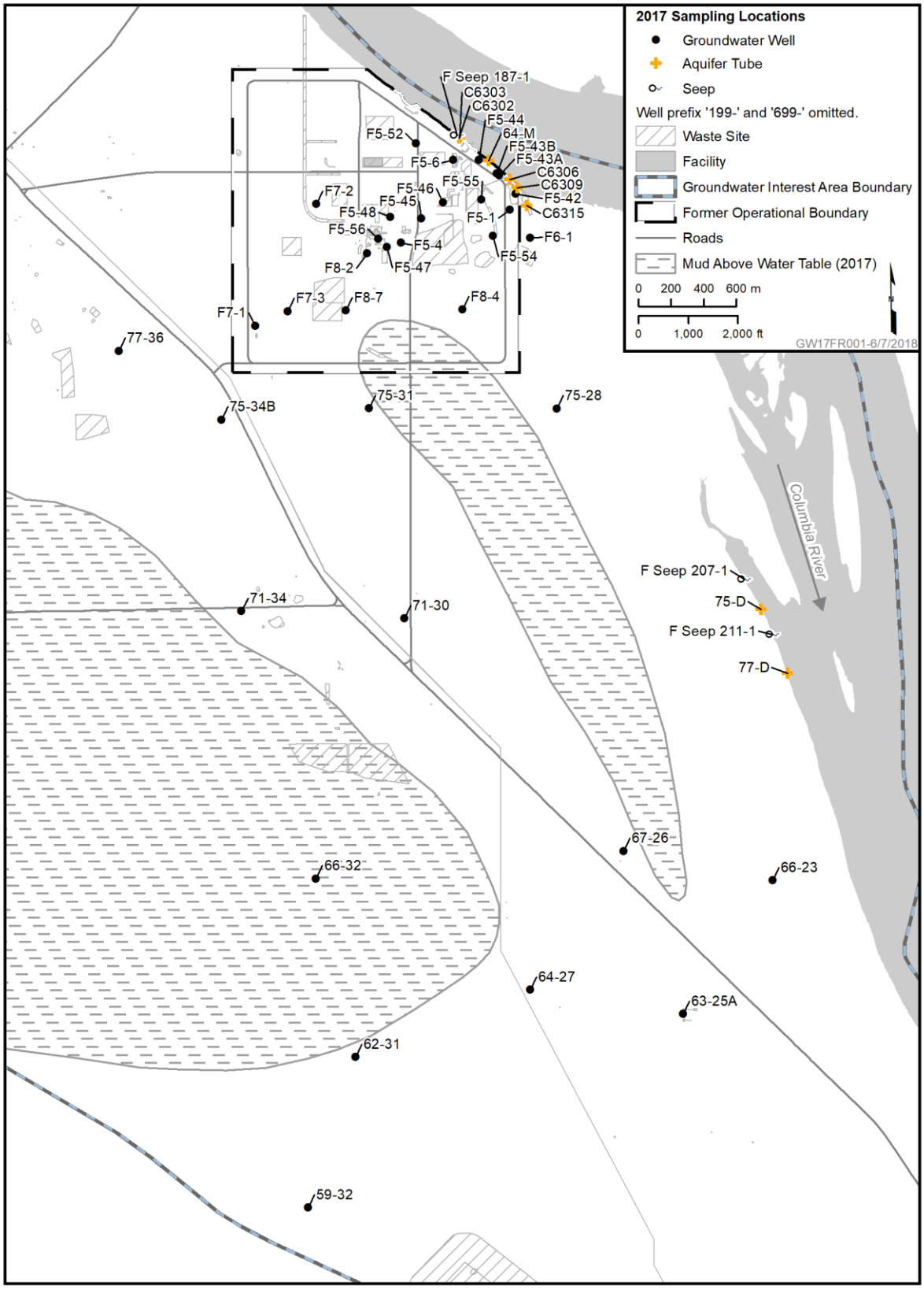


Figure 3-1. 100-FR Sampling Locations, 2017

Table 3-1. 100-FR at a Glance

F Reactor operations: 1945 to 1965 **Biological experiments:** 1945 to 1976				
Groundwater Monitoring				
Contaminants of Concern, Cleanup Level[a]	**Year**	**Maximum Concentration (Well)**	**Plume Area[b] (km^2)**	**Shoreline Impact (m)**
Nitrate, 45 mg/L[c]	2017	342 (199-F5-56)	8.8	0
	2016	124 (199-F8-7)	5.0	0
Hexavalent chromium, 48 µg/L[d]/10 µg/L[d]	2017	44 (199-F5-46)	0/0.28[e]	0/60
	2016	70 (199-F5-46)	0/0.23[e]	0/0
Strontium-90, 8 pCi/L	2017	120 (199-F5-55)	0.13	0
	2016	126 (199-F5-55)	0.13	0
Trichloroethene, 4 µg/L	2017	13 (199-F7-1)	0.90	0
	2016	15 (199-F7-1 and 699-75-34B)	1.3	0
Remediation				
Waste sites in the 100-FR-1 and 100-FR-2 Operable Units: 100% complete.[f] Record of Decision for final remedial action was signed in 2014. Monitored natural attenuation for groundwater.				

a. From EPA et al., 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*.

b. Estimated area at a concentration greater than the listed cleanup level.

c. 45 mg/L (expressed as the NO_3 ion) is an equivalent concentration to the federal drinking water standard for nitrate of 10 mg/L (expressed as NO_3-N). To convert nitrate as the NO_3 ion, the NO_3-N drinking water standard value is multiplied by 4.43.

d. 48 µg/L in the upland area (WAC 173-340, "Model Toxics Control Act—Cleanup") and 10 µg/L where groundwater discharges to surface water (WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington").

e. Plume area >10 µg/L in the 100-F Area. Wells in the western part of the groundwater interest area are not included because the 10 µg/L standard does not apply to inland areas.

f. Sites with status of closed, interim closed, final closed, no action, not accepted, or rejected as of December 31, 2017.

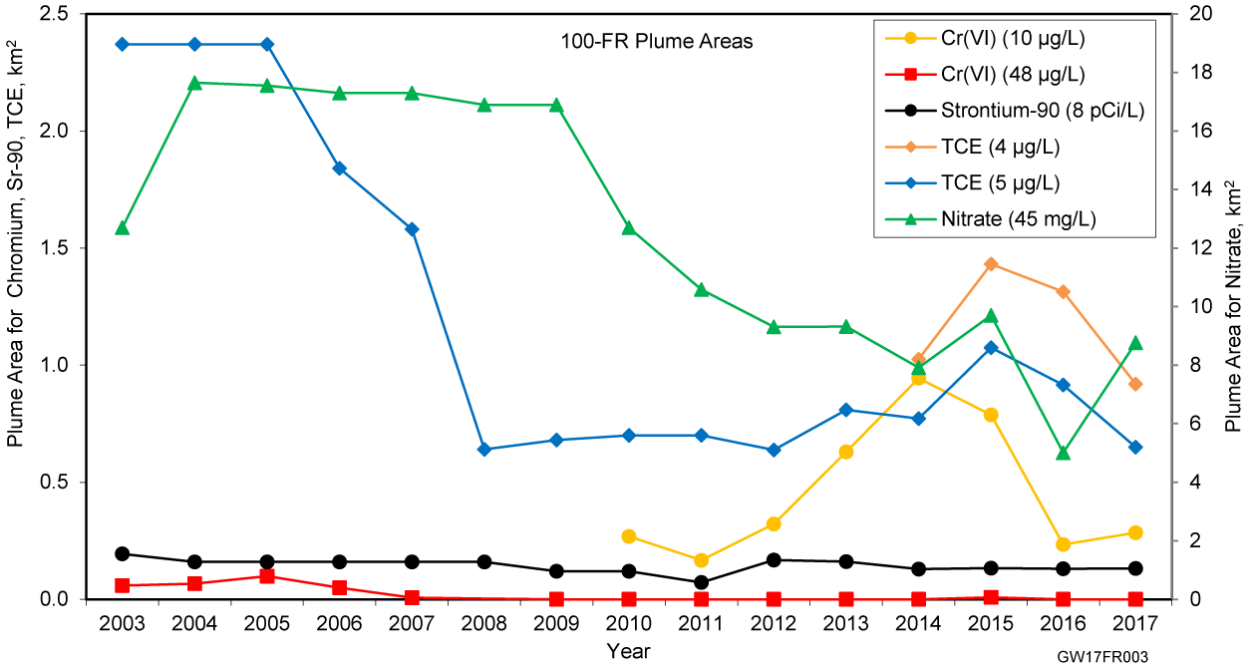


Figure 3-2. 100-FR Plume Areas

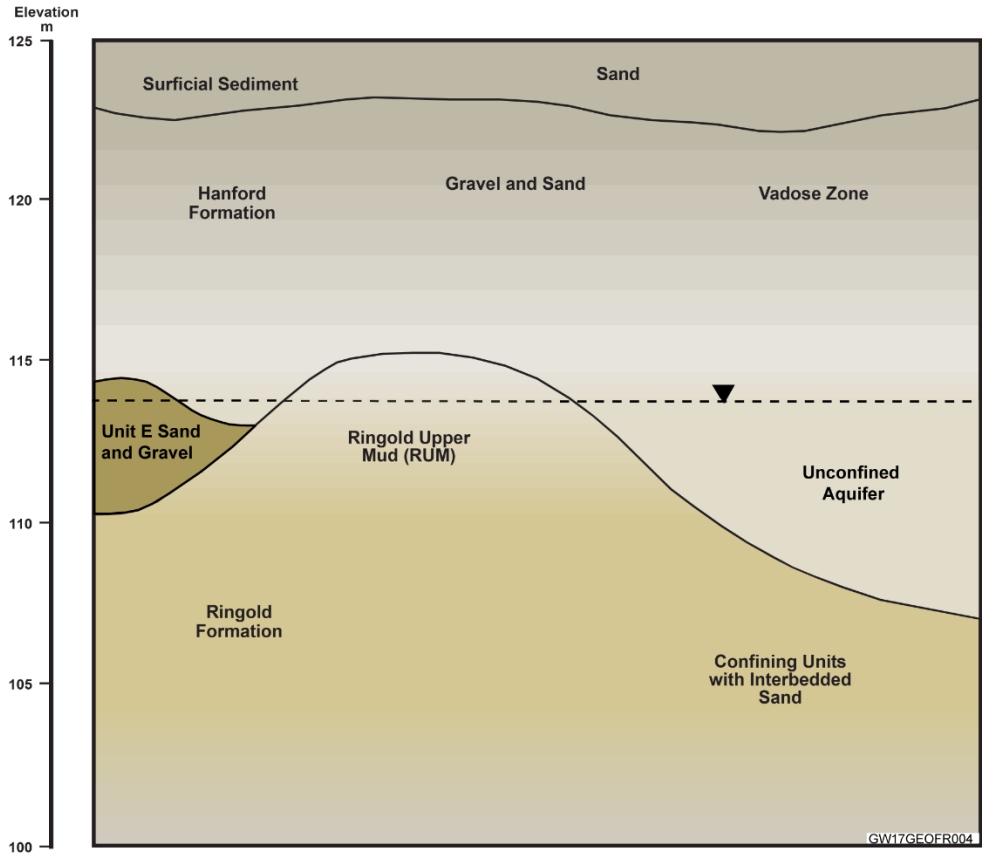
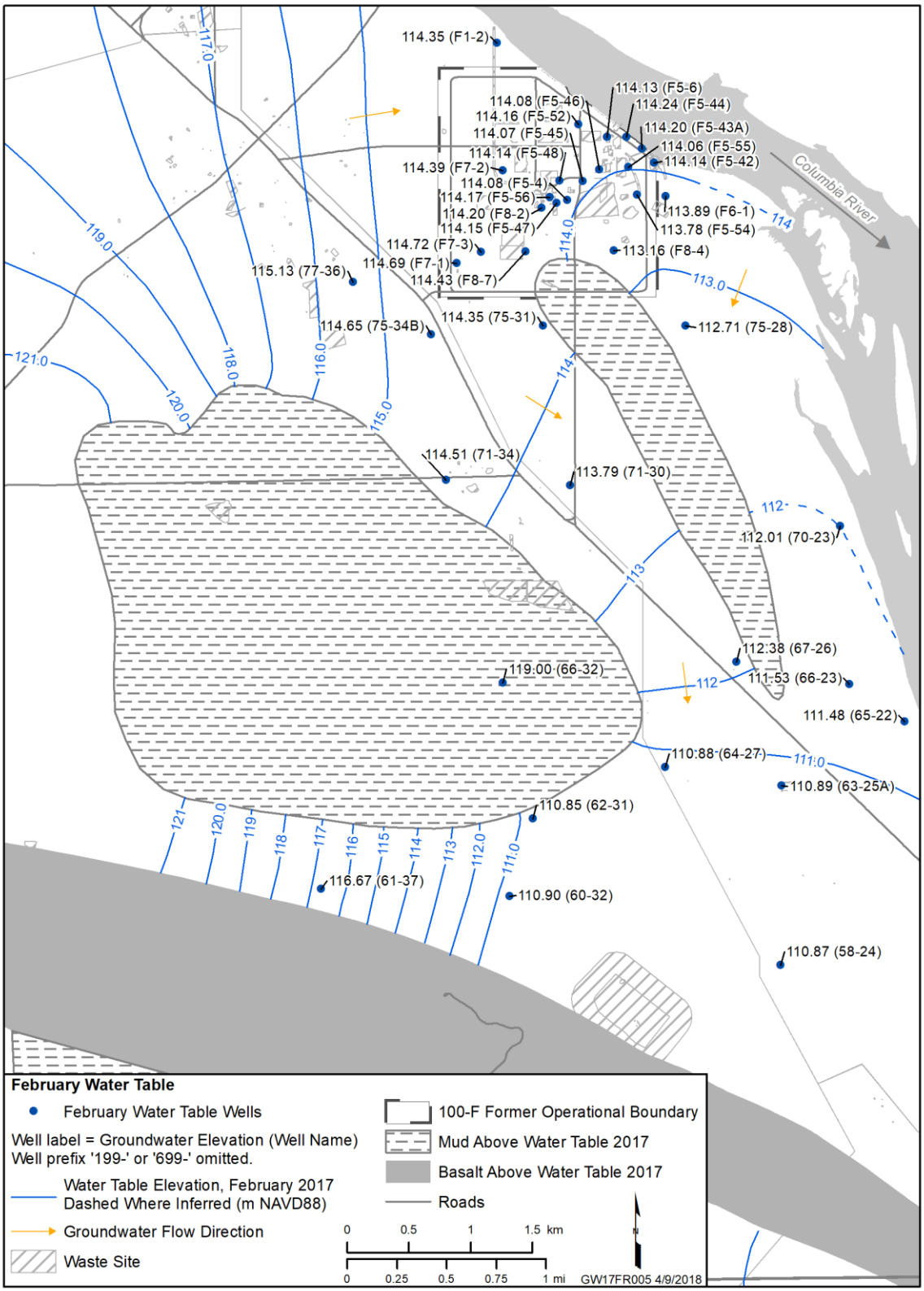


Figure 3-3. 100-FR Geology



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 3-4. 100-FR Water Table, February 2017

3.2 Nitrate

A large nitrate plume with concentrations above the 45 mg/L cleanup level extends from the 100-F Area to the south (Figure 3-5). Past sources of nitrate contamination included the experimental animal farm (e.g., 116-F-9 animal leach trench and 118-F-6 Burial Ground), and various septic tanks and leach fields located throughout the 100-F Area. These sites have been remediated. Pre-Hanford Site agriculture is another apparent source of nitrate contamination, especially in the southern part of the groundwater interest area (SGW-61298).

The interpretation of the 100-FR nitrate plume changed twice in recent years. Before new wells were installed in 2016, nitrate contamination was interpreted as a continuous plume extending from the 100-F Area over 5 km (3 mi) to the south to well 699-62-31 (Figure 3-6 in DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*). After the new wells were installed, the fall 2016 nitrate plume interpretation (Figure 3-8 of DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*) included separate north and south plumes, with concentrations below the 45 mg/L cleanup level in between the plumes.

In 2017, nitrate distribution was interpreted as a single, continuous plume (Figure 3-5), similar to 2015 and earlier years. The change was primarily based on an increase in concentrations in well 699-67-26, which was installed in 2016 and is located 3.0 km (1.9 mi) south of the 100-F Area. The nitrate concentration increased from less than 10 mg/L in 2016 and early 2017 to near or above the 45 mg/L cleanup level in June, August, and October 2017 (Figure 3-6). The higher concentrations are similar to other wells in the southern part of the nitrate plume, which have stable or declining trends. Various lines of evidence suggest that pre-Hanford Site agricultural sources may be responsible for nitrate contamination in the southern part of the OU (SGW-61298).

Nitrate concentrations also increased abruptly in 2017 in well 699-71-34, installed in 2016 and located 1.5 km (0.9 mi) south of the 100-F Area. The concentration increased from 53 to 172 mg/L between February and March 2017, and to 204 mg/L by October 2017 (Figure 3-6). These concentrations were higher than any observed in the 100-F Area during operational years. Additional sampling was conducted for anions, metals, and alkalinity. The changes persisted, but the reason for the increase is unknown.

Nitrate concentrations in most wells in the northern part of the plume are stable or decreasing (Figure 3-7). A notable exception in 2017 was well 199-F5-56, located in the central 100-F Area near the reactor building. Nitrate increased from 115 mg/L in 2016 to 342 mg/L in 2017, the highest nitrate concentration ever recorded in a 100-FR well. Specific conductance also increased, while chloride decreased sharply, which seems to indicate a real change in groundwater chemistry rather than an analytical error. Nitrate concentrations did not increase in nearby wells. The sampling frequency for well 199-F5-56 and nearby wells was increased in 2018 to investigate the change.

Nitrate concentrations are low in wells closer to the Columbia River in the northeastern 100-F Area (Figure 3-8). The water in wells nearest the river has low specific conductance (160 to 250 µS/cm), indicating the influence of inflowing river water, even during periods of low river stage. Thus, groundwater with the highest nitrate concentrations does not flow directly into the Columbia River adjacent to the 100-F Area.

Well 699-66-32, located more than 3 km (2 mi) south of the 100-F Area, monitors perched groundwater that is not connected to the unconfined aquifer. In 2017, the nitrate concentration ranged from 44.3 to 58.4 mg/L. This nitrate is attributed to agricultural sources present in the region before the Hanford Site was established (SGW-61298).

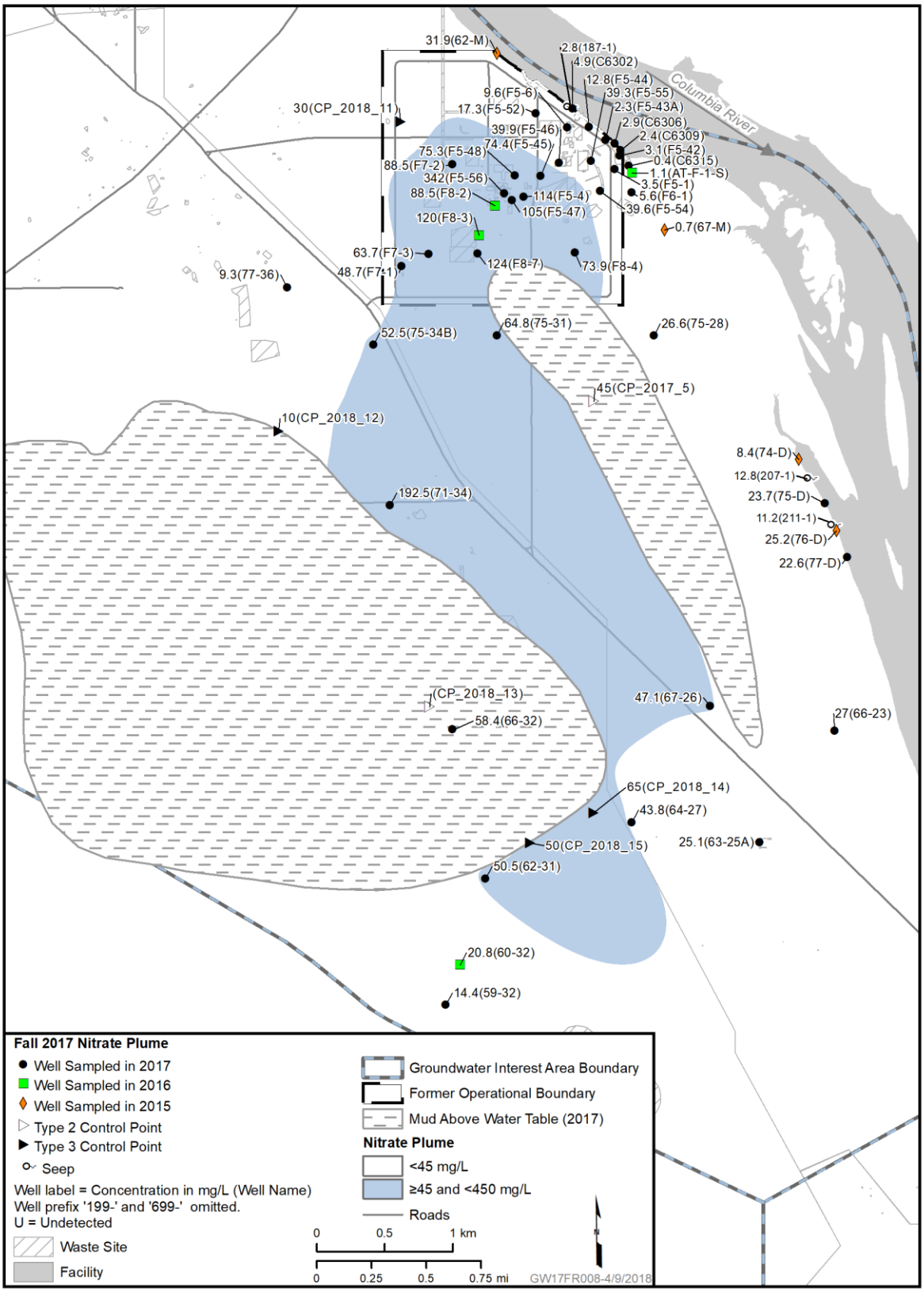


Figure 3-5. 100-FR Nitrate Plume, Fall 2017

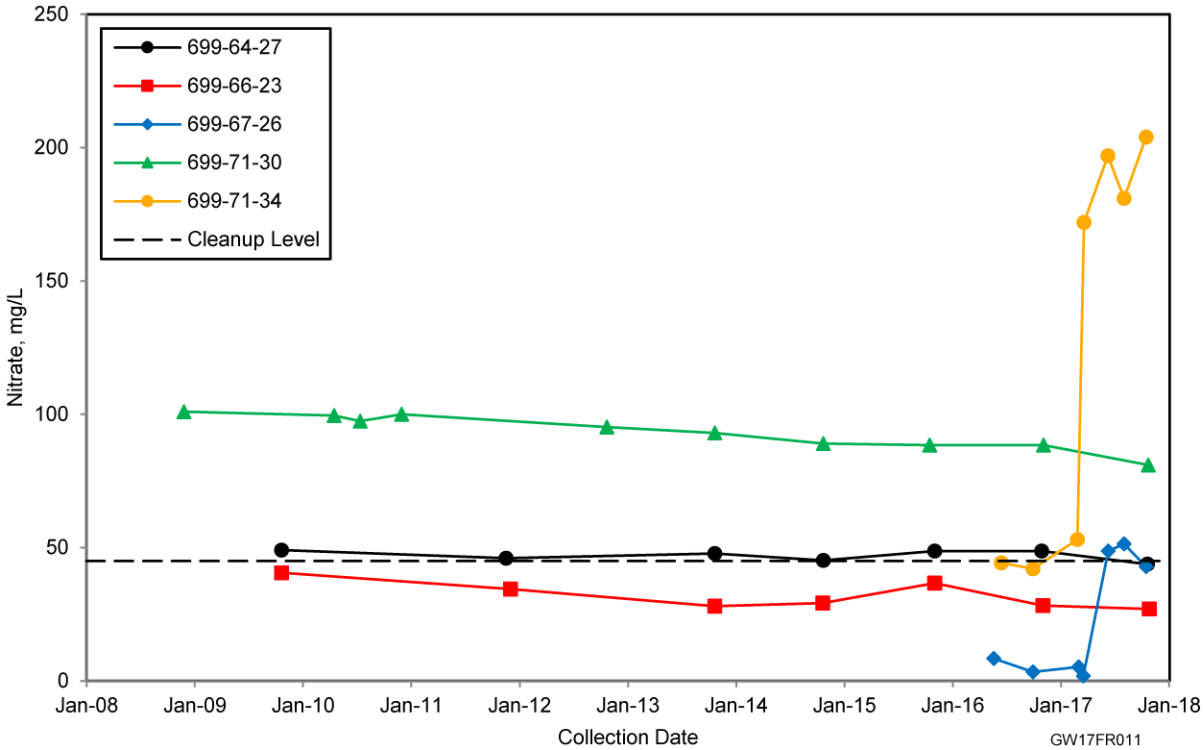


Figure 3-6. 100-FR Nitrate Data for Wells in Southern Part of Plume

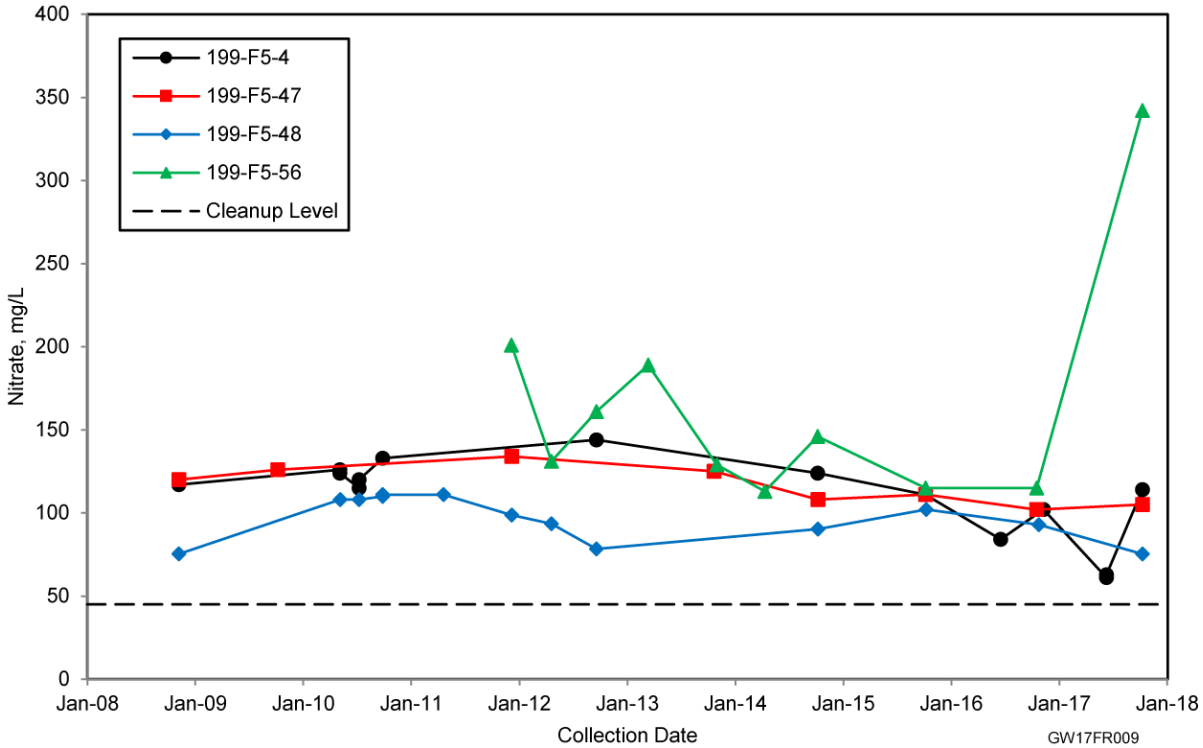


Figure 3-7. 100-FR Nitrate Data for Wells in Northern Part of Plume

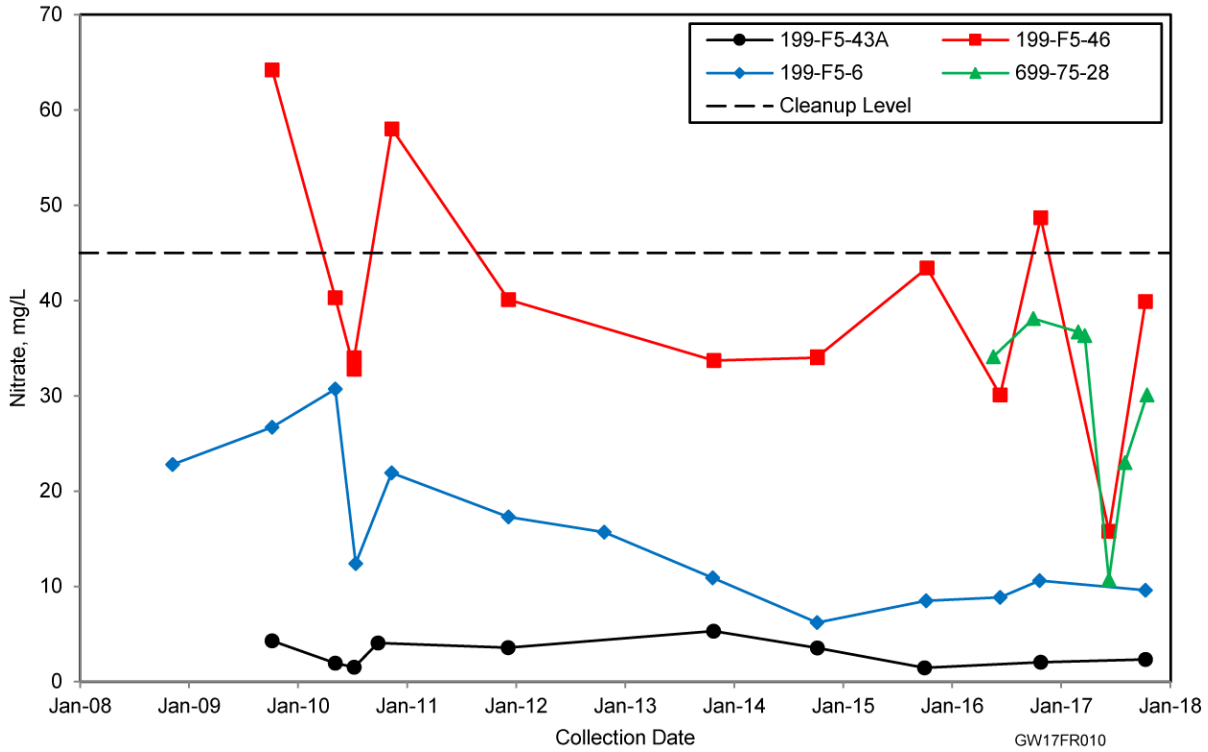


Figure 3-8. 100-FR Nitrate Data for Wells near the Columbia River

The highest nitrate concentrations in aquifer tubes have historically been detected in tube 75-D, which is 2 km (1.2 mi) downstream. Concentrations ranged from 25 to 36 mg/L between 2011 and 2017. Two seeps in 100-FR were sampled in October 2017 and had nitrate concentrations of 2.7 and 12.8 mg/L.

3.3 Trichloroethene

The TCE concentrations exceed the 4 µg/L cleanup level in several wells in 100-FR (Figure 3-9). Process knowledge of the former 600-127 waste site, located just west of the 100-F Area, suggests that it may have contributed to the TCE plume. This site has been remediated.

The TCE concentrations have declined overall in the southwestern plume since 1992 but have been variable in recent years (Figure 3-10). Well 199-F7-1 continued to have the highest TCE concentration in 2017 at 13 µg/L. The concentration declined below the 4 µg/L cleanup level for the first time in well 699-77-36. TCE was not detected in well 699-75-31 to the east or in well 699-71-34 to the south. However, TCE continued to be detected at concentrations below the cleanup level in older well 699-71-30.

TCE is detected in several wells in the central 100-F Area. In 2017, concentrations exceeded the cleanup standard in only well 199-F5-45 (Figure 3-11). TCE increased in October 2016 in this well, so it was resampled in March 2017 and had a similar concentration (11 µg/L). The concentration declined to 7.9 µg/L in October 2017, and the cause of the variability is unknown. There does not appear to be a correlation between TCE concentrations and water levels.

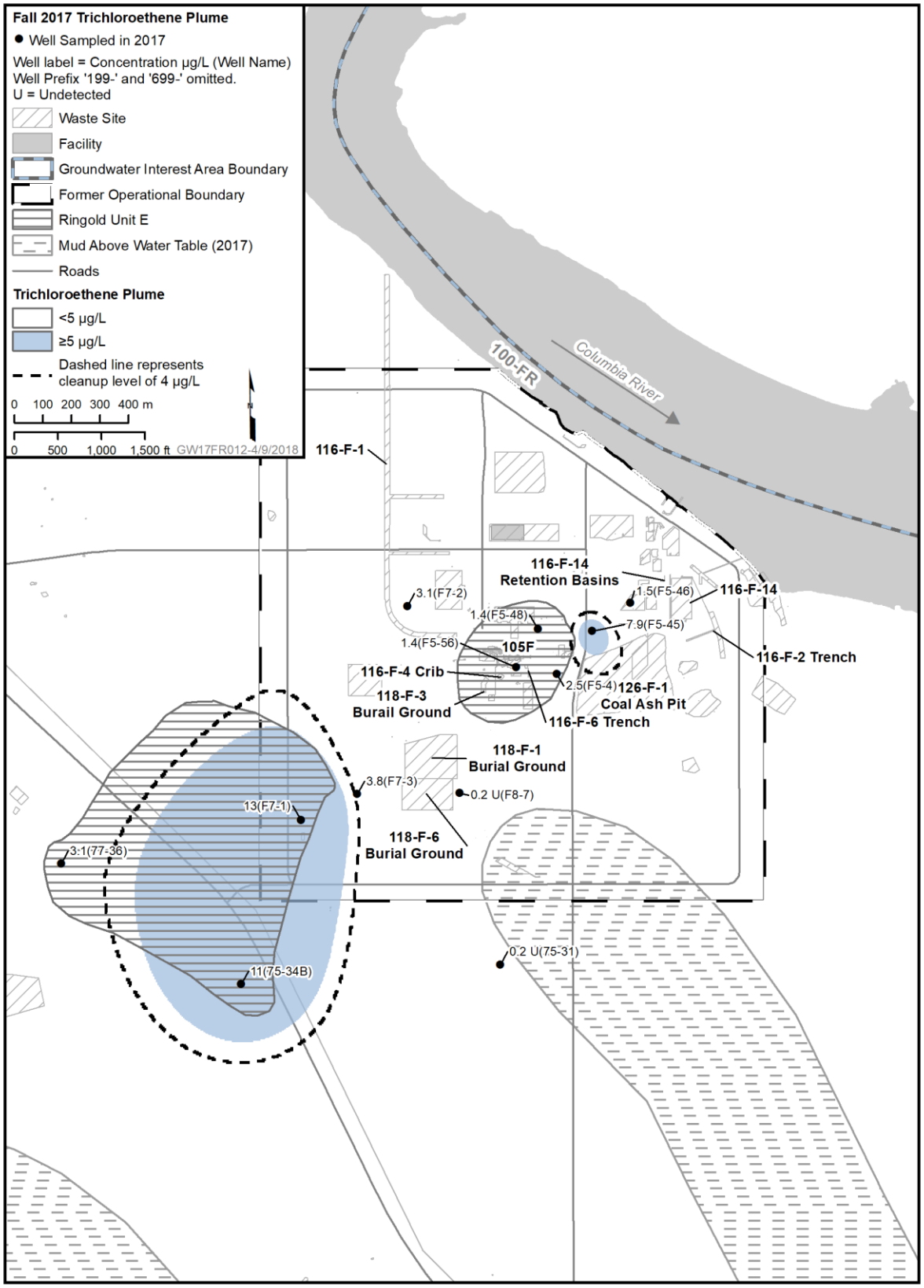


Figure 3-9. 100-FR TCE Plume, 2017

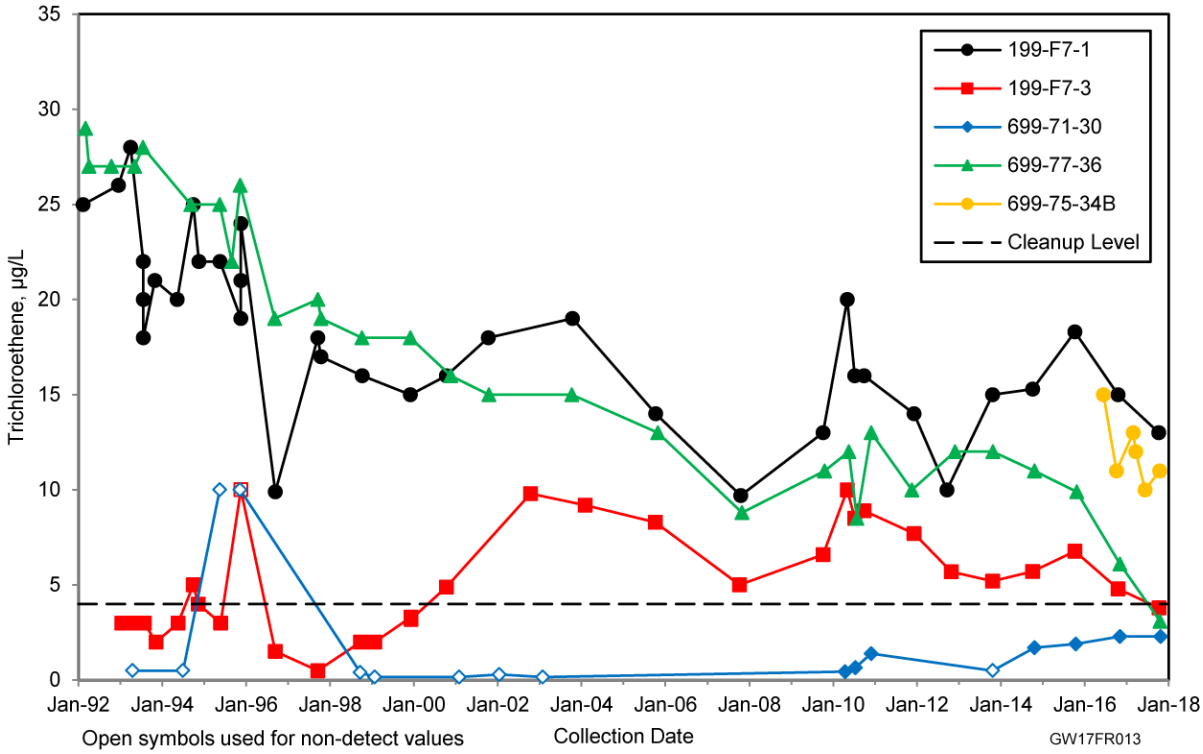


Figure 3-10. 100-FR TCE Data for Wells in Southern 100-F Area

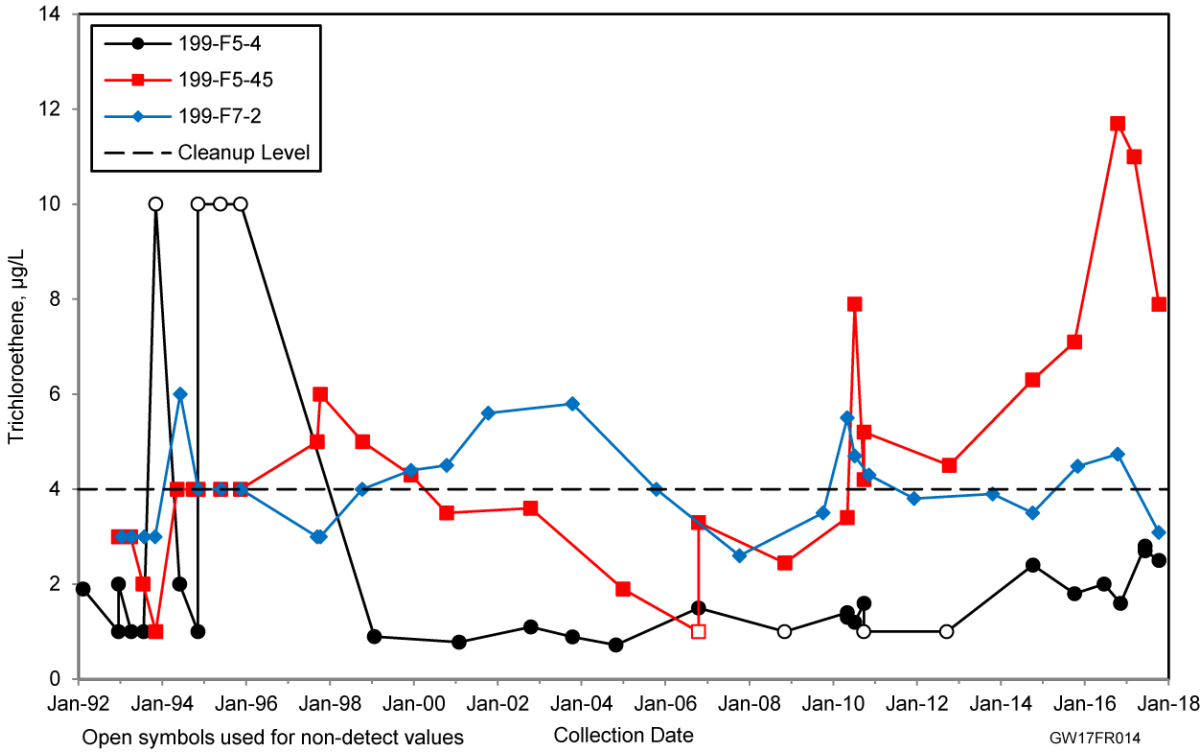


Figure 3-11. 100-FR TCE Data for Wells in Central 100-F Area

Interpretations of geologic logs indicate that the aquifer in the southwestern 100-F Area is within a remnant of Ringold unit E rather than in the Hanford formation. The presence of less transmissive sediments may explain the persistence of TCE in this region (Figure 3-9). A smaller remnant of Ringold unit E is present in the central 100-F Area where other traces of TCE are found.

Well 699-77-54, located in the western part of the 100-FR groundwater interest area, consistently has TCE concentrations above 5 µg/L, with a 2017 result of 13 µg/L. The well is not needed to meet monitoring objectives defined in the current 100-FR-3 SAP (DOE/RL-2014-44-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for the 100-F/IU Groundwater*) but is monitored for 100-KR. The well also has elevated concentrations of Cr(VI) (24 µg/L in 2017).

3.4 Hexavalent Chromium

Former sources of Cr(VI) in 100-FR included facilities near the reactor building, trenches and retention basins near the Columbia River, and pipelines from the reactor building to these near-river facilities, primarily in the northern and eastern 100-F Area. The waste sites have been remediated, and concentrations in groundwater are expected to continue declining over time.

The Cr(VI) in 100-FR is present in a relatively small, low-concentration plume (Figure 3-12). Historically, the highest concentrations were in well 199-F5-46, where levels declined from greater than 300 µg/L in the early 1990s to less than 30 µg/L in 2010 through 2014. In 2017, concentrations in well 199-F5-46 varied from 9 µg/L in June during high river stage to 44 µg/L in October at low river stage (Figure 3-13). Cr(VI) concentrations increased between 2016 and 2017 in wells 199-F5-4, 199-F5-45, and 199-F5-47. In wells and aquifer tubes downgradient of well 199-F5-46, concentrations did not exceed the 10 µg/L surface water standard.

3.5 Strontium-90

Primary sources of strontium-90 included the 116-F-14 Retention Basin and 116-F-2 Trench in the eastern 100-F Area. Additional sources of strontium-90 were present near the reactor building and burial grounds. Concentrations exceed the 8 pCi/L cleanup level in only three wells (Figure 3-14).

In the eastern 100-F Area, wells 199-F5-55 and 199-F5-1 continued to have strontium-90 concentrations above the cleanup level in 2017 (Figure 3-15). Well 199-F5-55 had the highest concentrations, with a maximum of 120 pCi/L in October 2017. This borehole was installed to characterize the former 116-F-14 Retention Basin waste site and was completed as a monitoring well to obtain representative groundwater samples. Because the well is only 20 m (66 ft) from the former contaminant source, concentrations would be expected to increase when water levels rise if there was a significant mass of residual strontium-90 in the lower vadose zone. However, concentrations are inversely related to water levels, indicating that a vadose zone source of strontium-90 is not present near the well. The groundwater contamination is localized, and the closest downgradient well (199-F5-1) has much lower concentrations. Strontium-90 concentrations in aquifer tubes are below the cleanup level.

Strontium-90 concentrations in well 199-F5-56, near the F Reactor building, also exceeded the cleanup level (Figure 3-15). A concentration of 45.9 pCi/L was observed in 2017, an increase from 2016 that appears to be directly correlated with groundwater elevations. Nitrate also increased in this well in fall 2017 (Section 3.2). This borehole was drilled to characterize a waste site and was completed as a well to obtain representative groundwater samples. No other wells near well 199-F5-56 had detectable strontium-90.

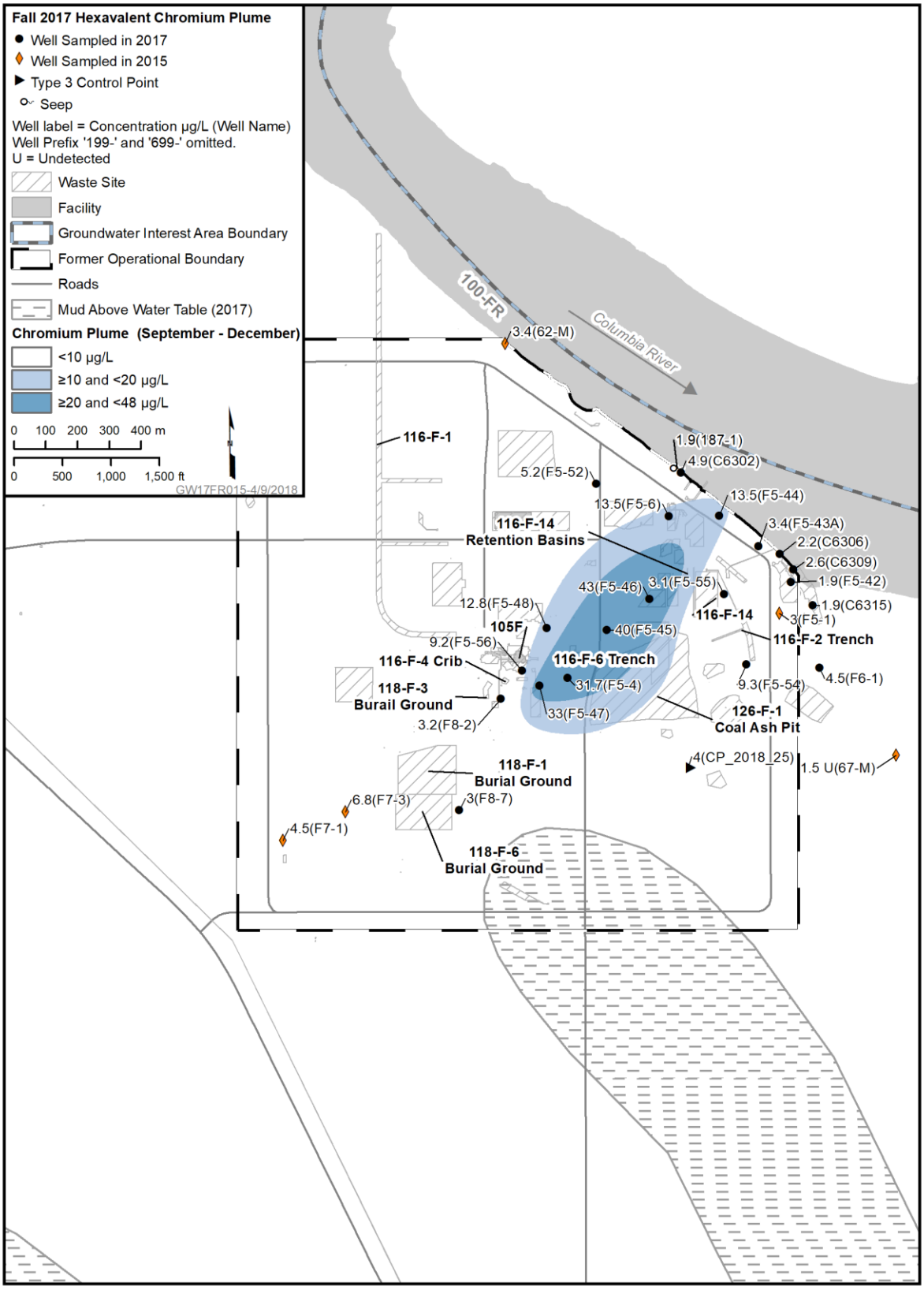


Figure 3-12. 100-FR Cr(VI) Plume, 2017

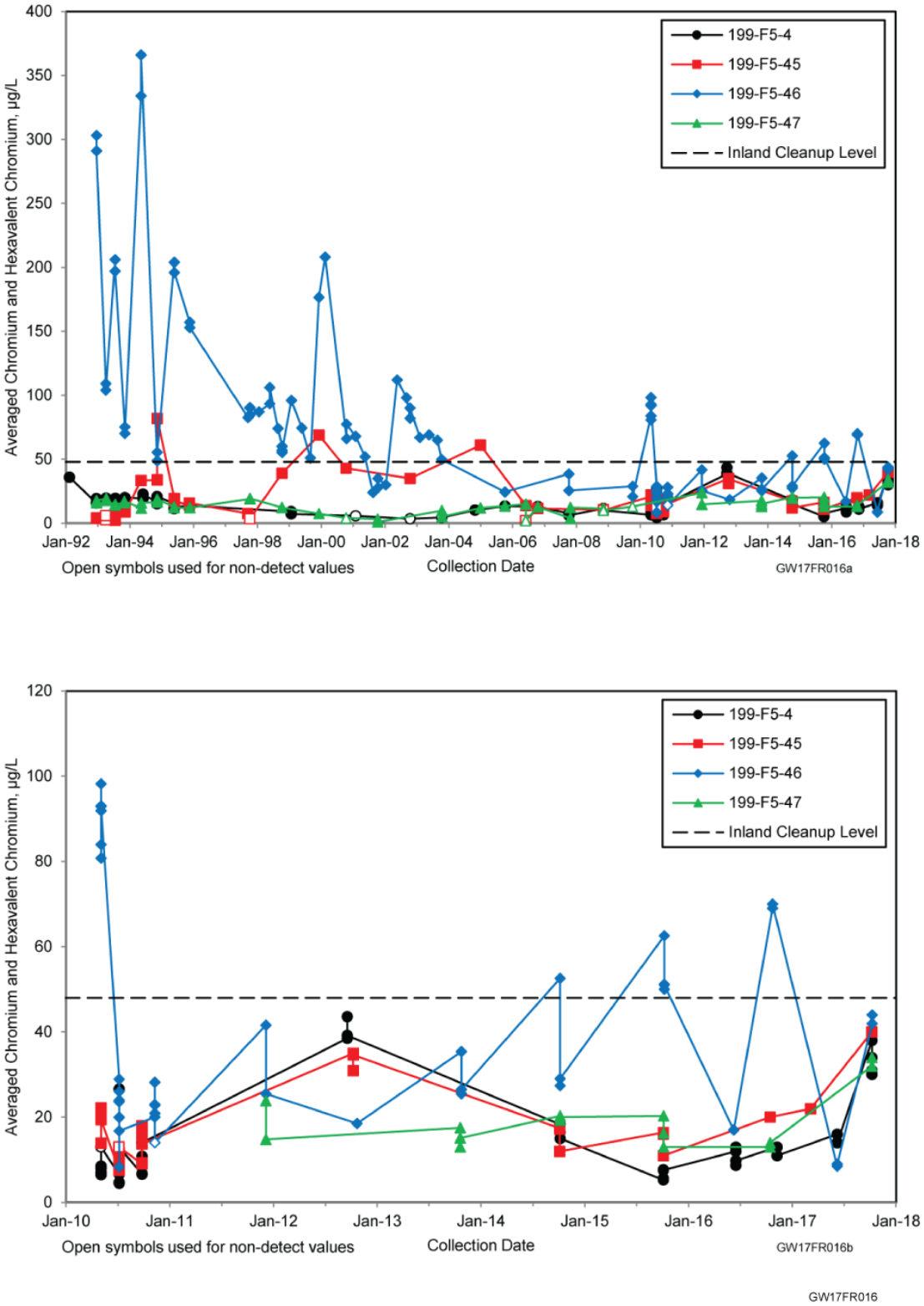


Figure 3-13. 100-FR Dissolved Chromium Data for 100-FR Wells, 1992-2017 (Top Panel) and 2010-2017 Detail (Bottom Panel)

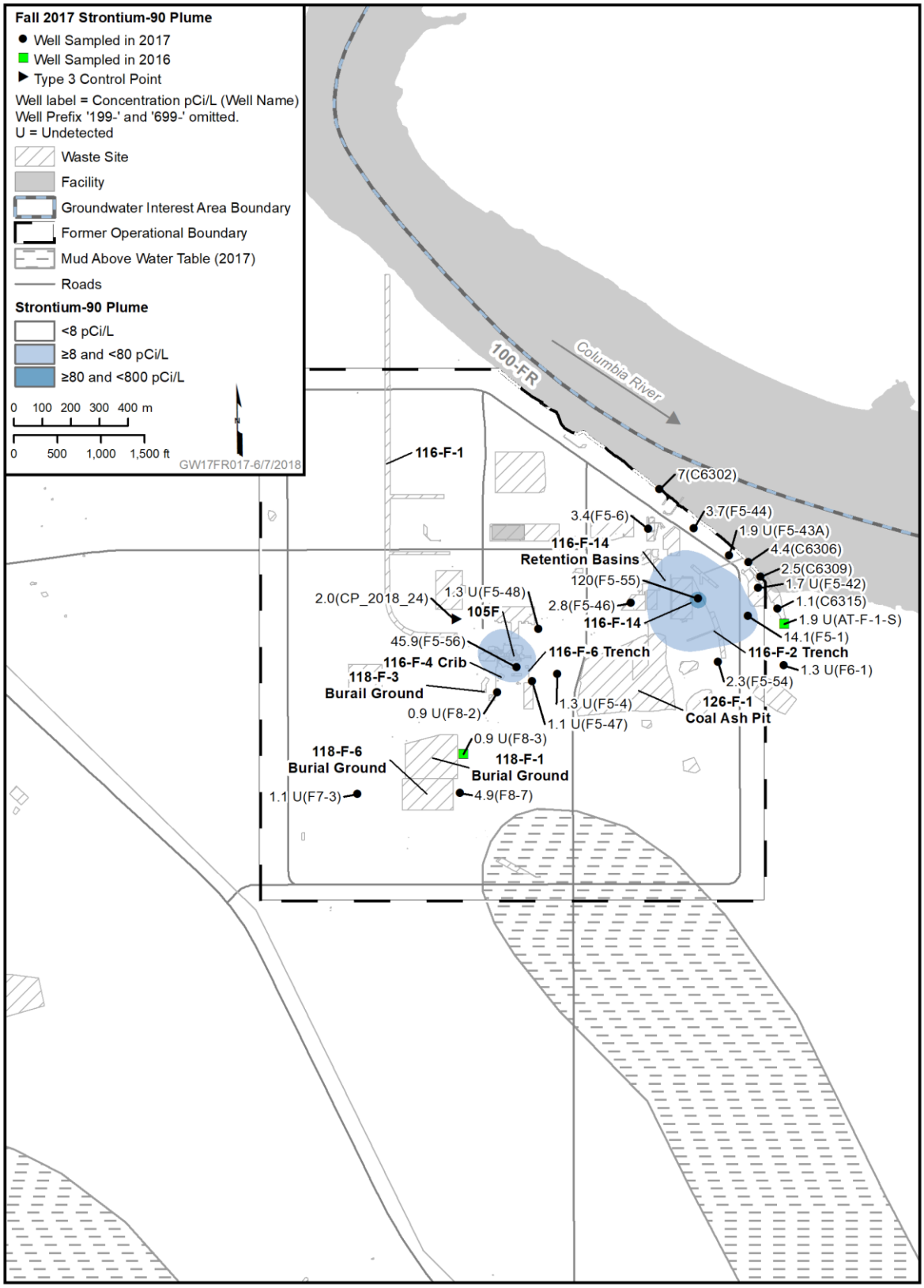


Figure 3-14. 100-FR Strontium-90 Plume, 2017

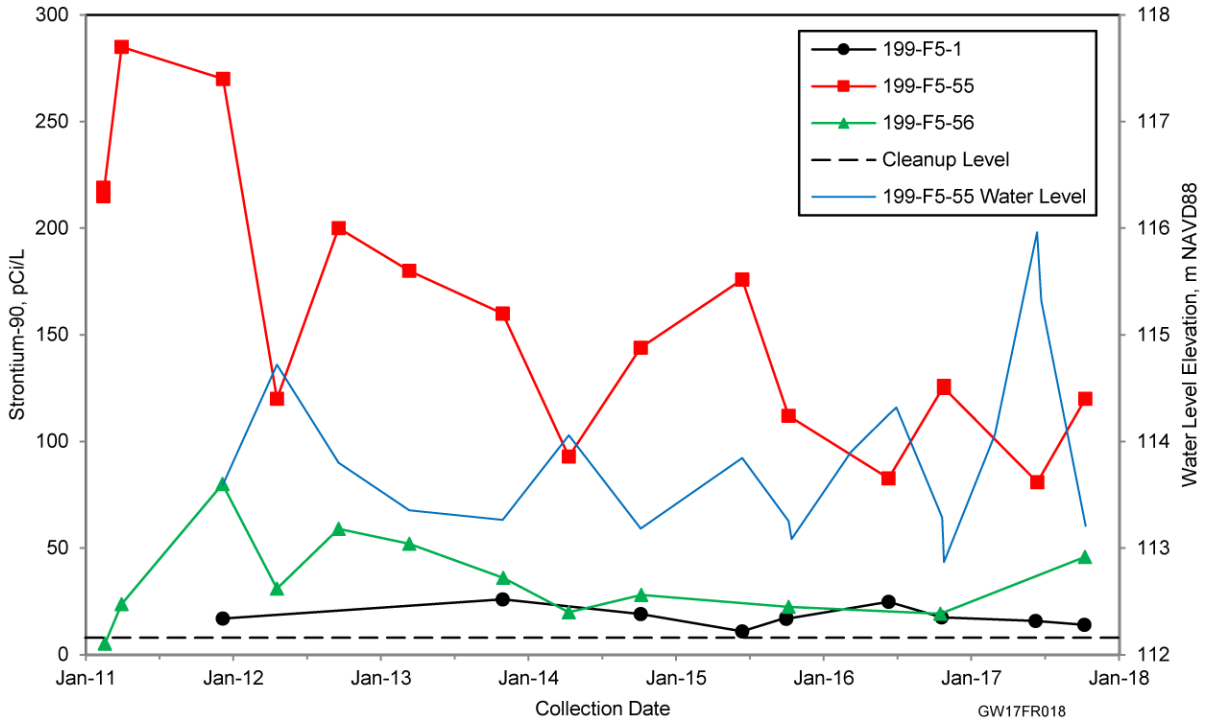


Figure 3-15. 100-FR Strontium-90 Data for Wells 199-F5-1, 199-F5-55, and 199-F5-56

3.6 Other Analytes

The CERCLA groundwater SAP (Appendix A of DOE/RL-2014-44-ADD2) requires monitoring the TCE degradation products vinyl chloride and *cis*-1,2-dichloroethene (*cis*-1,2-DCE) in selected wells during the MNA remedy. Results continued to be below detection limits in 2017.

Antimony, cadmium, and cobalt are monitored in four wells to determine if they meet action levels. The following summarizes the 2014 through 2017 results based on a total of 17 filtered and 17 unfiltered samples:

- **Antimony:** Seven detections, maximum 0.47 µg/L. All results and detection limits were below the 5.6 µg/L action level.
- **Cadmium:** One detection at 0.1 µg/L. All detections were below the 0.25 µg/L action level. Some detection limits in 2016 and 2017 were higher than the action level (0.27 to 0.30 µg/L).
- **Cobalt:** Sixteen detections, maximum 0.744 µg/L. All results and detection limits were below the 4.8 µg/L action level.

The CERCLA groundwater SAP (Appendix A of DOE/RL-2014-44-ADD2) does not identify sulfate as a COC, but it is reported with analytical results for anions. Sulfate concentrations in perched aquifer well 699-66-32 were above the 250 mg/L secondary DWS, with a maximum detection of 383 mg/L in 2017 (Figure 3-16). This concentration was higher than any historical sulfate concentrations in the 100-F Area, and like nitrate, may be related to pre-Hanford Site agriculture (SGW-61298). Other wells in the southern 100-FR groundwater interest area also have elevated sulfate, but levels are below the DWS.

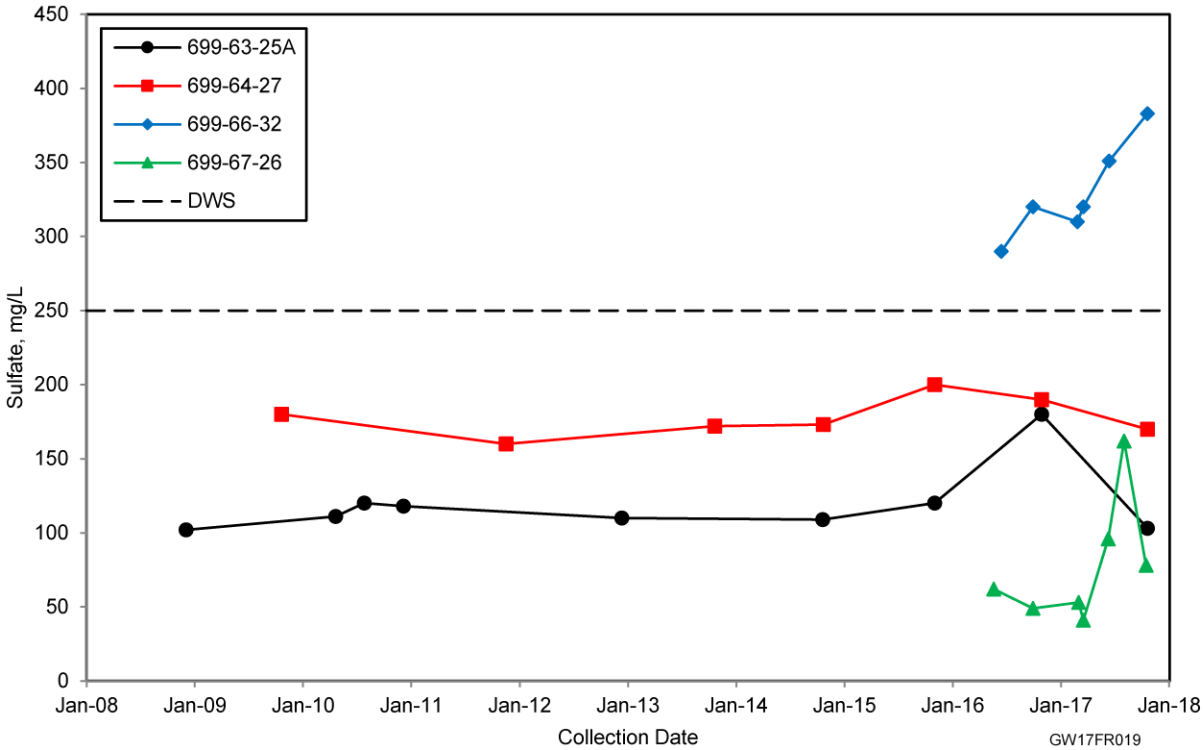


Figure 3-16. 100-FR Sulfate Data for Wells in Southern 100-FR

3.7 CERCLA Remediation and Monitoring

The remedy for 100-FR-3 OU groundwater, as described in the 2014 CERCLA ROD (EPA et al., 2014), is MNA of Cr(VI), nitrate, strontium-90, and TCE. DOE/RL-2014-44-ADD2 includes a groundwater SAP, which was modified by TPA-CN-0736, *Tri-Party Agreement Change Notice Form: DOE/RL-2014-44-ADD2, Rev. 0, Remedial Design Report/Remedial Action Work Plan Addendum for 100-F/IU Groundwater*. Appendix A lists the exceptions to CERCLA sampling in 2017.

The first stage of 100-FR-3 OU groundwater remedy implementation included installing new wells, starting performance monitoring sampling, and reporting sampling results in the annual groundwater monitoring report (Table 6-1 of DOE/RL-2014-44-ADD2). Subsequent stages of remediation will include installing additional wells and evaluating MNA progress to support the sitewide CERCLA 5-year review. The first 100-FR performance report is anticipated to be prepared in 2020.

The SAP specifies that the new wells would be sampled quarterly for the first year, and sampling frequency could decrease thereafter. The fourth quarter sampling event occurred in June 2017, but because of unexpected results, additional samples were collected in August 2017. Quarterly sampling will continue in 2018.

Well 699-67-26, located where the aquifer is thin, pumped dry when sampling was attempted in February 2017. The samplers returned the next week and pumped at a lower rate, and sampling was successful. The well again pumped dry during the March 2017 sampling event. The samplers allowed the well to recharge and then collected the samples. The well did not pump dry in June, August, or October.

A report on the results of the first year of monitoring Phase 1 wells was drafted in 2017 and published in 2018 (SGW-61298). The report includes updated maps and cross sections to reflect interpretations of hydrogeology based on the new wells and boreholes. It also presents recommendations for Phase 2 wells. Because of unexpected increases in nitrate and Cr(VI) concentrations, the sampling frequency increased in some wells in 2018, and the SAP is being revised via a Tri-Party Agreement change notice.

3.8 Atomic Energy Act Monitoring

AEA groundwater monitoring was conducted at 30 groundwater wells and aquifer tubes in the 100-FR groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 100-FR are nitrate and strontium-90. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Wells were sampled in accordance with SAP requirements in 2017. Significant changes were made to the monitoring network with the decommissioning of two wells. Appendix C lists the sampling exceptions for 2017 AEA monitoring of the 100-FR groundwater wells.

Concentrations of radionuclides detected in groundwater samples from 41 wells[1] and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard. The DWSs for cumulative alpha emitters and uranium mass were not exceeded. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at three locations in this groundwater interest area (Table 3-2). Two of the locations are near the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. CERCLA remedial action decisions (i.e., MNA for the 100-FR-3 OU) provide longer-term protection of the public and the environment.

Table 3-2. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-FR in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr	
	Minimum	Maximum
199-F5-1	7.05	7.9
199-F5-55	40.45	60
199-F5-56	22.95	22.95

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Note: None of the wells in 100-FR had total effective dose ≥100 mrem/yr, cumulative alpha activity ≥15 pCi/L, or cumulative uranium mass ≥30 µg/L.

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

4 100-HR

The 100-HR-3 Groundwater OU, in the northern Hanford Site, encompasses the 100-HR-D and 100-HR-H groundwater interest areas, which together make up 100-HR (Figure 1-1). This chapter includes an overview; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2017; and a summary of 2017 groundwater monitoring results.

4.1 Overview

Groundwater in 100-HR was contaminated by waste releases associated with past operation of the D, DR, and H Reactors and associated support facilities. At the end of 2017, 98% of the waste sites were classified as closed, interim closed, final closed, no action, not accepted, or rejected. The final 2% of the waste sites will be remediated under a ROD for final remedial action.

Table 4-1 lists key facts about 100-HR, including plume areas. A plume area is not included for uranium because it is present in only a few locations. Additional details about 100-HR history, waste sites, and hydrogeology are provided in Chapters 1 and 3 of the 100-D/H RI/FS (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*). Figures 4-1 and 4-2 show the locations of monitoring, extraction, and injection wells and aquifer tubes. Data from monitoring seeps and springs are shown on each of the plume figures presented but were not used for plume development due to their transient nature. Plume mapping details, including descriptions of terms (e.g., Type 1 control point) used in the figure legends, are provided in Section 1.5.

Vadose zone thickness, which also represents the depth to groundwater, ranges from 0 to 27 m (0 to 89 ft), with an average thickness of 20 m (66 ft) in 100-HR-D and 11.3 m (37.1 ft) in 100-HR-H. The thickness of the unconfined aquifer ranges from 12 m (39 ft) in 100-HR-D to less than 1 m (3.3 ft) in portions of 100-HR-H, with the aquifer generally thinning from west to east. The thickness of the unconfined aquifer mimics the topography of the RUM (DOE/RL-2008-42, *Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*). The uneven surface of the silt- and clay-rich RUM forms the base of the unconfined aquifer. Water-bearing units are found within and below the RUM and form confined or semiconfined aquifers. The uppermost water-bearing unit of the RUM is typically referred to as the RUM aquifer. The extent and hydraulic interconnection of the RUM water-bearing unit (laterally and vertically) and the degree of leakage or confinement of the overlying fine-grained RUM layer remain uncertain due to a lack of wells within the lower water-bearing units. As noted in Section 4.4, recent and future evaluations are helping to determine the hydraulic connectivity between RUM wells, connections between the RUM aquifer and the overlying unconfined aquifer, and connections between the RUM and the Columbia River. Tests conducted in 2016 also provided some estimates of aquifer parameters (Section 4.4).

The unconfined aquifer is primarily present in Ringold unit E in 100-HR-D and in the Hanford formation gravel in 100-HR-H (Figure 4-3). Across the Horn, the geology is transitional, changing from predominantly Ringold unit E in the west to Hanford formation farther east. Pockets of Ringold unit E are found as remnants in various locations. In the areas across the Horn where Ringold unit E is absent, channels formed and resulted in preferential groundwater flow pathways.

Table 4-1. 100-HR at a Glance

Reactor operations: D Reactor: 1944 to 1967; DR Reactor: 1950 to 1964; H Reactor: 1949 to 1965				
Groundwater Monitoring				
Contaminant, Water Quality Standard, Units	**Year**	**Maximum Concentration (Well)**	**Plume Area[a] (km^2)**	**Shoreline[b] (m)**
Hexavalent chromium, 48/10[c] µg/L	2017	730 (199-D5-103)	0.04/3.3	0/567
	2016	640 (199-D5-103)	0.06/4.0	0/283
Nitrate, 45 mg/L	2017	217 (199-H3-29)	<0.01	0
	2016	66.4 (199-H4-84)	<0.01	0
Strontium-90, 8 pCi/L	2017	27.8 (199-D5-132)	0.02	0
	2016	30.1 (199-D5-132)	0.02	21
Tritium, 20,000 pCi/L	2017	9,440 (199-D4-13)	0	0
	2016	10,600 (199-D3-5)		
Uranium, 30 µg/L	2017	142[d] µg/L (199-H3-28)	Not calculated[e]	0
	2016	50 (199-H4-84)		
Remediation				
Waste sites: 98% complete.[f] Groundwater interim action for hexavalent chromium 1997 through present.				

a. Estimated area at a concentration greater than the listed water quality standard.

b. Length of shoreline intersected by plume above listed water quality standard.

c. 48 µg/L in the upland area (WAC 173-340, "Model Toxics Control Act—Cleanup") and 10 µg/L where groundwater discharges to surface water (WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington").

d. Depth-discrete characterization sample collected during drilling.

e. Limited to isolated occurrences; no defined plume.

f. Sites with closed, interim closed, final closed, no action, not accepted, or rejected status as of December 31, 2017.

Groundwater in 100-HR flows generally to the east-northeast, from the 100-D Area across the Horn and toward 100-H Area. Flow in the 100-H Area is to the east and northeast, generally toward the Columbia River. The operation of P&T systems as interim actions for Cr(VI) influences groundwater flow direction and velocity throughout 100-HR, creating depressions and mounds in the water table. Figures 4-4 and 4-5 show the water table contours for March 2017, a transitional river stage period. Changes in river stage formerly affected groundwater flow directions. The P&T system has become more robust over time with the addition of wells in key locations; however, the effect of the river stage on plume configuration has lessened. Plume changes are now primarily controlled by modifications to the P&T system during the year.

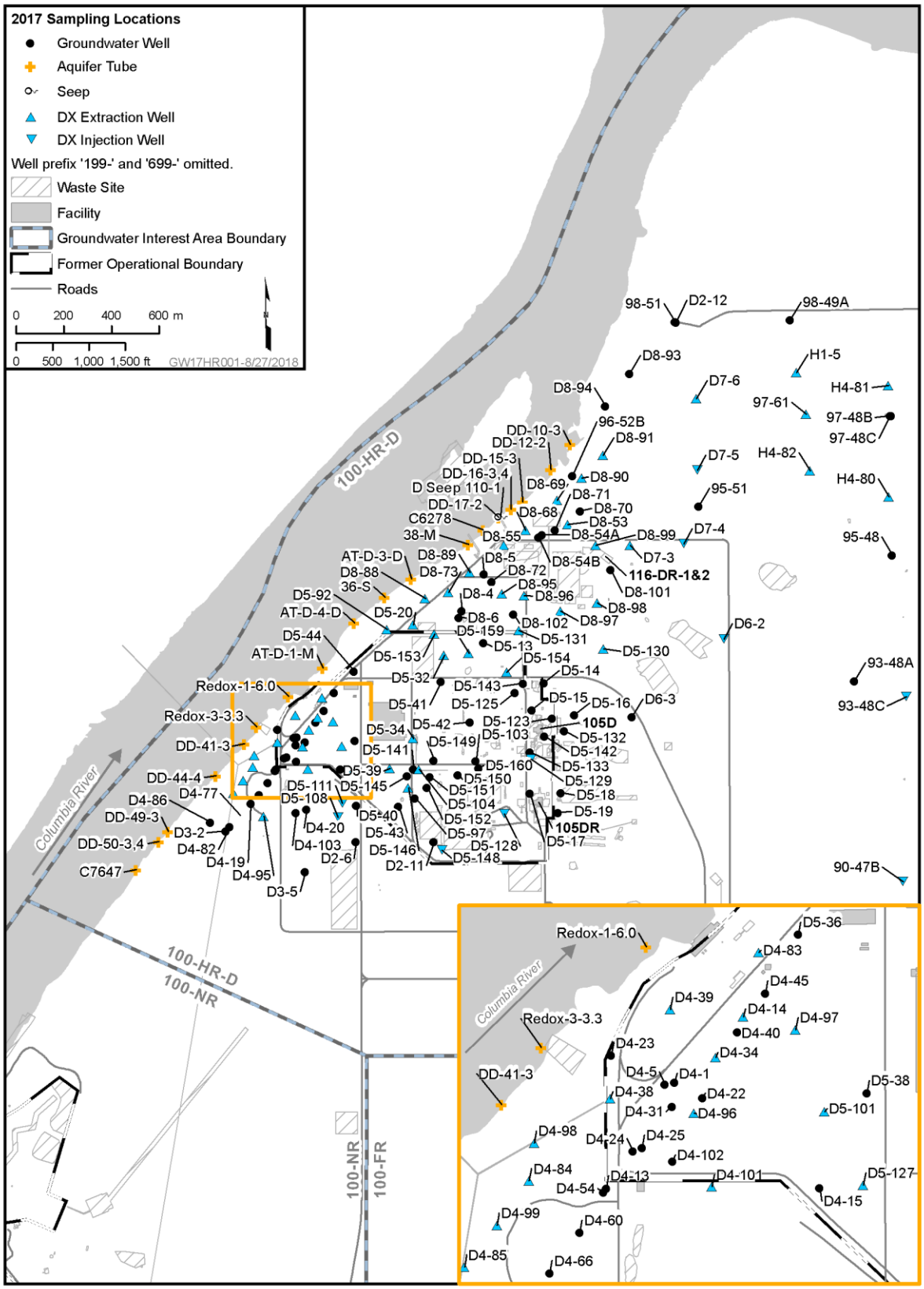


Figure 4-1. 100-HR-D Sampling Locations, 2017

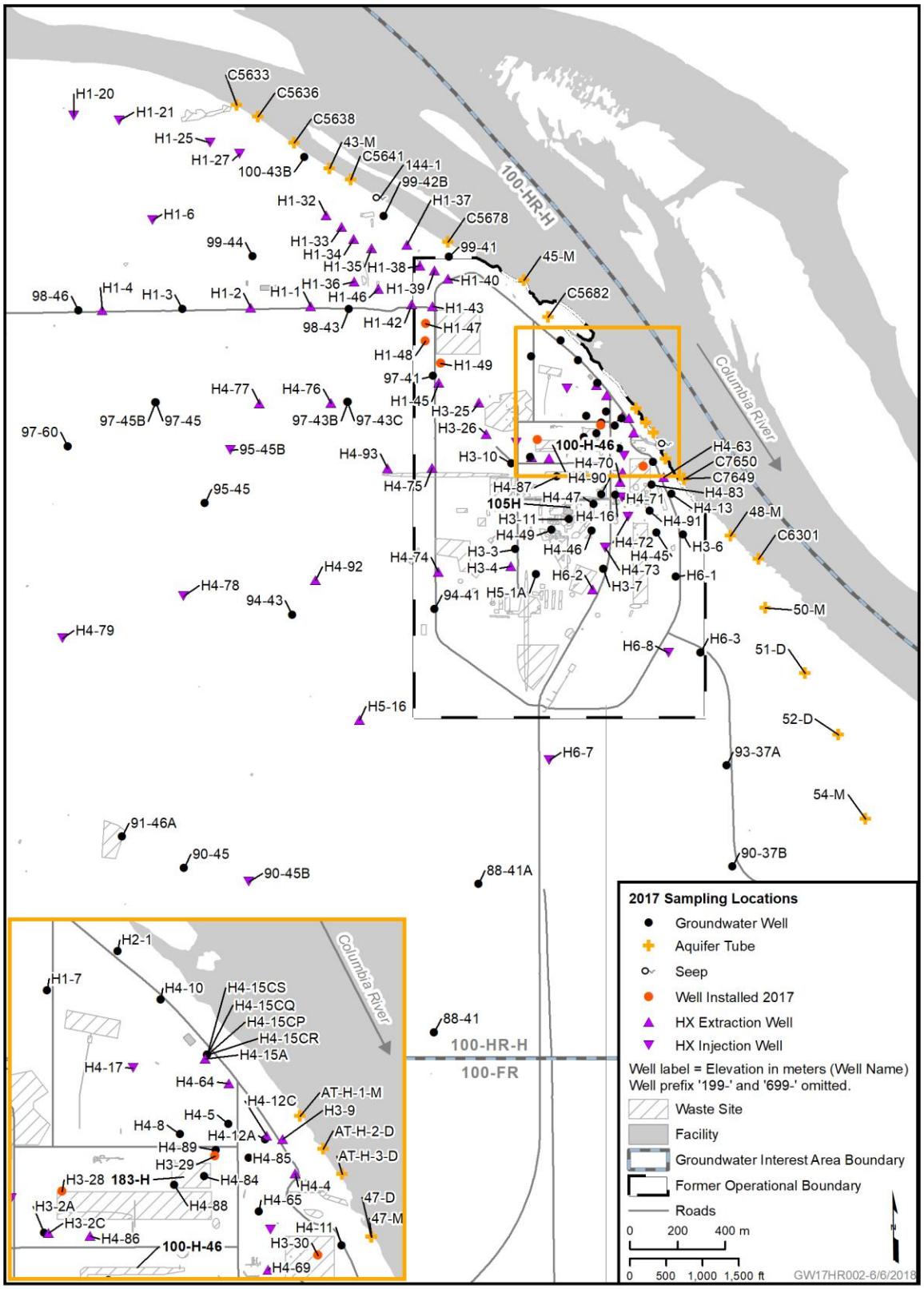


Figure 4-2. 100-HR-H Sampling Locations, 2017

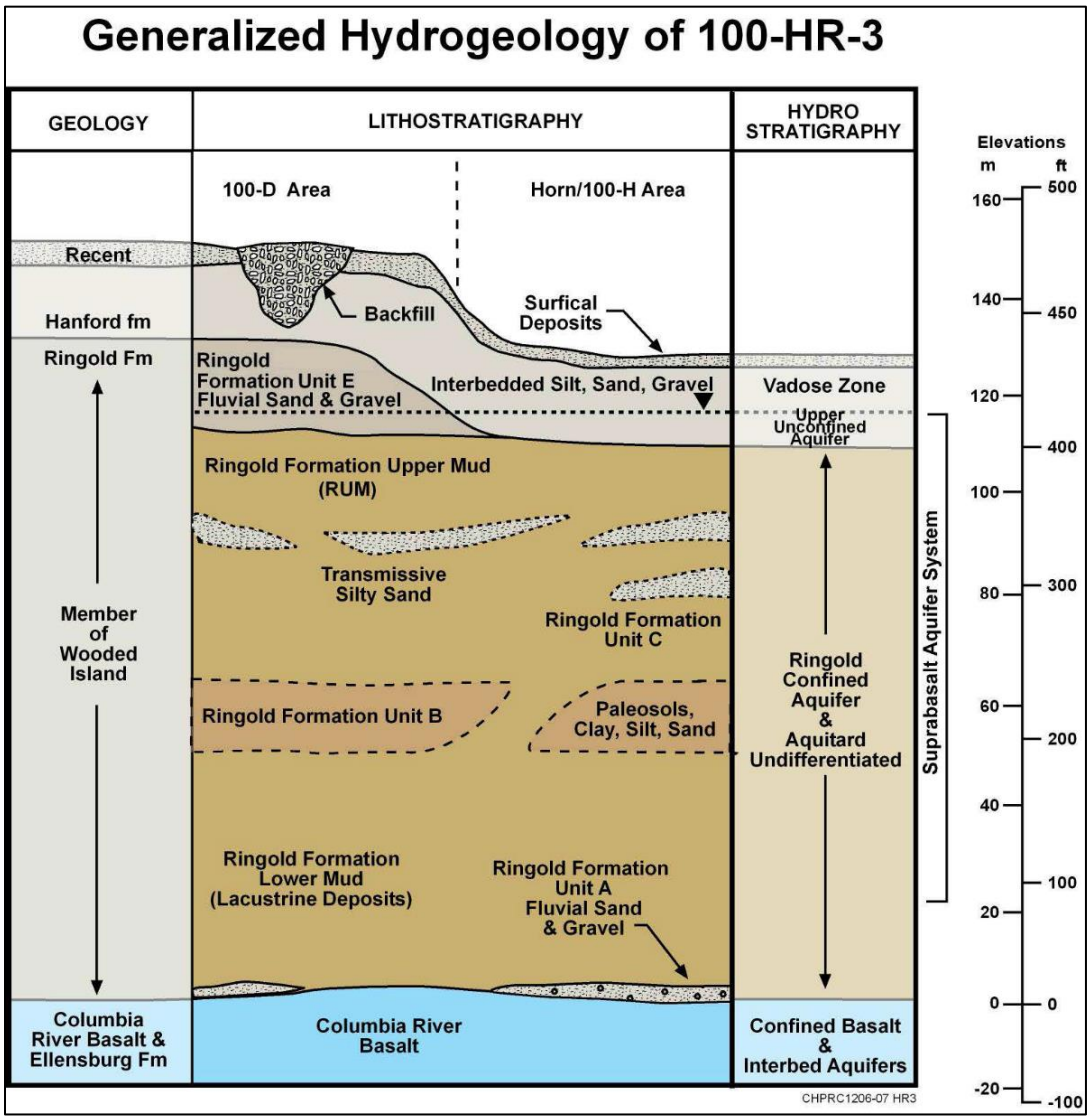
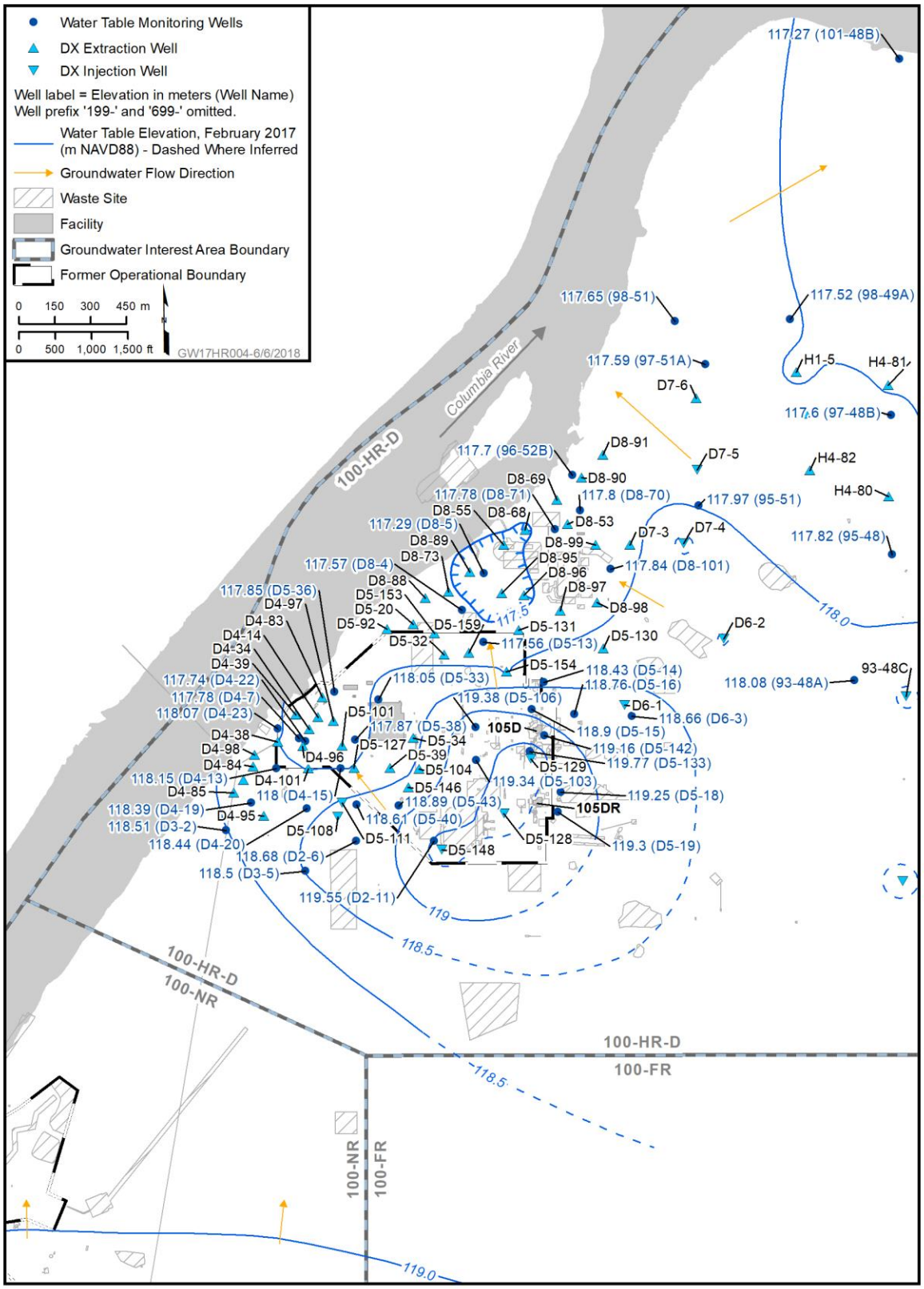


Figure 4-3. 100-HR Hydrogeology

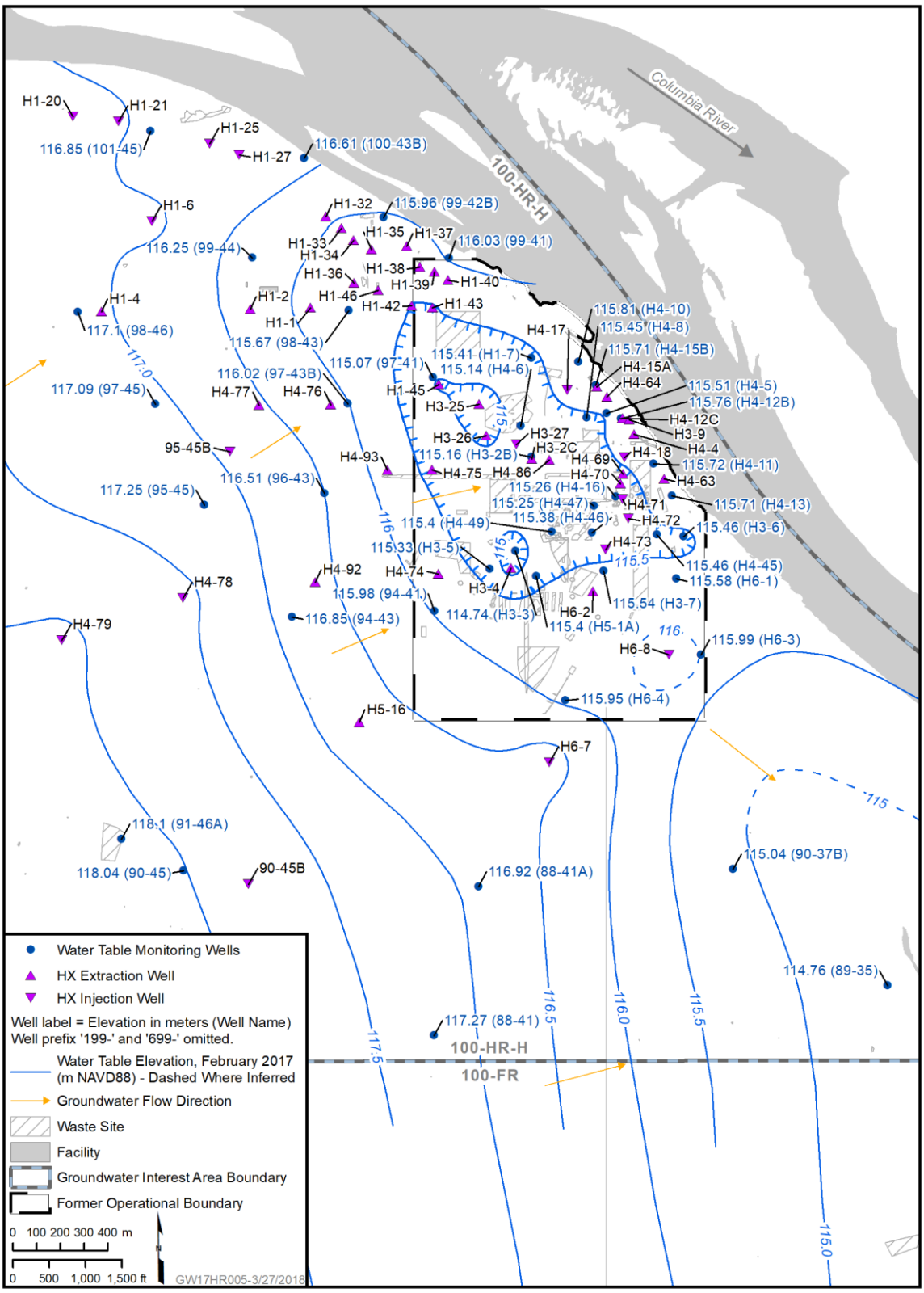
Contaminants of potential concern (COPCs) in the 100-HR unconfined aquifer were identified in the interim ROD (Tables 1 and 2 of EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Interim Remedial Actions Benton County, Washington*) and include Cr(VI), total chromium, nitrate, strontium-90, and tritium. Figure 4-6 illustrates how the areas of the contaminant plumes have changed over time. Figure 4-7 shows the Cr(VI) plume in 1999, 2 years after the first P&T system began operating, and in 2017, after 20 years of active P&T. The P&T systems have shrunk the plume and eliminated nearly all of the concentrations greater than 100 µg/L.

Within the unconfined aquifer, vertical stratification of Cr(VI) was identified in areas below waste sites where highly concentrated sodium dichromate was handled, such as beneath the 100-D-100 waste site excavation area (SGW-58416, *Persistent Source Investigation at 100-D Area*). However, the stratification is not well defined or consistent in all parts of 100-HR.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-4. 100-HR-D Water Table, March 2017



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-5. 100-HR-H Water Table, March 2017

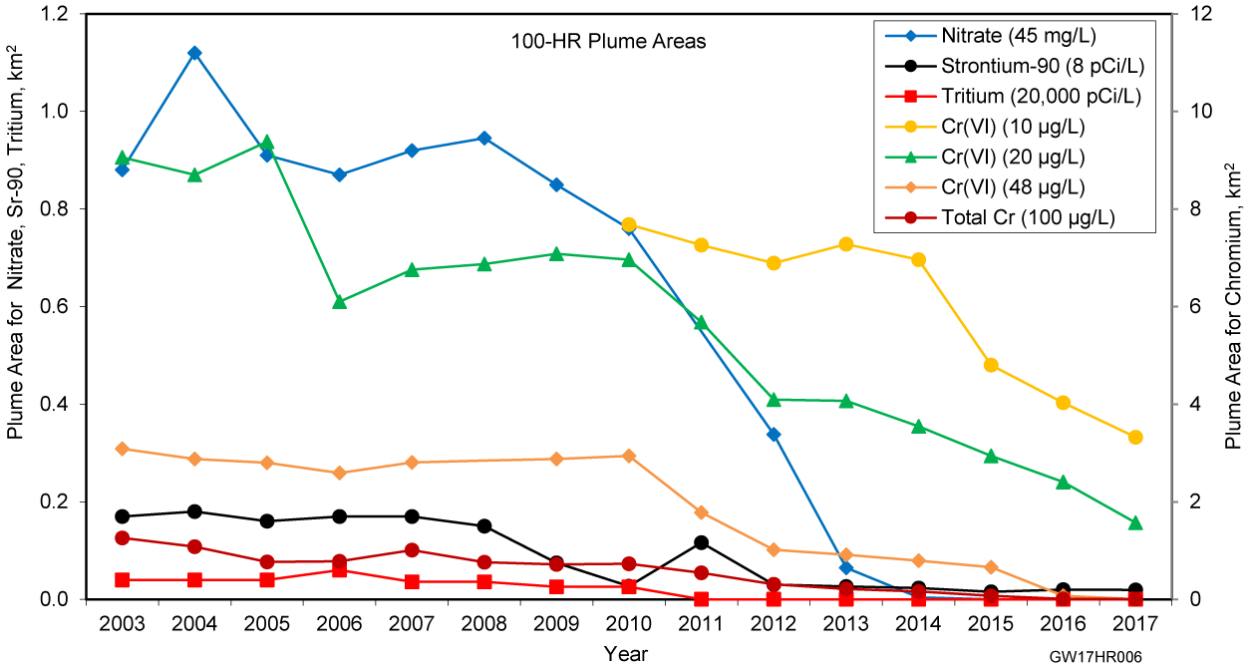


Figure 4-6. 100-HR Plume Areas

4.2 100-HR-D Hexavalent Chromium

In 100-HR, Cr(VI) is the most widely distributed COPC. Cr(VI) in groundwater resulted from historical releases of two different types of wastewater. The first type of release included spills, leaks, and unintentional discharge of concentrated sodium dichromate solutions used as feed chemicals for conditioning reactor cooling water. A high-concentration release of sodium dichromate stock solution is the primary cause of the southern Cr(VI) plume. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-DR-1&2 Trenches during an infiltration test in 1967, which had high volumes of water with lower concentrations of sodium dichromate. The releases to the 116-DR-1&2 Trenches are the primary cause of the northern Cr(VI) plume and the plume across the Horn (Section 4.3.1).

Based on the 2014 investigation of the 100-D-100 waste site (the result of a high-concentration sodium dichromate release), there are two CSMs for Cr(VI) in groundwater along the River Corridor. The first and more prevalent CSM may still apply to lower concentration releases (e.g., contaminated cooling water), but the presence of a secondary source is not confirmed. In these areas of low-concentration source material, it is assumed that Cr(VI) is essentially entirely mobile and moves easily with the groundwater. A second CSM for Cr(VI) applies at high-concentration sites (e.g., those spills and releases containing high-concentration sodium dichromate solution), where it has been shown that a chromium-substitute calcite may be present in the soil at the groundwater/vadose interface. The presence of chromium-substitute calcite provides a slow-leaching source of Cr(VI) to the aquifer, resulting in a long-term secondary source (Section 7.3 of SGW-58416).

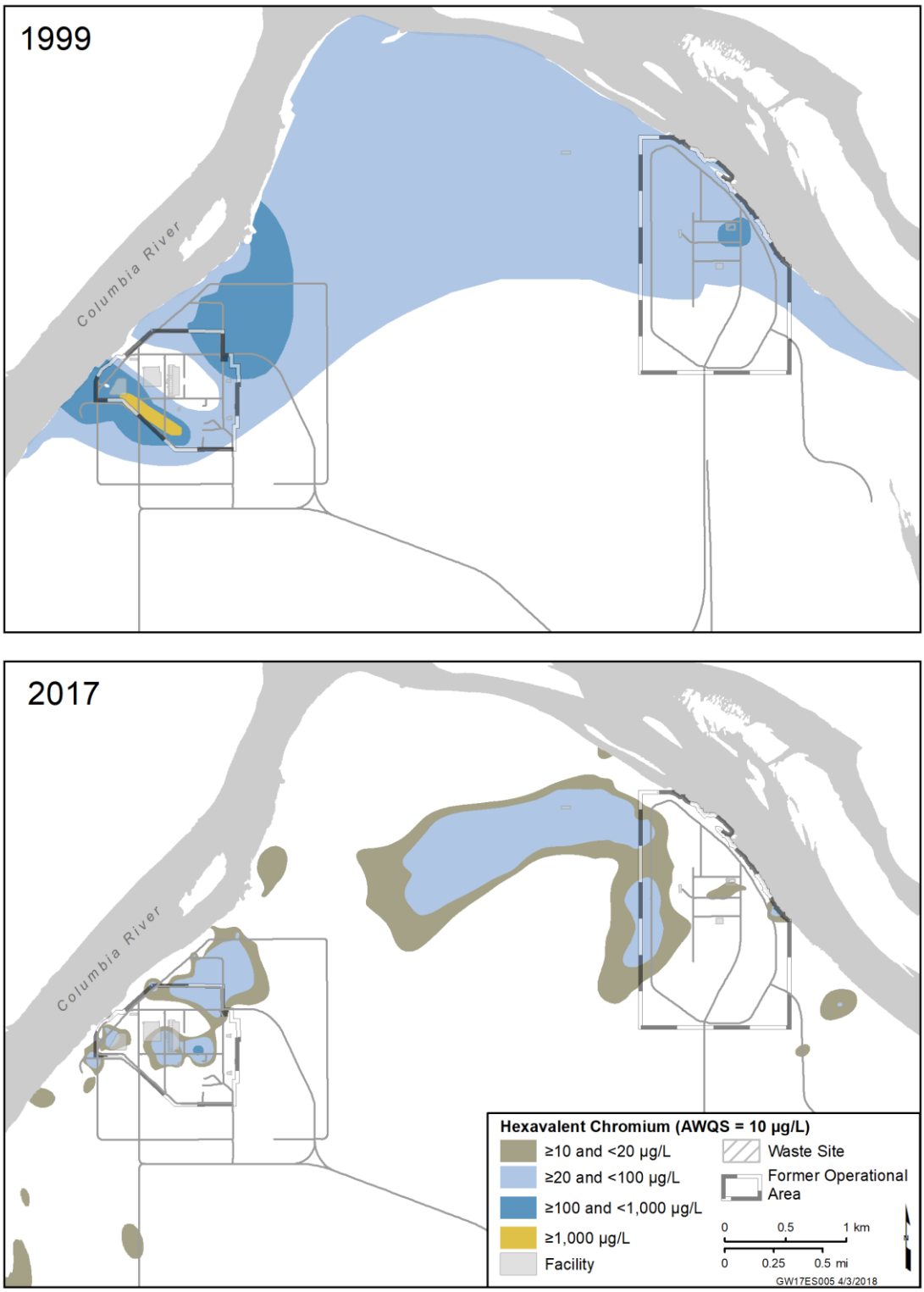


Figure 4-7. 100-HR Cr(VI) Plume in 1999 (Early in Interim Action Period) and 2017 (During Interim Action)

4.2.1 Southern Plume at 100-D

The overall Cr(VI) plume size in the southern portion of the 100-D Area (Figures 4-8 and 4-9) is smaller than in previous years, with a general reduction in concentrations across the area. Concentrations in most locations in the southern plume were below the MTCA (WAC 173-340) standard of 48 µg/L. Several wells near the former 100-D-100 and 100-D-30/104 excavation areas and the former 100-D-56 pipeline continue to exhibit concentrations above 48 µg/L. Wells 199-D5-104 and 199-D5-34 (Figure 4-10) continue to show a decreasing trend, but concentrations in both wells began to asymptote during 2016 with the rate of concentration decline slowing. This trend continued throughout 2017.

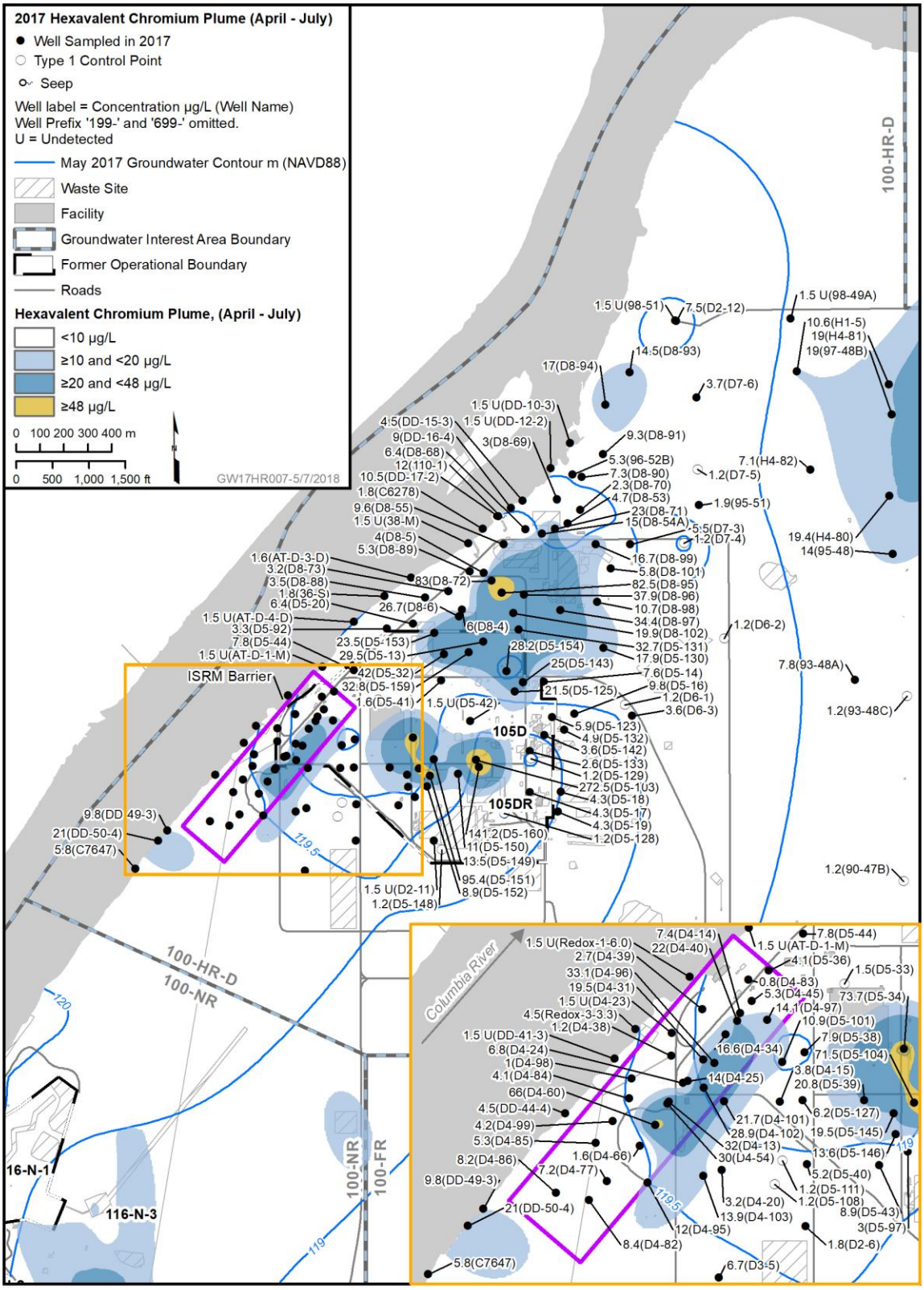
In contrast to the overall declining trends, well 199-D5-103, located near the former 100-D-56 sodium dichromate supply pipeline and between the 100-D-100 and 100-D-30/104 excavations, is exhibiting quickly increasing concentrations (Figure 4-10). It is known that visual Cr(VI) staining remained along the eastern sidewall of the 100-D-100 excavation during the 2014 excavation activities, near current wells 199-D5-103 and 199-D5-160. The concentrations and amount of remaining material are unknown. It is hypothesized that the high water levels experienced during 2017 resulted in the remobilization of Cr(VI) remaining within the deep vadose zone. Well 199-D5-103 had Cr(VI) concentrations of 730 µg/L by December 2017 and now exhibits the highest Cr(VI) levels within 100-HR.

The in situ redox manipulation (ISRM) barrier is located on the southern end of the 100-D Area. Cr(VI) concentrations in 2017 were slowly declining at the northern end of the ISRM barrier. The Cr(VI) along the barrier is below 48 µg/L, with the exception of well 199-D4-60, which had a filtered Cr(VI) result of 68 µg/L in November 2017. It is unknown if a continuing source is present near the ISRM barrier because Cr(VI) concentrations are still generally decreasing, and this area may have lower hydraulic conductivity or less groundwater flow than surrounding areas.

Consistent with previous years, the fall 2017 samples from aquifer tubes and the near-shore monitoring wells indicate that Cr(VI) continues to reach the shoreline of the Columbia River downgradient and south (i.e., upriver) of the ISRM barrier (Figures 4-8 and 4-9). The plume may be migrating to the south around the ISRM barrier along a preferential pathway, or it could be coming from a southern source. During 2016, aquifer tube Redox-3-3.3, located along the shoreline downgradient of the ISRM barrier, had an elevated average Cr(VI) value of 21.5 µg/L. This was related to the temporary shutdown of nearby extraction well 199-D4-38. With the extraction well back in operation, concentrations at aquifer tube Redox-3-3.3 have since declined, and the average Cr(VI) value in 2017 was 4.5 µg/L. The only other area with elevated aquifer tube concentrations was south of the ISRM at aquifer tube clusters DD-50 and DD-49. The highest Cr(VI) concentration in these aquifer tubes in 2017 was 22 µg/L in DD-50-4.

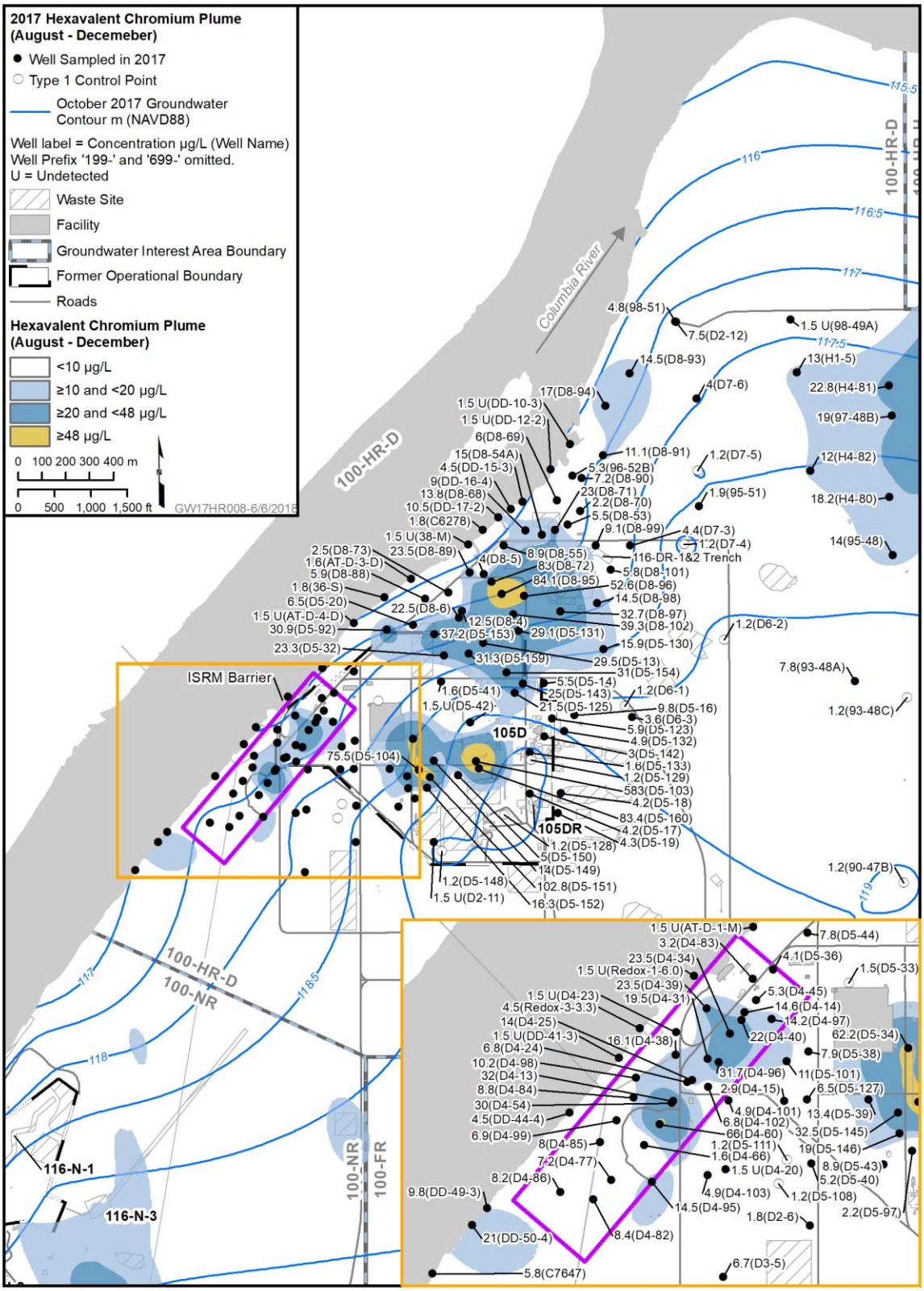
4.2.2 Northern Plume at 100-D

The overall footprint of the northern 100-D Area Cr(VI) plume (Figures 4-8 and 4-9) was slightly smaller in 2017 than in previous years. The area of the plume with concentrations greater than 48 µg/L continued to decline in response to continued P&T extraction and system optimization. The small area of concentrations greater than 48 µg/L are primarily located near the 120-D-1 (100-D Pond) waste site, the 126-D-1 coal ash waste site, and southwest of the 116-DR-1&2 Trenches. Consistent with previous years, extraction well 199-D8-95 had the highest concentrations in the northern 100-D plume, with a maximum of 150 µg/L in January 2017. Well 199-D8-95 and nearby extraction well 199-D8-96 had concentrations over 48 µg/L during 2017, but both wells exhibited declining trends over the year, with concentrations at the end of 2017 at 98 and 54 µg/L, respectively (Figure 4-11). No other wells in the northern plume had concentrations above 48 µg/L during 2017.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-8. 100-HR-D Cr(VI) Plume, Spring/Summer 2017 (High River Stage)



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-9. 100-HR-D Cr(VI) Plume, Fall 2017 (Low River Stage)

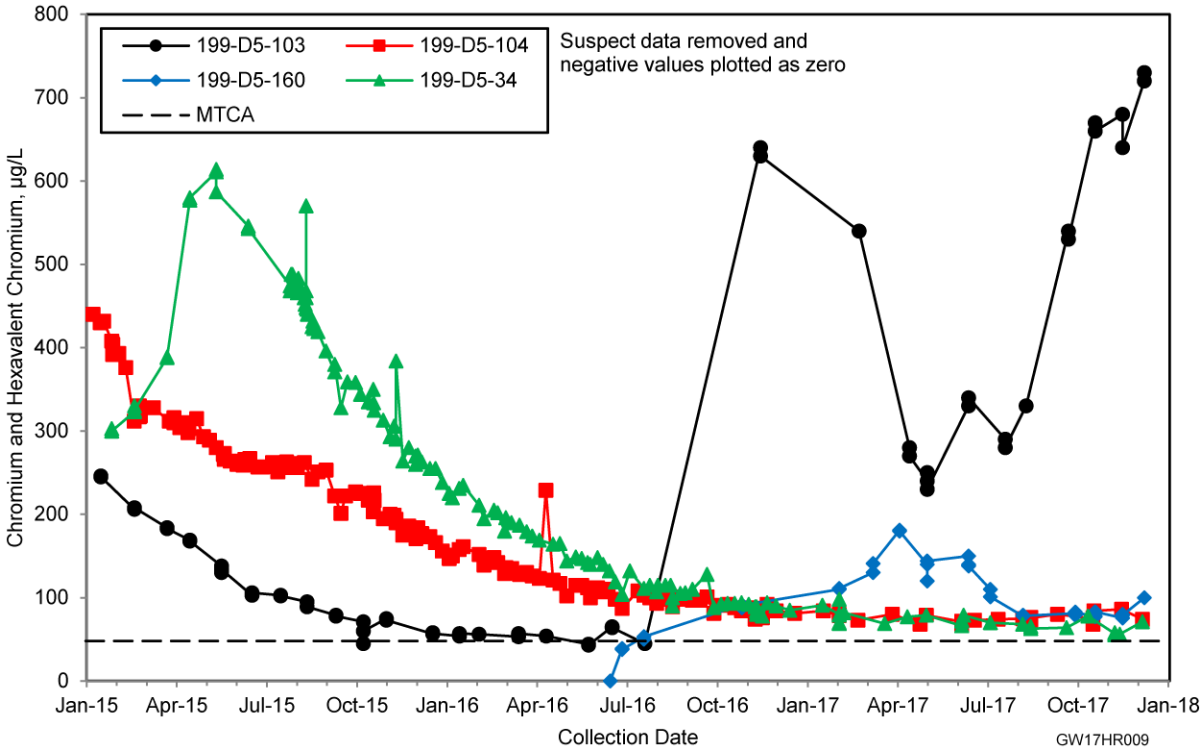


Figure 4-10. 100-HR Cr(VI) Data for Wells 199-D5-103, 199-D5-104, 199-D5-160, and 199-D5-34

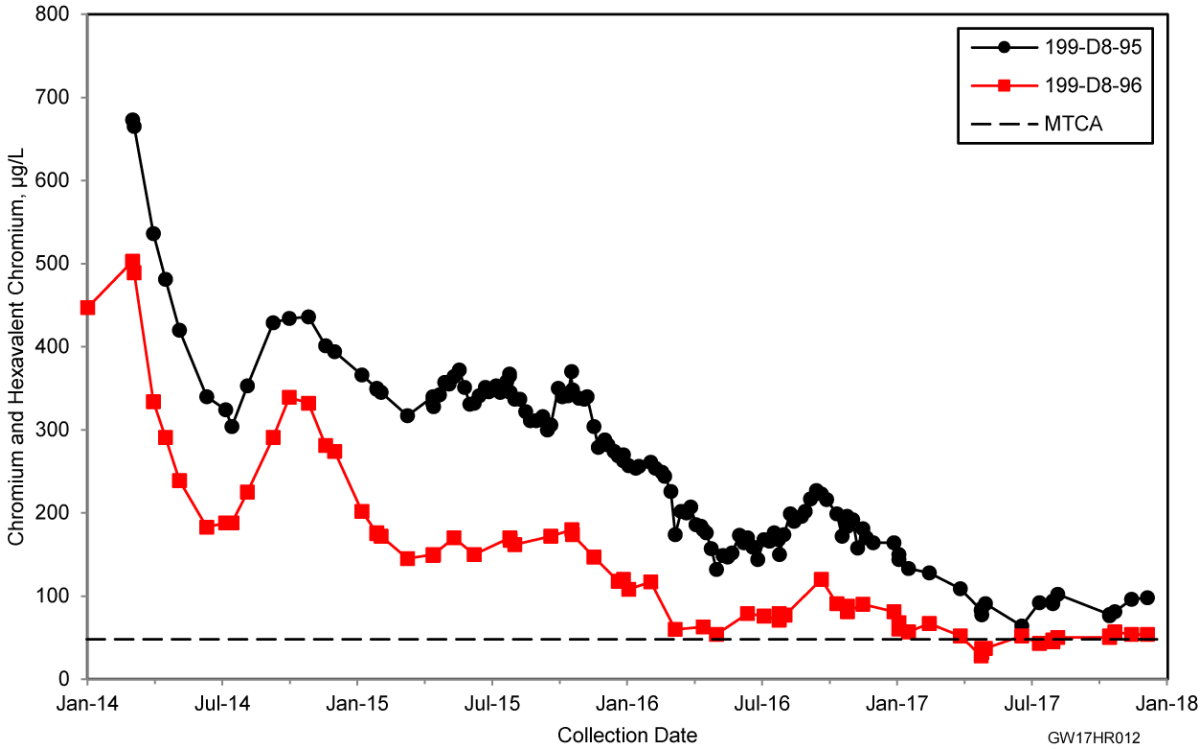


Figure 4-11. 100-HR Cr(VI) Data for Extraction Wells 199-D8-95 and 199-D8-96

Despite years of remediation, low to moderate levels of contamination remain in wells located between the 116-DR-1&2 Trenches and the Columbia River (Figures 4-8 and 4-9). Upgradient injection and near-river extraction have resulted in stable concentrations in the area at about 10 to 15 µg/L. It is suspected that a continuing source remains near the 116-DR-1&2 Trenches, but no source area has been clearly identified.

Downgradient of the 116-DR-1&2 Trenches, aquifer tubes DD-17-2 and DD-16-4 continued to exhibit Cr(VI) concentrations at or near 10 µg/L. While capture of the plume in this area has improved due to P&T system modifications, Cr(VI) continued to reach the river in 2017 at concentrations near 10 µg/L.

4.3 100-HR-H Hexavalent Chromium

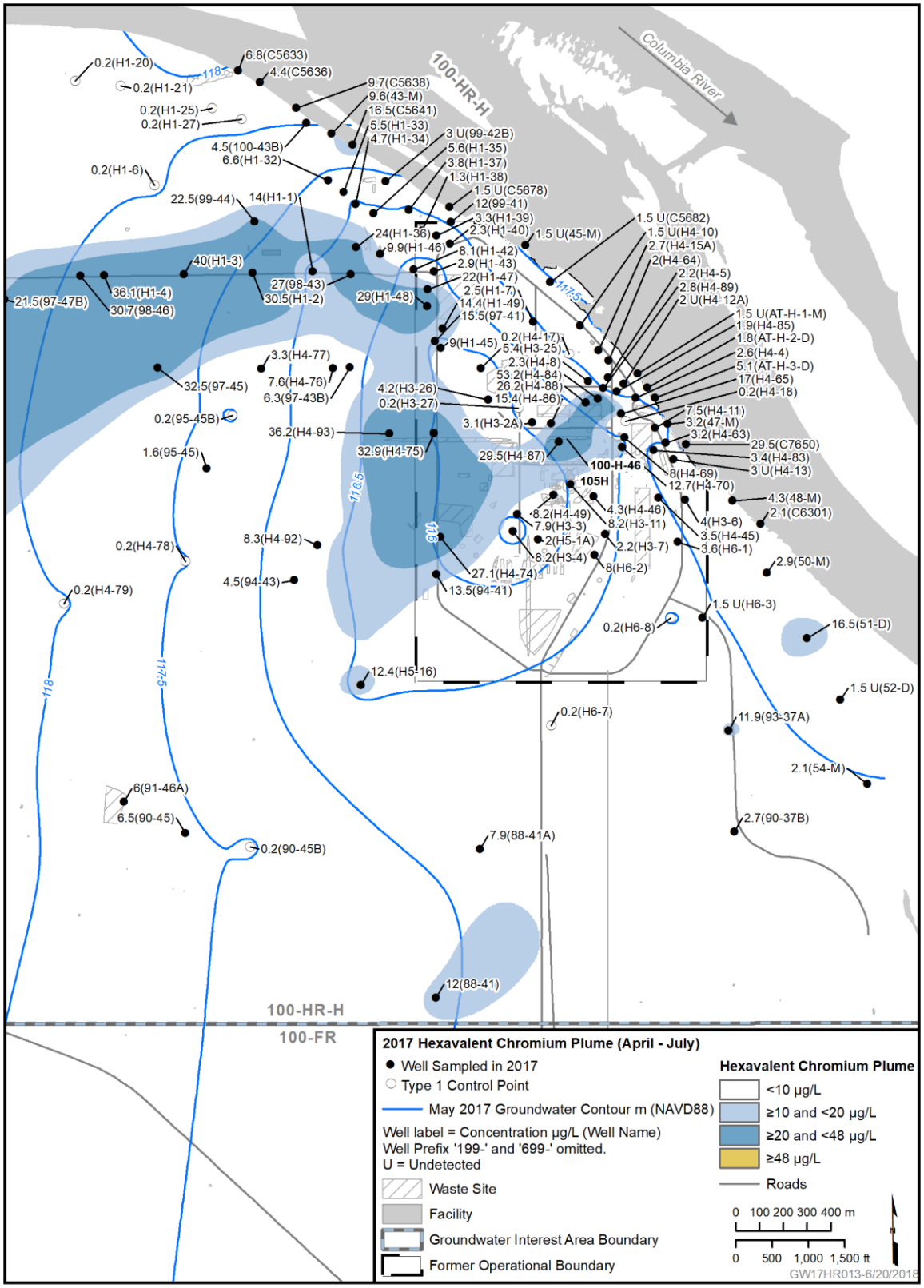
Discharge to the 116-DR-1&2 Trenches during 1967 resulted in the unconfined aquifer Cr(VI) plume that extends across the Horn from the 100-D Area to the 100-H Area (Figures 4-12 and 4-13) (DOE/RL-2010-95). This plume encompasses the largest area of 100-HR, but the plume area is continuing to shrink and concentrations are declining. In 2017, Cr(VI) concentrations were at or below the MTCA (WAC 173-340) standard of 48 µg/L across the Horn. Remediation activities continue to reduce contaminant levels slowly, but removal effectiveness is complicated by the hydrogeology of the area.

Extraction pumps require a minimum of 0.6 m (2 ft) of water above the pump intake to operate. Across the Horn and in the northern portion of the 100-H Area, the aquifer is less than 1 m (3 ft) thick in some locations during low river stage, with the thinnest locations along the northern portion of the Horn. During low river-stage periods, the amount of water available in the aquifer is minimal, and even when pumps are set low into well sumps, there may be insufficient water for the pumps to operate. The reduced operational period during low river stage can adversely affect hydraulic containment. Injection of water into the Horn appears to have helped move the contaminants toward the extraction wells, but a rise in water level in response to the injection has not been confirmed.

Cr(VI) in the 100-H operational area is primarily from H Reactor operations. The areas of elevated concentrations are located near the 183-H Solar Evaporation Basins and in an area north of H Reactor at wells 199-H4-86 and 199-H4-87. Seasonal water table variations in these areas result in corresponding fluctuations in Cr(VI) concentrations, indicating a potential continuing source. Figure 4-14 presents the water table fluctuations in well 199-H4-88, located within the 183-H Solar Evaporation Basins, and the corresponding response in Cr(VI).

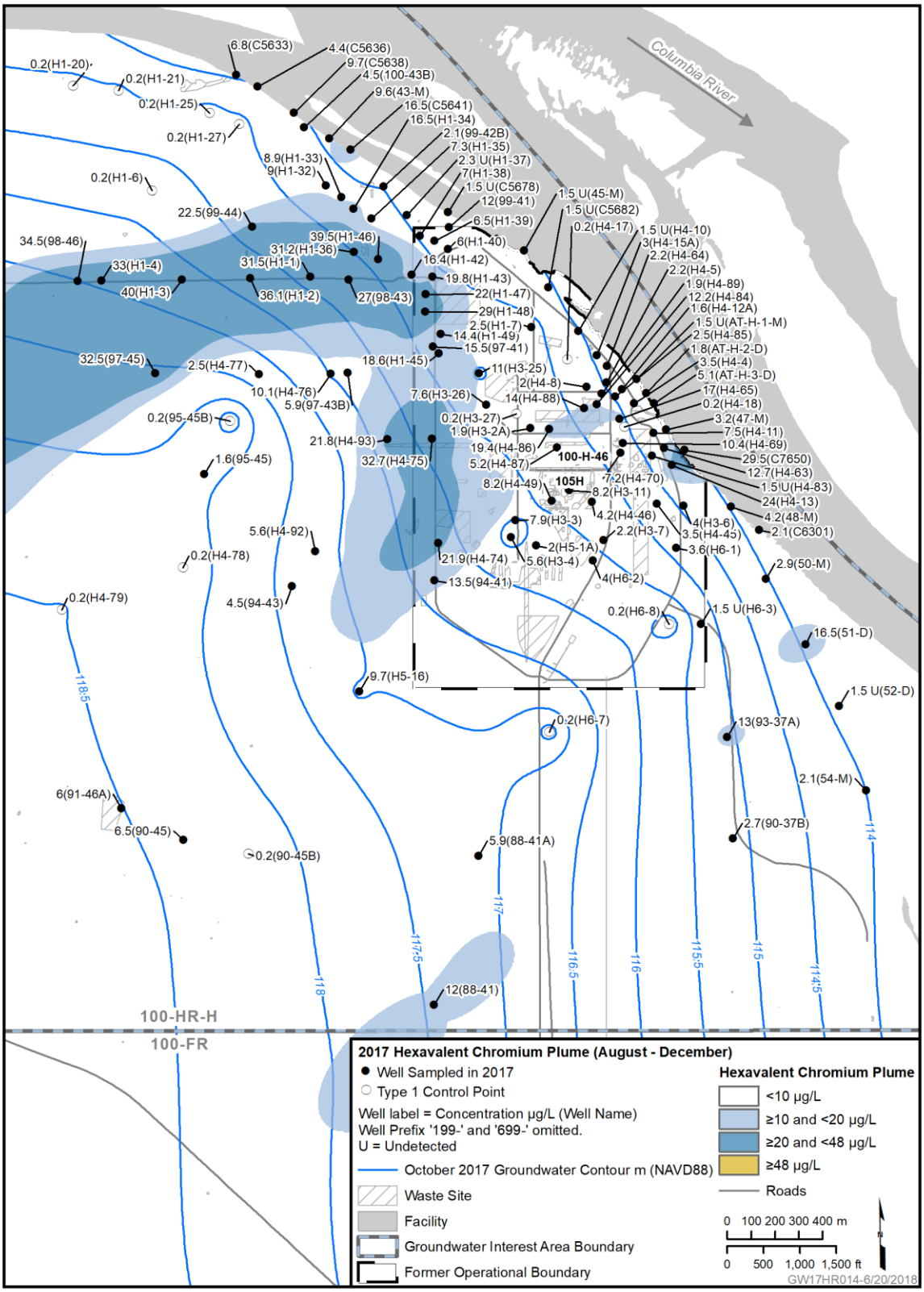
4.3.1 Plume in the Horn

The overall Cr(VI) concentrations in the Horn area unconfined aquifer are slowly declining and were below 48 µg/L for the first time during 2017. Ongoing P&T system operations are attributed with the reduction in Cr(VI); however, the complex hydrogeology and thin aquifer across the Horn has resulted in a slow response to remediation. Injection of P&T system effluent in the middle and south of the Horn was increased in 2015 and 2016 and appears to be moving the remaining Cr(VI) mass toward the extraction locations and resulting in a shrinking plume. Injection well 699-95-45B, which currently accepts approximately 530 L/min (140 gal/min), was added to the system in late 2015; injection well 699-90-45B was added to the system in late 2016 and currently accepts about 490 L/min (130 gal/min).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-12. 100-HR-H Cr(VI) Plume, Spring/Summer 2017 (High River Stage)



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-13. 100-HR-H Cr(VI) Plume, Fall 2017 (Low River Stage)

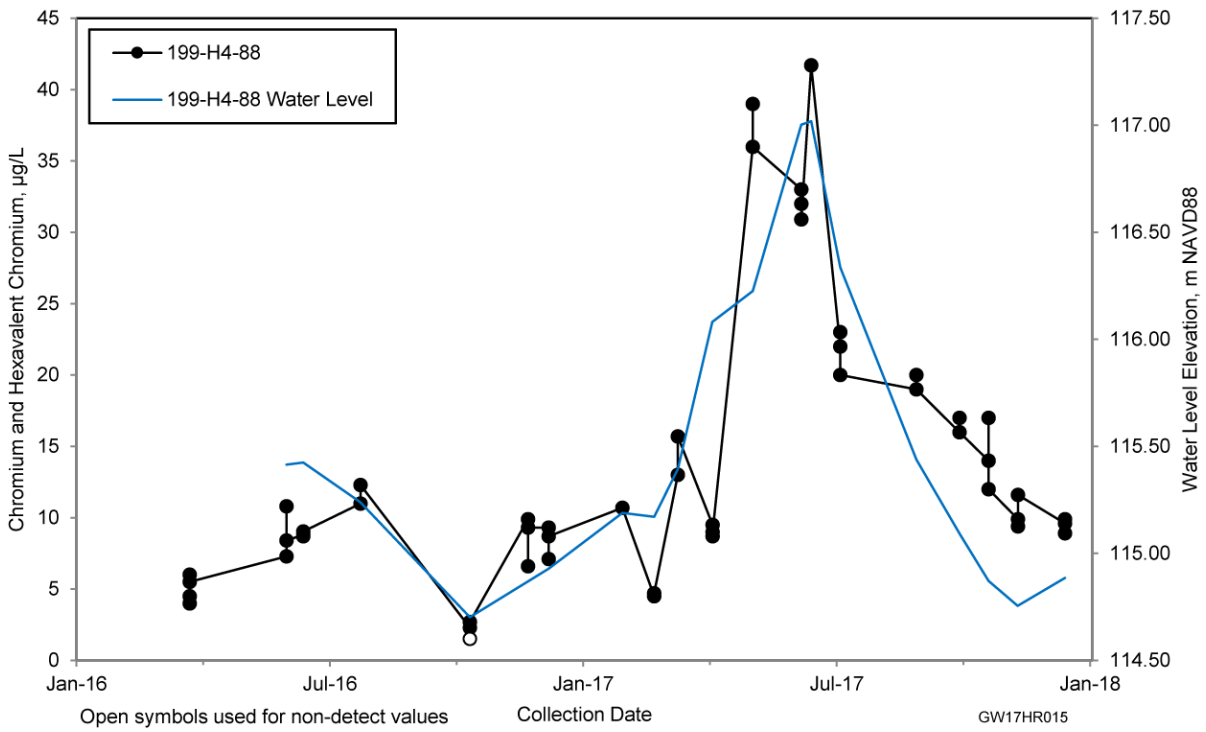


Figure 4-14. 100-HR Cr(VI) Data and Water Level for Well 199-H4-88

Areas of elevated concentrations but less than 48 µg/L remain in the Horn near extraction wells 199-H4-93, 199-H4-75, 199-H1-4, and 199-H1-2, and near monitoring well 699-97-45. Wells 199-H4-93 and 199-H4-75 are located in the southwest area of the Horn. The aquifer is less than 3 m (10 ft) thick in this area, limiting groundwater extraction from these two wells, especially during the early spring. The extraction rate of well 199-H3-93 was averaging 68 L/min (18 gal/min) when operational during 2017, but the well was offline until the end of February 2017. Similarly, well 199-H4-75 averaged 57 L/min (15 gal/min) during 2017. As a result of the low flow rates, which are typical in this area, Cr(VI) concentrations are declining slowly. Concentrations in wells 199-H4-93 and 199-H4-75 were at 20 and 29 µg/L, respectively, by December 2017, compared to 47 µg/L in both wells at the end of 2016. Concentrations in wells 199-H1-4 and 199-H1-2 (located in the middle of the Horn) changed little during 2017, averaging 34 and 36 µg/L, respectively. The stable Cr(VI) concentrations in these two extraction wells was typical across the Horn during 2017.

Closer to the river and north of the 100-H Area, concentrations fluctuated seasonally. The lower concentrations generally occurred during high river stage, when groundwater gradients are directed inland in near-river areas. For example, well 199-H1-46 had seasonal average Cr(VI) concentrations of 9.9 and 39.5 µg/L during the high and low river stages, respectively. Flow rates in well 199-H1-46 were between 75 and 95 L/min (20 and 25 gal/min) during high river stage (when concentrations are low) and between 19 and 38 L/min (5 and 10 gal/min) during low river stage in 2017.

Consistent with previous years, Cr(VI) was detected along the Columbia River shoreline above 10 µg/L in aquifer tube C5641 during low river stage (Figure 4-13). Slightly upriver, aquifer tubes C5638 and 43-M also exhibited elevated Cr(VI) concentrations with levels just below 10 µg/L, at average concentrations of 9.7 and 9.6 µg/L, respectively. These aquifer tubes are located in an area where plume capture is difficult due to the thin aquifer.

4.3.2 Plume at 100-H Area and South

The Cr(VI) concentrations in the 100-H Area unconfined aquifer are typically less than 10 µg/L. In recent years, however, the amount of injection water within the 100-H operational area has been reduced. The reduction was conducted, in part, to determine if any continuing sources remained. As a result, a maximum Cr(VI) concentration of 130 µg/L was detected in well 199-H4-84 in April 2017, and concentrations over 30 µg/L were detected in several other monitoring wells within the 100-H Area during 2017. The areas of elevated Cr(VI) are near the 183-H Solar Evaporation Basins (wells 199-H4-84 and 199-H4-88) and near upgradient waste sites 126-H-2 and 100-H-46 (wells 199-H4-86 and 199-H4-87, respectively). At each of the waste site locations, the associated wells exhibit elevated Cr(VI) concentrations during periods of high water levels and are areas of suspected or known continuing sources in the lower vadose zone.

Aquifer tube C7650, located downgradient of the 107H Retention Basin, continues to have elevated Cr(VI) concentrations, averaging 29.5 µg/L during 2017. Cr(VI) concentrations also continued to be above 10 µg/L in aquifer tube 51-D, located to the south of the 100-H Area. This appears to be an isolated area of slightly elevated Cr(VI), and concentrations are slowly declining.

4.4 Hexavalent Chromium in the Ringold Upper Mud Unit

The surface of the RUM forms the base of the unconfined aquifer in 100-HR. In 100-HR-D, the RUM material is primarily silt and clay and is relatively thick, providing a barrier between the unconfined aquifer and the first water-bearing unit within the RUM. Across the Horn and in 100-HR-H, data from borehole logs indicate that the uppermost RUM material is thinner and contains more sand and gravel than elsewhere at 100-HR. In addition, reworked RUM material is present in small pockets, mostly within the Horn and the 100-H Area. This material contains gravel in a silt and clay matrix that represents a transition zone above the more massive silt or clay. This may result in a less competent barrier between the unconfined aquifer and the RUM aquifer below, possibly contributing to a hydraulic connection between the two units.

Within the RUM, thin sand-to-gravel layers with variable hydraulic conductivities act as confined or semiconfined leaky aquifers (DOE/RL-2010-95). Multiple water-bearing units are known to be present in the 100-H Area. Within the 100-D Area and in the Horn, deeper water-bearing units are suspected but are not confirmed or monitored.

4.4.1 Ringold Upper Mud Unit Plume at 100-HR-D

Three wells in the 100-D Area monitor the first water-bearing unit of the RUM. Cr(VI) has not been detected in well 199-D4-141, which is located south of the 182D reservoir. The other RUM wells are 199-D8-54B (located near the 116-DR-1&2 Trench) and 199-D5-134 (located north of D Reactor). The Cr(VI) concentrations in these wells have fluctuated historically, with concentrations below 10 µg/L. Concentrations in well 199-D8-54B have been trending slowly upward, with a maximum concentration in 2017 of 8.8 µg/L. These wells will continue to be monitored to track concentrations.

4.4.2 Ringold Upper Mud Unit Plume in the Horn

Elevated concentrations of Cr(VI) are known to be present within the Horn. Figure 4-15 presents the annual average concentrations during 2017 for the RUM wells. The maximum concentration is presented only for wells drilled in 2017. A plume is not depicted due to the varied spatial distribution of Cr(VI) concentrations, a limited number of wells for such a large area, and uncertainty regarding the lateral continuity of the RUM aquifer. Based on current knowledge, elevated Cr(VI) concentrations are present in a small area centered near well 699-97-48C, which had a maximum concentration of 140 µg/L in 2017 and is exhibiting an increasing trend.

Concentrations are declining in well 699-97-61, located west of 699-97-48C, which may indicate the tailing edge of the plume. Well 699-97-61 had a maximum concentration of 196 µg/L in 2016 and 123 µg/L in 2017. None of the other wells in the same area are completed in the RUM, and it is uncertain if the plume extends farther to the north or south. To the east, RUM well 699-97-45B has Cr(VI) levels just above the detection limit. It is presumed that this well represents the eastern boundary of the Cr(VI) plume, but as in the west, there are limited wells in the area and no wells to define the plume to the north or south. It should also be noted that wells 699-97-61 and 699-97-45B are 675 m (2,200 ft) apart, and in the Horn, all of the RUM wells are nearly in a straight line running west to east. Additional wells are planned to be installed in the Horn as funding becomes available.

4.4.3 Ringold Upper Mud Unit Plume at 100-HR-H

There are several water-bearing units within the RUM in the 100-H Area. The source of contamination in the RUM aquifer in this area is hypothesized to be Cr(VI)-contaminated groundwater in the overlying unconfined aquifer that was driven downward through the upper RUM material and into the RUM aquifer by high hydraulic heads during reactor operations (Section 4.1.5.3 of DOE/RL-2010-95). This hypothesis is supported by the fact that the RUM in the 100-H Area includes a relatively thin zone of silt and clay material separating the two aquifers. Under current conditions, the RUM aquifer in the 100-H Area exhibits slightly higher head than the unconfined aquifer, indicating a small upward vertical gradient. This gradient has been decreasing over time (Section 3.7.2.2 of DOE/RL-2010-95), likely due to groundwater extraction at several RUM wells.

The top of the zones with higher hydraulic conductivity is typically 3 to 5 m (9 to 16 ft) below the RUM surface. This material also exhibits a substantial sand and gravel fraction, making the competency of the RUM material as a confining layer questionable. To date, Cr(VI) contamination has been identified in only the uppermost of these units, with the lower water-bearing zones having levels at or near the detection limits.

The first water-bearing unit in the RUM is better defined in the 100-H Area than elsewhere across 100-HR. Three new wells were installed in 2017, with well 199-H3-29 having the highest Cr(VI) concentration (140 µg/L) in the 100-H Area (including in the unconfined aquifer). Assuming a hydraulic connection, well 199-H3-29 is located just upgradient of RUM extraction wells 199-H4-12C and 199-H3-9. Together, these two extraction wells average 158 L/min (42 gal/min). Wells 199-H4-12C and 199-H3-9 have slowly declining Cr(VI) concentrations (Figure 4-16). Well 199-H2-1, to the north, has exhibited an increasing trend, with concentrations at 20 µg/L in November 2017. It is unknown if this well is hydraulically connected to the high-concentration wells (199-H4-12C, 199-H3-9, and 199-H3-29) located near the 183-H Solar Evaporation Basins.

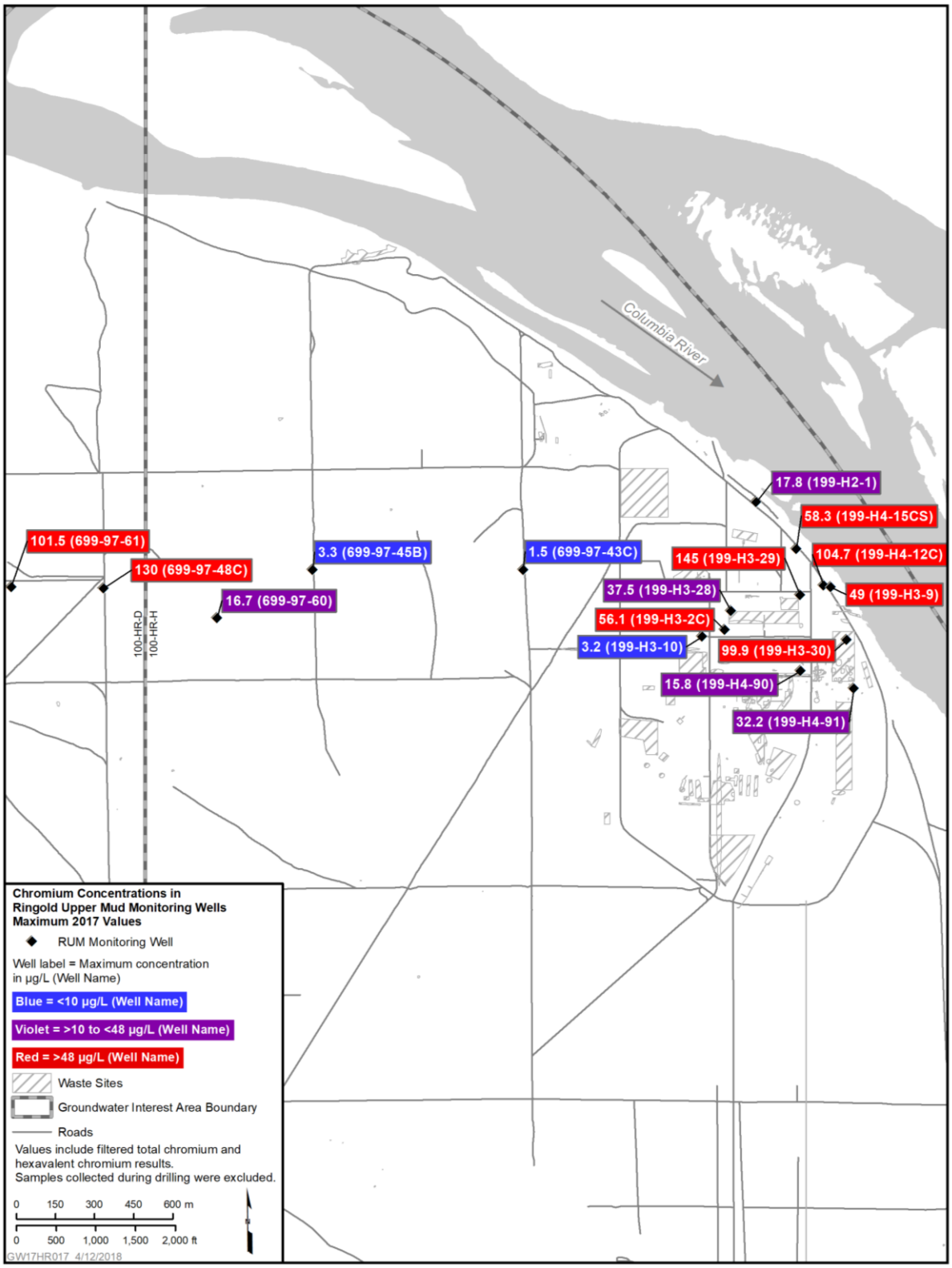


Figure 4-15. 100-HR Cr(VI) Concentrations in the RUM Monitoring Wells, 2017

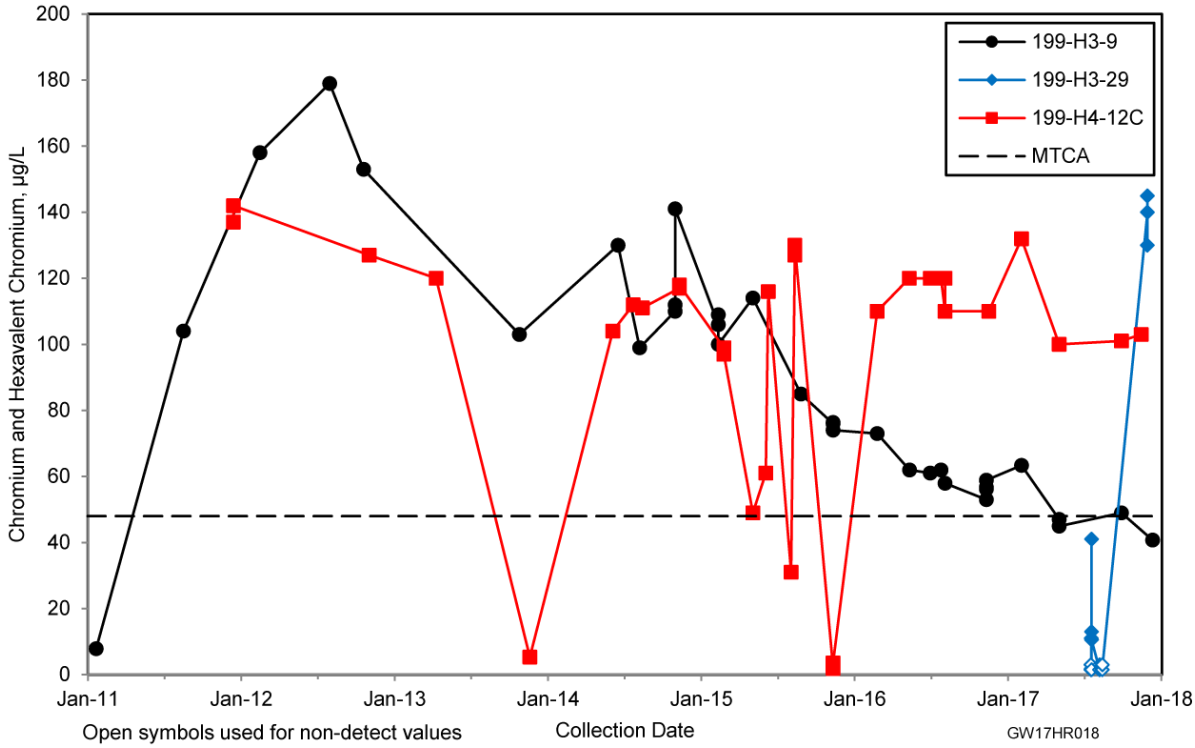


Figure 4-16. 100-HR Cr(VI) Data for RUM Wells 199-H3-9, 199-H3-29, and 199-H4-12C

New RUM well 199-H3-30 also exhibits high Cr(VI) levels, with concentrations at 88 µg/L in December 2017 (post-development). This well is located within the footprint of the former 107H Retention Basin (waste site 116-H-7). The presence of Cr(VI) in this location is consistent with the current CSM for the area. South of the retention basin, concentrations at well 199-H4-91 have been stable at about 30 to 40 µg/L. Slightly inland at well 199-H4-90, Cr(VI) levels are lower and typically range from 8 to 15 µg/L (Figure 4-17).

In 2016, a series of hydraulic characterization and aquifer tests were performed in five RUM wells in the 100-H Area (199-H3-10, 199-H3-2C, 199-H4-90, 199-H3-9, and 199-H4-12C). The results of these tests and analyses were evaluated to help determine the hydraulic connectivity between RUM wells and the connections between the RUM aquifer and the overlying unconfined aquifer and Columbia River. The results were published in 2017 in SGW-60571, *Aquifer Testing of the First Water-Bearing Unit in the RUM at 100-H*.

Results of the aquifer characterization tests identified and quantified the RUM confining layer leakage, which provides initial leakage parameter estimates that can be used for modeling contaminant transport from the overlying unconfined aquifer to the underlying RUM aquifer. All of the drawdown derivative patterns were characteristic of leaky confined aquifers (PNL-8539, *Selected Hydraulic Test Analysis Techniques for Constant-Rate Discharge Tests*). This is typical for confining layers that are relatively thin with overlying productive aquifers (i.e., those with high transmissivity and storativity), which is consistent with the hydrogeologic model for the 100-H Area (DOE/RL-2010-95). Thus, these tests provided specific evidence of leaky aquifer conditions and estimates of the leaky, confining layer properties.

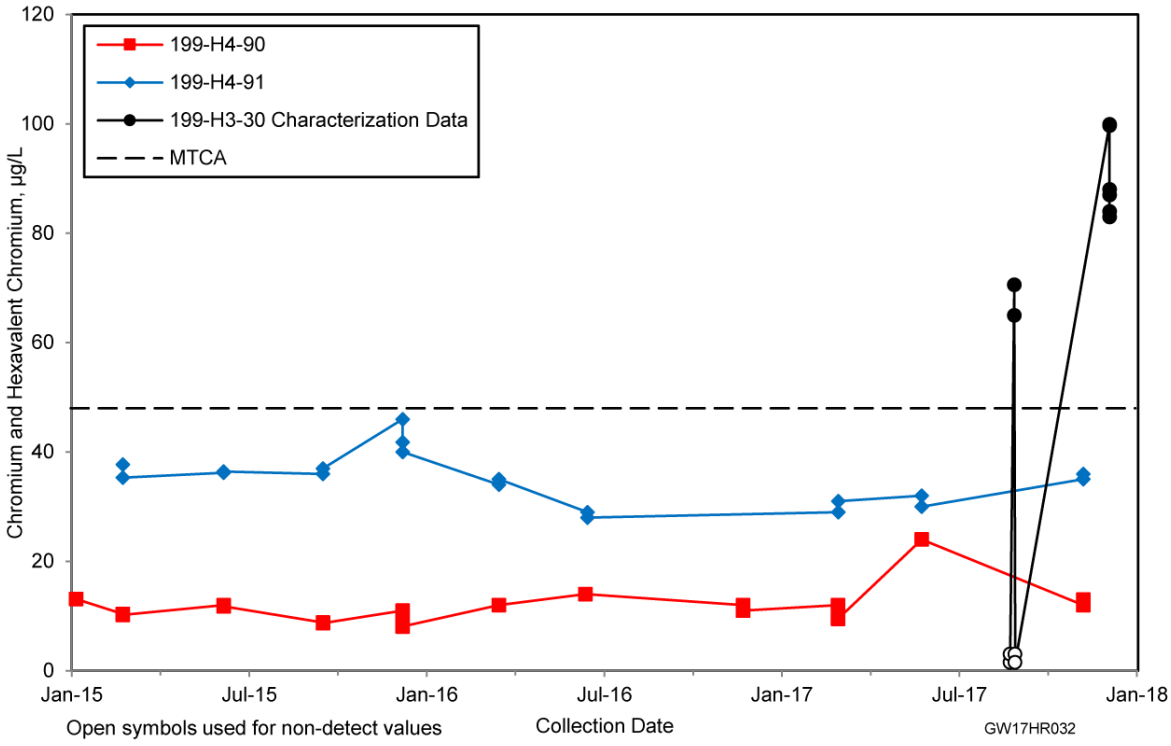


Figure 4-17. 100-HR Cr(VI) Data for RUM Wells 199-H3-30, 199-H4-90, and 199-H4-91

As demonstrated from the Phase 2 characterization tests, leakage from the overlying unconfined aquifer through the RUM confining layer is sufficient to limit the lateral propagation of test drawdown response that would occur if non-leaky, confined aquifer conditions were present. Phase 2 characterization test results suggest that hydrologic continuity of the RUM aquifer is likely to extend 300 m (1,000 ft) and perhaps considerably more.

SGW-60571 also evaluated whether the unconfined aquifer and the RUM aquifer are hydraulically connected to the Columbia River. Selected 100-H Area wells completed in the unconfined aquifer above the RUM appear to exhibit a hydraulic communicative response, whereas wells completed within the uppermost RUM aquifer exhibit either a hydraulic communicative or loading response. The wide areal response to river-stage fluctuations suggests that both the unconfined and uppermost RUM aquifers are hydraulically connected to the Columbia River. However, the nature and extent of the hydraulic communication interface between the RUM aquifer and the river is unclear. Hydraulic communication may be limited to a few local or preferential contact interfaces where the RUM aquifer is in direct contact with the river channel, or the connection may be more broadly extensive along the river shoreline.

Additionally, the study provided quantitative aquifer hydraulic properties (e.g., transmissivity and storativity) for the first water-bearing unit of the RUM. The test results will support future decisions for remediating affected groundwater in the 100-H Area.

4.5 Nitrate

Primary sources of nitrate in 100-HR groundwater included gas condensate from the reactors, septic systems and sewer lines, former agricultural practices, and waste sites that received nitric acid. The nitrate plume was largely collocated and is extracted during P&T operations. The area of the plume with nitrate concentrations above the 45 mg/L DWS equivalent has declined and now is exhibited in only a few wells.

Nitrate concentrations in the 100-D Area remained below the DWS and continued to decline in 2017. The highest concentration in the 100-D Area in 2017 was 40.7 mg/L in well 199-D8-97 (Figure 4-18). Wells 199-D5-130 and 199-D8-98 showed the next highest nitrate concentrations in 100-D, at 39.4 and 37.6 mg/L, respectively.

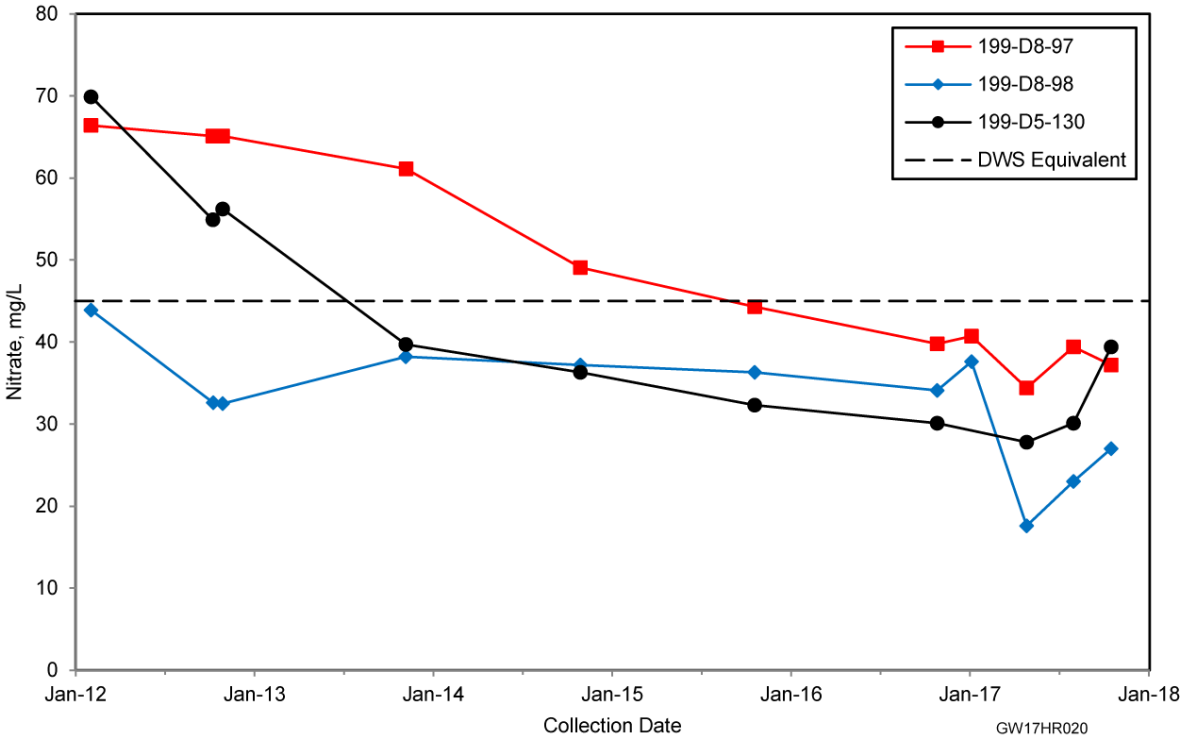


Figure 4-18. 100-HR Nitrate Data for Wells 199-D8-97, 199-D8-98, and 199-D5-130

The highest nitrate concentrations in 100-HR during 2017 were found near the former 183-H Solar Evaporation Basins. Nitrate concentrations above 45 mg/L were detected in wells 199-H4-84 and 199-H4-88, with a maximum concentration of 124 mg/L at well 199-H4-84. Nitrate concentrations in well 199-H4-84 increased in spring 2017, reaching a peak in July, and then declining through the summer and fall when water levels dropped, which is consistent with concentration responses to water-level trends in a source area (Figure 4-19). The unusual decrease in nitrate and specific conductance during May and June appears to be related to the dilution from an influx of river water. However, adjacent wells 199-H4-88 and 199-H4-89 showed increases in nitrate concentrations during high river stages, with maximum concentrations of 76.6 and 48.7 mg/L, respectively.

Nitrate concentrations in the first water-bearing unit of the RUM remained much lower than in the unconfined aquifer in the 100-D Area and the Horn. Concentrations in the 100-D Area are typically below 2 mg/L, and concentrations in the Horn were below 4 mg/L. In the 100-H Area, nitrate concentrations remained low in the RUM in most locations. Concentrations in the RUM have increased in recent years in wells 199-H4-90, 199-H4-91, and 199-H4-12C, with a maximum of 21.7 mg/L in well 199-H4-12C. In new RUM wells 199-H3-28 and 199-H3-30, nitrate concentrations were at 23.5 mg/L and below 8 mg/L, respectively. However, new RUM well 199-H3-29 exhibits elevated concentrations of nitrate with an increasing trend. Nitrate levels in the well were at 155 mg/L during post-development sampling in November and increased to 416 mg/L by January 2018, exceeding the DWS of 45 mg/L. This is the first location in the RUM aquifer with an exceedance of nitrate. It should be noted that well 199-H3-29 is located near the 183-H Solar Evaporation Basins, where the RUM is known to be a leaky, confining unit.

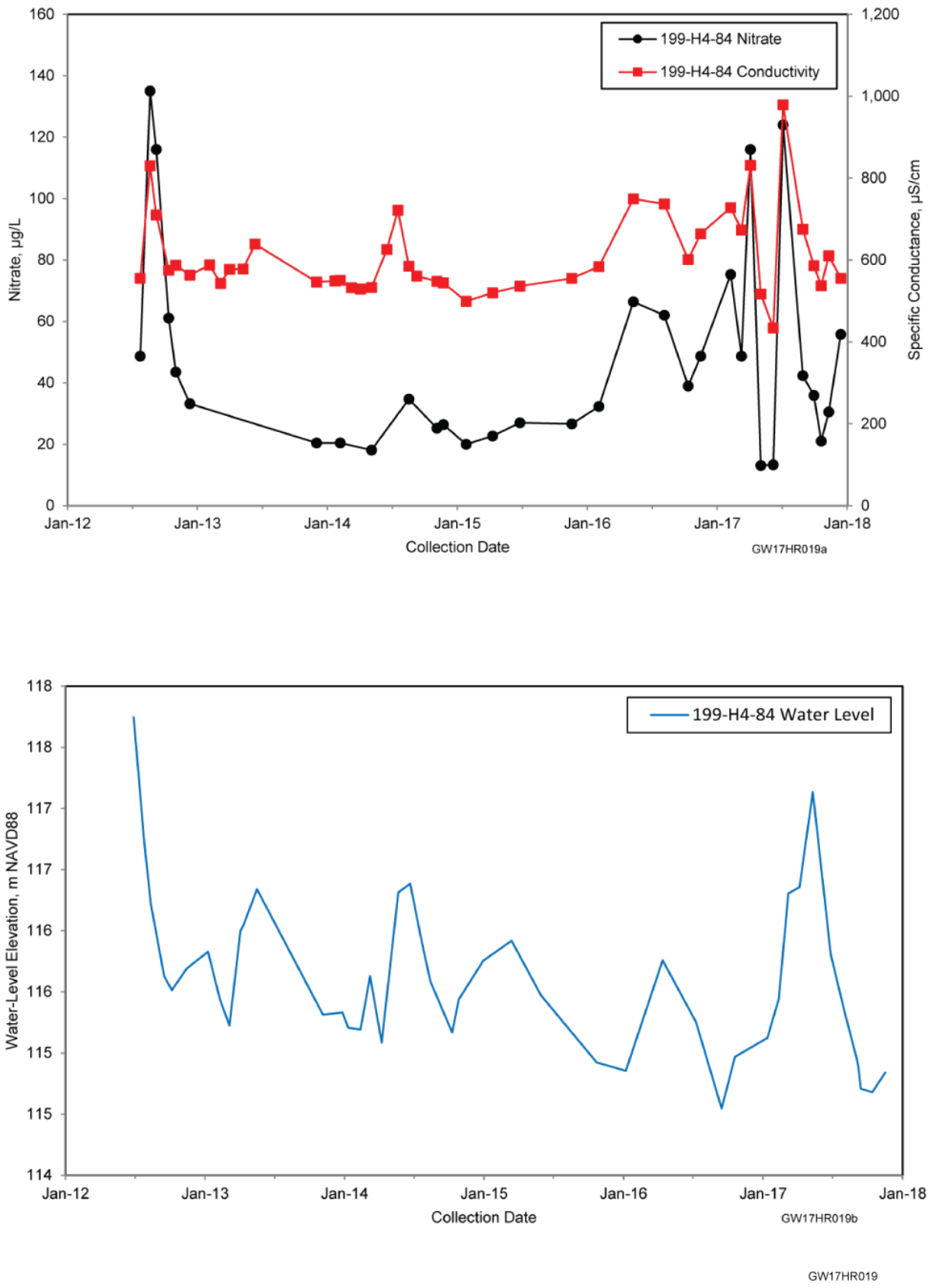


Figure 4-19. 100-HR Nitrate, Specific Conductance, and Water-Level Data for Well 199-H4-84

4.6 Strontium-90

Strontium-90 was present in waste disposed at both the 100-D and 100-H Areas. Elevated concentrations are present in groundwater in isolated locations near D Reactor and the 107H Retention Basin (Figures 4-20 and 4-21). The concentrations and distribution of strontium-90 are declining gradually in both areas, consistent with natural radiological decay.

Groundwater near the former fuel storage basin (FSB) at D Reactor is monitored for strontium-90. Wells 199-D5-132 and 199-D5-142 are located near the FSB and continue to have strontium-90 concentrations above the DWS of 8 pCi/L. The highest strontium-90 concentration was identified in well 199-D5-132 at 27.8 pCi/L (February 2017). The average concentration dropped from 28.1 pCi/L in 2016 to 21.4 pCi/L in 2017. Strontium-90 concentrations in downgradient wells exhibit some fluctuation but remained below the 8 pCi/L DWS.

Historically, strontium-90 concentrations above DWS have been found in groundwater near the former 116-D-7 and 116-DR-9 Retention Basins in the northern 100-D Area. In 2017, the highest strontium-90 concentration in that area was 3.93 pCi/L in well 199-D8-68, a decline from previous years. Strontium-90 was detected at low concentrations in aquifer tubes downgradient from the retention basins, which is consistent with previous years. The highest detection was 3.74 pCi/L in aquifer tube C6278.

Strontium-90 levels in 100-H Area groundwater continue to exceed the DWS near the former 116-H-7 Retention Basin and 116-H-1 Trench, located near the Columbia River and east of H Reactor (Figure 4-21). This is the only area in 100-H with strontium-90 above the DWS. Strontium-90 concentrations in this area showed notable increases in 2017, likely due to the unusually high water levels in areas with known or suspected continuing sources in the lower vadose zone.

The highest strontium-90 concentration in the 100-H Area was 25.8 pCi/L in well 199-H4-83 in November 2017, which was an increase from 2016 (Figure 4-22). Concentrations were also elevated in nearby well 199-H4-13 and in well 199-H3-11 (located near H Reactor), with maximum concentrations of 23.1 and 14.4 pCi/L, respectively. Slightly elevated concentrations were also detected south of the 116-H-7 Retention Basin at wells 199-H4-45 and 199-H3-6. Strontium-90 was not detected in samples collected from aquifer tubes located downgradient of this area.

Previously, RUM wells were not located within the footprint of the 100-H or 100-D Area strontium-90 plumes. During late 2017, new RUM well 199-H3-30 was installed in the footprint of the 107H Retention Basin. New RUM wells 199-H3-28 and 199-H3-29 were installed upgradient and slightly downgradient of the 183-H Solar Evaporation Basins. Early analytical results from these wells indicate that strontium-90 is not present in the RUM aquifer.

In 2015, strontium-90 was detected for the first time at RUM extraction well 199-H4-12C at 6.05 pCi/L. Since the 2015 detection, well 199-H4-12C has been on a quarterly sampling schedule, with no detectable strontium-90 in 2016 or 2017. This well will continue to be monitored for strontium-90.

4.7 Tritium

Tritium concentrations in 100-HR are decreasing overall, with concentrations below 10,000 pCi/L during 2017. Historically, tritium occasionally exceeded the 20,000 pCi/L DWS in wells near the ISRM barrier in the southern portion of the 100-D Area and near DR Reactor. The last tritium concentration that exceeded the DWS in 100-HR was in 2014 at well 199-D4-20. Concentrations in well 199-D4-20 were at 2,970 pCi/L in 2017. The highest tritium concentration in 100-HR groundwater during 2017 was 9,440 pCi/L at well 199-D4-13, which is part of an increasing trend.

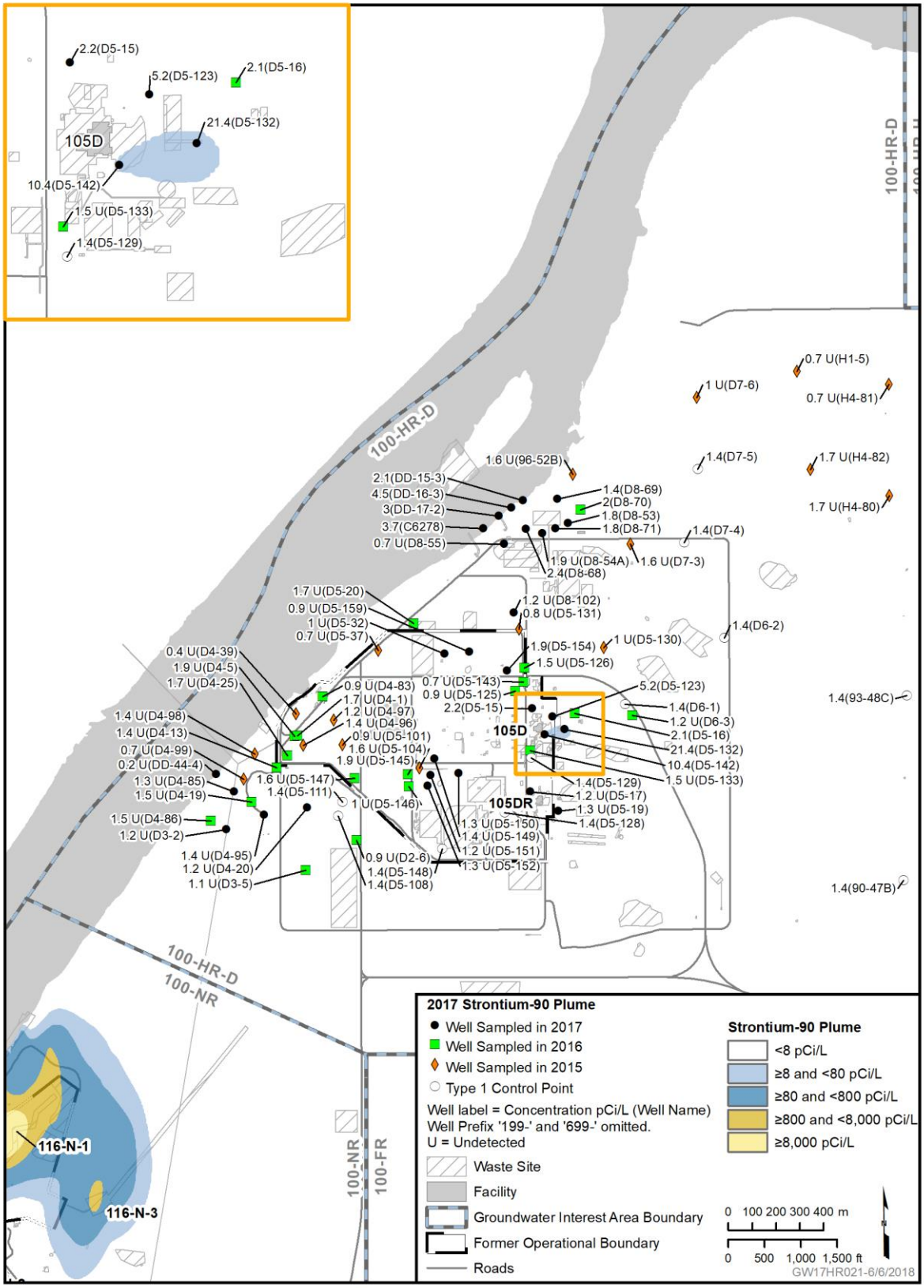


Figure 4-20. 100-HR-D Strontium-90 Plume, 2017

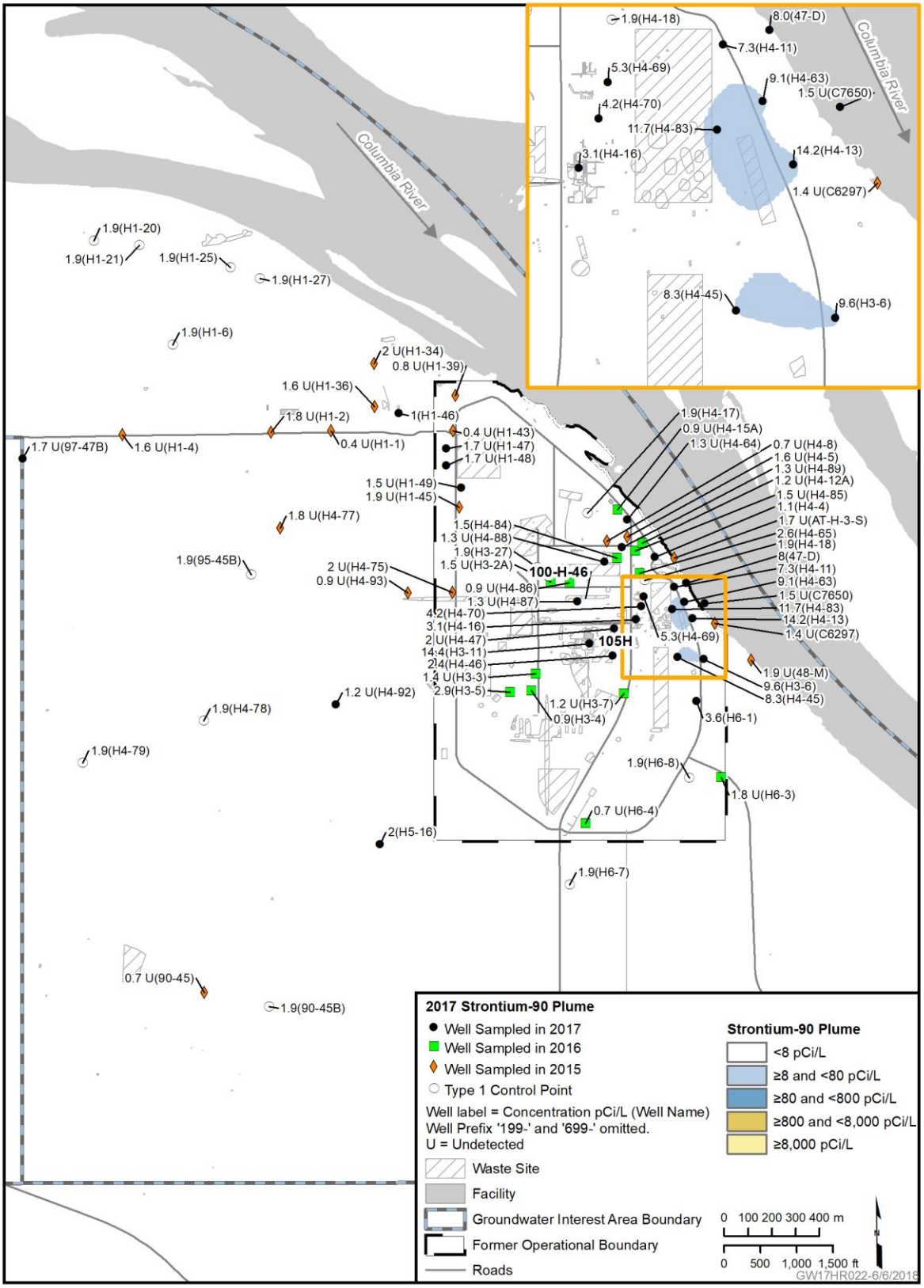


Figure 4-21. 100-HR-H Strontium-90 Plume, 2017

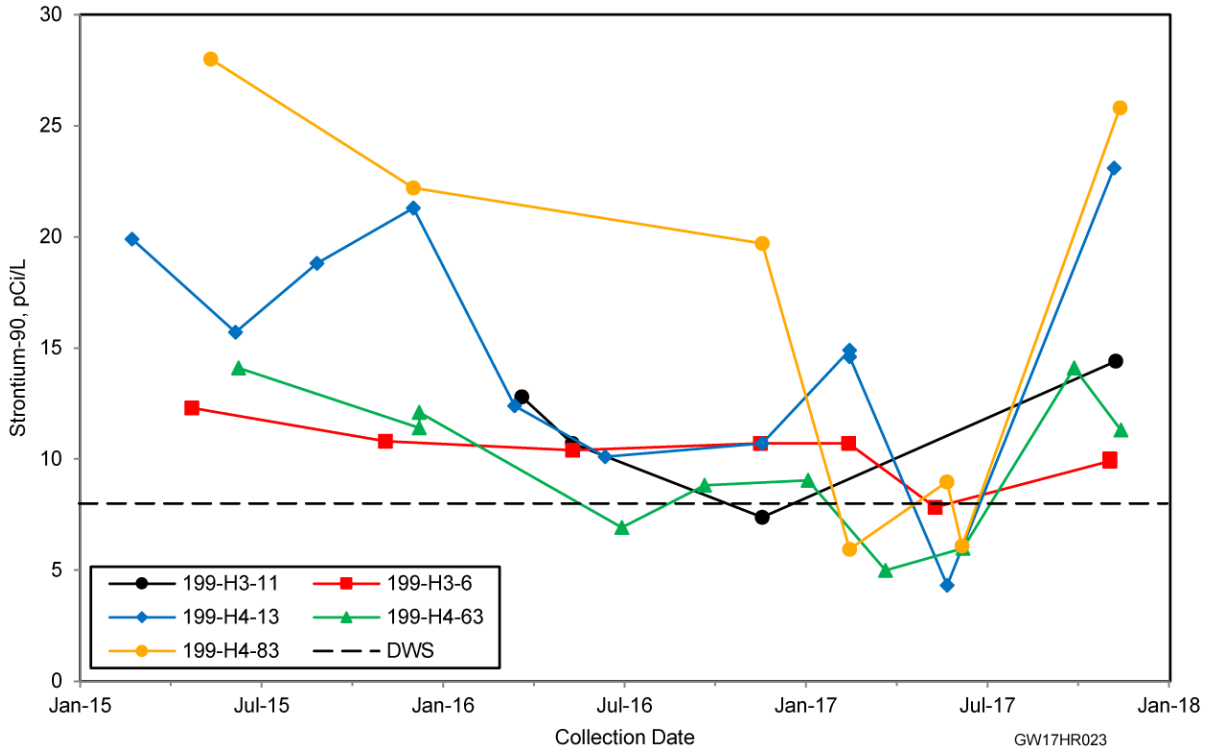


Figure 4-22. 100-HR Strontium-90 Data in Wells in Eastern 100-H Area

4.8 Uranium

Uranium is present in groundwater near the former 183-H Solar Evaporation Basins in the 100-H Area (Section 4.11) and exceeded the DWS of 30 µg/L in two wells during 2017. Concentrations in well 199-H4-84 ranged from 127 µg/L in July to 11 µg/L in October (Figure 4-23). The duplicate sample in July had a slightly lower result of 119 µg/L. Elevated uranium concentrations were also observed in well 199-H4-88, located within the western portion of the basins. The uranium concentration in well 199-H4-88 ranged from 4.5 µg/L in February to 55.2 µg/L in June.

Like Cr(VI), uranium concentrations increase in this source area during or following high water table conditions. Since the river had higher peak stages during 2017 than in 2016, the number of exceedances of the DWS was not unexpected, and the groundwater level correlates with the elevated uranium concentrations.

Uranium was also detected in well 199-H4-65 at 25.9 µg/L in November 2017. This result was 10 times higher than previous results and is being reviewed as suspect data. The well is located south and downgradient from the 183-H Solar Evaporation Basins and has not been analyzed on a regular basis for uranium due to the presence of low levels (less than 5 µg/L) until 2017. The sample frequency for this well will be increased to better evaluate the elevated result from November 2017.

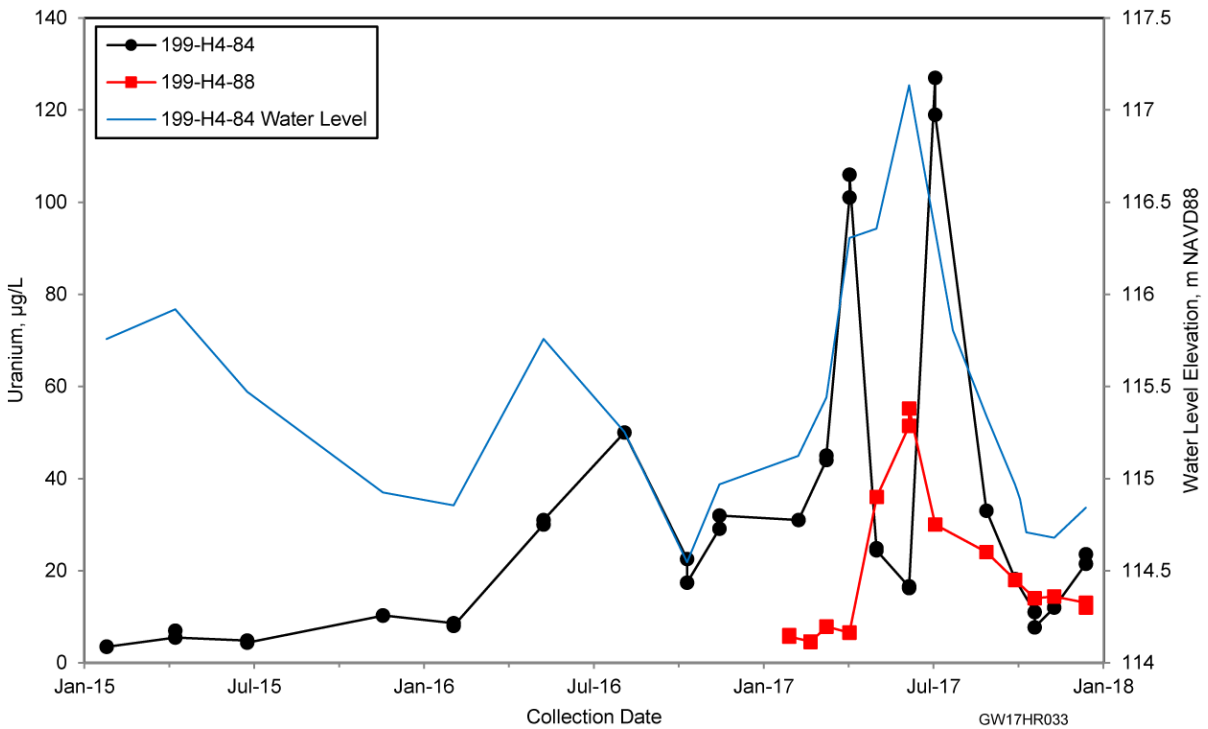


Figure 4-23. 100-HR Uranium Data and Water Levels in Wells 199-H4-84 and 199-H4-88

4.9 Sulfate

The area around the ISRM barrier in the 100-D Area has historically had elevated levels of sulfate related to sodium dithionite solution injections. There were no exceedances of the 250 mg/L secondary DWS at the ISRM barrier or elsewhere in 100-HR during 2017.

Sulfate concentrations tend to increase in wells located near P&T injection wells. Groundwater that has been treated by the DX P&T system is affected by the addition of sulfuric acid, which is used to lower the pH in the influent groundwater because the ResinTech[1] SIR-700 ion-exchange resin treatment technology is more efficient at a lower pH. Sodium hydroxide is added to the treated groundwater prior to injection into the aquifer to neutralize the acid and return the pH to near neutral. Sulfate concentrations in the effluent during 2017 averaged 161 mg/L.

During 2017, the highest concentrations of sulfate were found in monitoring well 199-D5-149 and extraction well 199-D5-101, with maximum concentrations at or near the DWS (Figure 4-24). The wells are located downgradient of injection wells 199-D5-128, 199-D5-129, and 199-D5-148 (Figure 4-1).

[1] ResinTech® is a registered trademark of ResinTech, Inc., West Berlin, New Jersey.

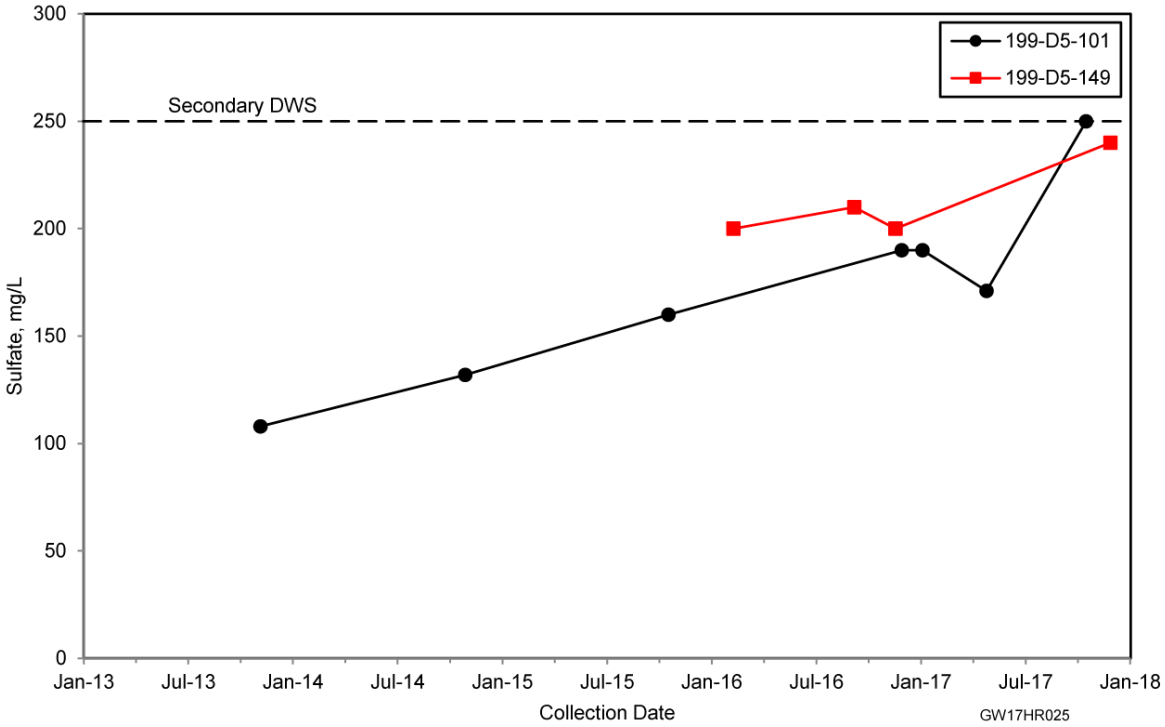


Figure 4-24. 100-HR Sulfate Data in Wells 199-D5-101 and 199-D5-149

4.10 CERCLA Remediation and Monitoring

CERCLA groundwater activities in the 100-HR-3 OU included groundwater monitoring and operating and optimizing interim remediation systems for Cr(VI) (including adding new wells and realigning existing wells). The current DX and HX P&T systems are operated under the authority of the interim action ROD (EPA/ROD/R10-96/134) and the subsequent 2009 explanation of significant differences (EPA et al., 2009, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington*). Groundwater is monitored to evaluate the effectiveness of interim remedial actions and to track plumes, plume areas (Figure 4-6 and Table 4-1), and trends. The current CERCLA SAP is DOE/RL-2013-30, *Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring*, as modified by TPA-CN-0743, *Tri-Party Agreement Change Notice Form: Sampling and Analysis Plan for 100-HR-3 Groundwater Operable Unit Monitoring*. Table A-1 in Appendix A lists the sampling exceptions for 2017.

A total of six new wells were installed in 2017 (Table 4-2) as part of remedial optimization. Wells 199-H1-47, 199-H1-48, and 199-H1-49 were installed for use as extraction wells. The wells were completed in the unconfined aquifer along the shoreline north of the 100-H Area, where plume containment has been difficult. Three wells were also installed in the RUM aquifer: 199-H3-28, 199-H3-29, and 199-H3-30. These wells are located in the 100-H Area, with well 199-H3-28 located inland near well 199-H3-2C; well 199-H3-29 located near the 183-H Solar Evaporation Basins; and well 199-H3-30 located within the 107H Retention Basin. The RUM wells 199-H3-28 and 199-H3-29 are currently planned for connection to the HX P&T system.

Table 4-2. New Wells Installed in 100-HR in 2017

Well Name	Well ID	Purpose*	Construction Depth (m bgs)	Construction Depth (ft bgs)	Drilled Depth (m bgs)	Drilled Depth (ft bgs)	Acceptance Date	Comment
199-H1-47	C9637	100-HR-3 unconfined aquifer extraction	13.2	43.4	13.9	45.6	12/13/2017	
199-H1-48	C9638	100-HR-3 unconfined aquifer extraction	13.8	45.1	15.4	50.7	12/13/2017	
199-H1-49	C9639	100-HR-3 unconfined aquifer extraction	18.6	61.2	36.7	120.5	12/13/2017	
199-H3-28	C9715	100-HR-3 RUM extraction	35.5	116.4	36.7	120.4	12/13/2017	Some of the analytical results from samples collected during drilling are suspect due to low dissolved oxygen content in the sample, which may affect hexavalent chromium results.
199-H3-29	C9716	100-HR-3 RUM extraction	29.3	96.3	70.0	230.5	12/13/2017	
199-H3-30	C9717	100-HR-3 RUM extraction	26.9	88.2	35.1	115.0	12/13/2017	

*DOE/RL-2013-35-ADD9, *100-HR-3 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 9: Wells 199-H1-47, 199-H1-48, 199-H1-49, 199-H3-28, 199-H3-29, and 199-H3-30*.

bgs = below ground surface
ID = identification
RUM = Ringold upper mud unit

4.10.1 CERCLA Decision Documents and Plans

In 2010 and 2011, DOE conducted extensive field studies, as described in an RI/FS work plan addendum (DOE/RL-2008-46-ADD1, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) and SAP (DOE/RL-2009-40, *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study*). Changes to the SAP were documented in Tri-Party Agreement change notices (TPA-CN-368 and TPA-CN-460, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-40, Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study, Rev. 0*).

The RI/FS results were evaluated, and DOE submitted Draft A of the RI/FS and the proposed plan for 100-D/H in late 2012 (DOE/RL-2010-95; DOE/RL-2011-111, Draft A, *Proposed Plan for Remediation of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*). The RI/FS was reviewed by Ecology, revised, and approved as Rev. 0 in October 2014. The RI/FS results support selection of final remedies under CERCLA using an approach that integrates source and groundwater remedial actions, which is documented in the proposed plan (DOE/RL-2011-111, Rev. 0). In 2016, the proposed plan was made available for public comment, public comments were received and incorporated, and work on the ROD for final remedial action commenced. The signed ROD will identify the final remedial alternative.

Remedial action decisions will address the integrated cleanup of source waste sites and groundwater. The general objectives for all of these decisions are to protect human health and the environment, restore groundwater to beneficial use, and protect aquatic life in the Columbia River from exposure to 100-HR groundwater COPCs exceeding ambient water quality criteria.

4.10.2 Pump and Treat

DOE has operated a groundwater P&T system in the 100-HR-3 OU since 1997 under an interim action ROD (EPA/ROD/R10-96/134), which was amended in 1999 (EPA/AMD/R10-00/122, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*). Two P&T systems (DX and HX) currently operate in 100-HR (Figure 4-25) in accordance with the 2009 explanation of significant differences (EPA et al., 2009). A passive interim remedial action system, the ISRM, is monitored but is no longer maintained.

Table 4-3 summarizes DX and HX P&T operations. These facilities were constructed in response to the 2009 explanation of significant differences (EPA et al., 2009), which expanded the capacities of the P&T system and replaced the existing older DR-5 and HR-3 systems. These systems are described in previous P&T reports (e.g., DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009, Volumes 1 & 2*).

In 2017, the DX and HX systems removed a combined total of 56 kg of Cr(VI) from 2,921 million L (771 million gal) of groundwater (Table 4-3). Due to continuing and effective remediation, the mass of Cr(VI) remaining in the aquifer is declining, which results in lower mass recovery, as shown in Figure 4-26. Most of the Cr(VI) mass removed from the DX and HX systems during 2017 originated in what remains of the plume interior, where concentrations are higher. The overall areal extent of the plumes continues to decline (Figure 4-6), illustrating plume response to remediation. Operation of the remediation systems and groundwater monitoring results for 2017 are described in DOE/RL-2017-67.

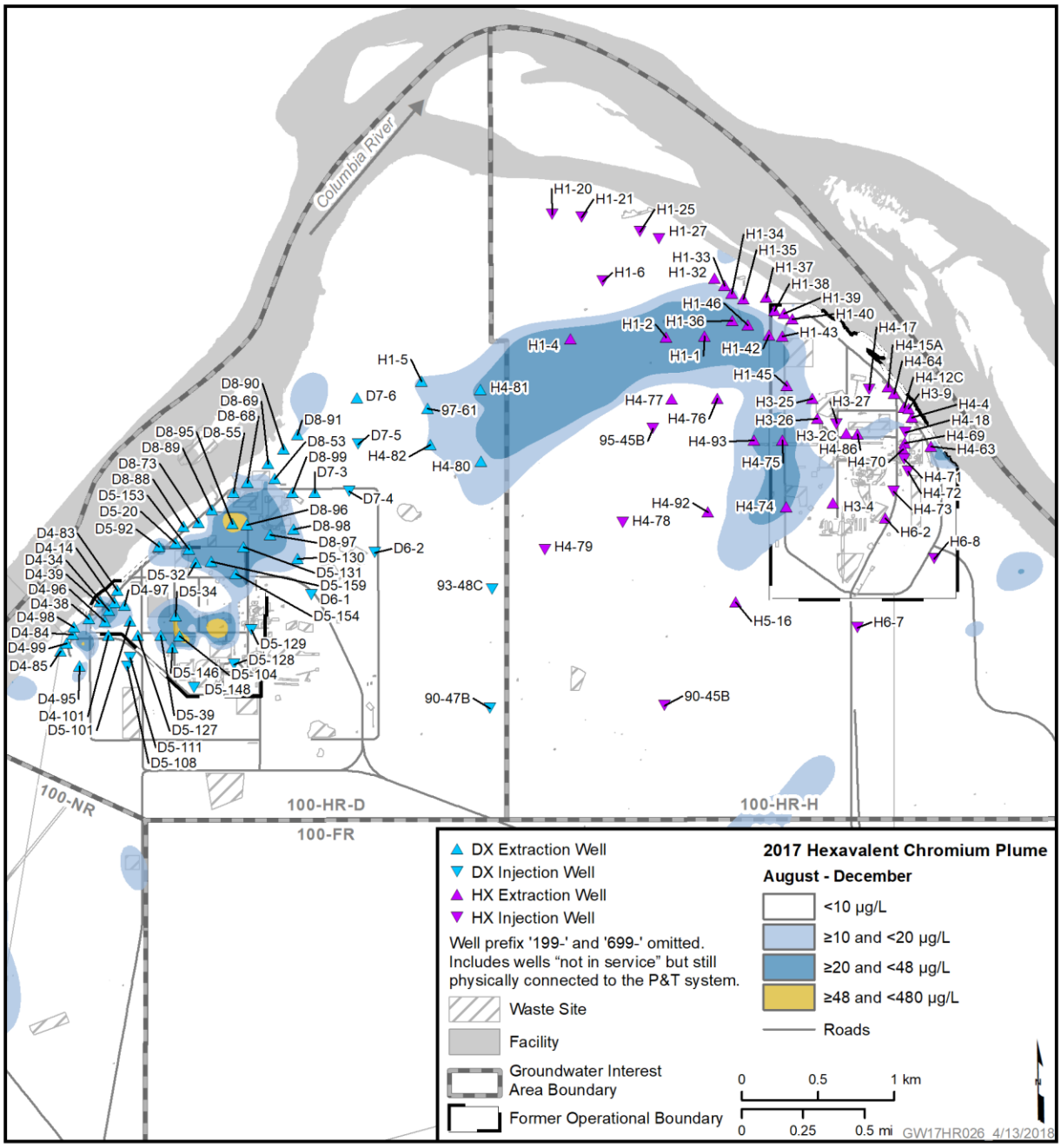


Figure 4-25. 100-HR-3 Remedy Overview

During 2017, 85 active extraction wells and 28 active injection wells operated, including those that only operated a short time during the year. System realignments at the DX system included disconnecting four injection wells located north of the 100-D Area and converting them to monitoring wells. At the HX system, realignments included converting injection well 199-H1-3 to a monitoring well.

Table 4-3. 100-HR-3 Remedy Summary

Current 100-HR-3 P&T Systems (2017)		
P&T system	DX	HX
Design capacity (L/min [gal/min])	2,935 (775)	3,788 (900)
Extraction wells	48	37
Injection wells	11	17
Average flow rate (L/min [gal/min])	2,829 (747)	2,806 (741)
Volume treated (million L [million gal])	1,470 (388)	1,451 (383)
Cr(VI) mass removed (kg)	30.4	25.9
Average Cr(VI) influent concentration (µg/L)	21.8	18.3
Average Cr(VI) effluent concentration (µg/L)	<2	<2
All 100-HR-3 P&T Systems, 1997-2017		
Volume treated (million L [million gal])		21,050 (5,561)
Cr(VI) mass removed (kg)		2,460
In Situ Redox Manipulation Barrier, 1999-2017		
Barrier no longer maintained but reduced conditions remain.		

Cr(VI) = hexavalent chromium
P&T = pump and treat

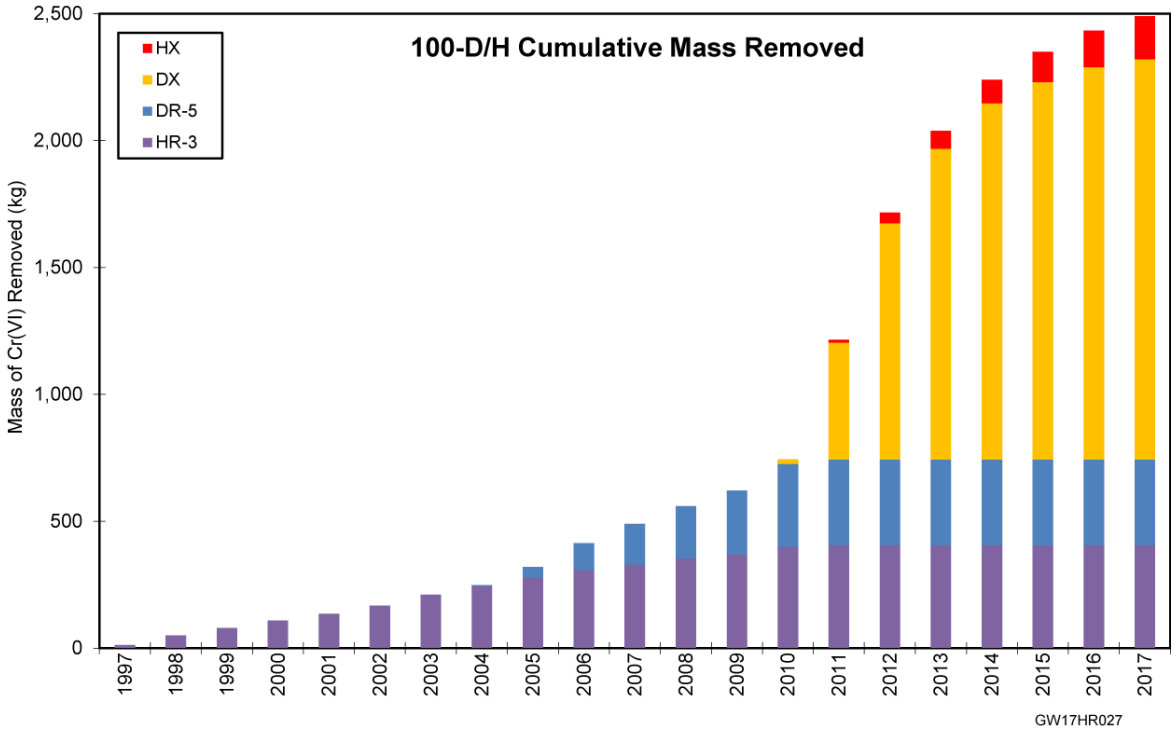


Figure 4-26. 100-HR-3 P&T Cr(VI) Mass Removal

The spatial distribution of specific conductance (Figures 4-27 and 4-28) indicates areas where plume capture is more successful. Areas with lower values along the river indicate where the river water is pulled toward nearby extraction wells. These figures correlate well with areas where the plume is under hydraulic control, as discussed in DOE/RL-2017-67.

4.10.3 In Situ Redox Manipulation Barrier

In 2000, an ISRM barrier was added to the existing P&T remedy. Due to Cr(VI) breakthrough at this barrier, a notice of nonsignificant change to the ROD was issued in 2010, indicating that the barrier would no longer be actively maintained and shifting the groundwater remedy to the P&T system (11-AMCP-0002, "Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Washington. July 2010, Memo to File Regarding: Supplemental Actions for the In-Situ Reduction/Oxidation Manipulation Barrier Performance for the 100-HR-3 Groundwater Operable Unit Interim Remedy"). Groundwater at the ISRM site is still monitored as part of CERCLA interim action monitoring, with Cr(VI) as the target contaminant. Where it is still effective, the ISRM barrier reduces oxygen content in the aquifer, so dissolved oxygen is also monitored.

In 2017, the ISRM barrier continued to convert some Cr(VI) to a nontoxic, immobile form (trivalent chromium) in the southern portion of the barrier, as suggested by the dissolved oxygen (Figure 4-29). The dissolved oxygen levels near and along the ISRM barrier are increasing overall. The dissolved oxygen concentrations are relatively high upgradient of the treatment zone, decreasing significantly through the treatment zone, and recovering as groundwater flow approaches the river. The P&T system capture is improving in that area in response to system modifications.

Groundwater samples collected from some wells in the ISRM barrier have gross beta levels above 50 pCi/L, the level where additional monitoring is usually required by EPA. However, the gross beta activity is primarily caused by naturally present potassium-40 in the pH buffer used during sodium dithionite injections for the ISRM barrier (Section 2.5 of PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). The highest gross beta concentration associated with the ISRM barrier in 2017 was 83.4 pCi/L in well 199-D4-1.

4.11 RCRA Monitoring at the 183-H Solar Evaporation Basins

The 183-H Solar Evaporation Basins (116-H-6 waste site) (Figure 4-30) consisted of four basins in the 100-H Area. The basins were originally part of the larger 183-H water treatment facility, which had 12 additional basins. Following decommissioning of the water treatment facility, the four remaining basins were used to evaporate various liquid waste streams, including neutralized spent acid etch solutions from the 300 Area fuel fabrication facilities. The waste solutions contained various contaminants, including chromium, uranium, and nitrate. The basins were used for waste evaporation from July 1973 until November 1985 and were demolished in 1995. The contaminated soil was removed to a depth of 4.6 m (15 ft) below Basin 1 in 1996 (DOE/RL-97-48).

Groundwater protection was demonstrated through modeling, and Ecology approved a modified RCRA closure in May 1997 (Soper, 1997, "Re: Acceptance of "Closure Certification for the 183-H Solar Evaporation Basins (T-1-4)," 96-EAP-246). Clean closure of the site was not achieved because fluoride and nitrate levels in soil below the 4.6 m (15 ft) deep excavation exceeded the MTCA (WAC 173-340) Method B cleanup levels for groundwater protection. Therefore, the TSD unit was closed in place under the modified closure provisions of the Hanford RCRA Permit with specified measures for post-closure care.

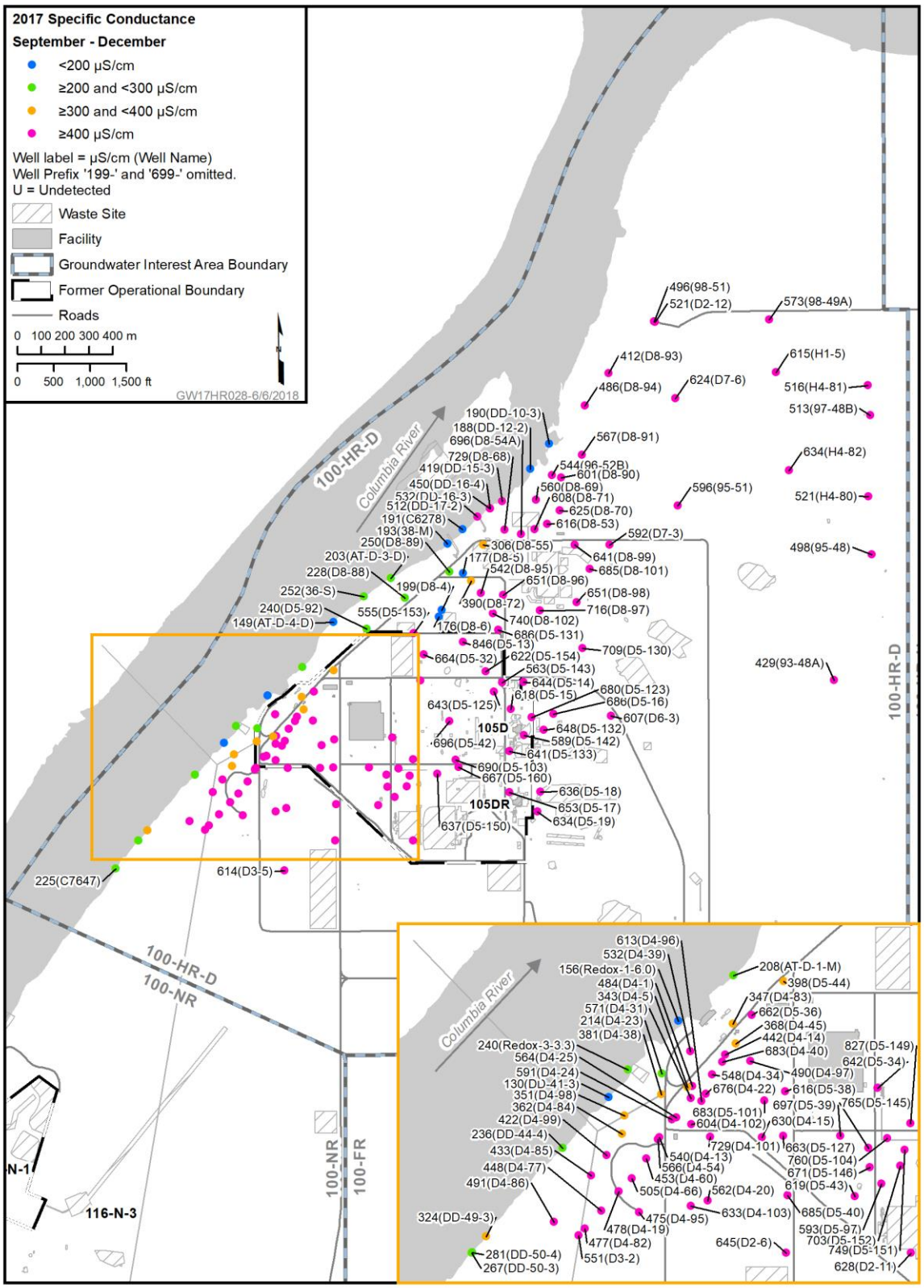


Figure 4-27. 100-HR-D Specific Conductance Map, Fall 2017

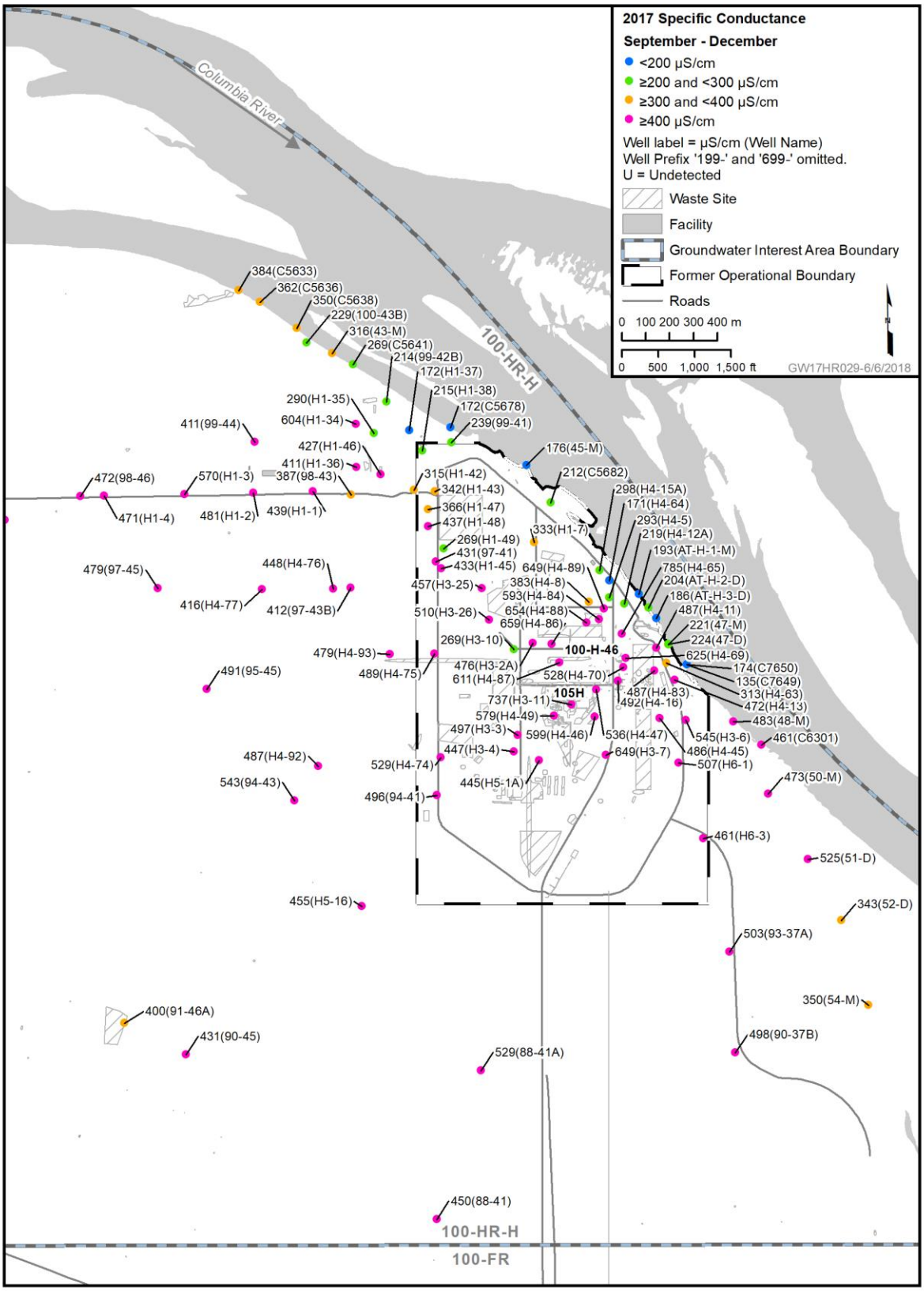


Figure 4-28. 100-HR-H Specific Conductance Map, Fall 2017

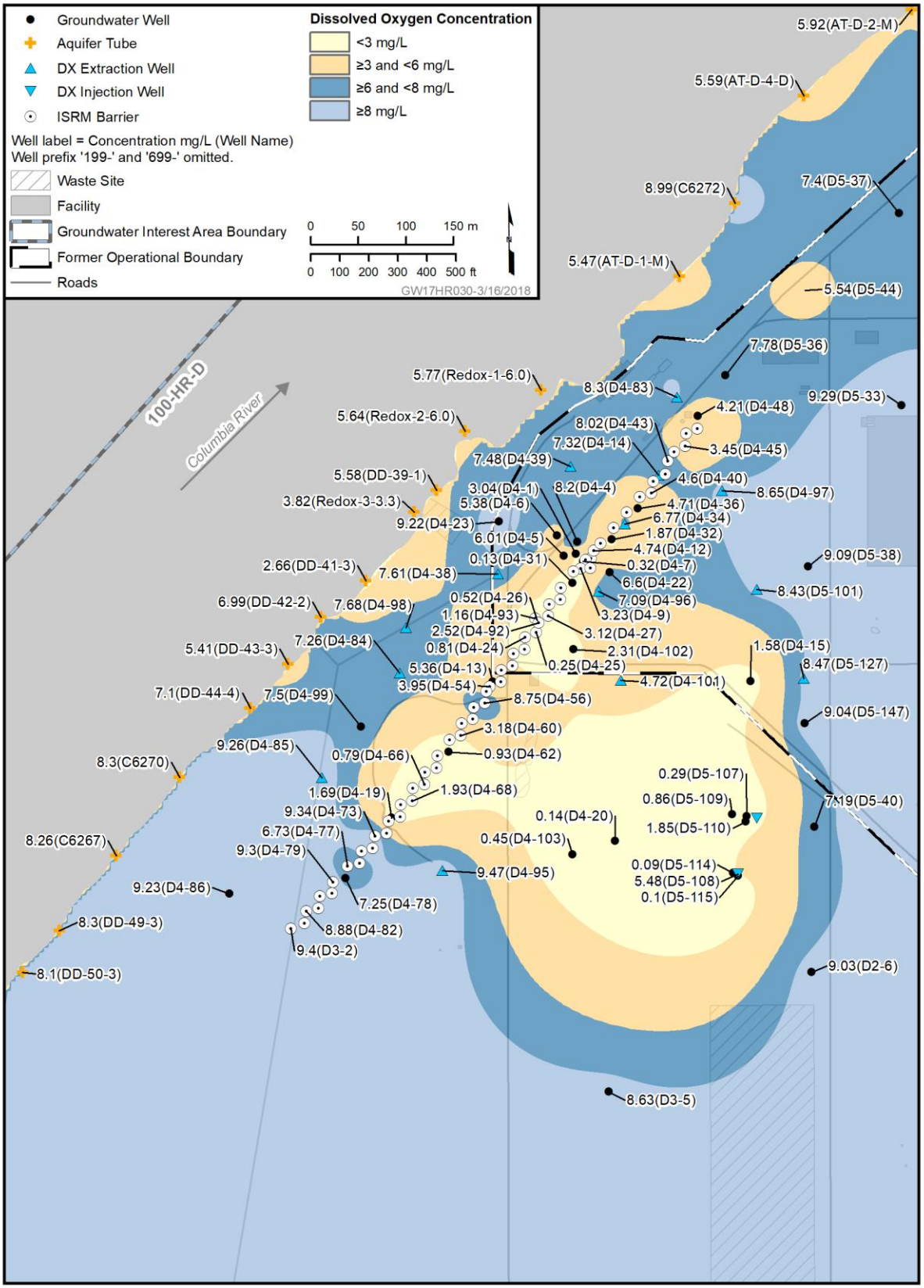
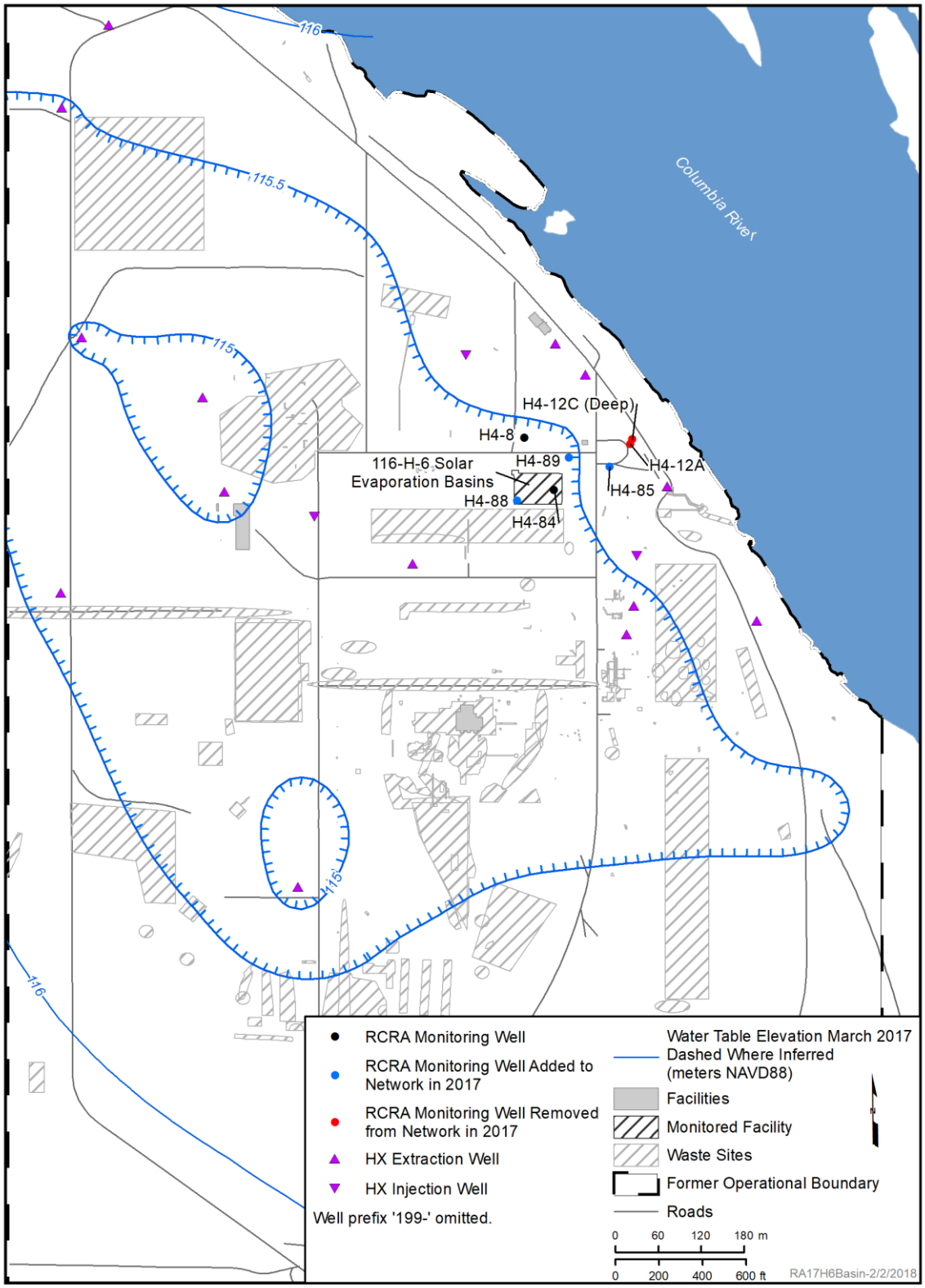


Figure 4-29. Dissolved Oxygen at 100-HR-3 ISRM Barrier, 2017



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 4-30. 183-H Solar Evaporation Basins (116-H-6)

Groundwater monitoring to meet RCRA requirements is conducted in accordance with DOE/RL-2015-28, *Final Status Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*, which was incorporated into Part VI of the Hanford RCRA Permit, Revision 8c, on May 24, 2017. This new plan supersedes PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*. The new plan monitors total chromium (collected as a filtered sample) and nitrate as dangerous waste constituents identified for corrective action monitoring. Other constituents identified for monitoring in the previous plan (PNNL-11573) (uranium, technetium-99, and fluoride) were removed in this revised plan.

The revised groundwater monitoring plan also modified the groundwater monitoring well network. The plan removed well 199-H4-12C, which is completed in the semiconfined RUM aquifer, from the monitoring network. Monitoring well 199-H4-12A was replaced with 199-H4-85, which is located closer to the 183-H Solar Evaporation Basins and is completed in the unconfined aquifer. New wells 199-H4-88 and 199-H4-89 were drilled in 2016 and were added to the monitoring network.

Table B-14 in Appendix B lists the wells monitored for RCRA under the current revised plan. Wells are sampled semiannually for dangerous waste constituents (total chromium [filtered] and nitrate) and field parameters. New wells 199-H4-88 and 199-H4-89 will be sampled quarterly for 2 years to collect sufficient samples to support statistical evaluation. The unconfined aquifer is very thin below the 183-H Solar Evaporation Basins, and most of the wells are screened across the entire aquifer. The saturated aquifer thickness varies from less than 1 m (3 ft) in the fall during low river stage to 3 m (10 ft) in the spring and early summer during high river stage.

The results for 183-H Solar Evaporation Basins groundwater monitoring are reported semiannually. DOE prepared two semiannual reports for 2017 monitoring (SGW-61639, *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins: January – June 2017*) (SGW-61763, *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins: July – December 2017*).

The CERCLA P&T extraction and injection wells influence groundwater flow near the 183-H Solar Evaporation Basins. The March 2017 water table shows a local groundwater depression created by the P&T extraction wells (Figure 4-30). The estimated groundwater velocities during 2017 ranged from 0.1 to 5.1 m/d (0.7 to 16.7 ft/d), and flow directions ranged from southwest to east-northeast (Table B-15 in Appendix B).

Table B-16 in Appendix B summarizes the results from RCRA sample events performed under the newly revised monitoring plan. Total chromium (filtered sample) remained below the permit concentration limit of 48 µg/L in each of the five wells in the monitoring network. The maximum concentration observed in the network during the RCRA sample events was 19 µg/L in well 199-H4-88 (located within the footprint of Basin 1 of the 183-H Solar Evaporation Basins).

Nitrate exceeded the Hanford RCRA Permit concentration limit of 45 mg/L in wells 199-H4-88 and 199-H4-89 during both RCRA sample events (Table B-16 in Appendix B). The nondetect value for nitrate in well 199-H4-85 on November 10, 2017, appears to be a suspect result and is currently under additional review.

As shown in Table B-14 in Appendix B, low water table conditions during the November sampling event resulted in four of the wells being pumped dry prior to full sample volume collection. The pumps were shut off, the wells were allowed to recharge, and then sampling continued. The on/off cycling of the sampling pumps likely agitated the well water columns and stirred up sediment that normally rests on the bottom of the wells. This likely explains the unusually high turbidity in wells 199-H4-8, 199-H4-84, and 199-H4-89. In 2017, the wells were sampled with a portable (nondedicated) pump. Staff will evaluate

whether installing dedicated sampling pumps with the intake located near the bottom of the screened interval will help prevent high turbidity in future low-water sampling events.

Many of the analytical results from November 2017 samples from well 199-H4-85 were anomalous, so a data review was conducted. Reported values of specific conductance (32.8 µS/cm) and anions (near or below detection limits) were unreasonably low for groundwater. Dissolved oxygen, pH, and temperature were also much lower than the data previously reported. The evaluation concluded that the data should be rejected as not representative for unknown reasons. Data review qualifiers of "R" were assigned to all of the November 10, 2017, data from well 199-H4-85. The well will be resampled, and a video survey of the well is planned.

Under the new corrective action monitoring plan, filtered total chromium and nitrate data are evaluated as follows:

- If any of the last 8 to 10 sample results exceed the concentration limits established in the Hanford RCRA Permit, the upper confidence limits (UCLs) on the mean are calculated and compared to the applicable concentration limit.
- If all of the last 8 to 10 results are below the concentration limit, a UCL is not calculated and a visual evaluation is allowed.
- The data set may include non-RCRA sampling results until at least eight RCRA sample results are available.

The statistical evaluation is conducted semiannually (SGW-61639; SGW-61763). The 95% UCL for total chromium (filtered) exceeded the Permit concentration limit from well 199-H4-84 (Table B-17 in Appendix B). For nitrate, wells 199-H4-84 and 199-H4-88 had 95% UCLs that exceeded the concentration limit (Table B-17 in Appendix B).

4.12 Atomic Energy Act Monitoring

AEA groundwater monitoring was scheduled at 60 groundwater wells and aquifer tubes in the 100-HR groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 100-HR are nitrate, strontium-90, and tritium. Historically, nitrate has been monitored through the AEA as an indicator of contaminant migration and continues to be monitored in the current SAP (DOE/RL-2015-56). One well in the 100-D Area was not sampled in accordance with SAP requirements (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues and scheduling constraints.

Radionuclide concentrations detected in groundwater samples from 165 wells[2] and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard at any of the groundwater wells in 100-HR. The DWS for cumulative alpha emitters was not exceeded. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at nine locations in this interest area (Table 4-4). The DWS uranium mass was exceeded at four locations, one of which was part of characterization sampling at a new well. Some of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater.

[2] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

CERCLA remedial action decisions (i.e., P&T for 100-HR-3) provide additional protection of the public and the environment.

Table 4-4. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-HR in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥ 30 µg/L	
	Minimum	Maximum	Minimum	Maximum
199-D5-132	9.75	13.9		
199-D5-142	4.39	6.3		
199-H1-49			54.4	54.4
199-H3-11	7.2	7.2		
199-H3-28			142*	142*
199-H3-6	5	5.35		
199-H4-11	4.6	4.8		
199-H4-13	7.45	11.55		
199-H4-45	4.15	4.15		
199-H4-63	4.52	7.05		
199-H4-83	4.48	12.9		
199-H4-84			31	127
199-H4-88			30	55.2

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Notes: None of the wells in 100-HR had total effective dose ≥100 mrem/yr or cumulative alpha activity ≥15 pCi/L.

Blank cells indicate no exceedances.

*Characterization sampling.

5 100-KR

This chapter presents information for the 100-KR groundwater interest area, which includes the 100-KR-4 OU and an adjacent region to the east (Figure 1-1). This chapter includes an overview, a discussion of CERCLA- and AEA-related groundwater activities conducted in 2017, as well as a summary of 2017 groundwater monitoring results.

5.1 Overview

Groundwater in 100-KR was contaminated by waste releases associated with past operations of the KE and KW Reactors and from associated support facilities. At the end of 2017, 72% of the waste sites were classified as closed, interim closed, no action, not accepted, or rejected. Removing contaminants from the vadose zone eliminates secondary sources of contamination that could migrate to groundwater and reduces the risk of direct exposure at the surface.

Three general regions of 100-KR are discussed in this chapter. “K West” is the region around the former KW Reactor and associated waste sites. “K East” is the region around the former KE Reactor and associated waste sites. The third region is associated with the former 116-K-2 Trench and extends from the 100-K Area to the 100-N Area.

Table 5-1 lists key facts about 100-KR contamination. Chapters 1 and 3 of the 100-K RI/FS (DOE/RL-2010-97, Draft A, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*) contain additional details about 100-KR history, waste sites, and hydrogeology. The primary waste sites known or suspected to have contributed to groundwater contamination include the 183.1KE and 183.1KW Headhouse tank farms, 116-KE-1 and 116-KW-1 gas condensate cribs, 116-KE-3 and 116-KW-2 FSB cribs/reverse wells, 116-K-1 Crib, 116-K-2 Trench, leaks from the 105-KE and 105-KW FSBs (e.g., UPR-100-K-1), and 118-K-1 Burial Ground. Figure 5-1 shows the locations of key features in 100-KR and the 2017 groundwater sampling locations. Section 1.5 provides plume mapping details, including descriptions of terms used in the figure legends (e.g., Type 1 control point).

The unconfined aquifer in 100-KR ranges from 5.2 m to more than 32 m (17.1 to 105 ft) thick and is primarily present in the Ringold unit E sand and gravel (Figure 5-2). This unit is overlain by the gravel and interbedded sand and silt of the Hanford formation, which comprises the bulk of the vadose zone. The vadose zone ranges from less than 1 m (3.3 ft) thick near the Columbia River to 32 m (105 ft) thick inland. The uneven surface of the silt- and clay-rich RUM forms the bottom of the unconfined aquifer. Contaminant concentrations are generally highest within the uppermost portion of the aquifer near the water table; however, mobile contaminants (e.g., Cr(VI)) have been detected over the entire aquifer thickness, particularly near source areas.

Table 5-1. 100-KR at a Glance

Reactor operations: KE Reactor, 1955 to 1971; KW Reactor, 1955 to 1970				
2017 Groundwater Monitoring				
Contaminant, Water Quality Standard, Units	**Year**	**Maximum Concentration**	**Plume Area[a] (km^2)**	**Shoreline[b] (m)**
Hexavalent chromium, 48/10[c] µg/L	2017	840 (199-K-23)	0.05/1.4[d]	0/305
	2016	330 (199-K-111A)	0.11/1.7[d]	0/311
Tritium, 20,000 pCi/L	2017	3,810,000 (199-K-227[e])	0.01	0
	2016	730,000 (199-K-207)	0.12	0
Nitrate, 45 mg/L	2017	115 (199-K-230[e])	0.20	0
	2016	75.3 (199-K-185)	0.05	0
Strontium-90, 8 pCi/L	2017	15,600 pCi/L (199-K-222)	0.03	0
	2016	164 (199-K-200)	0.03	0
Carbon-14, 2,000 pCi/L	2017	28,500 (199-K-106A)	0.04	0
	2016	40,100 (199-K-106A)	0.05	0
Trichloroethene, 5 µg/L	2017	9.73 (199-K-230[e])	0.10	0
	2016	9.48 (199-K-185)	0.10	0
Remediation				
Waste sites: 72% complete.[f] Groundwater interim action for hexavalent chromium 1997 through present. Revised remedial investigation/feasibility study report anticipated in 2019.				

a. Estimated area at a concentration greater than the listed water quality standard.

b. Length of shoreline intersected by plume above listed water quality standard.

c. 48 µg/L in the upland area (WAC 173-340, "Model Toxics Control Act—Cleanup") and 10 µg/L where groundwater discharges to surface water (WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington").

d. Includes the Cr(VI) plume that has migrated into the 100-NR interest area. The groundwater plume area exceeding the interim groundwater target concentration of 20 µg/L at 100-K is 0.41 km^2.

e. Maximum concentration encountered during drilling.

f. Sites with status of closed, interim closed, final closed, no action, not accepted, or rejected as of December 31, 2017.

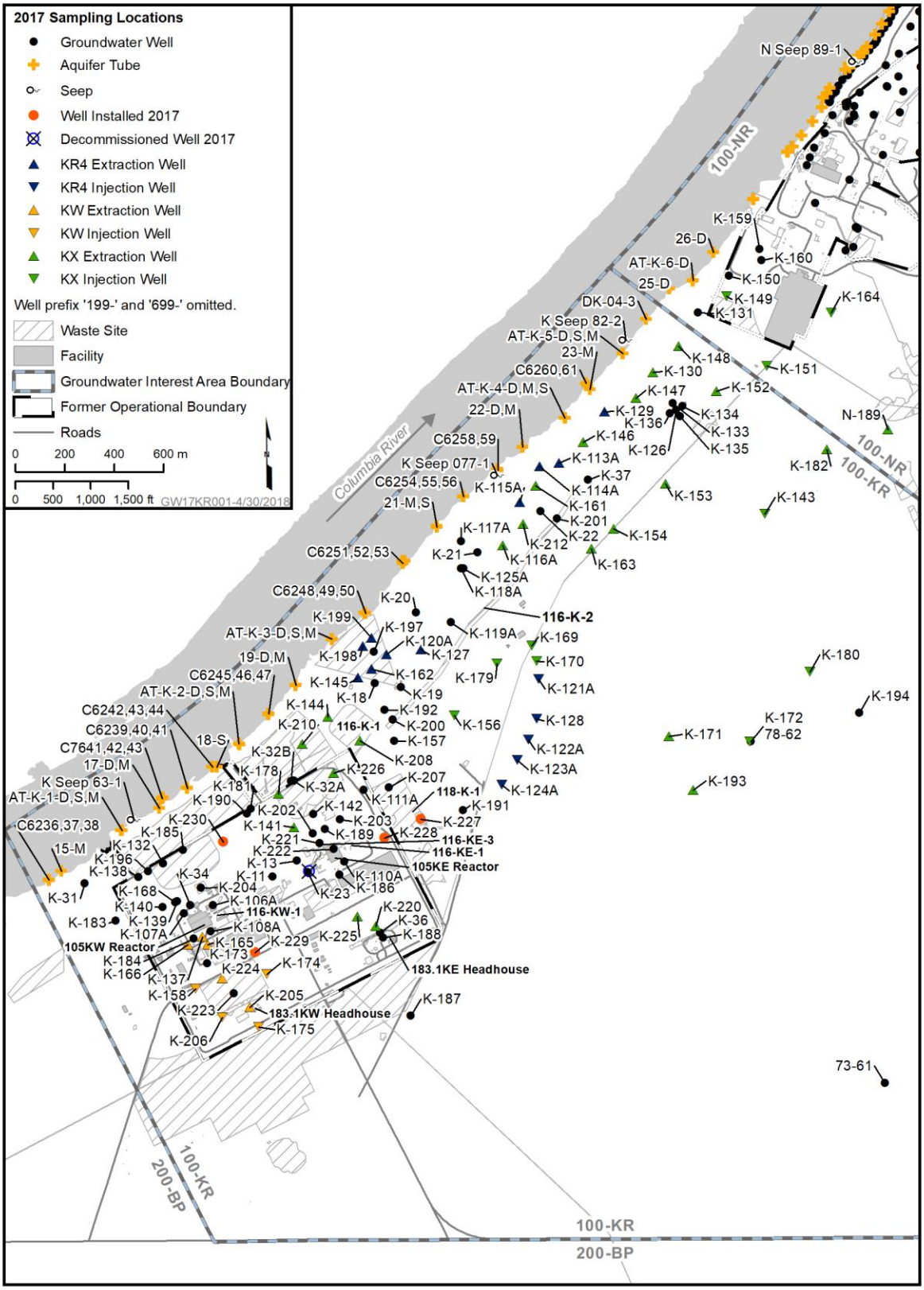


Figure 5-1. 100-KR Sampling Locations, 2017

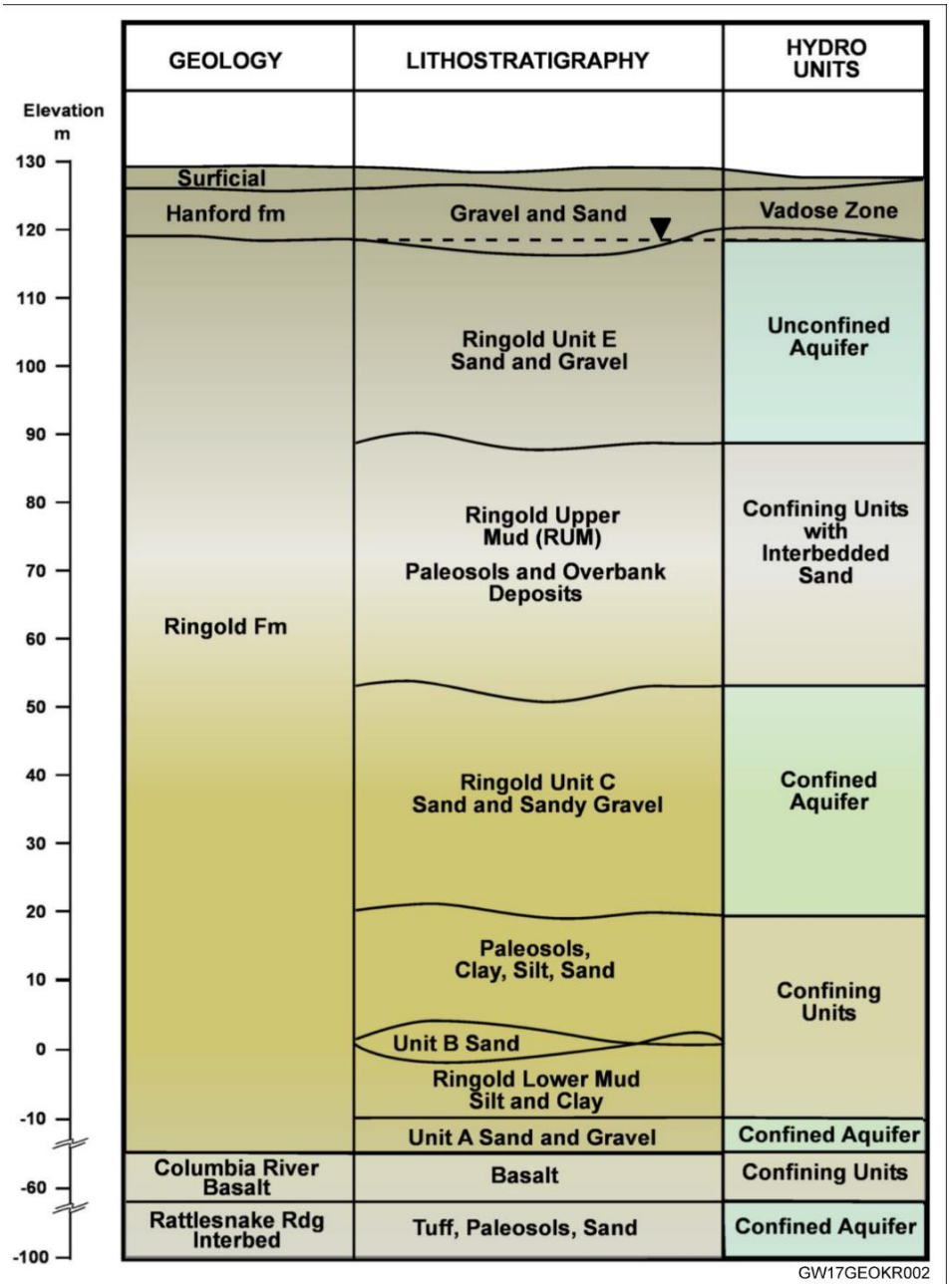


Figure 5-2. 100-KR Geology

Under natural conditions, the Columbia River is the discharge boundary for the unconfined aquifer in 100-KR. Prior to operation of P&T systems, groundwater flow was predominantly to the north and northwest (toward the river) and influenced by daily and seasonal fluctuations in river stage (Figure 2-12 in DOE/RL-96-84, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action*). Section 1.6.3 discusses the effects of changing river stage on groundwater flow. Operation of three P&T systems has changed groundwater flow direction in 100-KR, as noted by mounds and depressions in the water table surface (Figure 5-3). Injection of treated groundwater from the combined discharges from the KR4 and KX P&T systems creates significant mounding (i.e., conditions of radial flow) near the 116-K-2 Trench and near the boundary of 100-KR and 100-NR. Extracting groundwater from the aquifer creates several cones of

depression along the river. When the KW P&T system was shut down between January and April 2017, groundwater flowed to the north (Figure 5-3). In previous years, operation of the KW P&T had caused a sustained northwest flow direction. Groundwater farther inland of 100-KR generally flows to the north and northeast, toward 100-NR and 100-HR-D (Figure 1-2).

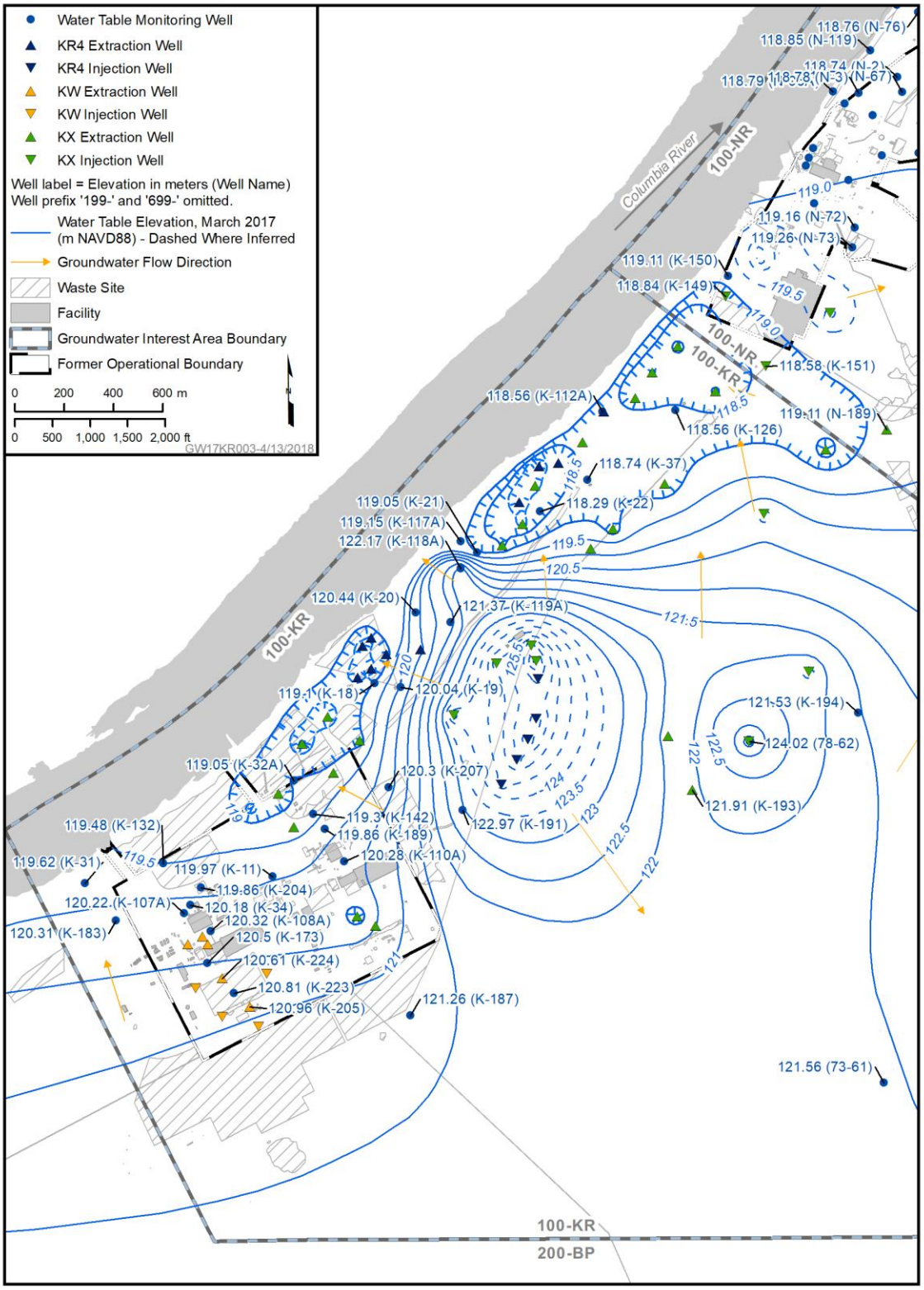
Contaminants in the 100-KR unconfined aquifer were identified in the RI/FS (DOE/RL-2010-97, Draft A) and include chromium (total and Cr(VI)), tritium, nitrate, strontium-90, carbon-14, and TCE. Figure 5-4 shows how the plume areas have changed since 2003. Chromium in groundwater at some locations has been measured as total chromium (in filtered and/or unfiltered aliquots) instead of (or in addition to) Cr(VI). Anthropogenic chromium in groundwater at 100-KR is understood to be present as Cr(VI), so total chromium in filtered aliquots and Cr(VI) are discussed as Cr(VI) for purposes of this report.

5.2 Hexavalent Chromium

Cr(VI) in groundwater at 100-KR resulted from historical releases of two different types of wastewater. The first type of release included spills, leaks, and limited unintentional discharge of concentrated sodium dichromate dihydrate solutions used as feed chemicals for conditioning reactor cooling water. The second type of release included spent reactor cooling water from retention basin leaks and intentional discharges to the 116-K-1 Crib and 116-K-2 Trench. As a result of these discharges, three general Cr(VI) plume areas developed: (1) a plume originating at or near the 183.1KW Headhouse tank farm and extending riverward, (2) a plume originating at or near the 183.1KE Headhouse tank farm and extending riverward, and (3) a plume originating at the 116-K-1 Crib and 116-K-2 Trench and spreading outward toward 100-NR. These plumes have been reshaped and/or dissected by operation of the groundwater P&T systems at 100-KR, which have substantially reduced the observed groundwater Cr(VI) concentrations since 1996 (Figure 5-5).

Figures 5-6 and 5-7 illustrate the plumes during high river stage in 2017, and Figures 5-8 and 5-9 illustrate the plumes during low river stage. The plume associated with the 116-K-1 Crib and 116-K-2 Trench has been most affected by the ongoing remediation and is now separated into several small areas of contamination. The maximum concentration in a 100-KR monitoring well in 2017 was 840 µg/L at well 199-K-23, which is located west of KE Reactor.

The extent of Cr(VI) along the river, based on aquifer tube sampling and near-river wells, remained relatively stable compared to the 2016 plume. During 2017, Cr(VI) concentrations above 10 µg/L were detected in aquifer tubes AT-K-3-D, C6256, and 22-D. This was consistent with the 2016 detection locations, with concentrations showing a slight decline during 2017. In addition to measurements collected from the near-river environment at aquifer tubes, shoreline seeps at 100-KR were also sampled in 2017 (Section 1.6.3). The four seeps sampled during 2017 along the 100-KR shoreline had Cr(VI) concentrations below the 10 µg/L aquatic standard.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 5-3. 100-KR Water Table, March 2017

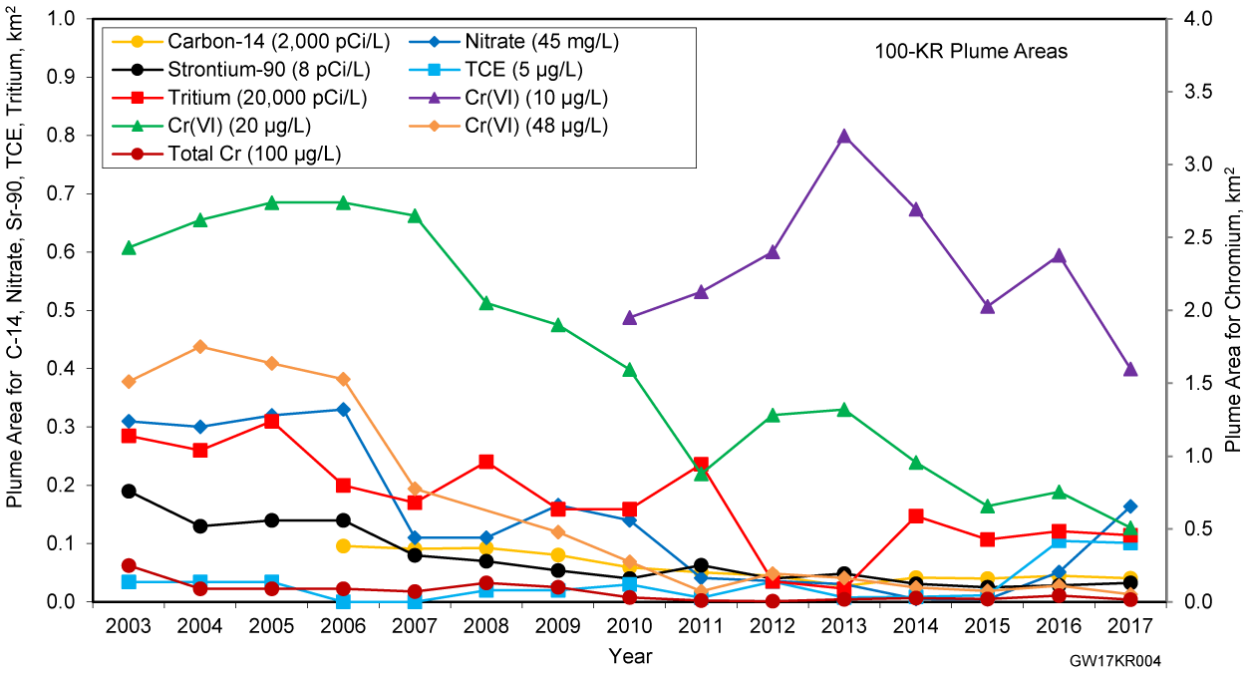


Figure 5-4. 100-KR Plume Areas

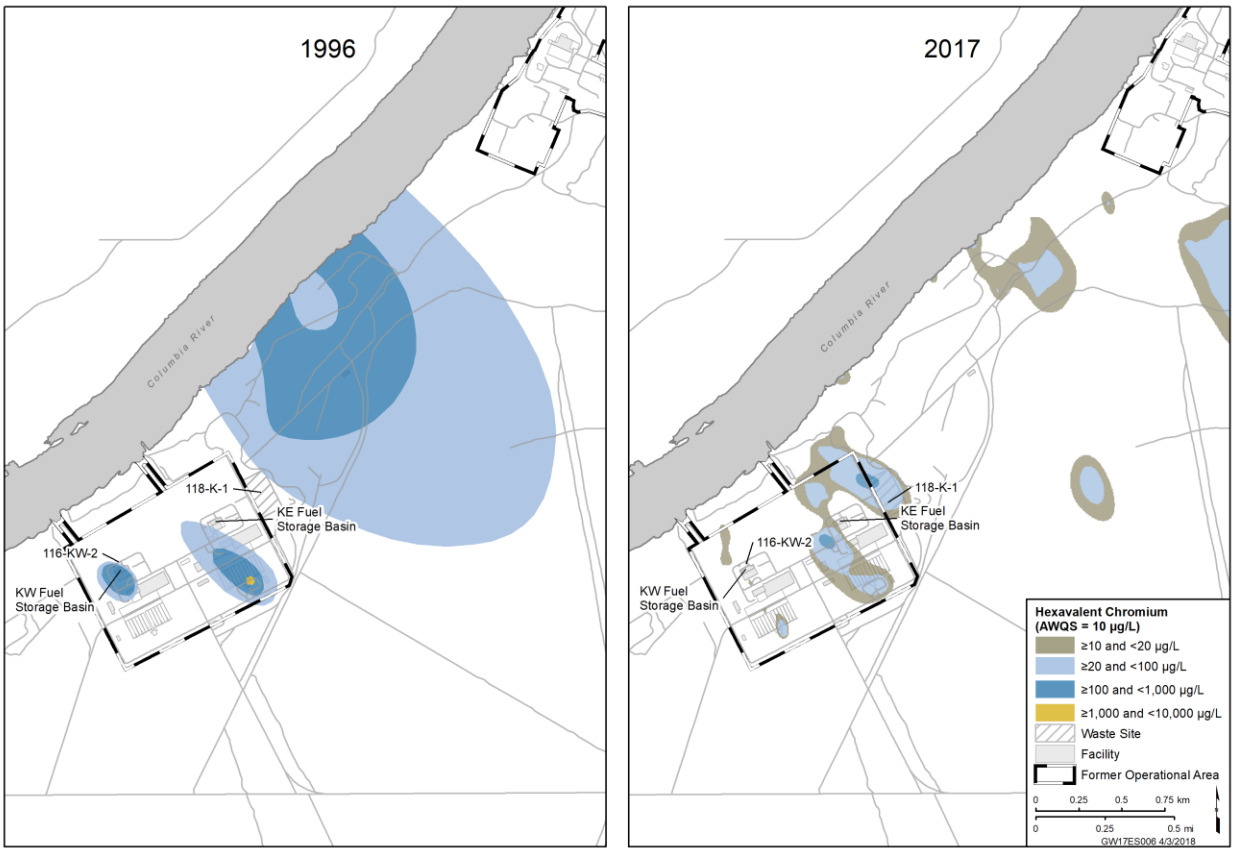
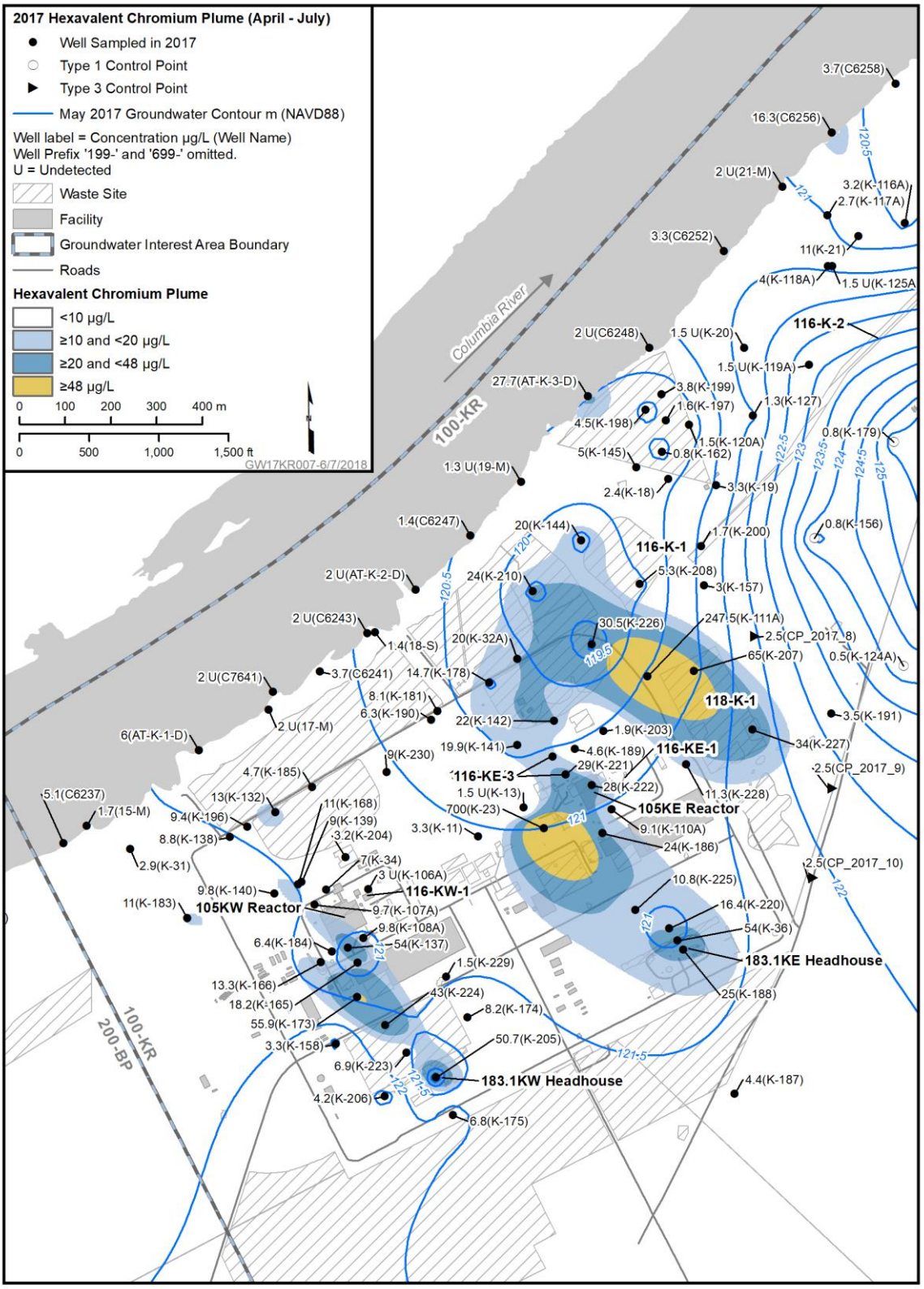
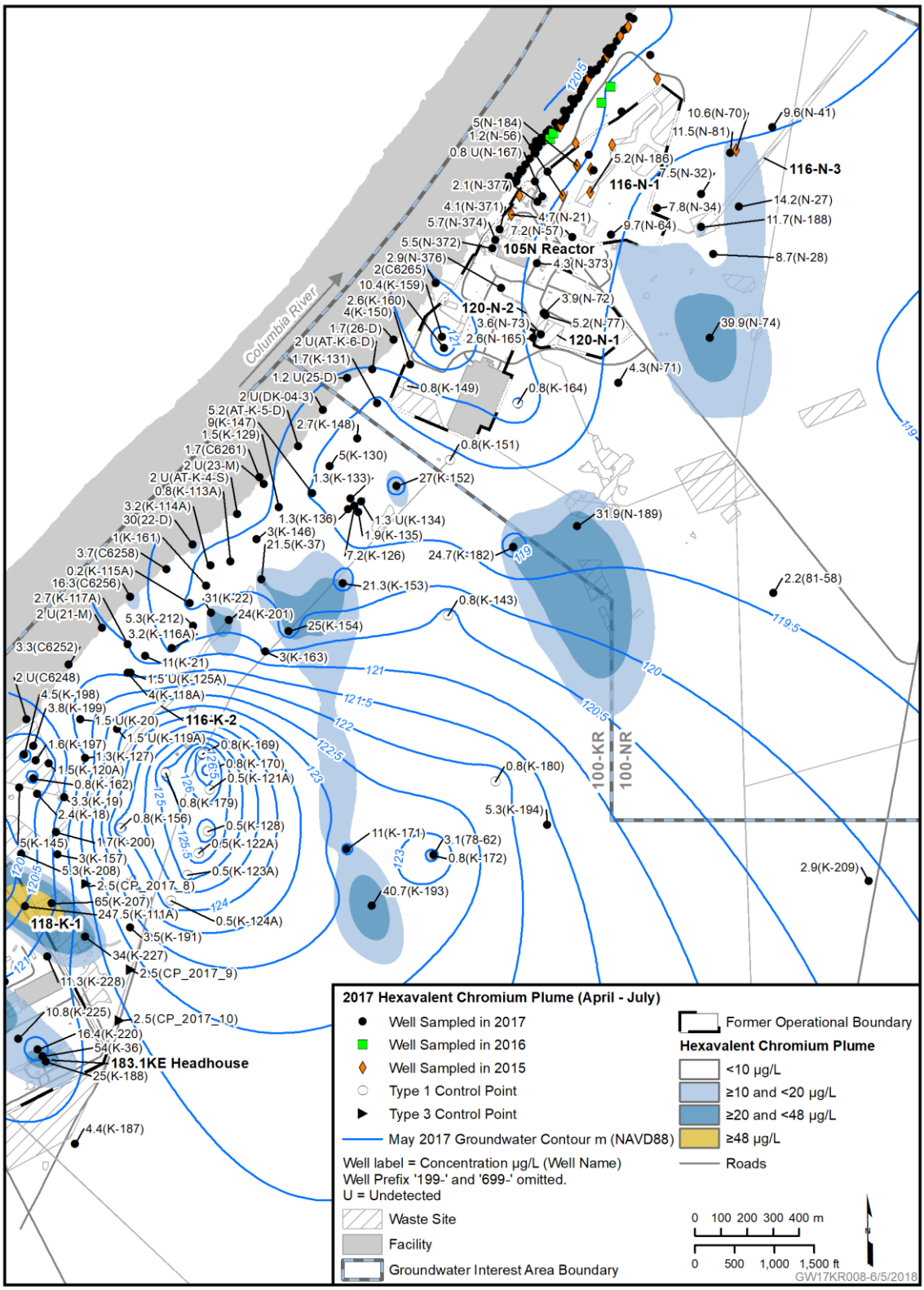


Figure 5-5. 100-KR Cr(VI) Plume in 1996 (Before Interim Action) and 2017 (During Interim Action)



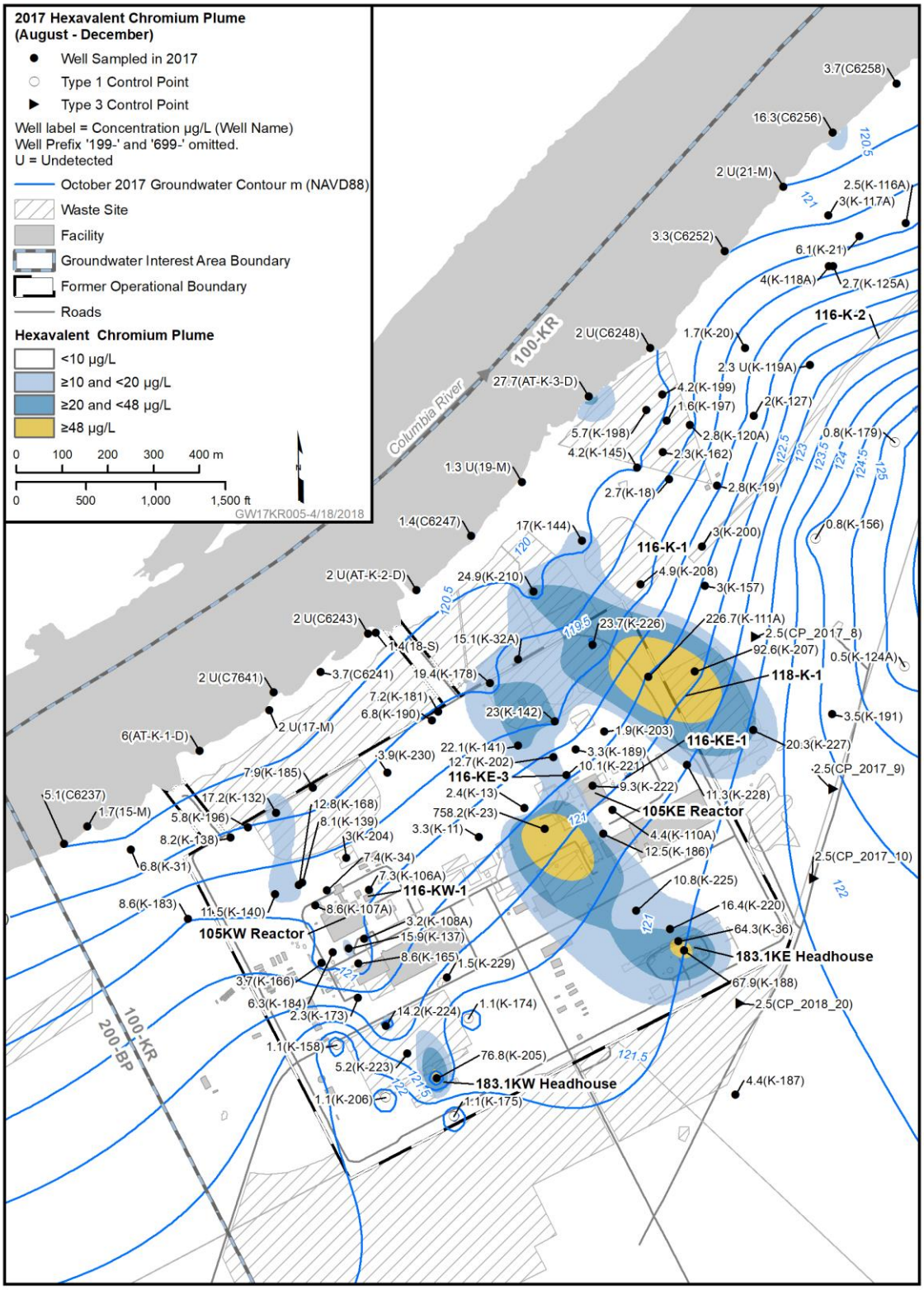
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 5-6. 100-KR Cr(VI) Plume, KE and KW Reactor Vicinity (2017 High River Stage)



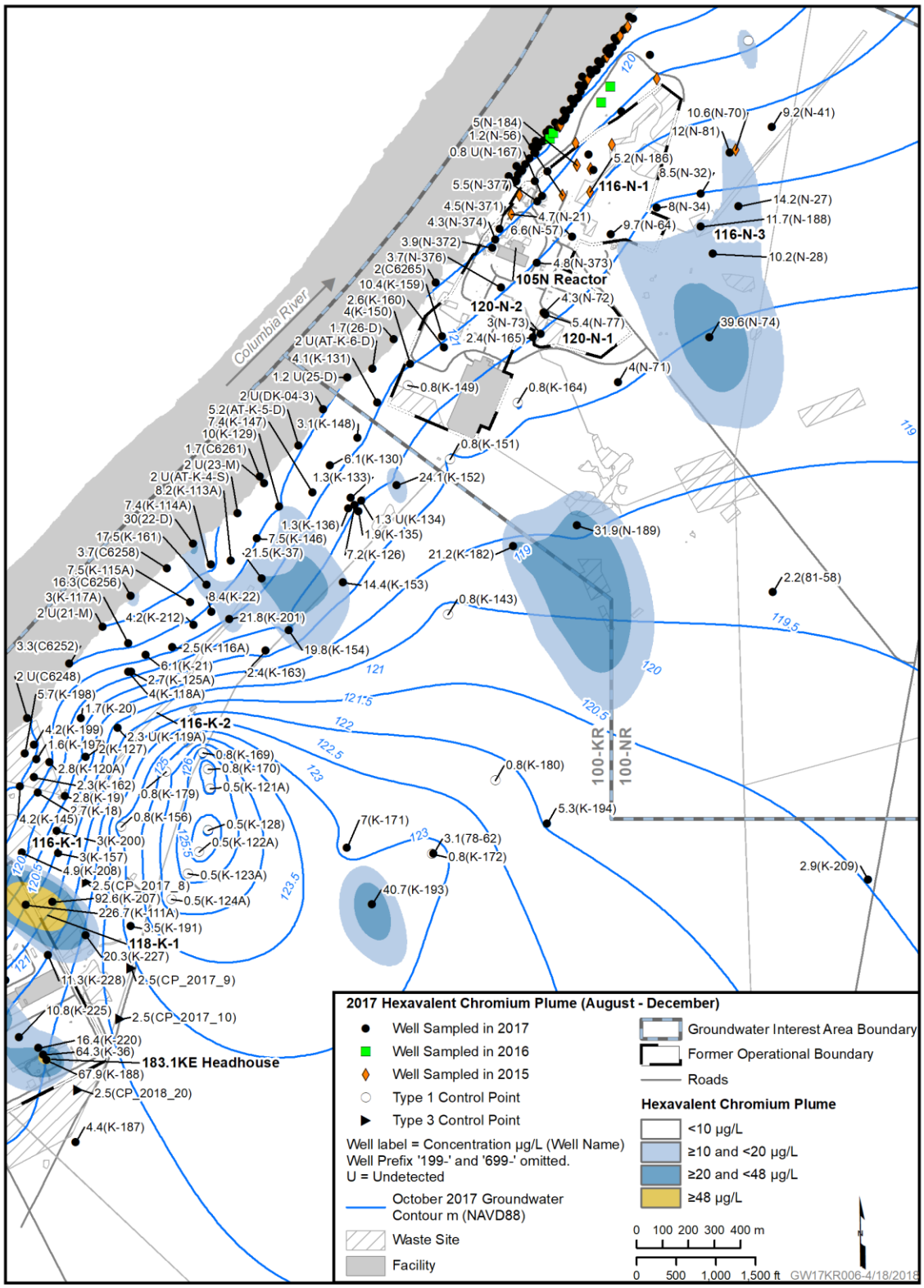
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 5-7. 100-KR Cr(VI) Plume, 116-K-2 Trench and 100-N Area (2017 High River Stage)



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 5-8. 100-KR Cr(VI) Plume, KE and KW Vicinity (2017 Low River Stage)



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 5-9. 100-KR Cr(VI) Plume, 116-K-2 Trench and 100-N Area (2017 Low River Stage)

During 2017, wells 199-K-227, 199-K-228, 199-K-229, and 199-K-230 were drilled as monitoring wells with a configuration that allows them to be used for the P&T system in the future if needed. Construction details are provided in DOE/RL-2013-36-ADD4, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 4: Wells 199-K-227, 199-K-228, 199-K-229, and 199-K-230*. The wells were drilled to better define the CSM and provide plume delineation, as described in SGW-60843, *FY2018 Plume Containment and Remediation Utilization Plan*. Cr(VI) samples were collected during drilling and following well development. Table 5-2 lists the intended use and technical justification for the four wells, as well as any significant findings during or after drilling. The field data collected during drilling were inconsistent with the post-development sample results and are being evaluated. Routine Cr(VI) monitoring results are consistent with the anticipated concentrations.

5.2.1 K West Associated Plume

The K West Cr(VI) plume has been depicted as a narrow band with relatively high concentration, starting near the 183.1KW Headhouse and extending toward the Columbia River.

The KW P&T system was shut down for a rebound study on May 16, 2016, because Cr(VI) concentrations had declined below the 20 µg/L interim remedial action target. The purpose of the study was to evaluate the potential for concentrations to remain below cleanup levels and to determine if continuing secondary source material exists in the deep vadose zone. During the rebound study, groundwater was monitored to track contaminant trends in accordance with DOE/RL-2016-42, *Sampling and Analysis Plan for KW Pump and Treat System Rebound Study*.

Results of the rebound study (SGW-62061, *KW Rebound Study Summary Report and Assessment*) indicated that Cr(VI) concentrations changed very little in wells and aquifer tubes located between the KW Reactor and the Columbia River while the P&T system was offline. From January through March 2017, wells downgradient of KW Reactor continued the 2016 trend of concentrations less than the groundwater remediation target of 20 µg/L (Figure 5-10). Well 199-K-132 had the highest concentration in this area at 17 µg/L.

In contrast, Cr(VI) concentrations in wells between the KW Reactor and 183.1KW Headhouse increased when the P&T system was offline, and a plume reappeared (Figure 5-11). Wells 199-K-205 and 199-K-224 had maximum concentrations of 150 and 450 µg/L, respectively, during the first quarter of 2017. These results suggest that several areas of secondary source material continue to cause elevated Cr(VI) concentrations in groundwater. Concentrations at wells 199-K-137 and 199-K-166 also exceeded the cleanup target, so the KW rebound study was discontinued and the KW P&T system restarted on April 12, 2017. Prior to the restart, the well system was changed to optimize the remedial action. Wells were reconnected, and new extraction well 199-K-224 was added to the P&T system. Comparing Figures 5-11 and 5-8 illustrates the decrease in plume size after system restart and modification.

5.2.2 K East Associated Plume

The K East Cr(VI) plume currently presents as two separate areas: (1) a high-concentration area near the head of the 116-K-2 Trench, 116-K-1 Crib and the 118-K-1 Burial Ground; and (2) a high-concentration area extending from the 183.1KE Headhouse (Figures 5-6 and 5-8). The plume near the 118-K-1 Burial Ground is inferred to be commingled with the contamination from the 116-K-1 Crib and 116-K-2 Trench.

Table 5-2. Wells Installed or Decommissioned in 100-KR in 2017

Well		Purpose*	Depth				Acceptance or Decommission Date	Comment
			Construction		Drilled			
Name	ID		m bgs	ft bgs	m bgs	ft bgs		
199-K-23	A4652	Decommissioned.	24.4	80	24.4	80	10/26/2017	Decommissioned to support soil remediation efforts at the 116-KE-2 Crib.
199-K-227	C9711	Dual-purpose monitoring well for plume definition at the southern end of the 118-K-1 Burial Ground and evaluation of potential tritium source.	52.8	173.4	53.1	174.3	9/14/2017	Soil in the deep vadose zone had a maximum concentration of tritium at 6,040 pCi/g. Groundwater maximum concentration of tritium at 3.8 million pCi/L. Groundwater samples collected during drilling and sent for laboratory analysis of Cr(VI) appear to be representative Field analyses produced erroneous results and were flagged suspect.
199-K-228	C9712	Dual-purpose monitoring well to define the current high-concentration Cr(VI) plume near the KE Reactor. No monitoring wells exists between the 183KE Headhouse, 118-K-1 Burial Ground, and KE Reactor.	50.6	166.0	51.0	167.2	8/17/2017	Field Cr(VI) measurements taken during drilling indicated the highest concentrations at the top of the aquifer.

Table 5-2. Wells Installed or Decommissioned in 100-KR in 2017

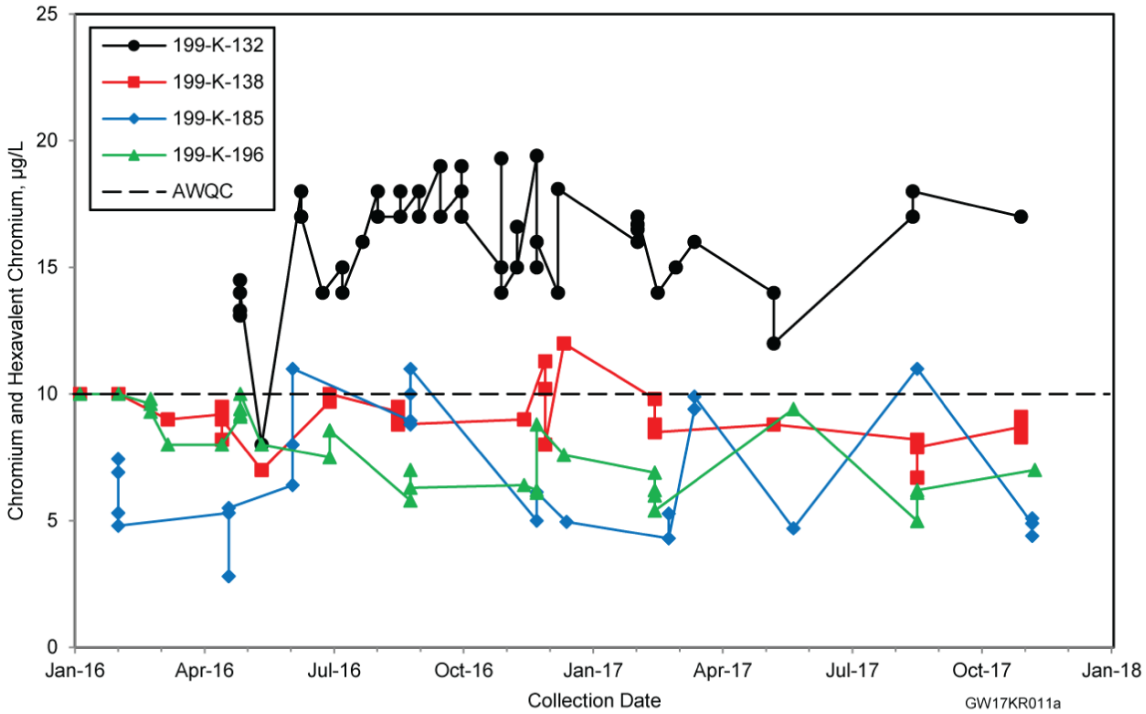
Well		Purpose*	Depth				Acceptance or Decommission Date	Comment
			Construction		Drilled			
Name	ID		m bgs	ft bgs	m bgs	ft bgs		
199-K-229	C9713	Dual-purpose monitoring well for plume delineation downgradient of the 183KW Headhouse and south of the KW switch yard.	58.0	190.4	58.3	191.3	9/28/2017	Field Cr(VI) measurements taken during drilling indicated the highest concentrations at the top of the aquifer.
199-K-230	C9714	Dual-purpose monitoring well for plume delineation between the KW and KE Reactors.	43.6	143.0	44.2	145.1	8/17/2017	Groundwater samples collected during drilling and sent for laboratory analysis of Cr(VI) appear to be representative. Field analyses produced erroneous results and where flagged suspect. Elevated nitrate was detected at the top of the aquifer during drilling.

*DOE/RL-2013-36-ADD4, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 4: Wells 199-K-227, 199-K-228, 199-K-229, and 199-K-230.*

bgs = below ground surface

Cr(VI) = hexavalent chromium

ID = identification



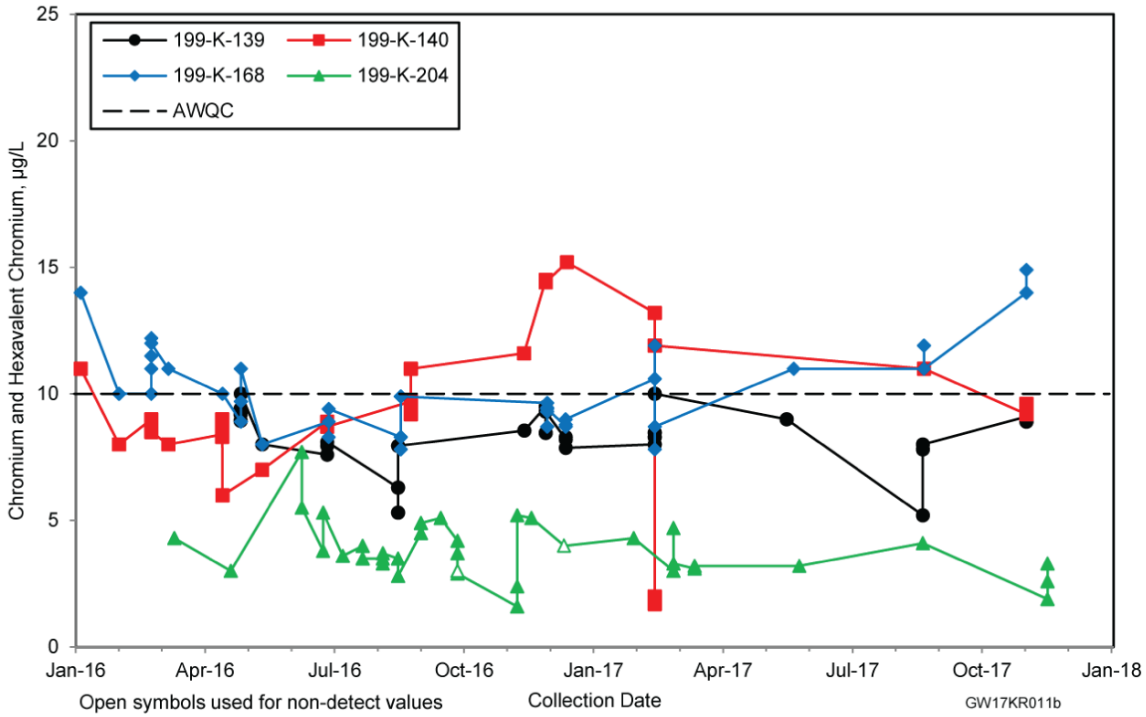


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Figure 5-10. 100-KR Cr(VI) Data for Monitoring Wells Downgradient of KW Reactor

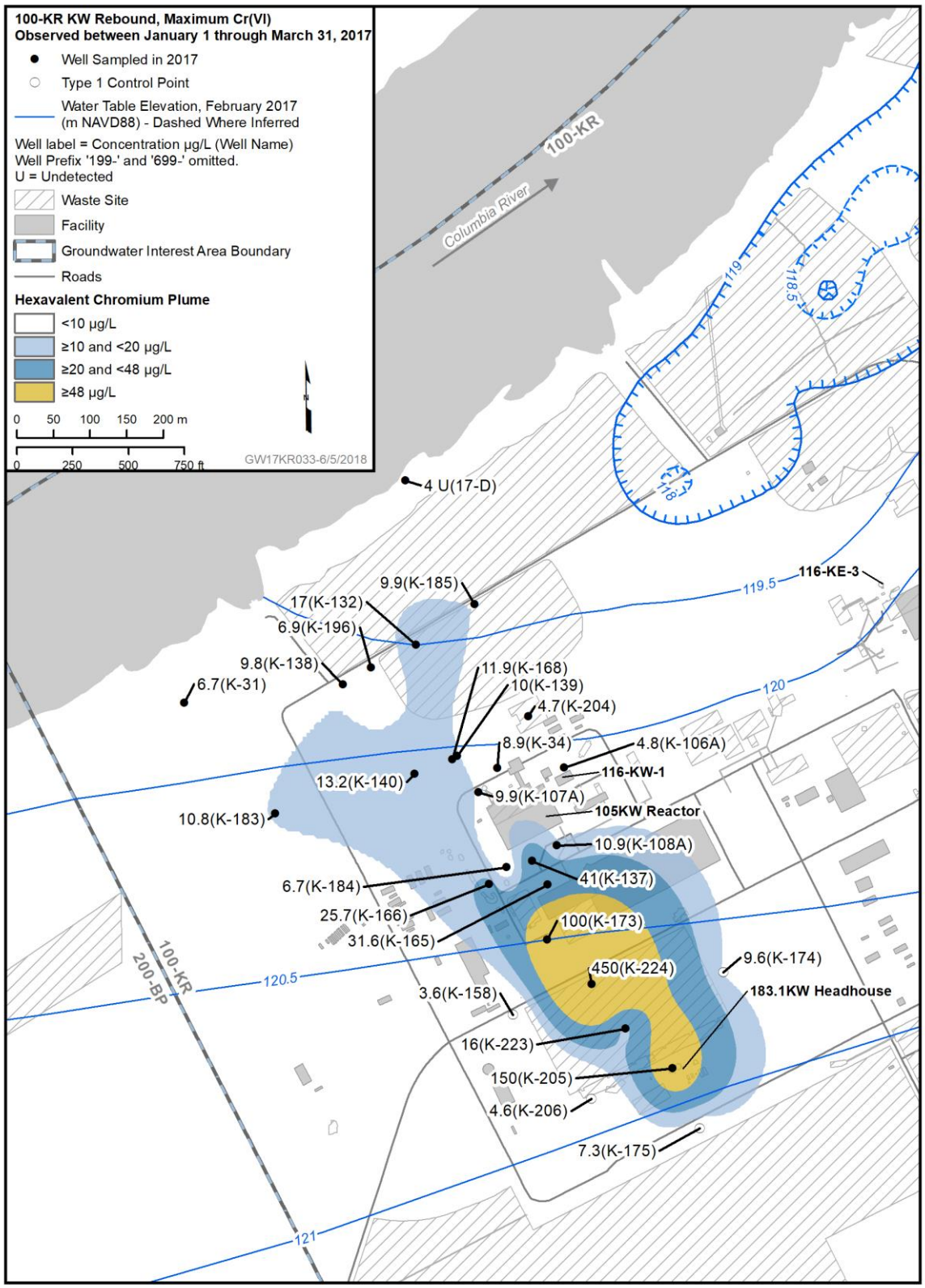


Figure 5-11. 100-KR KW Rebound, Maximum Cr(VI) Observed from January 1 Through March 31, 2017

Elevated Cr(VI) concentrations extend from the 183.1KE Headhouse and sedimentation basin to the area west of KE Reactor at well 199-K-23. The concentration in well 199-K-23 was 840 µg/L in August 2017, a significant increase from less than 10 µg/L during 2015 and 2016. The highest previous result in well 199-K-23 was 115 µg/L in June 2012. The recent increase in concentration is theorized to be related to contamination originating near the 183.1KE Headhouse, similar to the condition observed at K West. Until mid-2014 when well 199-K-220 was installed, monitoring was not conducted between the 183.1KE Headhouse and well 199-K-23. It is likely that the elevated Cr(VI) concentrations now observed in well 199-K-23 originated near the sedimentation basin, downgradient of any monitoring locations. In addition, remediation activities at the sedimentation basin in 2017, along with an elevated water table, may have mobilized Cr(VI) in the lower vadose zone. The upgradient extent of the plume remains defined by well 199-K-187 and the nearby injection wells.

The Cr(VI) plume segment on the northeast side of KE Reactor is inferred to be related to previous releases from the 116-K-1 Crib, 116-K-2 Trench, and 118-K-1 Burial Ground. Monitoring wells in this area continued to exhibit elevated Cr(VI) concentrations in 2017. In addition, based on the concentrations observed in new wells 199-K-227 and 199-K-228, and with the recent changes to the plume near the headhouse, it is likely that the 118-K-1 Burial Ground is contributing to contamination in this area. The highest Cr(VI) levels in this area are found in well 199-K-111A (250 µg/L), which is consistent with data from previous years.

Elevated Cr(VI) concentrations were detected in well 199-K-226 in 2016 during vertical profile sampling, with a maximum of 330 µg/L near the top of the aquifer. In May 2017, well 199-K-226 was converted into an extraction well and has operated at pumping rates between 190 and 450 L/min (50 and 120 gal/min). Samples from this operating extraction well ranged from 21 to 37 µg/L in 2017.

Some inland wells (more than 200 m [660 ft] from the river) exhibit transient increases in Cr(VI) concentration during periods of seasonally high groundwater elevation. Examples of these changes are observed in K East well 199-K-189 (Figure 5-12). This correlation indicates that this well may be located close to a secondary source in the vadose zone.

5.2.3 116-K-2 Trench Associated Plume

The Cr(VI) groundwater plume associated with the 116-K-2 Trench occurs in multiple isolated plume segments (Figures 5-7 and 5-9). This plume, which was once continuous over the length of the 116-K-2 Trench, has been dissected as a result of ongoing P&T system operations, including injection in upgradient areas. Near the southwest end of the trench in wells 199-K-111A and 199-K-226, the Cr(VI) plume appears to be commingled with contamination originating from the 183.1KE Headhouse area and/or the 118-K-1 Burial Ground (Section 5.2.2).

During the 2017 high river stage (as in previous years), a long, thin plume was interpreted to extend inland from the 116-K-2 Trench to well 199-K-193 (Figure 5-7). During the 2017 low river stage (Figure 5-9), the plume was split because the concentration in well 199-K-171 declined. However, due to the presence of only a few wells between 199-K-193 and the trench, the isolation of Cr(VI) in that area is not conclusive.

At the north end of the former 116-K-2 Trench, Cr(VI) concentrations greater than 20 µg/L are found in wells 199-K-201, 199-K-37, 199-K-154, and occasionally in 199-K-22 and 199-K-153. Between August and December 2017, Cr(VI) concentrations in extraction wells 199-K-113A, 199-K-114A, and 199-K-115A briefly increased to greater than 10 µg/L. However, well 199-K-161 increased from 9 to 22 µg/L, and the Cr(VI) plume is interpolated to reach the Columbia River (Figure 5-9).

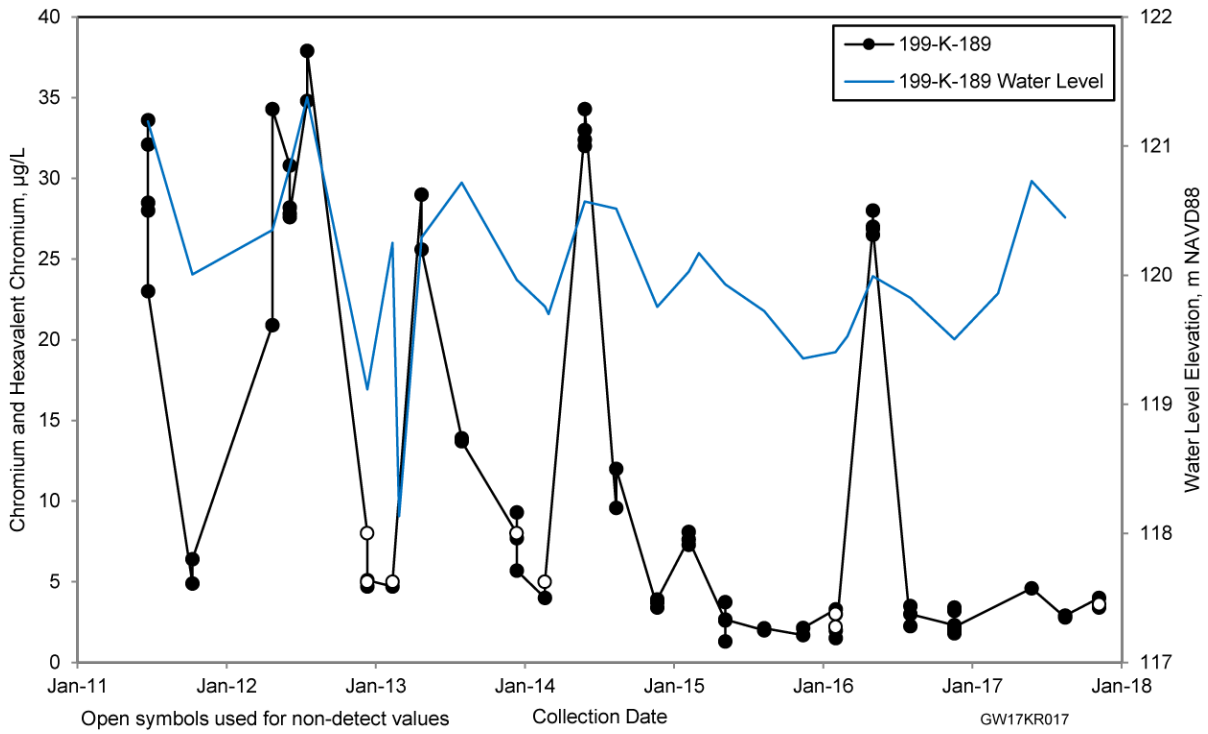


Figure 5-12. 100-KR Cr(VI) Data for Well 199-K-189 (Located Downgradient of KE Reactor, Indicating Correlation to Transient Water Level)

After an increase from 2012 through 2016, Cr(VI) concentrations decreased slightly in 2017 in aquifer tube 22-D (to 35 and 27 µg/L) in unfiltered and filtered samples. The aquifer tube is downgradient of KR4 P&T extraction well 199-K-114A. The specific conductance in the aquifer tube remained greater than 200 µS/cm, suggesting that groundwater is continuing to discharge at this location.

The northeastern portion of the 116-K-2 Trench plume (Figure 5-9) extends northeast into 100-NR, as evidenced by Cr(VI) in KX P&T extraction well 199-K-182 and newly aligned extraction well 199-N-189. Concentrations in well 199-N-189 declined in 2017 as a result of pumping. The Cr(VI) concentration in well 199-N-74, located 2 km (1.2 mi) from the end of the trench, was 38 µg/L in 2017, which is consistent with previous years. Cr(VI) continued to be detected in wells farther northeast in 100-NR (Figures 5-7 and 5-9).

Consistent with previous years, Cr(VI) concentrations greater than 10 µg/L are also observed in isolated wells east and northeast of the 100-K Area (e.g., 699-87-55 and 699-77-54). The origin of this contamination is unknown, but it may be related to historical releases in the 100-K or 100-D Areas.

Due to increased pumping rates at groundwater extraction wells, particularly wells between the river and the 116-K-2 Trench, the hydraulic gradient has reversed at some locations. Figure 5-13 illustrates specific conductance data for fall 2017. This specific conductance is consistent with the influence of mixing groundwater with river water. The Columbia River water typically has specific conductance of 130 to 140 µS/cm. Groundwater elevation contours for 2017 (Figure 5-3) indicate that the P&T systems imposed hydraulic capture of groundwater along the affected shoreline, consistent with the specific conductance observations. The Cr(VI) concentrations observed in the aquifer tubes were deemed to be representative of the near-river boundary condition for plume interpolation in 2017.

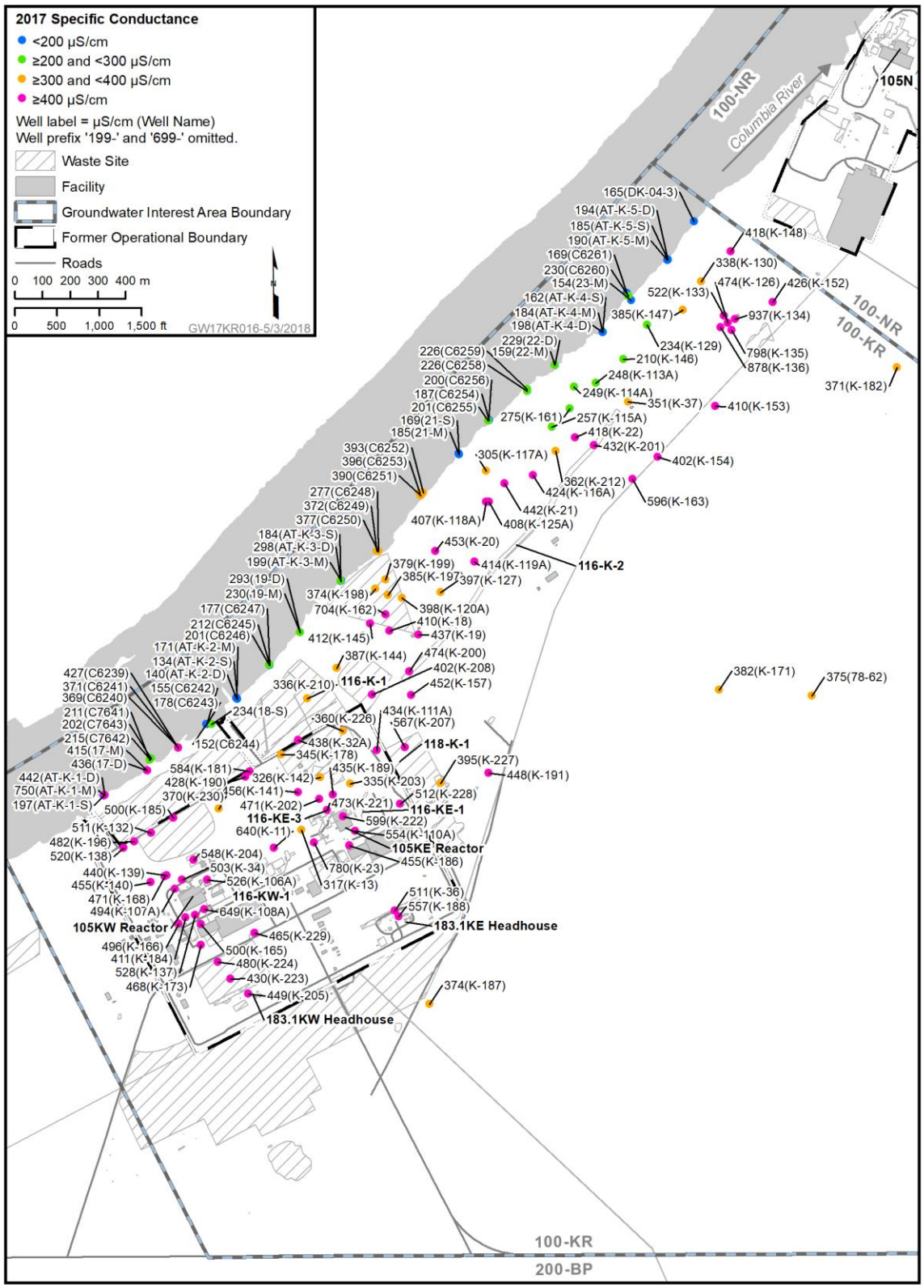


Figure 5-13. 100-KR Specific Conductance (2017 Low River Stage)

5.3 Tritium

The major historical sources of tritium contamination in 100-KR include the following:

- Releases of reactor gas dryer condensate to the 116-KE-1 and 116-KW-1 Cribs (tritium activity concentrations up to 1×10^{10} pCi/L in the condensate in accordance with HW-76258, *Reactor Gas Drier Condensate Waste – Decontamination Studies*)
- Release of FSB water to the 116-KE-3 and 116-KW-2 cribs and reverse wells, and to UPR-100-K-1 (tritium activity concentrations up to 6×10^{9} pCi/L in the basin water in accordance with WHC-EP-0877, *K Basin Corrosion Program Report*, Section 4.0)
- Contaminated solid waste disposed at the 118-K-1 Burial Ground (tritium activity concentrations up to 13,400 pCi/g in deep vadose zone soil remaining after surface remediation in accordance with CVP-2013-00002, *Cleanup Verification Package for the 118-K-1 Burial Ground*)
- Release of contaminated reactor cooling water to the retention basins, 116-K-1 Crib, and 116-K-2 Trench

In 2017, two tritium plumes were present in 100-KR groundwater at levels above the DWS (Figure 5-14), compared to three plume areas during 2016. No plume was present at K West, as tritium concentrations in well 199-K-106A declined from a maximum of 91,900 pCi/L in August 2016 to 17,900 pCi/L in August 2017 (Figure 5-15). Although all concentrations in the area near KW Reactor were below the 20,000 pCi/L DWS, concentrations in downgradient well 199-K-204 increased steeply, reaching 12,900 pCi/L by November 2017. This suggests that well 199-K-204 is at the head end of a migrating tritium plume originating from the 116-KW-1 Crib. Carbon-14 and chloride are following the same pattern in this location, indicating contaminant migration. Moderate levels of tritium (between 1,000 and 2,000 pCi/L) remain in wells 199-K-139 and 199-K-168.

Northwest of KE Reactor, a small area of the K East tritium plume (Figure 5-14) appears to have originated at the 116-KE-1 Crib. Wells 199-K-221 and 199-K-222 both exhibited elevated tritium during 2017, with maximum concentrations of 31,700 and 71,100 pCi/L, respectively. Well 199-K-202 also exhibited elevated tritium during 2017, with a maximum concentration of 47,900 pCi/L.

Tritium concentrations also exceeded the DWS near the 118-K-1 Burial Ground. The highest concentration in groundwater during 2016 (730,000 pCi/L) was in well 199-K-207, located within the footprint of the former 118-K-1 Burial Ground. Concentrations declined to 157,000 by the end of 2017. Wells 199-K-227 and 199-K-228 were installed in 2017 to investigate tritium concentrations in this area, and well 199-K-227 detected concentrations as high as 3,810,000 pCi/L during drilling (Table 5-3). Tritium concentrations decreased with depth in the aquifer to 306,000 pCi/L. Subsequent lower tritium concentrations during the post-development and routine sampling may be attributed to the pump being set lower in the aquifer during the sampling events. To check for higher concentrations in the upper portion of the aquifer, the pump was set near the top of the aquifer to collect a sample on November 17, 2017. The concentration (778,000 pCi/L) was lower than 2,600,000 pCi/L detected in the drilling sample from a similar depth. Seasonal variation may account for some of the difference between the results, but the large difference may also be the result of plume migration or some other unknown factor.

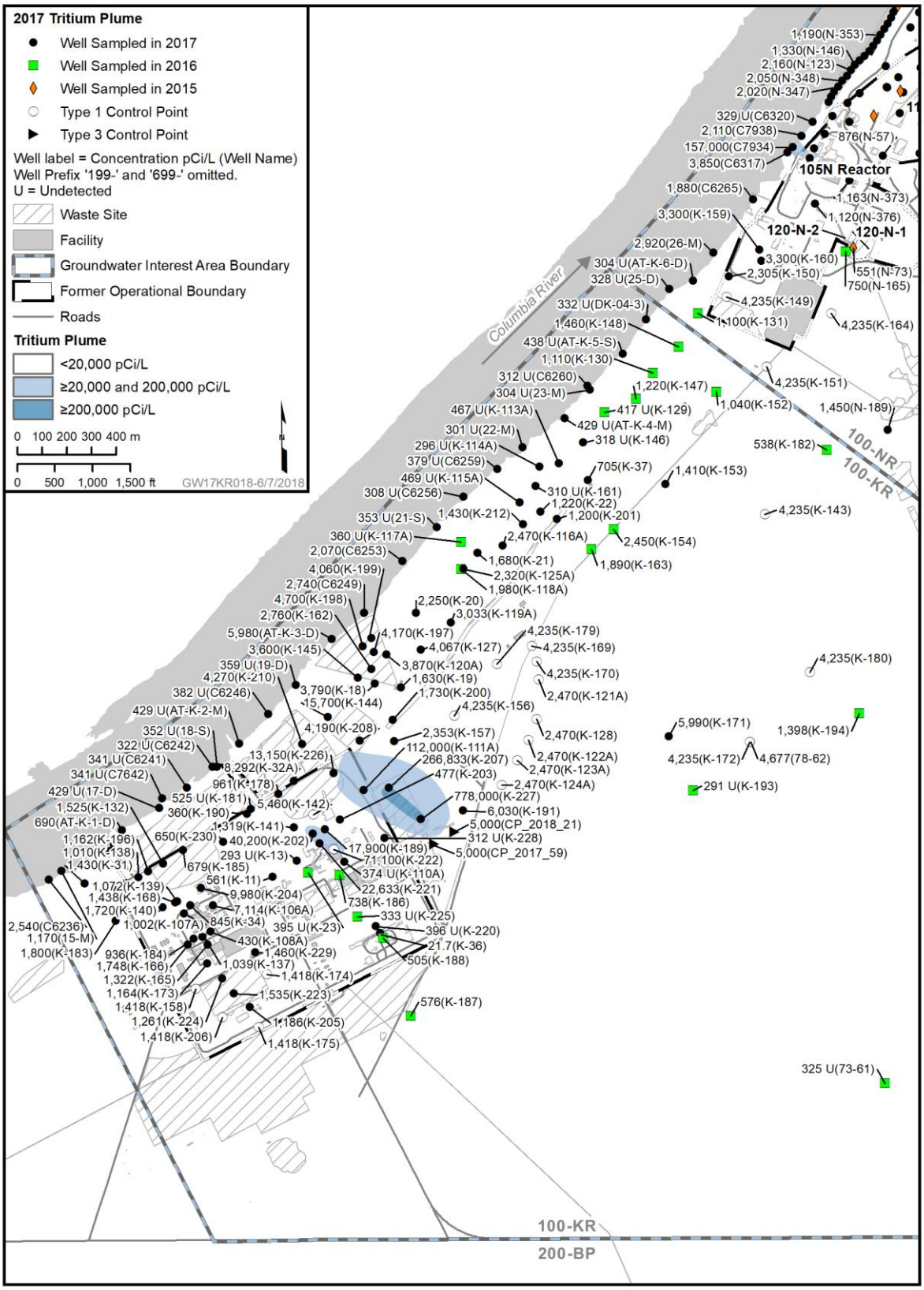


Figure 5-14. 100-KR Tritium Plume, 2017

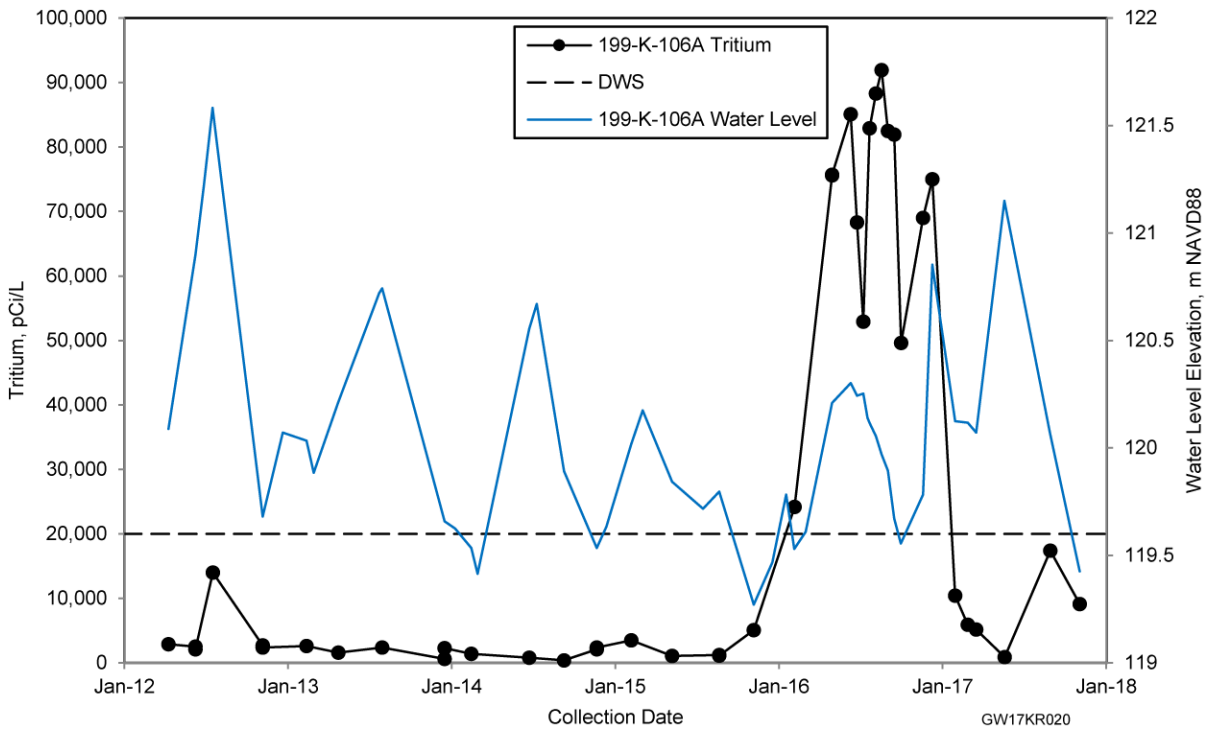


Figure 5-15. 100-KR Tritium and Water Levels in Well 199-K-106A, Downgradient of the 116-KW-1 Gas Condensate Crib

Table 5-3. Tritium Concentrations Observed in Well 199-K-227

Sample Date	Depth (m [ft] bgs)	Tritium (pCi/L)	Sample Comment
6/14/2017	24.3 (79.7)	3,590,000 3,810,000	During drilling sample
6/19/2017	29.3 (96.0)	2,600,000 2,790,000	During drilling sample
6/28/2017	45.0 (147.7)	306,000	During drilling sample
8/28/2017	28.3 (92.7)*	418,000	Post-development sample
11/17/2017	21.5 (70.5)*	778,000	Routine sample

*Depth of pump intake. Well is screened from 19.3 to 51.3 m (63.4 to 168.4 ft) bgs. The water table is at 21.5 m (70.5 ft) bgs and the Ringold upper mud unit at 51.3 m (168.3 ft) bgs.

bgs = below ground surface

Tritium concentrations at well 199-K-207 (within the footprint of the 118-K-1 Burial Ground) and well 199-K-111A (downgradient) continued to decline in 2017 (Figure 5-16). The tritium trends in these wells are consistent with a plume migrating downgradient, away from the source area. Tritium in well 199-K-157 (upgradient of well 199-K-207) remained below 3,000 pCi/L during 2017. The 118-K-1 Burial Ground and 116-KE-1 Crib are likely continuing sources of groundwater contamination.

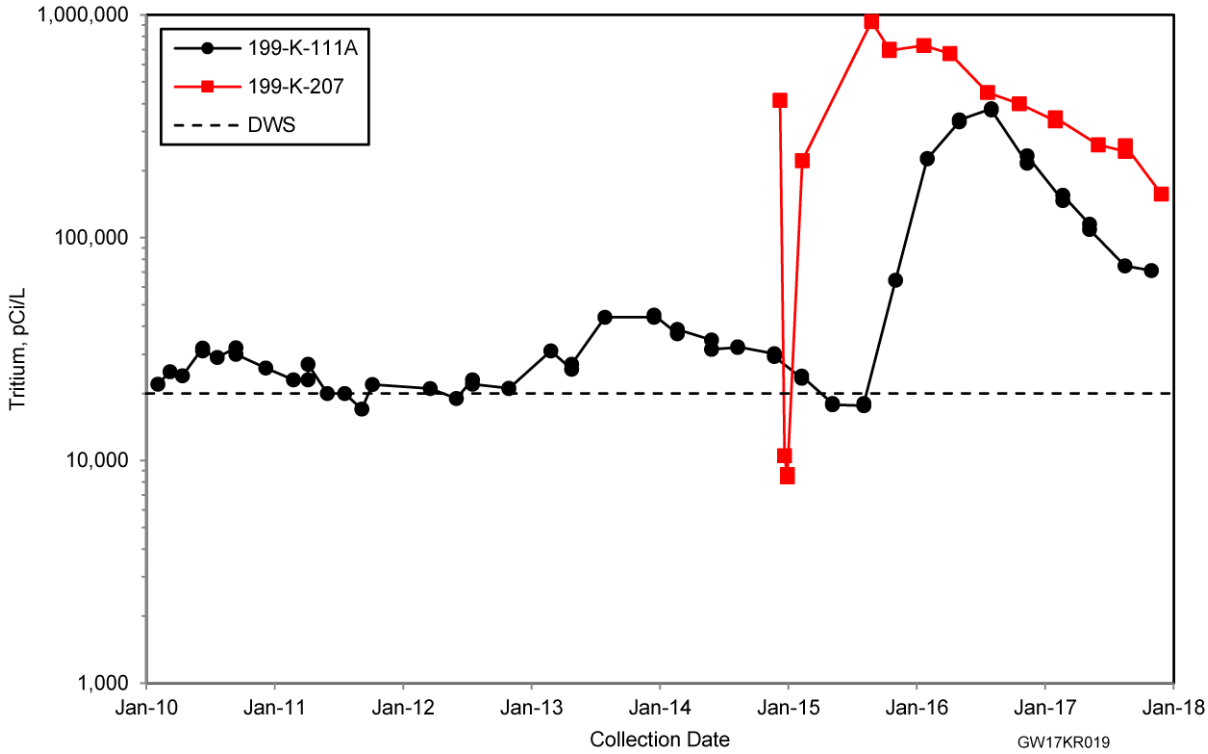


Figure 5-16. 100-KR Tritium Data for Wells 199-K-111A and 199-K-207 (Located Northeast of KE Reactor)

Extraction wells for Cr(VI) remediation also capture tritium; however, because the tritium is not treated, it passes through the treatment system and is returned to the aquifer via inland injection wells. Based on the design of the P&T system, much of this water will be recaptured by the downgradient extraction wells, and the tritium will be recirculated and continue to decay. The average effluent tritium concentrations of the P&T systems in 2017 were 2,470 pCi/L, 4,235 pCi/L, and 1,418 pCi/L for the KR4, KE, and KW P&T systems, respectively. Based on aquifer tube data and the plume map presented, tritium is not currently reaching the river at concentrations above the DWS.

5.4 Nitrate

Nitrate concentrations continued to exceed 45 mg/L in several 100-KR wells in 2017 (Figure 5-17). The nitrate observed in 100-KR is attributed primarily to oxidation of high concentrations of ammonia in reactor gas dryer condensate (i.e., up to 36,000 mg/L) that was discharged to the 116-KE-1 and 116-KW-1 Cribs. Additional nitrate contributions to groundwater may have come from sanitary waste drain fields at various locations in 100-KR.

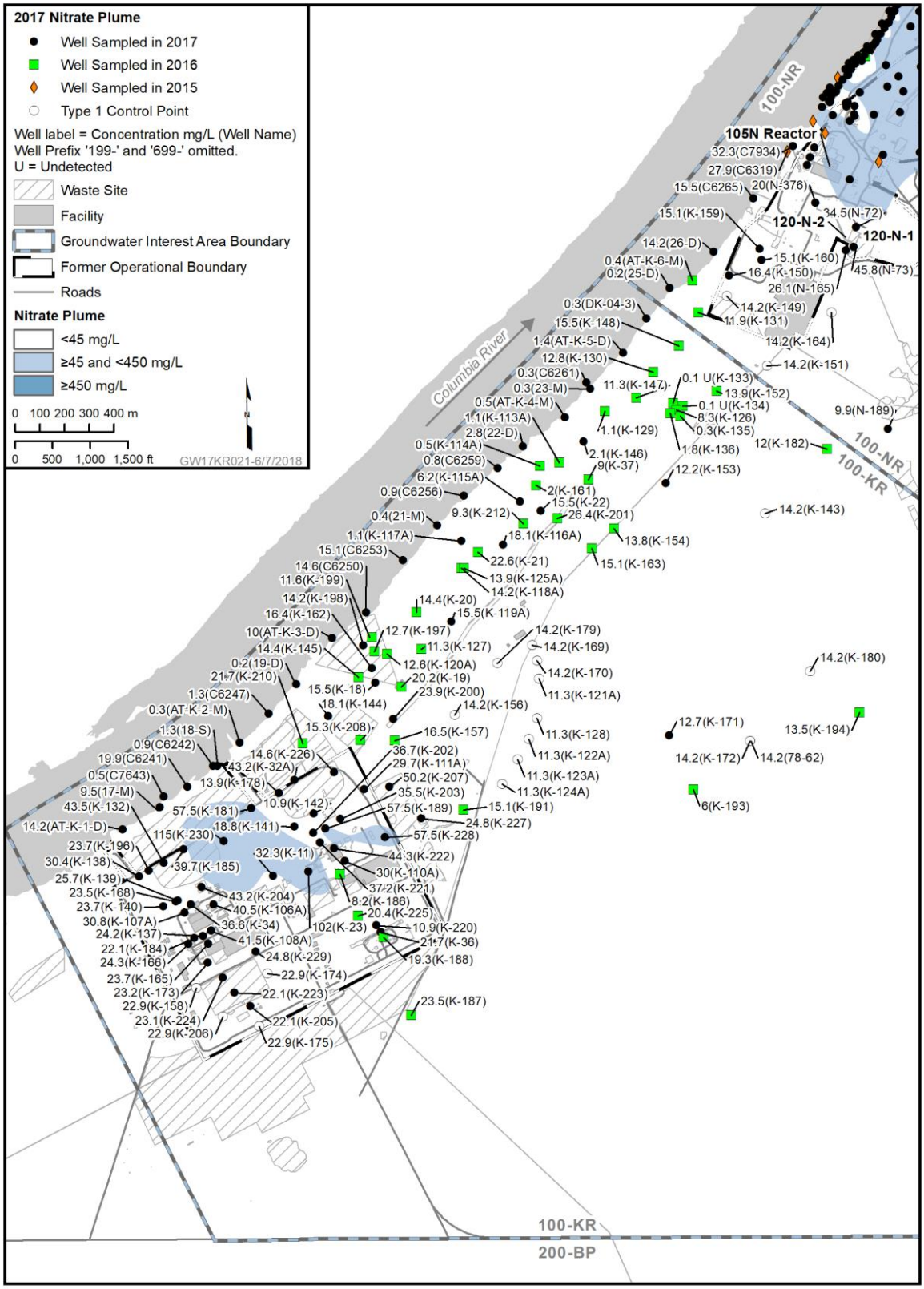


Figure 5-17. 100-KR Nitrate Plume, 2017

Comparing the distribution of nitrate in 2017 (Figure 5-17) and 2016 (Figure 5-21 of DOE/RL-2016-67) shows three differences:

- The 2017 average concentrations in K West wells were all below 45 mg/L, so no plume is interpreted in that region, where a plume was present in 2016.
- In 2017, a plume is present in K East wells, where 2016 concentrations were below 45 mg/L.
- Well 199-K-230, drilled in April 2017 and located between the KW and KE P&T systems in a previous unmonitored area, exhibited a nitrate concentration of 115 mg/L during drilling. It is likely that the concentrations are part of a previously unmonitored plume segment originating from the upgradient sanitary waste drain fields.

During the rebound study in 2016, nitrate concentrations in K West wells 199-K-106A, 199-K-132, 199-K-185, and 199-K-204 increased above the 45 mg/L DWS. During 2017, nitrate concentrations were variable, but the yearly average declined below 45 mg/L (Figure 5-18).

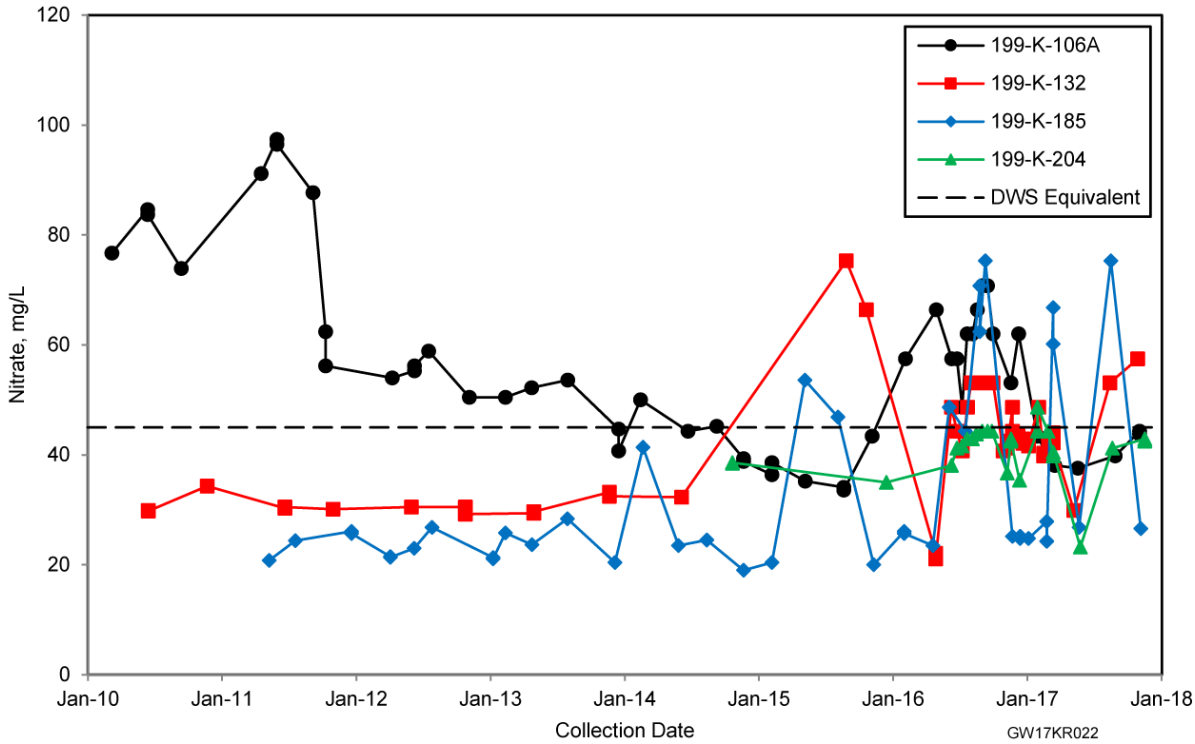


Figure 5-18. 100-KR Nitrate Data for Wells near KW Reactor

Near K East, nitrate concentrations increased in several wells, resulting in a plume near the KE Reactor and 116-KE-1 gas condensate crib (Figure 5-17). Concentrations in well 199-K-189, downgradient of the gas condensate crib, have been increasing since the end of 2014 and exceeded the DWS in November 2017. Concentrations also increased in downgradient wells 199-K-141, 199-K-142, and 199-K-202, further indicating a migrating plume. Nitrate was also detected at a maximum of 57.5 mg/L in new well 199-K-228, indicating a larger area of impact than previously identified.

Also in K East, but not apparently related to the gas condensate cribs, nitrate concentrations increased in well 199-K-23. In 2015, nitrate concentrations in well 199-K-23 were above the DWS; however, concentrations dropped as low as 0.8 mg/L in 2016. The increase to 102 mg/L in 2017 could be the result of waste site remediation efforts of nearby septic system and tile fields (100-K-103, 100-K-107, and 100-K-108) or the result of an unmonitored plume migrating from upgradient. Well 199-K-23 was decommissioned to support waste site remediation of the 116-KE-2 waste site, so furthering sampling is not possible. Downgradient well 199-K-13 has not shown an increase in nitrate, but the sampling frequency of this well has been increased to monitor for this condition at well 199-K-23.

Aquifer tubes C6241 and 17-D (downgradient from K West) have historically exhibited nitrate concentrations above 45 mg/L but have been below that level since 2013 and 2011, respectively. During 2017, concentrations in both locations exhibited a slight increase but remained below 30 mg/L. The 100-K Spring 63-1 (near the K West nitrate plume) had a nitrate concentration of 1.6 mg/L in September. Nitrate concentrations in aquifer tubes and seeps may increase as the nitrate plume continues to migrate toward the river.

5.5 Strontium-90

Strontium-90 is a fission product generated within the reactor fuel during nuclear reactor operation. It was historically released during fuel failure events and resulted in contamination of reactor cooling water. Strontium-90-contaminated cooling water, along with irradiated fuel fragments, could have been released to the 116-K-2 Trench under off-normal conditions, as well as to the reactor FSBs during discharge of irradiated fuel from the reactors. Cooling water contaminated by fuel rod failure fission products was also held in the 107KE or 107KW retention basins and subsequently discharged to the 116-K-2 Trench. The highest strontium-90 concentrations in groundwater are associated with historical releases from the FSBs and their associated drainage systems. The FSBs also contained cooling water contaminated with strontium-90. Discharges of reactor cooling water to the 116-K-2 Trench are apparent sources of strontium-90 in 100-KR groundwater. Other historical sources of strontium-90 were discharges to the 116-KW-2 and 116-KE-3 FSB cribs and reverse wells, as well as leakage from the 105-KE FSB (e.g., UPR-100-K-1 at the 105-KE FSB).

Strontium-90 is found in low levels in many wells across 100-KR. Concentrations above the 8 pCi/L DWS appear to be limited to three small plumes that do not extend to the Columbia River (Figure 5-19). Concentrations in aquifer tube 22-M, which exhibited a maximum strontium-90 concentration of 6.48 pCi/L in 2016, declined in 2017. This condition appears to represent downgradient migration of strontium-90 toward the river from the distal end of the trench.

Three wells had strontium-90 concentrations above 8 pCi/L in K West (199-K-107A, 199-K-34, and 199-K-139) (Figure 5-20), consistent with the 2016 monitoring results. Concentrations increased slightly in wells 199-K-107A and 199-K-139 during the rebound study in 2016 but declined in 2017. Overall, the plume in this area is essentially unchanged, with concentrations of strontium-90 slowly declining.

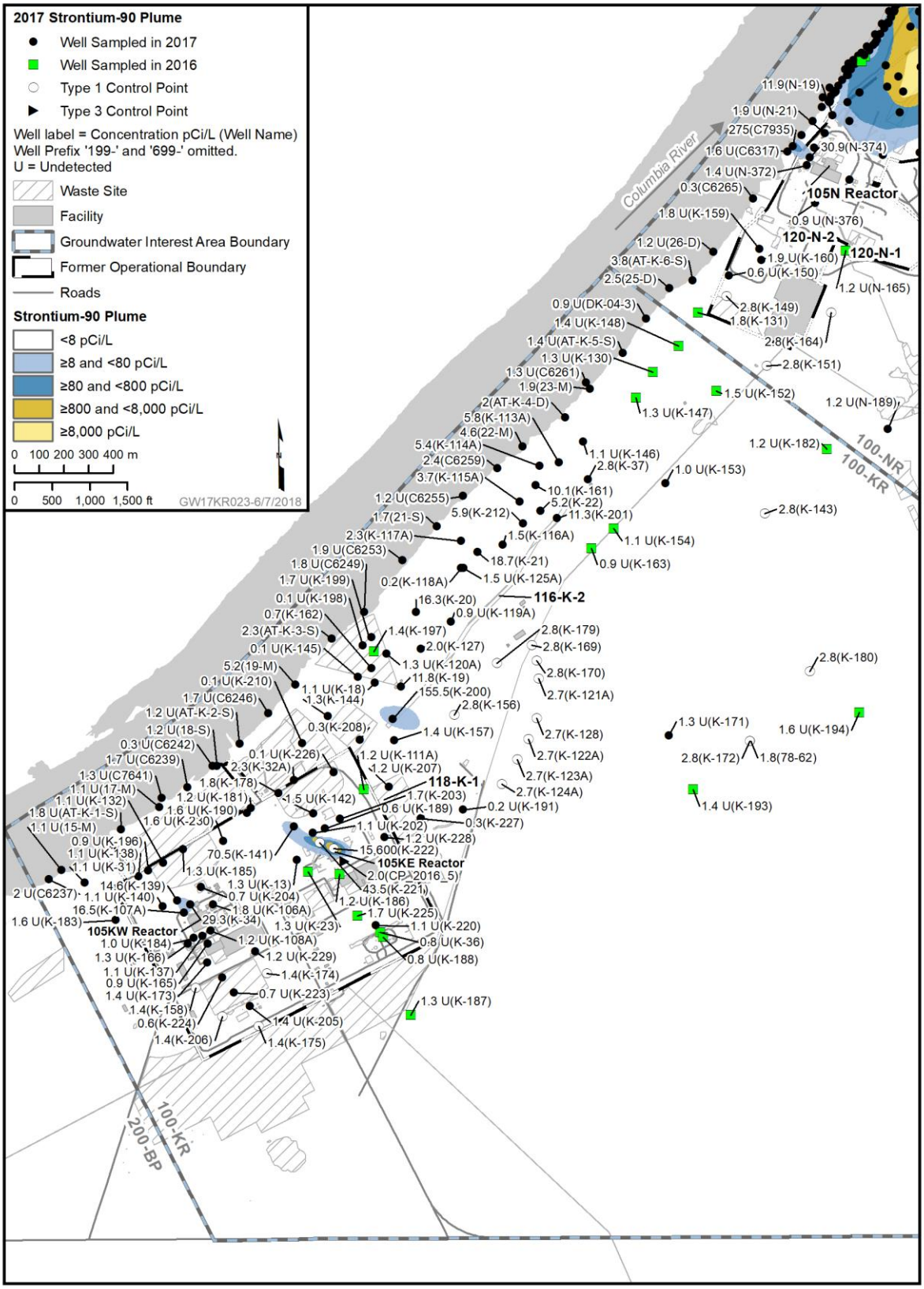


Figure 5-19. 100-KR Strontium-90 Plume, 2017

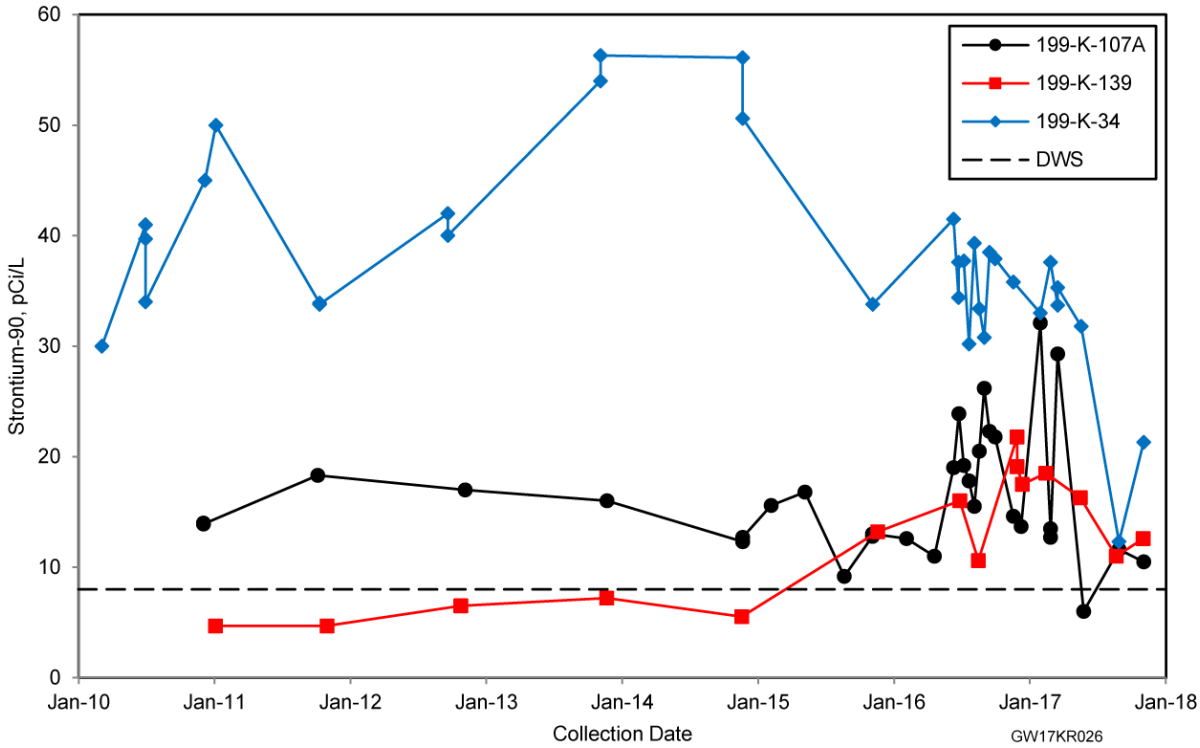


Figure 5-20. 100-KR Strontium-90 Data for Wells 199-K-34, 199-K-107A, and 199-K-139 (Located Downgradient of KW Reactor)

Wells near the KE Reactor had the highest strontium-90 (15,600 pCi/L) concentrations in 100-KR in 2017. Wells 199-K-221 and 199-K-222 were drilled in 2015 to investigate the source areas near KE Reactor waste sites 116-KE-3 and UPR-100-K-1 (leakage from the former 105-KE FSB). The results of characterization efforts are presented in SGW-60149, *Report for Soil Borings and Well Installations in the UPR-100-K-1 and 116-KE-3 Waste Sites*. Elevated strontium-90 concentrations were identified in soil and groundwater samples at both well locations during drilling. Groundwater sampling results from well 199-K-222 were elevated during drilling, but subsequent sampling results were lower than anticipated. As a result, the sample collection method was revised at the beginning of 2017 to obtain water from the upper portion of the aquifer near the water table, where the highest concentration was measured during drilling (4,000 pCi/L). Strontium-90 concentrations, along with co-contaminants tritium, carbon-14, and nitrate, increased after adjusting the sampling method. Total uranium was also detected for the first time above the 30 µg/L DWS in well 199-K-222 at a maximum concentration of 34.9 µg/L. This result is currently under review; however, total uranium was added to subsequent sampling events for 2018 to confirm the condition.

Downgradient of the 105-KE FSB and well 199-K-222, strontium-90 concentrations in extraction well 199-K-141 continued to increase (Figure 5-21). This trend indicates ongoing downgradient migration of the strontium-90 plume associated with leakage near the KE Reactor at waste sites 116-KE-3 and UPR-100-K-1.

At the head end of the 116-K-2 Trench, strontium-90 continued to exceed the DWS in well 199-K-200 in 2017, averaging 156 pCi/L (Figure 5-19). Wells downgradient of the trench generally exhibited stable to declining concentrations, with some seasonal variation noted in wells 199-K-161 and 199-K-20. Concentrations above the DWS were detected in wells 199-K-19, 199-K-20, 199-K-21, and 199-K-161. A slight increase was also noted in well 199-K-20, with a concentration of 16.3 pCi/L in 2017.

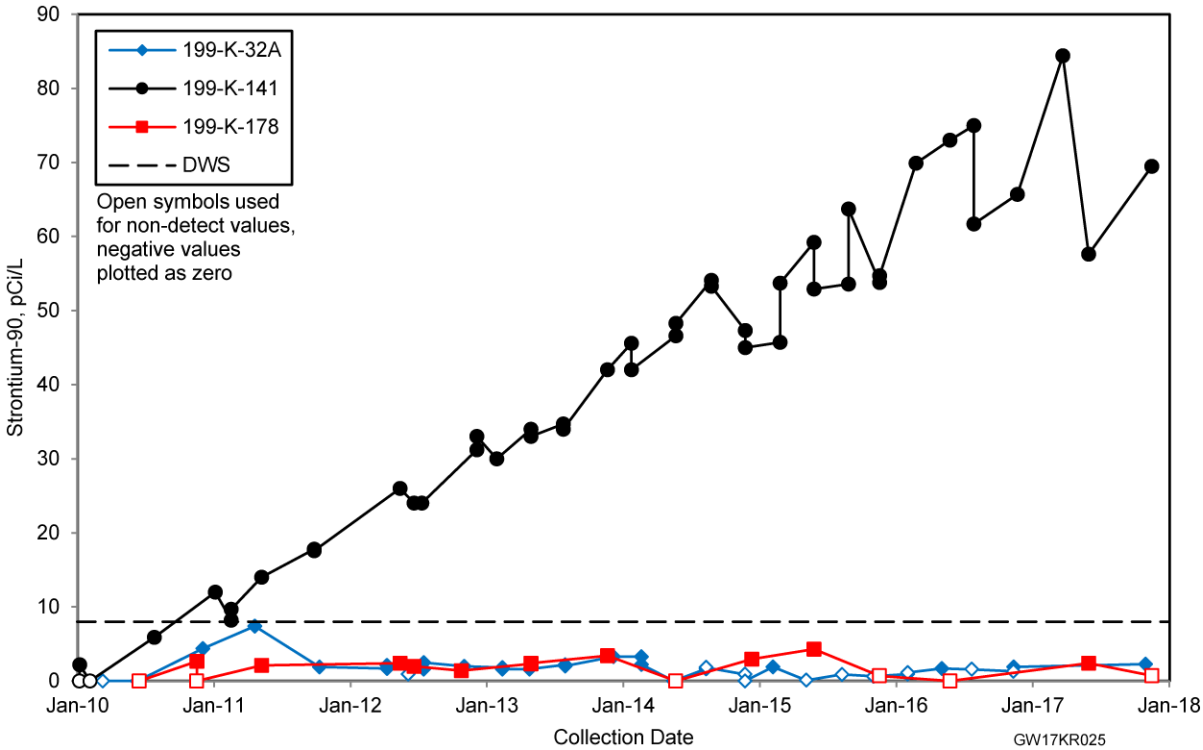


Figure 5-21. 100-KR Strontium-90 Data for Wells 199-K-32A, 199-K-141, and 199-K-178 (Located Downgradient of KE Reactor)

5.6 Carbon-14

Most of the carbon-14 in 100-KR groundwater originated from historical discharges of reactor gas dryer regeneration condensate to the 116-KE-1 and 116-KW-1 gas condensate cribs. Carbon-14 in gas dryer condensate collected during operation ranged from 2.9×10^{8} pCi/L at the KW Reactor to 1.04×10^{9} pCi/L at the KE Reactor. The gas condensate stream contained tritium ranging from 3×10^{9} pCi/L to 1×10^{10} pCi/L and ammonia ranging from 9,000 to 36,000 mg/L (HW-76258).

The 2017 carbon-14 plumes (Figure 5-22) exhibited little change in extent from 2016. In K West, concentrations remained consistent with previous years in the majority of the area, including during the period of the KW P&T system rebound study. Downgradient of the 116-KW-1 gas condensate crib, however, concentrations increased during the rebound study. For example, carbon-14 concentrations in well 199-K-106A increased to 40,100 pCi/L in July 2016. In 2017, concentrations in well 199-K-106A ranged from 14,200 to 28,500 pCi/L (Figure 5-23). In well 199-K-204, concentrations declined from 26,600 pCi/L in January 2017 to 15,000 pCi/L in November.

A carbon-14 plume is also present in K East. The plume was formerly defined by wells 199-K-29 and 199-K-30, which monitored conditions downgradient of the 116-KE-1 Crib but were later decommissioned. Control points based on estimated migration of historically high carbon-14 detections continued to be used in the 2017 plume map, which allows more representative estimation of the extent of carbon-14 in groundwater where monitoring data are limited.

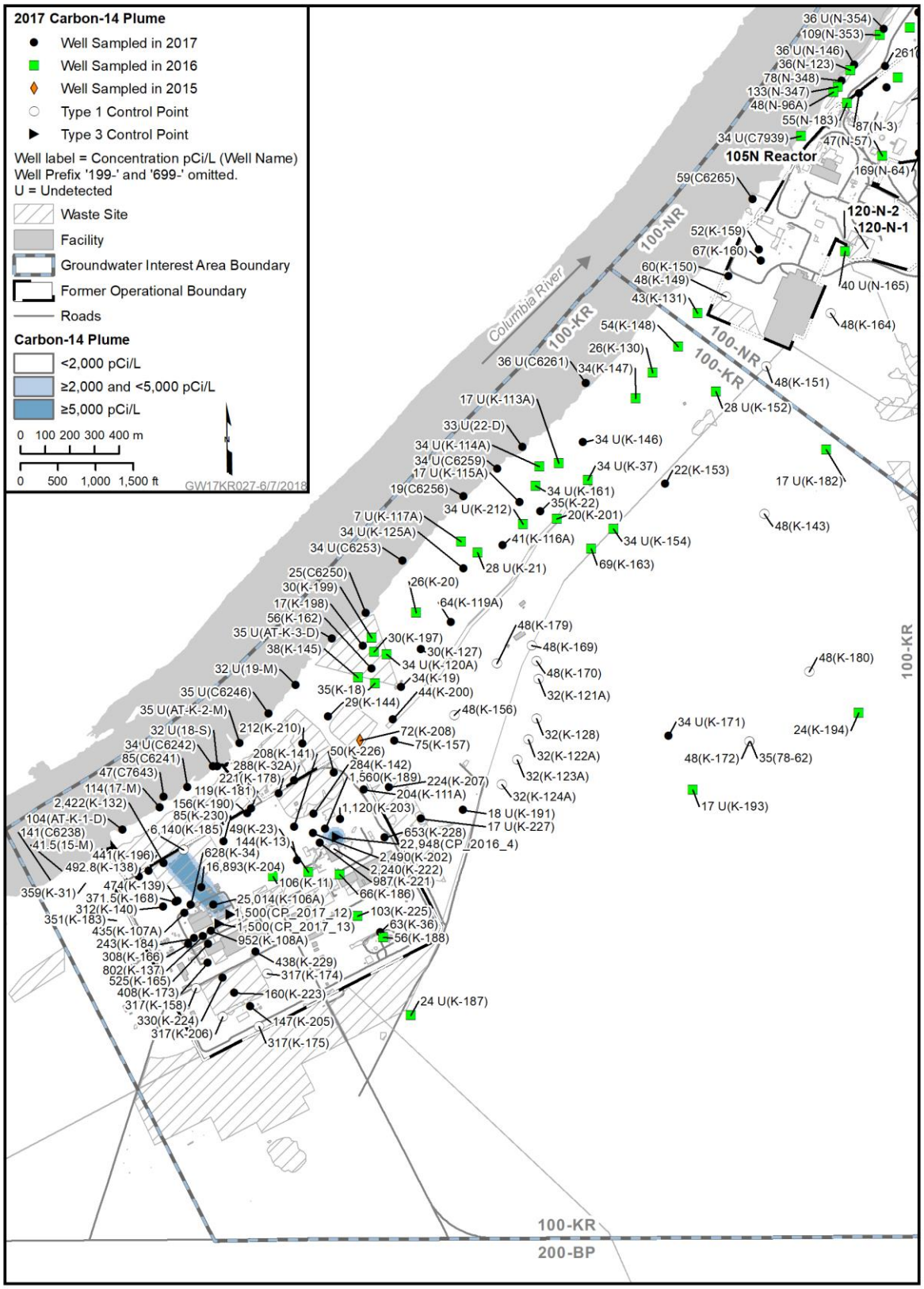


Figure 5-22. 100-KR Carbon-14 Plume, 2017

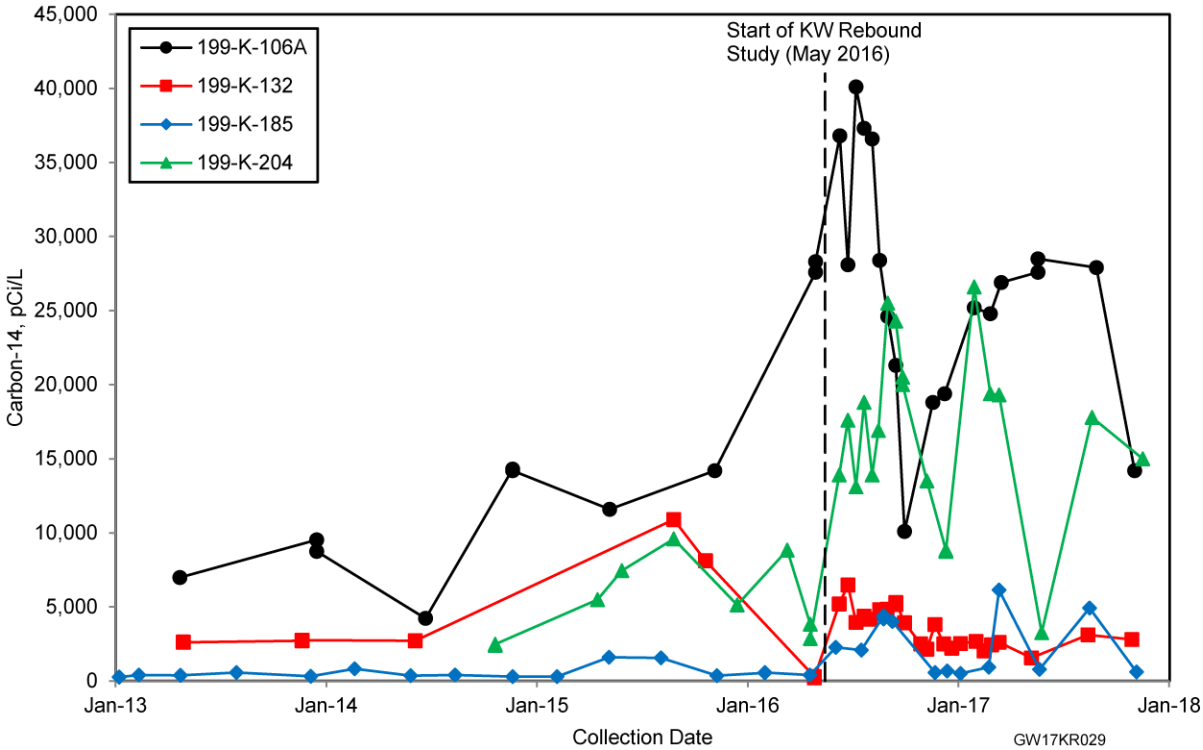


Figure 5-23. 100-KR Carbon-14 Data for Wells Downgradient of the 116-KW-1 Gas Condensate Crib

In 2017, carbon-14 in K East exceeded the DWS in wells 199-K-202 and 199-K-222. In well 199-K-202, concentrations ranged from 110 to 3,170 pCi/L. The lowest observed concentration was collected during the high river stage. River water appears to intrude inland to this location based on the drop in specific conductance (Figure 5-24). A similar condition was observed in 2016 at well 199-K-189, where concentrations ranged from 163 to 2,480 pCi/L and showed a similar drop in specific conductance. In 2017, the carbon-14 concentration in well 199-K-189 decreased to 1,560 pCi/L.

At well 199-K-222 (located in the footprint of the former 105-KE FSB), carbon-14 concentrations increased from less than 200 pCi/L in 2016 to 2,240 pCi/L in October 2017, after the pump intake depth was raised to the upper part of the well screen. This increase may indicate that contamination in the deep vadose zone continues to feed the carbon-14 plume from the 116-KE-1 gas condensate crib.

Carbon-14 continued to be detected at relatively low concentrations in aquifer tubes near the KE Reactor area (below 500 pCi/L).

5.7 Trichloroethene

The sources of TCE at 100-KR are likely related to the use of solvents during equipment maintenance activities, but specific release points have not been identified. TCE continues to be detected above the 5 µg/L DWS in K West (Figure 5-25). Concentrations in monitoring wells 199-K-11, 199-K-185, and 199-K-190 continued to exceed the DWS during 2017. New well 199-K-230 also had concentrations exceeding the DWS during most of the year, with a maximum of 9.73 µg/L in April 2017.

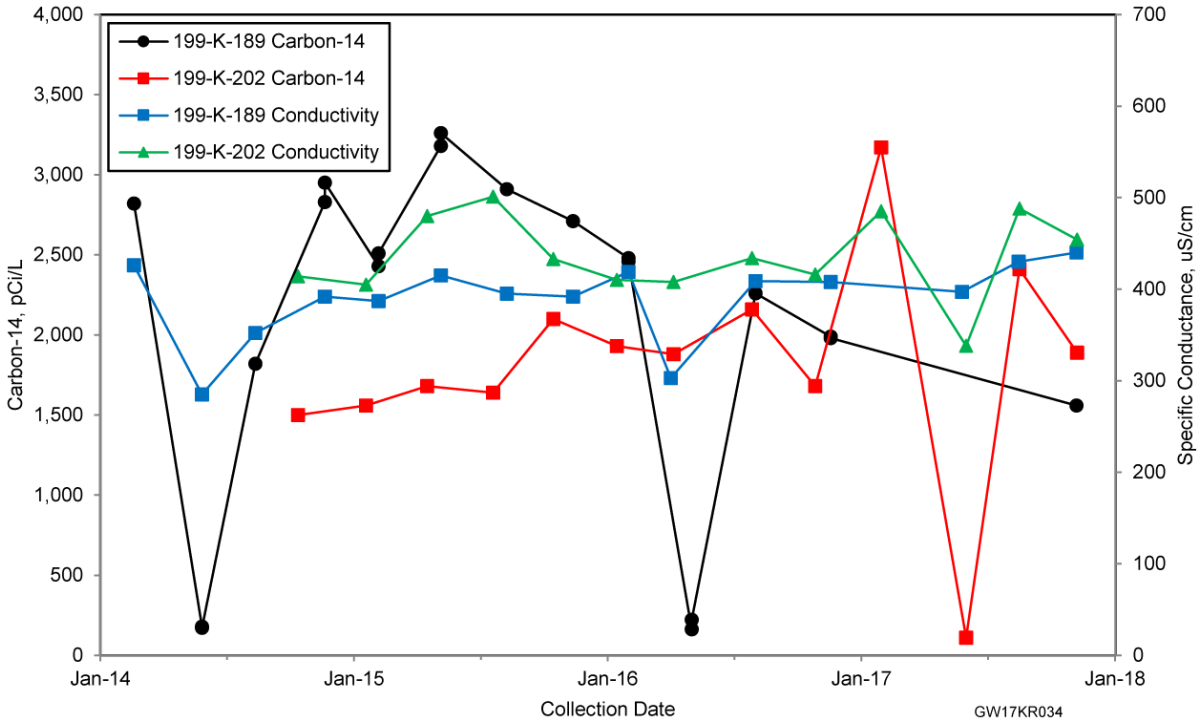


Figure 5-24. 100-KR Carbon-14 and Specific Conductance in Wells 199-K-189 and 199-K-202

The ongoing injection of TCE at levels below the 5 µg/L DWS through KW P&T injection wells has resulted in a dispersed TCE plume near the KW Reactor. Figure 5-26 shows the TCE plume using the maximum concentration observed throughout K West, rather than the annual average. To ensure plume delineation, the maximum concentration will be used to map the TCE plume in 100-KR, which will ensure that the plume does not artificially disappear due to averaging.

The TCE concentrations in aquifer tubes downgradient of the K West plume were generally below 1.0 µg/L. TCE was reported at 0.96 µg/L in aquifer tube AT-K-1-D in 2017 (flagged as "J," indicating an estimated concentration). Concentrations above 1.0 µg/L were detected in aquifer tubes outside the primary K West plume at cluster C6236, C6237, and C6238. This condition is likely due to KW P&T operations and the injection of low-concentration TCE into the injection wells. Similar concentrations are observed inland at monitoring wells located near injection points. 100-K Spring 63-1, located riverward of well 199-K-132, had TCE at concentrations below 1.0 µg/L during 2017.

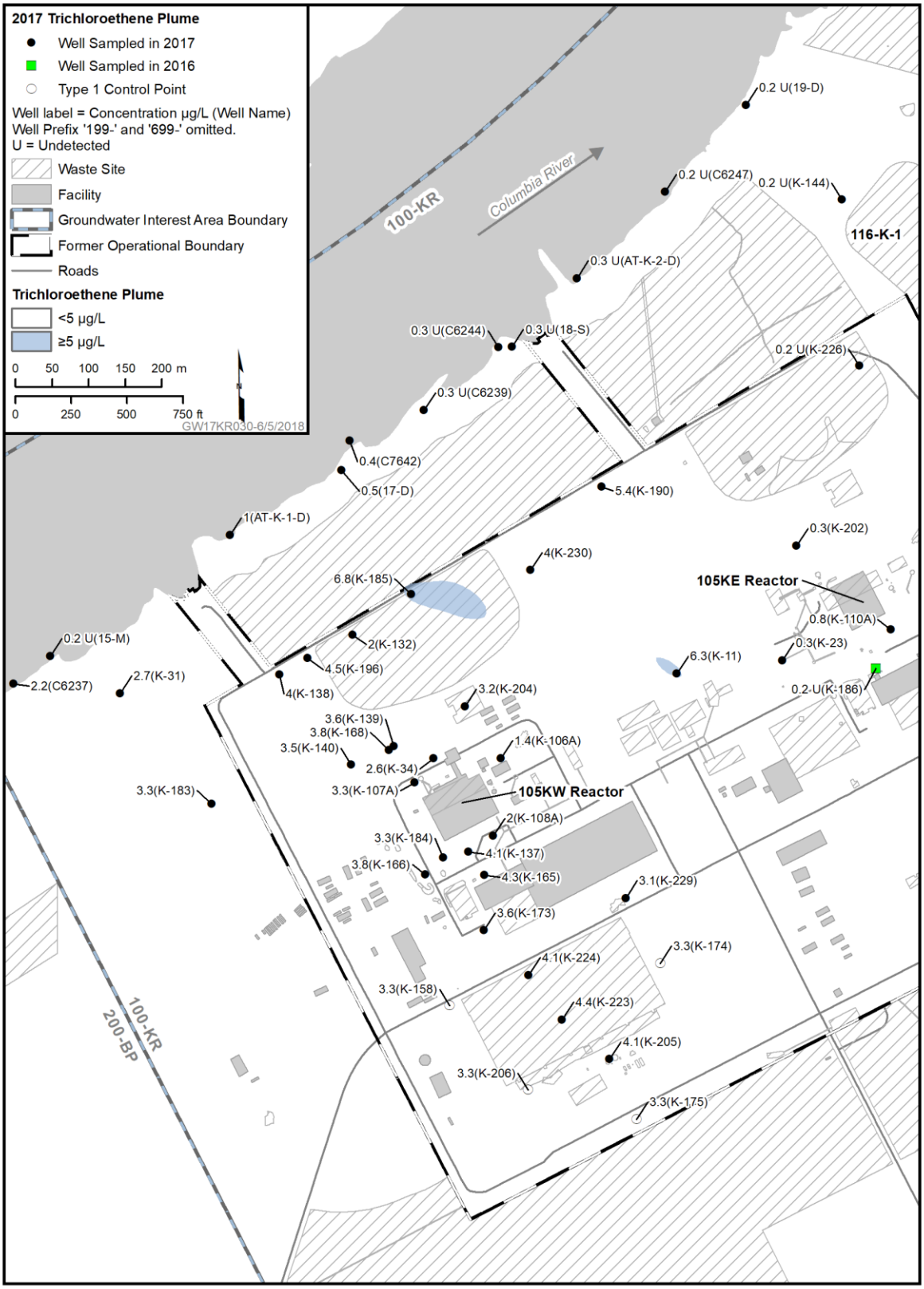


Figure 5-25. 100-KR Average TCE Plume, 2017

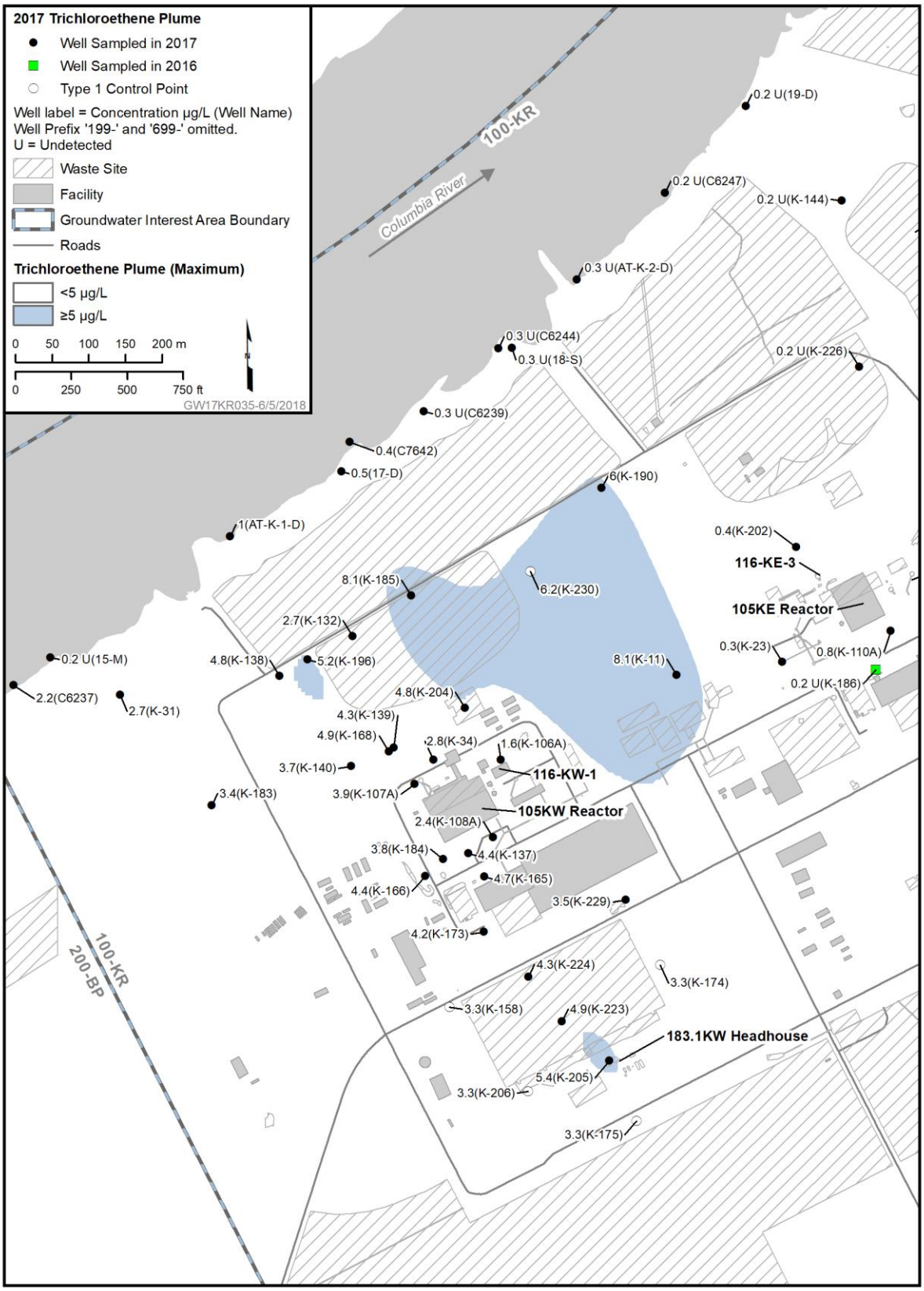


Figure 5-26. 100-KR Maximum TCE Plume, 2017

5.8 CERCLA Remediation and Monitoring

CERCLA groundwater activities at 100-KR included groundwater sampling and analysis at monitoring well locations and the operation of three interim groundwater remediation systems focusing on removing Cr(VI) (Figure 5-1). CERCLA groundwater sampling is conducted in accordance to the SAP (DOE/RL-2013-29, *Sampling and Analysis Plan for the 100-KR-4 Groundwater Operable Unit Monitoring*), as modified by TPA-CN-0797, *Tri-Party Agreement Change Notice Form: Sampling and Analysis Plan for the 100-KR-4 Groundwater Operable Unit Monitoring*, and includes monitoring interim remedial actions for effectiveness and monitoring wells throughout 100-KR to track Cr(VI) and co-contaminants carbon-14, nitrate, strontium-90, TCE, and tritium. These constituents, which have been identified as groundwater COCs through the RI/FS process, may be captured and extracted incidentally by the interim remedial action P&T system. However, these constituents are not treated by the interim action and, therefore, are considered to be co-contaminants of Cr(VI), which is the primary target of the interim action. Technetium-99 has also been detected in groundwater, with concentrations consistently less than 100 pCi/L, which is much less than the 900 pCi/L DWS. The highest technetium-99 concentrations in 2017 were in wells 199-K-222 (510 pCi/L) and 199-K-227 (486 pCi/L). Technetium-99 has not been identified as a COC in 100-KR.

Petroleum hydrocarbons (measured as total petroleum hydrocarbons [TPH]) were encountered in the vadose zone during drilling of wells 199-K-167 (decommissioned), 199-K-173, and 199-K-186. Low levels of petroleum hydrocarbons (all less than 100 µg/L of diesel, gasoline, kerosene, and motor-oil range hydrocarbons) were detected in groundwater during 2016. In 2017, all samples analyzed for TPH were reported below detection limits.

5.8.1 CERCLA Decision Documents and Plans

In 2017, DOE began revising the 100-K RI/FS (DOE/-RL-2010-97, Draft A). The revision incorporates supplemental data associated with the 105-KE FSB and 116-KE-3 crib and reverse well, as well as data collected to support soil and groundwater interim remedial actions. Completion of the RI/FS will provide the framework for a proposed plan, which will evaluate alternatives and recommend a preferred alternative. DOE and EPA will issue a ROD that incorporates stakeholder input and identifies the selected alternatives for waste site and groundwater cleanup. Interim remedial actions will continue until the ROD is completed. Completion of the RI/FS is anticipated in 2019.

5.8.2 Pump and Treat

In 2017, a total of 40 extraction wells and 21 injection wells were operated for P&T groundwater remediation operations. By the end of 2017, 38 extraction wells and 19 injection wells were in use for groundwater remediation (Table 5-4 and Figure 5-27). The three P&T systems (KR4, KX, and KW) are capable of treating a combined total of more than 7.9 million L (2.1 million gal) of groundwater per day. The combined P&T systems in 100-KR removed 36.7 kg of Cr(VI) from groundwater in 2017. Since 1997, the P&T systems have removed 904.2 kg of Cr(VI) from the aquifer. DOE/RL-2017-67 provides additional details.

Table 5-4. 100-KR-4 P&T Summary

P&T system	KW[a]	KR4	KX
100-KR-4 P&T Systems, 2017			
Design capacity (L/min [gal/min])	1,250 (330)	1,250 (330)	3,410 (900)
Extraction wells (post-realignment)[b]	5	11	22
Injection wells (post-realignment)[b]	4	5	10
Average flow rate (L/min [gal/min])	1,162.3 (306.8)[c]	994.3 (262.5)	2,729.3 (720.5)
Volume treated (million L [million gal])	432.7 (114.3)	516.1 (136.3)	1,359.6 (359.2)
Cr(VI) mass removed (kg)	14.4	1.3	21.0
Average Cr(VI) influent concentration (µg/L)	35.1	3.3	16.1
Average Cr(VI) effluent concentration (µg/L)	<2	<2	<2
All 100-KR-4 P&T Systems, 1997–2017			
Volume treated (million L [million gal])			23,591 (6,232)
Cr(VI) mass removed (kg)			904

a. The KW P&T system was on standby from May 2016 through April 2017 for a rebound test.

b. The number of extraction and injection wells does not include those wells that are not operational.

c. Average flow rate while KW P&T system was operating after standby.

Cr(VI) = hexavalent chromium

P&T = pump and treat

An interim action ROD for the 100-KR-4 OU was issued in April 1996 (EPA/ROD/R10-96/134). One of the remedial action objective (RAOs) is to protect aquatic receptors in the Columbia River from groundwater contaminants. The interim action ROD included a preliminary estimated dilution factor of 1:1 for groundwater entering the Columbia River at the 100-K, 100-D, and 100-H Areas under the assumption that dilution of groundwater with river water is expected before the groundwater would reach the aquatic receptor point of concern within the river substrate. This established an operational target for Cr(VI) treatment system effluent at 20 µg/L. For purposes of managing the interim remedial action, the working assumption is that groundwater at 20 µg/L at onshore, near-river monitoring locations will achieve the surface water standard of 10 µg/L at the point where groundwater discharges to the river (EPA et al., 2009).

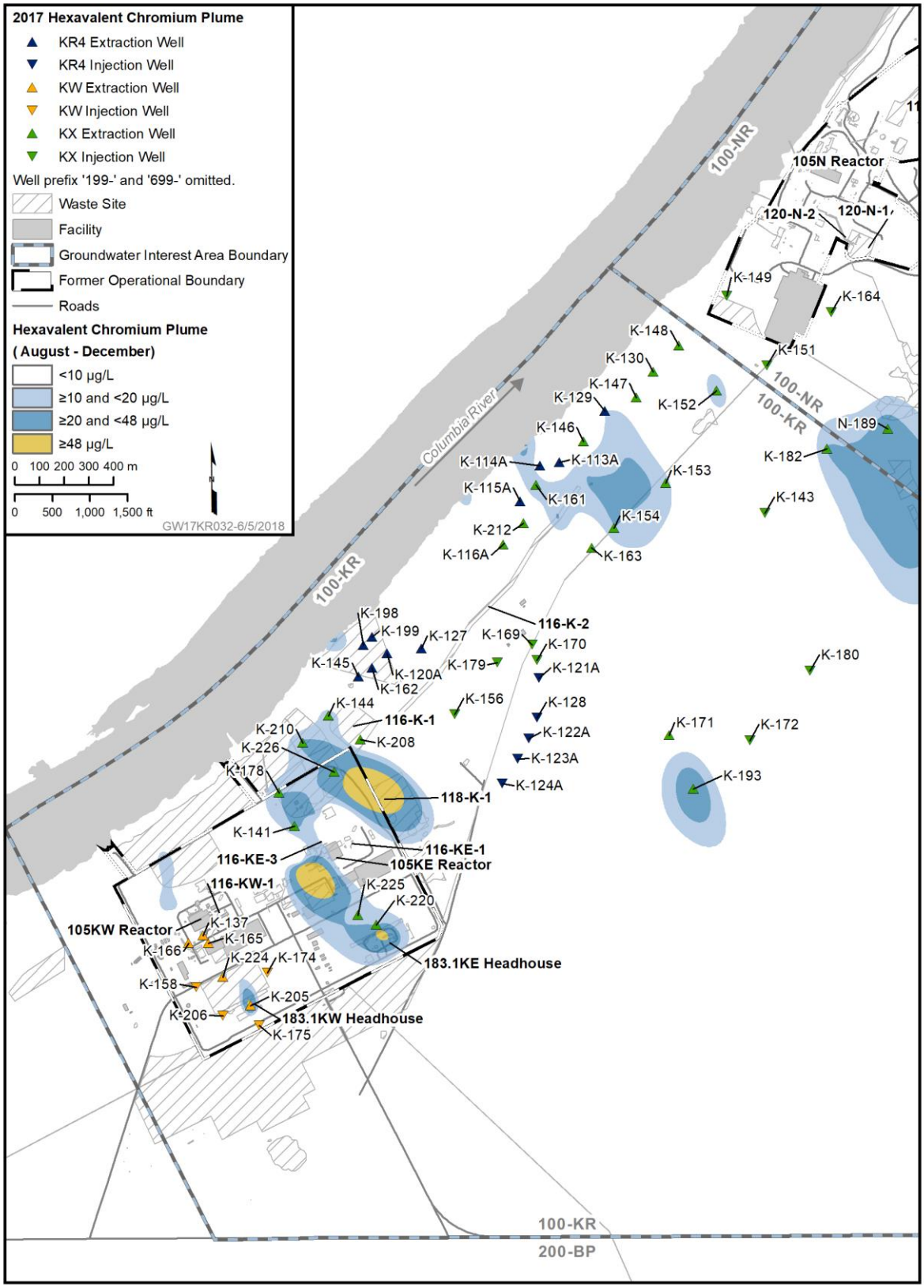


Figure 5-27. 100-KR P&T Well Locations

Since the interim action ROD was published, DOE has implemented three P&T systems to remediate Cr(VI) contamination in 100-KR-4 OU groundwater and to protect the Columbia River. All of the systems operated in 2017. A total of 38 compliance and performance monitoring wells are identified for these systems:

- The original P&T system, KR4, began operating in 1997 and focuses on contamination originating beneath the 116-K-2 Trench.
- The KX P&T system is focused on two areas: the northeastern end of the 116-K-2 Trench, where the Cr(VI) plume historically migrated toward 100-NR-2; and near the KE Reactor facilities. The KX system began operating in 2009.
- The KW P&T system began operating in 2007 and focuses on the Cr(VI) plume at the KW Reactor facilities. The system was shut down between May 16, 2016, and April 12, 2017, to perform a rebound study (Section 5.2.1).

Groundwater P&T systems will continue to operate in the 100-KR-4 OU. These systems provide protection of the Columbia River from Cr(VI)-contaminated groundwater that would cause an exceedance of the 10 µg/L ambient water quality criterion (AWQC) and help maintain hydraulic containment of the remaining Cr(VI) plumes.

Under the current configuration, the 100-KR-4 P&T systems are demonstrating progress toward the interim RAOs (Table 5-4 and Figure 5-5). Operation of the systems and containment of the plumes address the first and third RAOs defined in the ROD (EPA/ROD/R10-96/134):

- **RAO #1:** Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.
- **RAO #3:** Provide information that will lead to a final remedy.

To evaluate completion of the interim action and determine if continuing secondary source material exists in the deep vadose zone, DOE performed a rebound study at the KW P&T, as defined in the remedial design/remedial action work plan (RD/RAWP) (DOE/RL-2013-33, *Remedial Design/Remedial Action Work Plan for the 100-KR-4 Groundwater Operable Unit Interim Action*). At the beginning of 2016, Cr(VI) concentrations at the extraction and monitoring wells near the KW P&T were below the interim action remediation target. As discussed in Section 5.2.1, a rebound study SAP (DOE/RL-2016-42) was prepared to determine whether contaminant concentrations will remain below cleanup levels when the aquifer is no longer under the influence of active remediation. The results of the study are documented in the rebound study report (SGW-62061).

Plume containment and ICs meet the second RAO defined in the ROD (EPA/ROD/R10-96/134):

- **RAO #2:** Protect human health by preventing exposure to contaminants in the groundwater.

5.9 Atomic Energy Act Monitoring

AEA groundwater monitoring was scheduled at 63 groundwater wells and aquifer tubes in the 100-KR groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 100-KR are carbon-14, nitrate, strontium-90, and tritium. Historically, nitrate has been monitored through the AEA as an indicator of contaminant migration and continues to be monitored in accordance with the current AEA SAP (DOE/RL-2015-56). Wells were sampled in accordance with SAP requirements in 2017. One significant change to the monitoring network was

made in 2017 to decommission well 199-K-23. Appendix C lists the sampling exceptions for 2017 AEA monitoring of the 100-KR groundwater wells.

Radionuclide concentrations detected in groundwater samples from 144 wells[1] and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED exceeded the 100 mrem/yr standard at two groundwater wells in 100-KR. The DWSs for cumulative alpha emitters were not exceeded, but two wells did exceed the EPA net alpha activity standard. The DWS for cumulative uranium mass concentration was exceeded at one well. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 22 locations in this groundwater interest area (Table 5-5). Some of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. CERCLA remedial action decisions (i.e., P&T for the 100-KR-4 OU) provide additional protection of the public and the environment.

Table 5-5. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-KR in 2017

Monitoring Location/ Well Name	Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
199-K-106A			30.22	59.28				
199-K-107A			4.08	16.19				
199-K-111A			14.71	31				
199-K-132			4.1	6.53				
199-K-139			6.67	10.49				
199-K-141			29.47	42.97				
199-K-161			5.05	5.05				
199-K-185			9.93	12.34				
199-K-189			7.4	7.4				
199-K-19			5.55	6.73				
199-K-20			8.6	8.6				
199-K-200			73.01	83.42				
199-K-201			4.28	7.9				
199-K-202			4.07	15.92				
199-K-203			4.15	4.15				
199-K-204			7.26	53.2				

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

Table 5-5. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-KR in 2017

Monitoring Location/ Well Name	Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
199-K-207			31.70	69				
199-K-21			9.68	9.68				
199-K-221			6.22	28.39				
199-K-222	1,268.15	1,426.7	4.53	7,820.96	34.9	34.9	77.92	77.92
199-K-227	148.34	203.27	61.39	764.16				
199-K-34			7.32	20.27			18.24	18.24

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Note: Blank cells indicate no exceedance.

6 100-NR

This chapter presents information on the 100-NR groundwater interest area, which encompasses the 100-NR-2 OU and the surrounding area, adjacent to the Columbia River (Figures 1-1 and 6-1). This chapter includes an overview and discussion of CERCLA, RCRA, and AEA groundwater monitoring and associated waste site (i.e., vadose zone) cleanup efforts.

6.1 Overview

Among the Hanford Site plutonium-production reactors, the design of N Reactor (operational from 1964 to 1986) was unique because it was a dual-purpose reactor, producing plutonium for defense and steam for electrical power. Soil and groundwater contamination in 100-NR is primarily associated with waste from the reactor and associated processes. About 92% of the waste sites in 100-NR have been remediated, evaluated, or both under a CERCLA interim action ROD (EPA/ROD/R10-99/112, *Interim Remedial Action of Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units*). Groundwater continues to be monitored in accordance with CERCLA, RCRA, and AEA requirements and is being remediated under the interim action ROD. Additionally, DOE/RL-2012-15, Draft A, *Remedial Investigation/Feasibility Study for the 100-NR-1 and 100-NR-2 Operable Units*, is being finalized to support decision making that will lead to the issuance of a ROD for final remedial action. Details on the history of 100-NR are provided in Section 1.3 of DOE/RL-2012-15, Draft A.

Strontium-90 is the primary groundwater contaminant in 100-NR. Other contaminants include nitrate, TPH as diesel (TPH-D), chromium (total), Cr(VI), tritium, and sulfate. Strontium-90 and TPH-D are being remediated under a CERCLA interim action ROD (EPA/ROD/R10-99/112). An apatite PRB was installed between 2006 and 2011 to reduce the flux of the strontium-90 in groundwater moving toward the Columbia River. TPH-D (free product) is also being removed from groundwater in two wells, and a bioventing system (operational since 2012) is being used to remediate TPH-D in the deep vadose zone.

Groundwater across most of 100-NR generally flows to the north and northwest toward the Columbia River (Figure 6-2). Groundwater flow continued to be influenced in 2017 by the KX P&T remediation system, as indicated by mounding and the reduction in pressure head located in the southwest portion of 100-NR. Cr(VI) contamination from 100-KR has migrated into the 100-NR groundwater interest area (Chapter 5) and is being remediated as part of the 100-KR-4 OU remedy. Table 6-1 summarizes information on the 100-NR groundwater plumes, Figure 6-1 shows wells and aquifer tubes sampled in 2017, and Figure 6-3 shows the change in groundwater plume areas over time. Section 1.5 provides plume mapping details for the contaminant plume interpretations presented in this chapter, including descriptions of terms (e.g., Type 1 control point) used in the figure legends.

The vadose zone in 100-NR is up to 23 m (76 ft) thick and is composed of gravels and sands of the Hanford formation and Ringold unit E (Figure 6-4). The unconfined aquifer is 6.5 to 14 m (21 to 46 ft) thick and is primarily located within Ringold unit E. When the Columbia River stage is high, the water table can rise into the Hanford formation in wells near the shoreline. Groundwater concentrations vary with changes in water table elevation, which mobilize contamination in the vadose zone. The RUM is the base of the unconfined aquifer. One thin, noncontinuous, confined, water-bearing zone has been documented within the upper portion of the RUM in well 199-N-80.

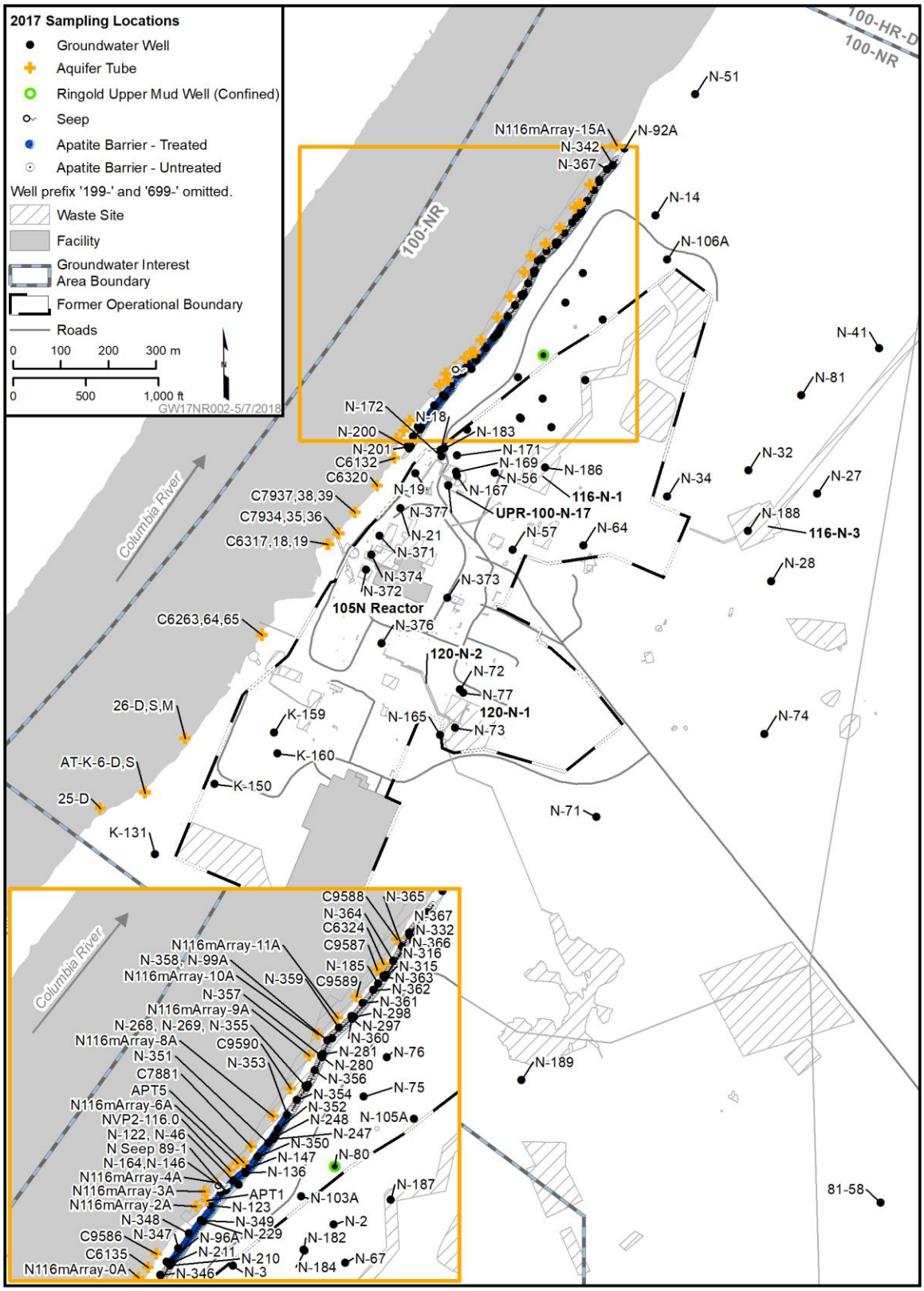
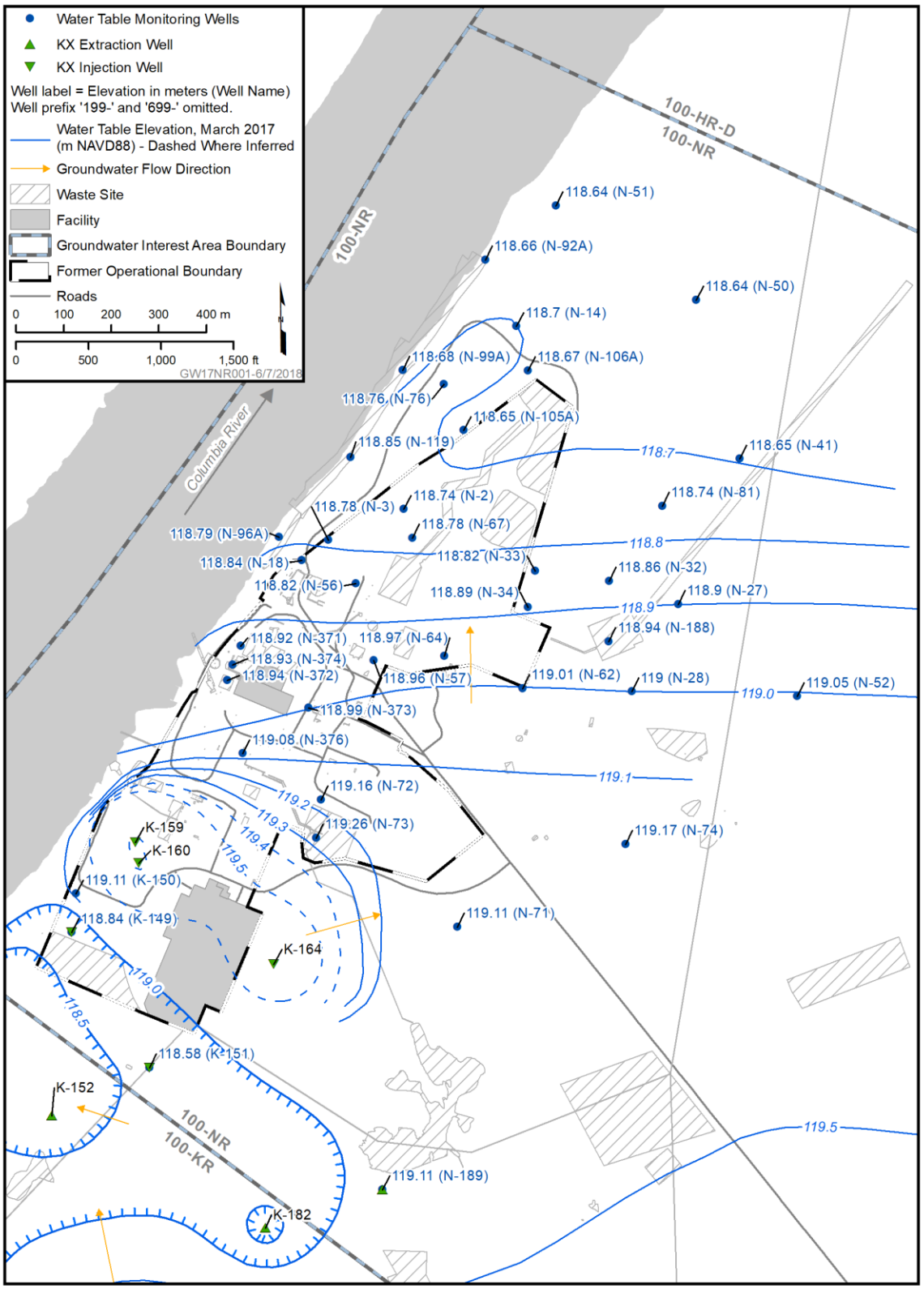


Figure 6-1. 100-NR Sampling Locations, 2017



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 6-2. 100-NR Water Table, March 2017

Table 6-1. 100-NR at a Glance

N Reactor operations: 1964 to 1986				
Groundwater Monitoring				
Contaminant, Water Quality Standard, Units	**Year**	**Maximum Concentration**	**Plume Area[a] (km^2)**	**Shoreline[b] (m)**
Strontium-90, 8 pCi/L	2017	14,200 (199-N-187)	0.63	650
	2016	12,600 (199-N-67)	0.63	675
Nitrate, 45 mg/L	2017	319 (199-N-348)	0.66	67
	2016	443 (199-N-67)	0.59	63
Diesel (as total petroleum hydrocarbons), 0.5 mg/L	2017	16.6 (199-N-18)	0.02	0
	2016	17.2 (199-N-18)	0.02	48
Hexavalent chromium, 48 µg/L/10 µg/L[c]	2017	130 (RUM 199-N-80)	—[d]	—[d]
	2016	117 (RUM 199-N-80)		
Tritium, 20,000 pCi/L	2017	282,000 (199-N-374)	<0.01	64
	2016	373,000 (aquifer tube C7934)	—[e]	—[e]
Remediation				
Waste sites: 92% complete.[f] **Groundwater (interim action):** 1995 to present Record of Decision for final remedial action is anticipated in 2020.				

a. Estimated area at a concentration greater than the water quality standard in the upper part of the unconfined aquifer.

b. Length of shoreline intersected by plume above listed water quality standard.

c. 48 µg/L in the upland area (WAC 173-340, "Model Toxics Control Act—Cleanup") and 10 µg/L where groundwater discharges to surface water (WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington").

d. The 100-NR hexavalent chromium contamination is limited to a single well monitoring a water-bearing unit of the RUM. The hexavalent chromium in the unconfined aquifer at 100-NR originated from 100-K Area sources (Chapter 5).

e. Not calculated in 2016.

f. Sites with status of final closed, interim closed, no action, not accepted, or rejected, as of December 31, 2017.

RUM = Ringold upper mud unit

6.2 Strontium-90

The primary source of strontium-90 in the 100-NR groundwater interest area was liquid waste disposed to the 116-N-1 Crib and Trench and the 116-N-3 Crib and Trench from N Reactor. Concentrations in groundwater vary with fluctuating water levels and due to installation of the PRB along the shoreline. However, the size and shape of the strontium-90 plume (Figure 6-5) changes very little from year to year because of the low mobility of strontium-90.

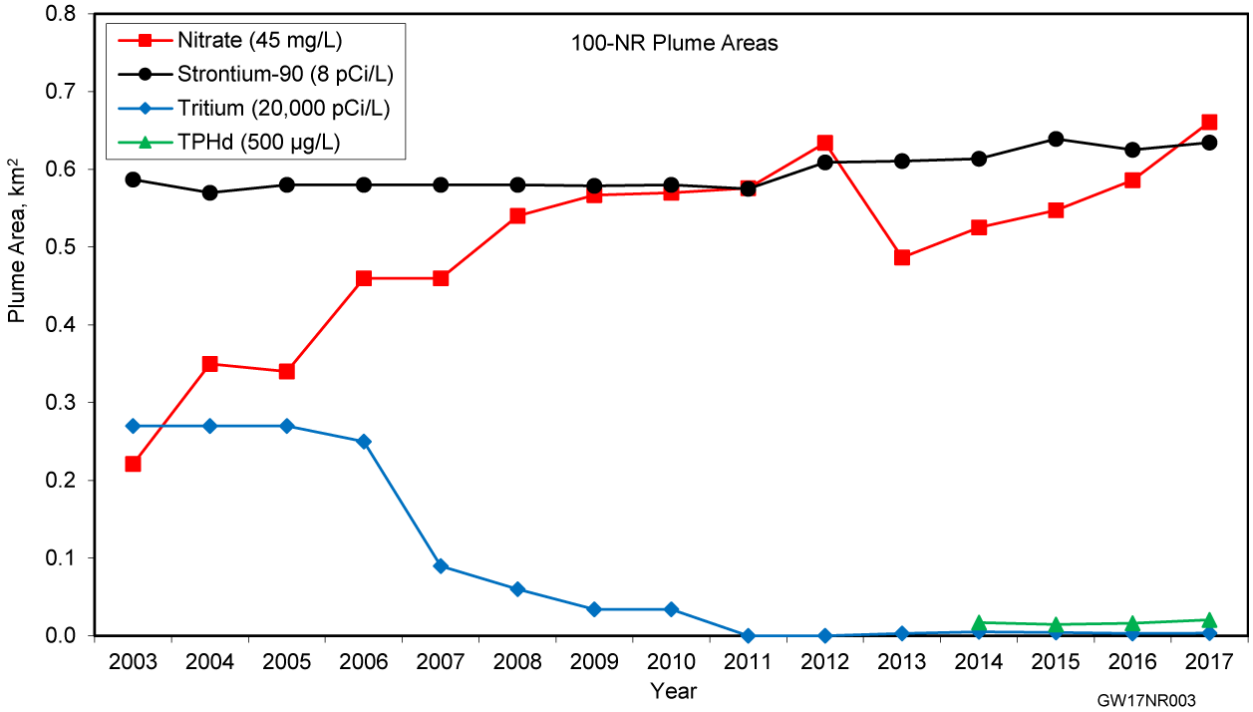


Figure 6-3. 100-NR Plume Areas

The strontium-90 plume extends laterally from beneath the 116-N-1 and 116-N-3 waste sites to the Columbia River at concentrations exceeding the DWS (8 pCi/L). Strontium-90 concentrations exceeding 800 pCi/L are found beneath the head end of the 116-N-3 Crib, as well as beneath and downgradient of the 116-N-1 Trench. Groundwater concentrations between 8 and 80 pCi/L are peripheral to the highest concentration area and are consistent with historical radial flow away from the 116-N-1 and 116-N-3 Cribs and Trenches when the liquid waste disposal sites were receiving effluent.

The highest concentration of strontium-90 in 100-NR groundwater in 2017 was 14,200 pCi/L at well 199-N-187, located in the main body of the plume beneath the 116-N-1 Trench. This was higher than the 2016 maximum concentration of 12,600 pCi/L at well 199-N-67, within the same high-concentration area of the plume. The strontium-90 concentration at well 199-N-67 decreased to 10,400 pCi/L in 2017. The maximum concentration in an aquifer tube in 2017 was detected in NVP2-116.0 (2,390 pCi/L).

The only strontium-90 above the DWS outside of the main plume (described above) is defined by well 199-N-374 and aquifer tube cluster C7934/C7935/C7936, downgradient of N Reactor (Figure 6-5). The presumed sources of the strontium-90 were UPRs from the N Reactor FSB and associated facilities and pipelines (UPR-100-N-3, UPR-100-N-7, and UPR-100-N-12). The aquifer tubes are located near the engineered fill around the 1908-N outfall, which suggests that outfall construction created a preferential pathway for migration of contaminated groundwater to the river (Section 4.2 in SGW-49370, *Columbia River Pore Water Sampling in 100-N Area, December 2010*). In 2017, the maximum concentrations in this plume ranged from 73.7 pCi/L at well 199-N-374 to 275 pCi/L at the aquifer tube cluster. Concentrations closer to the source at well 199-N-374 are generally increasing over time, while aquifer tube concentrations are generally decreasing.

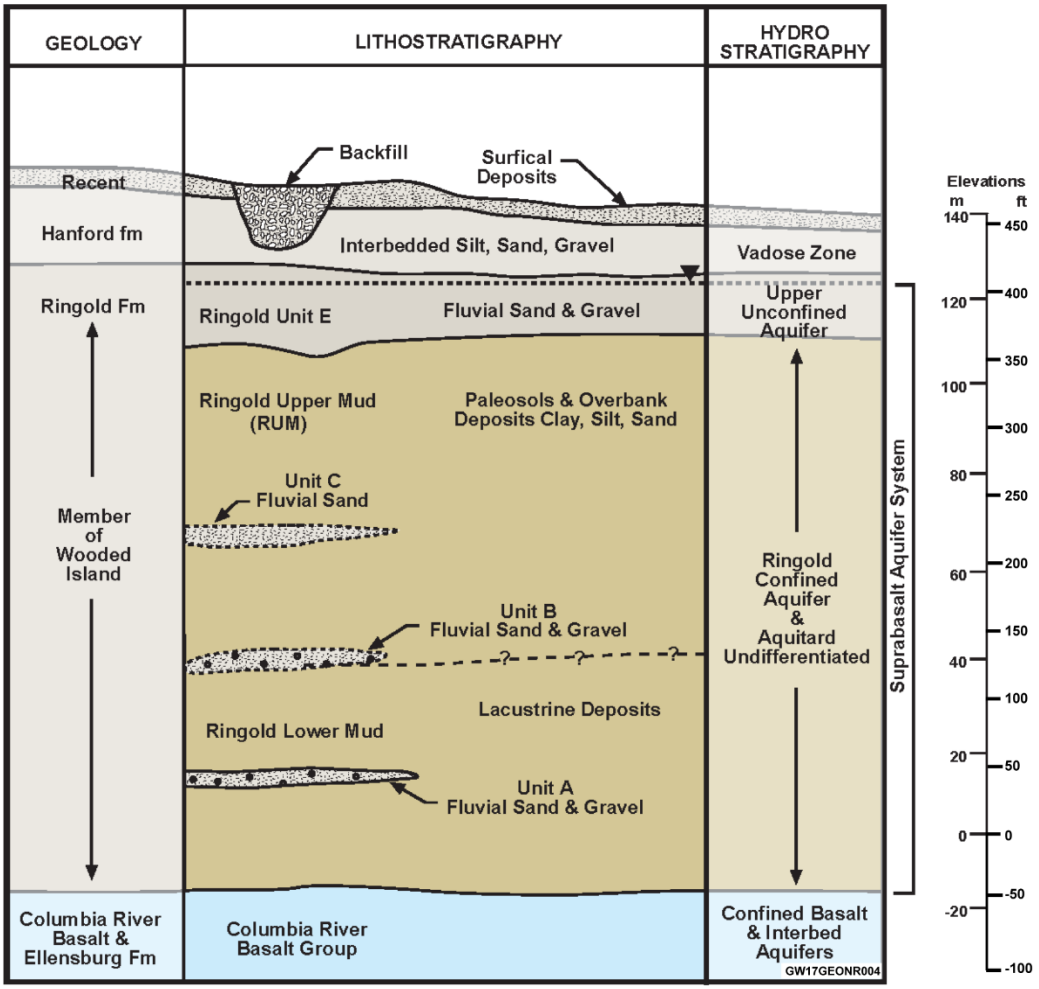


Figure 6-4. 100-NR Geology

Most of the strontium-90 is limited to the upper portion of the aquifer. For example, concentrations in well 199-N-182, screened at the base of the aquifer near the head end of the 116-N-1 Trench, ranged from 52 to 144 pCi/L, while concentrations in the upper portion of the aquifer in nearby well 199-N-184 ranged from 212 to 5,000 pCi/L. Similarly, strontium-90 concentrations are higher in the shallow aquifer tubes (C7934 and C7935) than in deeper aquifer tube C7936 (Figure 6-6). Strontium-90 concentrations in aquifer tubes are also consistent with the concentrations in near-shore monitoring wells.

Strontium-90 concentrations fluctuate with changes in water levels in 100-NR wells. The water table was up to 6.1 m (20 ft) higher beneath the 116-N-1 and 116-N-3 waste sites during 100-N operations due to the effluent discharges. As the water table declined, strontium-90 remained sorbed to sediment in the lower vadose zone. When river stage is high and the water table rises beneath these waste sites, strontium-90 from the vadose zone may be remobilized, increasing the concentrations in groundwater. This is illustrated in Figures 6-7 and 6-8 for wells 199-N-81 and 199-N-67, respectively, which show that strontium-90 concentrations generally increase when the water level is elevated and decrease when the water level is lower.

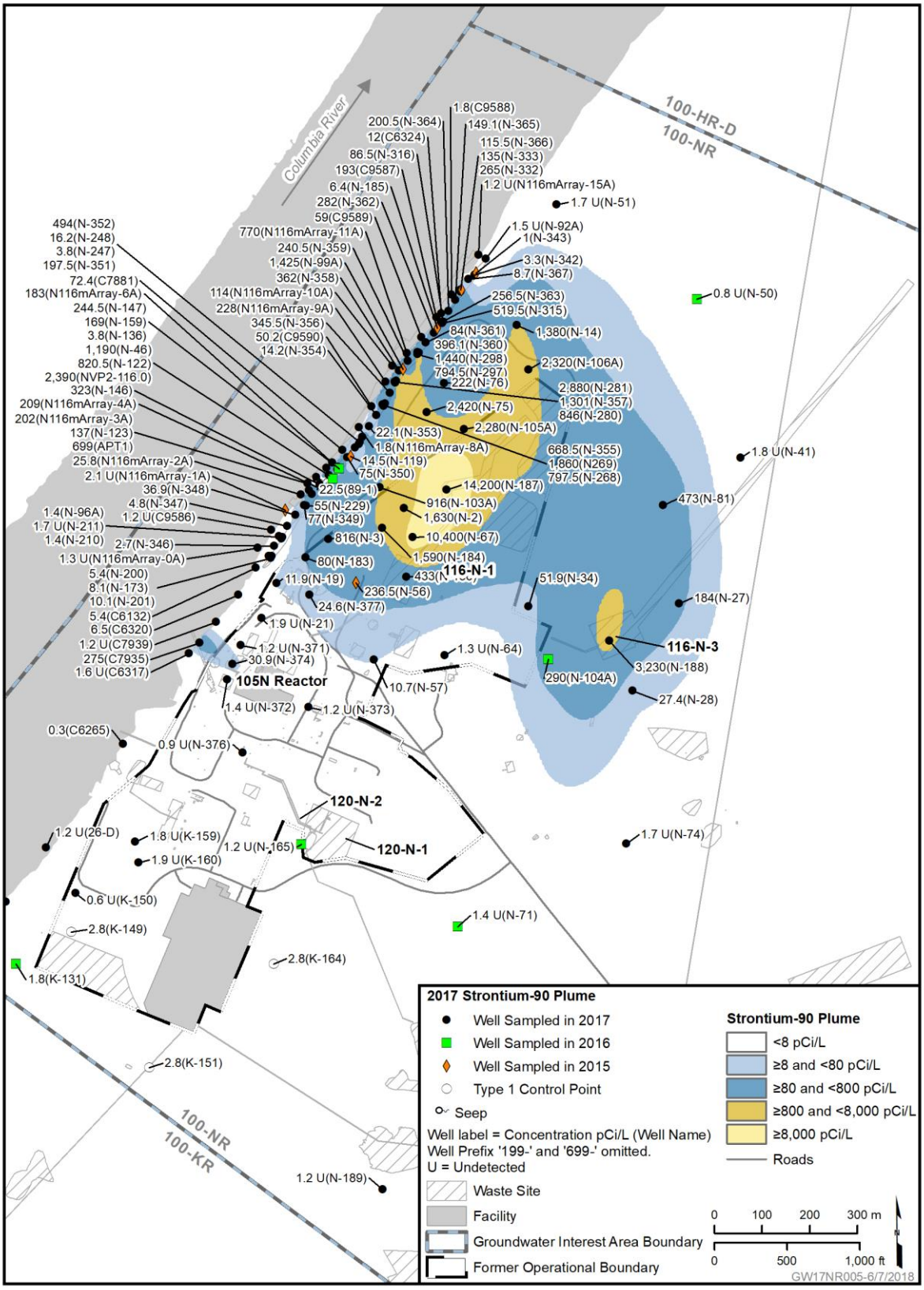


Figure 6-5. 100-NR Strontium-90 Plume, 2017

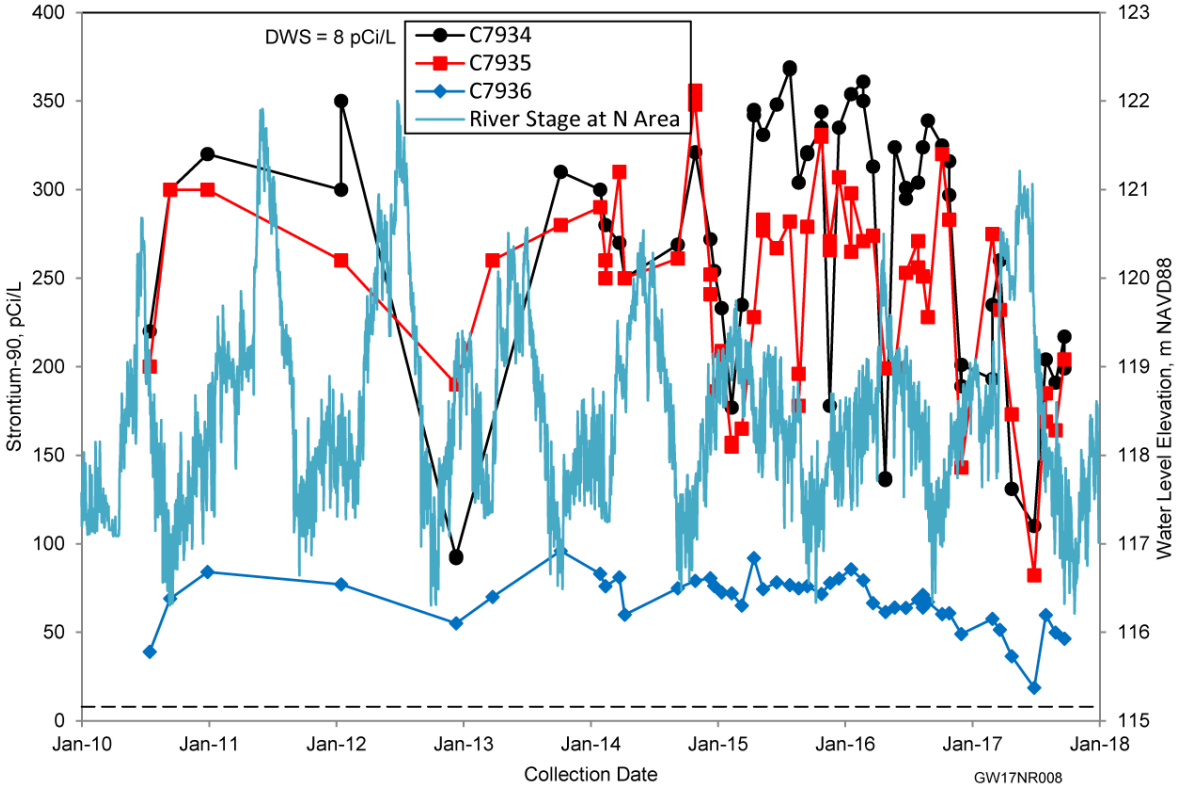


Figure 6-6. 100-NR Strontium-90 Data for Aquifer Tubes C7934, C7935, and C7936

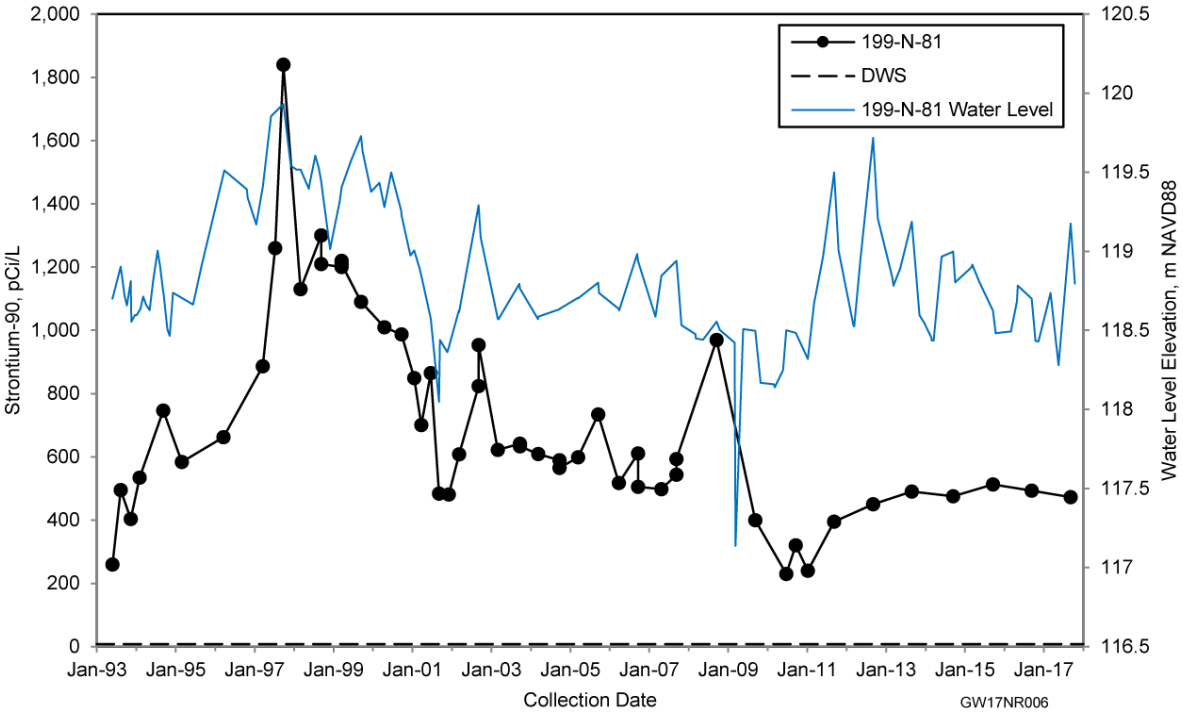


Figure 6-7. 100-NR Strontium-90 Data for Well 199-N-81, Downgradient of the 116-N-3 Crib and Trench

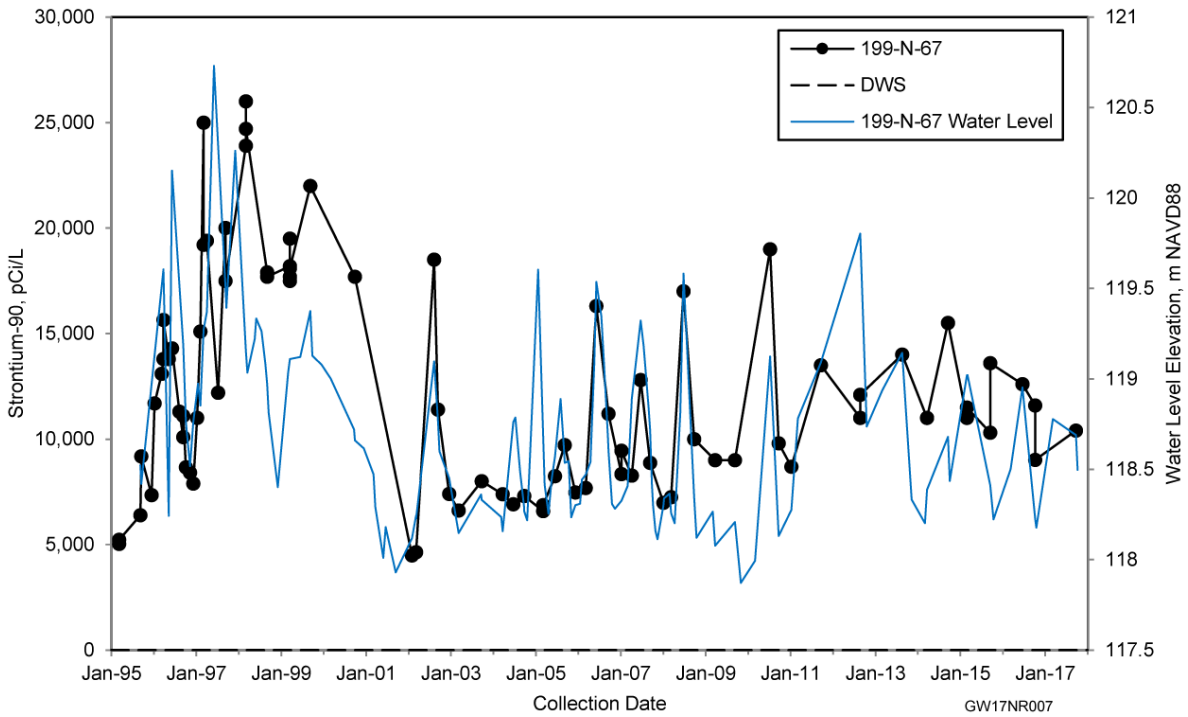


Figure 6-8. 100-NR Strontium-90 Data for Well 199-N-67, Downgradient of the 116-N-1 Crib and Trench

At the 116-N-1 waste site (Figure 6-8), strontium-90 concentrations in well 199-N-67 show no obvious long-term decline and vary with changes in the water level. The 116-N-1 waste site received a greater mass of strontium-90 than the 116-N-3 waste site and presumably has more residual strontium-90 in the lower vadose zone. At the 116-N-3 waste site (Figure 6-7), concentrations declined with water level between the late 1990s and 2010, and concentrations increased with seasonally high water levels in 2011 and 2012. Since 2012, however, concentrations at well 199-N-81 have not fluctuated with changing water levels. This may be a result of high water levels in 2011 and 2012 remobilizing strontium-90 higher up in the vadose zone, thus masking the effects of water-level changes that are lower than the 2011 and 2012 levels.

Strontium-90 concentrations in several wells within the downriver, untreated portion of the apatite barrier (north of well 199-N-354) exceeded 800 pCi/L in 2017. This localized, high-concentration area has been interpreted to extend upgradient toward the 116-N-1 source based on concentrations above 800 pCi/L at wells 199-N-75 and 199-N-105A. Section 6.7.2 provides additional discussion for strontium-90 concentrations at the apatite PRB.

The highest strontium-90 concentration detected in a shoreline seep in 2017 was 22.5 pCi/L in 100-N SPRING 89-1. This seep is located near well 199-N-123 in the main strontium-90 plume (Figures 6-1 and 6-5).

6.3 Tritium

Tritium concentrations remained elevated above the 20,000 pCi/L DWS in a small area downgradient of N Reactor, extending from monitoring well 199-N-374 to aquifer tube cluster C7934/C7935/C7936, adjacent to the Columbia River (Figure 6-9). Maximum concentrations above the DWS in the aquifer tube cluster ranged from 27,000 to 157,000 pCi/L in 2017, with the higher concentrations in the upper part of the aquifer, about 4.6 m (15 ft) bgs in C7934. Concentrations generally declined with depth in aquifer tubes C7935 and C7936, screened at depths about 6.4 and 9.1 m (21 and 30 ft) bgs, respectively. Data

indicate that tritium concentrations in the aquifer are generally higher along the river in the upper portion of the aquifer. Since 2015, tritium concentrations in the three aquifer tubes have generally decreased (Figure 6-10).

The maximum tritium concentration in 2017 was 282,000 pCi/L in well 199-N-374, located near UPRs from the N Reactor FSB (annual average 128,925 pCi/L, as shown in Figure 6-9). The highest tritium concentration was observed about 3 months after the 2017 high-river-stage event. This observation of higher concentrations after high river stage suggests that tritium was mobilized from the vadose zone after the water table elevation increased to about 119 m (390 ft). During the low-river-stage sampling event in December 2017, lower concentrations (22,300 pCi/L) were observed as water moved out of bank storage (Figure 6-11). Data suggest that residual tritium remains in the deep vadose zone that is mobilized in groundwater with increased water levels.

As reported in previous annual groundwater reports, the source of tritium contamination is likely from UPRs from the N Reactor FSB, associated facilities, and pipelines. The tritium observed in this small plume is attributed to mobilization of residual tritium in the lower vadose zone as a result of adding dust-suppression water during interim remedial actions around the reactor.

The only other monitoring well in 100-NR with tritium concentrations above the DWS in recent years was well 199-N-186 in the 116-N-1 Crib. From 2015 to 2017, concentrations declined from 20,800 to 8,310 pCi/L. Concentrations in this well have been generally declining since 2013.

One shoreline seep (100-N SPRING 89-1) was sampled for tritium in 2017. The concentration was below detection.

6.4 Nitrate

Nitrate exceeds 45 mg/L in groundwater beneath the 116-N-1 and 116-N-3 waste sites and the N Reactor area to the southwest (Figure 6-12). The 116-N-1 and 116-N-3 waste sites appear to be the source of nitrate based on the persistent plume beneath these sites. The highest concentration in 2017 was 319 mg/L in well 199-N-348, downgradient of 116-N-1. Concentrations in this well vary inversely with river stage.

Nitrate concentrations were relatively low in groundwater during 116-N-1 and 116-N-3 liquid waste disposal operations (Figures 6-13 and 6-14). The nitrate concentrations increased after discharges to the waste sites ceased. Nitrate was not documented as a waste disposed to the sites, but compounds that could break down into nitrate were used and disposed (namely ammonium hydroxide, hydrazine, and to a lesser extent, morpholine [Section 1.3.2.3 of DOE/RL-2012-15, Draft A]). These compounds were used as corrosion inhibitors for the N Reactor cooling water system. It is theorized the nitrate plume resulted from bacterial nitrification of ammonium flushed to groundwater by the large-volume discharges to the waste sites.

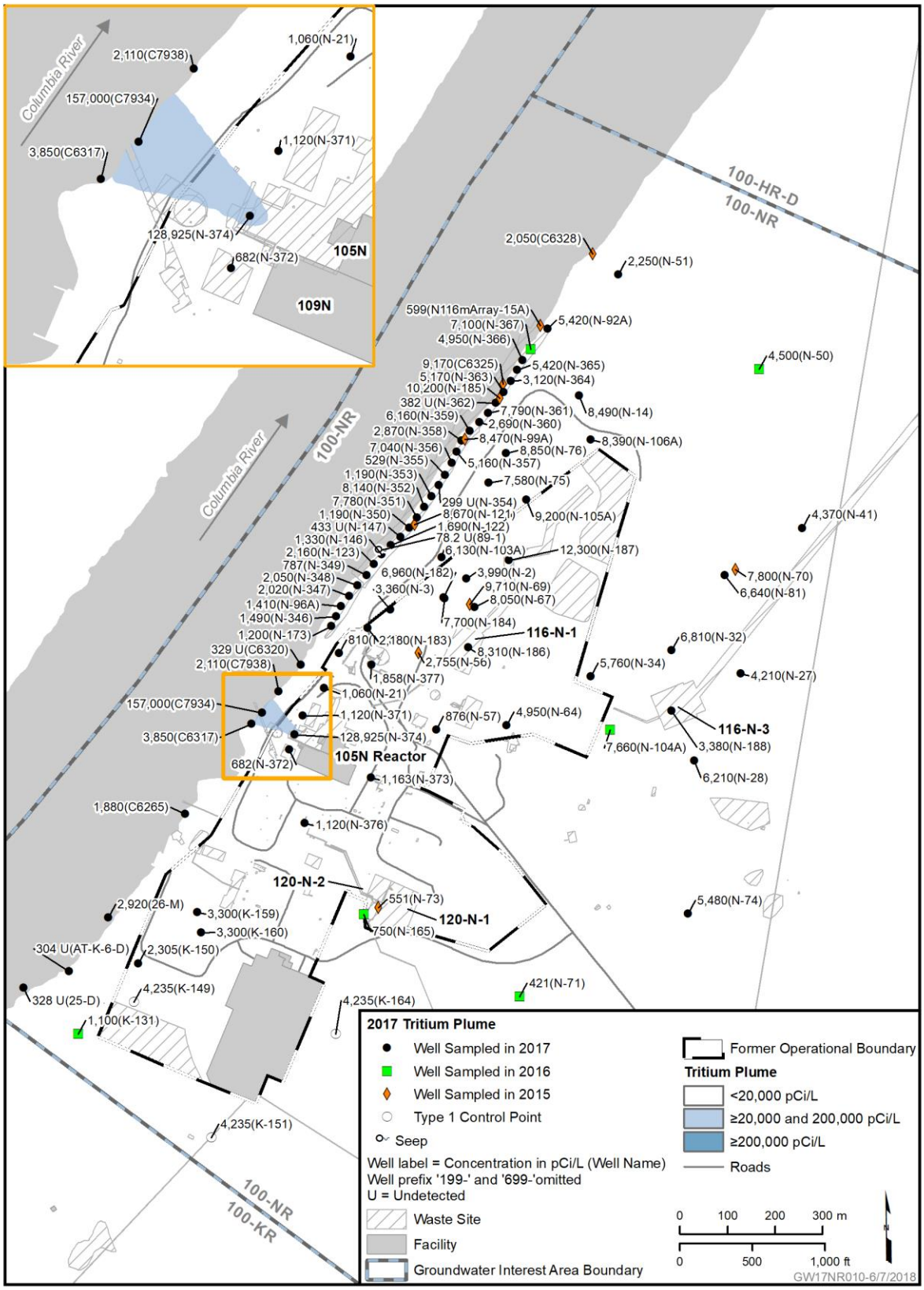


Figure 6-9. 100-NR Tritium Plume, 2017

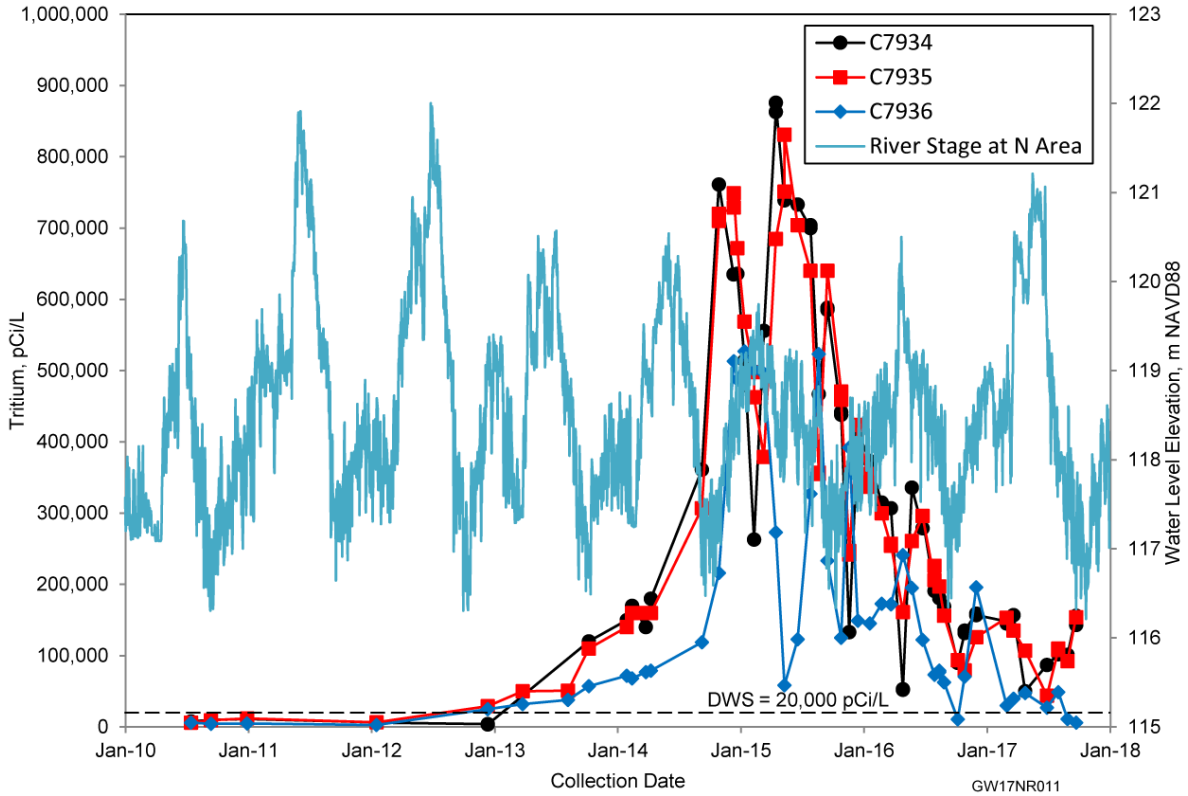


Figure 6-10. 100-NR Tritium Data for Aquifer Tubes C7934, C7935, and C7936

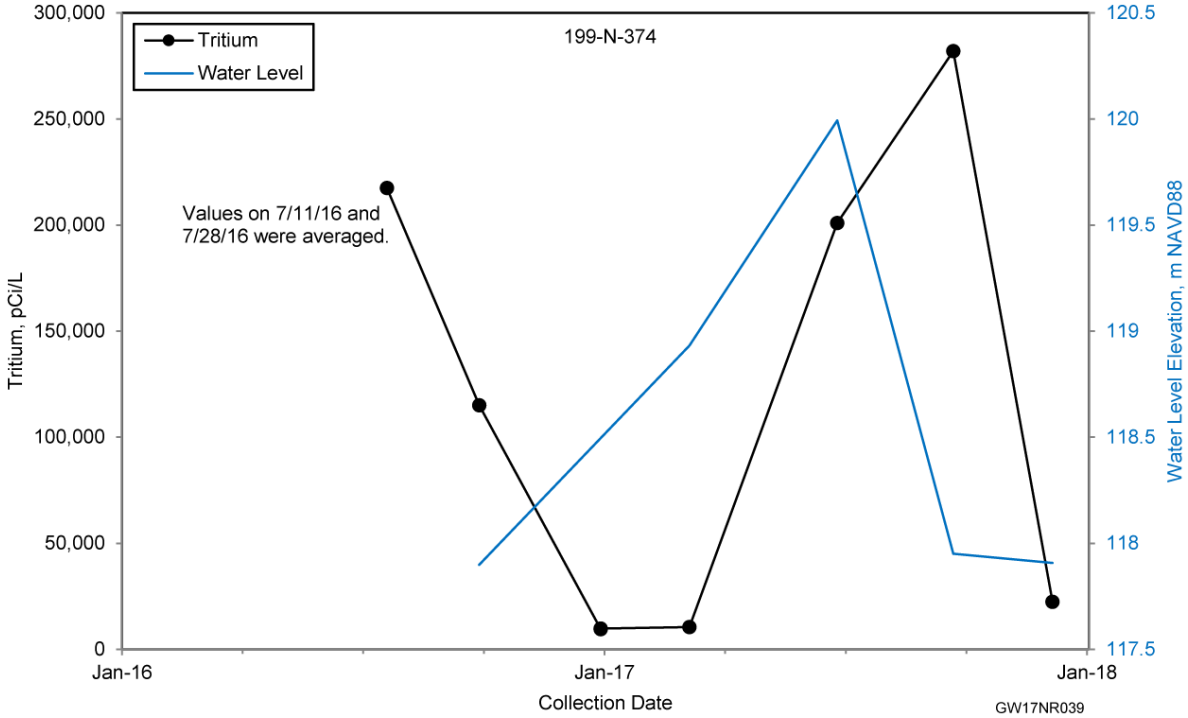


Figure 6-11. 100-NR Tritium and Water-Level Data at Well 199-N-374

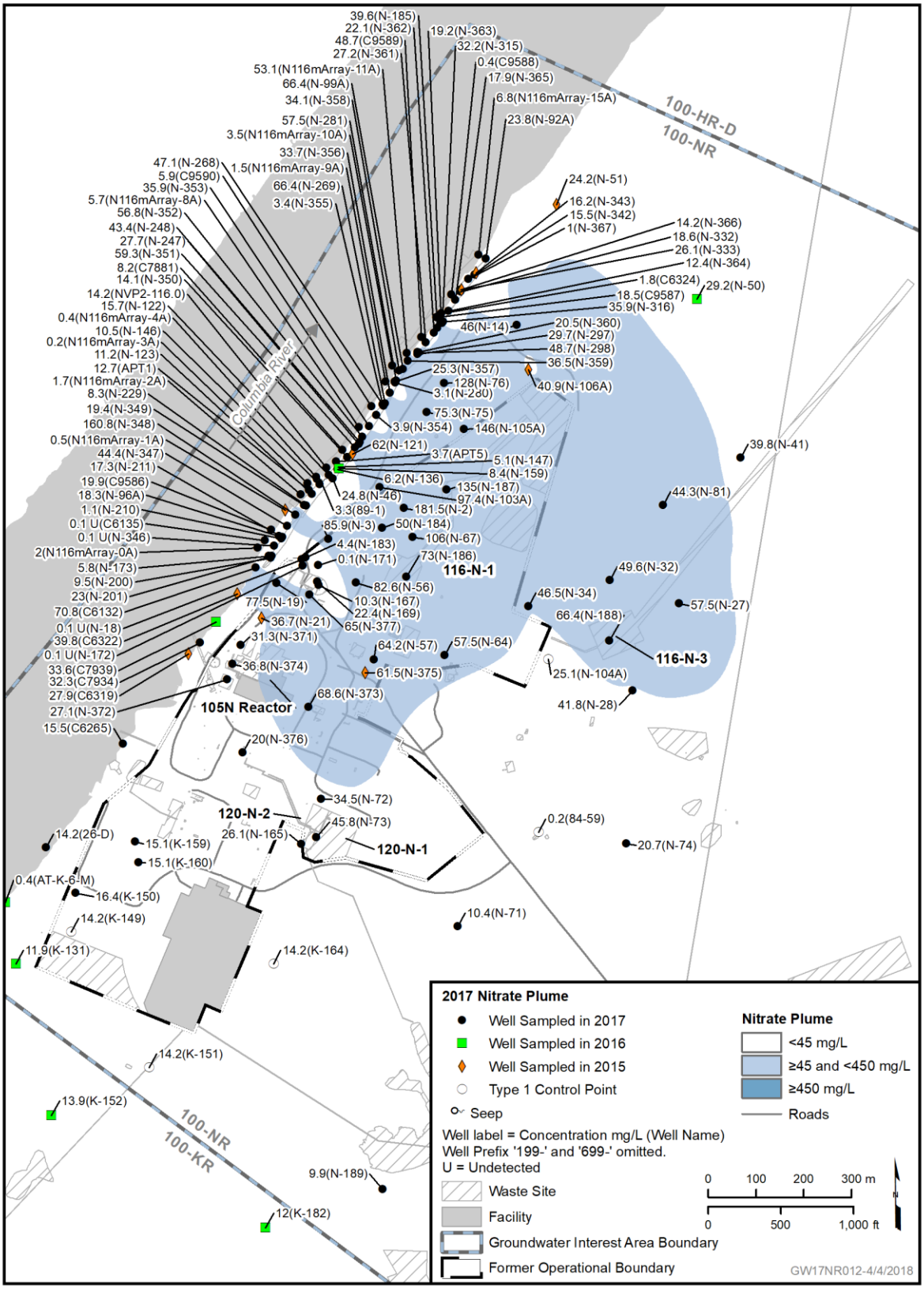


Figure 6-12. 100-NR Nitrate Plume, 2017

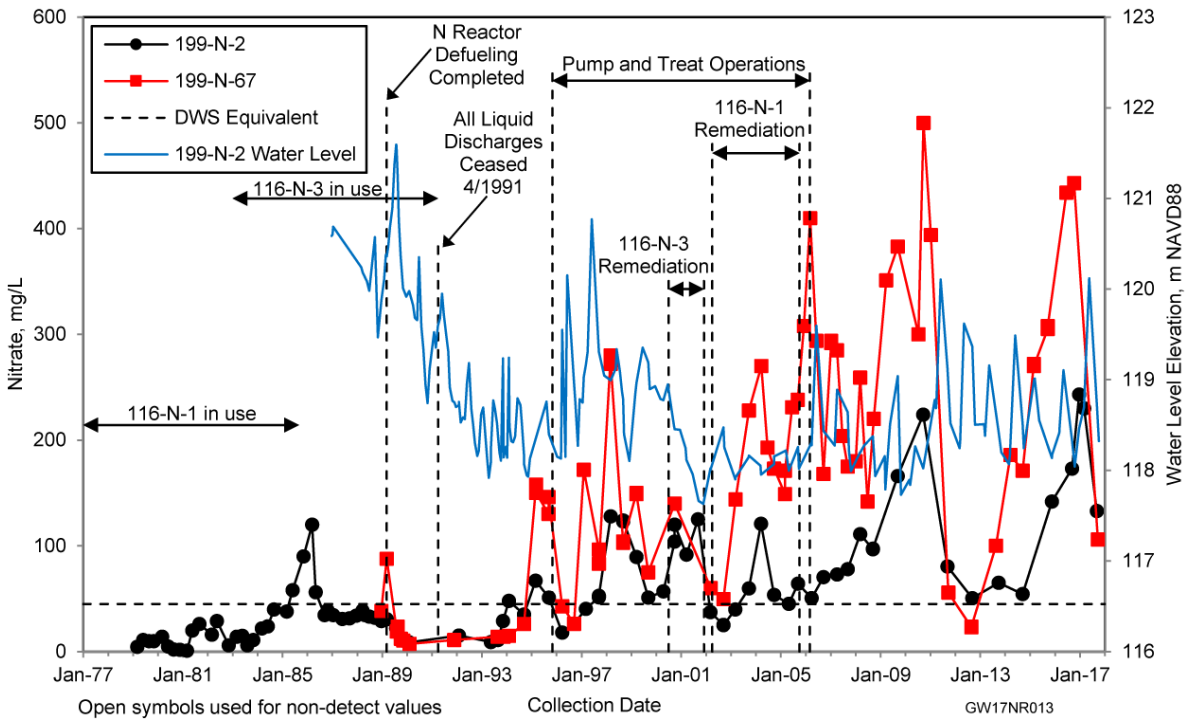


Figure 6-13. 100-NR Nitrate Data for Wells 199-N-2 and 199-N-67

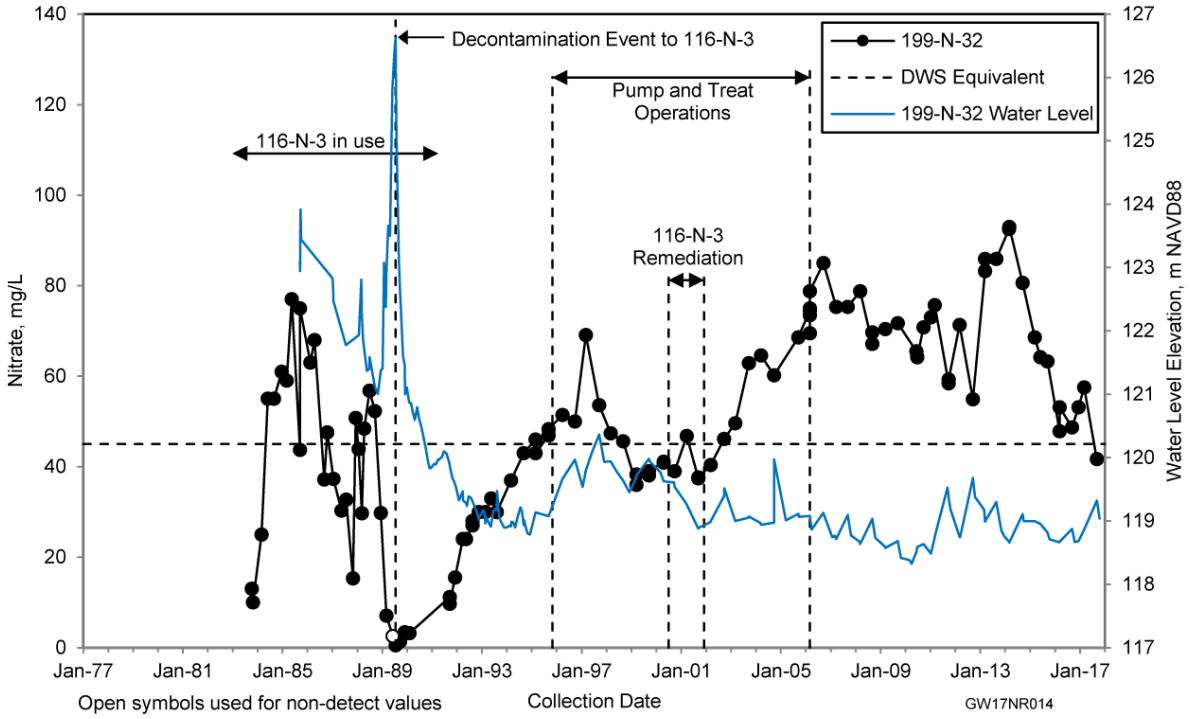


Figure 6-14. 100-NR Nitrate Data for Well 199-N-32

The increasing nitrate trends since the end of liquid waste disposal are postulated to result from sorption of nitrate into groundwater from the rewetted and saturated sediments rather than from vadose zone drainage. This is supported by comparing trend charts of wells 199-N-2 and 199-N-28 to upgradient well 199-N-74 for various metals and anions. Figures 6-15 through 6-17 provide comparisons of chloride, magnesium, and strontium trends. The trends show low concentrations of the metals and anions at wells 199-N-2 and 199-N-28 before 2000, which is attributed to the large discharge volumes. Upgradient well 199-N-74 was also affected by mounding of the water table from historical discharges, but concentrations were not as suppressed as those observed for the downgradient wells. The trends show that concentrations in the downgradient wells recovered to match upgradient concentrations after the water table mound dissipated. Figures 6-18 and 6-19 show that nitrate to chloride, magnesium, and strontium have similar concentration trends at wells 199-N-2 and 199-N-28, respectively. This suggests that the higher nitrate concentration in the downgradient wells is from nitrate formed by nitrification of ammonium in the saturated sediments beneath and downgradient of the waste sites rather than vadose zone source migration to groundwater beneath the waste sites because nitrate is not trending upward faster than other constituents shown in Figures 6-18 and 6-19.

Nitrate concentrations near the 120-N-1 waste site were very low when the site was in use but began to increase in the mid-1990s (Figure 6-20). Only low levels of nitrate (1 mg/L) were detected in the 120-N-1 effluent (Section 2.4.4 of DOE/RL-96-39, *100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures Study/Closure Plan*). These factors suggest that 120-N-1 was not the source of the nitrate plume in the southwest region of 100-NR. The probable source of the nitrate in these wells, and this portion of the nitrate plume southwest of the reactor, was from several septic systems located just upgradient and west of the pond location. Large-capacity sanitary sewage systems are an acknowledged source of nitrate that can adversely affect groundwater quality.

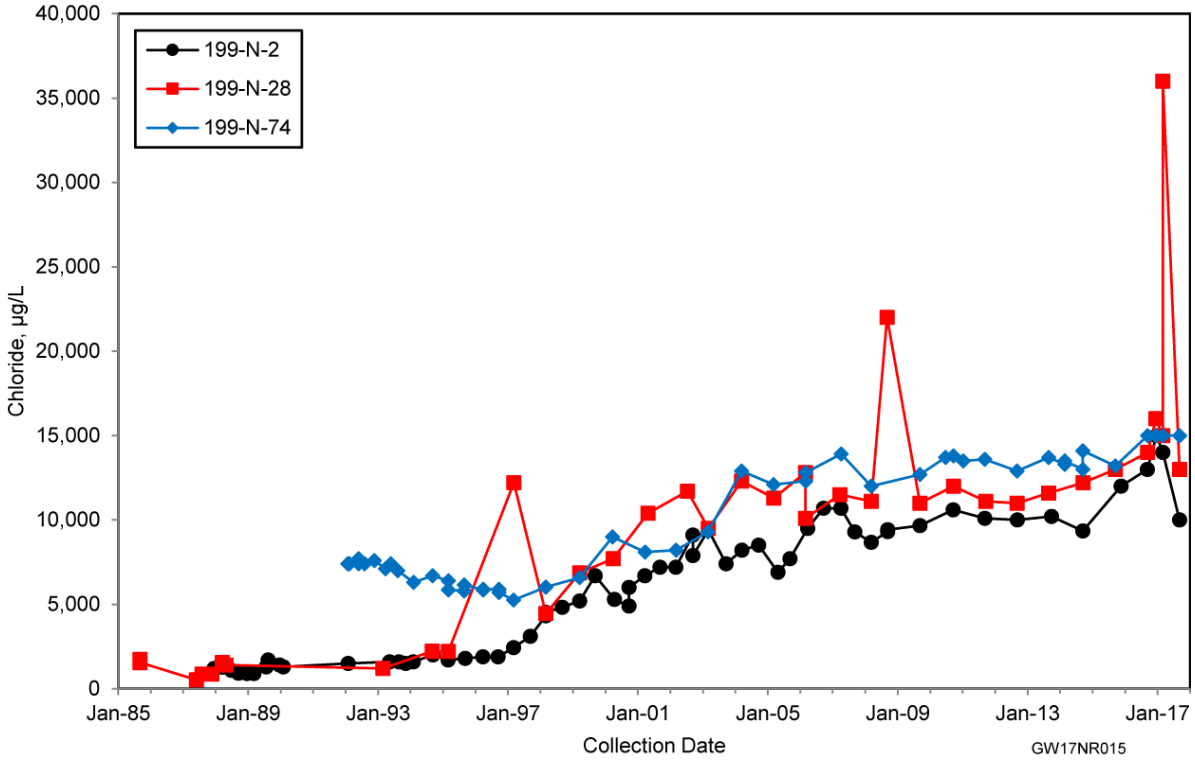


Figure 6-15. 100-NR Chloride Trend Comparison for Wells 199-N-2 and 199-N-28 to Upgradient Well 199-N-74

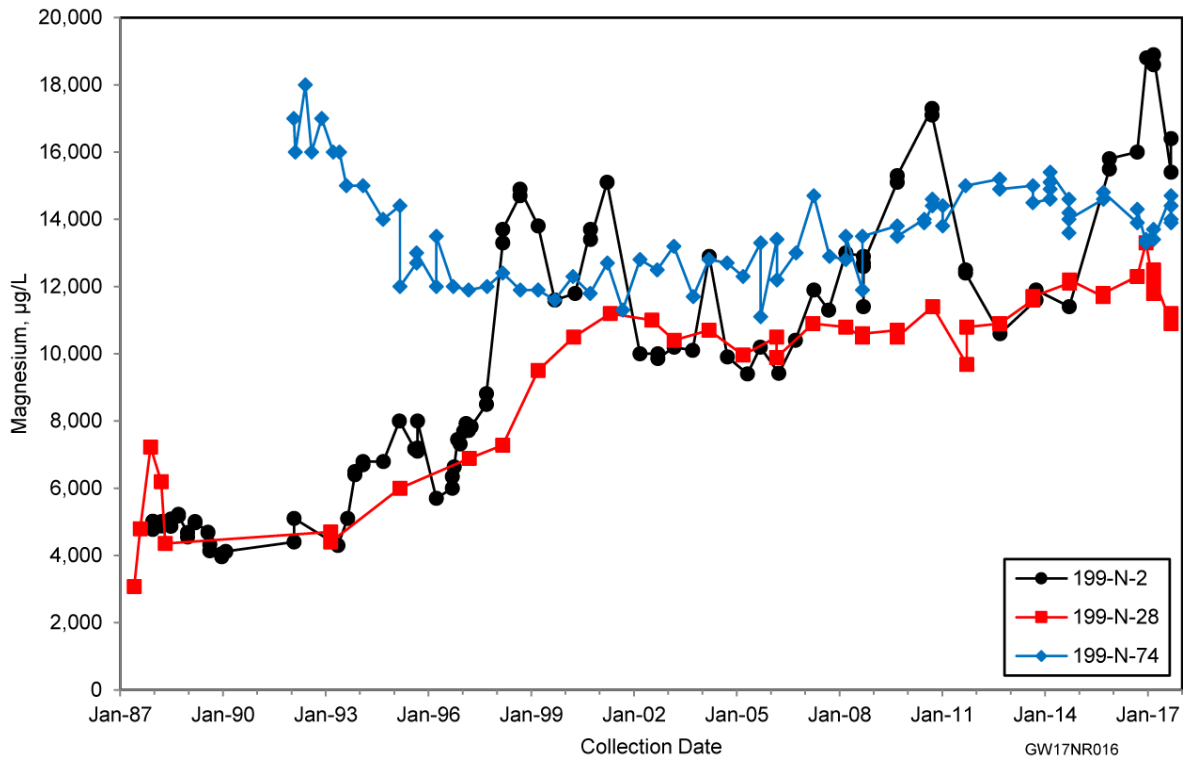


Figure 6-16. 100-NR Magnesium Trend Comparison for Wells 199-N-2 and 199-N-28 to Upgradient Well 199-N-74

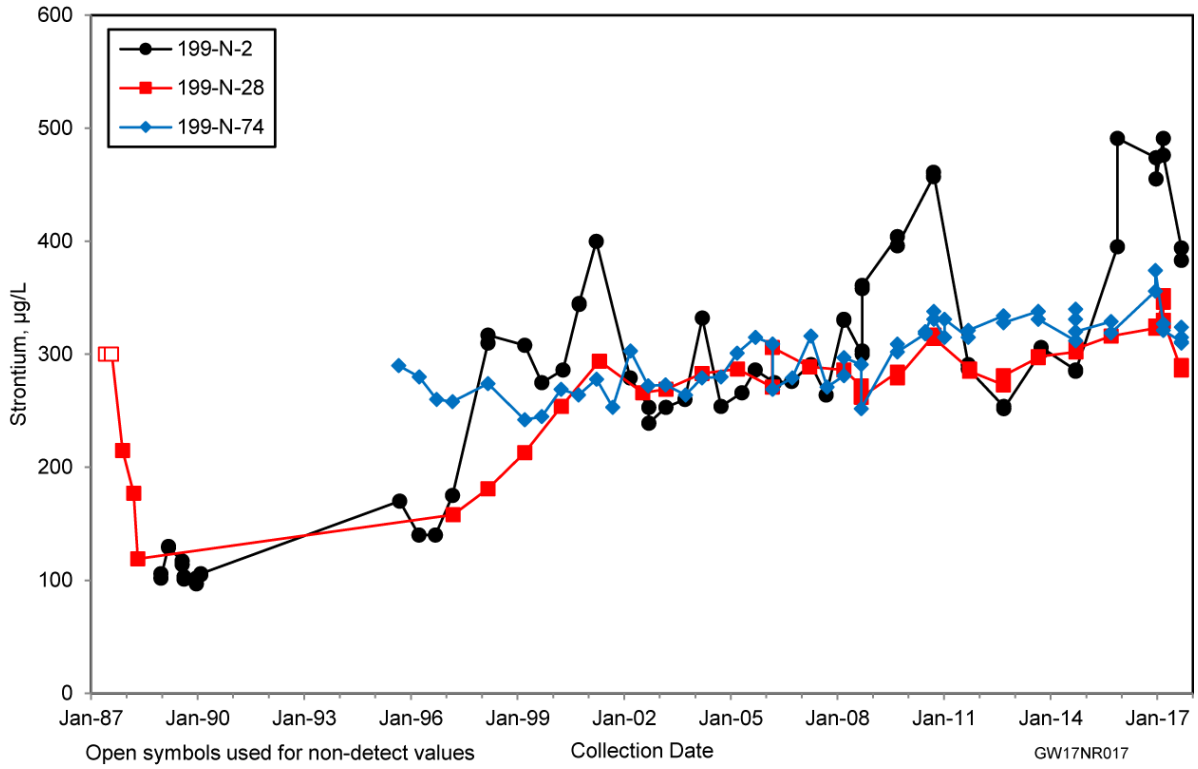


Figure 6-17. 100-NR Strontium Trend Comparison for Wells 199-N-2 and 199-N-28 to Upgradient Well 199-N-74

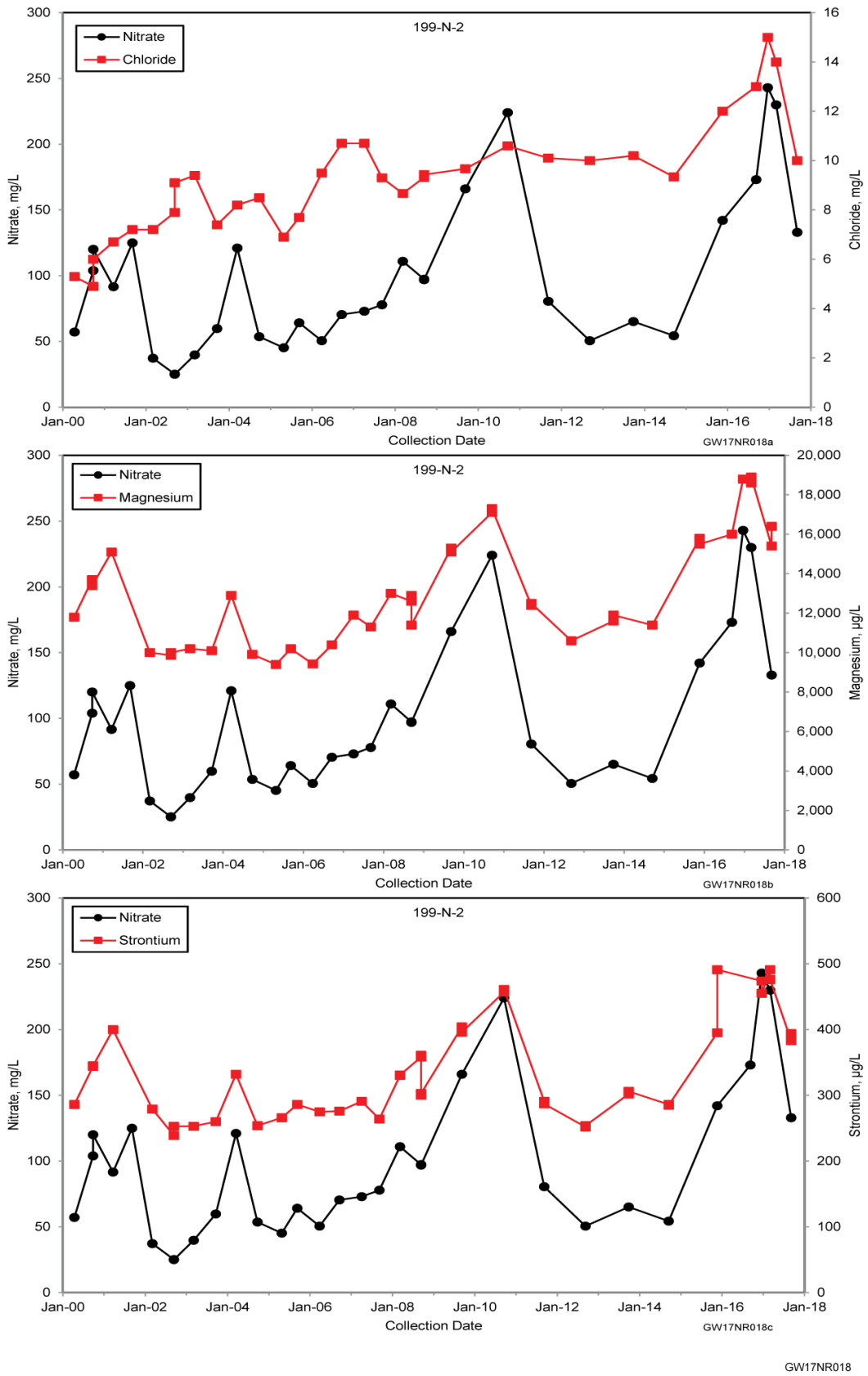


Figure 6-18. 100-NR Nitrate to Chloride, Magnesium, and Strontium Trend Comparison for Well 199-N-2

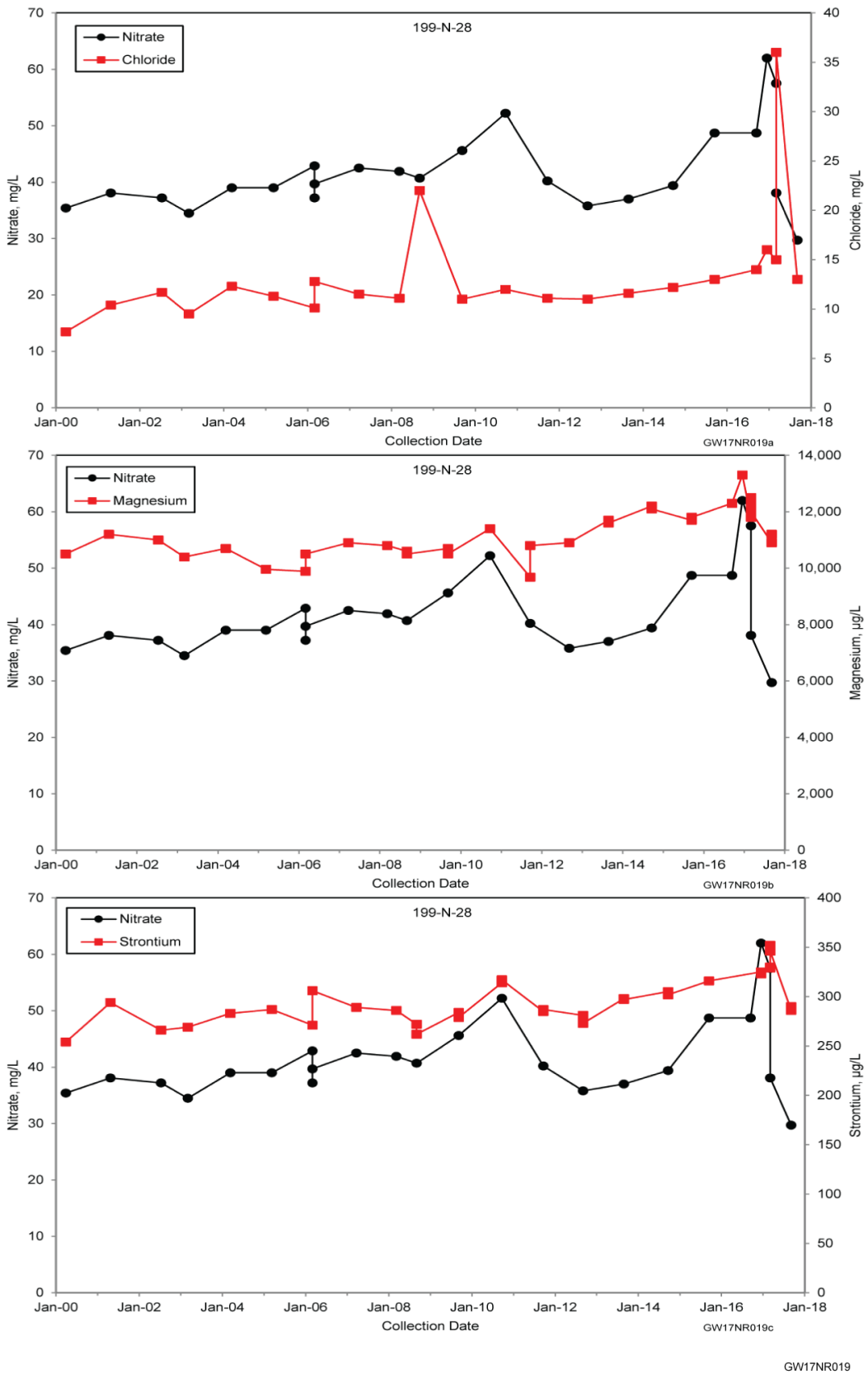


Figure 6-19. 100-NR Nitrate to Chloride, Magnesium, and Strontium Trend Comparison for Well 199-N-28

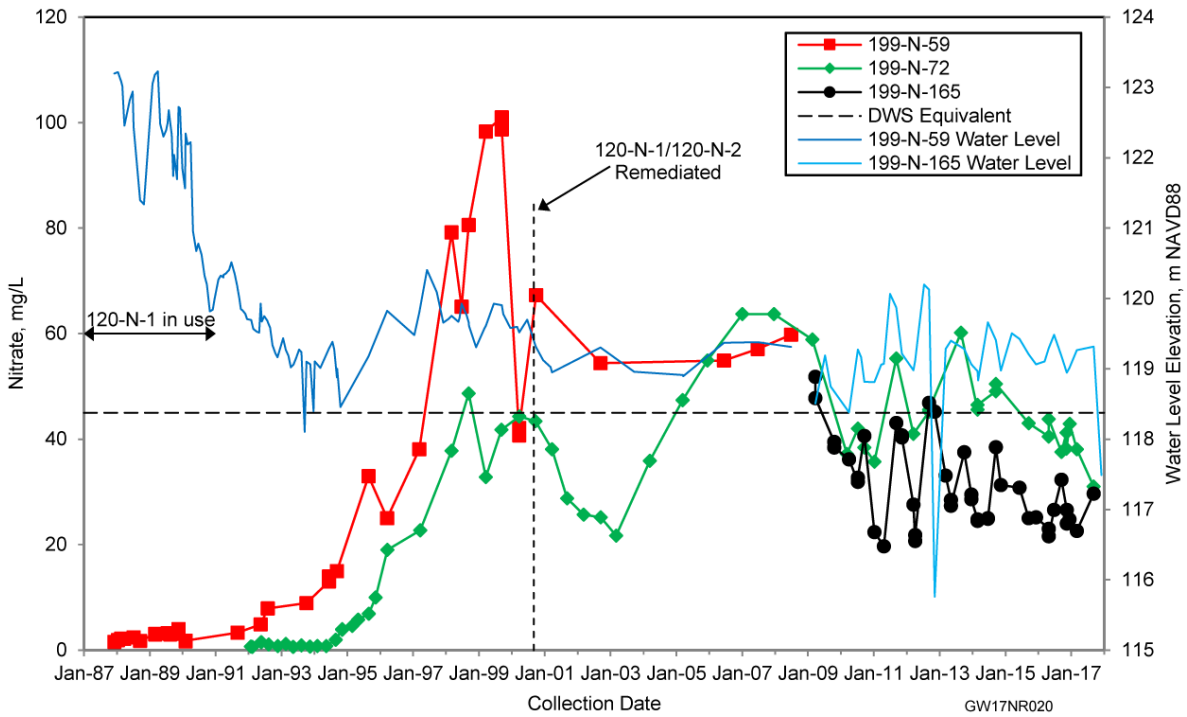


Figure 6-20. 100-NR Nitrate Data for Wells 199-N-59, 100-N-72, and 199-N-165

Nitrate concentrations are lower in wells associated with the TPH-D groundwater plume because of chemical reduction during biodegradation of the TPH-D contamination. Low dissolved oxygen levels, lower pH, detectable nitrite, and elevated iron and manganese indicate the presence of reducing conditions in this part of the aquifer.

Nitrate concentrations are highest in the upper part of the unconfined aquifer. Concentrations in deep wells 199-N-69, 199-N-70, and 199-N-182 are lower than in shallow wells, with little variation in concentration over time. Well 199-N-182 was the only deep well sampled in 2017 for nitrate. The nitrate concentration was 46.9 mg/L, similar to the 2016 concentration of 48.7 mg/L.

In 2017, the maximum nitrate concentration in an aquifer tube was 70.8 mg/L at C6132. The nitrate concentration in seep 100-N SPRING 89-1 was 3.3 mg/L.

6.5 Total Petroleum Hydrocarbons–Diesel

The primary source of TPH-D groundwater contamination was a 1966 diesel fuel spill (UPR-100-N-17). A small, relatively narrow groundwater plume extends downgradient from the spill to the river (Figure 6-21). The two highest concentrations in 2017 were detected in wells 199-N-18 and 199-N-167 (16.6 and 13.0 mg/L, respectively). In 2017, the maximum aquifer tube concentration was detected in tube C6135 (4.43 mg/L). The concentration of TPH-D in shoreline seep 100-N SPRING 89-1 was less than detection.

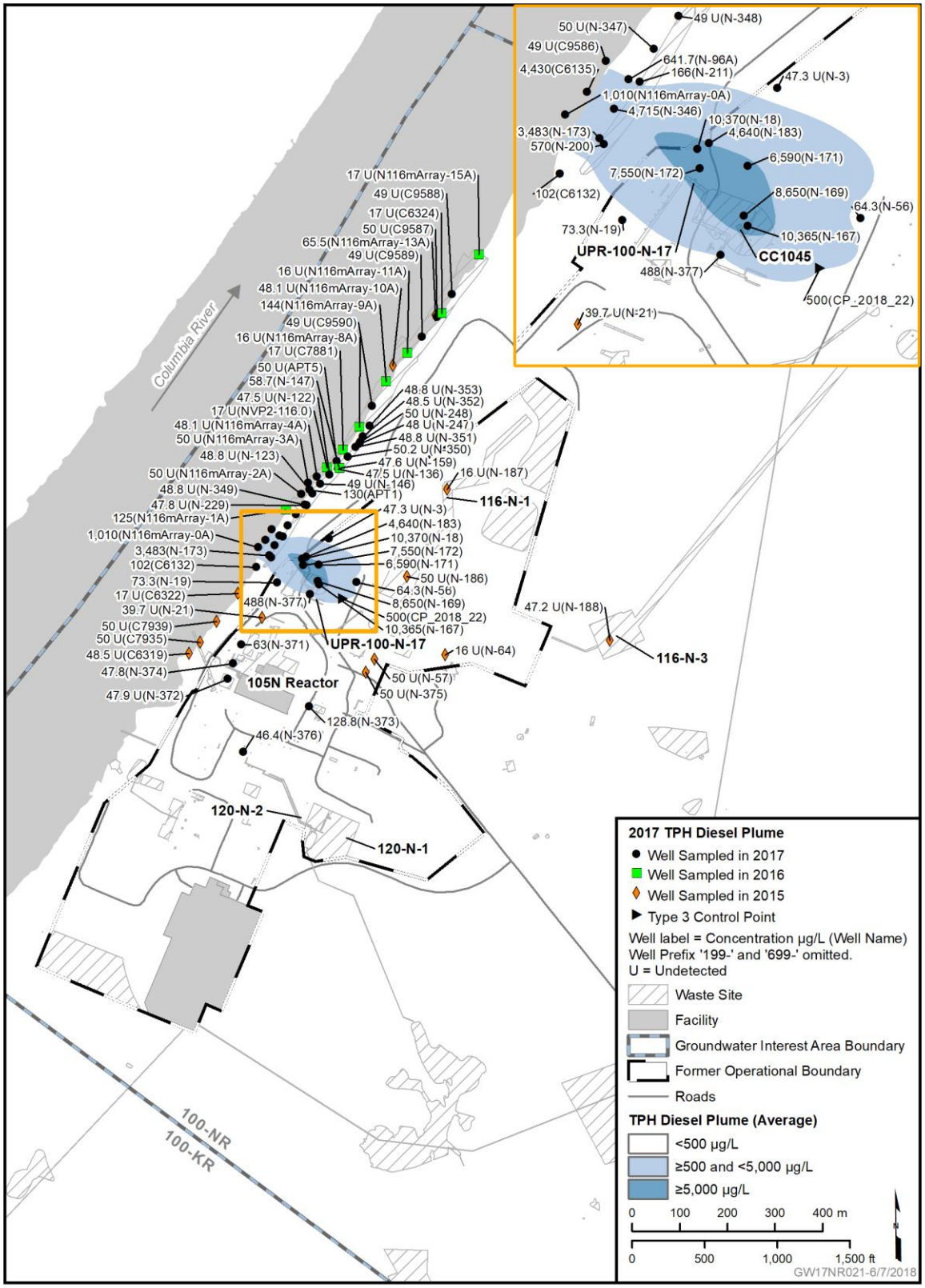


Figure 6-21. 100-NR TPH-D Plume, 2017

The TPH concentrations in groundwater generally decreased from 2012 through 2016, presumably due to in situ bioremediation (i.e., bioventing) in the vadose zone. In situ bioventing introduces oxygen to promote aerobic biodegradation of TPH-D in the deep vadose zone to carbon dioxide and water. The data from the bioventing pilot test (2010 through 2011) were used to support design of a full-scale bioventing system, which began operating at UPR-100-N-17 in December 2012 using two vadose zone injection wells (199-N-167 and 199-N-172) and two vadose zone gas monitoring wells (199-N-169 and 199-N-171). Additional information on bioventing system operation is provided in WCH-600, *Annual Operations and Monitoring Report for UPR-100-N-17: November 2012 – February 2014*; and DOE/RL-2016-34, *Annual Operations and Monitoring Report for UPR-100-N-17: March 2015-February 2016*. Some natural biodegradation of diesel occurs in groundwater, as shown by the anomalously low nitrate groundwater concentrations in this area (Section 6.4). Section 6.7.3 discusses the TPH-D remediation activities for 2017.

In 2017, TPH-D concentrations increased in most of the monitoring wells and aquifer tubes. The increases are related to the high water table, which likely remobilized TPH-D contamination in the vadose zone.

6.6 Hexavalent Chromium

Sodium dichromate was used in N Reactor operations from 1964 to 1972. The chemical was used in lesser amounts than other 100 Area reactors because of the cooling system design and the use of corrosion-resistant metals (e.g., zircaloy) in the fuel and facility (Section 1.3.2 of DOE/RL-2012-15, Draft A). Although chromium was present in the effluent discharged to the 116-N-1 Crib and Trench, it was never detected in samples of the effluent (Section 3.1.1.4 of DOE/RL-90-22, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit, Hanford Site, Richland, Washington*). Discharges to 116-N-1 continued for 10 years after the use of sodium dichromate had ceased. As a result, the mobile portion of chromium was thoroughly flushed from the vadose zone and into the unconfined aquifer. Because a groundwater mound was present, the diluted effluent spread radially, with some portion reaching the Columbia River by the end of the N Reactor operational period (Section 4.8.1.4 of DOE/RL-2012-15, Draft A).

In 2017, Cr(VI) (including filtered total chromium) was detected at levels above the 10 µg/L AWQC in several unconfined wells in the eastern and southern 100-NR. Cr(VI) concentrations were less than the MTCA (WAC 173-340) Method B cleanup level of 48 µg/L. The source of most of the Cr(VI) contamination in 100-NR is likely the 116-K-2 Trench, where a portion of the 100-KR Cr(VI) plume has migrated northward into 100-NR (Section 5.2).

In 2017, well 199-N-80 had the highest Cr(VI) concentration (130 µg/L) and the only dissolved chromium concentration above the 100 µg/L DWS in (Figure 6-22). This well is located downgradient of the 116-N-1 Trench and is screened in a thin, confined, water-bearing zone in the upper portion of the RUM. This water-bearing zone has not been identified in surrounding wells and boreholes, which indicates that the lens is not laterally continuous (Section 4.4.3 of DOE/RL-2012-15, Draft A). The Cr(VI) and filtered total chromium concentrations in this well are similar, indicating that the dissolved chromium is primarily Cr(VI). The Cr(VI) detected in RUM well 199-N-80 likely originated from disposal of chromium-bearing liquid waste that was driven into this relatively shallow, confined interval when there was a high hydraulic head. The contamination currently remains trapped and relatively stagnant in the locally confined interval (Section 4.8.1.4 of DOE/RL-2012-15, Draft A).

Groundwater data collected to date indicate that Cr(VI) concentrations are below the 10 µg/L AWQC in aquifer tube and seep samples.

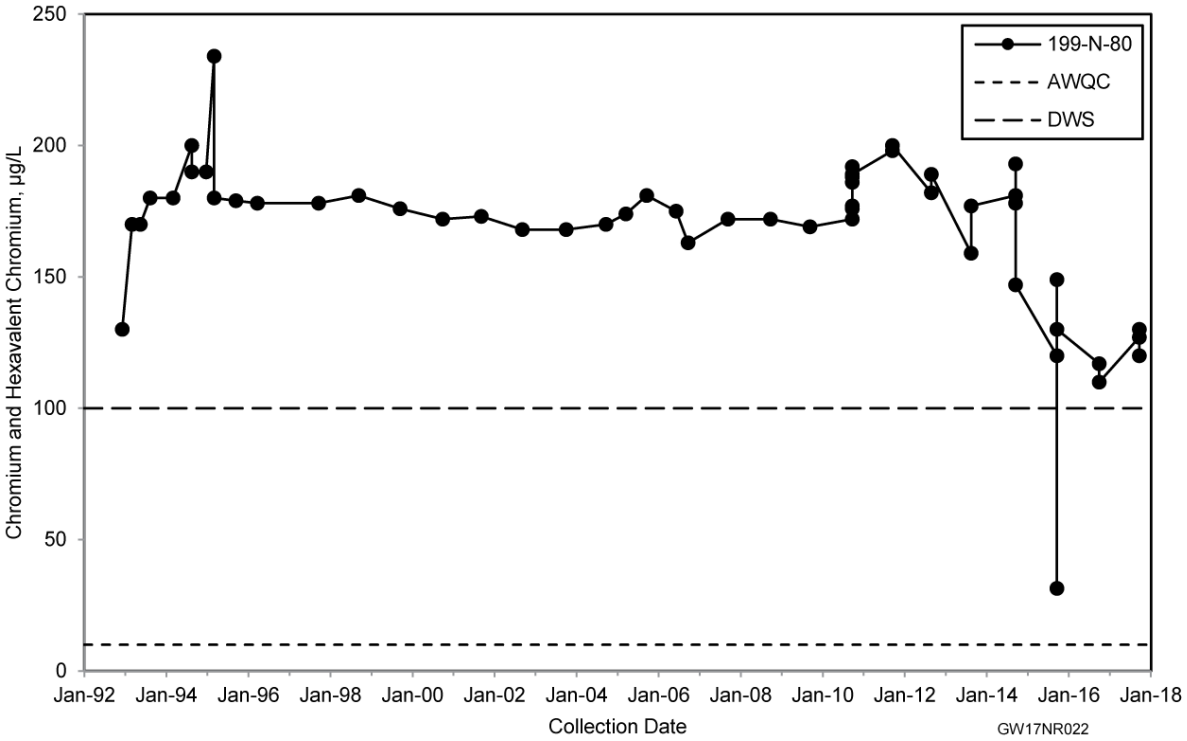


Figure 6-22. 100-NR Filtered Chromium Data for RUM Well 199-N-80

6.7 CERCLA Remediation and Monitoring

In 2017, CERCLA activities in 100-NR included routine groundwater monitoring, continued interim remedial actions for strontium-90 and TPH-D contamination, and continued preparation of the 100-N RI/FS report. CERCLA sampling is conducted primarily in June and September, with selected wells also monitored in March. Table A-1 in Appendix A lists the 2017 sampling exceptions. DOE/RL-2017-67 provides additional details about CERCLA remediation activities for 2017.

6.7.1 CERCLA Decision Documents and Plans

Groundwater monitoring is described in the RD/RAWP (DOE/RL-2001-27, *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*), which presents the approach for implementing the interim remedial actions for the 100-NR-2 OU, as specified in the interim action ROD (EPA/ROD/R10-99/112). The RD/RAWP includes the activities necessary to install and maintain an apatite PRB for the 100-NR-2 OU, as specified in EPA, 2010, *U.S. Department of Energy 100-NR-1 and NR-2 Operable Units Hanford Site – 100 Area Benton County, Washington Amended Record of Decision, Decision Summary and Responsiveness Summary*. Appendix A of the RD/RAWP provides the SAP for interim remedial actions and routine groundwater monitoring.

DOE submitted Draft A of the RI/FS report (DOE/RL-2012-15, Draft A) to Ecology, the lead regulatory agency for the 100-NR-1 and 100-NR-2 OUs, in June 2013 for review. The comment resolution process continued through 2017 for the draft RI/FS. The comment resolution process for Draft A of the RI/FS report determined that a Draft B RI/FS would be prepared. The Draft B RI/FS report will be issued in 2019 for regulatory agency review. The RI/FS report will be used to support future cleanup decisions specified in a proposed plan and ROD.

6.7.2 Apatite Barrier

The CERCLA interim action ROD (EPA/ROD/R10-99/112, as amended by EPA, 2010) identifies the remedial action applicable for strontium-90 in groundwater in the 100-NR-2 OU. When the ROD was issued in 1995, the interim action for strontium-90 in groundwater was P&T, which operated from 1995 until 2006. The system removed 1.8 Ci of strontium-90 from the aquifer, which is less than the quantity removed by natural decay during the same period. Because strontium-90 binds strongly to sediment, the P&T system was not effective in cleanup of strontium-90 from the aquifer.

One of the requirements of the interim action ROD (EPA/ROD/R10-99/112) was to evaluate alternative technologies for groundwater cleanup. Therefore, in 2006, Ecology, EPA, and DOE (also referred to as the Tri-Parties) approved placing the P&T system in cold-standby status and constructing a PRB. A 90 m (300 ft) long apatite PRB was completed as a treatability test, and the results indicated that the apatite technology showed promise as a remedial option. The interim action ROD was amended in 2010 (EPA, 2010) to allow for expansion of the apatite barrier and permanent decommissioning of the 100-NR-2 P&T system, which was completed in 2017. It is expected that the apatite PRB will provide a 90% reduction in strontium-90 flux to the river (as measured by a 90% reduction in strontium-90 concentrations in the PRB monitoring wells).

The original 90 m (300 ft) long apatite PRB was created from 2006 through 2008 by injecting apatite-forming solutions into 16 wells (PNNL-19572, *100-NR-2 Apatite Treatability Test: High-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization Final Report*). As groundwater flows through the PRB, strontium-90 is chemically sequestered within the apatite PRB and binds to the soil. The expanded PRB well network was installed between late 2009 and early 2010, extending the well network upriver and downriver for a total length of 760 m (2,500 ft) (Figure 6-23). In September 2011, two segments of the extended well network (one upriver and one downriver of the original barrier) were injected with apatite-forming solution, extending the PRB to 300 m (1,000 ft) (SGW-56970, *Performance Report for the 2011 Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit*). This expansion was in accordance with the design optimization study (DOE/RL-2010-29, *Design Optimization Study for Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit*), which had seven objectives for evaluating barrier implementation and effectiveness. Data from the injections and subsequent performance monitoring were used to evaluate the objectives in SGW-56970. DOE/RL-2017-67 presents the performance monitoring results for 2017.

In 2017, groundwater samples were collected from performance monitoring wells and aquifer tubes during moderately high river stage in June and during low river stage in September. Table 6-2 compares spring and fall 2017 data to pre-treatment baseline conditions and includes a summary of percent reduction in strontium-90 concentrations since 2011 for the treated PRB segment monitoring wells. Semiannual performance monitoring will continue for the apatite PRB in 2018.

Performance monitoring wells for the central (original) segment of the PRB showed an overall reduction in strontium-90 concentrations following apatite injections in 2008 (Figure 6-24). During injections, a temporary spike in strontium-90 occurred because the high ionic strength of the apatite solution temporarily mobilized cations and anions. The high concentration at monitoring well 199-N-123 in 2011 was associated with the temporary spike during injections for the barrier extension upriver of the original barrier segment.

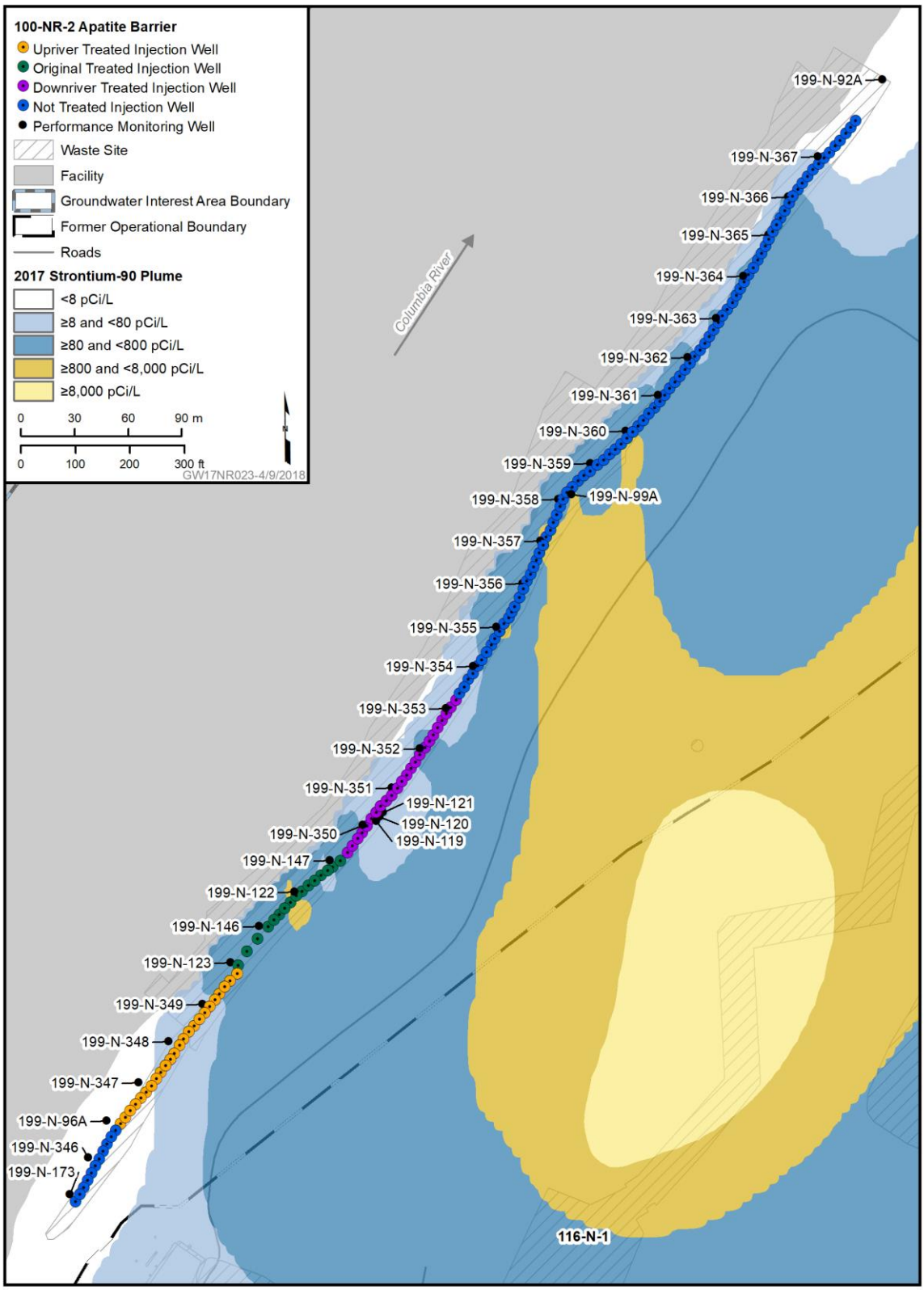


Figure 6-23. 100-NR Apatite Barrier

Table 6-2. 100-NR Remedy Summary

Performance Monitoring at the Apatite PRB								
Well Name	Number of Baseline Samples	Number of Baseline Nondetects	Strontium-90 Concentration (pCi/L)				Percent Reduction in Strontium-90 (Baseline Maximum to 2017[c])	
			Minimum Detected Baseline	Maximum Baseline	Spring 2017[a]	Fall 2017[b]		
Upriver Apatite PRB								
			April 2010		June 2017	Sept. 2017	Spring	Fall
199-N-96A	56	8	1.54[d]	37.9[d]	1.1	1.6	97	96
199-N-347	1	1	7[e]	7[e]	4.2	7.8	52	0
199-N-348	1	0	1,800	1,800	11.4	62.3	99	97
199-N-349	2	0	220	230	98.6	36	58	84
Central (Original) Apatite PRB								
(See footnote f)			(See footnote g)		June 2017	Sept. 2017	Spring	Fall
199-N-122	10	0	657	4,630	521	1,120	88	76
199-N-146	4	0	318	985	143	503	85	49
199-N-147	3	0	522	1,842	211	238	89	87
199-N-123	6	0	689	1,180	112	162	91	86
Downriver Apatite PRB								
			July 2010		June 2017	Sept. 2017	Spring	Fall
199-N-350	1	0	240	240	81	69	66	71
199-N-351	1	0	350	350	81	436	78	0
199-N-352	1	0	580	580	123	865	79	0
199-N-353	1	0	83	83	6.0	56	94	33
PRB Monitoring Well 2011–2017 Performance Summary								
Monitoring Well	Pre-Injection Baseline	Concentration (pCi/L) (Percent Reduction from Baseline[c])						
		2011	2012	2013	2014	2015	2016	2017
Upriver Apatite PRB (Treated in 2011)								
199-N-96A	37.9	—[h]	2.3 (94%)	4.1 (89%)	1.6 (96%)	3.8 (90%)	3.04 (92%)	1.6 (96%)
199-N-347	7[e]	—[h]	7.8 (-12%)	6.9 (1.4%)	5.1 (27%)	4.7 (33%)	4.8 (32%)	6.0 (31%)
199-N-348	1,800	—[h]	54 (97%)	34 (98%)	35 (98%)	71 (96%)	76 (96%)	37 (98%)
199-N-349	230	—[h]	37 (84%)	46 (80%)	87 (62%)	111 (52%)	90 (61%)	67 (66%)

Table 6-2. 100-NR Remedy Summary

Performance Monitoring at the Apatite PRB								
Well Name	Number of Baseline Samples	Number of Baseline Nondetects	Strontium-90 Concentration (pCi/L)				Percent Reduction in Strontium-90 (Baseline Maximum to 2017[c])	
			Minimum Detected Baseline	Maximum Baseline	Spring 2017[a]	Fall 2017[b]		
Central (Original) Apatite PRB (Treated 2006–2008)								
199-N-122	4,630[g]	366 (93%)	656 (86%)	472 (90%)	637 (86%)	809 (82%)	1,083 (77%)	821 (82%)
199-N-146	985[g]	204 (79%)	215 (78%)	225 (77%)	204 (79%)	184 (81%)	232 (77%)	323 (67%)
199-N-147	1,842[g]	272 (85%)	250 (86%)	135 (93%)	230 (88%)	174 (90%)	235 (87%)	225 (88%)
199-N-123	1,180[g]	704 (40%)[e]	204 (83%)	125 (89%)	91 (92%)	96 (92%)	126 (89%)	137 (88%)
Downriver Apatite PRB (Treated in 2011)								
199-N-350	240	—[h]	34 (86%)	21 (91%)	27 (89%)	76 (68%)	78 (68%)	75 (69%)
199-N-351	350	—[h]	26 (93%)	39 (89%)	95 (73%)	376 (-7%)	388 (-11%)	258 (44%)
199-N-352	580	—[h]	30 (95%)	29 (95%)	42 (93%)	368 (37%)	683 (-17%)	494 (15%)
199-N-353	83	—[h]	5.0 (94%)	3.2 (96%)	4.0 (95%)	7.3 (91%)	39 (54%)	31 (73%)
Total Petroleum Hydrocarbons (2003–2017)								
Product removal (top of aquifer)	A total of 900 g removed from well 199-N-18 and 600 g removed from well 199-N-183 in 2017; 17 kg removed over lifetime.							
Bioventing (vadose zone)	Introduces oxygen via two vadose zone injection wells to promote aerobic biodegradation of the TPH. Tested 2010–2011; full-scale December 2012 to present.							
Prior Remedy (1994–2006)								
P&T for strontium-90	1.8 Ci removed by P&T 1995–2006; facility demolished in 2016.							

a. Spring 2017 samples were collected from June 13 through June 29.

b. Fall 2017 samples were collected from September 22 through October 2.

c. The percent reduction in strontium-90 concentration is calculated as follows:
([baseline value] – [2017 value])/[baseline value]) × 100.

d. Between 1995 and 2011, the maximum baseline was measured on December 6, 1995; the minimum detected baseline was measured on June 13, 2006, and June 22, 2007.

e. Strontium-90 is a beta emitter. Gross beta concentrations are approximately two times the strontium-90 concentrations. The strontium-90 concentration was 1.1 (U) pCi/L. The gross beta concentration, 14 pCi/L, was divided by 2 to approximate the strontium-90 concentration of 7 pCi/L.

f. From Table 8.1 in PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*.

g. From Table 4.1 in PNNL-19572, *100-NR-2 Apatite Treatability Test: High Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization Final Report*.

h. Injections were performed in September 2011, so no performance was calculated for this year.

P&T = pump and treat
PRB = permeable reactive barrier
TPH = total petroleum hydrocarbons

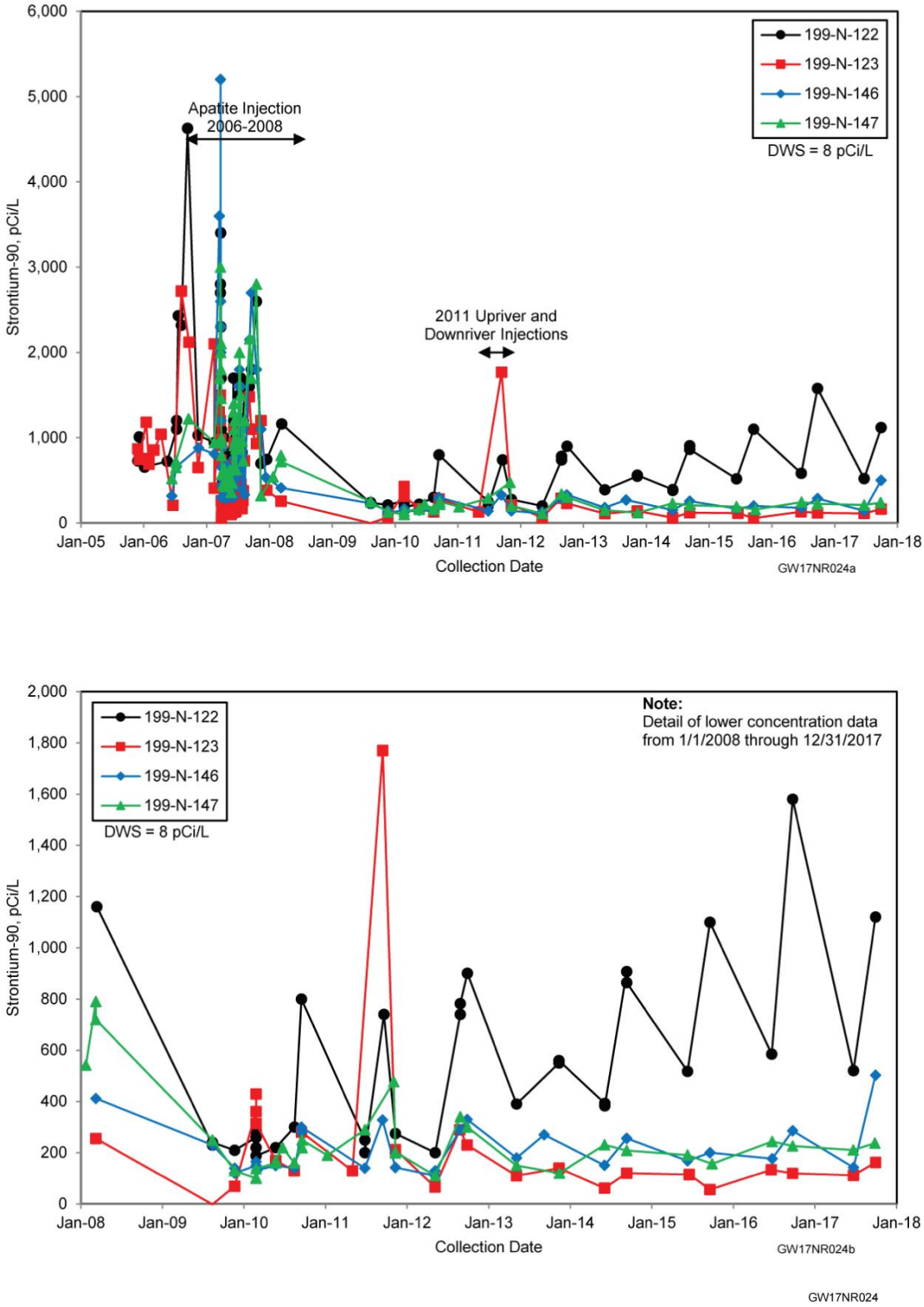


Figure 6-24. 100-NR Strontium-90 Data for Performance Monitoring Wells Along the Central Segment of the Apatite PRB

The percent reduction in strontium-90 concentrations in 2017 ranged from 85% to 91% in the spring and from 49% to 87% in the fall (Table 6-2). Concentrations in two of the original PRB segment monitoring wells (199-N-123 and 199-N-147) continued to be near the 90% reduction target. Strontium-90 concentrations have been trending upward at wells 199-N-122 and 199-N-146 since 2011 and 2016, respectively, but remain considerably lower than before injections began in 2006.

In the performance monitoring wells along the upriver barrier extension (Figure 6-23), the percent reduction in strontium-90 concentrations in 2017 ranged from 84% to 97% in the fall and from 58% to 99% in the spring at wells above the 8 pCi/L DWS. The baseline and the 2017 concentrations were below the DWS at well 199-N-347. Strontium-90 concentrations at well 199-N-349 declined in 2016 and 2017 following upward trends in 2014 and 2015 (Table 6-2).

In the performance monitoring wells along the downriver PRB extension (Figure 6-23), reduction in strontium-90 concentrations ranged from 0 to 71% in the fall and from 66 to 94% in the spring (Table 6-2). Strontium-90 concentration in downriver PRB segment monitoring wells 199-N-351 and 199-N-352 increased to pre-injection concentrations in 2016 and 2017. Concentrations at well 199-N-350 were increasing but stabilized in 2017.

Planning is in progress to reinject poor-performing areas of the PRB. Ongoing monitoring will determine the continued effectiveness of the apatite barrier and will support decisions regarding future apatite treatments and the need for reinjection in other portions of the PRB.

6.7.3 Petroleum Hydrocarbons

Removal of free product from well 199-N-18 continued in 2017 in accordance with the interim action ROD (EPA/ROD/R10-99/112). Diesel is removed using a polymer “smart sponge” that selectively absorbs petroleum products from the surface of the water in the well. About every 2 months, two sponges are placed into well 199-N-18 and left to remediate the diesel. The sponges are weighed prior to placement and again after removal. The weight difference is the amount of diesel removed from the well.

In 2017, smart sponge assemblies were also installed in well 199-N-183, which was drilled near well 199-N-18 as a replacement. Diesel odor and an oil sheen have been observed in the new well periodically during sampling. The smart sponges were installed and changed out at the same frequency used for well 199-N-18. As a result of the ongoing use of passive remediation, 900 g of diesel were removed from well 199-N-18 and 600 g of diesel were removed from well 199-N-183 (Table 6-2) during 2017. Removal of diesel from wells 199-N-18 and 199-N-183 will continue in 2018.

6.8 RCRA Monitoring

This section describes the monitoring results for the following four RCRA WMAs in 100-NR: 116-N-1 Crib and Trench, 116-N-3 Crib and Trench, 120-N-1 Percolation Pond, and 120-N-2 Surface Impoundment (Figure 6-1). Groundwater is monitored at these facilities to meet the requirements of RCRA and WAC 173-303,“Dangerous Waste Regulations,” for dangerous waste constituents. DOE/RL-2017-65 presents the results of RCRA monitoring on the Hanford Site in 2017. The information from the 2017 RCRA report is repeated in this section for completeness. Groundwater data for these facilities are available in the HEIS database and in the data files accompanying this online report version. Appendix B includes well and constituent lists, flow rates, and statistical tables for the four RCRA units in 100-NR.

6.8.1 116-N-1 Crib and Trench

The 1301-N TSD unit, also known as the 116-N-1 waste site (Figure 6-25), was an unlined crib and trench used for disposal of liquid effluent from the 1960s through 1985. The effluent contained small quantities of dangerous waste and large volumes of radioactive waste. During remediation, the waste site was excavated from 4.6 to 6.1 m (15 to 20 ft) to remove shallow vadose zone sediment where most of the radionuclide contamination resided. The waste site was backfilled with clean soil and revegetated with native shrubs and grasses. The waste site is undergoing RCRA closure and is classified as interim closed under CERCLA (Section 1.3.2.6 of DOE/RL-2012-15, Draft A). Two characterization wells were drilled in 2011 as part of the 100-NR-1 and 100-NR-2 OUs RI to assess groundwater protection beneath the remediated waste site. The soil characterization data indicated no remaining RCRA dangerous waste constituents above groundwater protection values. Ecology approved the request for a Class 2 Modification to the 1301-N and 1325-N Liquid Waste Disposal Facilities (LWDFs) in December 2017. The Class 2 Modification adds a clean closure option for both the 1301-N and 1325-N LWDFs. This modification is expected to become effective in 2018.

The 1301-N unit is included in the Hanford RCRA Permit, which states that groundwater monitoring during the RCRA closure period will follow the requirements of BHI-00725, *100-N Pilot Project: Proposed Consolidated Groundwater Monitoring Program*; and WHC-SD-EN-AP-038, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N Sites*.

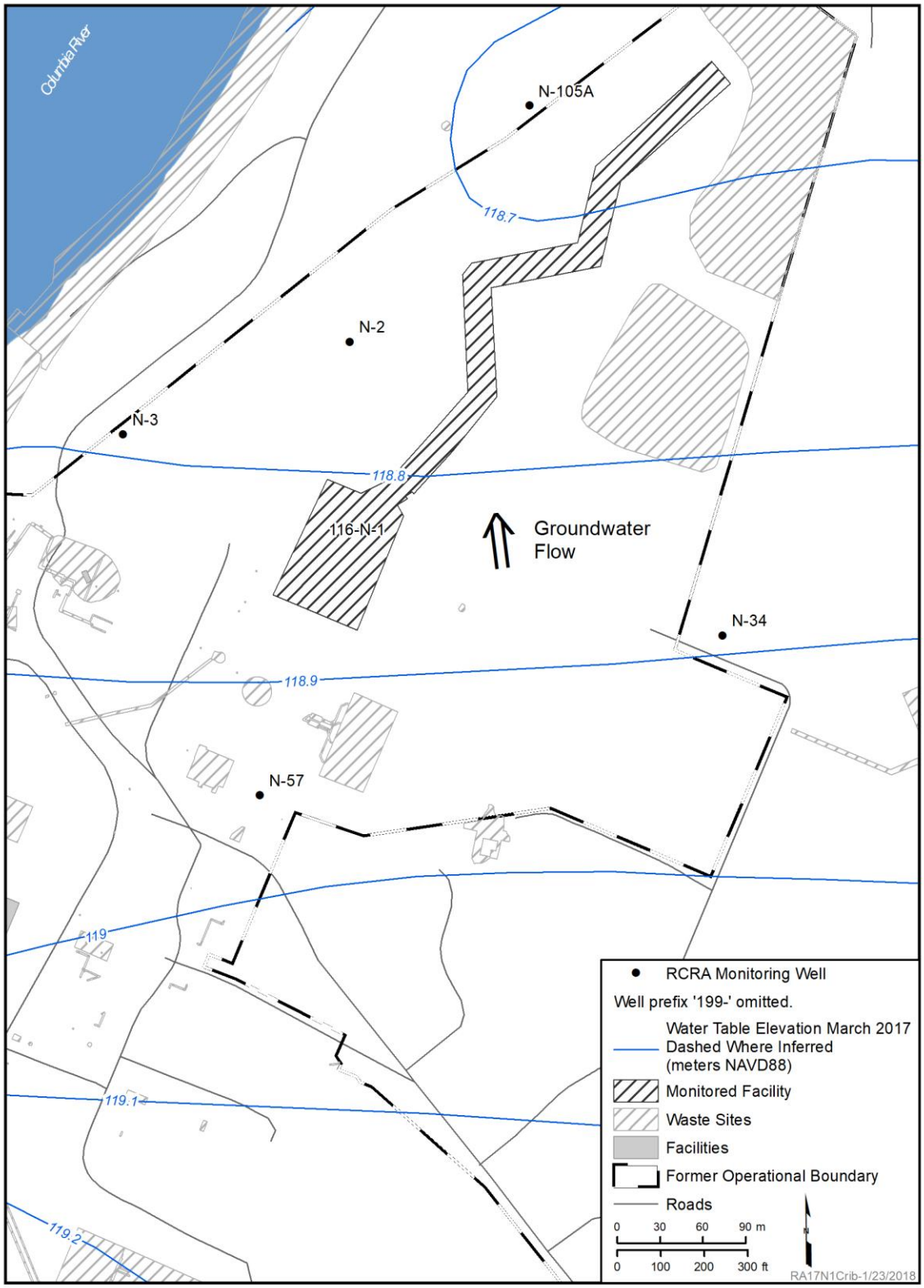
Two upgradient wells and three downgradient wells are used for RCRA monitoring (Table B-2 in Appendix B). The water table in the 100-N Area fluctuates in response to river stage, but it is not declining overall. The 1301-N monitoring wells produced representative samples in 2017 and are expected to do so in the future; no changes to the monitoring network were made in 2017.

The water table in March 2017 sloped to the north and northwest (Figure 6-25). Trend surface analysis of the water-level data showed a hydraulic gradient of 7.0×10^{-4} m/m. Estimates of the groundwater flow rate ranged from 0.01 to 0.26 m/d (0.05 to 0.85 ft/d) (Table B-3 in Appendix B).

Upgradient and downgradient wells are scheduled for sampling twice each year for RCRA contamination indicator parameters (pH, specific conductance, TOC, and TOX; Table B-4 in Appendix B) and turbidity, and once each year for groundwater quality and supporting parameters (chloride, iron, manganese, sodium, sulfate, and alkalinity; Table B-5 in Appendix B). Well sampling was conducted as scheduled in 2017 with no critical mean exceedances.

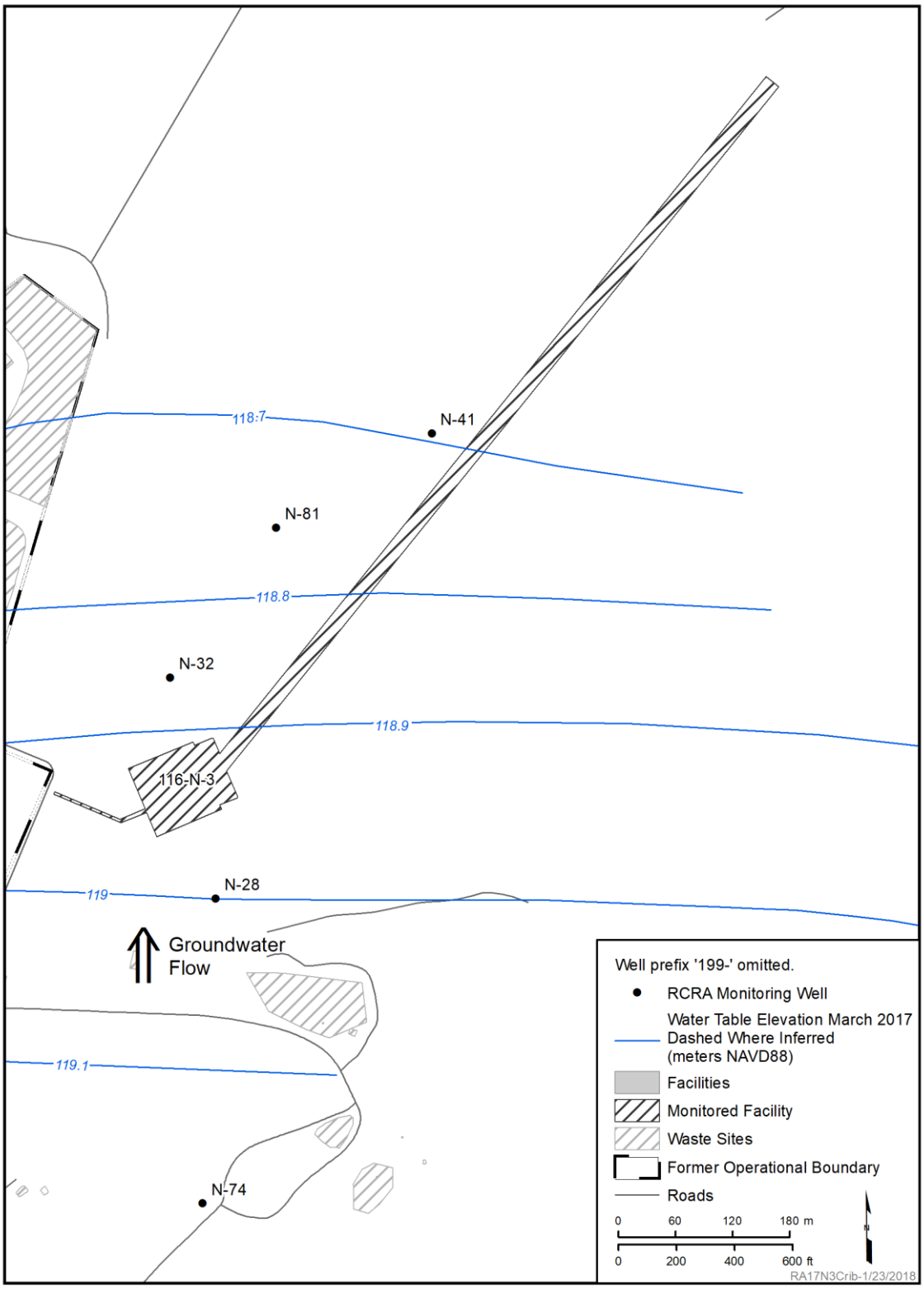
6.8.2 116-N-3 Crib and Trench

The 1325-N TSD unit, also known as the 116-N-3 waste site (Figure 6-26), was an unlined crib and trench used to dispose liquid effluent from 1983 through 1991. The N Reactor was on cold standby beginning in 1987, but effluent was generated and disposed at a reduced rate until 1991. The effluent contained small quantities of dangerous waste and a large volume of radioactive waste. The waste site was excavated to 1.5 m (5 ft) below the engineered structure to remove vadose zone material (which contained the highest concentrations of radionuclides), backfilled with clean soil, and revegetated with native shrubs and grasses. The waste site is undergoing RCRA closure and is classified as interim closed under CERCLA (Section 1.3.2.6 of DOE/RL-2012-15, Draft A). One characterization well was drilled in 2011 as part of the 100-NR-1 and 100-NR-2 OUs RI (DOE/RL-2012-15, Draft A) to assess protection of groundwater beneath the remediated waste site. The soil characterization data indicated no remaining RCRA dangerous waste constituents above groundwater protection values. Ecology approved the request for a Class 2 Modification to the 1301-N and 1325-N LWDFs in December 2017. The Class 2 Modification adds a clean closure option for both the 1301-N and 1325-N LWDFs. This modification is expected to become effective in 2018.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 6-25. RCRA 1301-N (116-N-1) Monitoring Well Locations



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 6-26. RCRA 1325-N (116-N-3) Monitoring Well Locations

The 1325-N unit is included in the Hanford RCRA Permit, which states that groundwater monitoring during the RCRA closure period will follow the requirements of BHI-00725 and WHC-SD-EN-AP-038.

Upgradient well 199-N-74 and downgradient wells 199-N-32, 199-N-41, and 199-N-81 monitor the site (Table B-6 in Appendix B). Well 199-N-28 is monitored for supporting information and previously reflected potential impacts from treated groundwater injected into a nearby well during operation of the 100-N Area P&T. Data from well 199-N-28 are not evaluated statistically. The water table in the 100-N Area fluctuates in response to river stage, but it is not declining overall. Monitoring wells produced representative samples in 2017 and are expected to do so in the future. No changes to the monitoring network were made in 2017. Groundwater flows to the north beneath the 1325-N site (Figure 6-26), turns to the northwest, and discharges to the Columbia River. The hydraulic gradient in March 2017 was 6.6×10^{-4} m/m, with the groundwater flow rate estimated from 0.01 to 0.24 m/d (0.04 to 0.80 ft/d) (Table B-7 in Appendix B).

In 2017, all five wells in the RCRA network were sampled twice (in March and September) for RCRA contamination indicator parameters (pH, specific conductance, TOC, and TOX; Table B-8 in Appendix B) and turbidity, and once (in September) for groundwater quality and supporting parameters (chloride, iron, manganese, sodium, sulfate, and alkalinity; Table B-9 in Appendix B). Iron exceeded the secondary DWS in samples from well 199-N-32. The presence of chromium and manganese indicates that these metals are potential corrosion products from the carbon steel well screens and casing.

The analytical laboratory did not perform TOX analyses on the September samples from wells 199-N-28 and 199-N-74. By the time this was discovered, the samples had exceeded the recommended holding times, so the network was resampled for TOX on October 15, 2017.

The TOX results from 1325-N downgradient monitoring well 199-N-41 exceeded the TOX critical mean in the September and October samples (Table B-8 in Appendix B). Verifications samples were collected on November 20, 2017, with split samples going to GEL Laboratory (GEL) and TestAmerica–St. Louis (TASL). The quadruplicate sample results from GEL were all above the TOX critical mean, while the TASL results were all below the critical mean; therefore, the verification splits did not confirm a TOX exceedance. Sample results from GEL had laboratory qualifiers of “C,” indicating that the analyte was detected in both the associated QC blank and in the sample, and the sample concentration was less than or equal to five times the blank concentration. GEL reported 4.82 µg/L for the TOX method blank. This could be a result of inadequate column purge, and sample results may be biased high.

The TOX sample results from TASL had laboratory qualifiers of “N,” indicating that the spike sample recovery was outside control limits. The matrix spike sample had 82% recovery, below the lower acceptable recovery range of 85% to 117%, indicating that the results may be biased low. The laboratory control sample recovery was 101% and within the acceptable recovery range of 90% to 116%; therefore, low matrix spike recovery in the sample is suspected to be from interferences in the sample matrix.

Volatile organic analysis was also performed on the well 199-N-41 verification samples because of historical chloroform detection in the area. Acetone and chloroform were the only two volatile organic analytes (VOAs) detected by both GEL and TASL. Acetone results were all either undetected or flagged as “J” (detected below the practical quantitation limit [PQL] and the reported value is an estimate). Concentrations were well below the action level (7,200 µg/L) and acetone is a common laboratory contaminant; therefore, acetone was determined not to be associated with contamination release from 1325-N. Chloroform was reported above detection limits by both GEL and TASL. The TASL results averaged 1.15 µg/L, and the GEL results averaged 1.36 µg/L (flagged as “J”).

No organics were documented as having been discharged to 1325-N, and previous assessments for the 100-N Area RCRA sites identified the likely chloroform source as chlorinated water from a paint spray booth in an upgradient paint shop. Figure 6-27 shows that chloroform has historically been higher in the upgradient well for 1325-N (well 199-N-74) compared to well 199-N-41, as well as the other 1325-N downgradient monitoring wells.

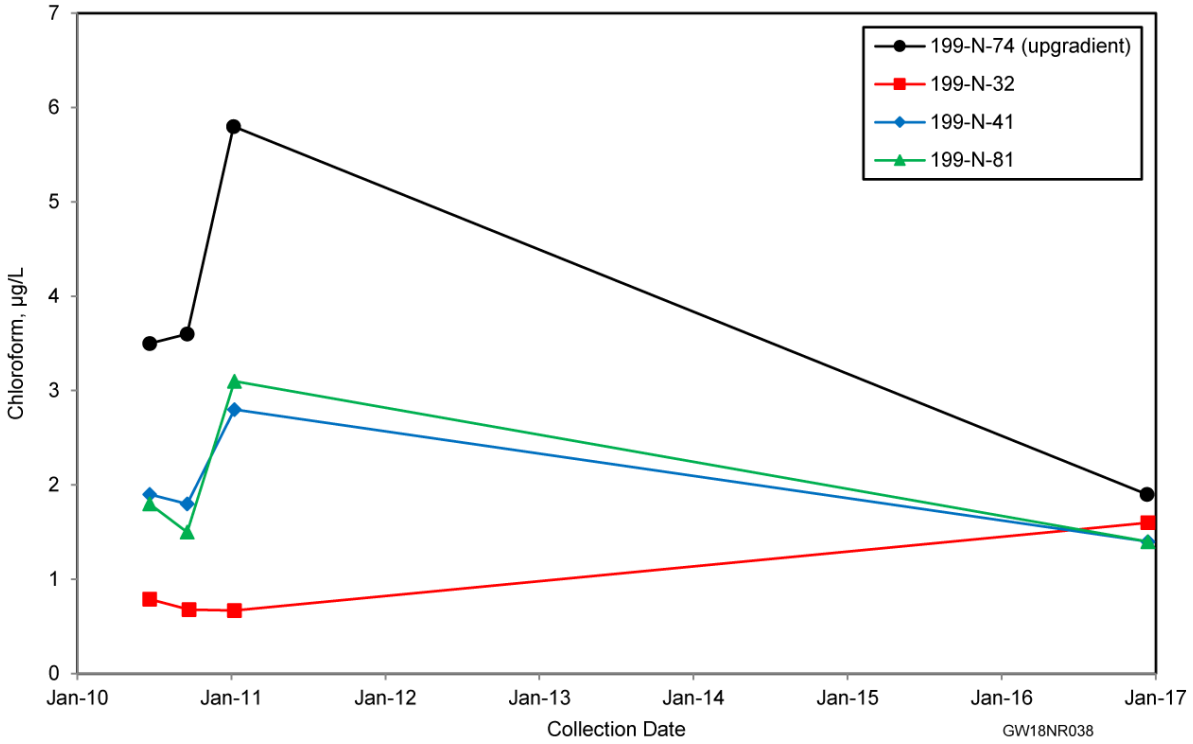


Figure 6-27. Chloroform Comparison of 1325-N Upgradient Well to Downgradient Wells

The verification sample results for TOX from the splits were inconclusive in verifying an exceedance to the TOX indicator parameter. The VOA analyses indicated that the TOX is associated with chloroform. Organics were not documented as having been discharged to 1325-N, and the upgradient to downgradient well comparison indicates that the TOX exceedance at well 199-N-41 is not a release from 1325-N but rather from migration of chloroform from an upgradient source. Therefore, 1325-N remains in detection monitoring.

Statistical comparisons for specific conductance were performed in 2017 using the intrawell testing method for 1325-N, and there were no exceedances (Table B-8 in Appendix B). Applying intrawell testing (as identified in EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*) provides a method to account for the spatial variability in the specific conductance indicator parameter for statistical comparisons. Intrawell testing is a parametric analysis of variance method applicable for detection monitoring, as provided in WAC 173-303-645(8)(h)(i). Applying the intrawell comparison for specific conductance reduces the number of false positives associated with the nonregulated sulfate present in groundwater. As discussed in previous RCRA reports (e.g., DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*), the presence of sulfate in groundwater causes exceedances of the specific conductance critical mean in upgradient/ downgradient (interwell) statistical comparisons. Sulfate is not a regulated waste constituent, but its presence results in significant spatial variability in specific conductance.

6.8.3 120-N-1 Percolation Pond and 120-N-2 Surface Impoundment

The 1324-N and 1324-NA facilities, also known as the 120-N-2 and 120-N-1 waste sites (Figure 6-28), were TSD units used to treat and dispose corrosive nonradioactive waste from 1977 to 1990. Both units have been remediated and backfilled. The remediation consisted of removing and disposing the site structures, which included a liner system, a small sampling shed, fencing, and other miscellaneous debris. The waste sites are undergoing RCRA closure and are classified as interim closed under CERCLA (Section 1.3.2.6 of DOE/RL-2012-15).

The 1324-N/NA units are included in the Hanford RCRA Permit, which states that groundwater monitoring during the RCRA closure period will follow the requirements of BHI-00725 and WHC-SD-EN-AP-038. The units are monitored as a single WMA due to their proximity and similar waste types.

Upgradient well 199-N-71 and downgradient wells 199-N-72, 199-N-73, 199-N-77, and 199-N-165 monitor site groundwater (Table B-10 in Appendix B). The 199-N-77 well screen is at the base of the unconfined aquifer, and statistical data comparisons are not performed on this well. No changes were made to the monitoring network in 2017.

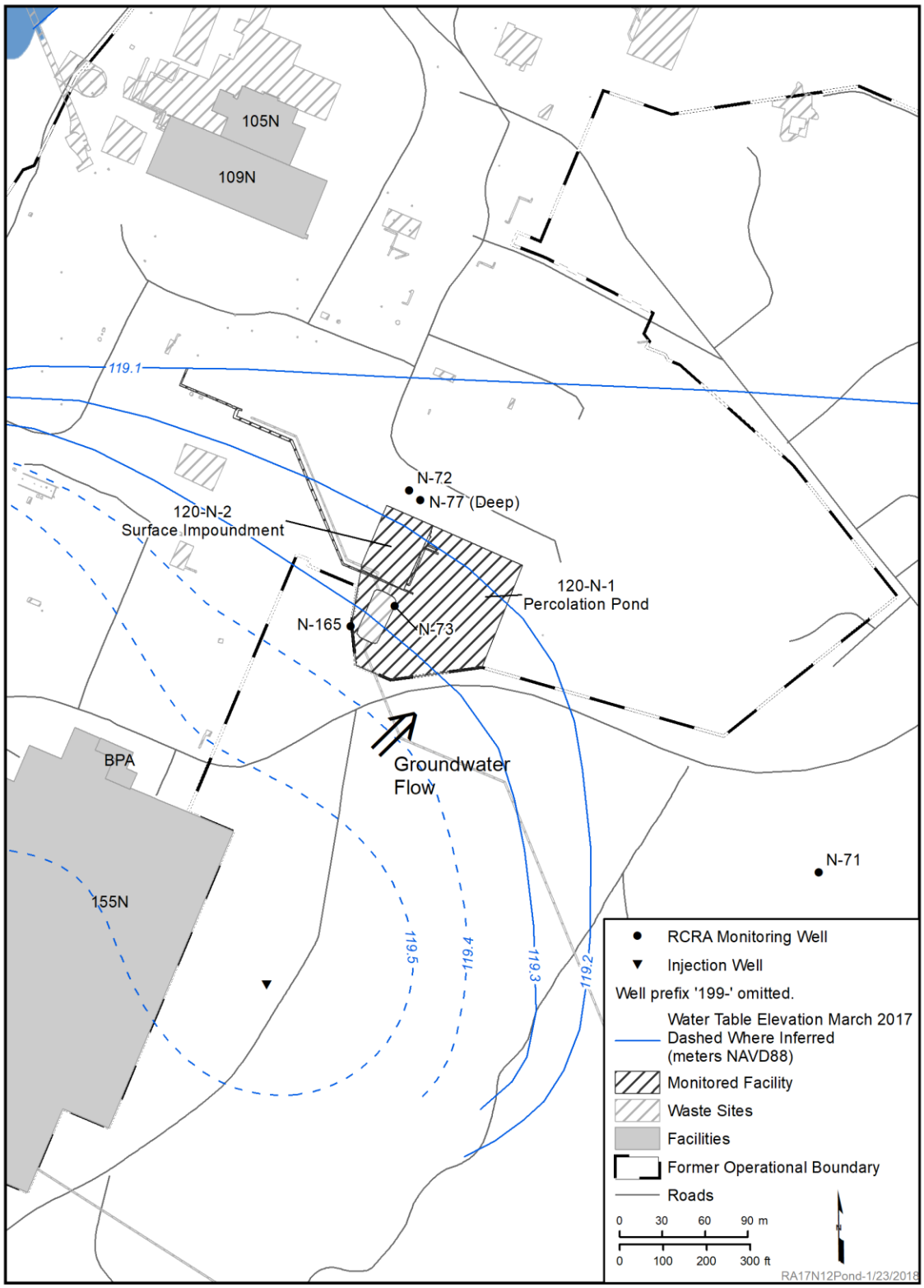
The 100-KR-4 OU injection wells, located south and west of the 1324-N/NA site, have raised the water table and continued to affect groundwater flow in 2017. Trend surface analysis of March 2017 data from the 1324-N/NA monitoring well network indicated that the local water table sloped to the northeast. The hydraulic gradient was estimated to be 7.5×10^{-4} m/m in March 2017, with flow rates from 0.015 to 0.28 m/d (0.050 to 0.9 ft/d) (Table B-11 in Appendix B). The direction of flow has varied from northeast to north-northwest over the past 3 years.

All five monitoring wells were sampled as planned during 2017: semiannually for RCRA contamination indicator parameters (pH, specific conductance, TOC, and TOX; Table B-12 in Appendix B) and turbidity; and annually for groundwater quality and supporting parameters (chloride, iron, manganese, sodium, sulfate, and alkalinity; Table B-13 in Appendix B). The average TOC concentration in well 199-N-73 exceeded the critical mean in September. Verification split samples were collected on October 31, 2017, with splits going to GEL and TASL. Verification sample results did not confirm a TOC exceedance. The quadruplicate sample results from both laboratories were all below the critical mean.

Statistical comparisons for specific conductance were performed using the intrawell testing method (Section 6.8.2) for 1324-N and 1324-NA in 2017, and there were no exceedances (Table B-12 in Appendix B). As discussed in previous RCRA reports (e.g., DOE/RL-2016-66), the presence of sulfate in groundwater causes exceedances of the specific conductance critical mean in downgradient to upgradient (interwell) statistical comparisons. Sulfate is a not a regulated waste constituent, but its presence results in significant spatial variability in specific conductance.

6.9 Atomic Energy Act Monitoring

AEA groundwater monitoring was scheduled at 67 groundwater wells and aquifer tubes in the 100-NR groundwater interest area in accordance with DOE/RL-2015-56. The primary AEA constituents for 100-NR are strontium-90, nitrate, and tritium. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Four wells in the 100-NR were not sampled in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues and dry wells.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 6-28. RCRA 1324-N (120-N-2) and 1324-NA (120-N-1) Monitoring Well Locations

Radionuclide concentrations detected in groundwater samples from 136 wells[1] and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The DWSs for cumulative alpha emitters and uranium mass were not exceeded. The estimated TED exceeded the 100 mrem/yr standard at 16 groundwater wells in 100-NR (Table 6-3). The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 78 locations in this interest area. Some of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. CERCLA remedial action decisions (e.g., 100-NR PRB) provide additional protection of the public and the environment.

Table 6-3. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-NR in 2017

Monitoring Location/ Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
199-N-103A			459.75	459.75		
199-N-105A	207.75	207.75	1141.84	1141.84		
199-N-106A	211.35	211.35	1161.67	1161.67		
199-N-122	101.91	101.91	260.5	560.34		
199-N-123			56	81.43		
199-N-14	125.90	125.90	691.69	691.69		
199-N-146			71.5	251.76		
199-N-147			105.5	119		
199-N-173			10.64	10.64		
199-N-183			40.44	40.44		
199-N-184	145.66	145.66	797.09	797.09		
199-N-186			218.16	218.16		
199-N-187	1291.55	1291.55	7102.46	7102.46		
199-N-188	293.81	293.81	1615.67	1615.67		
199-N-19			6.11	6.11		
199-N-2	148.39	148.39	815.79	815.79		
199-N-201			5.05	5.05		
199-N-229			24	31.05		
199-N-248			8.1	8.1		
199-N-268			272.5	525		
199-N-269	169.09	169.09	930	930		

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

Table 6-3. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-NR in 2017

Monitoring Location/ Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
199-N-27			92.84	92.84		
199-N-28			14.94	14.94		
199-N-280			416	432		
199-N-281	261.82	261.82	1440	1440		
199-N-297	109.09	109.09	194.5	600		
199-N-298	130.91	130.91	720	720		
199-N-3			432.36	432.36		
199-N-315			158	361.5		
199-N-316			43.25	43.25		
199-N-332			76.5	188.5		
199-N-34			27.10	27.10		
199-N-347			4.28	4.28		
199-N-348			5.7	31.72		
199-N-349			18.16	49.3		
199-N-350			34.74	40.55		
199-N-351			40.45	219.56		
199-N-352			61.5	434.13		
199-N-353			28.04	28.04		
199-N-354			6.4	7.75		
199-N-355			329.61	339		
199-N-356			130.5	216.41		
199-N-357	153.91	153.91	456	846.03		
199-N-358			177.57	185		
199-N-359			109	132.73		
199-N-360			49.1	347.87		
199-N-361			17.06	68.5		
199-N-362			93.5	188.5		
199-N-363			79.5	178.03		
199-N-364			73	128.12		
199-N-365			47.1	103.08		
199-N-366			19.95	96.808		

Table 6-3. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 100-NR in 2017

Monitoring Location/ Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
199-N-367			4.33	4.33		
199-N-374			4.73	77.05		
199-N-377			10.08	17.25		
199-N-57			5.52	5.52		
199-N-67	945.97	945.97	5201.79	5201.79	60.07	60.07
199-N-75	220.39	220.39	1211.52	1211.52		
199-N-76			113.37	113.37		
199-N-81			237.83	237.83		
APT1			255.5	349.5		
APT5			85.5	90.5		
C6324			4.01	6		
C7881			28.55	36.2		
C7934			72.36	161.4		
C7935			49.95	168.1		
C7936			14.77	39.61		
C9587			94.5	96.5		
C9589			29.5	29.5		
C9590			18.05	25.1		
N116mArray-10A			57	57		
N116mArray-11A			197.5	385		
N116mArray-2A			9.5	12.9		
N116mArray-3A			55.5	101		
N116mArray-4A			104.5	104.5		
N116mArray-6A			50	91.5		
N116mArray-9A			110.5	114		
NVP2-116.0	111.82	217.27	615	1195		

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Notes: None of the wells in 100-NR had cumulative uranium mass ≥30 µg/L.

Blank cells indicate no exceedances.

7 300-FF

This chapter presents information for the 300-FF groundwater interest area, including an overview; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2017. The groundwater monitoring results for 2017 are also summarized.

7.1 Overview

The 300-FF groundwater interest area is located in the southeastern Hanford Site. It includes the 300-FF-5 OU, where groundwater was contaminated by releases at the 300 Area Industrial Complex, 618-10 Burial Ground/316-4 Crib, and 618-11 Burial Ground. Table 7-1 summarizes key facts about 300-FF. Section 1.5 provides details about plume mapping, including descriptions of terms (e.g., Type 1 control point) used in the figure legends.

The 300-FF groundwater contamination originated primarily from historical routine disposal of liquid effluent associated with fabrication of nuclear fuel assemblies and research involving the processing of irradiated fuel. Because the principal liquid waste disposal facilities have been out of service for decades and most have been remediated by removing contaminated soil (Section 4.0 of DOE/RL-2004-74, *300-FF-1 Operable Unit Remedial Action Report*), the contamination remaining in the underlying vadose zone and aquifer is residual. Over 95% of the 300-FF waste sites have been remediated or did not require remediation.

The groundwater in 300-FF is monitored under CERCLA, RCRA, and AEA, as discussed in Sections 7.6, 7.7, and 7.8. The CERCLA contaminants in the groundwater are uranium, gross alpha, TCE, *cis*-1,2-DCE, tritium, and nitrate. The former 300 Area Process Trenches (316-5) are regulated under RCRA and are undergoing post-closure monitoring. Wells and aquifer tubes are monitored for uranium, nitrate, and radionuclides under the AEA. Figure 7-1 shows the locations of wells sampled in 2017.

Groundwater in the unconfined aquifer beneath the southeastern portion of the Hanford Site flows east or southeast toward the Columbia River (Figure 7-2). This flow direction is induced by regional groundwater flow that converges from the northwest, west, and southwest. Flow patterns throughout the region are complicated by the variable permeability of sediment in the upper portion of the unconfined aquifer. Near the Columbia River, groundwater flow is also influenced by river-stage fluctuations. In 2017, groundwater underlying the 300 Area Industrial Complex flowed south during late February.

The highest seasonal river elevations typically occur from May through June and the lowest from September through mid-November (Section 4.4.2 of DOE/RL-2010-99, *Remedial Investigation/ Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*). The river-stage elevation (based on data from the river gauge in the 300 Area) increased in March 2017 and remained elevated through June 2017. The highest river-stage elevation in late May 2017 was 0.6 to 1.4 m (2.0 to 4.7 ft) higher than the highest elevations in 2013 through 2016.

Contamination is generally found in the upper portion of the unconfined aquifer (i.e., the interval of Hanford formation gravelly sediment that lies below the water table) (Figure 7-3). The thickness of the contaminated portion of the unconfined aquifer is variable because of the undulating contact between the Hanford formation and the underlying Ringold unit E. In addition, significant seasonal fluctuations in water table elevation (Section 3.0 of PNNL-17034, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site, Washington*) affect the thickness of the contaminated zone. Beneath the 300 Area Industrial Complex, paleochannels filled with permeable Hanford formation sediment act as preferential pathways for groundwater flow (Figure 4-89 in DOE/RL-2010-99).

Table 7-1. 300-FF at a Glance

Fabrication of nuclear fuel assemblies: 1943 to 1987

Research in irradiated fuel processing: 1950s to 1960s

300-FF includes the 300 Area Industrial Complex, 618-10 Burial Ground/316-4 Crib, and 618-11 Burial Ground.

Groundwater Monitoring				
Contaminant, Cleanup Level[a], Units	**Year**	**Maximum Concentration**	**Plume Area[b] (km^2)**	**Shoreline[c] (m)**
Uranium (300 Area, 618-10), 30 µg/L	2017	8,450[d] (399-1-129)	0.60	1,203
	2016	1,180 (399-1-62)	0.34	1,183
Gross alpha (300 Area, 618-10), 15 pCi/L	2017	168 (399-6-3)	Not calculated[e]	Not calculated[e]
	2016	41.3 (399-2-1)		
cis-1,2-DCE (300 Area), 16 µg/L	2017	191 (399-1-16B)	Undefined[f]	Undefined[f]
	2016	228 (399-1-16B)		
Trichloroethene (300 Area), 4 µg/L	2017	1.99 (399-1-16B)	Undefined[f]	Undefined[f]
	2016	2.09 (399-1-16B)		
Tritium (618-11), 20,000 pCi/L	2017	570,000 (699-13-3A)	0.10	None
	2016	799,000 (699-13-3A)	0.13	
Nitrate (618-11), 45 mg/L	2017	186 (699-13-3A)	0.30[g]	None
	2016	181 (699-S28-E12)	0.18[g]	
Remediation				

Waste sites: 95% complete.[h]

Groundwater: Monitored natural attenuation, groundwater monitoring, enhanced attenuation, and institutional controls on the use of groundwater.

The Record of Decision for final remedial action was issued in November 2013; implementation began in 2015.

a. EPA et al., 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*.

b. Estimated area at a concentration greater than the cleanup level.

c. Length of shoreline intersected by plume above listed cleanup level.

d. Characterization sample collected using a bailer during drilling from a depth of 7.6 m (25 ft) below ground surface.

e. Because gross alpha activity is associated with uranium, it is being addressed with the remediation of uranium.

f. Organics are locally present in deeper sediments. Plumes cannot be defined by current data.

g. Excludes nitrate from offsite.

h. Sites with status of final closed, interim closed, no action, not accepted, or rejected as of December 31, 2017.

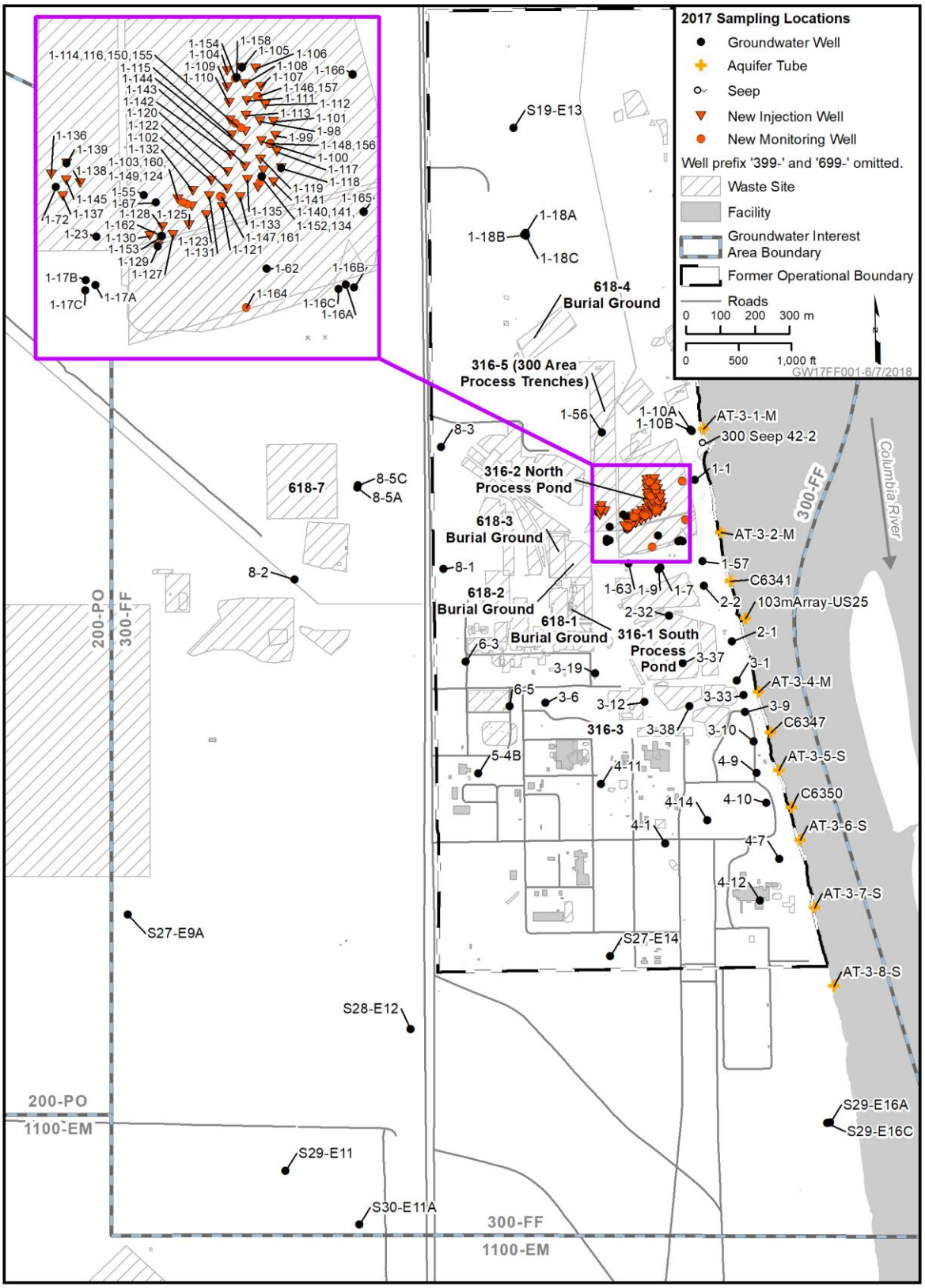
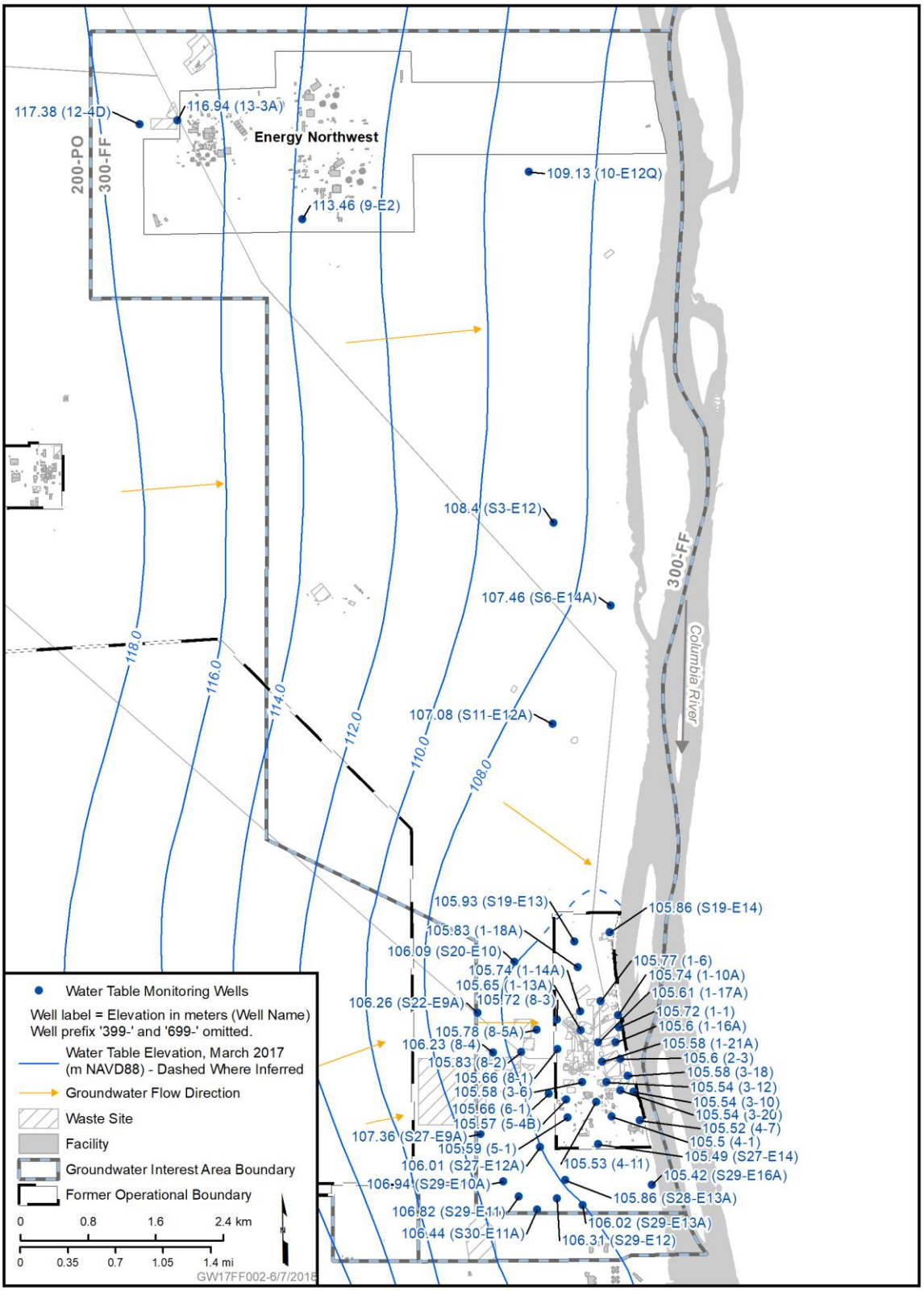


Figure 7-1. 300-FF Sampling Locations, 2017



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 7-2. 300-FF Water Table, February 2017

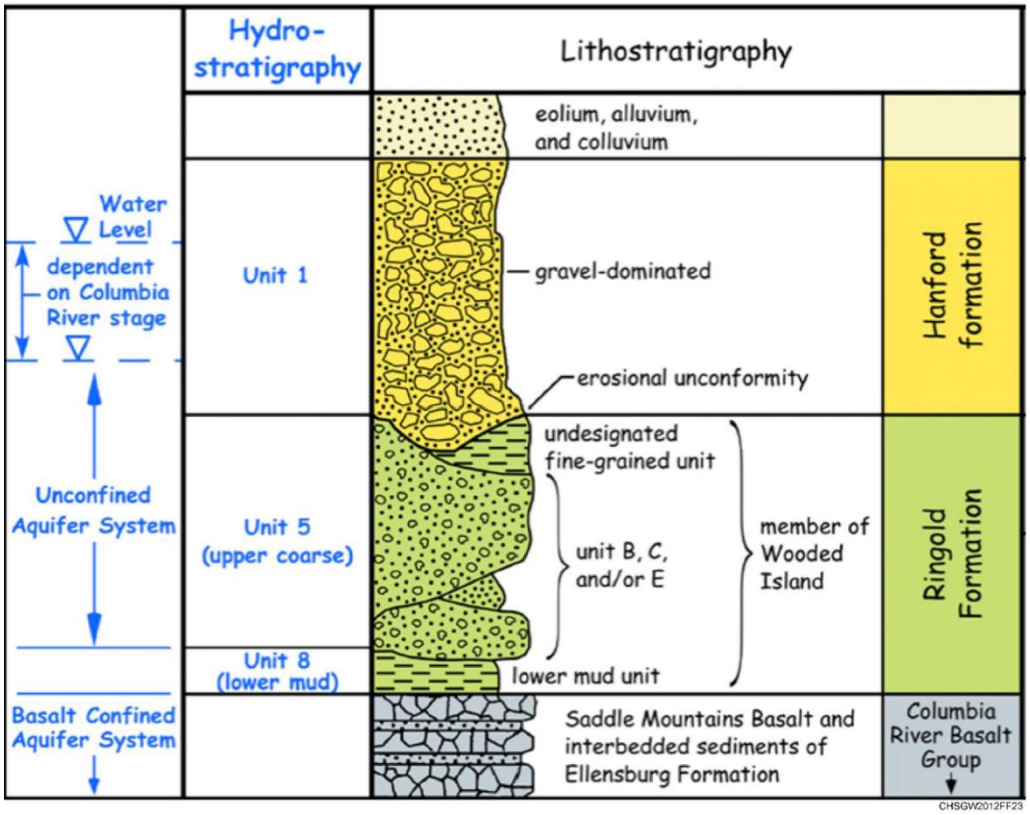


Figure 7-3. 300-FF Geology

In the 300 Area, contaminant discharge to the river occurs via riverbank seeps that flow across the beach region (riparian zone) during periods of low river stage and by groundwater upwelling through the riverbed. The rate of contaminant discharge to the river is influenced by daily and seasonal river-stage fluctuations (Section 3.1 of PNNL-17708, *Three-Dimensional Groundwater Models of the 300 Area at the Hanford Site, Washington State*; Section 2.4.1 of PNNL-22048, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*).

Effects of high river elevations include temporary reversal of flow direction, dilution of contamination in groundwater near the river by the intrusion of clean river water, and possible influences on contaminant mobility caused by changes in the geochemical environment. Changes in the geochemical environment are most pronounced where river water intrudes into the aquifer. River water is lower in alkalinity (lower in bicarbonate content) and lower in specific conductance than groundwater (Section 3.6.1.4 of DOE/RL-2010-99).

Figure 7-4 illustrates how estimates of plume areas in the 300-FF groundwater interest area have changed since 2003. Figure 7-5 illustrates the uranium plume as interpreted in 1996 and 2017.

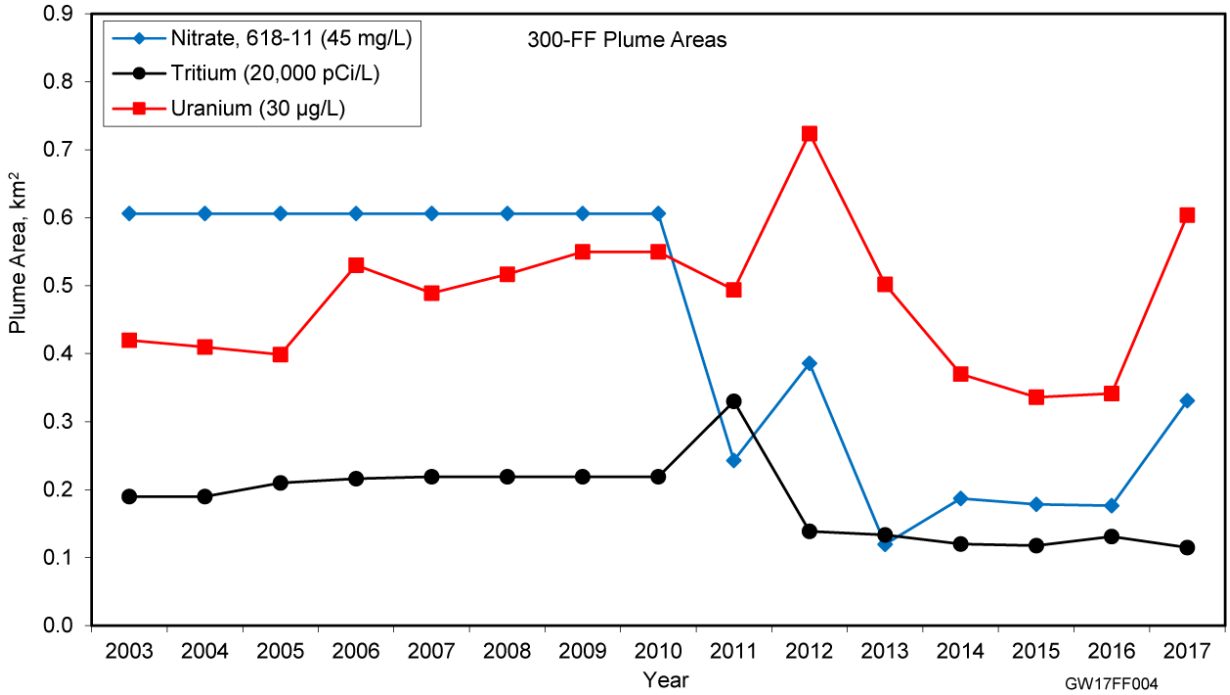


Figure 7-4. 300-FF Plume Areas

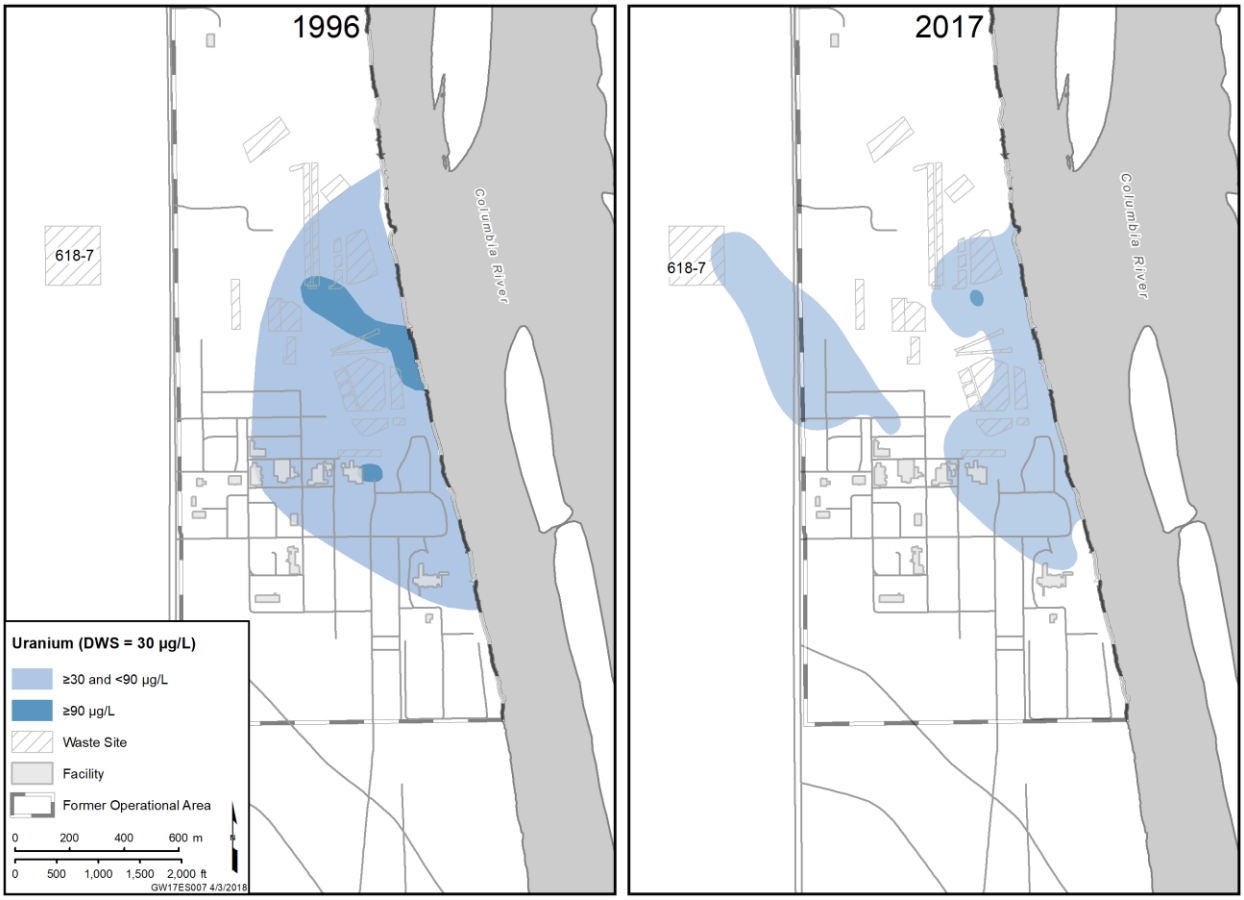


Figure 7-5. 300-FF Uranium Plume in 1996 and 2017

7.2 Uranium

Large volumes of liquid waste containing uranium were discharged to the former South Process Pond (316-1) (from 1943 to 1975), North Process Pond (316-2) (from 1948 to 1975), and 300 Area Process Trenches (316-5) (from 1975 to 1987). Discharge of cooling water with small quantities of nonhazardous maintenance and process waste continued at the 300 Area Process Trenches until December 1994 (Section 3.1.1 of the final status groundwater monitoring plan for the 300 Area Process Trenches in Part VI of the Hanford RCRA Permit, Revision 8c). Contaminated soil was removed from the 300 Area Process Trenches in 1991. Additional excavation of contaminated soil occurred at this site and at other major liquid waste disposal sites in the 300 Area Industrial Complex from 1997 through 2000.

The areal extent of the uranium plume exceeding the cleanup level (30 µg/L) is estimated to be 0.60 km^2 (0.23 mi^2) beneath the 300 Area Industrial Complex (Figure 7-6). The persistence of the plume is attributed to resupply of mobile uranium from sources in the vadose zone and the groundwater interface (the deepest part of the vadose zone wetted when the water table rises during high river stage) (Section 4.4.4.3 of DOE/RL-2010-99).

The uranium plume map and trend plots are based on concentrations in wells in the long-term CERCLA, RCRA, and AEA monitoring networks. Uranium concentrations in wells in the Stage A enhanced attenuation network that were monitored in 2015 during phosphate injections (Section 7.6.2) are not included. Characterization samples collected during drilling are also not included because the samples are not considered to be representative of aquifer conditions.

During seasonal low water table conditions, the highest uranium concentrations are often observed near the river, where uranium introduced inland during the preceding period of high water table conditions (due to groundwater contact with residual uranium in the lower vadose zone) has migrated downgradient to the shoreline, and intrusion of river water into the zone beneath the shoreline is lessened because of the lower river stage (Section 3.3 of PNNL-17034). Figure 7-7 depicts the inverse variation of uranium concentration with water table elevation at well 399-1-16A, a location representative of near-river conditions.

Typical characteristics of the uranium plume during seasonal high water table conditions include lowered concentrations along portions of the Columbia River shoreline and increased concentrations farther inland near the source areas. The reduction in concentrations near the shoreline is caused by dilution from the intrusion of river water into the aquifer. The increase in concentrations near the source areas is caused by mobilization of residual contamination in the lower vadose zone resulting from temporary elevation of the water table. The high water table in spring 2017 rewet the higher portions of the lower vadose zone where residual uranium remains that is not contacted by typical water table elevations. Figure 7-8 depicts the positive variation of uranium concentration with water table elevation at well 399-1-17A, a location representative of inland conditions near source areas.

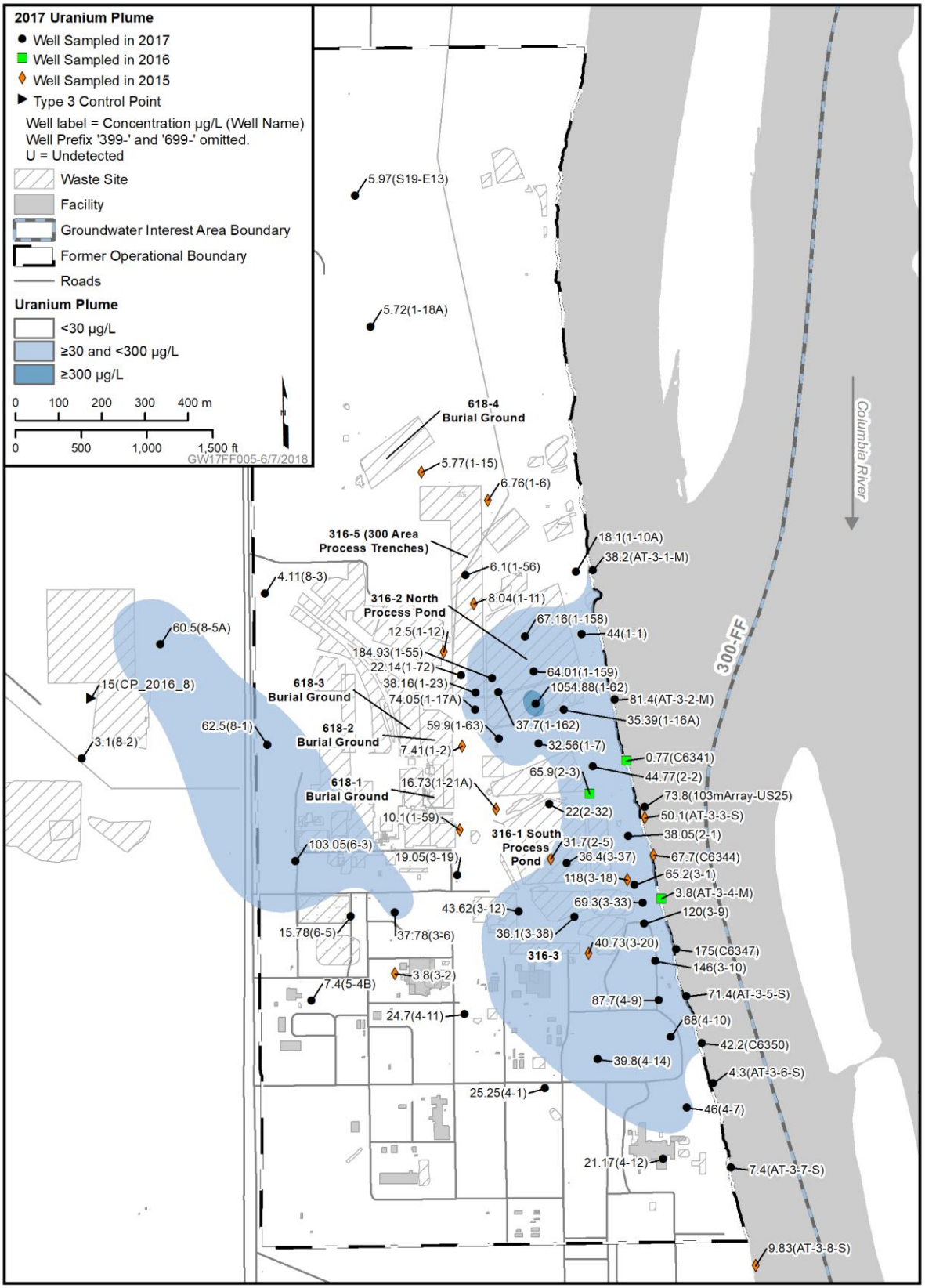


Figure 7-6. 300-FF Uranium Plume, 2017

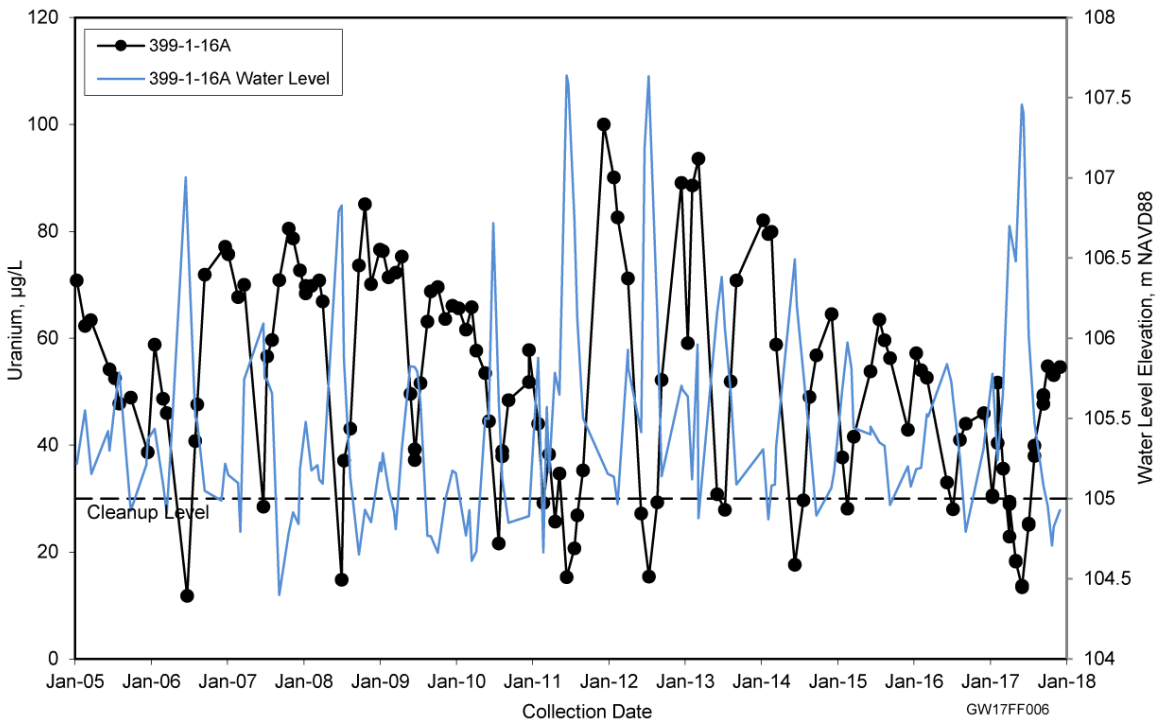


Figure 7-7. 300-FF Uranium and Water-Level Data for Well 399-1-16A (near River)

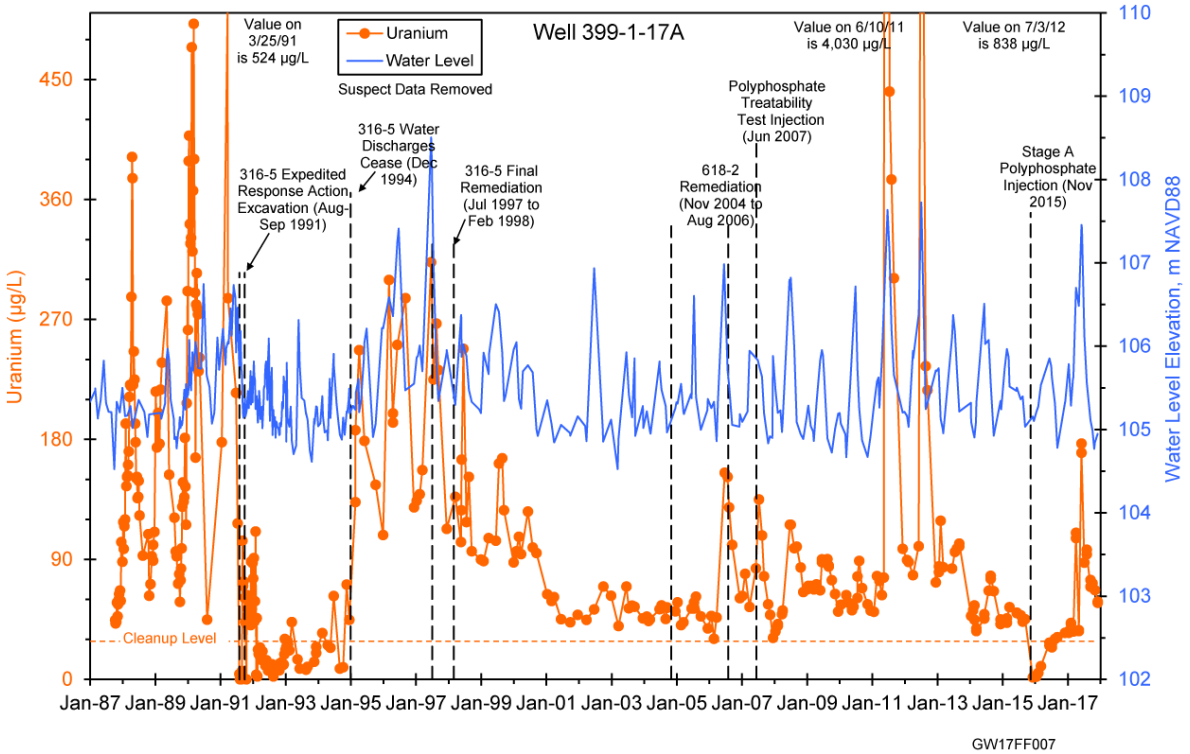


Figure 7-8. 300-FF Uranium and Water-Level Data for Well 399-1-17A (Inland)

Stage A of the uranium sequestration remedy was implemented at the southern end of the 300 Area Process Trenches and North Process Pond in November 2015 (Section 7.6.2). Stage B of the remedy was planned to be implemented in 2017; however, Stage B was postponed for one year to allow time for additional groundwater monitoring and evaluation (TPA-CN-0784, *Tri-Party Agreement Change Notice Form: DOE/RL-2014-13-ADD2 Rev. 0, Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*). In 2017, six wells near and downgradient of the Stage A enhanced attenuation area were monitored monthly for uranium in accordance with DOE/RL-2014-42-ADD1, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum for Stage B Uranium Sequestration* (Figure 7-9). Five additional wells were monitored monthly beginning in October. Groundwater uranium concentrations were lower in some downgradient monitoring wells following implementation of Stage A but increased as a result of the high water table in 2017. For example, the uranium concentration in well 399-1-17A decreased to 1.6 µg/L in December 2015 and increased to concentrations just above the cleanup level during 2016 (Figure 7-8). Concentrations increased in spring 2017 during the high water table conditions, which mobilized residual uranium from the deep vadose zone at this location and/or at an upgradient location. Uranium concentrations also decreased below the cleanup level in well 399-1-7 in 2016 but increased in late summer and fall 2017 as the inland groundwater concentrations migrated downgradient.

The highest uranium concentration in 2017 for routine groundwater monitoring was 1,260 µg/L in well 399-1-62 (Figure 7-6 shows the average value). Uranium concentrations at this well did not increase in response to high water table conditions in 2012 (June) or 2013 (May). The 2017 concentration may reflect migration of uranium from upgradient sources. The highest uranium concentration in 2017 for all samples was 8,450 µg/L in a characterization sample collected during drilling of uranium sequestration injection well 399-1-129 (Figure 7-1 inset) (Section 7.6.1). Soil samples collected during drilling of this well had increasing uranium concentrations with depth. The uranium concentration in the deepest soil sample was 51.6 mg/kg, collected from 9.1 to 9.9 m (30 to 32.5 ft) on March 22. A groundwater sample collected using a bailer on May 4 had a uranium concentration of 5,460 µg/L. The confirmatory sample collected using a bailer on May 17 from a depth of 7.6 m (25 ft) had the maximum value of 8,450 µg/L.

Uranium concentrations increased in 2017 in wells downgradient of the former 618-7 Burial Ground. A uranium plume developed in this region during remediation activities conducted during 2007 and 2008. By the end of 2010, concentrations at nearby downgradient wells 399-8-5A and 399-8-1 continued to decrease, indicating passage of the contaminant plume (Figure 7-10). Since then, uranium concentrations have increased during periods of high water table conditions, suggesting that mobile uranium remains in the lower portion of the vadose zone near well 399-8-5A. Uranium concentrations were relatively stable in response to the relatively stable water table elevation in 2015 and 2016 but increased in 2017, exceeding the cleanup level (Figure 7-6).

The uranium concentration at well 399-6-3, which is 0.6 km (0.4 mi) southeast of the 618-7 Burial Ground, increased from 17 µg/L in 2015 to 140 µg/L in December 2016 (Figure 7-10). The increase was confirmed by a subsequent sample in April 2017. By August 2017, the uranium concentration had returned to 15 µg/L. The uranium at downgradient well 399-3-6 increased from 17 µg/L in 2016 to 56 µg/L in August 2017; the concentration was 22 µg/L in December (Figure 7-10). A possible source for this elevated uranium result has not been identified.

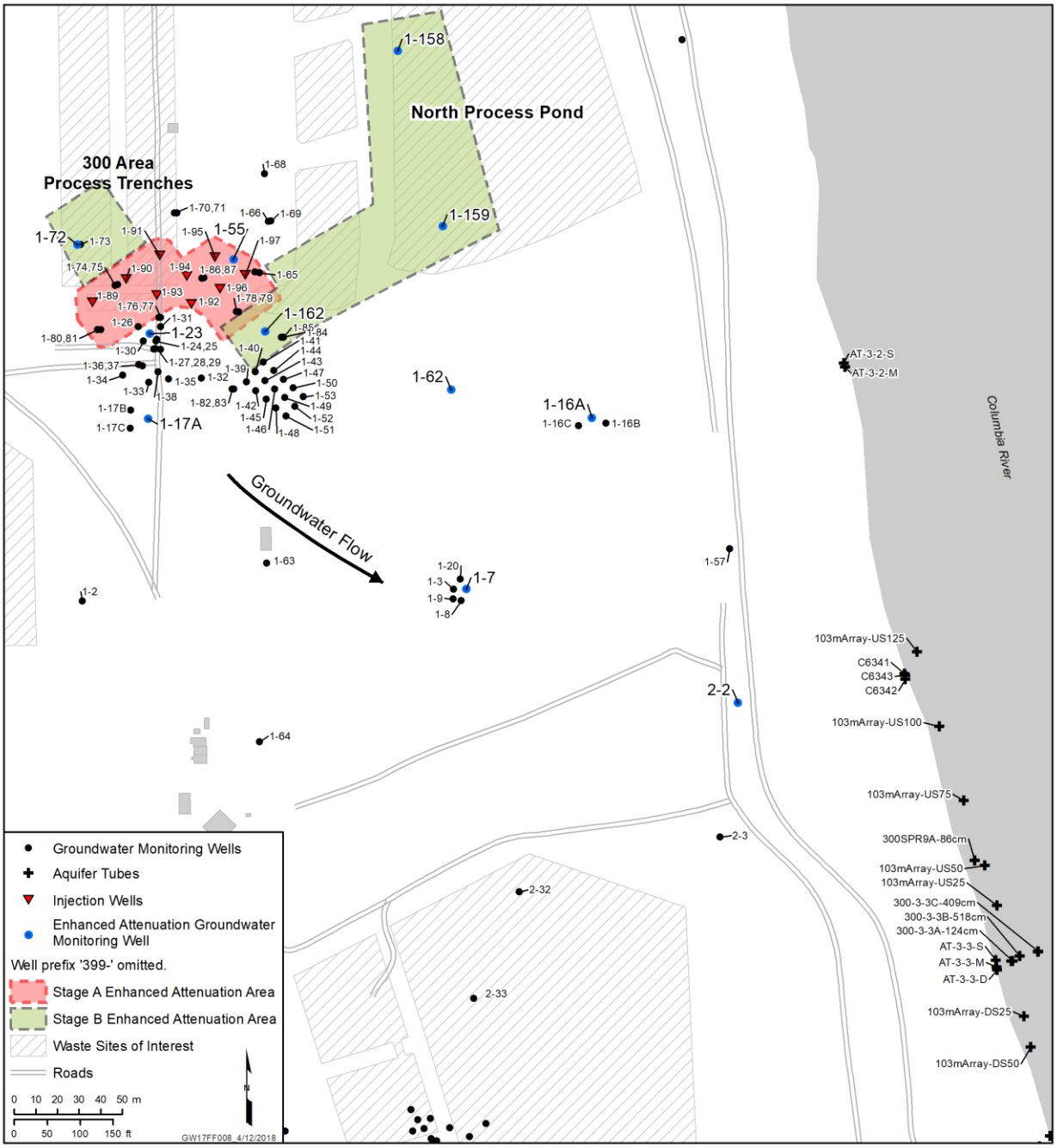


Figure 7-9. Location of Groundwater Monitoring Wells near and Downgradient of the Enhanced Attenuation Area

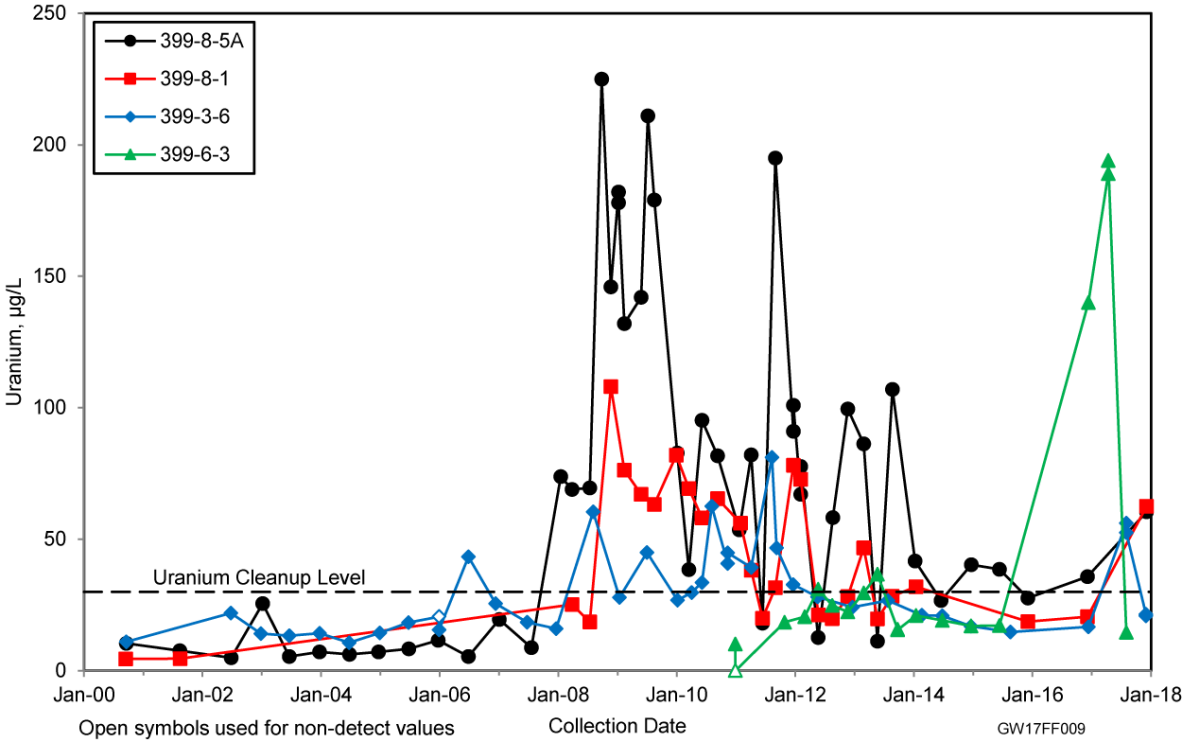


Figure 7-10. 300-FF Uranium Data for Wells Downgradient of the 618-7 Burial Ground

Uranium is also detected in groundwater near the former 618-10 Burial Ground and 316-4 Crib, located northwest of the 300 Area Industrial Complex; the 316-4 Crib is adjacent to the easternmost corner of the 618-10 Burial Ground. From 1948 to 1955 and in 1962, uranium-contaminated organic solvents were disposed to the 316-4 Crib. The liquid waste was discharged into the crib from tank trucks, which were then flushed with water from well 699-S6-E4A (Section 2.1 of DOE/RL-2017-49, *Cleanup Verification Package for the 316-4 Liquid Waste Disposal Crib*). The crib and some of the contaminated adjacent soil were removed in 2004 and 2005, and the site was backfilled in 2005; however, some uranium contamination was known to remain in the soil beneath the excavated site (Sections 3.4.1.4 and 3.4.2.1 of DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site*; EPA/ESD/R10-00/524, *EPA Superfund Explanation of Significant Difference for the 300-FF-5 Record of Decision: Hanford 300-Area (USDOE)*). Final remediation of the 316-4 Crib began in November 2016 and was completed in May 2017. Excavation was conducted to the groundwater interface (Section 4.1 of DOE/RL-2017-49). Well 699-S6-E4A was decommissioned in 2016 to support the remediation; a replacement well will be installed downgradient of the former 316-4 Crib (page viii of DOE/RL-2017-49).

The 618-10 Burial Ground operated from March 1954 until September 1963 and received a variety of waste from 300 Area operations, including solid waste and containerized liquid waste that was placed in the burial trenches and high-level waste that was placed in vertical pipe units, which were open to soil at the bottom (DOE/RL-2017-61, *Cleanup Verification Package for the 618-10 Burial Ground*). The trenches were remediated from March 2011 to March 2017 by excavating and removing the waste drums and anomalous items. The vertical pipe units were removed from March 2016 to June 2017. The remaining soil within the 618-10 Burial Ground was excavated from April to September 2017. The deepest excavation was to an elevation of 126 m (413 ft), 13 m (43 ft) above the groundwater interface (DOE/RL-2017-61). Well 699-S6-E4L was decommissioned in August 2015 to support excavation at the 618-10 Burial Ground.

Uranium concentrations increased above the DWS in 2004 in wells 699-S6-E4A and 699-S6-E4L, near the southeastern fence line of the 618-10 Burial Ground and the 316-4 Crib (Figure 7-11). This increase was caused by infiltration of dust-control water applied during the 316-4 Crib excavation and backfilling. Concentrations were elevated above the DWS again in well 699-S6-E4L in 2012 through 2014.
In March 2015, the uranium concentration in well 699-S6-E4L was 28.4 µg/L, which is below the cleanup level (Figure 7-11). The increase from 2012 through 2014 is attributed to infiltration of dust-control water during remedial actions that started in 2011 at the 618-10 Burial Ground. Because the water table elevation in this area has steadily declined by 1 m (3.3 ft) since 1998, the increase in uranium is not attributed to rewetting of the vadose zone by seasonal changes in the water table.

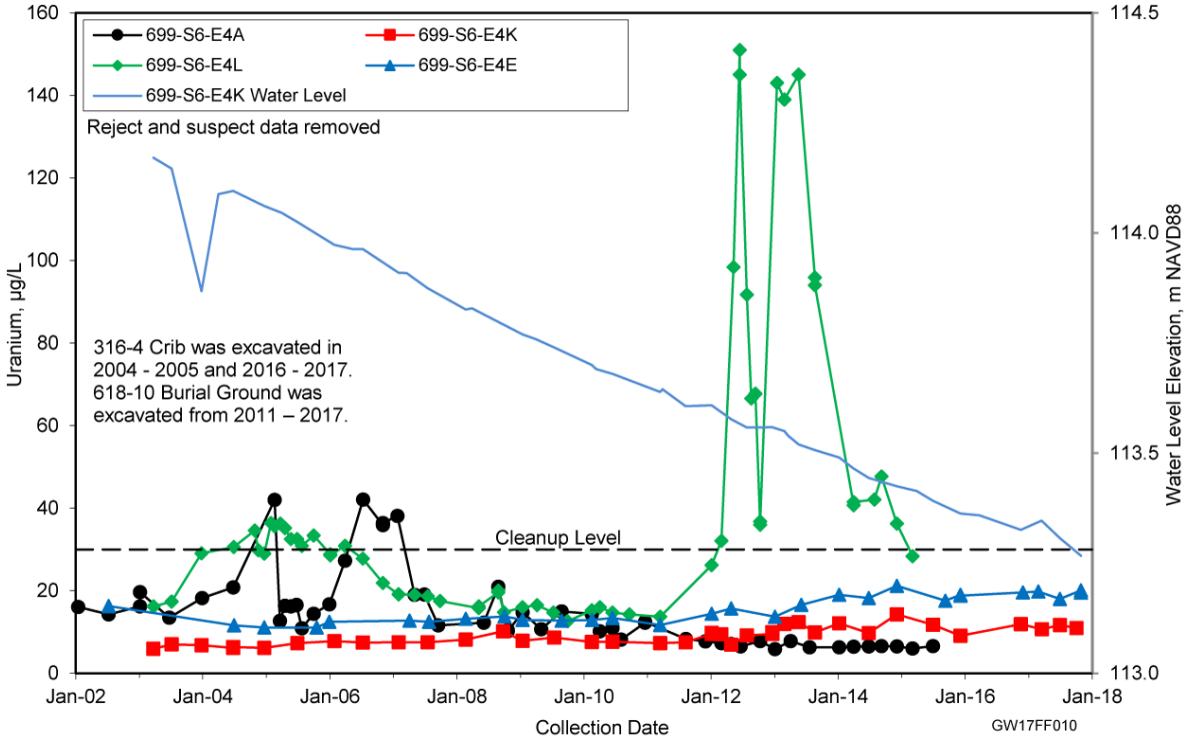


Figure 7-11. 300-FF Uranium and Water-Level Data for Wells 699-S6-E4A, 699-S6-E4E, 699-S6-E4K, and 699-S6-E4L

In accordance with the SAP (DOE/RL-2014-42), groundwater samples are being collected from the remaining three wells during and following remediation. In 2017, uranium concentrations were the highest at well 699-S6-E4E, which is downgradient of former well 699-S6-E4L (Figure 7-11). Concentrations of constituents associated with soil fixatives (e.g., calcium and chloride) were elevated at wells 699-S6-E4E and 699-S6-E4K in 2017; slight increases in soil fixatives occurred at well 699-S6-E4B.

Uranium concentrations in wells monitoring the lower portion of the unconfined aquifer in the 300 Area Industrial Complex are typical of natural background levels (estimated to range between 0.5 and 12.8 µg/L) (Table ES-1 in DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*), indicating little or no downward migration of uranium below the saturated Hanford formation sediment. Hydrographs for wells screened in saturated Hanford formation sediment or underlying Ringold unit E sediment are virtually identical, indicating no significant vertical gradients.

Uranium contamination is not present in the few wells that monitor the uppermost confined aquifer, which is a low to moderately permeable interval within the Ringold lower mud unit. Hydrographs for confined wells 399-1-16C and 399-1-17C show a distinct upward hydraulic gradient, with hydraulic heads 8 to 9 m (26 to 30 ft) higher than in adjacent water table wells. These two deep wells are screened across the basalt/Ringold lower mud contact and show basalt-confined aquifer conditions. The hydrograph for well 399-1-18C, which monitors the lowest Ringold Formation sediment, shows very little head difference compared to the adjacent water table well.

Gross alpha activity in 300-FF groundwater is attributed to uranium and exceeded the 15 pCi/L cleanup level at numerous wells in the 300 Area Industrial Complex, where uranium concentrations were also elevated in 2017.

7.3 Tritium

Tritium is found in groundwater associated with the 618-11 Burial Ground at concentrations exceeding the 20,000 pCi/L cleanup level. The source of the plume is tritium gas released from buried radiological solid waste in a series of caissons located along the north side of the burial ground (PNNL-13675, *Measurement of Helium-3/Helium-4 Ratios in Soil Gas at the 618-11 Burial Ground*). The narrow tritium plume extends for 1.2 km (0.7 mi) to the east of (i.e., downgradient from) the 618-11 Burial Ground. The plume passes just to the north of the Energy Northwest Columbia Generating Station (Figure 7-12) and appears to be contained within the saturated Hanford formation gravels of the unconfined aquifer. The tritium attributed to the 618-11 Burial Ground lies within the larger, lower concentration tritium plume that is part of 200-PO (Section 4.4.5 of DOE/RL-2010-99).

Tritium concentrations near the 618-11 Burial Ground have declined from the maximum values observed in 1999 and 2000 (Figure 7-13). The trend in groundwater at well 699-13-3A, adjacent to the eastern fence line of the burial ground, suggests that an episodic event of unknown nature caused a tritium release from buried materials to contaminate groundwater. The tritium concentrations were relatively constant at well 699-13-3A from 2006 until 2016 but declined significantly in 2017. The maximum concentration in 2017 was 570,000 pCi/L. At wells farther downgradient from the 618-11 Burial Ground (e.g., 699-13-2D and 699-12-2C), trends reflect plume migration. The conceptual model for the plume, including a simulation of plume evolution over time, indicates that tritium concentrations will be below the cleanup level when the plume reaches the Columbia River (Section 5.1 of PNNL-15293, *Evaluation of the Fate and Transport of Tritium Contaminated Groundwater from the 618-11 Burial Ground*). Groundwater wells monitored by Energy Northwest do not show evidence of this plume above the cleanup level, and tritium is not detected in Energy Northwest water supply wells.

7.4 Nitrate

Nitrate concentrations exceeding the 45 mg/L cleanup level are found near the 618-11 Burial Ground and in the southern portion of the 300 Area Industrial Complex, where the principal sources of nitrate are currently agricultural and industrial activities not associated with the Hanford Site. The nitrate in the southern portion of the 300 Area Industrial Complex is not part of the 300-FF-5 OU (EPA et al., 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*).

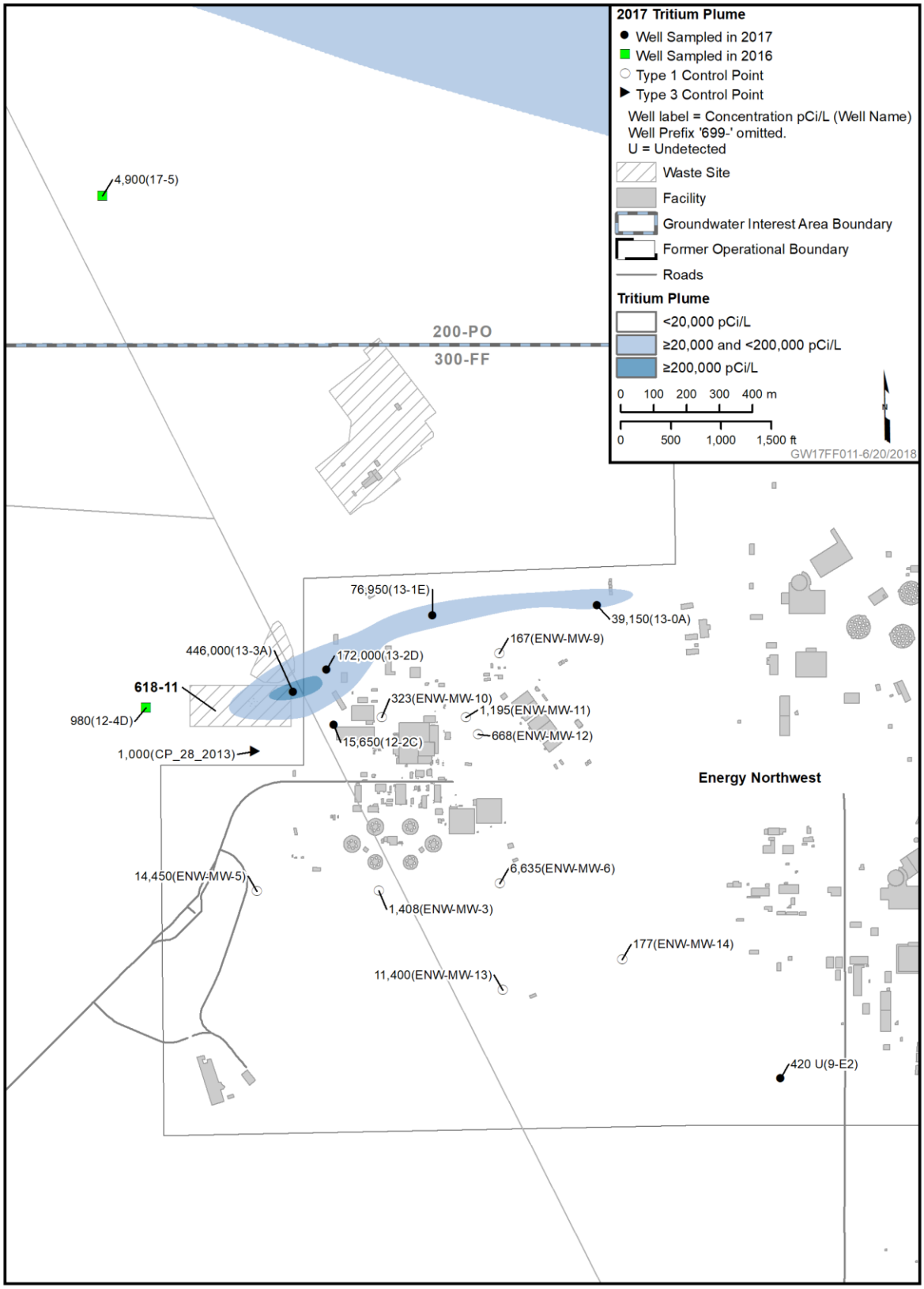


Figure 7-12. 300-FF Tritium near the 618-11 Burial Ground, 2017

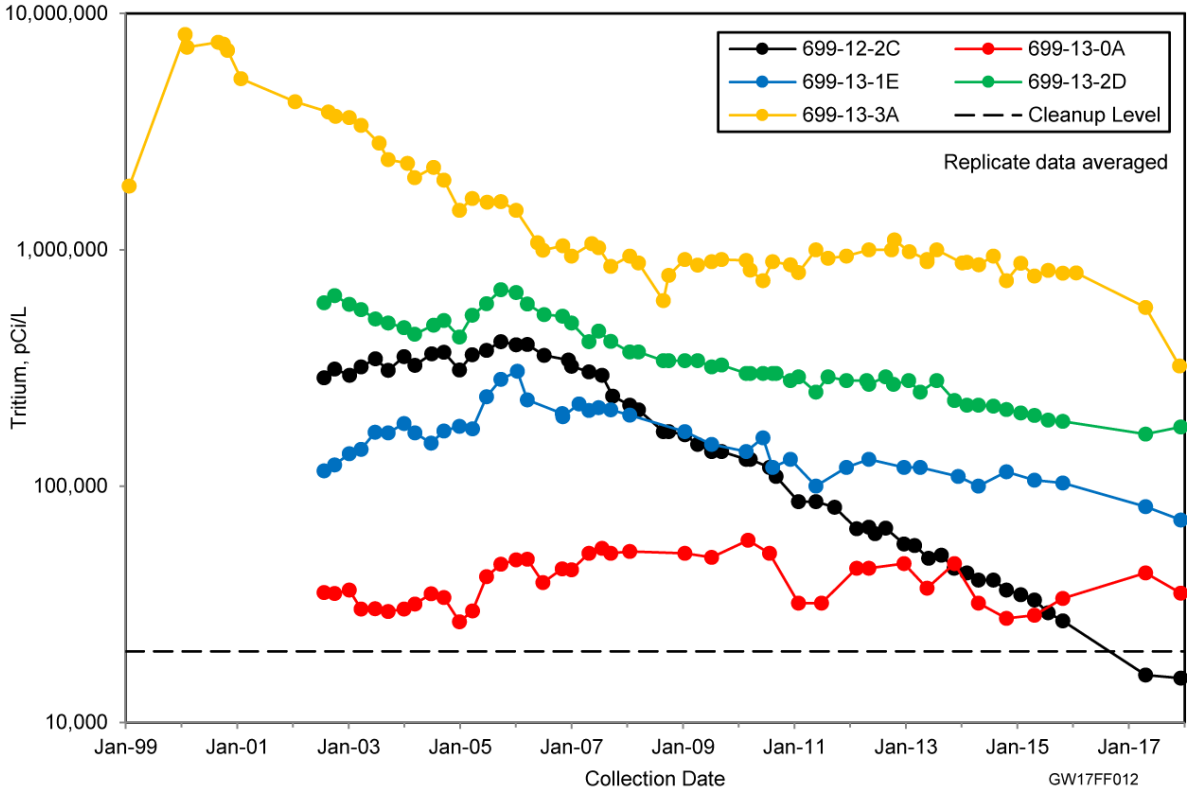


Figure 7-13. 300-FF Tritium Data for Wells 699-12-2C, 699-13-0A, 699-13-1E, 699-13-2D, and 699-13-3A

Nitrate concentrations near the 618-11 Burial Ground continued to exceed the cleanup level in 2017 (Figure 7-14). Concentrations at well 699-13-3A have generally decreased since 2010; however, the concentration tripled in 2017, from a maximum concentration of 57.5 mg/L in 2016 to 186 mg/L in 2017 (Figure 7-15). The well was resampled in January 2018, which confirmed (164 mg/L) the December increase. Nitrate concentrations increased at the other wells monitored at the 618-11 Burial Ground. Historical records for materials sent to the burial ground do not indicate significant quantities of nitrate-bearing wastes. Because the elevated nitrate in groundwater corresponds to elevated tritium, which is attributed to the 618-11 Burial Ground, the nitrate contamination is also attributed to the burial ground (Section 4.4.5 of DOE/RL-2010-99).

Nitrate concentrations exceeding 45 mg/L in the southern portion of the 300 Area Industrial Complex reflect migration of contaminated groundwater from sources to the southwest. For example, the maximum nitrate concentration near the southwestern corner of the 300 Area Industrial Complex (at well 699-S28-E12 in the 1100-EM interest area) was 173 mg/L in December 2017, and the concentration at well 699-S27-E14, 616 m (2,021 ft) to the northeast, was 102 mg/L in December 2017. Nitrate also migrates into the 300 Area Industrial Complex from the northwest as part of the sitewide plume that originates in the 200 East Area, with concentrations typically ranging from 25 to 30 mg/L.

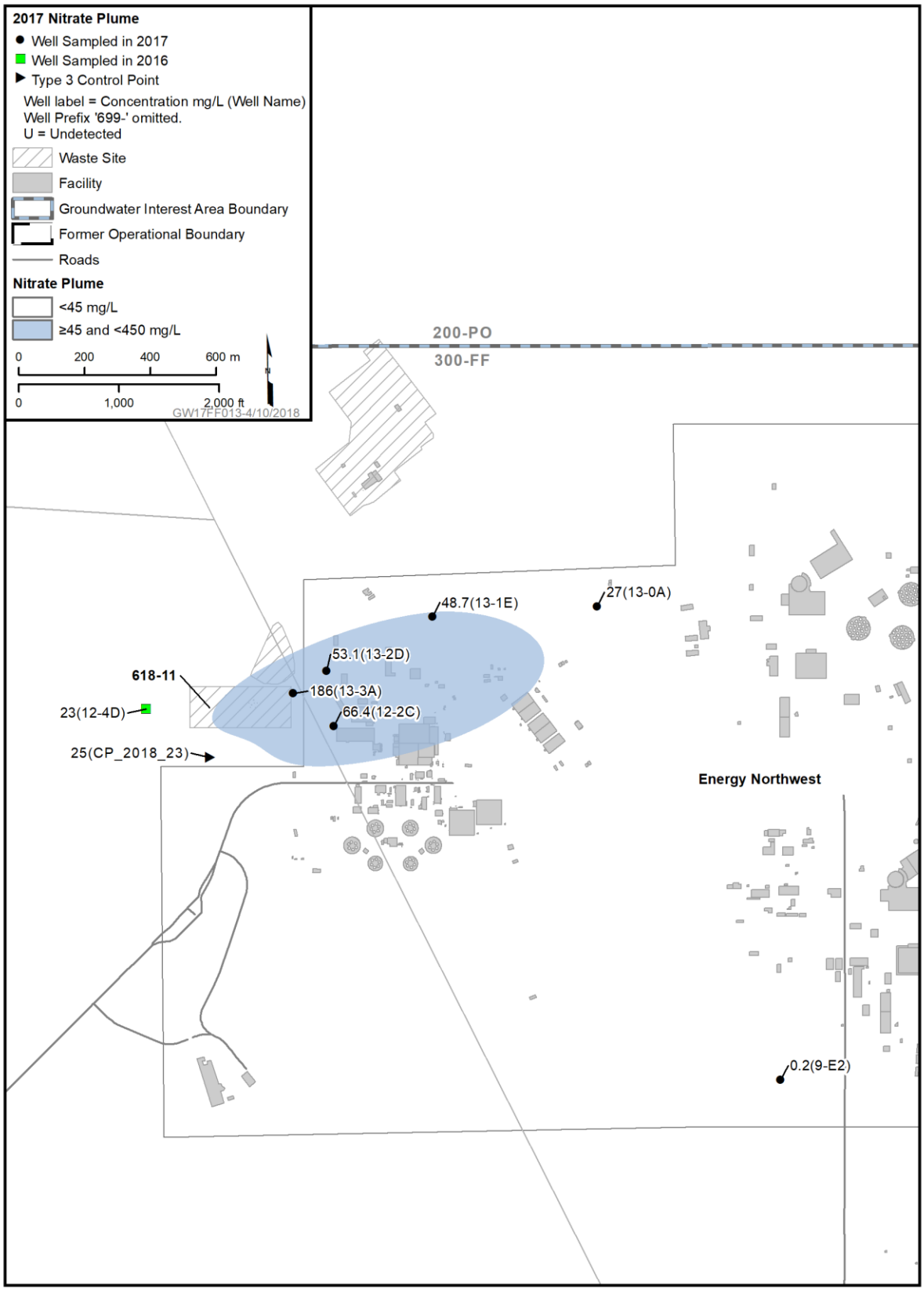


Figure 7-14. 300-FF Nitrate near the 618-11 Burial Ground, 2017

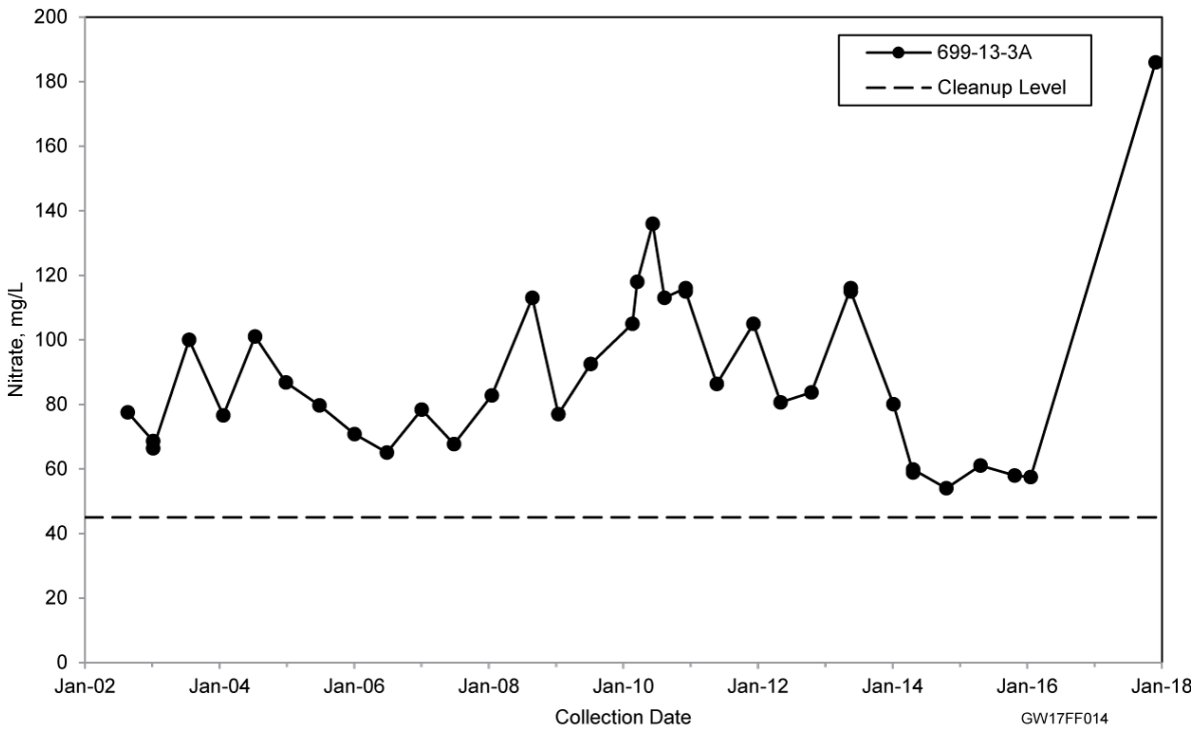


Figure 7-15. 300-FF Nitrate Data for Well 699-13-3A

7.5 Trichloroethene and *cis*-1,2-Dichloroethene

The volatile organic compounds (VOCs) TCE and *cis*-1,2-DCE are found in localized areas of groundwater beneath the 300 Area Industrial Complex at concentrations exceeding cleanup levels. *Cis*-1,2-DCE is a degradation product of TCE and tetrachloroethene (PCE). These original compounds degrade by dechlorination under conditions that include very low oxygen and the presence of certain types of microbes (Section 1.2 of PNNL-17666, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington*).

TCE and PCE were widely used in the 300 Area Industrial Complex in degreasing operations associated with the fuels fabrication process (Section 3.1 of PNNL-17666). TCE and PCE were discharged to the South Process Pond (316-1) and North Process Pond (316-2). The RI/FS evaluated PCE and concluded that it was not a COC (Section 8.1.1 of DOE/RL-2010-99).

The SAP for implementation of the 2013 remedy (DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*) identified nine wells in the 300 Area Industrial Complex for long-term monitoring of TCE. Calculations completed in 2015 (using data through 2014) demonstrated that eight of the nine wells had reached the cleanup level for TCE (4 µg/L). These eight wells were removed from the CERCLA long-term TCE monitoring network (Section 3.5.2.1 of DOE/RL-2014-42). In 2017, the concentration of TCE in the ninth well, 399-4-14, ranged from 1.00 to 1.29 µg/L (minimum and maximum results flagged as "J," indicating estimated concentrations). Calculations in 2017 (using data through 2016) demonstrated that this well had reached the cleanup level for TCE. The calculations follow the methodology presented in SGW-58883, *Methodology for the Calculation of Concentration Trends, Means, and Confidence Limits for Performance and Attainment Monitoring*.

During drilling in 2006, TCE (maximum of 630 µg/L) was encountered in groundwater associated with an interval of relatively finer grained sediment within Ringold unit E (Section 2.1 of PNNL-17666). Because this finer grained interval has a very low permeability and does not readily yield groundwater, monitoring wells have not been screened in this interval. This interval is incised by the river channel. Contamination slowly migrates within these sediments and into overlying or adjacent permeable Hanford formation sediment, as evidenced by periodic detections of TCE in aquifer tube samples that were previously collected from screens positioned near this contact (Section 4.8.4.4 of DOE/RL-2010-99).

In the lower portion of the unconfined aquifer, *cis*-1,2-DCE concentrations continued to exceed the cleanup level (16 µg/L) at well 399-1-16B, with a 2017 maximum of 191 µg/L (Figure 7-16). Well 399-1-16B is downgradient of the 300 Area Process Trenches (316-5) and North Process Pond (316-2), and it is screened in Ringold Formation unit E gravel. The elevation of the well screen is 7 m (23 ft) deeper than the elevation of the Columbia River maximum channel depth (Section 4.4.4.5 of DOE/RL-2010-99). The origin for *cis*-1,2-DCE is likely degradation of TCE and/or PCE disposed to the former North Process Pond (316-2) and/or former 300 Area Process Trenches (316-5) (Sections 3.1 and 3.3 of PNNL-17666; Section 4.4.4.5 of DOE/RL-2010-99).

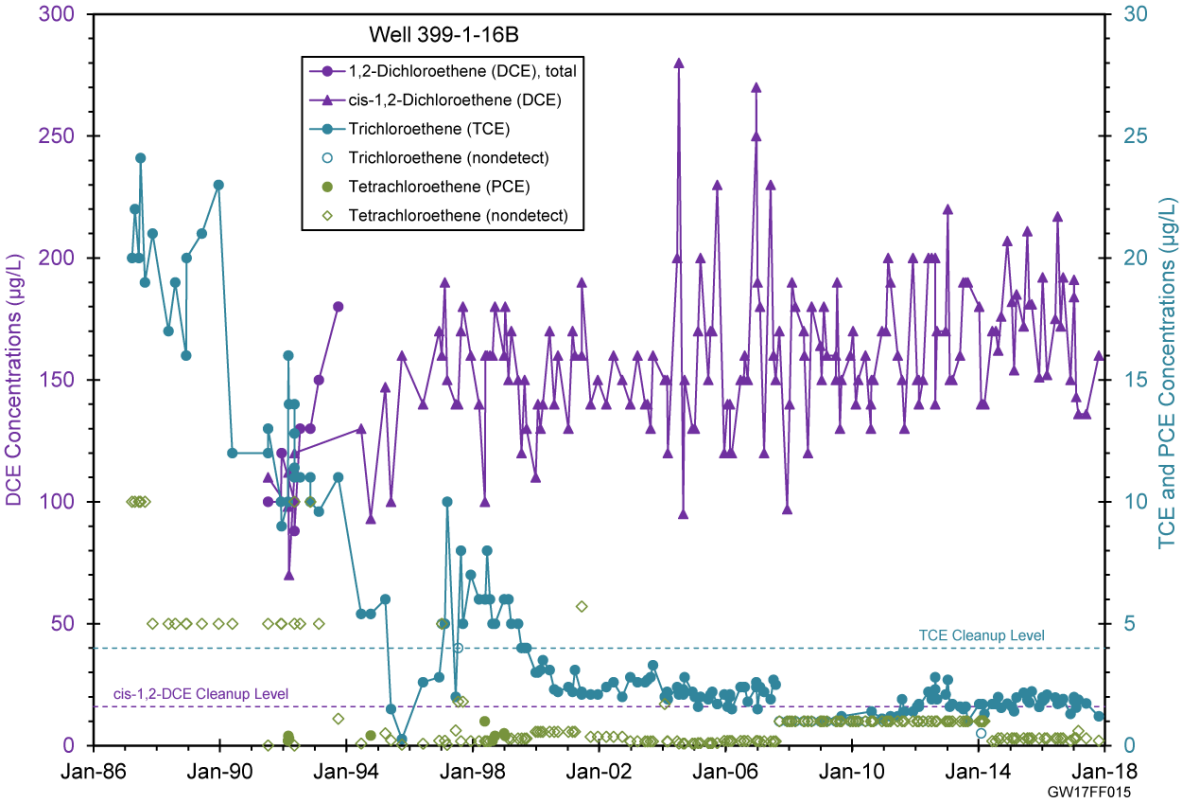


Figure 7-16. 300-FF *cis*-1,2-DCE, 1,2-DCE, TCE, and PCE Data for Well 399-1-16B

Well 399-1-57 is sampled for *cis*-1,2-DCE every 5 years under the CERCLA SAP (DOE/RL-2014-42). The well was most recently sampled in June 2015, when the concentration (61 µg/L) exceeded the cleanup level. The well is located 80 m (260 ft) southeast of well 399-1-16B. Well 399-1-57 is screened at mid-depth in the unconfined aquifer in Ringold unit E sandy gravel; the lowest extent of the screen just enters the top of the finer grained interval within Ringold unit E (Section 4.4.4.5 of DOE/RL-2010-99).

7.6 CERCLA Remediation and Monitoring

CERCLA remediation and monitoring activities in 2017 consisted of groundwater monitoring and performance evaluation of the groundwater remedies.

7.6.1 CERCLA Decision Documents and Plans

The ROD (EPA et al., 2013) was signed by EPA and DOE in November 2013. The COCs for groundwater are uranium, gross alpha, TCE, and *cis*-1,2-DCE at the 300 Area Industrial Complex; uranium and gross alpha at the 618-10 Burial Ground; and tritium and nitrate at the 618-11 Burial Ground. The RD/RAWP that implements the remedial actions in accordance with the 2013 ROD was issued in June 2015 (DOE/RL-2014-13-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*).

Groundwater monitoring required under the 2013 ROD (EPA et al., 2013) is implemented through a SAP issued in September 2015 (DOE/RL-2014-42). Sampling frequencies in the SAP range from once per quarter to once every 5 years, depending upon the COC and location. Most monitoring wells are screened at the top of the unconfined aquifer, across the water table. Several wells are screened in the lower portion of the unconfined aquifer, and a few wells are screened in the uppermost confined aquifer.

Groundwater monitoring to support Stage B of the enhanced attenuation remedy is implemented through an addendum to the SAP issued in December 2016 (DOE/RL-2014-42-ADD1). During 2017, 11 wells were monitored monthly.

Wells were sampled in accordance with the SAP (DOE/RL-2014-42) and SAP addendum (DOE/RL-2014-42-ADD1) requirements in 2017, with the following exceptions:

- Sampling at wells 399-1-7 and 399-2-2 in July was successful, but the anion analysis was canceled due to a commercial shipping issue.
- Sampling at well 399-4-14 in September was successful, but the VOA analysis was canceled due to a laboratory issue. The well was resampled in October.
- Sampling at well 399-4-7 in December was successful, but the water level could not be measured due to an access issue.

Minor exceptions to planned monitoring occurred due to maintenance issues and scheduling constraints. Appendix A lists the sampling exceptions during 2017 for the 300-FF-5 OU CERCLA monitoring wells. Figure 7-1 shows locations of wells sampled in 2017.

A total of 48 uranium sequestration injection wells and 19 uranium sequestration monitoring wells were installed in 2017 to support Stage B of the enhanced attenuation remedy (Table 7-2).

Table 7-2. Wells and Boreholes Installed in 300-FF in 2017

Well		Purpose*	Depth				Acceptance Date	Comment
			Construction		Drilled			
Name	ID		m bgs	ft bgs	m bgs	ft bgs		
399-1-98 through 399-1-145	C9642 through C9689	300-FF-5 OU uranium sequestration injection	10.2 to 13.8	33.4 to 45.2	10.3 to 14.0	33.8 to 45.8	April and May 2017	48 wells
399-1-146 through 399-1-166	C9690 through C9710	300-FF-5 OU uranium sequestration monitoring	11.0 to 13.8	36.2 to 45.3	11.0 to 14.3	36.2 to 47.0	April and May 2017	19 wells

*DOE/RL-2014-42-ADD1, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan Addendum for Stage B Uranium Sequestration*.

bgs = below ground surface

ID = identification

OU = operable unit

7.6.2 Groundwater Remediation

The RAOs identified in the ROD for the 300-FF-5 OU (EPA et al., 2013) are as follows:

- Prevent human exposure to groundwater containing COC concentrations above cleanup levels.
- Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above cleanup levels for protection of groundwater, and of surface water concentrations above cleanup levels for the protection of surface water at locations where groundwater discharges to surface water.
- Restore groundwater impacted by Hanford Site releases to cleanup levels that include DWSs, within a timeframe that is reasonable given the particular circumstances of the site.

The RAOs will be achieved through four remedy components: (1) MNA for nitrate, tritium, TCE, and *cis*-1,2-DCE; (2) groundwater monitoring for uranium, gross alpha, nitrate, tritium, TCE, and *cis*-1,2-DCE; (3) enhanced attenuation of uranium using sequestration by phosphate application in the vadose zone and at the top of the aquifer; and (4) ICs.

The enhanced attenuation component of the groundwater remedy involves infiltrating and injecting phosphate solutions to the vadose zone and top of the aquifer to sequester residual mobile uranium in insoluble minerals. The phosphate applications target a 1.2 ha (3 ac) area near the former 300 Area Process Trenches (316-5) and North Process Pond (316-2) in the 300 Area Industrial Complex. Uranium sequestration is being implemented using a staged approach. Stage A consisted of performing infiltration and injection of phosphate solutions in one quadrant (0.3 ha [0.75 ac]) of the 1.2 ha (3 ac) target area (Figure 7-9). Stage B phosphate application is planned to be implemented in the remaining three quadrants (0.9 ha [2.25 ac]). The purpose of Stage A was to perform the remedy on a small area, evaluate the effectiveness in meeting the goals of the ROD, and establish a baseline from which to refine operations for Stage B.

Stage A of the enhanced attenuation remedy was implemented in November 2015 in accordance with the SAP (Chapters 2 and 3 of DOE/RL-2014-42). Installation of the Stage A system is described in SGW-59455, *300-FF-5 Operable Unit Stage A Uranium Sequestration System Installation Report*. A report (SGW-59614, *300-FF-5 Operable Unit Enhanced Attenuation Stage A Delivery Performance Report*) evaluating the performance of the Stage A phosphate applications for uranium sequestration was issued in December 2016. Initial performance indicators are positive for uranium sequestration in the Stage A enhanced attenuation area. Initial amorphous phosphate minerals appear to be sequestering uranium, as expected. The permanence of the sequestration treatment depends on the current meta-stable compounds eventually forming stable minerals. The efficacy of the sequestration process will be evident after longer term groundwater results are available.

An addendum to the remedy implementation SAP (DOE/RL-2014-42-ADD1) was issued in December 2016 to provide the requirements for Stage B implementation, performance monitoring, and groundwater monitoring. Stage B of the remedy was planned to be implemented in 2017 but was postponed for one year to allow time for additional groundwater monitoring and evaluation (TPA-CN-0784). Uranium sequestration monitoring was conducted monthly at 11 wells during 2017. Stage B phosphate injections are planned for August/September 2018.

Calculations were completed in 2017 (using data through 2016) to evaluate whether each well in the groundwater network had reached the cleanup level for each required COC. The calculations follow the methodology presented in SGW-58883. The cleanup level was attained for TCE at well 399-4-14. Well 399-4-14 is the only well monitored for TCE under the CERCLA SAP (DOE/RL-2014-42). Calculations using 2017 data are underway in 2018.

Waste sites are being remediated to eliminate continuing sources of contamination. Remediation of the 618-10 Burial Ground and 316-4 Crib was completed in 2017. The following two groundwater wells were decommissioned to support waste site remediation: 699-S6-E4A in 2016 and 699-S6-E4L in 2015. A replacement well for well 699-S6-E4A is planned for 2018.

7.6.3 Other CERCLA Activities

The PNNL Subsurface Biogeochemical Research Scientific Focus Area continued field investigations and modeling along the Columbia River Corridor within the 300 Area during 2017 to evaluate groundwater/surface water interactions. The emphasis of these studies is understanding watershed-scale impacts of variable river discharge on biogeochemistry and ecology within the River Corridor. The scientific focus area investigated the effects of river stage on river/groundwater exchange using (1) a new approach for integrating measurements of vertical temperature profiles with time series of observed river stage and groundwater levels (Zhou et al., 2017, “A New Approach to Quantify Shallow Water Hydrologic Exchanges in a Large Regulated River Reach”); and (2) a three-dimensional hydrodynamic simulation of river flow coupled to subsurface flow in a 7 km (4.3 mi) river section. The scientific focus area also investigated the impacts of riparian vegetation and variable discharge on the behavior of organic carbon (Graham et al., 2017, “Carbon inputs from riparian vegetation limit oxidation of physically bound organic carbon via biochemical and thermodynamic processes”; Goldman et al., 2017, “Biogeochemical cycling at the aquatic-terrestrial interface is linked to parafluvial hyporheic zone inundation history”); nitrate (Liu et al., 2017a, “Effect of Water Chemistry and Hydrodynamics on Nitrogen Transformation Activity and Microbial Community Functional Potential in Hyporheic Zone Sediment Columns”); and chromium (Liu et al., 2017b, “Coupled Hydro-Biogeochemical Processes Controlling Cr Reductive Immobilization in Columbia River Hyporheic Zone”). These results are currently being incorporated into new biogeochemical reaction models that will improve numerical simulations of near-river (hyporheic zone) biogeochemistry

(Song et al., 2017, "Regulation-Structured Dynamic Metabolic Model Provides a Potential Mechanism for Delayed Enzyme Response in Denitrification Process").

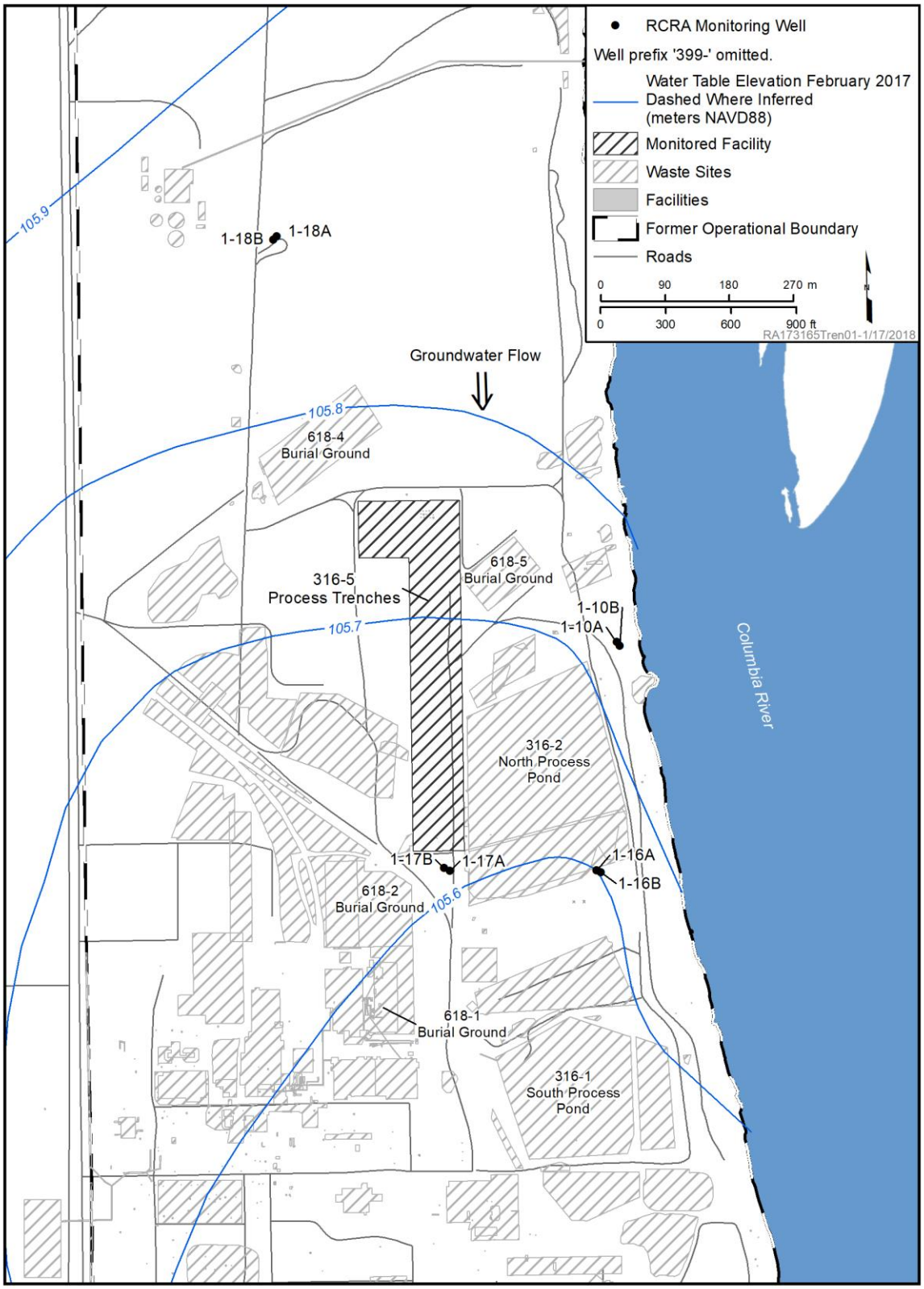
The scientific focus area is expanding the scope of River Corridor studies to other areas of the Hanford Reach. New data analysis and modeling methods are being developed to guide proposed placement of observational systems and support experimental design for the Hanford Reach. These methods include new approaches for representing the bathymetry and hydrodynamics of the river and coupling high-resolution surface and subsurface flow simulations over segments of the Hanford Reach. Observations of river water intrusion, reactive tracer tests, vertical temperature profiling, and automated sampling of hyporheic zone biogeochemical parameters are examples of critical data that will be assimilated into numerical models to provide enhanced predictive understanding of River Corridor and watershed function. Several additional papers are being developed summarizing the results of the above studies.

7.7 RCRA Monitoring at 316-5 Process Trenches

The former 300 Area Process Trenches (316-5 waste site) are monitored in accordance with the Hanford RCRA Permit. The 300 Area Process Trenches (Figure 7-17) received mixed waste effluent discharges from fuel fabrication and nuclear research laboratories in the 300 Area Industrial Complex from 1975 to 1987, followed by continued discharge of cooling water with small quantities of nonhazardous maintenance and process waste until December 1994. A comprehensive description, including a history of operations, is provided in Section 3.1.1 of the final status groundwater monitoring plan for the 300 Area Process Trenches in Part VI of the Hanford RCRA Permit, Revision 8c.

DOE remediated the 300 Area Process Trenches in 1991 under a CERCLA expedited response action by scraping contaminated soil to the north end of the trenches (DOE/RL-92-32, *Expedited Response Action Assessment for 316-5 Process Trenches*). Additional removal actions were performed in 1997 and 1998, followed by backfilling and surface restoration in 2004 (Chapter 3 of DOE/RL-2004-74). DOE/RL-93-73, *300 Area Process Trenches Modified Closure/Postclosure Plan*, states that groundwater remediation is deferred to the 300-FF-5 OU under CERCLA. DOE/RL-2014-13-ADD2 (modified by TPA-CN-700, *Tri-Party Agreement Change Notice Form: DOE/RL-2014-13-ADD2, Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater, Rev. 0*) describes the work elements and schedule for implementing the groundwater remedy selected in the 2013 CERCLA ROD (EPA et al., 2013).

Groundwater monitoring to meet RCRA requirements is conducted in accordance with the final status groundwater monitoring plan for the 300 Area Process Trenches, which was incorporated into Part VI of the Hanford RCRA Permit, Revision 8c, on May 24, 2017. This new plan supersedes WHC-SD-EN-AP-185, *Groundwater Monitoring Plan for the 300 Area Process Trenches*. The new plan monitors *cis*-1,2-DCE, TCE, and field parameters (pH, specific conductance, temperature, and turbidity). Sampling is conducted semiannually. In the new monitoring plan, the concentration limits for *cis*-1,2-DCE and TCE are 16 and 4 µg/L, respectively, consistent with the cleanup levels in the CERCLA ROD (EPA et al., 2013). Table 3-9 in the new plan summarizes the main differences between the new plan and the previous plan.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 7-17. 316-5 Process Trenches

The RCRA post-closure groundwater monitoring under the WAC 173-303-645 corrective action program uses wells at four locations: one upgradient (northwest) and three downgradient (east, southeast, and south) of the former 300 Area Process Trenches (Table B-41 in Appendix B). The most distant downgradient location is about 200 m (660 ft) to the southeast, along the dominant groundwater flow path from the trenches. Two wells are at each of the four locations. Well numbers ending in "A" are screened near the water table, and well numbers ending in "B" are screened in the lower portion of the unconfined aquifer.

The water table near the former trenches is not declining and is directly affected by the Columbia River stage. Dry well conditions are unlikely in the future (Section 3.2.5 of the final status groundwater monitoring plan in Part VI of the Hanford RCRA Permit, Revision 8c). Groundwater flows generally toward the south-southeast beneath the former trenches. In late February 2017, the gradient sloped to the south, and the estimated groundwater flow rate was 17 m/d (55 ft/d) (Table B-42 in Appendix B).

The sampling schedule for the monitoring wells is designed to accommodate two semiannual sampling events, with collection scheduled during high river stage (typically May through June) and low river stage (typically September to November). This annual report for 2017 includes *cis*-1,2-DCE and TCE results for samples collected in January, February, and March under the old plan and results for samples collected in June and October under the new plan. In 2017, sampling was performed as planned (Table B-43 in Appendix B).

The results of 300 Area Process Trenches groundwater monitoring are reported semiannually. DOE prepared two semiannual reports for 2017 (SGW-61150, *Post-Closure Corrective Action Groundwater Monitoring Report for the 300 Area Process Trenches: January – June 2017*; SGW-61754, *Post-Closure Corrective Action Groundwater Monitoring Report for the 300 Area Process Trenches: July – December 2017*).

During 2017, TCE concentrations were below the Hanford RCRA Permit limit and were mostly below the analytical detection limit (Table B-43 in Appendix B). The trace detections of TCE in well 399-1-16A may be from the former 300 Area Process Trenches or the former 316-2 North Process Pond.

In all of the well 399-1-16B samples, *cis*-1,2-DCE continued to exceed the permit limit, with concentrations ranging from 136 to 191 µg/L. Lower levels of *cis*-1,2-DCE were detected in well 399-1-17B, with a maximum of 1.9 µg/L.

In accordance with Section 3.3.2 of the final status groundwater monitoring plan in Part VI of the Hanford RCRA Permit, Revision 8c, a statistical evaluation was performed to compare the dangerous waste constituent results to the permit concentration limits. The evaluation applies to results at individual point of compliance (downgradient) wells (Table B-41 in Appendix B). The 95% UCL on the mean is used for results that exceed concentration limits. A nonstatistical analysis is used for results that are less than concentration limits.

The statistical evaluation is conducted semiannually (SGW-61150, SGW-61754). The only 95% UCL that exceeded the permit concentration limit in a downgradient well was for *cis*-1,2-DCE in well 399-1-16B (Table B-44 in Appendix B).

7.8 Atomic Energy Act Monitoring

AEA groundwater monitoring was scheduled at 75 groundwater wells and aquifer tubes in the 300-FF groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 300-FF are uranium, tritium, and nitrate. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Five wells were not sampled in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues, dry wells, and well access issues.

Concentrations of radionuclides detected in groundwater samples from 85 wells[1] and aquifer tubes were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4 (Table 7-3). The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at four locations in this interest area. The DWS for cumulative alpha emitters was not exceeded, but one location did exceed the EPA net alpha activity standard. The uranium mass DWS of 30 µg/L was exceeded at 44 locations. Some of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. CERCLA remedial action decisions (e.g., enhanced attenuation in 300-FF-5) provide additional protection of the public and the environment.

Table 7-3. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 300-FF in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
103mArray-US25			73.8	73.8		
399-1-1			44	44		
399-105			102	102		
399-1-118			64.2	116		
399-1-129			5460*	8450*		
399-1-139			49	90.7		
399-1-158			32.8	94		
399-1-159			52.8	71.2		
399-1-162			34.6	45.8		
399-1-16A			30.6	54.8		
399-1-17A			36.1	177		
399-1-23			30.2	82.2		

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

Table 7-3. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 300-FF in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
399-1-55			55.6	437		
399-1-62			847	1260		
399-1-63			59.9	59.9		
399-1-67			123	123		
399-1-7			45.9	54.1		
399-2-1			59.3	59.3		
399-2-2			32.9	81		
399-3-1			69.04	69.04		
399-3-10			146	146		
399-3-12			65.8	65.8		
399-3-33			69.3	69.3		
399-3-37			36.8	36.8		
399-3-38			36.1	36.1		
399-3-6			56.1	56.1		
399-3-9			120	120		
399-4-1			31.8	31.8		
399-4-10			68	68		
399-4-14			39.8	39.8		
399-4-7			46	46		
399-4-9			87.7	87.7		
399-6-3			194	194	28.59	28.59
399-8-1			65.79	65.79		
399-8-5A			60.5	60.5		
399-13-0A	7.06	8.6				
399-13-1E	14.4	16.38				
399-13-2D	33.56	35.6				
699-13-3A	64.4	114				
AT-3-1-M			38.2	38.2		
AT-3-2-M			81.4	81.4		

Table 7-3. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 300-FF in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
AT-3-5-S			71.4	71.4		
C6347			175	175		
C6350			42.2	42.2		

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Notes: Blank cells indicate no exceedances.

None of the wells in 300-FF had cumulative total effective dose ≥100 mrem/yr or cumulative alpha activity ≥15 pCi/L.

*Characterization sampling.

8 1100-EM

The 1100-EM interest area is a small region in the southeastern corner of the Hanford Site, south of the 300 Area (Figures 1-1 and 8-1). The adjacent offsite region, which includes part of the former 1100-EM-1 Groundwater OU, is informally known as Richland North. This chapter discusses groundwater monitoring results for 1100-EM and Richland North.

8.1 Overview

The former 1100-EM-1 OU included the inactive DOE Horn Rapids Landfill, used from the late 1940s to the 1970s for disposal of office and construction waste, asbestos, sewage sludge, fly ash, and reportedly numerous drums of unidentified organic liquids (Section 1.3 of DOE/RL-90-18, *Phase 1 Remedial Investigation Report for the Hanford Site 1100-EM-1 Operable Unit*). Following cleanup of 1100-EM-1 and related source OUs, it was delisted from the NPL and DOE transferred ownership of a portion of the property to the Port of Benton in 1998.

The Richland North Area includes the city of Richland north well field and recharge ponds. The city of Richland pumps Columbia River water into the recharge ponds, the water percolates to the groundwater, and is then pumped through surrounding wells for municipal use during peak demand periods (WHC-MR-0033, *Recharge to the North Richland Well Field*, p. 3). The Richland North Area also includes the AREVA NP, Inc.[1] nuclear fuel production facility, which is southwest (upgradient) of the inactive DOE Horn Rapids Landfill. Table 8-1 provides some key facts about 1100-EM. Table 3-7 in DOE/RL-2015-56 lists the monitoring wells and constituents.

Groundwater beneath 1100-EM and Richland North flows primarily west to east and discharges to the Columbia River (Figure 8-2). Groundwater flow from the west is diverted to the northeast and southeast around a recharge mound beneath Richland's recharge ponds. Other sources of recharge to the unconfined aquifer are the Yakima River, agricultural irrigation, and natural precipitation.

The thickness of the unconfined aquifer in this area is 5.6 to 9 m (18 to 30 ft), with all but the upper few meters residing in Ringold unit E (Figure 8-3). A silt- and clay-dominated facies forms a local, laterally extensive upper aquitard up to 10 m (33 ft) thick.

8.2 Nitrate

Nitrate concentrations are above 45 mg/L throughout much of 1100-EM, Richland North, and the southern part of 300-FF (Figure 8-4). Section 1.5 provides details about plume mapping, including descriptions of the terms used in the figure legends (e.g., Type 1 control point). Nitrate contamination has likely resulted from industrial and agricultural uses off the Hanford Site and migrated to the northeast. Agricultural uses include fertilizer applications to the irrigated fields west of 1100-EM. The highest nitrate concentrations in 2017 were in wells 699-S28-E12 (in the 300-FF groundwater interest area), 699-S31-E10A, and 699-S31-E10C (Figure 8-5), but the concentrations are declining. The wells are located downgradient of AREVA and the inactive DOE Horn Rapids Landfill.

[1] In early 2018, AREVA became Framatome.

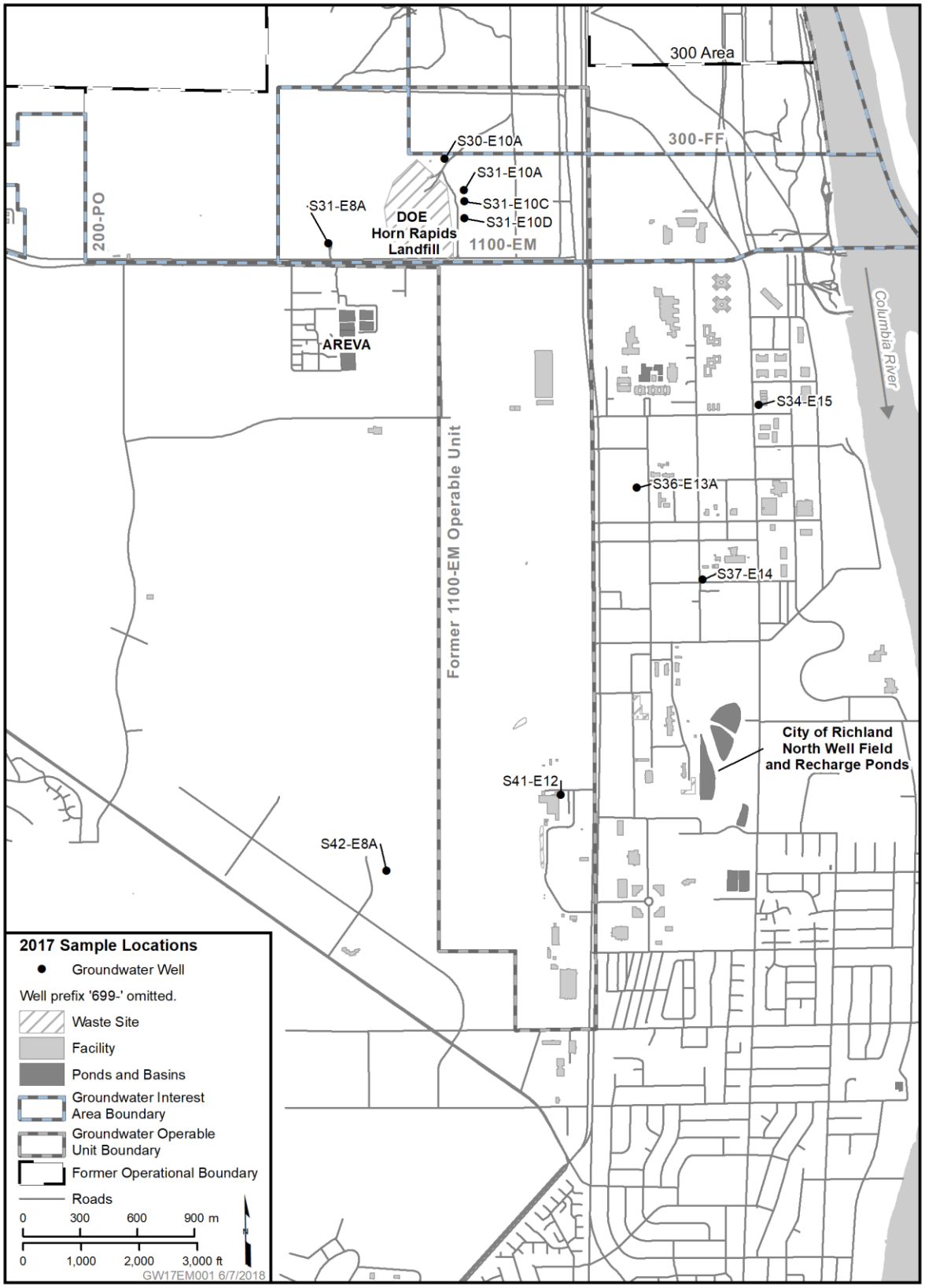


Figure 8-1. 1100-EM Sampling Locations, 2017

Table 8-1. 1100-EM at a Glance

Operations included industrial and automotive activities (1954 to 1985) and a landfill (1950s to 1970).		
Groundwater Monitoring		
Contaminant,[a] DWS, Units	**Year**	**Maximum Concentration**
Nitrate, 45 mg/L[b]	2017	150 (699-S31-E10A)
	2016	155 (699-S31-E10C)
Uranium, 30 µg/L	2017	34.5 (699-S31-E10C)
	2016	40.9 (699-S31-E10-D)
Remediation		
Waste sites (final action): 100% complete.[c] **Groundwater (final action):** Monitored natural attenuation has met remedial action goals. **Record of Decision for final remedial action:** 1993		

a. Nitrate and uranium in 1100-EM are from offsite sources. Plume areas are not calculated.

b. 45 mg/L (expressed as the NO_3 ion) is an equivalent concentration to the federal DWS for nitrate of 10 mg/L (expressed as NO_3-N). To convert nitrate as the NO_3 ion, the NO_3-N DWS value is multiplied by 4.43.

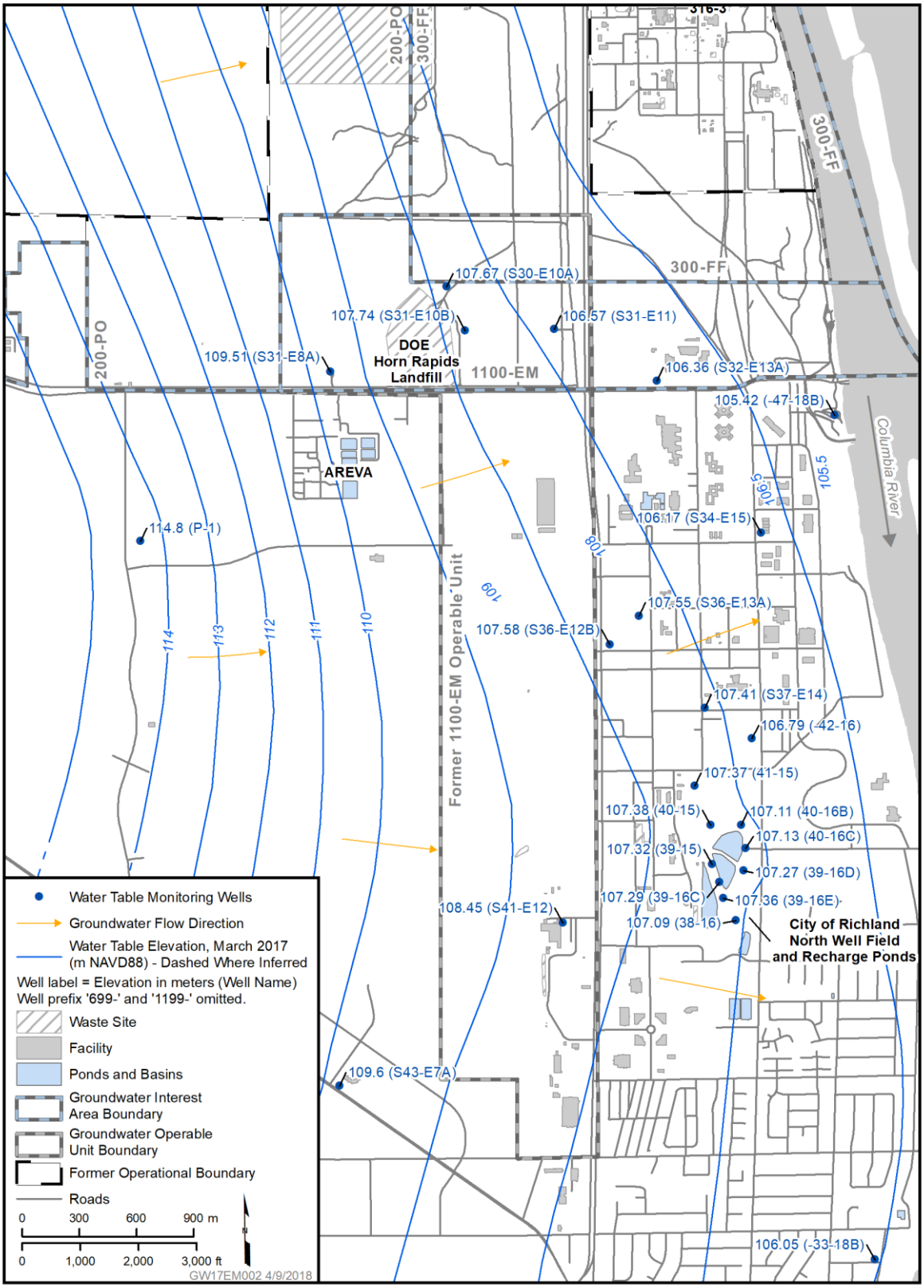
c. Sites with status of closed, interim closed, no action, not accepted, or rejected.

DWS = drinking water standard

8.3 Tritium

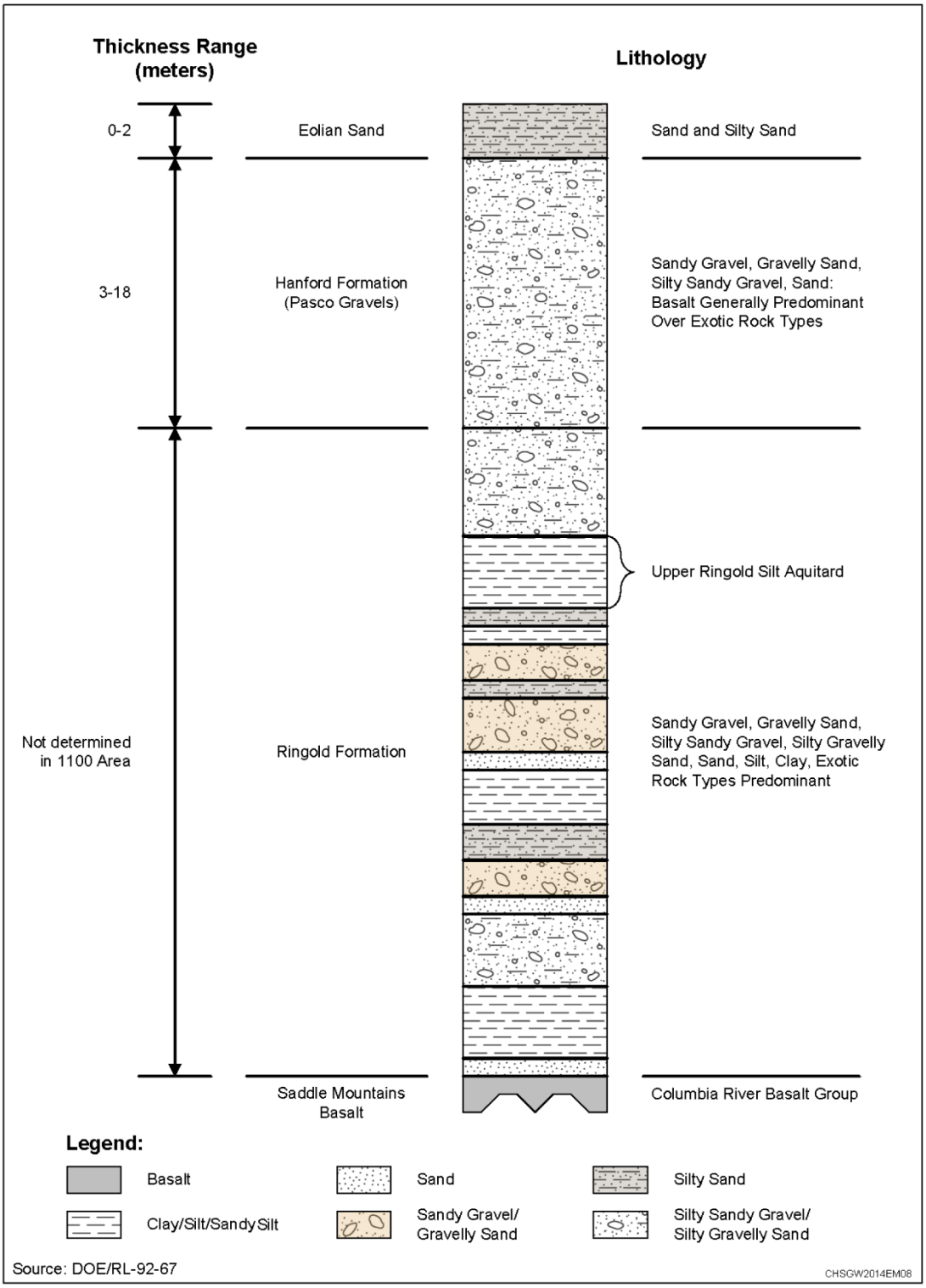
The Hanford Site tritium plume that originated in the 200 Areas extends southeast through the 600 Area and into the 300-FF groundwater interest area at levels below the 20,000 pCi/L DWS. The plume reached its maximum extent in this region in about 1999 (Figure 2.1-3 of PNNL-13116), then the plume began to shrink as concentrations in monitoring wells declined. The maximum tritium concentration in a well in the 300 Area in 2017 was 4,160 pCi/L (399-1-1).

Because groundwater flow in the 1100-EM groundwater interest area is generally west to east, the Hanford Site tritium plume does not migrate southward toward 1100-EM. Wells in 1100-EM are sampled for tritium every 3 to 6 years under the AEA SAP (Table A-25 of DOE/RL-2015-56). In recent years, concentrations remained near or below detection limits (less than 200 pCi/L).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 8-2. 1100-EM Water Table, March 2017



Source: Figure 2-2 of DOE/RL-92-67, *Final Remedial Investigation/Feasibility Study-Environmental Assessment Report for the 1100-EM-1 Operable Unit, Hanford*.

Figure 8-3. 1100-EM Geology

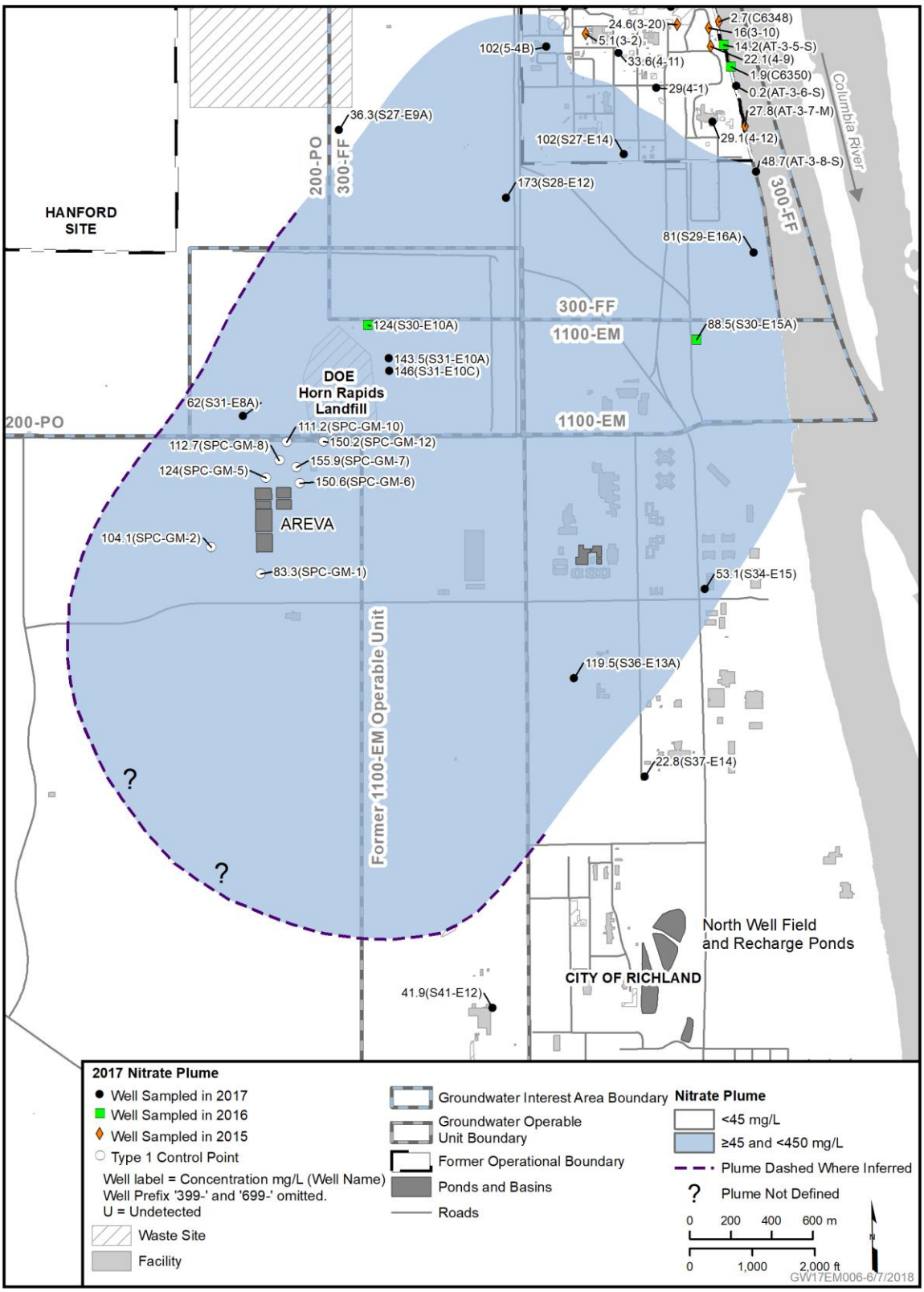


Figure 8-4. Nitrate Plume in 1100-EM, Richland North, and the 300 Area in 2017

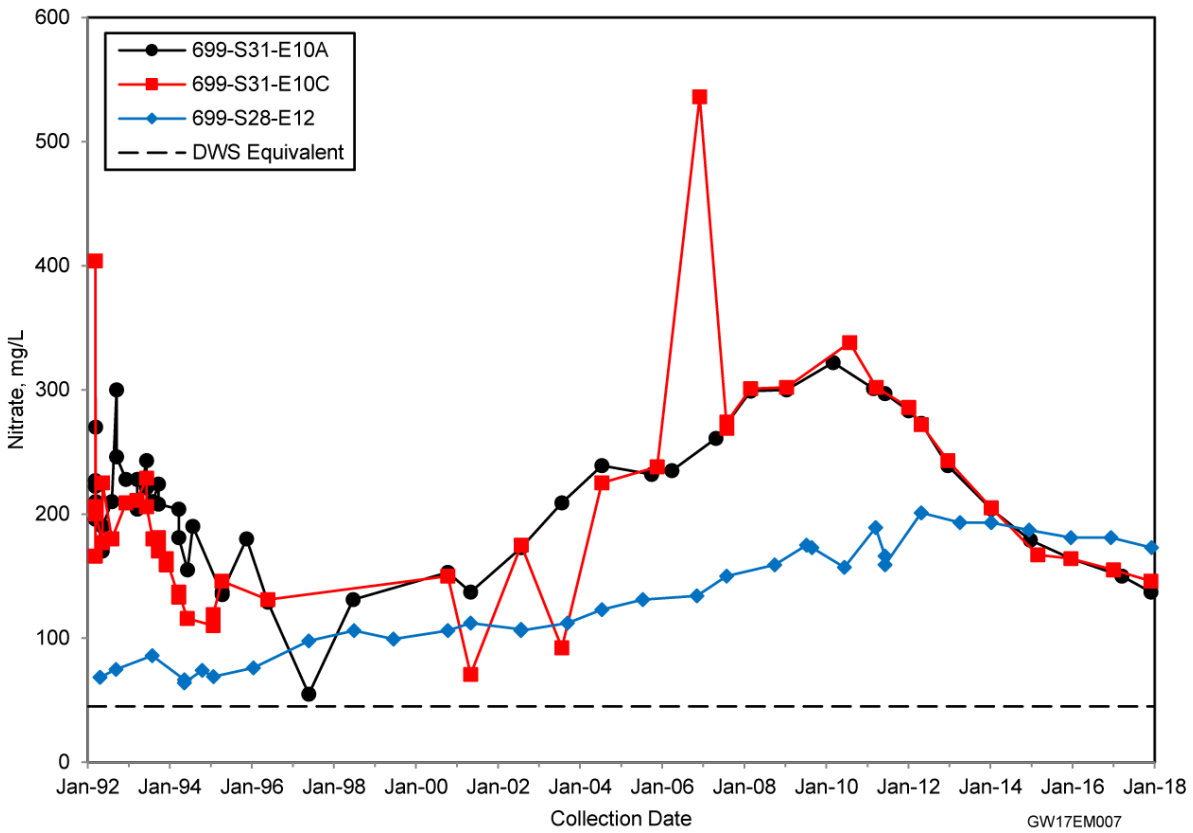


Figure 8-5. 1100-EM Nitrate Data for Wells 699-S28-E12, 699-S31-E10A, and 699-S31-E10C

8.4 Uranium

A uranium plume with concentrations above the 30 µg/L DWS originated from the offsite AREVA facility and affects monitoring wells in the southern part of the Hanford Site (Figure 8-6). An investigation of the site attributed the groundwater contamination to operation of a surface impoundment system in the 1970s and 1980s when some of the impoundments were single-lined and without leak collection capabilities (WAD 99082 8402, *Dangerous Waste Management Permit AREVA NP Inc.*). The impoundment system was subsequently removed.

The maximum uranium concentration in an AREVA well in 2017 was 32.7 µg/L. Concentrations in three Hanford Site wells downgradient from AREVA exceeded the 30 µg/L DWS in 2017. The maximum concentration was 34.5 µg/L in well 699-S31-E10C (Figure 8-7).

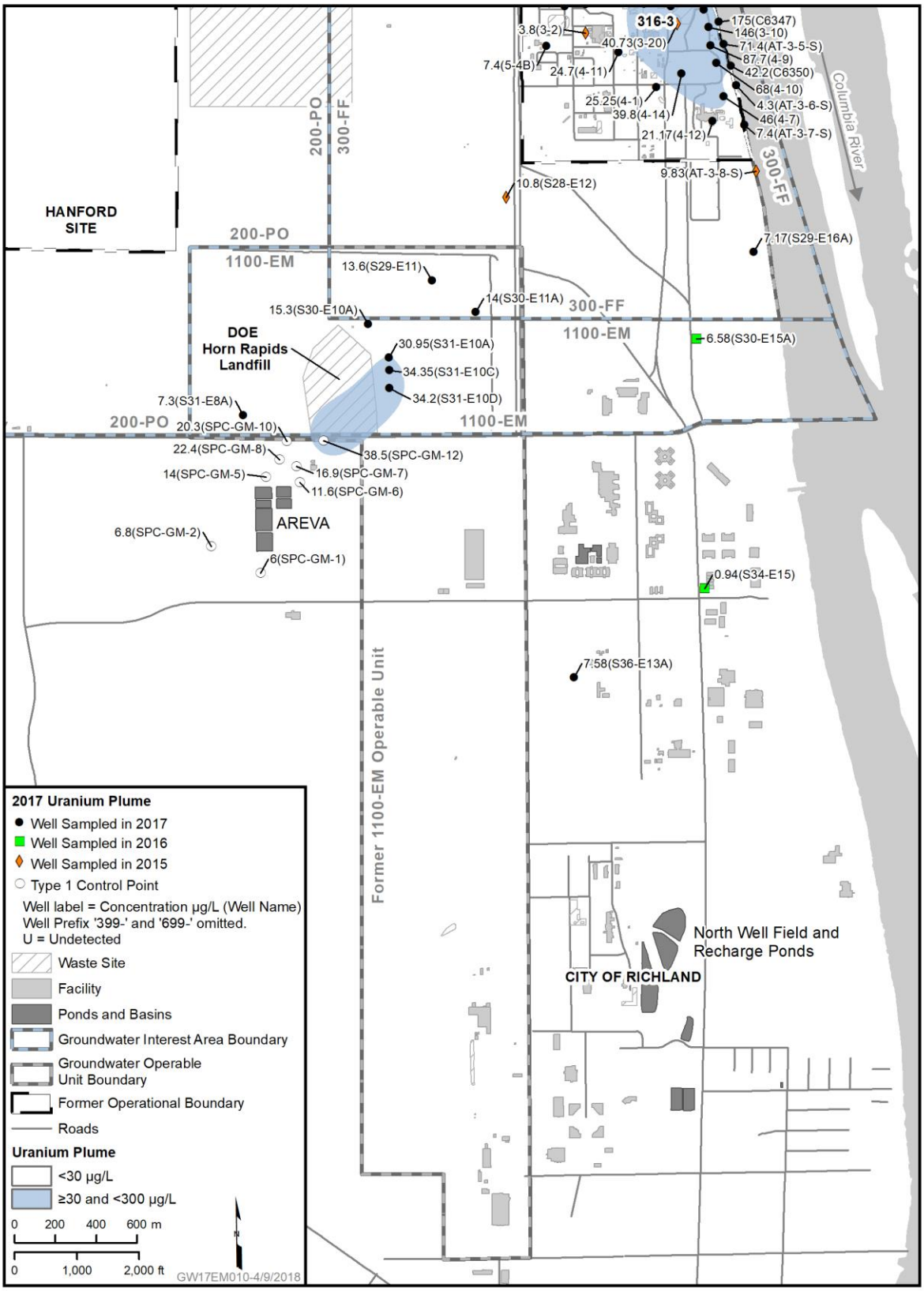


Figure 8-6. AREVA Uranium Plume, Richland North and 1100-EM, 2017

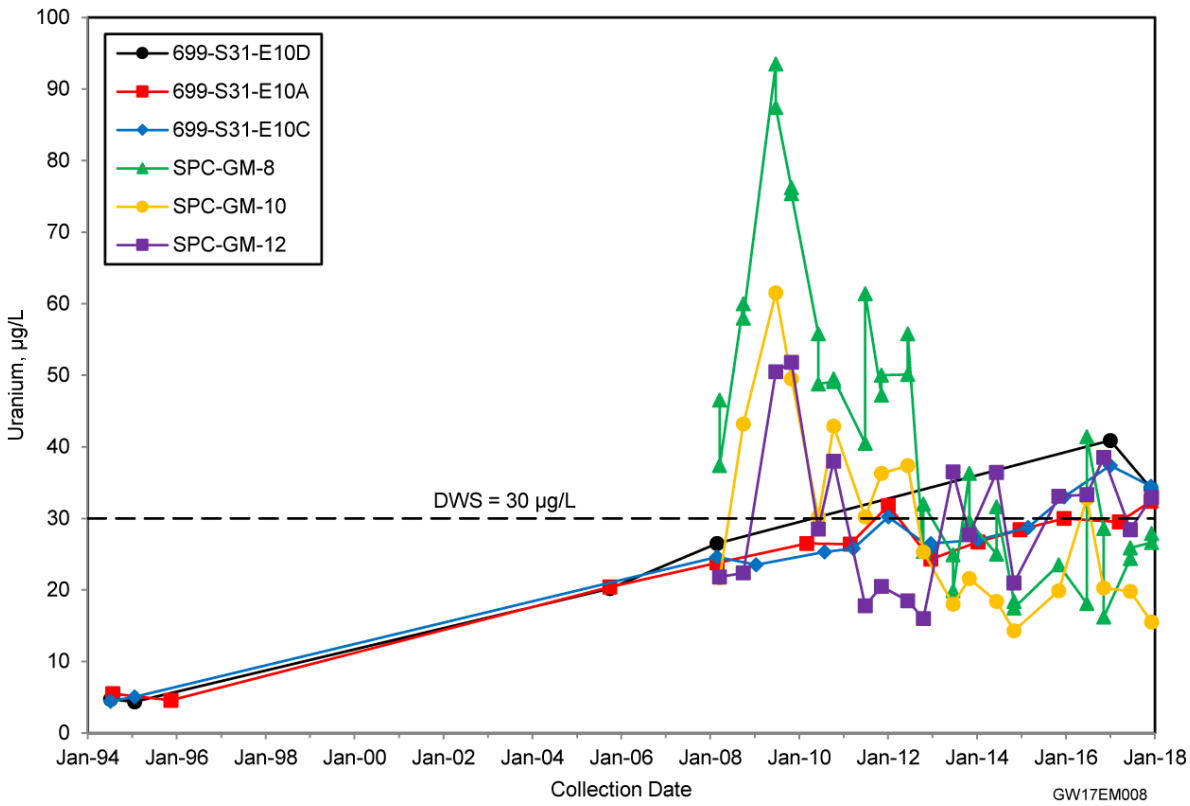


Figure 8-7. 1100-EM Uranium Data for Wells Downgradient of AREVA and Inactive Horn Rapids Landfill

8.5 CERCLA Remediation and Monitoring

In 1993, the Tri-Parties signed a ROD for the 1100 Area, which included the 1100-EM-1 Groundwater OU and the 1100-EM-2 and 1100-EM-3 Source OUs (EPA/ROD/R10-93/063, *Declaration of the Record of Decision for the USDOE Hanford 1100 Area*). The ROD had a groundwater component that relied on MNA for TCE, with a cleanup level of 5 µg/L. In 2006, the second CERCLA 5-year review (DOE/RL-2006-20) concluded that remedies selected for the 1100-EM-1 OU had been completed. The RAOs established in the ROD have been achieved and are protective of human health and the environment, so the 1100 Area was removed from the NPL and the Tri-Parties agreed to a reduction in groundwater monitoring (TPA-CN-163, *Change Notice for Modifying Approved Documents Work Plans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: PNNL-12220, "Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit"*). Monitoring included annual sampling of wells 699-S28-E12, 699-S31-E10A, and 699-S31-E10C for TCE, vinyl chloride, and 1,1-dichloroethene to ensure that remedial action goals were achieved. In 2015, TPA-CN-679, *Change Notice for Modifying Approved Documents Work Plans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: PNNL-12220, "Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit,"* eliminated the need for groundwater monitoring for the 1100-EM-1 OU.

8.6 Atomic Energy Act Monitoring

AEA groundwater monitoring was scheduled at six groundwater wells in the 1100-EM groundwater interest area and six wells in the Richland North Area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 1100-EM are nitrate and uranium and for Richland North are nitrate and tritium. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). One well was not sampled for 1100-EM in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to scheduling constraints.

Radionuclide concentrations detected in groundwater samples from five wells in 1100-EM and six wells in Richland North were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The only exceedances were for uranium mass above the 30 µg/L DWS at three locations in 1100-EM (Table 8-2). As discussed in Section 8.4, this contamination originated offsite. None of these wells are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater.

Table 8-2. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 1100-EM in 2017

Monitoring Location/ Well Name	Cumulative Uranium Mass ≥30 µg/L	
	Minimum	Maximum
699-S31-E10A	32.4	32.4
699-S31-E10C	34.5	34.5
699-S31-E10D	34.2	34.2

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Note: None of the wells in 1100-EM had total effective dose ≥100 mrem/yr, cumulative beta/photon emitters >4 mrem/yr, or cumulative alpha activity ≥15 pCi/L.

9 200-BP

This chapter presents information for the 200-BP groundwater interest area, which includes groundwater and associated contaminant plumes beneath the northern half of the 200 East Area and adjacent portions of the surrounding 600 Area (Figures 9-1 and 9-2). This chapter includes an overview; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2017; and a summary of 2017 groundwater monitoring results.

9.1 Overview

The 200-BP interest area, which includes the 200-BP-5 Groundwater OU and six RCRA sites, extends from the northern portion of the 200 East Area to the northwest, to the Columbia River shoreline. The main process separation facilities overlying the OU were B Plant and the Hot Semiworks Facility. Table 4-4 of the 200-BP-5 RI/FS (DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*) summarized the following sources of groundwater contamination, grouped within regions of 200-BP (Figure 9-2).

- B Complex (northwestern 200 East Area):
  - UPR from tank 241-BX-102 (highly contaminated waste stream that included uranium, technetium-99, tritium, iodine-129, and nitrate)
  - BY Cribs (moderately contaminated waste stream with technetium-99, iodine-129, cobalt-60, cyanide, and nitrate)
  - UPR near tank 241-B-105 (moderately contaminated waste stream with the same contaminants found at the BY Cribs)
  - 216-B-50 Crib (moderately contaminated waste streams with tritium)
  - 216-B-7 A&B Cribs (moderately contaminated waste stream with technetium-99, chromium, and nitrate)
  - 216-B-8 Crib (moderately contaminated waste stream with technetium-99, iodine-129, chromium, and nitrate)
- B Plant:
  - 216-B-12 Crib (moderately contaminated waste stream with uranium, tritium, and nitrate)
  - 216-B-5 injection well (moderately contaminated waste stream with uranium, strontium-90, cesium-137, plutonium-239, and nitrate; injected into the unconfined aquifer)
- WMA C:
  - Various UPRs (highly contaminated waste streams with technetium-99 and nitrate)
- 216-B-2-1 and 216-B-2-2 Ditches (nitrate)
- Gable Mountain Pond (nitrate and strontium-90)
- B Pond (tritium and iodine-129)

Current continuing sources to groundwater have been identified at the B Complex and WMA C (Section 4.2 of DOE/RL-2009-127).

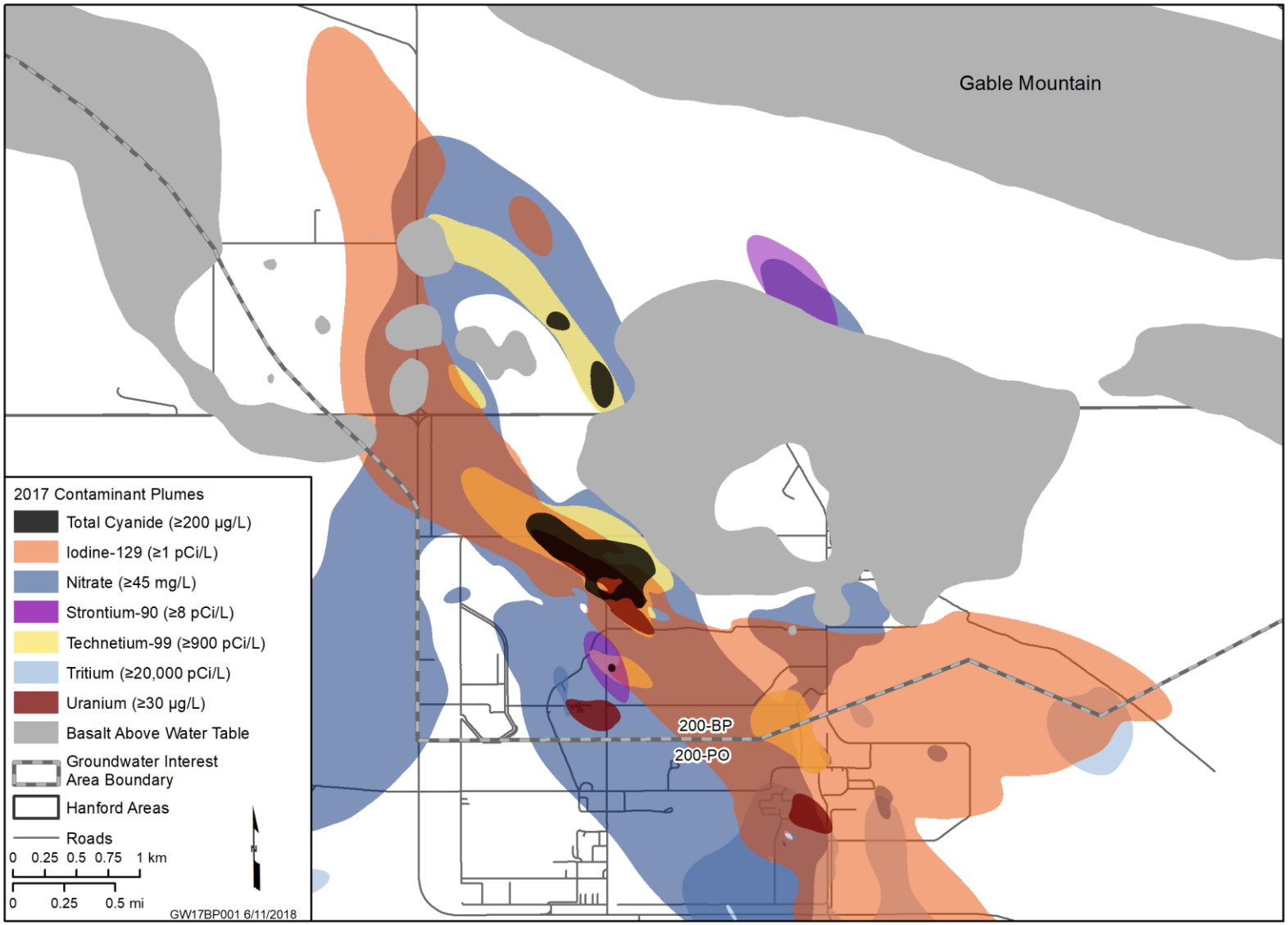


Figure 9-1. 200-BP Groundwater Interest Area and Geometry of Groundwater Contaminant Plumes

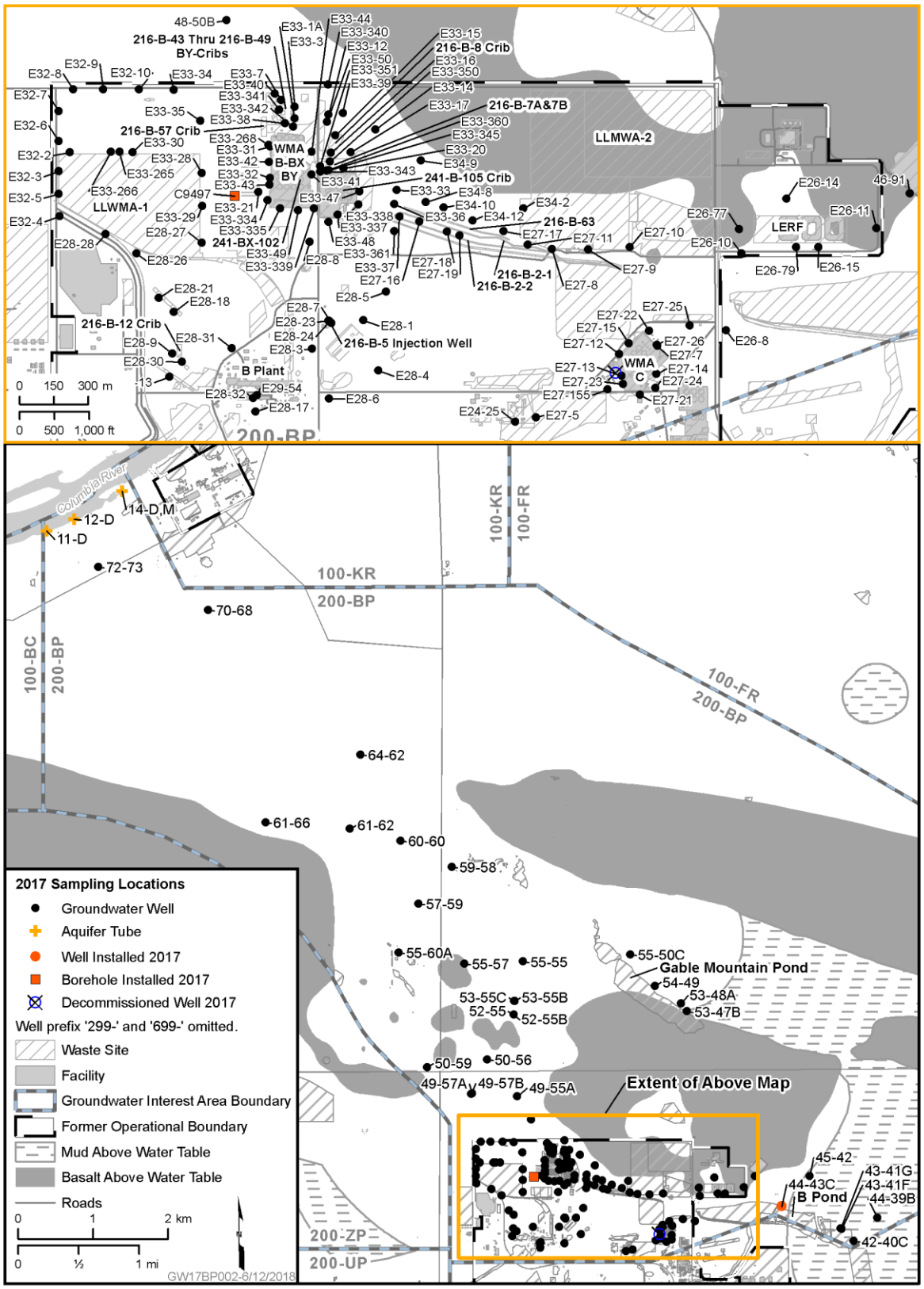


Figure 9-2. 200-BP Sampling Locations, 2017

Nitrate, iodine-129, technetium-99, and uranium are the most extensive groundwater plumes in 200-BP. These contaminants originated mainly from local sources, except for iodine-129, which predominantly migrated into 200-BP from 200-PO in the late 1980s and early 1990s. Groundwater contaminant ratios (e.g., technetium-99-to-nitrate) have been used to distinguish between different sources, as discussed in Section 4.4 of DOE/RL-2009-127. Other contaminants exceeding the DWS have smaller areal extent within 200-BP, including arsenic, cesium-137, cyanide, fluoride, plutonium-239/240, strontium-90, and tritium. In 2017, cesium-137, fluoride, and plutonium-239/240 exceeded the DWS only at monitoring wells adjacent to the decommissioned 216-B-5 injection well, where waste was discharged directly into the aquifer in the past. Arsenic exceeded the 10 µg/L DWS at 23 wells in 200-BP and appears to be associated with analytical variability, geochemical variability, and dispersion from the 216-B-8 Crib. All but two results were less than or equal to Hanford Site background (11.8 µg/L) (Table ES-1 of DOE/RL-96-61). The highest concentration was 23 µg/L near the 216-B-8 Crib at well 299-E33-16, a substantial decrease from 104 µg/L in August 2011. Other nearby wells showed no significant concentration change and the next highest arsenic level was 8.74 µg/L at well 299-E33-360. These contaminants are not discussed further in this chapter; see Section 4.4 of DOE/RL-2009-127 for additional information.

The highest levels of nitrate and uranium in the unconfined aquifer in 200-BP are detected within the northwest portion of the 200 East Area in an area referred to as the B Complex (e.g., WMA B-BX-BY and adjacent liquid waste sites) (see Figure 2 of DOE/RL-2016-41, *Action Memorandum for 200-BP-5 Operable Unit Groundwater Extraction*). Release of significant past contaminant inventories at the B Complex is compounded with a thin, highly permeable, unconfined aquifer, resulting in highly concentrated and extensive plumes. These plumes extend to the northwest and southeast within an ancestral Columbia River paleochannel that incised low-permeability Ringold deposits.

A treatability test (DOE/RL-2010-74, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*) was completed at the B Complex to determine if groundwater extraction was sustainable and a plausible alternative for remediating the groundwater. In December 2016, the Tri-Parties signed an action memorandum (DOE/RL-2016-41) allowing groundwater extraction for mitigation of technetium-99, uranium, and other contaminants. Because of the ongoing groundwater extraction, technetium-99 concentrations in the B Complex have declined and are now lower than at WMA C (Section 9.4).

Table 9-1 lists the plume areas and other pertinent information about 200-BP. Figure 9-3 shows changes in plume areas over time within 200-BP. Abrupt changes in plume area estimates, such as uranium in 2011 and strontium-90 in 2012, are caused by changes in interpretation (e.g., due to data from new wells or changes in plume mapping methods). Section 1.5 provides details about plume mapping, including descriptions of the terms (e.g., Type 1 control point) used in the figure legends.

In 2017, groundwater extraction at two B Complex wells caused declines in concentrations of technetium-99, uranium and other contaminants. The areal extent of the uranium plume exceeding 10 times the DWS (300 µg/L) decreased between 57% and 63% between 2016 and 2017 (ECF-200BP5-17-0245, *B Complex Uranium Plume Reduction Calculation Between Calendar Years 2016 and 2017*). Details of the concentration declines are discussed in the following sections.

Table 9-1. 200-BP at a Glance

B Plant operations: 1945 to 1952 (plutonium separation) 1967 to 1985 (strontium and cesium recovery)			
Groundwater Monitoring			
Contaminant, Water Quality Standard, Units	**Year**	**Maximum Concentration[a] (Well)**	**Plume Area[b] (km^2)**
Nitrate, 45 mg/L	2017	1,590 (299-E33-16)	8.0
	2016	1,510 (299-E33-15)	8.1
Iodine-129, 1 pCi/L[c]	2017	9.67 (299-E27-22)	6.6
	2016	5.27 (299-E27-155)	5.1
Technetium-99, 900 pCi/L[c]	2017	36,000 (299-E33-16)	1.7
	2016	32,700 (299-E33-3)	1.8
Uranium, 30 µg/L	2017	2,970 (299-E33-360)	0.29
	2016	3,790 (299-E33-345)	0.31
Strontium-90, 8 pCi/L[c]	2017	511 (299-E28-24)	0.44
	2016	4,470 (299-E28-25)	0.46
Free cyanide, 200 µg/L	2017	65.9 (299-E33-39 and 299-E33-342)	N/A[d]
	2016	Not analyzed	
Tritium, 20,000 pCi/L[c]	2017	53,700 (299-E28-31)	0.09
	2016	61,400 (299-E28-31)	0.10
Remediation			
Perched water extraction (200-DV-1 Operable Unit) and groundwater extraction as a removal action (200-BP-5 Operable Unit) in the B Complex.			

a. Maximum concentration within the regional unconfined aquifer (i.e., excludes the perched water beneath the B Complex) detected in 2017.

b. Estimated area above the listed water quality standard.

c. Single isotope equivalent drinking water standard. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr.

d. No free cyanide plume defined above 200 µg/L. Free cyanide not measured in 2016.

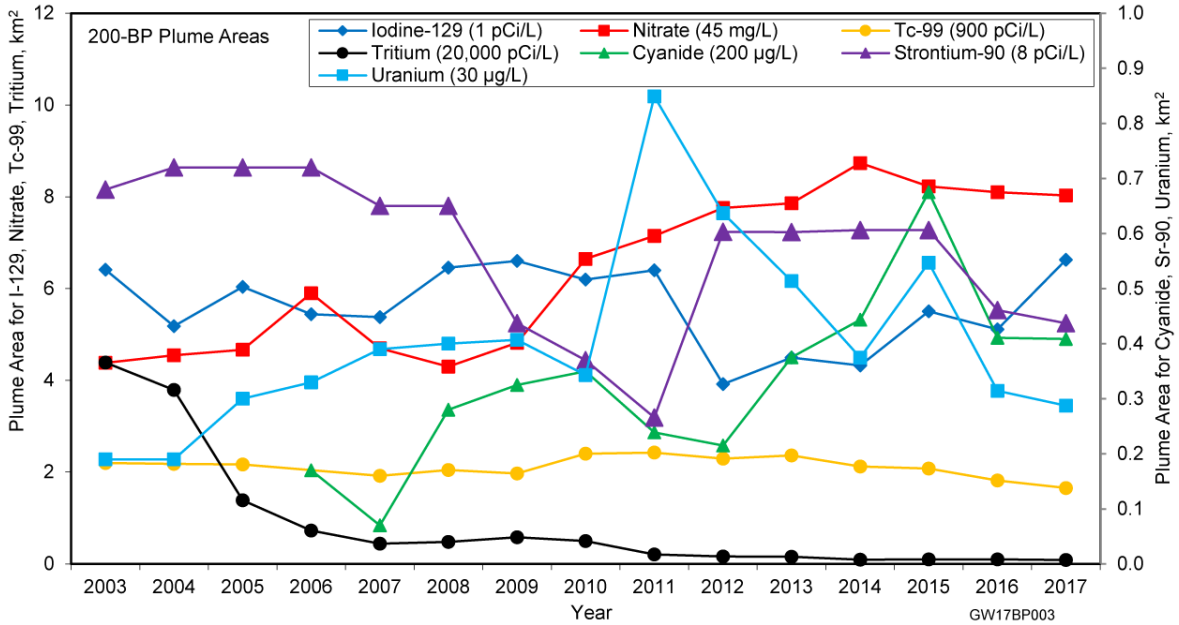


Figure 9-3. 200-BP Plume Areas

Groundwater conditions in 200-BP include a perched zone and unconfined, semiconfined, and confined aquifers. The perched water horizon lies 3 m (10 ft) above the water table, extending along the north side of the B Tank Farm (Figure 2-10 of DOE/RL-2011-102, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-DV-1 Operable Unit*). It is contaminated from a 1951 overfill event associated with tank 241-BX-102, when 347,000 L (91,600 gal) of contaminated liquid was released. The derived release inventory is estimated to include 2.27 Ci of technetium-99; 10,100 kg of uranium; 3,800 kg of nitrate; and 3.85 Ci of tritium (Appendix C of RPP-26744, *Hanford Soil Inventory Model, Rev. 1*). The 2011 reassessment of the 1951 release, as presented in Section 4.2.3 of RPP-RPT-47562, *Hanford BX-Farm Leak Assessment Report*, replaced the RPP-26744 estimate with 20,000 kg of released uranium. DOE is extracting water from the perched zone (Section 9.9), which is a part of the 200-DV-1 OU. Extraction of B Complex contaminated perched water is designed to eliminate contaminant migration into the unconfined aquifer (Section 9.9.2).

The unconfined aquifer within the 200 East Area boundary is the primary aquifer impacted by past waste disposal operations, and it comprises the suprabasalt sediment of the Ringold Formation, CCU, and Hanford formation (Figure 1-6). Depths from land surface to the water table in 200-BP range from less than 1 m (3 ft) near the Columbia River to 105 m (340 ft) in the southern portion of the groundwater interest area. The unconfined aquifer thickness varies from less than 1 m (3 ft) north of the 200 East Area to more than 40 m (130 ft) in Gable Gap. Within and south of Gable Gap, the aquifer is mainly composed of unconsolidated to semiconsolidated gravels of the Hanford formation and CCU. Additional details are provided in Section 4 of PNNL-19702, *Hydrologic Model for the Gable Gap Area, Hanford Site*. Within the northern portion of the 200 East Area and south of the Gable Gap area, deeper units of the Ringold Formation underlie, or have been incised by, the Hanford formation and Cold Creek sediments. An ancestral paleochannel of the Columbia River (Hanford formation gravels) extends from the northwest to the southeast. The base of the aquifer south of Gable Gap is the Elephant Mountain Member of the Columbia River Basalt Group.

Semiconfined aquifers are present in the Ringold Formation beneath and east of the higher permeability paleochannel. More specifically, the semiconfined aquifers are associated with hydrostratigraphic units 9B and 9C (Figure 1-6). Contaminants in the semiconfined area east of the 200 East Area are associated with the former B Pond and are limited to iodine-129 and tritium. Contaminants in the semiconfined aquifer in the western half of the 200 East Area are limited to nitrate and tritium, which are thought to be associated with the 216-B-12 Crib. Some portion of this contamination is also likely associated with past northwestward groundwater migration of PUREX Cribs contaminants from 200-PO.

Within the uppermost basalt-confined aquifer (Rattlesnake Ridge interbed), contamination exceeding the DWS is limited to technetium-99 at well 299-E33-12, beneath the B Complex area.

Water-level monitoring indicates a divide in the water table north of the 200 East Area and south of Gable Mountain and Gable Gap. Figure 9-4 illustrates water table contours based on April 2016 data as an example. The divide appears to be caused by water flowing in from the west and coincides with a buried basalt anticlinal ridge. North of this ridge, groundwater flow is interpreted toward the north through the gap between Gable Mountain and Gable Butte. Groundwater south of this ridge is interpreted to flow south-southeast into the northwestern quarter of the 200 East Area. The water table in the highly transmissive sediments of the paleochannel responds to seasonal changes in Columbia River stage that propagate from the north. However, water-level monitoring conducted between 2014 and 2016 indicated that the flow divide persisted even during periods of high river-stage effects. Before 2011, the divide was farther south, and groundwater flow in the northwestern quarter of the 200 East Area was toward the north. The flow direction changed 180 degrees in July 2011 due to ongoing water table declines in the 200 East Area and temporal Columbia River stages.

Figure 9-5 shows the groundwater flow directions in the 200 East Area. The inferred directions are based on contaminant migration and low-gradient water table maps. Figure 9-6 provides a more detailed depiction of the water table in a portion of the 200 East Area. The process used to complete the detailed water table map is discussed in ECF-200E-18-0016, *Preparation of 200 East Area Water Table Maps for Calendar Year 2017*. The use of water-level data to determine groundwater flow directions in the 200 East Area has been problematic because of a very low hydraulic gradient magnitude combined with a relatively large depth to water. This results in a low signal-to-noise ratio in the water-level elevation measurements, making it difficult to determine the hydraulic gradient. This problem has been reduced by improving the accuracy of the water-level measurements by resurveying well casing elevations and performing borehole path surveys. In addition, this method analyzes the data by trend surface analysis using average monthly measurements over a 12-month timeframe. While this process reduces error by averaging, it only provides a general regional direction of groundwater flow, which is sometimes not consistent with localized contaminant migration. Thus, flow direction is also determined by local plume geometries with local improved water-level accuracy measurements when sufficient to provide statistically reliable gradient and direction determinations, consistent with the plume geometries.

9.2 Nitrate

Groundwater contamination exceeding the 45 mg/L DWS equivalent covers a large portion of the southern half of 200-BP, and concentrations greater than 450 mg/L are focused at the B Complex and B Plant (Figure 9-7). These two areas are associated with uranium recovery waste where specific liquid waste sites received over 1 million kg of nitrate waste (Appendix C of RPP-26744). The amount of nitrate disposed in these two areas is over an order of magnitude greater than other areas where nitrate exceeds the DWS. Sections 9.2.1 and 9.2.2 discuss changes in contaminant concentration for the B Complex and 216-B-12 plumes between 2016 and 2017.

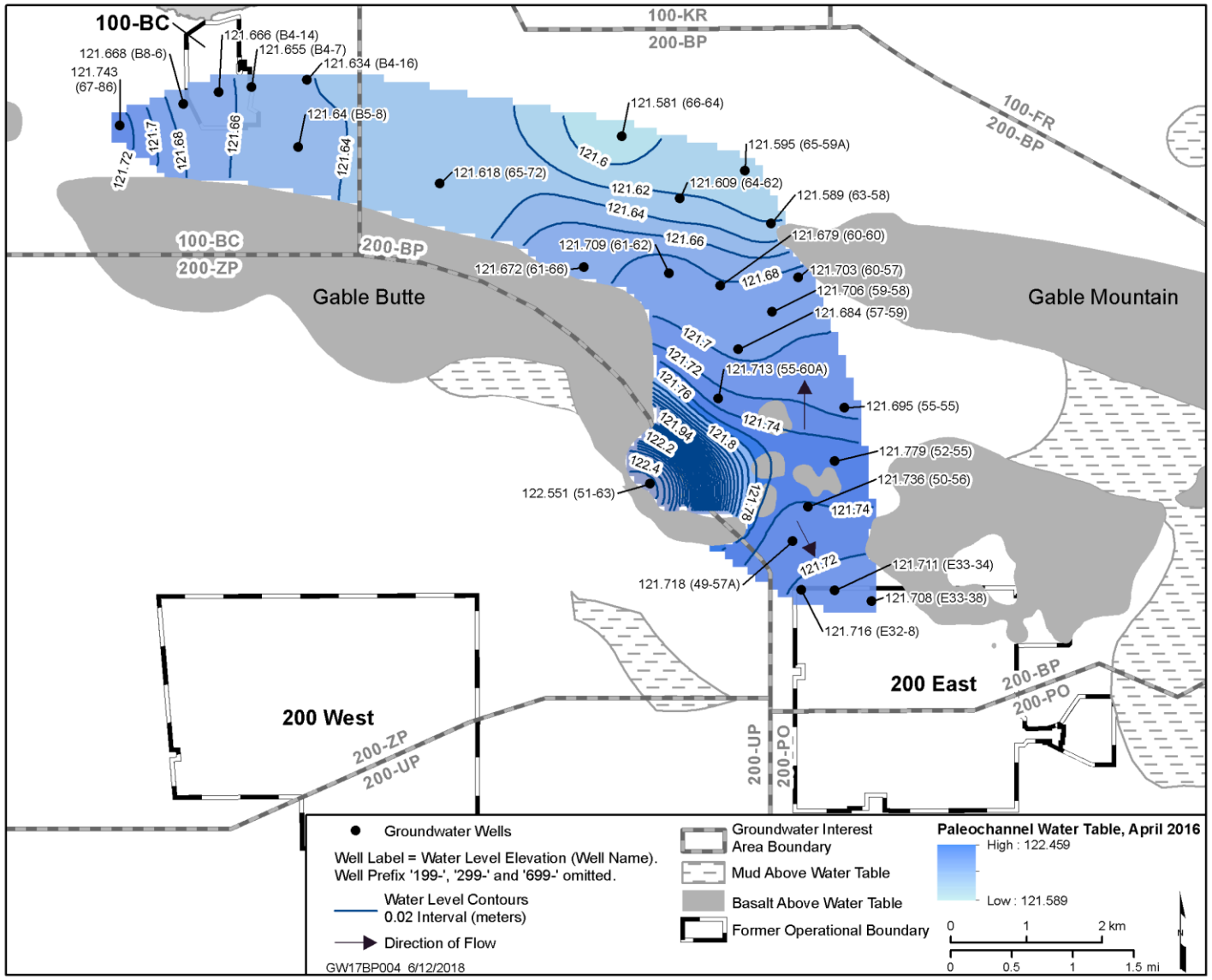
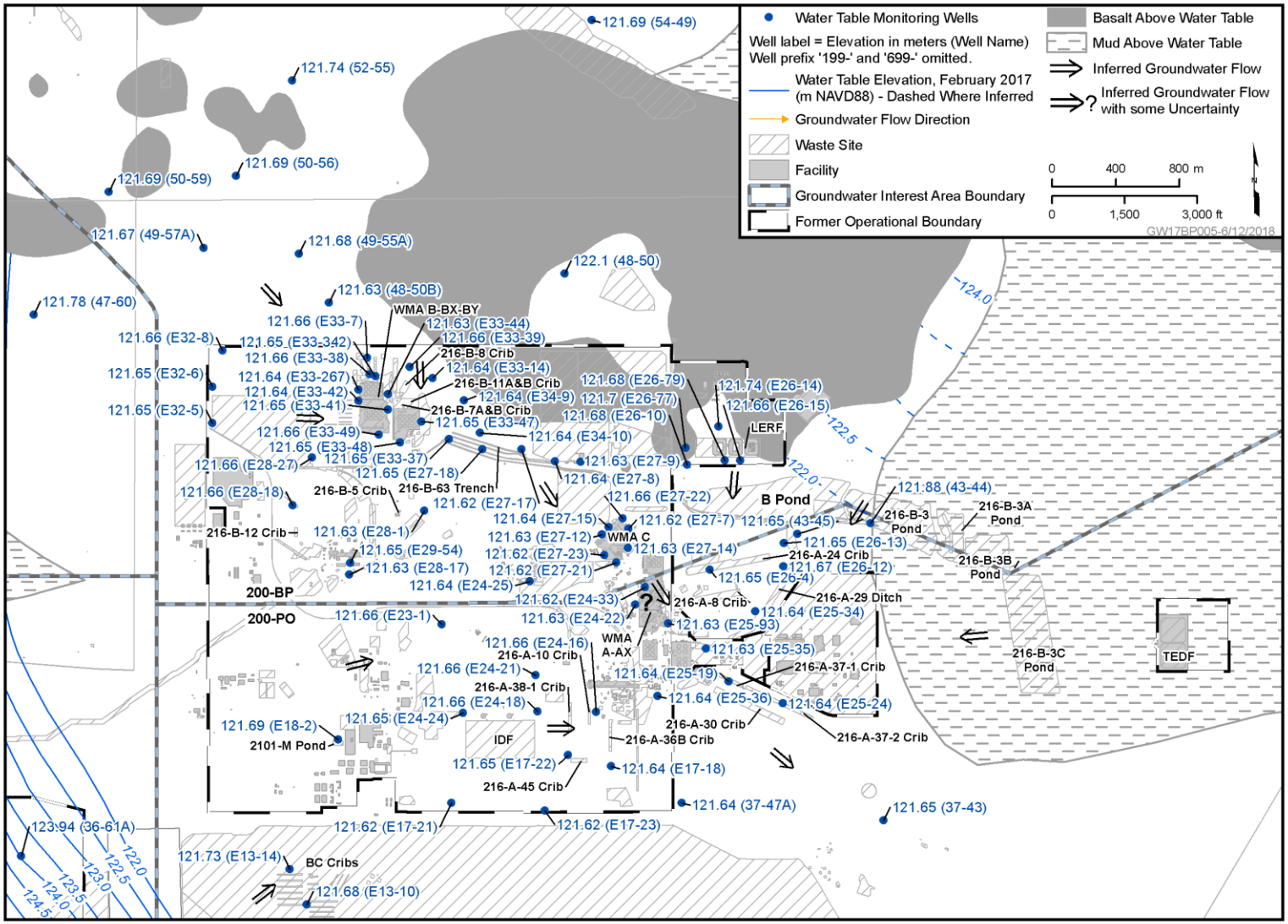
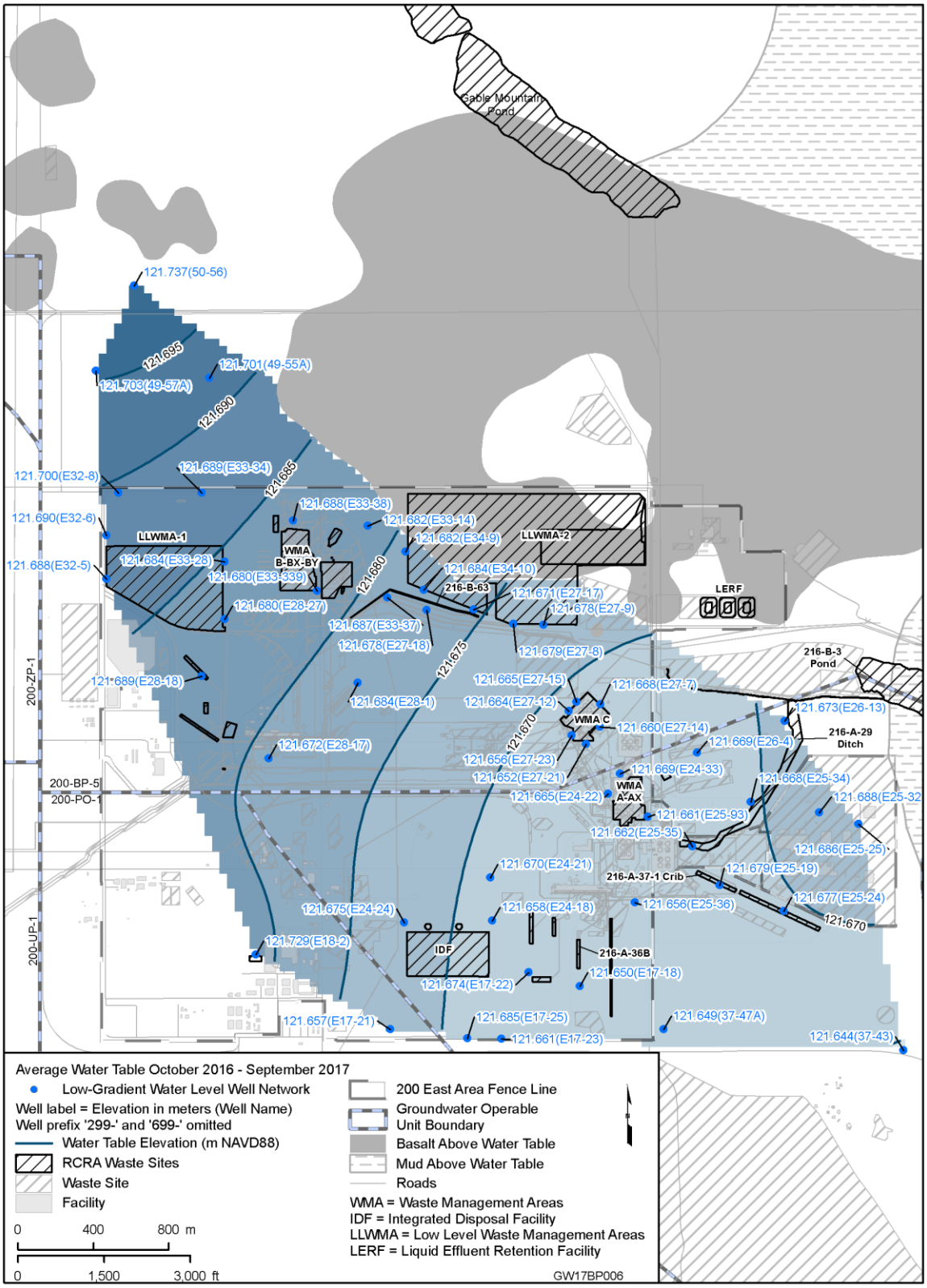


Figure 9-4. Water Table Map for the Paleochannel North of the 200 East Area, April 2016



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 9-5. Interpreted Groundwater Flow Directions in the 200 East Area, 2017



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 9-6. Monthly Average 200 East Area Low Hydraulic Gradient Water Table Map, 2017

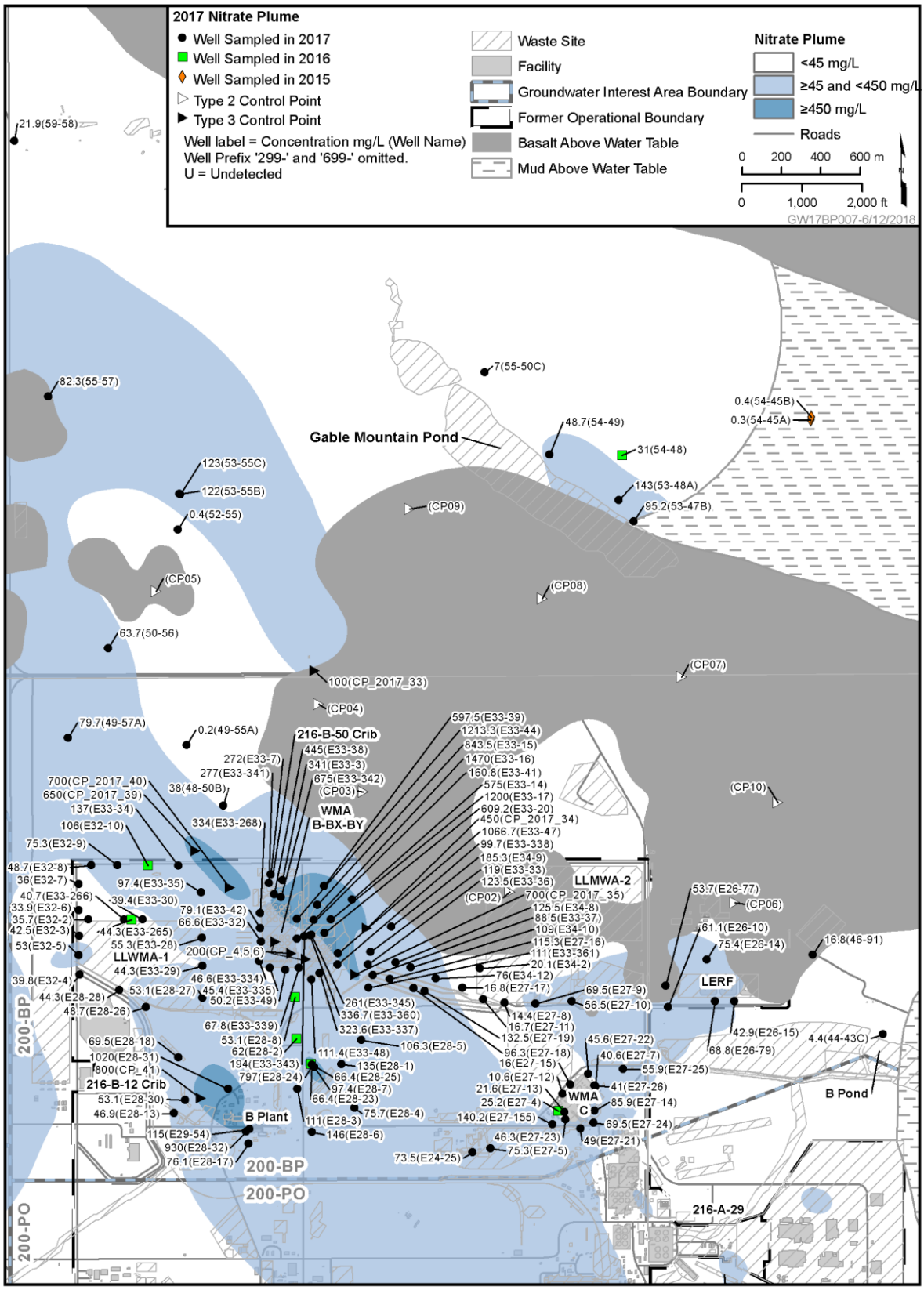


Figure 9-7. 200-BP Nitrate Plume, 2017

Three other sources contribute to local nitrate plumes in the southern half of 200-BP: Gable Mountain Pond, UPRs associated with the 216-B-2 Ditches, and UPRs associated with the C Tank Farm. Nitrate concentrations at these locations did not change significantly nor did the extent. Thus, these sites are not discussed in this annual report, but detailed discussions for these sites are provided in Section 9.2 of DOE/RL-2016-67. The southern extent of the 200-BP nitrate plume merges with the 200-PO plume (discussed in Chapter 10).

9.2.1 B Complex

The significant mass released at the B Complex area, nearly 7 million kg from the BY Cribs alone, is compounded with a thin, highly permeable, unconfined aquifer resulting in highly concentrated and extensive plumes (Figure 9-7). Plumes have extended from the B Complex since before the 1950s, mainly to the north-northwest until mid-2011, when the flow direction became southeast.

Nitrate concentrations in remnant plumes to the north-northwest are either decreasing or variable (top panel of Figure 9-8). All wells except 699-57-59 continued to exceed the 45 mg/L DWS equivalent in 2017. Wells 699-49-57A and 699-55-57 have variable concentration trends, fluctuating between 80 and 90 mg/L. Concentrations in wells 699-50-56 and 699-50-59 decreased between 2016 and 2017. Well 699-53-55C had nearly the same nitrate concentration in 2017 as measured in 2016 (123 mg/L). The plume configuration did not change significantly from 2016 to 2017.

Nitrate concentrations at wells in the northwestern portion of the B Complex decreased in 2015 and 2016 because of groundwater extraction at well 299-E33-268. The concentrations rebounded during equipment modifications (late 2016 and early 2017) and subsequently decreased upon resumed extraction from wells 299-E33-268 and 299-E33-360. Well 299-E33-38 provides an example of this pattern (bottom panel of Figure 9-8). The concentration decreased from 885 to 487 mg/L between May and November 2016, increased slightly in early 2017, and declined to 319 mg/L by November 2017. In June 2017, extraction rates were increased at well 299-E33-360 and terminated at well 299-E33-268.

Nitrate concentrations in the central portion of the B Complex display two different trends: increasing and decreasing (top panel of Figure 9-9). Three wells in the central portion of the B Complex (299-E33-16, 299-E33-20, and 299-E33-47) showed increasing trends in 2017 because of their location with respect to current high-concentration plumes and extraction well 299-E33-360. Well 299-E33-16, which had the highest concentration in 200-BP groundwater in 2017 (1,590 mg/L), is located between the highly concentrated nitrate plume east of the BY Cribs and the extraction well. As a result, nitrate concentrations will temporarily increase. The increase in well 299-E33-47 is associated with capture of past contaminant migration from the B Tank Farm to the southeast. Concentrations in the remaining wells in the central portion of the B Complex are rapidly declining, reflecting ongoing groundwater extraction. For example, the concentration in well 299-E33-44 declined from 1,460 mg/L in August 2016 to 930 mg/L in November 2017 (Figure 9-9).

The bottom panel of Figure 9-9 illustrates nitrate concentrations in wells in the southern portion of the B Complex and extending to the southeast. Concentrations in wells closest to the southern boundary of the B Tank Farm or within the primary contaminant migration pathway are declining most rapidly: 299-E28-5, 299-E33-337, and 299-E33-361. Farther east, well 299-E28-8 appears to be along the eastern periphery of migrating nitrate plumes and does not appear significantly affected by groundwater extraction within the B Complex.

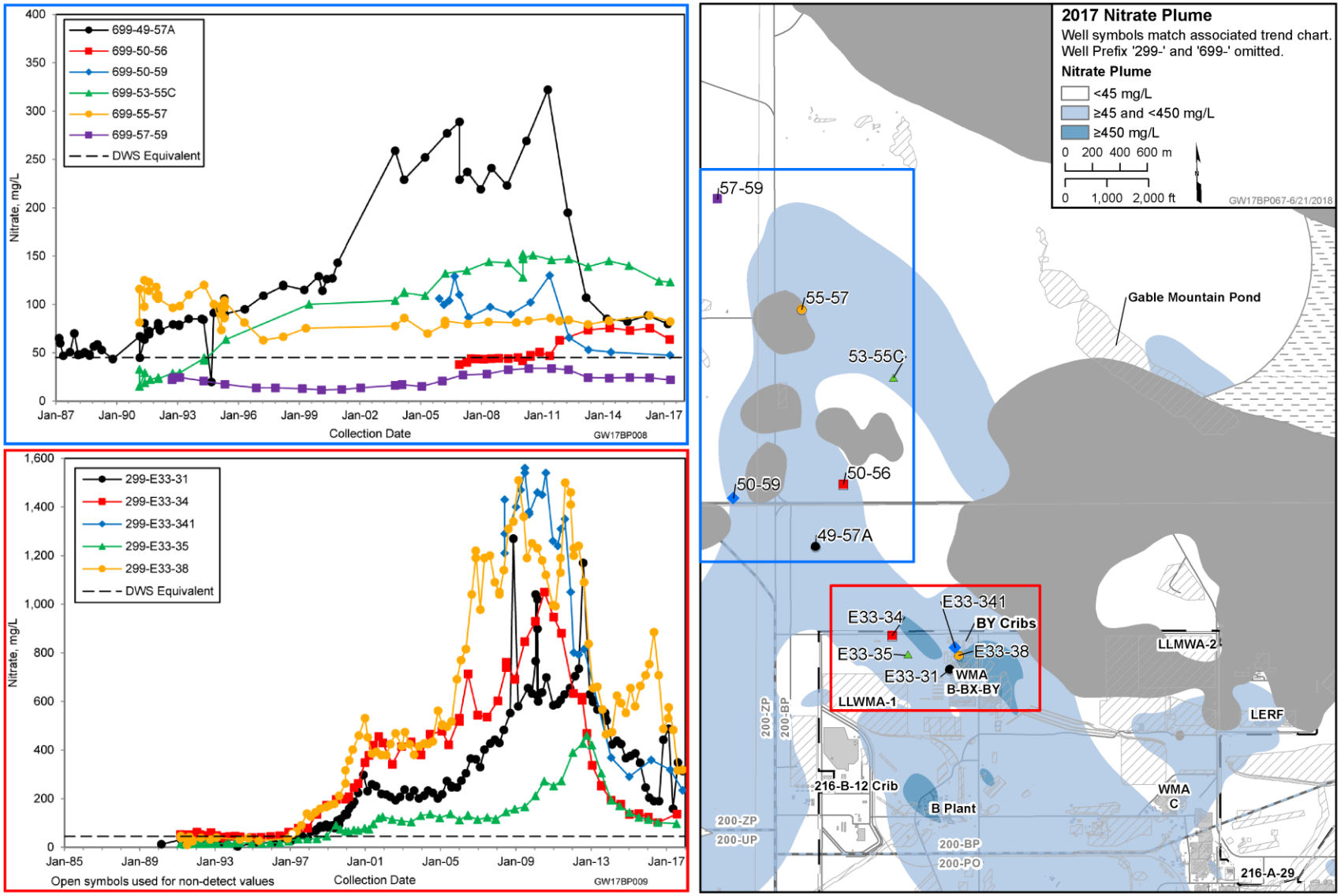


Figure 9-8. 200-BP Nitrate Data at Wells North and Northwest of the BY Cribs (Top Panel) and in the Northwestern Portion of the B Complex (Bottom Panel)

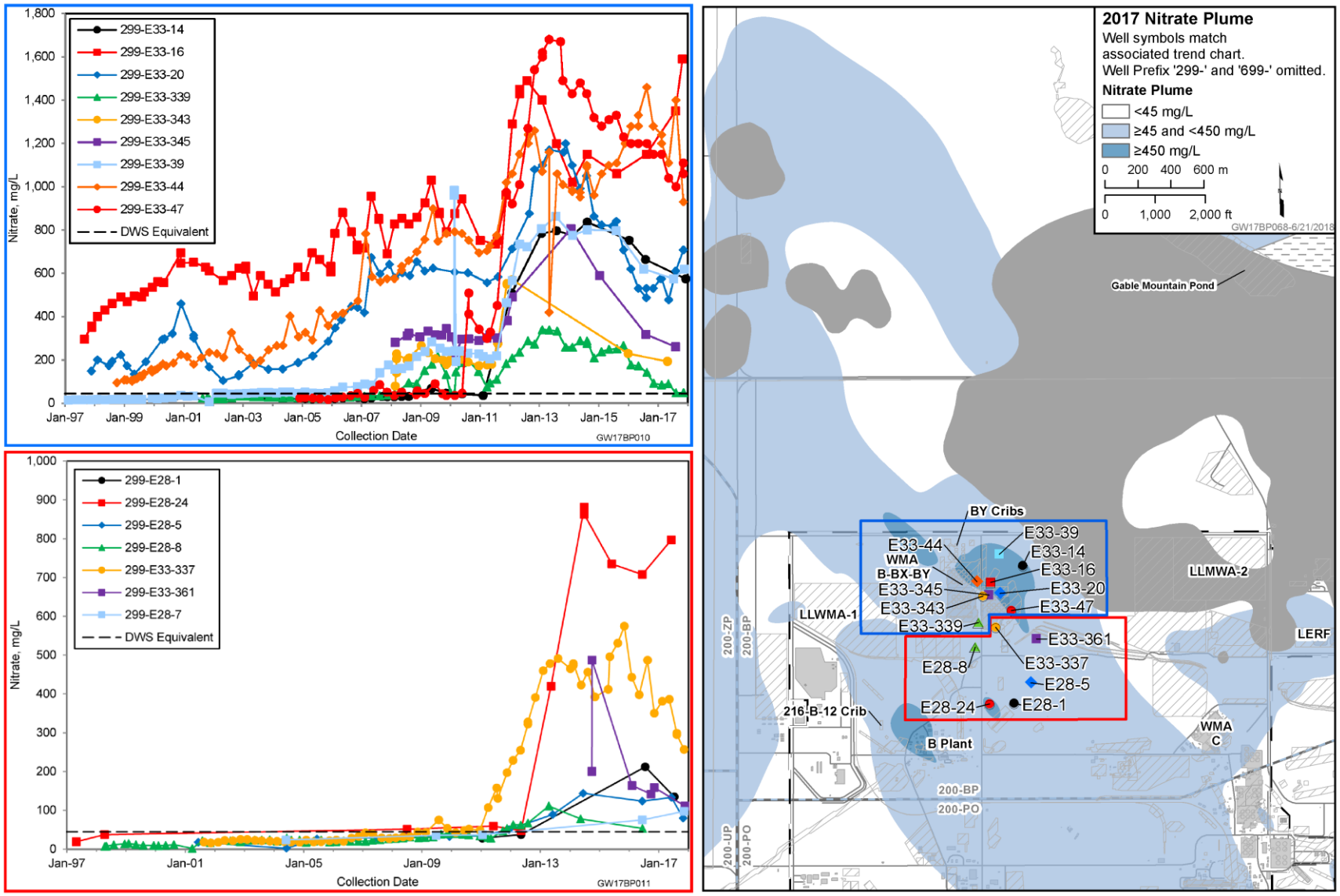


Figure 9-9. 200-BP Nitrate Data at Wells in the Central and South-Southeast Portions of the B Complex

Farther south at well 299-E28-24, the nitrate concentration was 797 mg/L in 2017, similar to levels observed in 2014 through 2016 (bottom panel of Figure 9-9). The nitrate contamination at this location is in the lower part of the permeable Cold Creek aquifer sediments, and although presumably associated with a B Complex area source, appears unaffected by B Complex groundwater extraction at this time. The plume appears to extend eastward toward well 299-E28-1, located 150 m (492 ft) east of well 299-E28-24, then to the southeast based on concentration comparison between wells 299-E28-1 and 299-E28-7. Technetium-99-to-nitrate ratios at wells 299-E28-1, 299-E28-24, and 299-E33-337 indicate that scavenged waste is impacting these wells (Figure 9-10). The only known source of scavenged waste releases in the northwest quarter of the 200 East Area is the B Complex. The technetium-99-to-nitrate ratio at well 299-E28-7 also appears to be converging with the other three wells. The low technetium-99-to-nitrate ratio at well 299-E28-7 appears to reflect the southern extent of the plume. The removal action work plan (DOE/RL-2017-11) proposed a dual-use monitoring well southeast of this area. Dual-use monitoring wells, which are designed as possible extraction or injection wells but are used initially as monitoring wells, will be constructed with relatively long screened intervals. The well may have sections of blank casing with annular seals installed within the screened interval to allow for the installation of packers to prevent vertical flow. This helps to optimally target contamination within the aquifer and ensure that representative samples are obtained during use as a monitoring well.

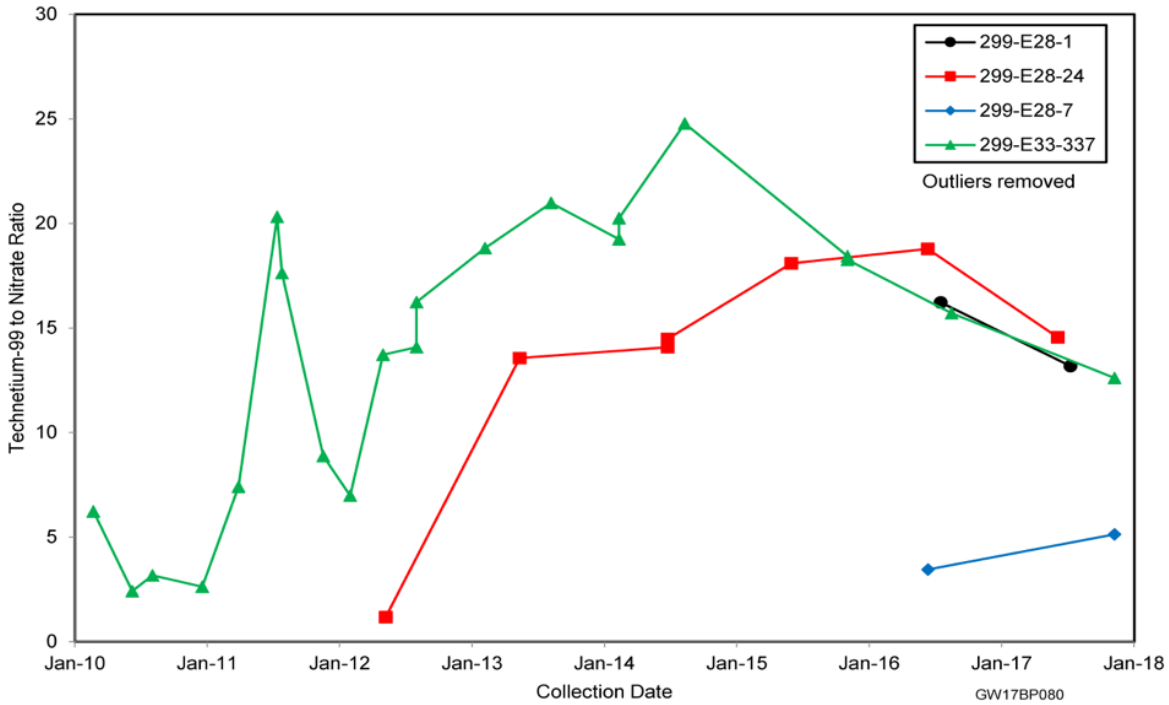


Figure 9-10. Technetium-99-to-Nitrate Ratio Comparison for Wells 299-E28-1, 299-E28-7, 299-E28-24, and 299-E33-337

9.2.2 216-B-12 Crib

At B Plant, the main nitrate source was the 216-B-12 Crib, where current monitoring indicates possible contributions of relatively low nitrate concentrations (less than 60 mg/L). Concentrations are much higher within the low-permeability Ringold aquifer sediments, in the deeper part of the aquifer underlying the permeable Cold Creek aquifer. The deep plume was presumably loaded during active discharges of uranium recovery waste at the 216-B-12 Crib (1952 through 1957), when 371 million L (over 98 million gal) of liquid waste were discharged, containing nearly 3 million kg of nitrate. The aquifer is much thicker beneath B Plant than at B Complex.

A region of nitrate with concentrations above 450 mg/L is defined near the 216-B-12 Crib (Figure 9-7). The extent of this deep plume is uncertain, as it is currently only defined by wells 299-E28-31 and 299-E28-32, which were installed in 2015 and are screened 12 to 20 m (39 to 66 ft) below the water table. In 2017, nitrate concentrations in wells 299-E28-31 and 299-E28-32 were 1,020 and 930 mg/L, respectively. Section 9.2.2 of DOE/RL-2016-67 provides additional information about the distribution of nitrate with depth. Future actions in this area will be determined through the ROD.

9.3 Iodine-129

An iodine-129 plume with concentrations above the 1 pCi/L DWS (Figure 9-11) covers an area from Gable Gap southeast into 200-PO. The iodine-129 plume migrated into 200-BP primarily from sources located in the 200-PO groundwater interest area: 216-A-10 Crib vicinity, 216-A-29 Ditch, and B Pond (discussed in Chapter 10). The 2017 concentrations were generally higher in 200-BP wells than in 2016, which caused the interpreted plume extent to expand. In 2017, the MDA for iodine-129 ranged from 0.5 to 0.8 pCi/L, with analytical uncertainty typically about 0.6 pCi/L. Small changes in reported concentrations (within the range of uncertainty) can create noticeable changes in the mapped plume extent.

In 2017, iodine-129 concentrations increased in the Gable Gap area at wells 699-55-55 (1.59 ±0.61 pCi/L) and 699-57-59 (2.45 ± 0.61 pCi/L) (Figure 9-12). Because there are no apparent iodine-129 sources in Gable Gap (except the remnant plume near well 699-57-59), it appears that the iodine-129 in well 699-55-55 is an isolated plume. Expansion of this plume toward well 699-55-55 (to the southeast) seems unlikely based on water-level elevations. As a result, an isolated plume lobe was created at well 699-55-55. Four other wells located south of Gable Gap appear to indicate no connection of iodine-129 extending from northwest of the B Complex and the iodine-129 in Gable Gap (Figures 9-11, 9-12, and 9-13).

The plume extending to northwest of the B Complex is defined by wells 699-49-55A, 699-49-57A, and 699-50-59 (Figure 9-11). Concentrations in these wells did not change significantly in 2017.

Iodine-129 concentrations near the B Complex increased in 12 wells from less than the DWS in 2016 to greater than the DWS in 2017. This overall increase caused the plume interpretation to expand in this area.

Iodine-129 concentrations near the 216-B-5 injection well (monitoring wells 299-E28-24 and 299-E28-5) increased in 2017, causing the plume interpretation to expand to the west in this area.

Iodine-129 concentrations in the east Low-Level Waste Management Area (LLWMA) 2 wells (299-E27-8, 299-E27-9, and 299-E27-10) from less than the DWS in 2016 to greater than the DWS in 2017, causing the plume interpretation to expand to the north in this area.

Although the extent of the iodine-129 plume at WMA C and B Pond did not expand significantly, concentrations in the wells generally increased between 2016 and 2017.

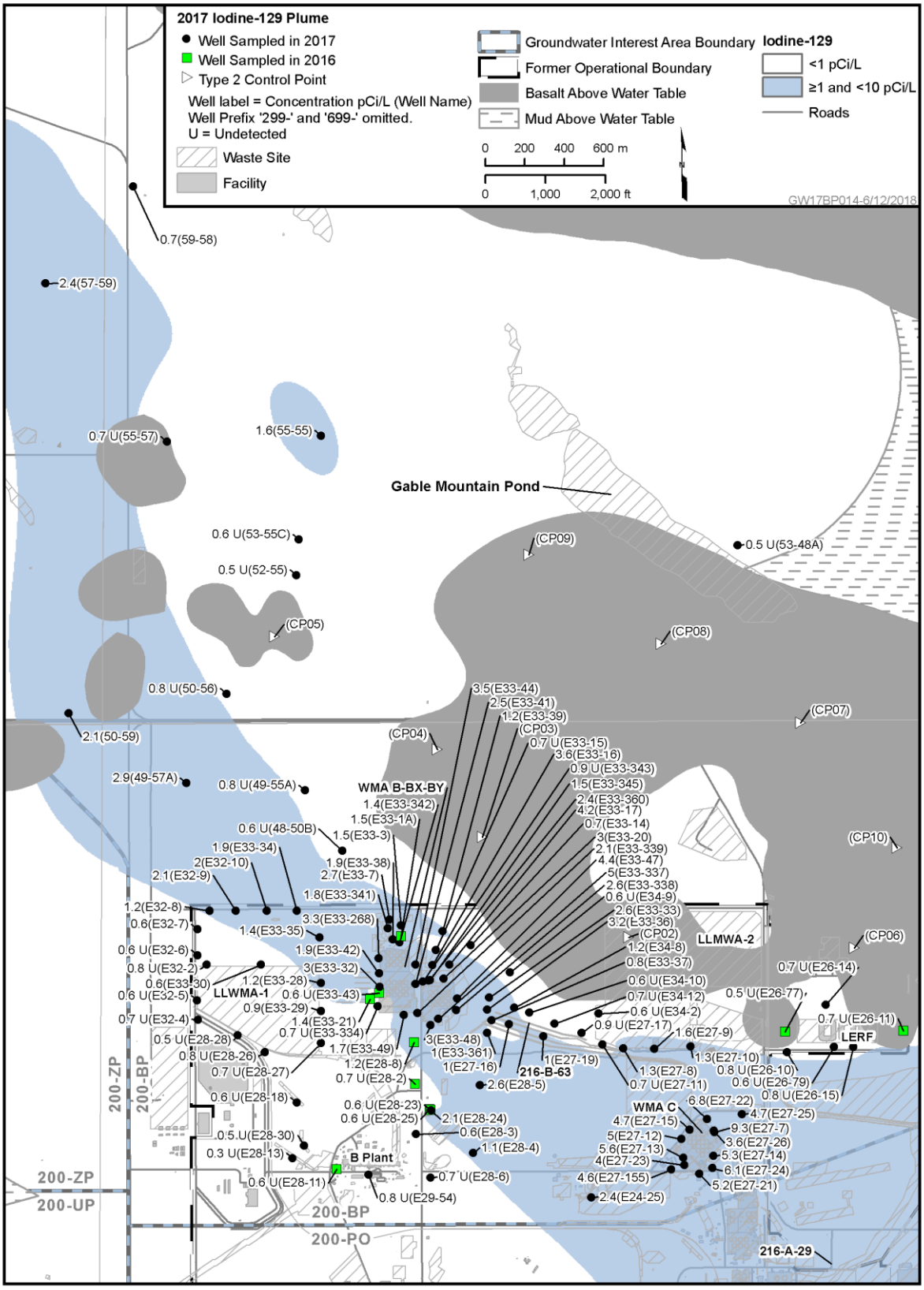


Figure 9-11. 200-BP Iodine-129 Plume, 2017

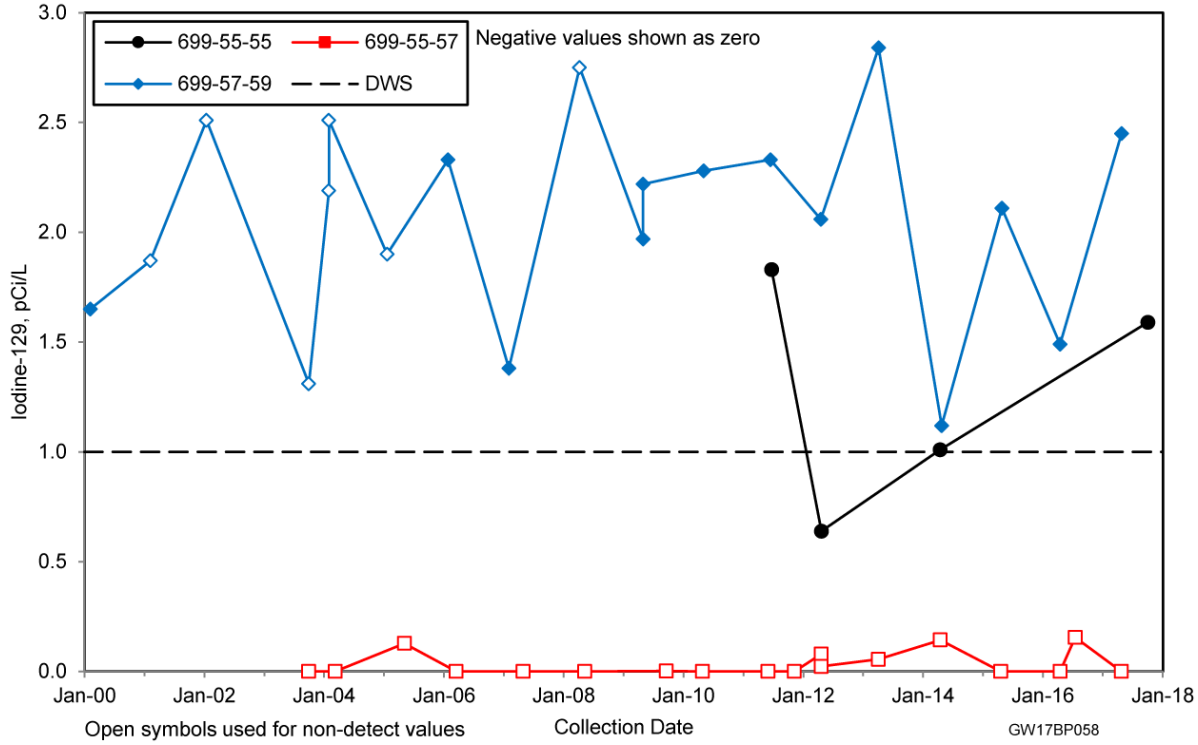


Figure 9-12. 200-BP Iodine-129 Data at Gable Gap Wells 699-55-55, 699-55-57, and 699-57-59

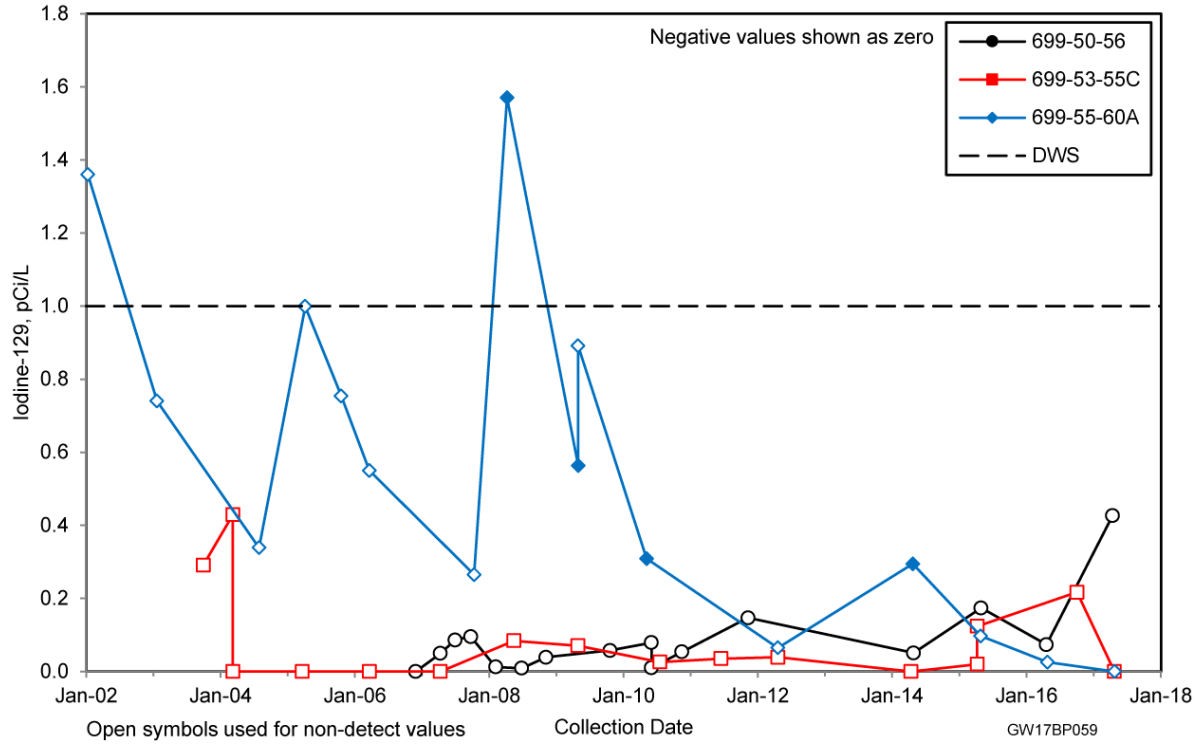


Figure 9-13. 200-BP Iodine-129 Data at Wells 699-50-56, 699-53-55C, and 699-55-60A

9.4 Technetium-99

Technetium-99 in 200-BP groundwater (Figure 9-14) is primarily associated with past discharge sites and UPRs of liquid scavenged waste. The scavenging process was used in the 1950s to reduce the cesium-137 and strontium-90 levels of uranium-recovery and first-cycle decontamination waste before disposal to the soil column. In 200-BP, sources of elevated technetium-99 groundwater are limited to the B Complex and WMA C. The inventory of technetium-99 disposed to the BY Cribs within the B Complex is two orders of magnitude greater than other areas where technetium-99 exceeds the DWS. The significant inventory released at the BY Cribs (nearly 130 Ci) is compounded with a thin, highly permeable, unconfined aquifer, resulting in highly concentrated and extensive plumes (Figure 9-14). Plumes have presumably extended from the BY Cribs since the mid-1950s, mainly to the north-northwest until mid-2011, when the flow direction became southeast.

Sections 9.4.1 and 9.4.2 discuss contaminant distribution changes for the B Complex and WMA C plumes between 2016 and 2017.

9.4.1 B Complex

This section describes the groundwater technetium-99 concentration changes between 2016 and 2017 at the B Complex. The remnant plumes to the north-northwest are also discussed, which were sourced mainly by the BY Cribs prior to a groundwater flow direction change in 2011. Changes in groundwater concentrations are also discussed for wells south and southeast of the B Complex.

Groundwater P&T in this area is affecting technetium-99 concentrations. Startup of extraction well 299-E33-360 in 2017, downgradient of the most prominent source of technetium-99 loading into the unconfined aquifer (the BY Cribs), began reducing the concentrated plume east of the BY Cribs. Continued extraction should remove or greatly reduce the technetium-99 concentration and extent at the B Complex.

Technetium-99 concentrations in wells monitoring the remnant plumes to the north-northwest are either decreasing or remain stable (top panel of Figure 9-15). Only three wells continue to exceed the 900 pCi/L DWS: 699-50-56, 699-53-55C, and 699-55-57. The plume configuration did not change significantly in this area in 2017.

Technetium-99 concentrations in wells within the northwestern portion of the B Complex decreased during 2017 due to groundwater extraction (Section 9.9.1). The bottom panel of Figure 9-15 provides the concentration trends for the primary wells in the northwestern portion of the B Complex. Concentrations declined in all of the wells, but levels continued to exceed the 900 pCi/L DWS. Well 299-E33-38 had the highest concentration in this group of wells, 6,230 pCi/L in November 2017, which was a decline from 21,000 pCi/L observed in 2016.

Technetium-99 concentrations in the central portion of the B Complex were declining by the end of 2017 (top panel of Figure 9-16). Concentrations in well 299-E33-16 increased to 36,000 pCi/L after pumping from extraction well 299-E33-360 began because of its location between the high-concentration plume to the north and the extraction well to the south. The concentration subsequently declined to 31,400 pCi/L in October. Technetium-99 concentrations in wells 299-E33-14 and 299-E33-39 (within the concentrated north-central B Complex plume) declined after extraction began at well 299-E33-360. Concentrations in most of the wells in this region continued to exceed the 900 pCi/L DWS but are declining.

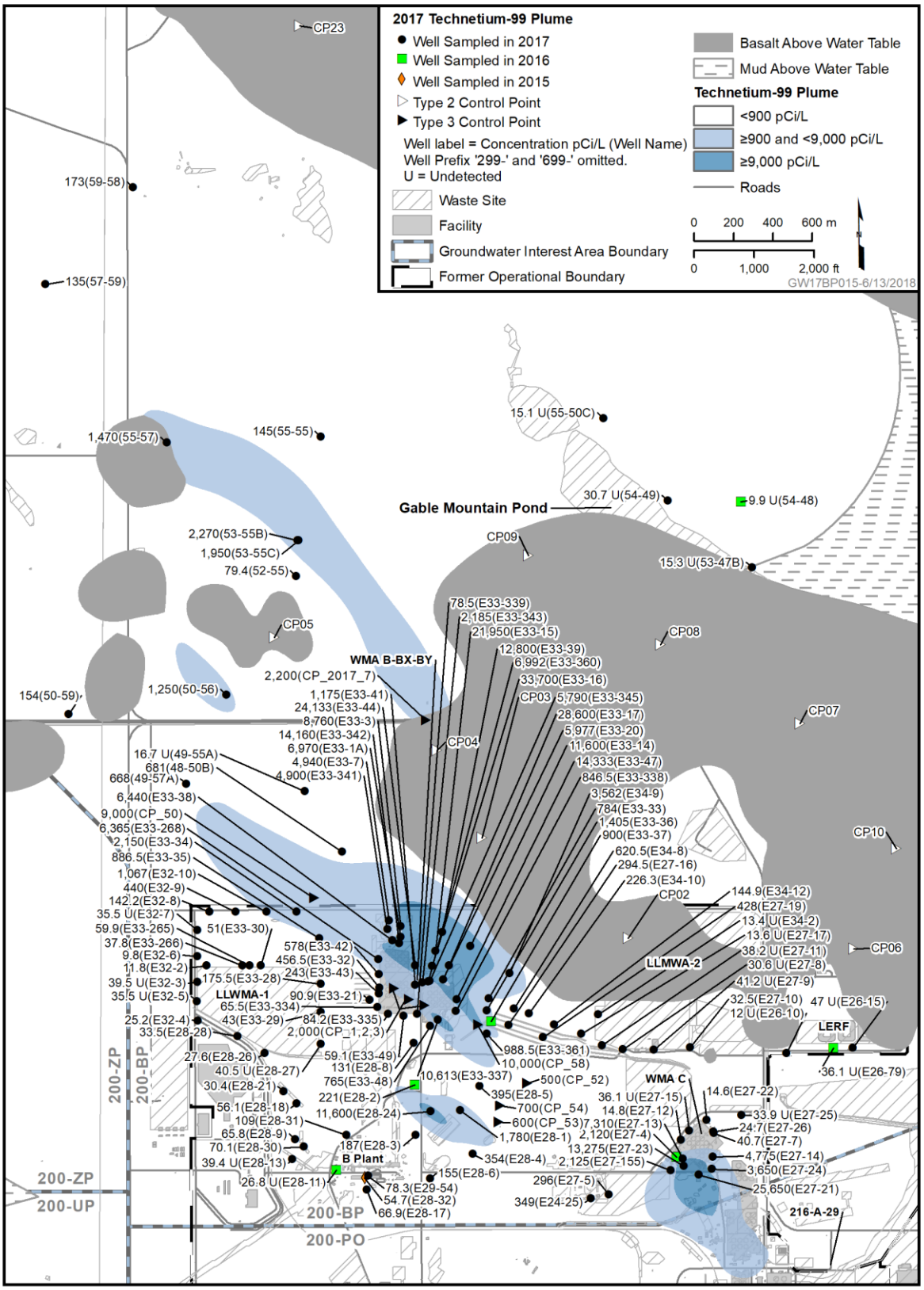


Figure 9-14. 200-BP Technetium-99 Plume, 2017

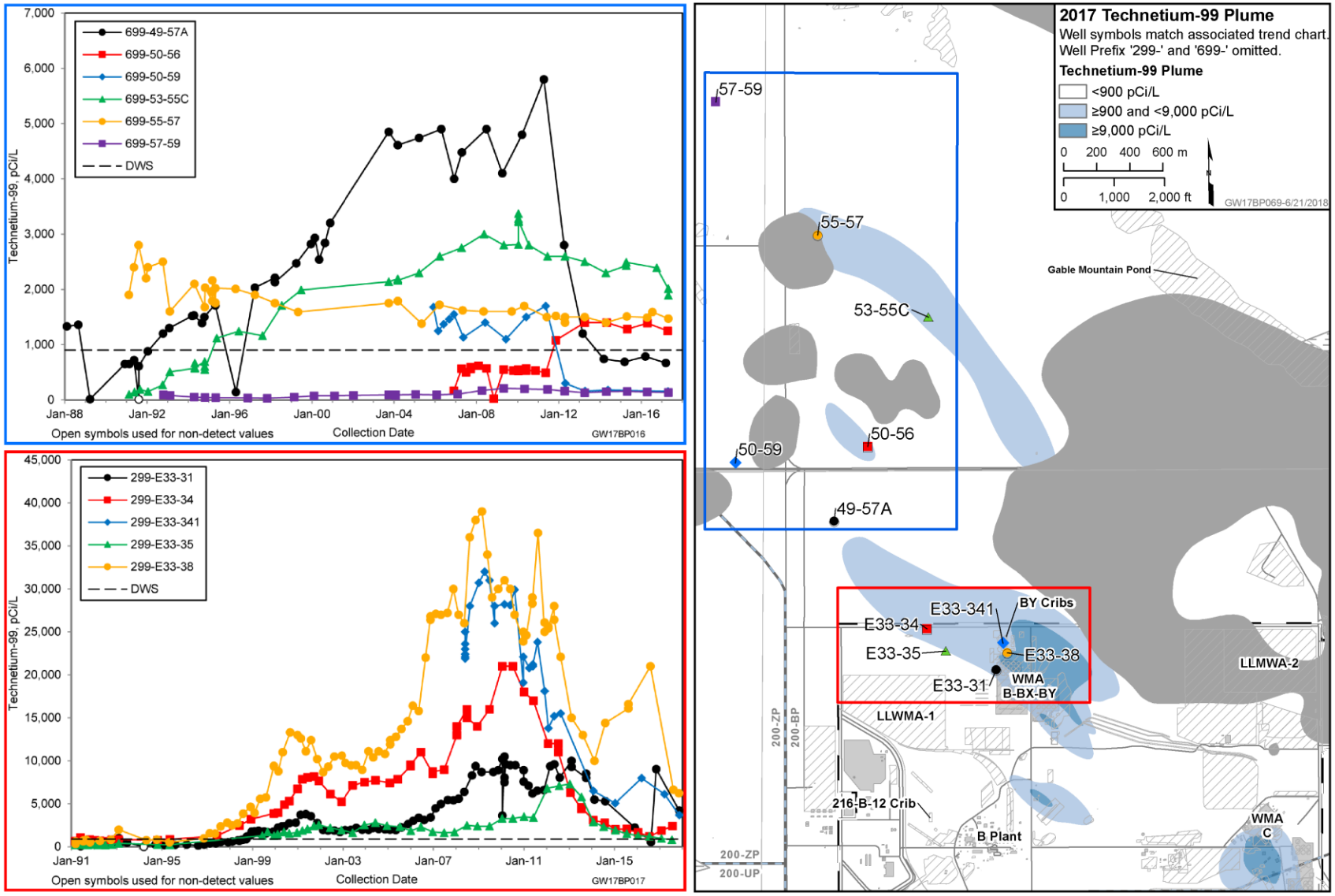


Figure 9-15. 200-BP Technetium-99 Data at Wells North and Northwest of the BY Cribs (Top Panel) and in the Northwestern Portion of the B Complex (Bottom Panel)

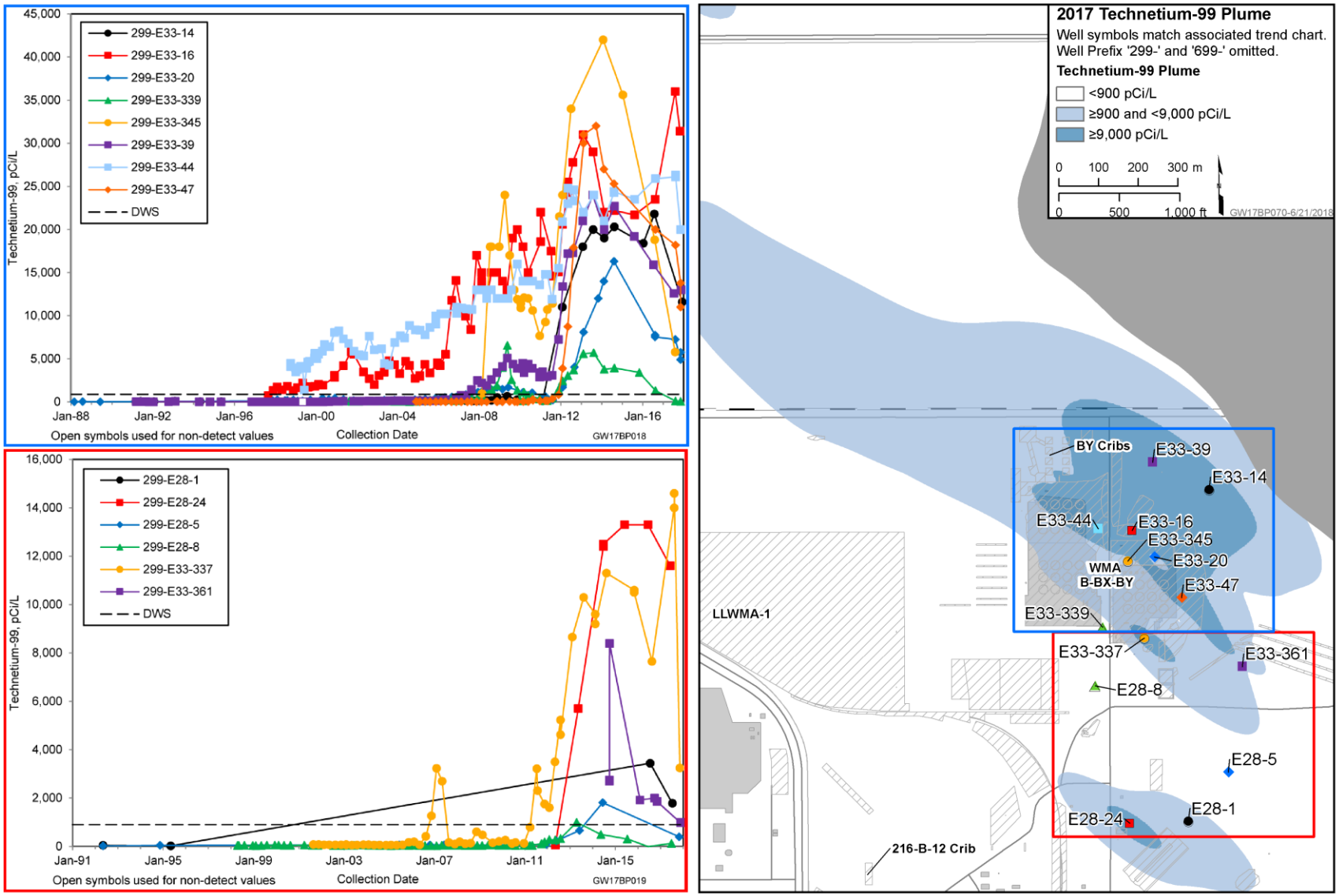


Figure 9-16. 200-BP Technetium-99 Data at Wells in the Central and South-Southeast Portions of the B Complex

Technetium-99 concentrations in the southern portion of the B Complex and extending to the southeast display three different effects due to plume migration and groundwater extraction. The wells closest to the southern boundary of the B Tank Farm or within the primary migration pathway (299-E28-5, 299-E33-337, and 299-E33-361) are declining most rapidly (bottom panel of Figure 9-16). The decline is associated with either capture or diminished plume migration. Farther east, well 299-E28-8 appears to be along the eastern periphery of migrating technetium-99 plumes and does not appear significantly affected by groundwater extraction.

Concentrations in well 299-E28-24, located 660 m (2,200 ft) south of extraction well 299-E33-360, declined from 13,300 to 11,600 pCi/L between 2016 and 2017. This change appears to reflect source variability rather than groundwater extraction from the B Complex.

9.4.2 Waste Management Area C

Technetium-99 sources in WMA C have affected groundwater quality. This section describes changes between 2016 and 2017 at upgradient and downgradient wells. Some analyses provide evidence of multiple sources of contamination and changing hydraulic conditions.

Technetium-99 concentrations in wells north (upgradient) of WMA C are very low to undetected and showed no change between 2016 and 2017 (Figure 9-17). Technetium-99 concentrations at downgradient wells ranged from steady, to variable, to increasing. The following discussion focuses on the downgradient wells.

Technetium-99 concentrations increased at wells 299-E27-14 and 299-E27-23 (Figure 9-17). The concentration in well 299-E27-14 was 7,070 pCi/L in December 2017 as compared to 1,440 pCi/L in December 2016. The technetium-99-to-nitrate ratio at well 299-E27-14 also increased during 2017, from 28 in March to 84 in December (Table 9-2). An increasing technetium-99-to-nitrate ratio indicates contributions of PUREX Plant waste mixing with the lower technetium-99-to-nitrate ratio scavenged waste. Technetium-99-to-nitrate ratios of 20 to 30 are indicative of scavenged waste, while ratios of PUREX waste exceed 500. Previous technetium-99-to-nitrate ratio observations indicate that PUREX waste primarily affects the wells on the west side of WMA C under normal hydraulic conditions. However, in 2017, significant increases of Treated Effluent Disposal Facility (TEDF) discharges increased the water table by more than 10 cm (3.9 in.) (Figure 9-18), which appears to have affected groundwater flow. The effluent does not infiltrate the unconfined aquifer, but hydrostatic loading on top of the Ringold Formation mud units can cause the water table in the adjacent aquifer to rise. The changing hydraulic conditions appear to have caused more dispersive/ transverse contaminant migration than normal, causing technetium-99 and the technetium-99-to-nitrate ratio at well 299-E27-14 to change. Another contributing cause of the observed changes could be the influence of an existing or new source of higher technetium-99-to-nitrate-ratio waste. No specific waste sources have been identified as the source of these changes.

Technetium-99 concentrations have been increasing at well 299-E27-23 since June 2016 (Figure 9-17), concurrent with continued high concentrations at well 299-E27-21. Technetium-99 levels above 14,000 pCi/L had not occurred concurrently in these wells in the past. This change suggests that a larger vadose zone contribution is entering the aquifer, more transverse plume migration is occurring, additional sources exist, or some combination of the these. The technetium-99-to-nitrate ratios at both wells suggest a PUREX waste; however, the difference in the ratio appears to suggest multiple sources (Figure 9-19). Theoretically, if only one source is impacting both wells, then the technetium-99-to-nitrate ratio should be comparable between the two wells.

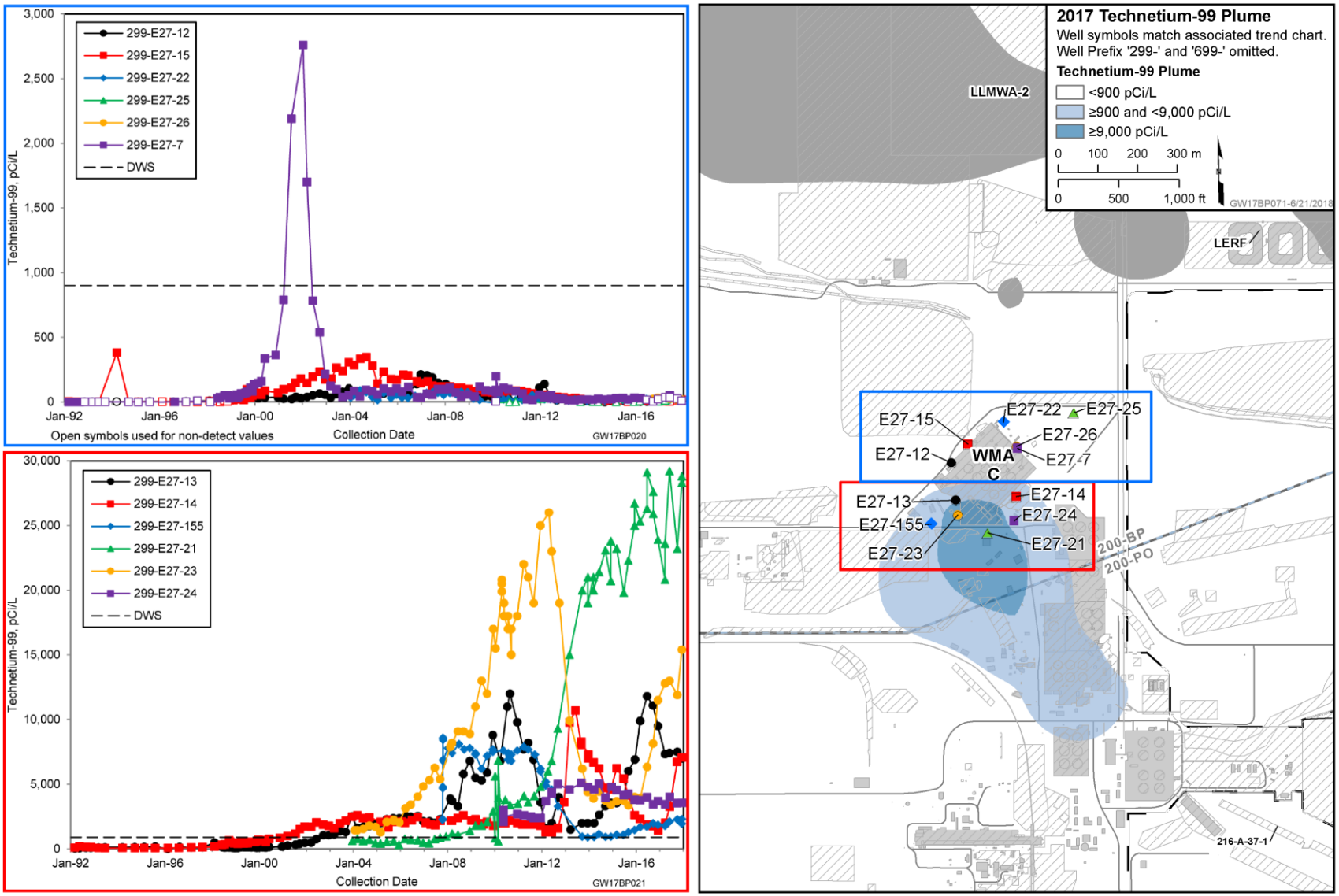


Figure 9-17. 200-BP Technetium-99 Data at WMA C Upgradient and Downgradient Wells

Table 9-2. Technetium-99-to-Nitrate Ratio for Well 299-E27-14

Date Sampled	Technetium-99 (pCi/L)	Nitrate (mg/L)	Technetium/Nitrate Ratio
3/12/2014	6,700	88.5	76
6/4/2014	6,230	91.2	68
9/11/2014	4,720	84.6	56
12/4/2014	4,590	99.2	46
3/6/2015	6,250	94.3	66
6/16/2015	5,440	110	49
9/2/2015	4,120	111	37
12/8/2015	2,620	106	25
3/1/2016	2,340	93	25
6/17/2016	1,900	84.1	23
9/19/2016	1,770	79.7	22
3/27/2017	2,020	71.7	28
6/6/2017	3,270	74.8	44
9/28/2017	6,740	113	60
12/8/2017	7,070	84.1	84

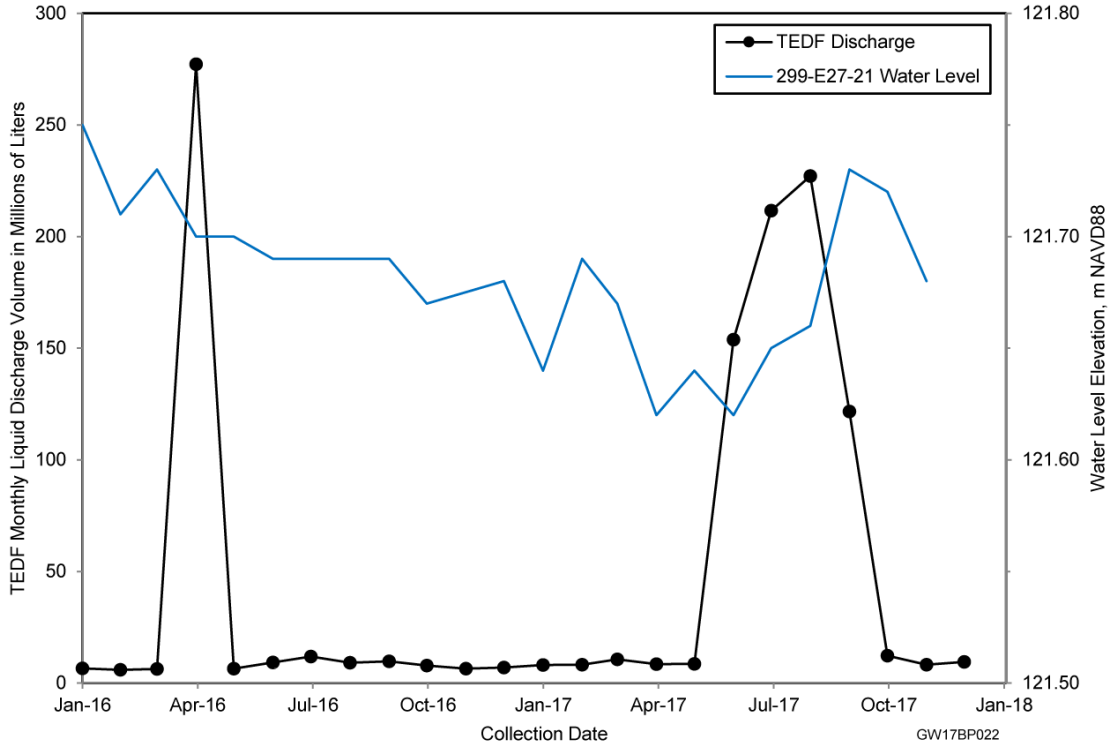


Figure 9-18. Comparison of TEDF Monthly Discharge Volumes with Water Levels at Well 299-E27-21

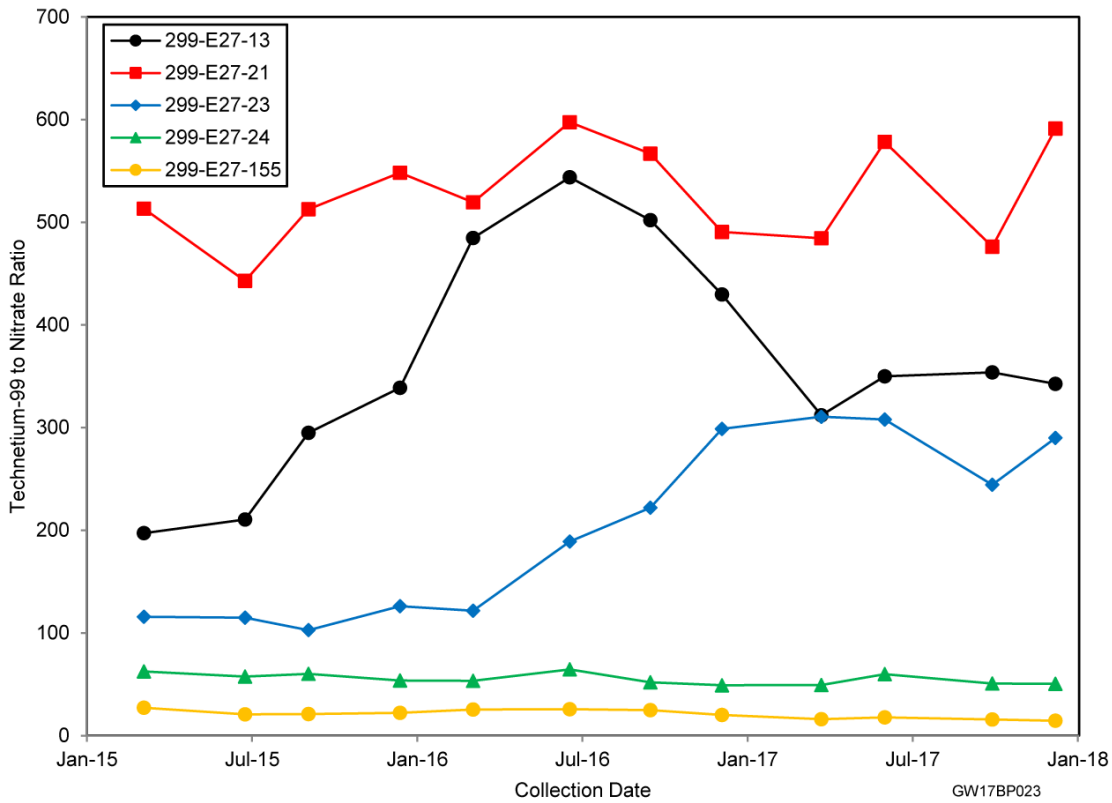


Figure 9-19. Comparison of Technetium-99-to-Nitrate Ratio Changes at WMA C Downgradient Wells

Decreasing and more recent stable concentrations at well 299-E27-13 (Figure 9-17) contrasted with the increasing concentrations in well 299-E27-23. One possible scenario for the difference in trends may be a source upgradient of well 299-E27-13 and another source between wells 299-E27-13 and 299-E27-23. Alternatively, one source may impact both wells, in which well 299-E27-13 is on the upgradient periphery of the contaminant source in the vadose zone. Theoretically, if only one source is impacting both wells, then the technetium-99-to-nitrate ratio should be comparable between the two wells. Figure 9-19 indicates that the ratios merged in June 2017; however, in the past, the ratios have been different. This suggests that two or more sources appear to be impacting groundwater quality in this area.

Technetium-99 concentrations appear to be stable at deep-screened wells 299-E27-24 and 299-E27-155 (Figure 9-17). The technetium-99-to-nitrate ratio at well 299-E27-24 is similar to well 299-E27-14 and suggests the same scavenged waste source (Figure 9-19). It is unclear why well 299-E27-24 does not have more variability in technetium-99 concentrations, as is noted at well 299-E27-14 (Figure 9-17).

The technetium-99-to-nitrate ratio at well 299-E27-155 remains low, similar to well 299-E27-24 (Figure 9-19). The similar technetium-99-to-nitrate ratio between wells 299-E27-14, 299-E27-24, and 299-E27-155 may indicate a long-term scavenged waste plume that migrated west and northwest during Hanford Site operations under the influence of B Pond discharges, and that the plume is now migrating back to the southeast. There do not appear to be any local sources to the west or northwest, except the B Complex area. However, based on the hydraulic conditions of the unconfined aquifer, it does not appear that sufficient time has elapsed since the groundwater flow direction change in 2011 for B Complex waste to migrate to well 299-E27-155. As a result, it seems more likely that the contamination at well 299-E27-155 is remnant WMA C waste.

9.5 Uranium

Uranium contamination in 200-BP is associated with two sources: a UPR occurring in 1951 of liquid metal waste from tank 241-BX-102 in the B Complex; and the liquid waste discharge of uranium-recovery process condensate from 1952 to 1957 at the 216-B-12 Crib (west of B Plant). The uranium inventory associated with each of these releases exceeded 10,000 kg (Appendix C of RPP-26744). The tank 241-BX-102 source impacts a thin perched horizon, as well as the thin unconfined aquifer 3.1 m (10 ft) below the perched horizon. Uranium contamination is concentrated in the perched horizon, which is less than 5 m (16 ft) thick; however, gravitational force on the water is sufficient to overcome the capillary action of the fine-grained sandy-silt to silty sand. Thus, the perched horizon acts as a continuous source of groundwater contamination near and beneath the B and BX Tank Farms. The 200-DV-1 OU is addressing the perched horizon (as discussed in Section 9.9.2). Groundwater extraction in the 200-BP-5 OU is addressing the unconfined aquifer beneath the perched horizon (Section 9.9.1). The 216-B-12 Crib is monitored by downgradient well 299-E28-30 and shows minor contributions of uranium contamination to the groundwater at this time. Sections 9.5.1 and 9.5.2 provide further discussion of the two uranium plumes.

9.5.1 B Complex

The uranium plume associated with the tank 241-BX-102 release extends northwest and southeast of the northern boundary of the B Tank Farm (Figure 9-20). Groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test, was refocused in 2017 near the source of the uranium plume (Section 9.9.1). Extraction from the new location reduced uranium concentrations in monitoring wells by 11% to 78% between 2016 and 2017. Figure 9-21 shows the decrease of the plume exceeding 300 µg/L, based on the same set of monitoring wells. ECF-200BP5-17-0245 provides additional information about the decrease in the uranium plume.

The upper panel of Figure 9-22 shows uranium trends in selected wells in the B Complex. Concentrations in well 299-E33-345 declined from 5,600 µg/L in 2014 to 819 µg/L in 2017. Concentrations remained above 1,000 µg/L in well 299-E33-20 but have declined since 2016.

9.5.2 B Plant

The interpreted 2017 uranium extent exceeding the DWS was significantly smaller in 2017 than in 2015 based on lower concentrations at wells 299-E28-3, 299-E28-17, and 299-E28-31. The plume is now defined by wells 299-E28-6 and 299-E29-54, with concentrations ranging between 43 and 55 µg/L (Figure 9-20, and bottom panel of Figure 9-22). Two years of low uranium concentrations from well 299-E28-31 suggest that the higher uranium concentrations identified during drilling (Section 9.6.2 of DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*) may not have been representative. Samples collected in 2015 during the drilling of well 299-E28-31 indicated uranium concentrations as high as 286 µg/L. However, routine groundwater samples from the same depth in 2016 and 2017 were at 5.38 and 5.71 µg/L, respectively.

The 216-B-5 injection well was a former source of uranium. Uranium concentrations exceeded the DWS only in well 299-E28-24 in 2017 (56 µg/L; Figure 9-20). Concentrations in nearby wells 299-E28-23 and 299-E28-7 remained below the DWS. Thus, the plume extent is relatively small and appears to be diminishing under natural conditions.

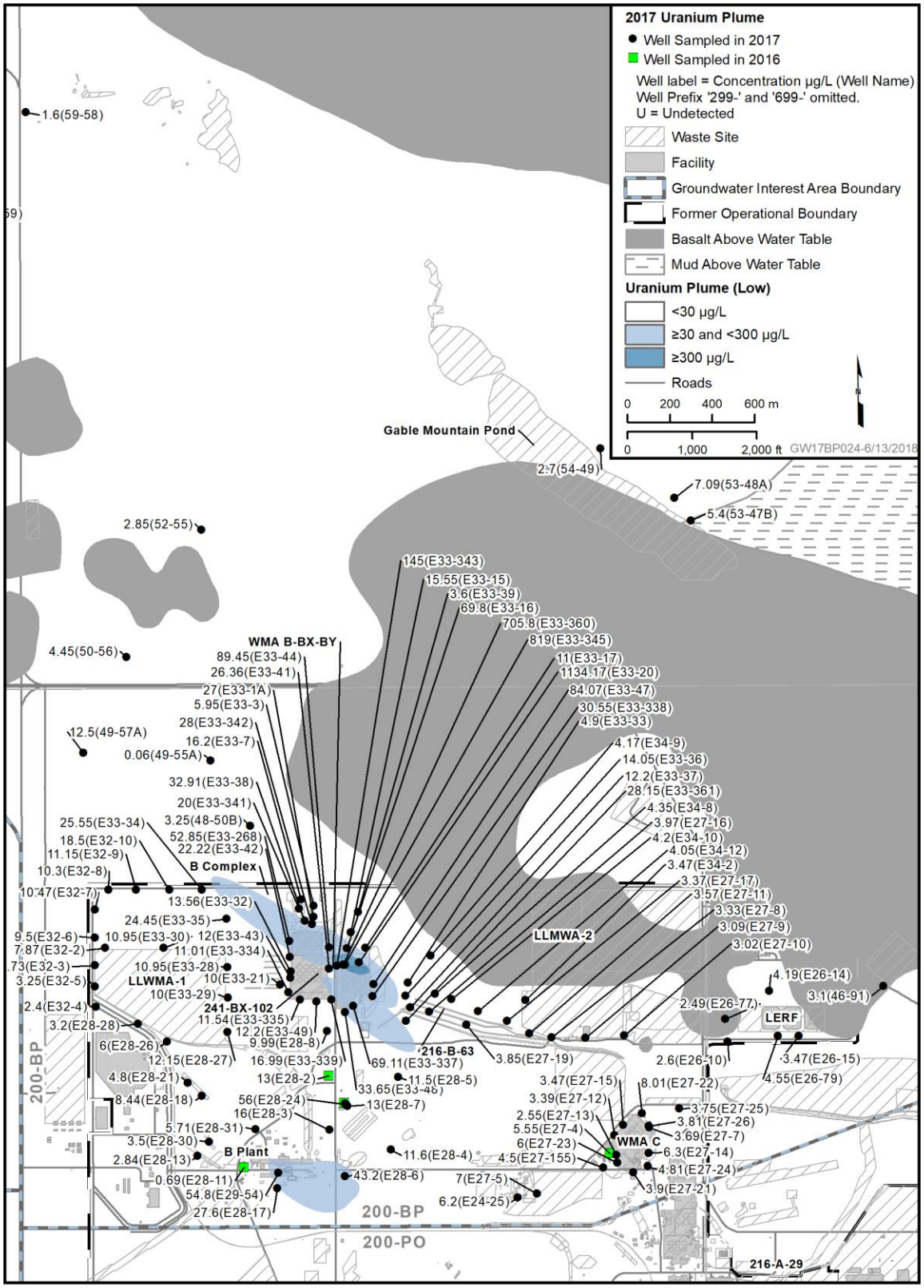
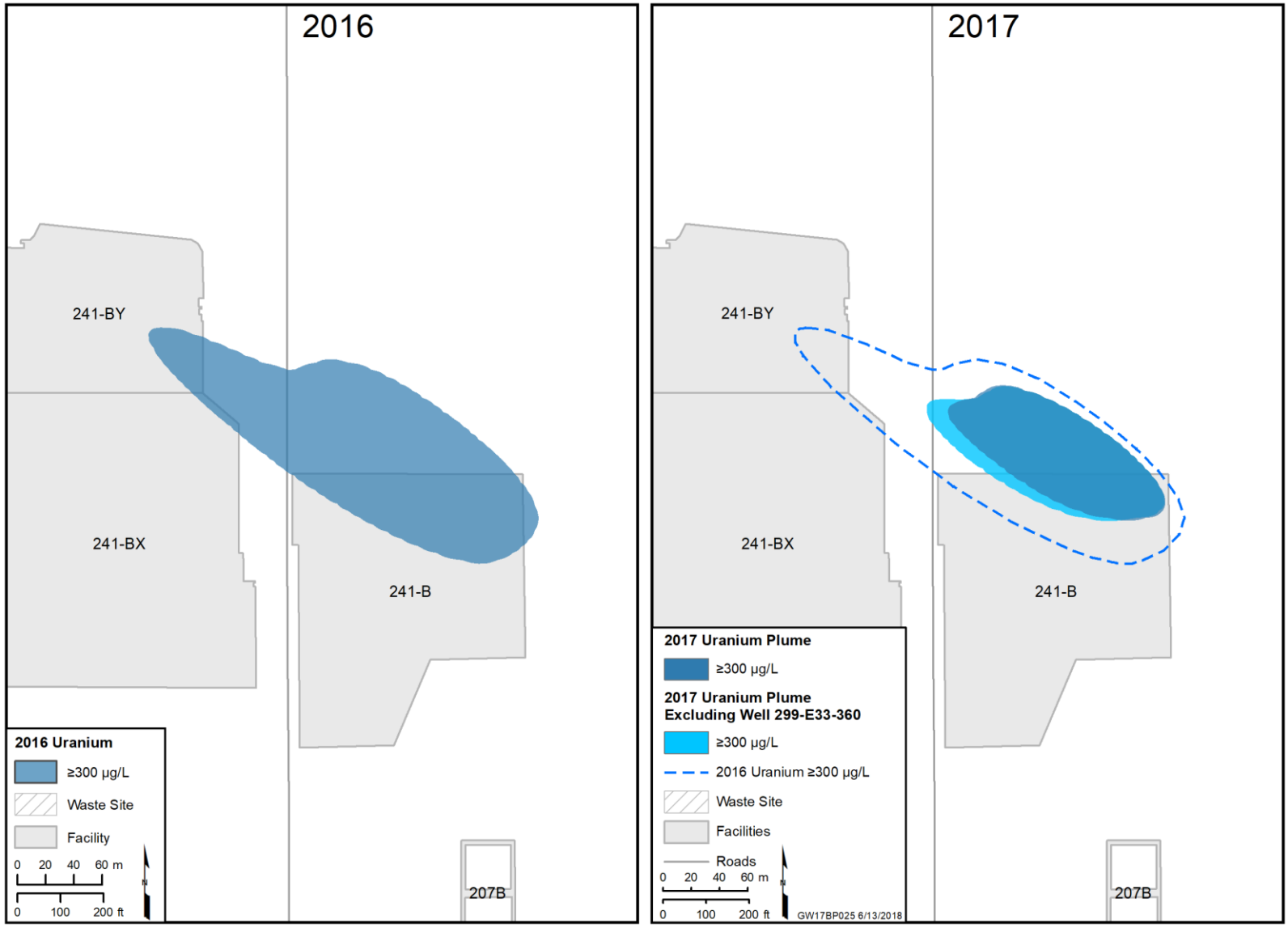


Figure 9-20. 200-BP Uranium Plume, 2017



Reference: ECF-200BP5-17-0245, *B Complex Uranium Plume Reduction Calculation Between Calendar Years 2016 and 2017*.

Figure 9-21. Comparison of August 2016 and December 2017 B Complex Uranium Plume Exceeding 300 µg/L

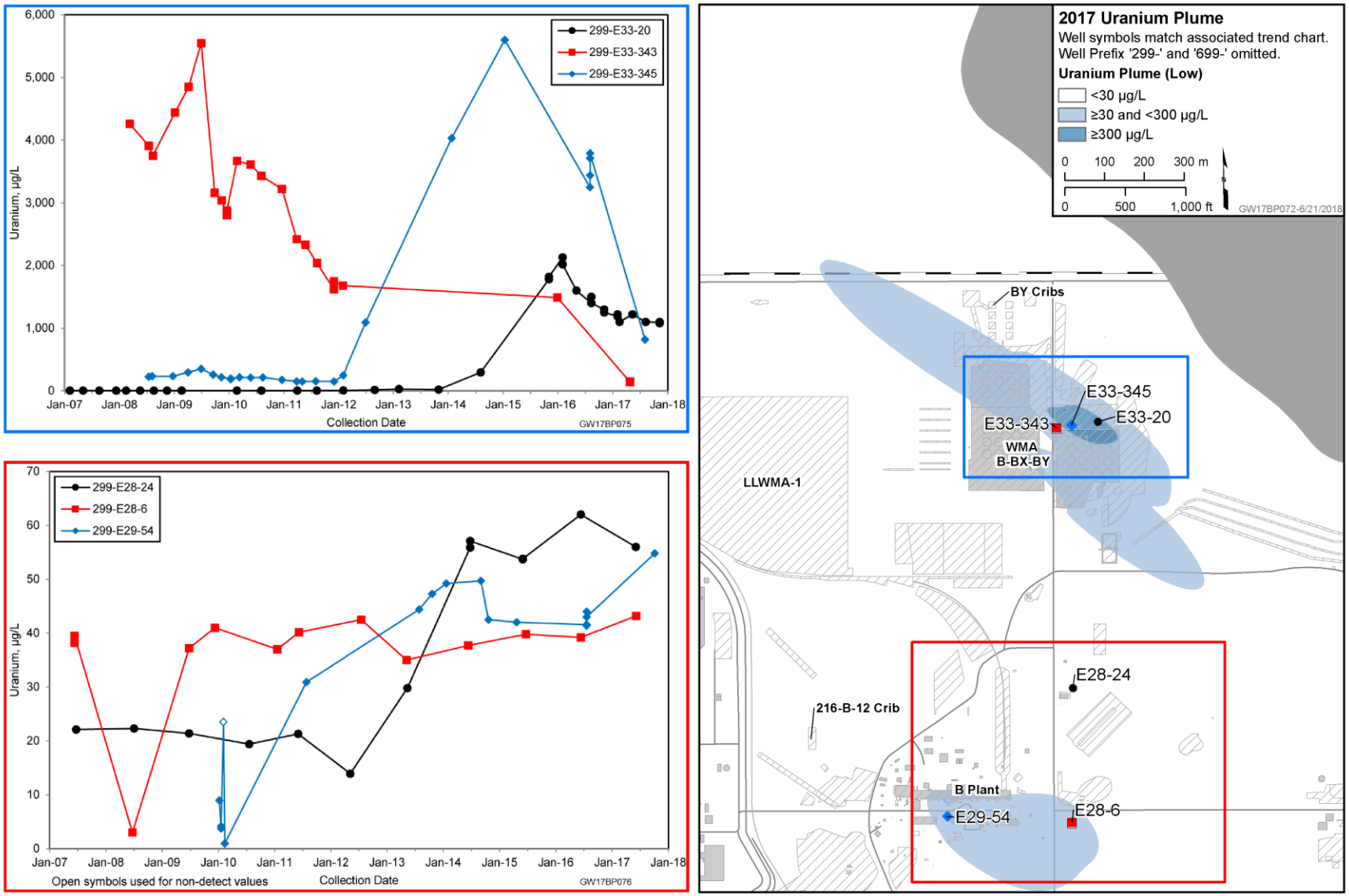


Figure 9-22. 200-BP Uranium Data in Wells at B Complex and B Plant

9.6 Strontium-90

Strontium-90 exceeds the 8 pCi/L DWS near the former Gable Mountain Pond (inactive and dry since the mid- to late 1980s) and near the 216-B-5 injection well. Strontium-90 tends to bind to vadose zone sediments; in 200-BP, it reached groundwater only at locations where the vadose zone is relatively thin (e.g., less than 12 m [39 ft] at Gable Mountain Pond) or where waste was injected into the aquifer (216-B-5 injection well).

The extent of strontium-90 exceeding the DWS closely outlines the area of the former Gable Mountain Pond, with concentrations diminishing to the west where the aquifer is thicker (Figure 9-23). Well 699-53-47B, which is perforated across the 2 m (6.6 ft) thick aquifer, had the highest concentration in this region in 2017 (280 pCi/L). Strontium-90 decreased from a peak of 1,080 pCi/L in 1997 to 280 pCi/L in 2017. Three other wells were sampled in 2017 at Gable Mountain Pond, with concentrations decreasing in two of the three wells and remaining less than detection in well 699-55-50C.

Strontium-90 is detected in wells near the 216-B-5 injection well (Figure 9-23). The highest concentration in 2017 was 511 pCi/L in well 299-E28-24, where levels have declined since 2013 (Figure 9-24). Well 299-E28-25, which was not sampled in 2017, had a concentration of 4,470 pCi/L in 2016, which was a sharp increase from previous years. Well 299-E28-25 is scheduled for sampling in 2018. The areal extent of the plume is bound by strontium-90 less than detection levels at wells 299-E28-1 and 299-E28-4 to the east and southeast, respectively.

9.7 Cyanide

Cyanide in 200-BP groundwater is primarily associated with past discharge sites and UPRs of liquid scavenged waste. The scavenging process was used in the 1950s to reduce the cesium-137 and strontium-90 levels of uranium-recovery and first-cycle decontamination waste before disposal to the soil column. The primary scavenging process used sodium ferrocyanide and nickel sulfate; however, reducing strontium-90 to meet cribbing criteria required calcium nitrate for some tanks. As a result, groundwater cyanide contamination is considered to be in the form of an iron-ferrocyanide complex. In 200-BP, sources of cyanide in groundwater are limited to the B Complex and WMA C.

A 2016 EPA document clarifies that total cyanide methods are allowed for screening, but cyanide is regulated as free cyanide, and the 200 µg/L DWS applies to free cyanide (EPA, 2016, *Cyanide Clarification of Free and Total Cyanide Analysis for Safe Drinking Water Act (SDWA) Compliance*). Cyanide forms complexes with various metals, and only a portion is bioavailable as free cyanide. Chlorinating water for municipal water supplies may increase the amount of bioavailable cyanide, so EPA defines “free” as amenable to chlorination. Total cyanide concentrations in groundwater are typically much higher than free or amenable cyanide concentrations. Free cyanide has a MTCA (WAC 173-340) cleanup level of 4.8 µg/L. Sections 9.10.1 and 9.10.2 provide additional discussion of free and amenable cyanide at WMA B-BX-BY and WMA C, respectively. Because total cyanide only exceeded the 200 µg/L indicator threshold at the B Complex, total cyanide is not discussed for WMA C in this section.

The three main sources contributing to cyanide in groundwater at the B Complex are tank waste supernatant discharged to the BY Cribs, UPRs from pipelines containing tank waste in the B Tank Farm, and possible tank waste overfill and transfer line leaks in tank 241-BX. Section 3.1.8 of PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*, further discusses the conceptual model for the BY Cribs. Further discussion of the UPRs is provided in Table 5-1 of RPP-RPT-49089, *Hanford B-Farm Leak Inventory Assessments Report*; and Section 4.3.3 of RPP-RPT-47562.

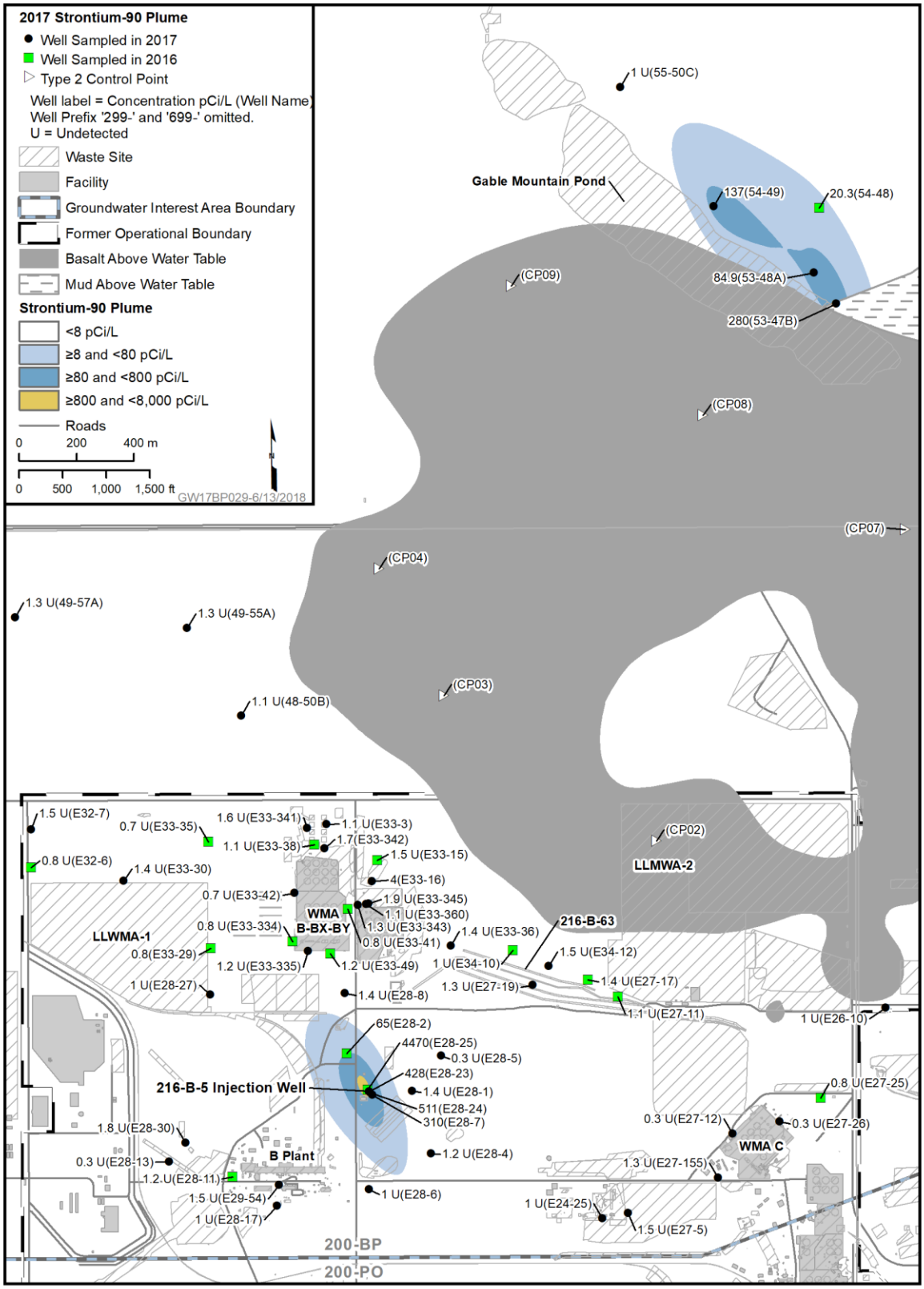


Figure 9-23. 200-BP Strontium-90 Plume, 2017

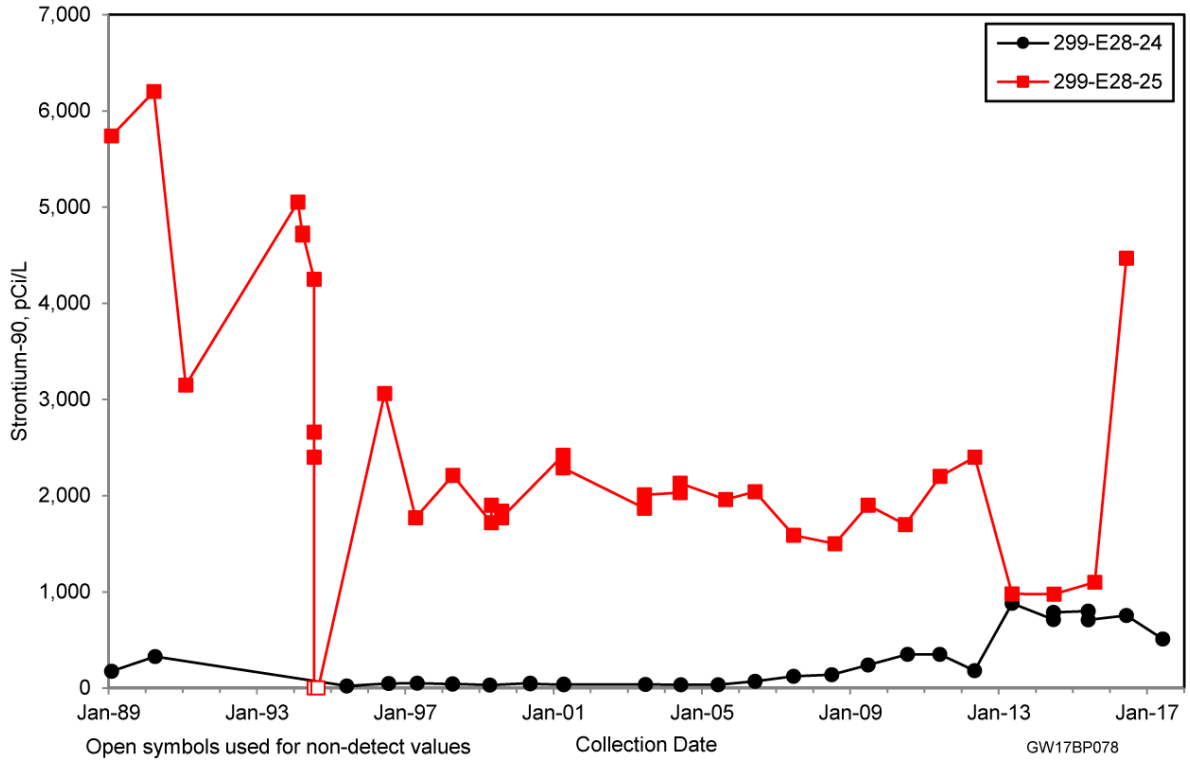


Figure 9-24. 200-BP Strontium-90 Data in Wells Near the Former 216-B-5 Injection Well

The area north of the B Complex is characterized as a thin aquifer (2 m [6.6 ft] or less), which had elevated total cyanide in the 1990s. Previous modeling of the plumes in this area indicated that concentrations would increase as the plumes migrated northwest through well 699-53-55C. Historically, total cyanide concentrations did increase to 195 µg/L in 2009 but have decreased since that time. The aquifer near well 699-53-55C is substantially thicker than to the south. A remnant elevated plume is still depicted in the thin aquifer south of well 699-53-55C (Figure 9-25). It is uncertain if significant concentrations of cyanide still exist in this area, as there are no unconfined groundwater producing wells to determine the extent of remaining cyanide. Amenable and free cyanide analyses have not been performed at wells in this region.

The interpretation of the total cyanide plume to the northwest of the B Complex did not change significantly in 2017. Cyanide concentrations are primarily interpreted by concentration differences between well 699-49-57A and wells within the B Complex (top panel of Figure 9-26). Concentrations at well 699-49-57A declined in 2012 and 2013, shortly after a flow direction reversal. Total cyanide concentrations at well 699-49-57A have fluctuated between 20 and 30 µg/L since 2013. North of well 699-49-57A, wells 699-50-56 and 699-55-57 maintained consistent concentrations, ranging between 55 and 73 µg/L since the groundwater flow direction change in 2011.

Total cyanide concentrations observed in wells within the northwestern portion of the B Complex decreased in 2015 and 2016 because of groundwater extraction (Section 9.9.1), as shown in the bottom panel of Figure 9-26. The concentrations rebounded during equipment modifications in late 2016 and early 2017, subsequently decreasing upon resumed extraction from wells 299-E33-268 and 299-E33-360. Only well 299-E33-38 showed concentrations that continued to exceed the indicator threshold of 200 µg/L, but concentrations declined from 1,020 to 286 µg/L between 2016 and 2017.

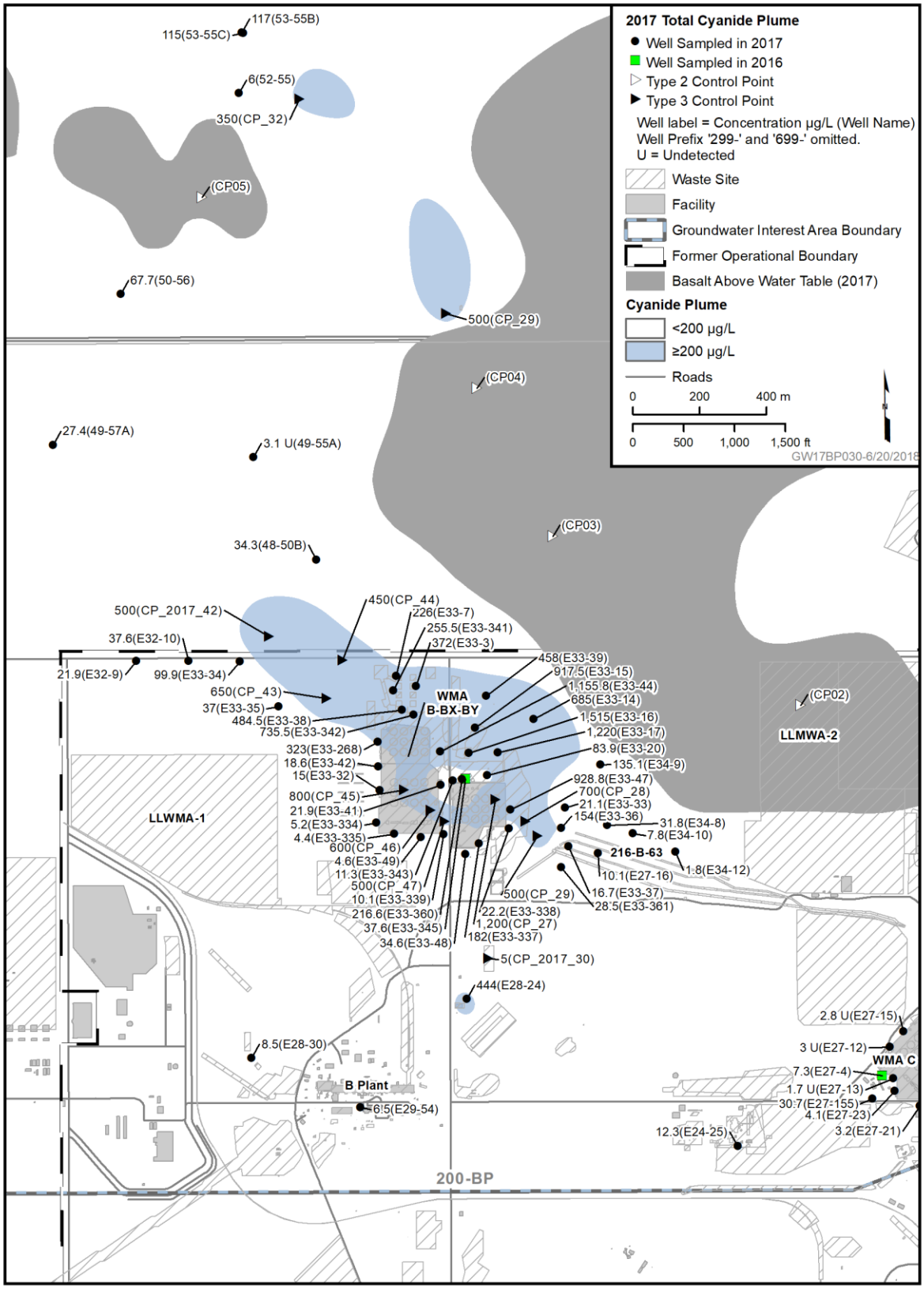


Figure 9-25. 200-BP Total Cyanide Plume, 2017

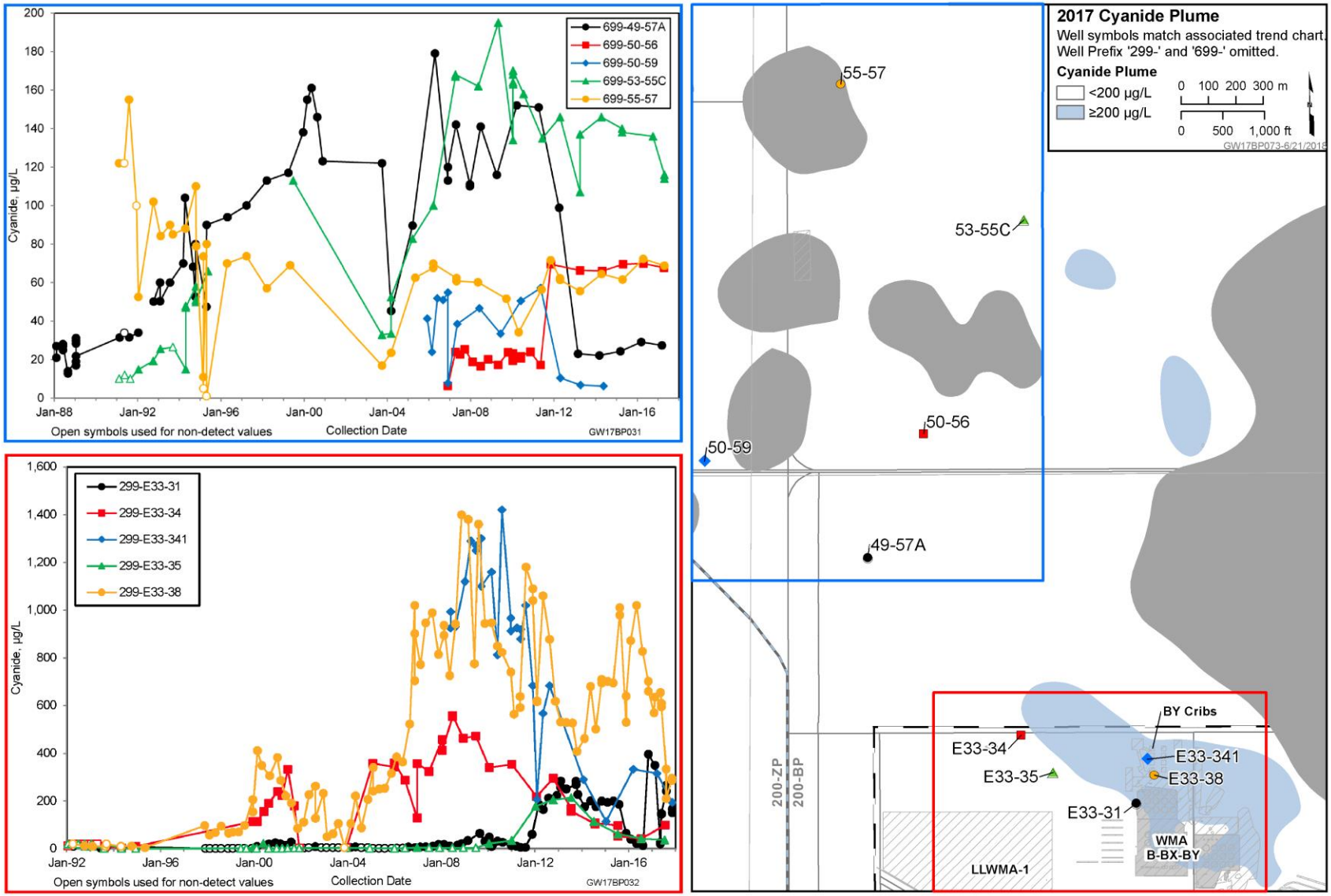


Figure 9-26. 200-BP Total Cyanide Data at Wells North and Northwest of the BY Cribs (Top Panel) and in the Northwestern Portion of the B Complex (Bottom Panel)

In 2017, free cyanide and amenable cyanide were analyzed in some B Complex wells. None of the free cyanide results, and only sporadic amenable cyanide results, exceeded the 200 µg/L DWS. Inconsistencies in the amenable cyanide results raised questions regarding data quality (Section E9.6.2 in Appendix E). Some results have QC qualifiers, indicating a lack of consistency between parent and duplicate results. Filtered and unfiltered sample results also varied much more than expected, and the results were inconsistent between one sample event and the next (Figure 9-27). Similar inconsistences were also noted for free and total cyanide in some wells but to a lesser extent (Figure 9-28).

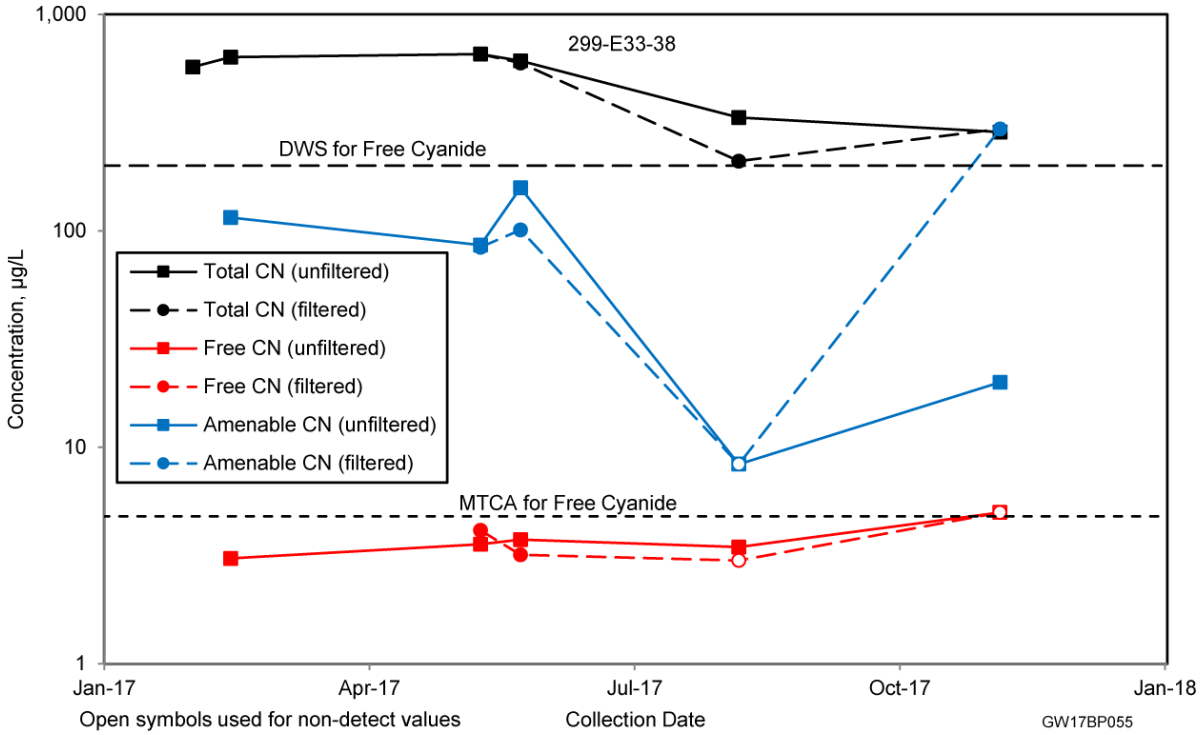
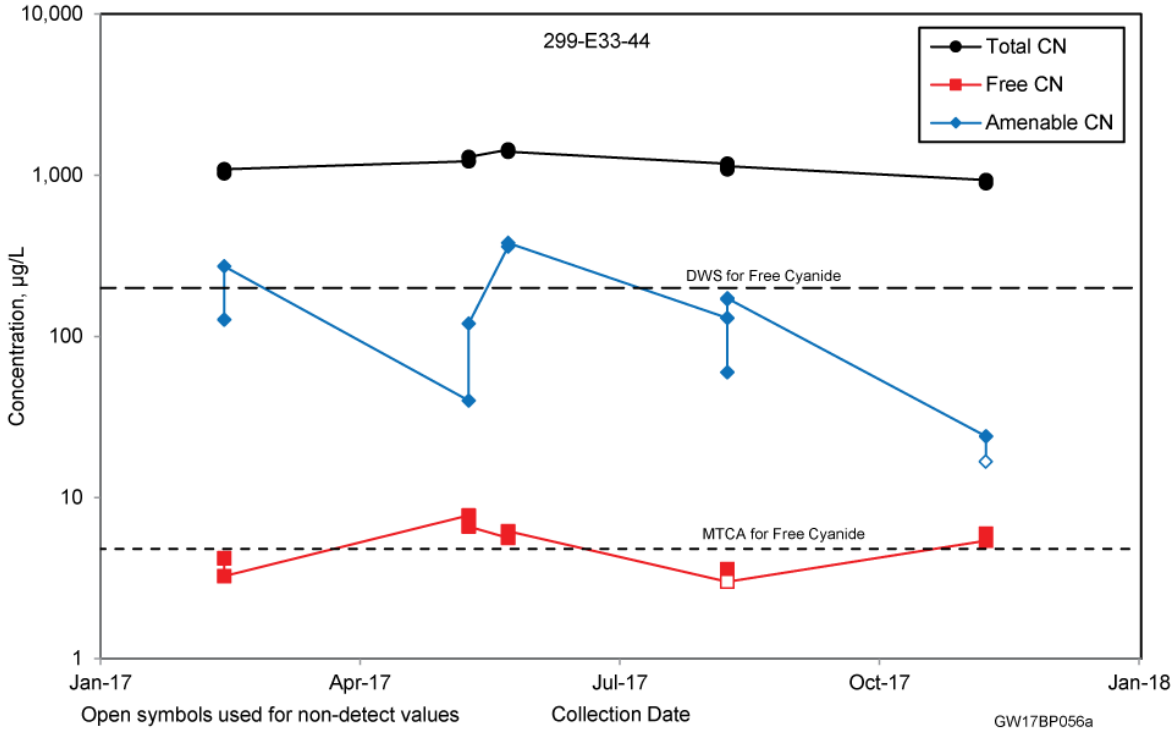


Figure 9-27. 200-BP Total, Free, and Amenable Cyanide Data in Well 299-E33-38

Figure 9-29 shows maximum concentrations of free cyanide in 200-BP for 2017 (excluding suspect data points). The extent of free cyanide concentrations above the 4.8 µg/L MTCA standard (WAC 173-340) in the B Complex is uncertain because analytical detection limits for free cyanide ranged from 3 to 5 µg/L in 2017. Nearly all of the detections were flagged as "B," indicating that the results were less than the required detection limit but greater than or equal to the MDL.

Total cyanide concentrations in the central portion of the B Complex display two different trends: increasing or decreasing. Wells 299-E33-16, 299-E33-20, and 299-E33-345 in the central portion of the B Complex displayed increasing trends in 2017 because of their location with respect to current high-concentration plumes and extraction well 299-E33-360 (top panel of Figure 9-30). Well 299-E33-16 is located between the highly concentrated total cyanide plume east of the BY Cribs and the extraction well. As a result, total cyanide concentrations increased as the northern concentrated plume migrates toward the extraction well. Cyanide concentrations slightly increased in wells 299-E33-20 and 299-E33-345, but the migrating plume is smaller, and these wells are not within the direct migration path of the contaminant plume. Concentrations in wells 299-E33-14, 299-E33-39, 299-E33-44, and 299-E33-339 are declining toward the 200 µg/L indicator threshold, reflecting ongoing groundwater extraction (Figure 9-30).



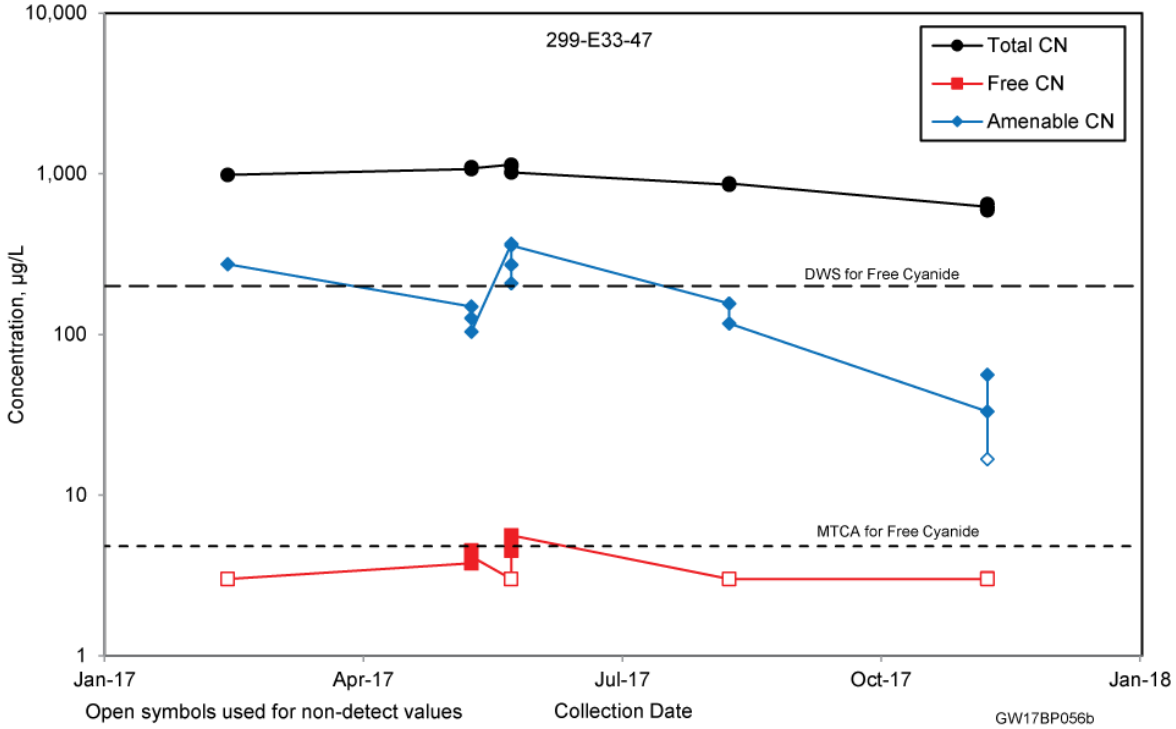


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Figure 9-28. 200-BP Total, Free, and Amenable Cyanide Data in Wells 299-E33-44 and 299-E33-47

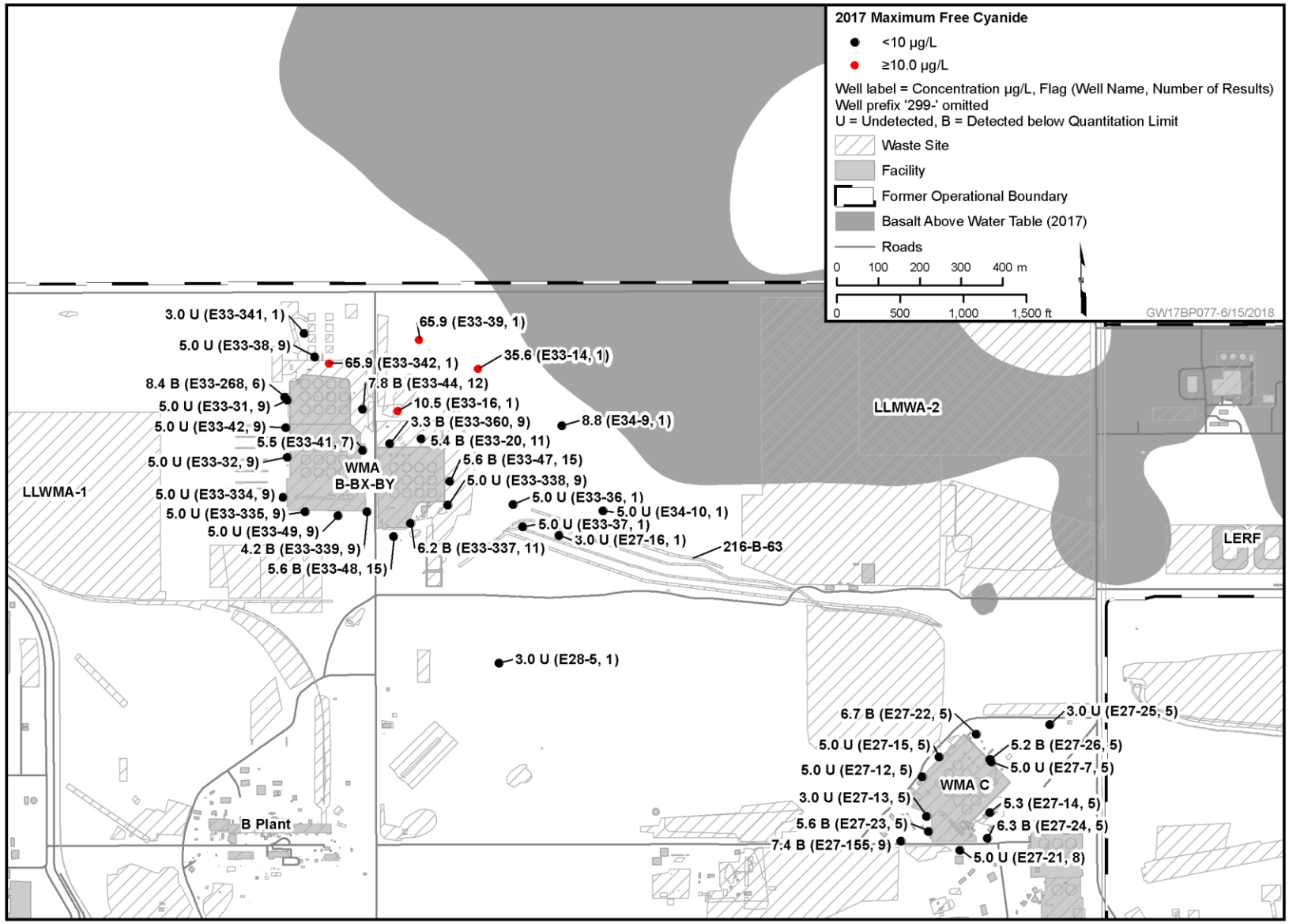


Figure 9-29. 200-BP Maximum Free Cyanide Detected in Groundwater, 2017

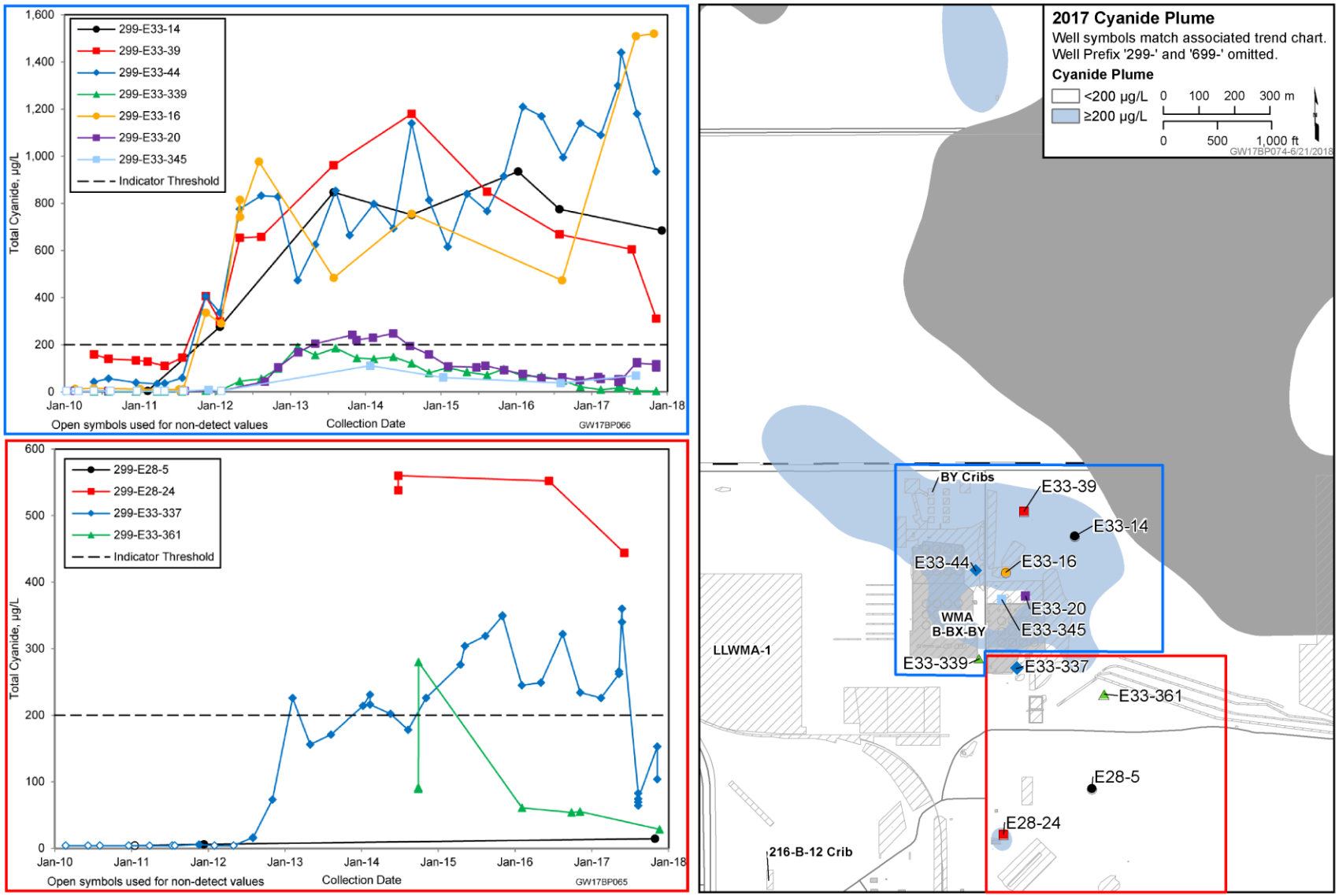


Figure 9-30. 200-BP Total Cyanide Data in Wells in B Complex Area

Total cyanide concentrations in the southern portion of the B Complex and extending to the southeast were generally declining or below the indicator threshold by the end of 2017. Concentrations declined most rapidly in well 299-E33-337, closest to the southern boundary of the B Tank Farm or within the primary migration pathway (bottom panel of Figure 9-30). Farther south and southeast, wells 299-E28-5 and 299-E33-361 define the south-southeast plume extent. Concentrations in well 299-E28-24, located 660 m (2,200 ft) south of extraction well 299-E33-360, declined from 552 to 444 µg/L between 2016 and 2017, but the decline appears to reflect source variability more than effects due to groundwater extraction from the B Complex.

9.8 Tritium

Tritium concentrations continued to exceed the 20,000 pCi/L DWS near the 216-B-12 Crib (near B Plant; Figure 9-31) and the 216-B-3 Pond. The former tritium plume exceeding the DWS near the 216-B-50 Crib is no longer present. Groundwater extraction in this area caused tritium levels at well 299-E33-3 (located 50 m [160 ft] southeast of the 216-B-50 Crib) to decline from 25,500 to 5,770 pCi/L between 2016 and 2017.

Near the 216-B-12 Crib, tritium currently exceeds the DWS in only the lower part of the aquifer. The 216-B-12 Crib received 2,340 Ci of tritium from 1952 to 1957. In the 1980s, the tritium plume began migrating to the northwest, and levels exceeding 200,000 pCi/L were detected in wells north of the crib. Concentrations subsequently declined below the 20,000 pCi/L DWS in the upper part of the unconfined aquifer. Sampling during drilling of wells 299-E28-30 and 299-E29-54 (in 2010) and wells 299-E28-31 and 299-E28-32 (in 2015) identified a deep zone of elevated tritium within low-permeability hydrostratigraphic units 9A, 9B, and 9C at 8 m (26 ft) below the water table. A 2017 routine sample from well 299-E28-31, screened 11.6 m (38 ft) below the water table, detected tritium at 53,700 pCi/L. A 2017 sample from well 299-E28-32, screened from 17.3 m (56.8 ft) below the water table near the bottom of the aquifer, detected tritium at 34,900 pCi/L. Wells 299-E28-30 and 299-E29-54 monitor the upper part of the unconfined aquifer, where tritium concentrations are below the DWS.

The tritium plume at B Pond is associated with previous PUREX Plant discharges. Because of the decline in the water table beneath B Pond due to the termination of discharges in the mid-1990s, the unconfined aquifer is no longer present beneath B Pond. Concentrations exceeding the DWS are currently found in only one 200-BP well (699-42-40A). The tritium level at this well has been stable since 2007, and an early 2018 result was 33,700 pCi/L. This tritium plume is expected to continue to decrease in size and vanish in the near future because tritium has a short half-life (12 years), and discharges were terminated more than 20 years ago, reducing the ability for tritium to migrate. Chapter 10 includes additional discussion of the B Pond tritium plume.

9.9 CERCLA Remediation and Monitoring

This section summarizes activities in the 200-BP-5 Groundwater OU and the 200-DV-1 Deep Vadose Zone OU.

9.9.1 200-BP-5 Operable Unit

DOE submitted the Draft A RI report (DOE/RL-2009-127) to Ecology in August 2015. The RI report describes the nature and extent of contamination and identifies the COPCs for the 200-BP-5 OU.

Groundwater monitoring under CERCLA in 2017 transitioned from DOE/RL-2001-49, *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit*; to DOE/RL-2014-33, Draft A, *Sampling and Analysis Plan for the 200-BP-5 Groundwater Operable Unit*. Table A-1 in Appendix A lists the sampling exceptions for 2017.

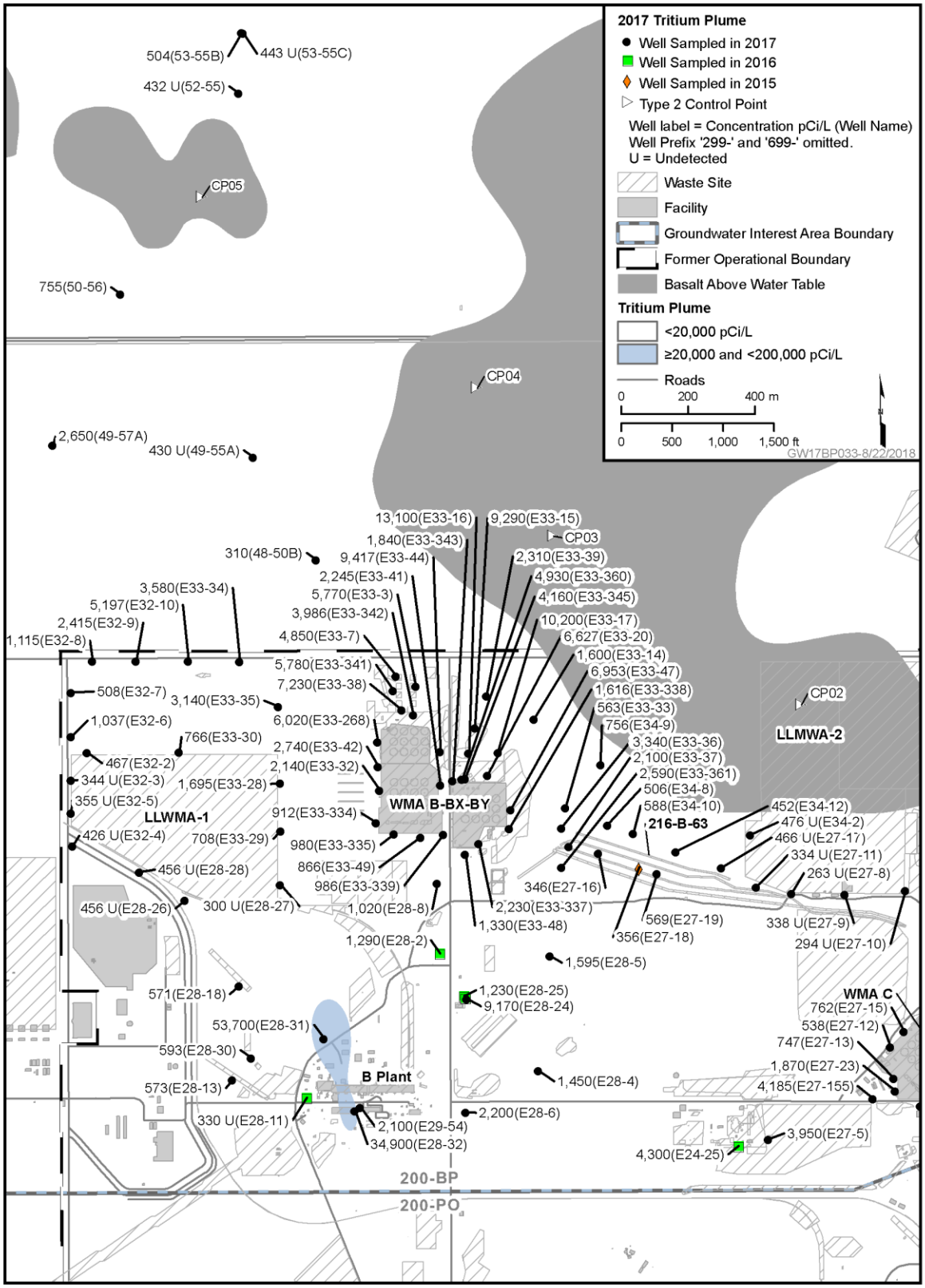


Figure 9-31. 200-BP Tritium Plume, 2017

Groundwater extraction at well 299-E33-268, initiated in September 2015 as a treatability test, proved that extraction rates greater than 586 L/min (150 gal/min) could be sustained in the unconfined aquifer at the B Complex and that P&T was a plausible alternative to remediate technetium-99 and uranium. A December 2016 action memorandum (DOE/RL-2016-41) documented the decision to implement a non-time-critical removal action for the B Complex technetium-99 and uranium plumes exceeding 10 times the DWS. The extracted groundwater is treated at the 200 West P&T before reinjection in the 200 West Area. Extraction well 299-E33-360 was added to the B Complex extraction network in 2017. In June 2017, extraction from well 299-E33-360 was increased and extraction from well 299-E33-268 was terminated. This change was based on modeled capture results of B Complex contaminants exceeding 10 times the DWS. Continued extraction at well 299-E33-360 is modeled to remove 2.3 Ci of technetium-99 and 160 kg of uranium within a 5-year period (DOE/RL-2017-11, Draft A, *Removal Action Work Plan For 200-BP-5 Operable Unit Groundwater Extraction*). Table 9-3 and Figure 9-32 summarize the mass of contaminants removed from groundwater in 2017 and since startup.

Table 9-3. 200-BP Remediation Summary

Contaminant	Removed 2017	Removed Since Startup
200-BP-5 Operable Unit Groundwater Extraction (Single Well, 2015–2016; Two Wells, 2017) Estimated Values		
Cyanide (kg)	44	102
Iodine-129 (Ci)	1.44×10^{-3}	1.70×10^{-3}
Nitrate (kg)	17,071	87,261
Technetium-99 (g; Ci)	95.1; 1.62	171; 2.90
Tritium (Ci)	1.27	2.69
Uranium (kg)	123	137
Perched Water Extraction Removal Action (Single Well, 2011–2015; Three Wells, 2016–2017)		
Nitrate (kg)	1,324	2,102
Technetium-99 (g; Ci)	2.7, 4.5×10^{-2}	5.2; 8.8×10^{-2}
Uranium (kg)	78	157

A removal action work plan (DOE/RL-2017-11, Draft A) was drafted in 2017 that describes how the removal action in the B Complex will be implemented. Appendix C of the removal action work plan contains a performance action SAP. The Tri-Parties reviewed the work plan and SAP, comment disposition continued through the end of 2017, and the final version is planned for issuance in early 2018. Also in 2017, DOE/RL-2003-30, *Waste Control Plan for the 200-BP-5 Operable Unit*, was replaced by DOE/RL-2017-64, *Post Remedial Investigation Waste Control Plan and Removal Action Waste Management Plan for the 200-BP-5 Groundwater Operable Unit*. Chapter 6 of DOE/RL-2017-67 provides additional information about the 200-BP-5 removal action in 2017.

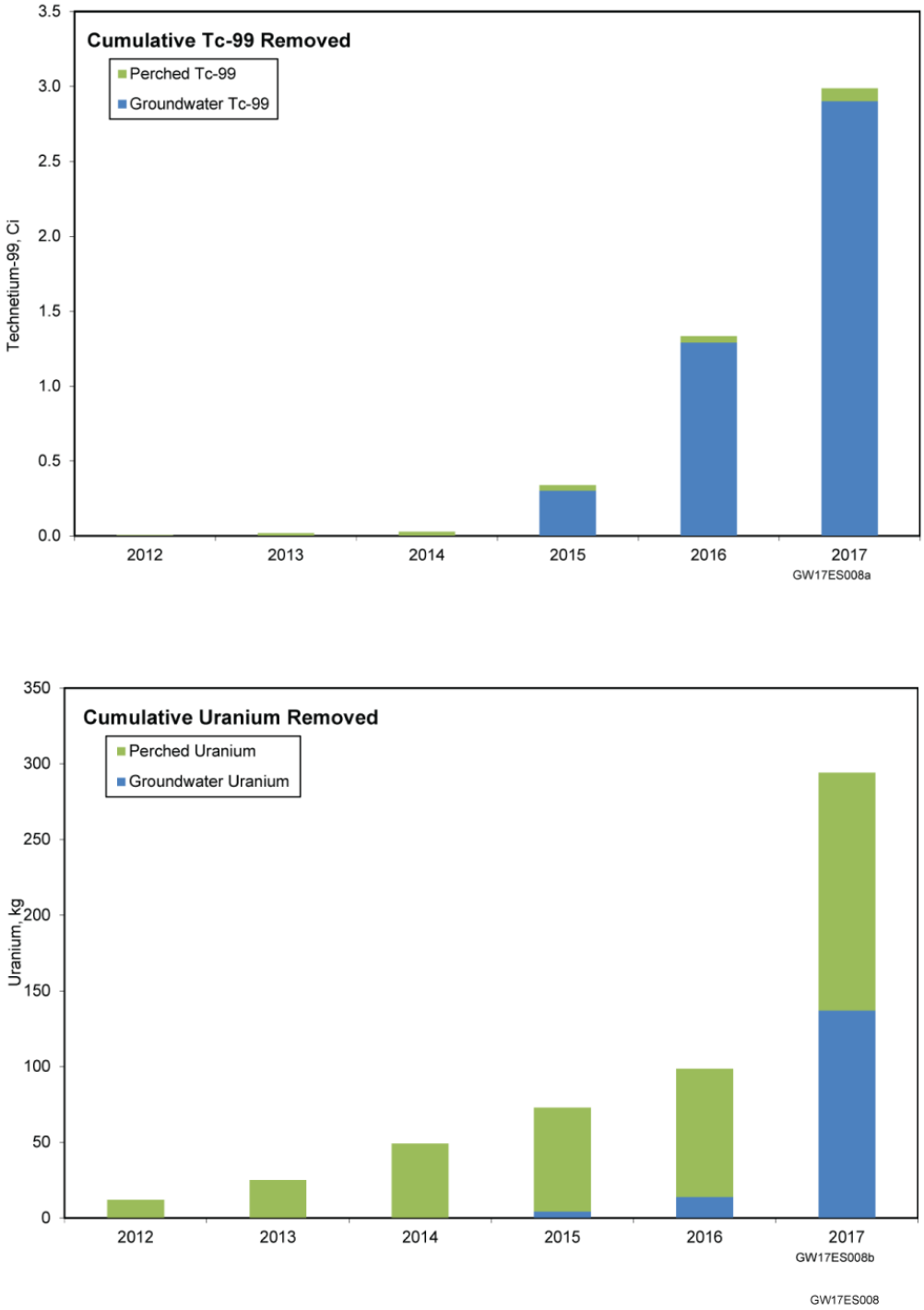


Figure 9-32. 200-BP Contamination Removed from Groundwater and Perched Water in the B Complex Area

9.9.2 200-DV-1 Operable Unit

The 200-DV-1 OU was created in 2010 to support remedy selection for waste sites with deep vadose zone contamination in the Central Plateau. In general, deep vadose zone contamination is considered to be contamination that poses a potential threat to groundwater and is challenging to remediate using standard surface-based remedies. The goal for the 200-DV-1 OU is to ensure long-term protection of groundwater in the Central Plateau. A total of 43 waste sites are assigned to the 200-DV-1 OU. In the 200 East Area, the 200-DV-1 OU waste sites are near WMA B-BX-BY. In the 200 West Area, the 200-DV-1 OU waste sites are near WMAs T, TX-TY, and S-SX. However, the OU does not include the tank farms.

In August 2011, DOE began a treatability test at perched water well 299-E33-344 (DOE/RL-2011-40, *Field Test Plan for the Perched Water Pumping/Pore Water Extraction Treatability Test*). The treatability test investigated the feasibility of removing contaminants by extracting water from the perched water horizon. Two additional perched water extraction wells (299-E33-350 and 299-E33-351) were added to the system in 2016, and the treatability test transitioned to a CERCLA removal action (DOE/RL-2014-34, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*). In 2017, contaminated perched water was conveyed to the 200 West P&T through the same cross-site pipeline used for the 200-BP-5 removal action. Through the end of December 2017, a combined total of 2,630,000 L (690,000 gal) of water has been removed, containing 2,102 kg of nitrate; 5.2 g of technetium-99; and 157 kg of uranium (Table 9-3 and Figure 9-32). Chapter 5 of DOE/RL-2017-67 provides additional information about the 200-DV-1 perched water removal action in 2017.

Characterization activities in the 200-DV-1 OU are being performed in accordance with DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*; and DOE/RL-2011-104-ADD1, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 1: Attenuation Process Characterization*. The characterization of 26 boreholes began in July 2015 and continued into 2016. In 2017, the last four boreholes were drilled to total depth, sampled, analyzed, and decommissioned. One of these boreholes was located in the 200-BP groundwater interest area (Table 9-4) and the other boreholes are in 200-UP and 200-ZP. Characterization data from the boreholes will be used to refine the CSMs and will guide future remedy selection for 200-DV-1 OU waste sites. In 2018, 28 shallow boreholes will be drilled and sampled to determine potential risk to human health and/or the environment during current or future land use in accordance with DOE/RL-2011-104-ADD2, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 2: Supplemental Shallow Soil Risk Characterization Sampling*.

9.10 RCRA Monitoring

DOE/RL-2017-65 presents the results of RCRA groundwater monitoring for the Hanford Site in 2017. This section repeats that information for the RCRA WMAs in 200-BP. These WMAs are monitored under RCRA requirements for dangerous waste/dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials. Data from unit-specific monitoring are also integrated into CERCLA groundwater investigations. Dangerous constituents and radionuclides are occasionally discussed jointly in this section to provide comprehensive interpretations of groundwater contamination. Pursuant to RCRA, the source, special nuclear, and byproduct material components of radioactive mixed waste are not regulated under RCRA but are instead regulated by DOE, acting pursuant to its AEA authority. Therefore, the inclusion of information on radionuclides in such a context is for informational purposes only and may not be used to create conditions or other restrictions set forth in any RCRA permit.

Table 9-4. Wells and Boreholes Installed or Decommissioned in 200-BP in 2017

Well Name	Well ID	Purpose	Construction Depth (m bgs)	Construction Depth (ft bgs)	Drilled Depth (m bgs)	Drilled Depth (ft bgs)	Acceptance or Decommission Date	Comment
299-E27-4	C4125	Decommissioned	N/A	N/A	N/A	N/A	12/11/2017	Corroded Waste Management Area C well
699-44-43C	C9615	216-B-3 Pond monitoring[a]	61.7	202.3	61.7	202.3	8/17/2017	Well is in 200-BP interest area, but 216-B-3 Pond is in the 200-PO interest area (Chapter 10)
C9497	C9497	200-DV-1 characterization[b]	N/A	N/A	83.6	274.3	8/17/2017	Decommissioned

a. See Chapter 10.

b. DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*; and DOE/RL-2011-104-ADD1, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit Addendum 1: Attenuation Process Characterization*.

bgs = below ground surface

ID = identification

N/A = not applicable

The 200-BP groundwater interest area contains six RCRA WMAs with groundwater monitoring requirements: WMA B-BX-BY, WMA C, 216-B-63 Trench, Liquid Effluent Retention Facility (LERF), LLWMA-1, and LLWMA-2 (Figure 9-2). The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for this reporting period. Groundwater data are available in the HEIS database and in the data files accompanying this report. Appendix B provides additional information, including well and constituent lists, and statistical tables.

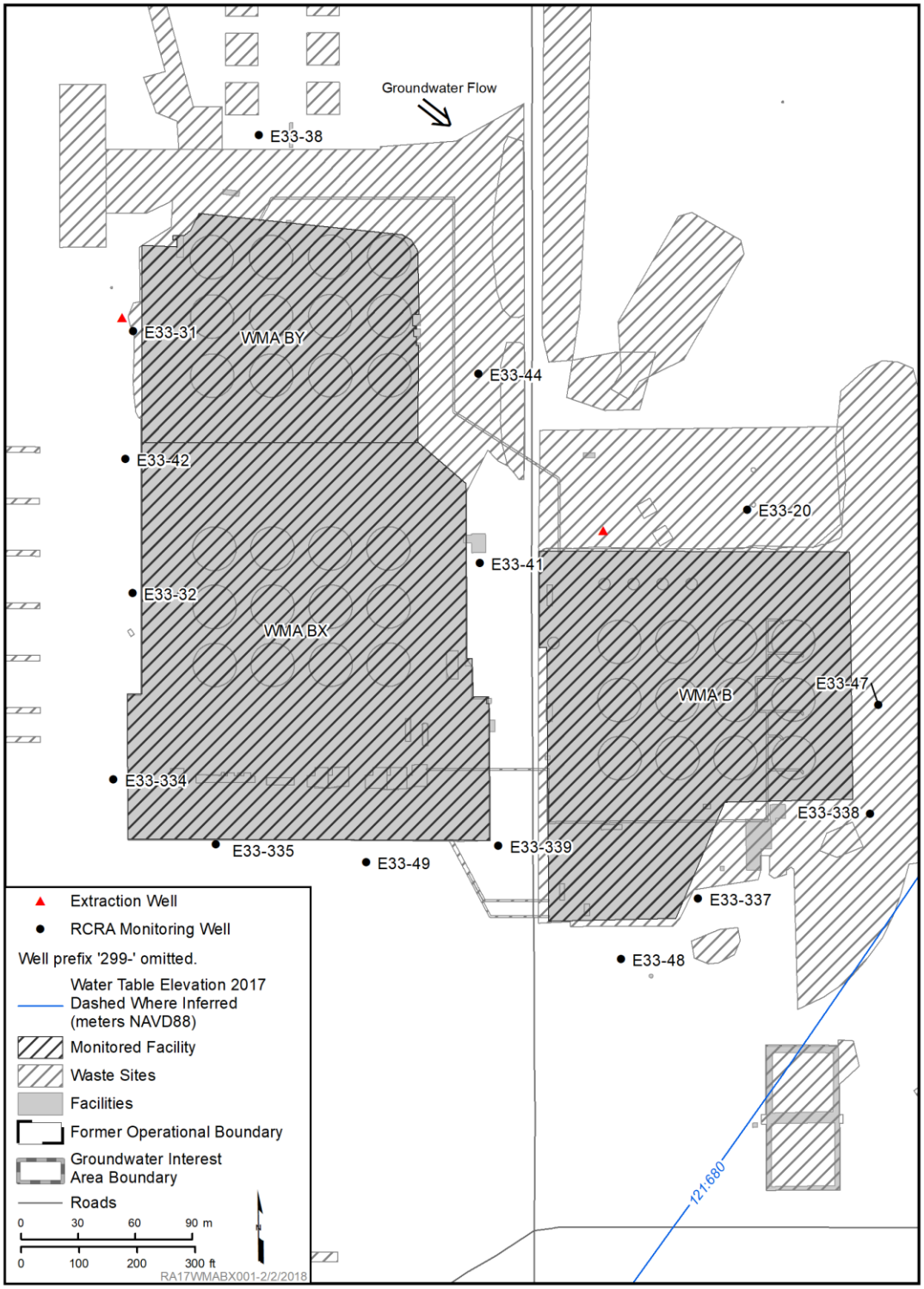
9.10.1 Waste Management Area B-BX-BY

WMA B-BX-BY is located in northwestern 200 East Area (Figure 9-33). It was constructed in stages: B Tank Farm between 1943 and 1944, BX Tank Farm between 1946 and 1947, and BY Tank Farm between 1948 and 1949. All three tank farms provided interim storage of radioactive mixed waste, primarily from the bismuth phosphate, PUREX, and uranium extraction processes. However, no self-boiling waste from PUREX Plant or REDOX Plant was sent to the B-BX-BY Tank Farms prior to removal of high heat-generating fission products. All of the 24 SSTs in the B and BX Tank Farms were built to store up to 2.0 million L (530,000 gal) of liquid waste. In the B Tank Farm, four additional tanks each had a capacity of 208,000 L (55,000 gal). Each of the 12 SSTs in the BY Tank Farm had a 2.9 million L (770,000 gal) capacity. Ancillary equipment at WMA B-BX-BY includes 13 diversion boxes, the 244-BXR waste transfer vault, 5 catch tanks, and several connecting underground lines.

Of the 40 tanks in WMA B-BX-BY, 20 tanks are known or assumed leakers (Table 4-1 of HNF-EP-0182, *Waste Tank Summary Report for Month Ending November 30, 2016*). To minimize the probability and severity of future leaks, most of the drainable liquid in each tank has been removed and transferred to DSTs. Additional UPRs within WMA B-BX-BY include tank overfills, waste loss from spare inlet nozzles or cascade lines, pipeline leaks, and surface releases.

DOE monitors groundwater beneath WMA B-BX-BY under an interim status assessment program in accordance with 40 CFR 265.93(d)(4), “Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, Disposal Facilities,” “Preparation, Evaluation, and Response”; as defined in DOE/RL-2012-53, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY*. While developing DOE/RL-2012-53, an assessment of historical process chemistry, leak assessment reports, and groundwater contaminants concluded that cyanide had affected groundwater quality beneath the B Tank Farm. The probable cyanide source and a conceptual model for transport were provided as part of the determination. Although other releases from WMA B-BX-BY have affected groundwater, there is currently no evidence of additional dangerous waste or dangerous waste constituents.

The WMA B-BX-BY well network consists of six upgradient and nine downgradient wells (Table B-75 in Appendix B). Most of the well screens extend across the entire unconfined aquifer to the underlying basalt surface. The water table elevation at WMA B-BX-BY declined an average of 1.4 cm/yr (0.6 in./yr) between 2012 and 2017. The wells have adequate water columns in the screened interval for sampling during the next decade.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 9-33. Waste Management Area B-BX-BY

Groundwater gradient magnitudes and flow directions were determined using the 200 East Area low-gradient monitoring network for the period of October 2016 through September 2017 (Figure 9-6). The estimated gradient average is 7.0×10^{-6} m/m, dipping to the southeast (Table B-76 in Appendix B). The estimated groundwater flow rate ranged from 0.59 to 0.66 m/d (2.0 to 2.2 ft/d). In 2017, groundwater was pumped from two extraction wells near WMA B-BX-BY as part of a CERCLA removal action for the B Complex technetium-99 and uranium plumes (DOE/RL-2016-41). Figure 9-33 illustrates the extraction well locations. Because the hydraulic conductivity of the aquifer is so high, the wells do not create a discernible cone of depression, but it can be assumed that groundwater extraction affects flow directions locally. Groundwater extraction will continue in 2018.

All of the network wells were sampled quarterly during the reporting period, except for decommissioned well 299-E33-18 (Table B-75 in Appendix B). Well 299-E33-41 was sampled twice in May because of incorrect cyanide preservation during the first sampling trip.

The dangerous waste constituent cyanide is sourced from the BY Cribs and WMA B-BX-BY (B and BX Tank Farms). The monitoring plan requires analysis for total cyanide, and five wells had total cyanide results above 200 µg/L in 2017, including 299-E33-337 and 299-E33-47 (Figure 9-34). In 2017, WMA B-BX-BY groundwater samples were analyzed by methods to determine free cyanide and cyanide amenable to chlorination, as well as total cyanide, and Table B-77 in Appendix B summarizes the results.

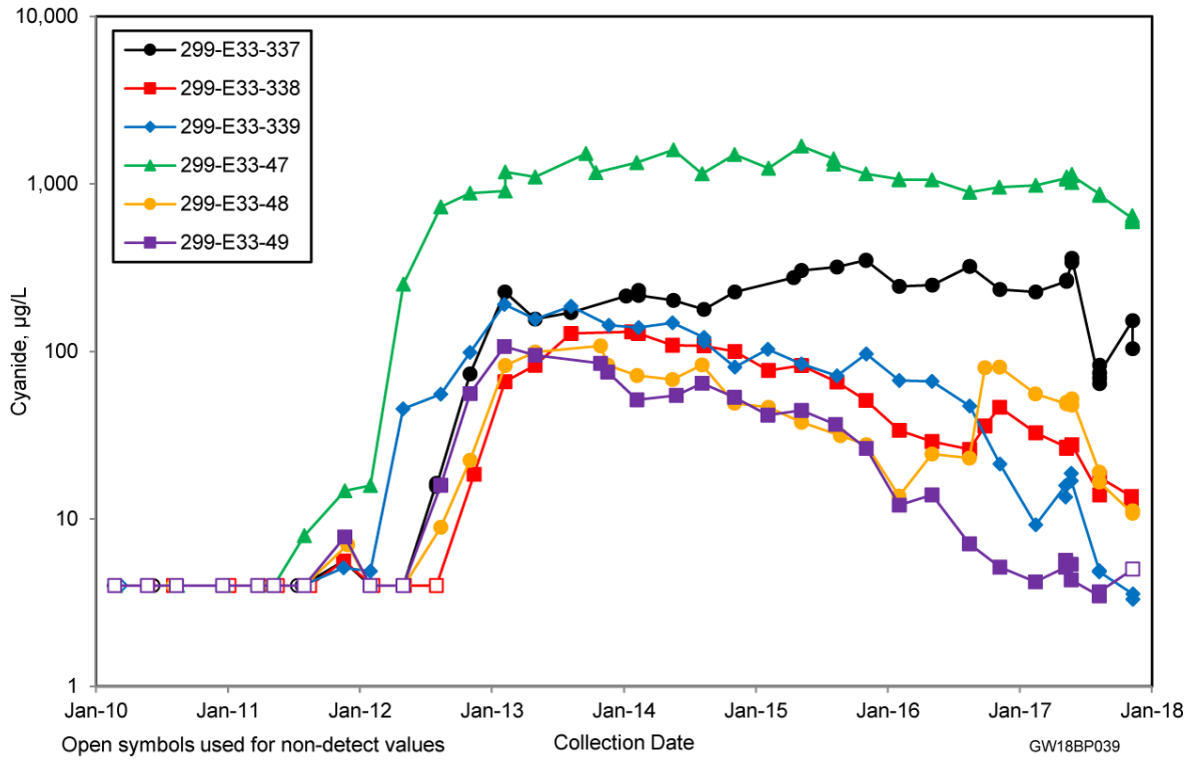


Figure 9-34. Total Cyanide in WMA B-BX-BY Wells

Nitrate exceeds the DWS in all WMA B-BX-BY wells, with the highest concentrations at downgradient wells 299-E33-44 and 299-E33-47. Well 299-E33-44 also had sulfate concentrations above the secondary DWS.

9.10.2 Waste Management Area C

WMA C is located in the east-central portion of the 200 East Area (Figure 9-35). Constructed in 1943 and 1944, WMA C provided interim storage of radioactive mixed waste, primarily from the bismuth phosphate, PUREX, and uranium extraction processes. High-level liquid waste from these processes was stored in 12 SSTs, each with a capacity of 2.01 million L (530,000 gal). Four additional SSTs, each with a capacity of 208,000 L (55,000 gal), were also used to store high-level liquid waste. Ancillary equipment at WMA C includes seven diversion boxes, the 244-CR vault with four permitted tanks, the 241-C-301 catch tank, one french drain, two dry wells (liquid waste disposal units associated with the 241-C-801 cesium loadout facility), and several connecting underground lines. Of the 16 underground tanks in WMA C, 7 tanks were confirmed or assumed to have leaked (DOE/RL-2009-77, *Groundwater Quality Assessment Plan for the Single-Shell Waste Management Area C*) and retrieval processes since 1998 have removed the liquid waste. Additional sources include waste losses from spare inlet nozzles or cascade lines, pipeline leaks, and surface releases.

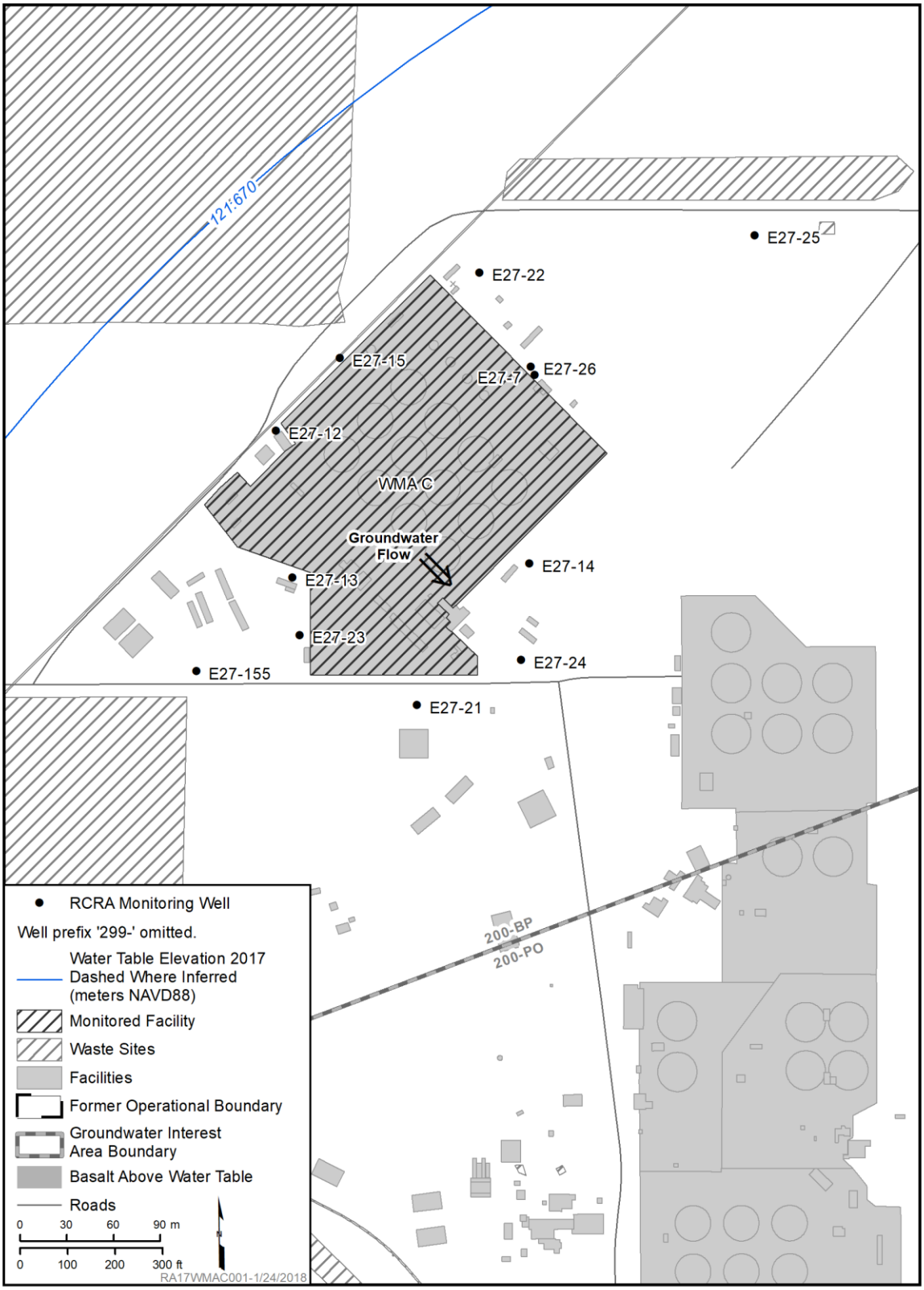
DOE monitors groundwater beneath WMA C under an interim status assessment program in accordance with 40 CFR 265.93(d)(4), as defined in DOE/RL-2009-77. While developing DOE/RL-2009-77, an assessment of historical process chemistry, leak assessment reports, and groundwater contaminant distribution concluded that cyanide had affected groundwater beneath the C Tank Farm. Although other releases from WMA C have affected groundwater, there is currently no significant evidence of additional dangerous waste or dangerous waste constituents.

Table B-78 in Appendix B lists the wells monitored for WMA C. Well 299-E27-4 was formerly in the monitoring network; however, because of casing corrosion, the well was removed from service in 2016 and decommissioned in 2017. WMA C monitoring wells are *Washington Administrative Code* compliant, except for well 299-E27-7. Replacement well 299-E27-26 was installed in 2016, and samples were collected from both wells in 2017. Total cyanide concentrations are somewhat higher in the new well (9 to 14 µg/L in 2017) than in the old well (less than 8 µg/L). Specific conductance and nitrate are the same in the new and old wells. A revised assessment plan will remove well 299-E27-7 and add well 299-E27-26.

Excluding outliers, the water table elevation at WMA C declined an average of 1.2 cm/yr (0.5 in./yr) between 2012 and 2016. The WMA C groundwater wells have adequate water in the screened intervals for sampling during the next two decades.

Groundwater gradient magnitude and flow direction were determined using a low-gradient monitoring network across the 200 East Area (Figure 9-6). The estimated average gradient was 4.9×10^{-6} m/m, dipping toward the southeast (Table B-79 in Appendix B). The estimated flow rate was 0.41 m/d (1.4 ft/d). All of the wells were sampled quarterly during the reporting period (Table B-78 in Appendix B).

Table B-80 in Appendix B summarizes the analytical results for 2017. Total cyanide continued to be detected in some of the WMA C wells in 2017. Wells 299-E27-24 and 299-E27-155 showed increasing concentrations of total cyanide (Figure 9-36). As discussed in Section 9.7, the 200 µg/L DWS and 4.8 µg/L MTCA standard (WAC 173-340) apply to free cyanide. In 2017, WMA C groundwater samples were analyzed by methods to determine free cyanide and cyanide amenable to chlorination. Free cyanide results were near or below detection limits. Amenable cyanide concentrations were also near detection limits, except in sporadic cases that appear to be related to data quality issues (discussed in Section 9.7).



Reference: NAVD88, *North American Vertical Datum of 1988*, as revised.

Figure 9-35. Waste Management Area C

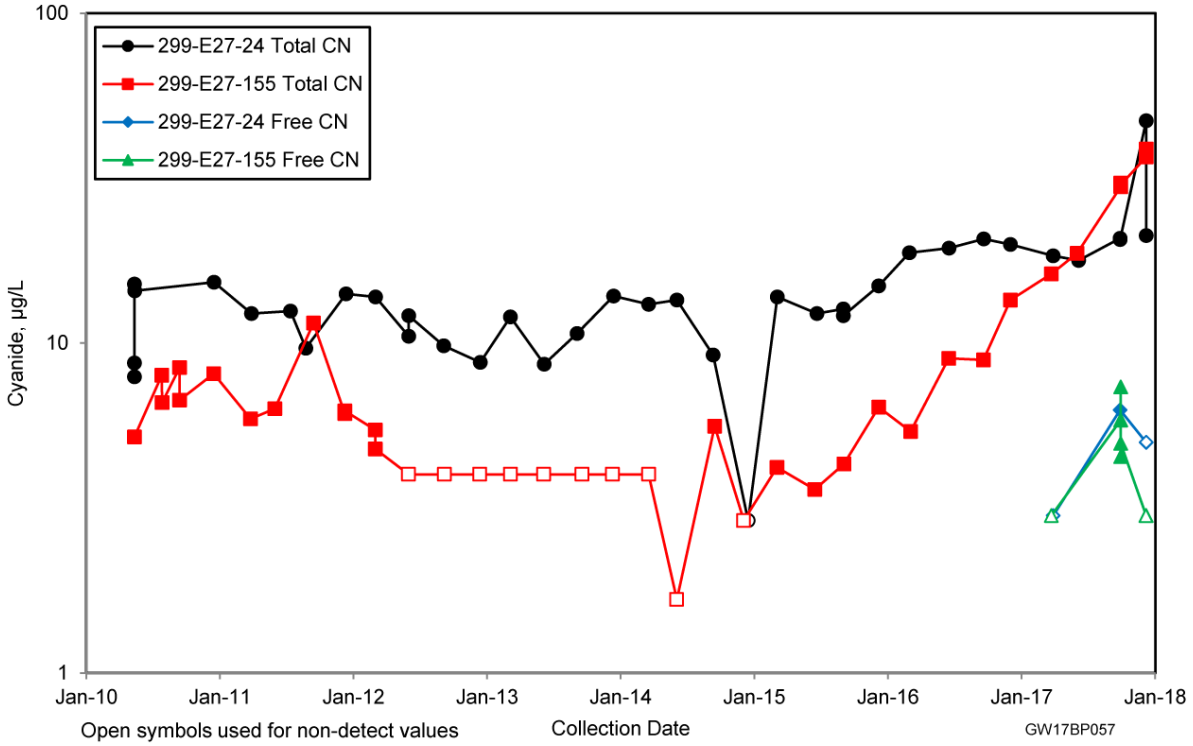


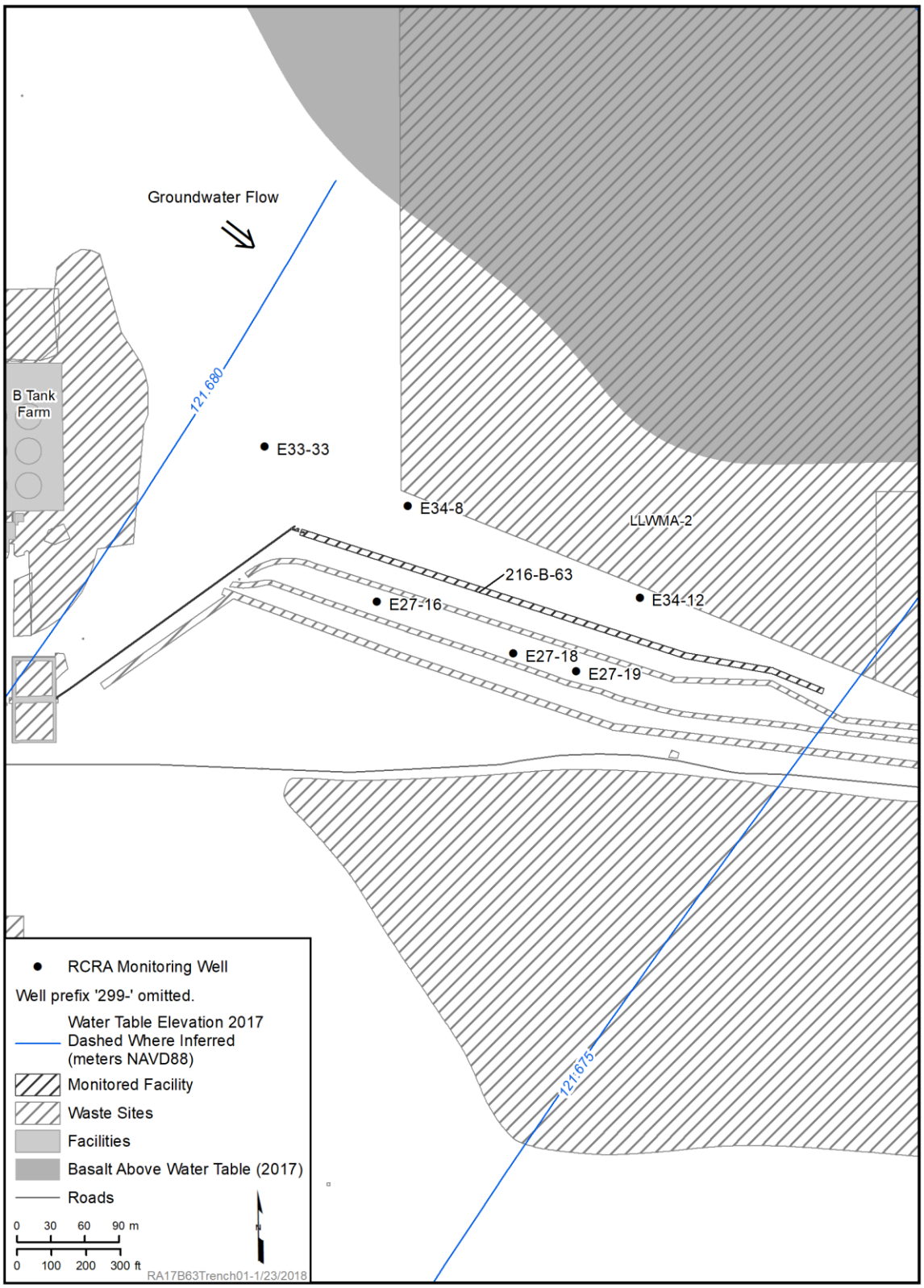
Figure 9-36. Total and Free Cyanide in Wells 299-E27-24 and 299-E27-155

Iron exceeded the secondary DWS in unfiltered samples from six wells (Table B-80 in Appendix B) and filtered samples from well 299-E27-13. Well 299-E27-13 also exceeded the secondary DWS for manganese in filtered and unfiltered samples. Nitrate and sulfate also exceeded DWSs in 2017.

9.10.3 216-B-63 Trench

The 216-B-63 Trench TSD unit is located in the north-central portion of the 200 East Area (Figure 9-37). Beginning in 1970, it was used as an emergency percolation trench for chemical sewer waste from B Plant (RHO-CD-798, *Current Status of the 200 Area Ponds*). Major contributors to this waste stream were the 2902-B high tank (containing potable sanitary water), cooling water from B Plant and the 225B Waste Encapsulation and Separation Facility, some 221B steam condensate, and demineralizer effluent. Minor contributions may have included the chemical makeup overflow system (sodium hydroxide and sodium nitrite), air conditioning units, and space heaters (radiators). The effluent compositions were kept below regulated values (WHC-EP-0342, Addendum 6, *B Plant Chemical Sewer Stream-Specific Report*).

Before November 1985, acidic effluent from anion exchanger regeneration and the basic effluent from cation exchanger regeneration were discharged without neutralization (WHC-EP-0287, *Waste Stream Characterization Report*, p. A.9-2). In March and April 1987, incidental corrosive liquid waste releases were discharged to the 216-B-63 Trench. The corrosive waste discharges were regulated under RCW 70.105, "Hazardous Waste Management," and its implementing requirements in WAC 173-303. Discharges to the 216-B-63 Trench ceased in 1992.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 9-37. 216-B-63 Trench

DOE monitors the groundwater under an interim status indicator evaluation program in accordance with 40 CFR 265, Subpart F, "Groundwater Monitoring," as defined in DOE/RL-2008-60, *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench*. Table B-33 in Appendix B presents construction information and water levels for the 216-B-63 wells. The monitoring network consists of three upgradient and three downgradient wells screened in the upper portion of the aquifer at the water table. Most of the well screens extend to within 1.5 m (5 ft) of the underlying basalt surface. The water table elevation at the 216-B-63 Trench declined an average of 1.8 cm/yr (0.7 in./yr) between 2012 and 2017. Based on this information, the 216-B-63 Trench monitoring wells have adequate water in the screened interval for sampling over the next two decades or longer.

Groundwater gradient magnitude and flow direction were inferred using a low-gradient monitoring network across the 200 East Area (Figure 9-6). The groundwater gradient calculated for the 216-B-63 Trench area was 8.5×10^{-6} m/m, dipping to the southeast, and the estimated groundwater flow rate was 0.73 m/d (2.4 ft/d) (Table B-34 in Appendix B). Groundwater extraction at WMA B-BX-BY may cause local deviations from the estimated groundwater flow direction and rate.

As required by 40 CFR 265.93(b), downgradient average indicator parameters were compared to upgradient critical mean values semiannually. The average pH in well 299-E27-19 exceeded the upper critical mean in April 2017 (Table B-35 in Appendix B). Verification sampling in June did not confirm the exceedance. Other indicator parameters remained below critical mean values or limit of quantitation (LOQs) in 2017.

Table B-36 in Appendix B summarizes the 2017 results for groundwater quality parameters (40 CFR 265.92(d)(1), "Sampling and Analysis") and additional constituents required by the monitoring plan (DOE/RL-2008-60). Nitrate was the only parameter with a concentration above a water quality standard. Nitrate reflects contaminant migration from sources northwest of 216-B-63 (e.g., BY Cribs) (Figure B-3 in Appendix B).

9.10.4 Liquid Effluent Retention Facility

Located on the eastern boundary of the 200 East Area, the LERF is a TSD unit with three lined surface impoundment basins (Figure 9-38). Construction of LERF was completed in 1991 using a dual-confinement barrier concept (i.e., dual basin liners and pipe-in-a-pipe transfer piping system) to minimize human exposure and the potential for accidental releases to the environment. A leachate detection, collection, and removal system and the basin covers also reduce possible environmental or personnel exposure. The basins are located side by side, with 18 m (60 ft) of separation between them. Each basin (cell) is 100 by 82 m (330 by 270 ft), with a maximum fluid depth of 6.7 m (22 ft).

The LERF provides aqueous waste storage and treatment prior to final treatment in the 200 Area ETF. Treatment at LERF consists of flow and pH equalization. Flow equalization allows for several smaller waste streams that are intermittently received at the LERF basins to accumulate for continuous higher volume campaign processing at the ETF. The LERF continues to receive liquid waste from a number of onsite facilities, with the largest volume from the 242A evaporator.

The LERF is incorporated into Part III of the Hanford RCRA Permit. Groundwater is monitored under the permit and in accordance with DOE/RL-2013-46, Rev. 0, *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility*. The monitoring plan was revised in 2017 (DOE/RL-2013-46, Rev. 1), and a permit modification became effective November 26, 2017. All of the 2017 sampling events occurred before the permit modification became effective.

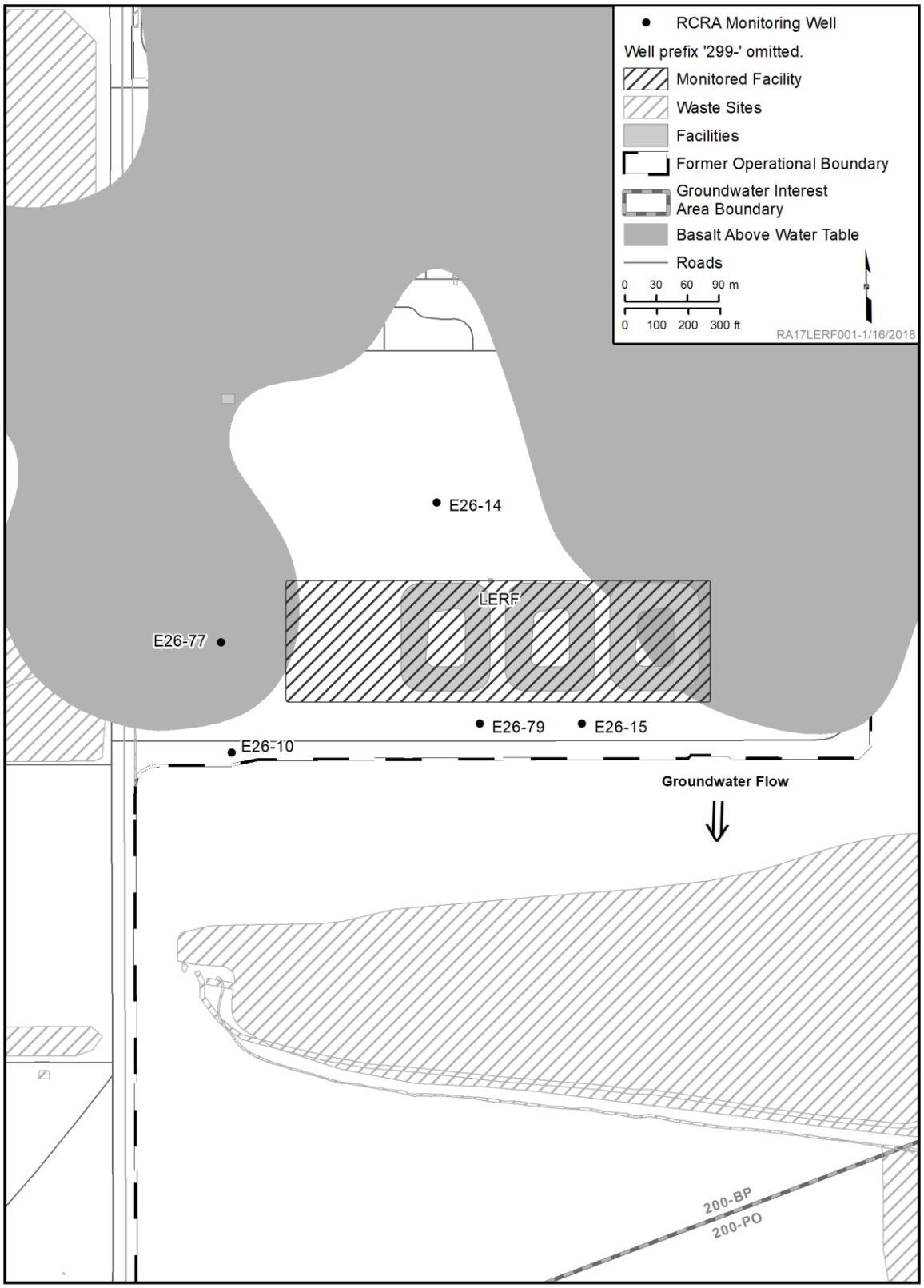


Figure 9-38. Liquid Effluent Retention Facility

Table B-49 in Appendix B lists the wells in the LERF monitoring network. Four of the five well screens extend to the underlying basalt or within the basalt fracture zone. Well 299-E26-14 extends to within 0.9 m (3 ft) of the underlying basalt surface. The water table elevation at LERF declined an average of 1.1 cm/yr (0.4 in./yr) between 2012 and 2017. Based on this information, the LERF groundwater wells have adequate water columns in the screened interval for sampling during the next two decades. Monthly water-level measurements were collected in 2017, and the hydraulic gradient was calculated for each data set. The average gradient was 3.0×10^{-4} m/m toward the south (Table B-50 in Appendix B). The estimated groundwater flow rate was 0.12 m/d (0.39 ft/d) or 44 m/yr (145 ft/yr).

In 2017, LERF monitoring wells were scheduled for semiannual sampling for indicator parameters in January and July. However, wells were sampled six to eight times due to the factors explained in Table B-51 in Appendix B.

Based on the July groundwater sampling event, two indicator parameters (pH at well 299-E26-79 and specific conductance at well 299-E26-15) appeared to have exceeded critical mean values in downgradient wells. DOE notified Ecology and proceeded with verification sampling activities. However, Ecology concluded that no exceedances had occurred based on the following factors:

- DOE demonstrated that longer well purging is required at well 299-E26-79 to obtain a representative pH measurement (SGW-61435, *2017 LERF Hydrogeology Investigation*). Because the pH measurement was within the appropriate pH range of results, there was no exceedance.
- Well 299-E26-15 was not yet part of the LERF well network in August 2017, so data from the well did not yet pertain to the LERF groundwater monitoring program.

Average specific conductance also exceeded the critical mean value in upgradient well 299-E26-14 in July 2017. Because the exceedances were in an upgradient well, they did not trigger groundwater quality assessment.

Table B-52 in Appendix B summarizes the 2017 monitoring results for other constituents. Nitrate continued to exceed its standard in upgradient well 299-E26-14 and downgradient well 299-E26-79 due to a regional plume.

Under the revised groundwater monitoring plan (DOE/RL-2013-46, Rev. 1), compliance wells will be monitored beginning in 2018 for waste constituents indicative of releases from the LERF: 1-butanol, carbon tetrachloride, Cr(VI), and n-nitrosodimethylamine.

9.10.5 Low-Level Waste Management Area 1

LLWMA-1 is located in the northwest corner of the 200 East Area (Figure 9-39). The 218-E-10 Burial Ground (14 unlined and covered trenches) received low-level radiological waste from 1955 to 2000. Low-level mixed waste was received in the northern portion of Trench 9 from 1987 to 1993. Dangerous chemicals in the low-level mixed waste portion of the 218-E-10 Burial Ground are regulated under RCRA and its implementing requirements in 40 CFR 265, Subpart F, as referenced by WAC 173-303-400, "Interim Status Facility Standards." The LLWMA-1 monitoring network is designed to detect indicators of dangerous waste or dangerous waste constituents affecting groundwater from the 218-E-10 Burial Ground. The monitoring network encompasses the LLWMA-1 boundary to provide coverage for potential groundwater flow direction changes. DOE monitors groundwater under an interim status indicator evaluation program in accordance with 40 CFR 265.93(b), as defined in DOE/RL-2009-75, Rev. 1, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*.

The current LLWMA-1 monitoring network consists of seven wells screened in the upper portion of the aquifer at the water table (Table B-53 in Appendix B). The water table elevation at LLWMA-1 declined an average 2.7 cm/yr (1.1 in./yr) between 2012 and 2017. Based on this information, the LLWMA-1 wells are expected to have adequate water columns in the screened interval for sampling. A new well is planned near the southeastern corner of LLWMA-1. Based on the low-gradient water table map (Figure 9-6), the estimated hydraulic gradient beneath LLWMA-1 in 2017 was 7.6×10^{-6} m/m, sloping to the southeast (Table B-54 in Appendix B). The average groundwater flow rate was estimated at 0.65 m/d (2.1 ft/d). Groundwater extraction at WMA B-BX-BY may cause local deviations from the estimated groundwater flow direction and rate.

In 2017, LLWMA-1 monitoring wells were sampled semiannually for indicator parameters as scheduled (Table B-55 in Appendix B). Specific conductance, pH, TOC, and TOX did not exceed critical mean values, and LLWMA-1 remains in indicator evaluation monitoring.

Table B-56 in Appendix B summarizes the groundwater quality parameters and other constituents for LLWMA-1. Nitrate concentrations were greater than 45 mg/L in three wells due to a regional nitrate plume (Figure B-3 in Appendix B).

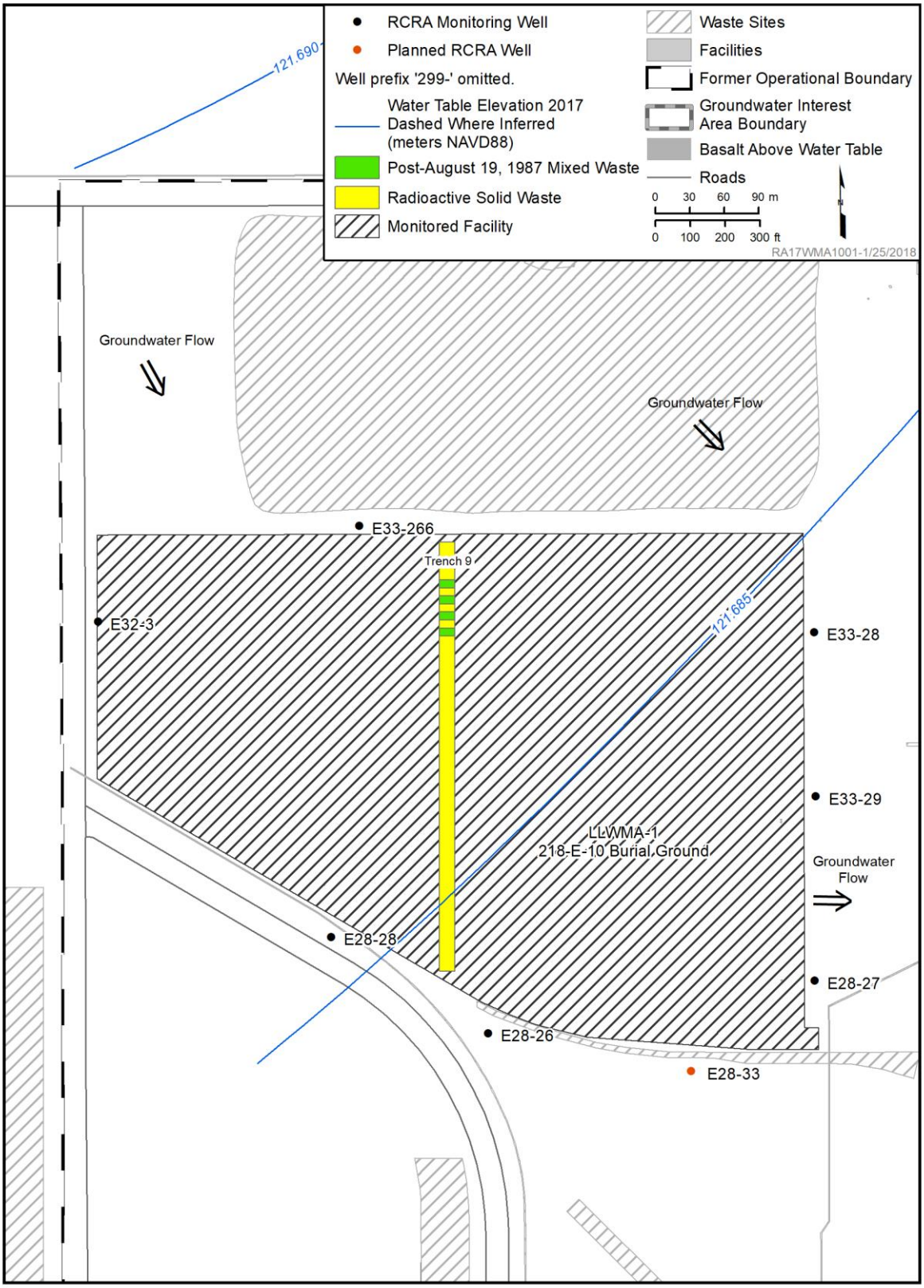
9.10.6 Low-Level Waste Management Area 2

LLWMA-2 is located in the northeastern corner of the 200 East Area (Figure 9-40) and consists of the 218-E-12B and 200-E-304 Burial Grounds, which contain 39 inactive and covered north-south-oriented trenches (in 216-E-12B) and one active uncovered trench (Trench 94 in 200-E-304). The 218-E-12B Burial Ground received solid, low-level, radiological, and transuranic waste from 1967 to 2004 and is not subject to the requirements of WAC 173-303. LLWMA-2 continues to follow the implementing requirements in WAC 173-303-400, as defined in DOE/RL-2009-76, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*.

Table B-57 in Appendix B lists construction information and water levels for LLWMA-2 wells. The water table elevation at LLWMA-2 declined an average of 1.5 cm/yr (0.6 in./yr) between 2012 and 2017. The wells are expected to have adequate water in the screened interval for sampling during the next two decades.

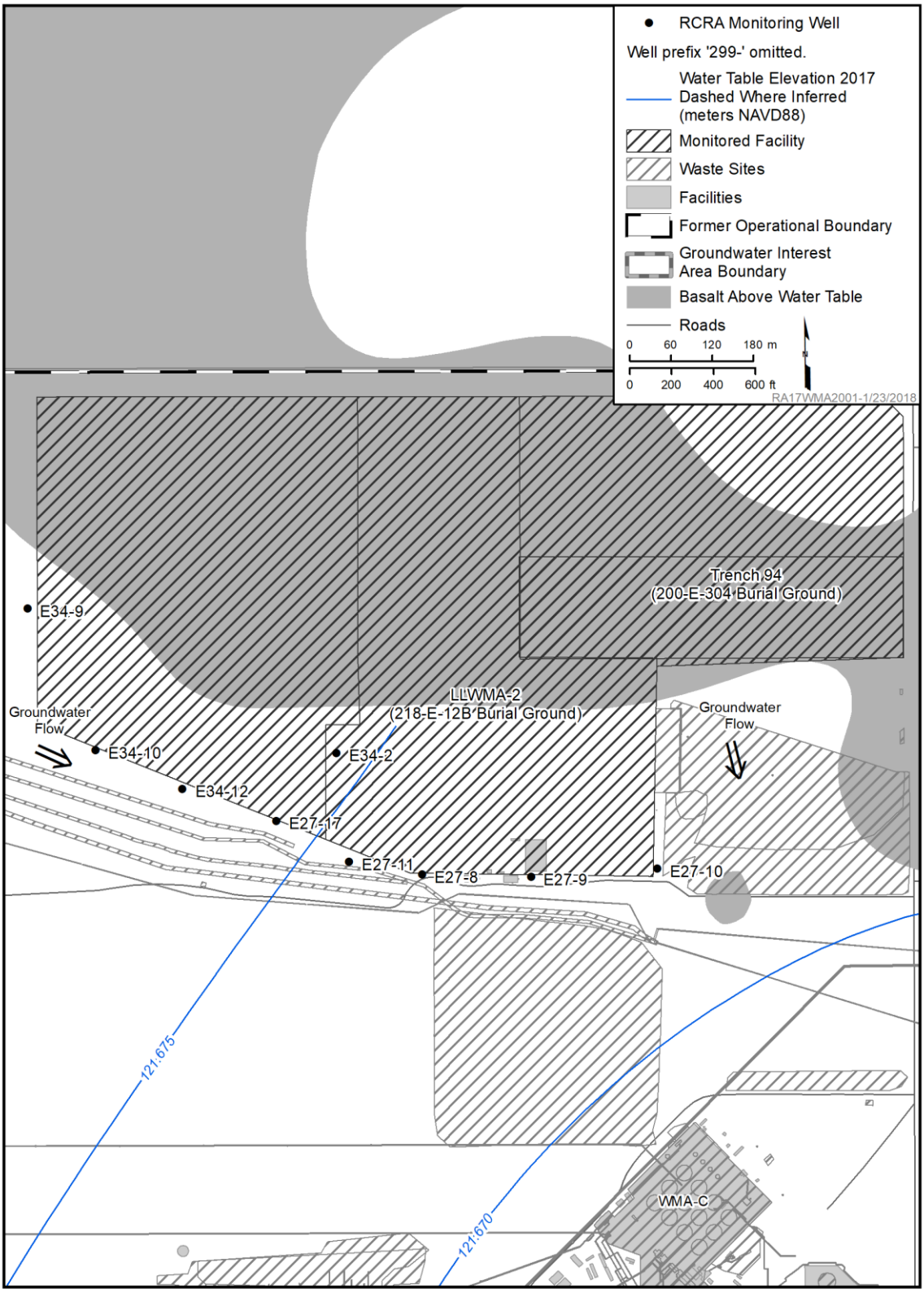
Groundwater gradient magnitudes and flow directions were determined using the 200 East Area low-gradient monitoring network from September 2016 through October 2017 (Figure 9-6). The average gradient in the western half of the monitoring network was 8.5×10^{-6} m/m, dipping to the southeast (Table B-58 in Appendix B). The gradient could not be calculated in the eastern portion of the LLWMA, but it likely has similar magnitude, with a flow direction more to the south. Estimates of groundwater flow rates range from 0.064 to 0.73 m/d (0.21 to 2.4 ft/d). Groundwater extraction at WMA B-BX-BY may cause local deviations from the estimated groundwater flow direction and rate.

All of the LLWMA-2 wells were sampled semiannually as required during the reporting period (Table B-59 in Appendix B). There were no confirmed critical mean exceedances in 2017. The average pH in well 299-E27-11 in April exceeded the upper limit, but verification sampling results did not confirm the exceedance. The site remains in interim status detection monitoring.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 9-39. Low-Level Waste Management Area 1



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 9-40. Low-Level Waste Management Area 2

Table B-60 summarizes groundwater quality parameters and other constituents required by 40 CFR 265.92(b)(2). Iron, nitrate, and sulfate concentrations exceeded DWSs but did not originate in LLWMA-2, as explained below:

- Iron exceeded the secondary DWS in unfiltered samples from well 299-E27-10. Previous video surveys of the well show moderate encrustation of apparent amorphous ferric hydroxide (orange in color). Other metals associated with stainless-steel corrosion (chromium and nickel) are also found in this well at elevated levels. It is likely that corrosion in this well affected the samples.
- Sulfate and nitrate continued to exceed applicable standards in wells 299-E27-9 and 299-E27-10. The elevated sulfate and nitrate appear to be ongoing loading from the vadose zone associated with UPRs to the 216-B-2 Ditches in the early 1960s and 1970s. The conceptual model for migration from the 216-B-2 Ditches includes northeast migration through the vadose zone to groundwater and southward migration within the aquifer to wells 299-E27-9 and 299-E27-10. Sulfate could also be associated with gypsum mobilized by dust-suppression water used during excavation of sediments associated with Trench 94.
- The elevated nitrate in wells 299-E34-9, 299-E34-10, and 299-E34-12 appears to be associated with southeastern migration from sources to the northwest, primarily the BY Cribs (Figure B-3 in Appendix B).

9.11 Atomic Energy Act Monitoring

AEA groundwater monitoring was conducted at 135 groundwater wells in the 200-BP groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 200-BP are iodine-129, nitrate, technetium-99, uranium, and tritium. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Thirteen wells were not sampled in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues, well access issues, a dry well, and scheduling constraints. One significant exception to the monitoring network was the decommissioning of well 299-E27-4.

Radionuclide concentrations detected in groundwater samples from 150 wells[1] were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED exceeded the 100 mrem/yr standard at three groundwater wells in 200-BP (Table 9-5). The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 83 locations in this interest area. The DWSs for cumulative alpha emitters were not exceeded, but one location did exceed the EPA net alpha activity standard. The uranium mass DWS of 30 µg/L was exceeded at 20 locations. None of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. CERCLA remedial action decisions will provide additional protection of the public and the environment.

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

Table 9-5. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-BP in 2017

Monitoring Location/ Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
299-E24-25			11.27	11.27				
299-E27-10			5.44	5.44				
299-E27-12			12.71	27.26				
299-E27-13			31.07	55.92				
299-E27-14			8.98	59.36				
299-E27-15			18.83	18.83				
299-E27-155			7.96	33.95				
299-E27-16			5.05	6.00				
299-E27-19			6.18	6.18				
299-E27-21			104.89	129.78				
299-E27-22			15.75	38.74				
299-E27-23			56.89	69.22				
299-E27-24			15.33	40.37				
299-E27-25			18.80	18.80				
299-E27-26			8.61	20.93				
299-E27-7			37.41	37.41				
299-E27-8			4.12	6.40				
299-E27-9			6.44	6.44				
299-E28-1			7.91	7.91				
299-E28-23			230.44	230.44			17.02	17.02
299-E28-24			320.50	320.50	56.00	56.00		
299-E28-31			11.22	11.22				
299-E28-32			6.98	6.98				
299-E28-4			6.34	6.34				
299-E28-5			10.88	12.12				
299-E28-6					43.20	43.20		
299-E28-7			157.22	157.22				
299-E29-54					54.80	54.80		
299-E32-10			10.75	15.11				
299-E32-8			7.77	7.77				
299-E32-9			10.18	11.82				

Table 9-5. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-BP in 2017

Monitoring Location/ Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
299-E32-12			4.49	4.49				
299-E33-14			54.70	54.70				
299-E33-15			102.08	102.08				
299-E33-16			154.80	182.23	60.60	79.00		
299-E33-17			147.08	147.08				
299-E33-1A			30.98	30.98				
299-E33-20	151.41	151.42	36.97	48.06	1100.00	1325.91		
299-E33-268			38.01	47.58	44.50	61.20		
299-E33-28			4.73	7.00				
299-E33-29			4.35	4.35				
299-E33-3			46.25	46.25				
299-E33-31			42.49	42.49	46.20	78.40		
299-E33-32			14.72	14.72				
299-E33-33			14.04	14.04				
299-E33-337			25.84	92.58	44.4	116		
299-E33-338			13.31	15.66	32.6	41.5		
299-E33-339			7.27	10.99				
299-E33-34			15.64	20.38				
299-E33-341			27.28	33.44				
299-E33-342			41.83	98.91				
299-E33-343			10.17	10.17	150	150		
299-E33-345			32.72	32.72	819	819		
299-E33-35			7.02	13.29				
299-E33-350	6291.26	15040.32	173.33	214.27	61257.89	147272.20		
299-E33-351	3099.65	3699.98	75.00	186.73	29629.78	36473.63		
299-E33-36			15.09	24.61				
299-E33-360			32.10	48.88	112.95	2970.00		
299-E33-361			8.80	8.80				
299-E33-38			37.44	38.31	30.64	41.7		
299-E33-39			61.10	63.01				
299-E33-41			14.00	17.73	33.20	34.00		

Table 9-5. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-BP in 2017

Monitoring Location/ Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
299-E33-42			10.76	10.76	31.00	31.00		
299-E33-44			103.26	136.50	59.00	113.00		
299-E33-47			67.46	113.94	76.90	91.20		
299-E33-48			15.51	15.51	36.20	54.30		
299-E33-49			7.12	7.12				
299-E33-7			33.85	33.85				
299-E34-8			6.69	8.70				
299-E34-9			6.32	28.19				
699-43-41F			18.38	18.38				
699-43-41G			4.40	4.40				
699-45-42			11.31	11.31				
699-49-57A			14.94	14.94				
699-50-56			5.71	5.71				
699-50-59			9.00	9.00				
699-53-47B			140.00	140.00				
699-53-48A			42.45	42.45				
699-53-55B			10.19	10.19				
699-53-55C			8.93	8.93				
699-54-49			68.50	68.50				
699-55-55			7.00	7.00				
699-55-57			6.72	6.72				
699-57-59			11.52	11.52				
699-59-58			4.37	4.37				

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford.*

Note: Blank cells indicate no exceedances.

9.11.1 Low Level Waste Management Area 1

Additional monitoring is integrated into the AEA SAP as part of existing performance assessment monitoring plans for LLWMA-1 and LLWMA-2, as described in DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*. The COCs for this monitoring plan are iodine-129, technetium-99, tritium, and uranium. Trend plots of the indicator parameters did not indicate groundwater quality effects associated with the 218-E-10 or 218-E-12B Burial Grounds in 2017.

Iodine-129 concentrations exceeded the DWS in seven LLWMA-1 wells during 2017. The elevated concentrations are associated with wells along the north and northeast boundaries of the burial ground, considered upgradient or cross gradient. The concentration trends at wells with elevated iodine-129 varies from decreasing to increasing. The elevated iodine-129 is associated with plumes from the northwest that are migrating into the area under the current south-southeast groundwater gradient. Wells along the south and southeast boundary of the burial ground continue with less than detection limits for iodine-129. The 2017 groundwater data do not indicate a release associated with the 218-E-10 Burial Ground.

Technetium-99 concentrations exceeded the DWS in three LLWMA-1 wells during 2017. The elevated concentrations are associated with wells along the northeast boundary of the burial ground, considered cross gradient. The concentration trends at wells with elevated technetium-99 varies from stable to variable. The elevated technetium-99 is associated with plumes from the northwest that are migrating into the area under the current south-southeast groundwater gradient. Corresponding downgradient wells continue to trend with upgradient wells with lower concentrations because of transverse dispersion. The downgradient wells do not provide evidence of a release from the 218-E-10 Burial Ground.

Tritium concentrations in upgradient LLWMA-1 wells continue to decline. Two 2017 results from upgradient wells were out of trend and an RDR was submitted. The downgradient wells were less than detection limits during 2017. The downgradient wells do not provide evidence of a release from the 218-E-10 Burial Ground.

None of the LLWMA-1 uranium values exceeded the DWS in 2017. The highest concentrations remain in the northern wells where previous plumes from the south and southeast had migrated through most recently. One exception is well 299-E28-27, which appears to have been in the northern path of 216-B-12 Crib uranium recovery waste. The decreasing concentration trends in LLWMA-1 wells indicate continued transverse dispersion as these plumes migrate south-southeast. The trend plots do not show any indication of contributions from the 218-E-10 Burial Ground.

In summary, the performance assessment indicator parameters for LLWMA-1 did not indicate groundwater quality effects associated with the 218-E-10 Burial Ground in 2017.

9.11.2 Low Level Waste Management Area 2

Iodine-129 concentrations exceeded the DWS in four LLWMA-2 wells during 2017. The elevated concentrations are associated with an isolated well along the southwestern corner and the three eastern wells downgradient of the 218-E-12B Burial Ground. The isolated well is considered cross gradient from the 218-E-12B Burial Ground, and elevated concentrations appear to be associated with other sources. Concentrations in the three eastern wells (299-E27-8, 299-E27-9, and 299-E27-10) have been trending downward since the early 1990s (when monitoring began at these wells). During the initial years of monitoring, these wells were considered upgradient to cross gradient, as the flow was primarily east to west. Although iodine-129 was not monitored consistently in well 299-E26-1, tritium showed higher concentrations than the three LLWMA-2 wells. Well 299-E26-1 was considered upgradient of the three

LLWMA-2 wells. Other wells between dominant iodine-129 sources and the three LLWMA-2 wells had even higher concentrations. Consequentially, iodine-129 appears to have migrated into the area and is still migrating out of the area near wells 299-E27-8, 299-E27-9, and 299-E27-10. Trend plots do not provide evidence that the 218-E-12B Burial Ground impacted groundwater in 2017.

Technetium-99 exceeded the DWS in one LLWMA-2 well during 2017. The elevated concentration is associated with wells along the west boundary of the burial ground, considered cross gradient. The concentration trend at this well is associated with plumes from the northwest that have migrated into the area under a southeast groundwater gradient. Other wells along the southwestern side of the burial ground are also impacted, but with lower concentrations. Only wells 299-E27-9 and 299-E27-10, located along the southeast corner of the burial ground, have unrelated technetium-99 concentrations. It is difficult to determine if the technetium-99 in these two wells is from the 218-E-12B Burial Ground or the result of other UPRs associated with the 216-B-2 Ditches. The 216-B-2-1 and 216-B-2-2 Ditches were impacted by UPRs in the 1963 and 1970. These releases may have had sufficient technetium-99 to impact groundwater at the concentrations detected in these two wells. Other co-contaminants included nitrate and various organics that implicate the 216-B-2 Ditches. As a result, there is insufficient evidence of a release from the 218-E-10 Burial Ground.

Tritium concentrations did not exceed the DWS in LLWMA-2 wells during 2017. Tritium concentrations are less than detection levels in the eastern wells. Tritium on the west side of LLWMA-2 ranged from less than detection to 1,160 pCi/L. The concentrations are associated with sources to the west. The three downgradient wells do not provide evidence of a release from the 218-E-10 Burial Ground.

The east LLWMA-2 wells have uranium concentrations below 4 µg/L and are reflective of natural background conditions. The west LLWMA-2 wells ranged from 3.6 to 5.3 µg/L and may reflect minor contributions of uranium from sources to the west. The trend plots do not show any indication of contributions from the 218-E-10 Burial Ground.

In summary, the performance assessment indicator parameters for LLWMA-2 did not indicate groundwater quality effects associated with the 218-E-12B Burial Ground in 2017.

10 200-PO

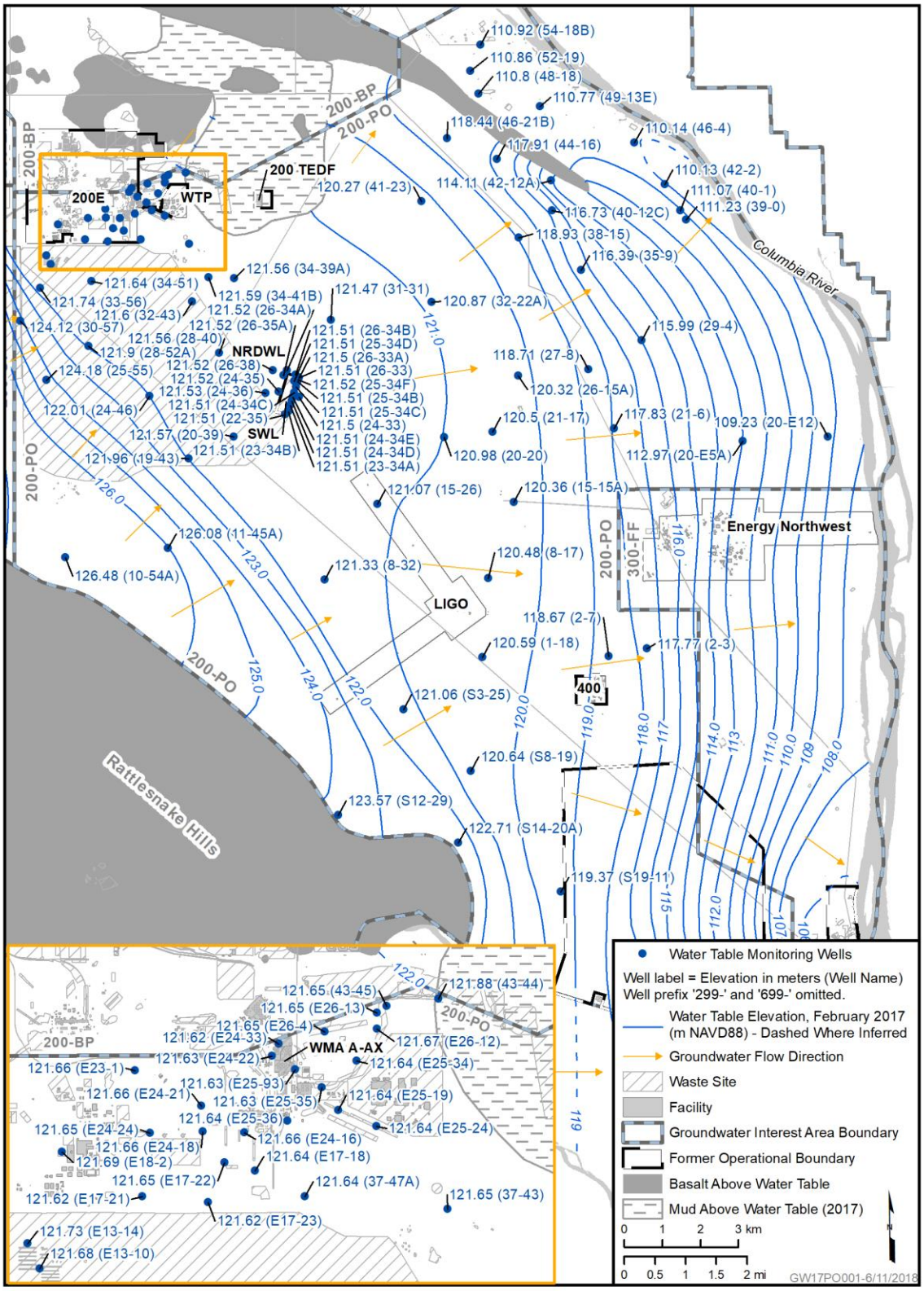
This chapter presents information for the 200-PO groundwater interest area, which includes groundwater contaminant plumes sourced beneath the southern half of the 200 East Area, extending to the south-southeast throughout much of the 600 Area to the adjoining 300 Area, 400 Area, and Columbia River (Figures 10-1 and 10-2). Groundwater monitoring in 200-PO is performed to meet AEA, CERCLA, RCRA, and *Washington Administrative Code* requirements. The 200-PO interest area is informally divided into the near-field area (includes the former operational areas within and near the 200 East Area) and the far-field area (includes wells downgradient of the near-field area, and aquifer tubes along the Columbia River, and generally comprises areas where site operations did not occur).

10.1 Overview

The 200-PO interest area includes the CERCLA 200-PO-1 OU and adjacent region, seven RCRA units (216-A-29 Ditch, 216-A-36B Crib, 216-A-37-1 Crib, 216-B-3 Pond [B Pond], Nonradioactive Dangerous Waste Landfill [NRDWL], Integrated Disposal Facility [IDF], and WMA A-AX [SST]), one state-regulated landfill (Solid Waste Landfill [SWL]), and the 400 Area. No current groundwater remediation systems are implemented within 200-PO. Table 10-1 summarizes some key facts about 200-PO. Section 1.5 provides plume mapping details, including descriptions of terms (e.g., Type 1 control point) used in the figure legends.

The unconfined aquifer in 200-PO is within the sands and gravels of the Hanford formation, CCU, and Ringold Formation (Figure 1-6). The base of the aquifer is the RLM (hydrostratigraphic unit 8), which locally confines the underlying Ringold unit 9. Finer-grained strata within Ringold unit 9 confine underlying sediments locally. In one location immediately east of the 200 East Area, there are no saturated sediments above the RLM, and the unconfined aquifer is absent. Detailed discussions of geology and hydrogeology within the 200-PO interest area are provided in Sections 3.4 and 3.6 of DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*; Section 3.1 of DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*; and Chapters 3 and 4 of PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*.

As shown in Figure 10-1, the unconfined groundwater gradient in the 200 East Area is extremely flat. More precise water-level measurement methods were developed that include using wells with limited screen length to reduce vertical flow influence, resurveying well casing elevations using a closed-loop process, correcting for borehole deviation from vertical, and analyzing the data by trend surface analysis. Figure 9-6 in Chapter 9 provides the low-gradient water-level map for 2017. In the southeastern part of 200 East Area, groundwater flows generally to the southeast. Groundwater continues to flow to the southeast from the 200 East Area to NRDWL, then turns to the east, and eventually discharges to the Columbia River (Figure 10-1). A paleochannel, created by Pleistocene cataclysmic floods, is filled with highly transmissive sands and gravels and influences the regional groundwater flow (Section 4.2.2 of PNNL-12261). Regional tritium and iodine-129 plume migration patterns follow the preferential groundwater flow path through this paleochannel southeast, away from the 200 East Area, and then east to the Columbia River.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-1. 200-PO Water Table, March 2017

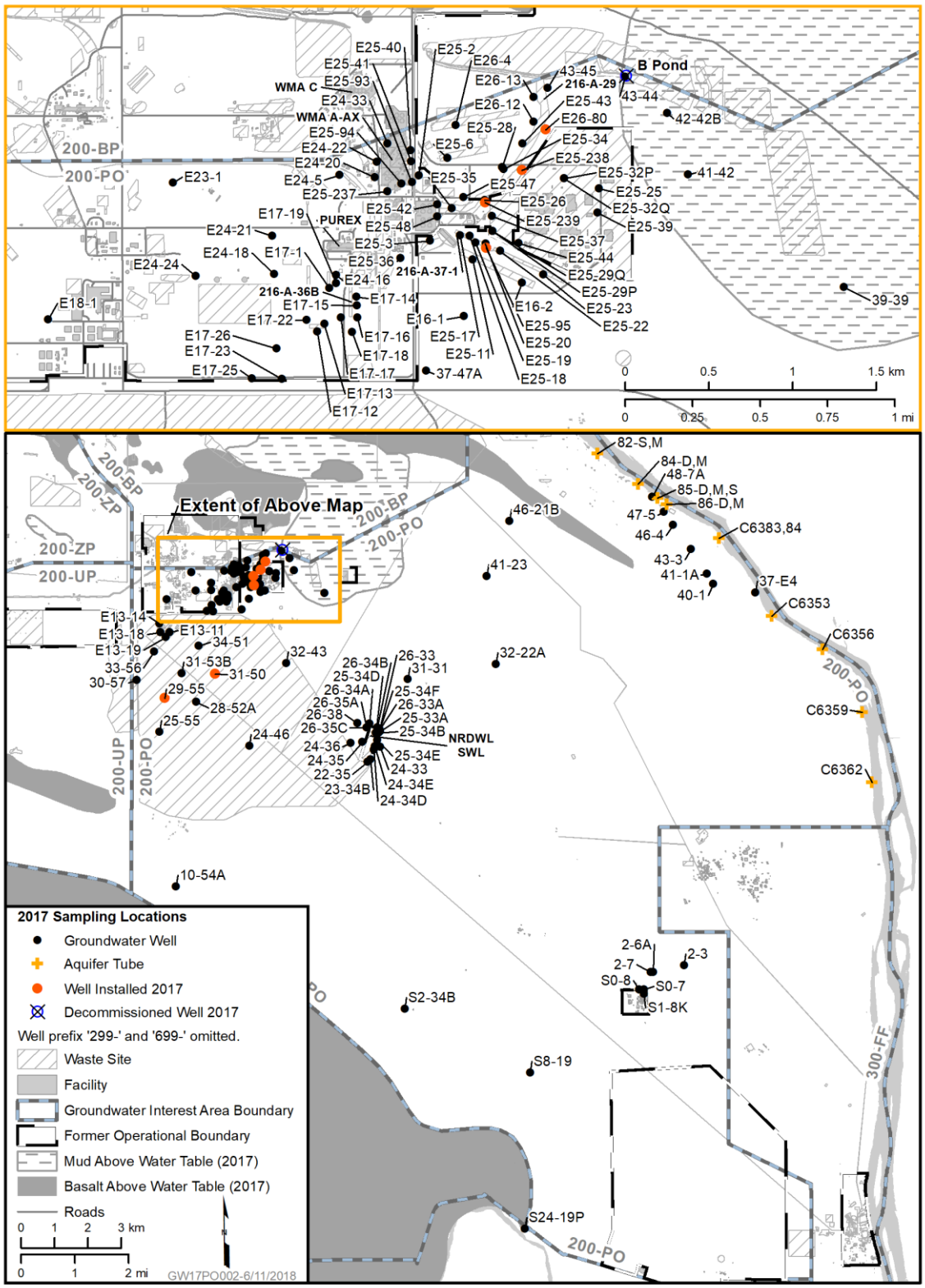


Figure 10-2. 200-PO Sampling Locations, 2017

Table 10-1. 200-PO at a Glance

PUREX Plant operations: 1956 to 1972 (plutonium separation); 1983 to 1989 (plutonium separation)			
Groundwater Monitoring			
Contaminant, Water Quality Standard, Units	**Year**	**Maximum Concentration (Well)**	**Plume Area[a] (km^2)**
Tritium, 20,000 pCi/L	2017	311,000 (299-E17-1)	62.4
	2016	418,000 (299-E17-14, 299-E17-19)	65.0
Iodine-129, 1 pCi/L[b]	2017	10.9 (299-E26-13)	64.8
	2016	8.91 (299-E17-14)	64.1
Nitrate, 45 mg/L	2017	120 (299-E17-14)	2.6
	2016	146 (299-E17-19)	2.4
Strontium-90, 8 pCi/L[b]	2017	13.3 (299-E17-14)	<0.01
	2016	13.7 (299-E17-14)	<0.01
Technetium-99, 900 pCi/L[b]	2017	5,360 (299-E24-22)	0.11
	2016	1,950 (299-E25-93)	0.08
Uranium, 30 µg/L	2017	63.0 (299-E25-36)	0.07
	2016	23.9 (299-E17-14)	0.03

a. Estimated area at a concentration greater than the listed water quality standard.

b. Single isotope equivalent drinking water standard. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr.

Groundwater within the 200-PO groundwater interest area has been contaminated primarily by releases from cribs, ponds, SSTs, and trenches associated with PUREX and B Plant operations. These include the PUREX Plant 216-A-10, 216-A-36B and 216-A-37-1 Cribs, where large volumes of effluent were discharged. Groundwater sampling within the groundwater interest area is directed by the SAPs, permits, Tri-Party Agreement (Ecology et al., 1989) change notices, and other documents that identify groundwater monitoring requirements. The CERCLA RI completed for the 200-PO-1 OU in 2012 identified tritium, iodine-129, nitrate, strontium-90, technetium-99, PCE, TCE, and uranium as final COPCs (Section 6.2 in DOE/RL-2009-85).

Figure 10-3 shows the plume areas measured from 2003 through 2017 for tritium, iodine-129, nitrate, uranium, and technetium-99. A change in calculated plume area occurred for some contaminants (e.g., nitrate) between 2011 and 2012 due to calculating areas by interest area boundary starting in 2012, instead of calculating by source area prior to 2012. These COPCs (except technetium-99) are primarily associated with PUREX Plant operations, which discharged liquid effluents to cribs and ditches in the southern part of the 200 East Area from 1956 to 1972 and from 1983 to 1988. Technetium-99 within 200-PO has been detected above the DWS near WMA A-AX.

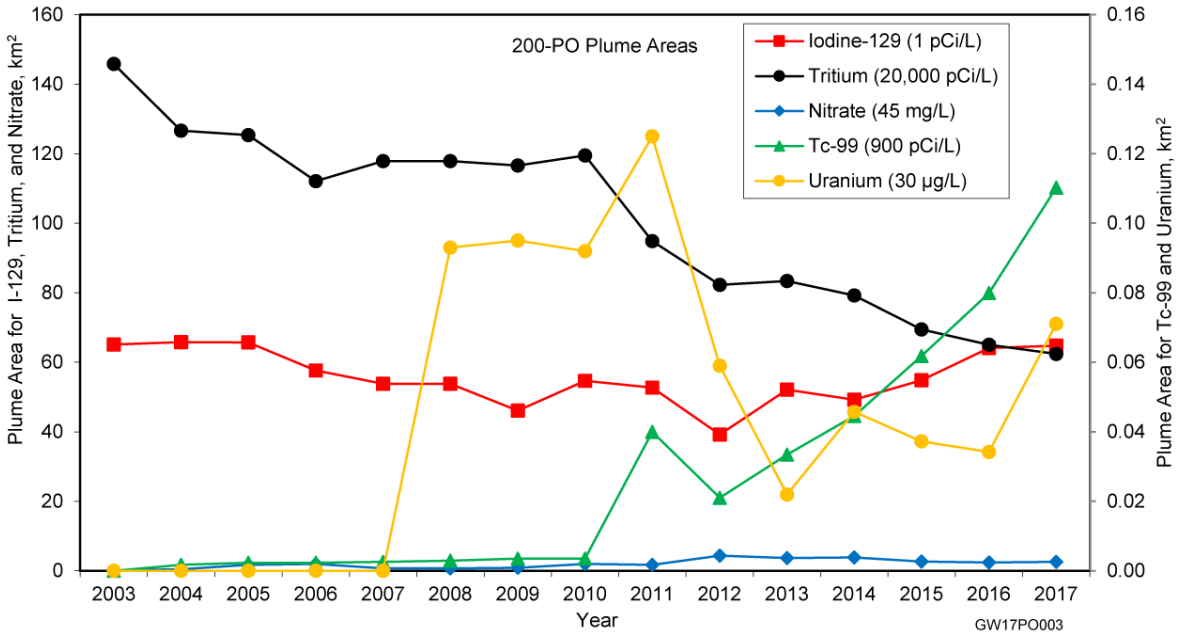


Figure 10-3. 200-PO Plume Areas

10.2 Tritium

The 200-PO near-field wells are sampled for tritium annually, and most far-field wells are sampled triennially (every 3 years). Triennial sampling events under TPA-CN-205, *Change Notice for Modifying Approved Documents/Work Plans in Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2003-4, Revision 1, Sampling and Analysis Plan for the 200-PO-1 Operable Unit*, have primarily been conducted in 2010, 2013, and 2016. A subset of far-field area wells is sampled annually.

Due to radioactive decay and dispersion, the tritium plume bounded by the 20,000 pCi/L contour has decreased in size by 66% since 1980 (from 185 to 62.4 km^2 [71.4 to 24.1 mi^2]) (Figure 10-4). The far-field portion of the plume is no longer connected to the near-field portion, and concentrations have declined substantially. Figures 10-5 and 10-6 show the 2017 plume in greater detail. The highest current and historical concentrations have been observed near the PUREX cribs and trenches, which were the major release points of this contaminant. Concentrations remain more than 10 times the 20,000 pCi/L DWS and have been relatively stable since 2000. Section 4.2 of DOE/RL-2009-85 states that vadose zone sources may be present. For 2017, the highest concentrations of tritium in the near-field area were 311,000 pCi/L in well 299-E17-1 (near the 216-A-10 Crib); 296,000 pCi/L in well 299-E17-14 (near the 216-A-36B Crib); and 256,000 pCi/L in well 299-E17-19 (near the 216-A-4 Crib) (Figure 10-7).

A tritium plume continues to be present in the far-field area, with a portion of the plume discharging into the Columbia River to the east (Figure 10-6). The far-field portion of the tritium plume did not change significantly between 2016 and 2017, with one exception. During 2017, the concentration at well 699-2-3 (location shown in Figure 10-2) dropped below 20,000 pCi/L, eliminating a small plume associated with the well. The highest concentration from far-field wells in 2017 was 322,000 pCi/L in well 699-13-3A, which was a decrease from 799,000 pCi/L in 2016. The tritium in this well originated at the 618-11 Burial Ground (discussed in Chapter 7).

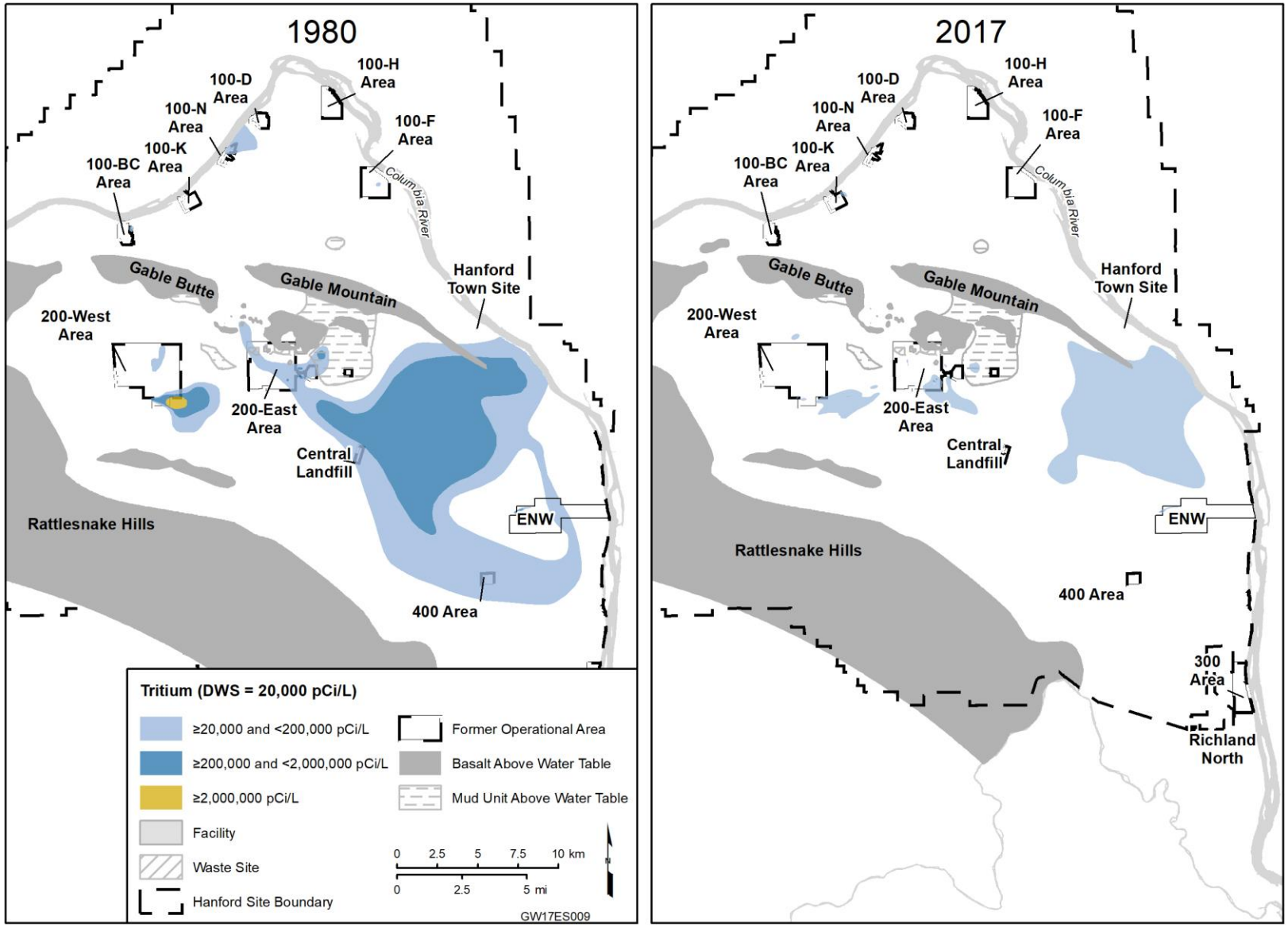


Figure 10-4. Hanford Site Tritium Plumes in 1980 and 2017

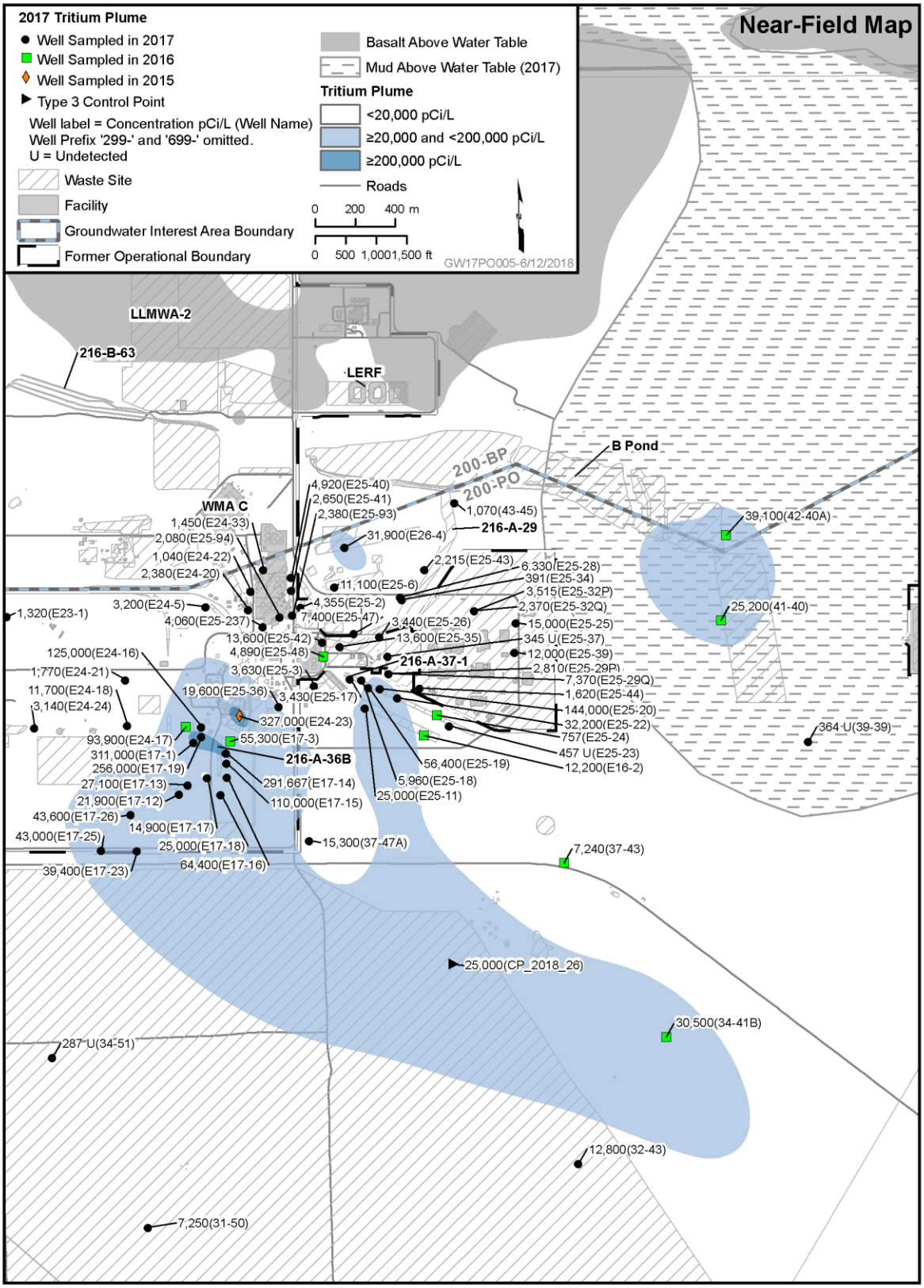


Figure 10-5. 200-PO Near-Field Tritium Plume, 2017

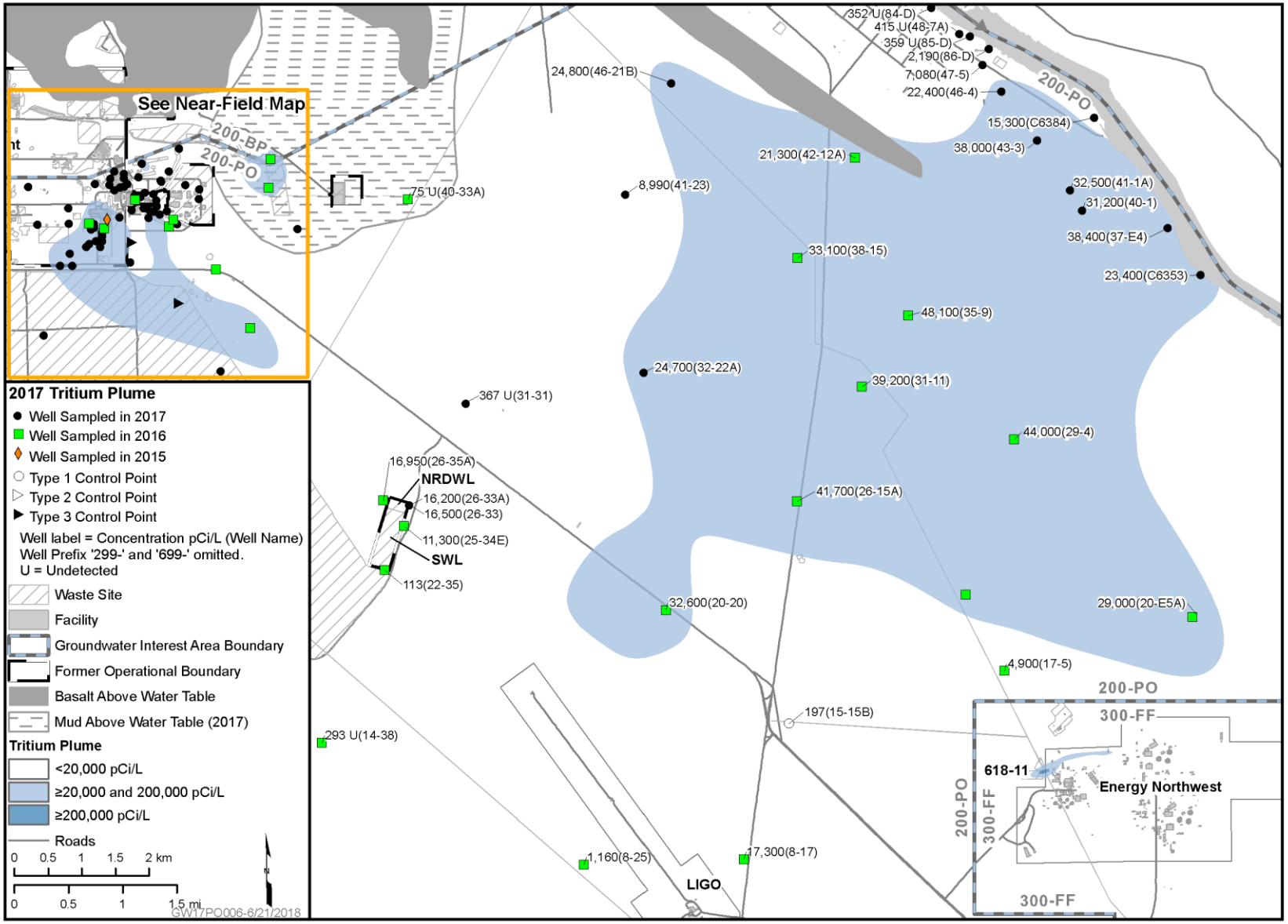


Figure 10-6. 200-PO Far-Field Tritium Plume, 2017

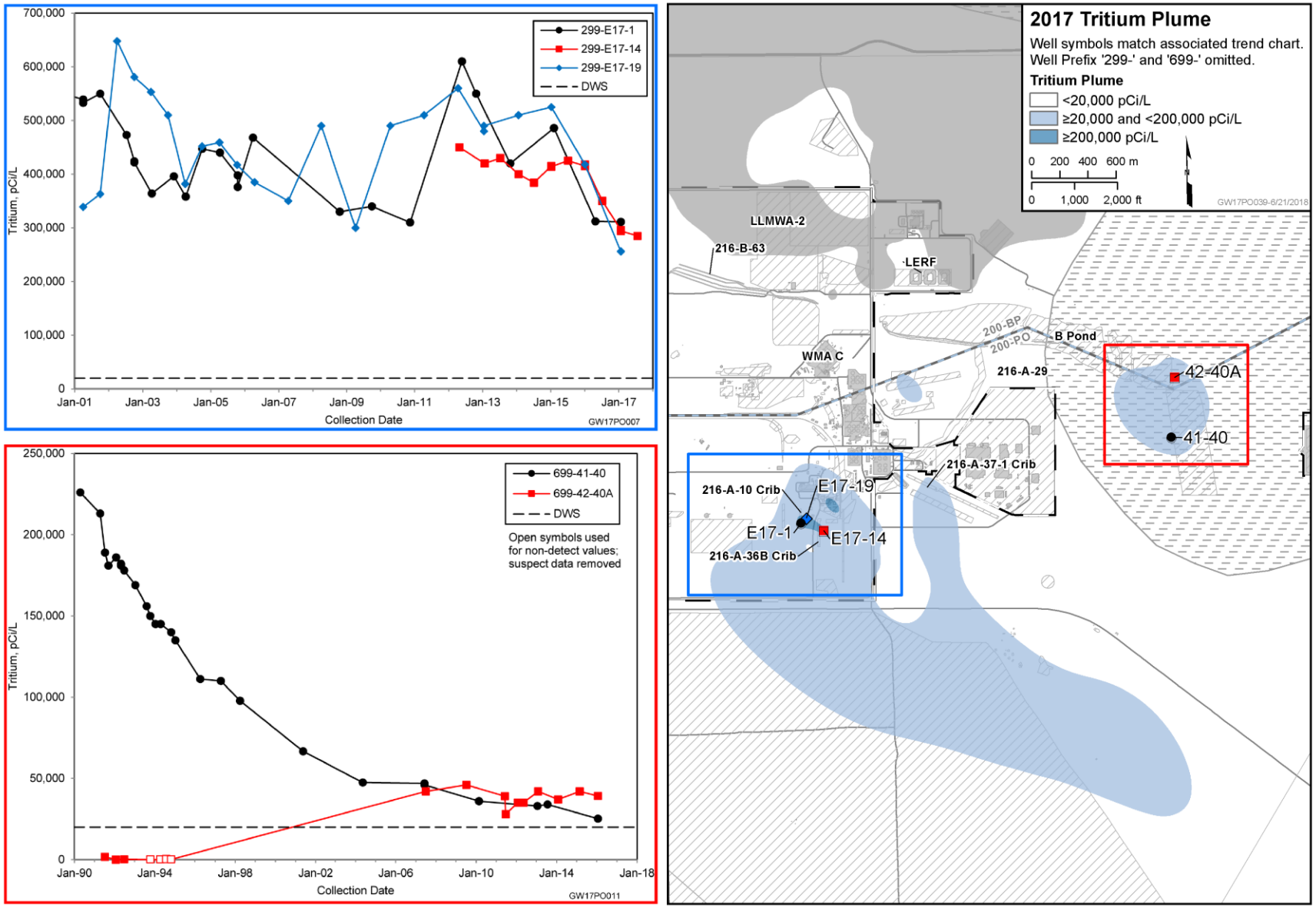


Figure 10-7. 200-PO Tritium Data for Selected Wells in the Near-Field Region

Continuing declines in tritium concentration in far-field wells 699-26-33, 699-28-40, and 699-31-31 (Figure 10-8) correlate with the decrease in plume size. These trends are expected to continue, as tritium in the groundwater decays at a rapid rate due to its short half-life.

In 2017, wells screened (or casings perforated) in the middle or lower portions of the unconfined aquifer had tritium results ranging from 2,370 pCi/L (299-E25-32Q) to 7,370 pCi/L (299-E25-29Q) in the near-field area. In the far-field area, concentrations ranged from 605 pCi/L in well 699-28-40 to 38,400 pCi/L in near-river well 699-37-E4 in 2017. Since 1997, concentrations of tritium at well 699-37-E4 have decreased (Figure 10-8).

In 2016 and 2017, tritium concentrations in wells near B Pond and screened in the Ringold-confined aquifer beneath the lower mud ranged from nondetect (699-39-39) to 39,100 pCi/L (699-42-40A). Since 2007, tritium levels have generally been stable at well 699-42-40A (Figure 10-7). Concentrations have decreased in nearby Ringold-confined well 699-41-40, from 226,000 to 25,200 pCi/L. Wells 699-42-40A and 699-41-40 were not sampled in 2017.

Seven wells screened in the basalt-confined aquifer are sampled triennially under DOE/RL-2003-04, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit*. Tritium has been detected only intermittently at low concentrations in samples collected from these wells, except well 699-42-40C (located near the B Pond in the 200-BP interest area). Tritium in well 699-42-40C has been detected since 1982, up to a maximum of 8,320 pCi/L in 1993. Since 1996, concentrations in well 699-42-40C have declined, and the 2017 result was 2,480 pCi/L (Figure 10-9). Appendix D provides a well location map and additional information about the basalt-confined aquifer.

10.3 Iodine-129

Iodine-129 concentrations greater than the 1 pCi/L DWS are found in a relatively dispersed plume that covers a large area within 200-PO (Figures 10-10 and 10-11). The highest historical concentrations were detected near the PUREX cribs and trenches. The majority of triennial far-field area well sampling was completed in 2016. The 2017 interpolated plume extent above the 1 pCi/L concentration in the far-field area has changed very little from 2016.

Iodine-129 concentrations in near-field area wells in 2017 ranged from nondetect to 10.9 pCi/L. The highest concentrations in 2017 were detected near the PUREX cribs and trenches, 216-A-29 Ditch, B Pond, and WMA A-AX. Trends in the wells with the highest concentrations are variable (Figure 10-12). Iodine-129 concentrations in well 299-E17-14 (near the PUREX Cribs) show a generally decreasing trend, while concentrations in 699-43-45 (located near B Pond and the north end of the 216-A-29 Ditch) have increased slightly. The highest concentrations of iodine-129 detected in the far-field area in 2017 occurred at wells 699-32-22A (7.36 pCi/L) and 699-41-23 (4.21 pCi/L).

Well 699-31-31 is one of the wells used to define the boundary of the iodine-129 plume as it extends to the southeast between the 200 East Area and the distal far-field area. Concentrations in this well decreased to nondetect following peak levels that occurred when a high-concentration slug of iodine-129 passed through the area between 1993 and 1994 (Figure 10-13). A review of concentration trends for other wells in the area that are equal distance from the plume margin indicated that current iodine-129 concentration trends for this well are consistent with the regional pattern.

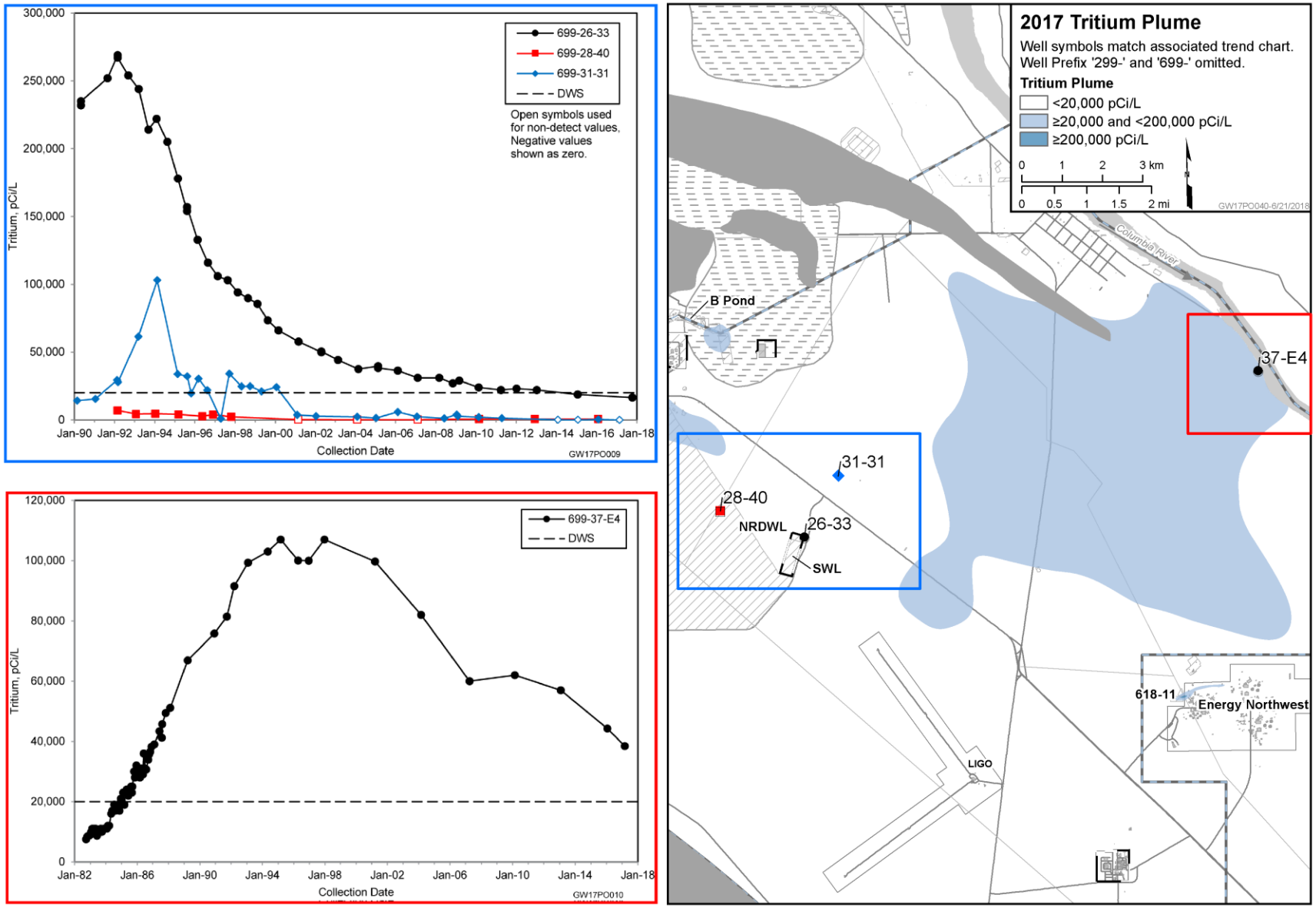


Figure 10-8. 200-PO Tritium Data for Selected Wells in the Far-Field Region

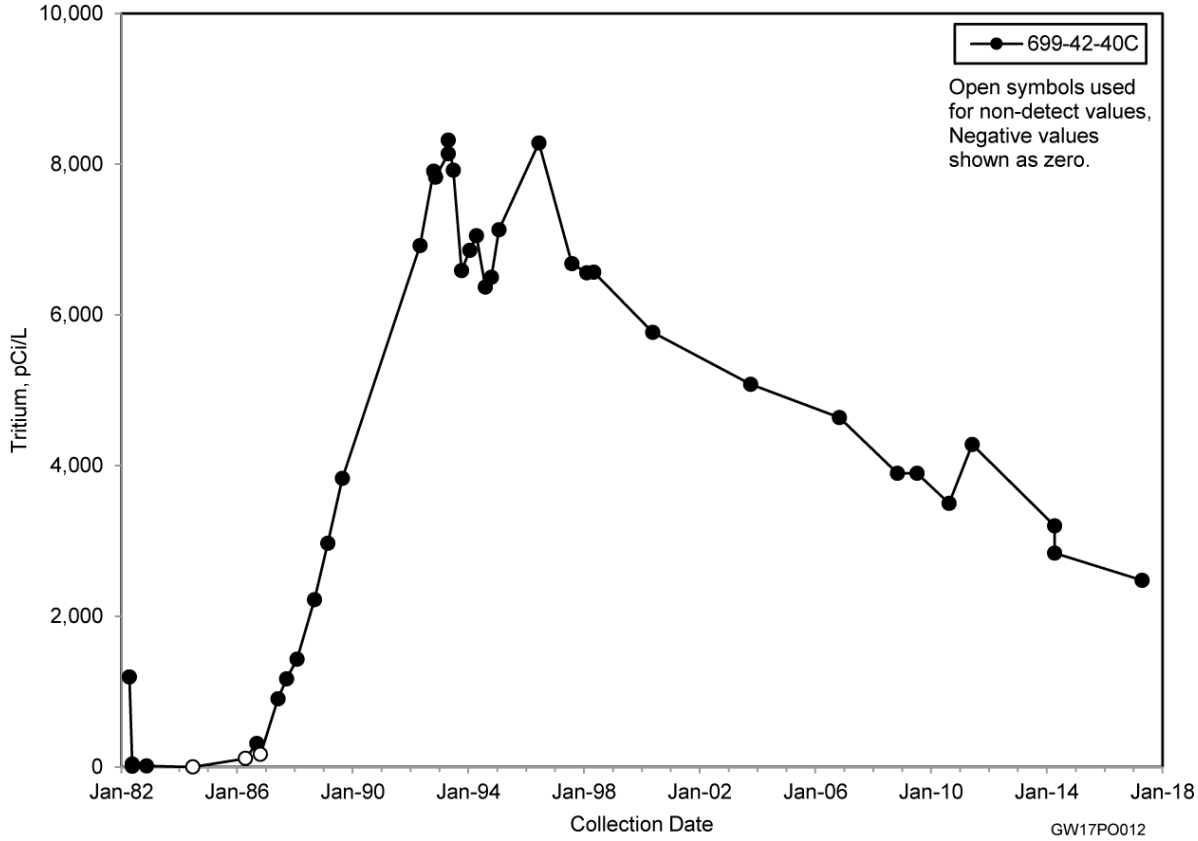


Figure 10-9. 200-PO Tritium Data for Basalt-Confined Well 699-42-40C

The iodine-129 plume has not reached the Columbia River at concentrations above the DWS and is typically undetected in 200-PO aquifer tubes. Tube 86-M had a reported concentration of 1.13 (±0.287) pCi/L in October 2017. However, the MDA of that sample was 0.912 pCi/L, so the result is within the range of uncertainty. Adjacent tube 86-D, screened deeper in the aquifer, had no detectable iodine-129 throughout the history of monitoring, and nearby monitoring wells do not typically detect iodine-129. Concentrations in near-river wells sampled in 2017 ranged from less than detection to 0.469 pCi/L.

Within the middle and lower portions of the unconfined aquifer in 2017, iodine-129 was detected at 3.89 pCi/L in well 299-E25-28, near the 216-A-29 Ditch. This concentration was comparable to previous results. Iodine-129 was not detected at levels above the DWS in far-field wells completed within the middle or lower portions of the unconfined aquifer during 2017.

For 200-PO, the Ringold-confined aquifer is monitored near B Pond and TEDF. In 2017, iodine-129 was detected above the DWS at one confined well. A value of 1.86 pCi/L in well 699-42-42B was measured, and concentrations are declining overall. Appendix D summarizes the results for other Ringold-confined wells.

Three wells screened in basalt-confined aquifers are sampled triennially within the 200-PO for iodine-129. Concentrations of iodine-129 within the basalt-confined aquifer wells have historically been near or below detection limits.

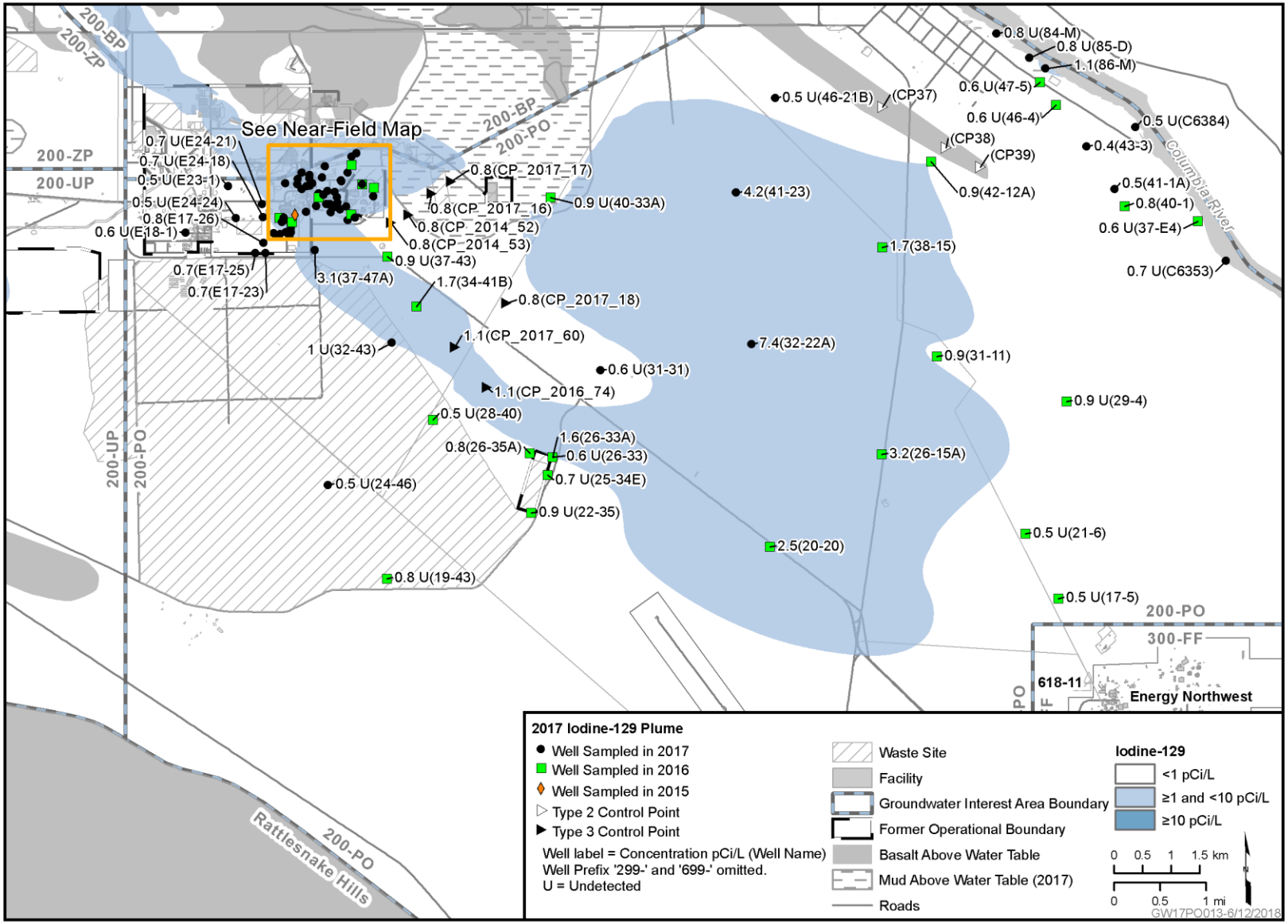


Figure 10-10. 200-PO Far-Field Iodine-129 Plume, 2017

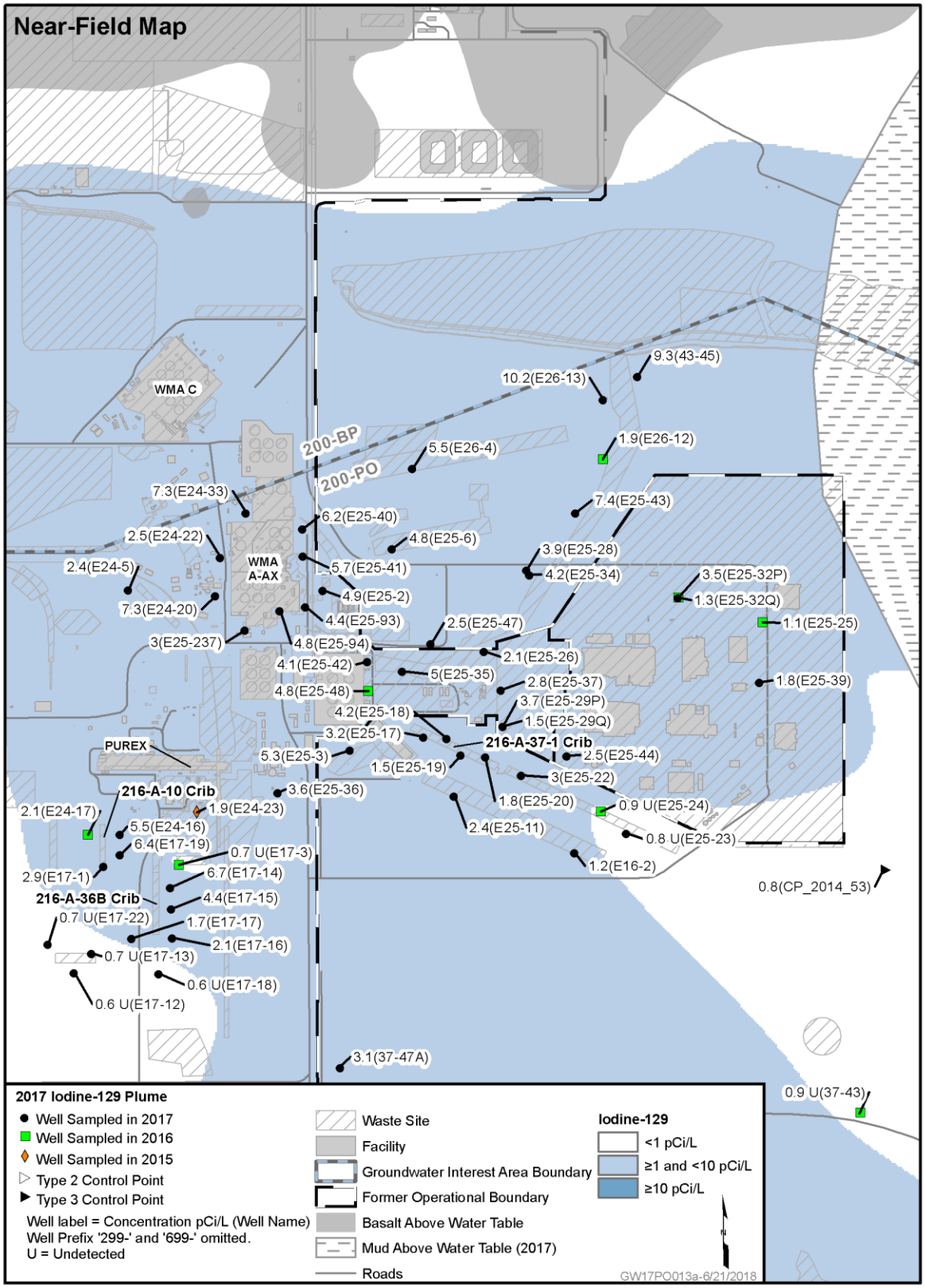


Figure 10-11. 200-PO Near-Field Iodine-129 Plume, 2017

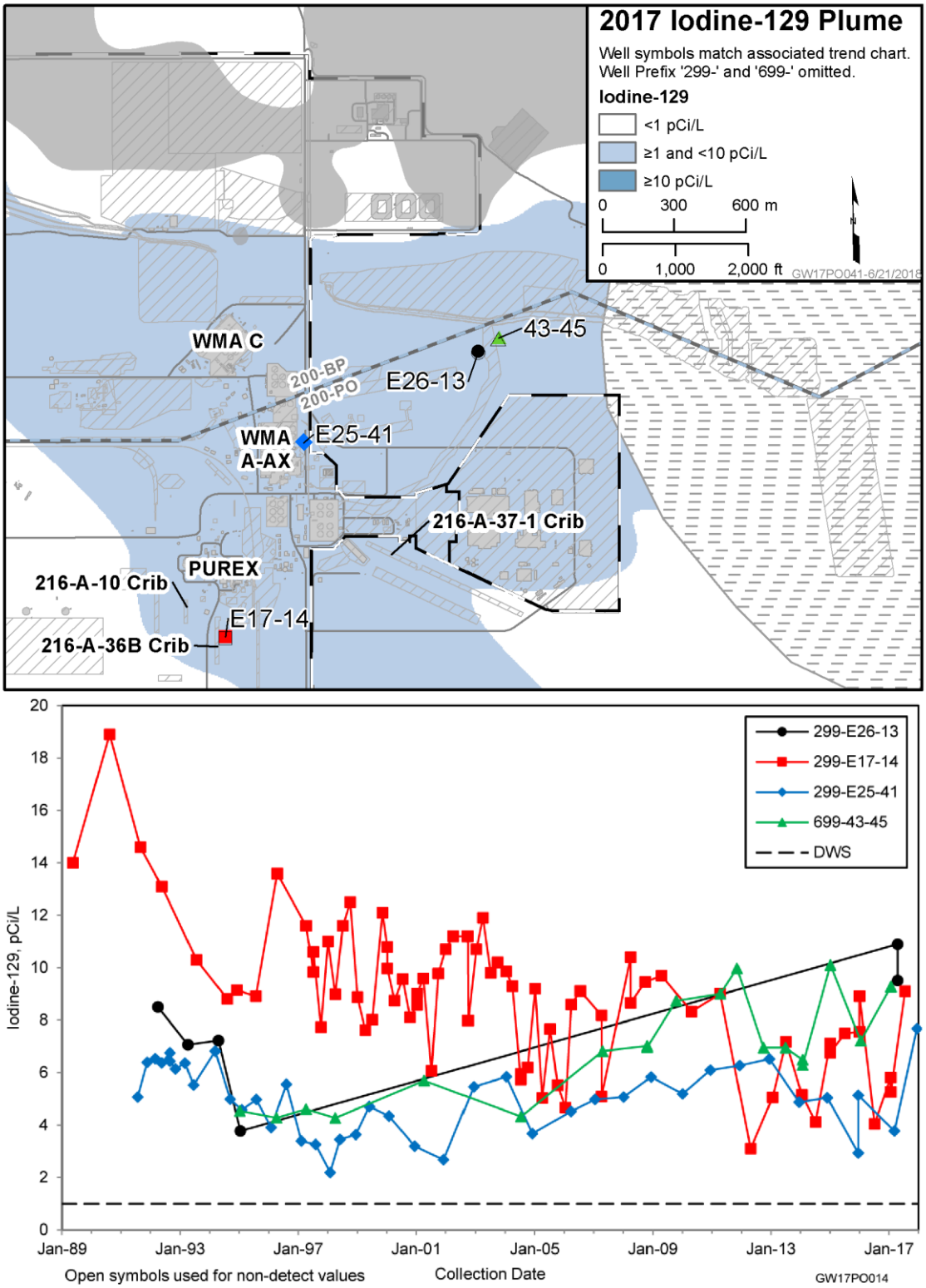


Figure 10-12. 200-PO Iodine-129 Data for Wells 299-E26-13, 299-E17-14, 299-E25-41, and 699-43-45

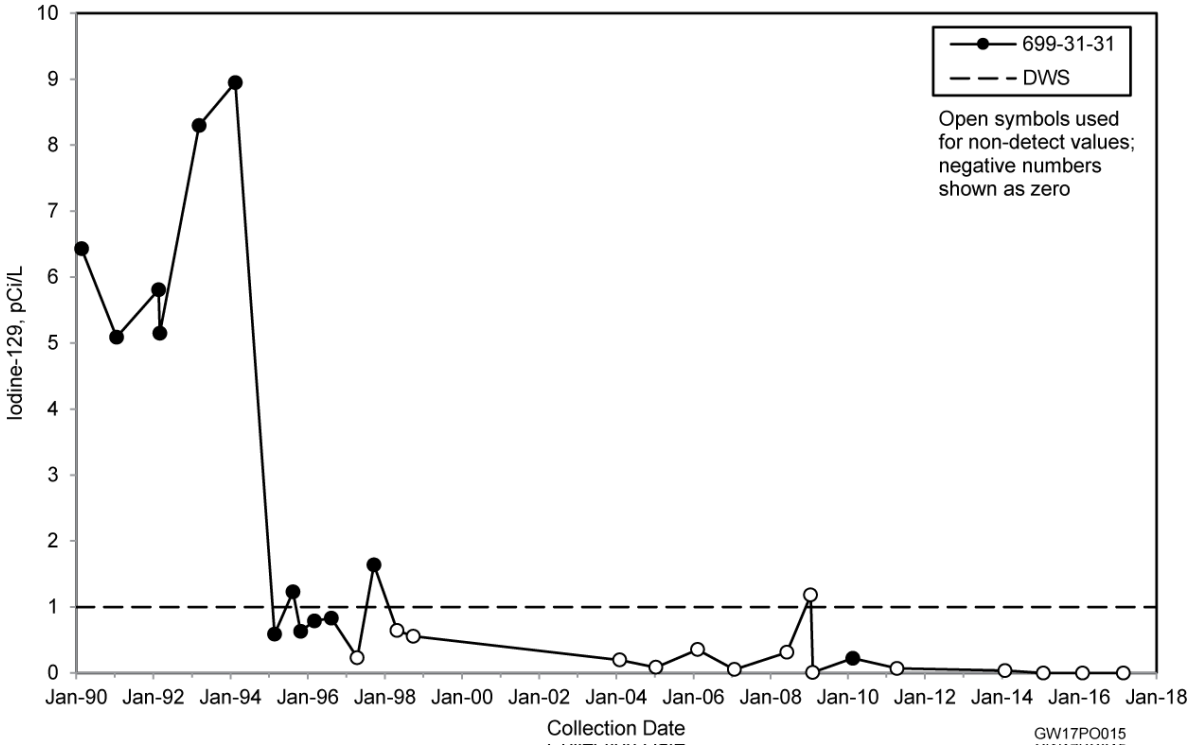


Figure 10-13. 200-PO Iodine-129 Data for Well 699-31-31

10.4 Nitrate

The highest historical concentrations of nitrate in 200-PO were detected near the PUREX cribs and trenches. The extent of nitrate at concentrations greater than 45 mg/L is limited to the near-field area (Figure 10-14). Historically, the nitrate plume was larger, but concentrations within the far-field area have decreased to less than 45 mg/L, except near the 618-11 Burial Ground (Chapter 7). Nitrate levels in wells 299-E24-22 and 299-E24-33 along the western margin of WMA A-AX continued to increase in 2017 as a plume from WMA C migrated downgradient. In June 2017, well 299-E24-5 had a nitrate concentration of 57.5 mg/L, exceeding 45 mg/L and resulting in expansion of the plume southwest of WMA A-AX.

In 2017, the highest nitrate concentrations in 200-PO were 120 mg/L at well 299-E17-14 (located downgradient of the 216-A-36B Crib) and 102 mg/L at well 299-E17-19 (located downgradient of the 216-A-10 Crib) (Figure 10-15). Some of the wells near the PUREX Cribs, including 299-E24-16, 299-E17-19, 299-E17-1, 299-E17-18 (near the 216-A-10 and 216-A-36B Cribs), 299-E25-17, 299-E25-18, and 299-E25-20 (near the 216-A-37-1 Crib), have exhibited increasing nitrate concentrations since early 2000.

Wells in the southeastern portion of the 200 East Area have had increasing nitrate concentrations since about 2002. Migration of the leading edge of the nitrate plume to the south and southeast is indicated by the increasing concentrations in wells 299-E17-26 and 299-E17-23 (Figure 10-16). The increase in nitrate concentrations in this portion of the 200 East Area may be related to changes in gradient and groundwater flow direction, and/or a vadose zone source(s) contribution associated with B Plant (Chapter 9). B Plant is the likely nitrate source because wells 299-E17-26 and 299-E17-23 are downgradient of B Plant, in line with a groundwater flow direction to the southeast.

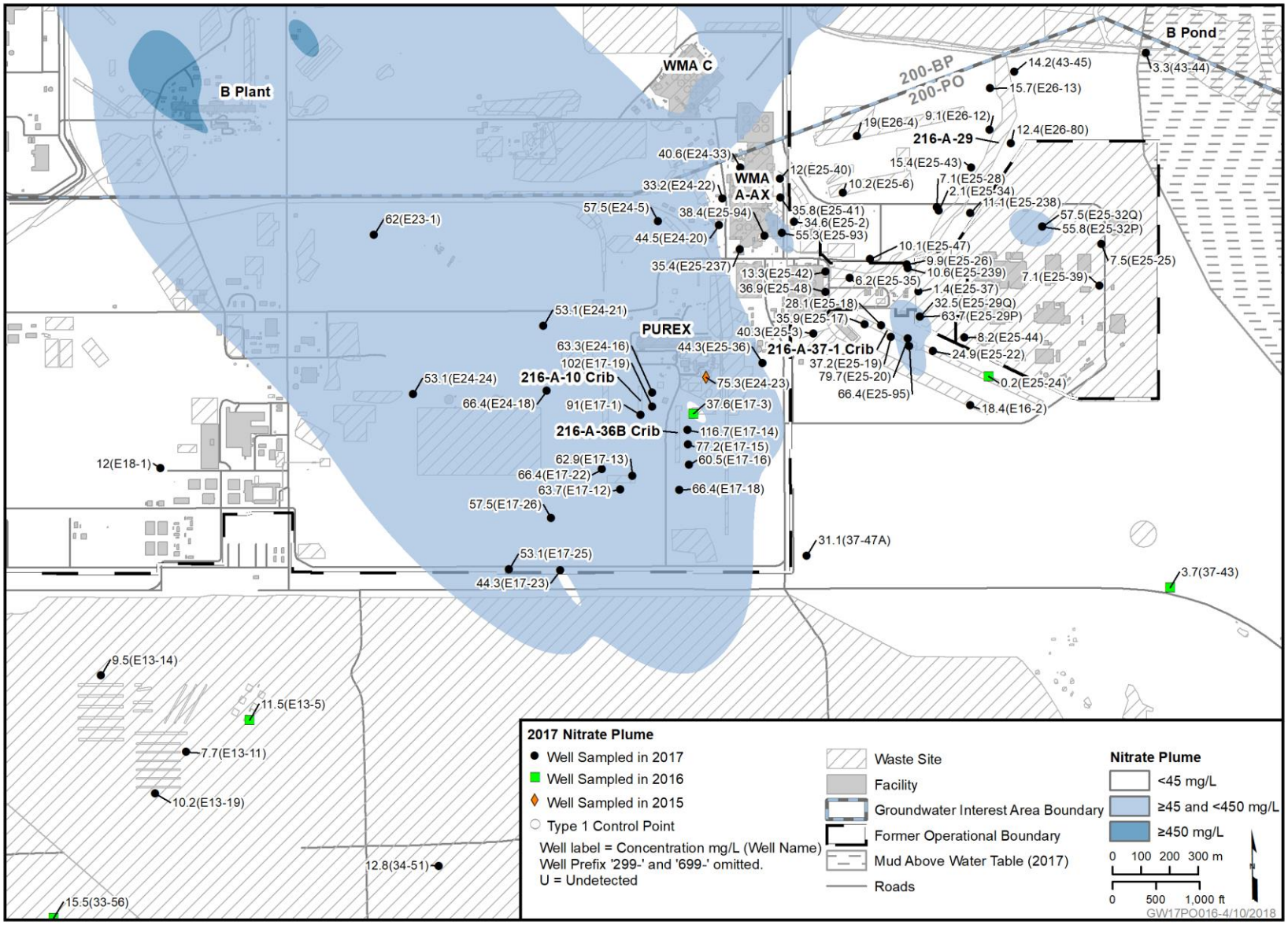


Figure 10-14. 200-PO Nitrate Plume, 2017

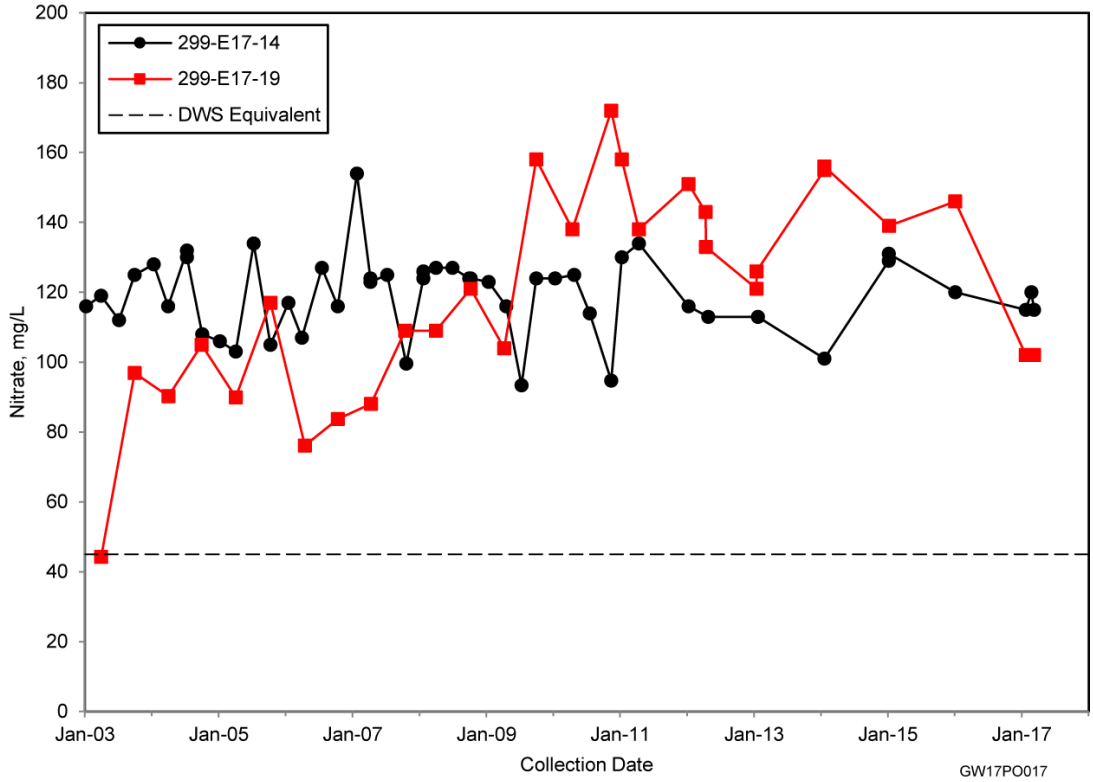


Figure 10-15. 200-PO Nitrate Data for Wells 299-E17-14 and 299-E17-19

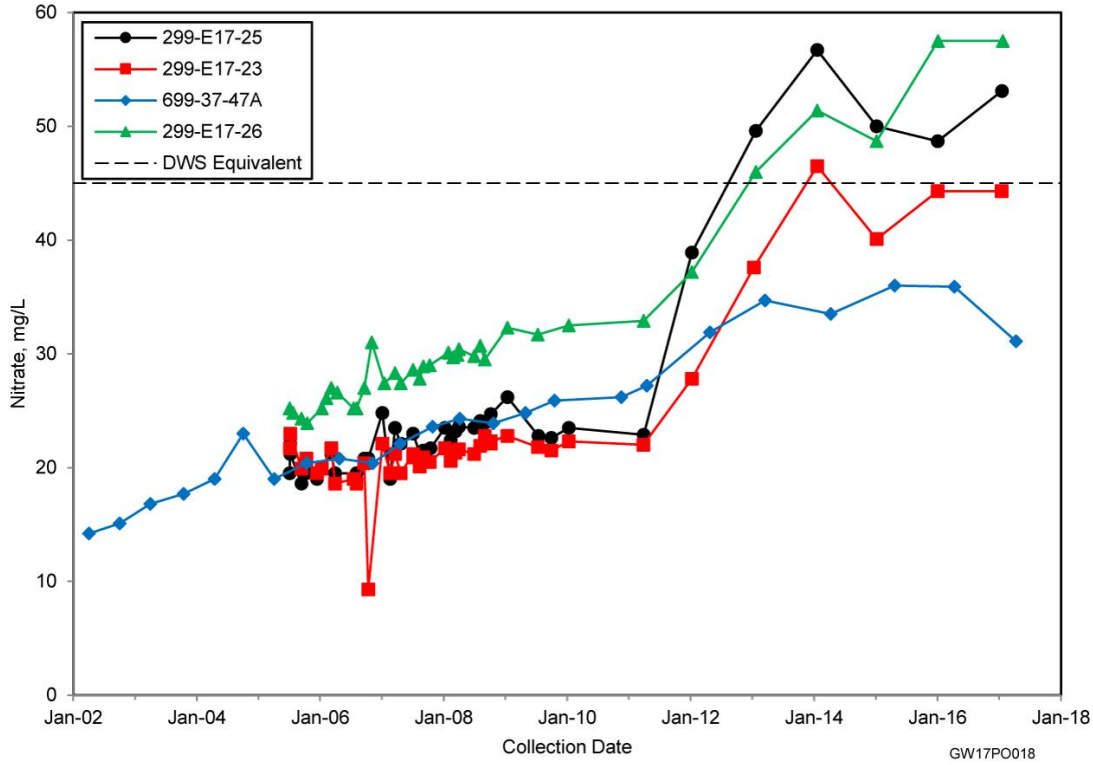


Figure 10-16. 200-PO Nitrate Data for Wells 299-E17-23, 299-E17-25, 299-E17-26, and 699-37-47A

The nitrate concentration in well 299-E25-32Q, monitoring the middle to lower portion of the unconfined aquifer, exceeded 45 mg/L in 2017. Concentrations have increased steadily from 4.4 mg/L in 2011 to 57.5 mg/L in 2017. In the far-field area, the maximum nitrate concentration in the deeper portion of the aquifer was 29.7 mg/L in near-river well 699-41-4A in 2017. Nitrate levels have been stable in this well since 2002.

In 2017, nitrate was detected in one well within the Ringold-confined aquifer above 45 mg/L, with a concentration of 97.4 mg/L measured in well 699-39-39. Beginning in 1995, nitrate concentrations increased as the water table elevation in the area decreased (Figure 10-17). Contamination from the unconfined aquifer may have migrated down the borehole annulus in the past when the B Pond groundwater mound was present. The high head may have forced the contaminated groundwater a limited distance into the RLM and thin silty or sandy lenses adjacent to the well. The saturated portion of the perforated interval is now entirely within the RLM. It is suspected that thin silty or sandy sequences may be present within the RLM adjacent to the well, yielding enough water for sampling. None of the wells completed in sand intervals below the RLM in this area show elevated nitrate concentrations. Wells open to Ringold unit A near B Pond are typically screened in gravelly sands and sandy gravels. Some wells (e.g., 699-40-39 and 699-40-40B) have sandy material overlying gravelly material in the screened interval, while other wells are screened entirely within material described as sandy gravels (e.g., 699-40-40A and 699-41-42).

Nitrate concentrations in the basalt-confined aquifer range from nondetect to 2.47 mg/L, which is much lower than in the unconfined aquifer.

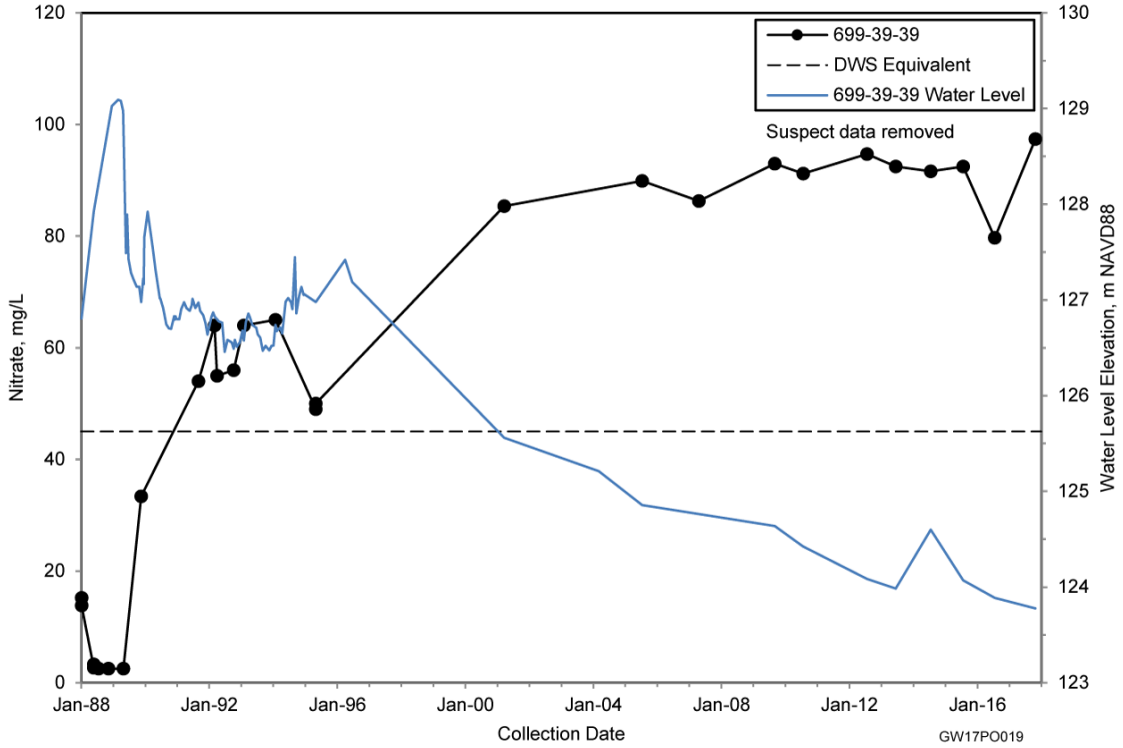


Figure 10-17. 200-PO Nitrate Data and Hydraulic Head in Ringold-Confined Well 699-39-39

10.5 Technetium-99

Technetium-99 has historically been detected in one relatively small area in the 200-PO near-field region around WMA A-AX (Figure 10-18). This plume appears to have sources in both WMA C (in 200-BP)

and WMA A-AX (in 200-PO). WMA A-AX is hydraulically downgradient of WMA C. In 2016, two separate plumes were defined (Figure 10-20 in DOE/RL-2016-67). In 2017, the two plumes merged as the technetium-99 concentration in well 299-E24-20 increased to 1,010 pCi/L. Concentrations have also increased in recent years in WMA A-AX wells 299-E24-22, 299-E24-33, and 299-E25-237 (Figure 10-19).

Comparing trends in downgradient well 299-E25-93 to upgradient well 299-E24-22 suggests that WMA A-AX may be a source of technetium-99 groundwater contamination. Until June 2013, the highest technetium-99 concentrations detected at WMA A-AX generally occurred in the downgradient well; this well demonstrated a decreasing concentration trend until that time (Figure 10-20). Concentrations in upgradient well 299-E24-22 (Figure 10-19) have been increasing since 2011. From June 2013 until July 2015, concentrations in both wells were similar, with increasing trends. This suggests that the leading edge of the WMA C plume was being detected in both wells between June 2013 and July 2015, while the highest concentration portion of the WMA A-AX plume had migrated beyond the monitoring network. Detections above the 900 pCi/L DWS southeast and downgradient of WMA A-AX in well 299-E25-93 before June 2013 are inferred to be primarily associated with WMA A-AX, although there may be some contribution from WMA C. This interpretation is also supported by different characteristics in the historical technetium-99 trends in upgradient wells 299-E24-33 and 299-E24-22 (Figure 10-19) compared to downgradient wells 299-E25-94, 299-E25-93, 299-E25-236, and 299-E25-237 (Figure 10-20). The increasing trend in the WMA A-AX upgradient wells is expected to continue as the WMA C plume continues migrating to the southeast toward WMA A-AX.

Groundwater flow rates at WMA C were interpreted to be 0.23 m/d (0.75 ft/d) toward the south-southeast, based on gradient and hydraulic conductivity. Based on this flow rate and a distance of 290 m (950 ft), the estimated minimum travel time between downgradient WMA C well 299-E27-21 and upgradient WMA A-AX well 299-E24-22 is 3.5 years. The calculated migration rate of technetium-99 from WMA C is discussed within quarterly groundwater assessment reports, including SGW-60546, *December 2016 WMA C Quarterly Report*.

In 2017, technetium-99 was reported at 643 pCi/L in well 699-37-47A, located near the southeast corner of the 200 East Area. Concentrations have been steadily increasing since consistent sampling of the well began in 2009 (Figure 10-21).

Technetium-99 concentrations ranged from nondetect to 82.2 pCi/L in 200-PO aquifer tubes in 2017.

Wells monitoring the Ringold-confined and basalt-confined aquifers historically have had little or no detectable technetium-99 and are no longer monitored for this analyte.

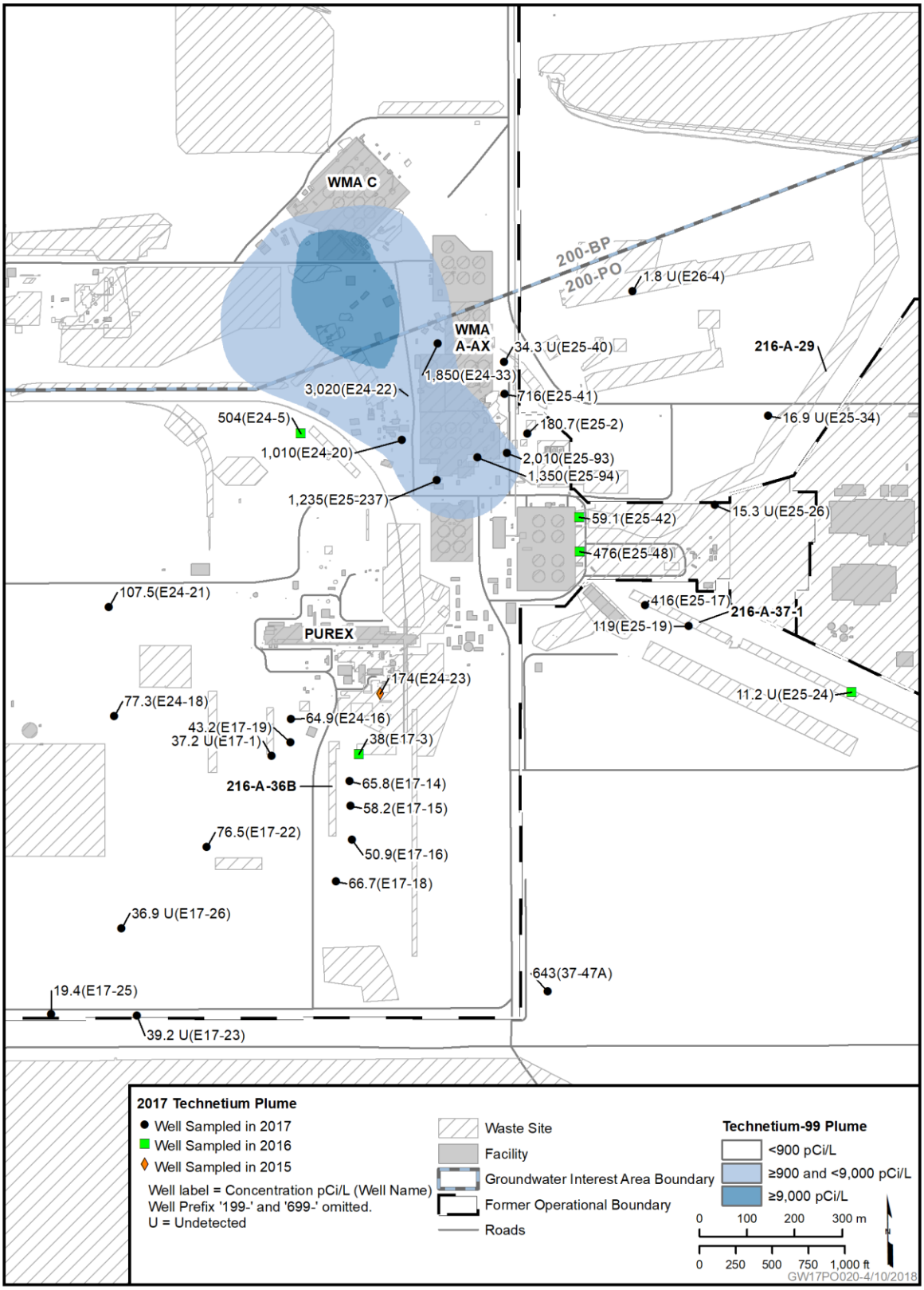


Figure 10-18. 200-PO Technetium-99 Plume, 2017

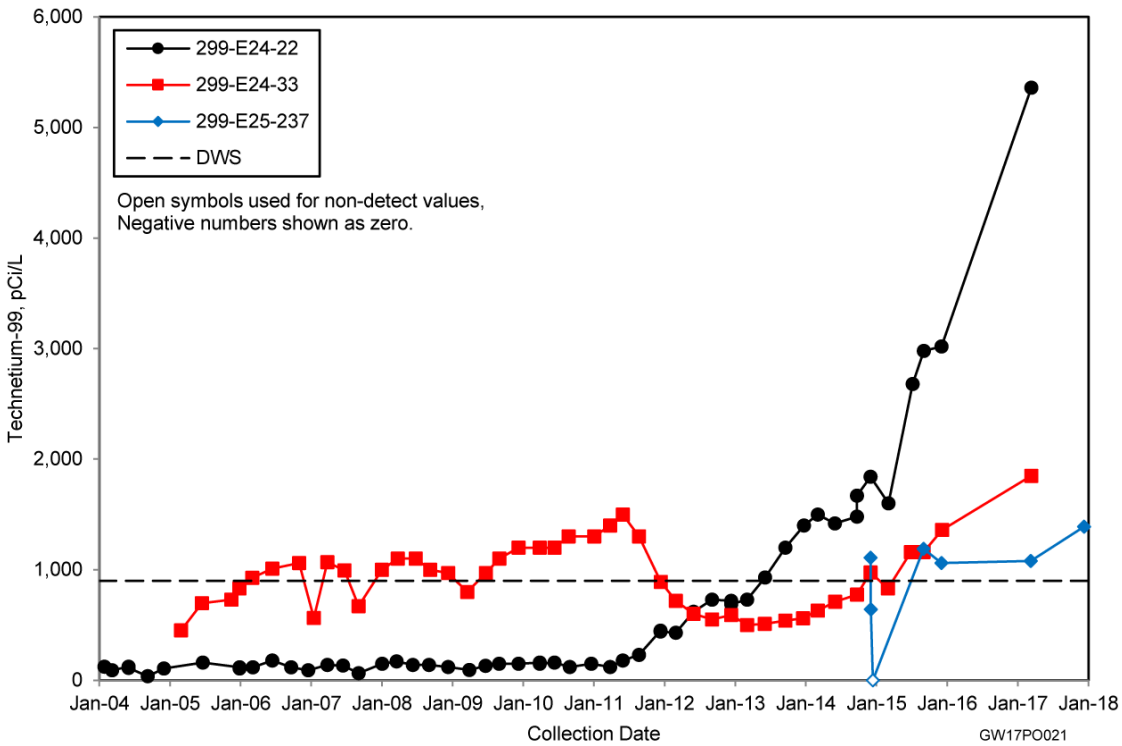


Figure 10-19. 200-PO Technetium-99 Data for WMA A-AX Upgradient Wells

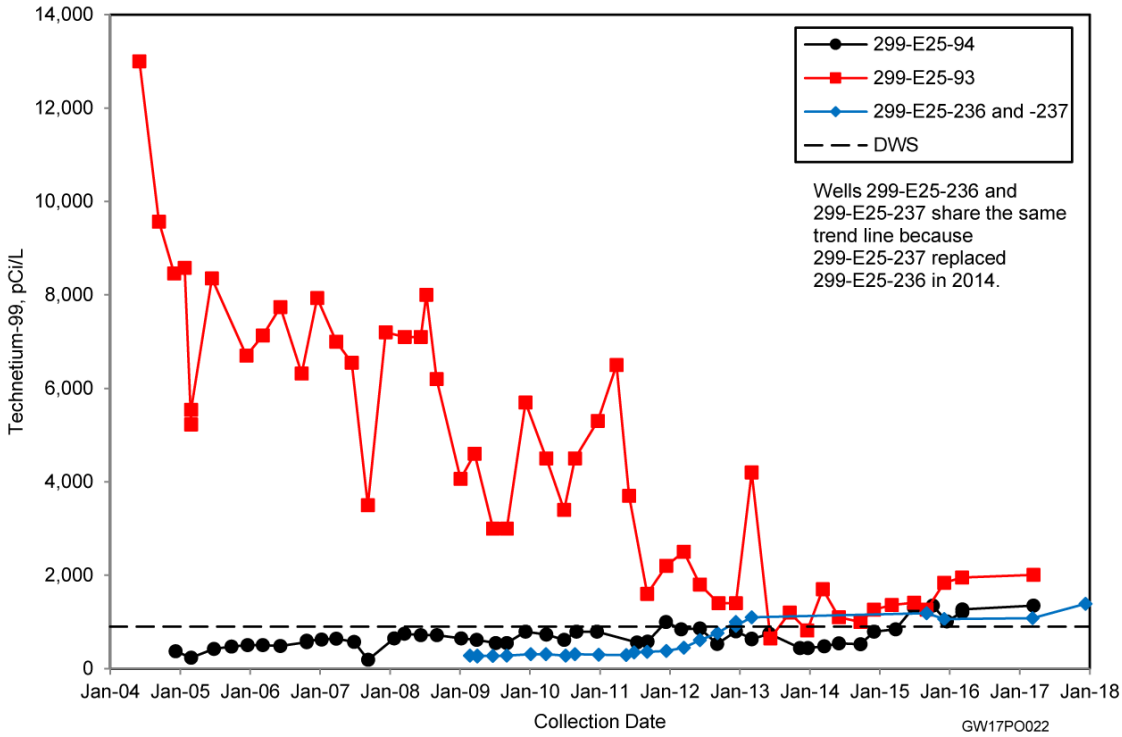


Figure 10-20. 200-PO Technetium-99 Data for WMA A-AX Downgradient Wells

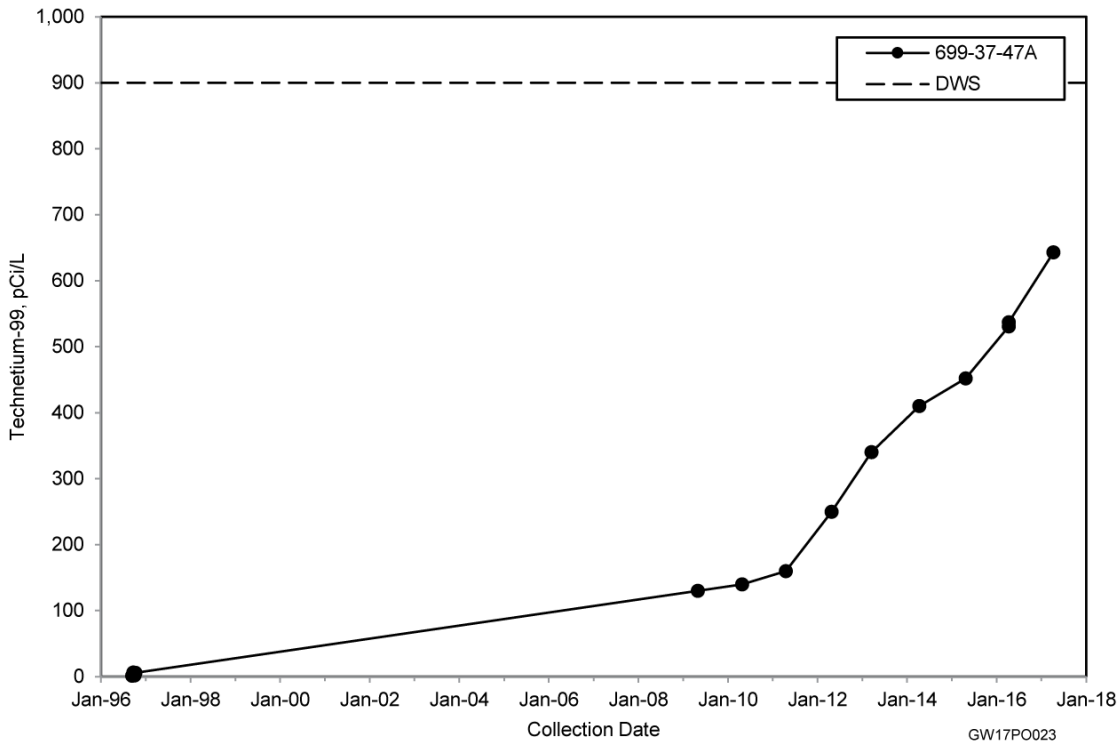


Figure 10-21. 200-PO Technetium-99 Data for Well 699-37-47A

10.6 Uranium

Uranium concentrations above the 30 µg/L DWS have been identified as a small plume near the PUREX cribs and trenches in the near-field area (Figure 10-22) and adjacent to the 618-10 Burial Ground (which is part of 300-FF) in the far-field area. Uranium remains somewhat mobile in groundwater at 200-PO, and the concentration changes observed are consistent with continued slow migration of uranium away from source areas. The highest concentration in 2017 was 63 µg/L in well 299-E25-36, an increase from 2015 (the low results in 2016 were suspected errors) (Figure 10-23). The interpreted plume extent expanded in 2017 because of this increase. Uranium concentrations at well 299-E17-14 (near the 216-A-36B Crib) and well 299-E24-16 (near the 216-A-10 Crib) remained slightly below the 30 µg/L DWS in 2017 (Figures 10-22 and 10-23).

During 2017, uranium within far-field unconfined, Ringold-confined, and basalt-confined aquifers remained well below the DWS. Concentrations ranged from nondetect to 11.4 µg/L in well 699-13-1A at the 618-11 Burial Ground.

10.7 Strontium-90

Strontium-90 has historically been detected in relatively small areas at concentrations greater than the DWS of 8 pCi/L near the 216-A-5, 216-A-10, and 216-A-36B Cribs. The only well in 200-PO with concentrations above the 8 pCi/L DWS in 2017 was 299-E17-14 (near the 216-A-36B Crib) (Figure 10-2), with an annual average of 12.0 pCi/L. Concentrations have declined since April 2008 (Figure 10-24).

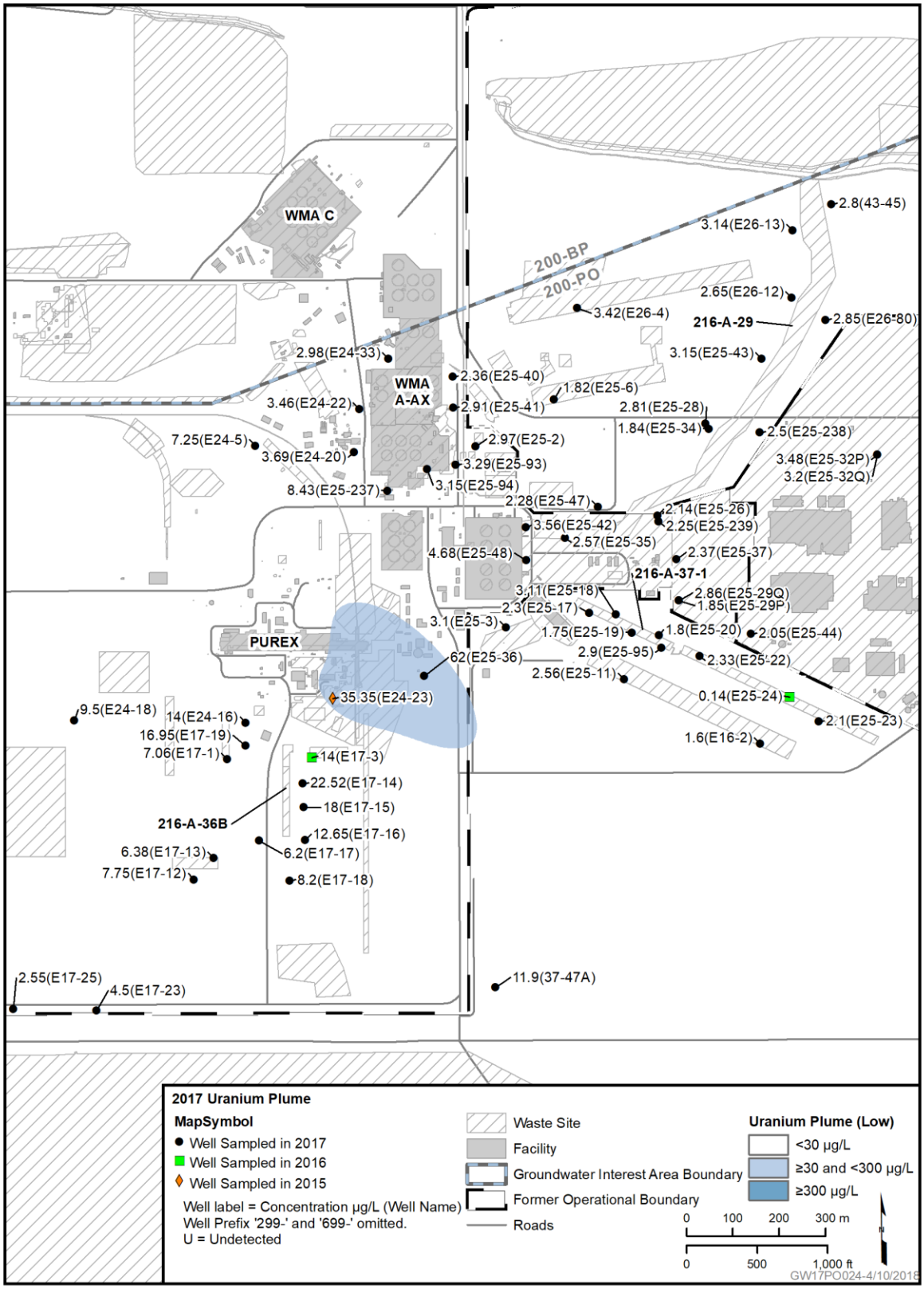


Figure 10-22. 200-PO Uranium Plume, 2017

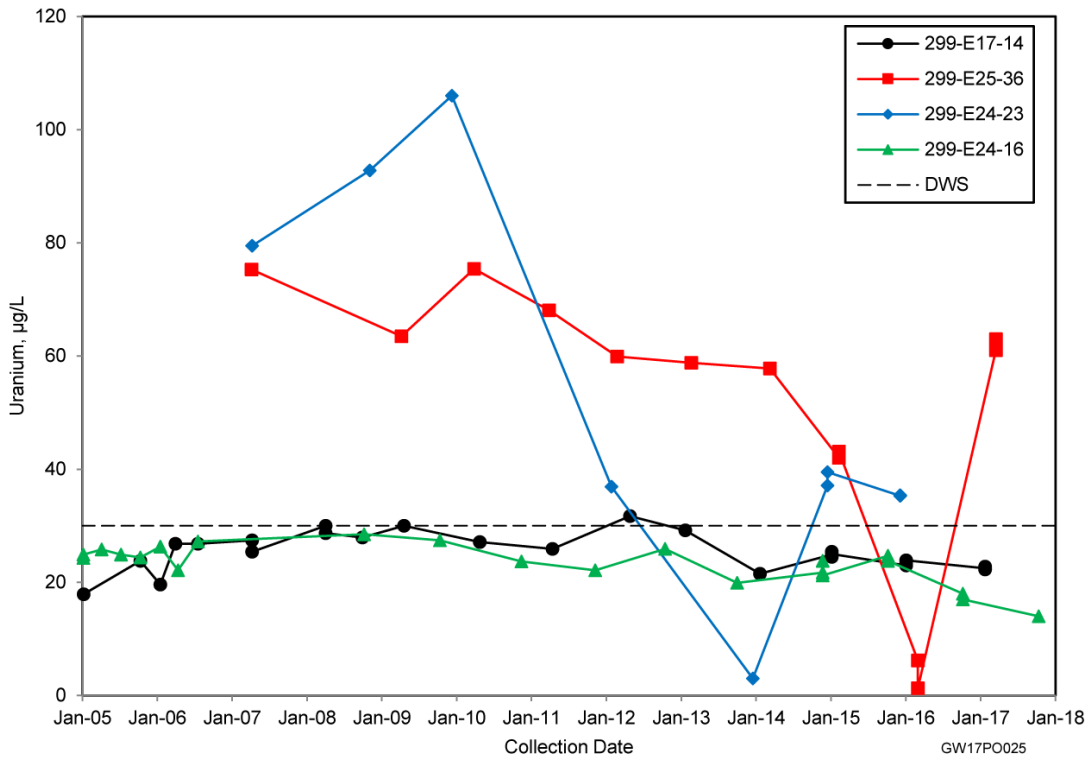


Figure 10-23. 200-PO Uranium Data for Wells 299-E17-14 (216-A-36B Crib), 299-E24-23 (216-A-4 Crib), 299-E24-16 (216-A-10 Crib), and 299-E25-36

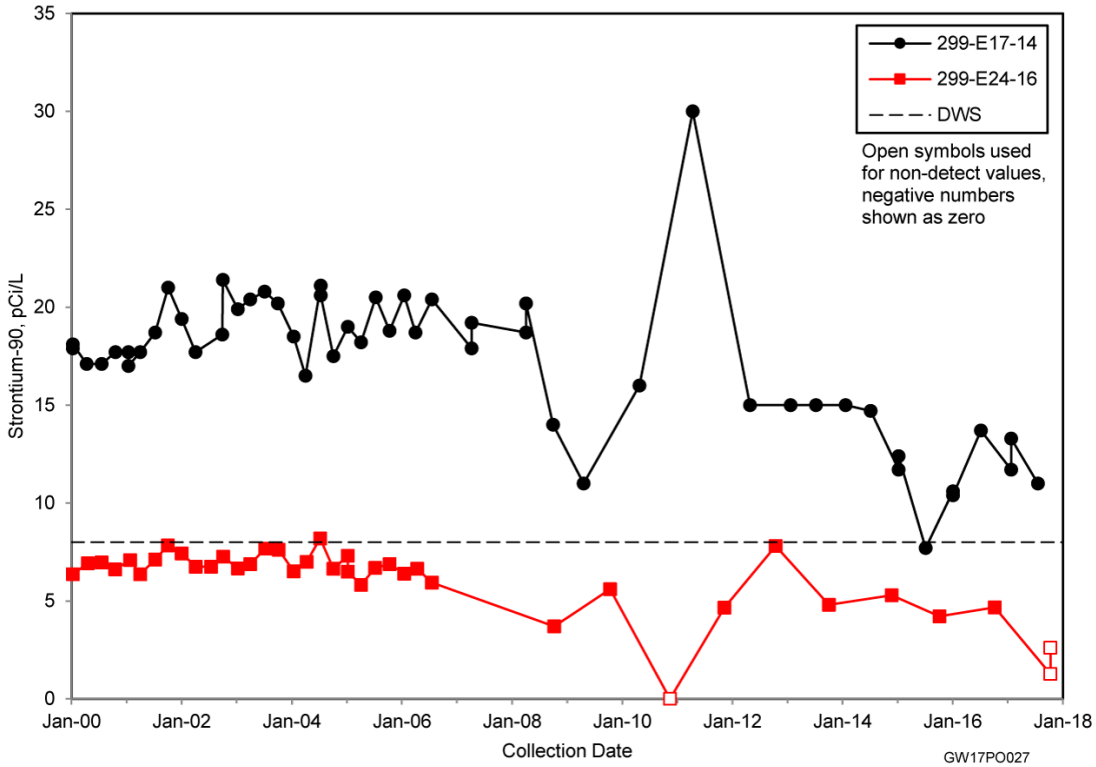


Figure 10-24. 200-PO Strontium-90 Data for Wells 299-E17-14 and 299-E24-16

Historically, concentrations of strontium-90 near the 216-A-10 Crib have exceeded the 8 pCi/L DWS in only one sampling event in one well (299-E24-16 at a concentration of 8.19 pCi/L in 2004). (Figure 10-24). Strontium-90 was not detected in well 299-E24-16 in 2017, down from 4.67 pCi/L in 2016. Strontium-90 is analyzed in only a few far-field wells and was not detected in 2017.

Wells screened in the middle or deep unconfined aquifer are no longer monitored for strontium-90 because it was typically undetected.

10.8 Tetrachloroethene and Trichloroethene

Concentrations of PCE are near or below detection limits in 200-PO. In 2017, PCE was detected at a maximum concentration of 0.83(J) µg/L in well 699-24-33, near the SWL (Figure 10-2), and below the 5 µg/L DWS. The laboratory "J" flag indicates that the value is estimated, the detection is uncertain, and the value reported is less than the PQL but greater than or equal to the MDL. Low-level detections of PCE were common in a few wells near NRDWL and the SWL used for RCRA and *Washington Administrative Code* monitoring before about 2007, but most results since then have been near or below detection limits..

In 2017, concentrations of TCE were near or below detection limits in 200-PO. TCE was detected at a maximum level of 1.73(J) µg/L in well 299-E17-19, located near the 216-A-10 Crib (Figure 10-2).

CERCLA monitoring for VOCs is also performed in conjunction with RCRA monitoring at NRDWL and *Washington Administrative Code* monitoring at the SWL.

10.9 CERCLA Monitoring

Groundwater monitoring in the 200-PO-1 OU under CERCLA is described in the SAP (DOE/RL-2003-04, as amended by TPA-CN-205); and DOE/RL-2007-31, *Remedial Investigation/ Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit*, as amended by TPA-CN-2-253, *Change Notice for Modifying Approved Documents/Workplans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records: DOE/RL-2007-31 Rev 0, Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Operable Unit*. Groundwater is monitored within the unconfined aquifer, Ringold-confined aquifers, and the basalt-confined aquifer. Wells and aquifer tubes (Figure 10-2) are generally sampled annually or triennially. Additional aquifer tube sampling within 200-PO is also conducted as defined in the SAP for aquifer sampling tubes (DOE/RL-2000-59, *Sampling and Analysis Plan for Aquifer Sampling Tubes*). Tables A-1 in Appendix A list the monitoring exceptions for 2017.

For purposes of CERCLA groundwater monitoring, the 200-PO-1 OU is informally divided into the near-field area (includes the former operational areas within and near the 200 East Area) and the far-field area (includes wells downgradient of the near-field area, and aquifer tubes along the Columbia River, and generally comprises areas where site operations did not occur). The river area is generally within 1 km (0.6 mi) of the west shore of the Columbia River. CERCLA sampling wells within the far-field area have been grouped into several sub-areas, including the BC Cribs, southeast transect, river transect, basalt-confined aquifer, and the general far-field area (DOE/RL-2003-04; TPA-CN-205).

The results of the RI were published in DOE/RL-2009-85 in 2012. The report recommended that the OU should advance to the next step in the CERCLA process, which is an FS to develop alternatives to remediate the groundwater contamination. The RI identified tritium, iodine-129, nitrate, strontium-90, technetium-99, PCE, TCE, and uranium as final COPCs. PCE and/or TCE were detected at very low (laboratory-estimated) concentrations (below the 5 µg/L DWS) in far-field area wells near the 216-A-10 Crib, 216-A-36B Crib, NRDWL, and SWL.

An RI addendum (DOE/RL-2009-85-ADD1, Draft A, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit Addendum 1*) was submitted to Ecology in 2015. The addendum was completed to address Ecology comments to update the baseline risk assessment to be consistent with the same timeframe used for the 200-BP-5 OU and to update the fate and transport model presented in the 200-PO-1 RI report (DOE/RL-2009-85).

10.10 RCRA Monitoring

The following sections, taken from DOE/RL-2017-65, describe the results of monitoring at seven individual WMAs within the 200-PO interest area conducted in accordance with RCRA regulations: 216-A-29, 216-A-36B, 216-A-37-1, B Pond, IDF, NRDWL, and WMA A-AX. Interim status groundwater quality assessment monitoring is conducted at 216-A-29, NRDWL, and WMA A-AX (40 CFR 265.93(d), as referenced by WAC 173-303-400). Interim status facility standards detection monitoring for indicator parameter evaluation is conducted at three sites: 216-A-36B, 216-A-37-1, and B Pond (40 CFR 265.92, as referenced by WAC 173-303-400). The IDF is not operational but is monitored as incorporated into the Hanford RCRA Permit to obtain baseline information.

Table 10-2 lists the wells installed in the 200-PO groundwater interest area in 2017. Five RCRA wells were installed, and one RCRA well was decommissioned.

10.10.1 Waste Management Area A-AX

WMA A-AX is located in the southeast quarter of the 200 East Area (Figure 10-25) and consists of 10 underground storage tanks, 2 of which are confirmed or assumed leakers (HNF-EP-0182). Leaks were reassessed in the 2014 revision of RPP-ENV-37956, *Hanford A and AX-Farm Leak Assessments Report*. To minimize the probability and severity of future leaks, most of the drainable liquid in each tank has been removed and transferred to DSTs. The extent of vadose zone contaminant migration from the tanks is uncertain. Although no dangerous waste groundwater contamination has been attributed to the tank releases, the WMA is in an interim status assessment program because specific conductance exceeded the critical mean value in 2005. Specific conductance of groundwater in the 200 East Area is elevated regionally (Figure B-2 in Appendix B).

WMA A-AX remained in assessment monitoring in accordance with 40 CFR 265.93(d) (as referenced by WAC 173-303-400) during 2017 and is monitored under DOE/RL-2015-49, *Interim-Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX*. The plan is a continuation of the first determination process of a previous plan (PNNL-15315, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*) and includes a comprehensive list of dangerous waste constituents for assessment.

Table 10-2. Wells Installed or Decommissioned in 200-PO in 2017

Well Name	Well ID	Purpose	Construction Depth (m bgs)	Construction Depth (ft bgs)	Drilled Depth (m bgs)	Drilled Depth (ft bgs)	Acceptance or Decommission Date	Comment
299-E25-95	C9630	216-A-37-1 Crib monitoring[a]	94.6	310.4	94.9	311.3	8/17/2017	
299-E25-238	C9617	216-A-29 Ditch monitoring[b]	90.8	297.9	92.0	302.0	8/17/2017	
299-E25-239	C9618	216-A-29 Ditch monitoring[b]	92.4	303.0	93.1	305.5	8/17/2017	
299-E26-80	C9616	216-A-29 Ditch monitoring[b]	80.7	264.9	83.0	272.3	8/17/2017	
699-29-55	C9634	200-UP-1 monitoring[c]	116.7	382.9	138.1	453.0	9/28/2017	
699-31-50	C9737	200-UP-1 monitoring[c]	121.0	397.1	142.8	468.5	12/5/2017	
699-43-44	B8758	Decommissioned	N/A	N/A	N/A	N/A	9/21/2017	Corroded 216-B-3 Pond well
699-44-43C	C9615	216-B-3 monitoring[d]	61.7	202.3	61.7	202.3	8/17/2017	Well is in 200-BP interest area (Chapter 9), but 216-B-3 Pond is in 200-PO interest area

a. DOE/RL-2010-92, Rev. 2, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*.

b. DOE/RL-2016-23, *216-A-29 Ditch Interim Status Groundwater Quality Assessment Monitoring Plan*.

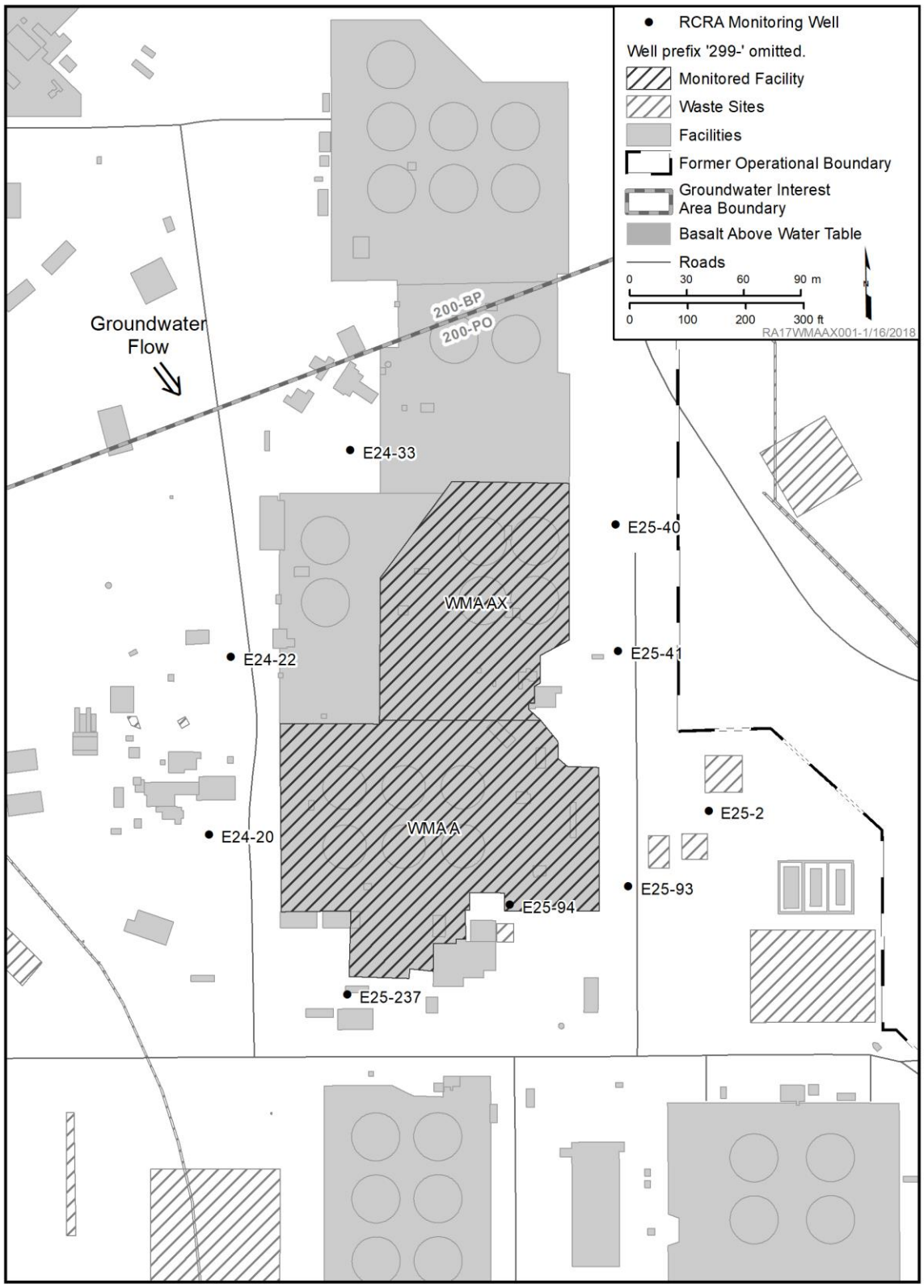
c. DOE/RL-2015-14, *Performance Monitoring Plan for the 200-UP-1 Groundwater Operable Unit Remedial Action* (as modified by TPA-CN-0802, *Tri-Party Agreement Change Notice Form: DOE/RL-2015-14, Performance Monitoring Plan for the 200-UP-1 Groundwater Operable Unit Remedial Action, Rev. 0*).

d. DOE/RL-2008-59, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*.

bgs = below ground surface

ID = identification

N/A = not applicable



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-25. Waste Management Area A-AX

The monitoring network includes three upgradient and six downgradient wells (Table B-72 in Appendix B). The average rate of water-level decline between 2012 and 2017 was 1.2 cm/yr (0.5 in./yr), and the wells all have adequate water in the screened interval for continued sampling. Wells are screened across the water table and monitor the upper portion of the unconfined aquifer. The estimated thickness of the unconfined aquifer is from 15 to 24 m (50 to 80 ft) near WMA A-AX.

Indications of corrosion were identified in well 299-E25-41 in 2016 and were confirmed with an inspection video log. Sampling of this well will continue as a portion of the monitoring network, with elevated unfiltered chromium, iron, and nickel attributed to corrosion. Well cleaning has been scheduled in an attempt to improve sample quality in the interim until the well can be replaced.

In 2017, groundwater near WMA A-AX was interpreted to flow to the south-southeast based on trend surface analysis results. Supporting evidence for the flow orientation included water-level measurements with slightly higher hydraulic heads to the northwest, as well as the distribution and migration of the nitrate plume in this area. This flow direction also corresponds to the orientation of a southeast-trending paleochannel in the area (Appendix E of DOE/RL-2011-118). Based on the 2017 trend surface analysis and low-gradient groundwater contour map for this area (Figure 9-6), the estimated hydraulic gradient is 1.4×10^{-6} m/m, with an estimated groundwater flow rate of 0.12 m/d (0.39 ft/d) (Table B-73 in Appendix B).

The monitoring network was sampled quarterly in 2017 to assess whether dangerous waste or dangerous waste constituents are present in the groundwater and to determine their extent and rate of migration. The assessment has not been completed. Assessment data will be evaluated in detail in a first determination report (40 CFR 265.94(d)(4), "Recordkeeping and Reporting").

Table B-74 in Appendix B summarizes the monitoring results for 2017. Nitrate continued to exceed the DWS equivalent in wells 299-E24-20 and 299-E25-93. Chromium exceeded the DWS in one unfiltered sample from well 299-E25-40 in June, but the filtered sample did not have detectable chromium. Iron and nickel were also elevated in the June unfiltered sample, suggesting the presence of particulate matter from the stainless-steel casing or screen. The well is scheduled for cleaning and inspection via video logging to evaluate the casing condition.

The June samples for herbicide analysis were not reported because laboratory calibration verification standards did not meet acceptance criteria. Samples for herbicides were recollected in July and August 2017. Low-level detections of pesticides, VOAs, semivolatile organic compounds, and dioxins were noted in 2017. All detected constituent concentrations were "J" qualified by the analytical laboratories, except for the tentatively identified compound 2-propanol (in well 299-E25-2). The laboratory "J" flag indicates that the value is estimated, the detection is uncertain, and the value reported is less than the PQL but greater than or equal to the MDL. Detailed evaluation and discussion of the groundwater quality assessment results will be presented in a first determination report.

Cyanide is detected in WMA C monitoring wells, located upgradient from WMA A-AX. Total cyanide was analyzed in WMA A-AX wells in 2017, although it is not required by the monitoring plan. The highest total cyanide concentration in 2017 was 5.5 µg/L in upgradient well 299-E24-33. Cyanide also was detected in upgradient well 299-E24-22 and downgradient wells 299-E25-93 and 299-E25-94.

10.10.2 216-A-36B Crib

The 216-A-36B Crib is a TSD unit located in the southeastern portion of the 200 East Area (Figure 10-26). The crib was 7 m (23 ft) deep, 150 m (490 ft) long, and 2.3 to 3.4 m (7.5 to 11.2 ft) wide at the base; the sides sloped at 1:1.5. The crib construction includes 7 m (23 ft) of naturally revegetated clean backfill soil. The crib was originally part of the 180 m (590 ft) long 216-A-36 Crib, which received PUREX Plant effluent from September 1965 to March 1966. In March 1966, the northernmost 30 m (98 ft) of the crib was isolated with a grout barrier. The southern portion of the crib (now known as 216-A-36B) is the only portion regulated as a RCRA TSD. The 216-A-36B Crib operated from March 1966 to October 1972 and was reactivated in November 1982 for the PUREX restart. It received 290 million L (76.6 million gal) of PUREX ammonia scrubber distillate and was permanently removed from service in September 1987. In May 2010, 15 cm (6 in.) of gravel was added to the surface of the 216-A-36B Crib.

The 216-A-36B, 216-A-10, and 216-A-37-1 Cribs were monitored under a RCRA interim status groundwater quality assessment program before 2011. The 216-A-10 Crib was officially closed and removed from the Hanford RCRA Permit on March 30, 2010. Since January 2011, the two remaining cribs (216-A-36B and 216-A-37-1) continue in RCRA interim status monitoring but are under indicator evaluation programs because the groundwater constituent detected (i.e., nitrate) is not a dangerous waste or dangerous waste constituent. In 2017, two upgradient wells and four downgradient wells were monitored for the 216-A-36B Crib (Figure 10-26; Table B-21 in Appendix B).

In November 2016, a revised groundwater monitoring plan was issued for 216-A-36B Crib (DOE/RL-2010-93, Rev. 2, *Interim Status Groundwater Monitoring Plan for the 216-A-36B PUREX Plant Crib*). The revised plan added one existing upgradient well (299-E17-1) and one existing downgradient well (299-E17-15) to the network. The two newly incorporated wells were sampled quarterly for one year for contamination indicator parameters, groundwater quality parameters, and site-specific constituents. Additional upgradient and downgradient wells are proposed for the current network when an updated monitoring plan for 216-A-36B is implemented.

The January and March herbicide results were not valid because laboratory control sample recovery limits were not met. The entire 216-A-36B network was then sampled two extra times, including events for February and March.

The low-gradient groundwater contour map for 2017 indicated groundwater flow to the east near the 216-A-36B Crib (Figure 9-6). The calculated groundwater flow rate is 0.0001 m/d (0.0004 ft/d) (Table B-22 in Appendix B). Table B-21 in Appendix B summarizes water-level information for the 216-A-36B monitoring network. The average rate of water-level decline between 2012 and 2017 was 3.0 cm/yr (1.2 in./yr). Based on this information, the monitoring wells all have adequate water in the screened interval for continued sampling.

The 216-A-36B Crib groundwater wells were monitored in 2017 for RCRA indicator parameters (TOC, TOX, pH, and specific conductance) (Table B-23 in Appendix B) and water quality parameters (Table B-24 in Appendix B). There were no exceedances of the 2017 critical mean values.

Groundwater quality parameters monitored for the site include chloride, iron, manganese, nitrate, phenols, sodium, and sulfate. Samples for analyses of alkalinity, calcium, magnesium, and potassium are collected to support cation-anion balance calculations for the calcium-bicarbonate-type groundwater (Table B-24 in Appendix B).

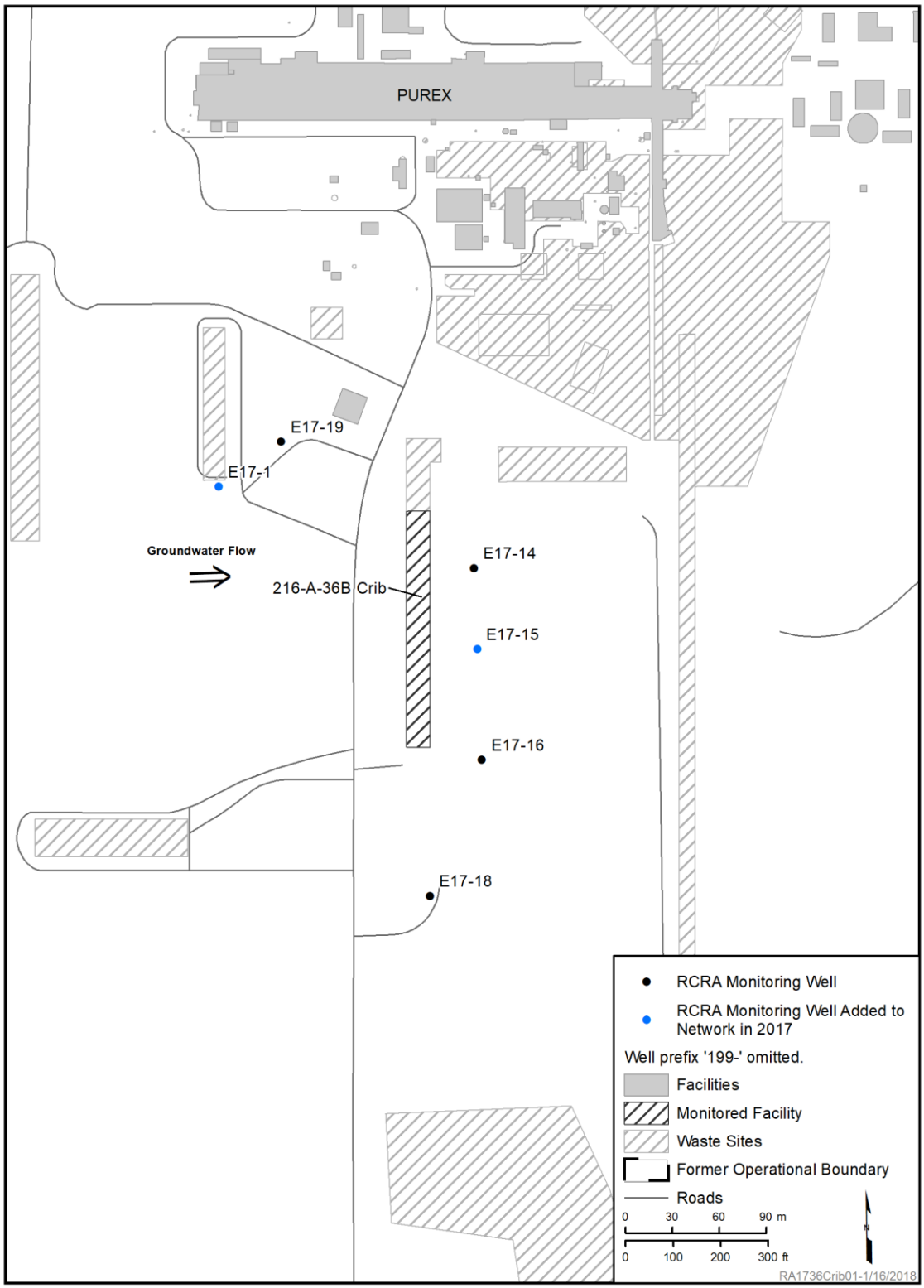


Figure 10-26. 216-A-36B Crib

In 2017, nitrate continued to be above the DWS in all of the network wells, and these levels are associated with a regional nitrate plume (Figure B-3 in Appendix B). Nitrate is a constituent of interest at the 216-A-36B Crib because it is a breakdown product of nitric acid, which was disposed to the 216-A-10 Crib, 120 m (390 ft) to the west.

Iron and manganese concentrations exceeded the secondary DWSs in samples from several wells (Table B-24 in Appendix B), with the highest concentrations in wells 299-E17-1 and 299-E17-18. These wells will be scheduled for video logging in 2018 to determine the cause of the elevated metals.

VOCs were monitored at the 216-A-36B Crib in 2017 to determine if previous historical, intermittent, low-level detections of TCE were still occurring. Statistical comparisons of upgradient and downgradient concentrations of TCE are not required under the current monitoring plan. During 2017, four network wells had TCE detections below the DWS of 5 µg/L:

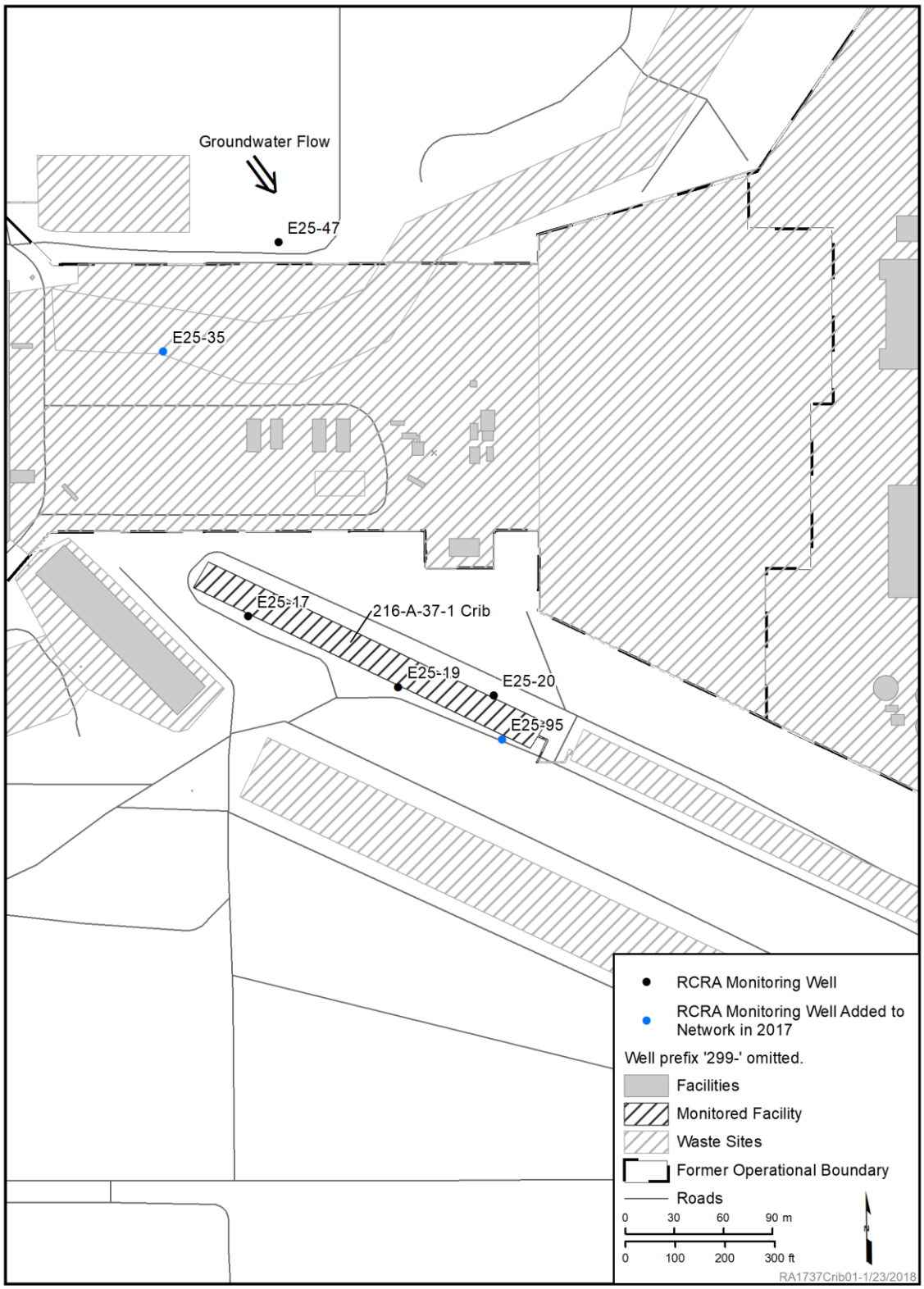
- Upgradient well 299-E17-19 at 1.56(J) to 1.73(J) µg/L
- Downgradient well 299-E17-14 at 0.74(J) to 0.86(J) µg/L
- Downgradient well 299-E17-15 at 0.40(J) to 0.42(J) µg/L
- Downgradient well 299-E17-16 at 0.57(J) to 0.76(J) µg/L

10.10.3 216-A-37-1 Crib

The 216-A-37-1 Crib TSD unit is located east of the 200 East Area (Figure 10-27). The crib was 5.2 m (17.1 ft) deep, 213 m (699 ft) long, and 33 m (108 ft) wide at the base, with sides sloped at 1:1. The crib operated from March 1977 through April 1989 and was used to percolate 242A evaporator process condensate to the soil column. It received spent halogenated and nonhalogenated solvents, as well as ammonia. During its operational life, this crib received 380 million L (98 million gal) of process condensate. Discharge of the evaporator process condensate to the crib continued through April 1989, when it was removed from service. In 1994, the bottom of the diversion box was filled with grout to prevent inadvertent discharges to the crib. In July 2000, vent risers from the crib were sealed to prevent potential passive radioactive emissions.

The 216-A-36B, 216-A-10, and 216-A-37-1 Cribs were monitored under a RCRA interim status groundwater quality assessment program before 2011. The 216-A-10 Crib was officially closed and removed from the Hanford RCRA Permit on March 30, 2010. Since January 2011, the two remaining cribs (216-A-36B and 216-A-37-1) continue in RCRA interim status monitoring but are under indicator evaluation programs because the groundwater constituent detected (i.e., nitrate) is not a dangerous waste or dangerous waste constituent.

In 2017, two upgradient wells and four downgradient wells were monitored for the 216-A-37-1 Crib (Table B-25 in Appendix B). The average rate of water-level decline between 2012 and 2017 was 3.6 cm/yr (1.4 in./yr). Based on this information, the monitoring wells all have adequate water in the screened interval for continued sampling.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-27. 216-A-37-1 Crib

Near the 216-A-37-1 Crib, the estimated groundwater flow in 2017 was toward the southeast. Flow directions are influenced by a northwest-southeast-trending paleochannel with high-permeability Hanford formation sediments near the crib, the Ringold lower mud unit at the water table east of the 200 East Area, and the higher water table elevations to the west and north. This interpretation of flow direction is supported mainly by the distribution of plumes emanating from near the crib and recent efforts to improve the accuracy of water-level measurements in the southeastern portion of the 200 East Area. The gradient magnitude for 2017 was calculated as 4.4×10^{-6} m/m. The estimated groundwater flow rate is 0.38 m/d (1.2 ft/d) (Table B-26 in Appendix B). Ongoing gradient network evaluation near the crib is expected to provide greater certainty in calculations of groundwater flow in this area.

Based on current groundwater flow interpretations, DOE/RL-2010-92, Rev. 2, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*, was implemented in April 2017. The revised plan incorporates the current groundwater flow direction interpreted from the low-gradient monitoring network, presents new geologic cross sections from data added to the Hanford South Geoframework Model (ECF-Hanford-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington, Fiscal Year 2016 Update*), reviews and summarizes historical monitoring results in relationship to changing flow directions, and updates the CSM. To improve monitoring capabilities upgradient and downgradient of the crib, the updated monitoring plan added an existing upgradient well and included a new downgradient well. Although not directly downgradient, use of existing network well 299-E25-20 will continue until the new downgradient well is installed because of its proximity to the crib and its use in delineating the nitrate plume associated with 216-A-37-1.

DOE/RL-2010-92, Rev. 3 was issued on September 27, 2017. This revision incorporates new downgradient monitoring well 299-E25-95, which was proposed under Rev. 2.

The 216-A-37-1 Crib network wells are monitored for RCRA indicator parameters (TOC, TOX, pH, and specific conductance) (Table B-27 in Appendix B), temperature, turbidity, water quality parameters, and other constituents (Table B-28 in Appendix B). Water-level measurements are collected semiannually. The network wells were sampled as scheduled in 2017. Analytical results for RCRA indicator parameters obtained from the 216-A-37-1 Crib network downgradient wells did not exceed the 2017 critical mean values, so the site remains in interim status indicator evaluation monitoring.

Manganese continued to exceed the 50 µg/L secondary DWS in filtered and unfiltered samples from wells 299-E25-19 and 299-E25-20 in 2017 (Table B-28 in Appendix B). Elevated concentrations of iron in well 299-E25-19 correspond with increased unfiltered chromium and nickel, which is associated with high turbidity and potential well casing corrosion. Chromium and nickel analyses are not monitoring plan requirements, but data were available from the required metals analyses. A video log of well 299-E25-19 in November 2016 documented significant well incrustation with iron oxide and biological material. The well was cleaned, and the post-cleaning video revealed debris from a damaged well pump within the sump. Sampling continued in 2017, but if the debris cannot be removed, the well will be evaluated for decommissioning and replacement.

Nitrate concentrations exceeded the DWS equivalent in downgradient wells 299-E25-20 and 299-E25-95. The exceedance at well 299-E25-95 was from the initial sampling event for that well. Nitrate concentrations at well 299-E25-20 have been above the DWS since March 2011. Nitrate concentrations in well 299-E25-17 are increasing and reached 35.9 mg/L in 2017.

Arsenic exceeded the 10 µg/L DWS in well 299-E25-35 in April 2017 (11.5 µg/L in filtered and unfiltered samples), but concentrations were below the standard for the remainder of the year. Gross beta was reported at 168 pCi/L in new well 299-E25-95 during the first sampling event in October 2017, which exceeded the comparison value of 50 pCi/L.

10.10.4 216-A-29 Ditch

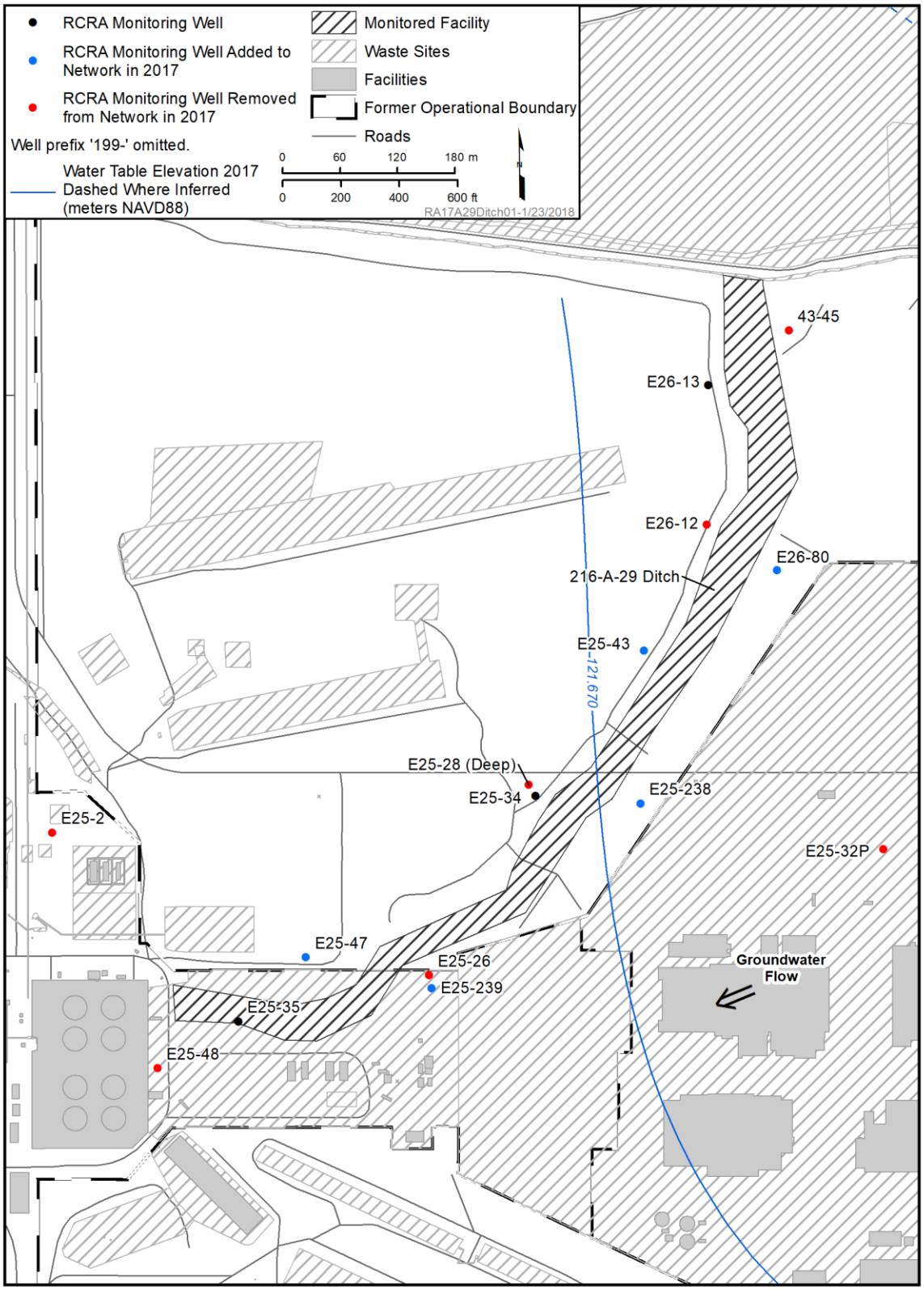
The 216-A-29 Ditch TSD unit is just east of the 200 East Area fence line (Figure 10-28) and is planned for closure. DOE submitted an updated closure plan (DOE/RL-2008-53, *Hanford Facility Dangerous Waste Closure/Postclosure Plan for the 216-A-29 Ditch*) to Ecology in 2014. The site is designated as a surface impoundment in accordance with WAC 173-303-040, "Definitions." It was placed into service in November 1955 to convey liquid effluent from the PUREX Plant chemical sewer to B Pond. Flow from the chemical sewer (low-level contaminants) was continuous, with an average volume of 3,700 L/min (970 gal/min).

The 216-A-29 Ditch received continuous discharge of corrosive waste and potentially hazardous spilled chemical materials from PUREX. The most significant chemical discharges included acidic and caustic effluents from backwashing during demineralizer column regeneration. From 1955 to 1986, daily discharges of sodium hydroxide and sulfuric acid solutions occurred. Treatment of this waste involved the successive addition of acidic and caustic waste, which neutralized waste in the ditch. The ditch also received spills from the PUREX chemical sewer (low-level contamination). After 1986, dangerous waste was no longer discharged to the chemical sewer. A complete estimated inventory of materials discharged to the 216-A-29 Ditch is provided in Appendix A of WHC-SD-EN-AP-045, *Ground Water Monitoring Plan for the 216-A-29 Ditch*.

The 216-A-29 Ditch was removed from service in 1991, partly backfilled with material from the ditch sides, and the portion of the ditch inside the 200 East Area security fence was brought to grade with clean fill material. The ditch outside of the 200 East Area security fence was topped with clean fill material in a series of 11 terraces progressing down the length of the ditch. Both areas were revegetated and posted as underground radioactive material areas.

In January 2016, the 216-A-29 Ditch was placed into a groundwater assessment program because specific conductance in wells 299-E25-32P, 299-E25-35, and 299-E25-48 exceeded the critical mean value in 2015. Three versions of the groundwater quality assessment monitoring plan (DOE/RL-2016-23, *216-A-29 Ditch Interim Status Groundwater Quality Assessment Monitoring Plan*) were used in 2017: Rev. 0 from January until May, Rev. 1 from May until September, and Rev. 2 beginning on September 27. Rev. 2 incorporated changes to the well network proposed in Rev. 1, including installing new wells and removing older wells. Table B-18 in Appendix B summarizes the changes to the network. Network groundwater wells all have adequate water columns in the screened interval for representative sampling over the next decade.

The current 216-A-29 Ditch groundwater monitoring network was based on groundwater flow directions estimated from evaluating low-gradient water table maps, comparing upgradient and downgradient well water chemistry along different ditch segments, using fate and transport modeling (including particle tracking), and reviewing historical migration patterns of 200 East Area nitrate and sulfate plumes (specifically near the ditch from 2000 to 2015). This analysis showed that during that time period, near the north end of the ditch, flow in the unconfined aquifer was to the south. At the south end of the 216-A-29 Ditch, groundwater flowed to the south-southeast.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-28. 216-A-29 Ditch

Large-volume effluent discharges at TEDF sometimes indirectly influence the gradient near the 216-A-29 Ditch and other 200 East Area locations. The effluent does not infiltrate the unconfined aquifer, but hydrostatic loading on top of the Ringold Formation mud units can cause the water table in the adjacent aquifer to rise. In 2017, the water-table gradient beneath the 216-A-29 Ditch dipped to the west-southwest (Figures 9-6 and 10-28; Table B-19 in Appendix B). ECF-200East-18-0016 provides more information about mapping the low-gradient water table in 200 East Area. The gradient magnitude was 4.04×10^{-6} m/m, and the calculated average flow velocity was 0.34 m/d (1.1 ft/d).

The network was sampled quarterly as required in 2017 (Table B-18 in Appendix B). The full network was sampled quarterly for assessment parameters to assess whether dangerous waste or dangerous waste constituents are present in the groundwater and their extent and rate of migration. After additional data have been collected and evaluated, the results will be included in a first determination report (40 CFR 265.93(d)(4)). Table B-20 in Appendix B summarizes the results for 2017.

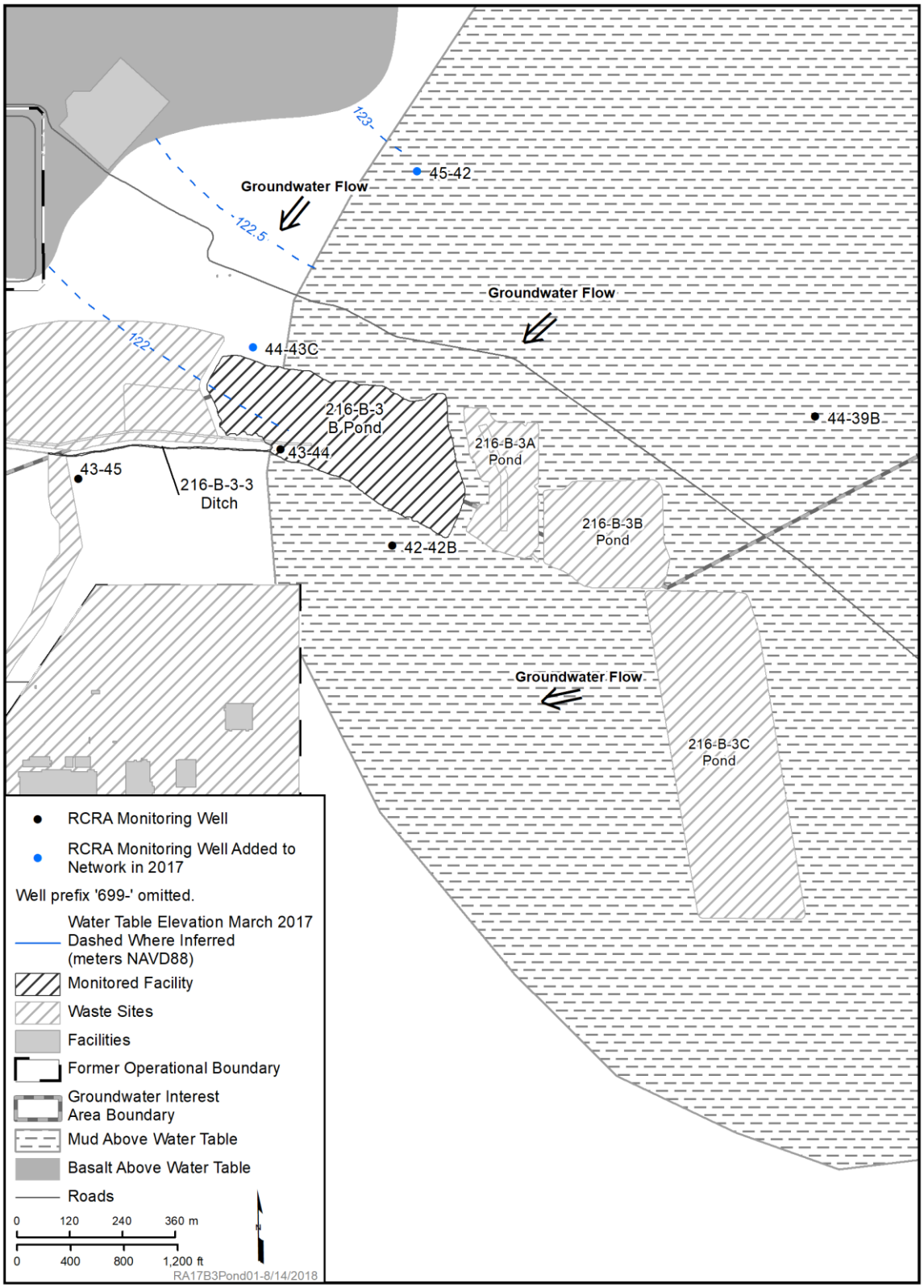
Nitrate exceeded the DWS in well 299-E25-32P in all sampling events in 2017. However, the nitrate concentration in new well 299-E25-238, which replaced 299-E25-32P, was less than the DWS at 11.1 mg/L. Iron exceeded the secondary DWS in an unfiltered sample from well 299-E25-34 in July; the filtered result was much lower, and subsequent concentrations were well below the secondary DWS. Manganese exceeded the secondary DWS in a filtered sample from well 299-E25-34 in July. The result (88.5 µg/L) was atypical for this well and did not agree with the unfiltered manganese result (6.7 µg/L).

10.10.5 216-B-3 Pond

The inactive 216-B-3 Pond (also known as B Pond) was located east of the 200 East Area (Figure 10-29) in a natural topographic depression. The TSD unit includes the main pond and an adjoining portion of the 216-B-3-3 Ditch. During operations, the pond covered about 14.2 ha (35 ac) with a depth up to 6.1 m (20 ft). The total estimated discharge to the pond since 1945 exceeded 10 billion L (2.6 billion gal) (PNNL-15479, *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility*). The dangerous waste received came from three primary sources: (1) corrosive and dangerous waste resulting from regeneration of demineralizer columns at PUREX, (2) spills of dangerous or mixed waste from PUREX and other facilities, and (3) off-specification chemical makeups at PUREX. The last known reportable discharge of chemical waste (sodium nitrite) occurred in 1987. In 1994, B Pond was backfilled with coarse-grained material and then covered with fine-grained material.

DOE/RL-2008-59, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*, provides a detailed description of the geology and hydrogeology at B Pond. In summary, because of the dipping beds of the Ringold Formation in this area and the erosional contact with the overlying Hanford formation, groundwater beneath B Pond can occur in both confined and unconfined states, depending on the location. The uppermost aquifer is unconfined west, southwest, and northwest of the main pond where the Ringold-confining units 8 and 9B are absent. The aquifer is progressively more confined to the east and southeast of the main pond. Confinement of the Ringold unit 9 aquifers to the east is supported by the fact that hydrologic response to TEDF discharges has not been observed in the TEDF wells completed in Ringold unit 9A since the facility began operating in 1995 (DOE/RL-2008-59). Figure 10-29 presents the approximate boundary of the Ringold Formation mud above the water table near B Pond.

The B Pond groundwater monitoring plan (DOE/RL-2008-59) was revised twice in 2017. Rev. 1 was issued in April 2017 and proposed a new well near the upgradient facility boundary to replace well 699-45-42. Rev. 2 was issued on September 27, 2017, and incorporates changes to the well network proposed in Rev. 1 (added new well 699-44-43C and removed well 699-45-42). Additionally, due to a failure of the well casing, downgradient well 699-43-44 was removed from the network and will be replaced by a new well (scheduled for installation in 2018). The two new wells will be sampled quarterly for one year for required interim status parameters and for 40 CFR 265, Appendix III, “EPA Interim Drinking Water Standards,” parameters.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-29. 216-B-3 Pond (B Pond)

Groundwater flow directions beneath B Pond range from southwest to west within the confined Ringold Formation and from southwest to south within the unconfined Hanford formation. The monitoring network consists of one upgradient well and three downgradient wells based on a groundwater flow direction to the southwest (Table B-29 in Appendix B). The network wells are screened across the top 1.3 to 6.4 m (4.2 to 21.1 ft) of the aquifer. The average rate of water-level decline over the last 5 years for network wells ranged from 2 cm/yr (0.8 in./yr) for well 699-43-45 to 8 cm/yr (3 in./yr) for well 699-44-39B. The rate of decline varies across the network because of differences in hydrogeology. The network wells have adequate water in the screened interval for representative sampling over the next decade. The 2017 estimated flow rate in the Ringold Formation is 0.068 m/d (0.22 ft/d) to the southwest (Table B-30 in Appendix B).

In accordance with WAC 173-303-400 and 40 CFR 265.92, the B Pond network wells are monitored semiannually for RCRA indicator parameters (TOC, TOX, pH, and specific conductance). TOX, pH, and specific conductance did not exceed critical mean values in 2017 (Table B-31 in Appendix B). TOC was detected above the critical mean in well 699-43-44 in January, March, and July 2017, but these exceedances did not trigger assessment because the data are not considered representative of groundwater due to casing structural failure observed during downhole videography of the well. All other individual TOC results for the network during 2017 were below the critical mean value.

Groundwater quality constituents monitored for the site include chloride, iron, manganese, phenols, sodium, and sulfate (Table B-32 in Appendix B). Iron and manganese concentrations exceeded secondary DWSs in well 699-44-43C at its initial sampling in October. The iron concentration also exceeded the secondary DWS in well 699-45-42 in the July sampling event. This well was replaced by 699-44-43C in Rev. 2 of the monitoring plan (DOE/RL-2008-59).

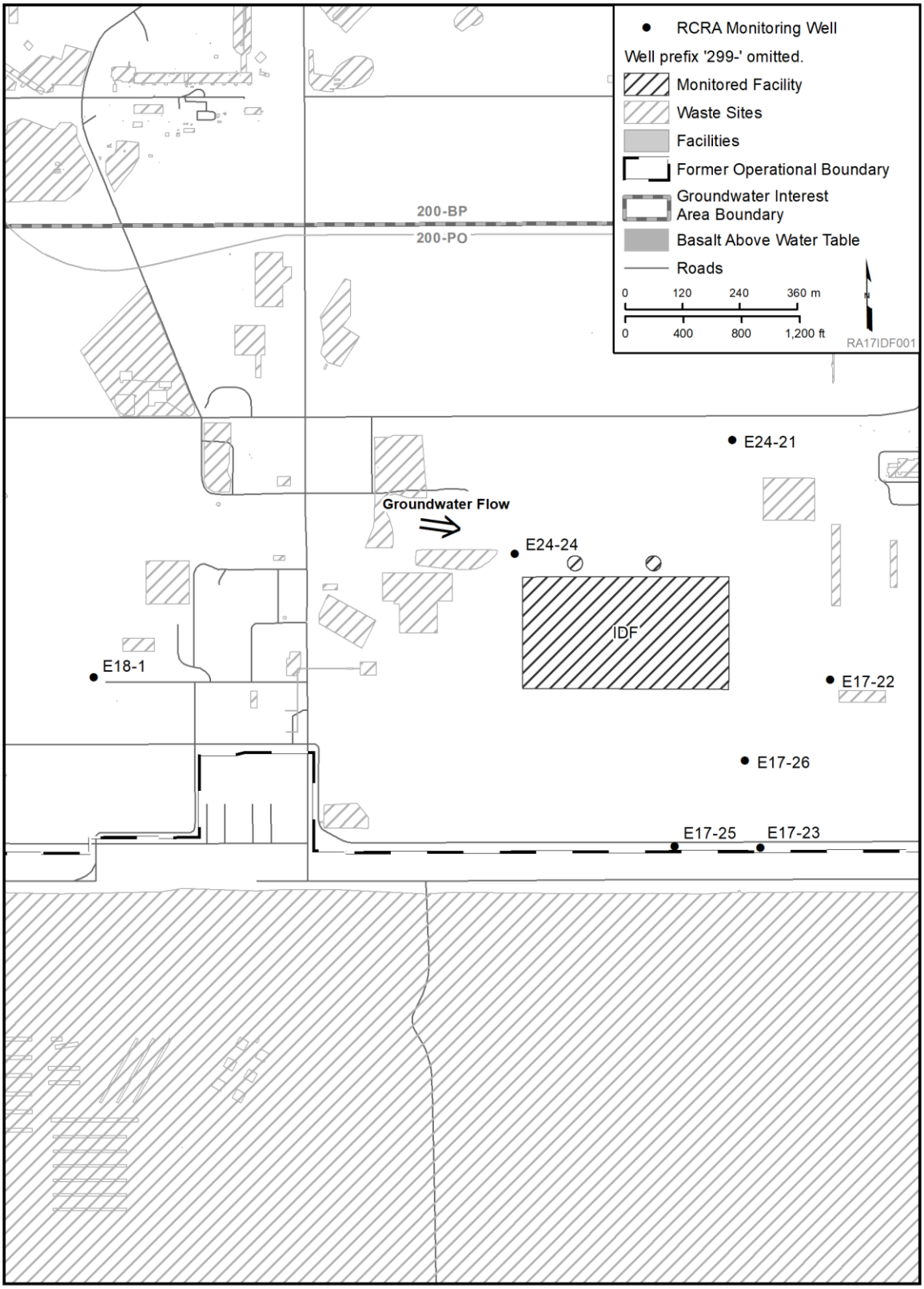
10.10.6 Integrated Disposal Facility

The IDF is an expandable, double-lined landfill with 0.07 km^2 (0.027 mi^2) of liner. It includes two distinct cells: an east cell for low-level radioactive waste, and a west cell for mixed waste. The IDF is not yet in use.

Construction of the first phase for IDF was completed in April 2006. DOE submitted a Part B RCRA Permit application to Ecology, which was incorporated into the Hanford RCRA Permit on April 9, 2006. The start date for IDF operations has not been determined, but it is monitored as part of a detection monitoring program described in Section III.11.E.1.b of 10-EMD-0080, Enclosure 1, “Class 1 Modifications to the Hanford Facility Resource Conservation and Recovery Act Permit, Quarter Ending June 30, 2010.”

The monitoring network for the IDF consists of two upgradient wells, one cross-gradient well, and four downgradient wells (Figure 10-30; Table B-45 in Appendix B). Since the IDF is not operational, the current monitoring objective is to collect baseline groundwater information. All network wells were sampled as scheduled during 2017.

Groundwater modeling was conducted in 2000 (PNNL-13400, *Groundwater Flow and Transport Calculations Supporting the Immobilized Low-Activity Waste Disposal Facility Performance Assessment*) to support an assessment of flow and transport conditions during future IDF use and to assist in positioning wells for the monitoring network. The early modeling results indicated a southeast flow direction. Beginning in 2008, data collection efforts were started to improve the accuracy of water-level measurements so flow direction beneath the PUREX Cribs and IDF could be evaluated in greater detail (Section 3.2 of DOE/RL-2011-01).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-30. Integrated Disposal Facility

The groundwater flow direction in 2017 was east, with an estimated flow rate of up to 1.1 m/d (3.7 ft/d) (Table B-46 in Appendix B). In recent years, the flow direction has varied from east-northeast (2008 to 2011) to southeast (2013 to 2014). Hydraulic conductivity is markedly different between the two unconfined aquifer units beneath the site. The water table is at an elevation of 121.7 m (399 ft) in Hanford formation flood channel deposits, which have an estimated hydraulic conductivity of 17,000 m/d (56,000 ft/d). The top of Ringold unit E, which has an estimated hydraulic conductivity of 3.26 m/d (10.7 ft/d), is at an elevation of about 104.5 m (343 ft) where it is thickest in the eastern portion of the IDF site. Hanford formation saturated thickness ranges from 15 to 20 m (49 to 66 ft) from east to west. The maximum saturated thickness of Ringold unit E is about 2 m (7 ft) in the eastern portion of the IDF site. Because the Hanford formation comprises a majority of the total saturated thickness, its associated hydraulic conductivity is considered the primary driver for overall groundwater flow velocity. Based on current groundwater flow interpretations, the monitoring network is considered adequate.

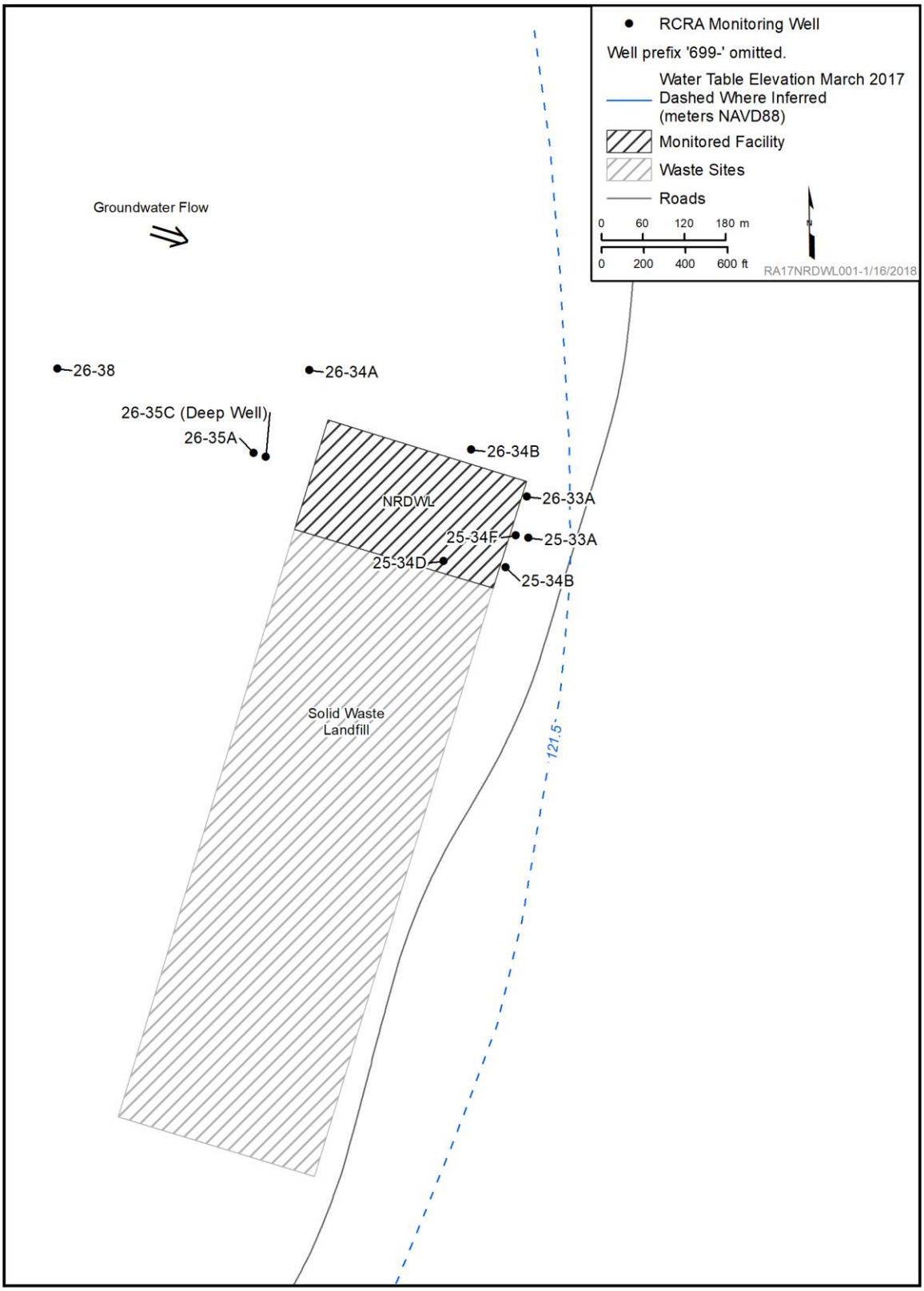
The wells are monitored annually for indicator parameters chromium (filtered), pH, specific conductance, TOC, and TOX (Table B-47 in Appendix B). In addition, monitoring includes the supplemental constituents alkalinity, anions, metals, and turbidity (Table B-48 in Appendix B). Upgradient/downgradient comparisons of indicator parameters are not required because the IDF is not in use. Unfiltered chromium, nickel, and iron were detected in well 299-E18-1 but concentrations were lower in 2017 than in 2016. Unfiltered iron exceeded the secondary DWS in well 299-E18-1 in the January sampling event. The well was scheduled for video logging, cleaning, and continued sampling in 2017, but these activities have not yet been performed. If indications of corrosion persist, the well will be evaluated for decommissioning and replacement. The Tri-Parties negotiate replacement wells annually in accordance with Tri-Party Agreement Milestone M-24-00.

Nitrate concentrations in 2017 were above 45 mg/L in five IDF wells, consistent with the 2016 monitoring results. Changes in the plume configuration and trends at individual wells indicate that nitrate is slowly migrating to the southeast, consistent with the flow direction calculated from trend surface analyses of water-level measurements. The maximum 2017 nitrate concentration was 66.4 mg/L in well 299-E17-22 (Table B-48 in Appendix B). Wells monitoring the IDF are within the regional 200 East Area nitrate plume (Figure B-3 in Appendix B).

10.10.7 Nonradioactive Dangerous Waste Landfill

The NRDWL is a TSD unit southeast of the 200 East Area located next to the SWL (Figure 10-31). This landfill has an area of 0.045 km^2 (0.017 mi^2) and consists of 19 parallel unlined trenches, each about 122 m (400 ft) long, 4.9 m (16 ft) wide at the base, and 4.6 m (15 ft) deep. The landfill received chemical, asbestos, and nonhazardous waste from 1975 to 1985.

NRDWL entered a groundwater quality assessment monitoring program in 2017. The site was previously monitored under a contamination indicator parameter program under DOE/RL-2015-32, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*. In October 2016, TOC exceeded its critical mean in wells 699-25-34B and 299-26-38, and specific conductance exceeded the critical mean in well 699-25-34B. Because iron-reducing bacterial growth can affect TOC and specific conductance, the wells were cleaned prior to confirmation sampling to reduce the potential for false-positive results. The wells were resampled, and TOC was at background concentrations in both wells. Results for specific conductance were above the critical mean and consistent with historical values. DOE notified Ecology of the exceedance on January 31, 2017 (17-AMRP-0089, "Notification of Exceedance of Critical Mean Values for Specific Conductance"). DOE/RL-2017-19, *Groundwater Quality Assessment Plan for the Nonradioactive Dangerous Waste Landfill, Hanford Site*, was issued in February 2017, and quarterly assessment sampling began in April 2017.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 10-31. Nonradioactive Dangerous Waste Landfill

Table B-69 in Appendix B lists the current monitoring well network. During the July 2017 sampling event, well 699-25-34D was not accessible due to extreme fire danger and was not sampled. Other wells were sampled as planned. Between 2012 and 2017, water levels declined an average of 1.9 cm/yr (0.7 in./yr).

Data compiled in 2017 and used for trend surface analysis indicate an east-southeast flow direction and a hydraulic gradient of 2.5×10^{-5} m/m (Table B-70 in Appendix B). This flow direction generally agrees with the southeast flow direction inferred from historical plume migration in this area and hydraulic head differences in the NRDWL/SWL area compared to the 200 East Area. The average groundwater flow rate was 0.014 m/d (0.045 ft/d). The NRDWL well network continues to be located appropriately to accomplish the monitoring objectives.

Table B-71 in Appendix B summarizes results of assessment monitoring for 2017. The monitoring network was sampled quarterly in 2017 to assess whether dangerous waste or dangerous waste constituents are present in the groundwater, their extent, and their rate of migration. The assessment has not been completed. Detailed evaluation and discussion of the groundwater quality assessment results will be presented in a first determination report (40 CFR 265.93(d)(4)).

10.11 Washington Administrative Code Monitoring – Solid Waste Landfill

The SWL is located south of and adjacent to the NRDWL (Figure 10-32). The landfill is regulated by Ecology in accordance with WAC 173-350, which requires monitoring of leachate, soil gas, and groundwater. Annual reporting for the SWL is additionally presented by MSA in DOE/RL-2015-21, Rev. 3, *Hanford Site Solid Waste Landfill Annual Monitoring Report October 2016 through September 2017*.

In 2017, sampling events were completed in January, April, August, and October under the monitoring plan, DOE/RL-2015-33, *Groundwater Monitoring Plan for the Solid Waste Landfill*. The monitoring plan is designed to meet the current governing regulation WAC 173-350. Compliance is determined by comparing results from downgradient monitoring wells with statistically derived background threshold values (BTVs) from upgradient wells.

Table 10-3 provides a summary of current network wells and the changes to the network that occurred in 2017 due to installation of replacement wells. Figure 10-32 shows the SWL groundwater monitoring wells and network wells that have been replaced during the last few years.

The results of the leachate, soil gas, and groundwater monitoring are reported annually in a separate report prepared by MSA (DOE/RL-2015-21). The following paragraphs provide a summary of groundwater monitoring results.

The results of groundwater sampling are evaluated to determine whether concentrations of any sampled constituents have increased significantly over established BTVs and/or the groundwater quality criteria or DWS. BTVs were calculated for applicable constituents under DOE/RL-2015-33 and are presented in ECF-200PO1-16-0144, *Calculation of Background Threshold Values (BTVs) for the Solid Waste Landfill (SWL) through CY 2016*. Samples collected in January and April 2017 have been evaluated against published BTVs calculated under PNNL-13014, *Groundwater Monitoring Plan for the Solid Waste Landfill*, and/or the groundwater quality criteria or DWS consistent with the January and April 2017 events since ECF-200PO1-16-0144 was issued in June 2017. The August and October 2017 events were evaluated against the calculated BTVs (ECF-200PO1-16-0144).

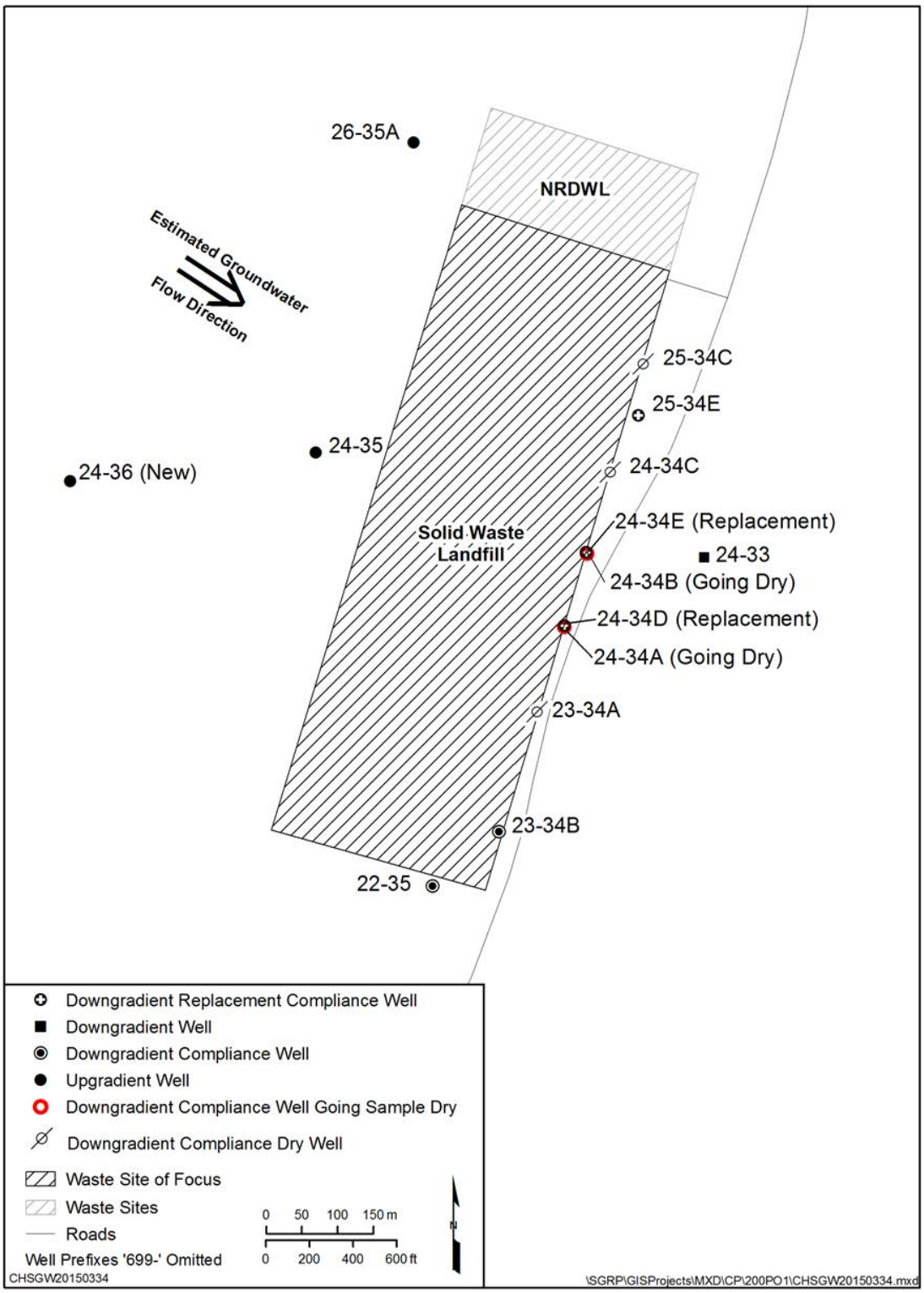


Figure 10-32. Solid Waste Landfill

Table 10-3. SWL Monitoring Well Network Changes

Well Number	Monitoring Status
Upgradient Groundwater Monitoring Wells	
699-24-35	Active
699-24-36[a]	Active
Downgradient Groundwater Monitoring Wells	
699-22-35	Active
699-23-34B	Active
699-23-34A	Inactive; sample dry[b]
699-24-34A	Inactive; sample dry[b] (removed under DOE/RL-2015-33)
699-24-34D[c]	Active; replaced 699-24-34A
699-24-34B	Inactive; going sample dry[b] (removed under DOE/RL-2015-33)
699-24-34E[c]	Active; replaced 699-24-34B
699-24-33 (deep well)	Active; nonstatistical use well
699-24-34C	Inactive; sample dry[b]
699-25-34C	Inactive; sample dry[b]
699-25-34E	Active; replaced 699-24-34C and 699-25-34C

Reference: DOE/RL-2015-33, *Groundwater Monitoring Plan for the Solid Waste Landfill*.

a. Well implemented in 2016.

b. Sample dry means insufficient water available in well to permit sample collection. Wells becoming sample dry have been replaced under the current groundwater monitoring plan DOE/RL-2015-33.

c. Installed in 2015.

Groundwater monitoring results for the analytes listed in the sampling plans are detailed in DOE/RL-2015-21. The BTV exceedances are summarized below.

Well 699-25-34E exceeded the chloride BTV of 7.82 mg/L in the April sampling event and the revised BTV of 6.3 mg/L in the October event. Wells 699-24-34E, 699-24-34D, 699-24-33, 699-24-34B, and 699-22-35 exceeded the chloride BTV of 6.3 mg/L in the October sampling event. Since the current sampling plan was implemented at the SWL in 2001, chloride has exceeded the BTV intermittently in all 10 of the network wells used prior to installing new and replacement wells in 2014 and 2015.

Coliform bacteria were detected above the BTV (one colony/100 mL) in downgradient wells 699-22-35, 699-24-34D, 699-24-33 and 699-24-34E. Well 699-24-34D had the maximum detected concentration in 2017 of 16 colonies/100 mL.

Dissolved manganese concentrations exceeded the BTV value of 10 µg/L well 699-24-34D in January 2017 (12.8 µg/L). This value was higher than normal and is presumed to be related to residual effects of well cleaning, as discussed in Section 10.13.2. 6 of DOE/RL-2016-67.

Nitrate concentrations were below the BTV of 29.0 mg/L for the January and April sampling events, but wells 699-22-35, 699-23-34B, 699-24-33, 699-24-34E, and 699-26-35A were all above the revised BTV of 14.6 mg/L in the October sampling event. The SWL is near the southwestern extent of

the historical elevated nitrate concentrations that once emanated from 200 East Area sources into the 200-PO far-field area. Concentrations of nitrate detected in the SWL have been consistent with the far-field interpretation of nitrate groundwater impacts.

In 2017, five of six downgradient wells (699-22-35, 699-23-34B, 699-24-33, 699-24-34D, and 699-25-34E) exceeded the specific conductance BTV of 583 µS/cm in the January and April sampling events. All six downgradient wells exceeded the revised BTV (576 mg/L) in the August and October sampling events. Three downgradient wells in 2017 had measurements above the 700 µS/cm limit of WAC 246-290-310, "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)." Specific conductance measurements in upgradient wells were below the BTV. Elevated specific conductance is principally caused by an increase of bicarbonate concentration in the groundwater at the SWL (Section 3.4 of DOE/RL-94-143, *Corrective Action Plan for the Hanford Site Solid Waste Landfill*). Since sampling began under the current sampling plan in 2001, specific conductance has exceeded the BTV intermittently in eight of the nine historical and current downgradient network wells and two upgradient wells (699-24-35 and 699-26-35A).

10.12 Atomic Energy Act Monitoring

AEA monitoring in 200-PO includes area-wide sampling, 400 Area water supply wells, and the IDF. Additional AEA monitoring at the IDF is described in RPP-PLAN-26534, *Integrated Disposal Facility Operational Monitoring Plan to Meet DOE Order 435.1*.

AEA groundwater monitoring was conducted at 91 groundwater wells and aquifer tubes in the 200-PO groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 200-PO are tritium, iodine-129, nitrate, strontium-90, technetium-99, and uranium. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Sixteen wells were not sampled in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred because of maintenance issues, well access issues, dry wells, and scheduling constraints. Significant exceptions to the network monitoring plan include decommissioning of well 699-44-43. Four other wells are recommended for removal and replacement due to decommissioning and well access issues.

Radionuclide concentrations detected in groundwater samples from 132 wells[1] were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard at any locations in 200-PO. None of the DWSs for cumulative alpha emitters were exceeded, but one location did exceed the EPA net alpha activity standard. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 64 locations in this interest area (Table 10-4). One location exceeded the DWSs for cumulative uranium mass concentration of 30 µg/L, and one location exceeded the net alpha-emitter activity of 15 pCi/L. Two of the locations that exceeded for beta/photon emitters, aquifer tubes 86-M and C6353, are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater. CERCLA remedial action decisions provide longer-term protection of the public and environment.

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

Table 10-4. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-PO in 2017

Monitoring Location/Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
299-E16-2	4.68	4.68				
299-E17-1	73.88	73.88			15.3	15.3
299-E17-12	4.38	4.38				
299-E17-13	5.42	5.42				
299-E17-14	89.39	99.19				
299-E27-15	41.90	41.90				
299-E17-16	21.67	21.67				
299-E17-17	9.62	9.62				
299-E17-18	5.30	5.30				
299-E17-19	77.19	77.19				
299-E17-23	10.26	10.26				
299-E17-25	11.56	11.56				
299-E17-26	11.59	11.59				
299-E24-16	49.77	49.77				
299-E24-20	34.28	34.28				
299-E24-22	33.95	33.95				
299-E24-33	37.55	37.55				
299-E24-5	10.16	10.16				
299-E25-11	14.76	14.76				
299-E25-17	15.25	15.25				
299-E25-18	18.07	18.07				
299-E25-19	18.09	18.09				
299-E25-2	16.08	23.64				
299-E25-20	35.88	35.88				
299-E25-22	18.60	18.60				
299-E25-237	13.32	22.19				
299-E25-26	9.21	9.21				
299-E25-28	16.83	16.83				
299-E25-29P	15.28	15.28				

Table 10-4. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-PO in 2017

Monitoring Location/Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
299-E25-29Q	7.51	7.51				
299-E25-3	21.93	21.93				
299-E25-32P	12.76	16.48				
299-E25-34	16.80	16.80				
299-E25-35	22.88	22.88				
299-E25-36	18.26	18.26	63.00	63.00		
299-E25-37	11.12	11.12				
299-E25-39	5.33	13.60				
299-E25-40	25.66	25.66				
299-E25-41	18.26	34.96				
299-E25-42	19.24	19.24				
299-E25-43	19.61	40.08				
299-E25-44	10.20	10.20				
299-E25-47	11.40	11.40				
299-E25-6	21.46	21.46				
299-E25-93	26.81	26.81				
299-E25-94	25.46	25.46				
299-E26-13	43.60	43.60				
299-E26-4	28.34	28.34				
499-S0-7	4.72	4.72				
699-2-3	4.09	4.09				
699-26-38					16.6	16.6
699-32-22A	34.60	34.60				
699-37-47A	18.32	18.32				
699-37-E4	7.68	7.68				
699-40-1	6.24	6.24				
699-41-1A	8.38	8.38				
699-41-23	18.64	18.64				
699-41-42	12.58	12.58				
699-42-42B	8.92	8.92				

Table 10-4. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-PO in 2017

Monitoring Location/Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L		Net Alpha-Emitter Activity ≥15 pCi/L	
	Min.	Max.	Min.	Max.	Min.	Max.
699-43-3	9.27	9.27				
699-43-45	37.33	37.33				
699-46-21B	4.96	4.96				
699-46-4	4.48	4.48				
86-M	4.89	4.89				
C6353	5.05	5.05				

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Notes: None of the wells in 200-PO had total effective dose ≥100 mrem/yr or cumulative alpha activity ≥15 pCi/L.

Blank cells indicate no exceedances.

10.12.1 400 Area

The 400 Area is located 16.2 km (10.1 mi) southeast of the 200 East Area. The 400 Area includes the Fast Flux Test Facility, ancillary facilities, and waste sites. Monitoring is conducted to provide information on the potential impact of sitewide contamination (primarily tritium, nitrate, and iodine-129) on the water supply wells, which provide drinking water and emergency supply water for the 400 Area (Chapter 7 of DOE/RL-2017-24). Well 499-S1-8J is the main water supply well, but occasionally wells 499-S0-7 and 499-S0-8 are used to supply water. Three wells were not sampled in accordance with AEA SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred because of maintenance issues and scheduling constraints. One significant change recommended for the network is the removal of well 499-S1-7C, which was decommissioned in 2007.

Wells sampled in 2017 for AEA SAP constituents in the 400 Area did not exceed DWSs. In well 499-S0-8, tritium was reported at 10,900 pCi/L in March and 5,460 pCi/L in November. In 2017, tritium was analyzed in well 499-S1-8K for the first time since 2001, and the result was below the DWS for the first time (10,100 pCi/L, flagged as “Q”). All other radionuclides sampled in 2017 were either nondetect or below 50% of the DWSs.

10.12.2 Integrated Disposal Facility

Additional AEA monitoring for the IDF is described in RPP-PLAN-26534. The IDF is a permitted RCRA facility (Section 10.10.6) and has additional groundwater sampling requirements under the AEA, as described in RPP-PLAN-26534. The plan describes sampling of two upgradient wells (299-E18-1 and 299-E24-24) and five downgradient wells (299-E17-22, 299-E17-23, 299-E17-25, 299-E17-26, and 299-E24-21) semiannually for gross alpha, gross beta, iodine-129, and technetium-99. Based on the current southeast groundwater flow direction, the monitoring network configuration includes one upgradient well (299-E24-24), two cross-gradient wells (299-E18-1 and 299-E24-21), and four downgradient wells (299-E17-22, 299-E17-23, 299-E17-25, and 299-E17-26). One well (299-E17-21) was not sampled in accordance with AEA SAP requirements in 2017 (Table C-1 in Appendix C).

Wells sampled in 2017 under the AEA and IDF monitoring plans exceeded DWSs for nitrate, tritium, and gross beta at levels consistent with regional plumes. Nitrate and tritium levels generally remained stable for wells that exceeded DWSs in 2017. Gross beta concentrations exceeded DWSs at wells 299-E24-21 and 299-E24-18, which have been increasing since 2015. Iodine-129 exceeded 50% of DWSs at two wells; however, evaluation of the lower limit of the error band indicates that the wells would not exceed 50% of the DWSs.

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11 200-UP

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 (Figure 1-1). This chapter includes an overview of the interest area; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2017; and a summary of the 2017 groundwater monitoring results.

11.1 Overview

With the exception of Environmental Restoration Disposal Facility (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). There are currently no active liquid waste disposal sites within the 200-UP groundwater interest area. The only active solid waste disposal site is ERDF, which receives waste from remedial actions at the Hanford Site. The SSTs in 200-UP have been interim stabilized (i.e., most of the drainable liquid from each tank has been transferred to DSTs). Table 11-1 lists key facts about 200-UP.

DOE is remediating groundwater in 200-UP (Section 11.11) and monitors groundwater under RCRA (Section 11.12) and the AEA (Section 11.13). Figure 11-1 shows the sample locations for 2017. In 2017, nine new groundwater wells and six vadose borings were drilled in 200-UP (Table 11-2).

Groundwater COCs, as defined by the 200-UP-1 interim action ROD (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*), are technetium-99, uranium, tritium, iodine-129, nitrate, chromium (Cr(VI) and total), and carbon tetrachloride. The carbon tetrachloride in 200-UP groundwater originated from waste sites in 200-ZP (Chapter 12). Additionally, groundwater COPCs identified in the interim action ROD are chloroform, 1,4-dioxane, strontium-90, PCE, and TCE, which have been found in groundwater to a limited extent and are routinely sampled in selected wells. Section 1.5 provides plume mapping details, including descriptions of terms (e.g., Type 1 control point) used in the figure legends.

Within 200-UP, groundwater occurs as an unconfined aquifer and as confined aquifers beneath the Ringold Formation lower mud unit and between the basalt flows. Geologic data indicate the lower mud is continuous beneath 200-UP, except for a small area along the east side of 200 West Area, just north of well 299-W11-97 (Attachment D in ECF-HANFORD-13-0029). The unconfined aquifer, impacted by past waste disposal operations within the OU, occurs within Ringold unit E; the base is the fine-grained lower mud (see Figure 1-6 for a generalized stratigraphic column for the Central Plateau). Carbon tetrachloride is present in the confined aquifer beneath the lower mud in the northern portion of 200-UP.

Depth from land surface to the water table ranges from 64 to 106 m (210 to 348 ft), with the largest depths occurring in the northeastern portion of the groundwater interest area. The thickness of the unconfined aquifer varies from 70 m (230 ft) in the west to near zero north of the interest area boundary where the top of the Ringold lower mud has been extrapolated to occur above the water table. The water table elevation and groundwater gradients in the 200 West Area have historically been affected by large-volume wastewater discharges (Chapter 2 in SGW-60338, *Historical Changes in Water Table Elevation and Groundwater Flow Direction at Hanford: 1944 to 2014*) and are currently affected by groundwater P&T and hydraulic control remedial actions. Groundwater flow in the unconfined aquifer is toward the east within the southern 200 West Area and toward the east-northeast in the eastern and northern portion of 200-UP (Figure 11-2).

Table 11-1. 200-UP at a Glance

Reduction-Oxidation Plant operations: 1952 to 1967 (plutonium separation) **U Plant operations:** 1952 to 1957 (uranium recovery)			
Groundwater Monitoring			
Contaminant, Cleanup Level[a]	**Year**	**Maximum Concentration (Well)**	**Plume Area[b] (km^2)**
Carbon tetrachloride, 3.4 µg/L	2017	801 (299-W14-71)	See 200-ZP
	2016	412 (299-W14-71)	
Chromium (hexavalent), 48 µg/L	2017	180 (299-W23-19)	11.1[c]
	2016	460 (299-22-93)	5.8[c]
Chromium (total), 100 µg/L	2017	224 (299-W23-19)	2.3[c]
	2016	390 (299-W22-93)	0.4[c]
Nitrate, 45 mg/L	2017	221 (299-W19-36)	5.8
	2016	531 (299-W19-36)	6.2
Iodine-129, 1 pCi/L	2017	22.8 (299-W21-3)	3.4
	2016	20.2 (299-W21-3)	4.2
Technetium-99, 900 pCi/L	2017	13,700 (299-W19-45, 299-W23-19)	0.12
	2016	39,000 (299-W19-36)	0.15
Tritium, 20,000 pCi/L	2017	218,000 (699-36-66B)	3.9
	2016	250,000 (699-36-66B)	5.4
Uranium, 30 µg/L	2017	5,000 (299-W19-36)	0.14
	2016	2,400 (299-W19-36)	0.3
Remediation			
Interim action Record of Decision (EPA et al., 2012) approved in September 2012. **U Plant interim actions:** 1994 to present. **S-SX Tank Farms interim action:** 2012 to present. **Iodine-129 plume hydraulic control:** 2015 to present. **Southeast chromium plume:** future remedial action.			

a. From Table 14 in EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*.

b. Estimated area above the cleanup level.

c. Hexavalent and total chromium plume areas include the portion that extends into the 200-PO groundwater interest area (2.9 and 0.08 km^2 [1.10 and 0.03 mi^2], respectively). The plume area grew in 2017 because new wells helped define the extent of the southeast plume.

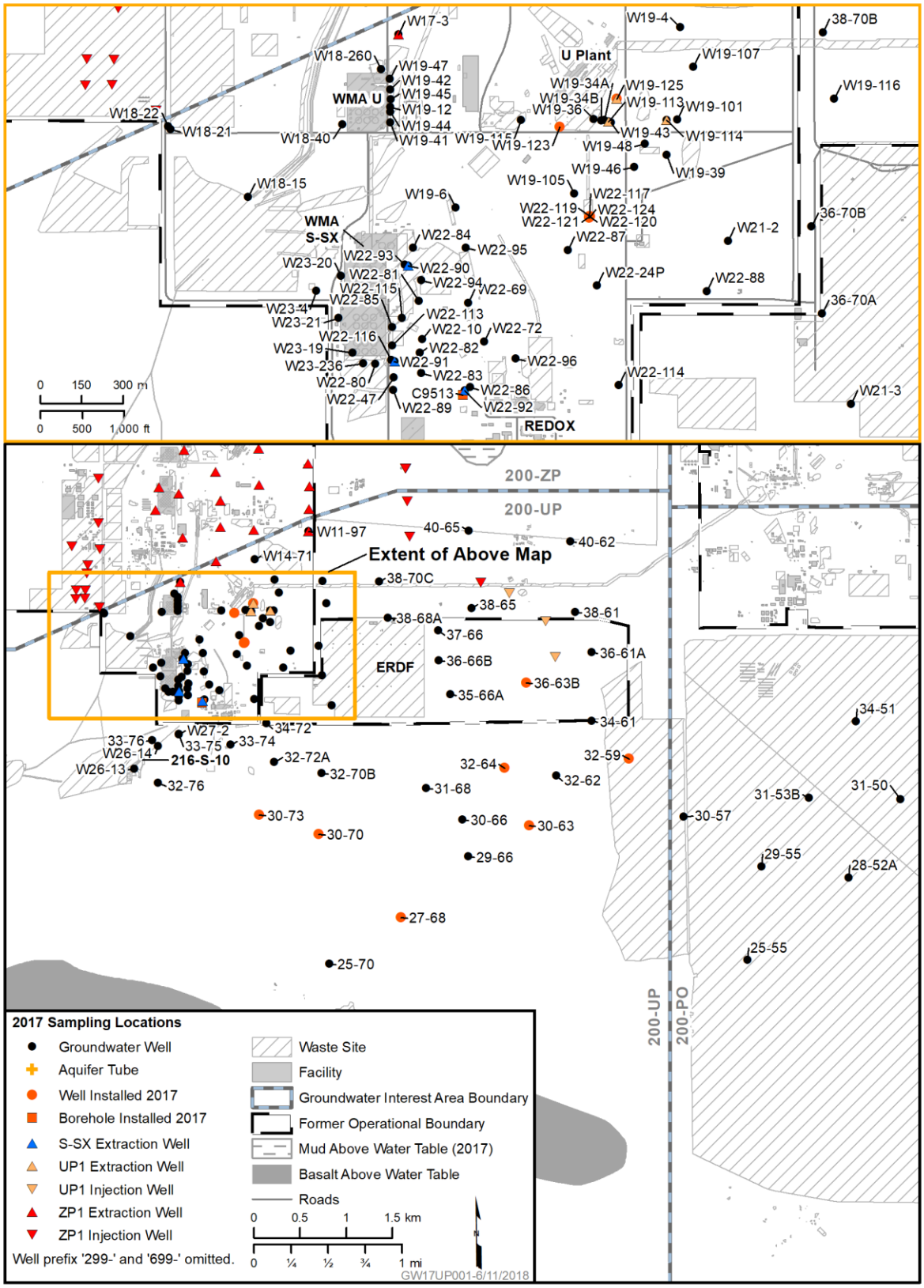


Figure 11-1. 200-UP Sampling Locations, 2017

Table 11-2. Wells and Boreholes Installed in 200-UP in 2017

Well Name	Well ID	Purpose	Construction Depth (m bgs)	Construction Depth (ft bgs)	Drilled Depth (m bgs)	Drilled Depth (ft bgs)	Acceptance or Decommission Date	Comment
299-W19-123	C9567	200-UP-1 dual-purpose monitoring-extraction[a]	136.9	449.0	139.3	457.0	11/21/2017	
299-W19-125	C9594	200-UP-1 dual-purpose monitoring-extraction[a]	133.2	437.0	133.3	437.3	7/11/2017	Extraction began in September 2017
299-W22-117	C9515	200-WA-1 vapor pilot test, instrumented monitoring[b]	24.5	80.4	26.6	87.3	7/3/2017	
299-W22-119	C9517	200-WA-1 vapor pilot test, instrumented monitoring[b]	24.3	79.8	24.8	81.5	7/3/2017	
299-W22-120	C9518	200-WA-1 vapor pilot test, instrumented monitoring[b]	25.1	82.5	25.1	82.5	7/3/2017	
299-W22-121	C9519	200-WA-1 vapor pilot test, instrumented injection[b]	24.7	81.2	24.8	81.5	7/3/2017	
299-W22-124	C9583	200-WA-1 vapor pilot test, instrumented monitoring[b]	24.5	80.4	24.5	80.5	7/3/2017	
699-27-68	C9632	200-UP-1 monitoring[a]	87.6	287.5	106.2	348.4	8/31/2017	
699-29-55	C9634	200-UP-1 monitoring[a]	116.7	383.0	138.1	453.0	9/28/2017	
699-30-63	C9602	200-UP-1 dual purpose monitoring-extraction[a]	122.6	402.2	124.3	407.7	3/30/2017	
699-30-70	C9635	200-UP-1 monitoring[a]	107.6	353.0	122.5	401.9	8/31/2017	

Table 11-2. Wells and Boreholes Installed in 200-UP in 2017

Well Name	Well ID	Purpose	Construction Depth (m bgs)	Construction Depth (ft bgs)	Drilled Depth (m bgs)	Drilled Depth (ft bgs)	Acceptance or Decommission Date	Comment
699-30-73	C9636	200-UP-1 monitoring[a]	81.6	267.8	122.6	402.3	12/14/2017	
699-31-50	C9737	200-UP-1 monitoring[a]	120.1	394.1	142.8	468.5	12/5/2017	
699-32-59	C9603	200-UP-1 dual-purpose monitoring-extraction[a]	126.1	413.9	127.0	416.7	3/23/2017	
699-32-64	C9601	200-UP-1 dual-purpose monitoring-extraction[a]	122.7	402.5	124.2	407.4	3/20/2017	
699-36-63B	C9593	200-UP-1 dual-purpose monitoring-extraction[a]	125.9	412.9	128.9	422.9	3/8/2017	
C9513	C9513	200-DV-1 characterization[c]	0.0	N/A	73.3	240.5	10/24/2017	Decommissioned

a. DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*.

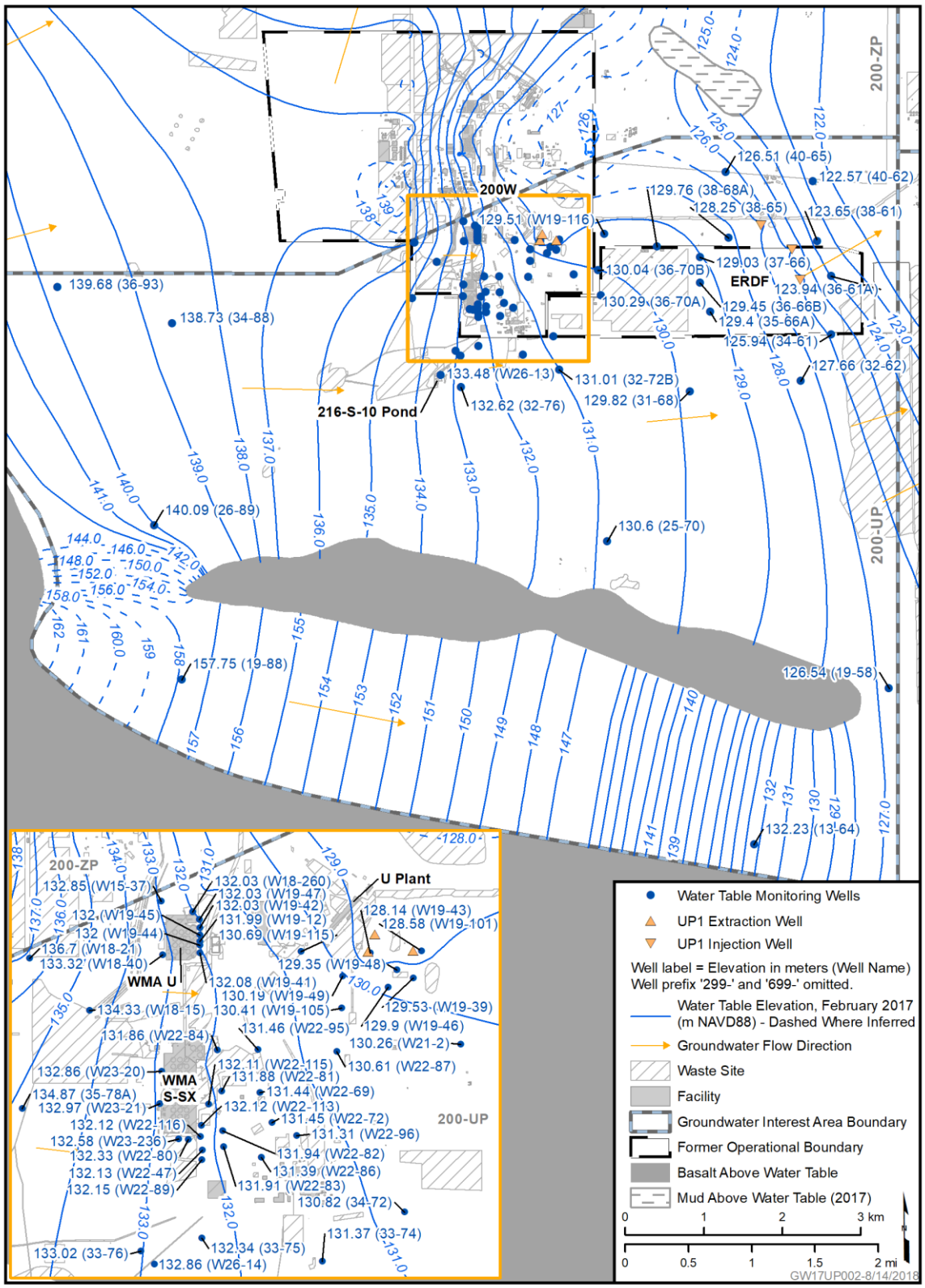
b. DOE/RL-2014-27, *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit.*

c. DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

bgs = below ground surface

ID = identification

N/A = not applicable



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 11-2. 200-UP Water Table Map, March 2017

Some of the contaminants in 200 West Area groundwater (particularly carbon tetrachloride and TCE) are unevenly distributed vertically; in some locations, the greatest concentrations occur near the bottom of the aquifer. The plume maps presented in this chapter are generally based on data from all wells, not only those screened in the upper part of the aquifer. If wells are paired (shallow/deep), the greater concentration is used for plume mapping. Figure 11-3 shows the areal extents of the plumes over time.

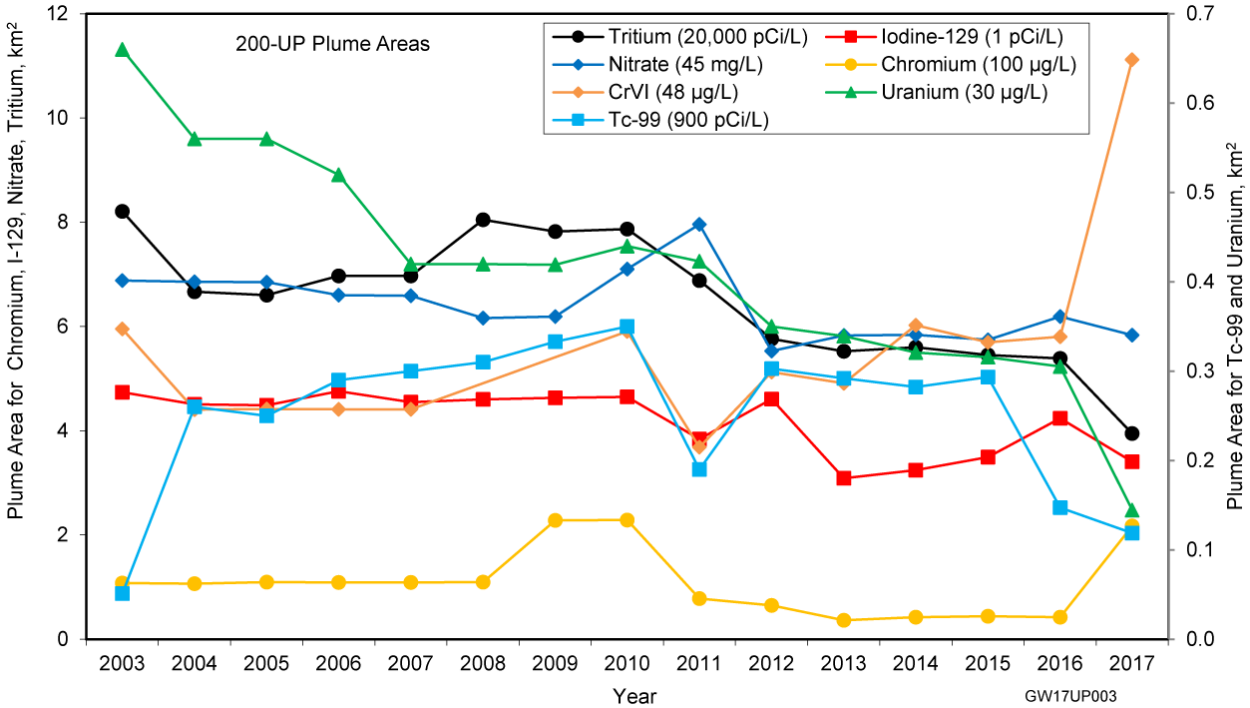


Figure 11-3. 200-UP Plume Areas

11.2 Technetium-99

Within 200-UP, technetium-99 concentrations exceed the 900 pCi/L cleanup level downgradient of WMA S-SX, the 216-U-1 and 216-U-2 Cribs (near U Plant), and WMA U (Figure 11-4).

11.2.1 Waste Management Area S-SX

Technetium-99 plumes occur downgradient of both the S and SX Tank Farms. The plume from the SX Tank Farm is attributed primarily to a 190,000 L (51,000 gal) leak from tank SX-115 during 1965 (Section 4.3 of RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*). The highest concentrations in this plume occur at well 299-W23-19, located next to tank SX-115 inside the SX Tank Farm fence line. During 2017, the highest concentration was 13,700 pCi/L in well 299-W23-19 (Figure 11-5). The 2017 concentration in well 299-W23-19 declined from an average of 14,970 pCi/L during 2016. The declining trend is attributed to a groundwater extraction system that began operating in July 2012. The nearest extraction well (299-W22-91) is located 155 m (509 ft) east-southeast of well 299-W23-19.

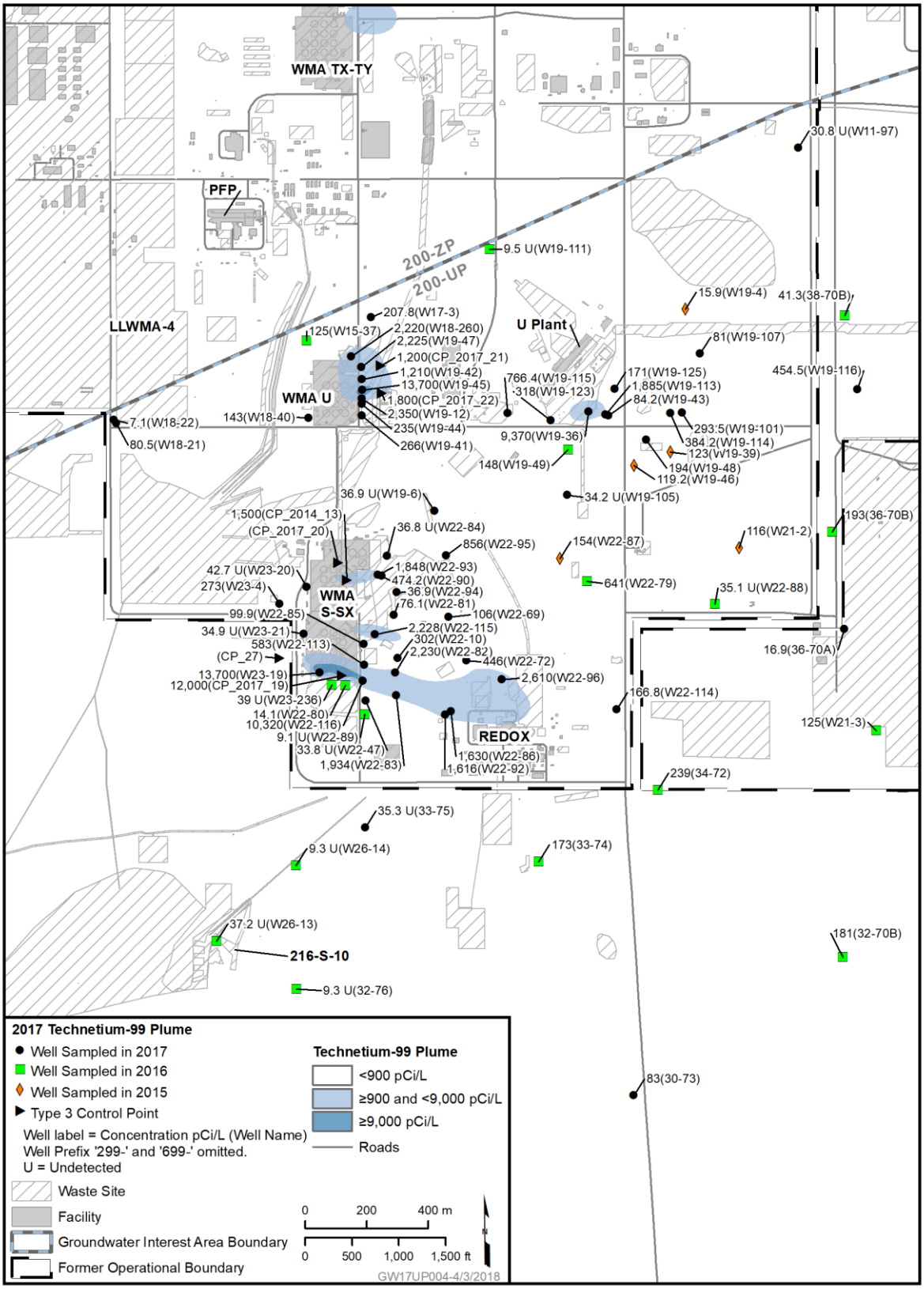


Figure 11-4. 200-UP Technetium-99 Plume, 2017

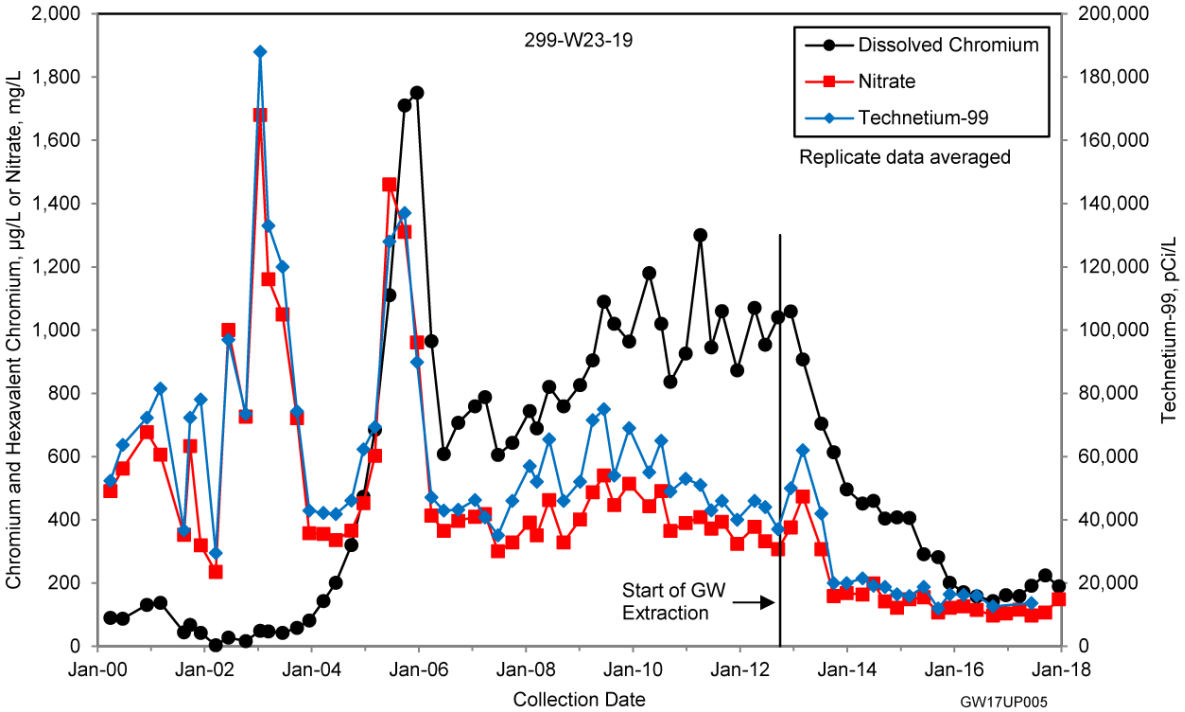


Figure 11-5. 200-UP Chromium, Nitrate, and Technetium-99 Data for Well 299-W23-19 at WMA S-SX

Technetium-99 concentrations in many wells downgradient of the SX Tank Farm are declining due to operation of the groundwater extraction system (Figure 11-6). Since startup in 2012, concentrations have declined to below the 900 pCi/L cleanup level in wells 299-W22-47 and 299-W22-113 (replacement well for 299-W22-49, which is dry). Concentrations are above the cleanup level in six other monitoring wells in the plume from the SX Tank Farm. Concentrations are declining in each of these six wells. Depth-discrete sample results indicate that this plume is in the upper 20 m (66 ft) of the aquifer at concentrations above the cleanup level (Section 4.2.1 of DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*).

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 that technetium-99 in the vadose zone has reached the groundwater (Sections 3.7.2 and 4.6 in RPP-RPT-48589, *Hanford 241-S Farm Leak Assessment Report*) and is the source of the plume downgradient from the S Tank Farm (Figure 11-4).

The plume was formerly defined by 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 historical 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 to replace well 299-W22-26. The well is located north of well 299-W22-26 because groundwater flow modeling indicates that the future flow direction will be to the northeast in response to operation of the 200 West P&T. The technetium-99 concentration in this well, while below the 900 pCi/L cleanup level, has been increasing since the well was drilled. The concentration during June 2017 was 886 pCi/L, slightly down from the 2016 result of 893 pCi/L (nearly above the cleanup level).

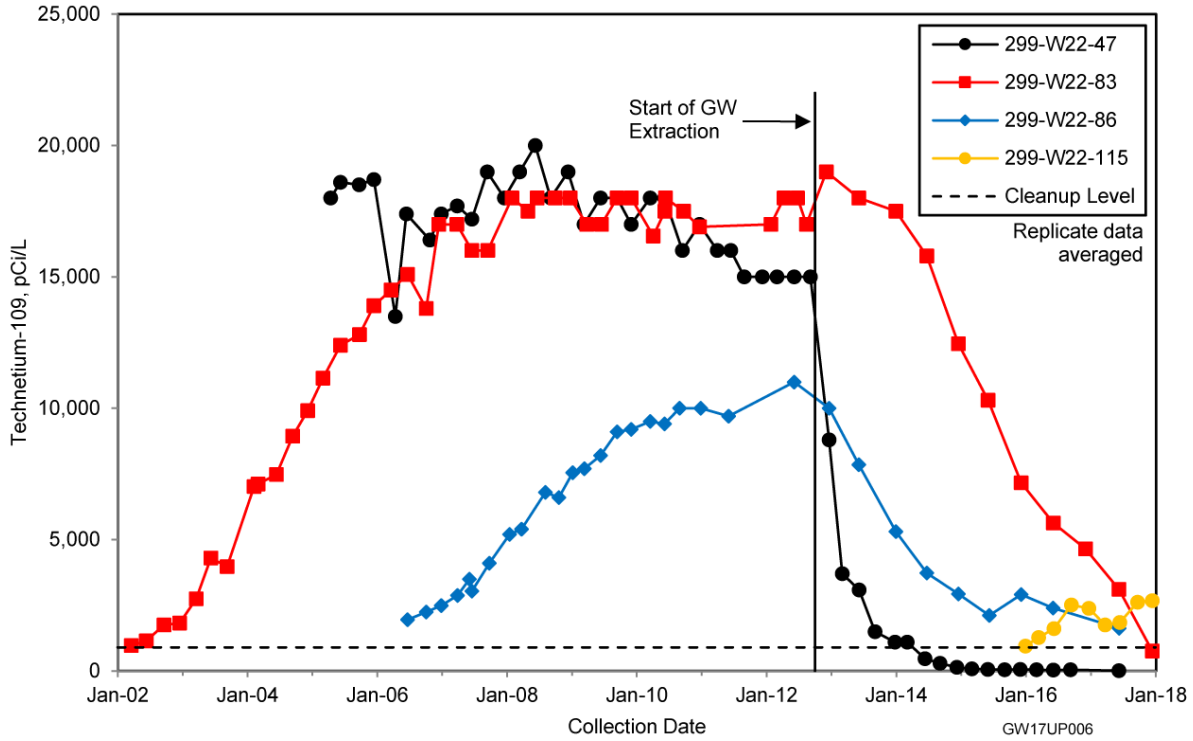


Figure 11-6. 200-UP Technetium-99 Data for Wells East of WMA S-SX

Well 299-W22-93 was drilled during 2015 to replace well 299-W22-44. The technetium-99 concentration in December 2015 was 1,850 pCi/L and increased only slightly to 2,020 pCi/L in 2017. The concentration in extraction well 299-W22-90 declined from a maximum concentration of 663 pCi/L in 2016 to 540 pCi/L in 2017. The lower concentrations in the extraction well are caused by concentration averaging as water is being pulled into this well from all directions, including from below the plume. Depth-discrete sample results during drilling of well 299-W22-90 indicated that the technetium-99 plume extends to a depth of 10 m (33 ft) below the water table (Section 3.3 of DOE/RL-2011-118).

The technetium-99 concentration in well 299-W22-115 (downgradient from the northern part of the SX Tank Farm) has increased to above the cleanup level (2,680 pCi/L in 2017 from a baseline of 520 pCi/L) (Figure 11-6), which suggests an emerging contamination issue from the tank farm.

11.2.2 216-U-1 and 216-U-2 Cribs

The technetium-99 plume near U Plant originated from the 216-U-1 and 216-U-2 Cribs, which were active in the 1950s and 1960s. A P&T system that operated in this plume from 1994 until March 2011 was effective in reducing technetium-99 concentrations in the aquifer to below 9,000 pCi/L (the cleanup level at that time). However, concentrations rebounded in former extraction well 299-W19-36 to 86,500 pCi/L in 2014; concentrations declined to 9,440 pCi/L in August 2017. Another groundwater extraction system for this area was constructed and began operating on September 26, 2015. It consists of extraction wells 299-W19-113, 299-W19-114, and 299-W19-125 (which began operating on September 20, 2017), and the water is treated at the 200 West P&T. The system is designed to remediate uranium, technetium-99, and the high-concentration portion of the nitrate plume in the U Plant area. The technetium-99 cleanup level is 900 pCi/L (EPA et al., 2012). Section 11.11.2 provides further discussion on the groundwater extraction system.

During 2017, technetium-99 concentrations exceeded the cleanup level in only monitoring well 299-W19-36 and extraction well 299-W19-113 (Figures 11-7 and 11-8). The concentration in monitoring well 299-W19-115 was 954 pCi/L in August 2017, decreasing to below the cleanup level at 642 pCi/L in October 2017. The highest concentration in this region was in well 299-W19-36 at 9,440 pCi/L (August 2017), a substantial reduction from the baseline of 51,400 pCi/L. Concentrations decreased to below the cleanup level at well 299-W19-34A to 168 pCi/L from 947 pCi/L in 2016. This well is screened from 13 to 18 m (43 to 58 ft) below the water table and is located 17 m (56 ft) from extraction well 299-W19-113. The decrease in well 299-W19-34A indicates that clean water is being drawn into the extraction well. It is certain that these results are affected by concentration averaging (i.e., dilution) as water is being drawn into the wells from all directions as well as from beneath the plume.

11.2.3 Waste Management Area U

WMA U is a source of technetium-99 groundwater contamination (PNNL-13282, *Groundwater Quality Assessment for Waste Management Area U: First Determination*). Concentrations in many downgradient wells are stable or slowly increasing, with the exception of well 299-W19-45, where concentrations have increased substantially since 2011 (Figure 11-9). During 2017, concentrations in this well increased to 13,700 pCi/L from the 2016 maximum of 8,730 pCi/L. During 2017, technetium-99 also exceeded the cleanup level in wells 299-W19-12, 299-W19-42, 299-W19-47, and 299-W18-260. Groundwater contamination at WMA U is believed to result from multiple sources in the WMA (HNF-EP-0182, *Waste Tank Summary Report for Month Ending December 31, 2012*). The contamination is within the 200 West P&T capture zone. Two additional wells are planned to be drilled in 2018 downgradient from the tank farm to delineate the technetium-99 plume.

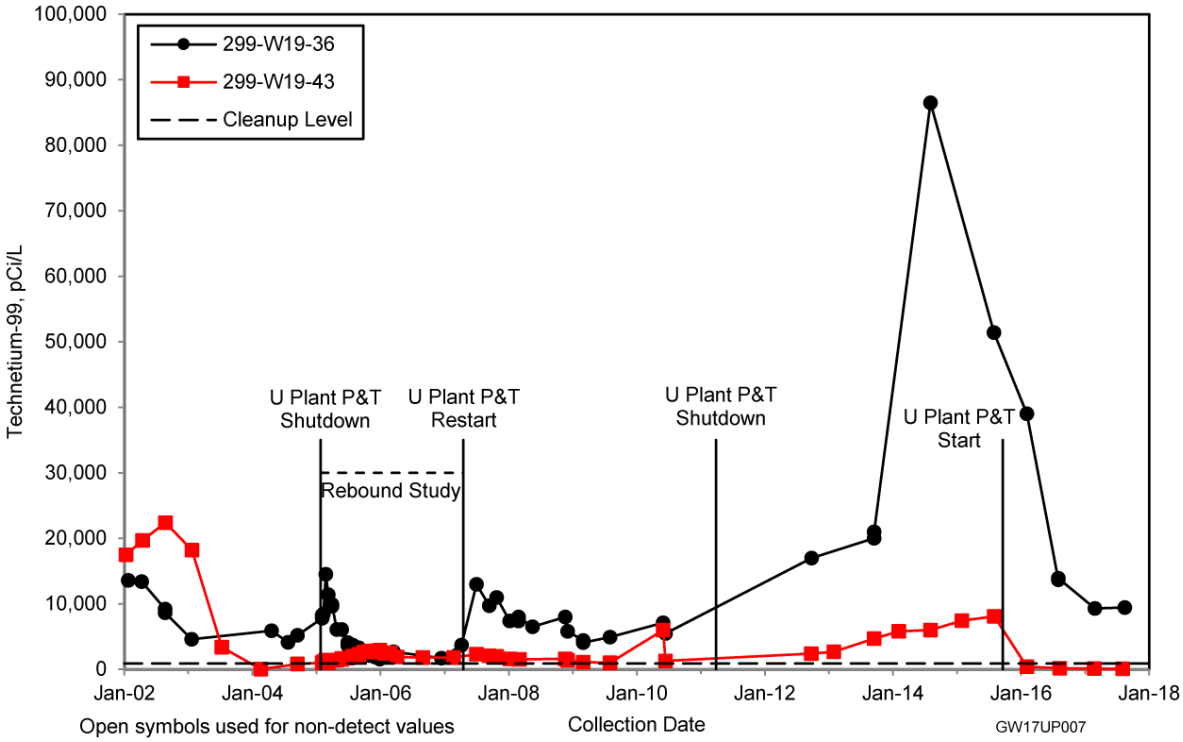


Figure 11-7. 200-UP Technetium-99 Data for Wells 299-W19-36 and 299-W19-43 near U Plant

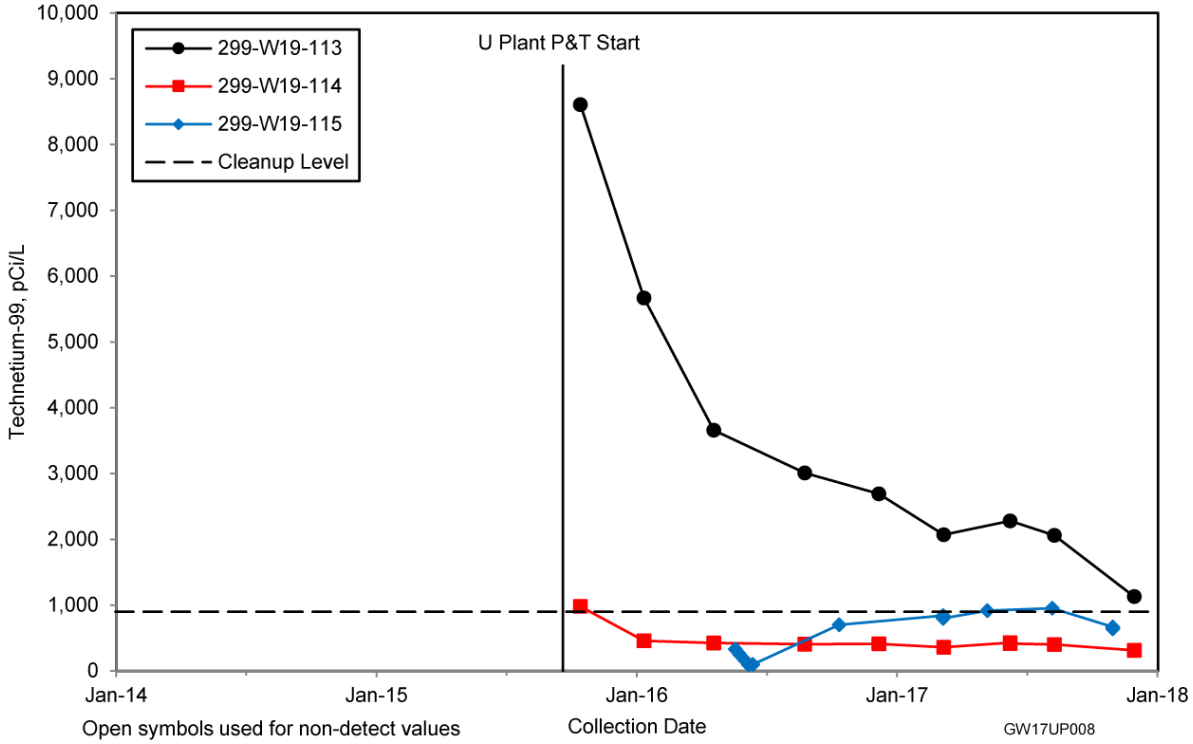


Figure 11-8. 200-UP Technetium-99 Data for Wells 299-W19-113, 299-W19-114, and 299-W19-115 near U Plant

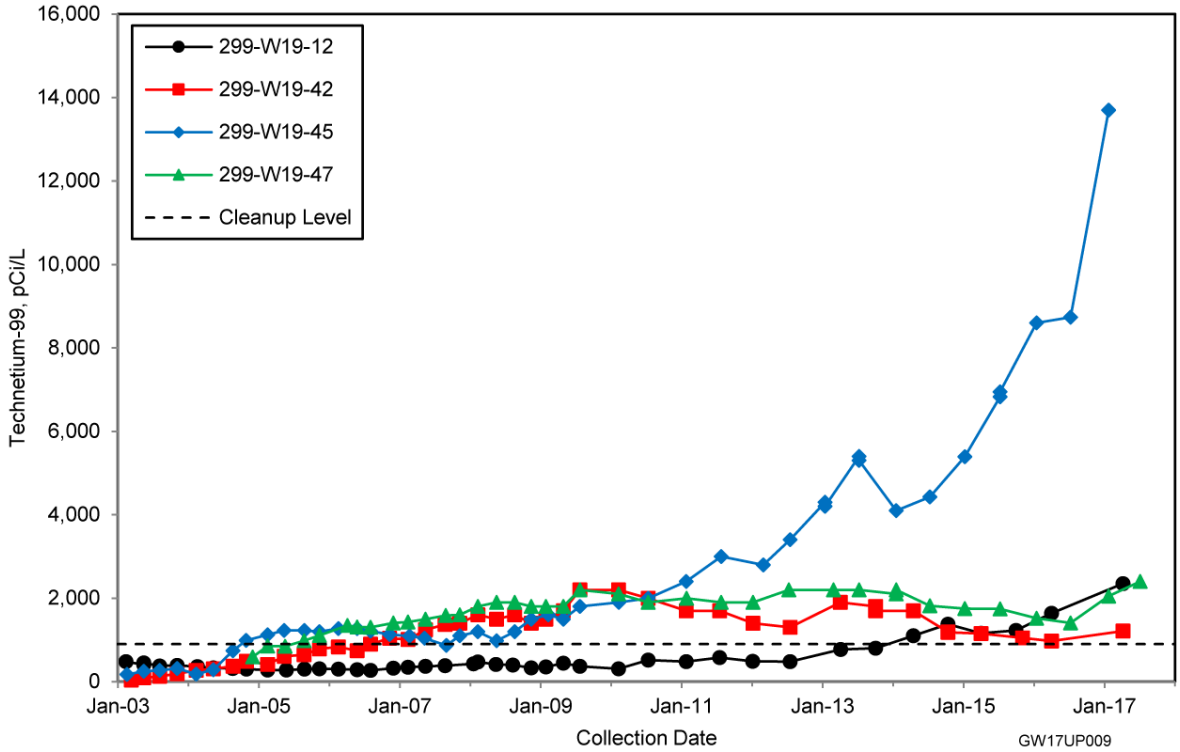


Figure 11-9. 200-UP Technetium-99 Data for Selected Wells at WMA U

11.3 Uranium

Uranium exceeds the 30 µg/L cleanup level in an area downgradient of the 216-U-1 and 216-U-2 Cribs, and near the 216-U-10 Pond (U Pond) (Figure 11-10).

Interpretations of the U Plant area uranium plume geometry differ between 2016 and 2017 (Figure 11-11). The eastern boundary of the plume at 30 µg/L extended farther east in the 2016 interpretation, and the difference is associated with observed concentrations at well 299-W19-116 (37 µg/L in 2016 and 8.3 µg/L in 2017). Well 299-W19-116 was drilled in 2016, and vertical profile groundwater samples were collected during drilling. The highest uranium concentration measured during drilling (37 µg/L) was at the uppermost sample depth at 3 m (9 ft) below the water table. The second highest uranium concentration, 8.1 µg/L, occurred at the next depth sampled at 12 m (39 ft) below the water table. The well was completed with a 10.7 m (35 ft) screen, the top of which was set 0.3 m (1 ft) above the water table. The baseline concentration from the completed well, collected at the end of development pumping, yielded a concentration of 10 µg/L.

The maximum vertical profile concentration result of 37 µg/L was used to prepare the 2016 plume map, whereas the average uranium concentration of 8.3 µg/L from four routine samples collected during 2017 (ranging from 7.6 to 8.8 µg/L) was used to prepare the 2017 plume map. This is consistent with established data selection conventions for preparing plume maps for Hanford Site annual groundwater reports (ECF-Hanford-18-0013). Concentration averaging explains why the sample results from the completed well are lower than the maximum concentrations during drilling. Samples from screened wells represent the flow-weighted, average concentration along the open well screen interval. When a plume is stratified within a screened interval, the flow-weighted average concentration will be lower than the peak concentration. Uncertainty exists regarding the eastern extent of the plume that will be clarified with continued monitoring and additional well installation.

Uncertainty exists regarding concentrations to the west of well 299-W19-116, between this well and 299-W19-101, and fate and transport modeling has shown that this uncertainty is important. If concentrations in this area are greater than approximately 50 µg/L, a more robust, active remedy would be needed (ECF-200UP1-17-0093, *Fate and Transport Analysis for U Plant Groundwater Plumes in the 200-UP-1 Operable Unit*). To resolve this uncertainty, additional wells are planned to be drilled west of well 299-W19-116.

11.3.1 216-U-1 and 216-U-2 Cribs Plume

The 216-U-1 and 216-U-2 Cribs were the source of a uranium plume extending to the east at levels above the 30 µg/L cleanup level (Figure 11-10). A P&T system operated in this plume from 1994 until March 2011 and was effective in reducing uranium concentrations below the 300 µg/L former cleanup level in the remediation target area; however, concentrations at most wells remained above the current 30 µg/L cleanup level.

A new groundwater extraction system for this area began operating during 2015. The system consists of extraction wells 299-W19-113, 299-W19-114, and 299-W19-125, and the water is treated at the 200 West P&T. The system is designed to remediate uranium, technetium-99, and the high-concentration portion of the nitrate plume in the U Plant area. Section 11.11.2 provides further discussion on the groundwater extraction system.

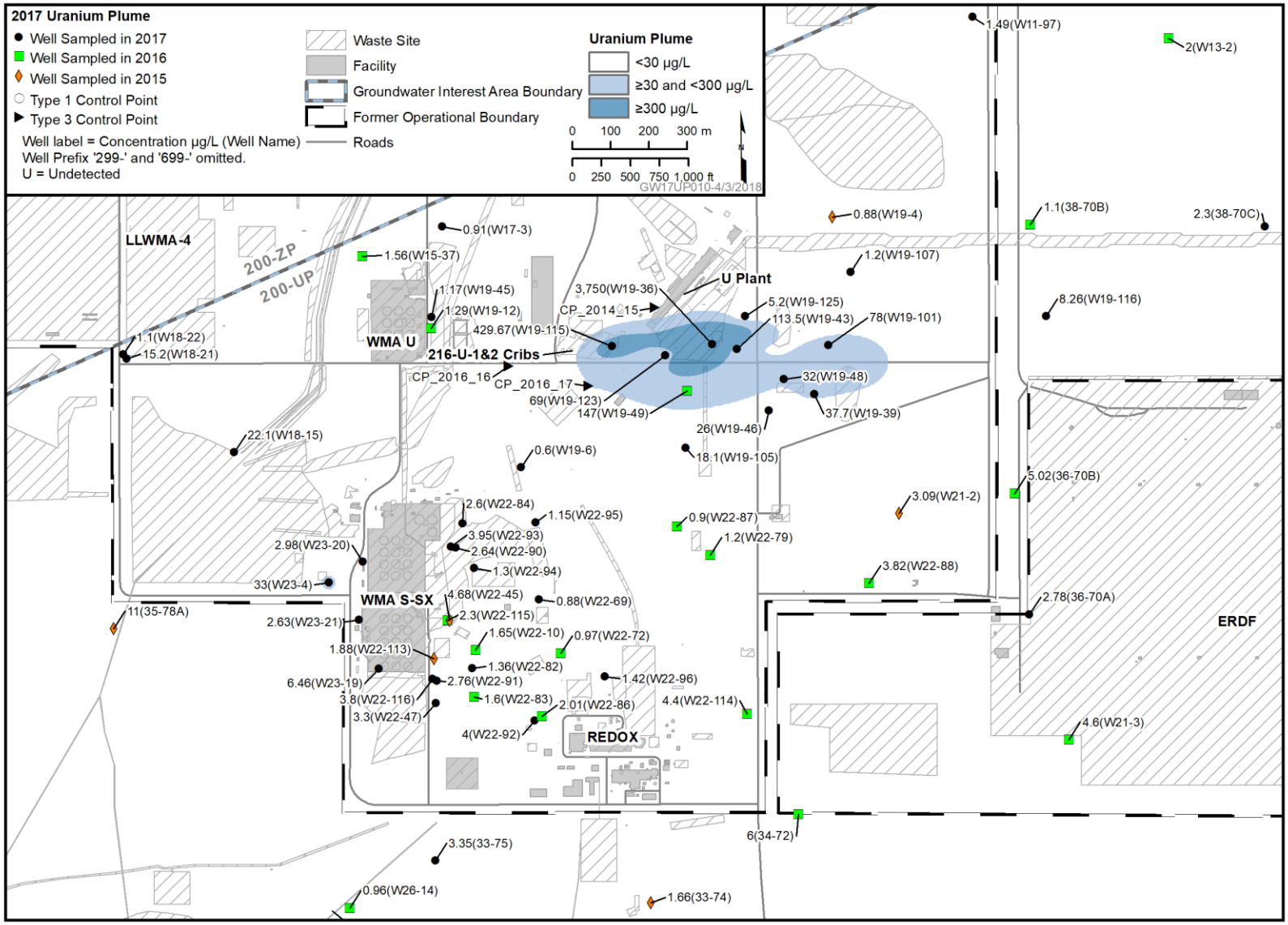


Figure 11-10. 200-UP Uranium Plume, 2017

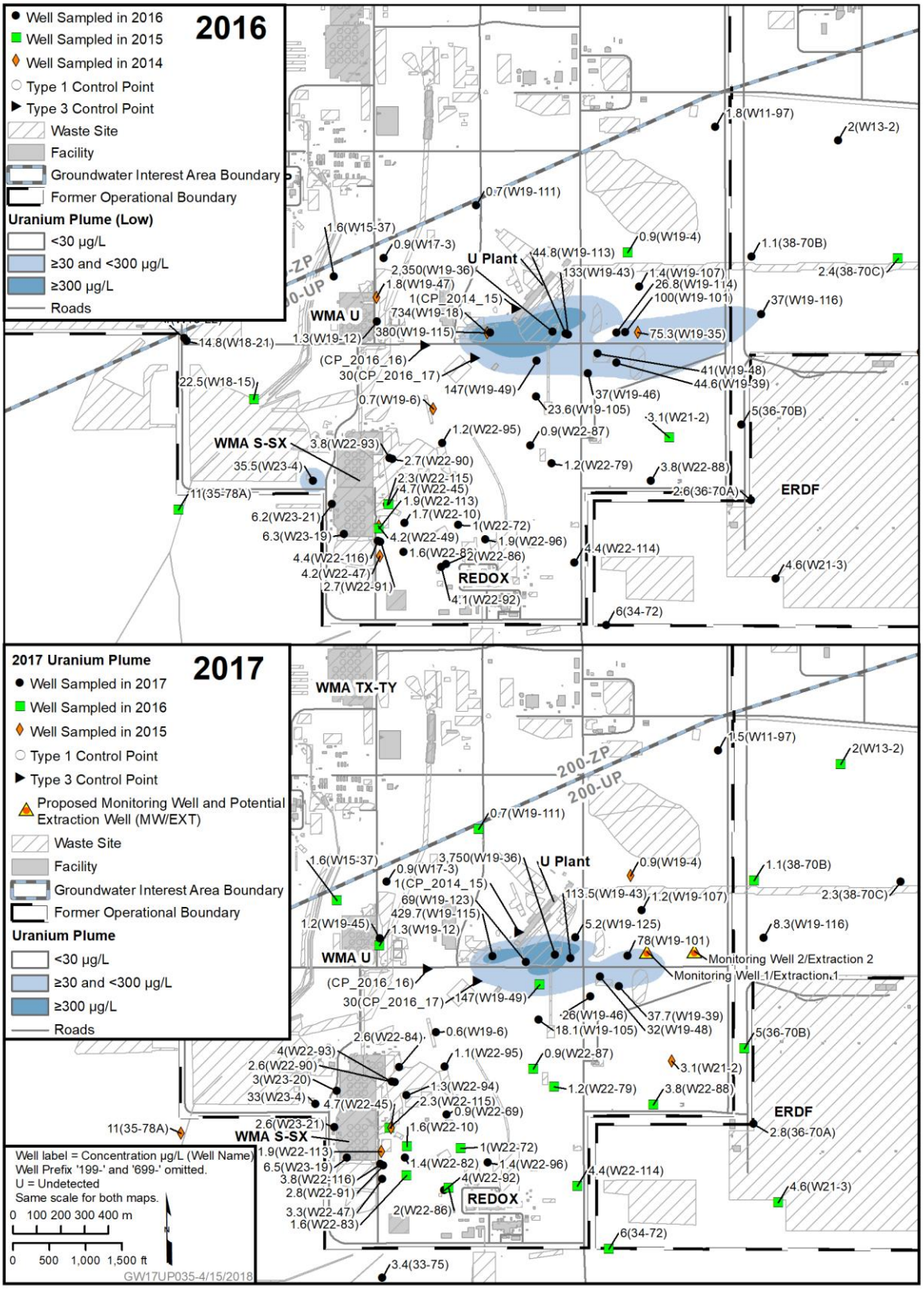


Figure 11-11. Comparison of 2016 and 2017 Uranium Plumes

Within this plume, two dual-use wells were drilled during 2017 (299-W19-123 and 299-W19-125). Well 299-W19-125 was added to the 200 West P&T operation, and well 299-W19-123 will currently be used as a monitoring well based on its lower-than-expected uranium concentrations observed during drilling. Tables 11-3 and 11-4 list the results of vertical profile sampling in the aquifer while drilling these wells. Uranium was not found to be above the 30 µg/L cleanup level at either well during drilling. However, concentrations increased in the post-development sample at well 299-W19-123 to 69 µg/L, compared to the maximum concentration during drilling (14 µg/L). The initially low uranium concentration may have been caused by reducing conditions induced by drilling. During well development, the reducing conditions dissipated, causing the uranium concentration to increase. The maximum uranium concentration observed during drilling of well 299-W19-125 was 5.2 µg/L, and the baseline sample result from the completed well was 1.55 µg/L. Results from other wells drilled in the area indicate that the uranium plume is limited to the upper 20 m (66 ft) of the aquifer throughout the remainder of the plume (Figure 11-13 of DOE/RL-2011-01).

The uranium concentration in well 299-W19-36 (near extraction well 299-W19-113) continued to increase during 2017 (Figure 11-12). The sample result for August 2017 was 5,000 µg/L, an increase from 2,400 µg/L in August 2016. Concentrations are much lower in other nearby wells. For instance, at well 299-W19-43, located 65 m (210 ft) east of well 299-W19-36, the concentrations were 133 and 119 µg/L during 2016 and 2017, respectively. This suggests that the region of high concentration is limited in areal extent, indicating that there may be a local source in this area.

Table 11-3. Depth Profile Sample Results for Well 299-W19-123 (February Through June 2017)

Depth Below Water Table (m)	Depth Below Water Table (ft)	Uranium (µg/L)	Nitrate (mg/L)	Technetium-99 (pCi/L)	Iodine-129 (pCi/L)	Carbon Tetrachloride (µg/L)	Trichloroethene (µg/L)
3.7	12.1	14	18.6 DZH	261	2.05	200 DA	0.3 UA
11.1	36.4	1.4	15.9 D	219	2.36	230 D	1.0
20.6	67.5	1.4	12.8 D	124	0.49 U	240 D	1.5
29.4	96.4	1.5	18.6 DZH	167	0.86 U	110 A	1.0 A
39.4	129.2	0.9	7.5 D	28.5 U	0.19 U	85 D	1.5 JD
49.5	162.5	0.77	6.6 D	38.3 U	0.04 U	65 D	2.4

Note: Screened interval depth from 1.6 to 12.2 m (5.1 to 40.1 ft) below the water table.

A = chain-of-custody issue
D = analyte was reported at a secondary dilution factor
H = laboratory holding time exceeded
U = not detected
Z = miscellaneous circumstances exist; additional information available

Table 11-4. Depth Profile Sample Results for Well 299-W19-125 (January Through March 2017)

Depth Below Water Table (m)	Depth Below Water Table (ft)	Uranium (µg/L)	Nitrate (mg/L)	Technetium-99 (pCi/L)	Iodine-129 (pCi/L)	Carbon Tetrachloride (µg/L)	Trichloroethene (µg/L)
4.2	13.9	2.7 G	88.5 D	203	0.41 U	390 D	12
9.1	29.7	5.2	97.4 DZH	291	0.50 U	260 D	15
18.4	60.3	1.1	43.4 D	172	0.18 U	69 D	4.9
27.3	89.5	1.0	15.9 DZH	65.9	0.11 U	97 D	3.6
36.4	119.3	0.86	12.4 DA	3.65 U	0.03 U	200 D	4.8

Note: Screened interval depth from 0 to 9.7 m (0 to 31.7 ft) below the water table.

D = analyte was reported at a secondary dilution factor

G = record has been reviewed and determined to be correct

H = laboratory holding time exceeded

U = not detected

Z = miscellaneous circumstances exist; additional information available

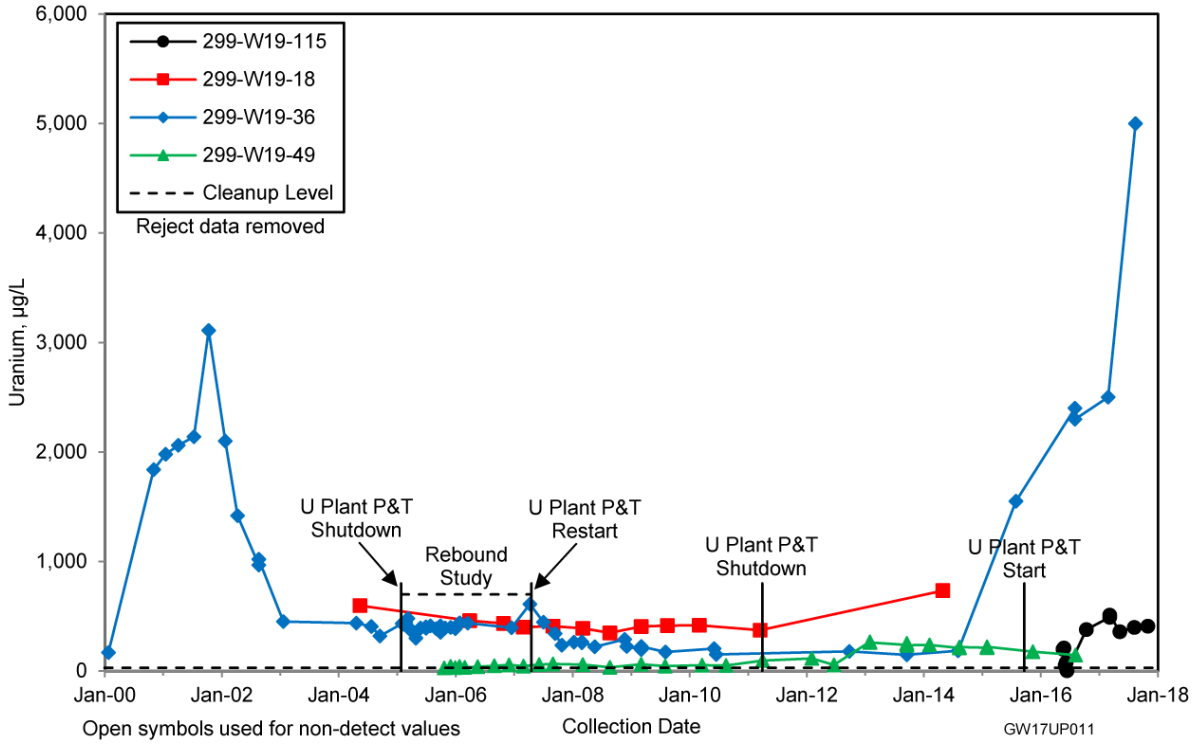


Figure 11-12. 200-UP Uranium Data for Wells 299-W19-18, 299-W19-115 (Replacement for 299-W19-18), 299-W19-49, and 299-W19-36 near U Plant

11.3.2 U Pond

Uranium exceeded the cleanup level in well 299-W23-4 (near U Pond and the 216-S-21 Crib) with a concentration of 33 µg/L in 2017. 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 kg of uranium (Section 4.2.2 of DOE/RL-2009-122; Appendix C, "SIM Production Output Files," in RPP-26744).

11.4 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 11-13). Smaller plumes are present near the 216-S-21 and 216-S-25 Cribs.

11.4.1 Eastern High-Concentration Area

The interpretation of the tritium plume east of the 200 West Area has improved in recent years because new monitoring wells were installed in 2016 and 2017. Several wells were drilled during 2017 to characterize the chromium plume southeast of the 200 West Area, and samples collected during drilling were analyzed for tritium. One of these wells (699-32-64) had tritium concentrations during drilling above the 20,000 pCi/L cleanup level in the upper portion of the aquifer (20,100 pCi/L) (Table 11-5); however, the maximum routine sample result in October 2017 was 10,100 pCi/L. Thus, the boundary of the plume is similar to that identified in the 2016 annual groundwater report (Figure 11-12 of DOE/RL-2016-67).

Tritium concentrations are declining in eight of nine wells within the 20,000 pCi/L cleanup-level contour, consistent with attenuation by dispersion and radiological decay. The highest tritium concentration measured in 200-UP during 2017 was 218,000 pCi/L in well 699-36-66B, a decline from 250,000 pCi/L in 2016.

11.4.2 216-S-25 Crib

Tritium exceeds the cleanup level in wells downgradient of the 216-S-25 Crib. The maximum tritium concentration in this area during 2017 was 84,400 pCi/L in well 299-W22-85 (east of the SX Tank Farm and 240 m [790 ft] downgradient from the crib) and is part of an increasing trend. 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 the 216-S-25 Crib for 6 months during 1985. The crib received an estimated 3,620 Ci of tritium (Appendix C in RPP-26744).

11.4.3 216-S-21 Crib

The tritium concentration in well 299-W23-4 near the 216-S-21 Crib (west of WMA S-SX and north of the 216-S-25 Crib) increased from 2003 to 2012 and remained above the cleanup level in 2017 (Figure 11-14). 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 was 110 million pCi/L in 1963 and 1964.

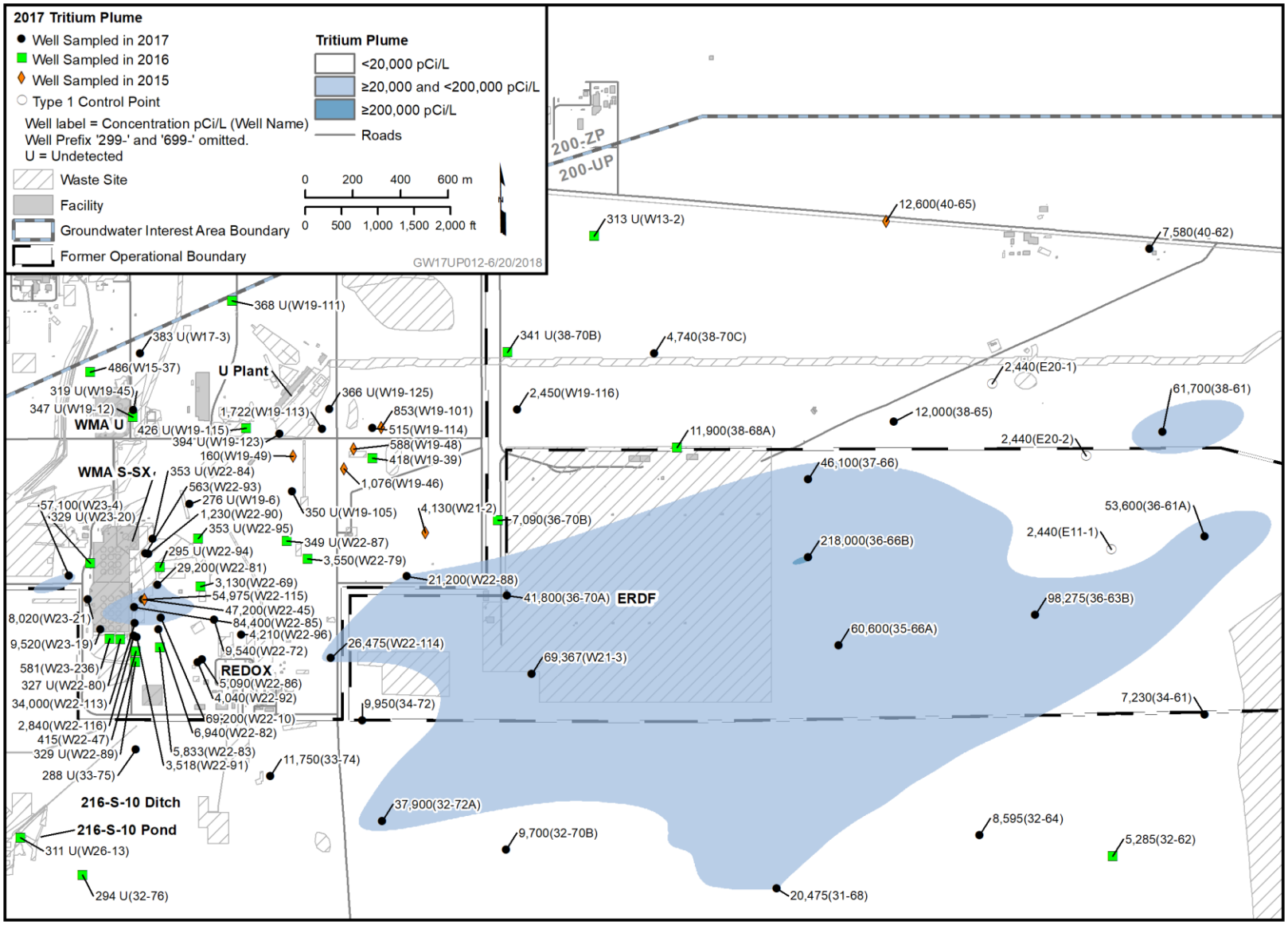


Figure 11-13. 200-UP Tritium Plume, 2017

Table 11-5. Depth Profile Sample Results for Well 699-32-64 (October and November 2016)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
10.3	33.9	29.5 D	31.7 D	20	14 Y	20,100
13.4	43.9	25.6 D	29.0 D	18	18	15,800 A
19.1	62.7	23.8 D	7.6 BD	2.3 B	5.2	4,790
25.6	83.9	12.5 D	4.0 UD	1.5 U	1.5 U	1,420
31.7	104.1	4.9 BD	4.0 UD	1.5 UA	1.5 UA	648

Notes: Screened interval depth from 0.25 to 35.25 m (1 to 115 ft) and 45.24 to 110.26 m (148 to 362 ft) below the water table.

Field analysis results excluded.

A = chain-of-custody issue

B = analyte was detected at a value less than the contract-required detection limit but greater than or equal to the method detection limit

D = analyte was reported at a secondary dilution factor

U = not detected

Y = suspect result

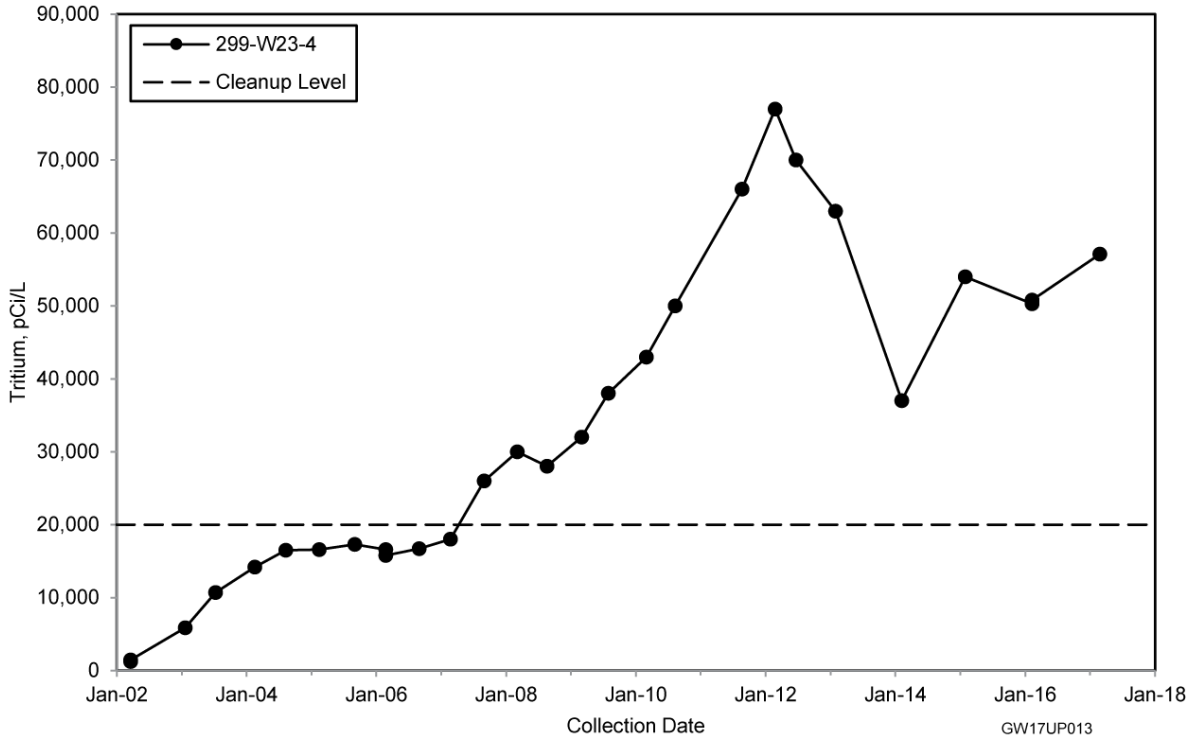


Figure 11-14. 200-UP Tritium Data for Well 299-W23-4 at the 216-S-21 Crib

11.5 Iodine-129

Iodine-129 plumes in 200-UP originated from U Plant and REDOX Plant waste sites, but the latter were the primary sources (Figure 11-15). Iodine-129 originated from the 216-U-1 and 216-U-2 Cribs near U Plant and from the REDOX Plant waste sites in the southern portion of the 200 West Area. East of the 200 West Area, these plumes merge and become indistinguishable. PNNL is currently completing an iodine-129 treatment technology remedy evaluation plan. This evaluation will identify the iodine-129 fate and transport processes and review groundwater remediation options.

11.5.1 Reduction-Oxidation Plant Waste Sites

The highest iodine-129 concentrations in 200-UP (greater than 10 times the 1 pCi/L cleanup level) originated from the REDOX Plant waste sites. This plume extends 2.5 km (1.6 mi) east into the 600 Area from the southeastern 200 West Area (Figure 11-15). Although short-term variability in sample results can cause substantial changes from year to year in some wells, long-term trends in this plume tend to be stable to slightly declining (Figure 11-16). The maximum concentration during 2017 was 22.8 pCi/L in well 299-W21-3. Based on depth-discrete results during drilling in 2016, concentrations above the 1 pCi/L cleanup level occur in the upper 20 m (70 ft) of the aquifer.

11.5.2 SX Tank Farm

Iodine-129 was previously found to occur beneath the SX Tank Farm at concentrations slightly above the 1 pCi/L cleanup level. The iodine-129 concentration was 2.0 pCi/L in a December 2011 sample from well 299-W23-19, located within the tank farm. Concentrations have declined since the July 2012 startup of groundwater extraction in the area. In June 2016, the iodine-129 concentration in well 299-W23-19 was 0.49 pCi/L (less than the cleanup level). Iodine-129 was not analyzed at this well in 2017. Iodine-129 was detected above the cleanup level at well 299-W22-26 (downgradient of the S Tank Farm) before the well became dry (2.8 pCi/L in 2011), but the source was the 216-S-9 Crib (Section 1.4.2.3 in DOE/RL-2009-122).

11.5.3 216-U-1 and 216-U-2 Cribs

The maximum iodine-129 concentration downgradient from the 216-U-1 and 216-U-2 Cribs during 2017 was 2.58 pCi/L. Two wells in this area had concentrations above the 1 pCi/L cleanup level during 2017: 299-W19-115 at 4.05 pCi/L, up from 1.56 pCi/L baseline in 2016; and new well 299-W19-123 at 2.58 pCi/L during post-development sampling. The plume from the 216-U-1 and 216-U-2 Cribs is typically at concentrations near 1 pCi/L, so this portion of the plume is interpreted as discontinuous at the 1 pCi/L level (Figure 11-15). The plume is interpreted to occur at a shallow depth near the source but deepens farther eastward. The plume is fully mixed vertically at well 699-38-70C, 1.8 km (1.1 mi) east of the cribs. This well is screened just above the lower mud unit and had a concentration of 0.66 pCi/L during 2017.

11.6 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) (Figure 11-17). The cleanup level for nitrate is 45 mg/L.

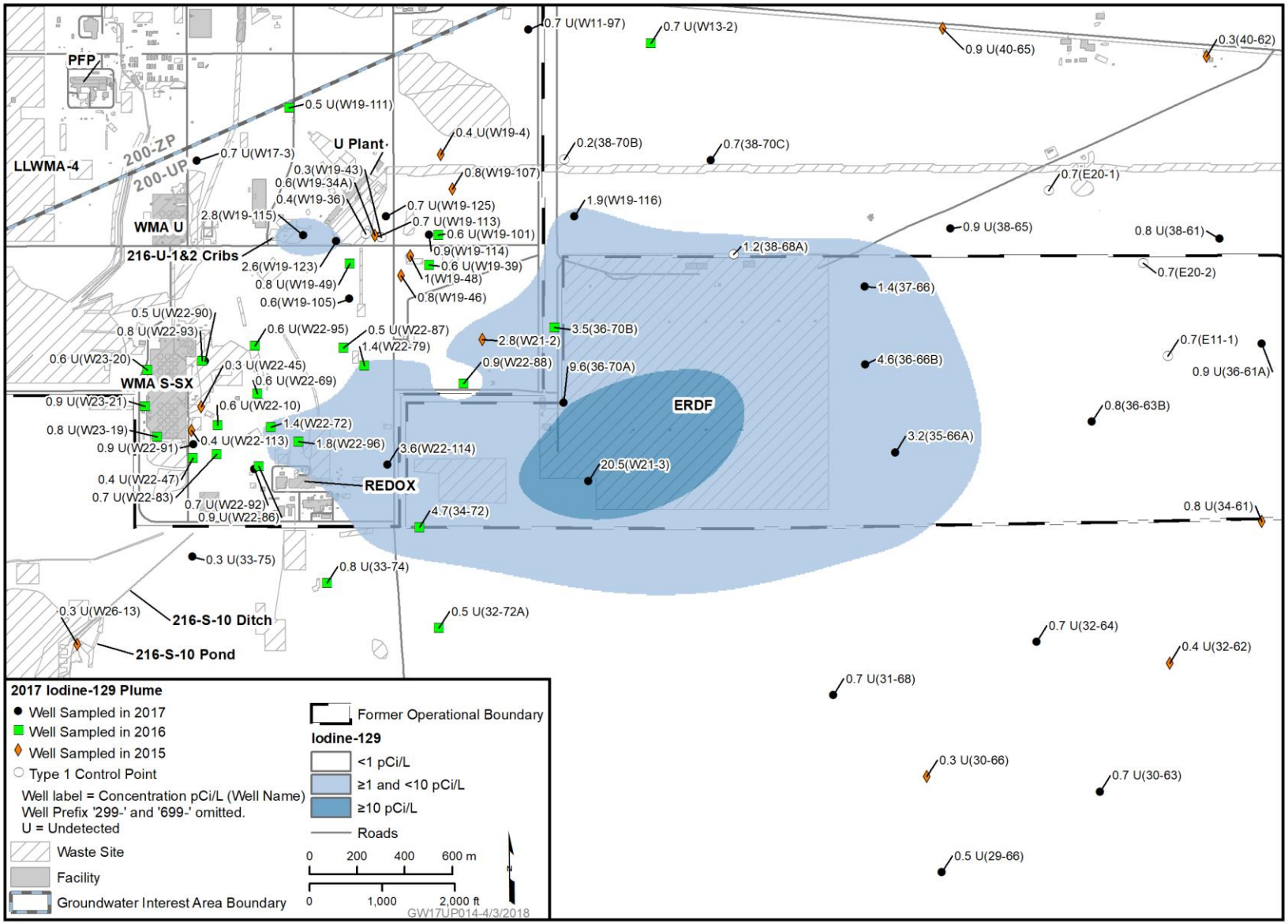


Figure 11-15. 200-UP Iodine-129 Plume, 2017

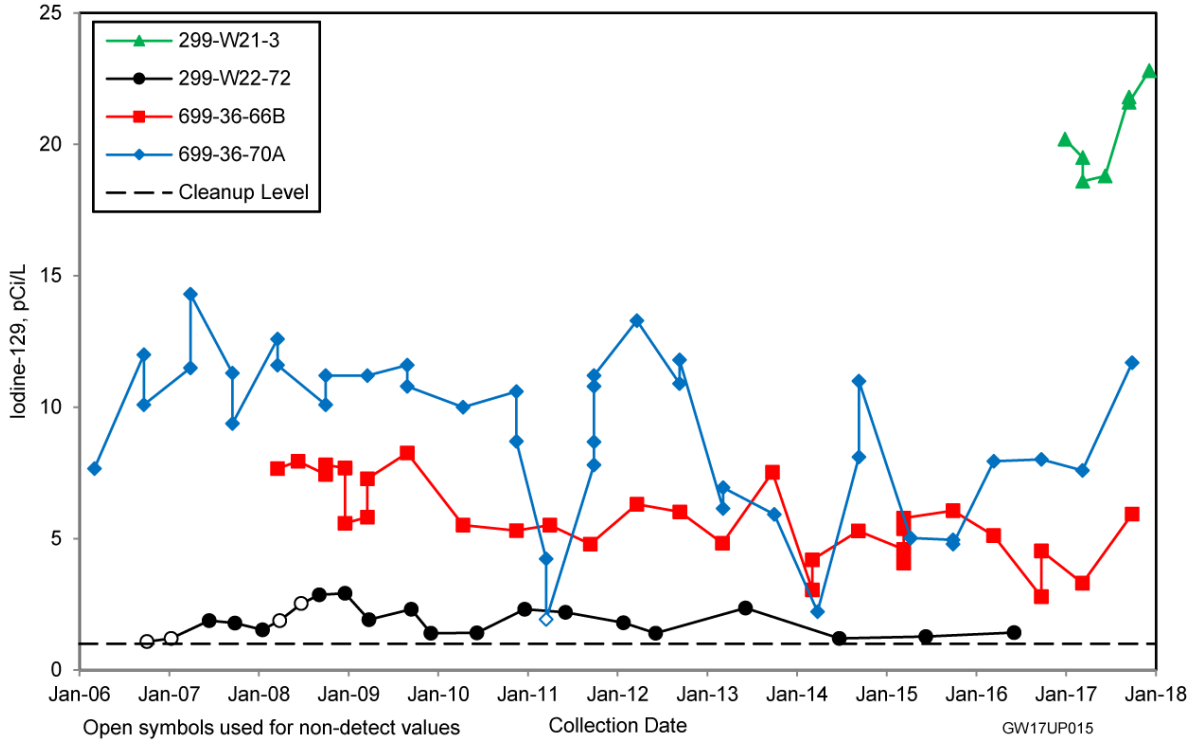


Figure 11-16. 200-UP Iodine-129 Data for Wells 299-W22-72, 699-36-66B, and 699-36-70A

11.6.1 U Plant Crib Sources

In the U Plant area, nitrate concentrations have been the highest in monitoring well 299-W19-36 and extraction well 299-W19-113. The 2017 maximum results were 221 mg/L at well 299-W19-36 and 133 mg/L at well 299-W19-113. Concentrations declined substantially in well 299-W19-36 since 2015 from 788 mg/L (Figure 11-18), which can be attributed to operation of extraction well 299-W19-113. Because past concentrations in well 299-W19-36 were higher than historical nitrate concentrations near the 216-U-1 and 216-U-2 Cribs (100 to 300 mg/L in the 1970s and 1980s), the nitrate at well 299-W19-36 may originate from a local source.

Depth profile groundwater samples were collected for nitrate during the drilling of wells 299-W19-123 and 299-W19-125. Nitrate was not found above the 45 mg/L cleanup level at well 299-W19-123 (Table 11-3), but the first two samples collected from well 299-W19-125 were above the cleanup level (Table 11-4). Thus, nitrate occurs above the cleanup level within the upper portion of the aquifer at well 299-W19-125.

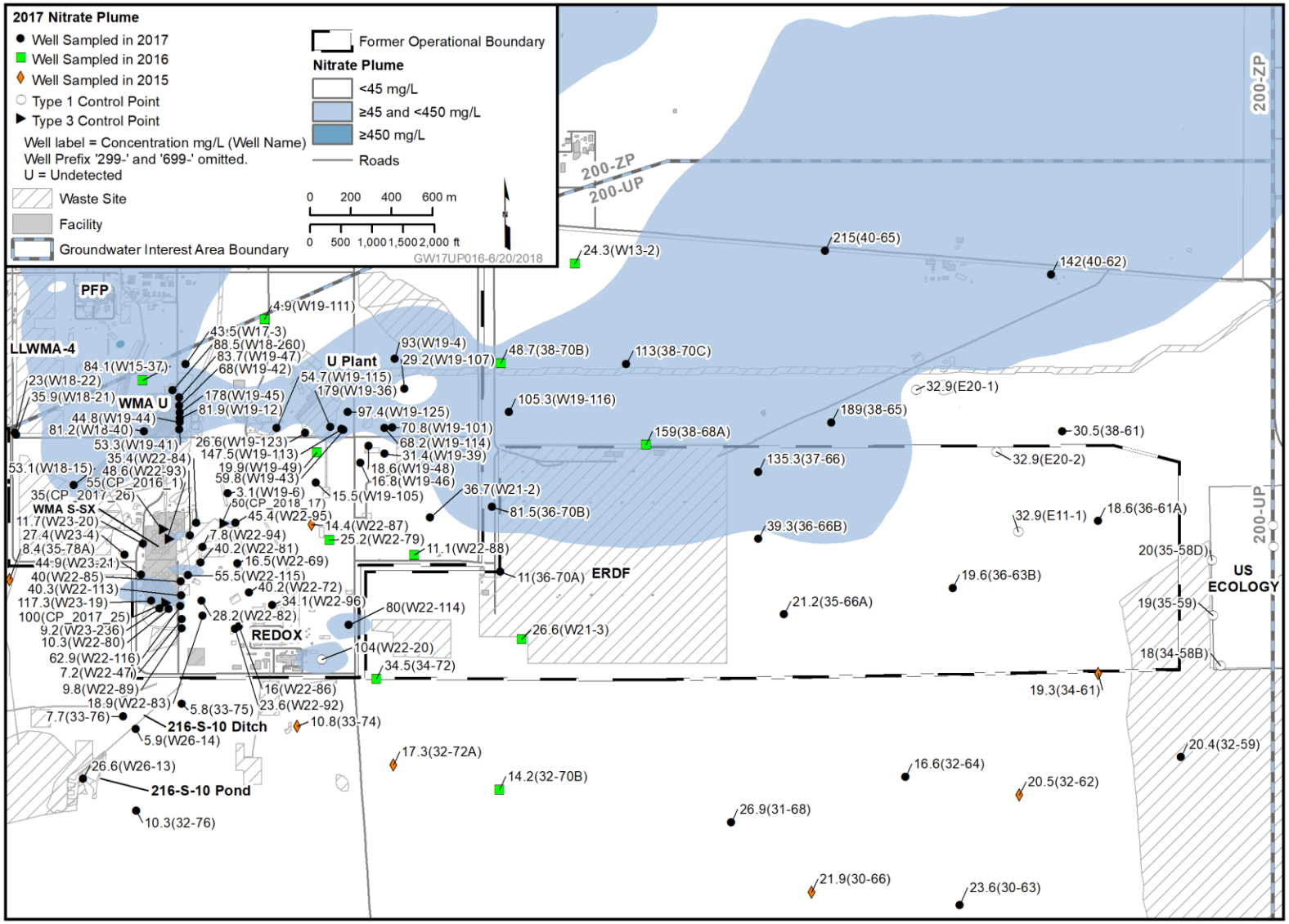


Figure 11-17. 200-UP Nitrate Plume, 2017

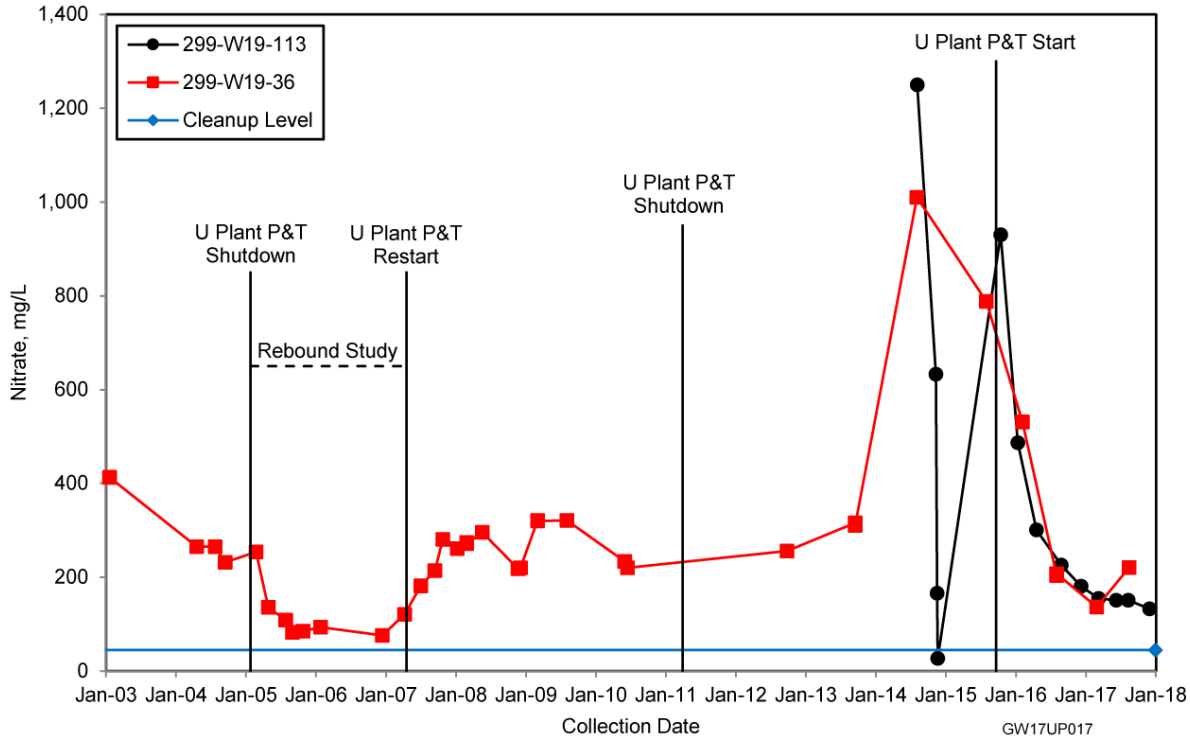


Figure 11-18. 200-UP Nitrate Data for Wells 299-W19-36 and 299-W19-43 near U Plant

11.6.2 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. During 2017, the concentration increased to above the cleanup level at southernmost downgradient well 299-W19-41. The concentration in upgradient well 299-W18-40 was 84.1 mg/L, with the trend increasing since this well was drilled in 2001. The upgradient nitrate source is treated water injected into wells formerly used for the 200-ZP-1 interim action P&T system. The injected water was treated for VOCs but still contained nitrate (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. The maximum nitrate concentration in a U Tank Farm well during 2017 was 186 mg/L in 299-W19-45 (Figure 11-19). Nitrate trends are increasing in wells 299-W18-40, 299-W18-260, 299-W19-12, 299-W19-42, 299-W19-45, and 299-W19-47. The declining trend that was occurring at 299-W19-41 has apparently reversed and is now increasing. Well 299-W19-44 is the only U Tank Farm well with an overall declining nitrate trend.

11.6.3 Waste Management Area S-SX and 216-S-25 Crib

A nitrate plume from the 216-S-25 Crib merges with a plume from the SX Tank Farm. Nitrate concentrations are the highest in well 299-W23-19 in the SX Tank Farm (149 mg/L in December 2017) (Figure 11-5). The overall decline at well 299-W23-19 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 in 1965 (Section 4.3 of RPP-ENV-39658), although other tank leaks may also contribute.

A nitrate plume from the S Tank Farm had a 2017 maximum concentration of 49.1 mg/L at well 299-W22-93. This plume originated from an overfill event at tank S-104 between 1966 and 1970.

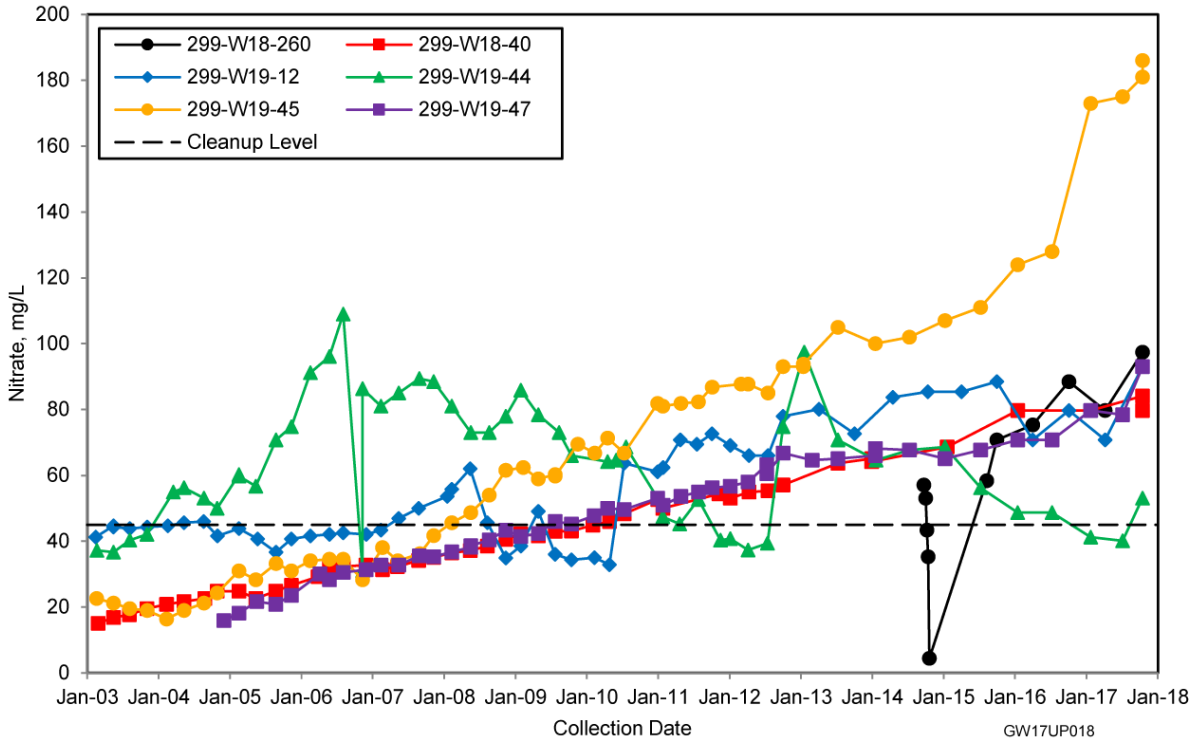


Figure 11-19. 200-UP Nitrate Data for Selected Wells at WMA U

11.7 Chromium

In 200-UP, two chromium plumes are present at WMA S-SX. An additional larger plume is in the 600 Area, east and southeast of the 200 West Area (known as the southeast chromium plume). Both total chromium and Cr(VI) are COCs for the 200-UP-1 OU; this section refers to them collectively as "chromium." Plume maps and graphs show dissolved chromium (i.e., filtered, total chromium, and Cr(VI) results). The 200-UP-1 cleanup level for total chromium is 100 µg/L and for Cr(VI) is 48 µg/L.

11.7.1 Waste Management Area S-SX

Two chromium plumes are found at WMA S-SX: one downgradient of the SX Tank Farm, and one downgradient of the S Tank Farm (Figure 11-20). Chromium concentrations in three wells in the SX Tank Farm plume exceeded the 48 µg/L cleanup level in 2017, where the highest concentration was at well 299-W23-19, with concentrations fluctuating between 159 and 224 µg/L (Figure 11-5).

Concentrations have declined substantially in well 299-W23-19 since the startup of groundwater extraction (the concentration was as high as 1,150 µg/L during 2012). Well 299-W22-86 has shown a declining trend since startup of the local P&T, from a high concentration of 159 µg/L in 2012 to 18.9 µg/L in 2017 (Figure 11-21). A declining trend was also noted at well 299-W22-83, where the highest concentration was 51.4 µg/L during 2017, down from 73 µg/L in 2016 (Figure 11-21). These declining trends are attributed to operation of the WMA S-SX groundwater extraction system. Concentrations also exceeded the cleanup level in well 299-W22-116 (93 µg/L), a replacement well for 299-W22-50 that was installed adjacent to extraction well 299-W22-91. Concentrations in extraction wells 299-W22-91 and 299-W22-92 are below the 48 µg/L cleanup level due to concentration averaging (i.e., dilution) as water is drawn into the extraction wells from below the plume. This plume is attributed primarily to a 190,000 L (51,000 gal) leak from tank SX-115 in 1965 (Section 4.3 of RPP-ENV-39658), although there may be contributions from other tank leaks.

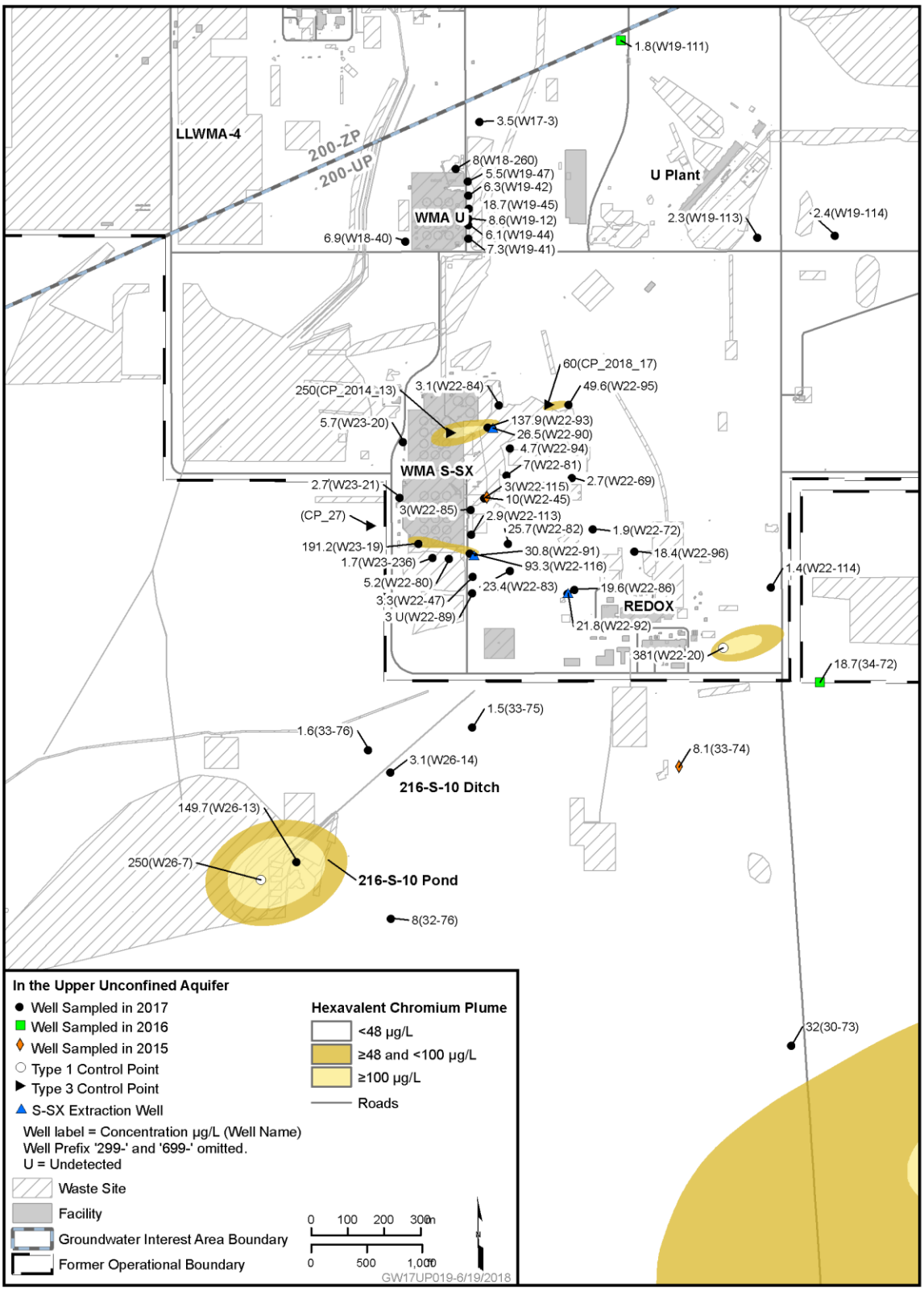


Figure 11-20. 200-UP Chromium Plume, 2017

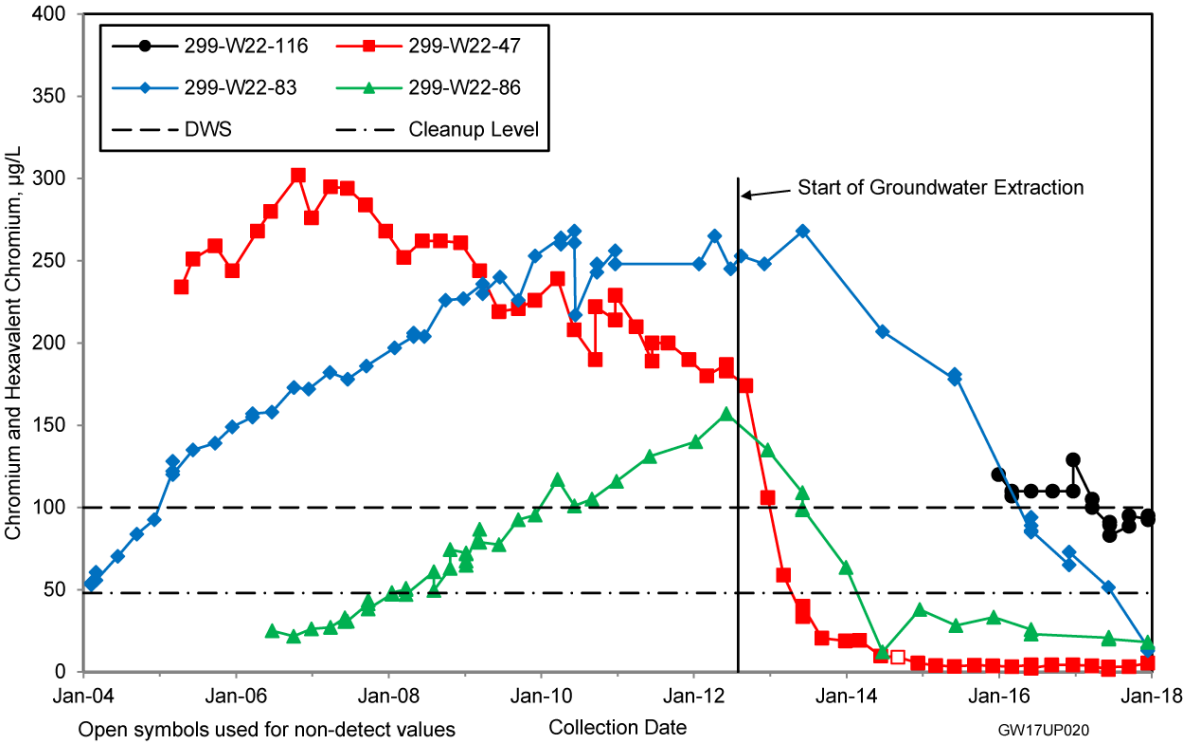


Figure 11-21. 200-UP Chromium Data for Monitoring Wells East of WMA S-SX

The S Tank Farm chromium plume originated from an overfill event at tank S-104 between 1966 and 1970. At near-field downgradient well 299-W22-93 (located adjacent to extraction well 299-W22-90), the chromium concentration during 2017 was 145 µg/L, a decrease from 390 µg/L in 2016. Concentrations in the extraction well are below the 48 µg/L cleanup level due to concentration averaging. The extraction well captures the S Tank Farm chromium plume near the source. Farther downgradient, chromium decreased to below the cleanup level at well 299-W22-95 (42.8 µg/L during December 2017) as the portion of the plume that is not captured continues to migrate downgradient. This portion of the plume is expected to disperse naturally to below the cleanup level.

11.7.2 Southeast Plume

The southeast chromium plume (Figure 11-22) originated primarily from effluent disposed 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).

Historically, the extent of this plume was uncertain due to a lack of monitoring wells, particularly on the south side of the plume. Characterization activities to better define the vertical and horizontal extent are described in the 200-UP-1 RD/RAWP (DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*). This work was initiated in 2016, completed in 2017, and data interpretation will take place in 2018. Ten wells were drilled to define the extent of contamination (Figure 11-22), and one well was added to better define the western extent. Three of these wells were completed in 2016, and the remaining eight wells were completed in 2017. Tables 11-6 through 11-13 show the results of depth profile sampling of the aquifer.

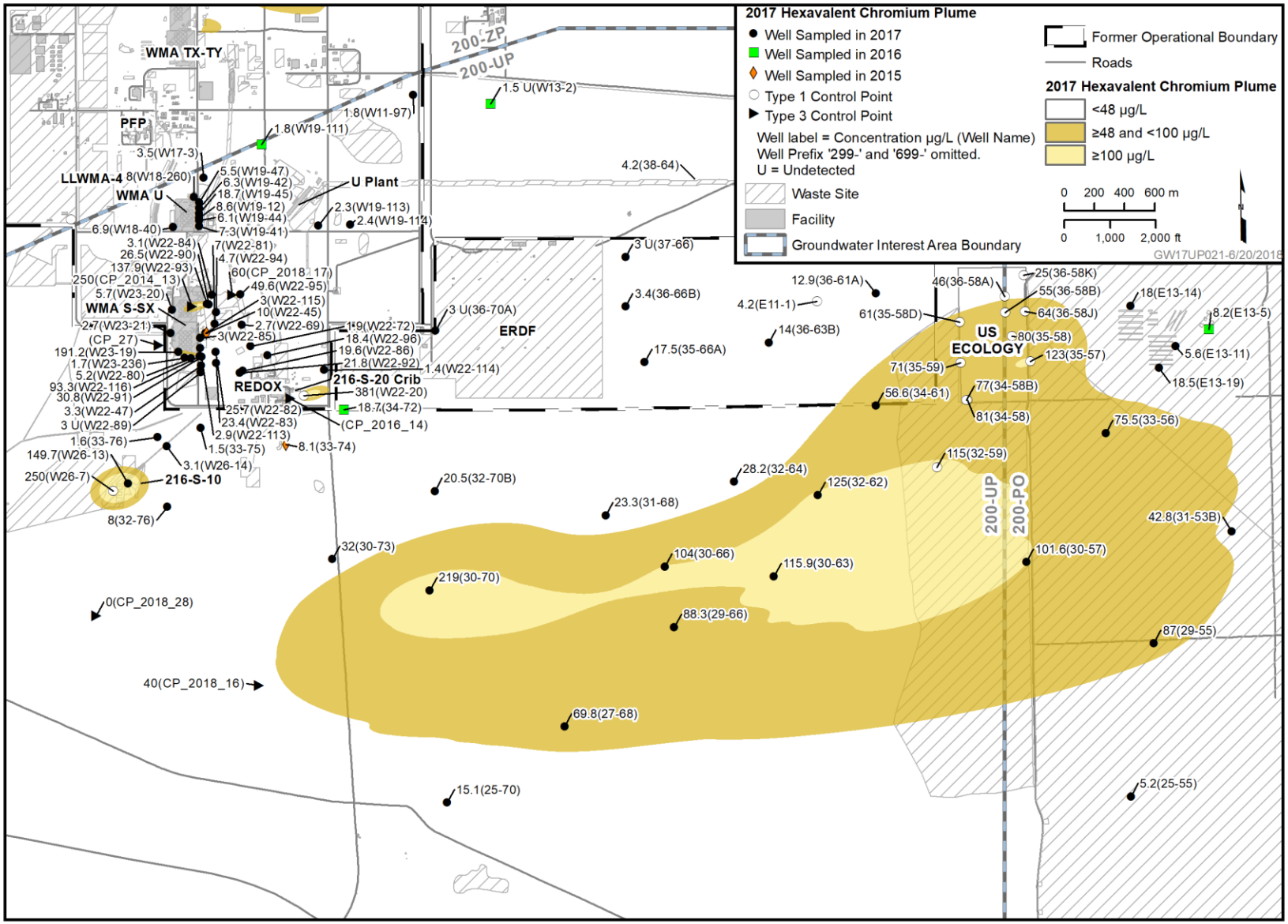


Figure 11-22. 200-UP Southeast Chromium Plume, 2017

Table 11-6. Depth Profile Sample Results for Well 699-27-68 (June 2017)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
5.6	18.3	82.5 D	55.5 D	43 G	53 G	1,330
11.5	37.7	30.8 D	22.6 D	16	20	1,180
17.4	57.2	63.6 D	60.1 D	37	52	1,700
24.1	79.0	19.8 DY	10.9 DY	1.5 UY	3.5 BY	3,460
29.9	98.1	97.9 D	69.8 D	36	53	3,980
36.0	118.1	63.6 DA	46.6DA	24 A	38 A	3,730 A

Notes: Screened interval depths from -1.0 to 8.4 m and 11.43 to 20.6 m (-2.5 to 27.5 ft and 37.5 to 67.5 ft) below the water table.

Field analysis results excluded.

A = chain-of-custody issue

B = analyte was detected at a value less than the contract-required detection limit but greater than or equal to the method detection limit

D = analyte was reported at a secondary dilution factor

G = record has been reviewed and determined to be correct

U = not detected

Y = suspect result

Table 11-7. Depth Profile Sample Results for Well 699-29-55 (July 2017)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
4.4	14.5	100 D	48.4 D	33	41	113 U
10.5	34.5	50.4 DA	34.3 DA	1.5 U	21	170 UA
19.6	64.4	156 D	17.2 D	1.5 U	15	27.6 U
25.8	84.5	93.2 D	78.6 D	53	61	48 U
31.9	104.5	57.4 D	22.9 D	7.8	8.7	156 U
37.9	124.5	23.8 DA	15.9 D	2.5 B	8.4	-6.94 U

Notes: Screened interval depth from -0.5 to 8.7 m and 19.4 to 28.5 m (-1.5 to 28.6 ft and 63.6 to 93.6 ft) below the water table.

Field analysis results excluded.

A = chain-of-custody issue

B = analyte was detected at a value less than the contract required detection limit but greater than or equal to the method detection limit

D = analyte was reported at a secondary dilution factor

U = not detected

Table 11-8. Depth Profile Sample Results for Well 699-30-63 (November and December 2016)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
7.1	23.3	57.1 D	46.5 D	1.5 U	31	3,670
13.3	43.6	151 D	126 D	91	100	3,790
19.3	63.3	147 D	105 D	90 ZH	99 ZH	3,700
25.4	83.4	151 D	81.5 D	9	54	3,830
31.5	103.2	126 D	92.1 D	59	88	2,930
37.5	123.1	83.4 D	49.5 D	46	47	2,810

Notes: Screened interval depth from 0 to 9.0 m, 12.0 to 21.2 m, and 24.2 to 36.4 m (0 to 29.5 ft, 39.5 to 69.5 ft, and 79.5 to 119.5 ft) below the water table.

Field analysis results excluded.

D = analyte was reported at a secondary dilution factor

H = laboratory holding time exceeded

U = not detected

Z = miscellaneous circumstances exist; additional information available

Table 11-9. Depth Profile Sample Results for Well 699-30-70 (May and June 2017)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi /L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
4.6	15.1	52.3 D	68.4 D	46	47	1,610
10.7	35.0	75 D	68.4 D	39	41	4,380
16.8	55.1	109 D	85.1 D	70	71	6,380
22.9	75.1	185 DG	176 DG	150	160 G	5,430
28.9	94.9	147 DG	142 DG	82	110	1,600
35.0	114.9	254 D	219 D	150 G	160	218 U
40.9	134.1	77.2 DY	8.5 BDY DY	1.5 UY	1.5 UY	289 U
47.0	154.1	42.4 DY	18.7	5.5 Y	8.1 AY	524

Notes: Screened interval depth from 0 to 6.0 m, 15.1 to 27.3 m, and 30.4 to 39.5 m (0 to 19.7 ft, 49.7 to 89.7 ft, and 99.7 to 129.7 ft) below the water table.

Field analysis results excluded.

A = chain-of-custody issue

D = analyte was reported at a secondary dilution factor

G = record has been reviewed and determined to be correct

U = not detected

Y = suspect result

Table 11-10. Depth Profile Sample Results for Well 699-30-73 (October 2017)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
3.3	10.7	21.8 D	20.9 A	8.4	12	730
9.3	30.6	13.4 D	11.3 D	3.4 B	7.6	1,200
15.3	50.3	20.3 D	4.0 UD	1.5 U	2.9 B	2,530
21.5	70.6	23.6 D	9.6 BD	1.9 B	3.1 B	5,750
27.5	90.3	24.3 D	12.0 D	1.5 U	3.6 B	2,370
33.7	110.6	18.8 D	12.4 D	1.5 U	1.5 B	2,310
39.7	130.4	34.8 D	7.0 BD	1.5 UA	2.8 BA	2,180
45.9	150.5	32.1 D	7.6 BD	1.5 U	3.0 B	1,820

Notes: Screened interval depth from 0 to 10.5 m (0 to 34.3 ft) below the water table.

Field analysis results excluded.

A = chain-of-custody issue

B = analyte was detected at a value less than the contract required detection limit but greater than or equal to the method detection limit

D = analyte was reported at a secondary dilution factor

U = not detected

Table 11-11. Depth Profile Sample Results for Well 699-31-50 (November 2017)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
5.1	16.7	4.0 UD	4.0 UD	1.5 U	1.5 U	-161 U
11.0	35.2	4.0 UD	4.0 UD	1.5 U	1.5 U	35.3 A
17.2	56.4	4.0 UD	4.0 UD	1.5 U	1.5 U	-132
23.0	75.2	4.0 UD	4.0 UD	1.5 U	1.5 U	-110
29.3	96.2	10.4 D	4.0 UD	1.5 U	1.5 U	-78.7
35.3	115.7	4.0 UD	4.0 UD	1.5 U	1.5 U	0.173
41.2	135.2	4.0 UD	4.0 UD	1.5 U	1.5 U	7,250 F

Notes: Screened interval from 0 to 10.5 m and 13.5 to 25.7 m (-0.5 to 34.3 ft and 44.3 to 84.3 ft) below water table.

Field analysis results excluded.

A = chain-of-custody issue

D = analyte was reported at a secondary dilution factor

F = under review

U = not detected

Table 11-12. Depth Profile Sample Results for Well 699-32-59 (January and February 2017)

Depth Below Water Table		Chromium, Total (µg/L)		Hexavalent Chromium (µg/L)		Tritium (pCi/L)
m	ft	Unfiltered	Filtered	Unfiltered	Filtered	
9.4	31.0	127 D	115.0 D	4.5 Y	110.0	1,120
15.3	50.3	144 D	77.1 D	110 A	81.0	877
21.7	71.2	132 D	98.7 D	54	65.0	946
24.7	81.0	106 D	41.8 D	35	39.0	888

Notes: Screened interval from -0.5 to 10.2 m and 13.2 to 30.0 m (-1.8 to 33.4 ft and 43.4 to 98.4 ft) below water table.
Field analysis results excluded.
A = chain-of-custody issue
D = analyte was reported at a secondary dilution factor
Y = suspect result

Table 11-13. Depth Profile Sample Results for Well 699-32-64 (October and November 2016)

Depth Below Water Table (m)	Depth Below Water Table (ft)	Chromium, Total (µg/L)	Hexavalent Chromium (µg/L)	Tritium (pCi/L)
10.4	34.0	31.7	14.0	20,100
13.4	44.0	29.0	18.0	15,800
19.1	62.7	7.6	5.2	4,790
25.6	84.0	12.5	<1.5	1,420
31.7	104.1	4.0	<1.5	648

Note: Screened interval depth from 0 to 10.8 m and 13.8 to 33.6 m (0 to 35.3 ft and 45.2 to 110.3 ft) below the water table.

During drilling in 2016, the chromium concentration at well 699-30-57 was higher than expected. This well was located where the southern boundary of the plume at the 48 µg/L concentration level was expected to occur, but a concentration of 110 µg/L was observed during drilling. This indicated that the plume extended farther south than previously mapped. As a result, several wells farther south and east were sampled for chromium during 2016 (699-25-55, 699-25-70, 699-28-52A, 699-31-53B, and 699-34-51). Initially, a total of six wells were planned to be drilled to characterize this plume, but as a result of the higher concentration at well 699-30-57, four additional wells were added (699-27-68, 699-29-55, 699-30-70, and 699-31-50 [locations shown in Figure 11-1]) to provide better definition of the plume extent. Well 699-30-73 was drilled at the end of 2017 (for a total of 11 southeast chromium plume wells) because of higher-than-expected chromium concentrations at well 699-30-70. As shown in Figure 11-3 and Table 11-1, the 2017 plume interpretation is larger than previous years because it incorporated data from the new wells.

Within the center of the plume, concentrations at well 699-32-62 have slowly declined from 254 to 130 µg/L since 1992 (Figure 11-23). This gradual reduction in concentration is likely due to the continued downgradient migration of the plume. Chromium is also elevated at well 699-30-66 (98 µg/L in 2017), which is completed deep in the aquifer just above the Ringold lower mud (Figure 11-23). Data indicate that 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 in Figure 11-20 of DOE/RL-2011-01).

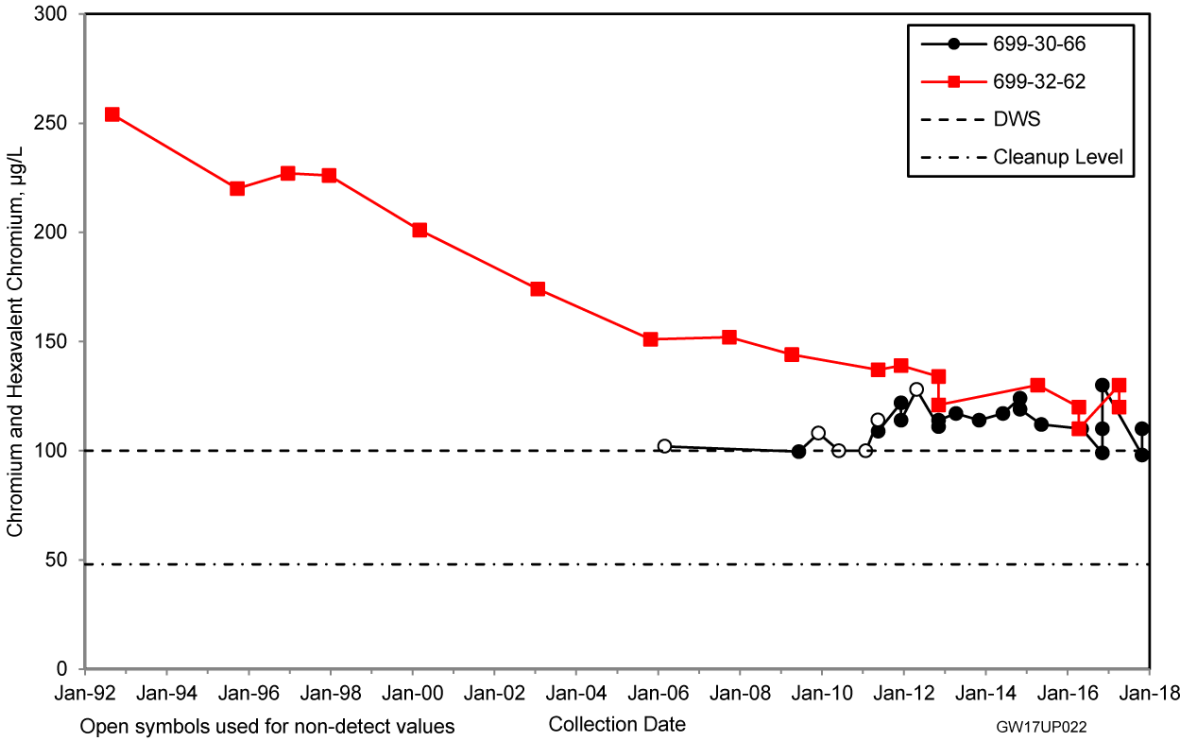


Figure 11-23. 200-UP Chromium Data for Wells 699-30-66 and 699-32-62 Southeast of the 200 West Area

Chromium continues to be observed in groundwater near both of the source locations (216-S-20 Crib and 216-S-10 Pond and Ditch). In well 699-34-72 (downgradient from the 216-S-20 Crib), total chromium was detected at 20 µg/L in a filtered sample collected in February 2016 (no samples were collected in 2017). In well 299-W26-13 (at the 216-S-10 Pond and Ditch), chromium averaged 147 µg/L in 2017 (Cr(VI) and total chromium results combined), and the trend has been overall increasing (Figure 11-24). Chromium is detected at lower concentrations in well 699-32-76, which is located 300 m (1,000 ft) to the east.

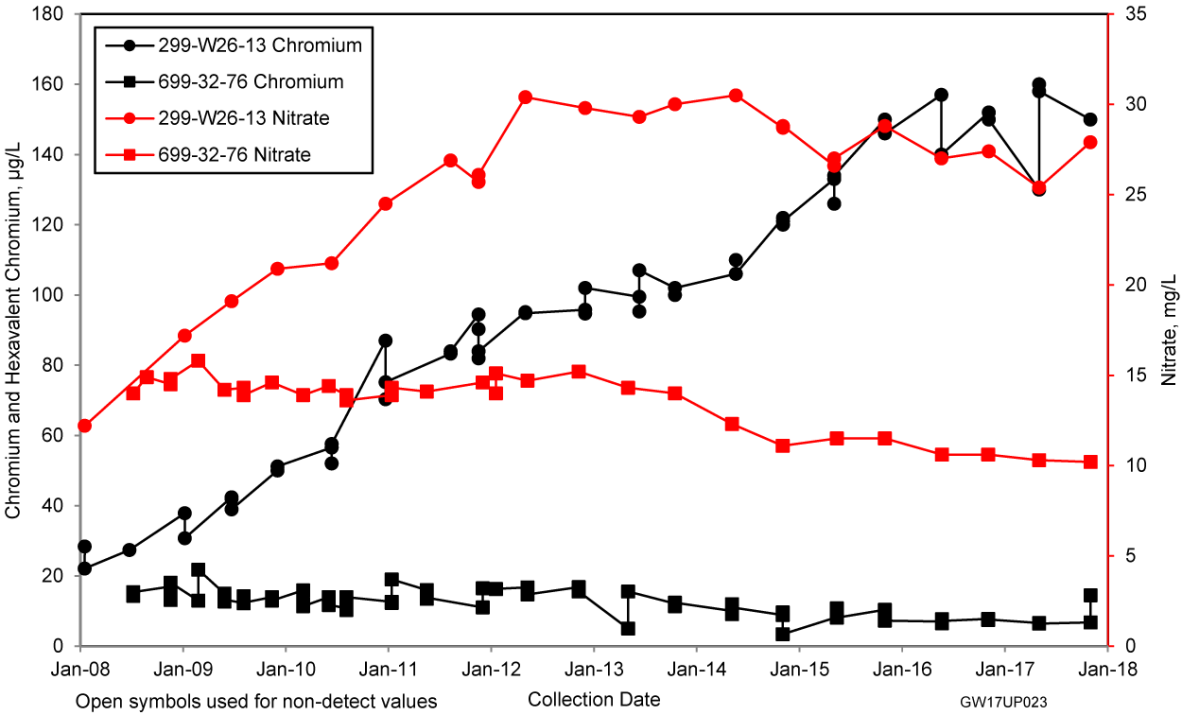


Figure 11-24. 200-UP Chromium and Nitrate Data for Wells 299-W26-13 and 699-32-76 at the 216-S-10 Pond and Ditch

11.8 Carbon Tetrachloride

Concentrations of carbon tetrachloride above the 3.4 µg/L cleanup level are widespread in 200-UP groundwater. The plume originated from PFP waste disposal sites in 200-ZP. Some of the ditches from PFP extended to U Pond, which may also have been a carbon tetrachloride source. Concentrations were more than 10 times the cleanup level in 24 wells and were above the cleanup level in 36 of the 57 wells sampled for carbon tetrachloride in 2017. In the southern 200 West Area, the plume extends up to 1.7 km (1.1 mi) east into the 600 Area (Figure 11-25). In the eastern portion of the plume, concentrations increase with depth (Figure 11-21 in DOE/RL-2011-01). The highest carbon tetrachloride concentration in 200-UP during 2017 was 412 µg/L at well 299-W14-71, which is screened at the bottom of the unconfined aquifer. The second highest concentration was 172 µg/L in well 299-W11-97. Chapter 12 provides additional information regarding carbon tetrachloride in the 200 West Area.

Chloroform is a degradation product of carbon tetrachloride and tends to be found in the same wells. This suggests that natural degradation of carbon tetrachloride may be occurring, although chloroform was also introduced to the aquifer from the 2607-Z Tile Field (Section 12.2.8 in DOE/RL-2011-01). During 2017, chloroform concentrations did not exceed the DWS (80 µg/L for total trihalomethanes) in 200-UP. The maximum concentration was 12.7 µg/L in well 299-W14-71. Depth-discrete sampling during well drilling showed that chloroform concentrations tend to increase with depth, similar to carbon tetrachloride.

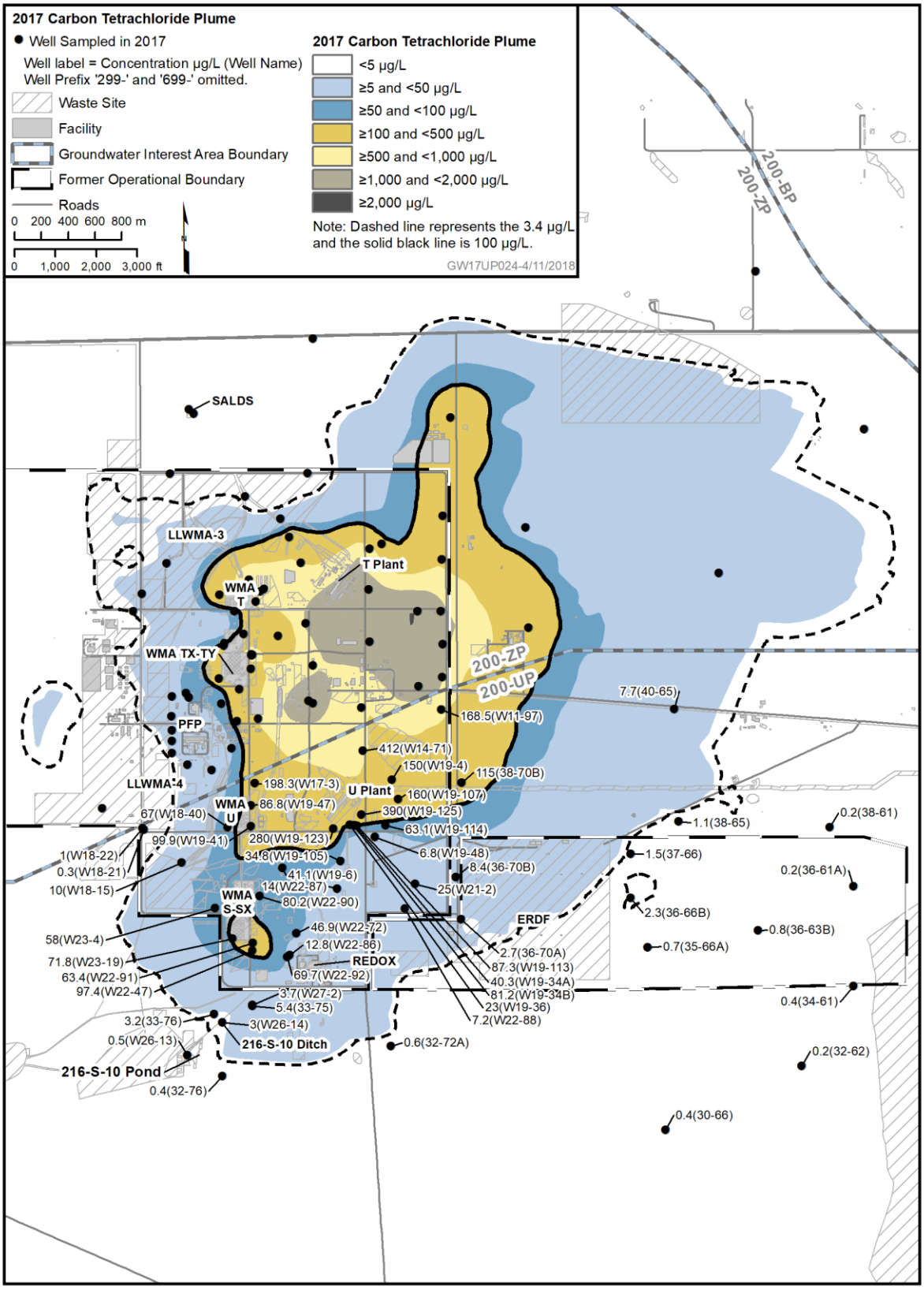


Figure 11-25. Carbon Tetrachloride Plume, 2017

11.9 Trichloroethene

TCE is found in groundwater in the northern portion of 200-UP (Figure 11-26). Depth-discrete sampling during well drilling showed that TCE concentrations increase with depth, similar to carbon tetrachloride and chloroform. During 2017, TCE was detected in 26 wells in 200-UP, with concentrations exceeding the DWS (5 µg/L) only at wells 299-W14-71 (12.5 µg/L), 299-W19-107 (6.6 µg/L), 299-W19-116 (6.3 µg/L), 299-W19-125 (average of characterization sample analysis, 8.1 µg/L), and 699-38-70B (8.5 µg/L) and in the deeper samples collected during drilling of well 299-W19-116 (maximum of 6.3 µg/L). Concentrations exceeded the 1 µg/L cleanup level for the 200-ZP-1 OU in 21 wells in 200-UP. Three of the four TCE degradation products (1,1-dichloroethene [DCE], 1,2-DCE [*cis*- and *trans*-], and chloromethane [i.e., vinyl chloride]), were also analyzed but not detected during 2017.

11.10 Strontium-90

Well 299-W22-10 (located near the 216-S-1 and 216-S-2 Cribs) was sampled for strontium-90 with a result of 19.1 pCi/L, above the 8 pCi/L DWS. Concentrations in this well have declined from a high of 76.2 pCi/L in 2001. The 216-S-1 and 216-S-2 Cribs received highly acidic waste from the REDOX Plant between 1952 and 1956. In 1955, the waste is believed to have corroded the casing of nearby well 299-W22-3, which allowed the effluent to bypass the soil column and flow down the well directly to the groundwater. This is the postulated pathway by which strontium-90 reached groundwater at this location.

11.11 CERCLA Remediation and Monitoring

During 2017, CERCLA groundwater monitoring for the 200-UP-1 OU was performed under the performance monitoring plan that was released during August 2015 (DOE/RL-2015-14, *Performance Monitoring Plan for the 200-UP-1 Groundwater Operable Unit Remedial Action*). Figure 11-1 shows the sampling locations for 2017. Two new, dual-use wells were constructed near U Plant, and eight wells were constructed to characterize the southeast chromium plume. Table 11-2 provides a summary of the wells installed during 2017, including vadose zone wells overlying the 200-UP-1 OU. Table A-1 in Appendix A lists the sampling exceptions for 2017.

Three active remedies operated in the 200-UP-1 OU during 2017: the WMA S-SX groundwater extraction system, the U Plant area P&T system, and the iodine-129 plume hydraulic control system.

11.11.1 CERCLA Decision Documents and Plans

An interim action ROD for the 200-UP-1 OU was issued in September 2012 (EPA et al., 2012), and an RD/RAWP was issued in September 2013 (DOE/RL-2013-07). The RD/RAWP is currently being updated in 2017–2018. The interim action ROD addresses uranium, technetium-99, total chromium, Cr(VI), carbon tetrachloride, and nitrate. The selected remedy in the interim action ROD consists of the following components:

- Groundwater extraction and treatment with MNA for all COCs, except iodine-129 and tritium
- MNA for the entire tritium plume and parts of the nitrate and carbon tetrachloride plumes not captured by the groundwater extraction remedies
- Hydraulic containment for iodine-129 while treatment technologies are investigated
- Remedy performance monitoring
- ICs

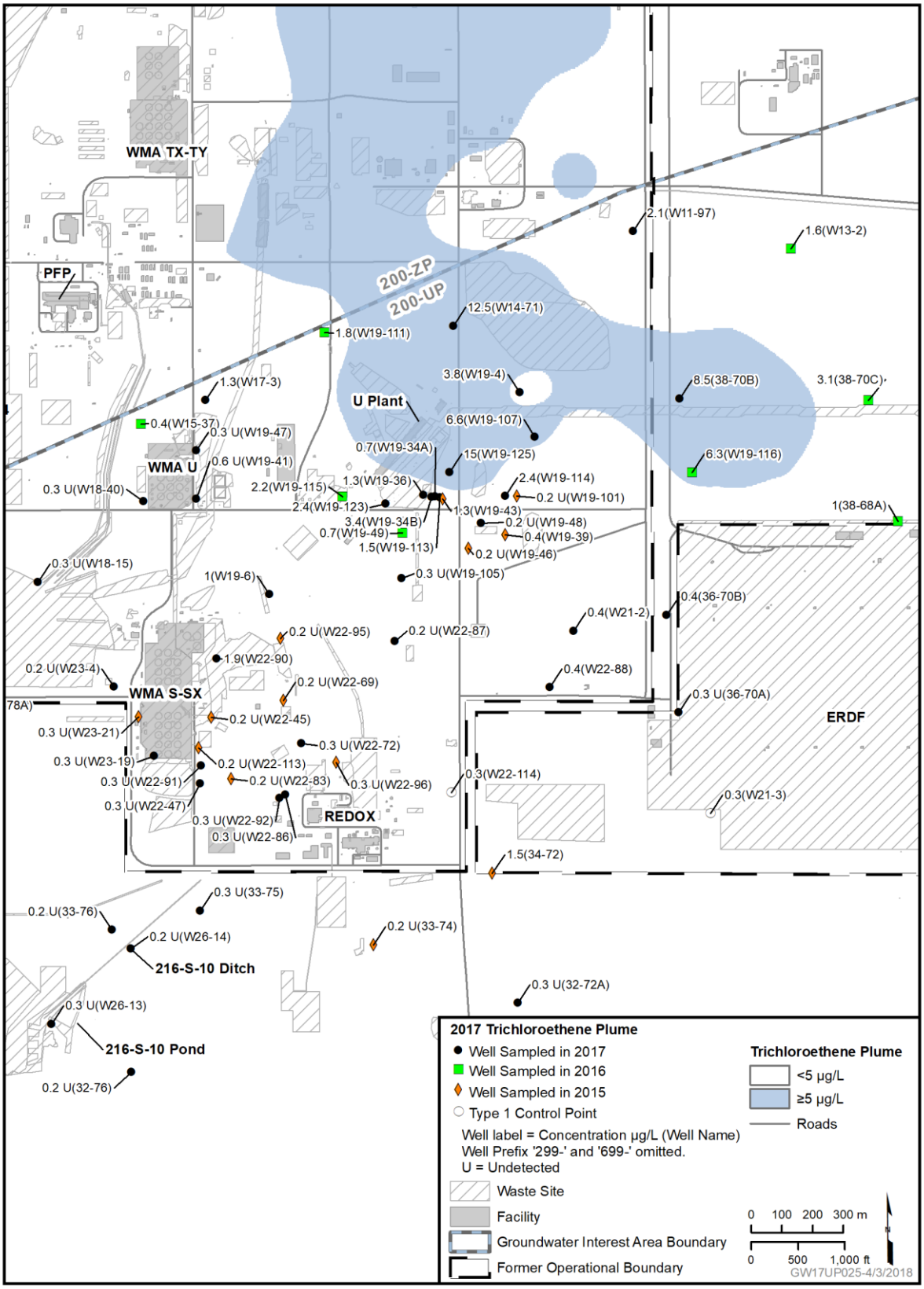


Figure 11-26. 200-UP TCE Plume, 2017

The RD/RAWP (DOE/RL-2013-07) describes implementation of the ROD and addresses the following topics:

- The approach to designing the P&T system for uranium and technetium-99 near U Plant, a P&T system for the chromium plume southeast of the 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 to support the 200-UP-1 remedies

Implementation of the RD/RAWP (DOE/RL-2013-07) began in 2014, and the following activities were completed during 2017:

- Continued operation of the U Plant area uranium/technetium-99 groundwater extraction system
- Continued operation of the iodine-129 plume hydraulic containment system
- Continued operation of the WMA S-SX technetium-99 groundwater extraction system
- Continued progress of characterization of the southeast chromium plume area
- Continued progress on finalizing the iodine-129 treatment technology evaluation plan
- Continued compilation of the iodine-129 plume conceptual model and related iodine species attenuation and transport characteristics

11.11.2 U Plant Area Pump and Treat

This remedy addresses uranium, technetium-99, carbon tetrachloride, and nitrate contamination near U Plant. The system consists of three extraction wells (299-W19-113, 299-W19-114, and 299-W19-123) that began operating in September 2015 and 2017 (for well 299-W19-123). Table 11-14 summarizes the volume of groundwater extracted and mass of contaminants removed through 2017.

Figure 11-27 shows the hydraulic capture zones for the three extraction wells. The capture zones cover much of the central and western portions of the uranium plume, although part of the high-concentration region (greater than 300 µg/L) near the source cribs is outside of the capture zones. Although not shown in Figure 11-27, the capture zones also cover the entire technetium-99 plume (Figure 11-4) and the high-concentration portion of the nitrate plume (i.e., greater than 450 mg/L in Figure 11-17).

The extraction wells were sampled quarterly during 2017. Maximum uranium concentrations were 169 µg/L in well 299-W19-113 (with an increasing trend) and 27.1 µg/L in well 299-W19-114 (with a stable trend). These concentrations are lower than in nearby monitoring wells (e.g., 5,000 µg/L in well 299-W19-36 and 119 µg/L in well 299-W19-43, both near 299-W19-113; and 81 µg/L in well 299-W19-101, near well 299-W19-114). Concentrations in the extraction wells are affected by concentration averaging. The uranium plume is located only in the upper part of the aquifer, but the extraction wells draw water from most of the aquifer thickness, so water from beneath the uranium plume is drawn into the extraction wells diluting the uranium concentrations. At the end of 2017, concentrations in extraction wells 299-W19-113 and 299-W19-114 were 2,280 and 430 pCi/L for technetium-99, 155 and 80 mg/L for nitrate, and 101 and 72 µg/L for carbon tetrachloride, respectively.

Table 11-14. 200-UP-1 Remedy Summary

Iodine-129 Plume Hydraulic Containment (2015–2017)		
Injection wells		3
Average flow rate in 2017, L/min (gal/min)		804 (212)
Monitored Natural Attenuation (2015–2017)		
Dispersion of all contaminants of concern		
Radioactive decay of tritium		
Current P&T Systems		
P&T System	**U Plant Area, 2017**	**WMA S-SX, 2017**
Design capacity (L/min [gal/min])	568 (150)	303 (80)
Extraction wells	3	3
Volume extracted (million L [million gal])	292 (77.0)	162 (42.7)
Mass of uranium removed, kg	17.9	Not applicable
Mass (activity) of Tc-99 removed, g (Ci)	15.5 (0.26)	18.3 (0.31)
Mass of nitrate removed, kg	27,354	4,362
Mass of carbon tetrachloride removed, kg	19.3	11.1
Mass of chromium removed, kg	N/A	4.5
All 200-UP-1 P&T Systems, 1994–2017		
Mass of uranium removed, kg		937
Mass (activity) of Tc-99 removed, g (Ci)		351 (5.96)
Mass of nitrate removed, kg		179,523
Mass of carbon tetrachloride removed, kg		152
Mass of chromium removed, kg		45.9

P&T = pump and treat
WMA = waste management area

Because of concentration averaging in the extraction wells, the best indicator of remedy performance is the concentrations in the monitoring wells. Uranium concentrations declined in five of the eight monitoring wells that had baseline concentrations above the cleanup level, with declines ranged from 70% to 85%. Uranium concentrations have increased in well 299-W19-36, near extraction well 299-W19-113. The August 2017 sample result for well 299-W19-36 was 5,000 µg/L, a 79% increase from the baseline of 1,550 µg/L (Figure 11-12). As stated in Section 11.3.1, there may be a local source of uranium in this area. Section 11.2.2 discusses the technetium-99 concentrations in this area, and Section 11.6.1 discusses the nitrate concentrations.

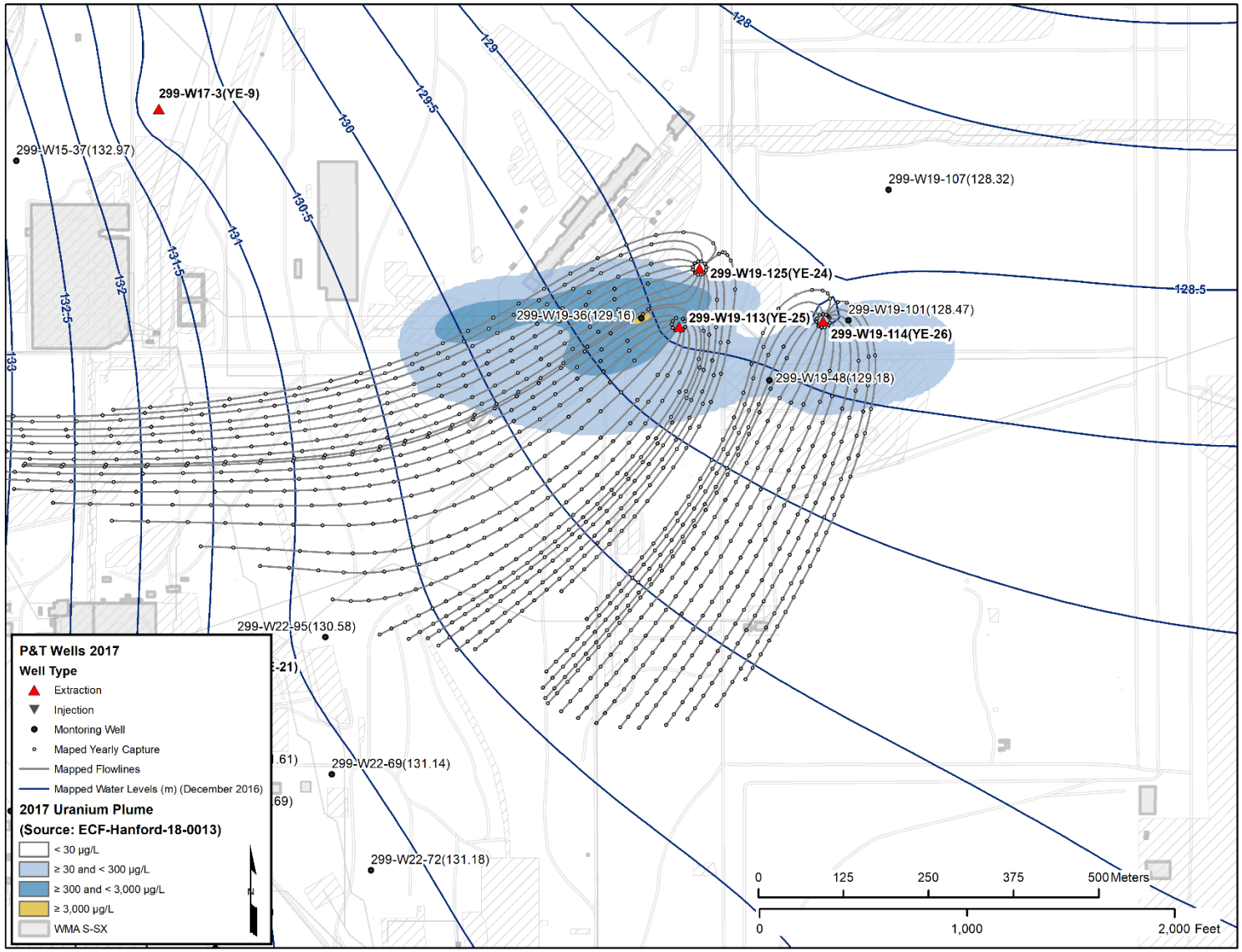


Figure 11-27. 200-UP Groundwater Capture Zones for the Uranium Plume Remedy

Drawdown of the water table due to startup of the groundwater extraction system in 2015 was analyzed to determine aquifer hydraulic properties. Drawdown was analyzed for the wells with automated water-level recorders: 299-W19-36, 299-W19-48, 299-W19-101, and 299-W19-107. The average results were a transmissivity of 220 m^2/d, a hydraulic conductivity of 4.7 m/d, and a specific yield of 0.12 (Table 5 in ECF-200UP1-16-0135, *Determination of Unconfined Aquifer Hydraulic Properties from Startup of the U Plant Area Pump and Treat System*). These results are within the ranges expected.

Additional details regarding the U Plant area groundwater extraction system are provided in the 2017 annual P&T system report (DOE/RL-2017-68).

11.11.3 S-SX Pump and Treat

The WMA S-SX groundwater extraction system began operating in July 2012 and consists of extraction wells 299-W22-90, 299-W22-91, and 299-W22-92 (Figure 11-28). Extracted water is pumped to the 200 West P&T. Table 11-14 summarizes the volume of groundwater extracted and mass of contaminants removed through 2017.

This system was specifically designed to capture the high-concentration portions of the technetium-99 plume. As shown by the hydraulic capture zones in Figure 11-28, the extraction wells are capturing almost all of the plume above 900 pCi/L near the sources in the S and SX Tank Farms.

Concentrations of chromium, nitrate, and technetium-99 in the extraction wells have declined since pumping began. The declines are due to a combination of removing contaminant mass/activity from the aquifer and concentration averaging (i.e., dilution) as water is drawn into the extraction wells from outside the plumes (vertically and laterally). WMA S-SX extraction well screens are slightly longer than the monitoring wells (up to 15 m [50 ft] for the extraction wells versus 11 m [35 ft] for the monitoring wells). A more important factor in the dilution is the convergence of streamlines to the extraction well screens laterally and vertically from areas of lower concentration because the wells are actively pumping. For this reason, concentrations in the monitoring wells are the best indicator of remedy performance.

The groundwater extraction system has reduced chromium, nitrate, and technetium-99 concentrations in many of the monitoring wells. Considering the wells with baseline concentrations above a cleanup level, chromium has declined in 5 of 6 wells, nitrate has declined in 11 of 12 wells, and technetium-99 has declined in 7 of 9 wells. Most of the increasing concentrations occurred in wells adjacent to extraction wells (e.g., 299-W22-93 and 299-W22-116), indicating that contamination is migrating toward the extraction wells or in wells monitoring the portion of the plumes not being captured (e.g., 299-W22-95 and 299-W22-96). The chromium concentration increased to above the 48 µg/L cleanup level at well 299-W22-95 (54.7 µg/L from a baseline of 9.9 µg/L). Nitrate also increased above the 45 mg/L cleanup level (49.1 mg/L from a baseline of 39.8 mg/L), and technetium-99 is near the cleanup level (856 pCi/L from a baseline of 310 pCi/L). Well 299-W22-95 is downgradient of the S Tank Farm and monitors the portion of the plume downgradient from the capture zone for well 299-W22-90. Chromium, nitrate, and technetium-99 concentrations have also increased at well 299-W22-96 (only technetium-99 is above a cleanup level, at 2,610 pCi/L during 2017) as the portion of the plume from the SX Tank Farm not being captured migrates downgradient. The plumes not being captured are expected to naturally disperse to below cleanup levels.

The technetium-99 concentration in well 299-W22-115 has increased to above the cleanup level (2,680 pCi/L from a baseline of 520 pCi/L) (Figure 11-6). This well is downgradient of the northern part of the SX Tank Farm and is outside of the capture zone for well 299-W22-91. The increased concentration in this well suggest an emerging contamination issue from the tank farm.

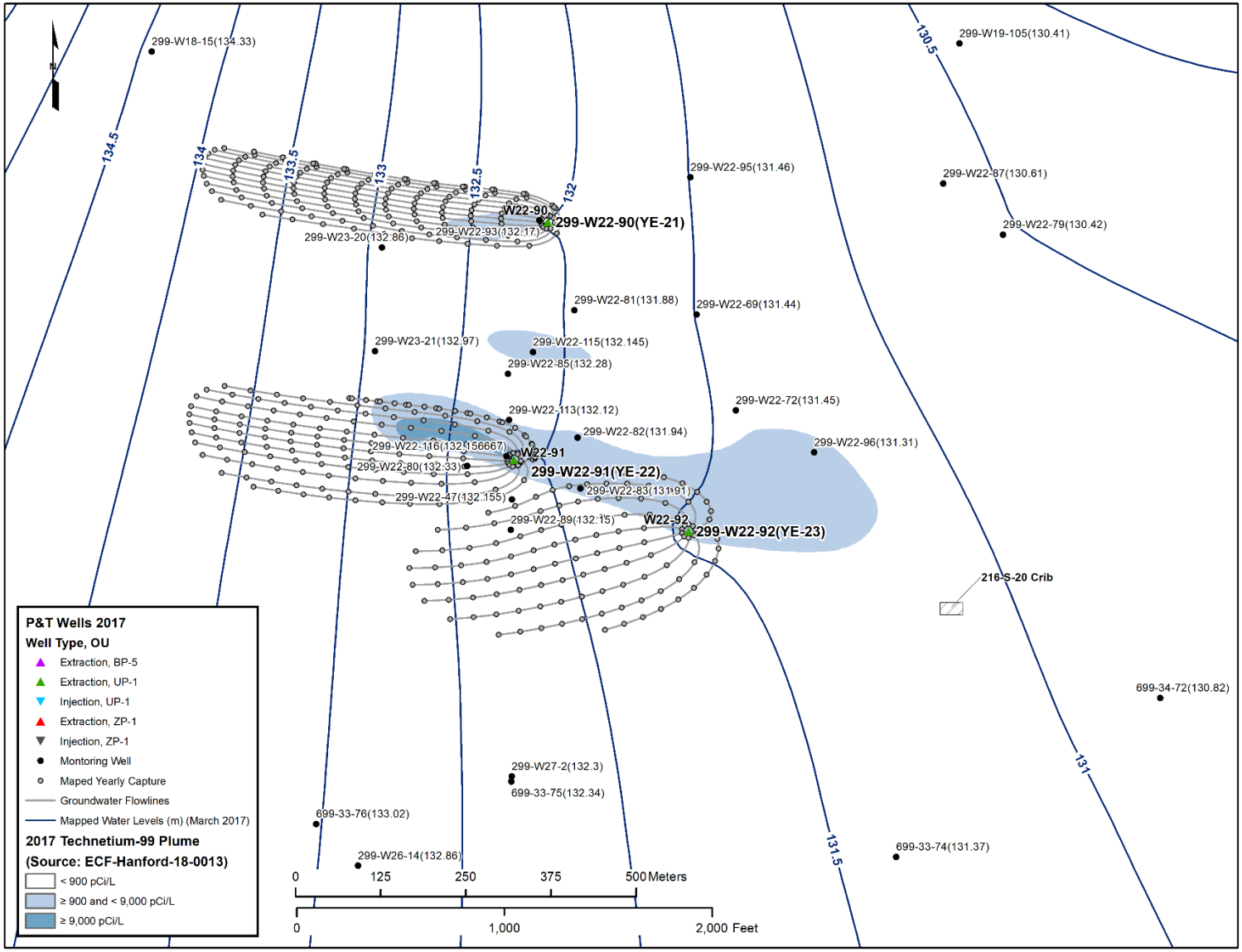


Figure 11-28. 200-UP Groundwater Capture Zones at WMA S-SX

11.11.4 Iodine-129 Plume Hydraulic Control

The 2012 interim action ROD (EPA et al., 2012) requires hydraulic containment of the iodine-129 plume while treatment technologies are evaluated. This remedy was implemented in 2015 by locating three injection wells for the 200 West P&T (299-E11-1, 299-E20-1, and 299-E20-2) on the eastern (downgradient) side of the plume (Figure 11-29). The locations and flow rates for these wells were determined by groundwater flow modeling, and the resulting design called for a minimum flow rate of 190 L/min (50 gal/min) and a maximum rate of 380 L/min (100 gal/min) to maintain hydraulic control. The injection wells began operating on October 28, 2015. Figure 11-29 shows the effect that operating the injection wells has on the water table.

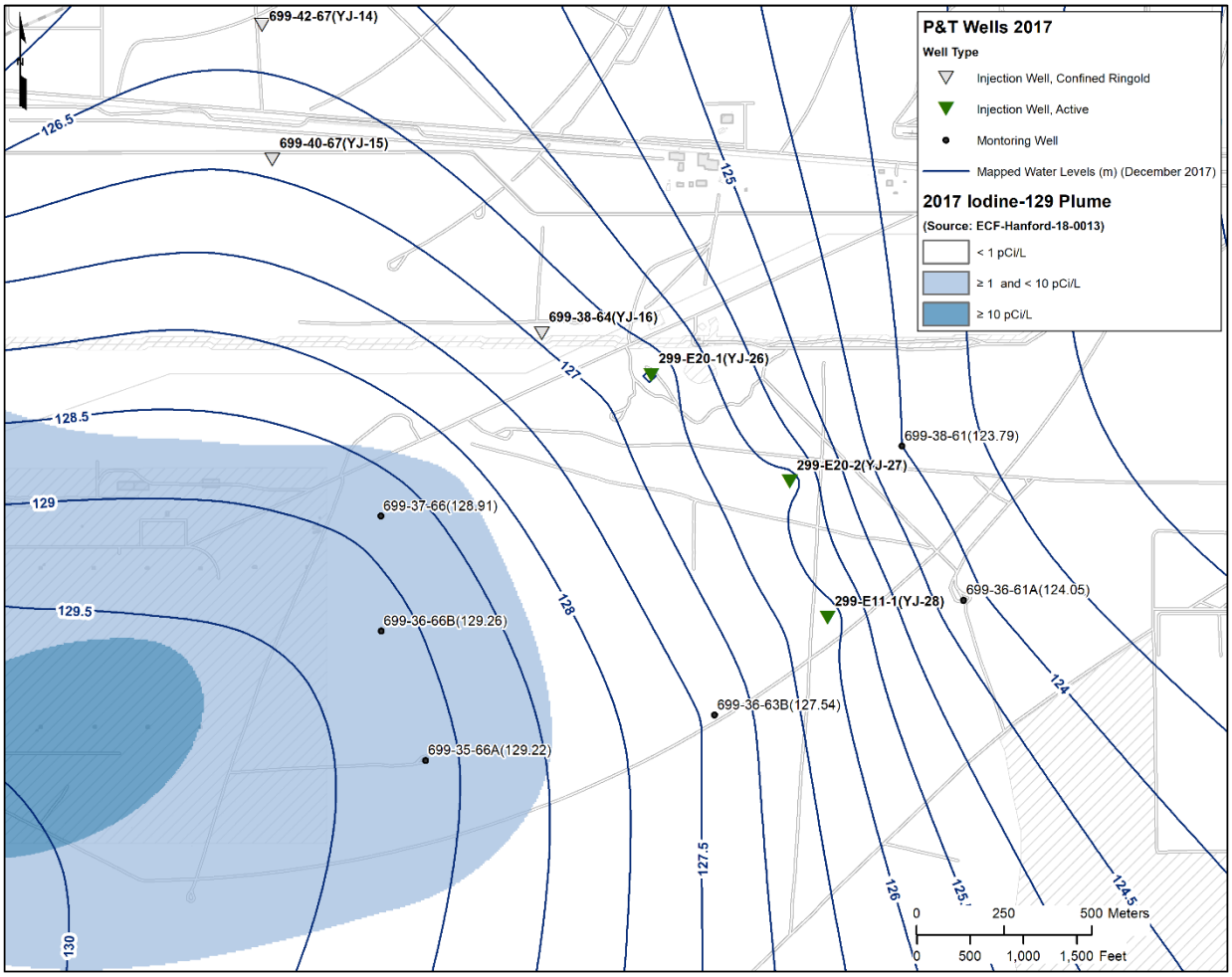


Figure 11-29. 200-UP Iodine-129 Plume Hydraulic Control Remedy Effect on Water Table

During 2017, flow rates in the injection wells met the design objective for most of the year. Each of the three injection wells operated at an average flow rate of 190 L/min (50 gal/min) or higher, thus meeting the design objective for hydraulic containment.

11.11.5 Monitored Natural Attenuation

MNA is specified in the interim action ROD (EPA et al., 2012) to be used in conjunction with active remedies (or as a standalone remedy, in the case of tritium) to achieve RAOs. Two primary MNA mechanisms have been identified for the 200-UP-1 OU: dispersion for all COCs, and radiological decay for tritium. These mechanisms are supported by the fate and transport modeling performed for the FS (Chapter 9 in DOE/RL-2009-122), which indicated that the portion of the plumes not affected by the planned active remedies will disperse (or decay) naturally to below cleanup levels.

MNA is evaluated statistically by calculating the upper one-sided 95% confidence limit on the mean of the plume concentrations, as specified in Section 2.3 of the RD/RAWP (DOE/RL-2013-07). The initial set of wells used for these calculations is specified in the performance monitoring plan (Chapter 3 in DOE/RL-2015-14). Methods and results of these calculations are reported in DOE/RL-2018-67.

11.11.6 Environmental Restoration Disposal Facility Monitoring

ERDF is a low-level radioactive mixed waste facility used to dispose solid waste from remedial actions on the Hanford Site. The facility consists of 10 disposal cells, 6 of which were active during 2017. Each disposal cell was constructed with a double-liner system to collect leachate from natural precipitation and water added as a dust suppressant. Leachate collected is sent to the 200 West P&T. During 2017, 260,300 metric tons (286,900 tons) of remediation waste containing 8,260 Ci of radioactivity were disposed at the facility.

Groundwater monitoring at ERDF is regulated under a CERCLA ROD (EPA/ROD/R10-95/100, *EPA Superfund Record of Decision: Hanford 200-Area (USDOE) Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County*), 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. Detailed discussion of leachate and groundwater sampling are provided in an annual summary report (e.g., WCH-633, *Groundwater, Leachate, and Lysimeter Monitoring and Sampling at the Environmental Restoration Disposal Facility, Calendar Year 2015*).

11.11.6.1 Leachate Monitoring

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 treatment facility. Periodic sampling and analyses of ERDF leachate is performed to ensure that the leachate maintains its delisting status and meets treatment acceptance criteria, and to assess whether additional analytes should be added to the routine groundwater monitoring program. Details of the sampling and analysis program for the leachate are provided in WCH-173, *Environmental Restoration Disposal Facility Leachate Sampling and Analysis Plan*.

Results of leachate sampling during 2017 indicated that no analytes need to be added to the groundwater monitoring program. Beginning in 2016, sampling was increased from semiannually to quarterly to provide additional data for the treatment facility. Sampling occurred in February, May, July, and November 2017. The July samples were analyzed for the biennial extended analysis list (more than 300 analytes). The other samples were analyzed for the routine list of approximately 50 constituents. None of the analytes exceeded a delisting level, and significant changes were not noted. Chromium remained above one-tenth of the Cr(VI) delisting level and continues to have an overall increasing trend. Nitrate concentrations remained greater than one-tenth of the delisting value, as they have since monitoring began.

11.11.6.2 Groundwater Sampling

Groundwater monitoring at ERDF is performed in accordance with CP-60092, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility, formerly WCH-198 Rev. 1*. The groundwater flow direction is toward the east-northeast (Figure 11-30). One upgradient well (699-36-70A) and three downgradient wells (699-37-66, 699-36-66B, and 699-35-66A) are sampled semiannually, typically in March and September. To detect potential impacts to groundwater quality, sample results are compared to baseline conditions established when monitoring began in 1996 using a tolerance interval approach (Appendix B in CP-60092). All monitoring wells were sampled successfully during 2017.

The results of groundwater monitoring at ERDF continued to indicate that the facility has not affected groundwater quality. Several constituents (tritium, iodine-29, nitrate, and carbon tetrachloride) are present in groundwater near or above the 200-UP-1 OU cleanup levels, but these constituents are elevated in both upgradient and downgradient wells. The plumes originated in the 200 West Area and have migrated toward ERDF. The majority of the analytes have remained essentially on trend, and no significant changes were noted in 2017.

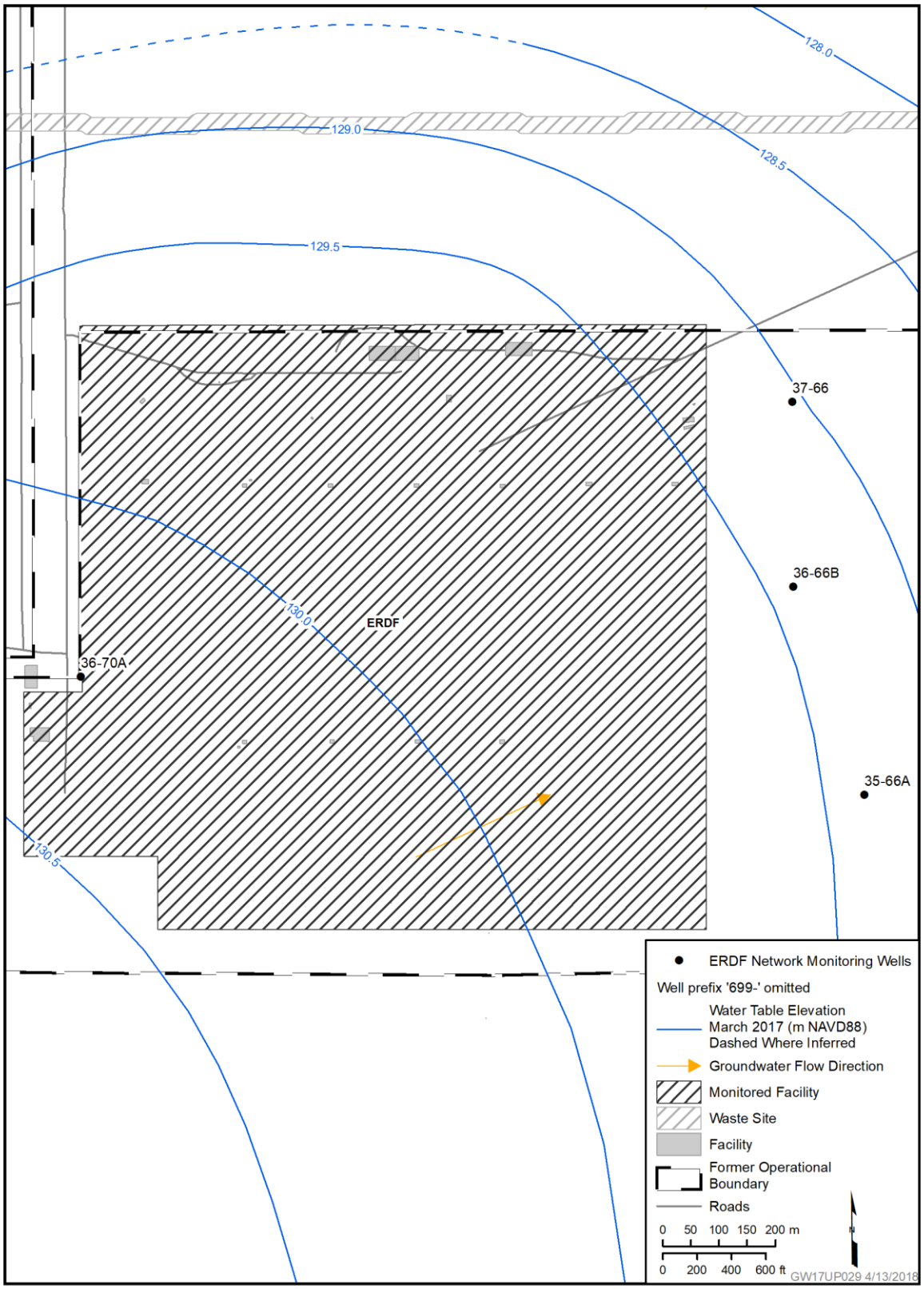
Uranium concentrations for all wells were consistent with Hanford Site background levels. Technetium-99 and gross beta concentrations are trending downward in the upgradient well and remained stable to trending downward in downgradient wells. Technetium-99 and gross beta (affected by technetium-99) in downgradient well 699-35-66A continued to show an upward trend from the low concentration detected in 2012. The maximum technetium-99 results remain approximately 15% of the 200-UP-1 OU cleanup level.

Chromium concentrations remained stable in the downgradient wells. Chromium levels in downgradient well 699-35-66A remained above the established upper tolerance value but below recent maxima. Maintenance and cleaning activities at well 699-36-70A appear to have returned analytical results for metals to pre-2013 stable levels.

11.12 RCRA Monitoring

DOE/RL-2017-65 presents the results of RCRA monitoring on the Hanford Site in 2017. The following sections describe the results of monitoring in accordance with RCRA regulations at three individual WMAs within 200-UP: WMA S-SX, WMA U, and the 216-S-10 Pond and Ditch. 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).

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 are also available from the PNNL PHOENIX system (http://phoenix.pnnl.gov/).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 11-30. 200-UP ERDF Monitoring Well Locations

11.12.1 Waste Management Area S-SX

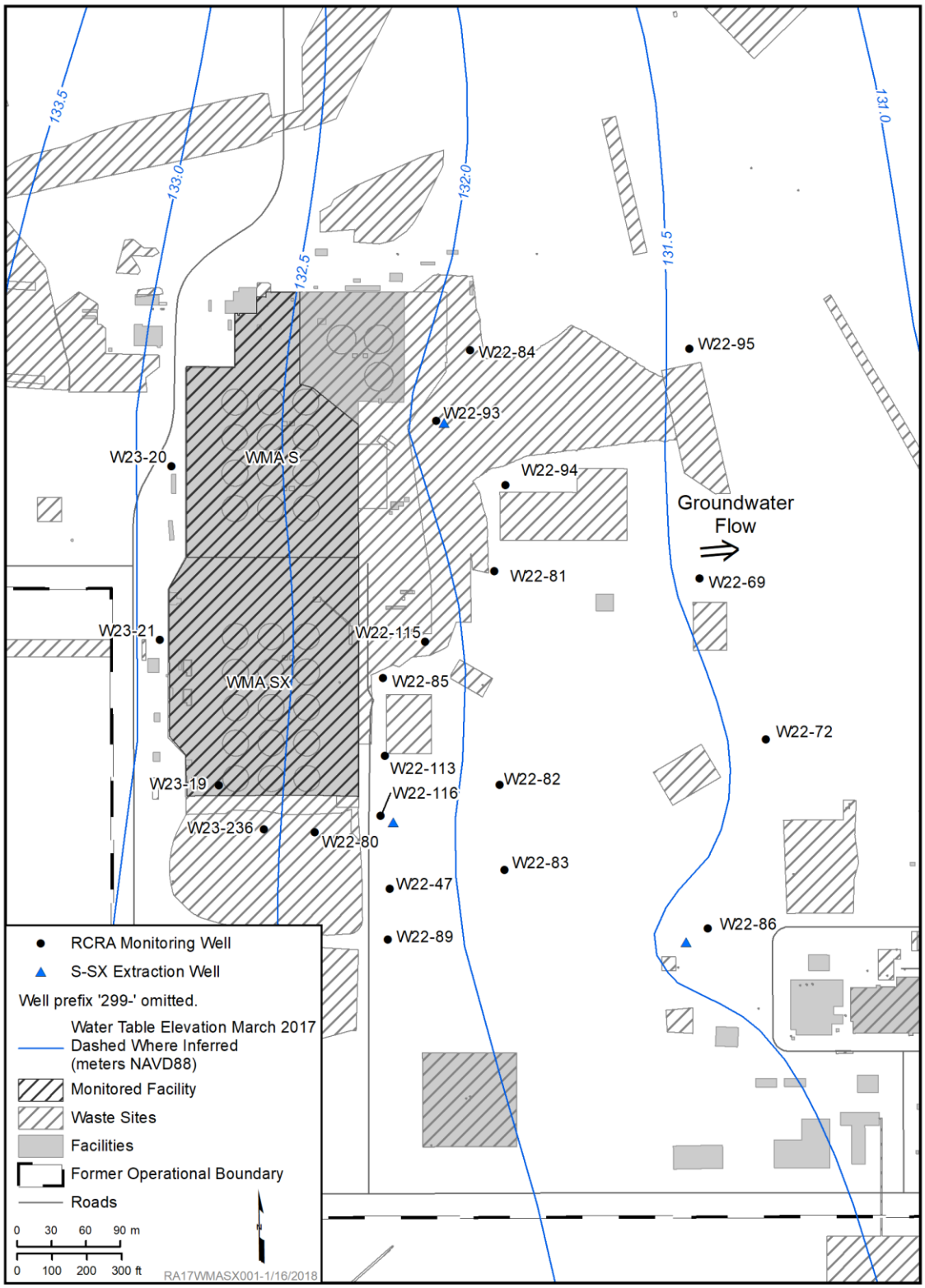
WMA S-SX (Figure 11-31) consists of the S and the SX Tank Farms. The S Tank Farm contains 12 SSTs, each with a capacity of 2.9 million L (758,000 gal). The SX Tank Farm contains 15 SSTs, each with a capacity of 3.8 million L (1,000,000 gal) (Section 1.2 of RPP-7884, *Field Investigation Report for Waste Management Area S-SX*). The WMA also includes the following ancillary equipment: 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 from the REDOX Plant in the 1950s and 1960s. To minimize the probability and severity of future leaks, most of the drainable liquid in each tank has been removed and transferred to DSTs.

In 1996, at the direction of Ecology, 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 chromium (Chapter 5.0 in PNNL-11810). Monitoring is currently performed under DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*. The objective of RCRA monitoring at WMA S-SX is to assess the extent and concentration of the dangerous waste constituent chromium in the groundwater and determine its rate of movement.

Table B-81 in Appendix B lists the monitoring wells for WMA S-SX. Based on the well distribution compared to the extent of contamination, the current well network is capable of monitoring the contamination distribution at WMA S-SX. All wells were sampled as required in 2017, and the WMA will remain in interim status groundwater quality assessment monitoring for 2018.

Water levels in the wells declined an average of 22 cm (8.7 in.) during 2017. This was greater than in 2016, when the decline was 18 cm (7.1 in.). The groundwater extraction system operating at WMA S-SX and the 200 West Area P&T system operated at a higher average rates during 2017, which may have contributed to the higher average decline in the local water level. Trend surface analyses performed on water-level measurements collected during March 2017 resulted in an estimated hydraulic gradient of 3.0×10^{-3} m/m toward the east (91 degrees azimuth). The estimated groundwater flow rate in 2017 was 0.15 m/d (0.49 ft/d) (Table B-82 in Appendix B), consistent with the 2016 value of 0.18 m/d (0.59 ft/d).

Table B-83 in Appendix B summarizes the assessment data. Groundwater beneath WMA S-SX is contaminated with the dangerous waste constituent chromium at levels above the DWS. The chromium is attributed to a 91,000 L (24,000 gal) overfill event from tank S-104 in the S Tank Farm (Sections 3.7.2 and 4.6 in RPP-RPT-48589) 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). Cr(VI) analysis is not required by the monitoring plan, but available data show concentrations about the same as total chromium. Because dissolved chromium is highly mobile in the aquifer, it migrates to the east at the same average flow rate as groundwater (0.15 m/d [0.49 ft/d]). Depth-discrete sampling while drilling well 299-W22-47 indicated that chromium was present within the upper 20 m (65 ft) of the aquifer.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 11-31. Waste Management Area S-SX

Groundwater extraction wells (Figure 11-31) have altered chromium plume migration. Instead of moving eastward, some of the chromium is drawn into the extraction wells. The groundwater extraction system has caused chromium concentrations to decline in several network wells. Of the six wells with baseline chromium concentrations above the 48 µg/L 200-UP-1 OU cleanup level prior to P&T, concentrations decreased in wells 299-W22-47, 299-W22-83, 299-W22-86, 299-W22-93, and 299-W22-116.
The chromium concentration in well 299-W22-95 increased between 2013 and 2016 and then leveled off in 2017 (54.7 and 52 µg/L in filtered and unfiltered samples). The increase in concentrations is consistent with downgradient migration of the S Tank Farm portion of the plume. At well 299-W23-19 inside the SX Tank Farm, the chromium concentration increased from 168 µg/L in December 2016 to 190 µg/L in December 2017 (Figure 11-32). The increase in well 299-W23-19 indicates that chromium is migrating downward through the vadose zone as a continuing source. At well 299-W22-93, directly downgradient of the S Tank Farm, the chromium concentration has been steady over the past few years (145 µg/L in December 2017), consistent with a continuing source.

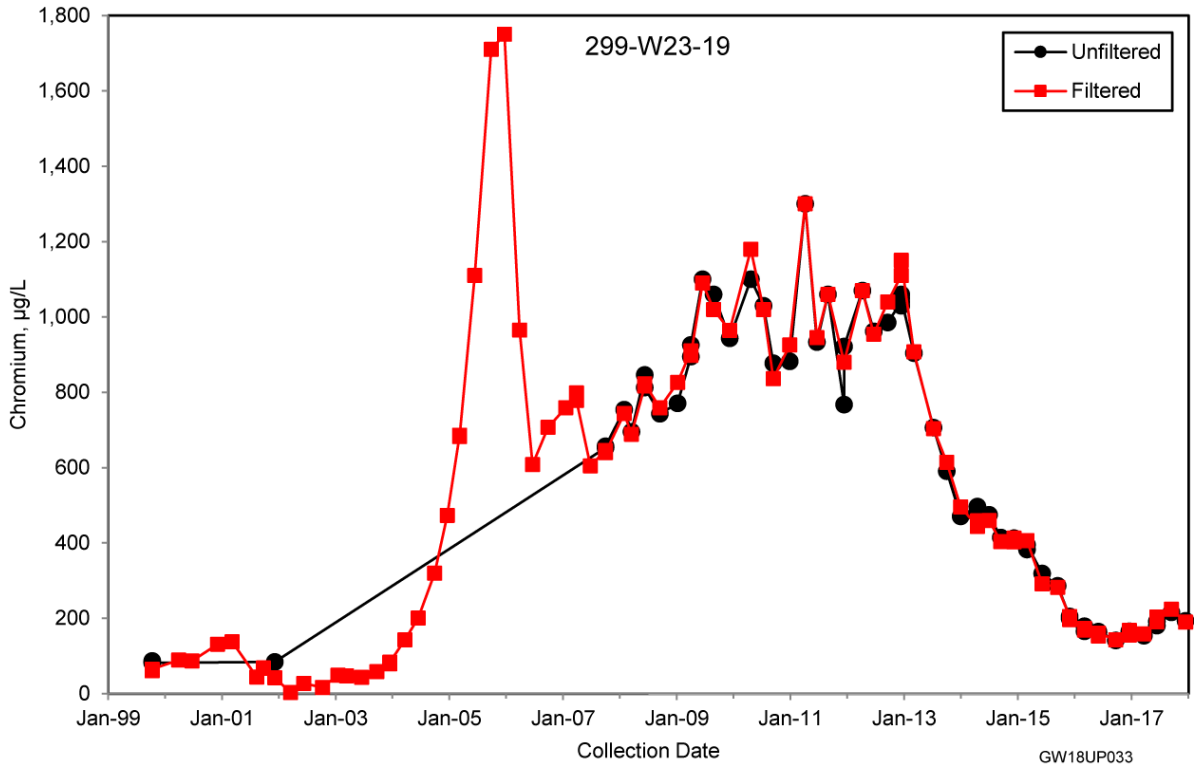
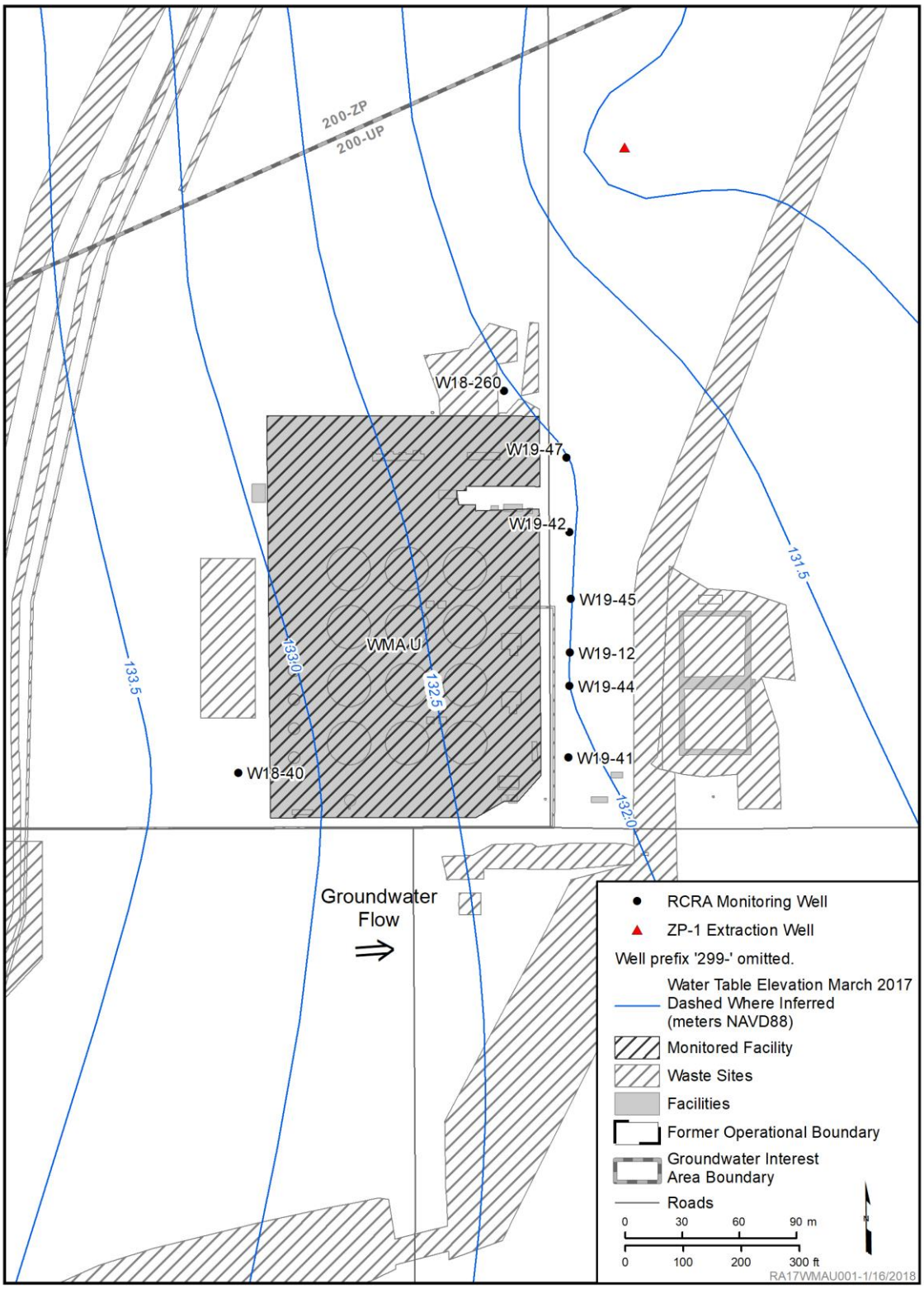


Figure 11-32. Chromium Concentration in Well 299-W23-19 in WMA S-SX

Manganese concentrations exceeded the secondary DWS in wells 299-W22-81 and 299-W23-21. Samples had high turbidity and elevated iron concentrations, and the wells will be cleaned in 2018. Five wells had nitrate concentrations above the DWS equivalent due to a regional contaminant plume.

11.12.2 Waste Management Area U

WMA U (Figure 11-33) contains 16 underground SSTs constructed between 1943 and 1944. Twelve SSTs have 2 million L (535,000 gal) capacities, and four have 210,000 L (55,000 gal) capacities (Section 1.2 of RPP-35485, *Field Investigation Report for Waste Management Area U*). The WMA also has a variety of ancillary equipment, 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.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 11-33. Waste Management Area U

WMA U 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 242T 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, most of the drainable liquid in each tank has been removed and transferred to DSTs.

WMA U was placed into assessment status in 2000 when specific conductance in downgradient WMA monitoring wells exceeded upgradient levels. An assessment of that finding in 2000 determined that the WMA had affected groundwater quality based on elevated nitrate and possibly chromium in downgradient wells (Chapter 6.0 in PNNL-13282). However, these contaminants were below their respective DWSs, and the affected area was limited to the southeastern corner of the WMA.

Groundwater at WMA U is currently monitored under DOE/RL-2009-74, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*. The objective of RCRA monitoring at WMA U is to assess the extent and concentrations of the dangerous waste constituent chromium in the groundwater and determine its rate of migration. Table B-90 in Appendix B lists the network wells, as well as the screen intervals and water-level information.

Groundwater flow beneath WMA U is affected by the 200 West Area P&T system. Trend surface analysis was performed on water-level measurements at WMA U during March 2017, and the hydraulic gradient magnitude was 7.1×10^{-3} m/m (Table B-91 in Appendix B), which is higher than the 2016 average of 5.0×10^{-3} m/m and the 2015 average of 5.2×10^{-3} m/m. Extraction well 299-W17-3 is 150 m (490 ft) north-northeast of the WMA. Flow rates in this well increased from an average of 320 to 424 L/min (85 to 112 gal/min) during the 4 months prior to March 2017, and the resulting increase in drawdown may account for the increased gradient at WMA U. In response to pumping in this well, the flow direction beneath the WMA was expected to turn toward the northeast, but the average 2017 direction was similar to previous years (east at 82 degrees azimuth). The estimated 2017 flow rate of 0.35 m/d (1.2 ft/d) is higher than the 2016 rate of 0.18 m/d (0.58 ft/d) due to the increased hydraulic gradient magnitude.

Water levels in the monitoring wells declined an average of 21 cm (8.3 in.) in 2017. This is less than the average decline of 37 cm (15 in.) in 2016. The reduced rate of decline is due to normal water-level responses to operation of the 200 West Area P&T system during 2017. Based on the well distribution at the WMA and the groundwater flow direction, the well network is currently capable of monitoring the distribution of dangerous waste contamination from the WMA.

Table B-90 in Appendix B provides a list of wells monitored at WMA U. All required sampling was performed successfully during 2017. Table B-92 in Appendix B summarizes the sampling results.

The dangerous waste constituent chromium is present in the groundwater at WMA U. During 2017, the highest chromium concentration (98.4 µg/L) was in an unfiltered sample from well 299-W19-12. The highest concentration in a filtered sample was 20.4 µg/L in well 299-W19-45. The filtered concentration in upgradient well 299-W18-40 was 7.5 µg/L. The WMA U is the source of groundwater contamination limited to the downgradient (east) side of the tank farm (Chapter 6.0 in PNNL-13282).

Chromium may be present at WMA U as a groundwater contaminant and as a result of stainless-steel well screen corrosion. Many of the network wells have elevated iron, manganese, and nickel, which (along with chromium) are the primary components of 304 stainless steel used to construct the network wells. In particular, nickel is a good indicator of stainless-steel corrosion because its natural concentration in Hanford Site groundwater is very low (90th percentile background is 1.56 µg/L [DOE/RL-96-61]). In wells 299-W19-45 and 299-W19-47, nickel is not routinely detected, and chromium concentrations

ranged from 14.9 to 21.1 µg/L in well 299-W19-45 and from 5.06 to 7.6 µg/L in well 299-W19-47. The lack of nickel in these wells indicates that the chromium is from groundwater contamination and not screen corrosion.

While dissolved chromium is highly mobile in the aquifer, it can migrate more slowly than the movement of moisture in the vadose zone beneath the tank farms at least initially following release from a tank. 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 Cr(VI), 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 reaction may explain the current low concentrations of chromium in the groundwater. In the aquifer, dissolved chromium migrates to the east at the calculated groundwater flow rate of 0.35 m/d (1.2 ft/d).

Concentrations of the nondangerous constituent nitrate are above 45 mg/L in all network wells, including the upgradient well. The upgradient nitrate source is treated water injected into wells formerly used for the 200-ZP-1 OU interim action P&T system. The injected water was treated for VOCs but still contained nitrate (Section 3.3.5 of DOE/RL-2011-118). Because nitrate in some downgradient wells is higher than the upgradient well, it is likely that WMA U is also a source of nitrate to the groundwater.

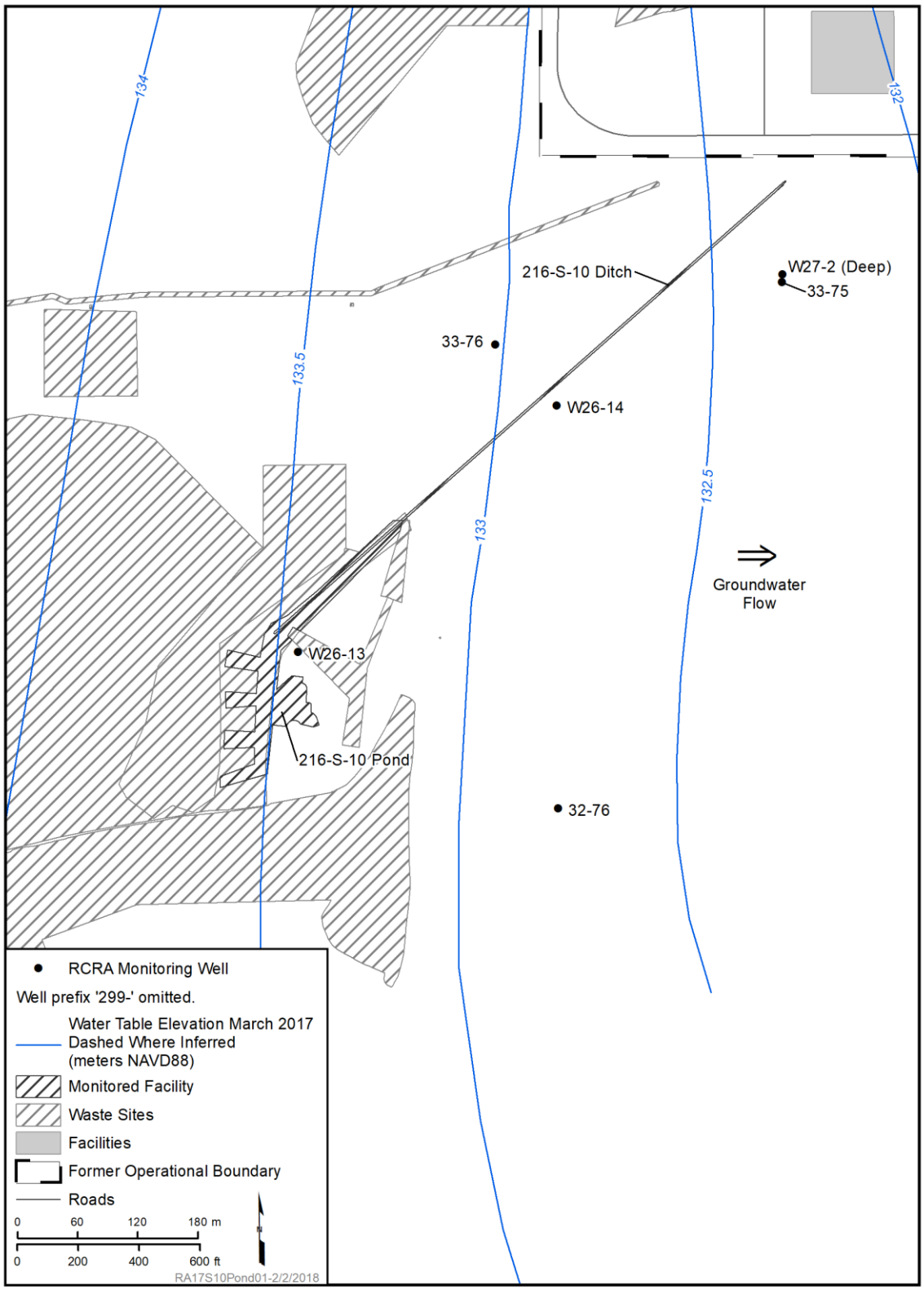
11.12.3 216-S-10 Pond and Ditch

The 216-S-10 Pond and Ditch, located outside the southwestern corner of the 200 West Area, comprised 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 0.748 ha (1.82 ac). The pond was shaped like a backward "E" with an extra leg, where each leg was a separate leaching trench. The ditch was also connected to the 216-S-11 Pond between 1954 and 1965, which was an overflow pond to accommodate excess discharges. During its active life from 1951 to 1991, the site received 6.6 billion L (1.7 billion gal) of effluent from the REDOX Plant chemical sewer. Figure 11-34 shows the major site features and monitoring well locations.

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, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*). Rev. 0 of the plan was in effect through May 2017, and DOE/RL-2008-61, Rev. 1 was implemented in June 2017. The monitoring well network consists of an upgradient well, four downgradient wells screened in the upper portion of the aquifer at the water table, and a downgradient well screened 50 m (164 ft) below the water table (Table B-37 in Appendix B).

Table B-38 in Appendix B summarizes groundwater flow beneath the 216-S-10 Pond and Ditch. The hydraulic gradient was determined by trend surface analysis using water-level measurements collected during March 2017 from five wells. The calculated flow direction was east (101 degrees azimuth), the hydraulic gradient magnitude was 2.8×10^{-3} m/m, and the estimated velocity was 0.14 m/d (0.46 ft/d). Water levels in the network wells declined at an average rate of 28 cm/yr (11 in./yr) from 2012 to 2017. Based on the calculated groundwater flow direction, the monitoring well network remains capable of detecting constituents migrating from 216-S-10 into the uppermost aquifer.

All of the network wells were sampled as planned in 2017. The wells completed at the water table were sampled twice for RCRA contamination indicator parameters (pH, specific conductance, TOC, and TOX; Table B-39 in Appendix B), and once for groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate) (Table B-40 in Appendix B). The groundwater was also sampled for site-specific analytes (Table B-40 in Appendix B).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 11-34. 216-S-10 Pond and Ditch

No indicator parameter critical mean exceedances occurred in 2017. Between 2007 and 2012, specific conductance generally trended upward in well 299-W26-13, from annual average values of 270 to 310 µS/cm. This increasing trend correlated to increasing chromium and nitrate concentrations. From 2012 through 2017, specific conductance has been relatively stable, consistent with a stable to slightly declining nitrate trend.

Chromium concentrations in well 299-W26-13 continued to exceed the 100 µg/L total chromium DWS in 2017 (158 µg/L maximum in May). The 216-S-10 Pond and Ditch system was the most substantial source of chromium in this area (Appendix C in RPP-26744), but other sources of chromium (216-S-5 Crib, 216-S-6 Crib, 216-S-11, 216-S-16, and 216-S-17 Ponds, and associated ditches) also exist. In particular, the 216-S-11 overflow pond received some of the same waste as 216-S-10 but is not part of the RCRA unit.

The network monitoring wells routinely show low to nondetected levels of TOX. The highest average concentration from quadruplicate samples was in downgradient well 699-32-76 (6.88 µg/L in November 2017), below the critical mean (42.44 µg/L). The TOX detections are attributed to carbon tetrachloride in several 216-S-10 wells. Well 699-33-75 had the highest carbon tetrachloride concentration in the network (5.42 µg/L in 2017), which exceeds the 3.4 µg/L cleanup level for the 200-UP-1 OU. Carbon tetrachloride was also detected in upgradient well 699-33-76 (3.20 µg/L in 2017). This constituent does not originate from 216-S-10; carbon tetrachloride is widespread in the groundwater beneath and near the 200 West Area and originates from waste disposal sites at PFP (Chapter 12 in DOE/RL-2016-09).

Concentrations of chromium (unfiltered), iron (unfiltered), manganese (unfiltered), and nickel (filtered and unfiltered) continue to be elevated in deep well 299-W27-2. These constituents are stainless-steel corrosion products, and this well has stainless-steel components. A downhole video of the well screen confirmed corrosion in this well. Chromium analysis completed in 2017 included filtered and unfiltered total chromium, as well as filtered and unfiltered hexavalent chromium (Cr(VI)). Total chromium analysis provides a summation of both trivalent chromium and mobile Cr(VI). Similar to the 2016 analysis results, the elevated chromium identified in well 299-W27-2 during 2017 comprised primarily undissolved trivalent chromium. Results for filtered total chromium and both filtered and unfiltered Cr(VI) were near or below the detection limits. The presence of undissolved trivalent chromium is consistent with well corrosion and does not indicate the presence of a Cr(VI) plume at 216-S-10.

Iron exceeded the secondary DWS in an unfiltered sample from well 299-W27-2 in 2017. The sample also had elevated total chromium, which is consistent with values attributable to well corrosion.

11.13 Atomic Energy Act Monitoring

AEA groundwater monitoring was conducted at 83 groundwater wells in the 200-UP groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 200-UP are iodine-129, nitrate, technetium-99, tritium, and uranium. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Eight wells were not sampled in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues, dry wells, weather conditions, well access issues, and scheduling constraints. One significant exception to the monitoring network was made to remove the canceled well 299-W22-123 from the network and schedule.

Radionuclide concentrations detected in groundwater samples from 97 wells[1] were used to estimate the cumulative TED and to compare to cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED exceeded the 100 mrem/yr standard at one groundwater well in 200-UP (Table 11-15). The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 40 locations in this interest area. No locations exceeded the DWSs for cumulative or net alpha emitters. The uranium mass DWS of 30 µg/L was exceeded at 10 locations. None of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater and through remedial action measures (e.g., P&T) to control the migration of contaminated groundwater to exposure points.

Table 11-15. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-UP in 2017

Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L	
	Min.	Max.	Min.	Max.	Min.	Max.
299-W18-260			9.87	9.87		
299-W19-101					82.95	82.95
299-W19-113			5.26	10.43	109.00	169.00
299-W19-114			5.00	5.78		
299-W19-115			11.74	20.28	360.00	510.00
299-W19-116			8.16	12.19		
299-W19-12			10.44	10.44		
299-W19-123			4.17	11.73	69.00	69.00
299-W19-36	543.61	543.61	41.33	41.96	2500.00	5139.15
299-W19-39					37.70	37.70
299-W19-42			5.38	5.38		
299-W19-43					108.00	119.00
299-W19-45			60.89	60.89		
299-W19-47			9.11	10.67		
299-W19-48					35.25	35.25
299-W21-3			90.42	101.70		
299-W22-10			24.73	24.73		
299-W22-113			9.34	9.44		
299-W22-114			18.00	22.16		
299-W22-115			19.64	22.19		

[1] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

Table 11-15. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-UP in 2017

Well Name	Cumulative Total Effective Dose ≥100 mrem/yr		Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr		Cumulative Uranium Mass ≥30 µg/L	
	Min.	Max.	Min.	Max.	Min.	Max.
299-W22-116			41.32	49.78		
299-W22-24P			20.44	20.44		
299-W22-81			6.18	6.18		
299-W22-82			11.30	11.30		
299-W22-83			13.82	13.82		
299-W22-85			17.32	17.32		
299-W22-86			8.26	8.26		
299-W22-88			4.24	4.24		
299-W22-91			12.91	19.51		
299-W22-92			6.86	9.24		
299-W22-93			7.42	8.98		
299-W22-96			12.44	12.44		
299-W23-19			62.79	62.79		
299-W23-4			12.63	12.63		
699-30-73					33.00	33.00
699-31-68			4.06	4.26	147.00	147.00
699-32-72A			7.58	7.58		
699-35-66A			15.64	24.81		
699-36-61A			10.72	10.72		
699-36-63B			21.12	25.00		
699-36-66B			24.10	57.09		
699-36-70A			38.82	55.35		
699-37-66			5.45	16.96		
699-38-61			12.34	12.34		
699-38-70C			5.97	5.97		

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Notes: Blank cells indicate no exceedances.

None of the wells in 200-UP had cumulative alpha activity ≥15 pCi/L.

The AEA groundwater monitoring is integrated with existing performance assessment monitoring for the ERDF. Iodine-129, tritium, and nitrate concentrations exceeded DWSs in 2017. Tritium concentrations continued to decline for all wells except 699-36-70A, where values remained stable. Iodine-129 values fluctuate but have generally increased. Gross beta concentrations at wells 699-35-66A and 699-37-66 exceeded 50% of the DWS. Increased values at well 699-37-66 are attributed to differing laboratory methods for samples sent out in 2017. Two gross beta results for well 699-35-66A were estimated values and flagged as “J+.” Nitrate exceeded DWSs at well 699-37-66 and generally remained stable for 2017. All other radionuclide concentrations were either nondetect or detected below 50% of the DWS.

12 200-ZP

This chapter presents information for the 200-ZP groundwater interest area, including an overview; a discussion of CERCLA-, RCRA-, and AEA-related groundwater activities conducted in 2017; and a summary of the 2017 groundwater monitoring results.

12.1 Overview

The 200-ZP groundwater interest area is located in the northern and central portions of the 200 West Area and nearby portions of the 600 Area (Figure 1-1). It includes the 200-ZP-1 Groundwater OU, where activities focus on groundwater remediation, monitoring, and reporting. Figure 12-1 shows key facility areas and wells. Groundwater COCs include carbon tetrachloride, chromium (total and Cr(VI)), iodine-129, nitrate, technetium-99, TCE, and tritium (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*). Table 12-1 lists some key facts about 200-ZP. Section 1.5 provides plume mapping details, including descriptions of terms (e.g., Type 1 control point) used in the figure legends.

Carbon tetrachloride is the main COC in groundwater, forming a plume with an area greater than 20 km^2 (7.7 mi^2) that extends north, south, and east from the source areas. The primary sources were discharges of liquid waste from the PFP plutonium-separation processes to the 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches (Section 1.2.2 in DOE/RL-2010-13, *200 West Area Groundwater Pump-and-Treat Remedial Design Report*). Except for nitrate and tritium, the remaining contaminant plumes within 200-ZP are within the boundaries of the carbon tetrachloride plume. A P&T system is currently remediating groundwater in the 200 West Area (Section 12.10.2). Figure 12-2 illustrates changes in plume areas from 2003 to 2017.

Within 200-ZP, groundwater occurs in an unconfined aquifer (within Ringold unit E) and in confined aquifers (beneath the Ringold lower mud unit and in basalt interbeds) (Figure 1-6). The base of the unconfined aquifer is the fine-grained lower mud (where present) or the top of basalt (where the lower mud is absent). The lower mud is absent where the Ringold Formation sediments were eroded by Ice Age floods and subsequently filled with Hanford formation sediments (Figure 12-3). Depths to the water table in 200-ZP range from 64 to 106 m (210 to 350 ft), with the greatest depths in the northeastern portion of the groundwater interest area. The thickness of the unconfined aquifer ranges from 0 m where the mud is above the water table east of the 200 West Area to more than 70 m (230 ft) in the northwest. In areas where the lower mud is missing, carbon tetrachloride migrated into Ringold unit A. The contaminated groundwater then flows beneath the lower mud, contaminating the Ringold-confined aquifer.

Groundwater in the 200 West Area generally flows east (Figure 12-4) but is influenced by the 200 West P&T. The water table has declined since wastewater discharge to various cribs, ponds, and ditches ceased during the 1980s and 1990s. Section 3.2 of DOE/RL-2011-118 provides detailed discussions of 200-ZP geology and hydrogeology.

Groundwater in 200-ZP is monitored under CERCLA to assess the performance of the final remedy, as documented in the ROD (EPA et al., 2008); under RCRA at WMA T, WMA TX-TY, LLWMA-3 Burial Ground, and LLWMA-4 Burial Ground; and under the *Washington Administrative Code* at the SALDS. Radionuclide monitoring is performed in accordance with the AEA and CERCLA. Figure 12-1 shows the wells sampled in 2017.

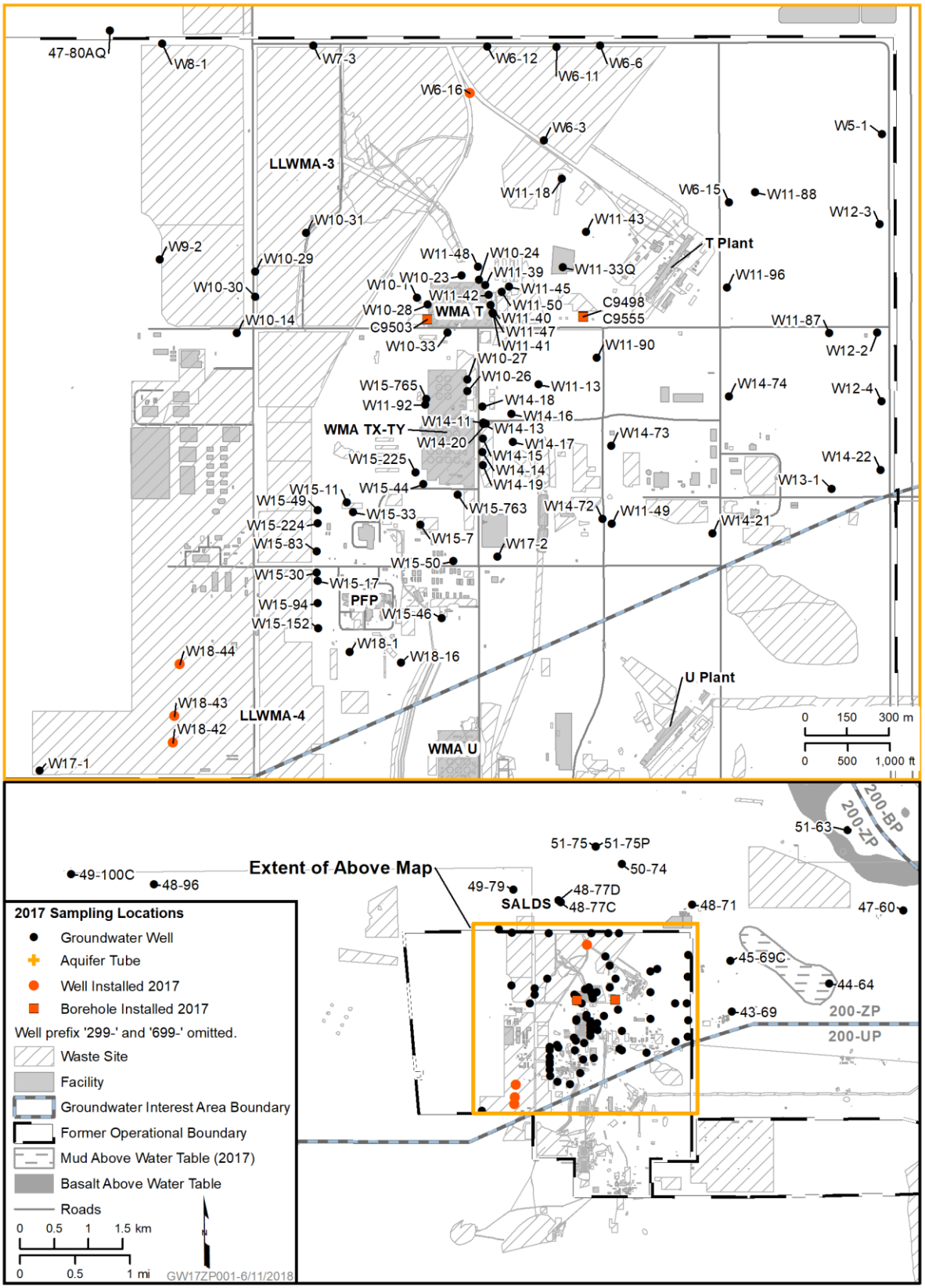


Figure 12-1. 200-ZP Sampling Locations, 2017

Table 12-1. 200-ZP at a Glance

T Plant operations: 1944 to 1956 (plutonium separation) **Plutonium Finishing Plant operations:** 1949 to 1989			
Groundwater Monitoring			
Contaminant, Cleanup Level,[a] Units	**Year**	**Maximum Concentration**	**Plume Area (km^2)**
Carbon tetrachloride, 3.4 µg/L	2017	1,960 (299-W11-87)	20.6
	2016	2,500 (299-W6-15)	19.9[b]
Hexavalent chromium, 48 µg/L	2017	160 (299-W11-43)	0.69
	2016	180 (299-W11-43)	0.79
Chromium (total), 100 µg/L	2017	463 (299-W14-16)	0.20
	2016	420 (299-W10-27)	0.21
Iodine-129, 1 pCi/L	2017	1.46 (299-W6-15)	0.20
	2016	1.2 (299-W14-11)	0.09
Nitrate, 45 mg/L	2017	620 (299-W14-16)	8.4
	2016	708 (299-W14-16)	7.8
Technetium-99, 900 pCi/L	2017	11,100 (299-W11-40)	0.04
	2016	10,700 (299-W14-13)	0.04
Trichloroethene, 1 µg/L	2017	16 (299-W14-72)	2.9
	2016	14 (299-W14-72)	1.6
Tritium, 20,000 pCi/L	2017	60,300 (699-48-77D)	0.14
	2016	58,800 (699-48-77D)	0.16
Remediation			
Soil vapor extraction: 1992 to 2012. **200-ZP-1 interim action P&T:** 1994 to 2012. **200 West P&T:** 2012 to present.			

a. From Table 11 of EPA et al., 2008 *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*

b. Area of full plume footprint (includes area within 200-UP and 200-ZP combined), all depths in unconfined aquifer, at >3.4 µg/L. The area greater than the 5 µg/L drinking water standard is 18.9 km^2 (7.3 mi^2).

P&T = pump and treat

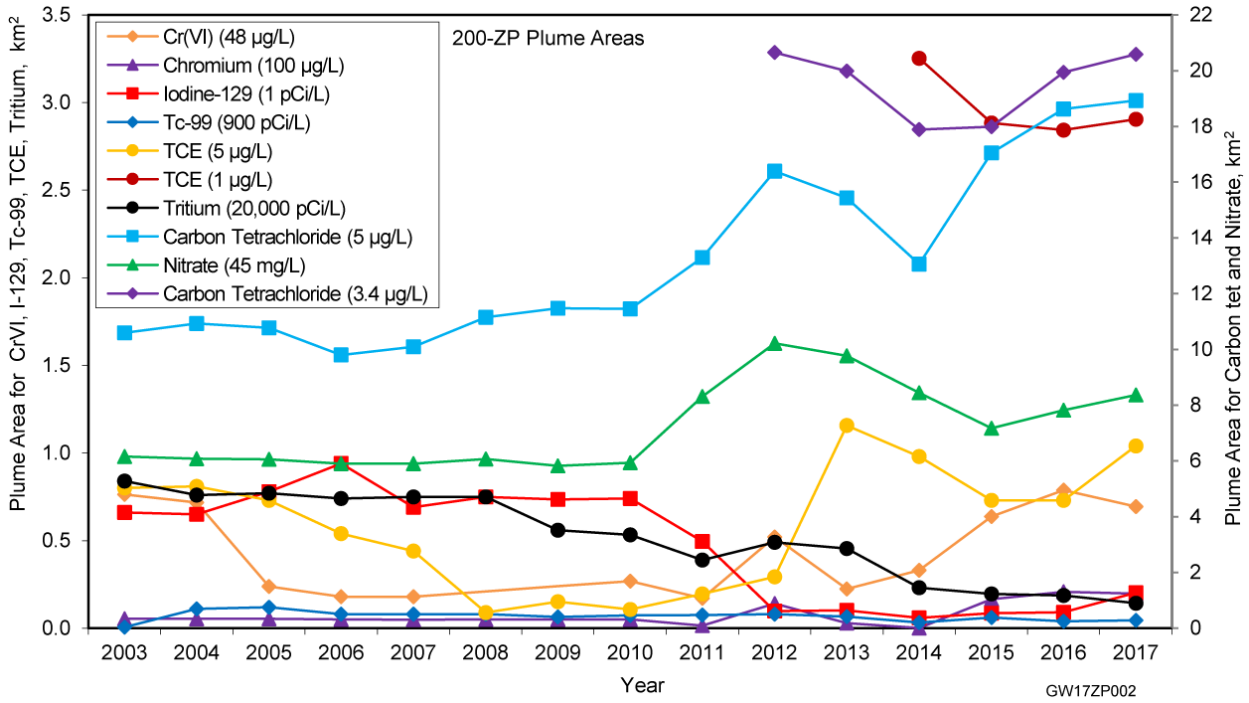
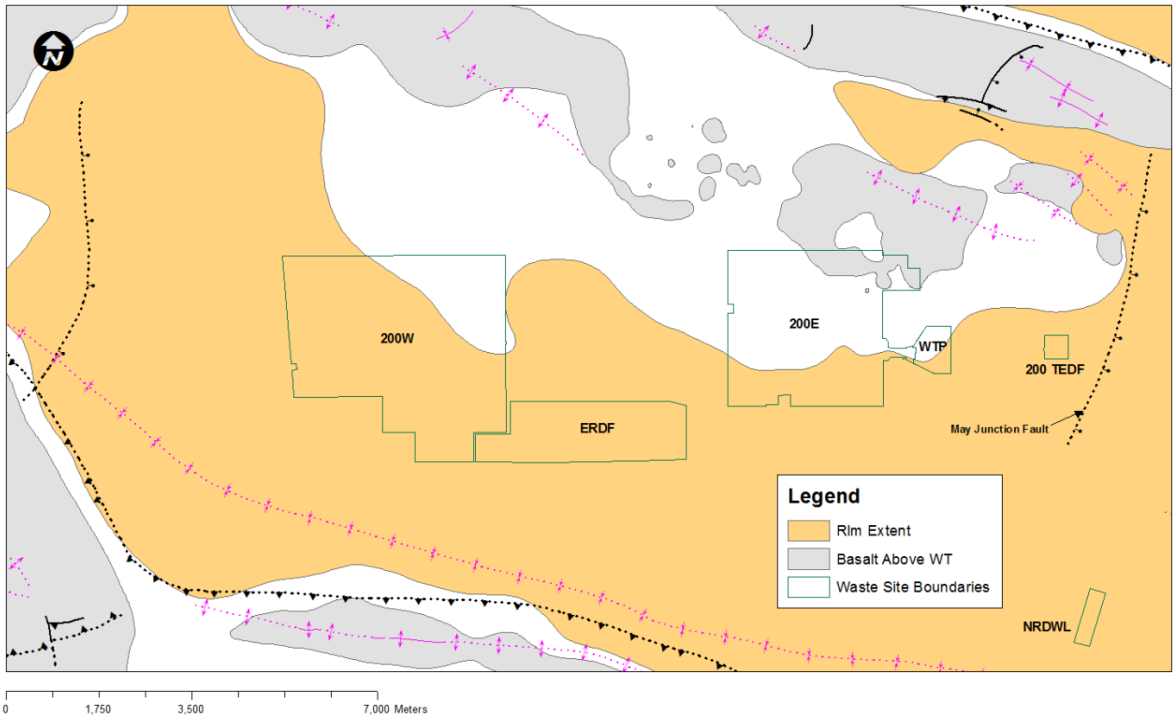
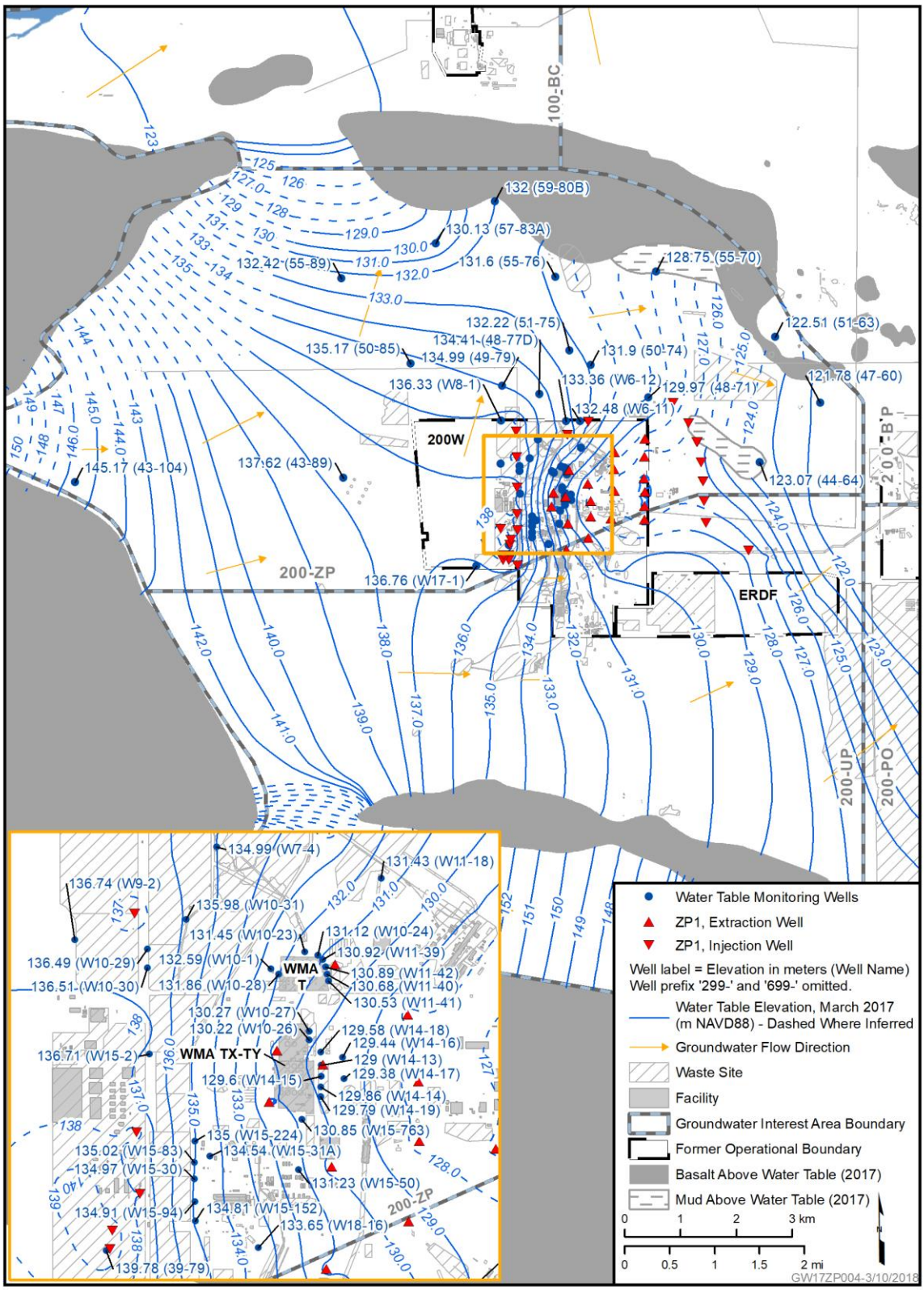


Figure 12-2. 200-ZP Plume Areas



Source: Geologic interpretations based on data from boreholes as documented in ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington, Fiscal Year 2016 Update*.

Figure 12-3. Extent of the Ringold Formation Lower Mud Unit



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 12-4. 200-ZP Water Table, March 2017

In some locations, the greatest concentrations of 200-ZP COCs occur near the bottom of the aquifer. The plume maps presented in this chapter are generally based on data from all wells, not only those screened in the upper part of the aquifer. If wells are paired (shallow/deep), the higher concentration is used for plume mapping. Plume mapping details are provided in ECF-HANFORD-18-0013.

12.2 Carbon Tetrachloride

Carbon tetrachloride exceeds the final cleanup level (3.4 µg/L) and the DWS (5 µg/L) under most of the 200 West Area (Figure 12-5). Investigations during well drilling revealed that in many locations, carbon tetrachloride contamination is present throughout the entire thickness of the unconfined and Ringold confined aquifers, not just the upper 15 m (50 ft). The plume interpretation considers all depths and is based on 2017 sampling data, sample data collected during drilling of new wells in previous years, and a computer model (ECF-200ZP1-16-0076, *Description of Groundwater Calculations and Assessments for the Calendar Year 2015 (CY 2015) 200 Areas Pump and Treat Report*). Initially, carbon tetrachloride concentrations exceeded 2,000 µg/L beneath PFP, but the high-concentration portion of the plume has responded to remediation by a P&T system (Section 12.10.2). The remedial action alternative for the portion of the plume beyond the influence of extraction wells is MNA. Figure 12-6 depicts a cut-away view of the three-dimensional plume simulation based on ECF-200ZP1-16-0076. Figure 12-7 illustrates the plume in the upper part of the aquifer in 1996 compared to the 2017 plume footprint.

As shown on the plume map (Figure 12-5), carbon tetrachloride extends to the east from the PFP source areas. Prior to startup of 200-ZP-1 interim actions in 1996, concentrations of carbon tetrachloride in 17 extraction wells and 23 monitoring wells exceeded 2,000 µg/L, and 20 of the wells exceeded 4,000 µg/L. During 2017, none of the wells exceeded 2,000 µg/L. In 2016, concentrations exceeded 2,000 µg/L in well 299-W11-87 (a monitoring well located next to extraction well 299-W12-2) and well 299-W6-15; however, concentrations declined to 1,960 and 1,210 µg/L, respectively, in 2017 (Figure 12-8). Seven other wells had carbon tetrachloride concentrations above 1,000 µg/L in 2017.

Carbon tetrachloride concentrations are declining where the highest concentrations formerly resided near PFP and west of the tank farms as a result of capture by extraction wells and natural attenuation (dispersion and degradation). For example, concentrations in well 299-W15-765 declined from 2,233 µg/L in 2012 to 32 µg/L in 2017 (a 99% decline). Concentrations in well 299-W14-11 declined from 1,700 µg/L in 2012 to 695 µg/L in 2017 (a 59% decline). The significant decline in the maximum carbon tetrachloride concentration (from 8,700 µg/L in 1990 to 1,960 µg/L in 2017) and the number of wells exceeding 2,000 µg/L (from 40 wells in 1990 to zero in 2017) demonstrates the effectiveness of remedial actions for carbon tetrachloride.

12.3 Chromium

Cr(VI) exceeds the final cleanup level (48 µg/L) downgradient of the SSTs at WMA T and WMA TX-TY (Figure 12-9). The highest concentration in 2017 was 160 µg/L in well 299-W11-43, about 500 m (1,600 ft) downgradient of WMA T. Groundwater extraction from wells 299-W11-50 and 299-W14-20 near the WMAs has caused concentrations to decline below the cleanup level in nearby monitoring wells (Figures 12-10 and 12-11). Concentrations in wells at the east side of the plume have increased in wells 299-W6-15, 299-W11-96, and 299-W14-74 (Figure 12-12). Chromium sources include past leaks from SSTs.

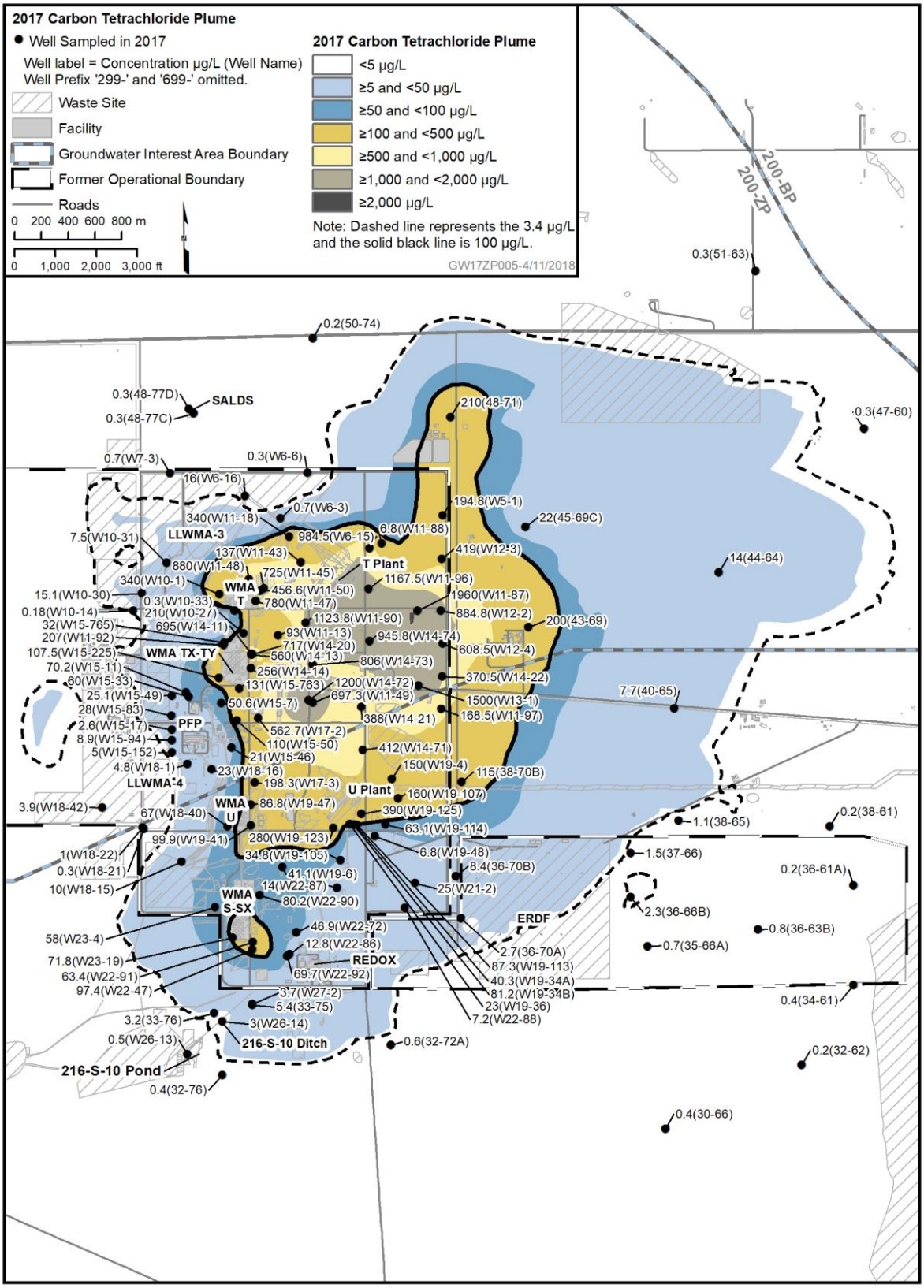


Figure 12-5. 200-ZP Carbon Tetrachloride Plume, 2017

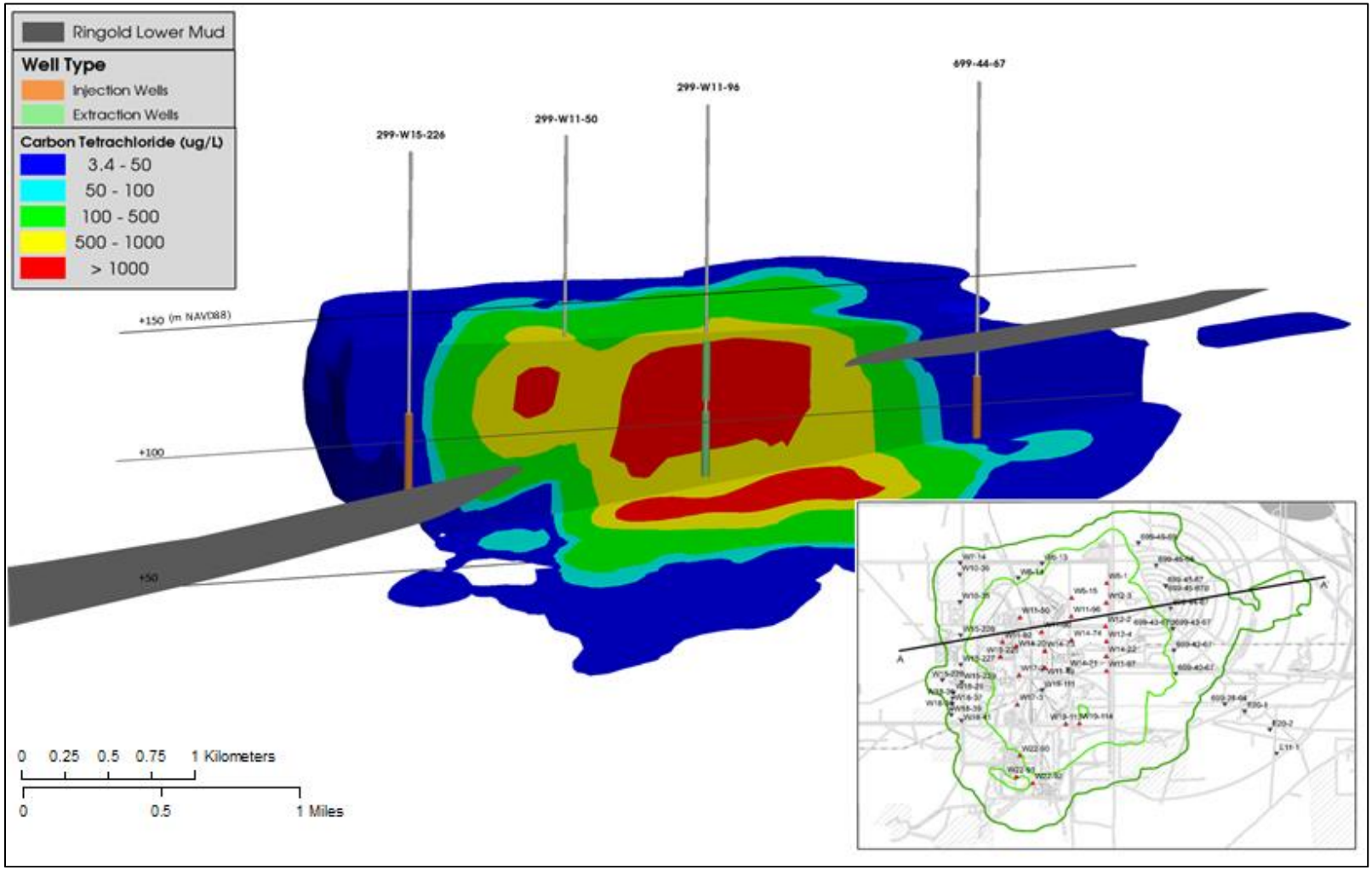


Figure 12-6. 200-ZP Cut-Away View of the Three-Dimensional Carbon Tetrachloride Plume Simulation, 2015

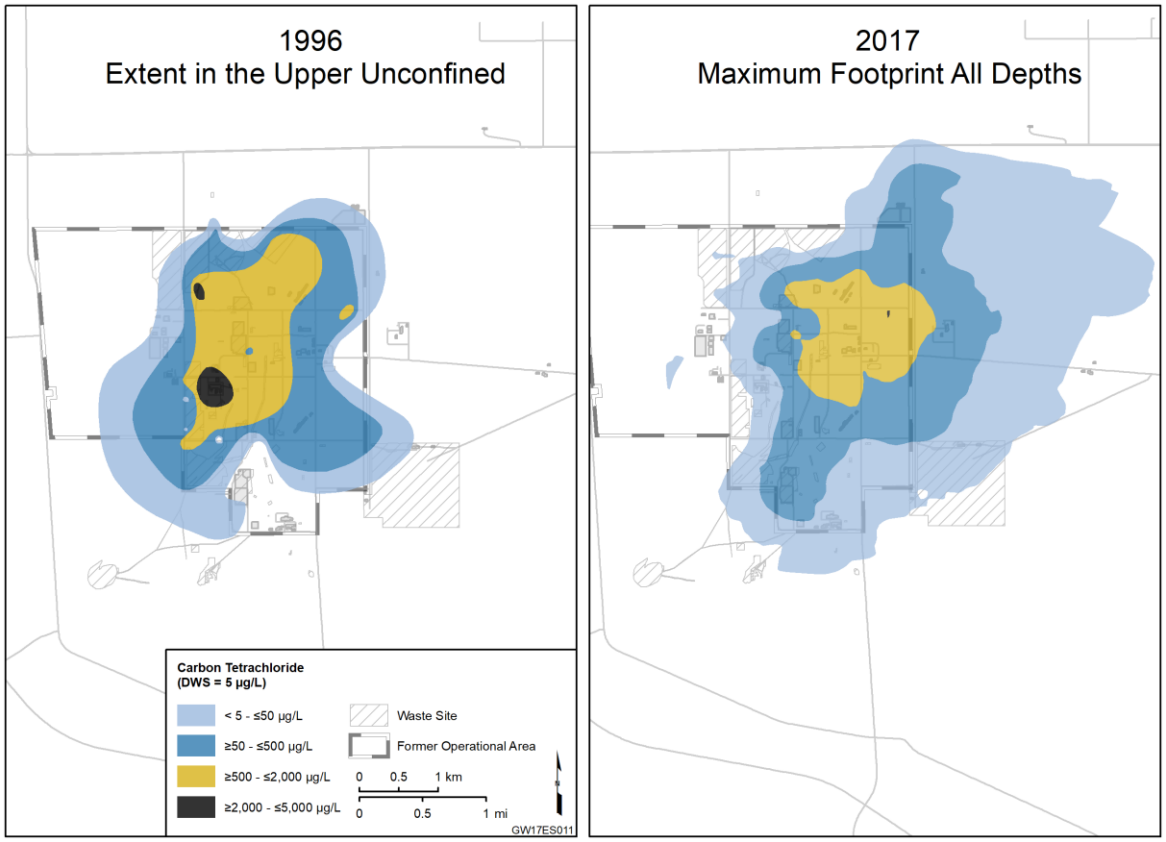


Figure 12-7. 200 West Carbon Tetrachloride Plume in 1996 and 2017

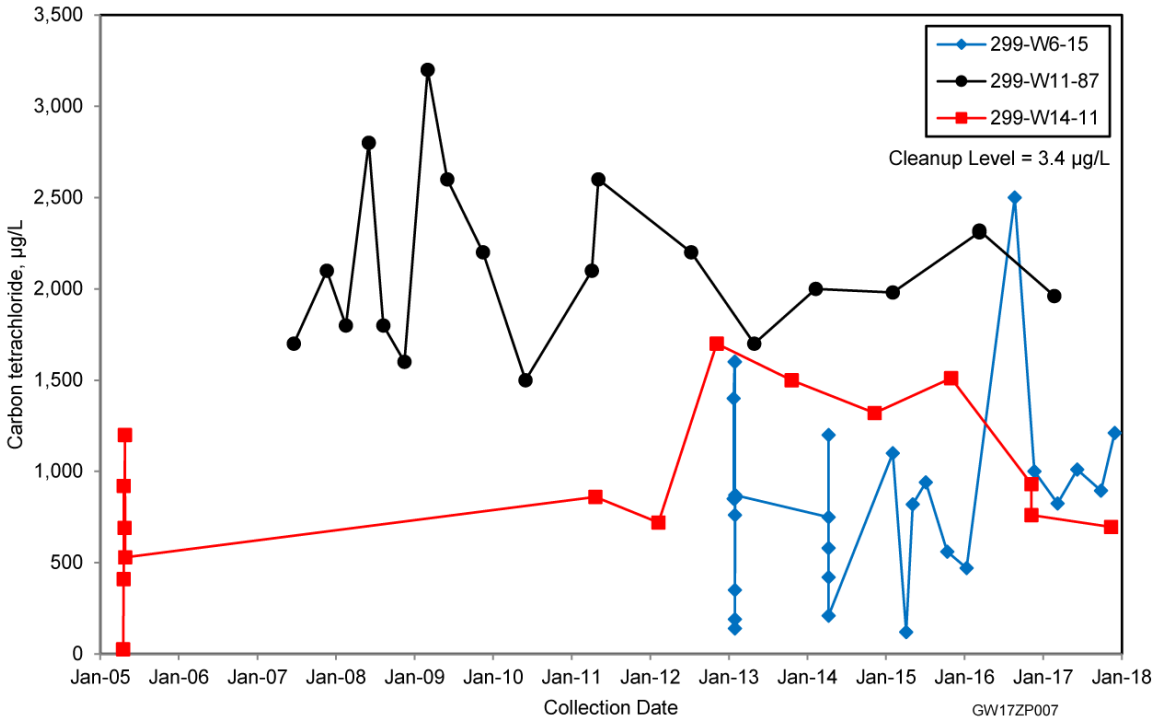


Figure 12-8. 200-ZP Carbon Tetrachloride Data for Wells 299-W6-15, 299-W11-87, and 299-W14-11

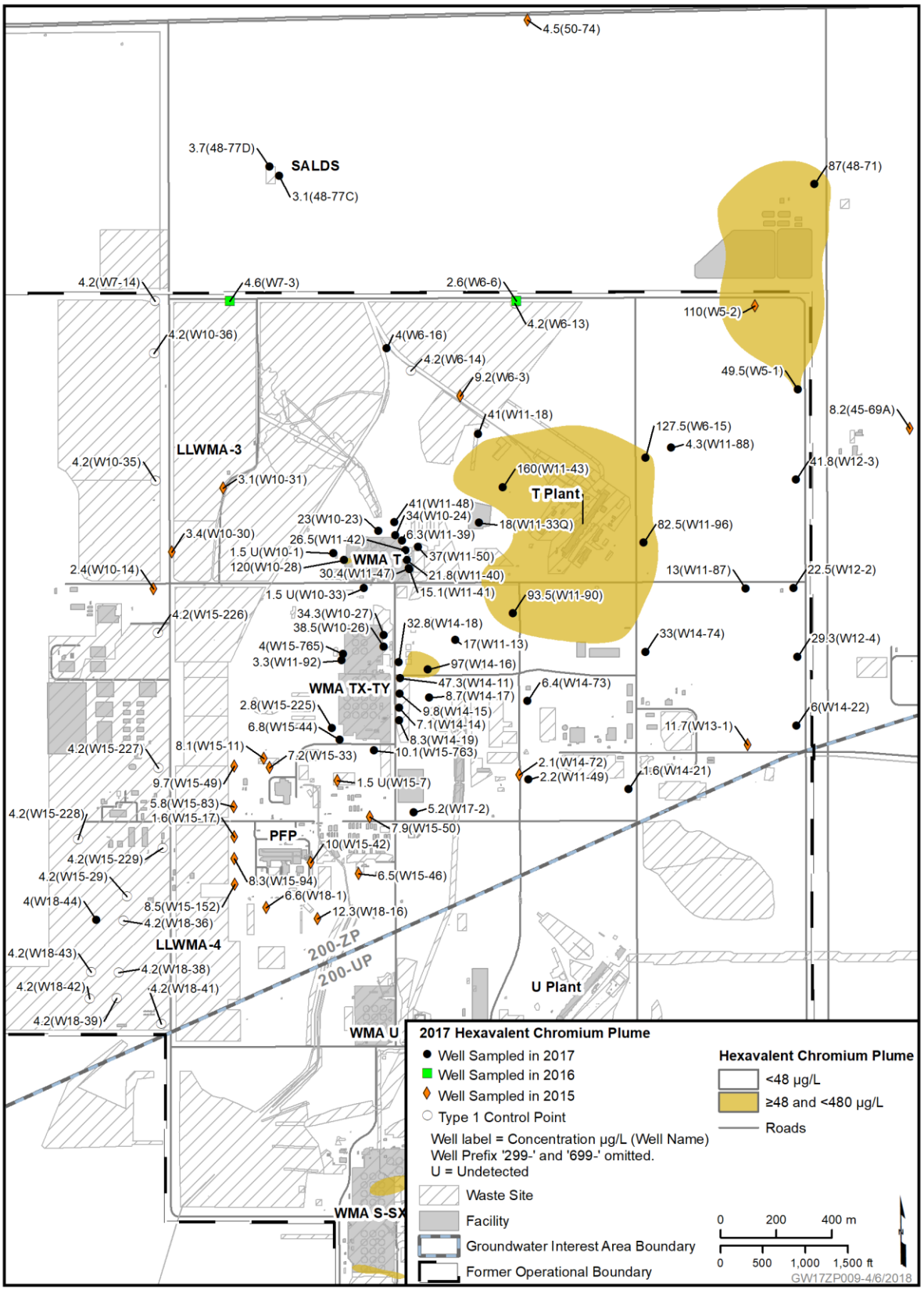


Figure 12-9. 200-ZP Cr(VI) Plume, 2017

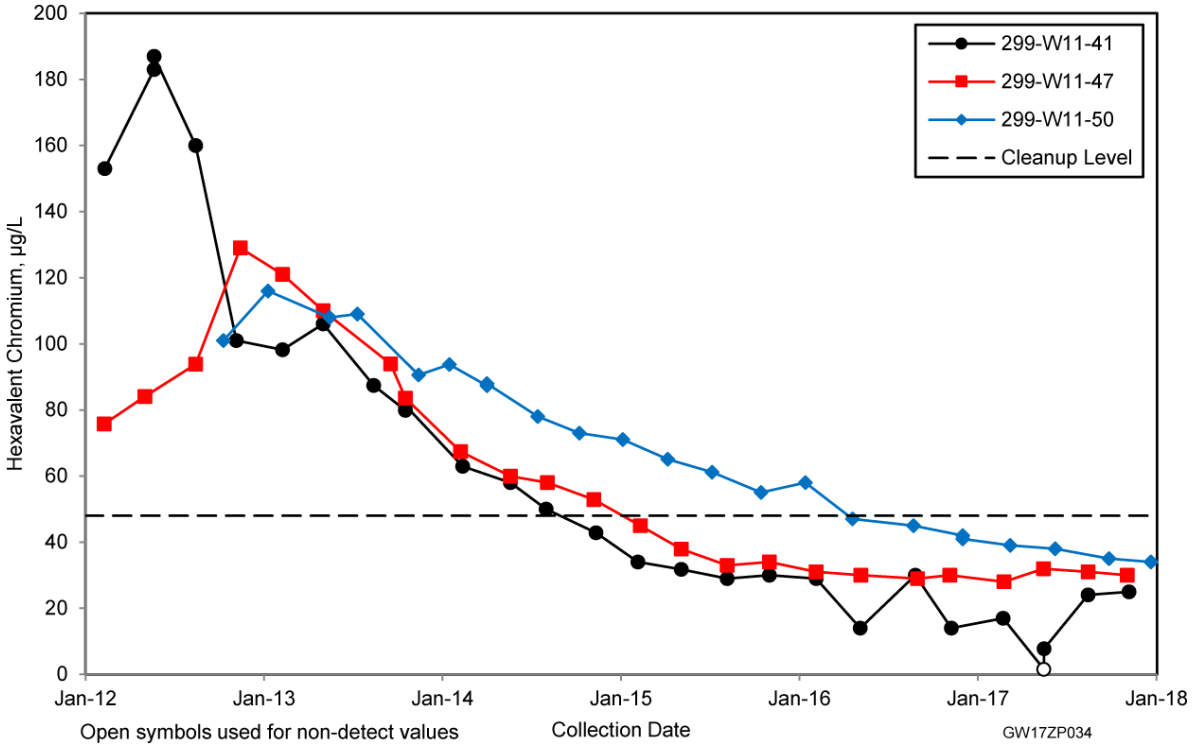


Figure 12-10. 200-ZP Cr(VI) Concentrations in Wells at WMA T

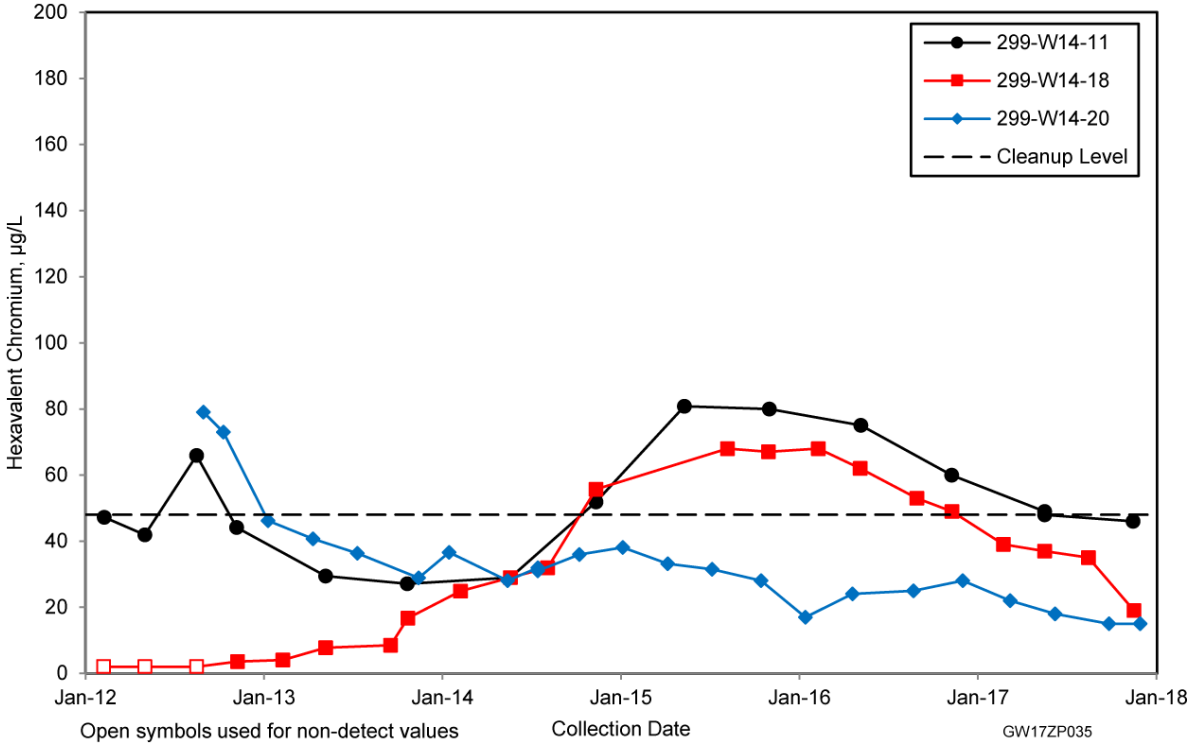


Figure 12-11. 200-ZP Cr(VI) Concentrations in Wells at WMA TX-TY

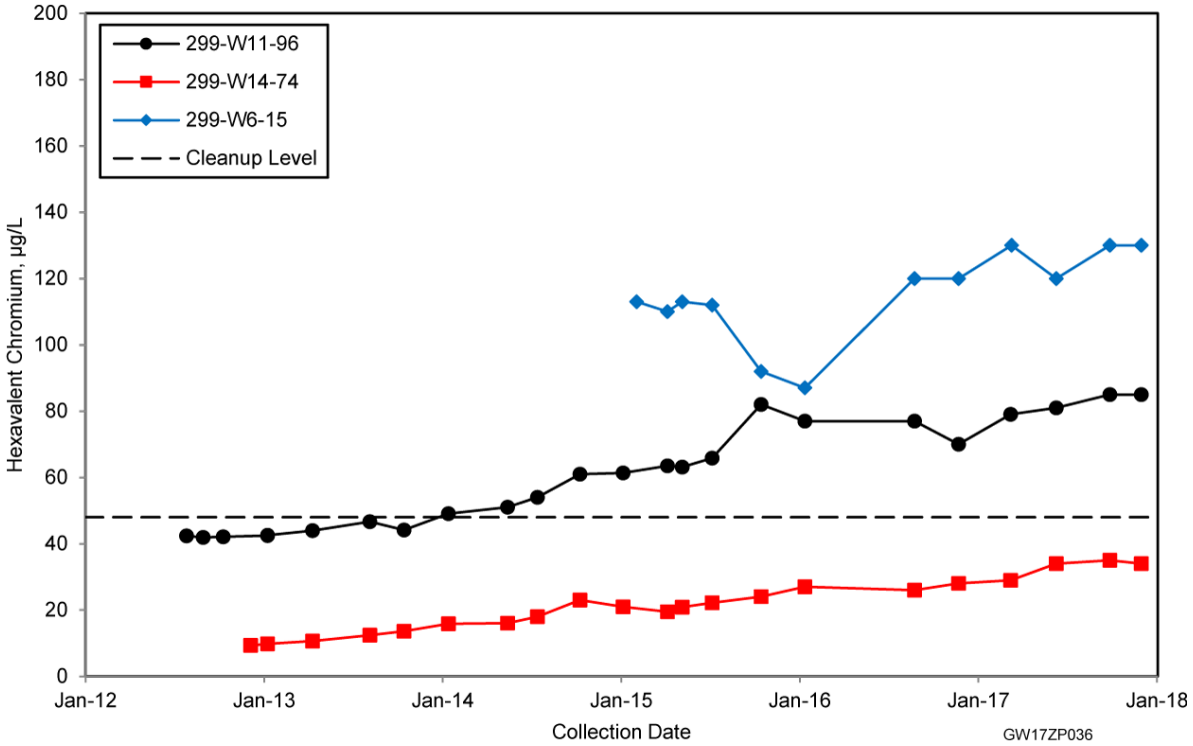


Figure 12-12. 200-ZP Cr(VI) Concentrations in Wells on the East Side of the Plume

Wells 299-W5-1 (an extraction well), 299-W5-2, and 699-48-71 define a Cr(VI) plume to the northeast (Figure 12-9). The highest concentrations were in drilling and development samples from well 299-W5-2 in 2015, but this well has not been routinely sampled due to delays in manufacturing the multi-pump system. Sampling is planned in 2018. Concentrations in wells 299-W5-1 and 699-48-71 have been stable since 2015.

Vertical distribution of Cr(VI) collected during drilling of wells near WMA T, WMA TX-TY, and adjacent cribs and trenches indicates the highest concentrations within the upper portion of the unconfined aquifer, as well as general decreasing concentration with depth. Vertical characterization data for Cr(VI) in the aquifer near WMA T and WMA TX-TY have been collected primarily during drilling and special study. In the northeast plume, vertical distribution of Cr(VI) for samples collected during drilling of well 299-W5-2 indicated the presence of elevated concentrations of 95 and 110 µg/L collected at about 22 and 29 m (72 and 129 ft), respectively, below the water table. The temporal separation in observations and measurements between wells with vertical characterization introduces substantial uncertainty in interpreting correlation between individual well data. In addition, a CERCLA P&T remedial action is currently operating near these wells.

Several wells exceeded the 100 µg/L cleanup level for total chromium in 2017. Total chromium concentrations are similar to Cr(VI) concentrations in 200-ZP groundwater, except in unfiltered samples that contain particulate matter from well screens or casing.

12.4 Iodine-129

Several wells in 200-ZP have iodine-129 concentrations that occasionally exceed the 1 pCi/L cleanup level. Sources of iodine-129 include past leaks from SSTs (containing metal and liquid waste) and chemical processing at T Plant. The MDA for iodine-129 varies from about 0.2 to 1 pCi/L.

The 2017 interpretation of iodine-129 distribution in 200-ZP did not change from 2016 (Figure 12-12 in DOE/RL-2016-67) and is not included in this report. Three wells have had concentrations exceeding 1 pCi/L since 2015: well 299-W5-2, located in northeastern 200 East Area (maximum of 1.38 pCi/L in a sample collected during drilling in 2015); well 299-W14-11, east of WMA TX-TY (1.2 pCi/L in 2016), and extraction well 299-W6-15, near T Plant (2017 results ranged from nondetect to 1.46 pCi/L).

Iodine-129 concentrations were much higher in some 200-ZP monitoring wells in the past. For example, in monitoring well 299-W14-13, iodine-129 declined from 50 pCi/L in 2000 to less than detection in 2016 and 2017. Well 299-W14-13 is located near an extraction well.

12.5 Nitrate

Nitrate concentrations greater than the final cleanup level (45 mg/L as nitrate) are present beneath much of 200-ZP (Figure 12-13). Nitrate concentrations across 200-ZP are declining in most wells due to remedial efforts. Sources of nitrate included liquid waste from PFP processes that was disposed to the cribs near WMA T and the 216-Z Cribs and Trenches. Three discrete, high-concentration plumes are discernible: one beneath WMA T and WMA TX-TY, one northeast of T Plant, and one at well 299-W18-16 (near the 216-Z Cribs and Trenches). These plumes merge at the 45 mg/L contour, extending from the 216-Z Cribs and Trenches to beyond the 200 West Area boundary to the northeast. This combined plume is distributed throughout the entire thickness of the aquifer.

The high-concentration areas of the nitrate plume beneath WMA T and WMA TX-TY are within the capture zones of 200 West P&T extraction wells 299-W11-50, 299-W14-20, and 299-W6-15. The highest concentration in 2017 was 620 mg/L at well 299-W14-16, a decrease from 708 µg/L in 2016 but higher than concentrations prior to 2015 (Figure 12-14). The increase in nitrate is likely due to the shifting regional nitrate plume and changes in groundwater flow.

Monitoring well 299-W10-28, located upgradient of WMA T, had the next highest concentration at 575 mg/L, an increase from the 2016 concentration of 261 mg/L. Well 299-W10-28 was resampled in the same month in 2017 (due to laboratory issues with the sample set) and had a subsequent value of 332 mg/L. Field measurements of specific conductance followed a similar trend. The elevated nitrate value of 575 mg/L is out of trend; however, based on the field measurement of specific conductance, the value is likely valid and representative of the purged water sample.

Monitoring well 299-W18-16 (southwest of WMA TX-TY) continued to have elevated nitrate concentrations of 505 mg/L, a decrease from the 2016 concentration of 575 mg/L (Figure 12-15). In the northeastern 200 West Area, nitrate concentrations in well 699-48-71 were 345 mg/L in 2017, declining since 2013 (Figure 12-15). Concentrations in characterization samples from nearby well 299-W5-2 in 2015 ranged from 97 to 753 mg/L, with the highest concentrations at a depth of 113 m (371 ft) below the water table. Injection wells to the east prevent this portion of the nitrate plume from migrating eastward.

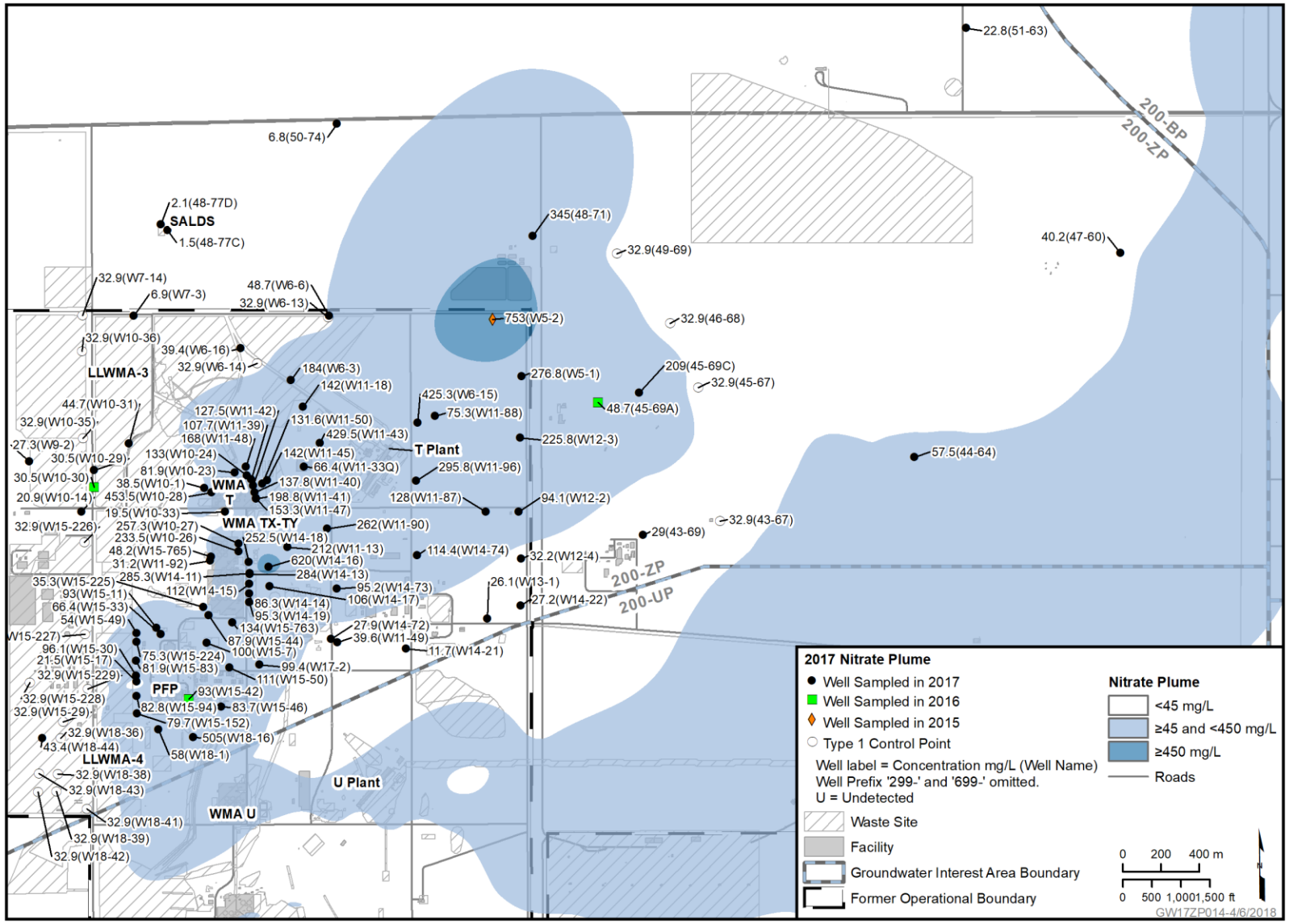


Figure 12-13. 200-ZP Nitrate Plume, 2017

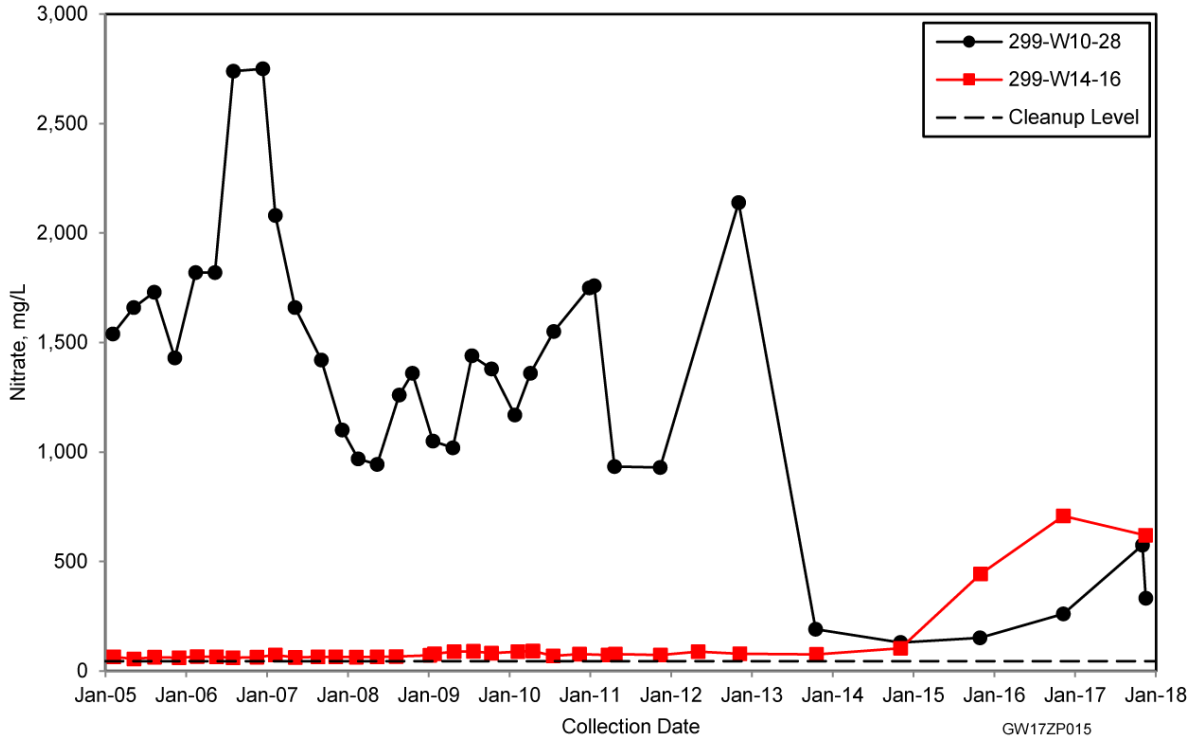


Figure 12-14. 200-ZP Nitrate Data in Wells 299-W10-28 and 299-W14-16

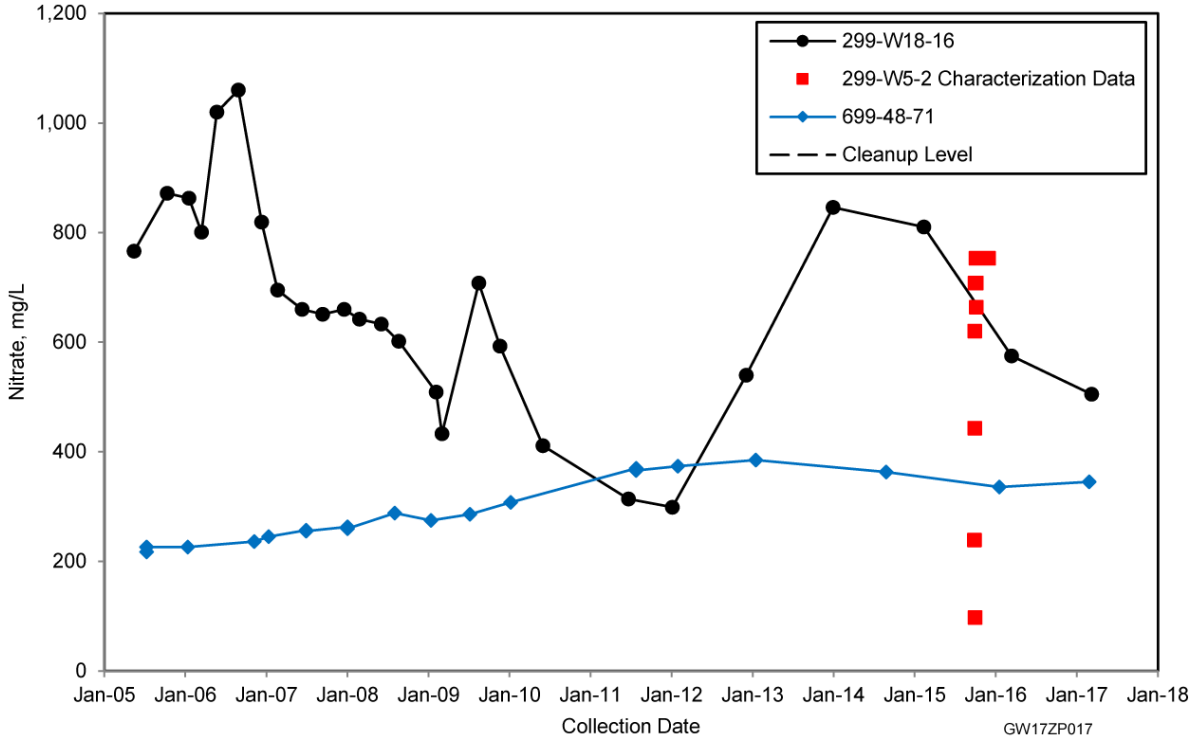


Figure 12-15. 200-ZP Nitrate Data in Wells 299-W5-2, 299-W18-16, and 699-48-71

12.6 Technetium-99

Technetium-99 exceeded the 900 pCi/L final cleanup level in two distinct plumes east of WMA T and WMA TX-TY (Figure 12-16). Sources of technetium-99 in 200-ZP were leaks from tanks and pipelines, and liquid waste disposal from plutonium-processing operations to cribs and trenches adjacent to the WMAs. Technetium-99 is found primarily in the upper 15 m (50 ft) of the unconfined aquifer (Section 2.8 of DOE/RL-2008-01). Plume size decreased from 0.11 km^2 (0.042 mi^2) in 2012 to 0.04 km^2 (0.015 mi^2) in 2016 and 2017 as a result of remediation activities.

After groundwater remediation at WMA T began in 2007, the technetium-99 plume moved toward the extraction wells, and concentrations increased in some monitoring wells and declined in other wells (Figure 12-17). The maximum concentration in 2017 was 11,100 pCi/L in monitoring well 299-W11-40. In 2016 and 2017, concentrations were near or below the cleanup level in wells 299-W11-39 and 299-W11-45, which had concentrations as high as 20,000 pCi/L in 2006 and 2007.

Groundwater extraction has occurred near WMA TX-TY since 2005. Concentrations in monitoring wells 299-W14-11 and 299-W14-13 (east of the WMA) have declined from their 2014 peak values but remain above 9,000 pCi/L (Figure 12-18). Well 299-W14-11 is screened about 6 m (20 ft) deeper than adjacent well 299-W14-11, but technetium-99 concentrations are about the same. Nearby extraction well 299-W14-20 (downgradient of WMA TX-TY) is screened across most of the aquifer thickness and has much lower concentrations. The extraction well draws in water from all directions and depths, so less-contaminated water is mixed with water from the plume. Data from the extraction wells were not used in creating the plume map provided in Figure 12-16. The plume at WMA TX-TY is defined to the north and south by wells 299-W14-18 (Figure 12-18) and 299-W14-15, respectively.

12.7 Trichloroethene

TCE exceeds the 5 µg/L DWS beneath a portion of the 200 West Area (Figure 12-19). The ROD (Table 11 of EPA et al., 2008) defines the final cleanup level as 1 µg/L.[1] The TCE plume is collocated with the carbon tetrachloride plume and is detected from the water table to the bottom of the aquifer. The interpreted plume size increased between 2012 and 2017 because analytical sample data collected from varying depth intervals during drilling were used to better define the extent of the TCE plume in 200-ZP. The reported laboratory MDL for TCE was 0.3 to 1 µg/L in 2017.

The maximum TCE concentration in 2017 was 16 µg/L in monitoring well 299-W14-72, an increase from 14 µg/L in 2017. However, concentrations declined in most wells, except those located near extraction wells. The high flow rate in extraction wells draws contaminated groundwater from the surrounding areas, effectively capturing contamination and temporarily increasing concentrations in nearby monitoring wells.

[1] DOE will clean up COCs for the 200-ZP-1 OU subject to MTCA (WAC 173-340) (carbon tetrachloride and TCE) so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

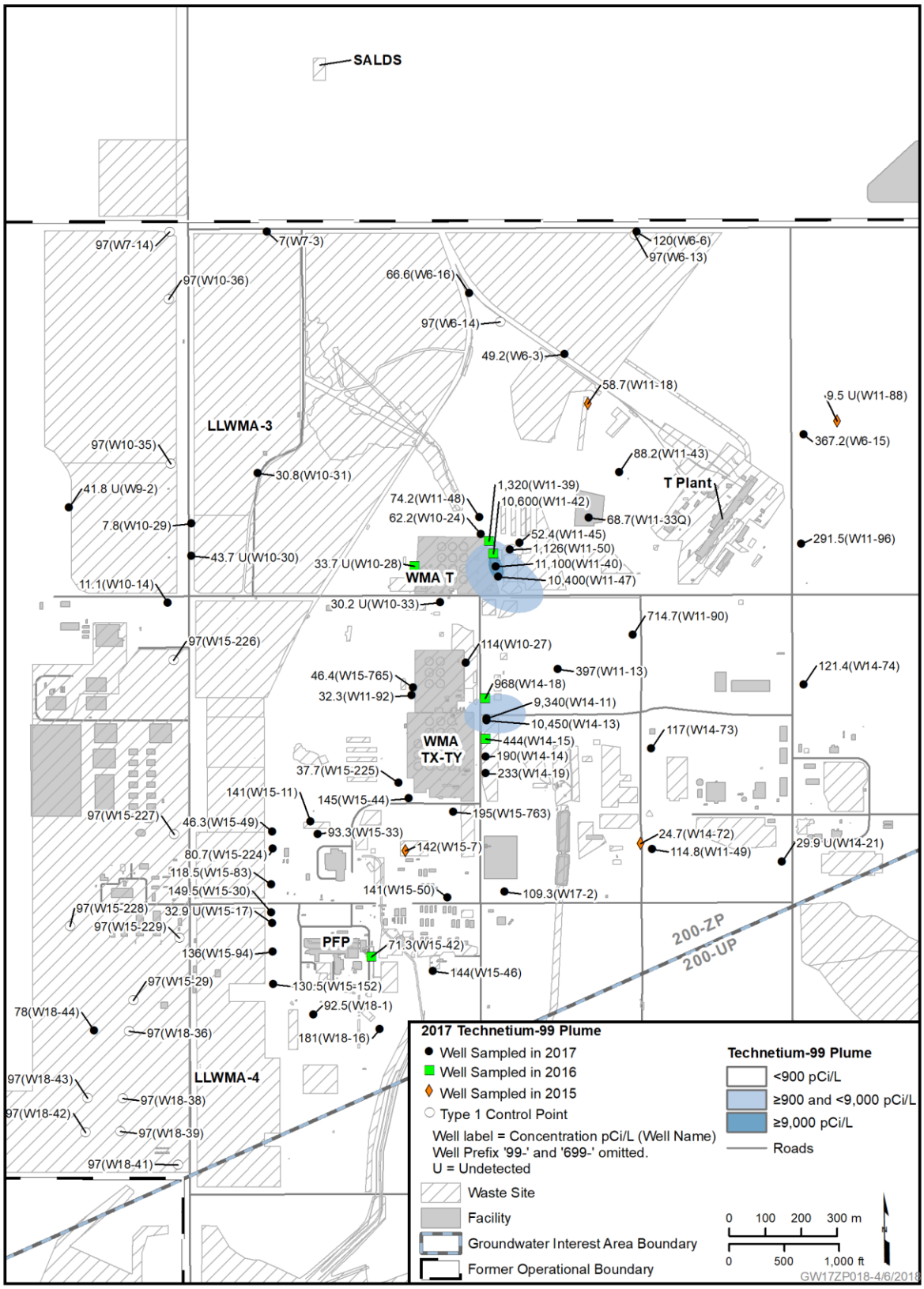


Figure 12-16. 200-ZP Technetium-99 Plume, 2017

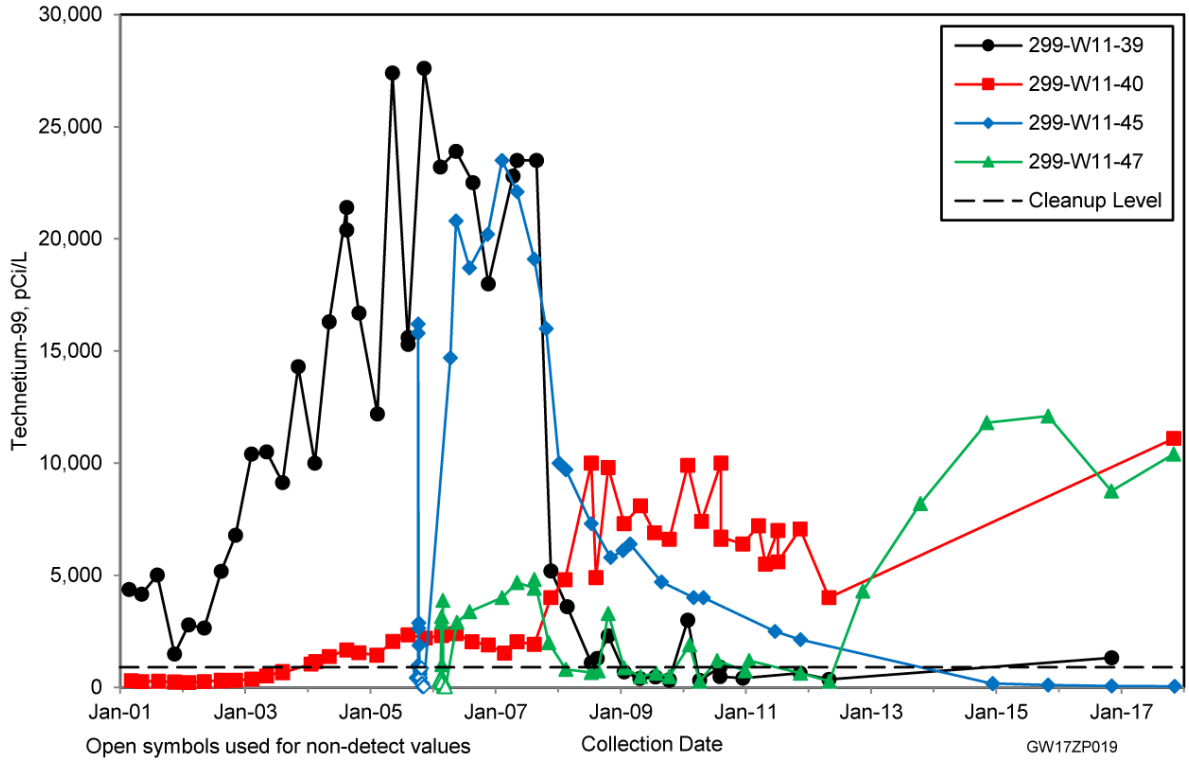


Figure 12-17. 200-ZP Technetium-99 Data in Wells East of WMA T

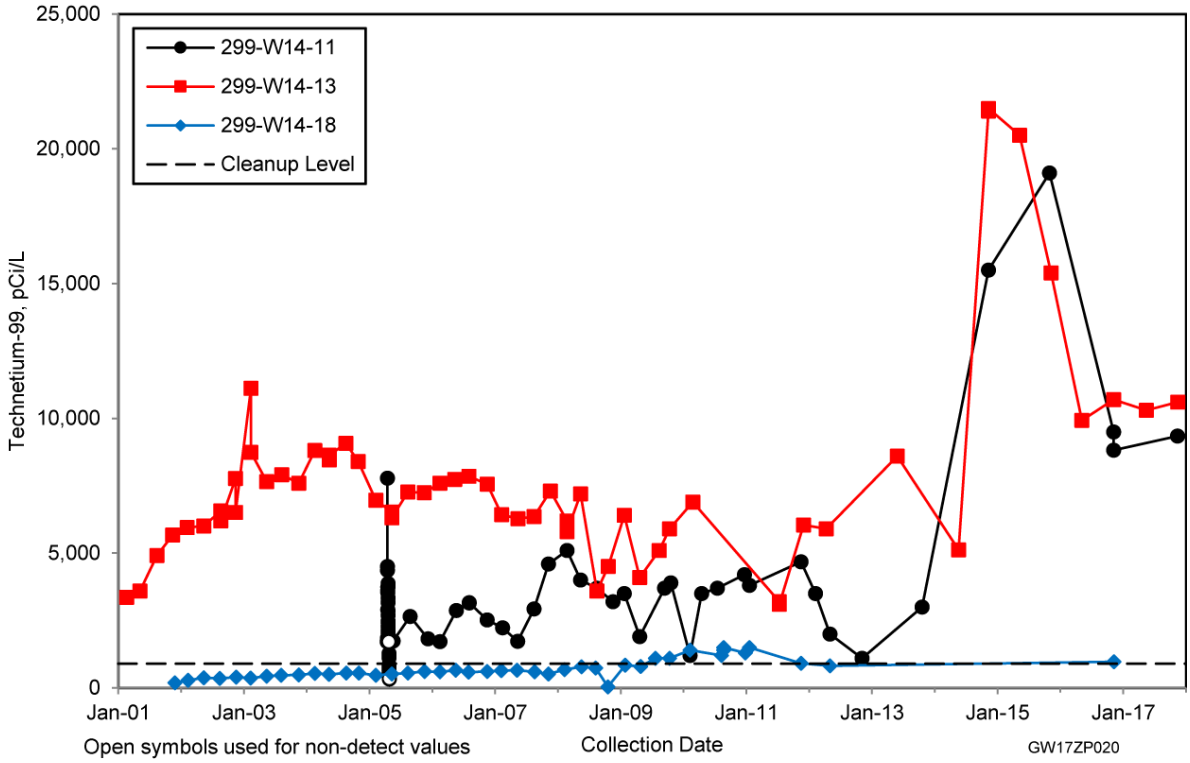


Figure 12-18. 200-ZP Technetium-99 Data in Wells East of WMA TX-TY

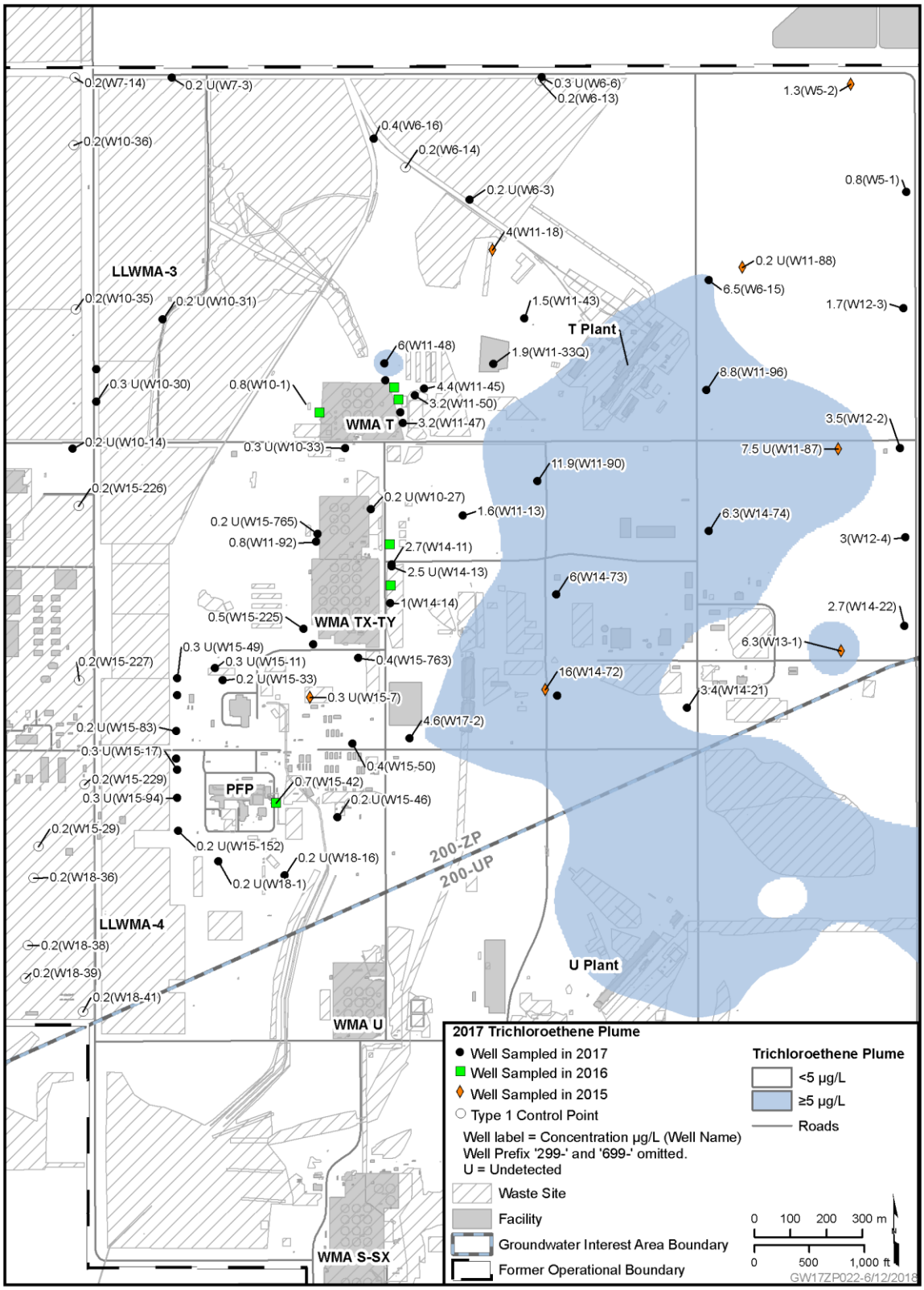


Figure 12-19. 200-ZP TCE Plume, 2017

12.8 Tritium

Tritium concentrations in groundwater have declined below the 20,000 pCi/L cleanup level in most of 200-ZP as a result of radioactive decay, dispersion, and groundwater extraction and injection. The only results above the cleanup level in 2017 were at two wells adjacent to the SALDS (Figure 12-20). Active permitted discharges at the SALDS are an ongoing source of tritium to groundwater in 200-ZP (discussed in Section 12.12). In 2017, concentrations ranged from 43,000 to 60,300 pCi/L in wells adjacent to SALDS, which is similar to levels in 2015 and 2016.

Inactive tritium sources in 200-ZP are liquid waste disposal facilities associated with plutonium processing to (including the 216-T-25 Trench) and past leaks from tanks and pipelines adjacent to WMA TX-TY. Outside of the SALDS plume, the highest concentration in 2017 was 12,800 pCi/L in monitoring well 299-W14-11 (east of WMA TX-TY).

12.9 Cyanide

Cyanide is not a COC for the 200-ZP-1 OU, but cyanide contamination has been observed downgradient of WMAs T and TX-TY since 2003. Ferrocyanide was used to form precipitates to bind with (scavenge) cesium-137 and settle out in underground storage tanks. Once the chemicals were added to the tanks, settling was allowed to occur for 7 to 10 days, and then the supernatant was decanted and discharged to the ground via cribs and trenches. Tanks T-107, TX-118, TY-101, TY-103, and TY-104 were used for the scavenging process in WMAs T and TX-TY.

In 2017, WMA TX-TY wells 299-W10-26, 299-W14-11, and 299-W14-18 had total cyanide concentrations exceeding the 200 µg/L DWS for free cyanide. These wells were sampled monthly for total, free, and amenable cyanide. As shown in Figure 12-21, free cyanide concentrations were much lower than total cyanide. Wells 299-W10-27 and 299-W14-13 also were sampled for total, free, and amenable cyanide in 2017, and the results were near or below detection limits. Section 12.11.2 includes additional discussion of cyanide at WMA TX-TY. Section 9.7 describes the various types of cyanide, regulatory standards, and apparent problems with 2017 amenable cyanide data.

Well 299-W11-41 at WMA T was sampled monthly for total, free, and amenable cyanide. There were no detections during 2017.

12.10 CERCLA Remediation and Monitoring

This section summarizes CERCLA activities in the 200-ZP groundwater interest area in 2017. In 2017, two deep vadose zone boreholes (Table 12-2 and Figure 12-1) were drilled to support characterization of the 200-DV-1 OU in 200-ZP. Summaries of the borehole drilling activities and characterization are provided in SGW-61595, *DV-1 T-Complex Field Summary Report*.

12.10.1 CERCLA Decision Documents and Plans

Groundwater contaminants in the 200-ZP-1 OU are being remediated under a CERCLA ROD (EPA et al., 2008). The selected remedy in the ROD consists of a combination of MNA, ICs, flow-path controls, and P&T.

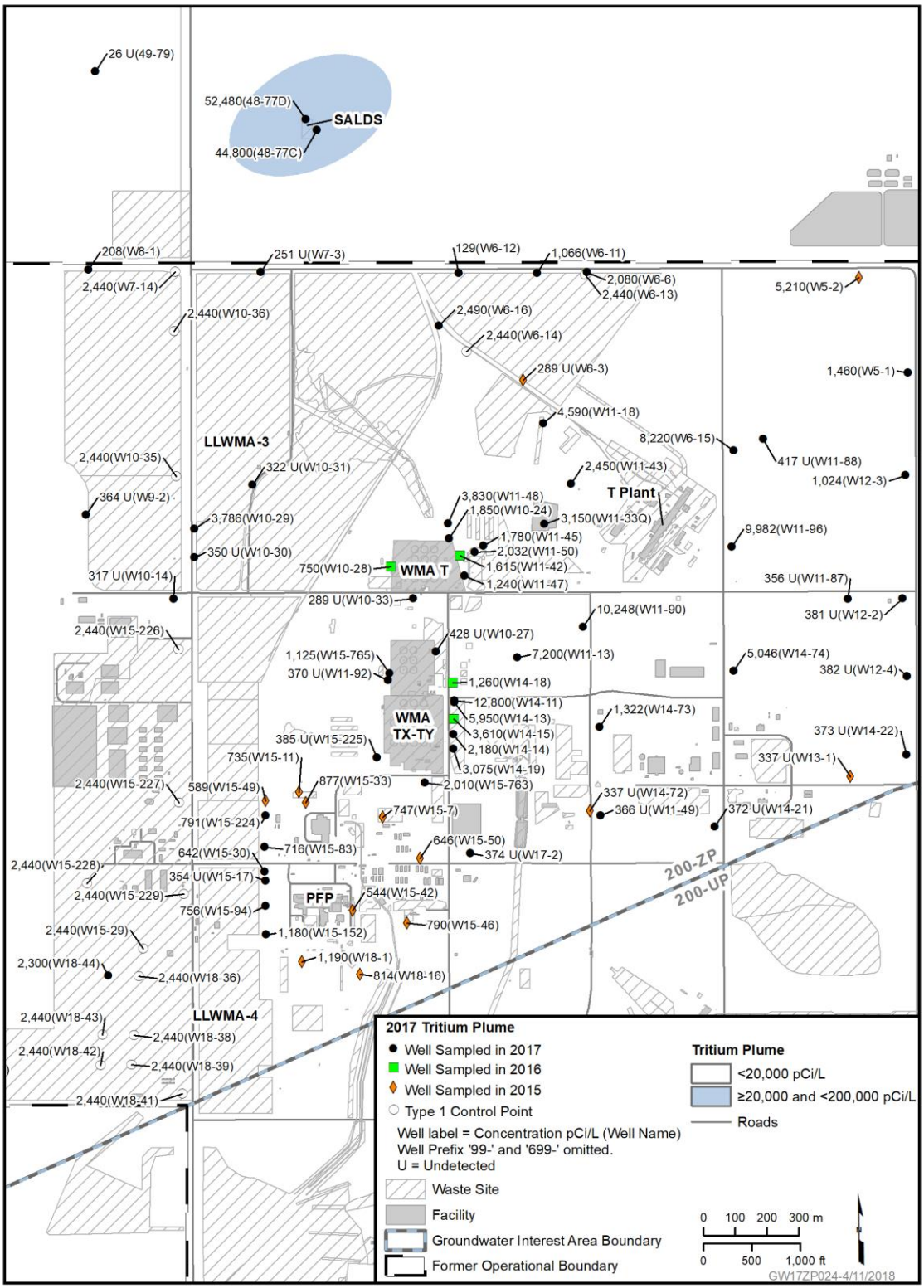
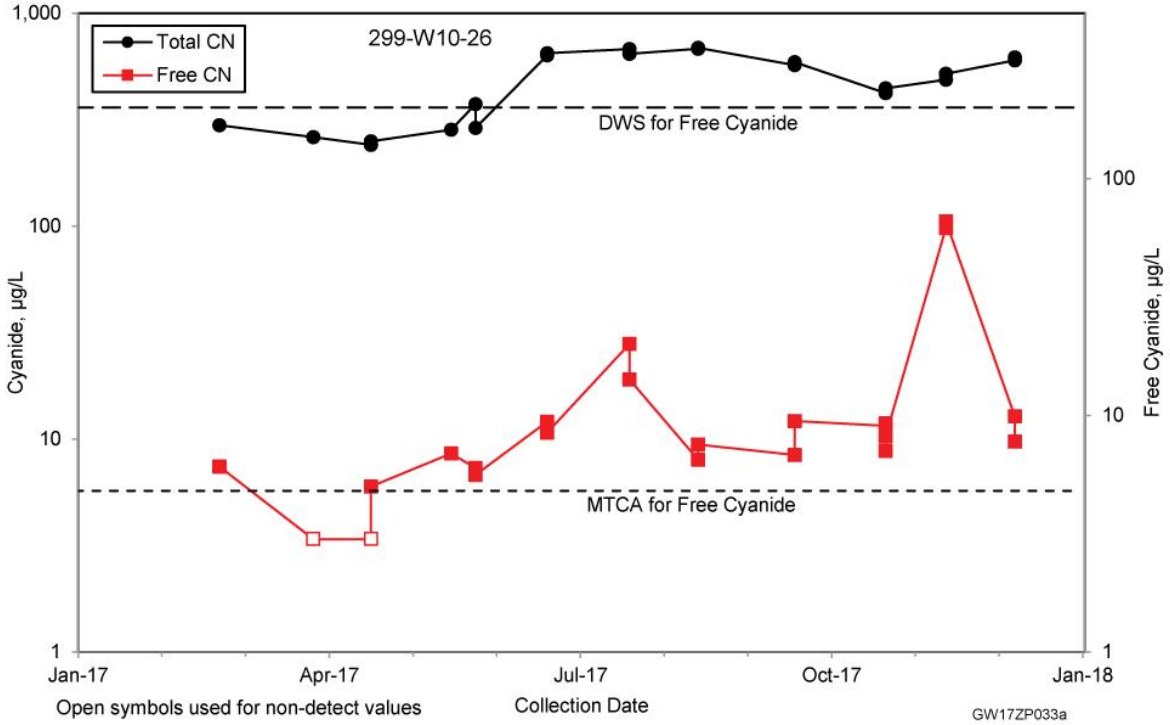


Figure 12-20. 200-ZP Tritium Plume, 2017



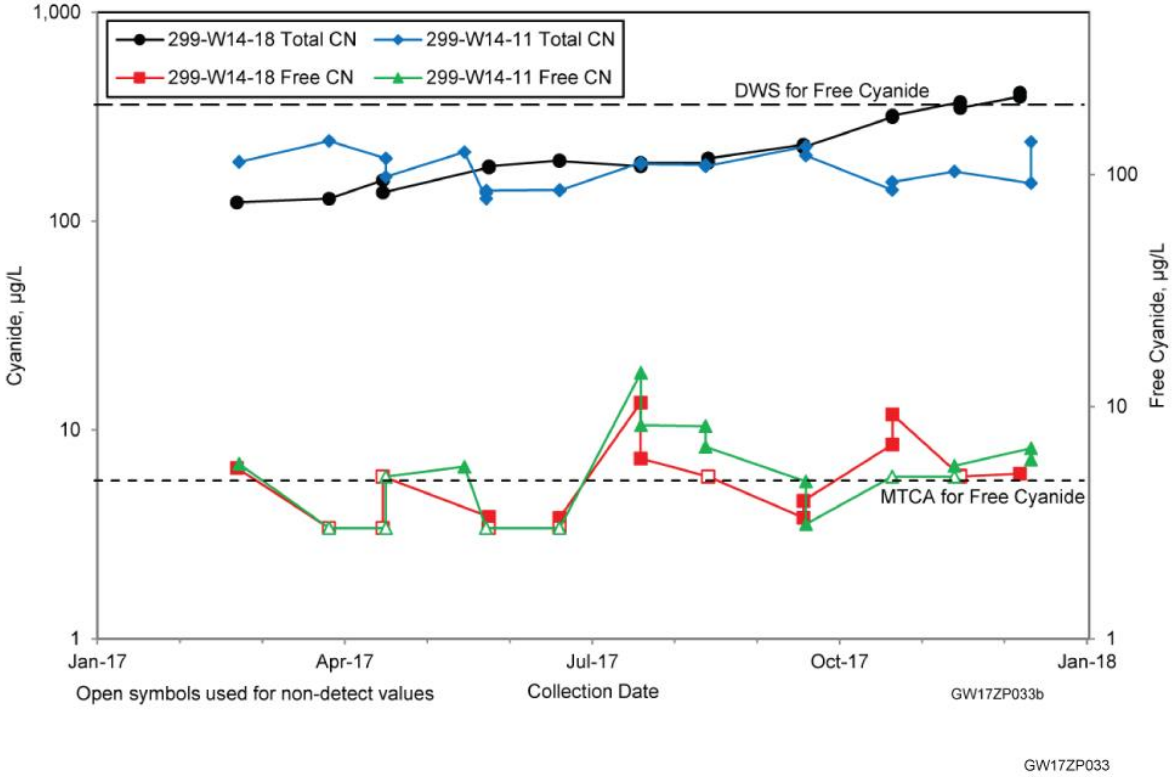


Figure 12-21. Total and Free Cyanide in WMA TX-TY Wells 299-W10-26, 299-W14-11, and 299-W14-18

Table 12-2. Wells and Borings Installed in 200-ZP in 2017

Well Name	Well ID	Well Purpose	Construction Depth (m bgs)	Construction Depth (ft bgs)	Drilled Depth (m bgs)	Drilled Depth (ft bgs)	Acceptance or Decommission Date	Comment
299-W6-16	C9561	200-ZP-1 injection[a]	145.4	477.2	145.7	478.0	11/9/2017	Well is pending operation for 2018
299-W18-42	C9563	200-ZP-1 injection[a]	136.2	447.0	154.8	507.9	8/28/2017	Well began operating in 2017
299-W18-43	C9564	200-ZP-1 injection[a]	136.0	446.3	136.2	446.7	7/31/2017	Well began operation in 2017
299-W18-44	C9565	200-ZP-1 injection[a]	135.8	445.6	153.5	503.6	12/4/2017	Well is pending operation for 2018
C9498	C9498	200-DV-1 characterization[b]	N/A	N/A	2.9	9.5	10/24/2017	Hit refusal; decommissioned
C9503	C9503	200-DV-1 characterization[b]	N/A	N/A	68.7	225.4	8/17/2017	Decommissioned
C9555	C9555	200-DV-1 characterization[b]	N/A	N/A	76.4	250.8	10/24/2017	Replacement for C9498; decommissioned

a. DOE/RL-2010-72, *Sampling and Analysis Plan for Remediation Wells in the 200-ZP-1 Operable Unit*.

b. DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit.*

bgs = below ground surface

ID = identification

NA = not applicable

The 200-ZP-1 performance monitoring plan (DOE/RL-2009-115, *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action*) guides groundwater monitoring activities associated with the 200-ZP-1 OU remedial action. The operations and maintenance plan (DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*) outlines the activities necessary to operate, maintain, and monitor performance of the 200 West P&T, from startup of operations through decommissioning of the system. No changes were made to either of these documents in 2017.

12.10.2 Pump and Treat

The 200 West P&T (Figure 12-22) began operating in 2012 and operated continuously through 2017. Table A-1 in Appendix A lists the 2017 sampling exceptions. Additional information about the 200 West P&T is provided in DOE/RL-2017-68.

Monitoring in 200-ZP is conducted annually (DOE/RL-2009-115) to evaluate the effectiveness of the remedial action to attain cleanup levels identified in the 200-ZP-1 ROD (EPA et al., 2008). Monitoring addresses the different components associated with the remedial action, including the treatment system, the extraction and injection well network, and the monitoring well network.

The 200-ZP-1 interim P&T operated between 1996 and 2012. The 200-ZP interim P&T and the WMA T P&T were removed from service in 2012. Background information for the interim P&T systems is provided in DOE/RL-2012-03, *Calendar Year 2011 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*. DOE/RL-2014-48, *Response Action Report for the 200-PW-1 Operable Unit Soil Vapor Extraction Remediation*, provides additional information about a former soil vapor extraction system, which was closed out in 2016.

As of December 2017, the final remedy P&T, the former interim remedy P&T, and vapor extraction systems have removed 106,910 kg of carbon tetrachloride from the subsurface. Remediation also removes other contaminants including chromium, nitrate, TCE, and technetium-99 (Table 12-3).

The 200 West P&T has a 9,500 L/min (2,500 gal/min) capacity and is designed to capture and treat contaminated groundwater and reduce the mass of COCs by at least 95% in 25 years. The P&T system removes COCs from groundwater using IX, anoxic and aerobic bioreactors, and air stripping. Since there is not a cost-effective method for tritium treatment and because of its 12-year half-life, MNA (natural radioactive decay) is predicted to reduce tritium concentrations to below the 20,000 pCi/L cleanup level within 125 years. The 200 West P&T, in combination with MNA, is expected to achieve cleanup levels for all COCs in 125 years. Because the 200 West P&T addresses all of the groundwater contamination in the northern 200 West Area, the interim P&T systems for carbon tetrachloride near PFP and technetium-99 at WMA T were shut down in May 2012.

The 200 West P&T extraction and injection well network (Figure 12-22) is designed to capture contamination within 200-ZP. The extraction wells are 20 cm (8 in.) in diameter with screens more than 30 m (98 ft) long, placed within 3 m (10 ft) of the bottom of each well. Aquifer testing was used to ensure that well spacing would be sufficient to capture contamination throughout the aquifer (Section 2.2 in DOE/RL-2010-13). The estimated hydraulic capture (Figure 12-23) is based on particle tracking using the water-level surfaces, as discussed in SGW-42305, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*.

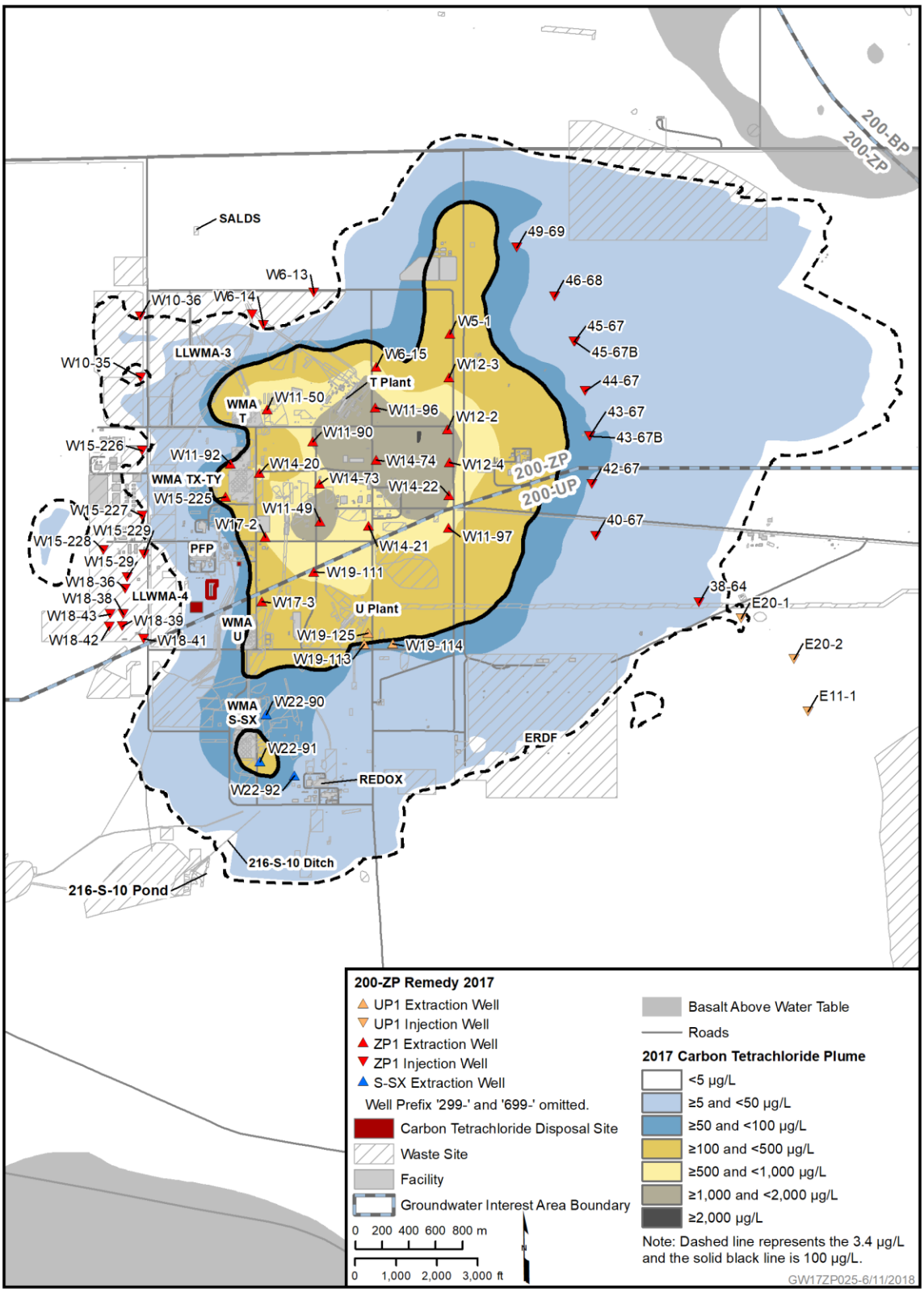


Figure 12-22. 200-ZP Remedy Overview

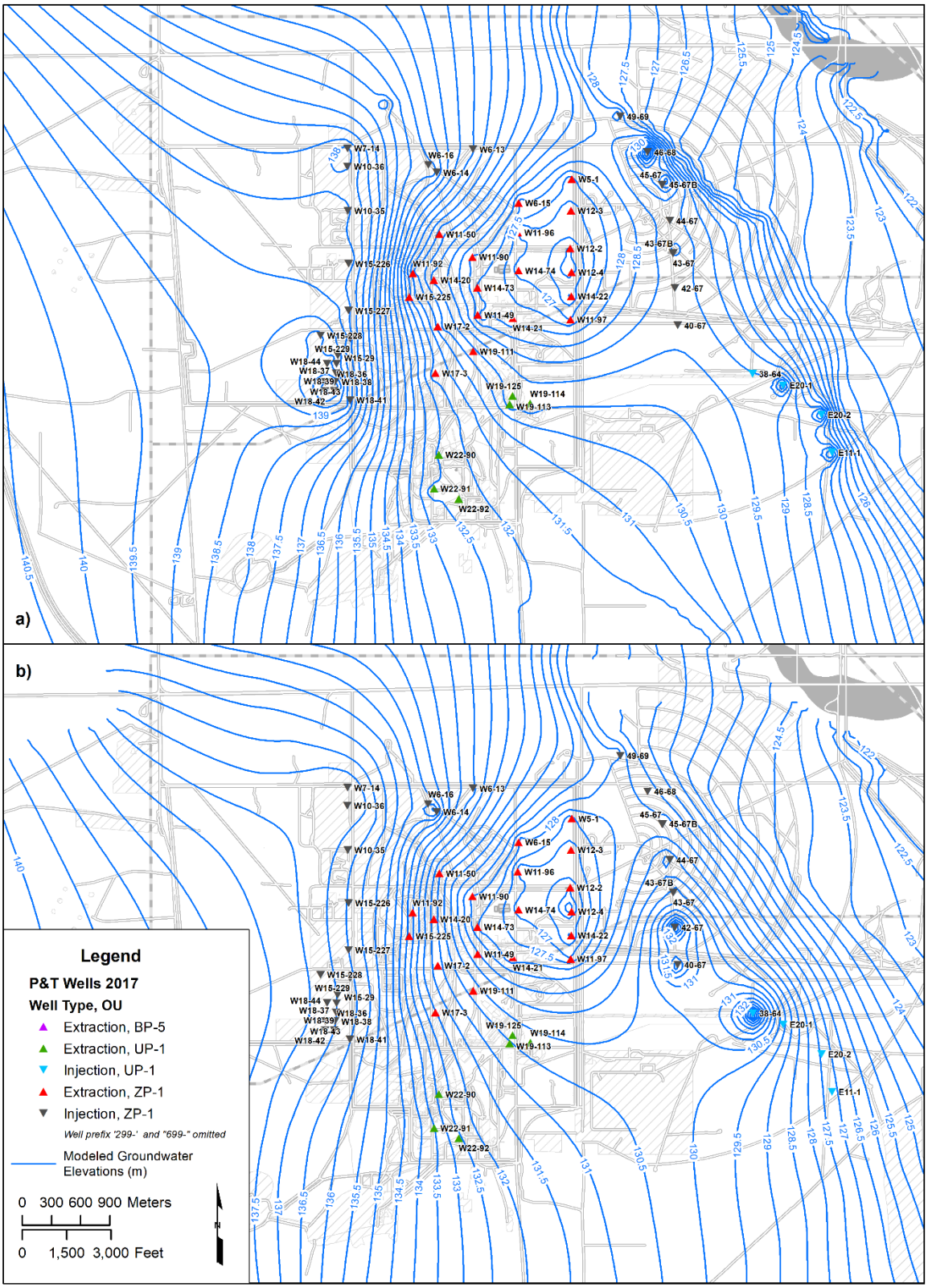


Figure 12-23. 200-ZP Groundwater Elevation Contours Computed Using Groundwater Modeling: (a) Above the Lower Mud at the End of 2017; (b) Below the Lower Mud at the End of 2017

DOE began analyzing 200 West Area effluent for total cyanide in 2015 because perched water from the 200-DV-1 OU and groundwater from the 200-BP-5 OU, which contains cyanide (Section 9.7), began to be treated in the 200 West P&T. Most results for 200 West Area effluent were below or near detection limits, with a maximum of 12 µg/L. DOE began analyzing 200 West Area effluent for free cyanide in 2017. The DWS and MTCA Method B standard (WAC 173-340) for free cyanide are 200 and 4.8 µg/L, respectively.

In 2017, tasks performed to achieve the final 200-ZP-1 ROD RAOs (EPA et al., 2008) included completing four injection wells to supplement the wells completed between 2009 and 2016 (Table 12-2). Table 12-3 lists the mass of contamination removed in 2017 compared to initial mass estimates from Table 7-1 of ECF-200ZP1-16-0076. Residual concentrations of COCs in the treated water were at or below cleanup levels and were returned to the aquifer via the injection well network, which includes 30 injection wells (29 of which operated in 2017). Two additional injection wells installed in 2017 were not yet connected to the system in 2017. DOE/RL-2017-68 provides additional details on 200 West P&T performance.

12.11 RCRA Monitoring

DOE/RL-2017-65 presents the results of RCRA monitoring on the Hanford Site in 2017. This section repeats that information for RCRA TSD units in 200-ZP, including the SST farms. Some of these units are monitored under RCRA requirements for dangerous waste constituents and under AEA for source, special nuclear, and byproduct materials.

The 200-ZP interest area contains four RCRA sites with groundwater monitoring requirements: WMA T, WMA TX-TY, LLWMA-3, and LLWMA-4. Interim status groundwater quality assessment monitoring was conducted at WMA T and WMA TX-TY (40 CFR 265.93(d), as referenced by WAC 173-303-400). Interim status indicator parameter evaluation monitoring was conducted at LLWMA-3 and LLWMA-4 (40 CFR 265.92 and 40 CFR 265.93(b), as referenced by WAC 173-303-400). The following discussion summarizes the results of statistical comparisons, assessment studies, and other developments for the reporting period. LLWMA-3 and LLWMA-4 also have AEA monitoring conducted under a performance assessment monitoring plan (DOE/RL-2000-72).

Groundwater data are available in the HEIS database and in the appendices accompanying this report. The database is available at https://ehs.hanford.gov/eda/. Appendix B includes additional information, including well and constituent lists, flow rates, and statistical tables.

12.11.1 Waste Management Area T

WMA T (Figure 12-24), which includes the T Tank Farm, is located in the northern portion of the 200 West Area and was used for interim storage of radioactive waste from reactor fuel chemical processing for plutonium production. WMA T contains 16 underground SSTs constructed in 1943 and 1944. Tanks T-101 through T-112 have capacities of 2,000,000 L (528,000 gal), and tanks T-201 through T-204 have capacities of 208,000 L (55,000 gal). In addition to the tanks, six diversion boxes and ancillary pumps, valves, and pipes are included in the Hanford RCRA Permit Part A Form for the T Tank Farm SST system.

Table 12-3. 200-ZP-1 Remedy Summary

Monitored Natural Attenuation (2012–2017)				
Dispersion of all COCs				
Radioactive decay of tritium				
Current 200 West P&T System				
		2017	**2012–2017**	
Extraction wells		30	--	
Injection wells		29	--	
Volume processed (million L [million gal])		3,881.78 (1,025.5)	17,265.20 (4,561.0)	
Contaminant	**Initial Mass[a]**	**Removed 2017**	**Total Removed 2012–2017**	**Percent Reduction**
Carbon tetrachloride (kg)	33,200	1,906	12,891	38.8
Chromium (kg)	3,520	89.37	408.99	11.6
Iodine-129 (Ci)	0.226	b	N/A	N/A
Nitrate as NO_3 (kg)	12,000,000	349,770	1,524,760	13
Technetium-99 (Ci/g)	25.6	2.87/168[c]	10.22/600[c]	Not calculated[c]
Trichloroethene (kg)	443	10.39	55.66	12.6
Tritium (Ci)	2,610	d	N/A	N/A
Uranium (kg)	Not calculated[e]	364.53	406.09	Not calculated[e]
Former 200-ZP-1 P&T Systems, 1994–2012				
Carbon tetrachloride mass removed (kg)			13,911	
Former Soil Vapor Extraction, 1992–2012				
Carbon tetrachloride mass removed (kg)			80,107	

a. Initial mass estimated from kriging (dissolved), computed as the mass above minimum interpolated concentration for each COC (Table 7-1 of ECF-200ZP1-16-0076, *Description of Groundwater Calculations and Assessments for the Calendar Year 2015 (CY 2015) 200 Areas Pump and Treat Report*).

b. Iodine-129 concentrations in the influent and effluent of the 200 West P&T were less than the detection limit (0.5 pCi/L).

c. Mass/activity removed includes the 200-UP-1, 200-DV-1, and 200-BP-5 Operable Units. Percent reduction not calculated.

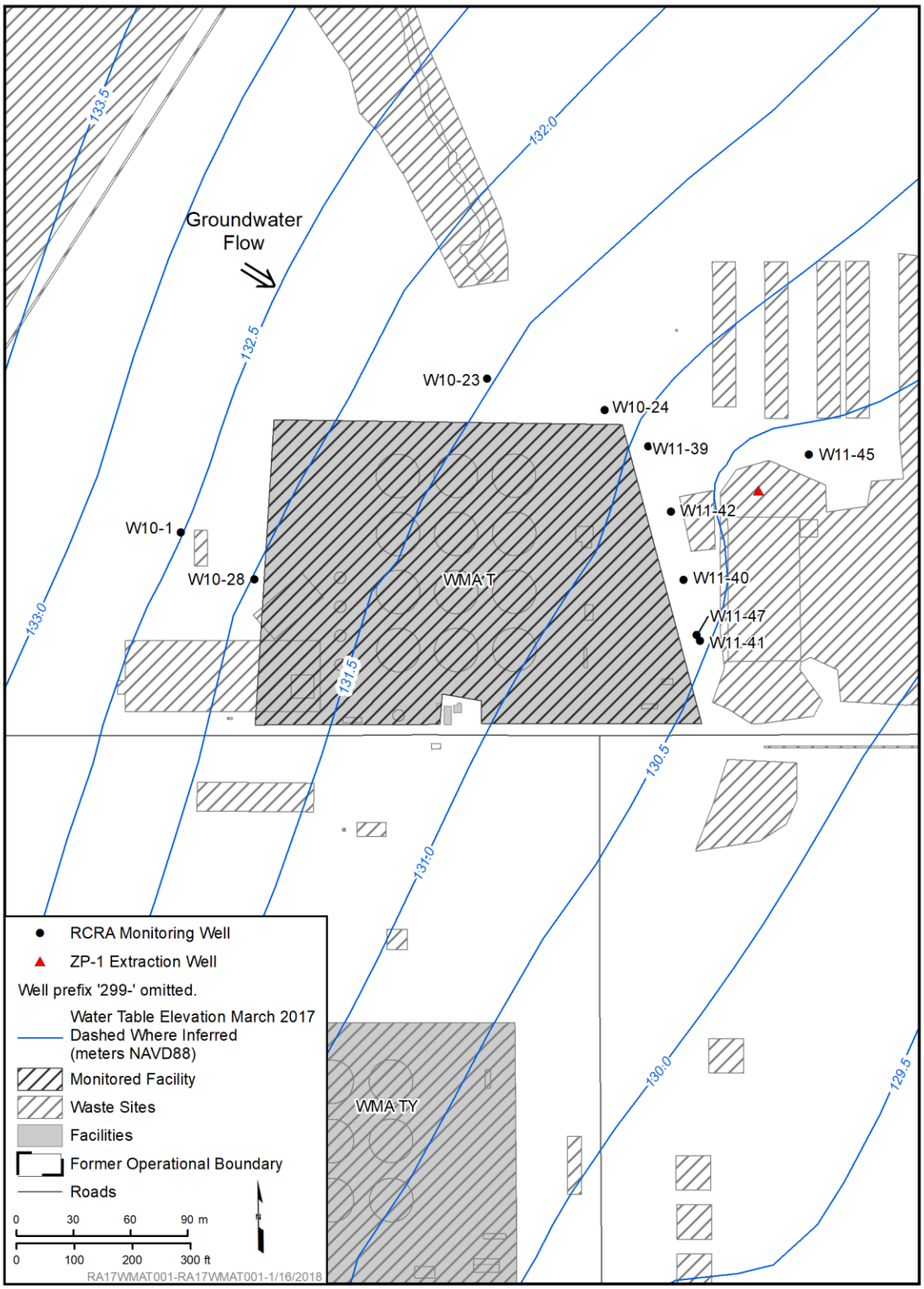
d. No treatment for tritium; remediation by monitored natural attenuation.

e. Uranium is not a 200-ZP-1 OU COC. It is included for 200-UP-1, 200-DV-1, and 200-BP-5 Operable Unit groundwater treated. Initial mass and percent reduction not calculated.

COC = contaminant of concern

N/A = not applicable

P&T = pump and treat



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 12-24. Waste Management Area T

The tanks in WMA T began receiving waste in 1944 and were in almost continual use until 1980, when all tanks in this WMA were removed from service. The SSTs received transuranic, high-level metal, and first-cycle waste from chemical processing of uranium-bearing, irradiated reactor fuel rods. Lesser amounts of other waste also were stored in the WMA T tanks. WHC-MR-0132; WRPS-55779-FP, *Hanford Tank Waste to WIPP – Maximizing the Value of our National Repository Asset - 14230;* and RPP-7218, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms*, provide more detailed information on WMA T waste inventory. Most of the drainable liquid in each tank has been removed, and the tanks have been interim stabilized. As interim corrective actions, berms were constructed around the tank farms in 2001 to stop run-on of natural precipitation, and all known water lines were tested or cut off. Interim surface barriers were placed over tanks in WMA T in 2008 to inhibit infiltration of precipitation.

The WMA T was placed in assessment in 1993 due to elevated specific conductance. Cr(VI) is a dangerous waste constituent monitored under the RCRA assessment program. From 1944 to 1980, the WMA received metal and first-cycle waste from chemical processing, including the bismuth phosphate, tributyl phosphate, and REDOX processes. Past leaks from SSTs and waste pipelines within the WMA are the sources of Cr(VI) contamination.

The monitoring network described in DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*, includes two upgradient, one assessment, one far-field, and six downgradient wells (Table B-84 in Appendix B). Assessment well 299-W10-23 is not directly upgradient or downgradient and is used to help distinguish other contaminant plumes impinging on WMA T. Wells are screened across the water table and monitor the upper portion of the unconfined aquifer. The 200 West Area P&T system caused water levels in WMA T wells to decline from the 1990s until 2016, when the decline ceased. The WMA monitoring wells have sufficient water for sampling (Table B-84 in Appendix B) and are not expected to go dry.

Extraction wells east of the WMA affect local groundwater flow (Figure 12-24). Groundwater flows to the east-southeast, and the estimated groundwater and contaminant flow rate beneath WMA T is 0.34 m/d (1.1 ft/d) (Table B-85 in Appendix B). The direction of groundwater flow is not expected to change with continued operation of the 200 West P&T.

The WMA T wells were sampled as required in 2017 (Table B-84 in Appendix B). During November 2017, recommended holding times for nitrate were exceeded prior to analysis. The network was resampled for the analyte later the same month. Well 299-W11-41 was sampled more than required in 2017 to provide information on cyanide contamination, which is not currently required under DOE/RL-2009-66.

Table B-86 in Appendix B summarizes the monitoring results for 2017. The concentration of the dangerous waste constituent Cr(VI) was 120 µg/L in well 299-W10-28 in 2017, an increase from 18 µg/L in 2016 and exceeding the MTCA standard (WAC 173-340). Concentrations of total chromium were about the same. Based on depth-discrete sample data from wells drilled in the vicinity, Cr(VI) is found in the top 45 m (150 ft) of the aquifer. The estimated unconfined aquifer thickness is about 52 m (170 ft) beneath WMA T.

Nitrate is also found in groundwater beneath the WMA and is from the same source as the Cr(VI). The nitrate plume beneath WMA T is within a regional nitrate plume and did not change significantly between 2016 and 2017; however, the maximum concentrations for the network increased. The highest nitrate levels in 2017 were in upgradient well 299-W10-28 (575 mg/L) and downgradient well 299-W11-41 (221 mg/L). While WMA T is a source of nitrate, other upgradient sources are larger contributors.

Fluoride concentrations were above the primary DWS in wells 299-W10-23, 299-W10-24, and 299-W11-39, which is consistent with previous results. Carbon tetrachloride and TCE are also present beneath WMA T; however, this contamination is associated with liquid disposal processes at PFP and not WMA T.

Monthly sampling for total cyanide, free cyanide, and cyanide amenable to chloride was initiated at well 299-W11-41 in February 2017. There were no detections during 2017.

12.11.2 Waste Management Area TX-TY

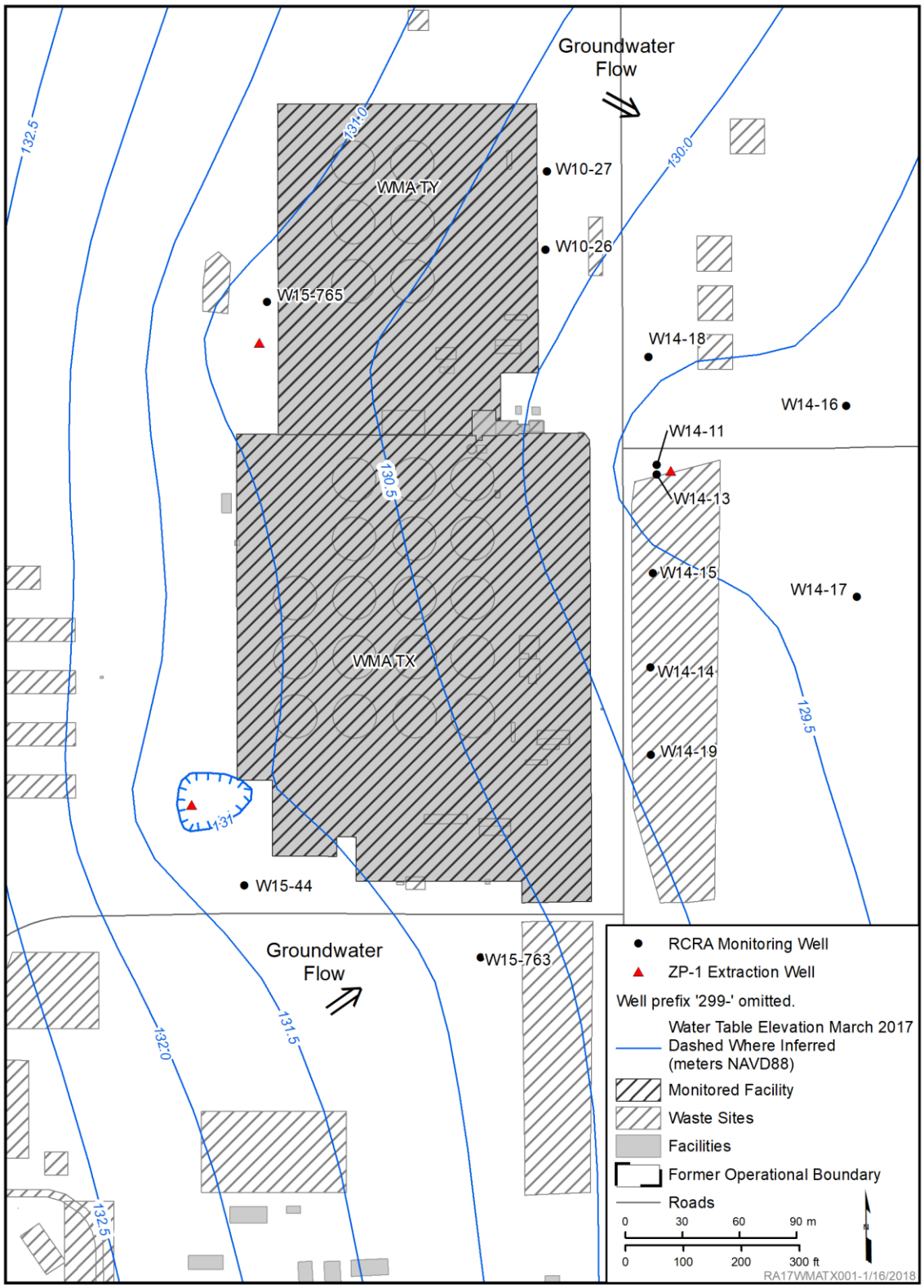
WMA TX-TY (Figure 12-25), which includes the TX and TY Tank Farms, is located in the northern portion of the 200 West Area and was used for interim storage of radioactive waste from reactor fuel chemical processing for plutonium production. The WMA contains 24 underground SSTs constructed in 1947 and 1948 for the TX Tank Farm and in 1951 and 1952 for the TY Tank Farm. Each tank has a capacity of 2.84 million L (750,000 gal). In addition to the tanks, six diversion boxes and ancillary pumps, valves, and pipes are included in the Hanford RCRA Permit Part A Form for the SSTs in the TX-TY Tank Farms system.

The tanks in WMA TX-TY began receiving waste in 1949, with the tanks in both farms used to support the bismuth phosphate process and the uranium-recovery program. Some of the tanks also received waste from REDOX and PUREX operations. Detailed information on WMA TX-TY is in DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*. Most of the drainable liquid in the tanks has been removed, and all tanks have been interim stabilized. As interim corrective actions, berms were constructed around the tank farms in 2001 to stop run-on of natural precipitation. Water lines were pressure tested and, if needed, were repaired. Lines no longer needed were cut and capped. Interim surface barriers were placed over tanks in the TY Tank Farm in 2011 to inhibit infiltration of precipitation.

The WMA is regulated under RCRA and its implementing requirements as described in DOE/RL-2009-67. WMA TX-TY is monitored under an interim status assessment program because of elevated specific conductance in two downgradient wells in 1993. The dangerous waste constituent Cr(VI) was monitored under the WMA TX-TY RCRA assessment program during the reporting period. Other dangerous waste constituents detected include carbon tetrachloride and TCE, which are from PFP sources. Table B-87 in Appendix B lists the current monitoring network for WMA TX-TY, consisting of one upgradient, two far-field, and 10 downgradient monitoring wells. Wells are screened across the water table and monitor the upper portion of the unconfined aquifer.

The 200 West P&T extraction wells on the east, west, and south sides of the WMA alter the groundwater flow direction and hydraulic gradients (Figure 12-25). Based on March 2017 water-level data, the flow direction is generally southeast within the northern portion and east-northeast within the southern portion of the WMA. Estimates of groundwater and contaminant flow rates beneath WMA TX-TY range from 0.19 to 35 m/d (0.62 to 1.2 ft/d) (Table B-88 in Appendix B). Between 2016 and 2017, monitoring well water levels increased 2 to 50 cm (0.8 to 10 in.) in wells in the northern portion and decreased 1 to 31 cm (0.4 to 12 in.) in wells in the southern portion of the WMA.

In 2017, wells were sampled quarterly to annually as planned (Table B-87 in Appendix B). Five wells were sampled more than required in 2017 to provide information on cyanide contamination. In 2018, the sampling frequency for Cr(VI) and supporting parameters will be increased to quarterly.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 12-25. Waste Management Area TX-TY

Table B-89 in Appendix B summarizes the monitoring results for 2017. The 2017 maximum Cr(VI) (97.0 µg/L in well 299-W14-16) was higher than the 2016 maximum (75.0 µg/L in well 299-W14-11). This increase is consistent with a general increasing trend in Cr(VI) in well 299-W14-16. The source for the Cr(VI) was past leaks from tanks and pipelines at WMA TX-TY. Based on depth-discrete sample data from wells drilled in the vicinity, Cr(VI) is found in the top 30 m (100 ft) of the aquifer. The estimated thickness of the unconfined aquifer is about 55 m (180 ft) beneath the WMA.

Total chromium is analyzed only in unfiltered samples. The maximum concentration in 2017 was 463 µg/L in well 299-W14-16. This was much higher than the Cr(VI) concentration, indicating the presence of undissolved trivalent Cr(VI). Aluminum is elevated in unfiltered samples from nine wells, most likely due to particulate matter from aquifer sediments.

During 2017, nitrate exceeded the DWS in all network wells. Nitrate concentrations have declined in WMA TX-TY monitoring wells from a maximum of 3,600 mg/L at 299-W14-11 in 2005 to 620 mg/L at 299-W14-16 in 2017. Most of the nitrate contamination is attributed to PFP operations, as well as past-practice disposal to cribs and trenches in the area.

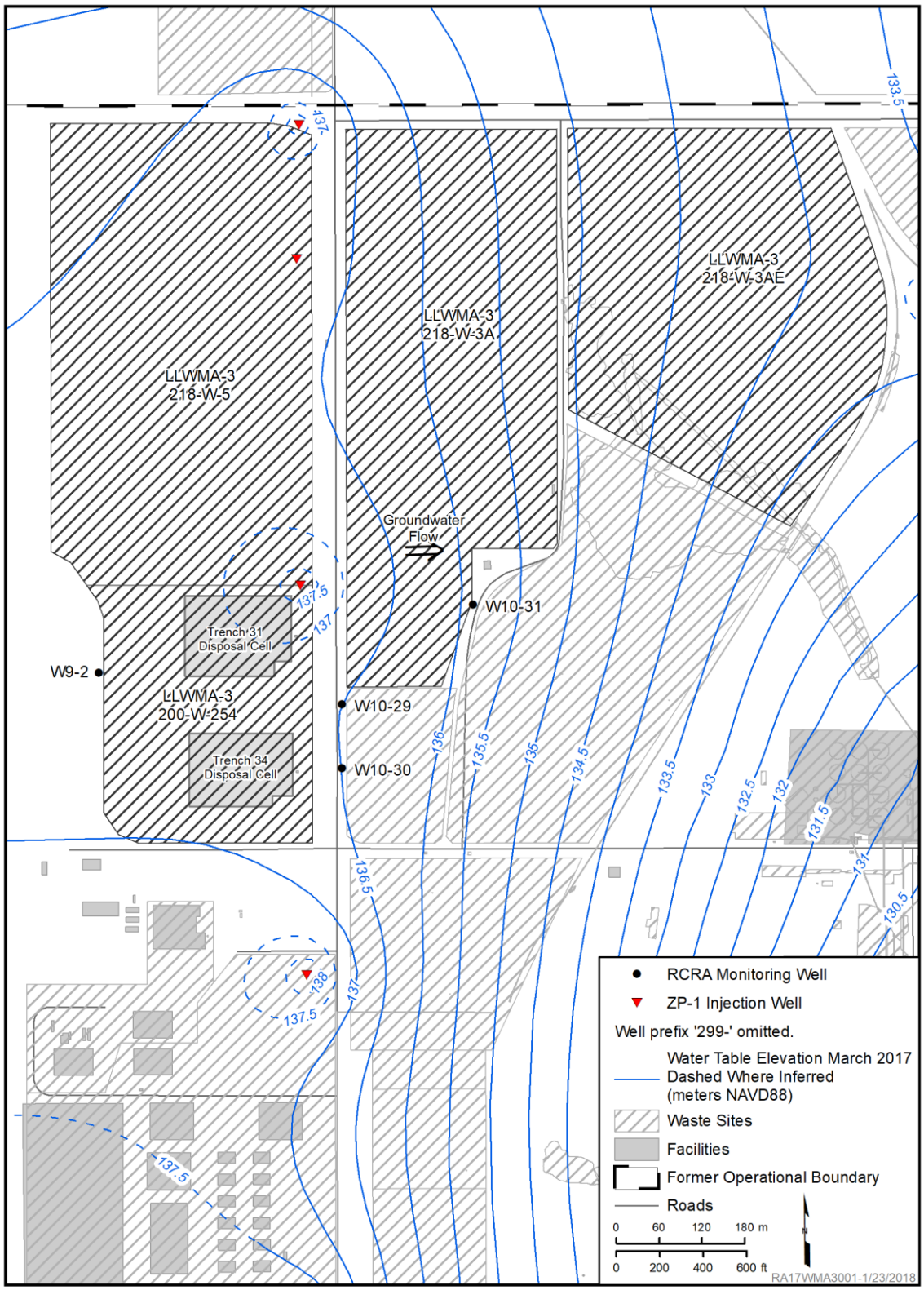
Monthly sampling for total cyanide, free cyanide, and cyanide amenable to chlorination was initiated at wells 299-W10-26, 299-W10-27, 299-W14-11, 299-W14-13, and 299-W14-18 in February 2017. Filtered samples were added to the suite of cyanide analysis beginning in May 2017. As discussed in Section 9.7, cyanide is regulated as free cyanide, and total cyanide concentrations in groundwater are typically much higher than free cyanide concentrations.

Total cyanide concentrations exceeded 200 µg/L in wells 299-W10-26, 299-W14-11, and 299-W14-18 (Figure 12-21). Free and amenable cyanide concentrations were much lower, and the highest free cyanide concentrations (greater than 60 µg/L in well 299-W10-26) were out of trend with the remainder of the data set. The highest concentration of cyanide amenable to chlorination was 348 µg/L in a filtered sample from well 299-W14-18, but the result was inconsistent with the unfiltered sample and the free cyanide results (less than 5 µg/L).

12.11.3 Low-Level Waste Management Area 3

LLWMA-3 (Figure 12-26) is located in the northwest quadrant of the 200 West Area and has four burial grounds (218-W-3A, 218-W-3AE, 218-W-5, and 200-W-254) within its boundary. The 218-W-3A Burial Ground (0.204 km^2 [0.079 mi^2]) has 57 unlined trenches and operated between 1970 and 1998. The 218-W-3AE Burial Ground (0.200 km^2 [0.077 mi^2]) has eight unlined trenches and operated between 1981 and July 2004. The 218-W-5 Burial Ground (0.27 km^2 [0.103 mi^2]) has 10 unlined trenches and began operating in 1986. The 200-W-254 Burial Ground (0.105 km^2 [0.041 mi^2] was originally within the 218-W-5 Burial Ground boundary.

In 2014, a new waste site code (200-W-254) was placed in the Waste Information Data System database to specifically identify the operating units (i.e., active areas) of the 218-W-5 Burial Ground containing Trenches 31 and 34 and associated waste treatment and storage pads. Constructed with double polyethylene liners, the trenches and pads are unique within LLWMA-3 and direct all surface runoff to a leachate collection and removal system. The 200-W-254 Burial Ground began operating in 1999 and continues to receive waste. Trenches 31 and 34 and associated waste treatment and storage pads are considered four separate dangerous waste management units.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 12-26. Low-Level Waste Management Area 3

LLWMA-3 is monitored under an interim status indicator program, as described in DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*. The monitoring network consists of one upgradient well and three downgradient wells that monitor Trenches 31 and 34 (Table B-61 in Appendix B). Each well was constructed in accordance with WAC 173-160, and the saturated thickness across screen intervals is expected to be adequate for future groundwater sampling.

Between 2012 and 2014, water levels increased due to the injection of water from the 200 West P&T system in and adjacent to LLWMA-3 (Figure 12-26). Groundwater levels declined 60 to 80 cm (24 to 31 in.) between 2015 and 2016 and increased 20 to 40 cm (8 to 16 in.) between 2016 and 2017.

The water table elevation in upgradient well 299-W9-2 remains higher than downgradient wells by at least 0.24 m (0.79 ft). Groundwater flows predominately to the east beneath LLWMA-3 but is locally affected by P&T injection wells. The estimated groundwater flow rates beneath LLWMA-3 range from 0.036 m/d (0.12 ft/d) within the southern portion to 0.21 m/d (0.69 ft/d) in the northern portion of this LLWMA (Table B-62 in Appendix B).

Wells in the LLWMA-3 monitoring network were sampled in 2017 for indicator parameters (specific conductance, pH, TOC, and TOX; Table B-63 in Appendix B), water quality parameters (chloride, iron, manganese, phenol sodium, and sulfate), and other parameters (Table B-64 in Appendix B).

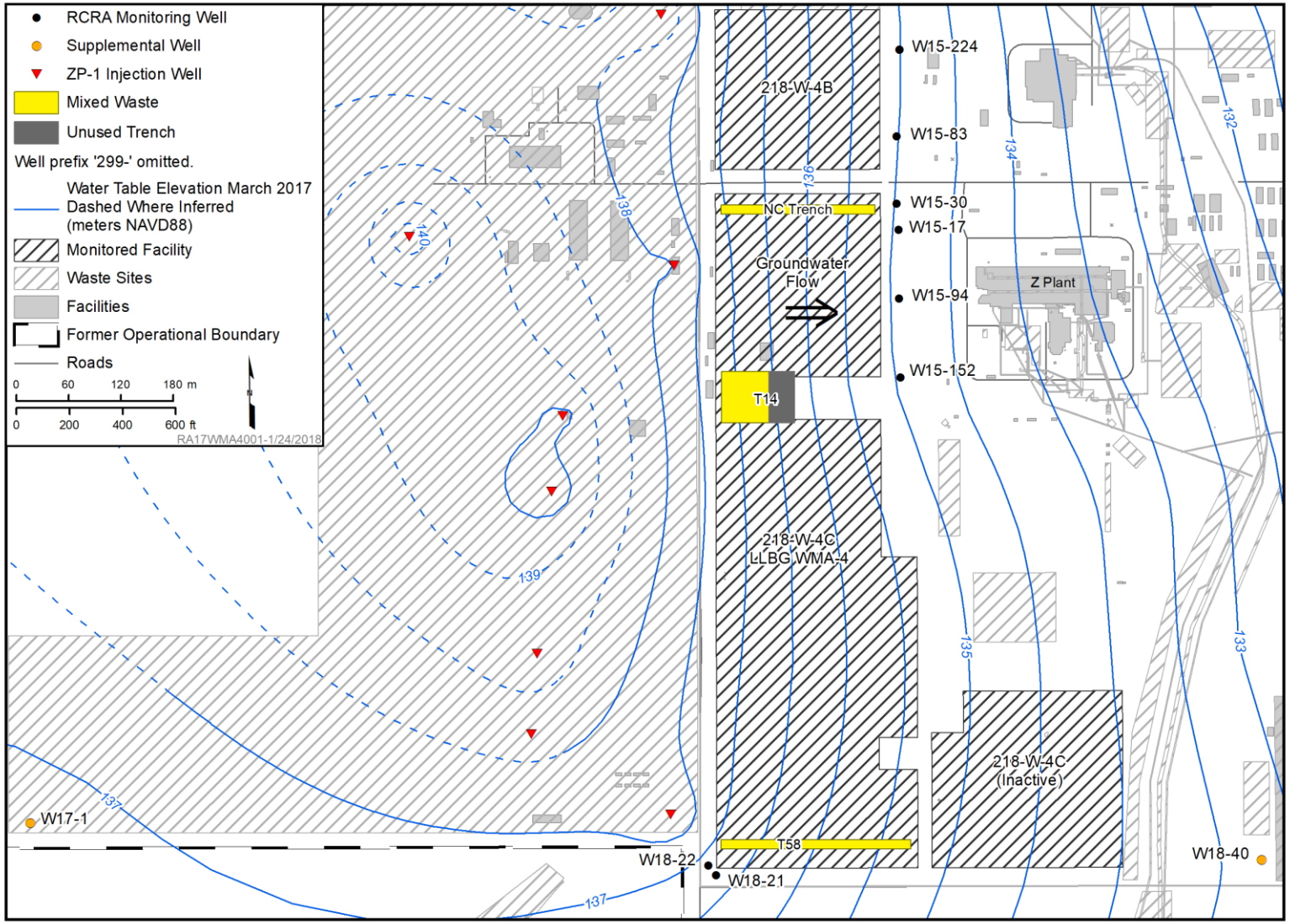
As shown in Table B-63 in Appendix B, the average specific conductance in downgradient well 299-W10-31 exceeded the critical mean value in March and September. The elevated specific conductance is presumed to be from increasing nitrate concentration associated with the migration of a regional nitrate plume. In 2017, the nitrate concentration in well 299-W10-31 was 44.7 mg/L. The highest nitrate concentration in a LLWMA-3 well in 2017 was 52.7 mg/L in 299-W10-30, which exceeds the 45 mg/L DWS equivalent and is an increase from 30.5 mg/L in 2016.

The TOX concentrations in well 299-W10-30 exceeded the critical mean value in March and September (Table B-63 in Appendix B). The TOX concentrations are consistent with observed levels of carbon tetrachloride in the area (SGW-59713-VA, *LLWMA-3 Groundwater Monitoring: 299-W10-31 Specific Conductance and TOX*; and SGW-61120, *Meeting Notes – Briefing to Ecology on LLWMA-3 RCRA Groundwater Monitoring*). The carbon tetrachloride concentration in well 299-W10-30 was 15.1 µg/L in 2017.

12.11.4 Low-Level Waste Management Area 4

LLWMA-4 (Figure 12-27) includes the 218-W-4B and 218-W-4C Burial Grounds and contains 28 unlined trenches used for disposal of low-level radioactive waste and low-level mixed waste. The 218-W-4B Burial Ground also has 12 below-grade caissons at its southern end that contain remote-handled, low-level waste and retrievable transuranic waste. The 218-W-4B Burial Ground was closed in 1990, and the 218-W-4C Burial Ground was closed in 2004. RCRA monitoring under DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*, is limited to dangerous waste in the low-level mixed waste portions of Trenches NC, 14, and 58.

The LLWMA-4 network includes six downgradient wells and two upgradient wells (Table B-65 in Appendix B). Upgradient well 299-W18-22 is screened at the bottom of the unconfined aquifer. The water level in upgradient well 299-W18-21, screened at the top of the aquifer, varies in response to changes in operation of nearby injection wells. The well was sampled with a bailer in 2017. Between 2012 and 2017, water levels increased in most LLWMA-4 monitoring wells (up to 71 cm [28 in.] in well 299-W15-224) and declined in other wells (up to 24 cm [9 in.] in well 299-W15-152).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 12-27. Low-Level Waste Management Area 4

Although not formally included in the LLWMA-4 monitoring network under DOE/RL-2009-69, upgradient well 299-W17-1 and downgradient well 299-W18-40 were sampled in 2016 and 2017 to provide supplemental groundwater data. Well 299-W17-1 was sampled quarterly for indicator parameters beginning in October 2016. Well 299-W18-40 was sampled semiannually beginning in January 2017. DOE and Ecology will determine locations for additional monitoring wells during the engineering evaluation process.

The P&T injection wells upgradient of LLWMA-4 (Figure 12-27) have caused the water table to rise and increased the hydraulic gradient since injection began in 2012. The general direction of groundwater flow is east, and the estimated flow rate is 0.57 m/d (1.9 ft/d) beneath this LLWMA (Table B-66 in Appendix B).

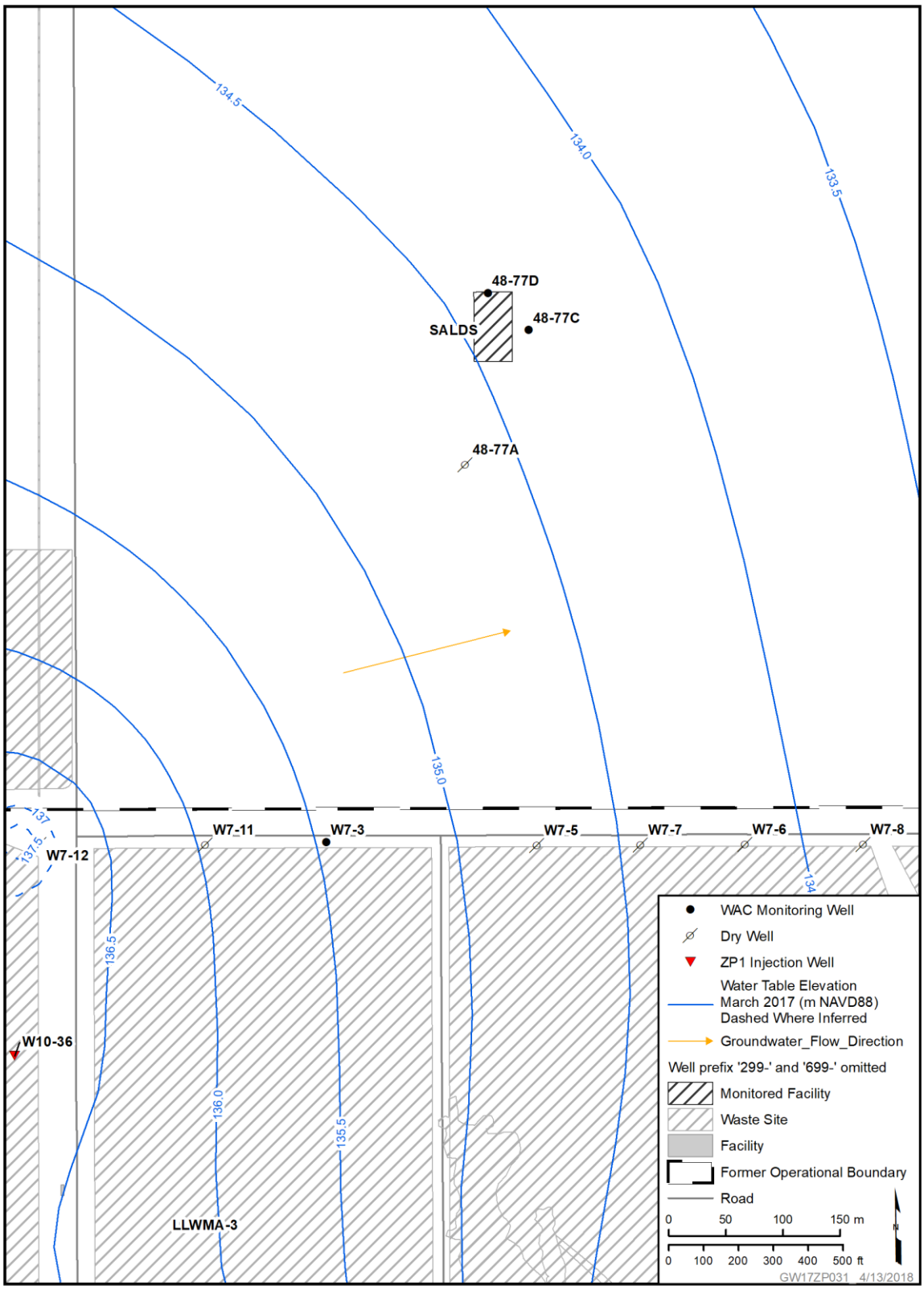
The well network was sampled as scheduled in 2017 for indicator parameters pH, specific conductance, TOC, and TOX (Table B-67 in Appendix B). During the July 2017 event, laboratory QC criteria were not met for TOX analysis, and the network wells were resampled for TOX.

Specific conductance, pH, and TOX in downgradient wells did not exceed critical mean values. The TOX results for well 299-W15-83 during the January 2017 sampling event averaged 59.30 µg/L and were below the then-published critical mean value of 86.51 µg/L established for calendar year 2016. The critical mean value for TOX was subsequently updated to 57.18 µg/L in 2017. The TOX results from well 299-W15-83 were flagged as suspect due to laboratory blank contamination.

Nitrate concentrations greater than 45 mg/L were detected in five wells (Table B-68 in Appendix B) as a result of a regional nitrate plume.

12.12 Washington Administrative Code Monitoring at the State-Approved Land Disposal Site

The ETF, regulated under WAC 173-216, processes aqueous wastes from various Hanford Site facilities. Treated water from the ETF is discharged to the SALDS (Figure 12-28), which is authorized to receive the effluent by Ecology, 2000, *State Waste Discharge Permit Number ST 4500* (hereinafter referred to as the Permit). The Permit was issued in June 1995, and the site began operating in December 1995. The SALDS is located 400 m (1,300 ft) outside the northern boundary of the 200 West Area and consists of a 35 m by 61 m (115 ft by 200 ft) drain field. DOE has taken the position that monitoring groundwater and providing data to Ecology is a matter of intergovernmental comity and cooperation, and that the Permit has no jurisdiction over radionuclides. Radionuclides are regulated by DOE under AEA authority, in the same way that permits for wastewater discharge to surface waters issued by the EPA under Section 402 of *Federal Water Pollution Control Act*, "National Pollutant Discharge Elimination System," of the *Clean Water Act of 1977* are preempted by the AEA from regulating radionuclides (40 CFR 122.2, "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System," "Definitions"; 426 U.S. 1, *Train v. Colorado Public Interest Research Group, Inc.*).



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 12-28. State-Approved Land Disposal Site

Under a 2015 Permit renewal, sampling for comparison to groundwater concentration limits is performed at the ETF verification tank prior to discharge to the SALDS. If concentrations in the discharged water are below Permit limits, then so are concentrations in the groundwater. The only analyte listed for groundwater sampling in the 2015 Permit is tritium. However, sampling of other analytes will continue until Ecology approves the revised monitoring plan (RPP-ENV-59215, *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site*). The revised version of RPP-ENV-59215 was submitted in December 2017 and removes discussion of required groundwater analytes and refers to RPP-PLAN-60544, *Sampling and Analysis Plan for the 200 Area State-Approved Land Disposal Site*, for the list of required analytes. Modification to the Permit was not completed in 2017.

During fiscal year 2017 (October 1, 2016, to September 30, 2017), 14.0 million L (3.71 million gal) of water containing 1.26 Ci of tritium were discharged to SALDS. Releases of tritium from the SALDS have resulted in a tritium plume in groundwater beneath the facility (Figure 12-20).

DOE monitors groundwater in the SALDS vicinity to track migration of the tritium plume and to compare concentrations of other constituents to Permit limits (prior to the revision of the Permit). Groundwater monitoring requirements are described in RPP-ENV-59215. Quarterly sampling is required for two wells proximal to the SALDS, and both annual and semiannual sampling are required for a set of tritium-tracking wells located farther away. Several wells are no longer sampled because they are dry. Table B-94 in Appendix B includes a list of wells sampled for the SALDS.

Monitoring results for the SALDS are reported in fiscal year annual reports, most recently in RPP-RPT-60453, *Results of the Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2017*. The Permit also specifies that periodic numerical modeling of the tritium plume be performed to predict future plume migration. The model was last updated during 2011.

Discharges to the SALDS previously formed a small groundwater mound, causing a localized area of radial flow beneath the facility. This mound is no longer evident on the regional water table map (Figure 12-4), and the regional groundwater flow direction in the SALDS vicinity is currently toward the east-northeast. The water table beneath the SALDS responds to discharges from the facility, but it also responds to operation of the nearby 200 West P&T system and the long-term regional decline of the water table. Between March 2015 and March 2017, the water level decreased an average of 0.44 m (1.4 ft) in the proximal wells. The long-term decline in the regional water table has caused 10 of the 19 tritium-tracking wells listed in the monitoring plan (RPP-ENV-59215) to become dry. One of the proximal wells (699-48-77A) is also dry. This issue also affected proximal well 699-48-77D in 2016 when it did not produce sufficient water for sampling in two out of four quarters. The well was successfully sampled four times in 2017. The third proximal well, 699-48-77C, is completed deeper in the unconfined aquifer and is not in danger of becoming dry.

During 2017, proximal wells 699-48-77C and 699-48-77D were sampled for constituents and parameters listed in the monitoring plan (Table 5.2 of RPP-ENV-59215), and the results are listed in Table 3-2 of RPP-RPT-60453. Tritium concentrations in the proximal wells correlate with the activity of tritium released, although the concentration response in deeper well 699-48-77C exhibits a time lag of several years. Recent trends in the proximal wells indicate declining tritium concentrations (Figure 12-29). The highest tritium concentrations during 2017 were 45,400 pCi/L in 699-48-77C and 60,300 pCi/L in 699-48-77D.

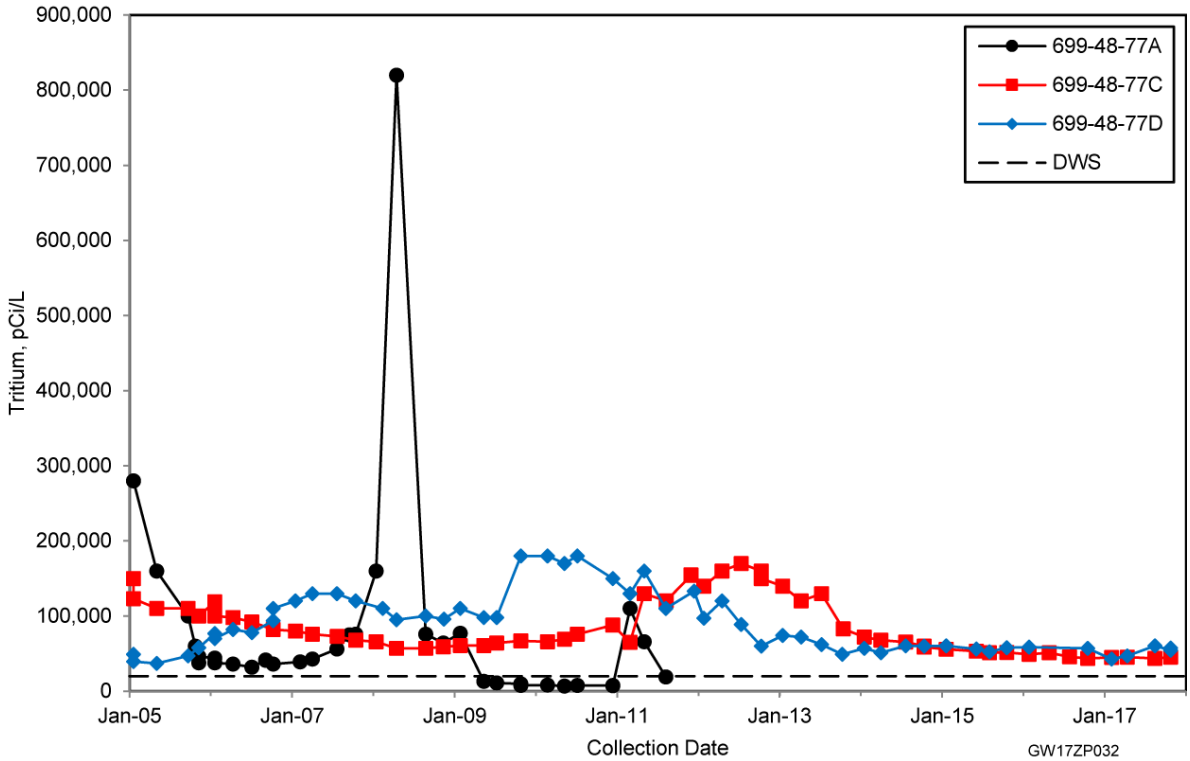


Figure 12-29. 200-ZP Tritium Data for Wells Monitoring the SALDS

To date, tritium from the SALDS has not been detected in any of the tritium-tracking wells (Section 3.2.2 of RPP-RPT-59750). The low levels of tritium observed in wells 299-W6-6, 299-W6-11, 299-W6-12, 299-W8-1, and 699-48-71 (Figure 12-20) are interpreted to have originated from past wastewater releases from other 200 West Area sources and from the 200 West P&T. Water extracted in the 200-ZP-1 OU contains tritium, but as with the ETF, the 200 West P&T does not remove tritium from the water. Thus, the water injected into the aquifer at injection wells contains tritium that is being detected in nearby monitoring wells.

12.13 Atomic Energy Act Monitoring

AEA groundwater monitoring was conducted at 74 groundwater wells in the 200-ZP groundwater interest area in accordance with the SAP issued in December 2015 (DOE/RL-2015-56). The primary AEA constituents for 200-ZP are iodine-129, nitrate, technetium-99, and tritium. Historically, nitrate has been monitored through AEA as an indicator of contaminant migration and continues to be monitored in the current AEA SAP (DOE/RL-2015-56). Six wells were not sampled in accordance with SAP requirements in 2017 (Table C-1 in Appendix C). Minor exceptions to planned monitoring occurred due to maintenance issues and scheduling constraints. Wells 299-W11-22 and 299-W11-26 within this monitoring network have been listed as candidates for decommissioning and will be removed from the monitoring network in 2018.

Radionuclide concentrations detected in groundwater samples from 90 wells[2] were used to estimate the cumulative TED and to compare the cumulative beta/photon emitters, alpha emitters, and uranium mass to DWSs, as described in Section 1.2.4. The estimated TED did not exceed the 100 mrem/yr standard

[2] The AEA calculations used data from wells sampled only for CERCLA, as well as those sampled specifically for the AEA.

in 200-ZP (Table 12-4). None of the DWSs for cumulative alpha emitters were exceeded, nor was the uranium mass DWS of 30 µg/L exceeded. The cumulative drinking water dose from beta/photon emitters exceeded the 4 mrem/yr standard at 11 locations in this interest area. None of these locations are adjacent to the Columbia River, which is the primary potential pathway for offsite exposure to Hanford Site contaminated groundwater. Members of the public are protected from exposure to groundwater through the implementation of ICs that restrict access to groundwater and through remedial action measures (e.g., P&T) to control the migration of contaminated groundwater to exposure points.

Table 12-4. Cumulative TEDs and Groundwater Concentrations that Exceeded Standards at Groundwater Monitoring Locations in 200-ZP in 2017

Monitoring Location/ Well Name	Cumulative Drinking Water Dose (Beta/Photon) ≥4 mrem/yr	
	Minimum	Maximum
299-W11-40	49.33	49.33
299-W11-47	46.47	46.47
299-W11-50	4.88	6.01
299-W11-90	5.02	6.70
299-W11-96	5.41	7.03
299-W14-11	44.07	44.07
299-W14-13	47.53	47.74
299-W14-20	4.64	4.80
299-W6-15	6.33	9.37
699-48-77C	8.74	9.08
699-48-77D	8.60	12.06

Reference: ECF-HANFORD-18-0015, *Calculation of Radiological Dose based on Calendar Year 2017 Atomic Energy Act Groundwater Monitoring at Hanford*.

Note: None of the wells in 200-ZP had a total effective dose ≥100 mrem/yr, cumulative alpha activity ≥15 pCi/L, or cumulative uranium mass ≥30 µg/L.

12.13.1 State-Approved Land Disposal Site

Additional monitoring is integrated into the AEA SAP (DOE/RL-2015-56) as part of existing performance assessment monitoring plans for SALDS. The primary COC is tritium, which exceeded the DWS at two wells: 699-48-77C (45,400 pCi/L) and 699-48-77D (60,300 pCi/L). Tritium concentrations at these wells continued to decline or remained stable during 2017 (Section 12.12). All other radionuclide concentrations were either nondetect or below 50% of DWSs. Nitrate concentrations exceeded the DWS at well 299-W6-6 (48.7 mg/L) in 2017 for the first time since sampling began.

12.13.2 Low Level Waste Management Areas 3 and 4

Additional monitoring is integrated into the AEA SAP (DOE/RL-2015-56) as part of existing performance assessment monitoring plans for LLWMA-3 and LLWMA-4, as described in DOE/RL-2000-72. The COCs for this monitoring plan are technetium-99, iodine-129, and uranium. Results for both LLWMA-3 and LLWMA-4 were below DWSs for all wells during 2017. Nitrate concentrations exceeded the DWS at both LLWMA-3 and LLWMA-4.

Tritium concentrations exceeded 50% of the DWS in LLWMA-3 downgradient well 299-W10-29 during the March 2017 sampling event. Tritium was below the MDA in all other LLWMA-3 wells during 2017, including subsequent sampling completed in well 299-W10-29 in September 2017. All other COCs remained below 50% of DWSs and were generally below MDAs. The 2017 groundwater data do not indicate a release associated with the 218-W-5 Trenches 31 and 34.

Iodine-129 concentrations exceeded 50% of the DWS at LLWMA-4 well 299-W15-152 (0.88 [±0.25] pCi/L). Concentrations had been below the MDA since sampling begin in 2012. The result is flagged with a "Q" review qualifier because it is associated with an out-of-limit field blank sample and an RDR was submitted. This well is downgradient of Trench 14. Iodine-129 concentrations for all other LLWMA-4 wells were below the MDA. The 2017 groundwater data do not indicate a release associated with the Trenches NC, 14, and 58.

Technetium-99 concentrations continued to decline in all LLWMA-4 wells. Uranium concentrations in upgradient well 299-W18-21 ranged from 14 to 16.1 µg/L in 2017 and are below the DWS of 30 µg/L, but continued to trend above the downgradient well concentrations (2.46 µg/L in well 299-W15-152). The 2017 groundwater data do not indicate a release associated with the Trenches NC, 14, and 58.

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Appendix A

Supporting Information for CERCLA Operable Units

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Table

Table A-1. CERCLA Well Sampling Exceptions, 2017 ..... A-1

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A1 Introduction

Table A-1 lists deviations (omissions) from *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) sampling requirements in 2017. In many cases, wells were sampled beyond the requirements listed in the sampling and analysis plans (e.g., wells were sampled more frequently or for additional constituents), and those exceptions are not noted in Table A-1.

Table A-1. CERCLA Well Sampling Exceptions, 2017

100-BC-5 Groundwater OU (DOE/RL-2003-38 as modified by TPA-CN-0734)	
Aquifer tubes and hyporheic sampling points	Sampling began in late August rather than September as specified in the sampling and analysis plan. Met the intent of the requirement because the river stage was low.
100-FR-3 Groundwater OU (DOE/RL-2014-44-ADD2, as modified by TPA-CN-0736)	
699-67-26, 699-71-34, 699-75-28, 699-75-31, 699-75-34B	January 2017 sample event delayed until February or March.
100-HR-3 Groundwater OU (DOE/RL-2013-30, as modified by TPA-CN-0743)	
199-D5-151, 199-D5-152	Missed one or more monthly samples.
199-D5-131, 199-D5-159, 199-D5-159, 199-D5-20, 199-D8-55, 199-D8-73, 199-H1-32, 199-H1-33, 199-H1-37, 199-H1-40, 199-H1-45, 199-H3-26, 199-H4-4	Missed one or more quarterly samples.
199-D5-134, 699-97-51A	Missed annual sample.
36-S	Aquifer tube unsuccessful; sampled 36-M instead.
100-KR-4 Groundwater OU (DOE/RL-2013-29, as modified by TPA-CN-0797)	
199-K-23	November sample event was canceled. Well was decommissioned to support waste site remediation efforts.
199-K-124A, 199-K-149, 199-K-151, 199-K-206	The 2017 events were canceled; operating P&T injection wells.
199-K-132	May sample event was successful; however, due to a laboratory issue, trichloroethene analysis was canceled.
199-K-140	Hexavalent chromium was omitted from sample paperwork for the May sample event.
199-K-141, 199-K-144, 199-K-226	August sample event was missed due to P&T issues.
199-K-188	August sample event was missed due to waste site backfilling efforts.
199-K-200	August event was successful; however, due to a laboratory issue, strontium-90 analysis was canceled.
199-K-220	August and November sample events missed due to P&T issues and well was disconnected from the P&T to support backfilling of 183.3KE Sedimentation Basin.

Table A-1. CERCLA Well Sampling Exceptions, 2017

199-K-224	May sample event was missed due to KW P&T alignment activities.
199-K-225	Calendar year 2017 events were missed due to P&T operation configuration, P&T issues, and well was disconnected from the P&T to support backfilling of 183.3KE Sedimentation Basin.
199-N-50	Missed annual sample.
AT-K-6-M	Aquifer tube determined to be broken; sample event canceled.
C6257	Aquifer tube did not yield water.
DK-04-2	Aquifer tube did not yield water; sampled DK-04-3 instead.
SK-063-2, SK-077-1	Seeps not sampled.
100-KR-4 Rebound Study (DOE/RL-2016-42, as modified by TPA-CN-0752)	
Aquifer tubes	Missed January sample; weather restrictions.
199-K-132, 199-K-173, 199-K-205, 199-K-223, 199-K-224	Missed a biweekly sampling event January; weather restrictions.
100-NR-2 Groundwater OU (DOE/RL-2001-27)	
199-N-105A, 199-N-165, 199-N-2, 199-N-28, 199-N-32, 199-N-41, 199-N-71, 199-N-72, 199-N-73, 199-N-74, 199-N-77, 199-N-81	Semiannual samples collected in March and September (no high river sample).
199-N-230, 199-N-333, 199-N-343	Missed both semiannual samples.
199-N-172, 199-N-211, 199-N-247, 199-N-248, 199-N-269, 199-N-27, 199-N-281, 199-N-298, 199-N-316, 199-N-367, Array-0A, Array-4A, Array-10A	Missed one semiannual sample.
199-N-50	Missed annual sample.
Aquifer tubes	Low-river sampling began in August rather than mid-September to mid-November as specified in the sampling and analysis plan. Met the intent of the requirement because river stage was low.
300-FF-5 Groundwater OU (DOE/RL-2014-42 and DOE/RL-2014-42-ADD1)	
399-4-14	September event was successful. However, volatile organic analysis was canceled due to a laboratory issue. Resampled in October.
399-1-7, 399-2-2	July sampling event was successful. However, anion analysis was canceled due to a commercial shipping issue.
399-4-7	December water level not collected due to access issue.

Table A-1. CERCLA Well Sampling Exceptions, 2017

200-BP-5 Groundwater Operable Unit (DOE/RL-2001-49, as modified by TPA-CN-578)	
299-E28-2, 299-E28-25	Missed annual sample.
299-E33-13, 299-E33-26, 299-E34-7, 699-53-47A	Wells were sample dry
299-E33-18	Decommissioned in 2013.
299-E33-205	Not accessible.
699-53-55A	Yields nonrepresentative samples; candidate for decommissioning.
200-PO-1 Groundwater OU (DOE/RL-2003-04, as modified by TPA-CN-205)	
299-E13-5, 299-E24-23, 299-E25-236, 499-S1-8J, 699-20-E12O, 699-42-40A, 84-S, 86-S, C6374	Missed annual sample.
83-D	Aquifer tube no longer exists.
200-UP-1 Groundwater OU (DOE/RL-2015-14, as modified by TPA-CN-0802)	
299-W19-105, 299-W19-39, 299-W19-46, 299-W19-48, 699-30-66	Missed one semiannual sample.
299-W19-49, 299-W22-49	Missed both semiannual samples.
299-W15-37, 299-W19-18, 299-W22-45, 299-W23-15, 699-35-78A	Missed annual sample.
200-ZP-1 Groundwater OU (DOE/RL-2009-115)	
299-W15-42, 299-W19-49, 699-35-78A, 699-45-69A	Missed annual sample.
299-W19-18	Well is sample dry.

Note: The references cited in this table are included in the Reference section of this appendix.

OU = operable unit

P&T = pump and treat

A2 References

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Appendix B

Supporting Information for RCRA and Other Monitored Facilities

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Terms

AEA	*Atomic Energy Act of 1954*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CG	cross gradient
cis-1,2 DCE	*cis*-1,2-dichloroethene
Cr(VI)	hexavalent chromium
DWMU	dangerous waste management units
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
GEL	GEL Laboratory
IDF	Integrated Disposal Facility
LERF	Liquid Effluent Retention Facility
LLWMA	low-level waste management area
LOQ	limit of quantitation
N/A	not applicable
NC	not calculated
NTU	nephelometric turbidity unit
P&T	pump and treat
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
SD	standard deviation
SWRI	Southwest Research Institute
TADN	TestAmerica - Denver
TASL	Test America - St. Louis
TCE	trichloroethene
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
TOC	total organic carbon
TOX	total organic halides
WMA	waste management area

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B1 Introduction

The U.S. Department of Energy (DOE) conducts groundwater monitoring at 25 dangerous waste management units (DWMUs) at the Hanford Site (Figure B-1). These units are regulated under Washington State dangerous waste regulations with authorization from the *Resource Conservation and Recovery Act of 1976* (RCRA). RCRA regulates the management of solid waste, hazardous waste, and certain underground storage tanks. It applies to active or recently active treatment, storage, and disposal (TSD) units. Groundwater monitoring is required at land disposal units including surface impoundments, landfills, or land treatment facilities to determine if they are affecting water quality in the uppermost aquifer at the Hanford Site. The uppermost aquifer is unconfined beneath most of the Hanford Site but is semiconfined in some locations.

Groundwater monitoring requirements for Hanford Site RCRA DWMUs fall into two broad categories: interim status or final status. Final status units have been incorporated into the *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereinafter referred to as the Hanford RCRA Permit). A permitted RCRA unit requires final status monitoring under WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." The RCRA units not currently incorporated into a permit require interim status monitoring under WAC 173-303-400(3)(c)(v), "Interim Status Facility Standards," as implemented by 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring." Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, contains all of the 2017 data for the RCRA wells, including data from other groundwater monitoring programs.

In 1989, DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). The agreement implemented remediation of the Hanford Site under the federal facility provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), Section 120, "Federal Facilities," and brought the Hanford Site into compliance with environmental requirements under RCRA, including groundwater monitoring. In the early 1990s, certain DWMUs had ceased operations and were scheduled to close. These units included ponds, ditches, trenches, cribs, and retention basins. Tri-Party Agreement milestones were agreed upon for the submission of closure plans, and the individual closure plans were submitted for regulatory approval. While awaiting approval and implementation of these closure plans, DOE developed interim status groundwater monitoring plans to monitor the effects of these units on groundwater until closures could be implemented. Tri-Party Agreement milestones have again been established to submit closure plans for approval and eventual implementation. Until these closures have been implemented or the units are included in the Hanford RCRA Permit, interim status groundwater monitoring will continue.

The information in this appendix was previously published in DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*.

B1.1 RCRA Groundwater Monitoring Programs

RCRA groundwater monitoring is conducted under one of three types of programs: contamination indicator evaluation (or detection) monitoring, groundwater quality assessment (or compliance) monitoring, or corrective action monitoring. Prior to closing these units, monitoring may move between these programs as groundwater circumstances change. Table 1-3 of the main text lists the Hanford Site RCRA units and their 2017 monitoring status.

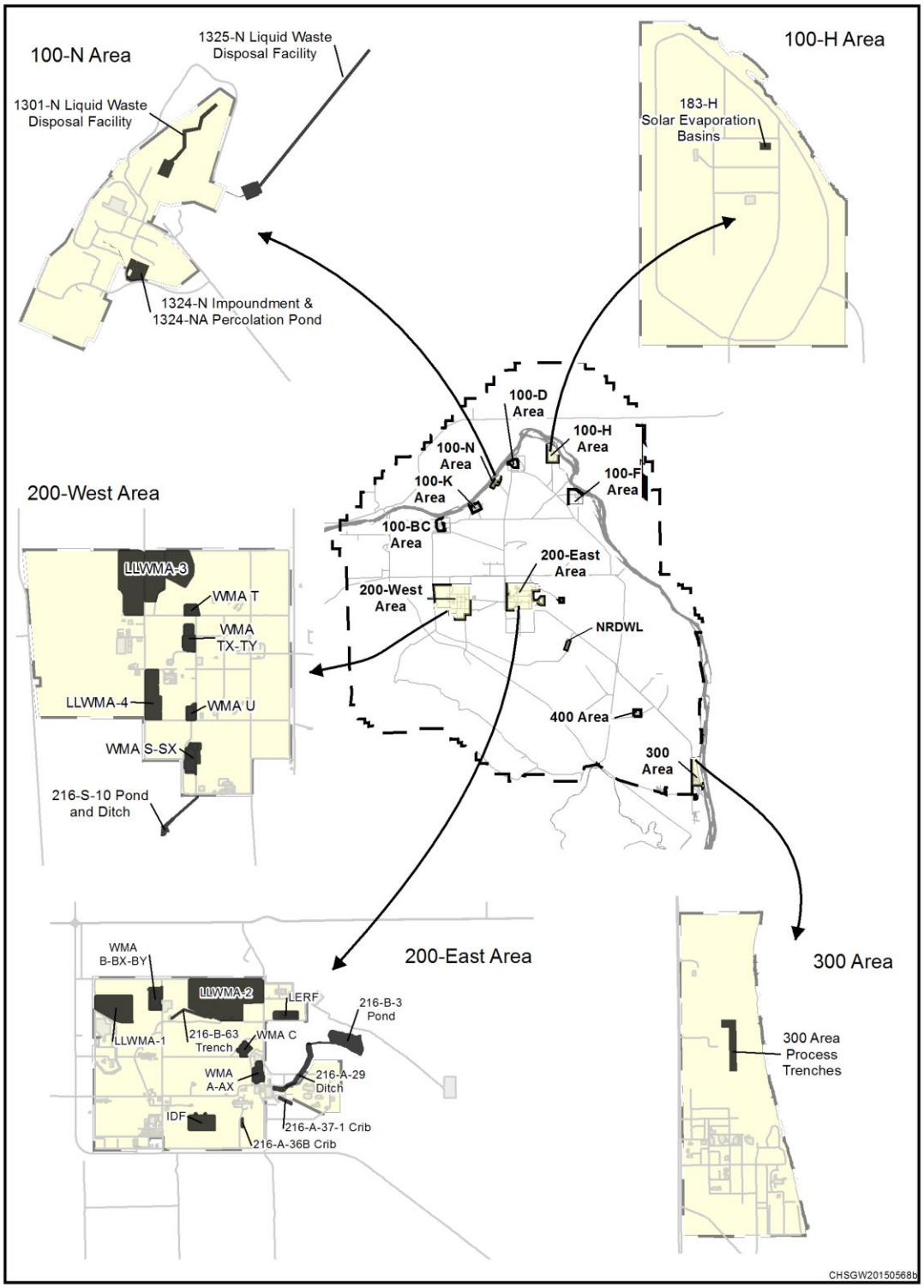

Figure B-1. Hanford Site RCRA Units

Contamination indicator evaluation (interim status) or detection (final status) monitoring programs use groundwater data from specified indicator parameters to determine and monitor the impact of the unit (if any) on groundwater. Unit-specific conditions in the Hanford RCRA Permit include (or will include) requirements for final status detection monitoring programs (e.g., comparing groundwater concentrations with groundwater protection standards). Under interim status, the indicator evaluation program continues until the unit is incorporated into the permit or until monitoring indicates a statistically significant change. A statistically significant change is determined by comparing concentrations of the specified indicator parameters in downgradient wells to a statistical comparison value (critical mean) that is derived from background measurements (usually from upgradient wells). If a downgradient well exceeds a critical mean value for any of the indicator parameters, the well is resampled. If the results of the second sampling event confirm the exceedance, the detection monitoring program changes to an assessment monitoring program.

Interim status indicator parameters are specific conductance and pH (field measurements), total organic carbon (TOC), and total organic halides[1] (TOX) (40 CFR 265.92(b)(3), "Sampling and Analysis"). The critical mean values for the indicator parameters represent 99% prediction limits, calculated based on samples from upgradient wells. The methodology used to calculate the critical mean value is the Student's t-test in accordance with 40 CFR 265.93(b), "Preparation, Evaluation, and Response."

Critical mean values are recalculated annually or whenever the number of analyses changes (e.g., due to adding or removing wells). ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*, describes the 2017 critical mean calculations. Tables in Section B.2 provide the 2017 critical mean values and the results of statistical comparisons for each unit monitored under a detection program. Annual recalculation accounts for changing hydrologic conditions due to natural or manmade causes (e.g., pump and treat [P&T] systems). If changes occur in a monitoring well network, critical mean values are recalculated for subsequent sampling events using the new well network. When a critical mean for TOC or TOX cannot be calculated using a parametric statistical test because more than 50% of data from the upgradient well are below detection limits, DOE has decided to use the limit of quantitation (LOQ) as the upper reporting limit.

The LOQs for TOC and TOX are estimated from quality control (QC) sample results, and they vary from laboratory to laboratory and from quarter to quarter. An indicator parameter exceedance is not declared unless the downgradient concentration exceeds both the critical mean and the applicable LOQ. If an LOQ is not yet available for the current quarter, the previous quarter's LOQ is used as a comparison value. The indicator parameter tables in Section B.2 list the applicable LOQs.

If an exceeded critical mean is verified in a downgradient well, a groundwater quality assessment plan is submitted to Ecology for review, after which a groundwater quality assessment program begins (interim status; 40 CFR 265.93(d)). The objective of the monitoring program is to assess the nature and extent of the problem.

Assessments may also consider and test for alternative explanations for critical mean exceedances. For example, specific conductance exceedances may be caused by nondangerous waste constituents such as sulfate (Section B1.4). Because of changes in the direction of groundwater flow and multiple past-practice CERCLA release sites, some assessments require evaluation of dangerous waste from other sources. These assessments can take time to evaluate before a first determination is made, and some sites in assessment can be returned to detection monitoring in accordance with 40 CFR 265.93(d)(6).

[1] Total organic halides are synonymous with total organic halogens, which is the term used in 40 CFR 265.92.

For final status detection monitoring (WAC-173-303-645(9)), appropriate indicator parameters or dangerous waste constituents are specified in the site permit for groundwater monitoring. If a statistically significant change in concentration occurs at the point of compliance, DOE must notify Ecology and resample the well(s) for dangerous waste constituents. The results of these analyses form the basis for a compliance monitoring program, established through a permit modification. For final status compliance monitoring (WAC-173-303-645(10)), if contaminant concentrations in groundwater have exceeded a permit concentration limit, groundwater remediation may be required. Corrective action groundwater monitoring would then be initiated to determine if the corrective action is effective.

Natural or anthropogenic changes in groundwater flow and water quality (e.g., those imposed by P&T systems) may affect the adequacy of RCRA groundwater monitoring networks. DOE is working with Ecology to review the monitoring networks and is evaluating the need for additional wells through the Hanford RCRA Permit (Revision 9) working group. DOE is preparing RCRA engineering evaluation reports and related final status monitoring plans (Table 1-3 of the main text), which are expected to be added to the Hanford RCRA Permit through Revision 9.

B1.2 Interim Status Reporting Requirements

40 CFR 265.94, "Recordkeeping and Reporting," includes reporting requirements for interim status units monitored under contamination indicator evaluation and assessment programs. For units monitored under contamination indicator parameter programs, the owner/operator must report the following information no later than March 1 each year (40 CFR 265.94):

- Concentrations of the contamination indicator parameters for each groundwater monitoring well, along with the required evaluations for these parameters (i.e., comparison to critical mean values)
- Any significant differences from initial background found in the upgradient wells
- Results of the evaluations of groundwater surface elevations and a description of the response to that evaluation, where applicable

For assessment sites, the owner/operator must submit an annual report with the results of the groundwater quality assessment program no later than March 1. The report should include the calculated (or measured) rate of migration of hazardous waste constituents in groundwater during the reporting period.
The assessment regulations also require quarterly determinations of concentrations, the extent of contamination, and the rate of contaminant migration, although these determinations are not specified in the reporting requirements.

DOE submitted DOE/RL-2017-65 to Ecology to meet reporting requirements for 2017.

B1.3 Final Status Reporting Requirements

Under the final status requirements of WAC 173-303-645, conditions specified in the Hanford RCRA Permit may specify reporting requirements. The following requirements apply to final status units:

- The 183-H Solar Evaporation Basins and 300 Area Process Trenches are monitored under corrective action and reported semiannually. The RCRA sections of Chapters 4 and 7 in the main text summarize the monitoring results for 2017.
- The 100-N Area RCRA facilities (1301-N, 1325-N, and 1324-N/NA) and the Liquid Effluent Retention Facility (LERF) are monitored under detection programs. The RCRA sections of Chapters 6 and 9 in the main text summarize the monitoring results for 2017.

- For the Integrated Disposal Facility (IDF), Section 5.5.4.3.3 "Groundwater Monitoring," of the Hanford RCRA Permit requires that "The results of the statistical evaluation and associated information will be submitted to Ecology quarterly in Hanford Site groundwater monitoring reports." Because the IDF is not in use, this statistical evaluation has not been prepared to date. The RCRA section of Chapter 10 in the main text summarizes the monitoring results for 2017.

B1.4 Specific Conductance

Specific conductance, one of the interim status contamination indicator parameters, is a measure of the ability of water to pass an electrical current, and it is affected by the presence of dissolved solids. The primary contributors to specific conductance in Hanford Site groundwater are bicarbonate, chloride, nitrate, sulfate, calcium, potassium, magnesium, and sodium. Many of these ions are present from natural sources, and others (notably nitrate and sulfate) were also introduced from Hanford Site waste disposal. Contaminants such as nitrate are commonly detected in concentrations of tens of mg/L and have a large effect on specific conductance. Specific conductance is not a good indicator of contaminants such as chromium that are present in concentrations of tens of µg/L (three orders of magnitude less).

Specific conductance is influenced by regional nitrate and sulfate plumes that originated at past-practice waste sites and some RCRA units. For example, specific conductance distribution in the 200 East Area (Figure B-2) is very similar to nitrate and sulfate distribution (Figures B-3 and B-4). Many of the RCRA TSD units in 200 East, 200 West, and 100-N Areas are located within regional nitrate or sulfate plumes. The online, interactive groundwater monitoring report "plume tool" (http://higrv.hanford.gov/Hanford_Reports_2016/Plume_Criteria/plumes.html) allows users to view nitrate plumes as they migrated over the years 1993 to 2016.

B2 Supporting Tables

Tables B-2 through B-92 provide supporting information for each of the RCRA DWMUs. Tables B-93 and B-94 provide supporting information for the Environmental Restoration Disposal Facility and the State-Approved Land Disposal Site.

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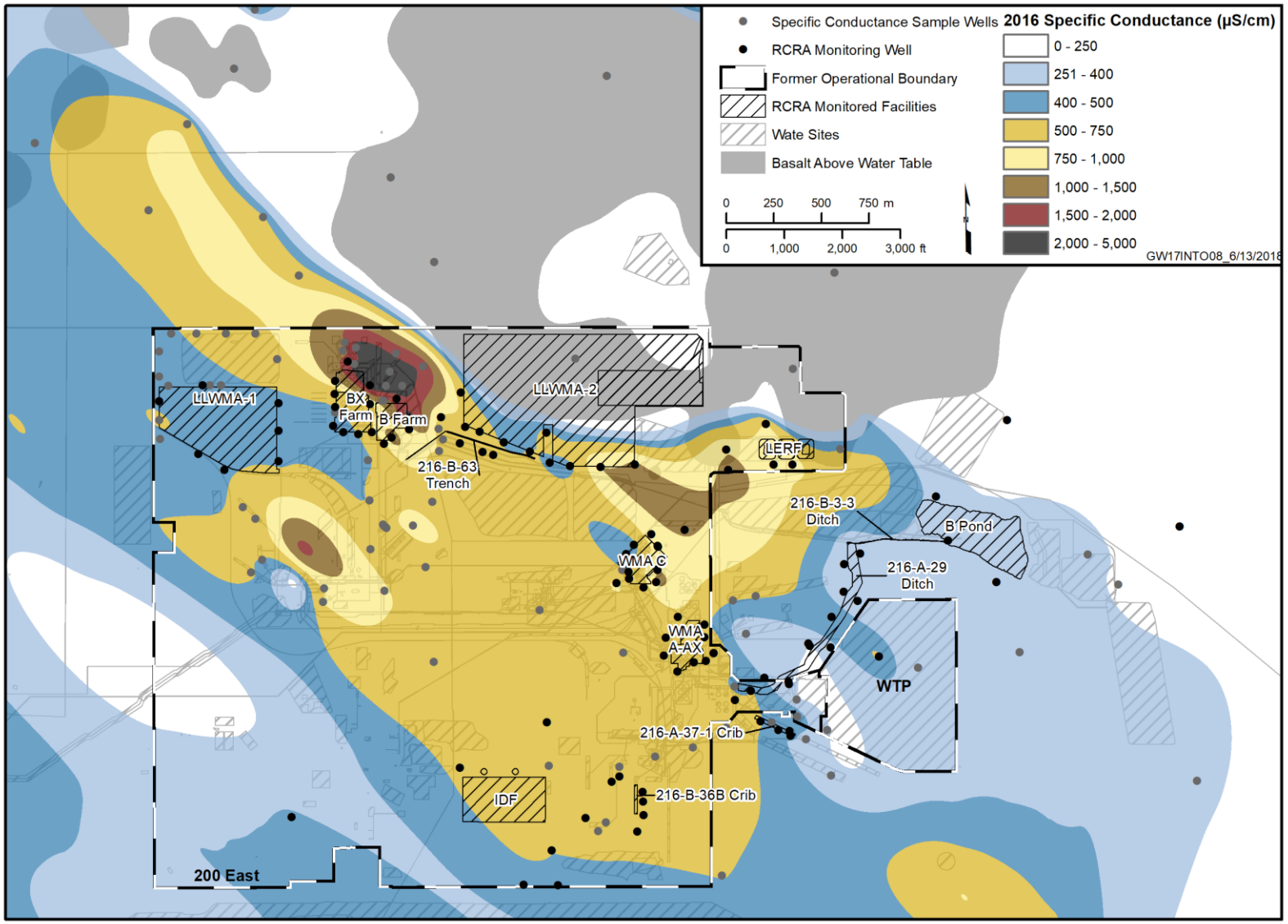

Figure B-2. Specific Conductance in 200 East Area, 2016

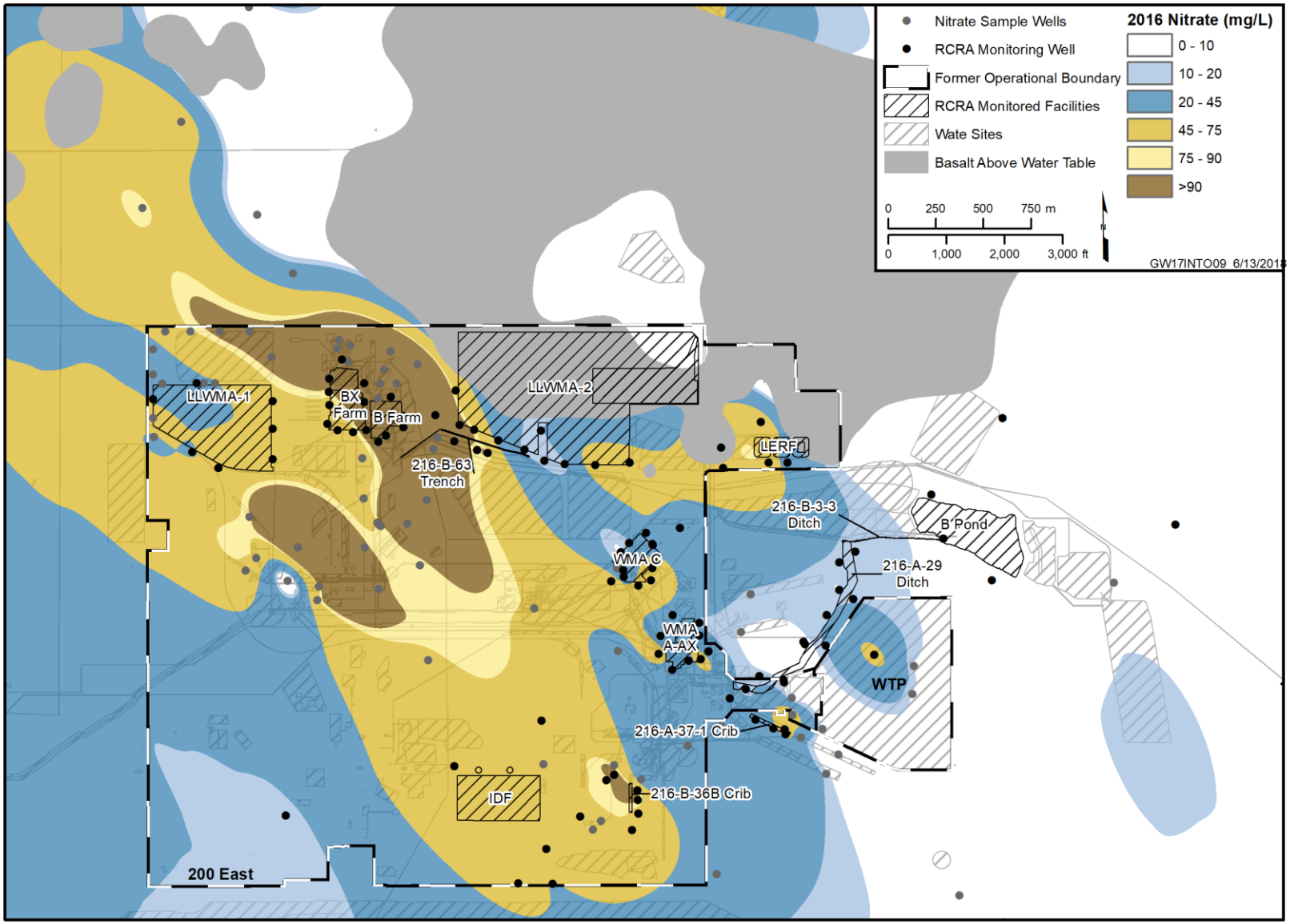

Figure B-3. Nitrate Distribution in 200 East Area, 2016

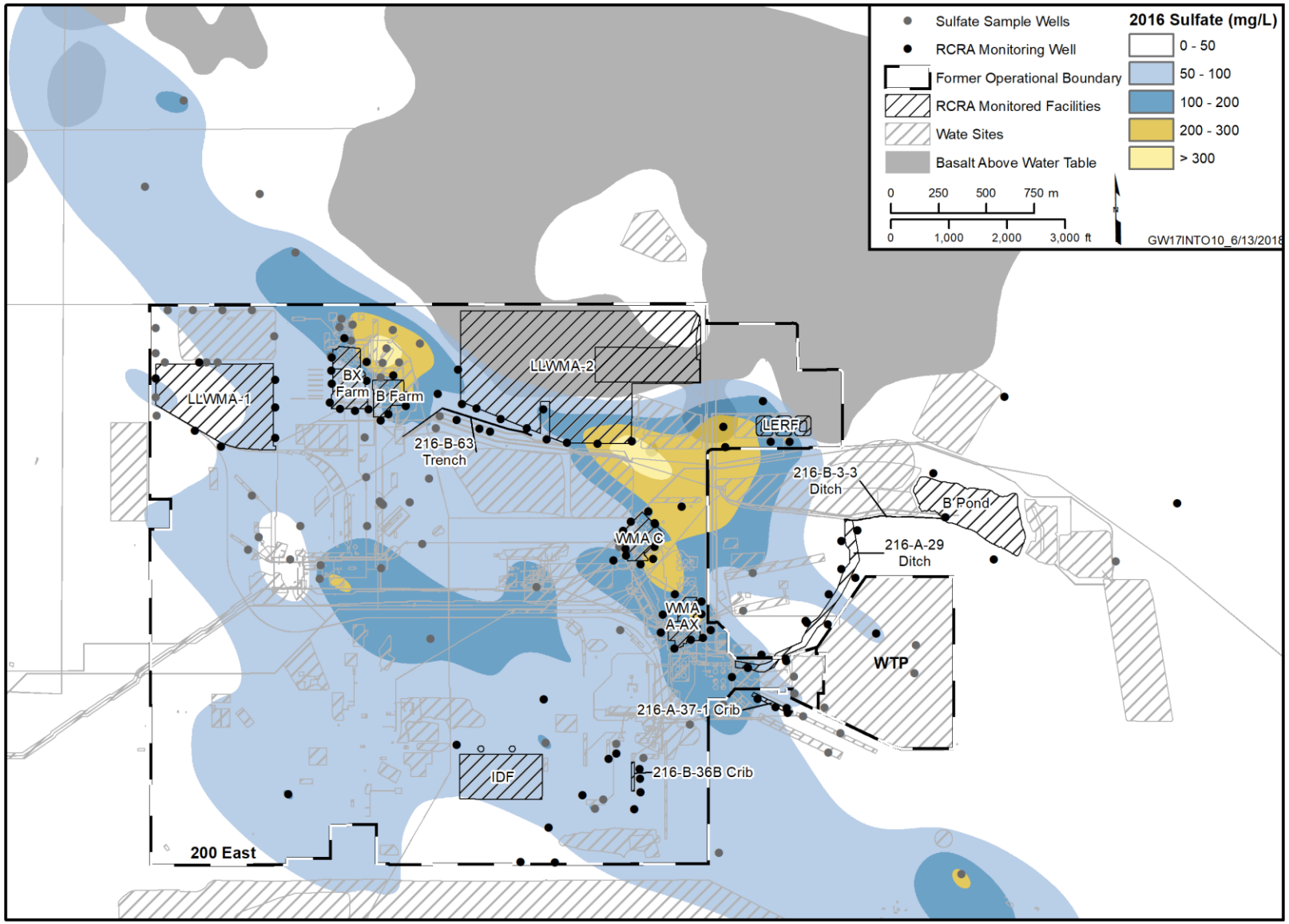

Figure B-4. Sulfate Distribution in 200 East Area, 2016

Table B-1. Hanford Site RCRA Monitoring Reports

Years	Publication Date	Reporting Year	Explanation
1988 to 1995	March 1	Fiscal year (October 1 to September 30)	Standalone RCRA reports. Hanford Sitewide groundwater reports published separately.
1996 to 2008	March 1	Fiscal year (October 1 to September 30)	Comprehensive report (RCRA, Hanford Sitewide, and CERCLA*).
2009 to 2014	July or August	Calendar year	Comprehensive report (RCRA, Hanford Sitewide, CERCLA*, and AEA). DOE and Ecology agreed on alternative schedules to allow the change to calendar year and extend time for reviewing the draft report.
2015 to 2017	March 1	Calendar year	Standalone RCRA report.
	August or September	Calendar year	Comprehensive report (RCRA, Hanford Sitewide, CERCLA,* and AEA). Included revisions to RCRA sections based on Ecology comments on RCRA report.

*The comprehensive groundwater annual reports include the results of CERCLA monitoring. Additional details are provided in separate annual reports for operable units with active remedial actions.

AEA = *Atomic Energy Act of 1954*

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

DOE = U.S. Department of Energy

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

Table B-2. 1301-N Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions*
			m	ft	m	ft	m	ft		m	ft		
199-N-2	DG	1964 (P)	129.9	426.2	111.6	366.2	118.72	389.50	9/5/2017	7.1	23.3	S	None
199-N-3	DG	1964 (P)	130.2	427.1	111.6	366.1	118.48	388.72	9/6/2017	6.9	22.6	S	None
199-N-34	UG	1983 (P)	130.3	427.6	116.9	383.6	119.36	391.61	9/5/2017	2.5	8.1	S	None
199-N-57	UG	1987 (C)	122.4	401.5	117.8	386.5	119.25	391.25	9/5/2017	1.4	4.7	S	None
199-N-105A	DG	1995 (C)	118.6	389.1	111.0	364.1	118.54	388.91	9/6/2017	7.6	24.8	S	None

Note: Requirements are from WHC-SD-EN-AP-038, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N Sites*, and Part V of the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended).

*See Table B-4 for sample dates.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

S = semiannually

UG = upgradient

Table B-3. Groundwater Velocity at the 1301-N Crib and Trench

Flow Direction	March 2017: north September 2017: northwest
Flow Rate (m/d)	March 2017: 0.01 to 0.26 September 2017: 0.05 to 0.87
Hydraulic Conductivity (m/d) (Source)	6.1 to 37 (PNL-8335, *Application of Three Aquifer Test Methods for Estimating Hydraulic Properties Within the 100-N Area*)
Effective Porosity	0.1 and 0.3 (assumed range)
Gradient (m/m)	March 2017: 7.0×10^{-4} September 2017: 2.4×10^{-3}
Comments	Gradient and direction determined by trend surface analysis using March and September 2017 data; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-4. 1301-N Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		**pH**		**Specific Conductance (µS/cm)**		**TOC (µg/L)**			**TOX (µg/L)**			**Lab (TOC and TOX)**	**Comment**
2017 Critical Mean[a]		**6.02**	**9.5**	**1,773**		**2,038**			**29.06**				
Well	**Sample Date**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**LOQ**	**Avg**	**SD**	**LOQ**		
199-N-105A	3/3/2017	8.00	0.00	703	4	521	20.6	NC[b]	<9.0	2.2	NC[b]	TADN	TOC and TOX split
						649	34.4	640	<3.4	0.1	7.8	GEL	
	9/6/2017	8.12	0.00	664	2	550	9.5	600	<3.3	0.0	10.9	GEL	

Table B-4. 1301-N Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
2017 Critical Mean[a]		6.02	9.5	1,773		2,038			29.06				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
199-N-2	3/3/2017	8.12	0.00	763	2	465	9.0	NC[b]	<7.7	0.0	NC[b]	TADN	TOC and TOX split
						<720	0.0	1640	<4.8	4.6	20.4	TASL	
	9/5/2017	8.19	0.01	632	1	<500	0.0	1,390	<2.4	0.4	18.2	TASL	
199-N-3	3/3/2017	7.45	0.00	878	0	<720	0.0	1,640	18.0	6.0	20.4	TASL	
	9/6/2017	7.38	0.00	950	0	<500	0.0	1,390	<5.3	2.7	18.2	TASL	
199-N-34	3/3/2017	8.15	0.00	595	1	404	34.3	NC[b]	<7.7	0.0	NC[b]	TADN	TOC and TOX split
						<720	0.0	1,640	<2.8	0.7	20.4	TASL	
	9/5/2017	8.18	0.00	704	0	<500	0.0	1,390	4.4	1.2	18.2	TASL	
199-N-57	3/6/2017	7.53	0.01	832	2	570	15.3	NC[b]	<7.7	0.0	NC[b]	TADN	TOC and TOX split
						780	23.4	640	<7.8	2.8	7.8	GEL	
	9/5/2017	7.51	0.01	1,112	2	1,088	14.8	600	12.7	3.9	10.9	GEL	

a. Critical mean values from Table 10 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

b. LOQ not calculated because field blank results were not available from this laboratory.

< = one or more of the replicate values was below the detection limit

GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-5. 1301-N Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	70	232	—	
Chloride	mg/L	10	110	250*	
Iron (unfiltered)	µg/L	<30	266	300*	
Iron (filtered)	µg/L	<22.0	219.0	300*	
Manganese (unfiltered)	µg/L	0.9	33.0	50*	
Manganese (filtered)	µg/L	<1	33	50*	
Sodium (unfiltered)	µg/L	5,740	61,200	—	
Sodium (filtered)	µg/L	5,740	61,100	—	
Sulfate	mg/L	42	140	250*	
Turbidity	NTU	0.2	4.4	—	

Note: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

*Secondary drinking water standard.

< = one or more of the replicate values was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-6. 1325-N Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
199-N-28	SI	1983 (P)	127.7	419.1	116.9	383.6	119.46	391.93	9/5/2017	2.5	8.3	S	Resampled for TOX[b]
199-N-32	DG	1983 (P)	128.6	421.9	117.6	385.9	119.32	391.47	9/5/2017	1.7	5.5	S	Resampled for TOX[b]
199-N-41	DG	1984 (P)	123.7	406.0	117.6	386.0	118.63	389.19	9/11/2017	1.0	3.2	S	Resampled for TOX[b]; November verification sampling for TOX exceedance
199-N-74	UG	1991 (C)	121.5	398.5	115.3	378.2	119.58	392.33	9/5/2017	4.3	14.1	S	Resampled for TOX[b]
199-N-81	DG	1993 (C)	119.9	393.4	113.9	373.6	119.18	391.00	9/5/2017	5.3	17.4	S	Resampled for TOX[b]

Note: Requirements are from WHC-SD-EN-AP-038, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N Sites*, and Part VI of the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended).

a. See Table B-8 for sample dates.

b. September TOX samples exceeded recommended holding times, so wells were resampled in October for TOX (see Table B-8).

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

S = semiannually

SI = sampled for supporting information

TOX = total organic halides

UG = upgradient

Table B-7. Groundwater Velocity at the 1325-N Crib and Trench

Flow Direction	March 2017: north October 2017: north-northeast
Flow Rate (m/d)	March 2017: 0.01 to 0.24 October 2017: 0.04 to 0.65
Hydraulic Conductivity (m/d) (Source)	6.1 to 37 (PNL-8335, *Application of Three Aquifer Test Methods for Estimating Hydraulic Properties Within the 100-N Area*)
Effective Porosity	0.1 and 0.3 (assumed range)
Gradient (m/m)	March 2017: 6.6×10^{-4} October 2017: 1.8×10^{-3}
Comments	Gradient and direction determined by trend surface analysis using March and October 2017 data; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-8. 1325-N Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)			TOC (µg/L)			TOX (µg/L)				
2017 Critical Mean[a]		7.59	8.5	Varies by Well			1,087			11.59				
Well	Sample Date	Avg	SD	Critical Mean	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ	Lab	Comment
199-N-28	3/3/2017	8.2	—	504.8	457	—	391	10	640	3.7	0.4	7.8	GEL	
	9/5/2017	8.4	—		393	—	350	—		N/A	N/A	N/A		TOX not analyzed[b]
	10/15/2017	—	—		—	—	—	—		<4.4	0.6	11.8	GEL	Resampled for TOX[b]
199-N-32	3/3/2017	7.8	0.0	588.0	468	1	457	34	640	<4.6	1.1	7.8	GEL	
	9/5/2017	8.3	0.0		431	3	390	2		<3.3	0.0	10.9	GEL	
	10/15/2017	—	—		—	—	—	—		<3.7	0.7	11.8	GEL	Resampled for TOX[b]
199-N-41	3/3/2017	8.1	0.0	731.0	594	1	543	23	640	<4.7	1.1	7.8	GEL	TOX split sample
							—	—		<7.7	0.0	NC[c]	TADN	
	9/11/2017	8.1	0.0		597	1	563	19		17.3	0.8	10.9	GEL	
	10/15/2017	—	—		—	—	—	—		13.9	5.0	11.8	GEL	Resampled for TOX[b]
	11/20/2017	—	—		—	—	—	—		20.1	1.2	11.8	GEL	Verification for TOX (split); see text
										10.0	0.9	17.7	TASL	

Table B-8. 1325-N Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)			TOC (µg/L)			TOX (µg/L)				
2017 Critical Mean[a]		7.59	8.5	Varies by Well			1,087			11.59				
Well	Sample Date	Avg	SD	Critical Mean	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ	Lab	Comment
199-N-74	3/3/2017	8.1	0.0	504.8	430	0	409	33	640	<5.7	3.2	7.8	GEL	
	9/5/2017	8.1	0.0		423	3	340	7		N/A	N/A			TOX not analyzed[b]
	10/15/2017	—	—		—	0	—	—		11.4	1.2		GEL	Resampled for TOX[b]
199-N-81	3/3/2017	8.1	0.0	613.0	496	0	<720	0	1,640	10.2	0.8	20.4	TASL	
	9/5/2017	8.2	0.0		519	1	<500	0		<3.8	1.2		TASL	
	10/15/2017	—	—		—	—	—	—		7.1	4.1		TASL	Resampled for TOX[b;]

Note: Yellow-highlighted cell indicates exceedances of a critical mean.

a. Critical mean values from Tables 11 and 12 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

b. September samples from wells 199-N-28 and 199-N-74 exceeded recommended holding times for TOX so samples were not analyzed. All wells were resampled for TOX on October 15, 2017.

c. LOQ not calculated because field blank results were not available from this laboratory.

< = one or more of the replicate values was below the detection limit
— = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
N/A = not applicable
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-9. 1325-N Sampling Summary for Groundwater Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	69	89	—	
Chloride	mg/L	13	81	250*	
Iron (unfiltered)	µg/L	<30	881	300*	199-N-32
Iron (filtered)	µg/L	<30	604	300*	199-N-32
Manganese (unfiltered)	µg/L	<1.0	42	50	
Manganese (filtered)	µg/L	<1.0	43	50	
Sodium (unfiltered)	µg/L	6,990	15,000	—	
Sodium (filtered)	µg/L	7,270	15,400	—	
Sulfate	mg/L	73	240	250*	
Turbidity	NTU	0.4	4.4	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Highlighted cells indicate concentrations greater than the comparison value.

*Secondary drinking water standard.

— = no comparison value

NTU = nephelometric turbidity unit

Table B-10. 1324-N/NA Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions*
			m	ft	m	ft	m	ft		m	ft		
199-N-71	UG	1991 (C)	121.8	399.6	115.5	378.9	119.61	392.41	9/6/2017	4.1	13.5	S	None
199-N-72	DG	1991 (C)	121.2	397.7	114.9	376.9	119.29	391.36	9/6/2017	4.4	14.4	S	None
199-N-73	DG	1991 (C)	121.2	397.7	115.0	377.2	119.37	391.62	9/6/2017	4.4	14.4	S	October verification sample for TOC exceedance
199-N-77	DG deep	1992 (C)	114.2	374.7	111.2	364.8	119.32	391.47	9/6/2017	8.1	26.7	S	None
199-N-165	DG	2008 (C)	120.0	393.8	115.5	378.8	119.32	391.46	9/6/2017	3.9	12.7	S	None

Note: Requirements are from WHC-SD-EN-AP-038, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N Sites*, and the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended).

*See Table B-12 for sample dates.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

S = semiannually

TOC = total organic carbon

UG = upgradient

Table B-11. Groundwater Velocity at 1324-N/NA Facilities

Flow Direction	March 2017: northeast September 2017: northwest
Flow Rate (m/d)	March 2017: 0.015 to 0.28 September 2017: 0.016 to 0.29
Hydraulic Conductivity (m/d) (Source)	6.1 to 37 (PNL-8335, *Application of Three Aquifer Test Methods for Estimating Hydraulic Properties Within the 100-N Area*)
Effective Porosity	0.1 and 0.3 (assumed range)
Gradient (m/m)	March 2017: 7.5×10^{-4} September 2017: 7.8×10^{-4}
Comments	Gradient is affected by groundwater mound from 100-K injection wells south and southwest of 1324-N/NA; local gradient and direction were determined by trend surface analysis using March and September 2017 water-level measurements from five wells; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradient and Velocity Calculations for RCRA Sites in 2017*.

Table B-12. 1324-N/NA Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		**pH**		**Specific Conductance (µS/cm)**			**TOC (µg/L)**			**TOX (µg/L)**			**Lab (TOC and TOX)**	**Comment**
2017 Critical Mean[a]		**7.37**	**8.72**	**Varies by Well**			**1,061**			**31.90**				
Well	**Sample Date**	**Avg**	**SD**	**Critical Mean**	**Avg**	**SD**	**Avg**	**SD**	**LOQ**	**Avg**	**SD**	**LOQ**		
199-N-165	3/2/2017	8.45	0.00	1,028	608	5	648	31	640	7.4	1.2	7.8	GEL	TOC and TOX split samples
	3/2/2017						449	39	NC[b]	12.1	2.2	NC[b]	TADN	
	9/6/2017	8.47	0.01		720	1	761	21	600	4.6	0.3	10.9	GEL	

Table B-12. 1324-N/NA Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)			TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
2017 Critical Mean[a]		7.37	8.72	Varies by Well			1,061			31.90				
Well	Sample Date	Avg	SD	Critical Mean	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
199-N-71	3/2/2017	8.18	0.00	471	375	0	<720	0	1,640	<11.7	5.6	20.4	TASL	
	9/6/2017	8.26	0.00		388	0	765	114	1,390	4.0	0.7	18.2	TASL	
199-N-72	3/2/2017	8.46	0.00	1,292	853	1	681	14	640	7.3	0.7	7.8	GEL	
	9/6/2017	8.49	0.00		744	2	527	10	600	8.0	1.2	10.9	GEL	
199-N-73	3/2/2017	8.34	0.00	1,045	730	1	<720	0	1,640	<5.4	3.8	20.4	TASL	
	9/6/2017	8.31	0.00		928	5	1,600	308	1,390	4.2	0.9	18.2	TASL	
	10/31/2017	8.48	0.00		571	4	480	12	540	—	—	—	GEL	Verification sampling for TOC (split); exceedance not confirmed
							<500	0	1,540	—	—	—	TASL	
199-N-77	3/2/2017	8.57	0.00	NC[c]	598	4	<720	0	1,640	19.7	1.0	20.4	TASL	
	9/6/2017	8.64	0.00		589	2	482	54	600	3.6	0.2	10.9	GEL	

Note: Yellow-highlighted cell indicates exceedance of a critical mean.

a. Critical mean values from Tables 13 and 14 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

b. LOQ not calculated because field blank results were not available from this laboratory.

c. Critical mean not calculated for well 199-N-77 (deep well); no statistical comparisons required.

< = one or more of the replicate values was below the detection limit
— = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-13. 1324-N/NA Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	106	190	—	
Chloride	mg/L	12	35	250*	
Iron (unfiltered)	µg/L	<30	280	300*	
Iron (filtered)	µg/L	<22	41	300*	
Manganese (unfiltered)	µg/L	<0.47	7.2	50*	
Manganese (filtered)	µg/L	<0.63	1.4	50*	
Sodium (unfiltered)	µg/L	23,000	174,000	—	
Sodium (filtered)	µg/L	23,000	172,000	—	
Sulfate	mg/L	54	220	250*	
Turbidity	NTU	0.82	6.3	—	

Note: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

*Secondary drinking water standard.

— = no comparison value

NTU = nephelometric turbidity unit

Table B-14. 183-H Groundwater Monitoring Network

Well Name	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency Old/New*	Comments; Sampling Exceptions*
		m	ft	m	ft	m	ft		m	ft		
199-H4-8	1986 (C)	117.0	383.9	114.0	373.9	114.64	376.13	11/10/2017	0.7	2.2	A/S	Well pumped dry in November; sampled after recharging
199-H4-84	2011 (C)	117.2	384.4	114.1	374.4	114.68	376.24	11/10/2017	0.6	1.8	A/S	Well pumped dry in November; sampled after recharging
199-H4-85	2013 (C)	119.7	392.6	113.6	372.7	114.48	375.58	11/10/2017	0.9	2.8	0/S	Well pumped dry in November; sampled after recharging; data later rejected
199-H4-88	2016 (C)	119.3	391.5	113.2	371.5	114.76	376.49	11/10/2017	1.5	5.0	0/Q	
199-H4-89	2016 (C)	118.6	389.2	114.1	374.2	114.43	375.42	11/10/2017	0.4	1.2	0/Q	Well pumped dry in November; sampled after recharging

Note: Requirements are from Part VI of the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended).

*Monitoring network was revised via permit modification beginning May 2017. Two additional wells (199-H4-12A and 199-H4-12C) were removed from the network and RCRA sampling was not required in 2017.

0 = no sampling required

A = annual

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

Q = quarterly

RCRA = *Resource Conservation and Recovery Act of 1976*

S = semiannual

Table B-15. Groundwater Velocity at 183-H Solar Evaporation Basins

Flow Direction	March and June – southwest; October – east-northeast
Flow Rate (m/d)	March: 0.1 to 2.7; June: 0.2 to 5.1; October: 0.2 to 4.1
Hydraulic Conductivity (m/d) (Source)	15 to 140 (PNL-6728, *Geohydrologic Characterization of the Area Surrounding the 183-H Solar Evaporation Basins*)
Effective Porosity	0.1
Gradient (m/m)	March: 1.9×10^{-3}; June: 3.6×10^{-3}; October: 2.9×10^{-3}
Comments	Gradient and direction determined by trend surface analysis (automated water-level network data for June; manual data for March and October); velocity calculated from Darcy equation (gradient is influenced by the pump-and-treat system)

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-16. 183-H Solar Evaporation Basins Sampling Summary, 2017

Well	Sample Date	Chromium (Filtered) (µg/L)	Nitrate (mg/L)	Dissolved Oxygen (mg/L)	pH	Specific Conductance (µS/cm)	Temperature (°C)	Turbidity (NTU)
Concentration Limit		**48**	**45**	—	—	—	—	—
199-H4-8	11/10/2017	3.0 (BC)	11.1 (D)	10.65	7.54	383	18.8	100
199-H4-84	11/10/2017	2.9 (BC)	30.5 (D)	8.64	7.56	610	16.6	>1,000
199-H4-85	11/10/2017	13.7 (DR)	0.124 (UDR)	3 (R)	6.81 (R)	32.8 (R)	11.6 (R)	0.52 (R)
199-H4-88	8/29/2017	19	54.9 (D)	6.54	7.54	699	19.6	1.74
	11/10/2017	11.6	44.3 (D)	6.76	7.5	653	17.5	7.3
199-H4-89	8/29/2017	3.4	19.3		7.26	481	22.3	4.05
	11/10/2017	1.2 (B)	48.7 (D)	5.88	7.11	817	18.7	59.3

Notes: Sample results were collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the permit concentration limit.

B = detected at less than the contract-required detection limit but greater than the method detection limit

C = detected in both the sample and the associated quality control blank

D = reported at a secondary dilution factor

F = under review (suspected error)

NTU = nephelometric turbidity unit

R = rejected (result is not valid)

U = undetected

Table B-17. Statistical Evaluation of 183-H Dangerous Waste Constituents, 2017

Well	Semiannual Period	Chromium (filtered) (µg/L)		Nitrate (mg/L)	
		95% UCL	Permit Concentration Limit	95% UCL	Permit Concentration Limit
199-H4-8	January–June	N/A[a]	48	N/A[a]	45
199-H4-8	July–December	N/A[a]	48	N/A[a]	45
199-H4-84	January–June	85.63[b]	48	69.33[b]	45
199-H4-84	July–December	102[b]	48	72.97[b]	45
199-H4-85	January–June	N/A[a]	48	N/A[a]	45
199-H4-85	July–December	N/A[a]	48	N/A[a]	45
199-H4-88	January–June	N/A[a]	48	46.392[b]	45
199-H4-88	July–December	N/A[a]	48	60.94[b]	45
199-H4-89	January–June	N/A[a]	48	N/A[c]	45
199-H4-89	July–December	N/A[a]	48	N/A[c]	45

References:

SGW-61639, *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins: January – June 2017*.

SGW-61763, *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins: July – December 2017* (in publication).

Note: Yellow-highlighted cell indicates the UCL exceeded a permit concentration limit.

a. None of the results in the data set exceeded the concentration limit; therefore, no UCL was calculated.

b. Includes samples collected for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* monitoring.

c. Fewer than eight samples have been collected (RCRA and non-RCRA combined); therefore no UCL was calculated.

N/A = not applicable

UCL = upper confidence limit

Table B-18. 216-A-29 Groundwater Monitoring Network

Well Name	Location Rev. 0[a]	Location Rev. 1 and 2[a]	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency Rev. 0/1/2[a]	Sampled Months and Exceptions
				m	ft	m	ft	m	ft		m	ft		
299-E25-2	UG	N/A	1955 (P)	122.3	401.1	110.1	361.1	121.71	399.30	10/9/2017	11.6	38.2	S/0/0	1, 4
299-E25-238	N/A	DG	2017 (C)	122.3	401.3	113.2	371.3	121.70	399.29	10/25/2017	8.5	28.0	0/Q/Q	10; new well
299-E25-239	N/A	DG	2017 (C)	122.8	402.7	113.6	372.7	121.71	399.31	10/25/2017	8.1	26.6	0/Q/Q	10; new well
299-E25-26	DG	N/A	1985 (P)	122.5	402.0	116.4	382.0	121.61	398.99	7/21/2017	5.2	17.0	S/Q/0	1, 4, 7; replaced by 299-E25-239
299-E25-28	DG	N/A	1986 (C)	104.8	343.9	98.7	323.9	121.70	399.27	10/9/2017	23.0	75.4	S/0/0	1, 4
299-E25-32P[b]	DG	N/A	1988 (C)	125.4	411.3	119.3	391.3	121.70	399.27	9/28/2017	2.4	8.0	S/Q/0	1, 4, 7; replaced by 299-E25-238
299-E25-34[b]	DG	UG	1988 (C)	125.8	412.6	119.7	392.6	121.72	399.33	10/1/2017	2.1	6.7	S/Q/Q	1, 4, 7, 10
299-E25-35[b]	DG	DG	1988 (C)	126.2	414.0	119.9	393.5	121.70	399.27	10/24/2017	1.7	5.7	S/Q/Q	1, 4, 7, 10
299-E25-43	DG	UG	1991 (C)	125.5	411.6	119.1	390.6	121.68	399.22	10/25/2017	2.6	8.6	0/Q/Q	1, 4, 7, 10
299-E25-47	DG	UG	1992 (C)	125.2	410.7	119.1	390.8	121.71	399.31	10/24/2017	2.6	8.5	0/Q/Q	4, 7, 10
299-E25-48	DG	N/A	1992 (C)	124.6	408.7	118.4	388.4	121.64	399.08	4/19/2017	3.3	10.7	S/0/0	1, 4
299-E26-12	UG	N/A	1991 (C)	125.9	413.1	119.5	392.1	121.74	399.41	10/13/2017	2.2	7.3	S/0/0	1, 4
299-E26-13[b]	UG	UG	1991 (C)	126.0	413.2	119.7	392.6	121.71	399.31	10/24/2017	2.0	6.7	S/Q/Q	1, 4, 7, 10
299-E26-80	N/A	DG	2017 (C)	122.5	402.0	113.4	372.0	121.70	399.26	10/24/2017	8.3	27.3	0/Q/Q	10; new well
699-43-45	DG	N/A	1989 (C)	126.5	414.9	120.3	394.6	121.66	399.15	7/14/2017	1.4	4.5	S/0/0	1, 4

Table B-18. 216-A-29 Groundwater Monitoring Network

Well Name	Location Rev. 0[a]	Location Rev. 1 and 2[a]	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency Rev. 0/1/2[a]	Sampled Months and Exceptions
				m	ft	m	ft	m	ft		m	ft		

Note: Requirements are from DOE/RL-2016-23, *216-A-29 Ditch Interim Status Groundwater Quality Assessment Monitoring Plan.*

a. Designation of upgradient and downgradient wells, sampling frequency, and constituents were revised during 2017. DOE/RL-2016-23, Rev. 0 was in effect through May 2017, Rev. 1 from May to September, and Rev. 2 beginning in September 2017.

b. Hydraulic head data for these wells were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

0 = not in monitoring network under applicable revision of the groundwater monitoring plan

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

N/A = not applicable

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly

S = semiannual

UG = upgradient

Table B-19. Groundwater Velocity at the 216-A-29 Ditch

Flow Direction	West-southwest
Flow Rate (m/d)	0.34
Hydraulic Conductivity (m/d) (Source)	Hanford formation and Cold Creek gravels: 17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	4.0×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-20. 216-A-29 Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	82	117	—	
Ammonia	µg/L	<20.7	241	—	
Calcium (unfiltered)	µg/L	23,400	76,000	—	
Calcium (filtered)	µg/L	23,100	75,200	—	
Chloride	mg/L	3.9	29	250[a]	
Chromium (unfiltered)	µg/L	<0.66	87.4	100[b]	
Chromium (filtered)	µg/L	<0.95	84.5	100[b]	
Iron (unfiltered)	µg/L	<17	542	300[a]	299-E25-34
Iron (filtered)	µg/L	<17	200	300[a]	
Magnesium (unfiltered)	µg/L	2,040	22,000	—	
Magnesium (filtered)	µg/L	6,640	21,700	—	
Manganese (unfiltered)	µg/L	<0.36	38.9	50[a]	
Manganese (filtered)	µg/L	<0.59	88.5	50[a]	299-E25-34
Nickel (unfiltered)	µg/L	<0.3	41	—	

Table B-20. 216-A-29 Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Nickel (filtered)	µg/L	<0.32	84.8	—	
Nitrate	mg/L	1.99	57.5	45[c]	299-E25-32P
pH	—	7.84	8.57	—	
Phenol	µg/L	<1.9	<3	2,400[d]	
Potassium (unfiltered)	µg/L	4,110	9,200	—	
Potassium (filtered)	µg/L	4,340	9,120	—	
Sodium (unfiltered)	µg/L	2,520	29,000	—	
Sodium (filtered)	µg/L	9,110	29,400	—	
Specific conductance	µS/cm	223	689	—	
Sulfate	mg/L	16	161	250[a]	
Total organic carbon	µg/L	<155	9,960	—	
Total organic halides	µg/L	<2.1	23.6	—	
Turbidity	NTU	0.14	230	—	
Additional Constituents Detected, Wells 299-E25-43, 299-E25-47, 299-E25-238, and 299-E25-239[e]					
Arsenic (unfiltered)	µg/L	4.2	9.2	10	
Arsenic (filtered)	µg/L	4	9	10[b]	
Barium (unfiltered)	µg/L	21	44.3	2,000[b]	
Barium (filtered)	µg/L	20	45.3	2,000[b]	
Chromium (unfiltered)	µg/L	<1.91	10.5	100[b]	
Chromium (filtered)	µg/L	<1.6	3.6	100[b]	
Fluoride	mg/L	0.19	0.507	4[b]	
Gross alpha	pCi/L	<0.76	3.57	15[f]	
Gross beta	pCi/L	3.57	8.96	50[f]	
Lead (unfiltered)	µg/L	<0.096	0.85	15[g]	
Lead (filtered)	µg/L	<0.096	0.85	15[g]	
Selenium (unfiltered)	µg/L	<1.8	5.5	50[b]	
Selenium (filtered)	µg/L	<1.7	5.66	50[b]	

Table B-20. 216-A-29 Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Silver (unfiltered)	µg/L	<0.023	1.09	100[a]	
Silver (filtered)	µg/L	<0.023	1.36	100[a]	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. The federal drinking water standards for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

e. Analyzed for first year in these wells. The following constituents were analyzed but not detected in 2017: 2,4,5-TP Silvex, 2,4-D, cadmium, coliform, Endrin, Lindane, mercury, methoxychlor, and toxaphene.

f. Concentration assumed to yield a dose equivalent of 4 mrem/yr.

g. Action level.

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-21. 216-A-36B Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E17-1	UG	1955 (P)	127.2	417.4	118.1	387.4	121.5	398.7	7/25/2017	3.4	11.3	Q	Sampled with bailer; extra sampling events; see text
299-E17-14	DG	1988 (C)	126.0	413.2	119.2	391.2	124.64	408.92	7/20/2017	5.4	17.7	S	Extra sampling events; see text
299-E17-15	DG	1988 (C)	125.5	411.8	119.6	392.3	121.35	398.14	7/20/2017	1.8	5.8	Q	Extra sampling events; see text
299-E17-16	DG	1988 (C)	125.4	411.4	119.3	391.4	121.55	398.78	7/20/2017	2.2	7.4	S	Extra sampling events; see text
299-E17-18[b]	DG	1988 (C)	125.8	412.6	118.8	389.8	121.63	399.04	7/20/2017	2.8	9.3	S	Extra sampling events; see text
299-E17-19[b]	UG	1988 (C)	126.8	416.0	119.9	393.4	121.44	398.41	7/20/2017	1.5	5.0	S	Extra sampling events; see text

Note: Requirements are from DOE/RL-2010-93, *Interim Status Groundwater Monitoring Plan for the 216-A-36B Purex Plant Crib*.

a. See Table B-23 for sample dates.

b. Hydraulic head data for these wells were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly (for first year; semiannually thereafter)

S = semiannually

UG = upgradient

Table B-22. Groundwater Velocity at the 216-A-36B Crib

Flow Direction	East
Flow Rate (m/d)	0.0001
Hydraulic Conductivity (m/d) (Source)	3.26 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.1 (CP-57037)
Gradient (m/m)	3.41×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-23. 216-A-36B Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment[b]
Critical Mean[a]		7.12	8.67	1,066		804			35.75				
Well	**Sample Date**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**LOQ**	**Avg**	**SD**	**LOQ**		
299-E17-1	1/24/2017	7.69	—	773	—	469	16	640	<3.33	0.00	7.8	GEL	No field quads
	2/24/2017	7.70	—	585	—	—	—	—	—	—	—	—	No field quads
	3/10/2017	7.86	—	669	—	425	95	640	<3.70	0.49	7.8	GEL	No field quads
	4/6/2017	7.10	—	620	—	192	39	NC	<15.65	0.43	NC	TADN	No field quads
	4/26/2017	7.56	0.35	620	11	<330	0	590	<4.19	1.49	8.3	GEL	
	7/25/2017	8.08	0.05	605	4	391	16	600	<3.33	0.00	10.9	GEL	
	10/10/2017	7.99	—	653	—	1,113	451	540	<5.14	2.98	11.8	GEL	No field quads

Table B-23. 216-A-36B Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment[b]
Critical Mean[a]		7.12	8.67	1,066		804			35.75				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E17-14	1/23/2017	7.96	0.01	702	0	<720	0	1,640	<2.78	1.00	20.4	TASL	
	2/24/2017	7.73	0.01	744	9	<720	0	1,640	—	—	—	TASL	
	3/10/2017	7.93	0.01	715	3	<720	0	1,640	5.00	1.99	20.4	TASL	
	7/20/2017	7.82	0.00	743	11	<500	0	1,390	4.03	2.19	18.2	TASL	
299-E17-15	1/24/2017	8.04	0.02	612	7	<720	0	1,640	<3.70	2.77	20.4	TASL	
	2/24/2017	7.86	0.00	629	2	<720	0	1,640	—	—	—	TASL	
	3/10/2017	8.08	0.01	609	3	<720	0	1,640	6.38	0.89	20.4	TASL	
	4/6/2017	8.13	0.00	614	1	<720	0	1,520	<2.10	0.00	20.4	TASL	
	4/26/2017	7.89	0.02	614	1	<745	43	1,520	<2.10	0.00	20.4	TASL	
	7/20/2017	8.01	0.00	644	6	<500	0	1,390	<2.70	0.64	18.2	TASL	
	10/10/2017	7.95	0.01	644	3	<500	0	1,540	6.70	0.68	17.7	TASL	
299-E17-16	1/24/2017	7.97	0.04	587	0	367	6	640	<3.33	0.00	7.8	GEL	
	2/24/2017	7.73	0.00	561	0	—	—	—	—	—	—	—	
	3/10/2017	7.97	0.00	589	0	<349	33	640	<3.50	0.29	7.8	GEL	
	7/20/2017	7.80	0.01	621	1	<360	52	600	<3.33	0.00	10.9	GEL	

Table B-23. 216-A-36B Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment[b]
Critical Mean[a]		7.12	8.67	1,066		804			35.75				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E17-18	1/24/2017	7.98	0.00	578	3	<720	0	1,640	<25.58	23.62	20.4	TASL	TOX flagged as "YQ"
	2/24/2017	7.70	0.00	563	1	<720	0	1,640	—	—	—	TASL	
	3/10/2017	7.93	0.00	583	0	<720	0	1,640	<3.45	2.01	20.4	TASL	
	7/20/2017	7.82	0.01	606	2	<500	0	1,390	<2.30	0.35	18.2	TASL	
299-E17-19	1/23/2017	7.91	0.00	694	1	<330	0	640	<4.16	0.60	7.8	GEL	
	2/24/2017	7.64	0.00	679	3	—	—	—	—	—	—	—	
	3/10/2017	7.86	0.00	689	2	<330	0	640	<3.66	0.58	7.8	GEL	
	7/20/2017	7.68	0.03	677	11	<333	4	600	<3.33	0.00	10.9	GEL	

Note: Highlighted cell indicates exceedance of a critical mean.

a. Critical mean values from Table 18 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

b. See Section 10.10.2 of the main text for explanation of extra sampling events.

< = one or more of the replicate values was below the detection limit
— = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
Q = associated quality control sample is out of limits
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides
Y = result suspect

Table B-24. 216-A-36B Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity[a]	mg/L	110	137	—	
Calcium (unfiltered)	µg/L	45,700	76,300	—	
Calcium (filtered)	µg/L	50,400	77,200	—	
Chloride	mg/L	14	18	250[b]	
Dissolved oxygen	mg/L	6.0	9.6	—	
Fluoride	mg/L	0.2	0.427	4[c]	
Iron (unfiltered)	µg/L	<30	35,400	300[b]	299-E17-1, 299-E17-15
Iron (filtered)	µg/L	<22	8,070[d]	300[b]	299-E17-1, 299-E17-16
Magnesium (unfiltered)	µg/L	15,500	23,200	—	
Magnesium (filtered)	µg/L	16,900	23,300	—	
Manganese (unfiltered)	µg/L	<0.9	417	50[b]	299-E17-1, 299-E17-18
Manganese (filtered)	µg/L	<0.9	49.1	50[b]	
Nitrate	mg/L	57.5	120	45[e]	All
Nitrite	mg/L	<0.046	0.591	3.3[e]	
Phenol	µg/L	<1.9	<3	2,400[f]	
Potassium (unfiltered)	µg/L	6,710	9,190	—	
Potassium (filtered)	µg/L	6,690	8,900	—	
Sodium (unfiltered)	µg/L	23,600	31,200	—	
Sodium (filtered)	µg/L	24,700	32,700	—	
Sulfate	mg/L	64	100	250[b]	
Temperature	°C	15.3	32	—	
Turbidity	NTU	0.32	66.7	—	
Detected Volatile Organic Analytes[g]					
Chloroform	µg/L	<0.13	0.3	80[c]	
Trichloroethene	µg/L	<0.25	1.73	5[c]	

Table B-24. 216-A-36B Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Includes total and bicarbonate alkalinity.

b. Secondary drinking water standard.

c. Primary drinking water standard.

d. Maximum filtered iron value is under review as a suspected error.

e. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

f. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

g. The following organics were analyzed but not detected in 2017: 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, carbon tetrachloride, methylene chloride, tetrachloroethene, and vinyl chloride.

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-25. 216-A-37-1 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency Rev. 1/2/3	Comments; Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E25-17	DG	1976 (P)	123.5	405.1	116.8	383.1	121.65	399.10	7/21/2017	4.9	16.0	S/S/S	None
299-E25-19	DG	1976 (P)	124.5	408.6	116.9	383.6	121.67	399.19	7/21/2017	4.8	15.6	S/S/S	None
299-E25-20	DG	1976 (P)	124.5	408.6	116.9	383.6	121.41	398.33	7/21/2017	4.5	14.7	S/S/S	None
299-E25-35[b]	UG	1988 (C)	126.2	414.0	119.9	393.5	121.65	399.12	7/21/2017	1.7	5.6	0/Q/Q	None
299-E25-47	UG	1992 (C)	125.2	410.7	119.0	390.5	121.65	399.10	7/21/2017	2.6	8.6	S/S/S	None
299-E25-95	DG	2017 (C)	122.3	401.2	113.1	371.2	122.64	402.38	8/1/2017	9.5	31.2	0/Q/Q	New well first sampled October 2017; not sampled for alkalinity

Note: Requirements are from DOE/RL-2010-92, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*, Rev. 1 was in effect until April 2017; Rev. 2 was in effect April through September 2017; and Rev. 3 was implemented in September 2017.

a. See Table B-27 for sample dates.

b. Hydraulic head data for this well were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

0 = not in monitoring plan

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly (for first year; semiannually thereafter)

S = semiannually

UG = upgradient

Table B-26. Groundwater Velocity at the 216-A-37-1 Crib

Flow Direction	West-southwest (based on 2017 data); contaminant plumes in the region indicate long-term average flow to the southeast
Flow Rate (m/d)	0.38
Hydraulic Conductivity (m/d) (Source)	17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	4.4×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-27. 216-A-37-1 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		**pH**		**Specific Conductance (µS/cm)**		**TOC (µg/L)**			**TOX (µg/L)**			**Lab (TOC and TOX)**	**Comment**
Critical Mean (January)*		**6.77**	**9.64**	**993**		**777**			**14.69**				
Critical Mean (July and October)*		**7.18**	**9.46**	**739**		**817**			**NC – Use LOQ**				
Well	**Sample Date**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**LOQ**	**Avg**	**SD**	**LOQ**		
299-E25-17	1/16/2017	7.88	0.02	547	1	<720	0	1,640	5.0	0.9	20.4	TASL	
	7/21/2017	7.89	0.00	565	1	<500	0	1,390	<2.1	0.0	18.2	TASL	
299-E25-19	1/24/2017	8.27	0.00	385	1	<720	0	1,640	7.8	3.4	20.4	TASL	
	7/21/2017	8.22	0.02	411	1	<500	0	1,390	8.9	2.0	18.2	TASL	

Table B-27. 216-A-37-1 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean (January)*		**6.77**	**9.64**	**993**		**777**			**14.69**				
Critical Mean (July and October)*		**7.18**	**9.46**	**739**		**817**			**NC – Use LOQ**				
Well	**Sample Date**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**LOQ**	**Avg**	**SD**	**LOQ**		
299-E25-20	1/16/2017	7.84	0.01	450	2	<720	0	1,640	<2.1	0.0	20.4	TASL	
	7/21/2017	7.75	0.00	458	0	<500	0	1,390	6.2	0.4	18.2	TASL	
299-E25-35	1/25/2017	8.10	0.00	514	1	<372	43	640	<10.3	0.0	7.8	GEL	
	4/18/2017	8.27	0.00	527	2	298	25	NC	<10.3	3.3	NC	TADN	
	7/21/2017	8.21	0.01	532	2	388	12	600	<3.6	0.5	10.9	GEL	
	10/24/2017	8.22	0.00	527	1	445	15	540	<3.6	0.5	11.8	GEL	
299-E25-47	1/16/2017	8.43	0.02	397	1	545	16	640	3.3	0.0	7.8	GEL	
	7/21/2017	8.36	0.01	412	1	436	48	540	<7.7	0.0	24.7	TADN	
299-E25-95	10/24/2017	7.93	0.01	508	1	<503	4	1,540	4.9	0.3	17.7	TASL	

*Critical mean values are from Tables 19 and 20 ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

< = one or more of the replicate values was below the detection limit
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-28. 216-A-37-1 Sampling Summary for Groundwater Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	84	95	—	
Calcium (unfiltered)	µg/L	37,100	57,000	—	
Calcium (filtered)	µg/L	37,600	57,200	—	
Chloride	mg/L	6.8	16	250[a]	
Chromium (unfiltered)	µg/L	<0.84	296	—	
Chromium (filtered)	µg/L	<0.86	10	—	
Fluoride	mg/L	0.24	0.571	4.0[b]	
Iron (unfiltered)	µg/L	<17	1,840	300[a]	299-E25-19
Iron (filtered)	µg/L	<17	200	300[a]	
Magnesium (unfiltered)	µg/L	10,900	16,600	—	
Magnesium (filtered)	µg/L	10,500	16,100	—	
Manganese (unfiltered)	µg/L	<1.1	92.5	50[a]	299-E25-19, 299-E25-20
Manganese (filtered)	µg/L	<0.9	89.3	50[a]	299-E25-19, 299-E25-20
Nickel (unfiltered)	µg/L	<0.5	136	—	
Nickel (filtered)	µg/L	<0.3	11	—	
Nitrate	mg/L	5.8	79.7	45[c]	299-E25-20, 299-E25-95
Nitrite	mg/L	<0.046	<0.125	3.3[c]	
Phenol	µg/L	<1.9	<3	2,400[d]	
Potassium (unfiltered)	µg/L	5,710	8,910	—	
Potassium (filtered)	µg/L	5,500	8,810	—	
Sodium (unfiltered)	µg/L	14,800	26,000	—	
Sodium (filtered)	µg/L	14,200	27,800	—	
Sulfate	mg/L	47	140	250[a]	
Temperature	°C	14.4	23.3	—	
Turbidity	NTU	0.28	38.2	—	

Table B-28. 216-A-37-1 Sampling Summary for Groundwater Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Additional Constituents Detected, Wells 299-E25-35 and 299-E25-95[e]					
Arsenic (unfiltered)	µg/L	4.9	11.5	10[a]	299-E25-35
Arsenic (filtered)	µg/L	4.8	11.5	10[a]	299-E25-35
Barium (unfiltered)	µg/L	32.8	55.3	2,000[a]	
Barium (filtered)	µg/L	33.1	55.9	2,000[a]	
Chromium (unfiltered)	µg/L	<4	17	100[a]	
Chromium (filtered)	µg/L	<4	10	100[a]	
Gross beta	pCi/L	19	168	50[f]	299-E25-95
Radium-228	pCi/L	< -0.0499	0.535	—	
Selenium (unfiltered)	µg/L	<2	3.5	50[a]	
Selenium (filtered)	µg/L	<2	3.5	50[a]	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Primary drinking water standard.

b. Secondary drinking water standard.

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

e. Analyzed for the first year in these wells. The following constituents were analyzed but not detected in 2017: 2,4,5-TP Silvex, 2,4-D, cadmium, coliform, Endrin, Lindane, gross alpha, lead, mercury, methoxychlor, radium-226, silver, and toxaphene.

f. Concentration assumed to yield a dose equivalent of 4 mrem/yr.

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-29. 216-B-3 Pond Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency Rev. 0/1/2	Comments; Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
699-42-42B	DG	1988 (C)	121.8	399.6	115.7	379.6	122.12	400.65	7/14/2017	6.4	21.1	S/S/S	None
699-43-44[b]	DG	1999 (C)	124.5	408.5	118.4	388.5	121.86	399.81	7/14/2017	3.5	11.3	S/S/0	Decommissioned in July 2017; to be replaced by 699-43-43B.
699-43-45	DG	1989 (C)	126.5	414.9	120.3	394.6	121.66	399.15	7/14/2017	1.4	4.5	S/S/S	None
699-44-39B	UG	1992 (C)	126.2	414.1	120.1	394.1	123.33	404.64	7/14/2017	3.2	10.5	S/S/S	None
699-44-43C	UG	2017 (C)	124.1	407.0	116.4	382.0	122.82	402.95	8/14/2017	6.4	20.9	0/Q/Q	New well
699-45-42	UG	1948 (P)	128.4	421.2	121.7	399.2	122.94	403.36	7/14/2017	1.3	4.2	0/S/0	Replaced by 699-44-43C
699-43-43B	DG	Planned for 2018	—	—	—	—	—	—	—	—	—	0/0/Q	Replacement for 699-43-44

Note: Requirements are from DOE/RL-2008-59, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*, Rev. 0 was in effect until April 2017, Rev. 1 was in effect from April through September, and Rev. 2 was implemented in late September 2017.

a. See Table B-31 for sample dates.

b. Hydraulic head data for this well were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

0 = not in groundwater monitoring network

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly

S = semiannually

UG = upgradient

Table B-30. Groundwater Velocity at the 216-B-3 Pond

Flow Direction	Ringold semiconfined: southwest; Hanford unconfined: west-southwest
Flow Rate (m/d)	Ringold semiconfined: 0.068; Hanford unconfined: 0.34
Hydraulic Conductivity (m/d) (Source)	Ringold Formation: 5.0 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*) Hanford formation: 17,000 (CP-57037)
Effective Porosity	Ringold Formation: 0.1 (CP-57037) Hanford formation: 0.2 (CP-57037)
Gradient (m/m)	Ringold semiconfined: 1.36×10^{-3}; Hanford unconfined: 4.04×10^{-6}
Comments	Ringold gradient based on three-point analysis of data collected in March 2017; Hanford gradient is the same as 216-A-29; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-31. 216-B-3 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment[b]
Critical Mean[a]		7.09	8.98	428		2,543			NC – Use LOQ				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
699-42-42B	1/26/2017	8.1	0.0	297	0	<330	0	640	<3.8	0.9	7.8	GEL	
	7/14/2017	7.8	0.0	325	0	315	44	540	<8.1	0.6	24.7	TADN	
699-43-44	1/29/2017	8.0	0.0	279	1	3,475	249	1,640	<6.5	3.5	20.4	TASL	
	3/23/2017	8.0	0.0	284	0	4,155	646	640	—	—	—	GEL	TOC verification; split samples
						3,900	430	1,640				TASL	

Table B-31. 216-B-3 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment[b]
Critical Mean[a]		7.09	8.98	428		2,543			NC – Use LOQ				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
	7/14/2017	7.8	0.0	302	0	7,325	130	1,390	<2.3	0.2	18.2	TASL	Assessment not triggered; see text
699-43-45	1/26/2017	8.3	0.0	275	2	<345	26	640	<3.3	0.0	7.8	GEL	
	7/14/2017	8.1	0.0	300	1	<335	6	600	<3.3	0.0	10.9	GEL	
699-44-39B	1/26/2017	8.2	0.0	252	0	<347	30	640	<3.3	0.0	7.8	GEL	
	7/14/2017	8.0	0.0	274	0	250	22	540	<7.7	0.0	24.7	TADN	
699-44-43C	10/12/2017	8.1	0.0	280	0	400	7	540	<3.3	0.0	11.8	GEL	New well
699-45-42	1/26/2017	8.0	0.0	332	1	422	7	640	<3.3	0.0	7.8	GEL	See footnote b
	7/14/2017	7.9	0.0	363	0	422	21	600	<3.3	0.0	10.9	GEL	
	10/12/2017	8.1	0.0	359	1	483	28	540	<3.3	0.0	11.8	GEL	See footnote b

Note: Yellow-highlighted cell indicates exceedance of a critical mean.

a. Critical mean values are from Tables 21 and 22 ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*. Critical mean values did not change between revisions to the monitoring network.

b. Well 699-45-42 was sampled in January in anticipation of being added to the revised monitoring plan. It was replaced by new well 699-44-43C in October (both wells were sampled in October).

< = one or more of the replicate values was below the detection limit
-- = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-32. 216-B-3 Sampling Summary for Groundwater Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity[a]	mg/L	91.6	128	—	
Arsenic (unfiltered)	µg/L	<5	10	10[b]	
Arsenic (filtered)	µg/L	4.6	10.1	10[b]	
Cadmium (unfiltered)	µg/L	<0.062	<1.5	5[b]	
Cadmium (filtered)	µg/L	<0.062	<1.5	5[b]	
Calcium (unfiltered)	µg/L	22,000	32,000	—	
Calcium (filtered)	µg/L	22,000	32,400	—	
Chloride	mg/L	3	13	250[c]	
Fluoride	mg/L	0.23	0.46	4[b]	
Iron (unfiltered)	µg/L	<30	1,200	300[c]	699-44-43C, 699-45-42
Iron (filtered)	µg/L	<17	99.7	300[c]	
Magnesium (unfiltered)	µg/L	7,980	12,000	—	
Magnesium (filtered)	µg/L	7,910	12,000	—	
Manganese (unfiltered)	µg/L	<1.02	190	50[c]	699-44-43C
Manganese (filtered)	µg/L	<1.00	170	50[c]	699-44-43C
Nitrate	mg/L	3.32	14.2	45[d]	
Nitrite	mg/L	<0.125	0.161	3.3[d]	
Phenol	µg/L	<2.00	<3.00	2,400[e]	
Potassium (unfiltered)	µg/L	4,250	5,120	—	
Potassium (filtered)	µg/L	4,220	5,220	—	
Sodium (unfiltered)	µg/L	10,700	23,200	—	
Sodium (filtered)	µg/L	10,900	22,900	—	
Sulfate	mg/L	16	50	250[c]	
Temperature	°C	15.6	18.9	—	
Turbidity	NTU	0.99	49.2	—	

Table B-32. 216-B-3 Sampling Summary for Groundwater Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Additional Constituents Detected, Wells 699-44-43C and 699-45-42[f]					
Barium (unfiltered)	µg/L	37.9	73.0	2,000[b]	
Barium (filtered)	µg/L	36.6	66.0	2,000[b]	
Coliform bacteria	MPN	1	65		
Gross alpha	pCi/L	<1.92	2.20	15[g]	
Gross beta	pCi/L	1.86	6.46	50[g]	
Lead (unfiltered)	µg/L	<0.18	1.00	15[h]	
Lead (filtered)	µg/L	<0.17	1.00	15[h]	
Radium-226	pCi/L	<0.030	0.173		
Selenium (unfiltered)	µg/L	0.88	2.60	50[b]	
Selenium (filtered)	µg/L	0.64	3.80	50[b]	
Silver (unfiltered)	µg/L	<0.02	1.00	100[c]	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents full the data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Includes total alkalinity and bicarbonate.

b. Primary drinking water standard.

c. Secondary drinking water standard.

d. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

e. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

f. Analyzed for first year in these wells. The following constituents were analyzed but not detected in 2017: 2,4,5-TP Silvex, 2,4-D, Endrin, Lindane, mercury, methoxychlor, radium-228, silver (filtered), and toxaphene.

g. Concentration assumed to yield a dose equivalent of 4 mrem/yr.

h. Action level.

< = one or more of the results was below the detection limit

— = no comparison value

MPN = most probably number

NTU = nephelometric turbidity unit

Table B-33. 216-B-63 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Comments; Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E27-16	DG	1990 (C)	126.2	414.1	119.8	393.1	121.65	399.12	10/8/2017	1.8	6.0	S	None
299-E27-18[b]	DG	1992 (C)	124.7	409.1	118.6	389.0	121.72	399.35	10/8/2017	3.2	10.4	S	None
299-E27-19	DG	1992 (C)	124.7	409.1	118.9	390.0	121.66	399.13	10/10/2017	2.8	9.1	S	Extra sampling events; see text
299-E33-33	UG	1989 (C)	126.0	413.4	119.6	392.4	121.69	399.24	10/8/2017	2.1	6.8	S	None
299-E34-8	UG	1990 (C)	126.0	413.2	119.4	391.7	121.58	398.88	10/9/2017	2.2	7.1	S	None
299-E34-12	UG	1992 (C)	126.6	415.3	120.4	395.0	121.63	399.04	10/9/2017	1.2	4.1	S	None

Note: Requirements are from DOE/RL-2008-60, *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench*.

a. See Table B-35 for sample dates.

b. Hydraulic head data for this well were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

S = semiannually

UG = upgradient

Table B-34. Groundwater Velocity at the 216-B-63 Trench

Flow Direction	Southeast
Flow Rate (m/d)	0.73
Hydraulic Conductivity (m/d) (Source)	17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	8.5×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-35. 216-B-63 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
2017 Critical Mean[a]		7.68	8.56	951		659			NC – Use LOQ				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E27-16	4/4/2017	8.27	0.00	675	0	445	25	590	<5.8	2.6	8.3	GEL	
	10/8/2017	8.25	0.00	692	1	<159	6	580	<7.7	0.0	23.7	TADN	
299-E27-18	4/4/2017	8.29	0.01	612	6	413	11	590	<3.3	0.0	8.3	GEL	
	10/8/2017	8.14	0.01	664	2	420	4	540	5.5	2.0	11.8	GEL	

Table B-35. 216-B-63 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
2017 Critical Mean[a]		7.68	8.56	951		659			NC – Use LOQ				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E27-19	4/4/2017	8.57	0.00	661	0	<720	0	1,520	<6.0	2.8	20.4	TASL	pH data later flagged as "Y" (suspect) based on May verification sampling; TOC less than LOQ (no exceedance)
	5/26/2017	8.14[b]	0.00	674	3	—	—	—	—	—	—	—	Verification sampling for April pH exceedances (not confirmed)
	6/14/2017	8.11	0.00	709	1	300	32	NC[c]	—	—	—	TADN	Resampled for TOC at lower detection limit; split samples for TOC
						<200	0	NC	—	—	—	SWRI	
	10/10/2017	7.96	0.00	714	0	238	15	580	<8.2	0.8	23.7	TADN	
299-E33-33	4/4/2017	8.16	0.01	660	4	<330	0	590	<3.3	0.0	8.3	GEL	
	10/8/2017	8.12	0.00	676	2	<157	3	580	<7.7	0.0	23.7	TADN	

Table B-35. 216-B-63 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
2017 Critical Mean[a]		7.68	8.56	951		659			NC – Use LOQ				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E34-12	4/4/2017	8.24	0.00	470	1	404	26	590	<3.3	0.0	8.3	GEL	
	10/9/2017	7.93	0.01	620	2	211	23	580	<7.7	0.0	23.7	TADN	
299-E34-8	4/4/2017	8.19	0.03	671	1	412	18	590	<3.3	0.0	8.3	GEL	
	10/9/2017	8.03	0.02	704	3	453	16	540	<3.6	0.3	11.8	GEL	

Note: Yellow-highlighted cell indicates exceedance of a critical mean.

a. Critical mean values from Table 23 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

b. Average field pH is listed. Samples were also analyzed in the laboratory for pH (see Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*).

c. LOQ not calculated because field blank results were not available from this laboratory.

< = one or more of the replicate values was below the detection limit
— = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
SWRI = Southwest Research Institute
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-36. 216-B-63 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	94.2	104	—	
Calcium (unfiltered)	µg/L	52,000	78,200	—	
Calcium (filtered)	µg/L	52,400	77,600	—	
Chloride	mg/L	13.9	26.1	250[a]	
Dissolved oxygen	mg/L	8.01	10.34	—	
Fluoride	mg/L	0.256	0.374	4.0[b]	
Iron (unfiltered)	µg/L	<30	116	300[a]	
Iron (filtered)	µg/L	<23.1	<30	300[a]	
Magnesium (unfiltered)	µg/L	13,200	21,400	—	
Magnesium (filtered)	µg/L	13,200	21,100	—	
Manganese (unfiltered)	µg/L	<1	<4	50[a]	
Manganese (filtered)	µg/L	<1	<4	50[a]	
Nitrate	mg/L	50	146	45[c]	All
Nitrite	mg/L	<0.108	<0.125	3.3[c]	
Phenol	µg/L	<1.9	<3	2,400[d]	
Sodium (unfiltered)	µg/L	21,900	28,100	—	
Sodium (filtered)	µg/L	21,300	27,000	—	
Sulfate	mg/L	75	101	250	
Temperature	°C	14.9	19.5	—	
Turbidity	NTU	0.63	4.35	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-37. 216-S-10 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Comments; Sampling Exceptions*
			m	ft	m	ft	m	ft		m	ft		
299-W26-13	DG	1999 (C)	137.4	450.8	126.7	415.7	133.61	438.34	11/1/2017	6.9	22.6	S	None
299-W26-14	DG	2003 (C)	136.6	448.1	125.9	413.1	132.96	436.22	11/1/2017	7.0	23.1	S	None
299-W27-2	DG/deep	1992 (C)	82.7	271.4	79.5	260.9	132.30	434.04	5/2/2017	52.8	173.2	A	None
699-32-76	DG	2008 (C)	134.8	442.2	124.1	407.2	132.61	435.07	11/1/2017	8.5	27.9	S	None
699-33-75	DG	2008 (C)	135.0	442.8	124.3	407.8	132.42	434.46	11/1/2017	8.1	26.6	S	None
699-33-76	UG	2008 (C)	135.5	444.7	124.9	409.7	133.13	436.78	11/1/2017	8.3	27.1	S	None

Note: Requirements are from DOE/RL-2008-61, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*.

*See Table B-39 for sample dates.

A = annually

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

S = semiannually

UG = upgradient

Table B-38. Groundwater Velocity at the 216-S-10 Pond and Ditch

Flow Direction	East-southeast
Flow Rate (m/d)	0.14
Hydraulic Conductivity (m/d) (Source)	5 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	2.8×10^{-3}
Comments	Gradient and direction determined by trend surface analysis of data collected in March 2017; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-39. 216-S-10 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean*		4.31	11.04	398		NC – Use LOQ			42.44				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-W26-13	5/2/2017	7.8	0.0	305	0	<331	2	590	<3.3	0.0	8.3	GEL	
	11/1/2017	7.7	0.0	307	0	<330	0	540	<3.3	0.0	11.8	GEL	
299-W26-14	5/2/2017	7.8	0.0	285	0	<720	0	1,520	<4.0	3.2	20.4	TASL	
	11/1/2017	7.6	0.0	283	0	286	22	580	<7.7	0.0	23.7	TADN	
299-W27-2	5/2/2017	7.5	—	369	—	351	—	590	<3.3	—	8.3	GEL	
699-32-76	5/2/2017	7.7	0.0	325	0	<720	0	1,520	<2.1	0.0	20.4	TASL	
	11/1/2017	7.5	0.0	323	1	<500	0	1,540	6.9	1.4	17.7	TASL	

Table B-39. 216-S-10 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean*		4.31	11.04	398		NC – Use LOQ			42.44				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
699-33-75	5/2/2017	7.6	0.0	292	1	<372	28	590	4.9	0.7	8.3	GEL	
	11/1/2017	7.5	0.0	286	0	<348	11	540	<3.3	0.0	11.8	GEL	
699-33-76	5/2/2017	7.5	0.0	308	0	<720	0	1,520	<2.1	0.0	20.4	TASL	
	11/1/2017	7.5	0.0	301	0	250	20	580	<7.8	0.1	23.7	TADN	

*Critical mean values from Table 24 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

< = one or more of the replicate values was below the detection limit
— = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-40. 216-S-10 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	101	132	—	
Aroclor-1254	µg/L	<0.032	<0.21	0.0005[a]	Required for Rev. 0 only
Benzo(a)pyrene	µg/L	<0.28	<0.95	0.0002[a]	Required for Rev. 0 only
Calcium (unfiltered)	µg/L	21,100	32,500	—	
Calcium (filtered)	µg/L	21,500	46,600	—	
Carbon tetrachloride	µg/L	<0.36	5.42	5[a]	699-33-75; required for Rev. 1 only
Chloride	mg/L	6.2	19.7	250[b]	
Chromium (unfiltered)	µg/L	<1.3	165	100[a]	299-W26-13
Chromium (filtered)	µg/L	<1.3	158	100[a]	299-W26-13
Cr(VI) (unfiltered)	µg/L	<1.5	160	48[c]	299-W26-13
Cr(VI) (filtered)	µg/L	<1.5	150	48[c]	299-W26-13
Copper (unfiltered)	µg/L	<1.15	<7	1[b]	Required for Rev. 0 only
Copper (filtered)	µg/L	<1	<7	1[b]	Required for Rev. 0 only
Fluoride	mg/L	0.39	0.488	4[a]	Required for Rev. 0 only
Iron (unfiltered)	µg/L	<17	328	300[b]	299-W27-2
Iron (filtered)	µg/L	<17	64	300[b]	
Magnesium (unfiltered)	µg/L	7,130	11,800	—	
Magnesium (filtered)	µg/L	7,320	11,900	—	
Manganese (unfiltered)	µg/L	<0.29	10	50[b]	
Manganese (filtered)	µg/L	<0.27	4	50[b]	
Mercury (unfiltered)	µg/L	<0.027	<0.067	2[a]	Required for Rev. 0 only
Mercury (filtered)	µg/L	<0.027	<0.067	2[a]	Required for Rev. 0 only
Nickel (unfiltered)	µg/L	<1.5	26.1	—	Required for Rev. 1 only
Nickel (filtered)	µg/L	<1.5	23.2	—	
Nitrate	mg/L	5.75	27.9	45[d]	
Nitrite	mg/L	<0.108	0.223	3.3[d]	Required for Rev. 0 only
Oxidation-reduction potential	mV	229.9	353	—	
Phenol	µg/L	<1.9	<3	2,400[c]	Not analyzed in 699-33-75

Table B-40. 216-S-10 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Potassium (unfiltered)	µg/L	2,840	3,760	—	Required for Rev. 0 only
Potassium (filtered)	µg/L	2,930	5,680	—	
Sodium (unfiltered)	µg/L	14,000	23,000	—	
Sodium (filtered)	µg/L	14,000	23,000	—	
Sulfate	mg/L	17	23	250[b]	
Temperature	°C	17.4	19.4	—	
Turbidity	NTU	0.66	4.94	—	
Zinc (unfiltered)	µg/L	<2.8	6	5,000[b]	Required for Rev. 0 only
Zinc (filtered)	µg/L	<2.8	<6	5,000[b]	Required for Rev. 0 only

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Primary drinking water standard.

b. Secondary drinking water standard.

c. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

d. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

< = one or more of the results was below the detection limit

— = no comparison value

Cr(VI) = hexavalent chromium

NTU = nephelometric turbidity unit

Table B-41. 300 Area Process Trenches Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency Old/New*	Comments; Sampling Exceptions
			m	ft	m	ft	m	ft		m	ft		
399-1-10A	DG	1986 (C)	106.9	350.8	102.3	335.8	104.76	343.69	10/24/2017	2.4	7.9	S8/S2	None
399-1-10B	DG deep	1991 (C)	82.7	271.3	79.6	261.3	104.83	343.93	10/22/2017	25.2	82.6	S8/S2	None
399-1-16A	DG	1986 (C)	107.0	351.0	102.4	336.0	104.71	343.53	10/24/2017	2.3	7.5	S8/S2	None
399-1-16B	DG deep	1987 (C)	84.8	278.4	81.8	268.4	104.95	344.32	12/01/2017	23.1	75.9	S8/S2	None
399-1-17A	DG	1986 (C)	107.7	353.5	103.2	338.5	104.77	343.72	10/24/2017	1.6	5.2	S8/S2	None
399-1-17B	DG deep	1986 (C)	85.0	278.8	81.9	268.8	104.79	343.79	10/24/2017	22.8	75.0	S8/S2	None
399-1-18A	UG	1986 (C)	107.3	352.1	102.8	337.1	105.20	345.16	10/22/2017	2.5	8.0	S8/S2	None
399-1-18B	UG deep	1987 (C)	86.0	282.1	82.9	272.1	105.25	345.31	10/22/2017	22.3	73.2	S8/S2	None

Note: Requirements are from the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended).

*Monitoring network was revised via permit modification beginning May 24, 2017.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

UG = upgradient

S2 = sampled semiannually (twice per year)

S8 = sampled semiannually with four samples in each semiannual period (8 months per year)

Table B-42. Groundwater Velocity at 300 Area Process Trenches

Flow Direction	South
Flow Rate (m/d)	17
Hydraulic Conductivity (m/d) (Source)	9,000 (ECF-300FF5-11-0151, *Groundwater Flow and Uranium Transport Modeling in Support of the 300 Area FF-5 RI/FS*)
Effective Porosity	0.17
Gradient (m/m)	3.1×10^{-4}
Comments	Gradient and direction determined by trend surface analysis of data collected in February 2017; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-43. 300 Area Process Trenches Dangerous Waste Constituents, 2017

Well	Sample Date	*cis*-1,2 DCE (µg/L)	TCE (µg/L)	Well	Sample Date	*cis*-1,2 DCE (µg/L)	TCE (µg/L)
Permit Concentration Limit		**16**	**4**	**—**	**—**	**16**	**4**
399-1-10A	1/12/2017	0.3 (U)	0.3 (U)	399-1-17A	1/12/2017	0.3 (U)	0.3 (U)
399-1-10A	2/6/2017	0.3 (TU)	0.3 (U)	399-1-17A	2/6/2017	0.3 (TU)	0.3 (U)
399-1-10A	3/6/2017	0.3 (U)	0.3 (U)	399-1-17A	3/3/2017	0.3 (U)	0.3 (U)
399-1-10A	6/2/2017	0.3 (U)	0.3 (U)	399-1-17A	6/2/2017	0.3 (U)	0.32 (J)
399-1-10A	10/24/2017	0.3 (U)	0.3 (U)	399-1-17A	10/24/2017	0.3 (U)	0.3 (U)
399-1-10B	1/12/2017	0.1 (U)	0.25 (U)	399-1-17A	10/24/2017	0.3 (U)	0.3 (U)
399-1-10B	2/6/2017	0.1 (U)	0.25 (U)	399-1-17B	1/12/2017	0.72 (J)	0.25 (U)
399-1-10B	3/6/2017	0.1 (U)	0.25 (U)	399-1-17B	2/6/2017	1.3	0.25 (U)

Table B-43. 300 Area Process Trenches Dangerous Waste Constituents, 2017

Well	Sample Date	*cis*-1,2 DCE (µg/L)	TCE (µg/L)	Well	Sample Date	*cis*-1,2 DCE (µg/L)	TCE (µg/L)
399-1-10B	6/2/2017	0.1 (U)	0.25 (U)	399-1-17B	3/3/2017	1.6	0.25 (U)
399-1-10B	10/22/2017	0.1 (U)	0.25 (U)	399-1-17B	6/2/2017	1.9	0.25 (U)
399-1-16A	1/12/2017	0.1 (U)	0.25 (U)	399-1-17B	10/24/2017	1.2	0.25 (U)
399-1-16A	2/6/2017	0.1 (U)	0.31 (J)	399-1-18A	1/12/2017	0.1 (U)	0.25 (U)
399-1-16A	3/3/2017	0.1 (U)	0.35 (J)	399-1-18A	2/6/2017	0.1 (U)	0.25 (U)
399-1-16A	6/2/2017	0.1 (U)	0.25 (U)	399-1-18A	3/3/2017	0.1 (U)	0.25 (U)
399-1-16A	10/24/2017	0.1 (U)	0.25 (U)	399-1-18A	6/2/2017	0.1 (U)	0.25 (U)
399-1-16B	1/12/2017	191 (D)	1.99 (J)	399-1-18A	10/22/2017	0.15 (U)	0.16 (U)
399-1-16B	1/12/2017	184 (D)	1.84 (J)	399-1-18B	1/12/2017	0.3 (U)	0.3 (U)
399-1-16B	2/6/2017	143 (DT)	1.56 (J)	399-1-18B	2/6/2017	0.3 (TU)	0.3 (U)
399-1-16B	3/3/2017	136 (D)	1.88 (DJ)	399-1-18B	3/3/2017	0.3 (U)	0.3 (U)
399-1-16B	6/2/2017	136 (D)	1.73 (J)	399-1-18B	6/2/2017	0.3 (U)	0.3 (U)
399-1-16B	10/24/2017	160 (D)	1.2	399-1-18B	10/22/2017	0.3 (U)	0.3 (U)

Note: Yellow-highlighted cells indicate exceedances of a permit concentration limit.

cis-1,2 DCE = *cis*-1,2-dichloroethene

D = analyte was reported at a secondary dilution factor

J = estimated value; constituent detected at a level less than the required detection limit and greater than or equal to the method detection limit

T = spike and/or spike duplicate sample recovery is outside control limits

TCE = trichloroethene

U = undetected

Table B-44. Statistical Evaluation of 300 Area Process Trenches Dangerous Waste Constituents, 2017

Well	Semiannual Period	*cis*-1,2 DCE (µg/L)		TCE (µg/L)	
		95% UCL	Permit Concentration Limit	95% UCL	Permit Concentration Limit
399-1-10A	January–June	N/A*	16	N/A*	4
399-1-10A	July–December	N/A*	16	N/A*	4
399-1-10B	January–June	N/A*	16	N/A*	4
399-1-10B	July–December	N/A*	16	N/A*	4
399-1-16A	January–June	N/A*	16	N/A*	4
399-1-16A	July–December	N/A*	16	N/A*	4
399-1-16B	January–June	185.2	16	N/A*	4
399-1-16B	July–December	182.4	16	N/A*	4
399-1-17A	January–June	N/A*	16	N/A*	4
399-1-17A	July–December	N/A*	16	N/A*	4
399-1-17B	January–June	N/A*	16	N/A*	4
399-1-17B	July–December	N/A*	16	N/A*	4

References:

SGW-61150, *Post-Closure Corrective Action Groundwater Monitoring Report for the 300 Area Process Trenches: January – June 2017*.

SGW-61754, *Post-Closure Corrective Action Groundwater Monitoring Report for the 300 Area Process Trenches: July – December 2017*.

Note: Yellow-highlighted cell indicates the UCL exceeded a permit concentration limit.

*None of the results in the data set exceeded the concentration limit; therefore, no UCL was calculated.

cis-1,2 DCE = *cis*-1,2-dichloroethene

N/A = not applicable

TCE = trichloroethene

UCL = upper confidence limit

Table B-45. IDF Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E17-22	DG	2002 (C)	122.6	402.1	111.9	367.0	121.67	399.16	1/25/2017	9.8	32.2	A	None
299-E17-23	DG	2002 (C)	122.3	401.4	111.9	367.3	121.60	398.95	1/25/2017	9.7	31.7	A	None
299-E17-25	DG	2002 (C)	122.4	401.7	111.8	366.7	121.68	399.22	1/25/2017	9.9	32.5	A	None
299-E17-26	DG	2005 (C)	121.4	398.2	110.7	363.2	121.72	399.34	1/23/2017	11.0	36.1	A	None
299-E18-1[b]	UG	1988 (C)	125.5	411.6	118.4	388.6	121.75	399.45	1/17/2017	3.3	10.9	A	None
299-E24-21	CG	2001 (C)	122.7	402.5	116.6	382.5	121.67	399.17	1/25/2017	5.1	16.6	A	None
299-E24-24	UG	2005 (C)	122.5	402.0	111.9	367.0	121.67	399.17	1/25/2017	9.8	32.2	A	None

Note: Requirements are from the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended). In accordance with 10-EMD-0080, Enclosure 1, "Class 1 Modification to the Hanford Facility Resource Conservation and Recovery Act Permit Quarter Ending June 30, 2010," groundwater sampling under the permit will continue annually during the pre-active life of the Integrated Disposal Facility.

a. See Table B-47 for sample dates.

b. Hydraulic head data for this well were not corrected for borehole deviation from vertical, which may cause reported head to be less than actual head.

A = annually

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

CG = cross gradient

DG = downgradient

UG = upgradient

Table B-46. Groundwater Velocity at the IDF

Flow Direction	East
Flow Rate (m/d)	0.0001 to 1.1
Hydraulic Conductivity (m/d) (Source)	3.26 (Ringold unit E) to 17,000 (Hanford formation) (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.1 (CP-57037)
Gradient (m/m)	6.59×10^{-6}
Comments	Gradient and direction determined by trend surface analysis on low-gradient network (SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*).

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-47. IDF Contamination Indicator Parameters, 2017

Well	Sample Date	Chromium (filtered)		pH	Specific Conductance	Total Organic Carbon		Total Organic Halides	
		µg/L	Flag	Standard Units	µS/cm	µg/L	Flag	µg/L	Flag
299-E17-22	1/17/2017	4.5	B	7.92	575	720	U	6.5	
299-E17-23	1/16/2017	12.1		7.87	478	401	B	3.33	U
299-E17-25	1/17/2017	10.3	D	7.77	485	720	U	5	
299-E17-26	1/23/2017	6.53		7.82	515	496	B	9.42	BC
299-E18-1	1/17/2017	6.7	BD	8.48	387	330	U	3.33	U
299-E24-21	1/24/2017	6.7		7.85	552	848	B	3.33	UQ
299-E24-24	1/23/2017	5	B	7.76	532	720	U	2.1	U

B = greater than detection limit but less than quantitation limit
C = analyte was detected both in the blank and in the associated laboratory quality control blank
D = analyte reported at a secondary dilution factor
Q = associated field quality control sample was out of limits
U = undetected

Table B-48. IDF Sampling Summary for Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	73.6	150	—	
Antimony (unfiltered)	µg/L	<1	<5.2	6[a]	
Antimony (filtered)	µg/L	<1	<5.2	6[a]	
Arsenic (unfiltered)	µg/L	<4	5.32	10[a]	
Arsenic (filtered)	µg/L	<4	<5	10[a]	
Barium (unfiltered)	µg/L	45.2	82.3	2,000[a]	
Barium (filtered)	µg/L	45.5	77.4	2,000[a]	
Cadmium (unfiltered)	µg/L	<0.2	<1.5	5[a]	
Cadmium (filtered)	µg/L	<0.2	<1.5	5[a]	
Calcium (unfiltered)	µg/L	31,000	59,100	—	
Calcium (filtered)	µg/L	32,800	60,200	—	
Chloride	mg/L	6.7	15	250[b]	
Cobalt (unfiltered)	µg/L	<0.1	<15	—	
Cobalt (filtered)	µg/L	<0.1	<15	—	
Copper (unfiltered)	µg/L	<0.35	<7	—	
Copper (filtered)	µg/L	<0.35	<7	—	
Fluoride	mg/L	0.3	0.42	4[a]	
Iron (unfiltered)	µg/L	<30	400	300[b]	299-E18-1
Iron (filtered)	µg/L	<22.7	<30	300[b]	
Magnesium (unfiltered)	µg/L	14,100	18,100	—	
Magnesium (filtered)	µg/L	13,500	18,500	—	
Manganese (unfiltered)	µg/L	<0.9	<4	50[b]	
Manganese (filtered)	µg/L	<0.9	<4	50[b]	
Nickel (unfiltered)	µg/L	<1.48	<10	—	
Nickel (filtered)	µg/L	<0.871	26.1	—	
Nitrate	mg/L	12	66.4	45[c]	299-E17-22, 299-E17-25, 299-E17-26, 299-E24-21, 299-E24-24
Nitrite	mg/L	<0.046	<0.046	3.3[c]	
Potassium (unfiltered)	µg/L	6,030	8,070	—	

Table B-48. IDF Sampling Summary for Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Potassium (filtered)	µg/L	6,130	8,110	—	
Silver (unfiltered)	µg/L	<0.4	<3	100[b]	
Silver (filtered)	µg/L	<0.4	4.7	100[b]	
Sodium (unfiltered)	µg/L	20,200	27,900	—	
Sodium (filtered)	µg/L	20,000	26,900	—	
Sulfate	mg/L	37	96	250[b]	
Turbidity	NTU	0.15	2.87	—	
Vanadium (unfiltered)	µg/L	<15	20.5	—	
Vanadium (filtered)	µg/L	<15	21.3	—	
Zinc (unfiltered)	µg/L	<3.3	<7.5	5,000[b]	
Zinc (filtered)	µg/L	<3.3	<7.5	5,000[b]	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Primary drinking water standard.

b. Secondary drinking water standard.

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-49. LERF Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head[a]		Head Date	Water Column		Sample Frequency (Rev. 0/1)[b]	Comment[c]
			m	ft	m	ft	m	ft		m	ft		
299-E26-10[d]	CG	1990 (C)	125.4	411.6	120.7	396.0	121.77	399.51	10/25/2017	1.1	3.5	0	Used for water levels only (Rev. 0 and 1)
299-E26-14	UG	2011 (C)	122.8	402.8	116.7	382.8	121.82	399.67	10/25/2017	5.1	16.8	S/S	
299-E26-15[d]	DG	2015 (C)	124.2	407.3	119.5	392.0	121.23	397.73	10/25/2017	1.7	5.7	0/S	Sampled, but not part of network in Rev. 0
299-E26-77[d]	CG	2008 (C)	122.0	400.3	114.5	375.5	121.78	399.54	10/25/2017	7.3	24.0	S/0	Water levels only in Rev. 1
299-E26-79	DG	2008 (C)	122.1	400.6	114.5	375.6	121.77	399.49	10/25/2017	7.3	23.9	S/S	

Note: Requirements are from Part III of the Hanford RCRA Permit (*Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended) and DOE/RL-2013-46, Rev. 0, *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility*.

a. Hydraulic head has been corrected for borehole deviation from vertical in all wells in this network.

b. Rev. 0 was in effect until the permit modification was effective on November 26, 2017. The 2017 sampling occurred under Rev. 0.

c. See Table B-51 for sample dates and exceptions.

d. Not compliance wells under Rev. 0 (wells 299-E26-10, 299-E26-15 and 299-E26-77).

0 = no sampling required

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

CG = cross gradient

DG = downgradient

S = semiannually

UG = upgradient

Table B-50. Groundwater Velocity at LERF

Flow Direction	South
Flow Rate (m/d)	0.12
Hydraulic Conductivity (m/d) (Source)	39.5 (DOE/RL-2013-46, *Groundwater Monitoring Plan for the Liquid Effluent Retention Facility*)
Effective Porosity	0.1 (DOE/RL-2013-46)
Gradient (m/m)	3.0×10^{-4}
Comments	Based on average of February, March, May, June, July, September, October, and November 2017 gradients; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

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Table B-51. LERF Contamination Indicator Parameters, 2017

Indicator Parameter		Carbon Tetrachloride		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
2017 Critical Mean*		Detection Limit		7.68	8.08	838		3,920			10.33				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E26-14	1/31/2017	<0.18	0	7.85	0.01	813	1	1,100	71	1,640	6.2	0.9	20.4	TASL	
	7/27/2017	—	—	7.88	0.00	908	1	—	—	—	—	—	—	—	Sample temperature out of limits. See 8/1/2017 for carbon tetrachloride, TOC, and TOX
	8/1/2017	<0.18	0	7.63	0.01	901	1	585	51	1,390	9.1	0.8	18.2	TASL	Resampled (see 7/27/2017 comment)
	8/28/2017	<0.3	—	7.88	—	925	—	—	—	—	—	—	—	—	Sampled for Appendix IX
	9/28/2017	—	—	7.88	0.04	—	—	—	—	—	—	—	—	—	Sampled for pH investigation
	10/18/2017	—	—	7.89	—	924	—	—	—	—	—	—	—	—	Sampled for alkalinity (missed on 8/1/2017)
299-E26-15	1/31/2017	<0.3	0	7.95	0.00	827	1	912	37	640	<4.0	0.4	7.8	GEL	
	7/27/2017	—	—	7.89	0.01	888	2	—	—	—	—	—	—	—	Sample temperature out of limits. See 8/1/2017 for carbon tetrachloride, TOC, and TOX
	8/1/2017	<0.3	0	7.75	0.00	877	0	1,270	31	600	<3.7	0.5	10.9	GEL	Resampled (see 7/27/2017 comment)
	8/28/2017	<0.3[b]	—	7.91	—	893	—	—	—	—	—	—	—	—	Sampled for Appendix IX
	9/28/2017	—	—	7.94	0.01	—	—	—	—	—	—	—	—	—	Sampled for pH investigation
	10/5/2017	—	—	7.91	0.09	861	1	—	—	—	—	—	—	—	Sampled for pH investigation
	10/12/2017	<0.3	0	7.83	0.00	853	1	990	8	540	<5.5	1.4	11.8	GEL	
	10/18/2017	—	—	7.94	—	900	—	—	—	—	—	—	—	—	Sampled for alkalinity (missed on 8/1/2017)
299-E26-79	1/31/2017	<0.3	0	8.08	0.02	755	2	755	29	640	<4.3	0.9	7.8	GEL	
	7/27/2017	<0.19	0	8.13	0.02	772	2	631	64	540	8.6	1.1	24.7	TADN	
	8/28/2017	<0.3	—	8.32	—	789	—	—	—	—	—	—	—	—	Sampled for Appendix IX
	9/28/2017	—	—	8.13	0.02	—	—	—	—	—	—	—	—	—	Sampled for pH investigation
	10/5/2017	—	—	7.99	0.09	759	0	—	—	—	—	—	—	—	Sampled for pH investigation
	10/18/2017	—	—	8.04	—	788	—	—	—	—	—	—	—	—	Sampled for alkalinity (missed on 8/28/2017)

Note: Yellow-highlighted cell indicates exceedances of a critical mean.

*Critical mean values from Table 25 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

< = one or more of the replicate values was below the detection limit
— = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

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Table B-52. LERF Sampling Summary for Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	87	99	—	
Calcium (unfiltered)	µg/L	65,500	92,000	—	
Calcium (filtered)	µg/L	70,100	90,000	—	
Chloride	mg/L	45	63	250[a]	
Cr(VI) (unfiltered)	µg/L	<2	<2	48[b]	
Cr(VI) (filtered)	µg/L	<2	<2	48[b]	Filtered Cr(VI) analyzed only in 299-E26-15
Magnesium (unfiltered)	µg/L	22,400	27,900	—	
Magnesium (filtered)	µg/L	24,100	29,500	—	
Nitrate	mg/L	42	78[d]	45[c]	299-E26-14, 299-E26-79
Nitrite	mg/L	<0.11	0.27	3.3[c]	
Potassium (unfiltered)	µg/L	9,010	10,000	—	
Potassium (filtered)	µg/L	9,030	10,200	—	
Sodium (unfiltered)	µg/L	28,400	37,000	—	
Sodium (filtered)	µg/L	28,600	37,400	—	
Sulfate	mg/L	147	210[d]	250	
Appendix IX	See Section 9.10.4 of the main text for a summary and Appendix A of DOE/RL-2017-65 for data.				

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cell indicates concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

d. Excludes "Y"-flagged data points in well 299-E26-79.

< = one or more of the results was below the detection limit

— = no comparison value

Cr(VI) = hexavalent chromium

Table B-53. Low-Level Waste Management Area (LLWMA)-1 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Comments; Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E28-26	DG	1987 (C)	124.9	409.6	118.7	389.5	121.68	399.21	7/27/2017	2.9	9.7	S	None
299-E28-27[b]	DG	1987 (C)	125.6	411.9	119.5	392.0	121.68	399.21	7/14/2017	2.2	7.2	S	None
299-E28-28	DG	1990 (C)	125.6	412.1	119.5	392.2	121.65	399.10	7/14/2017	2.1	6.9	S	None
299-E32-3	UG	1987 (C)	125.8	412.7	119.7	392.8	121.65	399.12	7/19/2017	1.9	6.3	S	None
299-E33-28[b]	DG	1987 (C)	125.2	410.6	119.1	390.6	121.67	399.18	7/14/2017	2.6	8.5	S	None
299-E33-29	DG	1987 (C)	120.6	395.5	117.5	385.6	121.64	399.07	7/14/2017	4.1	13.4	S	None
299-E33-266	UG	2010 (C)	123.4	404.8	117.3	384.8	121.55	398.77	7/14/2017	4.3	14.0	S	None
299-E28-33	DG	2018 (planned)	—	—	—	—	—	—	—	—	—	S	Awaiting drilling

Note: Requirements are from DOE/RL-2009-75, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*.

a. See Table B-55 for sample dates.

b. Hydraulic head data for these wells were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

UG = upgradient

S = semiannually

Table B-54. Groundwater Velocity at LLWMA-1

Flow Direction	Southeast
Flow Rate Range (m/d)	0.65
Hydraulic Conductivity (m/d) (Source)	17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	7.6×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-55. LLWMA-1 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean*		7.12	8.84	592		1,366			8.43				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E28-26	1/16/2017	7.97	0.05	483	1	<720	0	1,640	4.83	1.13	20.4	TASL	
	7/14/2017	7.92	0.00	516	0	1,033	137	1,390	<3.85	2.06	18.2	TASL	
299-E28-27	1/16/2017	8.00	0.10	495	1	<334	6	640	<3.33	0.00	7.8	GEL	
	7/14/2017	8.01	0.00	514	0	<500	0	600	<4.66	2.30	10.9	GEL	
299-E28-28	1/16/2017	8.06	0.02	434	1	<720	0	1,640	4.45	0.99	20.4	TASL	
	7/14/2017	7.90	0.01	460	0	<500	0	1,390	4.18	1.38	18.2	TASL	

Table B-55. LLWMA-1 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean*		7.12	8.84	592		1,366			8.43				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E32-3	1/16/2017	8.04	0.03	421	1	<330	0	640	<3.33	0.00	708	GEL	
	7/19/2017	7.78	0.01	436	1	<344	16	600	<3.33	0.00	10.9	GEL	
299-E33-266	1/16/2017	7.87	0.04	432	4	<763	74	1,640	<7.68	3.56	708	TASL	One TOX value flagged as "Y" (suspect).
	7/14/2017	7.98	0.00	438	0	543	21	540	<8.28	1.00	24.7	TADN	
299-E33-28	1/16/2017	8.09	0.02	490	1	<342	19	640	<3.33	0.00	708	GEL	
	7/14/2017	7.98	0.00	482	0	<330	0	600	<3.33	0.00	10.9	GEL	
299-E33-29	1/16/2017	8.12	0.01	441	0	<720	0	640	<3.95	2.21	20.4	TASL	
	7/14/2017	8.04	0.00	446	1	276	29	540	<8.05	0.61	24.7	TADN	

*Critical mean values from Table 27 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

< = one or more of the replicate values was below the detection limit
GEL = GEL Laboratory
LOQ = limit of quantitation
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-56. LLWMA-1 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Calcium (unfiltered)	µg/L	36,900	52,800	—	
Calcium (filtered)	µg/L	42,700	51,500	—	
Chloride	mg/L	11	15	250[a]	
Dissolved oxygen	mg/L	7.3	9.9	—	
Fluoride	mg/L	0.4	0.6	4.0[b]	
Iron (unfiltered)	µg/L	<30	114	300[a]	
Iron (filtered)	µg/L	<26	30	300[a]	
Magnesium (unfiltered)	µg/L	11,700	16,500	—	
Magnesium (filtered)	µg/L	13,100	15,900	—	
Manganese (unfiltered)	µg/L	<1.8	<4.0	50[a]	
Manganese (filtered)	µg/L	<0.7	<4.0	50[a]	
Nitrate	mg/L	41	58	45[c]	299-E28-26, 299-E28-27, 299-E33-28
Nitrite	mg/L	<0.05	0.17	3.3[c]	
Phenol	µg/L	<1.9	2.9	2,400[d]	
Potassium (unfiltered)	µg/L	5,510	6,800	—	
Potassium (filtered)	µg/L	5,310	7,090	—	
Sodium (unfiltered)	µg/L	22,200	28,600	—	
Sodium (filtered)	µg/L	22,400	28,300	—	
Sulfate	mg/L	36	71	250[a]	
Temperature	°C	16.2	19.5	—	Excludes rejected values in well 299-E28-28, 7/14/2017
Turbidity	NTU	0.23	3.05	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cell indicates concentration greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-57. LLWMA-2 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E27-8[b]	DG	1987 (C)	125.8	412.7	119.7	392.7	121.73	399.36	10/11/2017	2.0	6.6	S	None
299-E27-9[b]	DG	1987 (C)	125.3	411.1	119.4	391.8	121.73	399.38	10/11/2017	2.3	7.6	S	None
299-E27-10	DG	1987 (C)	126.2	413.9	120.0	393.6	121.74	399.39	10/11/2017	1.8	5.8	S	None
299-E27-11	CG	1989 (C)	126.0	413.5	119.6	392.5	121.65	399.11	10/11/2017	2.0	6.6	S	Resampled; see Table 2-47
299-E27-17[b]	CG	1991 (C)	125.5	411.9	119.1	390.9	121.72	399.34	10/1/2017	2.6	8.5	S	None
299-E34-2	UG	1987 (C)	125.2	410.9	119.2	390.9	121.74	399.39	10/11/2017	2.6	8.5	S	None
299-E34-9[b]	CG	1991 (C)	127.0	416.7	120.7	395.9	121.74	399.42	10/12/2017	1.1	3.5	S	Resampled; see Table 2-47
299-E34-10[b]	CG	1991 (C)	126.5	415.0	120.1	394.0	121.75	399.44	10/11/2017	1.6	5.4	S	None
299-E34-12	CG	1992 (C)	126.6	415.3	120.4	395.0	121.63	399.04	10/9/2017	1.2	4.1	S	None

Note: Requirements are from DOE/RL-2009-76, *Interim-Status Groundwater Monitoring Plan for the LLBG WMA-2*.

a. See Table B-59 for sample dates.

b. Hydraulic head data for these wells were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

CG = cross gradient

DG = downgradient

S = semiannually

UG = upgradient

Table B-58. Groundwater Velocity at LLWMA-2

Flow Direction	West portion of LLWMA-2: southeast; east portion: south-southeast
Flow Rate (m/d)	0.064 to 0.73
Hydraulic Conductivity Range (m/d) (Source)	For the east portion of the WMA, 1,500 to 6,700 (pump test results, PNL-6820, *Hydrogeology of the 200 Areas Low-Level Burial Grounds—An Interim Report*). For the west portion of the WMA, 17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	8.5×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

WMA = waste management area

Table B-59. LLWMA-2 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean[a]		**7.36**	**8.27**	**1,207**		**1,938**			**27.69**				
Well	**Sample Date**	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**	**LOQ**	**Avg**	**SD**	**LOQ**		
299-E27-10	4/6/2017	7.78	0.02	1,136	2	<720	0	1520	11.08	1.97	20.4	TASL	
	10/11/2017	7.69	0.02	1,164	2	<503	4	1,540	9.35	1.08	17.7	TASL	
299-E27-11	4/6/2017	8.48	0.01	493	1	171	12	NC	<9.20	1.17	NC[b]	TADN	pH later flagged as "Y" (suspect)

Table B-59. LLWMA-2 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean[a]		7.36	8.27	1,207		1,938			27.69				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
	5/26/2017	7.89[c]	0.01	501	0	—	—	—	—	—	—	—	Verification sampling for April pH exceedances (not confirmed)
	10/11/2017	8.07	0.02	518	0	410	49	540	10.16	2.95	11.8	GEL	
299-E27-17	4/5/2017	8.19	0.01	503	1	<720	0	1520	<2.23	0.22	20.4	TASL	
	10/11/2017	8.17	0.05	490	2	<500	0	1,540	6.73	1.06	17.7	TASL	
299-E27-8	4/4/2017	8.11	0.00	493	0	<720	0	1520	7.55	1.69	20.4	TASL	
	10/11/2017	8.01	0.00	464	0	<500	0	1,540	7.55	0.42	17.7	TASL	
299-E27-9	4/4/2017	8.13	0.01	1,056	10	961	35	590	<3.65	0.56	8.3	GEL	
	10/11/2017	8.05	0.02	1,079	6	876	3	540	8.22	3.48	11.8	GEL	
299-E34-10	4/5/2017	8.02	0.02	677	0	<720	0	1,520	7.65	3.51	20.4	TASL	
	10/11/2017	7.99	0.01	697	2	238	11	580	7.70	0.00	23.7	TADN	
299-E34-12	4/4/2017	8.24	0.00	470	1	404	26	590	<3.33	0.00	8.3	GEL	
	10/9/2017	7.93	0.01	620	1	211	23	580	<7.70	0.00	23.7	TADN	
299-E34-2	4/6/2017	8.06	0.00	578	0	<720	0	1,520	<4.95	3.69	20.4	TASL	
	10/11/2017	8.06	0.00	582	0	<500	0	1,540	5.00	1.46	17.7	TASL	

Table B-59. LLWMA-2 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean[a]		7.36	8.27	1,207		1,938			27.69				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-E34-9	4/10/2017	7.99	0.00	703	2	<720	0	1,520	<2.10	0.00	20.4	TASL	Originally sampled 4/5/2017 but a bottle broke; resampled
	10/12/2017	7.93	0.00	1,021	3	<500	0	1,540	3.63	1.38	17.7	TASL	

Note: Yellow-highlighted cell indicates exceedance of a critical mean.

a. Critical mean values from Table 7-17 of ECF-Hanford-16-0015, *Calculation of Critical Means for Calendar Year 2016 RCRA Groundwater Monitoring.* Critical mean values for 2017 (ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*) are not applicable because they were based on a revised monitoring plan that has not yet been implemented.

b. LOQ not calculated because field blank results were not available from this laboratory.

c. Average field pH is listed here. Samples were also analyzed in the laboratory for pH (see Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*).

< = one or more of the replicate values was below the detection limit

— = no data or not applicable

GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-60. LLWMA-2 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	64	112	—	
Calcium (unfiltered)	µg/L	49,900	152,000	—	
Calcium (filtered)	µg/L	45,300	148,000	—	
Chloride	mg/L	14	91	250[a]	
Chromium (unfiltered)	µg/L	6.3	64.0	—	
Chromium (filtered)	µg/L	<3.0	23.1	—	
Dissolved oxygen	mg/L	5.9	10.0	—	
Fluoride	mg/L	0.2	0.5	4.0[b]	
Iron (unfiltered)	µg/L	<30	532	300[a]	299-E27-10
Iron (filtered)	µg/L	<17	144	300[a]	
Manganese (unfiltered)	µg/L	<0.9	6.8	50[a]	
Manganese (filtered)	µg/L	<0.4	5.4	50[a]	
Nitrate	mg/L	14	235	45[c]	299-E27-10, 299-E27-9, 299-E34-10, 299-E34-12, 299-E34-9
Nitrite	mg/L	<0.1	<0.1	3.3[c]	
Phenol	µg/L	<1.9	<3.0	2,400[d]	
Potassium (unfiltered)	µg/L	4,790	12,900	—	
Potassium (filtered)	µg/L	7,280	13,400	—	
Sodium (unfiltered)	µg/L	12,200	43,000	—	
Sodium (filtered)	µg/L	15,400	41,000	—	
Sulfate	mg/L	75	394	250[a]	299-E27-10, 299-E27-9
Temperature	°C	17	19	—	
Turbidity	NTU	0.7	5.4	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-61. LLWMA-3 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Comments; Sampling Exceptions*
			m	ft	m	ft	m	ft		m	ft		
299-W9-2	UG	2011 (C)	135.9	445.8	125.2	410.8	136.79	448.79	9/13/2017	11.6	38.0	S	None
299-W10-29	DG	2006 (C)	136.9	449.3	126.3	414.3	136.43	447.61	9/13/2017	10.2	33.3	S	None
299-W10-30	DG	2006 (C)	137.1	449.8	126.4	414.8	136.43	447.61	9/13/2017	10.0	32.8	S	None
299-W10-31	DG	2006 (C)	136.5	447.9	125.8	412.9	135.93	445.95	9/13/2017	10.1	33.1	S	None

Note: Requirements are from DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*.

*See Table B-63 for sample dates.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

S = semiannually

UG = upgradient

Table B-62. Groundwater Velocity at LLWMA-3

Flow Direction	East (locally disrupted by groundwater injection wells)
Flow Rate (m/d)	Northern portion (218-W-3A): 0.21 Southern portion (Trenches 31 and 34): 0.036
Hydraulic Conductivity (m/d) (Source)	5.0 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	Northern portion (218-W-3A): 4.2×10^{-3} Southern portion (Trenches 31 and 34): 7.3×10^{-4}
Comments	Gradient for northern portion estimated from water table map; gradient for southern portion calculated between wells 299-W9-2 and 299-W10-29; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-63. LLWMA-3 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)			Lab (TOC and TOX)	Comment
Critical Mean[a]		7.43	8.63	462		1,413			9.32				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-W10-29	3/20/2017	8.00	0.00	405	0	<720	0	640	5.3	0.97	20.4	TASL	
						186	19	NC[b]	<7.70	0.00	NC[b]	TADN	TOC and TOX split
	9/13/2017	7.91	0.01	416	0	<720	0	1,390	3.65	0.36	18.2	TASL	
299-W10-30	3/20/2017	7.94	0.01	391	1	<355	41	640	10.04	2.30	7.8	GEL	See text regarding TOX exceedances
									12.08	2.55	NC[b]	TADN	
	9/13/2017	7.83	0.01	428	1	<344	23	600	10.38	0.04	10.9	GEL	
299-W10-31	3/20/2017	7.85	0.03	499	1	<720	0	1,640	<8.45	3.72	20.4	TASL	See text regarding specific conductance exceedances
	9/13/2017	7.85	0.00	505	0	<685	142	1,390	6.95	1.38	18.5	TASL	
299-W9-2	3/20/2017	8.03	0.00	393	1	<330	0	640	<3.80	0.82	7.8	GEL	TOC and TOX split samples
						377	92	NC[b]	<9.23	1.07	NC[b]	TADN	
	9/13/2017	8.11	0.04	409	0	<350	21	600	<3.44	0.14	10.9	GEL	

Note: Yellow-highlighted cells indicate exceedances of a critical mean.

a. Critical mean values from Table 29 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring*.

b. LOQ not calculated because field blank results were not available from this laboratory.

< = one or more of the replicate values was below the detection limit
GEL = GEL Laboratory
LOQ = limit of quantitation
NC = not calculated
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-64. LLWMA-3 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	110	116	—	
Calcium (unfiltered)	µg/L	33,600	56,800	—	
Chloride	mg/L	13.9	28.8	250[a]	
Chromium (unfiltered)	µg/L	3.34	24.2	100[b]	
Dissolved oxygen	mg/L	6.47	11.29	—	
Fluoride	mg/L	0.237	0.451	4[b]	
Iron (unfiltered)	µg/L	<28.7	214	300[a]	
Magnesium (unfiltered)	µg/L	12,400	19,300	—	
Manganese (unfiltered)	µg/L	0.53	8.53	50[a]	
Nitrate	mg/L	27.3	52.7	45[c]	299-W10-30
Nitrite	mg/L	<108	<108	3.3[c]	
Oxidation-reduction potential	mV	204	353	—	
Phenol	µg/L	<1.9	<3	2,400[d]	
Potassium (unfiltered)	µg/L	4,060	4,470	—	
Sodium (unfiltered)	µg/L	9,900	12,400	—	
Sulfate	mg/L	36.1	90.8	250[a]	
Temperature	°C	18.6	22	—	
Turbidity	NTU	0.73	5.52	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-65. LLWMA-4 Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Comments; Sampling Exceptions*
			m	ft	m	ft	m	ft		m	ft		
299-W15-17	Deep	1987 (C)	80.6	264.5	77.3	253.5	135.27	443.79	7/28/2017	58.0	190.3	S	None
299-W15-30	DG	1995 (C)	142.8	468.6	130.6	428.6	135.21	443.61	7/28/2017	4.6	15.0	S	None
299-W15-83	DG	2005 (C)	137.3	450.5	126.7	415.5	135.24	443.70	7/28/2017	8.6	28.2	S	None
299-W15-94	DG	2005 (C)	137.5	451.0	126.8	416.0	135.08	443.17	7/28/2017	8.3	27.1	S	None
299-W15-152	DG	2005 (C)	137.5	451.1	126.8	416.1	134.99	442.87	7/28/2017	8.2	26.8	S	None
299-W15-224	DG	2006 (C)	136.5	447.9	125.9	412.9	135.23	443.66	7/28/2017	9.4	30.7	S	None
299-W17-1	UG	2003 (C)	139.4	457.4	128.7	422.3	136.86	449.02	7/28/2017	8.1	26.7	Q	Not formally in network (see text)
299-W18-21	UG	1987 (C)	144.7	474.6	135.5	444.6	136.89	449.12	7/28/2017	1.4	4.5	S	Sampled with a bailer
299-W18-22	UG, Deep	1987 (C)	77.5	254.1	68.0	223.1	136.22	446.91	7/28/2017	68.2	223.8	S	None
299-W18-40	DG	2001 (C)	136.2	446.9	125.5	411.9	133.08	436.61	7/28/2017	7.5	24.8	S	Not formally in network (see text)

Note: Requirements are from DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*, as modified by TPA-CN-718, 2016, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-69, Interim Status Groundwater Monitoring Plan for the LLBG WMA-4, Revision 2*.

*See Table B-67 for sample dates.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

S = semiannually

Q = quarterly

UG = upgradient

Table B-66. Groundwater Velocity at LLWMA-4

Flow Direction	East
Flow Rate (m/d)	0.57
Hydraulic Conductivity (m/d) (Source)	5.0 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	1.2×10^{-2}
Comments	Gradient estimated from the March 2017 water table map; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-67. LLWMA-4 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)[a]			Lab (TOC and TOX)	Comment
Critical Mean[a]		6.94	8.83	725		1,926			57.18				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-W15-152	1/25/2017	7.73	0.00	550	1	<720	0	1,640	14.73	2.23	20.4	TASL	
	7/6/2017	7.69	0.01	562	1	<688	188	1,390	—	—	—	TASL	See 7/28/2107 for TOX
	7/28/2017	—	—	—	—	—	—	—	9.98	1.80	18.2	TASL	Resampled for TOX[b]
299-W15-17	1/24/2017	7.78	—	362	—	<330	—	640	3.64	—	7.8	GEL	
	7/6/2017	7.81	—	383	--	193	—	540	—	—	—	TADN	See 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	5.02	—	10.9	GEL	Resampled for TOX[b]

Table B-67. LLWMA-4 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)[a]			Lab (TOC and TOX)	Comment
Critical Mean[a]		6.94	8.83	725		1,926			57.18				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-W15-224	1/25/2017	7.89	0.12	510	1	<720	0	1,640	43.50	2.49	20.4	TASL	
	7/6/2017	7.77	0.01	536	0	315	30	540	—	—	—	TADN	See 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	35.30	3.02	18.2	TASL	Resampled for TOX[b]
299-W15-30	1/24/2017	7.88	0.02	521	1	<330	0	640	17.63	2.77	7.8	GEL	
	7/6/2017	7.97	0.00	536	0	328	23	540	—	—	—	TADN	See 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	18.93	1.01	10.9	GEL	Resampled for TOX[b]
299-W15-83	1/24/2017	7.83	0.00	487	0	<720	0	1,640	59.30	12.4	20.4	TASL	All four TOX values flagged as suspect; see text
	7/7/2017	7.87	0.00	481	8	240	27	540	—	—	—	TADN	See 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	23.95	0.50	18.2	TASL	Resampled for TOX[b]
299-W15-94	1/24/2017	7.85	0.00	534	0	<330	0	640	8.09	1.31	7.8	GEL	
	7/6/2017	7.83	0.00	570	0	433	31		—	—	—	GEL	See 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	8.01	0.34	10.9	GEL	Resampled for TOX[b]

Table B-67. LLWMA-4 Sampling Summary for Contamination Indicator Parameters, 2017

Indicator Parameter		pH		Specific Conductance (µS/cm)		TOC (µg/L)			TOX (µg/L)[a]			Lab (TOC and TOX)	Comment
Critical Mean[a]		6.94	8.83	725		1,926			57.18				
Well	Sample Date	Avg	SD	Avg	SD	Avg	SD	LOQ	Avg	SD	LOQ		
299-W18-21	1/24/2017	8.04	—	589	—	<720	0	1,640	4.6	2.14	20.4	TASL	No field quads in January due to bailed sample
	7/6/2017	8.21	—	618	—	359	67	540	—	—	—	TADN	No field quads in July due to bailed sample; see 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	16.5	3.31	18.2	TASL	Resampled for TOX[b]
299-W18-22	1/24/2015	8.11	—	400	—	<720	—	1,640	13.4	—	20.4	TASL	Deep upgradient well; no statistics
	7/12/2017	7.77	0.01	432	1	1,005	226	1,390	—	—	—	TASL	See 7/28/2017 for TOX
	7/28/2017	—	—	—	—	—	—	—	7.05	1.13	18.2	TASL	Resampled for TOX[b]

Note: Yellow-highlighted cell indicates exceedance of a critical mean.

a. Critical mean values from Table 31 of ECF-Hanford-17-0009, *Calculation of Critical Means for Calendar Year 2017 RCRA Groundwater Monitoring.*

b. Laboratory quality control criteria were not met for TOX analysis during the initial July sampling event; wells were resampled for TOX.

< = one or more of the replicate values was below the detection limit
-- = no data or not applicable
GEL = GEL Laboratory
LOQ = limit of quantitation
SD = standard deviation
TADN = TestAmerica – Denver
TASL = TestAmerica – St. Louis
TOC = total organic carbon
TOX = total organic halides

Table B-68. LLWMA-4 Sampling Summary for Water Quality Parameters and Other Constituents, 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	106	132	—	
Calcium (unfiltered)	µg/L	38,400	54,800	—	Excluded "Y"-flagged value[a]
Chloride	mg/L	11	41	250[b]	
Chromium (unfiltered)	µg/L	5	51.9	100[c]	Excluded "Y"-flagged value[a]
Dissolved oxygen	mg/L	6.24	10.51	—	
Fluoride	mg/L	0.25	0.49	4[c]	
Iron (unfiltered)	µg/L	<22	199	300[b]	Excluded "Y"-flagged value[a]
Magnesium (unfiltered)	µg/L	13,600	17,700	—	Excluded "Y"-flagged value[a]
Manganese (unfiltered)	µg/L	<1.6	4.4	50[b]	Excluded "Y"-flagged value[a]
Nitrate	mg/L	21.2	96.1	45[d]	299-W15-152, 299-W15-224, 299-W15-30, 299-W15-83, 299-W15-94
Nitrite	mg/L	<0.046	<0.125	3.3[d]	
Phenol	µg/L	<1.9	<2.86	2,400[e]	
Potassium (unfiltered)	µg/L	4,460	5,310	—	Excluded "Y"-flagged value[a]
Sodium (unfiltered)	µg/L	14,400	27,800	—	Excluded "Y"-flagged value[a]
Sulfate	mg/L	21	75	250[b]	
Temperature	°C	16.8	24	—	
Turbidity	NTU	0.38	1,000	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents full data set for 2017.

Yellow-highlighted cell indicates concentration greater than the comparison value.

a. Metals data from 299-W18-21 on 1/24/2017 were anomalously high as a result of excessive turbidity in the bailed sample and were flagged as "Y" (suspect).

b. Secondary drinking water standard.

c. Primary drinking water standard.

d. The federal drinking water standards for nitrate and nitrite are 10 mg/L and 1 mg/L, expressed as nitrogen. These equate to 45 mg/L and 3.3 mg/L when expressed as NO_3 and NO_2.

e. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-69. NRDWL Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
699-25-33A	Deep	1987 (C)	103.4	339.1	100.3	329.1	121.55	398.79	10/19/2017	21.2	69.7	Q	4, 7, 10
699-25-34B	DG	1986 (C)	125.7	412.4	119.6	392.4	121.57	398.85	10/19/2017	2.0	6.5	Q	4, 7, 10
699-25-34D	DG	1992 (C)	125.3	411.0	114.7	376.5	121.57	398.84	10/19/2017	6.8	22.4	Q	4, 10; Inaccessible in July
699-25-34F	DG	2015 (C)	122.6	402.2	113.4	372.2	121.58	398.88	10/16/2017	8.1	26.7	Q	4, 7, 10
699-26-33A	DG	2015 (C)	122.7	402.6	112.0	367.6	121.57	398.85	10/16/2017	9.5	31.3	Q	4, 7, 10
699-26-34A	UG	1986 (C)	125.7	412.5	119.6	392.5	121.58	398.88	10/18/2017	1.9	6.4	Q	4, 7, 10
699-26-34B	DG	1992 (C)	125.4	411.4	114.7	376.5	121.54	398.80	8/23.20/17	6.8	22.3	Q	4, 7, 10
699-26-35A	UG	1986 (C)	125.9	413.2	119.8	393.2	121.58	398.89	10/16/2017	1.7	5.7	Q	4, 7, 10
699-26-35C*	DG deep	1987 (C)	103.9	341.0	100.9	331.0	121.56	398.82	10/18/2017	20.7	67.9	Q	4, 7, 10
699-26-38	UG	2014 (C)	123.1	403.9	114.0	373.9	122.58	402.18	10/18/2017	8.6	28.3	Q	4, 7, 10

Note: Requirements are from Tablel 3-2 of DOE/RL-2017-19, *Groundwater Quality Assessment Plan for the Nonradioactive Dangerous Waste Landfill, Hanford Site*.

*Hydraulic head data for this well were not corrected for borehole deviation from vertical, which may cause reported head to be less than actual head.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

Q = quarterly

UG = upgradient

Table B-70. NRDWL Groundwater Velocity

Flow Direction	East-southeast
Flow Rate (m/d)	0.014
Hydraulic Conductivity (m/d) (Source)	109 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	2.5×10^{-5}
Comments	Gradient and direction determined by trend surface analysis of water-level data collected in March 2017; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-71. NRDWL Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	126	246	—	
Calcium (unfiltered)	µg/L	32,200	73,000	—	
Calcium (filtered)	µg/L	32,000	71,300	—	
Chloride	mg/L	5.9	17	—	
Chromium (unfiltered)	µg/L	3.1	18.8	100[a]	
Chromium (filtered)	µg/L	3.2	11.2	100[a]	
Iron (unfiltered)	µg/L	<17	251	300[b]	
Iron (filtered)	µg/L	<22	91.1	300[b]	
Magnesium (unfiltered)	µg/L	9,080	18,000	—	
Magnesium (filtered)	µg/L	9,120	18,500	—	
Manganese (unfiltered)	µg/L	<0.31	12.3	50[b]	
Manganese (filtered)	µg/L	<0.31	12.7	50[b]	
Nickel (unfiltered)	µg/L	<0.3	11	—	
Nickel (filtered)	µg/L	<0.3	21.7	—	
Nitrate	mg/L	5.31	44.3	45[c]	
pH measurement		7.11	8.43	—	
Potassium (unfiltered)	µg/L	4,450	8170	—	
Potassium (filtered)	µg/L	4,870	7,880	—	
Sodium (unfiltered)	µg/L	14,700	27,200	—	
Sodium (filtered)	µg/L	16,700	25,000	—	
Specific conductance	µS/cm	311	612	—	
Sulfate	mg/L	24.9	83	250[b]	
Temperature	°C	18.1	21.4	—	

Table B-71. NRDWL Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Total organic carbon	µg/L	<155	2,000	—	
Total organic halides	µg/L	<2.1	17.4	—	
Turbidity	NTU	0.1	3.49	—	
Detected Dangerous Waste and Other Constituents[d]					
Arsenic (unfiltered)	µg/L	<2	5.3	10[a]	
Arsenic (filtered)	µg/L	<2.2	4.7	10[a]	
Barium (unfiltered)	µg/L	35.8	70.5	2,000[a]	
Barium (filtered)	µg/L	36.4	70.7	2,000[a]	
Chromium (unfiltered)	µg/L	3.1	18.8	100[a]	
Chromium (filtered)	µg/L	3.2	11.2	100[a]	
Fluoride	mg/L	0.301	0.59	4[a]	
Gross alpha	pCi/L	<1.2	21.2	15[e]	
Gross beta	pCi/L	8.38	26.4	50[e]	
Lead (unfiltered)	µg/L	<0.096	1	15[f]	
Lead (filtered)	µg/L	0.096	1	15[f]	
Radium-226	pCi/L	< -0.0356	0.552	—	
Radium-228	pCi/L	< -0.0599	1.77	—	
Selenium (unfiltered)	µg/L	1.4	5.3	50[a]	
Selenium (filtered)	µg/L	1.5	4.7	50[a]	

Note: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

a. Primary drinking water standard.

b. Secondary drinking water standard.

c. The federal drinking water standards for nitrate is 10 mg/L, expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

d. Analyzed for one year. Samples were also analyzed for pesticides, herbicides, volatile organic compounds, semivolatile organic compounds, mercury, and silver. Results were below required detection limits.

e. Concentration assumed to yield a dose equivalent of 4 mrem/yr.

f. Action level.

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-72. WMA A-AX Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions[a]
			m	ft	m	ft	m	ft		m	ft		
299-E24-20	UG	1991 (C)	125.01	410.15	118.86	389.95	121.74	399.42	9/20/2017	2.9	9.5	Q	1, 3, 6, 7, 8, 9, 12
299-E24-22[b]	UG	2003 (C)	122.32	401.32	111.62	366.22	121.72	399.33	9/18/2017	10.1	33.1	Q	1, 3, 6, 7, 8, 9, 12
299-E24-33[b]	UG	2004 (C)	121.27	397.86	111.51	365.86	121.72	399.33	9/18/2017	10.2	33.5	Q	1, 3, 6, 7, 8, 9, 12
299-E25-2	DG	1955 (P)	122.10	400.58	109.91	360.58	121.67	399.19	9/15/2017	11.8	38.6	Q	1, 3, 6, 7, 8, 9, 12
299-E25-40	DG	1989 (C)	126.30	414.37	119.90	393.37	121.67	399.17	9/15/2017	1.8	5.8	Q	1, 3, 6, 7, 8, 9, 12
299-E25-41	DG	1989 (C)	126.91	416.38	120.51	395.38	121.68	399.21	9/15/2017	1.2	3.8	Q	1, 3, 6, 7, 8, 9, 12
299-E25-93[b]	DG	2003 (C)	122.47	401.81	111.77	366.71	121.69	399.24	9/15/2017	9.9	32.5	Q	1, 3, 6, 7, 8, 9, 12
299-E25-94[b]	DG	2004 (C)	121.36	398.17	110.69	363.17	121.93	400.02	9/18/2017	11.2	36.8	Q	1, 3, 6, 7, 8, 9, 12
299-E25-237	DG	2015 (C)	123.18	404.12	112.51	369.12	121.64	399.08	9/20/2017	9.1	30.0	Q	1, 3, 6, 7, 8, 9, 12

Note: Requirements are from DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX.*

a. Extra sampling events were due to missed hold times. See Section 9.10.2 of the main text for additional discussion.

b. Hydraulic head data for these wells were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly

UG = upgradient

Table B-73. Groundwater Velocity at WMA A-AX

Flow Direction	South-southeast
Flow Rate (m/d)	0.12
Hydraulic Conductivity (m/d) (Source)	17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	1.4×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-74. WMA A-AX Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	84	0	—	
Calcium (unfiltered)	µg/L	51,900	94,000	—	
Calcium (filtered)	µg/L	50,000	92,000	—	
Chloride	mg/L	11	35	250[a]	
Chromium (unfiltered)	µg/L	<1.1	128	100[b]	299-E25-40
Chromium (filtered)	µg/L	1.1	6.2	100[b]	
Cyanide[c]	µg/L	<1.67	5.5	—	
Iron (unfiltered)	µg/L	<22	300	300[a]	
Iron (filtered)	µg/L	<16	140	300[a]	
Magnesium (unfiltered)	µg/L	14,600	26,100	—	
Magnesium (filtered)	µg/L	14,500	26,700	—	
Manganese (unfiltered)	µg/L	<0.31	11.9	50[a]	
Manganese (filtered)	µg/L	<0.31	7.19	50[a]	
Nickel (unfiltered)	µg/L	<0.3	73.5	—	
Nickel (filtered)	µg/L	<0.3	20.7	—	
Nitrate	mg/L	10.2	57.5	45[d]	299-E24-20, 299-E25-93
pH Measurement	--	7.54	8.29	—	
Potassium (unfiltered)	µg/L	6,930	9,730	—	
Potassium (filtered)	µg/L	7,030	9,000	—	
Sodium (unfiltered)	µg/L	17,100	29,000	—	

Table B-74. WMA A-AX Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Sodium (filtered)	µg/L	17,300	30,000	—	
Specific conductance	µS/cm	517	835	—	
Sulfate	mg/L	102	226	250[a]	
Temperature	ºC	14.8	21	—	
Turbidity	NTU	0.1	230	—	
Dangerous waste constituents					See text

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. This analyte is not required under the groundwater monitoring plan but was analyzed in 2017.

d. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

< = one or more of the results was below the detection limit

— = no comparison value

NTU = nephelometric turbidity unit

Table B-75. WMA B-BX-BY Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-E33-20[a]	UG	1956 (P)	125.9	413.1	118.6	389.1	121.75	399.44	11/9/2017	3.1	10.3	Q	2, 5, 8, 11
299-E33-31	UG	1989 (C)	125.8	412.8	119.4	391.8	121.74	399.41	11/10/2017	2.3	7.6	Q	2, 5, 8, 11
299-E33-32	UG	1989 (C)	126.1	413.8	119.7	392.8	121.74	399.40	11/10/2017	2.0	6.6	Q	2, 5, 8, 11
299-E33-38	UG	1991 (C)	126.4	414.7	120.0	393.7	121.74	399.40	11/6/2017	1.7	5.7	Q	2, 5, 8, 11
299-E33-41	DG	1991 (C)	124.9	409.9	119.7	392.8	121.73	399.38	11/9/2017	2.0	6.6	Q	2, 5[b], 8, 11
299-E33-42	UG	1991 (C)	126.7	415.7	120.4	395.0	121.74	399.41	11/10/2017	1.4	4.4	Q	2, 5, 8, 11
299-E33-44	DG	1998 (C)	123.5	405.1	118.9	390.1	121.75	399.43	11/9/2017	2.8	9.3	Q	2, 5, 8, 11
299-E33-47	DG	2004 (C)	123.3	404.7	117.3	384.7	121.74	399.41	11/9/2017	4.5	14.7	Q	2, 5, 8, 11
299-E33-48	DG	2004 (C)	123.3	404.5	115.7	379.5	121.74	399.40	11/9/2017	6.1	19.9	Q	2, 5, 8, 11
299-E33-49	DG	2004 (C)	122.9	403.3	116.8	383.3	121.75	399.44	11/10/2017	4.9	16.2	Q	2, 5, 8, 11
299-E33-334	UG	2000 (C)	124.7	409.3	117.1	384.3	121.74	399.42	11/10/2017	4.6	15.2	Q	2, 5, 8, 11
299-E33-335[a]	DG	2000 (C)	124.2	407.4	118.1	387.4	121.73	399.36	11/10/2017	3.7	12.0	Q	2, 5, 8, 11
299-E33-337	DG	2001 (C)	124.1	407.3	116.5	382.3	121.73	399.37	11/9/2017	5.2	17.1	Q	2, 5, 8, 11
299-E33-338	DG	2001 (C)	123.8	406.1	117.7	386.1	121.74	399.42	11/6/2017	4.1	13.3	Q	2, 5, 8, 11

Table B-75. WMA B-BX-BY Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-E33-339	DG	2001 (C)	123.2	404.3	117.2	384.4	121.73	399.39	11/10/2017	4.6	15.0	Q	2, 5, 8, 11

Note: Requirements are from DOE/RL-2012-53, *Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area B-BX-BY*. That document also lists well 299-E33-18 as an upgradient well, but it was decommissioned in 2013 because it was a potential conduit for migration of contaminated perched water into the underlying aquifer.

a. Hydraulic head data for these wells were not corrected for borehole deviation from vertical, which may cause reported head to be less than actual head.

b. Sampled twice in May because of cyanide preservation error.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed prior to *Washington Administrative Code* requirements

DG = downgradient

Q = quarterly

UG = upgradient

Table B-76. Groundwater Velocity at WMA B-BX-BY

Flow Direction	Southeast
Flow Rate Range (m/d)	0.59 to 0.66
Hydraulic Conductivity Range (m/d) (Source)	17,000 to 18,800 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model, Version 7.1*, and 200-BP-5 Operable Unit treatability test results, respectively
Effective Porosity	0.2
Gradient Range (m/m)	7.0×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-77. WMA B-BX-BY Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	88.4	124	—	
Calcium (unfiltered)	µg/L	36,100	247,000	—	
Calcium (filtered)	µg/L	39,900	246,000	—	
Chloride	mg/L	11	55.2	250[a]	
Cyanide (total; unfiltered and filtered)	µg/L	<1.86	1,440	—	
Cyanide (amenable; unfiltered and filtered)[d]	µg/L	<1.67	380	200[b,c]	299-E33-38, 299-E33-44, 299-E33-47
Cyanide (free; unfiltered and filtered)[d]	µg/L	<3	57.3	200[b,c]	
Magnesium (unfiltered)	µg/L	10,400	70,600	—	
Magnesium (filtered)	µg/L	11,900	71,000	—	
Nitrate	mg/L	41.1	1,400	45[e]	All wells
pH		7.37	8.22	—	
Potassium (unfiltered)	µg/L	5,530	18,700	—	
Potassium (filtered)	µg/L	5,940	18,900	—	
Sodium (unfiltered)	µg/L	23,000	275,000	—	
Sodium (filtered)	µg/L	22,600	282,000	—	
Specific conductance	µS/cm	449	2,967	—	
Sulfate	mg/L	48.1	260	250[a]	299-E33-44
Total organic carbon	µg/L	<223	8,100	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. Applies to free cyanide. Note that the WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B," standard is 4.8 µg/L.

d. These analyses are not required under the groundwater monitoring plan but were performed in 2017.

e. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

< = one or more of the results was below the detection limit

— = no comparison value

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Table B-78. Waste Management Area (WMA) C Groundwater Monitoring Network

Well Name	Location[a]	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Comment	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft			
299-E27-7[a]	DG	1982 (P)	120.8	396.2	108.6	356.2	121.74	399.42	9/29/2017	13.2	43.2	Q	To be replaced by 299-E27-26 when assessment plan revised.	3, 6, 9, 12
299-E27-12[a]	UG	1989 (C)	126.4	414.7	120.0	393.6	121.68	399.20	8/1/2017	1.7	5.6	Q		3, 6, 9, 12
299-E27-13	DG	1989 (C)	126.8	416.0	120.4	394.9	121.68	399.21	9/29/2017	1.3	4.3	Q		3, 6, 9, 12
299-E27-14[b]	DG	1989 (C)	125.9	413.1	119.5	392.1	121.74	399.40	9/28/2017	2.2	7.3	Q		3, 6, 9, 12
299-E27-15[b]	UG	1989 (C)	126.6	415.4	120.2	394.4	121.74	399.42	9/29/2017	1.5	5.0	Q		3, 6, 9, 12
299-E27-21[b]	DG	2003 (C)	122.3	401.1	111.6	366.1	121.73	399.38	9/29/2017	10.1	33.2	Q		3, 6, 9, 12
299-E27-22[b]	UG	2003 (C)	123.1	403.8	110.9	363.9	121.76	399.48	9/28/2017	10.8	35.6	Q		3, 6, 9, 12
299-E27-23[b]	DG	2003 (C)	122.3	401.2	111.6	366.2	121.72	399.35	9/29/2017	10.1	33.1	Q		3, 6, 9, 12
299-E27-24	DG	2010 (C)	113.0	370.9	107.0	350.9	121.68	399.22	9/28/2017	14.7	48.3	Q		3, 6, 9, 12
299-E27-25	CG	2010 (C)	123.1	404.0	117.0	383.9	121.57	398.85	9/29/2017	4.6	15.0	Q		3, 6, 9, 12
299-E27-26	DG	2016 (C)	122.9	403.2	110.7	363.2	121.07[c]	397.22	6/5/2017	10.4	34.0	Q	Installed as replacement for 299-E27-7. Both wells sampled in 2017.	3, 6, 9, 12
299-E27-155	CG (deep)	2007 (C)	116.1	380.9	105.4	345.9	121.62	399.01	9/29/2017	16.2	53.1	Q	Not in monitoring plan but sampled in 2017.	3, 6, 9, 12

Note: Requirements are from DOE/RL-2009-77, *Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C.* The plan also includes downgradient well 299-E27-4, which was removed from service in 2016 and decommissioned in 2017 because of casing corrosion.

a. Designations as upgradient, downgradient, and cross gradient have been modified from DOE/RL-2009-77 due to a change in flow direction.

b. Hydraulic head data for these wells were corrected for borehole deviation from vertical. Corrections are not available for other wells in this network, which may cause reported head to be less than actual head.

c. Head in this well is consistently much lower than other wells in the network, suggesting that the well is deviated from vertical.

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

CG = cross gradient

DG = downgradient

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly

UG = upgradient

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Table B-79. Groundwater Velocity at WMA C

Flow Direction	Southeast
Flow Rate Range (m/d)	0.41
Hydraulic Conductivity (m/d) (Source)	17,000 (CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*)
Effective Porosity	0.2 (CP-57037)
Gradient (m/m)	4.9×10^{-6}
Comments	Gradient and flow direction represent average of October 2016 through September 2017; based on trend surface analysis on low-gradient well network; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-80. WMA C Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	56	133	—	
Chloride	mg/L	13	74	250[a]	
Cyanide (total; unfiltered and filtered)	µg/L	<1.67	47.2	—	
Cyanide (amenable, unfiltered and filtered)[d]	µg/L	<1.67	37.1	200[b,c]	
Cyanide (free; unfiltered and filtered)[d]	µg/L	<3	7.36	200 [b,c]	
Iron (unfiltered)	µg/L	<17	11,800	300[a]	299-E27-7, 299-E27-12, 299-E27-13, 299-E27-14, 299-E27-15, 299-E27-23
Iron (filtered)	µg/L	<16	9,510	300[a]	299-E27-13
Manganese (unfiltered)	µg/L	<0.31	282	50[a]	299-E27-13
Manganese (filtered)	µg/L	<0.3	213	50[a]	299-E27-13
Nitrate	mg/L	9.74	159	45[e]	299-E27-14, 299-E27-21, 299-E27-22, 299-E27-23, 299-E27-24, 299-E27-25, 299-E27-155
pH		6.19	8.87	—	
Sodium (unfiltered)	µg/L	12,000	30,000	—	
Sodium (filtered)	µg/L	12,500	30,000	—	

Table B-80. WMA C Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Specific conductance	µS/cm	413	1,151	—	
Sulfate	mg/L	64	350	250[a]	299-E27-14, 299-E27-22, 299-E27-24, 299-E27-25

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. Applies to free cyanide. Note that the WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B," standard is 4.8 µg/L.

d. These analyses are not required under the groundwater monitoring plan but were performed in 2017.

e. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

< = one or more of the results was below the detection limit

— = no comparison value

Table B-81. WMA S-SX Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency[a]	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-W22-47	DG	2005 (C)	135.8	445.6	125.2	410.6	132.09	433.38	6/28/2017	6.9	22.8	Q	6, 12
299-W22-69	DG	2006 (C)	134.7	442.0	124.0	406.9	131.44	431.23	6/28/2017	7.4	24.3	A	6, 12
299-W22-72	DG	2006 (C)	135.1	443.3	124.4	408.3	131.44	431.23	6/28/2017	7.0	23.0	A	6, 12
299-W22-80	DG	2000 (C)	137.5	451.1	126.8	416.0	132.27	433.94	6/29/2017	5.5	18.0	A	6, 12
299-W22-81	DG	2001 (C)	136.8	448.8	126.1	413.9	131.86	432.62	6/28/2017	5.7	18.8	A	6, 12
299-W22-82	DG	2001 (C)	137.2	450.2	126.5	415.1	131.93	432.84	6/28/2017	5.4	17.8	A	6, 12
299-W22-83	DG	2001 (C)	137.4	450.7	126.7	415.7	131.90	432.75	6/28/2017	5.2	17.1	A	6, 12
299-W22-84	DG	2001 (C)	137.1	449.7	126.4	414.7	131.76	432.28	6/29/2017	5.3	17.5	A	6, 12
299-W22-85	DG	2001 (C)	137.5	451.1	126.9	416.2	132.18	433.66	6/29/2017	5.3	17.4	A	6, 12
299-W22-86	DG	2006 (C)	135.2	443.5	124.5	408.4	131.39	431.07	6/28/2017	6.9	22.7	A	6, 12
299-W22-89	DG	2006 (C)	135.1	443.3	124.4	408.2	132.15	433.57	6/28/2017	7.7	25.4	A	6, 12
299-W22-93	DG	2015 (C)	132.3	434.1	121.6	399.1	131.57	431.65	6/29/2017	9.9	32.6	Q	3, 6, 9, 12
299-W22-94	DG	2013 (C)	133.2	436.9	122.5	401.9	131.77	432.30	6/28/2017	9.3	30.4	S	6, 12
299-W22-95	DG	2013 (C)	132.1	433.3	119.9	393.3	131.46	431.29	6/28/2017	11.6	38.0	S	6, 12
299-W22-113	DG	2014 (C)	132.7	435.5	123.6	405.4	132.05	433.23	6/29/2017	8.5	27.8	S	6, 12
299-W22-115	DG	2015 (C)	133.3	437.2	122.6	402.1	132.04	433.19	6/29/2017	9.5	31.1	S	6, 12
299-W22-116	DG	2015 (C)	132.5	434.8	121.9	399.8	132.05	433.22	6/29/2017	10.2	33.4	A	6, 12
299-W23-19[b]	DG	1999 (C)	138.3	453.6	128.9	423.0	132.71	435.39	6/29/2017	3.8	12.3	Q	3, 6, 9, 12

Table B-81. WMA S-SX Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency[a]	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-W23-20	UG	2000 (C)	138.3	453.8	126.7	415.8	132.77	435.61	6/29/2017	6.0	19.8	A	6, 12
299-W23-21	UG	2000 (C)	137.8	452.0	126.5	414.9	132.90	436.03	6/29/2017	6.4	21.1	A	6, 12; sampled with bailer in December
299-W23-236	DG	2015 (C)	132.9	436.0	122.2	401.0	132.51	434.73	6/29/2017	10.3	33.7	A	6, 12

Note: Requirements are from DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*.

a. Listed frequency is as required under the monitoring plan. Quarterly sampling was initiated in all wells in December 2017 in anticipation of a monitoring plan revision.

b. Water-level measurements are not possible from well 299-W23-19 because it is located within the tank farm fence line and sampled remotely from outside the fence. The water level was estimated as 0.2 m higher than at nearby well 299-W23-236.

A = annually

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

Q = quarterly

S = semiannually

UG = upgradient

Table B-82. Groundwater Velocity at WMA S-SX

Flow Direction	East
Flow Rate (m/d)	0.15
Hydraulic Conductivity (m/d) (Source)	5 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	3.0×10^{-3}
Comments	Gradient and direction determined by trend surface analysis of data collected in March 2017; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-83. WMA S-SX Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	70	301	—	
Calcium (unfiltered)	µg/L	18,400	51,400	—	
Calcium (filtered)	µg/L	17,300	51,200	—	
Chloride	mg/L	3.99	19.9	250[a]	
Chromium (unfiltered)	µg/L	<0.72	216	100[b]	299-W22-116, 299-W22-93, 299-W23-19, 299-W23-21
Chromium (filtered)	µg/L	<1.5	224	100[b]	299-W22-116, 299-W22-93, 299-W23-19
Cr(VI) (unfiltered)[c]	µg/L	<1.5	180	48[d]	299-W22-116, 299-W22-93, 299-W23-95, 299-W23-19
Magnesium (unfiltered)	µg/L	6,320	16,800	—	
Magnesium (filtered)	µg/L	6,310	16,900	—	
Manganese (unfiltered)	µg/L	<0.69	94.6	50[a]	299-W22-81, 299-W23-21
Manganese (filtered)	µg/L	<0.31	71.5	50[a]	299-W22-81
Nitrate	mg/L	5.58	149	45[e]	299-W22-115, 299-W22-116, 299-W22-93, 299-W22-95, 299-W23-19
pH Measurement		6.69	8.36	—	
Potassium (unfiltered)	µg/L	2,480	4,270	—	
Potassium (filtered)	µg/L	2,300	4,290	—	

Table B-83. WMA S-SX Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Sodium (unfiltered)	µg/L	13,900	32,600	—	
Sodium (filtered)	µg/L	12,200	33,000	—	
Specific conductance	µS/cm	238	630	—	
Sulfate	mg/L	14.8	70	250[a]	
Temperature	ºC	13.7	24.4	—	
Turbidity	NTU	0.26	388	—	
Dangerous waste constituents					See text

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. Not required by current monitoring plan. Data summarized for information.

d. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

e. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

< = one or more of the results was below the detection limit

— = no comparison value

Cr(VI) = hexavalent chromium

NTU = nephelometric turbidity unit

Table B-84. WMA T Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-W10-1	UG	1947 (P)	148.6	487.6	124.2	407.6	132.62	435.12	11/6/2017	8.4	27.5	A	11
299-W10-23	ASMT	1998 (C)	137.8	452.1	127.1	417.1	131.61	431.80	11/2/2017	4.5	14.7	B	11
299-W10-24	DG	1998 (C)	138.0	452.6	127.3	417.6	131.28	430.71	11/2/2017	4.0	13.1	A	11
299-W10-28	UG	2001 (C)	137.5	451.2	126.9	416.2	131.98	432.99	11/2/2017	5.1	16.8	A	11
299-W11-39	DG	2000 (C)	137.0	449.6	126.4	414.6	131.02	429.84	11/3/2017	4.6	15.2	A	11
299-W11-40	DG	2000 (C)	137.2	450.0	126.5	415.0	130.78	429.07	11/3/2017	4.3	14.1	Q	2, 5, 8, 11
299-W11-41	DG	2000 (C)	137.4	450.9	126.8	415.9	130.56	428.35	11/6/2017	3.8	12.5	Q	Monthly 2 through 12*
299-W11-42	DG	2000 (C)	137.9	452.6	127.3	417.6	130.99	429.75	11/3/2017	3.7	12.2	Q	2, 5, 8, 11
299-W11-45	Far-field	2006 (C)	127.2	417.4	122.7	402.4	130.45	427.98	11/8/2017	7.8	25.5	S	5, 11
299-W11-47	Deep	2006 (C)	126.1	413.8	116.7	382.8	130.65	428.65	11/2/2017	14.0	45.8	Q	2, 5, 8, 11

Note: Requirements are from DOE/RL-2009-66, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area T*.

*Well 299-W11-41 was sampled monthly for cyanide beginning in February 2017.

A = annually
ASMT = assessment of plume
B = biennial (every other year)
C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"
DG = downgradient
P = constructed prior to *Washington Administrative Code* requirements
Q = quarterly
S = semiannual
UG = upgradient

Table B-85. Groundwater Velocity at WMA T

Flow Direction	East-southeast
Flow Rate (m/d)	0.34
Hydraulic Conductivity (m/d) (Source)	5 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	6.7×10^{-3}
Comments	Gradient and direction determined by trend surface analysis of data collected in March 2017; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-86. WMA T Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	114	139	—	
Calcium (unfiltered)	µg/L	5,560	140,000	—	
Chloride	mg/L	13	24	250[a]	
Chromium (unfiltered)	µg/L	18.5	150	100[b]	299-W10-28
Cr(VI) (unfiltered)	µg/L	<1.5	120	48[e]	299-W10-28
Cyanide (total)[c]	µg/L	<1.67	<5	—	
Cyanide (free)[c]	µg/L	<1.67	<5	200[b,d]	
Cyanide (amenable)[c]	µg/L	<1.67	<5	200[b,d]	
Dissolved oxygen	mg/L	4.58	9.76	—	
Fluoride	mg/L	0.3	5	4[b]	299-W10-23, 299-W10-24, 299-W11-39
Magnesium (unfiltered)	µg/L	1,670	43,000	—	
Nitrate	mg/L	36.7	575	45[f]	All except 299-W10-23
pH		7.28	9.27	—	
Potassium (unfiltered)	µg/L	2,240	6,800	—	
Sodium (unfiltered)	µg/L	11,100	142,000	—	
Specific conductance	µS/cm	403	1,361	—	

Table B-86. WMA T Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Sulfate	mg/L	35	57	250[a]	
Temperature	ºC	12.6	21	—	
Turbidity	NTU	0.5	74	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. These analyses are not required under the groundwater monitoring plan but were performed in 2017.

d. Applies to free cyanide. Note that the WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B," standard is 4.8 µg/L.

e. WAC 173-340-705.

f. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

< = one or more of the results was below the detection limit

— = no comparison value

Cr(VI) = hexavalent chromium

NTU = nephelometric turbidity unit

Table B-87. WMA TX-TY Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-W10-26	DG	1998 (C)	138.53	454.50	127.86	419.50	130.33	427.59	11/13/2017	2.5	8.1	Q	2 through 12*
299-W10-27	DG	2001 (C)	137.54	451.24	126.87	416.24	130.39	427.79	11/13/2017	3.5	11.5	Q	2 through 12*
299-W14-11	Deep	2005 (C)	124.53	408.55	121.48	398.55	128.89	422.88	11/14/2017	7.4	24.3	S	2 through 12*
299-W14-13	DG	1998 (C)	138.20	453.43	127.54	418.43	129.13	423.65	11/15/2017	1.6	5.2	Q	2 through 12*
299-W14-14	DG	1998 (C)	138.48	454.33	127.81	419.33	129.86	426.05	11/13/2017	2.0	6.7	S	5, 11
299-W14-15	DG	2000 (C)	137.53	451.21	126.86	416.21	128.27	420.84	11/16/2017	1.4	4.6	Q	2, 5, 8, 11
299-W14-16	FF	2000 (C)	137.40	450.78	126.73	415.78	129.50	424.87	11/16/2017	2.8	9.1	A	11
299-W14-17	FF	2000 (C)	137.41	450.83	126.75	415.83	129.25	424.04	11/14/2017	2.5	8.2	A	11
299-W14-18	DG	2000 (C)	137.82	452.15	127.15	417.15	128.25	420.76	11/16/2017	1.1	3.6	A	2 through 12*
299-W14-19	DG	2002 (C)	136.62	448.24	125.96	413.24	129.74	425.66	11/1/2017	3.8	12.4	S	5, 11
299-W15-44	DG	2002 (C)	138.33	453.84	127.66	418.84	131.33	430.86	11/15/2017	3.7	12.0	S	5,11
299-W15-763	DG	2001 (C)	137.56	451.30	126.89	416.30	130.76	429.00	11/15/2017	3.9	12.7	S	5, 11
299-W15-765	UG	2001 (C)	137.45	450.95	126.78	415.95	130.81	429.16	11/15/2017	4.0	13.2	S	5, 11

Note: Requirements are from DOE/RL-2009-67, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area TX-TY*.

*Sampled monthly for cyanide (not required under monitoring plan).

A = annually

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

DG = downgradient

FF = far-field

Q = quarterly

S = semiannual

UG = upgradient

Table B-88. Groundwater Velocity at WMA TX-TY

Flow Direction	North portion: southeast South portion: east-northeast
Flow Rate (m/d)	North portion: 0.19 to 0.34 South portion: 0.20 to 0.35
Hydraulic Conductivity (m/d) (Source)	5 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	North portion: 6.9×10^{-3} South portion: 7.1×10^{-3}
Comments	Gradient and direction estimated from March 2017 water table map; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-89. WMA TX-TY Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	108	128	—	
Aluminum (unfiltered)	µg/L	<15	3,150	50[a]	299-W10-26, 299-W10-27, 299-W14-13, 299-W14-14, 299-W14-16, 299-W14-18, 299-W14-19, 299-W15-44, 299-W15-763
Calcium (unfiltered)	µg/L	35,600	159,000	—	
Chloride	mg/L	18	36	250[a]	
Chromium (unfiltered)	µg/L	6.58	463	100[b]	299-W14-16
Cr(VI) (unfiltered)	µg/L	<3.3	97	48[c]	299-W14-11, 299-W14-16
Cyanide (total; filtered and unfiltered)[d]	µg/L	<1.67	688	—	
Cyanide (amenable; filtered and unfiltered)[d]	µg/L	<1.67	348	200[b,e]	299-W14-18 (filtered sample; unfiltered sample had 84 µg/L)
Cyanide (free; filtered and unfiltered)[d]	µg/L	<3	66	200[b,e]	
Dissolved oxygen	mg/L	3.65	9.69	—	
Fluoride	mg/L	0.208	1.57	4[b]	
Magnesium (unfiltered)	µg/L	11,600	53,200	—	

Table B-89. WMA TX-TY Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Nitrate	mg/L	32.3	620	45[f]	All
pH	—	7.4	8.28	—	
Potassium (unfiltered)	µg/L	4,350	8,560	—	
Sodium (unfiltered)	µg/L	13,000	106,000	—	
Specific conductance	µS/cm	492	1,473	—	
Sulfate	mg/L	31.6	63.9	250[a]	
Temperature	ºC	10	21.9	—	
Turbidity	NTU	0.13	71.9	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Yellow-highlighted cells indicate concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. WAC 173-340-705, "Model Toxics Control Act – Cleanup," "Use of Method B."

d. Cyanide analyses are not required under the groundwater monitoring plan but were added to the sampling schedule in 2017.

e. Applies to free cyanide. Note that the WAC 173-340-705 standard is 4.8 µg/L.

f. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

< = one or more of the results was below the detection limit

— = no comparison value

Cr(VI) = hexavalent chromium

NTU = nephelometric turbidity unit

Table B-90. WMA U Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampled Months and Exceptions
			m	ft	m	ft	m	ft		m	ft		
299-W18-40	UG	2001 (C)	136.2	446.8	125.5	411.8	133.07	436.59	10/15/2017	7.5	24.8	A	1, 10*
299-W18-260	DG	2014 (C)	132.0	432.9	122.8	402.9	132.06	433.26	10/15/2017	9.2	30.3	S	4, 10
299-W19-12	DG	1983 (P)	141.7	464.8	130.4	427.8	131.99	433.03	10/15/2017	1.6	5.2	S	4, 10
299-W19-41	DG	1998 (C)	138.7	455.0	128.0	420.0	132.07	433.28	10/15/2017	4.0	13.2	S	4, 10
299-W19-42	DG	1998 (C)	138.4	453.9	127.7	418.8	132.03	433.18	10/15/2017	4.4	14.3	S	4, 10
299-W19-44	DG	2001 (C)	136.4	447.7	125.8	412.7	131.98	433.02	10/15/2017	6.2	20.4	S	1, 7, 10*
299-W19-45	DG	2001 (C)	137.4	450.6	126.7	415.7	132.08	433.32	10/16/2017	5.4	17.6	S	1, 7, 10*
299-W19-47	DG	2004 (C)	136.3	447.3	125.7	412.4	132.04	433.21	10/15/2017	6.3	20.8	S	1, 7, 10*

Note: Requirements are from DOE/RL-2009-74, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*.

*Listed frequency is as required under the monitoring plan. Quarterly sampling was initiated in all wells in October 2017 in anticipation of a monitoring plan revision.

A = annually
DG = downgradient
C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"
P = constructed prior to *Washington Administrative Code* requirements
S = semiannual
UG = upgradient

Table B-91. Groundwater Velocity at WMA U

Flow Direction	East
Flow Rate (m/d)	0.35
Hydraulic Conductivity (m/d) (Source)	6.12 (CP-47631, *Model Package Report: Central Plateau Groundwater Model, Version 8.3.4*)
Effective Porosity	0.1 (CP-47631)
Gradient (m/m)	7.1×10^{-3}
Comments	Gradient and direction determined by trend surface analysis of data collected in March 2017; velocity calculated from the Darcy equation

Reference: ECF-Hanford-17-0241, *Hydraulic Gradients and Velocity Calculations for RCRA Sites in 2017*.

Table B-92. WMA U Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Alkalinity	mg/L	79.6	98.8	—	
Calcium (unfiltered)	µg/L	29,800	59,400	—	
Calcium (filtered)	µg/L	29,500	59,200	—	
Chloride	mg/L	11.5	23	250[a]	
Chromium (unfiltered)	µg/L	5.06	98.4	100[b]	
Chromium (filtered)	µg/L	4.5	20.4	100[b]	
Magnesium (unfiltered)	µg/L	10,600	19,000	—	
Magnesium (filtered)	µg/L	10,300	19,500	—	
Nitrate	mg/L	40.1	186	45[c]	All
pH Measurement	—	7.76	8.72	—	
Potassium (unfiltered)	µg/L	3,400	5,120	—	
Potassium (filtered)	µg/L	3,260	5,040	—	
Sodium (unfiltered)	µg/L	17,400	27,000	—	
Sodium (filtered)	µg/L	18,100	27,000	—	
Specific conductance	µS/cm	362	646	—	
Sulfate	mg/L	23	33	250[a]	
Temperature	ºC	15.7	22.5	—	

Table B-92. WMA U Sampling Summary for 2017

Constituent	Units	Minimum	Maximum	Comparison Value	Exceeding Well(s); Comments
Turbidity	NTU	0.92	116	—	

Notes: Minimum and maximum are based on sample results collected specifically for this *Resource Conservation and Recovery Act of 1976* unit. Appendix A of DOE/RL-2017-65, *Hanford Site RCRA Groundwater Monitoring Report for 2017*, presents the full data set for 2017.

Highlighted cell indicates concentrations greater than the comparison value.

a. Secondary drinking water standard.

b. Primary drinking water standard.

c. The federal drinking water standard for nitrate is 10 mg/L expressed as nitrogen. This equates to 45 mg/L when expressed as NO_3.

— = no comparison value

NTU = nephelometric turbidity unit

Table B-93. Environmental Restoration Disposal Facility Groundwater Monitoring Network

Well Name	Location	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions
			(m)	(ft)	(m)	(ft)	(m)	(ft)		(m)	(ft)		
699-35-66A	DG	1957 (P)	142.5	467.6	123.6	405.6	129.19	423.84	9/27/2017	5.6	18.2	S	—
699-36-66B	DG	2008 (C)	130.9	429.3	120.2	394.3	129.23	423.97	9/27/2017	9.0	29.6	S	—
699-36-70A	UG	1994 (C)	136.7	448.6	127.5	418.4	130.11	426.87	9/27/2017	2.6	8.5	S	—
699-37-66	DG	2007 (C)	130.5	428.1	119.8	393.1	128.90	422.89	9/27/2017	9.1	29.8	S	—

Notes: Requirements are from WCH-198, *Groundwater Protection Plan for the Environmental Restoration Disposal Facility*.

Wells completed at the top of the unconfined aquifer.

C = well is constructed as a resource protection well under WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed before *Washington Administrative Code* requirements

S = to be sampled semiannually

Table B-94. State-Approved Land Disposal Site Groundwater Monitoring Network

Well Name	Purpose	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions
			(m)	(ft)	(m)	(ft)	(m)	(ft)		(m)	(ft)		
299-W6-11	TT	1992 (C)	137.9	452.5	131.8	432.4	132.48	434.63	3/9/2017	0.7	2.3	A	—
299-W6-12	TT	1992 (C)	137.4	450.8	132.8	435.6	133.36	437.53	3/9/2017	0.6	2.0	A	—
299-W6-6	TT	1991 (C)	88.9	291.7	85.7	281.0	132.52	434.79	3/9/2017	46.9	153.8	A	—
299-W7-3	TT	1987 (C)	63.2	207.3	61.2	200.6	134.92	442.66	3/9/2017	73.8	242.0	S	—
299-W8-1	TT	1987 (C)	142.3	466.9	136.1	446.6	136.33	447.26	3/9/2017	0.2	0.7	A	—
699-48-71	TT	1956 (P)	137.5	451.2	118.3	388.2	129.97	426.42	2/27/2017	11.7	38.3	A	—

Table B-94. State-Approved Land Disposal Site Groundwater Monitoring Network

Well Name	Purpose	Year Installed	Elevation Screen Top		Elevation Screen Bottom		Hydraulic Head		Head Date	Water Column		Sample Frequency	Sampling Exceptions
			(m)	(ft)	(m)	(ft)	(m)	(ft)		(m)	(ft)		
699-48-77C	Compliance	1994 (C)	117.5	385.4	111.5	365.7	134.25	440.46	3/12/2017	22.8	74.8	Q	—
699-48-77D	Compliance	1994 (C)	140.3	460.1	134.2	440.1	134.41	440.99	3/12/2017	0.3	0.8	Q	—
699-49-79	TT	1948 (P)	142.2	466.4	130.0	426.4	134.99	442.89	3/8/2017	5.0	16.5	A	—
699-51-75	TT	1957 (P)	138.0	452.6	124.2	407.6	132.22	433.79	3/8/2017	8.0	26.2	S	—
699-51-75P	TT	1977 (P)	83.1	272.6	81.6	267.6	132.23	433.84	3/8/2017	50.7	166.2	A	—

Note: Requirements are from RPP-ENV-59215, *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site.*

A = annually

C = constructed as a resource protection well in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

P = constructed prior to *Washington Administrative Code* requirements

Q = quarterly

S = semiannual

TT = tritium tracking

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Appendix C

Supporting Information for Atomic Energy Act Monitoring

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C1 Introduction

DOE/RL-2015-56, *Hanford Atomic Energy Act Sitewide Monitoring Plan*, defines the requirements for *Atomic Energy Act of 1954* (AEA) groundwater monitoring on the Hanford Site. The monitoring locations resulted from the approach to integrate groundwater monitoring that is already conducted under other regulations as part of an overall strategy to meet the requirements of the AEA groundwater monitoring plan. The approach involves shared sampling and analysis events to eliminate duplication of effort by multiple programs.

The AEA groundwater monitoring plan was published in December 2015 and was implemented in calendar year 2016. Sample collection from the monitoring locations identified in the plan was distributed over 3 years to start; not all wells were intended to be sampled during the first year of the monitoring program.

The AEA groundwater monitoring is integrated with other groundwater monitoring programs at the Hanford Site. To implement program integration, a comprehensive groundwater sampling and analysis schedule is developed each year by incorporating the sampling and analysis needs established in individual sampling and analysis plans. Integrating the AEA monitoring program into the comprehensive groundwater monitoring schedule includes scheduling AEA sampling events in conjunction with other programs (where possible) to avoid duplicative sampling events. Schedule integration may also result in situations where AEA monitoring data are collected on a slightly different schedule than established in the AEA sampling and analysis plan (DOE/RL-2015-56). Schedule integration includes other AEA monitoring activities. For example, monitoring required by the performance assessment groundwater monitoring plan for the Integrated Disposal Facility is performed in accordance with the schedule established in RPP-PLAN-26534, *Integrated Disposal Facility Operational Monitoring Plan to Meet DOE Order 435.1*. Sitewide surveillance sampling and analysis of the same wells under DOE/RL-2015-56 includes an expanded list of analytes monitored on a different frequency. The planned performance assessment monitoring was completed as scheduled in 2017.

Sample collection and analysis under DOE/RL-2015-56 focuses on radiological analytes and nitrate. The AEA groundwater monitoring program relies on existing *Resource Conservation and Recovery Act of 1976*; *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; and *Washington Administrative Code* monitoring activities for collecting and analyzing groundwater samples for nonradiological constituents of interest. The AEA groundwater monitoring program evaluates radiological data collected under the other programs to support AEA surveillance reporting activities.

Table C-1 lists sampling deviations and omissions for 2017 based on DOE/RL-2015-56 groundwater monitoring requirements. Wells not listed in Table C-1 were sampled according to monitoring requirements of DOE/RL-2015-56. In some cases, wells were sampled beyond the requirements listed in the sampling and analysis plan (e.g., wells were sampled more frequently or for additional constituents), and those exceptions are not noted in Table C-1.

Table C-1. AEA Well Sampling Exceptions, 2017

Well Name(s)	Sampling Exceptions and Explanation
100-BC Groundwater Interest Area	
—	No sampling exceptions.
100-FR Groundwater Interest Area	
699-66-30, 699-71-26	Decommissioned.
100-HR Groundwater Interest Area	
199-D5-128	Pump and treat configuration (injection well).
100-KR Groundwater Interest Area	
199-K-23	Decommissioned.
100-NR Groundwater Interest Area	
199-N-104A, 199-N-172, 199-N-367	Well sample dry; missed annual sampling for tritium.
199-N-50	Missed annual sampling for well maintenance issues.
1100-EM Groundwater Interest Area	
699-S30-E15A	Missed sampling; weather restrictions.
Richland North Groundwater Interest Area	
—	No sampling exceptions.
300-FF Groundwater Interest Area	
399-1-63,* 399-2-3	Well sample dry.
699-11-E4F, 699-11-E5A	Well access issues; located inside locked pump house.
399-6-3	Well maintenance issues; cord replacement.
200-BP Groundwater Interest Area	
299-E27-4	Decommissioned.
299-E28-2	Well maintenance issues: new pump installed.
299-E28-7, 299-E29-54, 699-54-49, 699-55-55	Delayed sampling; 299-E28-7 delayed for weather restrictions.
299-E28-11	Not operational; pump is not running.
299-E28-15, 299-E33-268	Not operational; no pump installed, pump is not running
299-E33-9, 299-E33-205	Well access issues; locked inside BY Tank Farms.
299-E33-37	Missed technetium-99 annual sampling; not scheduled.
699-42-40A	Well sample dry.

Table C-1. AEA Well Sampling Exceptions, 2017

Well Name(s)	Sampling Exceptions and Explanation
200-PO Groundwater Interest Area	
299-E13-4, 299-E13-15, 699-20-E12S	Well access issues; land subsidence issues, located in sand dune field.
299-E13-13	Well access issue; well is buried.
299-E17-9, 299-E25-9, 299-E17-21, 299-E24-4, 299-E25-21	Well sample dry.
499-S1-7B, 699-S2-34B	Delayed sampling; 699-S2-34B was part of consolidated trip sample for March.
499-S1-7C, 699-43-44	Decommissioned.
499-S1-8J	Well maintenance issues.
699-20-E12O	Obstruction in well.
699-36-58B	Well access issues; U.S. Ecology well.
200-UP Groundwater Interest Area	
299-W17-3, 299-W22-90, 299-W22-92	Delayed sampling.
299-W19-49	Well sample dry.
299-W22-123	Canceled well; U.S. Department of Energy canceled drilling of well.
699-17-70	Missed sampling due to weather conditions.
699-35-59	Well access issues; U.S. Ecology well.
699-35-78A	Well maintenance issues; pump replacement.
200-ZP Groundwater Interest Area	
299-W11-22, 299-W11-26	Candidate for decommissioning; potential multiple casing, no screened perforations.
299-W11-90, 299-W15-225, 299-W17-2	Delayed sampling.
299-W15-36	Well maintenance issues; reconfigure well and replace pump.

*Well 399-1-63 was successfully sampled for annual sampling in June, but scheduled triennial sampling was missed in December 2017.

C2 References

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Appendix D

Confined Aquifers

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Terms

Cr(VI)	hexavalent chromium
DWS	drinking water standard
RDR	request for data review
RUM	Ringold upper mud unit

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D1 Confined Aquifers

This appendix describes groundwater flow and groundwater quality in confined aquifers within the Ringold Formation and the upper portion of the Columbia River Basalt Group. The U.S. Department of Energy monitors groundwater quality in the confined aquifer systems because of the potential for downward migration of contaminants from the overlying unconfined aquifer in areas where confining units are absent or fractured.

D2 Ringold Confined Aquifers

Numerous wells at the Hanford Site monitor the confined water-bearing units in the Ringold Formation (Figure D-1). The most widespread Ringold confined aquifer is where the Ringold lower mud unit confines the underlying sediment of Ringold unit A (Figure 1-6 in the main text). Approximately 40 wells are screened in Ringold unit A, although not all of the wells have been sampled in recent years. Most of the wells are located in or near the Central Plateau; other wells are located in the southern Hanford Site (including the 300 Area), and one well is in the 100 Area.

Local water-bearing units in or beneath the Ringold upper mud unit (RUM) exist in the northern Hanford Site (Figure 1-4 in the main text). These units are not believed to be interconnected into a regionally confined aquifer. Twenty-one wells in the 100 Area are screened in water-bearing units within or beneath this unit.

D2.1 Groundwater Flow in Ringold Confined Aquifers

This section describes groundwater flow in the confined aquifer of Ringold unit A in the region near the 200 Areas and farther south. The elevation of this Ringold confined aquifer varies from 34 m (111.5 ft) (NAVD88, *North American Vertical Datum of 1988*) southwest of the 200 West Area (Plate 3 of PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*) to more than 128 m (420 ft) northeast of the 200 East Area (Plate 3 of PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*). Insufficient data are available from unit A in the northern part of the Hanford Site to interpret groundwater flow directions. Groundwater flow in the RUM is not characterized.

Figure D-2 presents the March 2017 potentiometric surface for a portion of the confined aquifer in Ringold unit A based on ECF-Hanford-17-0120, *Preparation of the March 2017 Hanford Site Water Table and Potentiometric Surface Maps*, which includes potentiometric surface map and water-level measurements from 27 monitoring wells. This map is subject to uncertainty because only a few wells monitor this aquifer. However, generalized flow patterns can be inferred from available data when the hydrogeologic framework (i.e., the extent of the confined unit, presence of basalt subcrops, and influence of the May Junction Fault) is considered.

Groundwater flow in the Ringold confined aquifer is generally west to east near the 200 West Area and west to east along the southern boundary of the aquifer near the Rattlesnake Hills. This flow pattern indicates that recharge occurs west of the 200 West Area in upgradient areas within the Cold Creek Valley, as well as in Dry Creek Valley and possibly the Rattlesnake Hills. Near the 200 East Area, flow in the Ringold confined aquifer converges from the west, south, and east before discharging to the unconfined aquifer where the Ringold lower mud is absent (Section 4.2.3 in PNNL-12261). This water is thought to flow southeast over the top of the confining unit (Section 2.4.3 in DOE/RL-2008-59, *Interim Status Groundwater Monitoring Plan for the 216-B-3 Pond*).

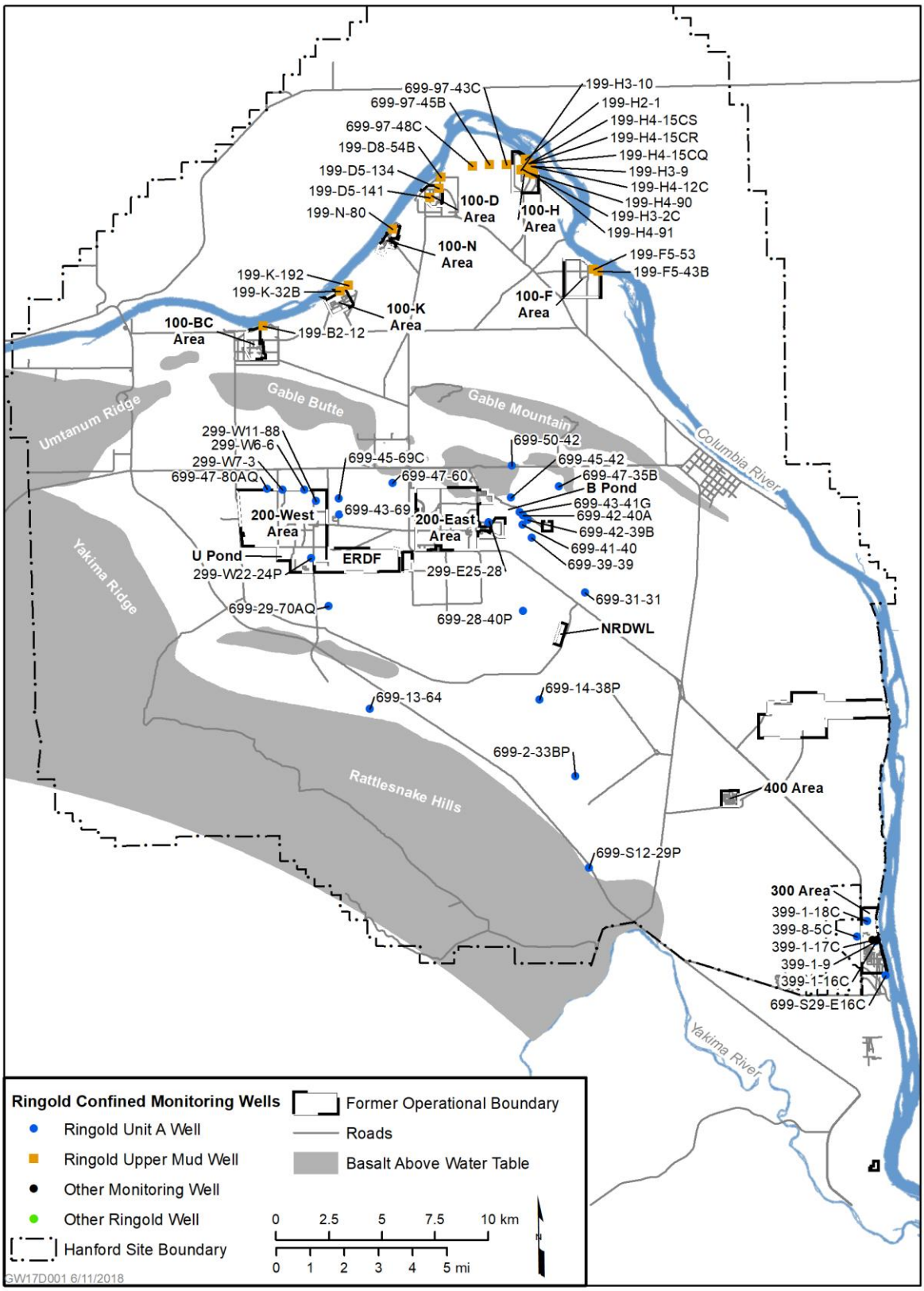
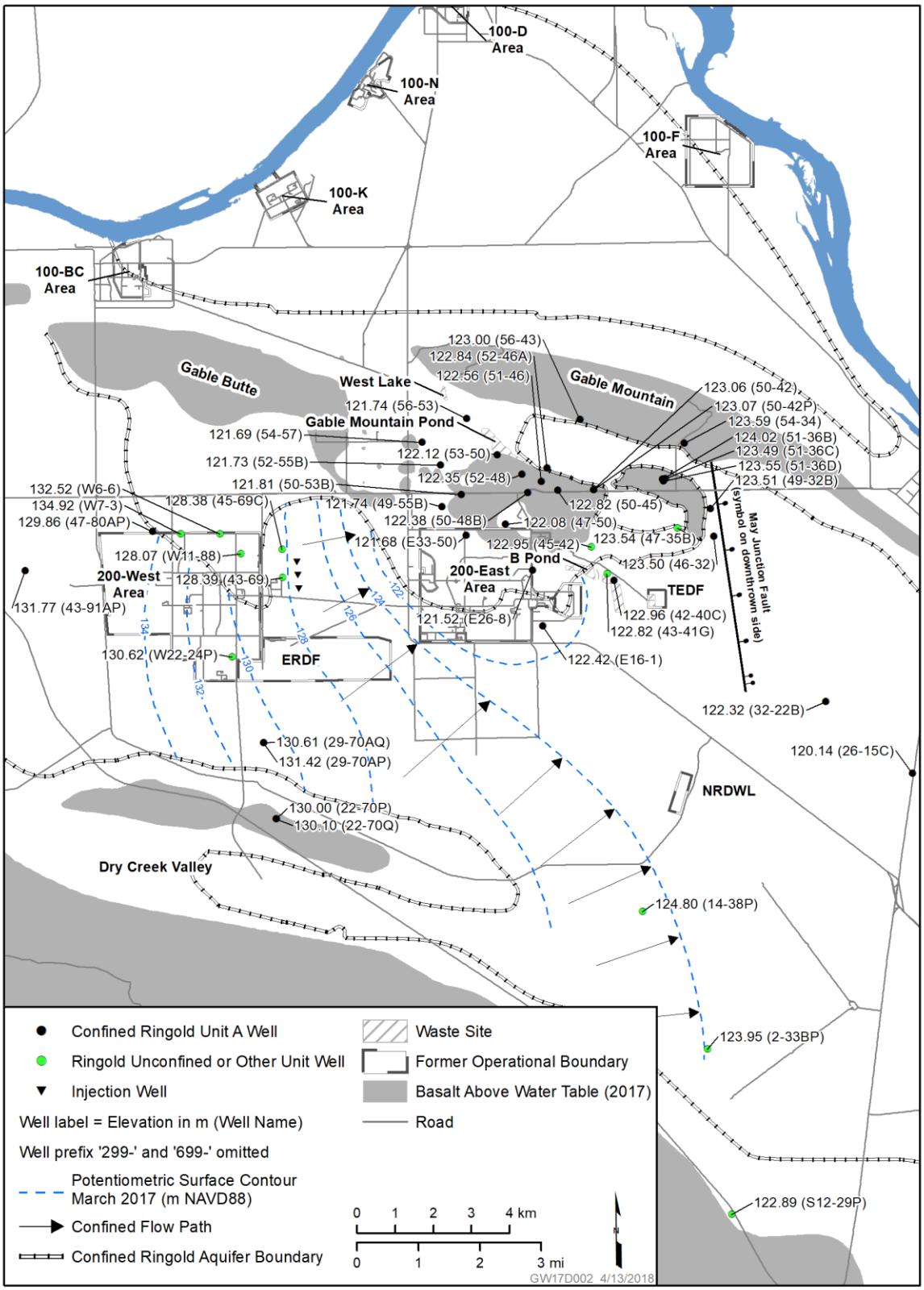


Figure D-1. Ringold Confined Aquifer Monitoring Wells



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure D-2. Potentiometric Surface for Ringold Unit A, March 2017

The head in confined wells in the 200 West Area declined up to 0.9 m (3.0 ft) between 2016 and 2017 in response to declining head in the overlying unconfined aquifer (ECF-Hanford-17-0120). A smaller decline was observed east of the 200 West Area near five pump-and-treat injection wells that are screened beneath the Ringold lower mud. A bend in the 128 m (420 ft) contour in shown in Figure D-2 illustrates the impact of the injection wells.

The head in confined wells near the 200 East Area was stable or declined up to 0.11 m (0.36 ft) between 2016 and 2017. Artificially elevated water levels are present northeast of the 216-B-3 Pond (B Pond). The high water levels reflect mounding from past wastewater discharges and cause southwest flow beneath B Pond where mounding is not as prevalent. Eastward flow away from the region of elevated water levels does not occur due to the north-south-trending May Junction Fault, located east of the B Pond area (Section 2.4.3 in DOE/RL-2008-59). Hydraulic head and water chemistry differences across this fault indicate that it is a barrier to groundwater flow in the confined aquifers (Sections 4.2.3 and 4.3.2 in PNNL-12261). While impermeable units have been juxtaposed against permeable units along part of the fault, the mud units may also have smeared along the fault zone and sealed it (Plates 8 and 9 in PNNL-12261). South of the B Pond area, the water flow divides, with some flow moving northwest toward the 200 East Area and some flow moving east or southeast. The exact location of the flow divide is not known because of a lack of water-level data in this area and uncertainty regarding the southward extent of the May Junction Fault.

The potentiometric contours for the Ringold confined aquifer (Figure D-2) are similar to the potentiometric surface contours for the upper basalt-confined aquifer system, indicating that flow patterns in the central portion of the Hanford Site are similar in both aquifers. Basalt bedrock from the topographic low area at Gable Gap near the 200 East Area was eroded significantly by late Pleistocene catastrophic flooding (Section 7.0 of PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*), which facilitates intercommunication between the unconfined and confined aquifers. The 200 East Area is a discharge area for both of the confined aquifers, which explains the similar flow patterns.

D2.2 Groundwater Quality in Ringold Confined Aquifers

Wells monitoring Ringold confined aquifers are sampled in accordance with the objectives of the groundwater operable units in which they are located. The main text of this report discusses the monitoring results, and highlights of the monitoring are summarized in the following discussion.

Aquifer tests for selected Ringold confined wells in 2016 indicate that the aquifer is a leaky, confined aquifer with variable vertical hydraulic conductivity across the 100-H Area (SGW-60571, *Aquifer Testing of the First Water-Bearing Unit in the RUM at 100-H)*. The RUM confined aquifer is hydraulically connected to the Columbia River. These factors are important for determining future movement of contaminants in the RUM and the overlying unconfined aquifer.

With few exceptions, groundwater in the RUM is not contaminated (Table D-1). Twenty-one wells screened in this unit were sampled at least once between 2016 and 2017; well 199-D5-134 was not sampled for radionuclides in 2016 or 2017, and well 199-F5-53 was not sampled. Three new wells were added to the monitoring network in 2017. Hexavalent chromium (Cr(VI)) concentrations are greater than the 48 µg/L WAC 173-340, “Model Toxics Control Act—Cleanup,” standard in some RUM wells in the 100-HR-H groundwater interest area (Figure D-3). It appears that portions of this unit east of the 100-D Area were eroded, allowing contaminated cooling water into water-bearing units within the mud from the overlying unconfined aquifer. This water moves more slowly than unconfined groundwater; therefore, the contamination persists.

Table D-1. Groundwater Quality in Ringold Confined Aquifers

Groundwater Interest Area	Wells Sampled	Groundwater Contamination[a] (DWS)
Wells Screened in Ringold Upper Mud Unit		
100-BC	199-B2-12	None
100-FR	199-F5-43B and 199-F5-53	None
100-HR-D and 100-HR-H	199-D5-134, 199-D5-141, 199-D8-54B, 199-H2-1, 199-H3-10, 199-H3-2C, 199-H3-28, 199-H3-29, 199-H3-30, 199-H3-9, 199-H4-12C, 199-H4-15CS, 199-H4-90, 199-H4-91, 699-97-43C, 699-97-45B, and 699-97-48C	Hexavalent chromium[b] (48 µg/L): up to 140 µg/L Nitrate (45 mg/L): up to 217 mg/L[d] Uranium (30 µg/L): up to 142.0 µg/L[d] Technetium-99 (900 pCi/L): up to 506.0 pCi/L[d]
100-KR-4	199-K-32B and 199-K-192	None
100-NR	199-N-80	Hexavalent chromium[b] (48 µg/L): up to 130 µg/L
Well Screened in Ringold Unit B		
100-HR-H	199-H4-15CR	None
Wells Screened in Ringold Unit A		
100-HR-H	199-H4-15CQ	None
300-FF	399-1-16C, 399-1-17C, 399-1-18C, 399-1-9, 399-8-5C, and 699-S29-E16C	None
200-BP	699-42-40A, 699-43-41G, and 699-45-42	Iodine-129 (1 pCi/L): up to 2.62 pCi/L Tritium (20,000 pCi/L): up to 39,100 pCi/L
200-PO	299-E25-28, 699-28-40P, 699-31-31, 699-39-39, 699-41-40, and 699-42-39B	Iodine-129 (1 pCi/L): up to 3.89 pCi/L Nitrate (45 mg/L): up to 97.4 mg/L Tritium (20,000 pCi/L): up to 25,200 pCi/L
200-UP	299-W22-24P	Iodine-129 (1 pCi/L): up to 4.7 pCi/L
200-ZP[c]	699-43-69, 699-45-69C, and 699-47-80AQ	Carbon tetrachloride (5 µg/L): up to 200 µg/L Nitrate (45 mg/L): up to 209 mg/L

a. Evaluation based on data from 2016 through 2017. Listed contaminants are present at levels one-half the DWS or greater.

b. May include total chromium results from filtered samples, as well as hexavalent chromium results.

c. Other wells in the 200-ZP groundwater interest area are screened in Ringold unit A, where the lower mud is not present: 299-W6-6, 299-W7-3, 299-W11-88, 299-W12-2, 299-W12-3, 299-W14-73, and 299-W14-74. The aquifer is not confined at these locations, and the results are not reported here.

d. Wells 199-H3-28 and 199-H3-29 characterization samples show evidence of uranium, technetium-99, and nitrate contamination.

DWS = drinking water standard

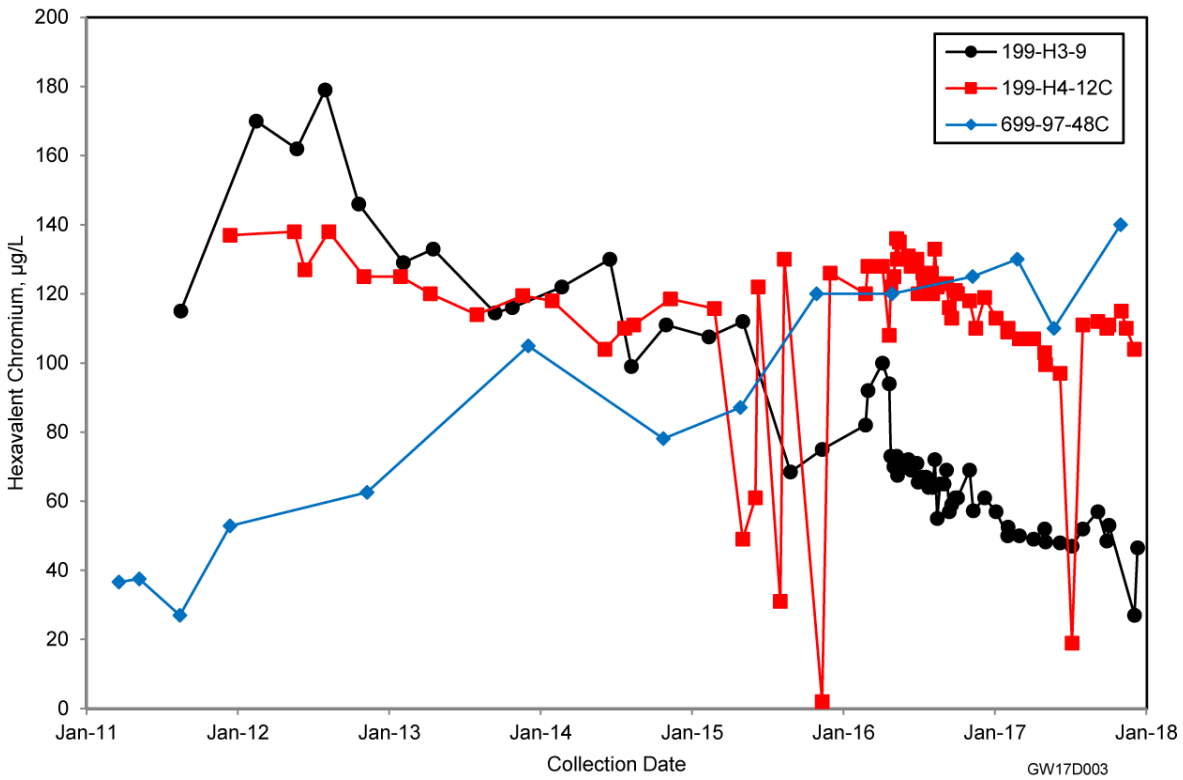


Figure D-3. Cr(VI) in Selected 100-HR-3 RUM Wells

The Cr(VI) concentrations in RUM well 199-H4-12C (an extraction well for 100-HR-3) showed a sudden downward spike in July 2017 (Figure D-3). A request for data review (RDR) was submitted for this sampling event and is awaiting final resolution. Similar spikes in data were observed in 2015. These spikes were attributed to influence of the overlying unconfined aquifer, where Cr(VI) concentrations are lower. A reduced pumping rate in 2016 eliminated subsequent changes. Decisional changes for the 2017 spike are awaiting the final results of the RDR.

Tritium and Cr(VI) concentrations are elevated in Ringold mud well 199-N-80, although tritium levels are below the drinking water standard (DWS) and are declining. This is the only well in 100-NR groundwater interest area that is screened in the mud. Attempts to install another well in a similar water-bearing zone in 2011 were unsuccessful; no water-bearing zone was encountered during drilling.

Three new Ringold mud wells were added to the 100-HR groundwater interest area in 2017. Characterization sampling at these wells detected Cr(VI), nitrate, technetium-99, and uranium at levels greater than 50% of DWSs or above the DWSs. Subsequent sampling of uranium concentrations dropped to levels well below 50% of the DWS, consistent with concentrations in proximal wells. Sampling in early 2018 indicated the presence of technetium-99 contamination in well 199-H3-29. These locations are upgradient and slightly downgradient of 183-H Solar Evaporation Basins. Tritium was detected in two wells but at levels well below 50% of the DWS.

Fourteen wells screened in Ringold unit A were sampled at least once between 2016 and 2017. Data from well 699-47-80AQ were rejected as unrepresentative of groundwater. The well was sampled with a bailer, was not purged, and specific conductance was less than 100 µS/cm, which is not realistic for groundwater. These rejected values indicate that the well should be removed from the list of sampled Ringold unit A wells unless the sampling method can be improved.

The region just east of the 200 West Area is contaminated with carbon tetrachloride, chromium, iodine-129, and nitrate. These contaminants apparently reached Ringold unit A in a region of the 200 West Area where the lower mud is absent. As the groundwater continues to flow toward the east where the lower mud is present, it becomes confined. Chapter 12 (200-ZP section of this report) discusses contaminant distribution with depth in the 200 West Area.

Well 299-W22-24P in the 200-UP groundwater interest area had the highest iodine-129 concentration in the Ringold confined aquifer in 2017 (4.7 pCi/L). Carbon tetrachloride exceeded DWSs in wells 699-43-69 and 699-45-69C in 2017. Nitrate exceeded the DWS at well 699-45-69C at 209 mg/L, which was less than a historical high value of 217 mg/L in 2016.

Seven wells screened in Ringold unit A exceeded DWSs for carbon tetrachloride, iodine-129, and nitrate, but these wells are not included in the evaluations herein, as the aquifer is not confined at these locations: 299-W6-6, 299-W7-3, 299-W11-88, 299-W12-2, 299-W12-3, 299-W14-73, and 299-W14-74.

The Ringold confined aquifer (unit A) is the uppermost aquifer in a region east of the 200 East Area (200-BP and 200-PO groundwater interest areas). The regional contaminants nitrate, iodine-129, and tritium are detected in wells monitoring this aquifer (Table D-1). Contamination has not been observed in wells located downgradient of the contaminated wells, indicating that it is of limited extent.

Iodine-129 contamination of Ringold confined wells in the 200 East Area exceeded the DWS at 699-43-41G, 699-42-42B, and 699-45-42. The highest level of contamination was 3.89 pCi/L at well 299-E25-28, which was less than the high concentrations at 200 West Area. Well 699-39-39 exceeded the DWS for nitrate at 97.4 mg/L. Tritium concentrations at wells sampled in 2017 did not exceed the DWS. However, wells 699-41-40 and 699-42-40A, which were sampled in 2016 but not 2017, did exceed the DWS for tritium in the previous year.

D3 Upper Basalt-Confined Aquifer

The upper basalt-confined aquifer groundwater system occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds within the upper Saddle Mountains Basalt. The thickest and most widespread sedimentary unit in this system is the Rattlesnake Ridge interbed, which is present beneath much of the Hanford Site. Groundwater also occurs within the Levey interbed, which is present only in the southern portion of the Hanford Site. A small interflow zone occurs within the Elephant Mountain Member of the upper Saddle Mountains Basalt and may be significant to the lateral transmission of water. The upper basalt-confined aquifer system is confined by the dense, low-permeability interior portions of the overlying basalt flows and in some places by silt and clay units of the lower Ringold Formation that overlie the basalt. Approximately 40 wells screened in the upper basalt-confined aquifer have been sampled or had water levels measured in recent years (Figure D-4).

An area of intercommunication between the unconfined and upper basalt-confined aquifers exists near the 200 East Area where the confining layers are eroded away or fractured. Several basalt-confined wells have shown evidence of intercommunication with the overlying unconfined aquifer (Section 3.0 of PNL-10817, *Hydrochemistry and Hydrogeologic Conditions within the Hanford Site Upper Basalt Confined Aquifer System*).

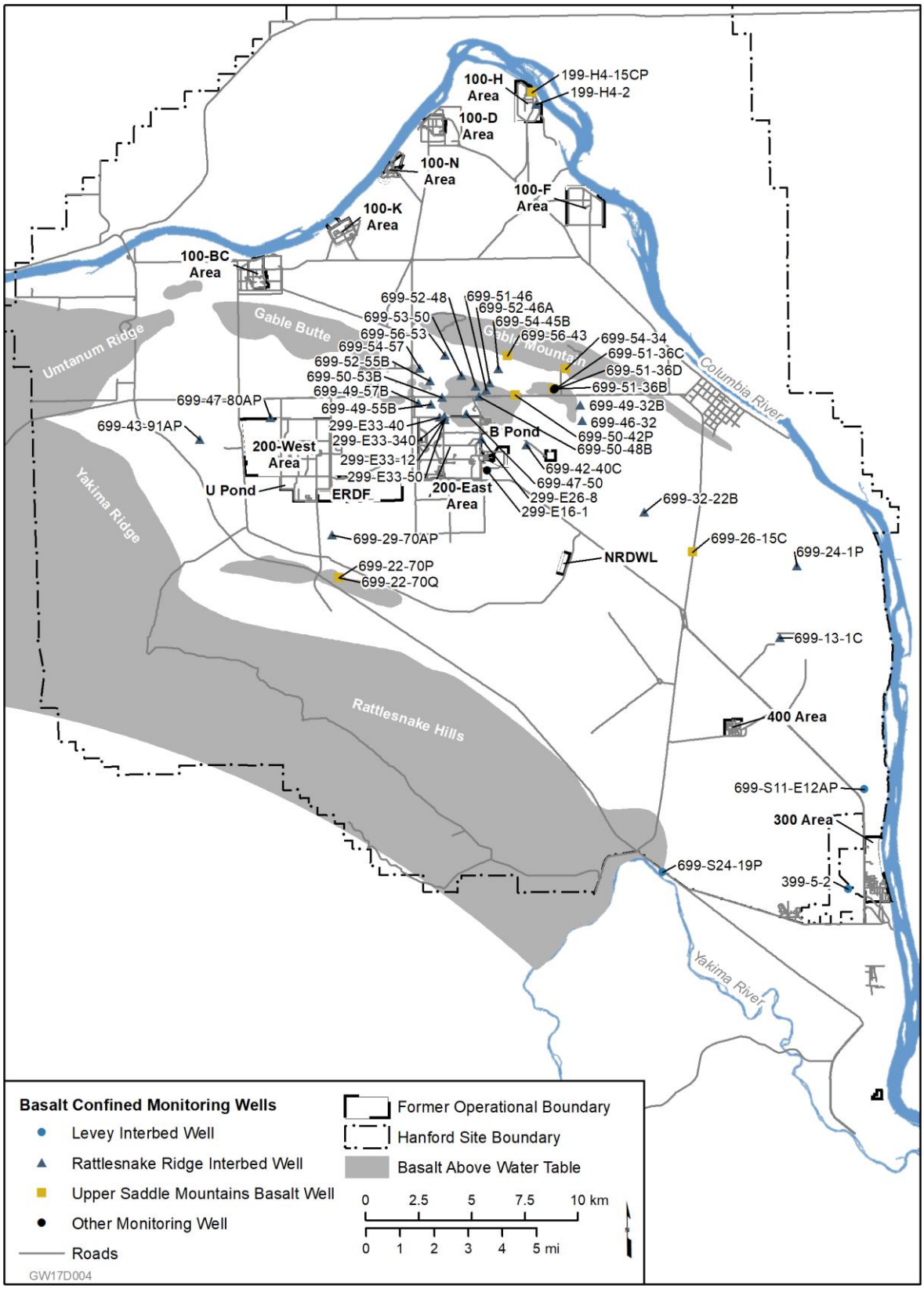


Figure D-4. Upper Basalt-Confined Aquifer Monitoring Wells

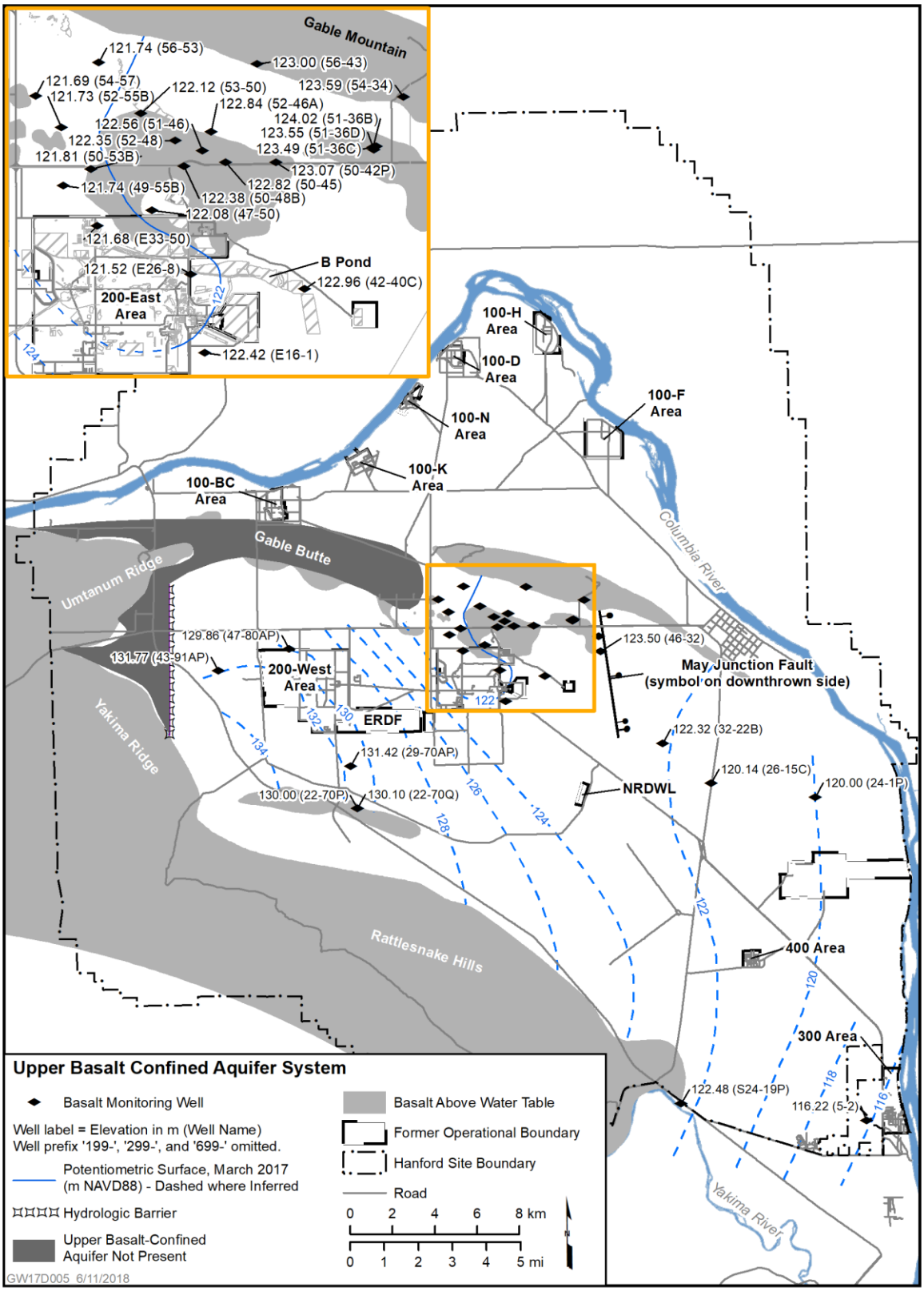
D3.1 Groundwater Flow in Upper Basalt-Confined Aquifer

Figure D-5 presents the interpreted 2017 potentiometric surface for the upper basalt-confined aquifer system south of Gable Butte and Gable Mountain based on the potentiometric surface map from ECF-Hanford-17-0120 and water-level measurements from 34 monitoring wells. The region to the north of Gable Butte and Gable Mountain was not contoured because of an insufficient number of wells in this area. Plate 1 of PNL-8869, *Preliminary Potentiometric Map and Flow Dynamic Characteristics for the Upper-Basalt Confined Aquifer System*, provides a generalized potentiometric surface map of this area. The upper basalt-confined aquifer system does not exist in the Cold Creek Valley and along the west portion of the Gable Mountain and Gable Butte structural area because of the absence of the Rattlesnake Ridge interbed.

Recharge to the upper basalt-confined aquifer system likely occurs from upland areas along the margins of the Pasco Basin and results from infiltrating precipitation and surface water where the basalt and interbeds are exposed at or near ground surface. Recharge may also occur from the overlying aquifers (i.e., the unconfined aquifer or confined aquifer in the Ringold Formation) in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge to this aquifer system. The Columbia River represents a discharge area for this aquifer system in the southeastern portion of the Hanford Site where the river has a lower head than the upper basalt-confined aquifer, but not for the northern portion of the Site where the river head is higher (Section 3.2 of PNL-8869). Discharge also occurs to the overlying aquifers in areas where the hydraulic gradient is upward. Discharge to the overlying unconfined aquifer near the Gable Butte and Gable Mountain structural area is believed to occur through windows eroded in the basalt.

South of Gable Butte and Gable Mountain, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site, toward the Columbia River. The north-south-trending May Junction Fault, located east of B Pond, acts as a barrier to groundwater flow in the unconfined aquifer and the confined aquifer within the Ringold Formation (Section 2.4.3 in DOE/RL-2008-59). It may also impede the movement of water in the upper basalt-confined aquifer system by juxtaposing permeable units opposite impermeable units. As with the Ringold confined aquifer, a flow divide is interpreted to exist southeast of the 200 East Area and B Pond in the upper basalt-confined aquifer system, but the exact location of this divide is uncertain because of a lack of wells in the area.

Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated between 0.7 and 2 m/yr (2.3 and 6.6 ft/yr) (Section 4.2 of PNL-10817), which is a considerably lower flow rate than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone (with silts and clays) and is much less permeable than the sediment in the unconfined aquifer. In addition, the magnitude of the hydraulic gradient is generally lower than in the unconfined aquifer.



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure D-5. Potentiometric Surface for Upper Basalt-Confined Aquifer, March 2017

The vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer varies spatially, as shown by comparison of observed heads depicted for 2014 in Figure D-5 of DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*. An upward gradient exists beneath most of the Hanford Site. A downward gradient exists in the western portion of the Hanford Site and near the B Pond recharge mound, as well as in regions north and east of the Columbia River. Near B Pond, the vertical head gradient between the unconfined aquifer system and the upper basalt-confined aquifer system has diminished in recent years but remains downward. An area of upward gradient beneath a portion of the 200 West Area is caused by groundwater extraction, which reduced heads in the unconfined aquifer.

In the 200 East Area, the potentiometric surface (Figure D-5) is similar to the potentiometric surface for the Ringold confined aquifer (Figure D-2). The basalt in this area was significantly eroded by late Pleistocene catastrophic flooding, which facilitates aquifer intercommunication (Section 7.0 of PNNL-19702). In the 200 East Area and to the immediate north, the vertical hydraulic gradient between the upper basalt-confined aquifer system and the overlying aquifer is upward. It is likely that the upper basalt-confined aquifer system currently discharges to the overlying aquifer in this region.

The 2017 potentiometric surface map (Figure D-5) shows flexures in the contours beneath the 200 West Area and the region to the east. This interpretation shows the influence of groundwater mounds (injection) and depressions (extraction) in the overlying unconfined and Ringold confined aquifers.

Water levels have been declining in most of the basalt-confined wells in the 200 East and 200 West Areas in response to reduced loading of the confined aquifer (i.e., a reduction in external stress) caused by water-level declines in the overlying unconfined aquifer and Ringold confined aquifer. The largest decline between 2016 and 2017 was 0.35 m (1.1 ft) in piezometer 699-47-80AP in the 200 West Area (ECF-Hanford-17-0120). Hydraulic head in the 200 East Area wells declined up to 0.1 m (0.33 ft).

D3.2 Groundwater Quality in Upper Basalt-Confined Aquifer

The upper basalt-confined aquifer system is not affected by contamination as much as the unconfined aquifer. Contamination in the upper basalt-confined aquifer system is most likely to occur in areas where the confining units have been eroded away or were never deposited, and where past disposal of large amounts of wastewater resulted in downward hydraulic gradients. Researchers have identified areas of intercommunication between the contaminated unconfined aquifer and the upper basalt-confined aquifer by geochemical signatures and the presence of nitrate and tritium in groundwater in some basalt-confined wells near the 200 East Area (Chapter 3.0 of PNL-10817). However, groundwater monitoring data do not indicate that contamination has migrated into the upper basalt-confined aquifer. Because of poor seals in wells constructed prior to implementation of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," intercommunication between aquifers has permitted groundwater flow from the unconfined aquifer to the underlying confined aquifer in the past, increasing the potential to spread contamination (e.g., at well 299-E33-12, as discussed below). Section 2.14.2 in DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, further discusses communication between the upper basalt-confined aquifer system and the overlying aquifers.

Fourteen wells screened in the upper basalt-confined aquifer were sampled between 2016 and 2017. Concentrations of contaminants are far below DWSs in the basalt-confined aquifer (Table D-2), except in wells 299-E33-12 and 299-E33-50. Past drilling practices and well construction at well 299-E33-12 allowed migration of groundwater from the overlying unconfined aquifer. The highest concentrations of contaminants continued to be observed in well 299-E33-12 in the northwestern 200 East Area. This well was drilled in 1953 and was uncased from just above the bottom of the unconfined aquifer through the

Rattlesnake Ridge interbed. Contamination is believed to have migrated from the unconfined aquifer, down the open borehole, and to the Rattlesnake Ridge interbed (Section 2.14.2 of DOE/RL-2008-01). The well was sealed from the unconfined aquifer in 1979, with an additional seal placed in the well in 1990 to shorten the open interval. Concentrations of nitrate and technetium-99 continued to be elevated in samples from this well, and possibly in a small area of the confined aquifer. Well 299-E33-50, located near 299-E33-12, consistently showed levels of technetium-99 between 25 and 50 pCi/L. However, in December 2017, iodine-129 and technetium-99 were detected in this well at values above historical trends; both constituents exceeded DWSs. An RDR was submitted for technetium and iodine-129. Technetium-99 was reanalyzed, and the values returned to historical levels. Results for iodine-129 were flagged for further review but were unable to be reanalyzed due to sample quantity. Other confined wells in this region showed no contamination. The hydraulic gradient is upward in this region.

Tritium detected at concentrations below the DWS in well 699-42-40C, located east of the 200 East Area (Section 10.3), continue to decline (2,480 pCi/L in 2017). The strong, downward hydraulic gradient formerly present in this region and partial erosion of the basalt confining unit allowed communication between the unconfined and basalt-confined aquifers (RHO-RE-ST-12 P, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*). The hydraulic gradient in this region remains downward.

Groundwater in basalt-confined wells in other regions of the Hanford Site is uncontaminated based on data from a small number of available wells that were sampled in recent years (Table D-2).

Table D-2. Groundwater Quality in Upper Basalt-Confined Aquifer

Groundwater Interest Area	Wells Sampled	Groundwater Contamination[a]
100-H	199-H4-15CP	None
200-BP	299-E26-8, 299-E33-12, 299-E33-340, 299-E33-40, 299-E33-50, 699-42-40C, 699-49-55B, 699-49-57B, 699-52-55B, and 699-54-45B	Nitrate: up to 32.6 mg/L[b,c] Tritium: up to 2,480 pCi/L Technetium: up to 1,010 pCi/L[b] Iodine-129: up to 3.11 pCi/L[b]
200-PO	299-E16-1, 699-24-1P, 699-32-22B, and 699-S24-19P	None
300-FF	699-13-1C and 699-S11-E12AP	None
Offsite	699-42-E9B	None

a. Evaluation based on data from 2016 through 2017. Listed contaminants are present at levels one-half the drinking water standard or greater.

b. Not representative of the basalt-confined aquifer. Migrated down wellbore from unconfined aquifer (see text discussion).

c. Nitrate values are based on 2015 data from well 299-E33-12.

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Appendix E

Groundwater Monitoring Data Usability Assessment

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Terms

ALS	ALS Laboratory
ASTM	ASTM International (formerly American Society for Testing and Materials)
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
EB	equipment blank
EPA	U.S. Environmental Protection Agency
EQL	estimated quantitation limit
ERA	Environmental Resources Associates
FB	field blank
FTB	full trip blank
FXR	field transfer blank
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GEL	GEL Laboratory
HEIS	Hanford Environmental Information System
IC	ion chromatography
ICP	inductively coupled plasma
ICP/AES	inductively coupled plasma/atomic emission spectrometry
ICP/MS	inductively coupled plasma/mass spectrometry
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MAPEP	U.S. Department of Energy Mixed Analyte Performance Evaluation Program
MDA	minimum detectable activity
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
N/R	not reported
PAH	polynuclear aromatic hydrocarbon

PCB	polychlorinated biphenyl
QA	quality assurance
QC	quality control
RAD	ERA InterLaB RadCheM Proficiency Testing Program
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR	request for data review
RPD	relative percent difference
RSD	relative standard deviation
S&GRP	Soil and Groundwater Remediation Project
SVOC	semivolatile organic compound
SWRI	Southwest Research Institute
TADN	Test America–Denver
TAKN	Test America–Knoxville
TARL	Test America–Richland
TASL	Test America–St. Louis
TCE	trichloroethene
TOC	total organic carbon
TOX	total organic halides
TPH	total petroleum hydrocarbons
VOC	volatile organic carbon
WP/WS	water pollution/water supply

E1 Introduction

This appendix presents the data usability assessment for laboratory data generated from routine groundwater samples collected during 2017 as part of the Hanford Site groundwater monitoring program. The purpose of this usability assessment is to determine whether these data meet the data quality requirements specified in CHPRC-00189, *Environmental Quality Assurance Program Plan*.

For the groundwater monitoring program during 2017, a total of 1,220 wells, aquifer tubes, and springs were sampled during a total of 2,604 sampling trips over the extent of the Hanford Site.[1] These sampling events generated 17,542 samples (3,406 field samples and 14,136 laboratory samples). From these 17,542 samples, Field Sampling Operations generated 17,800 field measurements, and seven analytical laboratories reported 149,071 laboratory results, for a total of 166,871 measurements. These sampling events only cover routine groundwater monitoring and do not include groundwater sampling events for special projects. The sampling events included are those in the Hanford Environmental Information System (HEIS) database as of February 8, 2018; the 2017 routine groundwater monitoring data entered into the HEIS database after that date are not included in this assessment.

E2 Purpose

The purpose of this data usability assessment is to determine whether the data generated from the 2017 groundwater monitoring effort meet the data quality requirements specified in CHPRC-00189. Meeting the data quality requirements of this document provides assurance that the data collected are of sufficient quantity and quality for the groundwater monitoring program.

E3 Scope

This assessment focuses on the laboratory chemical and radiochemical data collected for the groundwater monitoring program. The data are evaluated to determine whether they meet the analytical criteria outlined in CHPRC-00189. The methodology includes data verification and data usability evaluations.

- Data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. It includes confirmation that the specified sampling and analytical requirements have been completed as specified in CHPRC-00189. This evaluation is documented in Chapter E5. In addition, verification is performed for field quality control (QC) samples as specified in Chapter E6, and for laboratory QC samples as specified in Chapter E7.
- The data usability assessment determines the adequacy of the data to support the groundwater monitoring program requirements based upon the verification results. This evaluation is summarized in Section E8.2.

[1] The numbers in this paragraph refer to routine groundwater sample events for laboratory analysis and do not include in process samples for pump-and-treat systems.

E4 Groundwater Monitoring Program Analytical Data Quality Requirements

Table E-1 presents the groundwater monitoring program data requirements from CHPRC-00189. The QC results for groundwater monitoring samples were evaluated against these requirements as part of this data usability assessment (see Chapters E6 and E7). The QC samples governed by the QC requirements may be divided into field and laboratory components. Sections E4.2 and E4.3 describe these two types of QC samples.

Table E-1. Groundwater Field and Laboratory QC Elements and Acceptance Criteria

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action
General Chemical Parameters			
Alkalinity Chemical oxygen demand Conductivity Oil and grease pH Total dissolved solids Total organic carbon Total organic halides	Method blank[b] LCS Duplicate/MSD MS/MSD FB Field duplicate/split	<MDL 80 to 120% recovery ≤20% RPD[e] 75 to 125% recovery <MDL ≤20% RPD[e]	Flag with "C" Flag with "o" Review data[c] Flag with "N" Flag with "Q" Flag with "Q"
Ammonia and Anions			
Ammonia Anions Cyanide Sulfide	Method blank LCS Duplicate/MSD MS/MSD FB Field duplicate/split	<MDL 80 to 120% recovery ≤20% RPD[e] 75 to 125% recovery <MDL ≤20% RPD[e]	Flagged with "C" Flag with "o" Review data[c] Flag with "N" Flag with "Q" Flag with "Q"
Metals			
Hexavalent chromium ICP/AES metals ICP/MS metals Mercury Uranium	Method blank LCS Duplicate/MSD MS/MSD FB Field duplicate / split	<MDL 80 to 120% recovery ≤20% RPD[e] 75 to 125% recovery <MDL ≤20% RPD[e]	Flag with "C" Flag with "o" Review data[c] Flag with "N" Flag with "Q" Flag with "Q"
Volatile Organic Compounds			
TPH-gasoline by GC	Method blank LCS Duplicate/MSD MS/MSD Surrogate FB Field duplicate/split	<MDL 70 to 130% recovery ≤20% RPD[e] 70 to 130% recovery 60 to 140% recovery <MDL ≤20% RPD[e]	Flagged with "B" Flag with "o" Review data[c] Flag with "N" Review data[c] Flag with "Q" Flag with "Q"

Table E-1. Groundwater Field and Laboratory QC Elements and Acceptance Criteria

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action
Volatiles by GC/MS	Method blank LCS Duplicate/MSD MS/MSD Surrogate FB Field duplicate/split	<MDL[d] 70 to 130% recovery ≤20% RPD[e] 70 to 130% recovery 70 to 130% recovery <MDL[d] ≤20% RPD[e]	Flagged with "B" Flag with "o" Review data[c] Flag with "T" Review data[c] Flag with "Q" Flag with "Q"
Semivolatile Organic Compounds			
Extractable petroleum hydrocarbons by GC (aliphatic and aromatic hydrocarbon fractions)	Method blank LCS Duplicate/MSD MS/MSD Surrogate FB Field duplicate/split	<MDL 70-130% recovery ≤20% RPD[e] 70-130% recovery 60-140% recovery <MDL ≤20% RPD[e]	Flagged with "B" Flag with "o" Review data[c] Flag with "N" Review data[c] Flag with "Q" Flag with "Q"
Herbicides by GC PAHs by GC/MS PCBs by GC Pesticides by GC Phenols by GC Semivolatiles by GC/MS	Method blank LCS Duplicate/MSD MS/MSD Surrogate FB Field duplicate/split	<MDL 70-130% recovery ≤20% RPD[e] Statistically derived Statistically derived <MDL ≤20% RPD[e]	Flagged with "B" Flag with "o" Review data[c] Flag with "N" or "T" Review data[c] Flag with "Q" Flag with "Q"
TPH-diesel or -kerosene by GC	Method blank LCS Duplicate/MSD MS/MSD Surrogate FB Field duplicate/split	<MDL 70-130% recovery ≤20% RPD[e] 70-130% recovery 60-140% recovery <MDL ≤20% RPD[e]	Flagged with "B" Flag with "o" Review data[c] Flag with "N" Review data[c] Flag with "Q" Flag with "Q"
Dioxins, total, and/or congeners by HRGC/HRMS	Method blank LCS Duplicate Surrogate FB Field duplicate/split	<MDL Statistically derived ≤20% RPD[e] 40-135% recovery <MDL ≤20% RPD[e]	Flagged with "B" Flag with "o" Review data[c] Review data[c] Flag with "Q" Flag with "Q"

Table E-1. Groundwater Field and Laboratory QC Elements and Acceptance Criteria

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action
PCB congeners by HRGC/HRMS	Method blank	<MDL	Flagged with "B"
	LCS	Statistically derived	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	Surrogate	Statistically derived	Review data[c]
	FB	<MDL	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Radiological Parameters			
Alpha energy analysis: Americium/curium Neptunium Plutonium Radium-226 Thorium Uranium (isotopic)	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	Tracer	30 to 105% recovery	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Carbon-14	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	MS	75 to 125% recovery	Flag with "N"
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Chlorine-36 Radium-226 by Lucas cell (EPA Method 903.1 or equivalent) Radium-228 by gas-flow proportional counting (EPA Method 904.0/9320) Strontium-90	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	Tracer	30 to 105% recovery	Review data[c]
	Carrier	40 to 110% recovery	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Gamma energy analysis	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Gross alpha Gross beta	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"

Table E-1. Groundwater Field and Laboratory QC Elements and Acceptance Criteria

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action
Iodine-129	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	Tracer	30 to 105% recovery	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Selenium-79	Method blank	<MDA	Flag with "B"
	Duplicate	≤20% RPD[e]	Review data[c]
	Carrier	40 to 110% recovery	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Plutonium-241	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	Tracer	30 to 105% recovery	Review data[c]
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"
Technetium-99 Tritium	Method blank	<MDA	Flag with "B"
	LCS	80 to 120% recovery	Flag with "o"
	Duplicate	≤20% RPD[e]	Review data[c]
	MS	75 to 125% recovery	Flag with "N"
	FB	<MDA	Flag with "Q"
	Field duplicate/split	≤20% RPD[e]	Flag with "Q"

References: CHPRC-00189, *CH2M Hill Plateau Remediation Company Environmental Quality Assurance Program Plan*.

EPA Method 903.1, *Radium-226 - Radon Emanation Technique*.

EPA Method 904.0/9320, *Radium-228*.

a. For the laboratory duplicate types "LCS duplicate" and "surrogate duplicate," the RPD limit of 20% was used.

b. Does not apply to pH determinations.

c. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck, rerun, or flagging the associated groundwater monitoring data as suspect ("Y" flag) or rejected ("R" flag).

d. For the common laboratory contaminants 2-butanone, acetone, methylene chloride, toluene, and phthalate esters, the acceptance criterion is <5 times the MDL.

e. The RPD for batch sample duplicates and field duplicates is calculated only if at least one of the results is ≥5 times the laboratory MDL or MDA. The RPD for field splits is calculated only if at least one of the results is ≥5 times the larger MDL or MDA of the two analyzing laboratories.

Table E-1. Groundwater Field and Laboratory QC Elements and Acceptance Criteria

Constituent	QC Element	Acceptance Criterion[a]	Corrective Action

GC = gas chromatography
GC/MS = gas chromatography/mass spectrometry
EPA = U.S. Environmental Protection Agency
FB = field blank
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectroscopy
HRGC = high-resolution gas chromatography
HRMS = high-resolution mass spectrometry
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MDA = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PAH = polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyl
QC = quality control
RDL = required detection limit
RPD = relative percent difference
TPH = total petroleum hydrocarbons

Data flags:
B, C = possible laboratory contamination (analyte was detected in the associated method blank)
N = result may be biased (associated MS result was outside of the acceptance limits)
o = result may be biased (associated LCS result was outside of the acceptance limits)
Q = problem with associated field QC sample (field blank, field duplicate, and/or field split results were out of limits)
T = result may be biased (associated MS result was outside of the acceptance limits; used with GC/MS methods only)

E4.1 Analyte Reporting Conventions

To conform to the analyte reporting conventions used in the annual report and to provide comparability of analytical results among the reporting laboratories, the following analyte reporting conventions are used in this assessment:

- **Ammonium**: Ammonia, nitrogen-in-ammonia, and nitrogen-in-ammonium results are converted to and evaluated as ammonium ion.
- **Nitrate**: Nitrogen-in-nitrate results are converted to and evaluated as nitrate.
- **Nitrite**: Nitrogen-in-nitrite results are converted to and evaluated as nitrite.
- **Phosphate**: Phosphorus-in-phosphate results are converted to and evaluated as phosphate.
- **Strontium-90**: Total-beta-radiostrontium results are evaluated as strontium-90.

E4.2 Field Quality Control Sample Types

Field QC samples are used to assess the precision, repeatability, and potential contamination related to sampling and laboratory activities. Field QC samples include three types of field blanks (FBs) (equipment blanks [EBs], full trip blanks [FTBs], and field transfer blanks [FXRs]), field duplicates, and field split samples. Table E-2 summarizes the various field QC sample types, the required collection frequencies, and the actual collection frequencies. For groundwater samples, preservative reagents specific for the analyte(s) to be determined are added to the field QC sample bottles prior to the collection of the QC

samples. All field QC samples are delivered to the laboratory without any differentiation between the field QC samples and actual groundwater samples.

Table E-2. QC Field Samples

Field QC Sample Type	Number of Sampling Trips[a]	Number of QC Sample Sets Collected[b]	Frequency	
			Required[c]	Actual[d]
Full trip blanks	2,604	140	5%	5%
Field transfer blanks	289[e]	298	100%	103%
Equipment blanks	537[f]	67	10%[g]	12%
Field duplicates	2,604	157[h]	5%	6%
Field split samples	2,604	122[i]	As needed	5%
TOC quadruplicates	230[j]	238[k]	N/R	103%
TOX quadruplicates	231[j]	241[k]	N/R	104%

Reference: CHPRC-00189, *Environmental Quality Assurance Program Plan*.

a. Sampling trips include trips to wells, aquifer tubes, and springs. Sampling trips are counted only if they are associated with routine groundwater monitoring results in the Hanford Environmental Information System database "RESULT" table.

b. Values listed include only field blanks, field duplicates, and field split sample sets collected for routine groundwater monitoring sampling events. A QC sample set consists of all the QC samples of a particular QC sample type (e.g., full trip blanks or field duplicates) for a given well trip and may contain multiple sample numbers.

c. Required frequency is from CHPRC-00189.

d. Actual frequency = 100 × number of QC sample sets ÷ number of sampling trips.

e. For each day that volatile organic compound samples are collected, one field transfer blank is required for each laboratory receiving that day's volatile organic compound samples. Multiple field transfer blanks may be required each day that volatile organic compound samples are collected if these samples are to be shipped to more than one laboratory for analysis.

f. Number of sampling events for which nondedicated sampling equipment was used.

g. The 10% frequency is for routinely used, nondedicated sampling equipment. For new types of nondedicated sampling equipment, the equipment blank frequency is 100% until the decontamination procedure for the new equipment is shown to produce acceptable equipment blank results.

h Number of pairs of field duplicate sample sets collected.

i. Number of pairs of field split sample sets collected.

j. Number of sampling trips for which TOC or TOX samples were collected.

k. Number of sets of quadruplicate samples collected.

N/R = not required
QC = quality control
TOC = total organic carbon
TOX = total organic halides

- EBs are samples of reagent water that are pumped or washed through nondedicated sampling equipment. EBs are used to monitor the effectiveness of equipment decontamination procedures and to monitor for contamination associated with field sampling equipment.
- FTBs are samples that contain reagent water and any required preservatives. An FTB is used to check for contamination in sample bottles and laboratory sample preparation. The FTB is analyzed for all constituents of interest and is collected in the same types of sample bottles used to collect

groundwater samples. The FTB is filled during bottle preparation using the same sample preparation used for regular well samples. FTBs are not opened in the field.

- FXRs are analyzed for volatile organic compounds (VOCs) and are used to check for VOC contamination associated with sampling activities. At the time of sample collection, the FXR is filled at the sampling site by pouring reagent water from a clean glass container into VOC sample vials pre-loaded with any required preservative. After collection, the FXR is treated in the same manner as the other samples collected during the sampling event. One FXR is collected each day that groundwater samples are collected for VOCs. If the VOC samples collected on a given day will be shipped to multiple laboratories, then an FXR is collected for each laboratory for that day.
- Field duplicate samples are replicate samples collected to determine the precision of sampling and the laboratory analytical measurement process by comparing results with an identical sample collected at the same time and location. Matching field duplicates are collected and stored in separate containers and are analyzed as separate samples by the same laboratory.
- Split samples are replicate samples sequentially collected from the same location in the same sampling event and analyzed by different laboratories. Split samples are used to evaluate interlaboratory precision and comparability.

The FB results are evaluated by comparison with the method detection limit (MDL) or minimum detectable activity (MDA) of the performing laboratory. The FB results that exceed that limit and the results for any samples associated with the FB are assigned the review qualifier "Q." Associated samples are those collected on the same day and analyzed by the same method as the corresponding FB.

Field duplicate sample results are evaluated only if at least one result is five times the laboratory MDL or MDA. Split sample results are evaluated only if at least one result is five times the larger of the laboratory MDL or MDA of the two analyzing laboratories. Field duplicate and field split samples that qualify are evaluated using the relative percent difference (RPD) between the duplicate or split sample pair. The RPD is a measure of precision and is calculated as shown in Equation E-1:

$$RPD = \left| \frac{C_1 - C_2}{(C_1 + C_2)/2} \right| \times 100 \qquad \textbf{(Equation E-1)}$$

where:

C_1 = parent sample analyte concentration or activity

C_2 = duplicate sample analyte concentration or activity

A perfect match between the parent sample and its duplicate yields an RPD of 0%. Results for field duplicate samples that exceed the RPD limit of 20% are assigned a review qualifier of "Q". Only the two samples of the duplicate pair or split pair are considered to be associated samples.

Total organic carbon (TOC) and total organic halides (TOX) are *Resource Conservation and Recovery Act of 1976* (RCRA) indicator analytes; samples for these analytes are usually obtained in quadruplicate (40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis"). Field quadruplicate sample results are evaluated only if at least one result is at least five times the laboratory MDL. Field quadruplicate results that qualify are evaluated using the percent relative standard deviation (RSD) within the quadruplicate sample set. The percent RSD is a measure of precision and is calculated as shown in Equation E-2:

$$\%RSD = \frac{\sqrt{\frac{\sum_{i=1}^{n}(C_i - \overline{C})^2}{(n-1)}}}{\overline{C}} \times 100 \qquad \textbf{(Equation E-2)}$$

where:

$\%RSD$ = percent relative standard deviation

C_i = i^{th} sample concentration

$\overline{C}$ = average sample concentration

n = number of results (usually four)

A perfect match of results within a quadruplicate sample set yields a percent RSD of 0%. For any results in a qualifying quadruplicate data set that were less than the laboratory MDL, MDLs were used to compute the percent RSD equation. Quadruplicate split sample results are evaluated only if at least one quadruplicate average is greater than or equal to five times the larger of the laboratory MDLs of the two analyzing laboratories. To determine the precision of a set of split quadruplicate samples, the RPD of the two averages for the quadruplicate split samples is determined and compared to 20%. Results for field quadruplicate samples that exceed a percent RSD of 20% or quadruplicate split samples that exceed an RPD of 20% are not assigned a review qualifier.

E4.3 Laboratory Quality Control Sample Types

Laboratory quality assurance (QA)/QC requirements govern nearly all aspects of analytical laboratory operations, including instrument procurement, maintenance, calibration, and operation. During the analysis of groundwater samples, laboratory QC samples are used to assess potential sample contamination, precision, and accuracy related to laboratory activities. Laboratory QC samples may include method blanks, laboratory control samples (LCSs), laboratory control sample duplicates (LCSDs), matrix spike (MS) samples, matrix spike duplicates (MSDs), surrogates, and surrogate duplicates. These types of laboratory QC samples and the way they are evaluated are described below:

- Laboratory method blanks provide a measure of the cleanliness during sample preparation and analysis. The appearance of measurable analytes in the method blank may indicate contamination of customer samples during the analytical process.
- Laboratory sample duplicates, LCSDs, MSDs, and surrogate duplicates provide a measure of the reproducibility of the analytical process. The RPD is the metric used to determine reproducibility (Equation E-1). Laboratory sample duplicates qualify for evaluation only if at least one result is five times the laboratory MDL.
- LCSs, MS, and surrogates contain known amounts of analytes and provide a measure of the accuracy of the analytical process. Percent recovery is the metric used to determine analytical accuracy (Equation E-3). Percent recoveries consistently less than or >100% may indicate a bias in the analytical process.

These laboratory QC samples are included in sample preparation and analytical batches along with customer samples. An analytical batch typically consists of a maximum of 20 customer samples. The numbers and types of QC samples included in sample batches are dictated by the analytical method being used. Analytical methods usually use only a subset of the available types of QC samples.

At a minimum, most sample preparation and analytical methods include a method blank, one of the duplicate types (e.g., sample duplicate), and one of the standard types (e.g., LCS).

Laboratory analytical accuracy for LCSs, MS, and surrogates is evaluated using percent recovery as shown in Equation E-3:

$$Percent\ recovery = \frac{C_m}{C_a} \times 100 \qquad \textbf{(Equation E-3)}$$

where:

C_m = measured analyte concentration or activity

C_a = actual, known analyte concentration or activity

Perfect recovery of the measured analyte concentration or activity yields a percent recovery of 100%.

E4.4 Qualification Flags

When generating and evaluating environmental analytical data, any of several qualification flags may be assigned to an individual result. The HEIS database carries qualification flags applied from three sources: the laboratory (laboratory qualifier), a data reviewer (review qualifier), or a third-party data validator (validation qualifier). Table E-3 presents the laboratory qualifier flags, and Table E-4 outlines the review qualifier flags. For the 2017 groundwater monitoring data set, third-party validation was not performed, and validation qualifiers were not applied to the data set.

Table E-3. Laboratory Qualifier Data Quality Flags

Flag	Definition
B	Inorganics and Wetchem*: The analyte was detected at a value greater than or equal to the MDL but less than the practical quantitation limit. Organics: The analyte was detected in both the associated method blank and in the sample. Radionuclides: The associated method blank has a result ≤2 times the MDA and, after corrections, the result is greater than or equal to the MDA for this sample.
C	Inorganics and Wetchem*: The analyte was detected in both the sample and the associated method blank, and the sample concentration was ≤5 times the blank concentration.
D	All: Analyte was determined using a secondary dilution factor greater than one. The primary preparation required additional dilution either to bring the analyte within the calibration range or to minimize interference.
E	Inorganics: Reported value is estimated because of interference. See any comments that may be in the laboratory report case narrative. Organics: Concentration exceeds the calibration range of the GC/MS.
J	Organics: The analyte was detected at a value greater than or equal to the MDL but less than the practical quantitation limit.
N	All (except GC/MS methods): The MS recovery is outside control limits. The associated sample data may be biased.
o, O	All: The laboratory control sample recovery is outside control limits.

Table E-3. Laboratory Qualifier Data Quality Flags

Flag	Definition
T	Organics (GC/MS methods only): The MS recovery is outside control limits. The associated sample data may be biased.
U	All: The constituent was analyzed for but was not detected.
X, Y, Z	All: Indicates a result-specific comment is provided in the data report and/or case narrative.

*Wetchem is a miscellaneous group of analytical methods such as the colorimetric determination of hexavalent chromium, the titrimetric determination of alkalinity, or the distillation and titrimetric determination of sulfide.

GC/MS = gas chromatography/mass spectrometry
MDA = minimum detectable activity
MDL = method detection limit

Table E-4. Review Qualifier Data Quality Flags

Flag	Definition
A	Indicates an issue with the chain of custody that could affect data integrity.
F*	Result is undergoing further review. This review qualifier is assigned when an RDR is first processed.
G*	Result has been reviewed through the RDR process and determined to be correct, or the laboratory has supplied a corrected result after reviewing the original result or after reanalyzing the sample.
H	Laboratory holding time was exceeded before the sample was analyzed.
P*	Potential problem. Collection/analysis circumstances make the result questionable.
Q	An associated field QC sample is out-of-limits; the associated sample number is listed in the "Result Comment" field for the "Q"-flagged result. (See Section E4.2 for the definition of associated samples.)
R*	Do not use. Further review indicates the result is not valid. This review qualifier is used only when documented evidence exists that the result is not valid. Generally, results that are "R" qualified will be excluded from statistical evaluations, maps, and other interpretations.
Y*	Result is suspect. Review had insufficient evidence to show result valid or invalid.
Z*	Miscellaneous circumstance exists. Additional information for this record may be found in the "Result Comment" field in the HEIS database "RESULT" table and/or in the "Sample Comment" field in the HEIS sample table.

*These flags are applied as part of the RDR process.

HEIS = Hanford Environmental Information System
QC = quality control
RDR = request for data review

Of the review qualifier flags, the request for data review (RDR) process most commonly generates "F," "G," "R," and "Y" flags (Table E-4). The "F" flag indicates that the analytical result is under review within the RDR process; an "F" flag is typically resolved to a "G," "R," or "Y" flag during the RDR process. The "G" flag indicates that the result has been reviewed within the RDR process and determined to be valid. In some cases, the "G" flag is applied to a result after the reviewed result has been replaced by a new value from the laboratory; the new laboratory value may be a correction of the originally reported value or may be from a reanalysis of the sample. The "R" flag indicates that the analytical result has been reviewed and rejected as invalid based upon a known reason (e.g., instrument calibration failure). The "Y" flag indicates that the analytical result has been reviewed and is considered questionable based on additional evidence (e.g., a result that does not fit with the historical trend for the sample source and is inconsistent with related parameters).

The "Q" flag review qualifier is applied to the analytical results of those samples associated with field QC samples having analytical results that exceed the QC criteria identified in CHPRC-00189 and outlined in Table E-1. Section E4.2 defines the associated samples.

E5 Data Completeness

Data completeness is a measure of how much of the data set is judged to meet the quality criteria and, therefore, is usable for the groundwater monitoring program. The completeness goal is determined as a percentage of data judged "good" versus all data collected for the program and is set at a minimum of 85.0%[2] (DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*). Completeness statistics are calculated and presented for the following:

- Percentage of successful sampling events during 2017 versus the number of scheduled sampling events
- Percentage of field QC samples collected versus the number of QC samples required
- Percentage of the data set that meets quality criteria

E5.1 Percentage of Successful Sampling Events

During 2017, a total of 2,733 groundwater sampling events were planned; 2,640 of these sampling events were successfully executed for an overall sampling event completion rate of 96.6%. An additional 53 sample events originally scheduled for 2016 were performed in 2017 for a total of 2,693 well trips during 2017 to support groundwater data collection needs. The 2,604 well trips listed in Table E-2 are a subset of the 2,693 well trips and reflect only the 2017 sampling events that resulted in routine groundwater monitoring field and laboratory data appearing in the HEIS "RESULT" table as of February 8, 2018, when the data were pulled from the HEIS database. Sources sampled included wells, aquifer tubes, and springs. The overall completion rate for 2017 gives confidence that sufficient sampling events were completed to meet routine groundwater monitoring program requirements.

E5.2 Percentage of Field Quality Control Samples Collected

The types and collection frequencies of field QC samples for the groundwater monitoring program are provided in CHPRC-00189; the collection of quadruplicate samples at RCRA sites for TOC and TOX is mandated by 40 CFR 265.92. Section E4.2 provides a more complete discussion of field QC samples.

[2] DOE/RL-91-50 defines this completeness goal on a quarterly basis. For this data usability assessment, the completeness goal is applied over the entire year.

Table E-2 summarizes the QC types, the required collection frequencies, and the actual collection frequencies. The table indicates that the requirements for the minimum collection frequencies for groundwater monitoring field QC samples were met during 2017.

To determine the collection frequency for EBs, the only nondedicated sampling equipment currently tracked in the electronic database are bailer, Kabis,[3] and portable Grundfos.[4] Nondedicated sampling manifolds are also used to collect some groundwater samples but are not tracked in the HEIS database. Consequently, the number of well trips for EBs reported in Table E-2 underestimates the actual number of well trips that use nondedicated sampling equipment, and the actual sampling frequency for EBs <12%. Until the use of nondedicated sampling manifolds is tracked, a more accurate estimate of the actual sampling frequency for EBs is unavailable.

For the TOC quadruplicate samples, the sampling frequency is slightly >100% due to the collection of 11 split sample sets for TOC and 10 split sample sets for TOX.

E5.3 Percentage of Usable Data

This section provides an overview of data usability. Subsequent sections provide detailed information regarding data compliance with quality requirements.

Table E-5 summarizes the percentage of usable groundwater monitoring data generated from samples collected during 2017. Overall data completeness is 95.3%, which is well above the data completeness goal of 85.0% specified in DOE/RL-91-50 and indicates that the majority of data collected for the groundwater monitoring program is usable. The 2017 data completeness rate of 95.3% is slightly lower than the 96.7% rate in 2016 and the 97.0% rate in 2015.

Table E-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
Overall Percent Complete = 95.3%								
Overall Totals:	**166,871**	**37**	**420**	**120**	**4,260**	**1,482**	**1,860**	**7,774**
General Chemical Parameters: Percent Complete = 97.5%								
Totals	**22,984**	**12**	**31**	**26**	**361**	**18**	**160**	**569**
120.1_CONDUCT_FLD	1	—	—	—	—	—	—	0
150.1_PH	16	—	—	—	—	16	—	16
1664A_OILGREASE	61	—	—	—	2	—	1	3
2320_ALKALINITY	1,321	—	—	—	53	—	2	55
2540C_TDS	6	—	—	—	—	—	—	0
310.1_ALKALINITY	1,317	—	—	—	158	—	—	158
360.1_OXYGEN	1	—	—	1	—	—	—	1

[3] Kabis™ is a trademark of Sibak Industries, Solana Beach, California.

[4] Grundfos® is a registered trademark of Grundfos Holding, Bjerringbro, Denmark.

Table E-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
360.1_OXYGEN_FLD	2,581	1	—	3	—	—	—	4
9020_TOX	1,176	—	20	—	126	—	59	175
9060_TOC	1,210	—	—	—	18	1	98	108
9223_COLIFORM	77	—	—	—	4	1	—	5
CONDUCT_FLD	3,365	6	1	5	—	—	—	12
PH_ELECT_FLD	3,405	1	10	4	—	—	—	15
REDOX_PROBE_FLD	1,720	1	—	1	—	—	—	2
TEMP_FLD	3,365	—	—	8	—	—	—	8
TURBIDITY_FLD	3,362	3	—	4	—	—	—	7
Ammonia and Anions: Percent Complete = 89.2%								
Totals	**12,501**	**6**	**22**	**21**	**814**	**473**	**35**	**1,347**
300.0_ANIONS_IC	6,272	—	17	15	149	314	5	491
350.1_AMMONIA	51	—	—	—	8	—	14	18
353.2_NO3/NO2	6	—	—	—	—	6	—	6
376.1_SULFIDE	1	—	—	—	—	—	—	0
4500D_SULFIDE	70	—	—	—	—	—	—	0
9012_CYANIDE	1,014	—	1	4	42	4	12	62
9014_CYANIDE	394	—	—	2	—	2	—	4
9015_METALCN_IC	24	—	—	—	—	20	—	20
9034_SULFIDE	55	—	—	—	2	—	—	2
9056_ANIONS_IC	4,614	6	4	—	613	127	4	744
Metals: Percent Complete = 94.2%								
Totals	**65,473**	**12**	**293**	**7**	**2,413**	**22**	**1,271**	**3,818**
6010_METALS_ICP	25,394	—	154	—	1160	—	448	1,705
6020_METALS_ICPMS	37,017	6	134	5	1249	—	816	2,067
7196_CR6	2,605	6	5	2	4	22	4	43
7470_HG_CVAA	457	—	—	—	—	—	3	3
Volatile Organic Compounds: Percent Complete = 98.1%								
Totals	**29,613**	**0**	**68**	**30**	**394**	**62**	**65**	**574**
8260_VOA_GCMS	29,539	—	68	30	394	61	65	573

Table E-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
WTPH_GASOLINE	74	—	—	—	—	1	—	1
Semivolatile Organic Compounds: Percent Complete = 95.4%								
Totals	**27,170**	**0**	**2**	**1**	**142**	**907**	**294**	**1,259**
8081_PEST_GC	2,415	—	—	—	—	105	—	105
8082_PCB_GC	934	—	—	—	—	—	—	0
8151_HERBICIDE_GC	1,420	—	—	—	—	—	—	0
8270_SVOA_GCMS	19,375	—	—	1	4	802	12	817
8290_DIOXINS_GCMS	2,475	—	—	—	127	—	272	318
WEPH_GC	300	—	—	—	1	—	1	2
WTPH_DIESEL	251	—	2	—	10	—	9	17
Radiological Parameters: Percent Complete = 97.7%								
Totals	**9,130**	**7**	**4**	**35**	**136**	**0**	**35**	**207**
903.1_RA226_LUC	63	—	—	—	—	—	—	0
905.0_SR_GPC	42	—	—	—	—	—	—	0
906.0_H3_LSC	455	—	—	—	5	—	2	7
906.0ML_H3_LSC	1	—	—	—	—	—	—	0
9310_ALPHABETA_GPC	1,196	—	—	1	52	—	6	59
AMCMISO_EIE_PLT_AEA	74	—	—	—	—	—	—	0
AMCMISO_EIE_PREC_AEA	76	—	—	—	—	—	—	0
AMCMISO_IE_PLATE_AEA	1	—	—	—	—	—	—	0
BETA_GPC	2	—	—	—	—	—	—	0
C14_LSC	464	—	—	—	4	—	—	4
CL36_SEP_GPC	6	—	—	—	—	—	—	0
GAMMA_GS	2,505	5	—	7	5	—	3	19
I129_SEP_LSC	1	—	—	—	—	—	—	0
I129LL_SEP_LEPS_GS	490	—	2	22	11	—	—	33
I129LL_SEP_LSC	4	—	—	—	—	—	—	0
NP237_IE_PRECIP_AEA	12	—	—	—	—	—	—	0
NP237_LLE_PLATE_AEA	10	—	—	—	—	—	—	0
PU241_IE_LSC	159	—	—	—	—	—	—	0

Table E-5. Data Completeness Summarized by Method

HEIS Method Name	Total Results[a]	Results in Review[b]	Suspect Results[c]	Rejected Results[d]	Field QC Flags	Missed Holding Time	Method Blank Qualifiers	Results Flagged[e]
PUISO_EIE_PRECIP_AEA	16	—	—	—	—	—	—	0
PUISO_IE_PRECIP_AEA	56	—	—	—	—	—	—	0
PUISO_PLATE_AEA	164	—	—	—	—	—	—	0
PUISO_PRECIP_AEA	220	—	—	—	—	—	—	0
RA228_LSC	29	—	—	—	—	—	—	0
RAISO_SEP_GPC	30	—	—	—	1	—	—	1
SE79_SEP_IE_LSC	210	—	—	—	2	—	3	3
SR90_SEP_LSC	10	—	—	—	—	—	—	0
SRISO_SEP_PRECIP_GPC	844	—	—	—	18	—	17	30
SRTOT_SEP_PRECIP_GPC	24	—	—	—	—	—	—	0
TC99_EIE_LSC	365	—	1	1	10	—	—	12
TC99_ETVDSK_LSC	307	—	—	1	5	—	—	6
TC99_SEP_LSC	13	—	—	—	—	—	—	0
THISO_IE_PLATE_AEA	30	—	—	—	—	—	—	0
THISO_IE_PRECIP_AEA	24	—	—	—	—	—	—	0
TRITIUM_DIST_LSC	657	2	1	—	6	—	—	9
UISO_EIE_PRECIP_AEA	39	—	—	3	2	—	4	9
UISO_IE_PRECIP_AEA	318	—	—	—	9	—	—	9
UISO_PLATE_AEA	213	—	—	—	6	—	—	6

a. Groundwater monitoring results were pulled from the HEIS database on February 8, 2018, and include both field and laboratory results.

b. Results in review have a review qualifier of “F.”

c. Suspect results have a review qualifier of “Y.”

d. Rejected results have a review qualifier of “R.”

e. The value in the “Results Flagged” column may be less than the sum of the values in the individual flag columns if the same result has multiple QC issues.

HEIS = Hanford Environmental Information System

QC = quality control

Data completeness was judged on the following:

- "F," "R," and "Y" review qualifier flags associated with the data[5]
- "Q" flag review qualifiers for data associated with FBs exhibiting possible contamination, data with poor field sample duplicate reproducibility, or data with poor field split reproducibility
- Samples with missed holding times
- Samples with laboratory qualifiers indicating method blank contamination

Of the 166,871 total results noted in Table E-5, 95.3% met QC requirements. Of the 7,774 QC failures summarized in the table, 54.8% of the results were due to out-of-limit field QC and were flagged as "Q" flagged, and 23.9% were due to out-of-limit method blanks. Of the 4,260 "Q"-flagged results, 91.6% were "Q" flagged for associated out-of-limit FBs, 5.7% for field duplicates exceeding the RPD limit, and 3.2% for field splits exceeding the RPD limit. The "Q" flag percentages may sum to >100% because a result may be flagged for multiple field QC issues (e.g., out-of-limit FB and out-of-limit field duplicate). Details of the issues associated with these QC failures are provided in subsequent sections.

General chemical parameters had a completion rate of 97.5%. Alkalinity was most often flagged with QC failures; 8.1% (213 of 2,638 results) of the alkalinity results received a QC flag, with all but two due to apparent FB contamination. After alkalinity, TOX received the next largest number of QC flags (175 of 1,176 results, or 14.9%), with 126 results associated with out-of-limit FBs. Methylene chloride is strongly suspected to be a contaminant in the source deionized water used to generate TOX FBs and may explain most of the "Q"-flagged TOX results (SGW-52194, *Volatile Organic Compound Contamination in Groundwater Samples and Field Blanks*). Other parameters that exhibited 10 or more QC failures were TOC (108 of 1,210), laboratory pH (16 of 16; all for missed holding times), field pH (15 of 3,405), and field conductivity (12 of 3,362).

Ammonia and anions had the poorest completion rate at 89.2%; most of the failures were for the ion chromatography (IC) anions determined by EPA Method 300.0, *Determination of Inorganic Anions by Ion Chromatography*; and EPA Method 9056, *Determination of Inorganic Anions by Ion Chromatography*. Of all the QC failures for ammonia and anions, 60.4% were due to "Q" flag review qualifiers for data associated with contaminated FBs and poor field duplicate/field split reproducibility, and 35.1% were associated with missed holding times. The ammonia and anion analytes with more than 10% of total results flagged were ammonium ion (35.3%), chloride (20.8%), nitrate (19.8%), and phosphate (10.6%).

Metals had the second poorest completion rate at 94.2%. The metals with the most results flagged were those determined by EPA Method 6010, *Inductively Coupled Plasma—Optical Emission Spectrometry* (ICP/AES); and EPA Method 6020, *Inductively Coupled Plasma—Mass Spectrometry* (ICP/MS). Of the QC failures for metals, 63.2% were due to "Q" flag review qualifiers for data associated with contaminated FBs and poor field duplicate/field split reproducibility, and 33.3% were associated with laboratory method blank contamination. The metals with more than 10% of total results flagged were aluminum (14.5%), iron (13.9%), manganese (13.0%), and sodium (11.3%).

The VOCs had the best completion rate at 98.1%. The VOC most often flagged with QC failures was methylene chloride; 31.5% (313 of 993 results) of the methylene chloride results received a QC flag,

[5] The "F" review qualifier (i.e., result in review) was included in the assessment of 2017 groundwater monitoring results for this report. After the RDR review, "F"-flagged results will be resolved to one of the other RDR flags, as appropriate.

with 286 results associated with apparent FB contamination. As noted earlier for TOX, methylene chloride is suspected to be a contaminant in the source deionized water used to generate VOC FBs and may explain most of the "Q"-flagged methylene chloride results (SGW-52194). A total of 255 of the reported methylene chloride results for groundwater samples associated with contaminated FBs were less than the MDL. Other VOCs that exhibited 10 or more QC failures were acetone (58 of 991), 2-propanol (22 of 106), octamethylcyclotetrasiloxane (21 of 54), carbon disulfide (13 of 991), and chloroform (13 of 993). 2-Propanol is a likely field contaminant that is discussed in Section E9.5.1, and octamethylcyclotetrasiloxane is a breakdown compound from capillary columns.

Semivolatile organic compounds (SVOCs) had a completion rate of 95.4%; the majority of the failures were due to missed holding times. The SVOCs most often flagged with QC failures were those determined by EPA Method 8270, *Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*; 4.2% (817 of 19,375 results) of the SVOC results received a QC flag, with most due to missed holding times. Other SVOCs that exhibited 10 or more QC failures were the polychlorodibenzo-p-dioxins and polychlorodibenzofurans determined by EPA Method 8290, *Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High Resolution Mass Spectrometry (HRGC/HRMS)* (318 of 2,475); pesticides determined by EPA Method 8081, *Organochlorine Pesticides by Gas Chromatography* (105 of 2,415); and total petroleum hydrocarbons (TPH)-diesel fraction (17 of 251).

Radiological parameters had a completion rate of 97.7%. The radiological parameter most often flagged with QC failures was gross alpha/gross beta by EPA Method 9310, *Gross Alpha and Gross Beta*; 4.9% (59 of 1,196 results) of these results received a QC flag. The gross alpha/gross beta results break down to 14 of 563 gross alpha results and 45 of 633 gross beta results being flagged. A total of 52 of the gross alpha/gross beta results were flagged as "Q" for out-of-limit FBs, out-of-limit field duplicates, and out-of-limit field splits. Other radiological parameters that exhibited 10 or more QC failures were iodine-129 (33 of 495), strontium-90 (30 of 920), technetium-99 (18 of 685), tritium (16 of 1,113), and uranium-233/234 (11 of 190).

E5.4 Laboratory Information and Analytical Methods

Samples collected for the groundwater monitoring program were sent to the seven laboratories (described in Section E5.4.1) for analysis. Each sample is tracked by a unique HEIS database number. Analytical requests for chemical and radiochemical services to be completed by the laboratories were documented on the chain-of-custody forms. Analytical results provided by the laboratories were documented by sample delivery group in data packages. The analytical results were also electronically uploaded and stored in the HEIS database.

E5.4.1 Laboratory Information

The samples collected were analyzed at the following seven laboratories:

- ALS Laboratories (ALS, (Fort Collins, Colorado) provided sample analysis for chemical constituents; ALS generated 8.7% of the analytical laboratory results.
- GEL Laboratories, LLC (GEL) (Charleston, South Carolina) provided sample analysis for chemical and radiochemical constituents; GEL generated 40.4% of the analytical laboratory results.
- Southwest Research Institute (SWRI) (San Antonio, Texas) provided sample analysis for chemical and radiochemical constituents; SWRI generated 1.2% of the analytical laboratory results.

- TestAmerica–Denver (TADN) (Denver, Colorado) provided sample analysis for chemical constituents; TADN generated 14.9% of the analytical laboratory results.
- TestAmerica–Knoxville (TAKN) (Knoxville, Tennessee) provided sample analysis for polychlorodibenzo-p-dioxins and polychlorodibenzofurans; TAKN generated 1.1% of the analytical laboratory results.
- TestAmerica–Richland (TARL) (Richland, Washington) provided sample analysis for chemical and radiochemical constituents; TARL generated 7.7% of the analytical laboratory results.
- TestAmerica–St. Louis (TASL) (St. Louis, Missouri) provided sample analysis for chemical and some radiochemical constituents; TASL generated 26.0% of the analytical laboratory results.

Chapters E6 and E7 discuss the analytical data provided by these laboratories.

E5.4.2 Analytical Methods

For the analysis of chemical constituents, the analyzing laboratories used standard methods from the U.S. Environmental Protection Agency (EPA), ASTM International (formerly American Society for Testing and Materials), and the American Public Health Association. For radiological constituents, the analyzing laboratories used methods that are recognized as acceptable within the radiochemical industry.

Samples were analyzed using the methods listed in Table E-6. Both single- and multiple-component analytical methods were used. Single-component analytical methods, such as EPA Method 9012, *Total and Amenable Cyanide (Automated Colorimetric, With Off-Line Distillation)* for cyanide; or EPA Method 7470, *Mercury in Liquid Waste (Manual Cold-Vapor Technique)* for mercury, yield a single analytical result per analysis. Multi-component analytical methods (e.g., EPA Method 6020 for ICP/MS metals or EPA Method 8260, *Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)* for gas chromatography/mass spectrometry [GC/MS] for VOCs) yield results for multiple analytes per analysis. Multi-component methods may generate results for both target and nontarget analytes.

Table E-6. Analytical Methods

Parameter	Analytical Method	Source
General Chemical Parameters		
Alkalinity	EPA Method 310.1	EPA[a]
Alkalinity	Standard Method 2320	Standard methods[b]
Coliform	Standard Method 9223	Standard methods[b]
Oil and grease	EPA Method 1664A	EPA[d]
pH	EPA Method 150.1	EPA[a]
Total dissolved solids	Standard Method 2540C	Standard methods[b]
Total organic carbon	EPA Method 9060	EPA[e]
Total organic halides	EPA Method 9020	EPA[e]
Ammonia and Anions		
Ammonium by colorimetry	EPA Method 350.1	EPA[a]
Anions by IC	EPA Method 300.0	EPA[g]

Table E-6. Analytical Methods

Parameter	Analytical Method	Source
Anions by IC	EPA Method 9056	EPA[e]
Cyanide	EPA Method 9012	EPA[e]
Cyanide	EPA Method 9014	EPA[e]
Cyanide, metal complexes by IC	EPA Method 9015	EPA[e]
Nitrate/nitrite by colorimetry	EPA Method 353.2	EPA[a]
Sulfide	EPA Method 376.1	EPA[a]
Sulfide	Standard Method 4500D	Standard methods[b]
Sulfide	EPA Method 9034	EPA[e]
Metals		
Hexavalent chromium	EPA Method 7196	EPA[e]
Mercury	EPA Method 7470	EPA[e]
Metals by ICP/AES	EPA Method 6010	EPA[e]
Metals by ICP/MS	EPA Method 6020	EPA[e]
Volatile Organic Compounds		
Total petroleum hydrocarbons–gasoline	NWTPH-Gx	Ecology[f]
Volatile organic compounds by GC/MS	EPA Method 8260	EPA[e]
Semivolatile Organic Compounds		
Chlorinated herbicides by GC	EPA Method 8151	EPA[e]
Dioxins by GC/MS	EPA Method 8290	EPA[e]
Extractable petroleum hydrocarbon	WEPH-GC	Ecology[f]
Organochlorine pesticides by GC	EPA Method 8081	EPA[e]
Polychlorinated biphenyls by GC	EPA Method 8082	EPA[e]
Semivolatile organic compounds by GC/MS	EPA Method 8270	EPA[e]
Total petroleum hydrocarbons–diesel, –kerosene, –motor oil (high boiling)	NWTPH-Dx	Ecology[f]
Radiological Parameters		
Americium-curium isotopes	Ion-exchange separation/electroplate/ alpha energy analysis	Laboratory-specific
Americium-curium isotopes	Ion-exchange separation/precipitation/ alpha energy analysis	Laboratory-specific
Carbon-14	Chemical oxidation/LSC	Laboratory-specific
Chlorine-36	Silver precipitation/GPC	Laboratory-specific
Gamma-emitting isotopes	Gamma energy analysis	Laboratory-specific
Gross alpha-beta by GPC	EPA Method 9310	EPA[e]
Gross beta	GPC	Laboratory-specific

Table E-6. Analytical Methods

Parameter	Analytical Method	Source
Iodine-129	Separation/precipitation/LEPS	Laboratory-specific
Iodine-129	Separation/precipitation/LSC	Laboratory-specific
Neptunium-237	Ion-exchange separation/precipitation/ alpha energy analysis	Laboratory-specific
Neptunium-237	Liquid-liquid extraction/electroplate/ alpha energy analysis	Laboratory-specific
Plutonium isotopes	Ion-exchange separation/precipitation/ alpha energy analysis	Laboratory-specific
Plutonium isotopes	Separation/precipitation/alpha energy analysis	Laboratory-specific
Plutonium isotopes	Separation/electroplate/alpha energy analysis	Laboratory-specific
Plutonium-241	Ion-exchange separation/LSC	Laboratory-specific
Radium-226 by Lucas cell	EPA Method 903.1	EPA[j]
Radium-228	LSC	Laboratory-specific
Radium isotopes	Chelate separation/precipitation/alpha scintillation/GPC	Laboratory-specific
Selenium-79	Ion-exchange separation/LSC	Laboratory-specific
Strontium-90	EPA Method 905.0	EPA[j]
Strontium-90	Separation/LSC	Laboratory-specific
Strontium-90 (total-beta radiostrontium)	Separation/precipitation/GPC	Laboratory-specific
Technetium-99	Ion-exchange separation/LSC	Laboratory-specific
Technetium-99	Disk separation/LSC	Laboratory-specific
Technetium-99	Precipitation/ion-exchange separation/LSC	Laboratory-specific
Thorium isotopes	Ion-exchange separation/electroplate/ alpha energy analysis	Laboratory-specific
Thorium isotopes	Ion-exchange separation/precipitation/ alpha energy analysis	Laboratory-specific
Tritium	EPA Method 906.0	EPA[j]
Tritium	Distillation/LSC	Laboratory-specific
Uranium isotopes	Ion-exchange separation/precipitation/ alpha energy analysis	Laboratory-specific
Uranium isotopes	Separation/electroplate/alpha energy analysis	Laboratory-specific

a. EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*.

b. APHA/AWWA/WEF, 2012, *Standard Methods For the Examination of Water and Wastewater*.

c. O'Dell, 1993, *Method 410.4, Revision 2.0: The Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry*.

Table E-6. Analytical Methods

Parameter	Analytical Method	Source

d. EPA-821-R-98-002, *Method 1664, Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) by Extraction and Gravimetry*.

e. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended.

f. ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*.

g. EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*.

h. Peden, 1986, *Methods for Collection and Analysis of Precipitation*.

i. EPA-600/R-94/111, *Methods for the Determination of Metals in Environmental Samples, Supplement I*.

j. EPA/600/R-17/356, *Selected Analytical Methods for Environmental Remediation and Recovery (SAM)*.

Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
GC = gas chromatography
GC/MS = gas chromatography/mass spectrometry
GPC = gas proportional counting
IC = ion chromatography
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectrometry
LEPS = low-energy photon spectroscopy
LSC = liquid scintillation counting
NWTPH = Northwest total petroleum hydrocarbons

E5.5 Sample Preservation and Holding Times

Sample preservation and holding times are designed to ensure that the analytical results generated from a sample are representative of the sample source. Sample preservation is any method used to ensure that the analyte of interest is not altered between the time the sample is acquired and the time it is analyzed. Sample preservation includes selecting the correct sample container material (e.g., plastic or glass) and may include cooling the sample to ≤6°C (42.8°F), adjusting the sample pH with acids or bases, or adding other chemicals (e.g., sodium bisulfite) to prevent oxidation of the analytes of interest. Typically, any preservation chemicals are added to the sample container during container preparation, prior to taking the container to the sample site.

Holding times are defined as the time from sample collection or sample extraction to sample analysis. An extraction holding time is the time from sample collection to sample extraction. Holding times are calculated from the date of sample collection as recorded on the sample chain of custody. Analytes that may change quickly with time, such as coliform or hexavalent chromium (Cr(VI)), have short holding times, while other analytes such as acid-preserved metals and radionuclides have much longer holding times.

Table E-7 lists the sample preservation and holding-time requirements for the groundwater monitoring program. Upon receipt of a groundwater sample set, the analyzing laboratory inspects the contents of the sample set container (usually an ice chest) to ensure that the samples received reflect those listed on the accompanying chains of custody. During the receipt inspection, the samples are usually checked for any anomalies (e.g., missing samples, broken sample bottles, or absent tamper tape). The as-received sample temperature is also usually checked. Samples that are received immediately from the field will not have had time to cool to a preservation temperature ≤6°C (42.8°F); in this circumstance, the as-received condition of the samples is noted, and normal processing of the samples for analysis proceeds.

Table E-7. Groundwater Sample Container, Preservative, and Holding-Time Requirements

Parameter	Container	Preservative	Holding Time	Source
General Chemical Parameters				
Alkalinity	G/P	Cool to ≤6°C	14 days	40 CFR 136, Table II
Coliform	G/P	Cool to ≤10°C; 0.0008% $Na_2S_2O_3$	8 hours	40 CFR 136, Table II
Dissolved oxygen	G	None	As soon as possible	40 CFR 136, Table II
Hydrogen ion (pH)	G/P	None	As soon as possible	40 CFR 136, Table II
Oil and grease/hexane extractable material	G	Cool to ≤6 °C; HCl or H_2SO_4 to pH <2	28 days	SW-846, Table 3-2
Specific conductance	G/P	None	28 days	40 CFR 136, Table II
Total dissolved solids	G/P	Cool to ≤6°C	7 days	APHA/AWWA/WEF (2012), Standard Method 2540c
Total organic carbon	aG	Cool to ≤6°C; HCl or H_2SO_4 to pH <2	28 days	40 CFR 136, Table II
Total organic halides	G	Cool to ≤6°C; H_2SO_4 to pH <2	28 days	SW-846, Method 9020B
Ammonia and Anions				
Ammonia	G/P	Cool to ≤6°C; H_2SO_4 to pH <2	28 days	40 CFR 136, Table II
Cyanide	G/P	Cool to ≤6°C; 50% NaOH to pH>12	14 days	SW-846, Table 3-2
Cyanide, metal complexes	aG	Cool to ≤6°C; 50% NaOH to pH>12	14 days	SW-846, Method 9015
Bromide, chloride, fluoride, and sulfate	G/P	Cool to ≤6°C	28 days	SW-846, Table 3-2
Nitrate, nitrite, phosphate	G/P	Cool to ≤6°C	48 hours	SW-846, Table 3-2
Sulfide	G/P	Cool to ≤6°C; zinc acetate and NaOH to pH >9	7 days	SW-846, Table 3-2
Metals				
Hexavalent chromium	G/P	Cool to ≤6 °C	24 hours	SW-846, Table 3-2
Mercury	G/P	HNO_3 to pH<2	28 days	SW-846, Table 3-2
All other metals	G/P	HNO_3 to pH<2	6 months	SW-846, Table 3-2
Volatile Organic Compounds				
Total petroleum hydrocarbons-gasoline	aG	Cool to ≤6°C; HCl to pH<2	14 days	ECY 97-602

Table E-7. Groundwater Sample Container, Preservative, and Holding-Time Requirements

Parameter	Container	Preservative	Holding Time	Source
Volatile organic compounds	aGs	Cool to ≤6 °C; HCl or H_2SO_4 to pH <2	14 days	SW-846, Table 4-1
Semivolatile Organic Compounds				
Extractable aliphatic and aromatic petroleum hydrocarbons	aG	Cool to ≤6°C; HCl to pH<2	14 days before extraction, 40 days after extraction	ECY 97-602
Semivolatile organic compounds, organochlorine pesticides, and herbicides	aG/PTFE-lined cap	Cool to ≤6°C	7 days before extraction, 40 days after extraction	SW-846, Table 4-1
Polychlorinated biphenyls	aG/PTFE-lined cap	Cool to ≤6°C	1 year before extraction, 40 days after extraction	SW-846, Method 8082A
Polychlorodibenzo-p-dioxins, polychlorodibenzo-furans	aG/PTFE-lined cap	Cool to ≤6°C	30 days before extraction, 45 days after extraction	SW-846, Method 8290
Total petroleum hydrocarbons–diesel, –kerosene, –motor oil (high boiling)	aGs	Cool to ≤6°C; HCl to pH<2	14 days before extraction, 40 days after extraction	ECY 97-602
Radiological Parameters				
Americium isotopics, gamma spectroscopy radionuclides, plutonium isotopics, radium isotopics, strontium-90, and uranium isotopics	G/P	HNO_3 to pH<2	6 months	Laboratory procedure
Carbon-14, tritium	G	None	6 months	Laboratory procedure
Chlorine-36	G/P	None	6 months	Laboratory procedure
Gross alpha, gross beta	G/P	HNO_3 to pH<2	6 months	SW-846, Table 2-40(B)
Iodine-129	G/P	None	6 months	Laboratory procedure
Selenium-79	G/P	HNO_3 to pH<2	6 months	Laboratory procedure
Technetium-99	G/P	HCl or HNO_3 to pH<2	6 months	Laboratory procedure

Sources:

40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants."

APHA/AWWA/WEF, 2012, *Standard Methods For the Examination of Water and Wastewater*.

ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*.

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended.

Table E-7. Groundwater Sample Container, Preservative, and Holding-Time Requirements

Parameter	Container	Preservative	Holding Time	Source

aG = amber glass
aGs = amber glass with septum cap
G = glass
P = plastic
PTFE = polytetrafluorinatedethylene

Either at the time of receipt or immediately before sample preparation and analysis, the pH of samples that require pH adjustment is checked to ensure that the sample was properly preserved. If the pH is not correct for the sample type (e.g., pH is >2 for ICP metals or is <12 for cyanide samples), then the laboratory notes the anomaly and may adjust the sample pH. Any anomalies noted during sample receiving or with sample preservation are reported to the Soil and Groundwater Remediation Project (S&GRP) via sample issue resolution requests. If S&GRP does not deem that the anomaly will affect the sample results, the laboratory is instructed to proceed with the analysis. S&GRP may decide that the anomaly (e.g., a cyanide sample with pH <12) could jeopardize the integrity of the sample results; in this instance, the laboratory will be instructed to cancel the sample analysis.

E5.5.1 Sample Preservation

Of the 14,136 routine groundwater monitoring laboratory samples acquired during 2017, 69 samples (0.5%) were associated with sample preservation issues. Of the 69 samples with sample preservation issues, analyses of 17 were cancelled. This indicates that incorrect sample preservation is not a major issue for the groundwater monitoring program. Table E-8 lists the preservation issues and the analytes affected for the 2017 groundwater monitoring effort.

Table E-8. Groundwater Sample Preservation Issues and Dispositions

Preservation Issue/ Analytes	Disposition/Number of Samples Affected				
	Adjust pH and Report Results	Analyze Sample within 7-Day Holding Time	Cancel Analysis	No Action – Report Results	Totals
Totals	**33**	**1**	**17**	**18**	**69**
Headspace Present in Sample Bottle	**—**	**—**	**—**	**15**	**15**
9020_TOX	—	—	—	15	15
Incorrect pH	**33**	**1**	**8**	**3**	**45**
9060_TOC	—	—	—	2	2
9012_CYANIDE	2	—	8	—	10
6010_METALS_ICP	11	—	—	—	11
6020_METALS_ICPMS	9	—	—	—	9
8260_VOA_GCMS	—	—	—	1	1
WTPH_DIESEL	—	1	—	—	1
9310_ALPHABETA_GPC	2	—	—	—	2
GAMMA_GS	1	—	—	—	1
SRISO_SEP_PRECIP_GPC	1	—	—	—	1

Table E-8. Groundwater Sample Preservation Issues and Dispositions

Preservation Issue/ Analytes	Disposition/Number of Samples Affected				
	Adjust pH and Report Results	Analyze Sample within 7-Day Holding Time	Cancel Analysis	No Action – Report Results	Totals
TC99_EIE_LSC	2	—	—	—	2
TC99_ETVDSK_LSC	5	—	—	—	5
Incorrect Preservative	**3**	**—**	**1**	**—**	**1**
310.1_ALKALINITY	—	—	1	—	1
Incorrect Temperature	**—**	**—**	**8**	**—**	**2**
2320_ALKALINITY	—	—	1	—	1
8260_VOA_GCMS	—	—	7	—	7

E5.5.2 Holding Times

Table E-5 summarizes the number of sample results for each analytical method with missed holding times. Of the 149,071 groundwater monitoring laboratory results reported during 2017, a total of 1,482 analytical results (1.0%) were affected by missed holding times. This rate is worse than that reported for 2016 (474 missed holding times, 0.3%) and for calendar year 2015 (428 missed holding times, 0.3%). Table E-9 lists the reasons for the sample results documented by the sample issue resolution process. Most of the samples with missed holding times were analyzed within two times the holding time; S&GRP scientists and project coordinators deemed that these results are acceptable for the groundwater monitoring program.

Table E-9. Missed Sample Holding-Time Issues

Missed Holding Time Issue	Number of Results*	Percentage of Missed Holding Times
Totals	**686**	**100%**
Sample repreparation/reanalysis	253	36.9%
QC failure/reanalysis	196	28.6%
Instrument failure	79	11.5%
Other laboratory issue	79	11.5%
Late sample delivery (other)	45	6.6%
Late sample delivery (diverted)	18	2.6%
Dilution/reanalysis	12	1.7%
Analyst error	4	0.6%

*The 686 results listed in this table are those documented by the sample issue resolution process and do not necessarily include all results with missed holding times.

QC = quality control

For the short holding-time analytes Cr(VI) and the IC anions nitrate, nitrite, and phosphate, S&GRP personnel instructed GEL and TASL in 2014 to submit sample issue resolution forms for those analytes only when they were analyzed outside two times the holding time. Consequently, not all results with missed holding times are documented via the sample issue resolution process. All missed holding times were still to be noted in the case narratives of the laboratory analytical reports.

An explanation of the holding time issues follows:

- **Sample repreparation/reanalysis:** This issue covers those occasions for which a sample needed to be reprepared and reanalyzed due to, for example, incorrect initial sample preparation. This issue affected 253 SVOC analytes.
- **QC failure/reanalysis:** This missed holding time reason covers samples that were reanalyzed after the holding lapsed because of the failure of one or more QC samples to meet QC requirements during the initial analysis. This reason affected 84 results for pesticides, 71 results for the short holding-time anions nitrate, nitrite, and phosphate, 40 results for VOCs, and one result for Cr(VI).
- **Instrument failure:** This issue covers missed holding times caused by an instrument malfunction. All 79 results affected by this issue were for the short-holding-time anions nitrate, nitrite, and phosphate.
- **Other laboratory issues:** This issue covers miscellaneous laboratory issues that caused missed holding times such as lack of staffing to run the analysis or failure to properly log the sample for analysis. This issue affected 56 results for the short holding-time anions nitrate and nitrite, 19 SVOC results, two Cr(VI) results, one cyanide result, and one TOC result.
- **Late sample delivery (other):** This missed holding time reason covers delivery of a sample with insufficient or no time left to complete the analysis before the holding time expired. This issue affected 22 nitrate/nitrite results, 15 Cr(VI) results, and eight pH results.
- **Late sample delivery (diverted):** This missed holding time reason covers delivery of a sample with insufficient or no time left to complete the analysis before the holding time expired because the sample was diverted from the primary to a secondary laboratory. This issue affected 18 results for the short holding-time anions nitrate, nitrite, and phosphate.
- **Dilution/reanalysis:** When an analyte exceeded the calibration range during analysis, the sample was diluted and reanalyzed after the holding time lapsed. This issue affected 12 nitrate results.
- **Analyst error:** This issue covers missed holding times caused by the analyst failing to observe the sample holding time. The four results affected by this issue were for nitrate and nitrite.

Of the 686 total analytical results with missed holding times (noted in Table E-5), 272 were for SVOCs (7-day holding time prior to extraction); 262 were for nitrate, nitrite, and phosphate (48-hour holding time); 84 were for pesticides by gas chromatography (7-day holding time prior to extraction); 40 were for VOCs (14-day holding time); 18 were for Cr(VI) (24-hour holding time); and eight were for pH (holding time is “as soon as possible”). Cyanide and TOC each had one missed holding time.

Missed holding times by laboratory were as follows: ALS had 50, GEL had 84, SWRI had none, TADN had 19, TAKN had none, TARL had 254, and TASL had 279. The TARL missed holding times were for nitrate/nitrite/phosphate (236) and Cr(VI) (18). The TASL missed holding times were for SVOCs (253), nitrate/nitrite/phosphate (18), and pH (eight).

E6 Field Quality Control

This chapter discusses the 2017 groundwater monitoring field QC data that exceeded the QC acceptance criteria listed in Table E-1. Section E4.2 discusses the types of field QC samples that are evaluated in this section.

E6.1 Field Blanks

The FBs are used to assess potential contamination associated with sampling and laboratory activities. Analytical results for the FBs are assessed against the acceptance limits listed in Table E-1. Overall, the percentage of acceptable FB results evaluated during this reporting period was 93.9%. This percentage appears poorer when compared to 97.0% for 2016 and 97.9% for 2015. However, prior to 2017, the previous QC limit for FBs was twice the MDL or MDA. As of Revision 13 of CHPRC-00189, the QC limit for FBs is now the MDL or MDA. With this new, lower FB QC limit, more FBs appear to be showing some contamination. Even so, a percentage of 93.9% still indicates minimal problems with contamination during sampling and analysis.

The FB results greater than the acceptance criterion of the MDL or MDA are identified as suspected contamination. For the common laboratory contaminants 2-butanone, acetone, methylene chloride, toluene, and phthalate esters, the limit is five times the MDL. Results for samples associated with FBs that are above these criteria are assigned a review qualifier of "Q" in the HEIS database to indicate potential contamination issues. Section E4.2 defines the associated samples for blanks. Table E-10 presents the FB results that exceeded QC limits, and Table E-11 compares out-of-limit FBs with out-of-limit method blanks that were analyzed in the same analytical batch.

The remainder of the FB discussion in this section provides additional context for the information presented in Tables E-10 and E-11.

For 2017, 505 FB sets were obtained consisting of 1,375 samples that were analyzed to generate 18,116 sample results, of which 1,113 (6.1%) exceeded QC limits. By blank type, 67 EB sets were acquired consisting of 333 EB samples; these samples yielded 4,051 results, of which 91.7% met the acceptance criteria. For FTBs, 140 blank sets were acquired consisting of 744 samples that yielded 8,000 analytical results, of which 94.6% met the acceptance criteria. For FXRs, 298 blank samples yielded 6,065 analytical results, of which 94.4% met the acceptance criteria.

By compound class, the 489 general chemical parameter FB results yielded 112 results (22.9%) that exceeded QC limits, including 46 for alkalinity, 30 for bicarbonate alkalinity, 26 for TOX, 6 for TOC, 2 for bicarbonate, and 2 for oil and grease measurements. One alkalinity EB, B38NF8, had a reported value of 120,000 μg/L, which may represent a mix-up of a groundwater sample with the EB either in the field or in the laboratory.

Of the 984 ammonia/anion results, 147 results (14.9%) exceeded QC limits. Most of the out-of-limit results were for the IC anions: 69 for chloride, 51 for nitrate, and 14 for sulfate results.

Of the 5,582 FB metals results for 2017, 394 (7.1%) exceeded QC limits. Most of the exceedances were for the ICP/AES and ICP/MS metals: 37 for aluminum, 31 for iron, 30 for manganese, 29 for sodium, 27 for calcium, 26 for silver, 25 for nickel, 20 for uranium, and 20 for zinc results. The remaining 149 out-of-limit results were scattered among 19 other metals. One EB, B37WN5, had seven ICP/AES metal analytes that significantly exceeded the acceptance criterion. These blank results almost undoubtedly resulted from the mix-up between the actual blank sample and a groundwater sample, either in the field or in the laboratory. An RDR has been initiated to resolve these results.

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Total FBs Out = 1,113						
General Chemical Parameters: Total Out = 112						
Alkalinity	FTB	55	25	45.5	540 – 1,450 µg/L	1,000 – 15,000 µg/L
Alkalinity	EB	42	21	50.0	540 – 1,450 µg/L	1,000 – 120,000 µg/L
Bicarbonate	EB	10	2	20.0	1,450 µg/L	1,610 – 2,200 µg/L
Bi-carbonate alkalinity	EB	22	15	68.2	540 – 1,070 µg/L	1,000 – 120,000 µg/L
Bi-carbonate alkalinity	FTB	18	15	83.3	540 – 1,070 µg/L	1,000 – 2,000 µg/L
Oil and grease	EB	3	1	33.3	1,320 – 1,360 µg/L	1,890 µg/L
Oil and grease	FTB	2	1	50.0	1,320 – 1,350 µg/L	3,580 µg/L
Total organic carbon	FTB	83	6	7.2	155 – 720 µg/L	166 – 232 µg/L
Total organic halides	FTB	85	26	30.6	2.1 – 7.7 µg/L	2.2 – 49.1 µg/L
Ammonia and Anions: Total Out = 147						
Ammonium ion	FTB	5	3	60.0	21.9 – 28.7 µg/L	35 – 138 µg/L
Chloride	EB	55	21	38.2	20 – 200 µg/L	70.6 – 321 µg/L
Chloride	FTB	109	48	44.0	20 – 500 µg/L	67.3 – 760 µg/L
Cyanide	FTB	47	3	6.4	1.67 – 5 µg/L	1.73 – 214 µg/L
Cyanide amenable to chlorination	FTB	30	2	6.7	1.67 – 5 µg/L	1.73 – 214 µg/L
Fluoride	EB	55	1	1.8	26 – 66 µg/L	40.3 µg/L
Fluoride	FTB	109	1	0.9	20 – 130 µg/L	68 µg/L
Nitrate	EB	55	30	54.5	31 – 292 µg/L	155 – 1,020 µg/L
Nitrate	FTB	109	21	19.3	31 – 146 µg/L	163 – 358 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Phosphate	EB	9	1	11.1	205 – 530 µg/L	256 µg/L
Sulfate	EB	55	5	9.1	50 – 266 µg/L	135 – 1,100 µg/L
Sulfate	FTB	109	9	8.3	50 – 630 µg/L	143 – 620 µg/L
Sulfide	EB	4	1	25.0	2,200 µg/L	2,900 µg/L
Sulfide	FTB	8	1	12.5	33 – 2,200 µg/L	2,900 µg/L
Metals: Total Out = 394						
Aluminum	EB	59	18	30.5	8.7 – 20 µg/L	9.4 – 620 µg/L
Aluminum	FTB	100	19	19.0	8.7 – 20 µg/L	9.5 – 73 µg/L
Antimony	EB	70	5	7.1	0.049 – 6.2 µg/L	0.13 – 0.98 µg/L
Antimony	FTB	129	8	6.2	0.049 – 6.2 µg/L	0.05 – 0.72 µg/L
Arsenic	EB	70	2	2.9	0.18 – 5 µg/L	1.93 – 3.4 µg/L
Arsenic	FTB	131	2	1.5	0.18 – 5 µg/L	2.28 – 2.29 µg/L
Barium	EB	70	3	4.3	0.23 – 30 µg/L	0.931 – 2.44 µg/L
Barium	FTB	129	1	0.8	0.23 – 30 µg/L	0.54 µg/L
Beryllium	FTB	101	3	3.0	0.08 – 1 µg/L	0.11 – 0.17 µg/L
Beryllium	EB	61	4	6.6	0.08 – 1.5 µg/L	0.081 – 0.19 µg/L
Boron	EB	73	2	2.7	4.4 – 30 µg/L	33 – 48.4 µg/L
Boron	FTB	96	2	2.1	4.4 – 30 µg/L	4.5 – 5.7 µg/L
Calcium	EB	84	11	13.1	23 – 300 µg/L	30 – 93,400 µg/L
Calcium	FTB	125	16	12.8	23 – 300 µg/L	24 – 135 µg/L
Chromium	EB	105	8	7.6	0.5 – 4 µg/L	0.64 – 203 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Chromium	FTB	175	8	4.6	0.5 – 4 µg/L	0.54 – 8.1 µg/L
Cobalt	EB	70	2	2.9	0.054 – 3 µg/L	0.08 – 1.4 µg/L
Copper	EB	70	8	11.4	0.3 – 6 µg/L	0.59 – 11 µg/L
Copper	FTB	129	11	8.5	0.3 – 7 µg/L	0.57 – 3.4 µg/L
Hexavalent chromium	FTB	120	2	1.7	1.5 µg/L	2.1 µg/L
Iron	EB	84	16	19.0	16 – 30 µg/L	18 – 816 µg/L
Iron	FTB	125	15	12.0	16 – 30 µg/L	22 – 153 µg/L
Lead	EB	59	6	10.2	0.096 – 1 µg/L	0.11 – 3.2 µg/L
Lead	FTB	102	5	4.9	0.096 – 1 µg/L	0.1 – 0.14 µg/L
Magnesium	EB	84	8	9.5	10.7 – 300 µg/L	12.3 – 23,800 µg/L
Magnesium	FTB	125	7	5.6	10.7 – 300 µg/L	12.6 – 160 µg/L
Manganese	FTB	129	14	10.9	0.26 – 4 µg/L	0.36 – 19 µg/L
Manganese	EB	70	16	22.9	0.26 – 3 µg/L	0.33 – 22.4 µg/L
Molybdenum	EB	59	3	5.1	0.14 – 2 µg/L	0.18 – 1.9 µg/L
Molybdenum	FTB	100	3	3.0	0.14 – 2 µg/L	0.15 – 0.18 µg/L
Nickel	EB	70	12	17.1	0.3 – 11 µg/L	0.34 – 92.1 µg/L
Nickel	FTB	129	13	10.1	0.3 – 11 µg/L	0.593 – 6.9 µg/L
Potassium	EB	84	5	6.0	50 – 1,500 µg/L	61.2 – 6,310 µg/L
Potassium	FTB	125	4	3.2	50 – 1,500 µg/L	57.3 – 346 µg/L
Selenium	EB	59	2	3.4	0.18 – 3.5 µg/L	0.4 – 0.45 µg/L
Selenium	FTB	102	1	1.0	0.18 – 3.5 µg/L	0.27 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Silver	EB	70	25	35.7	0.023 – 3 µg/L	0.04 – 1.4 µg/L
Silver	FTB	129	1	0.8	0.023 – 3 µg/L	0.042 µg/L
Sodium	EB	84	9	10.7	26 – 300 µg/L	72 – 18,300 µg/L
Sodium	FTB	125	20	16.0	26 – 300 µg/L	68 – 512 µg/L
Strontium	EB	61	6	9.8	0.12 – 3 µg/L	0.15 – 1.6 µg/L
Strontium	FTB	101	9	8.9	0.12 – 2 µg/L	0.18 – 3.6 µg/L
Thallium	EB	59	4	6.8	0.014 – 0.9 µg/L	0.076 – 0.11 µg/L
Thallium	FTB	100	4	4.0	0.014 – 0.9 µg/L	0.059 – 0.095 µg/L
Thorium	EB	59	3	5.1	0.014 – 1.2 µg/L	0.02 µg/L
Thorium	FTB	100	1	1.0	0.014 – 1.2 µg/L	0.02 µg/L
Tin	EB	59	1	1.7	0.73 – 3 µg/L	0.81 µg/L
Uranium	FTB	124	16	12.9	0.022 – 0.4 µg/L	0.03 – 3.8 µg/L
Uranium	EB	66	4	6.1	0.022 – 0.4 µg/L	0.05 – 0.11 µg/L
Vanadium	EB	84	2	2.4	0.93 – 25 µg/L	1.7 – 2.32 µg/L
Vanadium	FTB	125	4	3.2	0.93 – 25 µg/L	1.1 – 5.6 µg/L
Zinc	EB	70	7	10.0	2 – 48 µg/L	2.2 – 150 µg/L
Zinc	FTB	129	13	10.1	2 – 48 µg/L	2.9 – 40.3 µg/L
Volatile Organic Compounds: Total Out = 384						
(m+p)-Xylene	EB	1	1	100	—	0.42 µg/L
1,2,3-Trichlorobenzene	FXR	3	3	100	—	0.27 – 0.37 µg/L
1,2,4-Trichlorobenzene	EB	1	1	100	—	0.34 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
1,2-Dichloroethane	FXR	298	2	0.7	0.13 – 0.3 µg/L	0.61 – 0.69 µg/L
1-Butanol	FTB	3	1	33.3	17 – 83.3 µg/L	110 µg/L
1-Butanol	FXR	4	4	100	—	51 – 89 µg/L
1-Chlorohexane	FXR	1	1	100	—	0.36 µg/L
2-Butanol	FTB	1	1	100	—	39 µg/L
2-Butanol	FXR	3	3	100	—	15 – 38 µg/L
2-Nitropropane	FXR	1	1	100	—	3.8 µg/L
2-Propanol	EB	1	1	100	—	27 µg/L
2-Propanol	FTB	2	2	100	—	19 – 100 µg/L
2-Propanol	FXR	41	41	100	—	6.4 – 300 µg/L
Acetone	FXR	298	7	2.3	2.75 – 15 µg/L	2.8 – 15 µg/L
Benzene	FXR	298	1	0.3	0.1 – 0.32 µg/L	0.19 µg/L
Benzoic acid, 2-[(trimethylsilyl) oxy]-,trimethylsilyl ester	FXR	6	6	100	—	1.3 – 7.2 µg/L
Benzoic acid, 5-methyl	FXR	1	1	100	—	6.6 µg/L
Bromochloromethane	FTB	1	1	100	—	0.46 µg/L
Bromodichloromethane	FXR	1	1	100	—	1.9 µg/L
Bromoform	FXR	1	1	100	—	1.4 µg/L
Carbon disulfide	FXR	298	4	1.3	0.1 – 1.6 µg/L	0.35 – 2.37 µg/L
Chlorobenzene	EB	18	1	5.6	0.11 – 0.3 µg/L	0.13 µg/L
Chlorobenzene	FTB	28	1	3.6	0.11 – 0.3 µg/L	0.18 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Chlorodifluoromethane	FXR	1	1	100	—	1.4 µg/L
Chloroform	FXR	298	4	1.3	0.1 – 0.3 µg/L	0.17 – 1.1 µg/L
Cyclohexanone	FXR	1	1	100	—	37 µg/L
Cyclotetrasiloxane, octamethyl	FXR	19	19	100	—	1.3 – 8.9 µg/L
Cyclotetrasiloxane, octamethyl	FTB	2	2	100	—	2.5 – 3.1 µg/L
Dibromochloromethane	FXR	1	1	100	—	2.1 µg/L
Ethyl acetate	FXR	1	1	100	—	1.5 µg/L
Ethylbenzene	FXR	298	2	0.7	0.12 – 0.31 µg/L	0.52 – 0.89 µg/L
Hexamethylcyclotrisiloxane	FTB	1	1	100	—	1.9 µg/L
Hexamethylcyclotrisiloxane	FXR	10	10	100	—	1.3 – 3.2 µg/L
Iodomethane	FXR	2	2	100	—	0.23 – 0.24 µg/L
Methylene chloride	EB	18	13	72.2	1.35 – 8 µg/L	1.5 – 57 µg/L
Methylene chloride	FTB	29	14	48.3	1.35 – 8 µg/L	2.1 – 140 µg/L
Methylene chloride	FXR	298	214	71.8	1.35 – 13.5 µg/L	1.4 – 80 µg/L
Naphthalene	EB	1	1	100	—	1.2 µg/L
Naphthalene	FXR	1	1	100	—	0.29 µg/L
n-Butylbenzene	FXR	2	2	100	—	0.35 – 0.54 µg/L
Nonaldehyde (pelargonic aldehyde)	FXR	3	3	100	—	0.74 – 1.1 µg/L
p-Cymene	FXR	1	1	100	—	0.66 µg/L
Styrene	FXR	1	1	100	—	0.39 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Total petroleum hydrocarbons–gasoline range	EB	3	1	33.3	16.7 µg/L	18.7 µg/L
Trichloroethene	FXR	298	1	0.3	0.16 – 0.31 µg/L	6.5 µg/L
Xylenes (total)	EB	18	1	5.6	0.19 – 0.3 µg/L	0.42 µg/L
Xylenes (total)	FXR	298	1	0.3	0.19 – 1 µg/L	0.68 µg/L
Semivolatile Organic Compounds: Total Out = 40						
1,2,3,4,6,7,8-Heptachlorodibenzofuran	FTB	5	1	20.0	0.16 – 12.9 µg/L	0.36 µg/L
1,2,3,4,6,7,8-Heptachlorodibenzofuran	EB	5	1	20.0	0.072 – 0.906 µg/L	0.42 µg/L
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	EB	5	1	20.0	0.15 – 1.08 µg/L	0.29 µg/L
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	EB	5	1	20.0	0.083 – 0.676 µg/L	0.33 µg/L
1,2-Diphenylhydrazine	FTB	1	1	100	—	0.28 µg/L
1-Methylnaphthalene	FTB	1	1	100	—	0.27 µg/L
2-Methylnaphthalene	FTB	10	1	10	0.28 – 0.98 µg/L	0.29 µg/L
Acenaphthene	FTB	12	1	8.3	0.0288 – 0.98 µg/L	0.32 µg/L
Aliphatic petroleum hydrocarbons >nC21-nC34	FTB	2	1	50.0	14.3 – 14.4 µg/L	45.5 µg/L
Cyclohexane	EB	3	3	100	—	35 – 37 µg/L
Cyclohexane	FTB	2	2	100	—	21 – 24 µg/L
Fluoranthene	FTB	12	1	8.3	0.0288 – 0.98 µg/L	0.28 µg/L
Fluorene	FTB	12	1	8.3	0.0288 – 0.98 µg/L	0.32 µg/L
Heptachlorodibenzofurans	FTB	5	1	20.0	0.16 – 12.9 µg/L	0.36 µg/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Heptachlorodibenzofurans	EB	5	1	20.0	0.092 – 11.8 µg/L	0.42 µg/L
Heptachlorodibenzo-p-dioxins	EB	5	1	20.0	0.28 – 11.8 µg/L	0.62 µg/L
Hexachlorodibenzo-p-dioxin	EB	5	3	60.0	0.16 – 11.8 µg/L	0.75 – 2.18 µg/L
Methylene chloride	EB	1	1	100	—	5 µg/L
Naphthalene	FTB	12	1	8.3	0.0288 – 0.98 µg/L	0.29 µg/L
Octachlorodibenzofuran	EB	5	3	60.0	0.039 – 1.07 µg/L	0.6 – 1.3 µg/L
Octachlorodibenzofuran	FTB	5	3	60.0	0.068 – 25.8 µg/L	0.46 – 1.79 µg/L
Octachlorodibenzo-p-dioxin	FTB	5	3	60.0	0.16 – 25.8 µg/L	1.39 – 3.29 µg/L
Octachlorodibenzo-p-dioxin	EB	5	4	80.0	0.11 – 0.735 µg/L	1.18 – 4.36 µg/L
Pentachlorodibenzo-p-dioxins	EB	5	1	20.0	0.083 – 11.8 µg/L	0.33 µg/L
Phenanthrene	FTB	12	1	8.3	0.0288 – 0.98 µg/L	0.36 µg/L
Total petroleum hydrocarbons–diesel range	FTB	6	1	16.7	31 – 50 µg/L	50 µg/L
Radiochemical Parameters: Total Out = 36						
Carbon-14	FTB	26	1	3.8	10.2 – 36 pCi/L	219 pCi/L
Europium-152	EB	1	1	100	7.31 pCi/L	7.78 pCi/L
Europium-154	FTB	21	1	4.8	2.35 – 802 pCi/L	1,060 pCi/L
Gross alpha	EB	14	1	7.1	0.648 – 2.61 pCi/L	2.6 pCi/L
Gross alpha	FTB	28	5	17.9	0.516 – 3.33 pCi/L	0.739 – 9.64 pCi/L
Gross beta	FTB	32	6	18.8	1.04 – 3.83 pCi/L	1.84 – 377 pCi/L
Gross beta	EB	15	2	13.3	1.25 – 3.66 pCi/L	5.88 – 13.4 pCi/L

Table E-10. FB Results Exceeding QC Limits

Constituent	Blank Type	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits*	Range of Out-of-Limit Results
Iodine-129	FTB	35	1	2.9	0.292 – 1.75 pCi/L	0.844 pCi/L
Potassium-40	FTB	15	1	6.7	28.3 – 13,200 pCi/L	50.2 pCi/L
Potassium-40	EB	1	1	100	73 pCi/L	141 pCi/L
Radium-228	FTB	5	1	20.0	0.442 – 2.32 pCi/L	0.535 pCi/L
Selenium-79	FTB	15	1	6.7	10.7 – 38.8 pCi/L	31.9 pCi/L
Strontium-90	EB	21	1	4.8	0.114 – 1.74 pCi/L	7.24 pCi/L
Strontium-90	FTB	41	3	7.3	0.115 – 1.91 pCi/L	0.181 – 3.92 pCi/L
Technetium-99	FTB	50	2	4.0	1.77 – 44.9 pCi/L	2.81 – 77.8 pCi/L
Tritium	FTB	59	5	8.5	175 – 537 pCi/L	258 – 2,430 pCi/L
Uranium-233/234	FTB	16	2	12.5	0.0415 – 0.609 pCi/L	0.173 – 0.611 pCi/L
Uranium-235	FTB	15	1	6.7	0.0627 – 0.609 pCi/L	0.149 pCi/L

*Because method detection limits are specific to the laboratory and may change during the reporting period, the limits are presented as a range. However, each result was evaluated according to the method detection limit in effect at the time the sample was analyzed. Entries with only an "—" indicate that the analyte is a tentatively identified compound that has no associated QC limit.

EB = equipment blank
FB = field blank
FTB = full trip blank
FXR = field transfer blank
QC = quality control

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
General Chemical Parameters											
B39XL9	6/2/2017	399-1-17A	FTB	Alkalinity	TADN	2320_ALKALINITY	376809	1,160	3,490	µg/L	BC
B3D986	10/16/2017	699-26-35A	FTB	Alkalinity	TADN	2320_ALKALINITY	392632	1,540	3,430	µg/L	BC
B396P6	4/25/2017	699-61-62	FTB	Total organic carbon	TADN	9060_TOC	373693	232	175	µg/L	BC
B3DJ02	11/1/2017	299-W26-14	FTB	Total organic carbon	TADN	9060_TOC	396986	170	178	µg/L	BC
B3DJ04	11/1/2017	299-W26-14	FTB	Total organic carbon	TADN	9060_TOC	396986	175	178	µg/L	BC
B3DJ06	11/1/2017	299-W26-14	FTB	Total organic carbon	TADN	9060_TOC	396986	166	178	µg/L	BC
B3DJC1	11/1/2017	299-W26-14	FTB	Total organic carbon	TADN	9060_TOC	396986	180	178	µg/L	BC
B380D0	1/24/2017	299-W15-83	FTB	Total organic halides	TASL	9020_TOX	292636	34.3	3.00	µg/L	
B38177	1/24/2017	299-W15-83	FTB	Total organic halides	TASL	9020_TOX	292636	47.0	3.00	µg/L	
B38179	1/24/2017	299-W15-83	FTB	Total organic halides	TASL	9020_TOX	292636	31.5	3.00	µg/L	
B38181	1/24/2017	299-W15-83	FTB	Total organic halides	TASL	9020_TOX	292636	49.1	3.00	µg/L	
B3B4B4	7/6/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	320395	4.70	2.37	µg/L	BC
B3B573	7/6/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	320395	3.20	2.37	µg/L	BC
B3B575	7/6/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	320395	4.60	2.37	µg/L	BC
B3B577	7/6/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	320395	6.90	2.37	µg/L	C
B3C119	7/28/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	323482	3.30	2.59	µg/L	BC
B3C141	7/28/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	323482	2.80	2.59	µg/L	BC
B3C143	7/28/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	323482	3.90	2.59	µg/L	BC
B3C145	7/28/2017	299-W15-152	FTB	Total organic halides	TASL	9020_TOX	323482	3.70	2.59	µg/L	BC

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
Ammonia and Anions											
B3D3J0	10/25/2017	299-E25-43	FTB	Ammonium ion	GEL	350.1_AMMONIA	1713549	35.0	53.2	µg/L	BC
B38MM9	3/21/2017	299-W22-116	FTB	Chloride	GEL	9056_ANIONS_IC	1649728	76.0	72.3	µg/L	BC
B391V7	4/4/2017	199-D5-152	EB	Chloride	GEL	9056_ANIONS_IC	1653632	169	112	µg/L	BC
B39233	4/4/2017	199-D8-102	EB	Chloride	GEL	9056_ANIONS_IC	1653632	74.6	112	µg/L	BC
B38CB3	2/1/2017	299-E33-20	FTB	Cyanide	TASL	9012_CYANIDE	291756	4.40	3.84	µg/L	BC
Metals											
B39TF8	6/2/2017	399-1-55	EB	Aluminum	TASL	6020_METALS_ICPMS	314017	28.3	27.4	µg/L	BDC
B3B4N8	7/18/2017	699-25-34F	FTB	Aluminum	TASL	6020_METALS_ICPMS	322969	30.9	24.5	µg/L	BCD
B396R0	4/14/2017	699-88-41A	EB	Aluminum	TADN	6020_METALS_ICPMS	371602	16.8	14.8	µg/L	B
B3D9F6	11/29/2017	499-S0-8	FTB	Aluminum	TADN	6020_METALS_ICPMS	399044	34.0	10.1	µg/L	BCN
B395Y5	3/3/2017	199-N-3	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP170306-3	18.0	54.0	µg/L	BC
B395Y6	3/3/2017	199-N-3	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP170306-3	18.0	54.0	µg/L	BC
B39NP1	6/6/2017	299-E27-14	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP170620-10	20.0	32.0	µg/L	BC
B39NP7	6/6/2017	299-E27-14	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP170620-10	37.0	32.0	µg/L	BC
B3BNL4	9/18/2017	299-E24-33	EB	Aluminum	ALS	6020_METALS_ICPMS	IP170928-2	620	55.0	µg/L	C
B3BNM3	9/18/2017	299-E24-33	EB	Aluminum	ALS	6020_METALS_ICPMS	IP170928-2	70.0	55.0	µg/L	BC
B3BWV5	9/12/2017	399-1-23	EB	Aluminum	ALS	6020_METALS_ICPMS	IP170928-2	340	55.0	µg/L	C
B3C0C7	9/12/2017	399-1-23	EB	Aluminum	ALS	6020_METALS_ICPMS	IP170928-2	34.0	55.0	µg/L	BC
B3F9K9	11/14/2017	299-W14-11	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP171128-10	11.0	12.0	µg/L	BC
B3F5W4	11/9/2017	199-N-173	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP171201-10	14.0	12.0	µg/L	BC
B3F7R0	11/9/2017	199-N-173	FTB	Aluminum	ALS	6020_METALS_ICPMS	IP171201-10	18.0	12.0	µg/L	BC
B38DX7	2/21/2017	199-H4-88	EB	Antimony	TADN	6020_METALS_ICPMS	364063	0.980	0.923	µg/L	BC

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B37Y00	2/24/2017	699-97-47B	EB	Arsenic	GEL	6020_METALS_ICPMS	1642744	1.93	1.84	µg/L	CB
B3BD21	8/10/2017	299-E33-47	FTB	Arsenic	GEL	6020_METALS_ICPMS	1690974	2.28	2.36	µg/L	CB
B3BD25	8/10/2017	299-E33-47	FTB	Arsenic	GEL	6020_METALS_ICPMS	1690974	2.29	2.36	µg/L	CB
B3F9P7	10/29/2017	699-S6-E4K	EB	Arsenic	ALS	6010_METALS_ICP	IP171108-1	3.40	9.60	µg/L	BC
B39BF4	5/11/2017	299-E33-44	FTB	Boron	TADN	6010_METALS_ICP	375317	5.70	4.93	µg/L	BC
B3FJJ4	12/14/2017	199-H4-88	EB	Boron	ALS	6010_METALS_ICP	IP171220-10	33.0	6.70	µg/L	C
B38DW8	2/21/2017	199-H4-88	EB	Calcium	TADN	6010_METALS_ICP	364026	42.3	38.3	µg/L	B
B3F3V4	11/17/2017	199-D4-102	EB	Calcium	TADN	6010_METALS_ICP	397254	95.4	70.2	µg/L	BC
B3F9H6	11/9/2017	299-E33-41	FTB	Calcium	TADN	6010_METALS_ICP	397254	43.7	70.2	µg/L	BC
B395Y5	3/3/2017	199-N-3	FTB	Calcium	ALS	6010_METALS_ICP	IP170306-3	73.0	27.0	µg/L	BC
B395Y6	3/3/2017	199-N-3	FTB	Calcium	ALS	6010_METALS_ICP	IP170306-3	55.0	27.0	µg/L	BC
B38F52	2/21/2017	299-W10-27	FTB	Chromium	ALS	6020_METALS_ICPMS	IP170227-9	3.50	4.70	µg/L	BC
B3CXR8	10/13/2017	22-M	FTB	Chromium	ALS	6020_METALS_ICPMS	IP171103-10	4.60	2.60	µg/L	BC
B3CXT5	10/13/2017	22-M	FTB	Chromium	ALS	6020_METALS_ICPMS	IP171103-10	2.20	2.60	µg/L	BC
B3D4J9	10/20/2017	199-H4-84	FTB	Chromium	ALS	6020_METALS_ICPMS	IP171106-2	2.70	4.20	µg/L	BC
B3D4L2	10/20/2017	199-H4-88	EB	Chromium	ALS	6020_METALS_ICPMS	IP171106-2	2.60	4.20	µg/L	BC
B3D670	10/20/2017	199-H4-88	EB	Chromium	ALS	6020_METALS_ICPMS	IP171106-2	2.60	4.20	µg/L	BC
B3F665	10/30/2017	199-K-186	FTB	Chromium	ALS	6020_METALS_ICPMS	IP171107-10	3.40	3.00	µg/L	B
B3F672	10/30/2017	199-K-186	FTB	Chromium	ALS	6020_METALS_ICPMS	IP171107-10	4.00	3.00	µg/L	B
B392Y0	4/3/2017	399-2-2	EB	Copper	TASL	6020_METALS_ICPMS	304601	0.920	0.484	µg/L	BDC
B39TF4	6/2/2017	399-1-55	EB	Copper	TASL	6020_METALS_ICPMS	314017	0.760	0.542	µg/L	BDC
B39TF8	6/2/2017	399-1-55	EB	Copper	TASL	6020_METALS_ICPMS	314017	1.30	0.542	µg/L	DC
B3BNH5	9/6/2017	199-N-72	FTB	Copper	TASL	6020_METALS_ICPMS	327955	0.810	0.602	µg/L	BDC

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B3DJN4	11/13/2017	299-W10-27	FTB	Copper	TASL	6020_METALS_ICPMS	342240	0.690	0.524	µg/L	BCD
B38DX7	2/21/2017	199-H4-88	EB	Iron	TADN	6010_METALS_ICP	364026	25.7	37.2	µg/L	B
B39BD7	5/11/2017	299-E33-44	FTB	Iron	TADN	6010_METALS_ICP	374398	23.5	29.0	µg/L	BC
B39B63	5/3/2017	199-H4-84	FTB	Iron	TADN	6010_METALS_ICP	374646	40.0	36.8	µg/L	BC
B39RB9	6/7/2017	199-H4-88	EB	Iron	TADN	6010_METALS_ICP	378296	29.0	33.2	µg/L	B
B38CD7	2/14/2017	299-E33-337	FTB	Iron	ALS	6010_METALS_ICP	IP170217-6	22.0	17.0	µg/L	BC
B395Y5	3/3/2017	199-N-3	FTB	Iron	ALS	6010_METALS_ICP	IP170306-3	35.0	30.0	µg/L	BC
B395Y6	3/3/2017	199-N-3	FTB	Iron	ALS	6010_METALS_ICP	IP170306-3	32.0	30.0	µg/L	BC
B3BNN0	9/20/2017	299-E25-237	FTB	Iron	ALS	6010_METALS_ICP	IP170929-10	24.0	18.0	µg/L	BC
B3BTK6	9/22/2017	199-D5-152	EB	Iron	ALS	6010_METALS_ICP	IP170929-10	46.0	18.0	µg/L	BC
B3D2L0	10/16/2017	699-26-35A	FTB	Iron	ALS	6010_METALS_ICP	IP171101-11	25.0	19.0	µg/L	BC
B3D3P2	10/16/2017	699-26-35A	FTB	Iron	ALS	6010_METALS_ICP	IP171101-11	26.0	19.0	µg/L	BC
B38DX7	2/21/2017	199-H4-88	EB	Lead	TADN	6020_METALS_ICPMS	364063	0.230	0.200	µg/L	BC
B3BNY4	9/28/2017	299-E27-24	FTB	Lead	ALS	6020_METALS_ICPMS	IP171004-10	0.140	0.180	µg/L	BC
B3BP02	9/28/2017	299-E27-24	FTB	Lead	ALS	6020_METALS_ICPMS	IP171004-10	0.110	0.180	µg/L	BC
B3BVC4	9/29/2017	199-H4-88	EB	Lead	ALS	6020_METALS_ICPMS	IP171006-10	0.110	0.100	µg/L	BC
B3D2L0	10/16/2017	699-26-35A	FTB	Lead	ALS	6020_METALS_ICPMS	IP171101-11	0.130	0.100	µg/L	BC
B3D3P2	10/16/2017	699-26-35A	FTB	Lead	ALS	6020_METALS_ICPMS	IP171101-11	0.110	0.100	µg/L	BC
B3F7R0	11/9/2017	199-N-173	FTB	Lead	ALS	6020_METALS_ICPMS	IP171201-10	0.100	0.150	µg/L	BC
B38DW8	2/21/2017	199-H4-88	EB	Magnesium	TADN	6010_METALS_ICP	364026	42.2	18.2	µg/L	BC
B38DW8	2/21/2017	199-H4-88	EB	Magnesium	TADN	6010_METALS_ICP	364026	42.2	55.3	µg/L	BC
B38DW8	2/21/2017	199-H4-88	EB	Magnesium	TADN	6010_METALS_ICP	364026	42.2	71.9	µg/L	BC
B38DX7	2/21/2017	199-H4-88	EB	Magnesium	TADN	6010_METALS_ICP	364026	37.6	18.2	µg/L	BC

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B38DX7	2/21/2017	199-H4-88	EB	Magnesium	TADN	6010_METALS_ICP	364026	37.6	55.3	µg/L	BC
B38DX7	2/21/2017	199-H4-88	EB	Magnesium	TADN	6010_METALS_ICP	364026	37.6	71.90	µg/L	BC
B3DHL9	11/10/2017	199-H4-88	FTB	Magnesium	TADN	6010_METALS_ICP	396345	16.7	36.10	µg/L	BC
B39MW7	6/13/2017	199-N-96A	FTB	Manganese	TADN	6010_METALS_ICP	378853	0.410	0.415	µg/L	BC
B39MW7	6/13/2017	199-N-96A	FTB	Manganese	TADN	6010_METALS_ICP	378853	0.410	0.430	µg/L	BC
B38F52	2/21/2017	299-W10-27	FTB	Manganese	ALS	6020_METALS_ICPMS	IP170227-9	2.70	4.70	µg/L	BC
B38M77	3/13/2017	299-E24-33	EB	Manganese	ALS	6020_METALS_ICPMS	IP170316-3	0.400	0.550	µg/L	BC
B38M85	3/13/2017	299-E24-33	EB	Manganese	ALS	6020_METALS_ICPMS	IP170316-3	0.450	0.550	µg/L	BC
B38NC3	3/8/2017	199-D5-151	EB	Manganese	ALS	6020_METALS_ICPMS	IP170316-3	0.520	0.550	µg/L	BC
B38ND2	3/8/2017	199-D5-151	EB	Manganese	ALS	6020_METALS_ICPMS	IP170316-3	0.460	0.550	µg/L	BC
B39NP1	6/6/2017	299-E27-14	FTB	Manganese	ALS	6020_METALS_ICPMS	IP170620-10	1.70	3.20	µg/L	B
B3D2L0	10/16/2017	699-26-35A	FTB	Manganese	ALS	6020_METALS_ICPMS	IP171101-11	0.71	0.70	µg/L	BC
B3D3P2	10/16/2017	699-26-35A	FTB	Manganese	ALS	6020_METALS_ICPMS	IP171101-11	0.900	0.700	µg/L	BC
B3D4J9	10/20/2017	199-H4-84	FTB	Manganese	ALS	6020_METALS_ICPMS	IP171106-2	2.10	4.00	µg/L	BC
B3D4L2	10/20/2017	199-H4-88	EB	Manganese	ALS	6020_METALS_ICPMS	IP171106-2	2.10	4.00	µg/L	BC
B3D670	10/20/2017	199-H4-88	EB	Manganese	ALS	6020_METALS_ICPMS	IP171106-2	2.40	4.00	µg/L	BC
B3D546	11/29/2017	499-S0-8	FTB	Molybdenum	TADN	6020_METALS_ICPMS	398346	0.180	0.172	µg/L	BC
B38MH4	3/24/2017	299-E27-23	FTB	Nickel	GEL	6020_METALS_ICPMS	1650957	0.593	0.600	µg/L	CB
B38MH8	3/24/2017	299-E27-23	FTB	Nickel	GEL	6020_METALS_ICPMS	1650957	0.619	0.600	µg/L	CB
B390M5	4/19/2017	699-43-45	FTB	Nickel	GEL	6020_METALS_ICPMS	1657758	0.769	0.723	µg/L	CB
B390N1	4/19/2017	699-43-45	FTB	Nickel	GEL	6020_METALS_ICPMS	1657758	0.767	0.723	µg/L	CB
B3B7D9	7/17/2017	399-1-55	EB	Nickel	TADN	6020_METALS_ICPMS	382203	6.20	0.585	µg/L	C
B38F52	2/21/2017	299-W10-27	FTB	Nickel	ALS	6020_METALS_ICPMS	IP170227-9	6.90	7.60	µg/L	BC

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B3D4J9	10/20/2017	199-H4-84	FTB	Nickel	ALS	6020_METALS_ICPMS	IP171106-2	1.40	2.80	µg/L	BC
B3D4L2	10/20/2017	199-H4-88	EB	Nickel	ALS	6020_METALS_ICPMS	IP171106-2	1.20	2.80	µg/L	BC
B3D670	10/20/2017	199-H4-88	EB	Nickel	ALS	6020_METALS_ICPMS	IP171106-2	3.60	2.80	µg/L	BC
B3F6Y4	11/3/2017	199-K-106A	FTB	Potassium	GEL	6010_METALS_ICP	1716077	57.3	66.7	µg/L	CB
B39058	4/5/2017	299-E34-9	FTB	Potassium	TADN	6010_METALS_ICP	370154	310	265	µg/L	BC
B39058	4/5/2017	299-E34-9	FTB	Potassium	TADN	6010_METALS_ICP	370154	310	342	µg/L	BC
B3FH16	12/12/2017	299-E33-360	FTB	Potassium	TADN	6010_METALS_ICP	399873	346	251	µg/L	BC
B38M77	3/13/2017	299-E24-33	EB	Potassium	ALS	6010_METALS_ICP	IP170316-3	190	180	µg/L	BC
B38NC3	3/8/2017	199-D5-151	EB	Potassium	ALS	6010_METALS_ICP	IP170316-3	190	180	µg/L	BC
B38ND2	3/8/2017	199-D5-151	EB	Potassium	ALS	6010_METALS_ICP	IP170316-3	200	180	µg/L	BC
B3BNP1	9/20/2017	299-E25-237	FTB	Selenium	ALS	6020_METALS_ICPMS	IP170929-10	0.270	0.270	µg/L	BC
B3BTK6	9/22/2017	199-D5-152	EB	Selenium	ALS	6020_METALS_ICPMS	IP170929-10	0.400	0.270	µg/L	BC
B3BTL5	9/22/2017	199-D5-152	EB	Selenium	ALS	6020_METALS_ICPMS	IP170929-10	0.450	0.270	µg/L	BC
B38PW7	3/21/2017	299-W22-116	FTB	Sodium	TADN	6010_METALS_ICP	368441	248	171	µg/L	BC
B39051	4/5/2017	299-E34-9	FTB	Sodium	TADN	6010_METALS_ICP	370930	188	186	µg/L	B
B39P57	6/12/2017	299-W23-19	FTB	Sodium	TADN	6010_METALS_ICP	378850	128	130	µg/L	BC
B3BLK1	7/7/2017	699-29-66	FTB	Sodium	TADN	6010_METALS_ICP	380505	167	130	µg/L	BC
B3BLK2	7/7/2017	699-29-66	FTB	Sodium	TADN	6010_METALS_ICP	380505	129	130	µg/L	B
B3B840	7/17/2017	399-1-55	EB	Sodium	TADN	6010_METALS_ICP	382408	120	148	µg/L	B
B3CXV2	9/20/2017	AT-K-3-D	FTB	Sodium	TADN	6010_METALS_ICP	389110	118	131	µg/L	B
B3CXV2	9/20/2017	AT-K-3-D	FTB	Sodium	TADN	6010_METALS_ICP	389110	118	144	µg/L	B
B3CXV2	9/20/2017	AT-K-3-D	FTB	Sodium	TADN	6010_METALS_ICP	389110	118	232	µg/L	B

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B3CXW0	9/20/2017	AT-K-3-D	FTB	Sodium	TADN	6010_METALS_ICP	389110	141	131	µg/L	BC
B3CXW0	9/20/2017	AT-K-3-D	FTB	Sodium	TADN	6010_METALS_ICP	389110	141	144	µg/L	BC
B3CXW0	9/20/2017	AT-K-3-D	FTB	Sodium	TADN	6010_METALS_ICP	389110	141	232	µg/L	BC
B38CD7	2/14/2017	299-E33-337	FTB	Sodium	ALS	6010_METALS_ICP	IP170217-6	85.0	62.0	µg/L	BC
B38CF4	2/14/2017	299-E33-337	FTB	Sodium	ALS	6010_METALS_ICP	IP170217-6	68.0	62.0	µg/L	BC
B38WC2	2/14/2017	299-E33-20	FTB	Sodium	ALS	6010_METALS_ICP	IP170217-6	83.0	62.0	µg/L	BC
B38WC3	2/14/2017	299-E33-20	FTB	Sodium	ALS	6010_METALS_ICP	IP170217-6	100	62.0	µg/L	BC
B395Y5	3/3/2017	199-N-3	FTB	Sodium	ALS	6010_METALS_ICP	IP170306-3	70.0	62.0	µg/L	BC
B395Y6	3/3/2017	199-N-3	FTB	Sodium	ALS	6010_METALS_ICP	IP170306-3	69.0	62.0	µg/L	BC
B38M77	3/13/2017	299-E24-33	EB	Sodium	ALS	6010_METALS_ICP	IP170316-3	120	71.0	µg/L	BC
B38M85	3/13/2017	299-E24-33	EB	Sodium	ALS	6010_METALS_ICP	IP170316-3	72.0	71.0	µg/L	BC
B38NC3	3/8/2017	199-D5-151	EB	Sodium	ALS	6010_METALS_ICP	IP170316-3	93.0	71.0	µg/L	BC
B38ND2	3/8/2017	199-D5-151	EB	Sodium	ALS	6010_METALS_ICP	IP170316-3	86.0	71.0	µg/L	BC
B3D3P2	10/16/2017	699-26-35A	FTB	Sodium	ALS	6010_METALS_ICP	IP171101-11	120	370	µg/L	BC
B3FDT3	11/10/2017	199-H4-84	EB	Sodium	ALS	6010_METALS_ICP	IP171129-11	340	390	µg/L	B
B3FKC2	12/11/2017	299-E24-33	EB	Strontium	ALS	6020_METALS_ICPMS	IP171220-2	0.370	0.210	µg/L	BC
B3FKD1	12/11/2017	299-E24-33	EB	Strontium	ALS	6020_METALS_ICPMS	IP171220-2	0.300	0.210	µg/L	BC
B3BNN0	9/20/2017	299-E25-237	FTB	Vanadium	ALS	6010_METALS_ICP	IP170929-10	1.40	1.20	µg/L	BC
B3BNP1	9/20/2017	299-E25-237	FTB	Vanadium	ALS	6010_METALS_ICP	IP170929-10	1.10	1.20	µg/L	BC
B3BTL5	9/22/2017	199-D5-152	EB	Vanadium	ALS	6010_METALS_ICP	IP170929-10	1.70	1.20	µg/L	BC
B395Y5	3/3/2017	199-N-3	FTB	Zinc	ALS	6020_METALS_ICPMS	IP170306-3	12.0	33.0	µg/L	BC
B395Y6	3/3/2017	199-N-3	FTB	Zinc	ALS	6020_METALS_ICPMS	IP170306-3	11.0	33.0	µg/L	BC
B3D4J9	10/20/2017	199-H4-84	FTB	Zinc	ALS	6020_METALS_ICPMS	IP171106-2	14.0	7.80	µg/L	BC

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B3D4L2	10/20/2017	199-H4-88	EB	Zinc	ALS	6020_METALS_ICPMS	IP171106-2	150	7.80	µg/L	C
B3D670	10/20/2017	199-H4-88	EB	Zinc	ALS	6020_METALS_ICPMS	IP171106-2	19.0	7.80	µg/L	BC
Volatile Organic Compounds											
B3D818	10/22/2017	399-1-18A	FXR	Methylene chloride	TADN	8260_VOA_GCMS	393514	3.30	2.22	µg/L	OB
B3D826	11/8/2017	199-N-169	FXR	Methylene chloride	TADN	8260_VOA_GCMS	395963	6.40	1.63	µg/L	B
Semivolatile Organic Compounds											
B3BNL7	9/18/2017	299-E24-33	EB	1,2,3,4,6,7,8-Heptachlorodibenzofuran	TAKN	8290_DIOXINS_GCMS	15039	0.420	1.83	µg/L	JB
B3BNL7	9/18/2017	299-E24-33	EB	Heptachlorodibenzofurans	TAKN	8290_DIOXINS_GCMS	15039	0.420	3.31	µg/L	JB
B3BNL7	9/18/2017	299-E24-33	EB	Heptachlorodibenzo-p-dioxins	TAKN	8290_DIOXINS_GCMS	15039	0.620	3.80	µg/L	JB
B3BNL7	9/18/2017	299-E24-33	EB	Hexachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	15039	0.750	4.50	µg/L	JB
B38M79	3/13/2017	299-E24-33	EB	Octachlorodibenzofuran	TAKN	8290_DIOXINS_GCMS	10434	0.600	3.40	µg/L	JB
B39NH4	6/15/2017	299-E24-22	FTB	Octachlorodibenzofuran	TAKN	8290_DIOXINS_GCMS	12401	1.03	2.67	µg/L	JB
B39NJ3	6/15/2017	299-E24-33	EB	Octachlorodibenzofuran	TAKN	8290_DIOXINS_GCMS	12401	1.21	2.67	µg/L	JB
B3B4N2	7/18/2017	699-25-34F	FTB	Octachlorodibenzofuran	TAKN	8290_DIOXINS_GCMS	13371	0.460	5.06	µg/L	JB
B3BNL7	9/18/2017	299-E24-33	EB	Octachlorodibenzofuran	TAKN	8290_DIOXINS_GCMS	15039	1.30	7.62	µg/L	JB
B38M79	3/13/2017	299-E24-33	EB	Octachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	10434	1.18	6.93	µg/L	JB
B39NH4	6/15/2017	299-E24-22	FTB	Octachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	12401	2.49	5.40	µg/L	JB
B39NJ3	6/15/2017	299-E24-33	EB	Octachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	12401	3.06	5.40	µg/L	JB
B3B4N2	7/18/2017	699-25-34F	FTB	Octachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	13371	1.39	7.95	µg/L	JB
B3BNL7	9/18/2017	299-E24-33	EB	Octachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	15039	4.36	13.1	µg/L	JB
B3FKC5	12/11/2017	299-E24-33	EB	Octachlorodibenzo-p-dioxin	TAKN	8290_DIOXINS_GCMS	17066	2.82	1.86	µg/L	JB
B3F9D8	11/9/2017	199-N-173	FTB	Total petroleum hydrocarbons–diesel range	TADN	WTPH_DIESEL	398536	50.0	37.6	µg/L	JB

Table E-11. Out-of-Limit FBs Compared with Out-of-Limit Method Blanks

Sample Number	Sample Date	Well Name	FB Type	Constituent	Lab	Method	Analysis Batch Number	FB Result	Method Blank Result	Units	FB Lab Qualifier
B3F9D8	11/9/2017	199-N-173	FTB	Total petroleum hydrocarbons–diesel range	TADN	WTPH_DIESEL	398536	50.0	42.0	µg/L	JB
Radiochemical Parameters											
B39WM1	6/6/2017	299-E27-14	FTB	Europium-154	SWRI	GAMMA_GS	G170605-1	1,060	13.4	pCi/L	
B3BT44	8/29/2017	06-M	FTB	Selenium-79	TARL	SE79_SEP_IE_LSC	7271036	31.9	19.9	pCi/L	B
B3CXT1	10/13/2017	22-M	FTB	Strontium-90	TASL	SRISO_SEP_PRECIP_GPC	335731	0.181	0.126	pCi/L	B
B3BH02	8/16/2017	199-K-221	FTB	Strontium-90	TARL	SRISO_SEP_PRECIP_GPC	7237015	1.59	1.89	pCi/L	
B3C0C2	9/28/2017	299-E27-24	FTB	Tritium	SWRI	906.0_H3_LSC	20171023_173	999	234	pCi/L	

ALS = ALS Laboratory
EB = equipment blank
FB = field blank
FTB = full trip blank
FXR = field transfer blank
GEL = GEL laboratory
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TAKN = TestAmerica–Knoxville
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis

The 2017 groundwater monitoring FBs yielded 7,911 VOC results. Of these results, 384 (4.9%) exceeded limits and included 241 methylene chloride results that ranged from 1.4 to 140 µg/L. During 2012, a study of VOC contamination in groundwater FBs determined that the deionized water used to generate the FBs is the most likely source of the methylene chloride and, to a lesser extent, carbon tetrachloride and chloroform found in the FBs (SGW-52194). The same study also concluded that the appearance of acetone, bromomethane, carbon disulfide, chloromethane, tetrachloroethene, and toluene in laboratory method blanks indicates that these volatile organic analytes may be introduced as contaminants during laboratory sample preparation and analysis and may appear as spurious analytes in groundwater samples. Installation of additional charcoal filtering to the deionized water supply to decrease the occurrence of spurious organic compounds in groundwater monitoring FBs was completed during 2016. Continued monitoring since this corrective action was implemented indicate that the charcoal filtering is ineffective at reducing the presence of organic compounds in FBs. No additional corrective actions are planned at this time.

The remaining VOC analytes with more than 10 out-of-limits results were 44 for 2-propanol (6.4 to 300 µg/L), 21 for octamethylcyclotetrasiloxane, and 11 for hexamethylcyclotrisiloxane. Octamethylcycltetrasiloxane and hexamethylcyclotrisiloxane are reported as tentatively identified compounds. These two VOCs are breakdown products of the capillary columns used to perform the analyte separations during GC/MS and are not native to the FBs or groundwater samples.
The 44 instances of 2-propanol were also reported as tentatively identified compounds in the FBs; the appearance of 2-propanol in the FBs and groundwater samples likely represents a field contamination issue during blank preparation and field collection. Section E9.5.1 discusses the 2-propanol contamination issue.

Of the 2,509 SVOC FB results, 36 exceeded QC limits. A total of 24 results for several polychlorodibenzo-p-dioxins and polychlorodibenzofurans accounted for the majority of the out-of-limit SVOC results.

Of the 641 radiochemical parameter results, 36 exceeded QC limits. The most common out-of-limits radiochemical parameters were eight gross beta, six gross alpha, five tritium, and four strontium-90.

Table E-11 compares the out-of-limit FB results with out-of-limit method blank results. Many of the table entries show that the FB and method blank results are similar in value, indicating that the source of FB contamination is likely caused by laboratory sample handling and preparation and is not the result of sample bottle preparation and sample collection activities. The inductively coupled plasma (ICP) metals provide most of the entries in Table E-11, with aluminum, calcium, iron, manganese, nickel, silver, sodium, uranium, and zinc the most common metal contaminants having 20 or more results out of limits.

E6.2 Field Duplicate Samples

Field duplicate samples are replicate groundwater samples sent to the same laboratory and are used to assess field sampling and laboratory measurement precision. In accordance with to Table E-1, the results of field duplicates must have a precision ≤20%, as measured by the RPD (Equation E-1). Field duplicates with at least one result greater than five times the MDL or MDA were evaluated. Field duplicate results that have an RPD >20% are given a review qualifier of “Q” in the HEIS database RESULT table to indicate potential precision issues. Field duplicate values with a review qualifier of “Y” were included in the assessment of duplicate precision.

For 2017, 157 duplicate sample sets were acquired, consisting of 763 sample pairs. The 763 sample pairs yielded 9,425 pairs of results, of which 2,087 result pairs (22.1%) met the evaluation criterion. Of the 2,087 result pairs, 1,965 (94.2%) met the RPD criterion, indicating reasonable field sampling and intralaboratory precision. Table E-12 presents the duplicate results that exceeded QC limits. For comparison, the 2016 percentage of acceptable duplicate results was 93.4%, and the 2015 percentage of acceptable duplicate results was 95.0%.

Table E-12. Field Duplicates Exceeding QC Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Total Field Duplicate Results Out = 122						
Ammonia and Anions: Total Out = 18						
Ammonium ion	GEL	3	1	1	100	139
Chloride	TARL	61	60	3	5.0	32.6 – 108
Cyanide amenable to chlorination	GEL	26	12	9	75.0	21.0 – 118
Fluoride	TARL	61	27	1	3.7	164
Nitrate	TARL	61	57	2	3.5	40.6 – 187
Sulfate	TARL	61	61	2	3.3	66.7 – 173
Metals: Total Out = 66						
Aluminum	ALS	15	7	6	85.7	46.7 – 167
Aluminum	TADN	20	1	1	100	36.7
Antimony	ALS	19	2	2	100	46.1 – 57.6
Barium	ALS	19	15	1	6.7	20.9
Barium	TASL	39	30	1	3.3	23.1
Chromium	ALS	37	21	1	4.8	32.3
Chromium	GEL	54	28	1	3.6	23.8
Chromium	TASL	47	16	1	6.2	48.0
Cobalt	ALS	19	2	1	50.0	23.1
Cobalt	TADN	35	5	1	20.0	127
Copper	TADN	35	6	3	50.0	40.0 – 48.6
Copper	TASL	39	2	2	100	23.8 – 26.7
Hexavalent chromium	TARL	163	81	2	2.5	21.5 – 135
Iron	ALS	18	4	1	25.0	167
Iron	GEL	44	9	2	22.2	37.5 – 134
Iron	TADN	35	12	6	50.0	20.7 – 152
Iron	TASL	37	8	3	37.5	25.4 – 37.2
Lead	TADN	20	1	1	100	51.4

Table E-12. Field Duplicates Exceeding QC Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Magnesium	GEL	44	44	1	2.3	132
Manganese	ALS	19	6	2	33.3	25.0 – 44.1
Manganese	TADN	35	18	8	44.4	21.5 – 95.1
Nickel	GEL	40	13	1	7.7	42.6
Nickel	TADN	35	10	1	10.0	42.9
Selenium	ALS	15	5	1	20.0	24.5
Silver	TADN	35	2	2	100	153 – 196
Sodium	ALS	18	18	1	5.6	23.3
Sodium	GEL	44	44	2	4.5	131 – 200
Thorium	ALS	15	1	1	100	33.3
Uranium	TASL	30	26	2	7.7	24.9 – 26.1
Vanadium	GEL	44	40	1	2.5	133
Vanadium	TASL	37	8	1	12.5	22.7
Zinc	ALS	19	3	3	100	78.1 – 199
Zinc	GEL	40	2	1	50.0	25.9
Zinc	TADN	35	2	2	100	45.6 – 146
Volatile Organic Compounds: Total Out = 8						
Acetone	TADN	12	3	3	100	95.4 – 135
Acetone	TASL	32	5	5	100	58.8 – 151
Semivolatile Organic Compounds: Total Out = 15						
1,2,3,4,6,7,8-Heptachlorodibenzofuran	TAKN	2	2	1	50.0	29.7
1,2,3,4,7,8,9-Heptachlorodibenzofuran	TAKN	2	2	2	100	46.5 – 71.8
Heptachlorodibenzofurans	TAKN	2	2	2	100	38.3 – 66.7
Heptachlorodibenzo-p-dioxins	TAKN	2	1	1	100	135
Hexachlorodibenzo-p-dioxin	TAKN	2	1	1	100	79.8
Octachlorodibenzofuran	SWRI	1	1	1	100	41.9
Octachlorodibenzofuran	TAKN	2	2	1	50.0	35.7
Octachlorodibenzo-p-dioxin	SWRI	1	1	1	100	30.2
Octachlorodibenzo-p-dioxin	TAKN	2	2	1	50.0	31.0
TPH-diesel range	GEL	2	2	1	50.0	23.8
TPH-motor oil (high boiling)	GEL	1	1	1	100	34.4
TPH-motor oil (high boiling)	TASL	3	2	2	100	53.2 – 195

Table E-12. Field Duplicates Exceeding QC Limits

Constituent	Laboratory	Number of Duplicates	Number of Duplicates Evaluated[a]	Number Out of Limits[b]	Percent Out of Limits	Range of Out-of-Limit RPD[c]
Radiochemical Parameters: Total Out = 15						
Cobalt-60	TASL	3	1	1	100	37.4
Gross alpha	TARL	16	1	1	100	23.5
Gross beta	GEL	14	9	1	11.1	20.8
Gross beta	TARL	17	13	1	7.7	26.4
Iodine-129	GEL	19	5	1	20.0	24.7
Iodine-129	SWRI	2	2	1	50.0	22.0
Iodine-129	TARL	8	3	1	33.3	28.4
Technetium-99	GEL	21	10	2	20.0	22.6
Uranium-233/234	GEL	7	6	1	16.7	38.8
Uranium-233/234	TARL	4	2	1	50.0	24.2
Uranium-235	GEL	7	2	2	100	53.7 – 53.8
Uranium-235/236	SWRI	2	2	1	50.0	21.6
Uranium-238	TARL	4	2	1	50.0	20.3

a. Duplicates with at least one result >5 times the MDL or MDA were evaluated.

b. Duplicate control limit is an RPD ≤20%.

c. In cases where a nondetected result was compared with a measured value, the MDL or MDA was used for the nondetected result.

ALS = ALS Laboratory
GEL = GEL Laboratory
MDA = minimum detectable activity
MDL = method detection limit
RPD = relative percent difference
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TAKN = TestAmerica–Knoxville
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis
TPH = total petroleum hydrocarbons

The general chemical parameters had 177 field duplicate result pairs, of which 111 pairs (62.7%) met the evaluation criterion. None of the field duplicate result pair had an out-of-limit RPD.

Ammonia and anions had 672 field duplicate result pairs, of which 414 pairs (61.6%) met the evaluation criterion. Of these duplicate pairs, 18 (4.3%) exceeding the RPD criterion; the out-of-limit RPD results ranged from 21.0% to 187%. The ammonia and anions constituents with most of the out-of-limit RPD results were nine cyanide amenable to chlorination, three chloride, and two each for nitrate and sulfate. The samples were a mixture of unfiltered and filtered samples; however, filtration is not expected to greatly affect the anion content of the samples.

Metals had 3,626 field duplicate result pairs, of which 1,376 pairs (37.9%) met the evaluation criterion. Metals also had the largest number of duplicate result failures, with 66 data pairs (4.8%) exceeding the RPD criterion; the out-of-limit RPD results ranged from 20.7% to 200%. The out-of-limit RPD results were scattered over the ICP/AES and ICP/MS metals, including 12 for iron, 10 for manganese, 7 for

aluminum, and 5 for copper. Historically, many of the out-of-limit duplicates for metals have been attributed to unfiltered samples in which heterogeneous distribution of suspended solids in the samples tend to cause discrepancies between result pairs. For 2017, 63.6% of the duplicate result failures for metals occurred in unfiltered samples; these failures may reflect the effect of suspended solids on the metals results. Failures among the filtered samples may indicate possible sample swaps either in the field or in the laboratory, a sample contamination event that affected only one of the duplicate pair, a dilution error during sample preparation, or natural variability between duplicate samples.

The VOCs had 2,325 field duplicate result pairs, of which only 31 pairs (1.3%) met the evaluation criterion. Of the 31 pairs, eight (25.8%) failed to meet the RPD criterion; all failures were for acetone. The out-of-limit RPD results ranged from 58.8 %to 151%. While none of the failing duplicate results were flagged with a laboratory qualifier of "B" (method blank contaminated), acetone is a common laboratory solvent that can appear as a contaminant in VOC analyses (SGW-52194).

The SVOCs had 2,105 field duplicate result pairs, of which only 26 pairs (1.2%) met the evaluation criterion. Of the 26 pairs, 15 (57.7%) exceeded the RPD criterion with out-of-limit RPD results ranging from 29.7% to 195%. Specifically, the SVOC constituents with the most out-of-limit RPD results were the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans analyzed at SWRI and TAKN (11 results) and the TPH analyzed at GEL and TASL (four results). For the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans, many of the results have laboratory qualifier "J" flags, indicating that the result is an estimated value less than the laboratory estimated quantitation limit (EQL) and, therefore, is subject to more measurement variability than values greater than the EQL. Many of these same results are also "B" flagged to indicate contamination in the batch method blank. Any contamination that may have also occurred in the actual samples during sample preparation and analysis is likely to increase the variability in results between samples and duplicates.

For the radiochemical parameters, 520 sample duplicate result pairs yielded 129 result pairs (24.8%) that met the evaluation criterion. Of these duplicate pairs, 15 (11.6%) exceeded the RPD criterion; the out-of-limit RPD results ranged from 20.3% to 53.8%. The 15 out-of-limit RPD results were scattered among nine different radiochemical parameters (Table E-12). All samples were unfiltered, and the heterogeneous distribution of suspended solids may explain some of the RPD failures for gross alpha and the uranium isotopes.

E6.3 Field Split Samples

Field split samples are duplicate samples that are sent to two different laboratories to allow interlaboratory comparisons of analytical results. These comparisons are used to evaluate the performance of the laboratories, to determine the extent of any analytical problems, and to confirm out-of-trend results. As shown in Table E-1, the precision acceptance criterion for field splits is an RPD ≤20%. Only those field split results pairs with at least one result greater than five times the MDLs or MDAs of both laboratories were evaluated. If the laboratory reported an EQL or equivalent instead of an MDL, the evaluation criterion was one times the EQL instead of five times the MDL. For TOC and TOX split samples, a matching set of quadruplicate samples was submitted to each of the two laboratories. To evaluate the interlaboratory reproducibility for TOC and TOX, an average result was first calculated for each laboratory's quadruplicate sample set, and then the average values from the two laboratories were used to calculate the RPD.

For 2017, 122 field split sample sets consisting of 281 sample pairs yielded 1,627 pairs of field-split results. Of the 1,627 result pairs, 194 pairs (11.9%) met the evaluation criterion. Of the evaluated field splits, 128 pairs (66.0%) met the 20% RPD criterion. For comparison, the percentage of pairs within the limit was 90.0% for 2016 and 87.4% for 2015. Table E-13 summarizes the results for field splits that exceeded the 20% RPD limit.

Table E-13. Field Splits Exceeding QC Limits

Constituent	Total Number of Splits	Number of Splits Evaluated[a]	Number Out of Limits	Percent Out of Limits	Range of Out-of-Limit RPD[b]
Total Field Split Results Out = 66					
General Chemical Parameters: Total Out = 1					
Total organic halides	10	1	1	100	67.0
Ammonia and Anions: Total Out = 12					
Chloride	16	16	2	12.5	21.4 – 23.4
Cyanide	21	3	1	33.3	20.4
Cyanide amenable to chlorination	6	3	3	100	186 – 193
Fluoride	16	14	4	28.6	29.8 – 41.0
Nitrate	16	16	2	12.5	22.4 – 29.9
Metals: Total Out = 9					
Aluminum	1	1	1	100	116
Arsenic	3	1	1	100	24.0
Chromium	7	3	2	66.7	32.2 – 134
Cobalt	3	1	1	100	118
Magnesium	4	4	1	25.0	134
Manganese	3	1	1	100	107
Strontium	3	3	1	33.3	132
Zinc	3	1	1	100	97.0
Volatile Organic Compounds: Total Out = 2					
Acetone	30	1	1	100	181
Methylene chloride	30	1	1	100	142
Semivolatile Organic Compounds: Total Out = 32					
1,2,3,4,6,7,8-Heptachlorodibenzofuran	17	4	4	100	162 – 177
1,2,3,4,7,8,9-Heptachlorodibenzofuran	17	4	4	100	144 – 176
1,2,3,4,7,8-Hexachlorodibenzofuran	17	1	1	100	167
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	17	1	1	100	135
1,2,3,6,7,8-Hexachlorodibenzofuran	17	1	1	100	174
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	17	1	1	100	153
1,2,3,7,8,9-Hexachlorodibenzofuran	17	1	1	100	170

Table E-13. Field Splits Exceeding QC Limits

Constituent	Total Number of Splits	Number of Splits Evaluated[a]	Number Out of Limits	Percent Out of Limits	Range of Out-of-Limit RPD[b]
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	17	1	1	100	153
2,3,4,6,7,8-Hexachlorodibenzofuran	17	1	1	100	176
Heptachlorodibenzo-p-dioxins	17	1	1	100	173
Hexachlorodibenzofurans	17	1	1	100	42.9
Octachlorodibenzofuran	17	5	5	100	145 – 175
Octachlorodibenzo-p-dioxin	17	10	10	100	145 – 196
Radiochemical Parameters: Total Out = 10					
Gross beta	37	12	8	66.7	20.3 – 113
Iodine-129	16	2	2	100	51.1 – 61.8

a. Split sample results were evaluated when at least one result was >5 times the method detection limit or minimum detectable activity of both laboratories. In cases where a measured value was compared with a nondetected result, the method detection limit or minimum detectable activity was used as the nondetected result.

b. Split control limit is an RPD ≤20%.

RPD = relative percent difference

For the general chemical parameters, 35 of 56 split results (62.5%) passed the evaluation criterion. Only one split sample RPD failure occurred, which was for TOX with an RPD of 67.0%.

Ammonia and anions had 113 split result pairs, of which 68 pairs (60.2%) met the evaluation criterion. Of the 68 pairs, 12 result pairs (17.6%) exceeded the RPD limit with RPDs ranging from 20.4% to 193%. The most notable failure is for cyanide amenable to chlorination; all three splits that passed evaluation for this analyte were between GEL and SWRI and returned RPDs between 186% and 193%. GEL reported all nondetects (<3.3 µg/L) for this analyte, while SWRI reported results that ranged from 90.2 to 146 µg/L. Eight IC anion split failures occurred for chloride, fluoride, and nitrate, with the failures having RPDs between 21.4% and 41.0%.

The metals analyses had 87 field split result pairs, of which 29 pairs (33.3%) met the evaluation criterion. Of the 29 pairs, 9 pairs (31.0%) exceeded the RPD limit with RPDs between 24.0% and 134%. Two sample/split pairs represent all nine out-of-limit RPDs for metals; neither sample/split pairs were filtered. One pair, B38F17 (TASL) and B38F19 (GEL), were both analyzed by ICP/AES and have chromium, magnesium, and strontium results with RPDs of 132% to 134%. The nearly identical RPDs for the three analytes suggest a likely dilution error by one of the laboratories. The other sample pair, B38F53 (ALS) and B38F55A (TADN), were both analyzed by ICP/MS. The RPDs for the six analytes aluminum, arsenic, chromium, cobalt, manganese, and zinc ranged from 24.0% to 118%. The difference in results for this split-sample pair may be partly due to nonhomogeneous particulates in the two samples. Furthermore, ALS flagged chromium, cobalt, and manganese for the B38F53 sample results with a “C” flag, indicating that the analytes were also observed in the batch method blank; possible contamination of the sample during preparation and analysis may account for additional variability between the sample and split.

The VOCs had 620 split sample result pairs, of which only 3 pairs (0.5%) met the evaluation criterion. Two of the three result pairs (66.7%) exceeded the RPD criterion. The two VOC split failures were for acetone (RPD of 181) and methylene chloride (RPD of 142); both split failures were between TADN and TASL.

The SVOCs had 515 split result pairs, of which 33 result pairs (6.4%) met the evaluation criterion. Of the 33 result pairs, 32 pairs (97.0%) failed to meet the RPD limit requirement. All 32 of the SVOC split failures were for the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans analyzed at SWRI and TAKN. The split failures had RPDs between 42.9% and 196%; most of the out-of-limit RPDs were well above 100%. All the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans split results from TAKN have "J" qualifier flags (the result is an estimated value less than the laboratory EQL) and are, thus, subject to more measurement variability than values greater than the EQL. All of these same results are also "B" flagged to indicate contamination in the batch method blank, as any contamination that may have also occurred in the actual samples during sample preparation and analysis is likely to increase the variability in results between samples and splits. In general, when the split sample results for the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans meet the evaluation criterion, those results appear to compare poorly between the two analytical laboratories.

Radiochemical parameters had 236 split result pairs, of which 26 pairs (11.0%) met the evaluation criterion. Of the 26 pairs, 10 result pairs (38.5%) exceeded the RPD criterion with RPDs between 20.3% and 113%. The split failures were posted for gross beta (eight) and iodine-129 (two). One gross beta split failure was between GEL and TARL (RPD of 60.1%). Three of the gross beta split failures were between TARL and SWRI, and the remaining four gross beta split failures were between GEL and SWRI. When the sample gross beta activities were approximately <60 pCi/L, SWRI tended to be biased low compared to the other laboratories. When the sample activities were approximately >60 pCi/L, SWRI tended to be biased high compared to the other laboratories. Section E8.1 provides additional discussion on the blind standards.

E6.4 Quadruplicate Total Organic Carbon and Total Organic Halides Samples

TOC and TOX are classified as RCRA indicator analytes, and the samples for these analytes are usually taken in quadruplicate (40 CFR 265.92). For these analytes, the percent RSD of the quadruplicate results was determined (as described in Section E4.2) and compared to a precision limit of 20%. Field quadruplicate sample results are evaluated only if at least one result is at least five times the laboratory MDL.

For TOC, 238 quadruplicate sample sets were taken. Of these 238 sample sets, five sets (2.1%) met the evaluation criterion; of these sets, only one set exceeded the precision criterion with a percent RSD of 173%. One possible explanation for this failure may be inconsistent removal of inorganic carbon (typically present as bicarbonate or carbonate) from the sample prior to determining the organic carbon in the sample. If inorganic carbon is not consistently and completely removed from the sample before determining organic carbon, the apparent concentration of organic carbon is likely to vary across a set of quadruplicate samples.

For TOX, 241 quadruplicate sample sets were taken. Of these 241 sample sets, 42 sets (17.4%) met the evaluation criterion; of these, 27 sets (64.3%, two from GEL and 25 from TASL) exceeded the precision criterion with a range of percent RSDs from 20.5% to 112%. One possible explanation for these failures may be inconsistent rinsing of inorganic chloride from the sample prior to the determination of organic halides in the sample. If inorganic chloride is not consistently and completely removed from the sample before determining organic halides, the apparent concentration of organic halides is likely to vary across

a set of quadruplicate samples. A second source of error, particularly for gas-pressured systems, is the loss of volatile organic halogens from the sample into the sample headspace during elution of the sample through the charcoal columns. Table E-14 presents the quadruplicate sample sets that exceeded QC limits.

Table E-14. TOC and TOX Quadruplicate Results Exceeding QC Limits

Well Name	Lab	Reporting Limit µg/L	Result 1 (µg/L)		Result 2 (µg/L)		Result 3 (µg/L)		Result 4 (µg/L)		%RSD*
Total Organic Carbon: Total Out = 1											
299-E25-43	GEL	330	338	B	330	U	9,960	—	462	B	173
Total Organic Halides: Total Out = 27											
199-N-2	TASL	2.1	2.1	U	12.8	—	2.1	U	2.1	U	112
199-N-3	TASL	2.1	8.2	—	18.0	—	23.3	—	22.5	—	38.5
199-N-41	GEL	3.33	20.3	—	12.4	—	6.7	B	16.3	—	41.7
199-N-57	GEL	3.33	10.6	—	19.3	—	11.1	—	9.6	B	35.3
199-N-71	TASL	2.1	16.0	—	14.0	—	2.1	U	14.7	—	55.2
199-N-73	TASL	2.1	11.6	—	2.1	U	4.9	B	2.8	B	81.0
199-N-81	TASL	2.1	13.8	—	5.3	—	2.7	B	6.4	Y	67.5
299-E17-18	TASL	2.1	2.1	U	52.7	—	2.1	U	45.4	—	107
299-E25-19	TASL	2.1	3.9	BC	13.2	C	6.9	C	7.1	C	50.2
299-E25-19	TASL	2.1	7.4	C	12.3	C	7.2	C	8.7	C	26.5
299-E25-26	TASL	2.1	11.4	C	23.6	—	4.8	BC	10.3	C	63.3
299-E25-26	TASL	2.1	12.5	—	2.1	U	2.1	B	2.1	U	111
299-E26-12	TASL	2.1	12.0	—	2.1	U	8.8	—	11.4	—	52.9
299-E27-10	TASL	2.1	12.7	YN	12.5	N	11.3	N	7.8	N	20.5
299-E33-266	TASL	2.1	2.1	U	11.4	Y	10.0	—	7.2	—	53.5
299-E34-10	TASL	2.1	4.2	B	4.1	B	10.7	—	11.6	—	53.0
299-E34-2	TASL	2.1	4.1	BN	11.2	N	2.1	UN	2.4	BN	86.0
299-W10-31	TASL	2.1	2.1	U	9.7	—	11.4	—	10.6	—	50.8
299-W15-152	TASL	2.1	9.6	—	11.8	C	11.3	C	7.2	C	20.8
299-W15-152	TASL	2.1	14.1	C	16.0	C	8.7	C	7.4	C	35.9
299-W15-83	TASL	2.1	48.5	—	73.4	—	69.8	—	45.5	—	24.2
299-W17-1	TASL	2.1	2.1	U	10.7	—	4.3	B	2.1	U	84.7
299-W17-1	TASL	2.1	6.0	C	8.7	C	18.6	—	20.4	—	53.2
299-W18-21	TASL	2.1	14.1	—	22.0	—	13.7	—	16.2	—	23.2
699-25-34B	TASL	2.1	10.8	—	6.7	—	3.4	B	8.1	—	42.5
699-25-34B	TASL	2.1	12.8	C	9.0	C	14.2	C	17.4	C	26.1
699-43-44	TASL	2.1	4.9	B	2.1	U	11.5	—	7.6	—	61.4

Table E-14. TOC and TOX Quadruplicate Results Exceeding QC Limits

Well Name	Lab	Reporting Limit µg/L	Result 1 (µg/L)	Result 2 (µg/L)	Result 3 (µg/L)	Result 4 (µg/L)	%RSD*

* The RSD was compared to the field duplicate relative percent difference limit of 20%.

RSD = relative standard deviation
TADN = TestAmerica–Denver
TASL = TestAmerica–St. Louis
TOC = total organic carbon
TOX = total organic halides

Data flags:

B = analyte detected between the reporting limit and the estimated quantitation limit
C = contamination found in batch method blank
N = matrix spike/matrix spike duplicate recovery exceeds upper or lower control limits
O = laboratory control sample/laboratory control sample duplicate recovery exceeds upper or lower control limits
U = analyte not detected above the reporting limit
Y = see result-specific comment in data package

E7 Laboratory Quality Control

This chapter discusses the 2017 groundwater monitoring laboratory batch QC data that exceeded the QC acceptance criteria listed in Table E-1. The types of laboratory QC samples that are evaluated in this section are discussed in Section E4.3. Table E-15 summarizes the laboratory QC data by laboratory, and Table E-16 summarizes the laboratory QC data by analyte class. Overall, the laboratory QC data indicate that laboratory analytical measurements for the groundwater monitoring program are produced within the QC limits identified in Table E-1. Of the 179,517 laboratory batch QC measurements reported with groundwater monitoring results, 96.9% of the measurements met the groundwater monitoring QC requirements. This is similar to 97.5% reported for 2016 and 98.6% reported for 2015. When the laboratories detect failures in batch QC samples, the laboratories usually apply a QC laboratory qualifier to the data (as noted in Table E-3).

E7.1 Laboratory Method Blanks

Laboratory method blanks are used to assess potential contamination associated with laboratory sample preparation and analysis. Of the 38,473 laboratory method blank results evaluated for 2017, 97.5% met the QC criteria outlined in Table E-1 indicating few overall problems with laboratory contamination. This is comparable to 97.4% reported for 2016 and 97.2% reported for 2015.

Table E-15. Laboratory QC Results by Laboratory

QC Parameter		ALS	GEL	SWRI	TADN	TAKN	TARL	TASL	Total
Laboratory QC results	Total	12,305	58,696	501	52,923	339	6,044	48,709	179,517
	Out	200	2,539	21	1,143	75	114	1,501	5,593
	Out percent	1.6	4.3	4.2	2.2	22.1	1.9	3.1	3.1
Method blanks	Total	2,287	14,509	208	9,533	175	2,102	9,659	38,473
	Out	158	127	7	494	51	21	85	943
	Out percent	6.9	0.9	3.4	5.2	29.1	1.0	0.9	2.5
Laboratory control samples	Total	2,385	12,562	150	9,847	119	1,796	11,356	38,215
	Out low	0	803	3	174	1	15	686	1,682
	Out high	0	24	0	31	3	25	37	120
	Out percent	0.0	6.6	2.0	2.1	3.4	2.2	6.4	4.7
Laboratory control sample duplicates	Total	106	209	—	797	—	—	3,157	4,269
	Out	0	29	—	30	—	—	11	70
	Out percent	0.0	13.9	—	3.8	—	—	0.3	1.6
Matrix spikes	Total	4,958	16,225	68	19,505	—	1,198	11,507	53,461
	Out low	10	233	3	148	—	29	361	784
	Out high	29	55	1	128	—	8	125	346
	Out percent	0.8	1.8	5.9	1.4	—	3.1	4.2	2.1
Matrix spike duplicates	Total	2,477	7,384	16	9,753	—	4	5,542	25,176
	Out	3	317	0	121	—	0	78	519
	Out percent	0.1	4.3	0.0	1.2	—	0.0	1.4	2.1

Table E-15. Laboratory QC Results by Laboratory

QC Parameter		ALS	GEL	SWRI	TADN	TAKN	TARL	TASL	Total
Sample duplicates	Total	11	963	59	32	45	944	226	2,280
	Out	0	24	7	0	20	16	5	72
	Out percent	0.0	2.5	11.9	0.0	44.4	1.7	2.2	3.2
Surrogates	Total	63	6,211	—	2,909	—	—	6,316	15,499
	Out low	0	863	—	2	—	—	44	909
	Out high	0	12	—	2	—	—	42	56
	Out percent	0.0	14.1	—	0.1	—	—	1.4	6.2
Surrogate duplicates	Total	18	633	—	547	—	—	946	2,144
	Out	0	52	—	13	—	—	27	92
	Out percent	0.0	8.2	—	2.4	—	—	2.9	4.3

ALS = ALS laboratory
GEL = GEL laboratory
QC = quality control
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TAKN = TestAmerica–Knoxville
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis

Table E-16. Laboratory QC Results by Analyte Class

QC Parameter		General Chemical Parameters	Ammonia/ Anions	Metals	Volatile Organic Compounds	Semivolatile Organic Compounds	Radiochemical Parameters	Total
Laboratory QC results	Total	2,484	8,231	75,325	50,443	38,429	4,605	179,517
	Out	117	115	939	612	3,682	128	5,593
	Out percent	4.7	1.4	1.2	1.2	9.6	2.8	3.1
Method blanks	Total	697	2,234	15,706	8,666	9,021	2,149	38,473
	Out	69	27	753	5	62	27	943
	Out percent	9.9	1.2	4.8	0.1	0.7	1.3	2.5
Laboratory control samples	Total	759	2,293	15,926	11,573	6,181	1,483	38,215
	Out low	0	13	0	30	1,621	18	1,682
	Out high	0	0	4	62	28	26	120
	Out percent	0.0	0.6	0.0	0.8	26.7	3.0	4.7
Laboratory control sample duplicates	Total	63	23	236	3,586	320	41	4,269
	Out	1	0	0	30	38	1	70
	Out percent	1.6	0.0	0.0	0.8	11.9	2.4	1.6
Matrix spikes	Total	607	2,163	28,985	10,732	10,486	488	53,461
	Out low	15	53	66	282	361	7	784
	Out high	22	16	81	102	124	1	346
	Out percent	6.1	3.2	0.5	3.6	4.6	1.6	2.1
Matrix spike duplicates	Total	95	37	14,336	5,366	5,253	89	25,176
	Out	5	0	35	90	382	7	519
	Out percent	5.3	0.0	0.2	1.7	7.3	7.9	2.1
Sample duplicates	Total	263	1,481	136	—	45	355	2,280
	Out	5	6	0	—	20	41	72
	Out percent	1.9	0.4	0.0	—	44.4	11.5	3.2

Table E-16. Laboratory QC Results by Analyte Class

QC Parameter		General Chemical Parameters	Ammonia/ Anions	Metals	Volatile Organic Compounds	Semivolatile Organic Compounds	Radiochemical Parameters	Total
Surrogates	Total	—	—	—	9,275	6,224	—	15,499
	Out low	—	—	—	0	909	—	909
	Out high	—	—	—	1	55	—	56
	Out percent	—	—	—	0.0	15.5	—	6.2
Surrogate duplicates	Total	—	—	—	1,245	899	—	2,144
	Out	—	—	—	10	82	—	92
	Out percent	—	—	—	0.8	9.1	—	4.3

QC = quality control

Evaluation of method blank results was based on the method blank QC limits listed in Table E-1. For the common laboratory contaminants 2-butanone, acetone, methylene chloride, phthalate esters, and toluene, the QC limit is five times the MDL. The laboratories flag results associated with out-of-limit blank results in the laboratory qualifier field in the HEIS database (as described in Table E-3). For inorganic analytes (including the indicator analytes TOC and TOX), results associated with an out-of-limit method blank are flagged as "C." For organic analytes, results associated with an out-of-limit method blank are flagged as "B." The laboratory may not flag the groundwater sample result if the analyte concentration in the method blank is <5.0% of the concentration of the analyte in a groundwater sample analyzed in the same batch. Table E-17 summarizes the 2017 out-of-limit method blank results.

E7.1.1 Method Blanks by Laboratory

By laboratory, ALS reported 5.9% of all method blank results for 2017. Of the 2,287 method blank results reported by ALS, 93.1% met the QC criterion with 158 method blank failures. Of the 158 method blank failures, 156 were for ICP metals and included aluminum (24), manganese (17), chromium (15), nickel (12), sodium (11), and iron (10); the remaining ICP metals had fewer than 10 failures. ALS also reported one method blank failure each for chloride and gross beta.

GEL reported 37.7% of all method blank results for 2017. GEL had a success rate of 99.1% for the 14,509 method blank results reported by that laboratory, with only 127 method blank failures. For the general chemical parameters, GEL reported method blank failures for TOC (1 of 54 blank results) and TOX (2 of 92). For ammonia and anions, GEL reported method blank failures for ammonium ion (6 of 10 blank results), chloride (2 of 176), phosphate (1 of 26), and sulfate (1 of 176). GEL reported 110 out-of-limits method blanks for the metals which included sodium (28), potassium (25), and nickel (11); the remaining ICP metals had fewer than 10 failures. GEL reported one VOC method blank failure for tetrahydrofuran and one SVOC method blank failure for aliphatic petroleum hydrocarbons (>nC21-nC34). For the radiochemical parameters, GEL posted two method blank failures for radium-228.

SWRI reported 208 method blank results, or only 0.5% of all method blank results for 2017. Of the 208 method blank results reported by that laboratory, 96.6% met the QC criterion, with only seven method blank failures. The seven blank failures were all for radionuclides: europium-154 (three), tritium (two), iodine-129 (one), and strontium-90 (one).

TADN reported 24.8% of all method blank results for 2017 and had a success rate of 94.8% for the 9,533 method blank results reported, with 494 method blank results that did not meet the QC criterion. For the general chemical parameters, TADN reported 59 out-of-limits method blanks for alkalinity/bicarbonate/carbonate (46 of 67 method blank results) and TOC (13 of 34). The out-of-limits method blank results represent a significant fraction of the method blank results for those general chemical parameters. For the anions, TADN reported a single method blank failure for cyanide. TADN reported 427 method blank failures for ICP metals including sodium (73), manganese (53), iron (46), calcium (40), magnesium (30), zinc (24), barium (21), boron (18), potassium (18), lead (11), molybdenum (11), silver (11), and aluminum (10); the remaining ICP metals had fewer than 10 method blank failures. TADN reported four out-of-limit method blanks for the VOC methylene chloride. Finally, TADN reported three SVOC method blank failures for TPH-diesel range.

TAKN reported the lowest success rate for method blanks, at 70.9% for the 175 method blank results reported by that laboratory; however, TAKN reported only 0.5% of all method blank results for 2017. The 51 method blank failures were for a number of polychlorodibenzo-p-dioxins and polychlorodibenzofurans. Six of the seven batches analyzed for these analytes at TAKN suffered from method blank contamination.

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Total Method Blanks Out = 943						
General Chemical Parameters: Total Out = 69						
Alkalinity	TADN	29	24	82.8	1,070 µg/L	2,490 – 4,250 µg/L
Bi-carbonate alkalinity	TADN	19	7	36.8	1,070 µg/L	1,140 – 1,780 µg/L
Carbonate alkalinity	TADN	19	15	78.9	1,070 µg/L	1,310 – 3,300 µg/L
Total organic carbon	GEL	54	1	1.9	330 µg/L	486 µg/L
Total organic carbon	TADN	34	13	38.2	155 µg/L	156 – 294 µg/L
Total organic carbon	TASL	40	1	2.5	500 – 720 µg/L	637 µg/L
Total organic halides	GEL	92	2	2.2	3.33 µg/L	5.1 – 9.68 µg/L
Total organic halides	TASL	34	6	17.6	2.1 µg/L	2.37 – 8.03 µg/L
Ammonia and Anions: Total Out = 27						
Ammonium ion	GEL	10	6	60.0	21.9 µg/L	23.3 – 60.4 µg/L
Ammonium ion	TASL	6	2	33.3	28.7 µg/L	29.4 – 34 µg/L
Chloride	ALS	5	1	20.0	60 µg/L	96 µg/L
Chloride	GEL	176	2	1.1	67 µg/L	72.3 – 112 µg/L
Chloride	TARL	177	2	1.1	100 µg/L	115 – 120 µg/L
Chloride	TASL	23	2	8.7	20 µg/L	24.1 – 54.2 µg/L
Cyanide	TADN	7	1	14.3	2 µg/L	2.29 µg/L
Cyanide	TASL	20	3	15.0	3.1 µg/L	3.84 – 5.03 µg/L
Fluoride	TARL	174	1	0.6	25 µg/L	27.8 µg/L
Nitrate	TARL	180	2	1.1	62 µg/L	72.2 – 119 µg/L
Phosphate	GEL	26	1	3.8	205 µg/L	206 µg/L
Sulfate	GEL	176	1	0.6	133 µg/L	210 µg/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Sulfate	TARL	180	2	1.1	130 µg/L	183 – 221 µg/L
Sulfate	TASL	23	1	4.3	50 µg/L	86.9 µg/L
Metals: Total Out = 753						
Aluminum	ALS	63	24	38.1	8.7 – 14 µg/L	9.6 – 1,200 µg/L
Aluminum	GEL	125	1	0.8	15 – 19.3 µg/L	15.4 µg/L
Aluminum	TADN	163	10	6.1	9.2 – 13 µg/L	9.85 – 62.5 µg/L
Aluminum	TASL	71	6	8.5	20 µg/L	24.5 – 33 µg/L
Antimony	ALS	87	9	10.3	0.049 – 6.2 µg/L	0.05 – 1.1 µg/L
Antimony	GEL	180	2	1.1	1 – 3.5 µg/L	1.01 – 3.98 µg/L
Antimony	TADN	268	3	1.1	0.4 – 5.2 µg/L	0.402 – 6.17 µg/L
Antimony	TASL	113	5	4.4	2 – 3 µg/L	2.68 – 9.16 µg/L
Arsenic	ALS	87	3	3.4	0.18 – 3.9 µg/L	4.7 – 9.6 µg/L
Arsenic	GEL	181	5	2.8	1.7 – 5 µg/L	1.84 – 2.36 µg/L
Arsenic	TADN	267	4	1.5	0.33 – 4.4 µg/L	5.26 – 6.27 µg/L
Barium	ALS	87	3	3.4	0.23 – 30 µg/L	0.57 – 4.3 µg/L
Barium	GEL	180	1	0.6	0.6 – 1 µg/L	0.678 µg/L
Barium	TADN	268	21	7.8	0.29 – 0.82 µg/L	0.308 – 1.9 µg/L
Barium	TASL	112	1	0.9	0.9 – 15 µg/L	1.93 µg/L
Beryllium	TADN	165	3	1.8	0.08 – 0.47 µg/L	0.097 – 0.226 µg/L
Beryllium	TASL	73	4	5.5	0.2 – 1.5 µg/L	0.214 – 0.33 µg/L
Boron	ALS	59	2	3.4	6.4 – 30 µg/L	6.7 – 8.3 µg/L
Boron	TADN	175	18	10.3	4.4 µg/L	4.61 – 60.9 µg/L
Cadmium	TADN	266	4	1.5	0.27 – 0.45 µg/L	0.48 – 0.6 µg/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Calcium	ALS	77	5	6.5	23 – 300 µg/L	27 – 590 µg/L
Calcium	GEL	156	3	1.9	50 µg/L	51.9 – 75.2 µg/L
Calcium	TADN	229	40	17.5	34.5 µg/L	34.9 – 869 µg/L
Chromium	ALS	103	15	14.6	0.82 – 3 µg/L	1 – 9.3 µg/L
Chromium	GEL	211	2	0.9	1 – 3 µg/L	1.07 – 1.66 µg/L
Chromium	TADN	319	4	1.3	0.5 – 0.66 µg/L	0.77 – 4.85 µg/L
Cobalt	ALS	87	4	4.6	0.07 – 3 µg/L	0.09 – 0.41 µg/L
Cobalt	GEL	180	1	0.6	0.1 – 1 µg/L	0.12 µg/L
Cobalt	TADN	268	5	1.9	0.054 – 1.2 µg/L	0.057 – 1.65 µg/L
Copper	ALS	87	1	1.1	1.1 – 6 µg/L	2.4 µg/L
Copper	TADN	266	5	1.9	0.56 – 4.2 µg/L	0.733 – 6.74 µg/L
Copper	TASL	114	26	22.8	0.4 – 7 µg/L	0.406 – 6.14 µg/L
Hexavalent chromium	TARL	258	1	0.4	1.5 µg/L	2.3 µg/L
Iron	ALS	77	10	13.0	16 – 30 µg/L	17 – 110 µg/L
Iron	GEL	156	1	0.6	30 µg/L	38.6 µg/L
Iron	TADN	232	46	19.8	22 µg/L	22.2 – 982 µg/L
Iron	TASL	82	1	1.2	30 µg/L	53.3 µg/L
Lead	ALS	63	5	7.9	0.096 – 0.85 µg/L	0.1 – 0.2 µg/L
Lead	GEL	126	2	1.6	0.5 µg/L	0.536 – 0.753 µg/L
Lead	TADN	171	11	6.4	0.18 µg/L	0.195 – 0.361 µg/L
Lead	TASL	70	1	1.4	1 µg/L	1.78 µg/L
Magnesium	TADN	232	30	12.9	10.7 µg/L	11.1 – 191 µg/L
Manganese	ALS	87	17	19.5	0.3 – 3 µg/L	0.55 – 4.7 µg/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Manganese	TADN	270	53	19.6	0.26 – 0.31 µg/L	0.29 – 3.17 µg/L
Manganese	TASL	115	7	6.1	0.9 – 4 µg/L	0.912 – 5.58 µg/L
Mercury	TADN	61	2	3.3	0.027 µg/L	0.0317 – 0.0367 µg/L
Molybdenum	ALS	64	3	4.7	0.15 – 0.6 µg/L	0.16 – 0.7 µg/L
Molybdenum	GEL	125	5	4.0	0.2 – 0.3 µg/L	0.208 – 0.317 µg/L
Molybdenum	TADN	161	11	6.8	0.14 µg/L	0.145 – 2.73 µg/L
Nickel	ALS	86	12	14.0	0.81 – 11 µg/L	1.5 – 7.6 µg/L
Nickel	GEL	180	11	6.1	0.5 – 1.5 µg/L	0.546 – 0.735 µg/L
Nickel	TADN	267	6	2.2	0.3 – 2.6 µg/L	0.352 – 4.24 µg/L
Nickel	TASL	113	1	0.9	2 – 10 µg/L	2.32 µg/L
Potassium	ALS	77	5	6.5	86 – 300 µg/L	160 – 190 µg/L
Potassium	GEL	156	25	16.0	50 µg/L	50.3 – 157 µg/L
Potassium	TADN	231	18	7.8	237 µg/L	249 – 799 µg/L
Selenium	ALS	64	1	1.6	0.18 – 3.5 µg/L	0.27 µg/L
Selenium	TADN	171	1	0.6	0.7 µg/L	0.761 µg/L
Silver	ALS	87	1	1.1	0.023 – 3 µg/L	0.05 µg/L
Silver	TADN	266	11	4.1	0.033 – 0.93 µg/L	0.038 – 1.69 µg/L
Sodium	ALS	77	11	14.3	26 – 300 µg/L	58 – 830 µg/L
Sodium	GEL	156	28	17.9	100 µg/L	101 – 597 µg/L
Sodium	TADN	232	73	31.5	117 µg/L	118 – 494 µg/L
Strontium	ALS	69	7	10.1	0.12 – 3 µg/L	0.13 – 2.5 µg/L
Strontium	TADN	164	4	2.4	0.3 µg/L	0.311 – 0.7 µg/L
Strontium	TASL	73	3	4.1	0.5 – 1.5 µg/L	0.518 – 0.67 µg/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Thallium	ALS	64	1	1.6	0.014 – 0.084 µg/L	0.04 µg/L
Thallium	TADN	163	9	5.5	0.05 µg/L	0.058 – 0.173 µg/L
Thorium	ALS	64	2	3.1	0.014 – 0.06 µg/L	0.04 – 0.09 µg/L
Thorium	GEL	125	1	0.8	0.6 – 0.7 µg/L	0.793 µg/L
Tin	ALS	64	3	4.7	0.73 – 3 µg/L	0.89 – 1.2 µg/L
Tin	GEL	125	6	4.8	1 µg/L	1.01 – 1.48 µg/L
Tin	TADN	162	1	0.6	0.77 µg/L	0.895 µg/L
Uranium	ALS	77	1	1.3	0.022 – 0.03 µg/L	0.05 µg/L
Uranium	GEL	157	8	5.1	0.067 µg/L	0.08 – 0.272 µg/L
Uranium	TADN	185	6	3.2	0.05 µg/L	0.068 – 0.224 µg/L
Vanadium	ALS	77	3	3.9	0.93 – 3 µg/L	1.2 – 2.2 µg/L
Vanadium	GEL	156	2	1.3	1 µg/L	1.16 – 1.2 µg/L
Vanadium	TADN	230	4	1.7	1.1 µg/L	1.23 – 1.74 µg/L
Vanadium	TASL	82	4	4.9	4 – 25 µg/L	4.4 – 10.7 µg/L
Zinc	ALS	87	8	9.2	2.8 – 48 µg/L	3.6 – 91 µg/L
Zinc	GEL	180	6	3.3	3.3 – 3.5 µg/L	3.31 – 4.82 µg/L
Zinc	TADN	268	24	9.0	2 – 4.5 µg/L	2.01 – 7.88 µg/L
Volatile Organic Compounds: Total Out = 5						
Methylene chloride[b]	TADN	74	4	5.4	1.6 µg/L	1.63 – 6.59 µg/L
Tetrahydrofuran	GEL	27	1	3.7	1.5 µg/L	1.71 µg/L
Semivolatile Organic Compounds: Total Out = 62						
1,2,3,4,6,7,8-Heptachlorodibenzodioxin	TAKN	7	3	42.9	0.34 – 1.18 µg/L	2.2 – 11.6 µg/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
1,2,3,4,6,7,8-Heptachlorodibenzofuran	TAKN	7	4	57.1	0.19 – 0.66 µg/L	0.76 – 10 µg/L
1,2,3,4,7,8,9-Heptachlorodibenzofuran	TAKN	7	3	42.9	0.26 – 0.87 µg/L	0.867 – 9.58 µg/L
1,2,3,4,7,8-Hexachlorodibenzofuran	TAKN	7	1	14.3	0.17 – 0.7 µg/L	5.98 µg/L
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	TAKN	7	1	14.3	0.23 – 0.95 µg/L	7.04 µg/L
1,2,3,6,7,8-Hexachlorodibenzofuran	TAKN	7	2	28.6	0.17 – 0.71 µg/L	0.781 – 6.21 µg/L
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	TAKN	7	1	14.3	0.24 – 0.96 µg/L	6.44 µg/L
1,2,3,7,8,9-Hexachlorodibenzofuran	TAKN	7	2	28.6	0.2 – 0.92 µg/L	0.804 – 6.65 µg/L
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	TAKN	7	2	28.6	0.22 – 0.89 µg/L	0.825 – 8.66 µg/L
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	TAKN	7	1	14.3	0.26 – 1.2 µg/L	2.96 µg/L
2,3,4,6,7,8-Hexachlorodibenzofuran	TAKN	7	2	28.6	0.18 – 0.73 µg/L	0.748 – 8.18 µg/L
2,3,4,7,8-Pentachlorodibenzofuran	TAKN	7	1	14.3	0.22 – 1.07 µg/L	4.19 µg/L
Aliphatic petroleum hydrocarbons >nC21-nC34	GEL	4	1	25.0	15 µg/L	101 µg/L
Dibenz[a,h]anthracene	TASL	26	1	3.8	0.046 – 1 µg/L	0.0468 µg/L
Dinoseb(2-secButyl-4,6-dinitrophenol)	TASL	38	1	2.6	0.73 – 2 µg/L	1.66 µg/L
Fluoranthene	TASL	26	1	3.8	0.034 – 1 µg/L	0.069 µg/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Fluorene	TASL	26	1	3.8	0.032 – 1 µg/L	0.0578 µg/L
Heptachlorodibenzofurans	TAKN	7	5	71.4	0.22 – 0.75 µg/L	0.76 – 19.6 µg/L
Heptachlorodibenzo-p-dioxins	TAKN	7	3	42.9	0.34 – 1.18 µg/L	2.8 – 18.4 µg/L
Hexachlorodibenzofurans	TAKN	7	2	28.6	0.18 – 0.88 µg/L	2.33 – 31.9 µg/L
Hexachlorodibenzo-p-dioxin	TAKN	7	3	42.9	0.23 – 0.93 µg/L	3.49 – 41.2 µg/L
Indeno(1,2,3-cd)pyrene	TASL	26	1	3.8	0.04 – 1 µg/L	0.0623 µg/L
Octachlorodibenzofuran	TAKN	7	5	71.4	0.095 – 1.1 µg/L	2.67 – 26.1 µg/L
Octachlorodibenzo-p-dioxin	TAKN	7	6	85.7	0.14 – 0.63 µg/L	1.86 – 36.5 µg/L
Pentachlorodibenzofurans	TAKN	7	1	14.3	0.23 – 1.12 µg/L	4.19 µg/L
Pentachlorodibenzo-p-dioxins	TAKN	7	2	28.6	0.26 – 1.2 µg/L	2.88 – 5.36 µg/L
Phenanthrene	TASL	26	1	3.8	0.065 – 1 µg/L	0.239 µg/L
Pyrene	TASL	26	1	3.8	0.037 – 1 µg/L	0.0471 µg/L
Tetrachlorodibenzo-p-dioxins	TAKN	7	1	14.3	0.31 – 2.9 µg/L	3.39 µg/L
Total petroleum hydrocarbons–diesel range	TADN	5	3	60.0	33 µg/L	37.6 – 46.7 µg/L
Radiochemical Parameters: Total Out = 21						
Carbon-14	TARL	34	1	2.9	11.9 – 18 pCi/L	38.3 pCi/L
Europium-154	SWRI	5	3	60.0	7.1 – 8.2 pCi/L	11 – 13.4 pCi/L
Gross alpha	TARL	57	2	3.5	0.507 – 0.981 pCi/L	0.814 – 0.999 pCi/L
Gross beta	ALS	2	1	50.0	0.995 – 1.08 pCi/L	1.21 pCi/L
Gross beta	TARL	46	2	4.3	1.45 – 2.11 pCi/L	1.62 – 2.39 pCi/L
Iodine-129	SWRI	13	1	7.7	0.651 – 0.996 pCi/L	1.24 pCi/L
Plutonium-241	TARL	24	1	4.2	10.1 – 14 pCi/L	13.7 pCi/L
Potassium-40	TARL	31	1	3.2	21.2 – 124 pCi/L	33.5 pCi/L

Table E-17. Method Blank Out-of-Limit Results

Constituent	Laboratory	Number of Results	Number Out of Limits	Percent Out of Limits	Range of QC Limits[a]	Range of Out-of-Limit Results
Radium-228	GEL	11	2	18.2	0.547 – 2.69 pCi/L	1.34 – 1.6 pCi/L
Selenium-79	TARL	38	1	2.6	9.51 – 23.4 pCi/L	19.9 pCi/L
Strontium-90	SWRI	16	1	6.2	0.829 – 1.93 pCi/L	1.73 pCi/L
Strontium-90	TARL	38	2	5.3	0.462 – 1.56 pCi/L	1.89 – 6.27 pCi/L
Strontium-90	TASL	23	4	17.4	0.112 – 0.809 pCi/L	0.126 – 0.976 pCi/L
Technetium-99	TARL	39	1	2.6	7.41 – 18.3 pCi/L	14.6 pCi/L
Tritium	SWRI	17	2	11.8	130 – 226 pCi/L	234 – 278 pCi/L
Tritium	TARL	45	2	4.4	28.6 – 625 pCi/L	491 – 507 pCi/L

a. For the nonradiochemical analytes, the QC limit for method blanks is the method detection limit. For radiochemical constituents, the QC limit is the minimum detectable activity.

b. The QC limit for this analyte is five times the method detection limit.

ALS = ALS Laboratory
GEL = GEL Laboratory
QC = quality control
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TAKN = TestAmerica–Knoxville
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis

TARL reported 5.5% of all method blank results for 2017. Of the 2,102 method blank results reported by that laboratory, 99.0% met the QC criterion with only 21 method blank failures. Of the 21 method blank failures, 13 were for radioanalytes. Gross alpha, gross beta, strontium-90, and tritium each had two out-of-limit method blank results and carbon-14, plutonium-241, potassium-40, selenium-79, and technetium-99 each had a single out-of-limit method blank. The IC anions had seven out-of-limit method blank results that included two each for chloride, nitrate, and sulfate, and one for fluoride. TARL reported one method blank failure for Cr(VI).

TASL reported 9,659 method blank results, or 25.1% of all method blank results for 2017. The laboratory had a success rate of 99.1%, with 85 method blank results that did not meet the QC criterion. For the general chemical parameters, TASL reported one out-of-limits method blank for TOC and seven out-of-limits method blanks for TOX. For the anions, TASL reported three method blank failures for cyanide, two each for ammonium ion and chloride, and one for sulfate. The majority of out-of-limit method blank results were for 59 method blank failures for ICP metals including copper (26); the remaining ICP metals had fewer than 10 method blank failures. TASL also reported seven SVOC method blank failures for the polynuclear aromatic hydrocarbons (PAHs).

E7.1.2 Method Blanks by Analyte Class

By analyte category, general chemical parameters had the lowest method blank success rate at 90.1% with 69 out-of-limit method blank results of the 697 method blank results. The general chemical parameter analytes with the poorest method blank success were alkalinity/-bicarbonate/-carbonate/-hydroxyl ion, with 46 of 326 method blank results out of limits. TOC had 15 failures of 137 results, followed by TOX with 8 failures of 180 results.

Ammonia and anions had a method blank success rate of 98.8%, with 27 method blank failures of 2,234 method blank results. The breakdown by analyte of method blank out-of-limit results versus total number of analyte method blank results includes ammonium ion (8 of 16 results), chloride (7 of 381 results), cyanide (4 of 117 results), fluoride (1 of 378 results), nitrate (2 of 385 results), phosphate (1 of 69 results), and sulfate (4 of 384 results).

Metals had the next lowest method blank success rate at 95.2%, with 753 method blank failures of 15,706 method blank results. The most common blank failures were sodium (112 of 547 results), manganese (77 of 652 results), iron (58 of 547 results), calcium (48 of 544 results), potassium (48 of 546 results), aluminum (41 of 422 results), zinc (38 of 648 results), copper (32 of 647 results), magnesium (30 of 547 results), and nickel (30 of 646 results). The remaining metals had fewer than 30 out-of-limit method blank results.

The VOC analyte class had a method blank success rate >99.0% (five failures in 8,666 results) and will not be discussed in detail, other than to note that the appearance of 2-propanol was not reported in any VOC method blank.

The SVOCs had a method blank success rate of 99.3% (62 failures of 9,021 results). Fifty-one of the failures were for a number of polychlorodibenzo-p-dioxins and polychlorodibenzofurans analyzed in six different batches by EPA Method 8290 at TAKN. The remaining 11 failures were for PAHs (six failures in a single batch analyzed at TASL), TPH-diesel (three failures analyzed in two different batches at TADN), and one failure each for aliphatic petroleum hydrocarbons (> nC21-nC34) (analyzed at GEL) and Dinoseb (analyzed at TASL).

The radiological analyte method blank results met the QC criterion at a success rate of 98.7% with 27 of 2,149 method blank results not meeting the QC criterion. The failed method blanks were for strontium-90 (seven), tritium (four), europium-154 (three), gross beta (three), gross alpha (two), radium-228 (two), and one each for carbon-14, iodine-129, plutonium-241, potassium-40, selenium-79, and technetium-99.

E7.2 Laboratory Control Samples and Laboratory Control Sample Duplicates

The LCS recoveries provide a measure of the accuracy of an analytical result, and the LCS duplicate RPD provides a measure of the repeatability of the analytical result. Laboratories may apply a qualifier of "O" or "X" and an accompanying explanatory note when LCS recoveries or LCSD RPDs are outside of the QC limits. For 2017, LCS and LCSD results were available across all of the analyte categories. In this section, "LCS" includes both LCSs and LCSDs when percent recoveries are being discussed.

Overall for 2017, 95.3% of the percent recoveries for the 38,215 reported LCS results, and 98.4% of the RPDs for the 4,269 reported LCSD results met the QC criteria listed in Table E-1. This is somewhat lower than the acceptance rates of 98.0% for LCS percent recoveries and 99.3% for LCSD RPDs during 2016 and the acceptance rates of 99.5% for LCS percent recoveries and 99.3% of the LCSD RPDs during 2015.

The primary reason for the lower LCS success rate is how the LCS recoveries were evaluated in 2017 compared to previous years. Prior to this 2017 data usability assessment, LCS recoveries were judged primarily against laboratory statistically generated LCS recovery limits. For the current reporting period, LCS recoveries were compared to the LCS recovery requirements of CHPRC-00189 (Table E-1). The change in LCS recovery limits from previous years to 2017 is most evident in the SVOC analytes; the SVOC LCS recoveries appear much poorer for the 2017 data set compared to previous years.

Nonetheless, these success rates of 95.3% for LCS percent recoveries and 98.4% for LCSD RPDs provide assurance that the analytical measurement processes are in reasonable control and are producing results with sufficient accuracy and precision to meet the needs of the groundwater monitoring program. Table E-18 summarizes the 2017 out-of-limits LCS and LCSD results.

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
General Chemical Parameters: Recovery Limits = 80% - 120%, RPD Limit = 20%						
Total organic halides	TADN	76	—	—	22	1
Ammonia and Anions: Recovery Limits = 80% - 120%, RPD Limit = 20%						
Sulfide	TASL	15	13	—	—	—
Metals: Recovery Limits = 80% - 120%, RPD Limit = 20%						
Aluminum	TADN	167	—	1	5	—
Mercury	TADN	70	—	2	9	—
Zinc	TADN	275	—	1	8	—
Volatile Organic Compounds: Recovery Limits = 70% - 130%, RPD Limit = 20%						
1,1,1-Trichloroethane	TADN	88	1	—	15	1

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
1,1-Dichloroethene	TADN	88	1	—	15	1
1,2-Dibromo-3-chloropropane	TADN	13	1	—	3	—
1,2-Dibromo-3-chloropropane	TASL	84	—	—	42	1
1,2-Dichloroethane	TADN	88	—	2	15	—
1,4-Dichlorobenzene	TADN	31	—	—	8	1
1-Butanol	GEL	27	—	1	—	—
2-Butanone	GEL	84	—	3	—	—
2-Butanone	TADN	88	1	5	15	1
2-Butanone	TASL	156	—	—	78	2
4-Methyl-2-pentanone	TADN	88	1	1	15	1
4-Methyl-2-pentanone	TASL	156	—	—	78	1
Acetone	GEL	84	—	2	—	—
Acetone	TADN	88	1	6	15	1
Acetone	TASL	156	—	—	78	1
Acrolein	TADN	13	5	—	3	1
Acrolein	TASL	84	—	5	42	—
Benzene	TADN	88	—	—	15	1
Bromomethane	TADN	13	—	1	3	—
Bromomethane	TASL	84	2	4	42	—
Carbon disulfide	TADN	88	1	—	15	1
Carbon tetrachloride	TADN	88	1	1	15	—
Chlorobenzene	TADN	88	—	—	15	1
Chloromethane	GEL	52	—	1	—	—
Chloromethane	TADN	13	1	1	3	—
Dichlorodifluoromethane	GEL	48	—	5	—	—
Dichlorodifluoromethane	TADN	13	—	1	3	—
Dichlorodifluoromethane	TASL	84	2	1	42	—
Ethylbenzene	TADN	88	—	—	15	1
Iodomethane	TASL	84	2	4	42	1
Isobutyl alcohol	TADN	13	—	2	3	—
Isobutyl alcohol	TASL	84	—	—	42	3
Methylene chloride	TADN	89	—	5	15	1

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
Tetrachloroethene	TADN	88	—	—	15	2
Tetrahydrofuran	TADN	6	1	—	3	1
trans-1,2-Dichloroethylene	TADN	31	—	—	8	1
Trichloroethene	TADN	88	1	—	15	—
Trichloromonofluoromethane	TADN	13	—	1	3	—
Trichloromonofluoromethane	TASL	84	—	3	42	1
Vinyl acetate	GEL	48	—	1	—	—
Vinyl acetate	TADN	13	6	—	3	1
Vinyl acetate	TASL	84	—	4	42	—
Vinyl chloride	GEL	89	—	1	—	—
Vinyl chloride	TADN	88	2	1	15	2
Xylenes (total)	TADN	88	—	—	15	1
Semivolatile Organic Compounds: Recovery Limits = 70% - 130%, RPD Limit = 20%[b]						
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	TAKN	7	—	1	—	—
1,2,3,7,8-Pentachlorodibenzofuran	TAKN	7	1	—	—	—
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	TAKN	7	—	1	—	—
1,2,4,5-Tetrachlorobenzene	GEL	25	14	—	1	—
1,2,4-Trichlorobenzene	GEL	25	17	—	1	—
1,2,4-Trichlorobenzene	TADN	7	4	—	1	—
1,2,4-Trichlorobenzene	TASL	19	18	—	—	—
1,2-Dichlorobenzene	GEL	25	18	—	1	—
1,2-Dichlorobenzene	TADN	7	5	—	1	—
1,2-Dichlorobenzene	TASL	19	18	—	—	—
1,3-Dichlorobenzene	GEL	25	20	—	1	—
1,3-Dichlorobenzene	TADN	7	5	—	1	—
1,3-Dichlorobenzene	TASL	19	18	—	—	—
1,4-Dichlorobenzene	GEL	29	22	—	1	—
1,4-Dichlorobenzene	TADN	7	5	—	1	—
1,4-Dichlorobenzene	TASL	24	23	—	—	—
1,4-Dioxane	GEL	34	34	—	1	—
1,4-Dioxane	TADN	8	3	—	1	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
2-(2-methyl-4-chlorophenoxy) propionic acid	GEL	25	6	—	2	—
2-(2-methyl-4-chlorophenoxy) propionic acid	TADN	24	4	—	7	—
2-(2-methyl-4-chlorophenoxy) propionic acid	TASL	8	2	4	—	—
2,3,4,6-Tetrachlorophenol	GEL	39	4	—	2	—
2,3,7,8-Tetrachlorodibenzo-p-dioxin	TAKN	7	—	1	—	—
2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	GEL	25	—	1	2	—
2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	TADN	24	7	—	7	—
2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	TASL	8	2	1	—	—
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	GEL	25	—	3	2	—
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	TADN	24	7	—	7	1
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	TASL	8	2	2	—	—
2,4,5-Trichlorophenol	GEL	39	5	—	2	—
2,4,5-Trichlorophenol	TASL	29	5	—	—	—
2,4,6-Trichlorophenol	GEL	39	5	—	2	1
2,4,6-Trichlorophenol	TASL	29	3	—	—	—
2,4-D(2,4-Dichlorophenoxyacetic acid)	GEL	25	—	1	2	—
2,4-D(2,4-Dichlorophenoxyacetic acid)	TADN	24	5	—	7	—
2,4-D(2,4-Dichlorophenoxyacetic acid)	TASL	8	2	1	—	—
2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	TADN	24	9	—	7	2
2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	TASL	8	2	2	—	—
2,4-Dichlorophenol	GEL	40	5	—	2	—
2,4-Dichlorophenol	TASL	33	6	—	—	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
2,4-Dimethylphenol	GEL	39	12	—	2	—
2,4-Dimethylphenol	TADN	14	4	—	1	—
2,4-Dimethylphenol	TASL	29	10	—	—	—
2,4-Dinitrophenol	GEL	39	15	—	2	—
2,4-Dinitrophenol	TASL	29	13	—	—	—
2,4-Dinitrotoluene	GEL	25	2	—	1	—
2,4-Dinitrotoluene	TASL	19	1	—	—	—
2,6-Dichlorophenol	GEL	39	—	—	2	1
2,6-Dinitrotoluene	GEL	25	3	—	1	—
2,6-Dinitrotoluene	TASL	19	2	—	—	—
2-Chloronaphthalene	GEL	25	13	—	1	—
2-Chloronaphthalene	TASL	19	13	—	—	—
2-Chlorophenol	GEL	39	10	—	2	1
2-Chlorophenol	TADN	14	2	—	1	—
2-Chlorophenol	TASL	29	14	—	—	—
2-Methyl-4 chlorophenoxyacetic acid	GEL	25	3	—	2	—
2-Methyl-4 chlorophenoxyacetic acid	TADN	24	8	—	7	—
2-Methyl-4 chlorophenoxyacetic acid	TASL	8	2	2	—	—
2-Methylnaphthalene	GEL	25	10	—	1	—
2-Methylnaphthalene	TADN	7	1	—	1	—
2-Methylnaphthalene	TASL	19	17	—	—	—
2-Methylphenol (cresol, o-)	GEL	40	22	—	2	—
2-Methylphenol (cresol, o-)	TADN	14	1	—	1	—
2-Methylphenol (cresol, o-)	TASL	33	31	—	—	—
2-Nitroaniline	GEL	25	5	—	1	—
2-Nitroaniline	TASL	19	4	—	—	—
2-Nitrophenol	GEL	40	8	—	2	1
2-Nitrophenol	TADN	14	1	—	1	—
2-Nitrophenol	TASL	33	5	—	—	—
3,3'-Dichlorobenzidine	GEL	25	2	1	1	—
3,3'-Dichlorobenzidine	TADN	7	1	—	1	—
3,3'-Dichlorobenzidine	TASL	19	5	—	—	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
3+4 Methylphenol (cresol, m+p)	GEL	42	17	—	2	—
3+4 Methylphenol (cresol, m+p)	TADN	14	2	—	1	—
3+4 Methylphenol (cresol, m+p)	TASL	31	25	—	—	—
3-Nitroaniline	TADN	7	6	—	1	—
3-Nitroaniline	TASL	19	1	—	—	—
4,4'-DDD (Dichlorodiphenyldichloroethane)	GEL	25	3	—	2	1
4,4'-DDE (Dichlorodiphenyldichloroethylene)	GEL	25	5	—	2	1
4,4'-DDT (Dichlorodiphenyltrichloroethane)	GEL	25	3	—	2	1
4,6-Dinitro-2-methylphenol	GEL	39	6	—	2	—
4,6-Dinitro-2-methylphenol	TASL	29	5	—	—	—
4-Bromophenylphenyl ether	GEL	25	5	—	1	—
4-Bromophenylphenyl ether	TASL	19	3	—	—	—
4-Chloro-3-methylphenol	GEL	39	6	—	2	—
4-Chloro-3-methylphenol	TASL	29	6	—	—	—
4-Chloroaniline	TADN	7	4	—	1	—
4-Chloroaniline	TASL	19	8	—	—	—
4-Chlorophenylphenyl ether	GEL	25	4	—	1	—
4-Chlorophenylphenyl ether	TASL	19	4	—	—	—
4-Nitroaniline	GEL	25	3	—	1	—
4-Nitrophenol	GEL	39	39	—	2	—
4-Nitrophenol	TASL	29	29	—	—	—
Acenaphthene	GEL	36	7	—	2	—
Acenaphthene	TASL	25	13	—	—	—
Acenaphthylene	GEL	36	7	—	2	—
Acenaphthylene	TASL	25	8	—	—	—
Acetophenone	GEL	25	3	—	1	—
Aldrin	GEL	25	6	—	2	1
Aldrin	TASL	14	3	—	—	—
Alpha-BHC	GEL	25	3	—	2	2
Alpha-chlordane	GEL	18	1	—	—	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
Aniline	GEL	25	5	—	1	—
Aniline	TADN	7	3	—	1	—
Anthracene	GEL	36	4	—	2	—
Anthracene	TASL	25	6	—	—	—
Aroclor-1016	GEL	18	2	—	2	—
Aroclor-1016	TASL	16	5	—	—	—
Aroclor-1260	GEL	18	2	—	2	—
Aroclor-1260	TASL	16	2	—	—	—
Aromatic petroleum hydrocarbons >nC12-nC16	GEL	4	1	—	—	—
Benzo(a)anthracene	GEL	36	5	—	2	—
Benzo(a)anthracene	TASL	25	5	—	—	—
Benzo(a)pyrene	GEL	36	4	—	2	—
Benzo(a)pyrene	TASL	25	10	—	—	—
Benzo(b)fluoranthene	GEL	36	6	—	2	—
Benzo(b)fluoranthene	TASL	25	11	—	—	—
Benzo(ghi)perylene	GEL	36	3	—	2	—
Benzo(ghi)perylene	TASL	25	11	—	—	—
Benzo(k)fluoranthene	GEL	36	2	—	2	—
Benzo(k)fluoranthene	TASL	25	10	—	—	—
Benzyl alcohol	GEL	25	12	—	1	—
beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	GEL	25	7	—	2	2
Bis(2-chloro-1-methylethyl)ether	GEL	25	9	—	1	—
Bis(2-chloro-1-methylethyl)ether	TASL	19	15	—	—	—
Bis(2-Chloroethoxy)methane	GEL	25	5	—	1	—
Bis(2-Chloroethoxy)methane	TASL	19	6	—	—	—
Bis(2-chloroethyl) ether	GEL	25	5	—	1	—
Bis(2-chloroethyl) ether	TASL	19	10	—	—	—
Bis(2-ethylhexyl) phthalate	GEL	28	6	—	1	—
Bis(2-ethylhexyl) phthalate	TASL	25	7	—	—	—
Butylbenzylphthalate	GEL	25	5	—	1	—
Butylbenzylphthalate	TASL	19	3	—	—	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
Carbazole	GEL	25	5	—	1	—
Carbazole	TASL	19	3	—	—	—
Chrysene	GEL	36	4	—	2	—
Chrysene	TASL	25	5	—	—	—
Dalapon	GEL	25	2	—	2	—
Dalapon	TADN	24	8	—	7	1
Dalapon	TASL	8	1	—	—	—
Delta-BHC	GEL	25	3	1	2	2
Delta-BHC	TASL	14	—	2	—	—
Dibenz[a,h]anthracene	GEL	36	3	—	2	—
Dibenz[a,h]anthracene	TASL	25	11	—	—	—
Dibenzofuran	GEL	25	5	—	1	—
Dibenzofuran	TASL	19	6	—	—	—
Dicamba	GEL	25	1	—	2	—
Dicamba	TADN	24	6	—	7	1
Dicamba	TASL	8	2	—	—	—
Dichloroprop	GEL	25	1	—	2	—
Dichloroprop	TADN	24	5	—	7	—
Dichloroprop	TASL	8	2	1	—	—
Dieldrin	GEL	25	2	—	2	1
Diethylphthalate	GEL	25	2	—	1	—
Diethylphthalate	TASL	19	3	—	—	—
Dimethyl phthalate	GEL	25	3	—	1	—
Dimethyl phthalate	TASL	19	3	—	—	—
Di-n-butylphthalate	GEL	25	5	—	1	—
Di-n-butylphthalate	TASL	19	3	—	—	—
Di-n-octylphthalate	GEL	25	7	—	1	—
Di-n-octylphthalate	TASL	19	4	—	—	—
Dinoseb(2-secButyl-4,6-dinitrophenol)	GEL	25	17	1	2	—
Dinoseb(2-secButyl-4,6-dinitrophenol)	TADN	24	21	—	7	3

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
Dinoseb(2-secButyl-4,6-dinitrophenol)	TASL	8	2	—	—	—
Diphenylamine+N-Nitrosodiphenylamine	GEL	25	6	—	1	—
Endosulfan I	GEL	25	6	—	2	1
Endosulfan II	GEL	25	7	—	2	2
Endosulfan sulfate	GEL	25	2	1	2	1
Endrin	GEL	25	4	—	2	1
Endrin aldehyde	GEL	25	8	—	2	2
Endrin ketone	GEL	18	1	1	—	—
Fluoranthene	GEL	36	6	—	2	—
Fluoranthene	TASL	25	5	—	—	—
Fluorene	GEL	36	6	—	2	—
Fluorene	TASL	25	6	—	—	—
Gamma-BHC (Lindane)	GEL	25	3	—	2	2
Heptachlor	GEL	18	2	—	—	—
Heptachlor	TASL	14	4	—	—	—
Heptachlor epoxide	GEL	25	3	—	2	1
Hexachlorobenzene	GEL	25	4	—	1	—
Hexachlorobenzene	TASL	19	1	—	—	—
Hexachlorobutadiene	GEL	25	20	—	1	—
Hexachlorobutadiene	TADN	7	5	—	1	—
Hexachlorobutadiene	TASL	19	18	—	—	—
Hexachlorocyclopentadiene	GEL	25	24	—	1	—
Hexachlorocyclopentadiene	TADN	7	7	—	1	1
Hexachlorocyclopentadiene	TASL	19	19	—	—	—
Hexachloroethane	GEL	25	21	—	1	—
Hexachloroethane	TADN	7	5	—	1	—
Hexachloroethane	TASL	19	18	—	—	—
Indeno(1,2,3-cd)pyrene	GEL	36	3	—	2	—
Indeno(1,2,3-cd)pyrene	TASL	25	11	—	—	—
Isophorone	GEL	25	5	—	1	—
Isophorone	TASL	19	11	—	—	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
Methoxychlor	GEL	25	2	—	2	1
Naphthalene	GEL	37	15	—	2	—
Naphthalene	TADN	7	1	—	1	—
Naphthalene	TASL	30	23	—	—	—
Nitrobenzene	GEL	25	5	—	1	—
Nitrobenzene	TASL	19	7	—	—	—
Nitrosopyrrolidine	GEL	25	5	—	1	—
n-Nitrosodimethylamine	GEL	25	25	—	1	—
n-Nitrosodi-n-propylamine	GEL	27	4	—	1	—
n-Nitrosodi-n-propylamine	TASL	20	7	—	—	—
Pentachlorophenol	GEL	42	3	—	2	—
Pentachlorophenol	TADN	15	1	—	1	—
Pentachlorophenol	TASL	33	12	—	—	—
Phenanthrene	GEL	36	4	—	2	—
Phenanthrene	TASL	25	5	—	—	—
Phenol	GEL	40	40	—	2	—
Phenol	TADN	14	1	—	1	—
Phenol	TASL	33	33	—	—	—
Pyrene	GEL	36	7	—	2	—
Pyrene	TASL	25	5	—	—	—
Pyridine	GEL	25	25	—	1	—
Pyridine	TADN	7	3	—	1	—
TPH–diesel range	GEL	23	6	—	1	—
TPH–diesel range	TASL	25	12	—	2	—
TPH–kerosene range	GEL	14	13	—	7	3
TPH–motor oil (high boiling)	GEL	18	1	—	1	—
trans-Chlordane	GEL	18	1	—	—	—
trans-Chlordane	TASL	14	1	—	—	—
Radiochemical Parameters: Recovery Limits = 70% - 130%, RPD Limit = 20%						
Carbon-14	SWRI	2	1	—	—	—
Cobalt-60	TARL	34	—	1	—	—
Gross alpha	SWRI	8	1	—	—	—

Table E-18. LCS Out-of-Limit Results

Constituent	Laboratory	Number of LCS[a]	Number Out of Limit Low	Number Out of Limit High	Number of LCSD	Number RPD Out of Limit
Gross alpha	TARL	57	1	—	—	—
Gross beta	TARL	46	—	1	—	—
Iodine-129	TARL	35	—	6	—	—
Plutonium-239/240	TARL	32	—	7	—	—
Plutonium-241	SWRI	4	1	—	—	—
Plutonium-241	TARL	26	7	—	—	—
Plutonium-241	TASL	5	—	1	—	—
Radium-226	TARL	14	—	2	—	—
Radium-228	TARL	11	—	3	—	—
Strontium-90	TARL	39	—	1	—	—
Technetium-99	TARL	39	4	—	—	—
Technetium-99	TASL	27	—	—	10	1
Tritium	TARL	45	—	1	—	—
Uranium-233/234	TARL	31	1	1	—	—
Uranium-235	TARL	4	2	1	—	—
Uranium-238	TARL	31	—	1	—	—

a. Includes both LCSs and LCSDs.

b. For polychlorodibenzo-p-dioxins and polychlorodibenzofurans, laboratory-specific limits for LCS recoveries were used.

GEL = GEL Laboratory
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
RPD = relative percent difference
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TAKN = TestAmerica–Knoxville
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis
TPH = total petroleum hydrocarbons

E7.2.1 Laboratory Control Samples by Laboratory

By laboratory, ALS reported 6.2% of all LCS values provided during 2017 and had the best success rate for LCS recoveries, at 100% with a success rate of 100% for LCSD RPDs.

GEL provided 32.9% of all LCS results reported and had the lowest success rate for LCS recoveries at 93.4%, with a success rate of 86.1% for LCSD RPDs. Table E-18 indicates that most of the GEL LCS recovery failures were for SVOCs. Of the 3,153 SVOC LCS results, 803 (25.5%) had recoveries less than the lower limit, and 10 (0.3%) were greater than the upper limit. TPH–diesel had the poorest performance, with 36.4% of the LCS recoveries less than the lower recovery limit and 33.3% of the LCSD RPDs out of limits. The next poorest LCS recoveries were for the EPA Method 8270 semivolatile compounds and PAHs with 29.3% of the LCS recoveries reported low; only 3.7% of the LCSD RPDs were out of limits. Also suffering primarily low recoveries were pesticides (15.3% low), polychlorinated biphenyl (PCBs)

(11.1% low), and herbicides (12.0% low). Pesticides also had poor LCSD RPDs, with 68.8% greater than the RPD limit. For the remaining analyte categories, GEL performed well, with at least 99.5% acceptance of LCS recoveries and 100% acceptance of LCSD RPDs.

SWRI provided only 0.4% of all LCS results reported and had a success rate of 98.0% for LCS recoveries; SWRI did not report any LCSD RPD values. SWRI reported three LCS recoveries that were less than the lower recovery limit: one failure each for carbon-14, gross alpha, and plutonium-241.

TADN provided 25.8% of all LCS results reported and had an LCS recovery success rate of 97.9% and a success rate of 96.2% for LCSD RPDs. Similar to GEL, most of the TADN LCS recovery failures were for SVOCs. Of the 1,001 SVOC LCS results, all 150 (15.0%) LCS failures were less than the lower limit. The SVOC LCS recovery failures were for the EPA Method 8270 semivolatile compounds (11.0% of the LCS recoveries biased low, 1.4% of the LCSD RPDs out of limits) and herbicides (33.3% of the LCS recoveries biased low, 11.4% of the LCSD RPDs out of limits). For the VOCs, TADN reported 51 LCS recovery failures of 2,185 analytes (EPA Method 8260); 24 of the failures were out low and 27 out high. The success rate for the EPA Method 8260 analyte LCSD RPDs was 95.0%. The EPA Method 8260 analytes with the most LCS recovery failures were 2-butanone (one low failure and five high), acetone (one low failure, six high), acrolein (five failures, all low), methylene chloride (five failures, all high), and vinyl acetate (six failures, all low). For the remaining analyte categories, TADN performed well, with at least 99.9% acceptance of LCS recoveries and at least 97.8% acceptance of LCSD RPDs.

TAKN provided only 0.3% of all LCS values reported and had a success rate for LCS recoveries of 96.6%; TAKN did not report any LCSD RPD values. TAKN reported one LCS recovery out low and three recoveries out high for the polychlorodibenzo-p-dioxins and polychlorodibenzofurans.

TARL provided 4.7% of all LCS results reported and had a success rate for LCS recoveries of 97.8%; TARL did not report any LCSD RPD values. All of the TARL LCS recovery failures were for the radioanalytical parameters. Of the 593 LCS recoveries reported, 40 (6.7%) were out of recovery limits. The radioanalytes with the most out-of-limit LCS results were iodine-129 (six failures, all high), plutonium-239/240 (seven failures, all high), plutonium-241 (seven failures, all low), and technetium-99 (four failures, all low). TARL reported no LCS failures for the IC anions or Cr(VI).

TASL had the next lowest success rate after GEL, with LCS recoveries at 93.6% and a success rate of 99.7% for LCSD RPDs. TASL reported 29.7% of all LCS results for 2017. Similar to GEL, most of the TASL LCS out-of-limits recoveries were for SVOCs. Of the 1,908 SVOC LCS recoveries, 667 (35.0%) were for recoveries less than the lower limit, and 15 (0.8%) were for recoveries greater than the upper limit. No LCSD RPD failures occurred for the SVOCs. TPH–diesel had the poorest LCS recovery rate with 12 of 25 LCS results (48.0%) out of limits, all low. The EPA Method 8270 SVOCs and PAHs had the next poorest LCS recovery rate, with 41.6% of LCS recoveries out of limits (all low). Of the remaining SVOC analytes, herbicides had a 40.0% failure rate (23.8% low and 16.3% high), PCBs had a 21.9% failure rate (all low), and pesticides had a 3.6% failure rate (2.9% low, 0.7% high). Of the anions determined at TASL, 15 LCS recoveries were reported for sulfide, of which 13 failed low (failure rate of 86.7%). This likely indicates a low bias for the TASL sulfide results.

E7.2.2 Laboratory Control Samples by Analyte Class

By analyte category, general chemical parameters had the best LCS recovery rate at 100% and only one RPD failure of 63 LCSD RPDs. The single RPD failure was for TOX at TADN.

Ammonia and anions had an LCS recovery success rate of 99.4%, with 13 LCS recovery failures of 2,293 LCS results, and all LCS failures were out low. A total of 23 LCSD RPD results were reported, and all met the RPD criterion. As noted previously, all 13 LCS failures were for sulfide measured at TASL.

Metals had an LCS recovery success rate of 100%, with only four failures of 15,926 LCS results. A total of 236 LCSD RPD results were reported for metals, and none exceeded the RPD criterion.

The VOC analyte class had an LCS recovery success rate of 99.2% (92 failures of 11,573 results) and a LCSD RPD success rate of 99.2% (30 failures of 3,586 results). Of the LCS recovery failures, 30 were out low and 62 were out high. The EPA Method 8260 analytes with the most LCS recovery failures were 2-butanone (one low failure, eight high), acetone (one low failure, eight high), acrolein (five failures low [all at TADN], and five failures high [all at TASL]), bromomethane (two failures low, five high), dichlorodifluoromethane (two failures low, seven high), iodomethane (two failures low, four high) methylene chloride (five failures, all high), and vinyl acetate (six failures low, five high).

The SVOCs had the poorest LCS recovery success rate at 73.3% (1,649 failures of 6,181 results), with an LCSD RPD success rate of 88.1% (38 failures of 320 results). The poorest performing SVOCs were for TPH (diesel, kerosene, and motor oil fractions), with a success rate of 64.0%; of 89 reported LCS recoveries, 32 LCS recoveries failed (all low). GEL reported 20 LCS failures of 55 LCS values, TADN zero failures of 9 values, and TASL 12 failures of 25 values. After TPH, the EPA Method 8270 SVOCs and PAHs had a success rate of 69.1% with 1,368 LCS recovery failures of 4,433 reported LCS recoveries. Of the 1,368 recovery failures, 1,367 were out low and one out high; GEL reported 677 failures of 2,308 values, TADN reported 70 of 634, and TASL reported 621 of 1,491. Herbicides had a success rate of 74.0%, with 148 LCS recovery failures of 570 reported LCS results. Of the 148 recovery failures, 129 were out low and 19 were out high; GEL reported 36 failures of 250 LCS values, TADN reported 80 of 240, and TASL reported 32 of 80. PCBs had an LCS recovery success rate of 84.3% with 11 LCS out-of-limits recoveries of 70 reported LCS values; the 11 out-of-limit LCS values all failed low. The remaining SVOC methods had LCS recovery success rates of 90% or better.

The radiological analyte LCS recoveries met the QC criteria at a success rate of 97.0%, with 44 of 1,483 LCS recoveries not meeting the QC criteria. Of the 44 failed LCS recoveries, 18 failed low and 26 failed high. For the LCSD RPDs, only one of 41 did not meet the RPD criterion for a success rate of 97.6%. The failed LCS recoveries were for iodine-129 (seven high), plutonium-239/240 (seven high), plutonium-241 (eight low, one high), and technetium-99 (four low).

E7.3 Matrix Spikes and Matrix Spike Duplicates

The MSs provide a measure of the accuracy of an analytical result and are used to determine if sample matrix effects may have affected analytical results. The MSDs give a measure of the repeatability of the analytical result. Only those samples that were spiked at a level at least one-fourth of the parent sample concentration were evaluated. For MS recovery failures, the laboratories apply a laboratory qualifier of “N” for non-GC/MS methods, and a laboratory qualifier of “T” for GC/MS methods. The MS/MSD results were available across all of the analyte categories. In this discussion, the set of MS recoveries also includes recoveries for MSDs.

Of the 54,790 MS results reported for 2017, 53,461 (97.6%) met the evaluation criterion. Of the 53,461 evaluated MS results, 97.9% met the percent recovery QC criteria cited in Table E-1. Of the 25,732 MS/MSD pairs reported, 25,176 (97.8%) met the evaluation criterion; of the 25,176 evaluated pairs, 97.9% met the RPD QC criteria of Table E-1. These success rates for percent recoveries and RPDs are somewhat better than those for the LCS and LCSD QC and provide additional assurance that the laboratories are producing data with sufficient accuracy and precision to meet the needs of the groundwater monitoring program. For comparison, 97.9% of the MS percent recoveries and 97.6% of the MSD RPDs met QC criteria in 2016, and 98.3% of the MS percent recoveries and 99.5% of the MSD RPDs met QC criteria in 2015. Table E-19 summarizes the 2017 out-of-limits MS and MSD results.

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
General Chemistry Parameters: Recovery Limits = 75% - 125%, RPD Limit = 20%						
Oil and grease	GEL	15	1	—	1	—
Total organic carbon	GEL	79	—	1	—	—
Total organic halides	GEL	93	—	4	—	—
Total organic halides	TADN	82	13	17	41	5
Total organic halides	TASL	58	1	—	—	—
Ammonia and Anions: Recovery Limits = 75% - 125%, RPD Limit = 20%						
Ammonium ion	TASL	6	—	4	—	—
Chloride	TARL	180	2	—	1	—
Cyanide	GEL	87	4	2	2	—
Cyanide	SWRI	10	3	—	—	—
Nitrate	TARL	127	5	3	—	—
Nitrite	TARL	191	8	1	1	—
Nitrite	TASL	27	10	—	—	—
Phosphate	TARL	20	7	2	—	—
Phosphate	TASL	4	—	1	—	—
Sulfate	GEL	181	—	1	—	—
Sulfate	TARL	116	1	1	1	—
Sulfide	TASL	15	13	—	—	—
Total iron cyanide	SWRI	3	—	1	—	—
Metals: Recovery Limits = 75% - 125%, RPD Limit = 20%						
Aluminum	ALS	148	—	2	74	—
Aluminum	TADN	366	1	4	183	5
Antimony	TADN	576	—	—	288	2
Antimony	TASL	146	—	—	73	1
Barium	TADN	564	1	5	282	1
Beryllium	ALS	148	—	—	74	1
Beryllium	TADN	374	—	1	187	2
Boron	ALS	124	—	4	62	—
Boron	TADN	332	—	1	166	1
Boron	TASL	120	2	—	60	—
Calcium	TADN	534	2	2	267	—

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Calcium	TASL	70	3	3	35	—
Chromium	ALS	252	—	4	126	—
Chromium	GEL	362	—	7	179	1
Chromium	TADN	734	10	1	367	—
Iron	ALS	170	—	4	85	—
Iron	TADN	542	3	5	271	2
Magnesium	GEL	249	4	—	123	—
Magnesium	TADN	544	—	2	272	—
Magnesium	TASL	160	2	—	80	1
Manganese	ALS	196	1	6	98	—
Manganese	GEL	259	2	3	129	—
Mercury	ALS	44	1	—	22	1
Mercury	TADN	132	—	—	66	2
Molybdenum	TADN	364	—	—	182	1
Molybdenum	TASL	112	—	—	56	1
Nickel	GEL	259	—	1	129	1
Nickel	TADN	576	5	—	288	—
Potassium	TADN	546	—	1	273	—
Potassium	TASL	160	4	—	80	1
Selenium	TADN	390	—	—	195	1
Sodium	GEL	167	5	3	81	—
Sodium	TADN	544	—	2	272	—
Sodium	TASL	132	1	—	66	1
Strontium	ALS	146	5	4	73	—
Strontium	GEL	72	1	2	36	—
Strontium	TADN	66	1	2	33	—
Strontium	TASL	106	1	—	53	1
Thorium	TADN	376	1	—	188	—
Tin	ALS	130	—	1	65	1
Tin	TADN	368	1	—	184	2
Tin	TASL	104	—	—	52	1
Uranium	ALS	198	3	4	99	—

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Uranium	TADN	412	—	1	206	—
Uranium	TASL	134	2	1	67	—
Zinc	GEL	262	—	2	130	2
Zinc	TADN	577	4	3	289	2
Volatile Organic Compounds: Recovery Limits = 70% - 130%, RPD Limit = 20%						
1,1,1-Trichloroethane	TADN	150	—	3	75	3
1,1,2-Trichloroethane	TADN	150	1	—	75	1
1,1-Dichloroethane	TADN	150	—	—	75	1
1,1-Dichloroethene	TADN	150	1	—	75	3
1,2-Dibromo-3-chloropropane	GEL	32	—	1	16	—
1,2-Dibromo-3-chloropropane	TADN	20	1	—	10	—
1,2-Dichloroethane	TADN	150	—	6	75	1
1,4-Dichlorobenzene	TADN	46	—	—	23	2
1-Butanol	TASL	12	1	—	6	2
2-Butanone	GEL	108	60	—	54	—
2-Butanone	TADN	150	8	16	75	7
2-Butanone	TASL	124	2	—	62	1
2-Hexanone	GEL	44	12	—	22	—
2-Hexanone	TADN	20	1	—	10	—
4-Methyl-2-pentanone	GEL	108	1	—	54	—
4-Methyl-2-pentanone	TADN	150	7	4	75	5
Acetone	GEL	108	95	—	54	2
Acetone	TADN	150	7	17	75	12
Acetone	TASL	132	9	5	66	6
Acrolein	TADN	20	6	—	10	1
Acrolein	TASL	34	—	2	17	—
Allyl chloride	TADN	20	1	—	10	1
Benzene	TADN	150	—	—	75	1
Bromomethane	GEL	32	—	—	16	1
Bromomethane	TADN	20	—	1	10	—
Bromomethane	TASL	34	—	2	17	1
Carbon disulfide	TADN	150	2	1	75	3

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Carbon tetrachloride	GEL	122	8	—	61	—
Carbon tetrachloride	TADN	152	2	6	76	3
Chlorobenzene	TADN	150	—	—	75	1
Chloroethane	TADN	20	—	1	10	—
Chloroform	GEL	122	1	—	61	—
Chloroform	TADN	150	4	1	75	1
Chloromethane	TADN	20	—	3	10	—
cis-1,2-Dichloroethylene	TADN	46	2	—	23	1
cis-1,3-Dichloropropene	TADN	20	2	—	10	—
Dichlorodifluoromethane	GEL	32	—	2	16	—
Dichlorodifluoromethane	TADN	20	2	4	10	1
Ethylbenzene	TADN	150	—	—	75	1
Iodomethane	TADN	20	—	—	10	1
Iodomethane	TASL	34	4	4	17	3
Isobutyl alcohol	TADN	20	—	2	10	—
Isobutyl alcohol	TASL	34	—	1	17	—
Methylene chloride	TADN	142	6	7	71	4
Methylene chloride	TASL	140	2	2	70	2
Styrene	TADN	20	—	—	10	1
Tetrachloroethene	GEL	106	2	—	53	—
Tetrachloroethene	TADN	150	3	—	75	5
Tetrahydrofuran	TADN	6	1	2	3	—
Tetrahydrofuran	TASL	12	—	—	6	1
Toluene	TADN	150	—	—	75	1
trans-1,2-Dichloroethylene	TADN	46	—	—	23	1
trans-1,3-Dichloropropene	TADN	20	1	—	10	—
Trichloroethene	TADN	154	4	—	77	1
Trichloroethene	TASL	148	2	—	74	—
Trichloromonofluoromethane	TADN	20	1	1	10	1
Vinyl acetate	TADN	20	8	—	10	1
Vinyl acetate	TASL	34	—	2	17	—
Vinyl chloride	TADN	150	7	6	75	5

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Xylenes (total)	GEL	106	1	—	53	—
Xylenes (total)	TADN	150	4	—	75	1
Semivolatile Organic Compounds: Recovery Limits = Laboratory Specific (Statistically Derived),[b] RPD Limit = 20%						
1,2,4,5-Tetrachlorobenzene	GEL	42	—	—	21	2
1,2,4-Trichlorobenzene	GEL	42	—	—	21	2
1,2,4-Trichlorobenzene	TASL	32	8	—	16	—
1,2-Dichlorobenzene	GEL	42	—	—	21	2
1,2-Dichlorobenzene	TASL	32	23	—	16	—
1,3-Dichlorobenzene	GEL	42	—	2	21	2
1,3-Dichlorobenzene	TASL	32	25	—	16	—
1,4-Dichlorobenzene	GEL	48	—	—	24	3
1,4-Dichlorobenzene	TASL	42	29	—	21	2
1,4-Dioxane	GEL	64	—	—	32	4
2-(2-methyl-4-chlorophenoxy) propionic acid	TADN	38	2	—	19	2
2-(2-methyl-4-chlorophenoxy) propionic acid	TASL	16	2	1	8	3
2,3,4,6-Tetrachlorophenol	GEL	62	—	—	31	4
2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	TADN	38	2	—	19	1
2,4,5-T(2,4,5-Trichlorophenoxyacetic acid)	TASL	16	2	—	8	2
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	TADN	38	2	—	19	1
2,4,5-TP(2-(2,4,5-Trichlorophenoxy)propionic acid)Silvex	TASL	16	2	—	8	2
2,4,5-Trichlorophenol	GEL	62	—	—	31	5
2,4,5-Trichlorophenol	TASL	50	1	—	25	1
2,4,6-Trichlorophenol	GEL	62	—	—	31	4
2,4,6-Trichlorophenol	TASL	50	1	—	25	1
2,4-D(2,4-Dichlorophenoxyacetic acid)	TADN	38	2	—	19	2

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
2,4-D(2,4-Dichlorophenoxyacetic acid)	TASL	16	2	—	8	1
2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	GEL	40	—	—	20	5
2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	TADN	38	2	—	19	4
2,4-DB(4-(2,4-Dichlorophenoxy)butanoic acid)	TASL	16	2	2	8	2
2,4-Dichlorophenol	GEL	62	—	—	31	3
2,4-Dichlorophenol	TASL	58	1	—	29	1
2,4-Dimethylphenol	GEL	62	—	—	31	3
2,4-Dinitrophenol	GEL	62	—	—	31	3
2,4-Dinitrophenol	TASL	50	2	—	25	1
2,4-Dinitrotoluene	GEL	42	—	—	21	3
2,6-Dichlorophenol	GEL	62	—	—	31	3
2,6-Dinitrotoluene	GEL	42	—	—	21	2
2-Chloronaphthalene	GEL	42	—	—	21	2
2-Chloronaphthalene	TASL	32	1	—	16	—
2-Chlorophenol	GEL	62	—	—	31	3
2-Chlorophenol	TASL	50	1	—	25	1
2-Methyl-4 chlorophenoxyacetic acid	GEL	40	—	1	20	—
2-Methyl-4 chlorophenoxyacetic acid	TADN	38	2	—	19	1
2-Methyl-4 chlorophenoxyacetic acid	TASL	16	2	1	8	2
2-Methylnaphthalene	GEL	42	—	—	21	2
2-Methylnaphthalene	TASL	32	1	—	16	—
2-Methylphenol (cresol, o-)	GEL	62	—	—	31	4
2-Nitroaniline	GEL	42	—	—	21	2
2-Nitroaniline	TASL	32	2	—	16	—
2-Nitrophenol	GEL	62	—	—	31	3
2-Nitrophenol	TASL	58	2	—	29	1
3,3'-Dichlorobenzidine	GEL	42	—	1	21	3
3,3'-Dichlorobenzidine	TADN	14	—	—	7	1
3+4 Methylphenol (cresol, m+p)	GEL	68	—	—	34	5
3+4 Methylphenol (cresol, m+p)	TASL	54	—	1	27	—

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
3-Nitroaniline	GEL	42	—	—	21	3
4,4'-DDD (Dichlorodiphenyldichloroethane)	GEL	34	1	—	17	3
4,4'-DDD (Dichlorodiphenyldichloroethane)	TASL	29	—	9	15	1
4,4'-DDE (Dichlorodiphenyldichloroethylene)	GEL	34	1	2	17	2
4,4'-DDE (Dichlorodiphenyldichloroethylene)	TASL	29	—	8	15	1
4,4'-DDT (Dichlorodiphenyltrichloroethane)	GEL	34	—	—	17	2
4,4'-DDT (Dichlorodiphenyltrichloroethane)	TASL	29	—	6	15	—
4,6-Dinitro-2-methylphenol	GEL	62	—	—	31	3
4,6-Dinitro-2-methylphenol	TASL	50	2	—	25	1
4-Bromophenylphenyl ether	GEL	42	—	—	21	2
4-Chloro-3-methylphenol	GEL	62	—	—	31	3
4-Chloroaniline	GEL	42	—	—	21	3
4-Chlorophenylphenyl ether	GEL	42	—	—	21	2
4-Nitroaniline	GEL	42	—	—	21	3
4-Nitrophenol	GEL	62	—	—	31	9
4-Nitrophenol	TASL	50	1	1	25	3
Acenaphthene	GEL	60	—	1	30	4
Acenaphthylene	GEL	60	—	—	30	4
Acetophenone	GEL	42	—	—	21	2
Aldrin	GEL	34	1	—	17	6
Aldrin	TASL	29	—	5	15	—
Alpha-BHC	GEL	34	1	—	17	3
Alpha-BHC	TASL	29	—	6	15	—
Alpha-Chlordane	GEL	30	1	1	15	3
Alpha-Chlordane	TASL	27	—	2	14	—
Aniline	GEL	42	—	—	21	3
Anthracene	GEL	60	—	—	30	3
Aroclor-1016	GEL	32	—	—	16	1

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Aroclor-1016	TASL	32	—	—	16	5
Aroclor-1260	GEL	32	—	—	16	2
Aroclor-1260	TASL	32	—	—	16	3
Aromatic petroleum hydrocarbons >nC21-nC34	GEL	8	1	—	4	—
Benzo(a)anthracene	GEL	60	—	1	30	3
Benzo(a)anthracene	TASL	44	1	—	22	—
Benzo(a)pyrene	GEL	60	—	—	30	3
Benzo(a)pyrene	TASL	44	11	—	22	—
Benzo(b)fluoranthene	GEL	60	—	—	30	3
Benzo(b)fluoranthene	TASL	44	13	—	22	—
Benzo(ghi)perylene	GEL	60	—	—	30	3
Benzo(ghi)perylene	TASL	44	14	—	22	2
Benzo(k)fluoranthene	GEL	60	—	—	30	3
Benzo(k)fluoranthene	TASL	44	13	—	22	—
Benzyl alcohol	GEL	42	—	—	21	2
beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	GEL	34	1	—	17	3
beta-1,2,3,4,5,6-Hexachlorocyclohexane (beta-BHC)	TASL	29	—	13	15	—
Bis(2-chloro-1-methylethyl)ether	GEL	42	—	—	21	2
Bis(2-chloro-1-methylethyl)ether	TASL	32	2	—	16	—
Bis(2-Chloroethoxy)methane	GEL	42	—	—	21	2
Bis(2-Chloroethoxy)methane	TASL	32	2	—	16	—
Bis(2-chloroethyl) ether	GEL	42	—	—	21	2
Bis(2-chloroethyl) ether	TASL	32	7	—	16	—
Bis(2-ethylhexyl) phthalate	GEL	44	—	—	22	3
Bis(2-ethylhexyl) phthalate	TASL	44	3	—	22	1
Butylbenzylphthalate	GEL	42	—	—	21	2
Carbazole	GEL	42	—	—	21	2
Chrysene	GEL	60	—	1	30	2
Chrysene	TASL	44	1	—	22	—
Dalapon	TADN	38	3	—	19	2

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Dalapon	TASL	16	—	—	8	2
Delta-BHC	GEL	34	1	—	17	4
Delta-BHC	TASL	29	—	2	15	—
Dibenz[a,h]anthracene	GEL	60	—	—	30	3
Dibenz[a,h]anthracene	TASL	44	12	—	22	2
Dibenzofuran	GEL	42	—	—	21	2
Dicamba	TADN	38	2	—	19	1
Dicamba	TASL	16	—	—	8	2
Dichloroprop	GEL	40	—	—	20	2
Dichloroprop	TADN	38	2	—	19	1
Dichloroprop	TASL	16	2	—	8	1
Dieldrin	GEL	34	1	—	17	3
Dieldrin	TASL	29	—	1	15	—
Diethylphthalate	GEL	42	—	—	21	2
Dimethyl phthalate	GEL	42	—	—	21	2
Di-n-butylphthalate	GEL	42	—	—	21	2
Di-n-octylphthalate	GEL	42	—	—	21	2
Dinoseb(2-secButyl-4,6-dinitrophenol)	GEL	40	—	4	20	4
Dinoseb(2-secButyl-4,6-dinitrophenol)	TADN	38	5	—	19	3
Dinoseb(2-secButyl-4,6-dinitrophenol)	TASL	16	2	—	8	2
Diphenylamine+N-Nitrosodiphenylamine	GEL	42	—	—	21	2
Endosulfan I	GEL	34	1	—	17	3
Endosulfan I	TASL	29	—	7	15	—
Endosulfan II	GEL	34	1	—	17	3
Endosulfan II	TASL	29	—	5	15	1
Endosulfan sulfate	GEL	34	1	—	17	3
Endosulfan sulfate	TASL	29	2	5	15	1
Endrin	GEL	34	4	—	17	4
Endrin	TASL	29	—	2	15	—
Endrin aldehyde	GEL	34	1	—	17	4
Endrin aldehyde	TASL	29	2	5	15	—
Endrin ketone	GEL	30	1	—	15	3

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Endrin ketone	TASL	27	2	4	14	—
Fluoranthene	GEL	60	—	—	30	3
Fluorene	GEL	60	—	—	30	4
Fluorene	TASL	44	1	—	22	—
Gamma-BHC (Lindane)	GEL	36	2	—	18	4
Gamma-BHC (Lindane)	TASL	29	—	6	15	—
Heptachlor	GEL	30	1	—	15	3
Heptachlor epoxide	GEL	34	1	—	17	3
Heptachlor epoxide	TASL	29	—	2	15	—
Hexachlorobenzene	GEL	42	—	—	21	2
Hexachlorobutadiene	GEL	42	—	—	21	2
Hexachlorobutadiene	TADN	14	—	—	7	1
Hexachlorobutadiene	TASL	32	10	—	16	—
Hexachlorocyclopentadiene	GEL	42	—	—	21	2
Hexachlorocyclopentadiene	TADN	14	—	—	7	2
Hexachloroethane	GEL	42	—	1	21	3
Hexachloroethane	TADN	14	—	—	7	1
Hexachloroethane	TASL	32	27	—	16	1
Indeno(1,2,3-cd)pyrene	GEL	60	—	—	30	2
Indeno(1,2,3-cd)pyrene	TASL	44	12	—	22	—
Isophorone	GEL	42	—	—	21	2
Methoxychlor	GEL	34	1	—	17	3
Methoxychlor	TASL	29	1	—	15	—
Naphthalene	GEL	60	—	—	30	2
Naphthalene	TASL	52	5	—	26	—
Nitrobenzene	GEL	42	—	—	21	2
Nitrobenzene	TASL	32	3	—	16	—
Nitrosopyrrolidine	GEL	42	—	—	21	3
n-Nitrosodimethylamine	GEL	42	—	—	21	2
n-Nitrosodi-n-propylamine	GEL	44	—	—	22	3
n-Nitrosodi-n-propylamine	TASL	34	4	—	17	—
Pentachlorophenol	GEL	64	—	—	32	4

Table E-19. MS Out-of-Limit Results

Constituent	Laboratory	Number of MS[a]	Number Out of Limit Low	Number Out of Limit High	Number of MSD	Number RPD Out of Limit
Pentachlorophenol	TADN	34	—	—	17	1
Pentachlorophenol	TASL	62	5	—	31	3
Phenanthrene	GEL	60	—	—	30	3
Phenol	GEL	62	—	—	31	3
Phenol	TASL	60	3	—	30	1
Pyrene	GEL	60	—	4	30	5
Pyridine	GEL	42	—	—	21	10
TPH-diesel range	GEL	40	12	2	20	4
TPH-diesel range	TASL	44	29	—	22	1
TPH-motor oil (high boiling)	GEL	26	—	2	13	2
trans-Chlordane	GEL	30	1	—	15	3
trans-Chlordane	TASL	27	—	4	14	—
Tributyl phosphate	GEL	50	—	3	25	2
Radiochemical Analytes: Recovery Limits = 75% - 125%, RPD Limit = 20%						
Carbon-14	TASL	16	1	—	4	1
Gross alpha	GEL	64	—	—	32	5
Gross beta	GEL	78	—	—	39	1
Technetium-99	TARL	30	2	—	—	—
Tritium	TARL	35	4	1	—	—

a. Includes both MS and MSDs.

b. Laboratory-specific limits were used to evaluate MS recoveries except for extractable petroleum hydrocarbons and total petroleum hydrocarbons; for these analytes the acceptable percent recovery range is 70% to 130%.

ALS = ALS Laboratory
GEL = GEL Laboratory
MS = matrix spike
MSD = matrix spike duplicate
RPD = relative percent difference
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis
TPH = total petroleum hydrocarbons

E7.3.1 Matrix Spikes by Laboratory

ALS reported 4,976 MS results, of which 4,958 (99.6%) met the evaluation criterion. These 4,958 MS results represent 9.3% of all MS results for 2017 that met the evaluation criterion. ALS reported MS data for TOC, IC anions, cyanide, ICP metals, VOCs; and the radioanalytes carbon-14, gross alpha, and gross beta. Of the 4,958 MS results ALS reported, 99.2% met the MS recovery QC criteria, which was the best percentage of MS recoveries reported for 2017. All 39 out-of-limit MS recoveries reported by ALS were for ICP metals and mercury. ALS reported 2,477 MSD results that met the evaluation criterion, and only

three failed to meet the MSD RPD criterion. The three MSD RPD failures were one each for beryllium, mercury, and tin.

GEL reported 16,839 MS results, of which 16,225 (96.4%) met the evaluation criterion. The 16,225 MS results represents 30.3% of all MS results for 2017 that met the evaluation criterion. GEL reported MS data for all six of the analyte categories encompassing a large number of analytes. Of the 16,225 MS results GEL reported, 98.2% met the MS recovery QC criteria. GEL reported 288 out-of-limit MS recoveries; most of these were for the VOCs (180 out low, 3 out high), the SVOCs (36 out low, 26 out high), and metals (12 out low, 18 out high). Of the VOCs, 2-butanone, 2-hexanone, and acetone reported the most MS recovery failures (Table E-19). Of the SVOCs, TPH reported the most MS recovery failures (12 low, 4 high); the remaining 46 SVOC out-of-limit MS recoveries were scattered among 30 analytes including EPA Method 8270 analytes, herbicides, pesticides, PAHs, and extractable petroleum hydrocarbons. Of the 30 MS recovery failures GEL reported for metals, most were for chromium, magnesium, manganese, sodium, and strontium (Table E-19). GEL reported 7,384 MSD results that met the evaluation criterion; of these, 317 (4.3%) failed to meet the MSD RPD criterion. A total of 304 MSD RPD failures were for the SVOCs. Of the SVOCs, 14 MSD RPD failures were for TPH; the remaining 290 SVOC MSD RPD failures were scattered among 100 other SVOC analytes, including the EPA Method 8270 analytes, herbicides, pesticides, PAHs, and PCBs. The remaining 13 non-SVOC MSD RPD failures were for chromium (one), nickel (one), zinc (two), acetone (two), bromomethane (one), gross alpha (five), and gross beta (one).

SWRI reported 72 MS results, of which 68 (94.4%) met the evaluation criterion. The 68 MS results represent 0.1% of all MS results for 2017 that met the evaluation criterion. SWRI reported MS data for TOC, cyanide, free cyanide, metal cyanides, and the radioanalytes carbon-14, technetium-99, and tritium. Of the 68 MS results ALS reported, 94.1% met the MS recovery QC criteria. Of the four out-of-limit MS recoveries reported by ALS, three were out low for cyanide and one was out high for total iron cyanide. SWRI reported 16 MSD results that met the evaluation criterion; all MSDs met the MSD RPD criterion.

TADN reported the most MS results (19,871) during 2017, of which 19,505 (98.2%) met the evaluation criterion. Of the 19,505 MS results, 98.6% met the QC recovery criteria. TADN reported 9,753 MSD results that met the evaluation criterion; 98.8% met the MSD RPD criterion. TADN reported MS recoveries and MSD RPDs for all of the analyte categories except for radiochemical parameters. Percentage-wise, the general chemical parameter analyte category had the poorest MS recoveries due to 30 failures of 82 recoveries (36.6%) for TOC (13 failures low, 17 failures high); TOC also had 5 of 41 MSD RPDs fall outside of the RPD limit. Numerically, most of the MS failures that TADN reported were for the VOCs, with 163 of 3,652 MS recoveries (4.5%) outside of the recovery limits; these failures were almost evenly split between MS recoveries less than the lower recovery limit (82) and those greater than the recovery limit (81). The most prominently affected VOCs were 2-butanone (8 low, 16 high), acetone (7 low, 17 high), methylene chloride (6 low, 7 high), vinyl chloride (7 low, 6 high), and 4-methyl-2-pentanone (7 low, 4 high). The remaining 25 VOC analytes with out-of-limit MS recoveries had fewer than 10 failed recoveries. For the remaining analyte categories, all 14 cyanide MS recoveries met the QC criteria, metals had 59 failed recoveries of 13,663 MS results (0.4%), and 98.8% SVOC MS recoveries met the QC criteria with only 24 failures. The 24 failed SVOC MS recoveries were for 10 herbicides; all the recoveries failed low and were mostly isolated to two analytical batches.

TAKN did not report any MS results for 2017.

TARL reported 1,405 MS values for 2017, of which 1,198 (85.3%) met the MS evaluation criterion. The 1,198 results constituted 2.2% of all MS results reported during 2017. Of the TARL MS results, 96.9% met the MS recovery requirements, with only 37 failures. TARL reported only four MSD results,

all of which met the MSD RPD criterion. Of the analyte categories, TARL reported MS results for IC anions, Cr(VI), and for the radioanalytical species carbon-14, technetium-99, and tritium. Of the IC anions, TARL had 30 MS recovery failures of 843 MS results: nitrate had five failures low and three failures high, nitrite had eight low and one high, and phosphate had seven low and two high; the remaining IC anions had two or fewer failures. Cr(VI) had 256 MS results with no recoveries outside of the recovery limits. Of the radioanalytical species, carbon-14 had no MS recoveries outside of the recovery limits; technetium-99 had 33 MS results, 2 of which failed low; and tritium had 35 MS results, 4 of which failed low and one high.

TASL returned 11,627 MS values for 2017, of which 11,507 (99.0%) met the MS evaluation criterion. The 11,507 values were 21.5% of all MS results reported during 2017. Of the TASL MS results, 95.8% met the MS recovery requirements with 361 MS recovery failures. TASL also reported 5,542 MSD results, of which 78 (1.4%) fell outside of the MSD RPD criterion. TASL reported MS results for all of the analyte categories: 231 results for the general chemical parameters (alkalinity, oil and grease, TOC, and TOX); 179 results for ammonia and anions (ammonium ion, cyanide, IC anions, and sulfide); 3,758 results for metals (ICP metals, Cr(VI), and mercury); 3,886 results for the chemical parameters, metals, and VOCs all had MS recovery success rates of 99.0% or better, while the radioanalytes had only a single MS recovery failure (see Table E-19). For ammonia and anions, TASL reported six ammonium MS results with four failures (all high), 27 nitrate MS results with 10 failures (all low), and 15 sulfide MS results with 13 failures (all low). The low MS recoveries for VOCs; 3,414 results for the SVOCs (EPA Method 8270 SVOCs, herbicides, pesticides, PAHs, and PCBs); and 39 results for the radioanalytical species (carbon-14, gross alpha, gross beta, and tritium). The general sulfide parallels the low LCS recoveries reported by TASL, which likely indicates a low bias for the sulfide results provided by TASL. For the SVOCs, TASL reported the poorest recovery rate of the three laboratories that reported SVOC data (3,414 MS results with 399 [11.7%] recoveries outside of the MS recovery limits). Of the out-of-limit MS recoveries, 301 recoveries were low and 98 recoveries were high (see Table E-19). TASL provided MSD results for metals, VOCs, SVOCs, and radioanalytes. The MSD RPD acceptance rate for metals and VOCs was >99.0%. The SVOCs returned a 96.9% and the radioanalytes returned a 75.0% success rate for MSD RPDs (see Table E-19).

E7.3.2 Matrix Spikes by Analyte Class

For the general chemical parameters, 607 MS results met the evaluation criteria; 37 MS recoveries were outside of the recovery limits for an acceptance rate of 93.9%. Five of 95 MSD RPDs were greater than the RPD limit for an acceptance rate of 94.7%. The general chemical parameter analyte with the most out-of-limit recoveries was TOX (233 MS results; 14 low and 21 high); most of the out-of-limit recoveries were produced at TADN.

For ammonia and anions, 2,163 MS results met the evaluation criteria; 69 MS recoveries were outside of the recovery limits for an acceptance rate of 96.8%. No MSD RPDs exceeded the RPD limit. GEL, SWRI, TARL, and TASL reported the ammonia and anion out-of-limits MS results. The analytes with the most out-of-limit MS recoveries were cyanide (134 MS results; seven low and two high), nitrate (342 MS results; five low and three high), nitrite (410 MS results; 18 low and one high), phosphate (48 MS results; seven low and three high), and sulfide (32 MS results; 13 low). Nitrite and sulfide exhibit a negative bias in their MS recoveries. Nitrite did not exhibit any out-of-limit LCS values, so the 18 low MS recoveries may indicate an occasional matrix effect. The low MS recoveries for sulfide are discussed above in the laboratory section for TASL.

For the metals, 28,985 MS results met the evaluation criteria; 147 MS recoveries were outside of the recovery limits for an acceptance rate of 99.5%. Of 14,336 MSDs, 35 exceeded the RPD limit for a success rate of 99.8%. ALS, GEL, TADN, and TASL reported the out-of-limits metal MS results and the out-of-limits MSD RPD results. The out-of-limits results were scattered over 25 different metals. Numerically, metals with 10 or more MS failures were calcium (828 MS results; five low and five high), chromium (1,538 MS results; 10 low and 12 high), iron (1,176 MS results; three low and nine high), manganese (1,181 MS results: three low and nine high), sodium (1,019 MS results; six low and five high), strontium (390 MS results; eight low and eight high), and uranium (1,012 MS results; five low and six high). None of the corresponding LCS results for these analytes reflect any out-of-limit recoveries. Therefore, analytes such as iron and manganese may be exhibiting either some occasional matrix effects in groundwater or possible effects from the heterogeneous distribution of metal-bearing particulates when the sample is sub-sampled for analysis. In any event, these effects are small compared to the overall success rate for the metals MS recoveries.

For the VOCs, 10,732 MSs met the evaluation criteria, with 384 MS recoveries outside of the recovery limits for an overall success rate of 96.4%. Of 5,336 MSDs, 90 exceeded the RPD limit for a success rate of 98.3%. GEL, TADN, and TASL reported out-of-limits MS and MSD RPD results scattered over 40 different VOC analytes. Numerically, the analytes with at least 10 MS recovery failures were 2-butanone (388 MS results; 70 low and 16 high), 2-hexanone (98 MS results; 13 all low), 4-methyl-2-pentanone (388 MS results; eight low and four high), acetone (396 MS results; 111 low and 22 high), carbon tetrachloride (424 MS results; 10 low and six high), methylene chloride (410 MS results; eight low and nine high), vinyl acetate (86 MS results; eight low and two high), and vinyl chloride (400 MS results; seven low and six high). For these analytes, most of the out-of-limit MS recoveries were low. The corresponding LCS recoveries for these analytes had fewer failures; therefore, a possible groundwater matrix effect may be causing the low MS recoveries.

For the SVOCs, 10,486 MSs met the evaluation criteria with 485 MS recoveries outside of the recovery limits for an overall success rate of 95.4%. Of the 5,253 evaluated MSDs, 382 were greater than the RPD criterion for a success rate of 92.7%. GEL, TADN, and TASL reported out-of-limit MS recoveries for 73 different SVOC analytes; 16 analytes had at least 10 MS failures. TASL reported most of these SVOC MS failures (discussed in the previous section). Table E-19 provides details for the SVOCs with out-of-limit MS recoveries and MSD RPD failures.

For the radiological analyses, 488 MS results met the evaluation criterion with eight MS recoveries outside of the recovery limits for an overall success rate of 98.4%. Seven of 89 MSDs exceeded the RPD criterion for a success rate of 92.1%. ALS, GEL, SWRI, TARL, and TASL all reported MS results for radiochemical properties; TARL and TASL reported out-of-limits MS results, while GEL and TASL reported the seven out-of-limits MSD results (for gross alpha). Analytes with out-of-limit MS recoveries include carbon-14 (98 MS results; one low), technetium-99 (36 MS results; two low), and tritium (147 MS results; four low and one high).

E7.4 Laboratory Sample Duplicates

Laboratory sample duplicates give a measure of the repeatability of an analytical result. Only those sample results with values five times greater than the MDL or the MDA, or one times the EQL, were evaluated. The RPDs for sample duplicates that met the evaluation criteria were compared to a maximum of 20%. When laboratory sample duplicate RPDs are outside of QC limits, laboratories may assign a laboratory qualifier of “X” and an accompanying explanatory note.

Of the 5,647 laboratory sample duplicates reported for 2017, a total of 2,280 (40.8%) met the evaluation criterion; of these, 40 RPDs exceeded the precision criteria for an overall acceptance rate of 96.8%. This acceptance rate is similar to those for the LCSD (98.4%) and MSD (97.9%) (discussed in previous sections) and demonstrates reasonable analytical reproducibility. By analyte class, laboratory sample duplicate data were reported for the general chemical parameters, ammonia and anions, metals, SVOCs, and radioanalytical parameters. For the radioanalytical parameters, the laboratory sample duplicate is the primary measure of analytical precision. Table E-20 summarizes the out-of-limit results for laboratory sample duplicates.

Table E-20. Laboratory Sample Duplicate Out-of-Limit Results

Constituent	Laboratory	Number of Laboratory Duplicates	Number Laboratory Duplicates Evaluated*	Number RPD Out of Limit	Range of RPD Out
General Chemical Parameters: RPD Limit = 20%					
Total organic halides	GEL	93	10	1	22.9
Total organic halides	TASL	34	11	4	22.0 – 40.0
Ammonia and Anions: RPD Limit = 20%					
Cyanide	GEL	85	32	1	23.3
Cyanide amenable to chlorination	SWRI	12	8	3	58.5 – 200
Fluoride	GEL	182	126	1	200
Free cyanide	SWRI	12	3	1	200
Semivolatile Organic Compounds: RPD Limit = 20%					
1,2,3,4,6,7,8-Heptachlorodibenzofuran	TAKN	11	2	1	165
1,2,3,4,7,8,9-Heptachlorodibenzofuran	TAKN	11	2	1	151
Heptachlorodibenzofurans	TAKN	11	3	2	50.0 – 158
Heptachlorodibenzo-p-dioxins	TAKN	11	4	1	72.0
Hexachlorodibenzo-p-dioxin	TAKN	11	6	3	33.0 – 66.0
Octachlorodibenzofuran	TAKN	11	8	5	22.0 – 155
Octachlorodibenzo-p-dioxin	TAKN	11	9	7	21.0 – 148
Radiochemical Parameters: RPD Limit = 20%					
Carbon-14	TASL	8	4	1	23.0
Gross alpha	SWRI	10	2	1	43.8
Gross beta	GEL	40	21	3	20.2 – 38.8
Gross beta	TARL	45	33	2	22.2 - 37.7
Iodine-129	GEL	44	5	1	20.3
Iodine-129	SWRI	13	3	1	22.4

Table E-20. Laboratory Sample Duplicate Out-of-Limit Results

Constituent	Laboratory	Number of Laboratory Duplicates	Number Laboratory Duplicates Evaluated*	Number RPD Out of Limit	Range of RPD Out
Iodine-129	TARL	34	14	4	20.6 – 242
Plutonium-239/240	GEL	50	2	1	24.7
Radium-226	GEL	13	1	1	34.9
Radium-228	TARL	11	4	3	39.6 – 69.7
Strontium-90	GEL	41	8	2	21.4 – 26.5
Strontium-90	TARL	37	11	1	92.3
Technetium-99	GEL	60	15	1	20.8
Uranium-233/234	GEL	39	30	4	22.8 – 36.7
Uranium-233/234	TARL	28	12	3	24.0 – 36.8
Uranium-235	TARL	28	1	1	22.4
Uranium-238	GEL	39	25	8	20.6 – 31.6
Uranium-238	SWRI	4	3	1	27.6
Uranium-238	TARL	28	9	2	41.9 – 91.2

*Meets the evaluation criterion that the sample-duplicate pair has at least one result ≥5 times the method detection limit or the minimum detectable activity.

GEL = GEL Laboratory
RPD = relative percent difference
SWRI = Southwest Research Institute
TAKN = TestAmerica–Knoxville
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis

E7.4.1 Laboratory Sample Duplicates by Laboratory

By laboratory, ALS reported 11 sample duplicates that met the evaluation criterion; all 11 duplicates met the RPD limit for a 100% success rate. Five of the duplicates were for ICP metals and six were for radioanalytes.

GEL had 963 duplicates meet the evaluation criteria, of which 24 exceeded the RPD limit for a 97.5% success rate. GEL reported duplicate RPDs for general chemical parameters (alkalinity/bicarbonate, pH, total dissolved solids, TOC, and TOX), ammonia and anions (ammonium, cyanide/free cyanide, and IC anions), metals (Cr(VI) and mercury), and a number of radioanalytes.

SWRI reported 59 sample duplicates that met the evaluation criterion; seven duplicates exceeded the RPD limit for an 88.1% success rate. A total of 20 duplicates were for cyanide (cyanide, cyanide amenable to chlorination, free cyanide, and total iron cyanide), of which 4 did not meet the RPD criterion. A total of 39 duplicates were for a number of radioanalytes, of which 3 failed to meet the RPD criterion.

TADN reported 32 sample duplicates that met the evaluation criterion; all 32 duplicates met the RPD limit for a 100% success rate. All 32 duplicates were for alkalinity.

TAKN had 45 duplicates meet the evaluation criteria, of which 20 exceeded the RPD limit for a 55.6% success rate. All the out-of-limit duplicate RPDs were for the polychlorodibenzo-p-dioxins and polychlorodibenzofurans. A number of the RPDs for these analytes greatly exceeded the 20% limit.

TARL had 944 duplicates meet the evaluation criteria, of which 16 exceeded the RPD limit for a 98.3% success rate. TARL reported sample duplicate RPDs for coliform bacteria, IC anions, Cr(VI), and a suite of radioanalytes. All 16 of the out-of-limit RPDs were associated with seven radioanalytes.

TASL reported 156 duplicates that met the evaluation criteria of which 5 exceeded the RPD limit for a 97.8% success rate. TASL reported duplicate RPDs for general chemical parameters (alkalinity/ bicarbonate, pH, TOC, and TOX), ammonia and anions (ammonium, cyanide, and IC anions), metals (Cr(VI)), and a number of radioanalytes. The duplicate RPDs outside of the QC limit were for TOX (four) and carbon-14 (one).

E7.4.2 Laboratory Sample Duplicates by Analyte Class

By analyte class, the general chemical parameters had 263 duplicates that met the evaluation criterion, of which 5 failed to meet the RPD criterion. Ammonia and anions had 1,481 duplicates meet the evaluation criterion, of which only 6 failed to meet the RPD criterion. Metals had 136 duplicates meet the evaluation criterion with no RPD failures. No sample duplicates were reported for the VOCs. The SVOCs reported 45 duplicates that met the evaluation criterion, of which 20 failed to meet the RPD criterion. As noted in the previous sample duplicate discussion for TAKN, the 20 out-of-limit duplicate RPDs were for the polychlorodibenzo-p-dioxins and polychlorodibenzofurans. For the radioanalytes, 355 sample duplicates met the evaluation criterion; 41 of these did not meet the RPD criterion.

E7.5 Surrogates

Surrogates are used to monitor percent recovery during the analysis of samples for VOCs, and SVOCs. Surrogates are typically deuterated, fluorinated, or brominated organic compounds with chemical properties similar to those of the analytes of interest in a sample but are not normally found in groundwater samples. Known amounts of the surrogates are added to the sample prior to sample preparation and analysis to monitor the recovery of the organic compounds during the analytical process.

For the current reporting period, ALS, GEL, TADN, and TASL reported surrogate data for VOCs and SVOCs. As Table E-21 indicates, percent recoveries for surrogates are compared either to the acceptance criteria (specified in Table E-1) or to statistically derived, laboratory-specific process control limits. The Table E-1 specified recoveries limit may be stricter than laboratory process control limits for those same analytes. Consequently, the Table E-1 criteria may generate more surrogate recovery failures than would the laboratory process control limits. When laboratory surrogate percent recoveries are outside of the laboratory QC limits, the laboratories may assign a laboratory qualifier of “X” and an accompanying explanatory note in the data report or case narrative.

Tables E-15 and E-16 indicate that for the 15,499 surrogates reported in 2017, 93.8% of the percent recoveries met the QC criteria for 2017. For 2017, a total of 2,144 surrogate duplicates were reported, with 95.7% meeting the RPD criterion. These success rates, along with those for the other measures of laboratory accuracy and precision, continue to provide assurance that the laboratories are producing data with sufficient accuracy and precision to meet the needs of the groundwater monitoring program. The 2017 surrogate success rate for surrogate percent recoveries is about the same as the 2016 success rate of 93.9% and somewhat lower than the 2015 success rate of 99.2%. Table E-21 lists the out-of-limit surrogate results for the current reporting period.

Table E- 21. Surrogate Out-of-Limit Results

Surrogate	Laboratory	Method	Number of Surrogates	Number Out Low	Number Out High	Number of Surrogate Duplicates	Number RPD Out of Limit
Volatile Organic Compounds[a]							
1,2-Dichloroethane-d4	TADN	8260_VOA_GCMS	517	0	0	94	2
1,2-Dichloroethane-d4	TASL	8260_VOA_GCMS	1,028	0	0	160	1
4-Fluorobromobenzene	TADN	8260_VOA_GCMS	517	0	0	94	4
4-Fluorobromobenzene	TASL	8260_VOA_GCMS	1,028	0	1	160	0
Dibromofluoromethane	TADN	8260_VOA_GCMS	517	0	0	94	1
Toluene-d8	TADN	8260_VOA_GCMS	517	0	0	94	2
Semivolatile Organic Compounds[b]							
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	GEL	8081_PEST_GC	154	16	0	21	5
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	GEL	8082_PCB_GC	150	10	1	18	4
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	TASL	8081_PEST_GC	105	0	5	14	1
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	TASL	8082_PCB_GC	114	0	0	16	3
2,4,5,6-Tetrachloro-m-xylene	GEL	8081_PEST_GC	154	27	2	21	5
2,4,5,6-Tetrachloro-m-xylene	GEL	8082_PCB_GC	150	69	0	18	2
2,4,5,6-Tetrachloro-m-xylene	TASL	8081_PEST_GC	105	0	3	14	0
2,4,6-Tribromophenol	GEL	8270_SVOA_GCMS	354	57	0	49	4
2,4,6-Tribromophenol	TASL	8270_SVOA_GCMS	253	2	0	34	3
2,4-Dichlorophenylacetic acid	GEL	8151_HERBICIDE_GC	180	3	7	22	2
2,4-Dichlorophenylacetic acid	TADN	8151_HERBICIDE_GC	112	0	0	26	2
2,4-Dichlorophenylacetic acid	TASL	8151_HERBICIDE_GC	51	7	10	8	1

Table E- 21. Surrogate Out-of-Limit Results

Surrogate	Laboratory	Method	Number of Surrogates	Number Out Low	Number Out High	Number of Surrogate Duplicates	Number RPD Out of Limit
2-Fluorobiphenyl	GEL	8270_SVOA_GCMS	354	60	0	49	4
2-Fluorobiphenyl	TASL	8270_SVOA_GCMS	290	7	0	40	3
2-Fluorophenol	GEL	8270_SVOA_GCMS	354	234	0	49	4
2-Fluorophenol	TADN	8270_SVOA_GCMS	93	0	0	18	1
2-Fluorophenol	TASL	8270_SVOA_GCMS	253	3	1	34	3
5-alpha-Androstane	GEL	8270_SVOA_GCMS	71	35	0	10	2
Nitrobenzene-d5	GEL	8270_SVOA_GCMS	354	48	0	49	4
Nitrobenzene-d5	TASL	8270_SVOA_GCMS	290	8	8	40	3
o-Terphenyl	GEL	WTPH_DIESEL	184	9	1	26	6
o-Terphenyl	TADN	WTPH_DIESEL	35	2	2	7	1
o-Terphenyl	TASL	WTPH_DIESEL	150	12	0	24	4
Phenol-d5	GEL	8270_SVOA_GCMS	354	235	0	49	4
Phenol-d5	TASL	8270_SVOA_GCMS	253	3	1	34	3
p-terphenyl-d14	GEL	8270_SVOA_GCMS	354	60	1	49	6
p-terphenyl-d14	TASL	8270_SVOA_GCMS	290	2	13	40	2

a. For the EPA Method 8260 analytes, the recovery limits are 70% to 130%. For WTPH-gasoline, the recovery limits are 60% to 140%. For all volatile organic compounds, the surrogate RPD control limit is 20%.

b. For the EPA Method 8270 analytes, herbicides, pesticides, phenols, polynuclear aromatic hydrocarbons, and polychlorinated biphenyls, the recovery limits are laboratory statistically derived. For the dioxins, the recovery limits are 40% to 135%. For WEPH–GC and WTPH–diesel, the recovery limits are 60% to 140%. For all semivolatile organic compounds, the surrogate RPD control limit is 20%.

GEL = GEL Laboratory
RPD = relative percent difference
TADN = TestAmerica–Denver
TASL = TestAmerica–St. Louis
WTPH = Washington total petroleum hydrocarbons

E7.5.1 Surrogate Results by Laboratory

Four laboratories reported surrogate results for 2017: ALS, GEL, TADN, and TASL. ALS reported 63 surrogate results with no out-of-limit recoveries and 18 surrogate duplicates with no RPDs exceeding the RPD limit. All of ALS surrogate results were reported for the EPA Method 8260 analytes.

GEL reported 6,211 surrogate results with 875 recoveries outside of the QC limits for a success rate of 85.9% and 633 surrogate duplicates with 52 RPDs outside of the RPD limit for a duplicate success rate of 91.8%. GEL reported surrogate results for the EPA Method 8260 analytes, TPH–gasoline range, EPA Method 8270 SVOCs, pesticides, PAHs, PCBs, phenols, extractable petroleum hydrocarbons, and TPH-diesel range. Of the 2,952 surrogate results GEL reported for the VOCs, all recoveries and surrogate duplicate RPDs met the QC criteria. All 875 recovery failures were for the SVOCs, with 863 surrogate recoveries failing low. Of the 2,195 surrogate results for the EPA Method 8270 analytes, 730 surrogate recoveries were outside of the recovery limits, with 729 recoveries failing low; these primarily affected the EPA Method 8270 SVOCs and PAHs and may indicate low-biased results for those analytes. GEL reported 308 surrogate results for pesticides, with 43 recoveries failing low and two high. For the PCBs, GEL reported 300 surrogate results, with 79 failing low and one high. For the surrogate duplicates, GEL reported 438 duplicate results, with 52 (11.9%) surrogate RPDs greater than the RPD limit. A total of 28 RPD failures of 304 duplicate results were for the EPA Method 8270 SVOCs; 10 RPD failures of 42 duplicate results were for pesticides.

TADN reported 2,909 surrogate results with only four recoveries outside of the QC limits for a success rate of 99.9%, and 547 surrogate duplicates included 13 RPDs outside of the RPD limit for a duplicate success rate of 97.6%. The four recovery failures were for TPH–diesel, with two failing low and two high. Of the RPD failures, 9 failures of 376 RPD results occurred for EPA Method 8260 VOCs. The four remaining RPD failures were for herbicides, EPA Method 8270 SVOCs, and TPH–diesel.

TASL reported 6,316 surrogate results with 86 recoveries outside of the QC limits for a success rate of 98.6%, and 946 surrogate duplicates included 27 RPDs outside of the RPD limit for a duplicate success rate of 97.1%. Of 4,162 surrogate results for the VOCs, TASL reported only one recovery failure and one RPD failure. The 85 remaining recovery failures and 26 RPD failures were for SVOC analytes. Of the SVOC analytes, TASL reported 1,629 surrogate results for the EPA Method 8270 analytes, with 25 recoveries failing low and 23 high. Pesticides had 210 surrogate results, with no low recoveries and eight recoveries high. Herbicides had 51 surrogate results, with seven recoveries low and 10 high. Finally, TASL reported 150 surrogate results for TPH–diesel, with 12 recoveries failing low and none high. Most of the surrogate RPD failures were for the EPA Method 8270 analytes; of 222 surrogate RPDs, 17 exceeded the RPD limit.

E7.5.2 Surrogate Results by Analyte Class

By analyte class, the VOCs had 9,275 surrogate results. Of these results, only one was outside of the recovery limits, for a 100% success rate. Of the 1,245 surrogate RPDs reported for the VOCs, only 10 RPDs exceeded the RPD limit, for a success rate of 99.2%.

The SVOCs had 6,224 surrogate results; of these, 964 recoveries were outside of the recovery limits for a success rate of 84.5%. Of the 964 failed SVOC recoveries, 909 were less than the lower recovery limit, while 55 exceeded the upper recovery limit. By surrogate recovery success rate, extractable petroleum hydrocarbons had 100%, TPH–diesel had a 93.0% success rate (369 results; 23 low and three high), herbicides had a 92.1% success rate (343 results; 10 low and 17 high), pesticides had a 91.1% success rate (598 results; 43 low and 10 high), the EPA Method 8270 analytes had an 82.2% success rate (4,382 results; 754 low and 24 high), and PCBs had an 81.8% success rate (440 results 79 low and one

high). A total of 739 of the low failures are attributed to GEL use of EPA Method 8270. GEL also reported most of the surrogate failures for pesticides (308 surrogate results; 43 low and 2 high) and PCBs (300 surrogate results; 79 low and one high).

Of the 899 surrogate RPDs reported for the SVOCs, 82 RPDs exceeded the RPD limit for a success rate of 90.9%. By surrogate RPD success rate, extractable petroleum hydrocarbons had 100%, EPA Method 8270 analytes had a 92.2% success rate (634 RPDs; 46 out), herbicides had a 91.1% success rate (56 RPDs; five out), pesticides had an 87.2% success rate (86 RPDs; 11 out), PCBs had an 84.5% success rate (58 RPDs; nine out), and finally TPH–diesel had an 80.7% success rate (57 RPDs; 11 out).

The poorest recovery rates among the individual SVOC surrogates were at GEL for the EPA Method 8270 surrogates 2-fluorophenol (66.1%; all low) and phenol-d5 (66.4%; all low). This may indicate a corresponding low recovery bias for target analyte phenols analyzed by EPA Method 8270 at GEL.

E8 Laboratory Performance

During 2017, laboratory performance was tracked using two methods: the groundwater quarterly blind standards program, and laboratory performance evaluation programs. Section E8.1 discusses the results of the blind standards program, and Section E8.2 discusses the laboratory performance evaluation programs.

E8.1 Quarterly Blind Standard Evaluations

The groundwater monitoring program issues blind standards to the supporting laboratories to provide a measure of intralaboratory and interlaboratory precision and accuracy. These standards help S&GRP troubleshoot analytical problems identified through data reviews and QC evaluations. The blind standards also may be used to confirm the adequacy of corrective actions to resolve analytical problems. Blind standards are required to be submitted to the participating laboratories on a quarterly basis (DOE/RL-91-50; CHPRC-00189). For 2017, this requirement was not met because the summer fire season prevented acquisition of the groundwater matrix needed for the third quarter blind standards. However, the fourth quarter blind standard results for 2016 were submitted after January 1, 2017, and were not reported in the 2016 usability assessment. The results will also be included in this report.

The quality requirements and control limits for the groundwater monitoring blind standards are provided in CHPRC-00189 and are listed in Table E-22. A success rate is calculated using Equation E-4 for the results returned by each supporting laboratory:

$$Success\ rate = \frac{Number\ of\ results\ meeting\ QC\ recovery\ criteria}{Total\ number\ of\ results\ reported} \times 100 \qquad \textbf{(Equation E-4)}$$

The acceptance criterion for the success rate is 80% (CHPRC-00189).

During 2017, the groundwater monitoring program sent blind standards to ALS, GEL, SWRI, TADN, TARL, and TASL. Of the blind standard results for all laboratories during 2017 (including the fourth quarter of 2016), 85.9% were acceptable. This percentage is somewhat lower than the success rates of 89.0% for 2016 and 89.7% for 2015. GEL, SWRI, TADN, and TASL did not meet the 80% acceptance criterion for one or more quarters during 2017 (including the fourth quarter of 2016). Table E-23 presents the success rates for each laboratory by quarter during 2017.

Table E-22. Groundwater Blind Standard Recovery and Precision Requirements

Analyte Class	Recovery Limits (% Recovery)	Precision Limit[a] (% RSD)
General chemical parameters	75 - 125	≤25
Ammonia and anions	75 - 125	≤25
Metals	80 - 120	≤20
Volatile organic compounds	75 - 125	≤25
Semivolatile organic compounds[b]	N/R	N/R
Radiological parameters	70 - 130	≤20

Source: CHPRC-00189, *CH2M Hill Plateau Remediation Company Environmental Quality Assurance Program Plan*.

Note: Blind standards are required to be submitted to participating laboratories on a quarterly basis; the identity of the analytes and their concentrations vary from quarter to quarter.

a. If the results are <5 times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

b. The blind standards program does not require semivolatile organic compound standards.

N/R = not required

RSD = relative standard deviation

Table E-23. Blind Standards Laboratory Success Rates for 2017

Laboratory	Success Rate (Percent) by Quarter[a]				
	2016, 4th Quarter[b]	1st Quarter	2nd Quarter	3rd Quarter[c]	4th Quarter
ALS	100	91.8	92.3	N/A	94.4
GEL	69.2	88.4	95.6	N/A	82.8
SWRI	87.5	54.2	67.9	N/A	72.4
TADN	53.8	72.1	94.4	N/A	81.6
TARL	92.3	94.2	100	N/A	83.3
TASL	43.3	86.3	92.2	N/A	84.2

a. Success rate = 100 × number of results within quality control recovery criteria/total number of results submitted. The minimum acceptable success rate is 80% (CHPRC-00189, *CH2M Hill Plateau Remediation Company Environmental Quality Assurance Program Plan*). Success rates less than the 80% criterion are denoted by the yellow-shaded cells.

b. These results were not reported in the 2016 annual groundwater report.

c. Third quarter blinds were not produced because the fire danger on the Hanford Site did not allow acquisition of the groundwater matrix for the blind standards.

ALS = ALS Laboratory

GEL = GEL Laboratory

N/A = not available

SWRI = Southwest Research Institute

TADN = TestAmerica–Denver

TARL = TestAmerica–Richland

TASL = TestAmerica–St. Louis

Pacific Northwest National Laboratory personnel prepared the blind standards for 2017. Blind standards were generally prepared in triplicate to check laboratory analytical accuracy and precision. For most constituents, the blind standards were prepared in a groundwater matrix from an appropriate background well to simulate actual groundwater samples. Multi-metal blind standards for analysis by ICP techniques were prepared in deionized water using commercially prepared metal standards. The blind standards were submitted to the laboratories as routine groundwater samples.

After the laboratories reported the blind standard results, the results were compared with the spiked concentrations to generate percent recoveries and percent RSDs. The percent recoveries and percent RSDs were compared to the control limits to determine whether the data met the QC criteria.[6] Out-of-limit results were reviewed for errors. In situations where several results for the same method were unacceptable, an RDR may be generated to reanalyze the blind samples (if within holding times) or to recheck the results. Chronic out-of-limit results were discussed with the laboratory, potential problems were investigated, and corrective actions were requested when appropriate. Occasionally, several laboratories reported very similar out-of-limit results; in those cases, a blind standard makeup error was suspected to have occurred. At the discretion of the S&GRP blind standards scientist, the out-of-limit results were removed from the laboratories' submitted results and were not counted. Table E-24 summarizes the blind standards that exceeded the recovery or precision criteria during 2017; results that are outside of the recovery or precision limits are in shaded cells.

Notable observations for the 2017 (including 2016 fourth quarter) blind standards are as follows:

- **General chemical parameters:** ALS, GEL, SWRI, TADN, and TASL returned results for TOC and TOX blind standards during 2017. The recovery acceptance limits for these analytes are 75% to 125% and a percent RSD limit of 25%. The highlights of these results are discussed below:
  - **Total organic carbon:** ALS, GEL, SWRI, TADN, and TASL reported results for the TOC blind standards throughout the reporting period. This standard is made from the nonvolatile standard material potassium acid phthalate. During the reporting period, the TOC concentration in the blind standards ranged from 1,000 to 2,010 µg/L. ALS reported 16 TOC results and SWRI returned four TOC results, all of which met the recovery and precision criteria. GEL, TADN, and TASL returned 16 results each for the reporting period; the out-of-limit recoveries for these three laboratories all exceeded the upper recovery limit. GEL returned four results (25.0%) out high, TADN returned six results (37.5%) out high, and TASL reported five results (31.2%) out high. None of the laboratories exceeded the precision limit. The recovery results may indicate that a fraction of the routine groundwater monitoring TOC results is biased somewhat high. The TOC field splits were checked for any corroborating information, and only one pair met the evaluation criterion and was between GEL and TASL; the RPD for this split was 6.3% and met the RPD acceptance criterion.

[6] If the blind standard concentration is less than five times the RDL for the analyte, the secondary precision criterion is used. The difference between the maximum and minimum values reported must be less than the RDL (DOE/RL-91-50).

Table E-24. 2017 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL/ MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
2016, 4th Quarter													
TOC	TADN	1,000	1,000	155	µg/L	75 - 125	122	130	128	128	25	2.7	N*
TOC	TASL	1,000	1,000	720	µg/L	75 - 125	140	130	150	140	25	5.8	N*
TOX (phenol)	GEL	100	10	3.33	µg/L	75 - 125	82.9	88.3	38.0	81.8	25	32.1	Y
TOX (VOA)	GEL	103.9	10	3.33	µg/L	75 - 125	30.3	35.1	78.0	—	25	54.9	Y
TOX (VOA)	TADN	103.9	10	7.7	µg/L	75 - 125	42.6	39.2	43.2	—	25	5.3	N
TOX (VOA)	TASL	103.9	10	2.1	µg/L	75 - 125	49.9	40.5	48.7	—	25	11.0	N
Hexavalent chromium	GEL	9.8	5	3.0	µg/L	80 - 120	31.0	30.6	31.0	—	20	0.8	N*
Hexavalent chromium	TARL	9.8	5	1.5	µg/L	80 - 120	122	112	122	—	20	5.0	N*
Chloroform	GEL	102	1.4	0.30	µg/L	75 - 125	50.2	50.7	50.3	—	25	0.5	N
Chloroform	TADN	102	1.4	0.16	µg/L	75 - 125	56.9	52.9	52.0	—	25	4.8	N
Chloroform	TASL	102	1.4	0.20	µg/L	75 - 125	44.1	43.1	44.1	—	25	1.3	N
Tetrachloroethene	GEL	101	0.5	0.30	µg/L	75 - 125	41.1	40.6	38.1	—	25	4.0	N
Tetrachloroethene	TADN	101	0.5	0.20	µg/L	75 - 125	48.5	45.5	43.6	—	25	5.4	N
Tetrachloroethene	TASL	101	0.5	0.18	µg/L	75 - 125	35.6	35.6	35.6	—	25	0.0	N
Carbon-14	TASL	510	50	10.8	pCi/L	70 - 130	41.2	61.6	61.2	—	20	21.3	Y
Cesium-137	GEL	25.1	6	9.28	pCi/L	70 - 130	125	109	149	—	20	15.9	Y*
Gross alpha	GEL	10.6	3	3.09	pCi/L	70 - 130	259	227	360	—	20	24.6	Y*
Gross alpha	TARL	10.6	3	2.75	pCi/L	70 - 130	111	85.3	125	—	20	18.7	Y*

Table E-24. 2017 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL/ MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
Plutonium-239	GEL	20.8	1	0.49	pCi/L	70 - 130	97.1	1.9	83.2	—	20	84.6	Y
Strontium-90	GEL	20.6	2	1.98	pCi/L	70 - 130	9.6	103	105	—	20	75.1	Y
Tritium	SWRI	259	700	250	pCi/L	70 - 130	150	163	220	—	20	21.2	N*
Tritium	TARL	259	700	484	pCi/L	70 - 130	194	< MDA	< MDA	—	20	2.7	N*
2017, 1st Quarter													
TOX (phenol)	GEL	498	10	3.33	µg/L	75 - 125	64.9	81.5	83.1	—	25	13.2	N
TOX (VOA)	GEL	447	10	3.33	µg/L	75 - 125	55.0	53.2	52.3	54.4	25	2.2	N
TOX (VOA)	TADN	447	10	38.5	µg/L	75 - 125	55.7	34.0	40.7	46.3	25	20.8	N
TOX (VOA)	TASL	447	10	10.4	µg/L	75 - 125	49.9	68.7	70.9	45.0	25	22.4	N
Nitrite	ALS	1,010	250	98.5	µg/L	75 - 125	68.3	71.6	65.0	—	25	4.8	N*
Boron	TADN	99.2	50	4.4	µg/L	80 - 120	13.5	13.4	4.4	—	20	49.8	N*
Chromium	ALS	24.9	10	1.1	µg/L	80 - 120	116	112	120	—	20	3.5	N*
Iron	TADN	397	100	22	µg/L	80 - 120	5.5	5.5	7.1	—	20	15.1	N*
Magnesium	TADN	396	1,000	11	µg/L	80 - 120	2,876	2,825	1,249	—	20	39.9	Y*
Zinc	ALS	99.2	10	9.1	µg/L	80 - 120	121	111	131	—	20	8.3	N
Zinc	GEL	99.2	10	17.5	µg/L	80 - 120	118	121	118	—	20	1.5	N
Carbon tetrachloride	GEL	98.0	1	0.30	µg/L	75 - 125	76.3	71.3	69.1	—	25	5.1	N
Carbon tetrachloride	TADN	98.0	1	0.76	µg/L	75 - 125	55.1	71.4	64.3	—	25	12.9	N
Carbon tetrachloride	TASL	98.0	1	0.91	µg/L	75 - 125	54.1	42.9	34.7	—	25	22.2	N

Table E-24. 2017 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL/ MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
Chloroform	GEL	4.87	1.4	0.30	µg/L	75 - 125	193	191	187	—	25	1.7	N*
Chloroform	TADN	4.87	1.4	0.16	µg/L	75 - 125	226	226	205	—	25	5.4	N*
Chloroform	TASL	4.87	1.4	0.10	µg/L	75 - 125	146	144	133	—	25	4.7	N*
Tetrachloroethene	GEL	4.81	0.5	0.30	µg/L	75 - 125	193	183	170	—	25	6.4	N
Tetrachloroethene	TADN	4.81	0.5	0.20	µg/L	75 - 125	173	166	148	—	25	8.0	N
Trichloroethene	TADN	98.1	1	0.64	µg/L	75 - 125	64.2	80.5	75.4	—	25	11.4	N
Trichloroethene	TASL	98.1	1	1.30	µg/L	75 - 125	63.2	53.0	47.9	—	25	14.2	N
Carbon-14	TARL	97.4	50	16.9	pCi/L	70 - 130	93.2	85.1	38.6	—	20	40.8	Y*
Carbon-14	TASL	97.4	50	12.2	pCi/L	70 - 130	79.8	72.3	69.7	—	20	7.1	N*
Gross alpha	GEL	309	3	3.00	pCi/L	70 - 130	131	145	127	—	20	6.9	N
Gross alpha	SWRI	309	3	1.72	pCi/L	70 - 130	50.5	59.5	40.8	—	20	18.7	N
Gross beta	SWRI	17.0	4	2.02	pCi/L	70 - 130	11.8	11.8	11.9	—	20	0.3	N*
Iodine-129	SWRI	9.97	1	0.93	pCi/L	70 - 130	55.1	56.6	55.8	—	20	1.4	N
Plutonium-239	TARL	1.47	1	0.61	pCi/L	70 - 130	173	105	129	—	20	25.1	N*
Tritium	SWRI	483	700	136	pCi/L	70 - 130	61.5	68.3	81.0	—	20	14.1	N*
2017, 2nd Quarter													
TOC	TASL	2,010	1,000	720	µg/L	75 - 125	129	124	109	109	25	8.7	N*
Nitrate	TASL	201,700	250	15,500	µg/L	75 - 125	134	138	136	—	25	1.6	N
Nitrite	TASL	2,030	250	46.0	µg/L	75 - 125	68.0	71.4	69.5	—	25	2.5	N
Beryllium	GEL	4.93	0.5	0.2	µg/L	80 - 120	119	123	120	—	20	2.0	N

Table E-24. 2017 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL/ MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
Beryllium	TADN	4.93	0.5	0	µg/L	80 - 120	87.2	75.1	81.1	—	20	7.5	N
Chromium	ALS	49.4	10	3	µg/L	80 - 120	97.2	78.9	97.2	—	20	11.5	N*
Copper	TADN	49.4	10	0.56	µg/L	80 - 120	86.6	74.1	86.6	—	20	8.8	N*
Hexavalent chromium	GEL	98.7	5	6	µg/L	80 - 120	114	133	107	—	20	11.1	N
Manganese	TADN	49.4	5	0	µg/L	80 - 120	88.7	74.5	90.7	—	20	10.4	N
Uranium	ALS	298.1	1	0.03	µg/L	80 - 120	97.3	77.2	97.3	—	20	12.8	N
Zinc	ALS	49.4	10	48	µg/L	80 - 120	144	126	111	—	20	12.8	Y*
Gross alpha	GEL	66.9	3.0	2.3	pCi/L	70 - 130	118	137	119	—	20	8.4	N
Gross alpha	SWRI	66.9	3.0	2.4	pCi/L	70 - 130	42.6	38.6	33.9	—	20	11.3	N
Gross beta	SWRI	55.5	4.0	2.1	pCi/L	70 - 130	85.2	66.6	74.4	—	20	12.4	N
Iodine-129	GEL	1.46	1	0.9	pCi/L	70 - 130	91.1	58.2	49.4	—	20	33.2	N*
Iodine-129	SWRI	1.46	1	0.9	pCi/L	70 - 130	89.0	67.3	69.9	—	20	15.7	N*
Strontium-90	SWRI	4.89	2	1.2	pCi/L	70 - 130	36.8	36.4	54.8	—	20	24.6	N*
2017, 3rd Quarter: blind standards not submitted to laboratories													
2017, 4th Quarter													
TOC	GEL	1,000	1,000	330	µg/L	75 - 125	127	128	133	134	25	2.7	N*
TOC	TADN	1,000	1,000	155	µg/L	75 - 125	132	122	135	130	25	4.3	N*
TOX (VOA)	GEL	92.9	10	3.3	µg/L	75 - 125	64.8	59.4	50.4	63.1	25	10.8	N
TOX (VOA)	TADN	92.9	10	7.7	µg/L	75 - 125	75.0	71.7	74.1	69.1	25	3.7	N
TOX (VOA)	TASL	92.9	10	2	µg/L	75 - 125	81.3	71.4	78.5	78.7	25	5.5	N

Table E-24. 2017 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL/ MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
Boron	ALS	50.2	50	6.6	µg/L	80 - 120	51.8	41.8	29.9	—	20	26.6	N*
Hexavalent chromium	GEL	9.66	5	3	µg/L	80 - 120	150	114	138	—	20	13.8	N*
Manganese	TASL	50.2	5	1	µg/L	80 - 120	111	109	125	—	20	7.4	N
Selenium	TASL	5.0	5	2	µg/L	80 - 120	108	100	72	—	20	20.3	N*
Vanadium	ALS	10.0	10	0.98	µg/L	80 - 120	79.0	93.0	91.0	—	20	8.6	N*
Vanadium	TASL	10.0	10	4	µg/L	80 - 120	66.0	60.0	74.0	—	20	10.5	N*
Carbon tetrachloride	GEL	5.16	1.0	0.3	µg/L	75 - 125	77.9	66.5	63.8	—	25	10.8	N
Carbon tetrachloride	TADN	5.16	1.0	0.2	µg/L	75 - 125	60.1	56.2	64.0	—	25	6.5	N
Carbon tetrachloride	TASL	5.16	1.0	0.2	µg/L	75 - 125	60.1	44.6	56.2	—	25	15.0	N
Chloroform	TADN	98.6	1.4	0.6	µg/L	75 - 125	71.0	64.9	66.9	—	25	4.6	N
Chloroform	TASL	98.6	1.4	0.5	µg/L	75 - 125	75.1	68.0	76.1	—	25	6.1	N
Tetrachloroethene	GEL	104	0.5	0.3	µg/L	75 - 125	64.7	59.1	60.8	—	25	4.7	N
Tetrachloroethene	TADN	104	1	0.8	µg/L	75 - 125	51.9	38.5	52.9	—	25	16.9	N
Tetrachloroethene	TASL	104	0.5	0.9	µg/L	75 - 125	69.2	55.8	67.3	—	25	11.4	N
Trichloroethene	TADN	5.63	1	0.2	µg/L	75 - 125	72.8	69.3	74.6	—	25	3.8	N
Trichloroethene	TASL	5.63	1	0.3	µg/L	75 - 125	65.7	58.6	69.3	—	25	8.4	N
Cesium-137	GEL	24.1	6	11	pCi/L	70 - 130	83.8	102	122	—	20	18.4	Y*
Cesium-137	TARL	24.1	6	3.68	pCi/L	70 - 130	98.3	94.2	134	—	20	20.1	Y*
Cesium-137	TASL	24.1	6	7.11	pCi/L	70 - 130	115	137	91.3	—	20	19.8	Y*

Table E-24. 2017 Blind Standard Out-of-Limit Results

Constituent	Laboratory	Spike Value	RDL	MDL/ MDA	Units	Recovery Limits (%)	Recovery 1 (%)	Recovery 2 (%)	Recovery 3 (%)	Recovery 4 (%)	Precision Limit (%)	Precision (%RSD)	Precision Criterion Exceeded?
Gross alpha	ALS	10.5	3	2	pCi/L	70 - 130	125	145	120	—	20	10.1	N*
Gross alpha	GEL	10.5	3	2	pCi/L	70 - 130	169	228	182	—	20	16.1	Y*
Gross alpha	SWRI	10.5	3	3.47	pCi/L	70 - 130	57.7	39.6	56.8	—	20	19.8	N*
Gross beta	SWRI	37.1	4	3.28	pCi/L	70 - 130	62.5	108	66.6	—	20	32.0	Y
Iodine-129	GEL	3.05	1.0	2.0	pCi/L	70 - 130	43.6	136	121	—	20	49.4	Y*
Iodine-129	TARL	3.05	1.0	0.7	pCi/L	70 - 130	144	161	123	—	20	13.4	Y*
Tritium	SWRI	235	700	229	pCi/L	70 - 130	166	98	157	—	20	26.2	N*
Tritium	TARL	235	700	418	pCi/L	70 - 130	< MDA	< MDA	247	—	20	20.3	N*

*The blind standard concentration was <5 times the RDL for this analyte. Therefore, the secondary precision criterion was used. The difference between the maximum and minimum value reported must be less than the RDL. Yellow-shaded cells indicate recoveries outside of recovery limits.

ALS = ALS Laboratory
GEL = GEL Laboratory
MDA = minimum detectable activity
MDL = method detection limit
RDL = required detection limit
RSD = relative standard deviation
SWRI = Southwest Research Institute
TADN = TestAmerica–Denver
TARL = TestAmerica–Richland
TASL = TestAmerica–St. Louis
TOC = total organic carbon
TOX = total organic halides
VOA = volatile organic analyte

- **TOX:** GEL, TADN, and TASL reported results for the TOX blind standards throughout the reporting period. Two types of standards were used to generate TOX blind samples each quarter: one based on the relatively nonvolatile compound 2,4,5-trichlorophenol, and one based on the same standards as those used for the VOC blind standard containing carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene (TCE). During the reporting period, the TOX concentration in the blind standards ranged from 90.6 to 498 µg/L. For the trichlorophenol-based standard, most of the recoveries reported by the laboratories were within the recovery limits. In contrast, the VOC-based TOX standards showed generally low recoveries, with the three laboratories reporting 28 of a total of 33 TOX recoveries less than the lower recovery limit. Out-of-limit low recoveries for the VOC-based TOX standards ranged from 30.3% to 74.1%. The predominantly low recoveries may reflect TOX recoveries for actual groundwater samples because the TOX content of many Hanford Site groundwater samples is likely due to VOCs. The TOX field splits were checked for any corroborating information, and only one pair met the evaluation criterion and was between GEL and TASL. The RPD for this split was 67.0%, with GEL reporting the higher value.

- **Ammonia and anions:** ALS, GEL, TADN, TARL, and TASL returned results for cyanide and the IC anions blind standards during 2017. The recovery acceptance limits for these analytes are 75% to 125% and a percent RSD limit of 25%. The highlights of these results are discussed below:

  - **Cyanide:** Four laboratories (ALS, GEL, TADN, and TASL) returned cyanide results for this reporting period. The cyanide concentration in the blind standards ranged from 49.5 to 202 µg/L. The 39 cyanide results returned by the four laboratories were all within the recovery limits. Three cyanide field split samples met the evaluation criterion; of these, only one split pair returned an RPD (20.4%) greater than the RPD acceptance criterion. The data appear to indicate that the cyanide results returned by the laboratories appear to have reasonable accuracy. This same statement may not be true for other cyanide species such as cyanide amenable to chlorination and free cyanide. Section E9.5.2 provides further information on the cyanide issues.

  - **IC anions:** Four laboratories (ALS, GEL, TARL, and TASL) returned IC anion results for this reporting period. Of the IC anions, nitrite continued to prove to be the most difficult to quantify accurately. For the reporting period, nitrite blind standard concentrations ranged from 479 to 2,030 µg/L. During this same period, the four laboratories reported 21 total nitrite results; GEL and TARL had no recovery or RPD failures for nitrite. ALS and TASL reported all nitrite blind standard recoveries <85%, with each laboratory having three nitrite results less than the lower recovery limit; the failed recoveries ranged from 65.0% to 71.6%. The range of nitrite concentrations in the blind standards appears to have been well above laboratory MDLs; at least none of the out-of-limit results were “B” flagged. Overall, these results indicate that the nitrite results from ALS and TASL are biased low. No split sample results for nitrite met the evaluation criterion, so split data are not available to compare interlaboratory performance for this analyte.

- **Metals:** Five participating laboratories returned results for metals blind standards during 2017. ALS, GEL, TADN, and TASL reported metals determined by ICP/AES and ICP/MS. GEL, TARL, and TASL reported Cr(VI) by colorimetry. GEL, TADN, and TASL reported mercury by cold-vapor atomic absorption. The recovery acceptance limits for the metals are 80% to 120% and a percent RSD limit of 20%. Those metals with more than three out-of-limit recoveries are discussed further:

- **Cr(VI):** For the reporting period, the concentration for Cr(VI) in the blind standards ranged from 9.66 to 98.7 µg/L. Eight of 27 (29.6%) Cr(VI) blind standard results fell outside of the recovery acceptance criteria; three failed low and five failed high. GEL reported the three low recoveries at 31.0% and three high recoveries with a range of 133% to 150%. All three low recoveries were for the 2016 fourth quarter blind standards; the three high recoveries occurred during the second quarter (one high) and fourth quarter (two high) of 2017. The two Cr(VI) recovery failures for TARL were both in the fourth quarter of 2016; both recoveries failed high at 122%. Despite the number of Cr(VI) recovery failures, no discernable pattern is evident. None of the Cr(VI) results reported by the laboratories generated percent RSD values greater than the percent RSD limit.

- **Vanadium:** During this reporting period, the spike concentration of vanadium was 10 µg/L and was prepared only during the fourth quarter of 2017. Four laboratories (ALS, GEL, TADN, and TASL) returned 12 results total for vanadium; all of the results were determined by ICP/AES. Of the 12 recoveries, four (33.3%) were outside of the recovery limits, with all four failing low. ALS had one recovery fail low at 79.0%. TASL had the remaining three low failures, with a range of 60.0% to 74.0%. ALS and TASL both qualified several of their vanadium results with a "B" flag, indicating that the results were greater than the MDL but less than the EQL. The 2016 data usability assessment reported three failed recoveries for TASL for vanadium during the fourth quarter of 2015 (one failed low and two failed high). The few failed recoveries for vanadium do not appear to establish any pattern other than to confirm that when the analyte concentration is between the MDL and EQL, measurement noise will have a greater effect on the accuracy of the result.

- **Zinc:** During the reporting period, the spike concentration of zinc was 49.4 to 99.2 µg/L and was prepared during all three quarters of 2017. Four laboratories (ALS, GEL, TADN, and TASL) returned 36 results total for zinc; all results were determined by ICP/AES. Of the 36 recoveries, five (13.9%) were outside of the recovery limits, with all five failing high. ALS had four recoveries fail high, with a range of 121% to 144%. GEL had the remaining high failure at 121%. ALS qualified six zinc results with a "B" flag, indicating that the results were greater than the MDL but less than the EQL. The high failed recoveries for zinc may indicate a possible high bias for zinc results. A comparison of the zinc blind standard results with zinc field split results revealed a single zinc split sample pair that met the evaluation criterion. The split was between ALS with a result of 49 µg/L and TADN with a result of 17 µg/L for an RPD of 97.0%.

- **VOCs:** GEL, TADN, and TASL returned results for the VOC blind standards during 2017. The recovery acceptance limits for these analytes are 75% to 125% and a percent RSD limit of 25%. The VOC blind standards contained carbon tetrachloride, chloroform, tetrachloroethene, and TCE at concentrations ranging from 4.81 to 104 µg/L. Of the 90 VOC results reported, 72 recoveries (80.0%) were out of limits, with 57 recoveries less than the lower recovery limit, which continues the historical trend of low recoveries for the VOC blind standards. The low recoveries ranged from 34.7% to 74.6%. Low recoveries for these analytes are attributed, in part, to losses of the VOCs from the blind standards during standards makeup and sample handling. The three laboratories also reported 15 results that exceeded the upper recovery limit, but this behavior tends to be the exception. The high recoveries ranged from 133% to 226% and were reported for the first quarter of 2017 for chloroform (GEL, TADN, and TASL) and tetrachloroethene (GEL and TADN). It may be possible that the chloroform and tetrachloroethene standards were made incorrectly, but the recoveries among the three laboratories were not consistent enough to conclude that a mis-made standard had occurred. Of the 30 precision results reported for the VOC blind standards during 2017, none exceeded the RSD limit. The VOC blind standards results were compared with the available split sample results. Of the

four VOCs used in the blind standards, only one split pair for TCE met the split evaluation criteria; TADN and TASL returned concentration values of 3.3 and 3.4 µg/L with an associated RPD of 3.0% for VOC samples B37Y75 and B37Y77.

- **Radiochemical parameters:** ALS, GEL, SWRI, TARL, and TASL returned results for radiochemical blind standards during 2017. The recovery acceptance limits for radiochemical parameters are 70% to 130% with a percent RSD limit of 20%. For 2017, the five laboratories returned 348 results, with 56 results (16.1%) outside of the recovery limits; 32 results failed low and 24 results failed high. Fourteen of 116% RSDs (12.1%) fell outside of the RSD limit. By laboratory, SWRI returned the poorest percent recovery success rate at 64.0%. The highlights of these results are discussed below:

  - **Carbon-14:** For 2017, the blind standard carbon-14 activities ranged from 97.4 to 605 pCi/L. The five laboratories returned a total of 33 carbon-14 results of which 5 (15.2%) did not meet the recovery criteria; all 5 failed low. TARL had one low recovery at 38.6%. The TASL four low recoveries ranged from 41.2% to 69.7%; three of the low recoveries occurred during the fourth quarter of 2016. In general, the blind standard carbon-14 recoveries for the five laboratories trend somewhat lower than 100%, but mostly meet the recovery requirements.

  - **Gross alpha:** For the reporting period, the blind standard gross alpha activities ranged from 10.5 to 309 pCi/L; the standards were spiked with plutonium-239. The five laboratories returned a total of 39 gross alpha results, of which 19 (48.7%) did not meet the recovery criteria; 9 recoveries failed low and 10 failed high. ALS reported three gross alpha results, with one recovery failing high at 145%. GEL reported 12 results, with 9 recoveries (75.0%) outside of the recovery limits; the 9 recoveries failed high with a range of 131% to 360%. SWRI reported nine gross alpha results; all recoveries (100%) failed low with a range of 33.9% to 57.7%. TARL reported 12 results and TASL reported 3 results; all of the results from these two laboratories met the recovery criteria. The large scattering of gross alpha recoveries among the laboratories indicates that results for this radiochemical parameter compare poorly among the laboratories. Reasons for the differences in gross alpha results among the laboratories are the use of different alpha-emitting radionuclides to standardize their gross alpha methods and the preparation methods used to prepare the gross alpha mounts for counting. Field split results for gross alpha were examined to further define biases among the laboratories. Unfortunately, of 38 field splits for gross alpha, none met the evaluation criteria for determining RPDs.

  - **Gross beta:** For gross beta during this reporting period, the blind standard activities ranged from 17.0 to 55.5 pCi/L; the standards were spiked with strontium-90. The five laboratories returned a total of 39 gross beta results, of which only 3 (7.7%) did not meet the recovery criteria; all 3 failed low. SWRI reported 12 gross beta results for the reporting period and had the 3 gross beta recoveries that failed low, with a recovery range of 62.5% to 66.6%. Most of the SWRI blind standard gross beta recoveries trended <100% but were still within the lower recovery limit. In general, the blind standard gross beta results from the five laboratories are reasonably comparable.

- **Iodine-129:** For 2017, the blind standard iodine-129 activities ranged from 1.46 to 9.97 pCi/L. GEL, SWRI, and TARL returned a total of 36 iodine-129 results, of which 11 (30.6%) did not meet the recovery criteria; 8 recoveries failed low and 3 failed high. The spike values tend to be close to the required detection limit of 1 pCi/L, so it is not surprising to see occasional out-of-limit recoveries for this radionuclide. For this reporting period, GEL reported 12 results (3 recoveries low and one high). SWRI reported 12 results, with 5 recoveries out (all low). TARL also reported 12 results (2 recoveries out high). No discernable bias was observed among the three laboratories reporting the iodine-129 blind standard results.

- **Strontium-90:** For the reporting period, the blind standard strontium-90 activities ranged from 4.89 to 101 pCi/L. The five laboratories returned a total of 45 strontium-90 results, of which only 4 recoveries (8.9%) did not meet the recovery criteria (all 4 failed low). All of the strontium-90 results for ALS, TARL, and TASL met the recovery limits. GEL had one of the low recoveries of 12 reported results, and SWRI had 3 recoveries fail low of 9 reported results. In terms of relative biases, SWRI tended to report lower recoveries (<100%) than the other four laboratories, while TARL tended to report higher recoveries (>100%) than the other laboratories.

- **Tritium:** During 2017, the blind standard tritium activities ranged from 235 to 1,010 pCi/L. GEL, SWRI, TARL, and TASL returned a total of 42 tritium results, of which 9 recoveries (21.4%) did not meet the recovery criteria; 2 recoveries failed low and 7 failed high. All of the tritium results for GEL (12 results) and TASL (6 results) met the recovery limits. SWRI reported 12 results, of which 2 recoveries failed low (ranging 61.5% to 68.3%) and 5 failed high (ranging 150% to 220%). TARL also reported 12 tritium results and had 2 recoveries fail high (ranging 194% to 247%). Almost all the high recovery failures were for tritium blind standards that were near or less than the laboratory MDAs, so many of these failures were false positives.

E8.2 National Performance Evaluation Studies

During 2017, Environmental Resources Associates (ERA) and U.S. Department of Energy (DOE) conducted national studies to evaluate laboratory performance for chemical and radiological constituents. ALS, GEL, SWRI, TADN, TARL, and TASL participated in the EPA-sanctioned water pollution/water supply (WP/WS) performance evaluation studies conducted by ERA. The laboratories also participated in the DOE Mixed Analyte Performance Evaluation Program (MAPEP), and five of the laboratories participated in the ERA InterLaB RadCheM Proficiency Testing Program (RAD). The results of those studies related to groundwater monitoring at the Hanford Site are described in this section.

E8.2.1 Water Pollution/Supply Performance Evaluation Studies

The purpose of WP/WS performance evaluation studies is to evaluate the performance of laboratories in analyzing selected organic and inorganic compounds in water matrices. An accredited agency (e.g., ERA) distributes standard water samples to participating laboratories. These samples contain specific organic and inorganic analytes at concentrations unknown to the participating laboratories. After analysis, the laboratories submit results to the accredited agency, which uses regression equations to determine acceptance and warning limits for the study participants. The results of these studies are expressed as a percentage of the results that the accredited agency found acceptable and independently verify the level of laboratory performance. If there is an unacceptable result, the laboratories may order an ERA QuiK™ Response WP/WS pollution/water supply samples, and results are reported in a comparable fashion.

™ QuiK is a trademark of Environmental Resources Associates, Golden, Colorado.

For the three WP/WS performance evaluation studies in which SWRI participated during 2017 (WS-255, WP-271, and WP-273), the percentage of results within the acceptance limits was 28% of eight total results reported (Table E-25). As noted in Table E-25, five constituents had an unacceptable result. None of these constituents are reported by SWRI in support of the groundwater program. SWRI may have participated in more WP/WS studies during 2017; however, only data for these three minimal studies were available at the time of this review.

Table E-25. Summary of SWRI Performance Evaluation Studies

Study Number	Date	Correct Results/ Total Results
Water Pollution/Water Supply Performance Evaluation Studies, Environmental Resource Associates		
WP-271	November 2017	1/1
WP-273	October 2017	1/1
WS-255	November 2017	0/5[a]
DOE Mixed Analyte Performance Evaluation Program (MAPEP), Radiological and Environmental Sciences Laboratory		
MAPEP-17-MaW36	June 2017	36/37[b]
MAPEP-17-XaW36	June 2017	1/1
MAPEP-17-MaW37	February 2018	37/37
MAPEP-17-XaW37	February 2018	1/1
MAPEP-17-ScRW37	February 2018	2/2
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates		
MRAD-27	November 2017	67/67

a. Unacceptable results were for ammonia, nitrate, nitrite, phosphate and selenium.

b. Unacceptable result was for cesium-134.

DOE = U.S. Department of Energy

For the four WP/WS performance evaluation studies in which ALS participated during the reporting period, the percentage of results within the acceptance limits was 97% of 761 total results reported (Table E-26). As noted in Table E-26, 23 different constituents had unacceptable results. Three analytes (copper, chloride, and phosphate) failed in two different studies. Currently, ALS mainly supports the groundwater program with metals analysis; however, a small percentage of samples have also been analyzed for cyanide, IC anions, VOCs, and limited radiological analyses. Acceptable results were achieved in the subsequent WS/WP or Rapid Response samples for all analytes that originally failed.

For the two WP performance evaluation studies in which TASL participated during 2017 (WP-0717 WS-0417), the percentage of results within the acceptance limits was 99.7% of 369 total results reported (Table E-27). As noted in Table E-27, only one constituent (TOC) had an unacceptable result. The laboratory successfully passed an earlier WS study for TOC. Acceptable results were also achieved for TOC in a Rapid Response sample.

Table E-26. Summary of ALS Performance Evaluation Studies

Study Number	Date	Correct Results/ Total Results
Water Pollution/Water Supply Performance Evaluation Studies, Environmental Resource Associates		
WP-234	February 2017	306/317[a]
WP-238	September 2017	286/294[b]
WS-109	March 2017	82/88[c]
WS-111	September 2017	61/62[d]
DOE Mixed Analyte Performance Evaluation Program (MAPEP), Radiological and Environmental Sciences Laboratory		
MAPEP-17-MaW36	June 2017	35/36[e]
MAPEP-17-XaW36	June 2017	1/1
MAPEP-17-MaW37	February 2018	34/36 [f]
MAPEP-17-XaW37	February 2018	1/1
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates		
RAD-109	May 2017	13/14[g]
RAD-111	November 2017	12/12
MRAD-26	May 2017	16/16
MRAD-27	November 2017	16/16

Notes: The multiple Quik Response and PT Express PE studies run by the laboratories are not included in this table.

a. Unacceptable results were for cobalt, copper, iron, manganese, nickel, strontium, sulfate, 2-nitrophenol, indeno(1,2,3-c,d)pyrene, and benzo(a)anthracene.

b. Unacceptable results were for chloride, phosphate, specific conductivity 3,3'-dichlorobenzidine, o-dinitrobenzene, hexachlorocyclopentadiene, benzo(b)fluoranthene, and fluorine.

c. Unacceptable results were for alkalinity, copper, chloride, total dissolved solids, total xylenes, and vinyl chloride.

d. Unacceptable result was for phosphate.

e. Unacceptable result was for iron-55.

f. Unacceptable results were for mercury and zinc.

g. Unacceptable result was for radium-226.

DOE = U.S. Department of Energy

Table E-27. Summary of TestAmerica Performance Evaluation Studies

Study Number	Date	Correct Results/Total Results		
		TASL	TARL	TADN
Water Pollution/Water Supply Performance Evaluation Studies, Environmental Resource Associates				
WP-0717	August 2017	307/308[a]	—	350/354[b]
WP-0267	June 2017	—	5/5	—
WP-0270	September 2017	—	31/31	—
WP-252	March 2016	—	31/31	—
WS-0417	June 2017	61/61	—	—
DOE Mixed Analyte Performance Evaluation Program (MAPEP), Radiological and Environmental Sciences Laboratory				
MAPEP-17-MaW36	June 2017	33/35[c]	19/19	16/16
MAPEP-17-XaW36	June 2017	1/1	1/1	—
MAPEP-17-MaW37	February 2018	36/36	18/20[d]	16/16
MAPEP-17-XaW37	February 2018	1/1	1/1	—
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates				
RAD-109	May 2017	—	12/14[e]	—
RAD-1111	November 2017	—	15/15	—
MRAD-27	November 2017	14/15	—	—

Notes: The multiple Quik Response and PT Express PE studies run by the laboratories are not included in this table.

a. Unacceptable results was for total organic carbon.

b. Unacceptable results were for hexavalent chromium, sulfide, volatile solids, and propazine.

c. Unacceptable results were for cobalt, amerecium-241 (both false positive).

d. Unacceptable results were for manganese-54 and nickel-63.

e. Unacceptable results were for radium-226 and iodine-131.

DOE = U.S. Department of Energy

TADN = Test America–Denver

TARL = TestAmerica–Richland

TASL = TestAmerica–St. Louis

For the WP performance evaluation studies in which TADN participated during 2017 (WP-0717), the percentage of results within the acceptance limits was 99% of 354 total results reported (Table E-27). As noted in Table E-27, four constituents had unacceptable results. Two of the constituents (Cr(VI) and volatile solids) are not reported by TADN in support of the groundwater program. Acceptable results were also achieved for all missed constituents in subsequent Rapid Response samples. TADN may have participated in more WP/WS studies during 2017; however, data for only one study was available at the time of this review.

For the two WP performance evaluation studies (WP-267 and WP-270) in which TARL participated during the reporting period, the percentage of results within the acceptance limits was 100% of 36 total results reported (Table E-27). The number of constituents evaluated for these two studies was very limited; therefore, the percentage of results is not directly comparable to that of the other laboratories.

For the 13 WP/WS performance evaluation studies in which GEL participated during 2017 (WP-264, WP-265, WP-267, WP-268, WP-270, WP-271, WP-273, WS-245, WS-248, WS-249, WS-252, WS-253 and WS-254), the percentage of results within the acceptance limits was 98% of 962 total results reported (Table E-28). A total of 15 different constituents had unacceptable results. Two constituents (phosphate and turbidity) failed in more than one study; however, turbidity is a not constituent run by GEL to support the groundwater program. All of the failed constituents passed in multiple subsequent studies or in QuiK Response program sample analyses.

Table E-28. Summary of GEL Performance Evaluation Studies

Study Number	Date	Correct Results/Total Results
Water Pollution/Water Supply Performance Evaluation Studies, Environmental Resource Associates		
WP-264	March 2017	2/2
WP-265	April 2017	1/1
WP-267	June 2017	348/351[a]
WP-268	July 2017	2/3[b]
WP-270	September 2017	2/2
WP-271	October 2017	1/1
WP-273	November 2017	358/364[c]
WS-245	January 2017	54/57[d]
WS-248	April 2017	6/7[e]
WS-249	May 2017	1/1
WS-252	August 2017	166/168[f]
WS-253	September 2017	3/4[g]
WS-254	October 2017	1/1
DOE Mixed Analyte Performance Evaluation Program (MAPEP), Radiological and Environmental Sciences Laboratory		
MAPEP-17-MaW36	June 2016	37/37
MAPEP-17-XaW36	June 2016	1/1
MAPEP-17-MaW37	December 2016	37/37
MAPEP-17-XaW37	December 2016	1/1

Table E-28. Summary of GEL Performance Evaluation Studies

Study Number	Date	Correct Results/Total Results
InterLaB RadCheM Proficiency Testing Program, Environmental Resource Associates		
RAD-109	May 2017	2/2
RAD-110	August 2017	24/25[h]
MRAD-26	May 2017	23/23
MRAD-27	November 2017	25/25

Notes: The multiple Quik Response and PT Express PE studies run by the laboratories are not included in this table.

a. Unacceptable results were for total hardness, phosphate and sulfide.

b. Unacceptable result was for phosphate.

c. Unacceptable results were for acetone, 2,2-dichloropropane, 1,1,1,2-tetrachloroethane, o-xylene, conductivity and chemical oxygen demand.

d. Unacceptable results were for 1,1-dichloroethylene, cis-1,3-dichloropropene and fluorotrichloromethane.

e. Unacceptable result was for selenium.

f. Unacceptable results were for thallium and turbidity.

g. Unacceptable result was for turbidity.

h. Unacceptable result was for radium-226.

DOE = U.S. Department of Energy

E8.2.2 InterLaB RadCheM Proficiency Testing Program Studies

The purpose of the RAD Proficiency Testing Program (also conducted by ERA) is used to evaluate the performance of laboratories in analyzing selected radionuclides. This program provides blind standards that contain specific amounts of one or more radionuclides in a water matrix to participating laboratories. After sample analysis, the results are forwarded to ERA for comparison with the known values and with results from other laboratories.

SWRI provided results for one study (MRAD-27) (Table E-25) with an acceptance percentage of 100% of six results. SWRI provided limited radiological support to the ground water program during 2017.

During the reporting period, ALS participated in four studies (RAD-109, RAD-111, MRAD-26, and MRAD-27) (Table E-26) with an acceptance percentage of 98% of 58 results. ALS does not currently perform analysis for the failed constituent (radium-226) in support of the ground water program, so the failure is not germane to groundwater monitoring data quality.

TASL participated in one study (MRAD-27) (Table E-27) and analyzed a total of 15 constituents with one unacceptable result (plutonium-239) for an acceptance of 93%. No other MRAD or RAD results were available for review; however, TASL passed this radioanalyte in the MAPEP studies. During 2017, TASL performed limited radiological support for the ground water program and only ran 18 samples for plutonium-239.

TARL reported results for two studies in 2017 (RAD-109 and RAD-111) (Table E-27), with two unacceptable constituents (radium-226 and iodine-131) out of 29 results, with an acceptance rate of 93%. TARL does not report results for iodine-131 to support the groundwater program, so the failure is not germane to groundwater monitoring data quality. Passing results were achieved for the two constituents in the second RAD PE study.

GEL participated in four studies (RAD-109, RAD-110, MRAD-26, and MRAD-27) and analyzed a total of 75 constituents with an acceptance rate of 99% (Table E-28). GEL reported one unacceptable result for radium-226; the unacceptable radium-226 result was measured using gas proportional detection. However, GEL uses a Lucas cell procedure to measure radium-226 in Hanford Site groundwater samples, so this failure is not germane to groundwater monitoring data quality.

TADN does not have radiological capacity, so RAD studies are not available for evaluation.

E8.2.3 DOE Mixed Analyte Performance Evaluation Program

The DOE MAPEP examines laboratory performance in analyzing soil and water samples containing metals and radionuclides. This data usability assessment considers only results from the water samples. The program is conducted at the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho. DOE evaluates the accuracy of the MAPEP results for inorganic and radiological analytes by determining if the results fall within 30% of the reference value. Two studies were available for all laboratories during the reporting period: MAPEP-17-36 and MAPEP-17-37. Five laboratories participated in both studies.

SWRI analyzed inorganics and radionuclides for both MAPEP studies (Table E-25). Of 77 constituents, one had an unacceptable result, yielding a 97% acceptable result rate. The failed result (cesium-134) was reported by SWRI to support the groundwater program; however, this failure was not repeated in other PE studies including the second MAPEP round.

ALS analyzed inorganics and radionuclides for both MAPEP studies (Table E-26). Of 74 constituents, 3 had unacceptable results, for a 96% acceptable result rate. The failed results were mercury, zinc, and iron-55. The mercury and zinc failures were not repeated in any other PE studies. ALS does not report iron-55 to support the groundwater monitoring program, so this failure is not germane to groundwater monitoring data quality.

TASL analyzed inorganics and radionuclides for both MAPEP studies (Table E-27). Of 73 constituents, 2 had unacceptable results, yielding a 97% acceptable result rate. The failed results (cobalt and americium-241) were both low-level false positives. TASL experienced the same false-positive issue for these analytes in 2016. None of the unacceptable results were repeated in the second MAPEP round.

TARL reported results for radionuclides for both MAPEP studies (Table E-27). Of 41 constituents, 2 had unacceptable results, yielding a 95% acceptable result rate. One of the missed constituents (manganese-54) is not reported by TARL to support the groundwater program, so this failure is not germane to groundwater monitoring data quality. The second missed constituent (nickel-63) was passed in the first MAPEP round.

TADN analyzed inorganics for both MAPEP studies (Table E-27). Of the 32 constituents reported, none were unacceptable, for a 100% acceptable result rate.

GEL analyzed inorganics and radionuclides for both MAPEP studies (Table E-28). Of 76 analytes, GEL had a 100% acceptable result rate with no missed analytes.

E9 Data Usability Conclusions

In general, this quality assessment for 2017 groundwater monitoring data shows that the majority of the data are usable for the purposes of groundwater monitoring. This assessment also noted some limitations in the data set, which are discussed in this chapter.

E9.1 Data Completeness

As detailed in Chapter E5 and in Tables E-2 and E-5, 96.6% of groundwater samples planned for 2017 were collected, the requirements for the number of field QC samples were met or exceeded, and 95.3% of the analytical results met the completeness criteria. Based on the review performed in this assessment, nearly all of the required samples, field QC, and analytical results were collected in accordance with the groundwater monitoring requirements of CHPRC-00189.

E9.2 Sample Preservation and Holding Time

As noted in Section E5.5.1, improper sample preservation was a minor issue, with only 0.5% of all laboratory samples affected by sample preservation issues; 17 analyses were canceled as a result of this issue. Missed holding times had somewhat more impact on the groundwater monitoring data set, with only 1.0% of the analytical results associated with missed holding times. Most of the results with missed holding times were still generated within two times the holding time and, therefore, were deemed usable by the groundwater monitoring program.

E9.3 Field Quality Control

Field QC samples were collected and analyzed in accordance with the groundwater monitoring requirements of CHPRC-00189. Field QC issues generated minimal impact to data usability. Chapter E6 discusses groundwater monitoring field QC samples in detail.

For the FBs, the number and types of FBs collected met groundwater monitoring collection requirements and 93.9% of the FB results were found to meet groundwater monitoring criteria. Of the 1,113 FB results that exceeded the criteria, 394 were for metals and 384 were for VOCs. Some of the out-of-limit metal results were likely due to sample swaps of the FB with a groundwater sample, either in the field or at the laboratory. A total of 115 out-of-limit FB metal results had associated method blank contamination. Most of the out-of-limit VOC results are likely due to probable contamination of the deionized water source used to generate the blank or to laboratory contamination during sample preparation and analysis. In particular, methylene chloride continued to appear as a contaminant from the deionized water used to make up the FBs. The appearance in FBs and groundwater samples of another VOC analyte, 2-propanol, is discussed more extensively in Section E9.5.1.

For the field sample duplicates, 22.1% of the reported field duplicate results met the evaluation criterion. Of these duplicate results, 94.2% were acceptable, indicating reasonable precision for field sampling operations and laboratory analysis.

Of the 2017 split sample results, 11.9% met the evaluation criterion, and 66.0% of those results met the precision criterion. This success rate for split sample results is less than the success rates for split samples in previous years, indicating poorer analytical agreement among laboratories than has been historically observed. The SVOCs (specifically the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans) accounted for 48.5% of all split result RPD failures, with 32 of 33 split results failing to meet the RPD criterion. For those SVOC compounds, this finding casts doubt on the veracity of the 309 routine groundwater monitoring results that were reported above the MDL. While the other analyte categories did

not render stellar performances for meeting the split sample RPD criteria, the split results for those categories do not call the results into question for an entire set of analytes. Section E6.3 provides additional information on the field split sample results.

For the field sample TOC and TOX quadruplicates, 2.1% of the reported quadruplicate laboratory results for TOC met the evaluation criterion; of these quadruplicate results, 80.0% met the reproducibility criterion. For TOX, 17.4% of the quadruplicate results met the evaluation criterion, and of these, 64.3% exceeded the reproducibility criterion. The poor reproducibility for TOX is sub-optimal and indicates that some deficiencies may exist in the laboratory sample preparation and analysis of these analytes. Groundwater monitoring personnel will continue to evaluate groundwater TOC and TOX data to determine what course of corrective actions may be needed to address this issue.

E9.4 Laboratory Quality Control

The frequency at which laboratory batch QC samples were analyzed met the requirements of CHPRC-00189. Overall, 96.9% of laboratory QC sample results met the groundwater monitoring requirements identified in Table E-1. This indicates reasonable control of sample preparation and analytical methods at the laboratories with respect to cleanliness, precision, and accuracy. Chapter E7 discusses the laboratory QC associated with groundwater monitoring samples in detail.

Of the laboratory method blanks, 97.5% met the QC requirements. This indicates adequate cleanliness during laboratory sample preparation and analysis. Numerically, most of these failures were for metals, with 753 of 15,706 blank results (4.8%) exceeding the QC criterion. Percentage-wise, the general chemical parameters had 9.9% (69 of 697 blank results) exceed the QC criterion.

As a measure of analytical accuracy, 95.3% of the LCS results, 97.9% of the MS results, and for the VOC and SVOC analytes, 93.8% of the surrogates met QC recovery requirements. This indicates that the analytical methods are yielding reasonable accuracy for the groundwater monitoring program. A glaring exception to these accuracy measures were the sulfide results from TASL, where 13 of 15 LCS recoveries were less than the lower recovery limit ,and 13 of 15 MS recoveries were less than the lower recovery limit. This indicates that the sulfide results generated at TASL are likely biased low.

With respect to analytical precision, 98.4% of the LCSDs, 97.9% of the MSDs, and 96.8% of sample duplicates met QC precision requirements. For the VOC and SVOC analytes, 95.7% of the surrogate duplicates met QC precision requirements. These precision results indicate that the analytical methods are producing groundwater monitoring data that meet groundwater monitoring precision requirements.

E9.5 Laboratory Performance

The blind standards program and the performance evaluation studies provided an additional check on laboratory performance. Chapter E8 provides additional details.

The evaluation of the blind standards for 2017 indicates that several participating laboratories failed to meet the 80% success rate requirement for the groundwater monitoring program. GEL, SWRI, TADN, and TASL did not meet the 80% acceptance criterion for one or more quarters during the reporting period (including the fourth quarter of 2016). Of the blind standard results for all laboratories during 2017, 85.9% were acceptable.

The following are the concerns from the 2017 blind standards program:

- **TOX:** The VOC-based TOX standards mostly had recoveries less than the lower recovery limit. These predominantly low recoveries may reflect TOX recoveries for actual groundwater samples because the TOX content of many Hanford Site groundwater samples is likely due to VOCs.
- **Nitrite:** For all of the 2017 nitrite blind standard results, ALS and TASL reported recoveries <85%, with two laboratories having a total of six nitrite recoveries less than the lower recovery limit. This is likely an indicator that the nitrite results from those two laboratories are biased low.
- **Gross alpha:** The large scattering of blind standard gross alpha recoveries among the laboratories indicates that results for this radiochemical parameter compare poorly among the laboratories. All of the SWRI gross alpha recoveries were <60%. All but one of the TARL gross alpha recoveries ranged between 70% and 115%. The ALS recoveries ranged between 120% and 145%, and the GEL recoveries ranged between 118% and 360%.

During 2017, ALS, GEL, SWRI, TADN, TARL, and TASL participated in national studies to evaluate laboratory performance for chemical and radiological constituents (see Section E8.2). In general, the acceptable performance of the laboratories in these evaluations adds confidence in the quality of groundwater monitoring data. Many of the analytes for which the laboratories returned out-of-limit performance evaluation results either are of no concern to the groundwater monitoring program or the laboratories do not analyze groundwater monitoring samples for those failed analytes. The laboratories also reported some failed results for a few analytes of interest to the groundwater monitoring program. In most of those instances, the laboratories were able to pass the performance evaluation for failed analytes with follow-up performance evaluation samples. The results of the performance evaluation studies indicate that the participating laboratories are overall providing analytical results within acceptable accuracy limits for analytes of interest to the groundwater monitoring program.

E9.6 Special Considerations

This section addresses concerns about groundwater monitoring data that are not covered elsewhere in this usability assessment. Two concerns in particular are discussed in the following sections: (1) the appearance of 2-propanol (isopropyl alcohol) in groundwater FBs and groundwater samples, and (2) the results for the various cyanide forms.

E9.6.1 2-Propanol (Isopropyl Alcohol)

The appearance of 2-propanol (Chemical Abstracts Service #67-63-0) in groundwater monitoring FBs and samples was discussed by S&GRP and generated several RDRs. An examination of all 2-propanol data in the HEIS database for 2017, including results for programs other than routine groundwater monitoring, revealed the following:

1. A total of 159 records exist in the HEIS “RESULT” table for 2-propanol in 2017. The concentration range for these results is 5.0 to 370 µg/L. Twelve 2-propanol results have a laboratory qualifier of “U” (not detected).
2. 2-Propanol is reported as a tentatively identified compound in 130 of the 159 records.
3. A total of 55 FBs (2 EBs, 6 FTBs, and 47 FXRs) have detected results for 2-propanol, with values ranging from 5.2 to 300 µg/L.
4. Of the 159 results for 2-propanol, 18 results (all detected values) are part of 17 field duplicate or field split pairs. Only one of these pairs (field duplicates B38JW1 and B38L33) have detected values

(140 and 86 μg/L, respectively) for both samples in the pair. For the remaining 16 duplicate or split pairs, only one sample in the pair has a detected value for 2-propanol, with detected values ranging from 5.9 to 140 μg/L.

5. Of the 147 results with detected values, 3 are from GEL, 60 are from TADN, and 84 are from TASL.

6. A review of the laboratory QC data for GEL, TADN, and TASL generated in conjunction with the 159 results for 2-propanol revealed no 2-propanol contamination in the method blanks. Follow-up discussions with the three laboratories confirmed that 2-propanol is not appearing as a contaminant in method blanks.

These six findings indicate that the appearance of 2-propanol in field samples and FBs is primarily an artifact of blank preparation and field sampling operations and that 2-propanol does not likely occur in Hanford Site groundwater. Finding 6 above clearly indicates that the appearance of 2-propanol in Hanford Site samples is not a laboratory contamination issue; it is likely that an intermittent field contamination issue is affecting both FBs and field samples. Possible sources for 2-propanol contamination during sampling include gasoline fumes, gasoline exhaust fumes, hand sanitizers, perfumes/colognes, and cleaning/degreasing products. Discussions with Field Sampling Operations pinpointed the most likely contamination culprit for FXRs and field samples to be gasoline exhaust fumes. At many wells, the parking options for a sampling truck around the well head are very limited, and it is not always possible to park the sampling truck downwind of the wellhead. This scenario does not readily explain the two EBs and the six FTBs with detectable amounts of 2-propanol (finding 3 above); another 2-propanol contamination source is likely affecting those FBs.

E9.6.2 2017 Cyanide Results

During 2017, several questions were raised regarding the reliability of the cyanide data generated for the various programs at CH2M HILL Plateau Remediation Company, especially for pump-and-treat operations. These questions prompted an examination of the cyanide data generated for groundwater monitoring. For 2017, cyanide analyses were requested for “cyanide” (i.e., “total cyanide”; Chemical Abstracts Service #57-12-5), “free cyanide,” “cyanide amenable to chlorination,” and complexes of cyanide with various metals. Ideally, results for cyanide are for all cyanide species in the sample, including cyanide bound in metal cyanide complexes. Free cyanide measures cyanide not bound in metal complexes. Cyanide amenable to chlorination measures free cyanide and cyanide that is very weakly bound in metal complexes. With these definitions of the various cyanide species, it should be apparent that for a given sample, the results for free cyanide and cyanide amenable to chlorination should be less than or equal to the results for (total) cyanide.

Part of examining the groundwater monitoring cyanide data consisted of comparing the results for cyanide, free cyanide, and cyanide amenable to chlorination for those samples that were analyzed for all three of the cyanide species. The available QC for the various cyanide results was also explored to see if any QC issues affected the interpretation of the groundwater monitoring cyanide results. Findings from these examinations are as follows:

1. For (total) cyanide, ALS, GEL, SWRI, TADN, and TASL reported 637 results during 2017. Of the reported results, 260 values were nondetects. For the 377 detected values, results ranged from 1.69 to 1,520 μg/L.

2. For free cyanide, GEL and SWRI reported 390 results with 279 nondetects. The 111 detected results ranged from 3.03 to 66.0 μg/L.

3. For cyanide amenable to chlorination, GEL and SWRI reported 381 results with 201 nondetects. The 180 detected results ranged from 1.69 to 380 µg/L.

4. SWRI was the only laboratory that provided metal cyanide speciation using EPA Method 9015. The laboratory reported a total of 24 results for the metal cyanide species hexacyanocolbaltate(III), total iron cyanide, tetracyanonickelate(II), and tricyanocuprate(I).

5. For 390 samples, GEL and SWRI provided results for total cyanide, free cyanide, and cyanide amenable to chlorination. Of these 390 samples, only two (B3DJ48 and B3F9J5) clearly have anomalous cyanide results (both samples were analyzed at SWRI). For sample B3DJ48, the total cyanide value was 11.2 µg/L and the free cyanide value was 57.3 µg/L. For sample B3F9J5, the total cyanide value was 7.22 µg/L and the cyanide amenable to chlorination value was 72.2 µg/L. The factor-of-ten difference between these two results suggests a probable transcription error.

6. During 2017, blind standard samples for total cyanide were sent to ALS, GEL, TADN, and TASL. All four laboratories returned results within the recovery and percent RSD limits. ALS had recoveries that ranged from 89.1% to 99.0%, GEL had recoveries ranging from 101% to 119%, TADN had recoveries ranging from 89.1% to 100%, and TASL had recoveries ranging from 88.5% to 112%.

7. The field QC for the cyanide species had the following issues:

    a. **FBs:** A total of 51 FBs were analyzed for total cyanide; only 3 had cyanide results greater than the MDL. A total of 30 FBs each were analyzed for free cyanide and cyanide amenable to chlorination; 2 FBs had cyanide-amenable-to-chlorination results greater than the MDL. A single FB was analyzed for the metal cyanides, with none of the results greater than the MDL.

    b. **Field duplicates:** A total of 106 field duplicate result pairs were received from GEL, SWRI, and TASL for the various cyanide species. Of these pairs, 37 met the evaluation criterion. GEL reported 12 of these result pairs for cyanide amenable to chlorination, of which 9 did not meet the RPD criterion. The out-of-limit RPDs ranged from 21.0% to 118%.

    c. **Field splits:** A total of 33 field split result pairs were received from ALS, GEL, SWRI, TADN, and TASL for the various cyanide species. Of these pairs, three met the evaluation criterion for total cyanide and three for cyanide amenable to chlorination. Of the three total cyanide split pairs, one pair between GEL and SWRI failed the RPD criterion with an RPD of 20.4%. The three pairs of results for cyanide amenable to chlorination were between GEL and SWRI; all three pairs failed the RPD criterion, with RPDs ranging from 186% to 193%.

8. The laboratory QC for the cyanide species had the following issues:

    a. **Method blanks:** For total cyanide, TADN reported seven method blank results, with one result greater than the MDL. TASL reported 20 method blank results, with three blanks exceeding the MDL. None of the other laboratories reported any method blank failures for the various cyanide species.

    b. **LCSs:** None of the LCSs were reported out of recovery limits for any of the cyanide species.

    c. **MSs:** GEL reported 87 MS results for total cyanide, with 2 recoveries less than the lower recovery limit and 2 greater than the upper recovery limit. SWRI reported 10 MS results for total cyanide, with 3 MS recoveries failing low. SWRI also reported three MS results for total iron cyanide, of which one exceeded the upper recovery limit. No other out-of-limit MS results were reported for the other cyanide species.

d. **Laboratory sample duplicates:** For total cyanide, GEL reported 32 laboratory duplicate results that met the evaluation criterion, of which only one failed to meet the RPD criterion (RPD of 23.3%). For free cyanide, SWRI reported three duplicate results that met the evaluation criterion; one RPD failed with a value of 200%. SWRI also reported eight duplicate results for cyanide amenable to chlorination that met the evaluation criterion. Of these eight, three failed the RPD criterion with RPDs that ranged from 58.5% to 200%.

In general, the above findings indicate that groundwater monitoring total cyanide data for 2017 are reliable. The blind standard results (finding 6) indicate that reliable total cyanide data are being returned from the four laboratories included in the 2017 studies. From the laboratory recovery ranges noted in finding 6, a bias in results may exist between GEL and ALS and between GEL and TADN, with GEL reporting somewhat higher recoveries than ALS and TADN. The field split results (finding 7c) seem to indicate reasonable agreement for total cyanide among laboratories. The field QC data seem to indicate few problems with FBs (finding 7a).

The cyanide amenable to chlorination results appear to be much less reliable. The field duplicate results indicate that GEL had difficulty generating reproducible results for cyanide amenable to chlorination (finding 7b). The field splits between GEL and SWRI returned very poor reproducibility for cyanide amenable to chlorination (finding 7c). SWRI appeared to have difficulty generating reproducible sample duplicate results for cyanide amenable to chlorination (finding 8d).

Additional evaluation is needed to form conclusions about the reliability of free cyanide results.

E9.7 Conclusions

Based on this data usability assessment, the sample results generally appear to accurately represent target analyte concentrations in Hanford Site groundwater, and the analytical data are sufficient in quantity and quality to be usable for the groundwater monitoring program. The percent of usable data for the 2017 groundwater monitoring data set is 95.3%, which easily exceeds the DOE/RL-91-50 groundwater monitoring program requirement of 85.0% data usability. Furthermore, 96.9% of the laboratory QC samples met QC requirements. This high rate of acceptable laboratory QC results indicates that laboratory accuracy, precision, and contamination control during sample preparation and analysis support use of the data set for the groundwater monitoring program. Field QC samples were collected and laboratory QC samples were analyzed at the frequencies required in CHPRC-00189.

Some specific concerns regarding the data set were identified during this data usability assessment:

1. **TOX:** The VOC-based TOX blind standards mostly had recoveries less than the lower recovery limit. These predominantly low recoveries may reflect TOX recoveries for actual groundwater samples because the TOX content of many Hanford Site groundwater samples is likely due to VOCs. For 2017, the 1,176 TOX results were reported to the groundwater monitoring program.

2. **Cyanide:** As discussed in Section E9.5.2, total cyanide results appear to be reliable. Cyanide amenable to chlorination results do not appear to be reliable for the reporting period. Clearly, additional monitoring of the quality of the results for the various cyanide species is warranted during 2018.

3. **Gross alpha:** The large scattering of blind standard gross alpha recoveries among the laboratories indicates that results for this radiochemical parameter compare poorly among the laboratories. All of the SWRI gross alpha recoveries were <60%. All but one of the TARL gross alpha recoveries ranged between 70% and 115%. The ALS recoveries ranged between 120% and 145%, while the GEL recoveries ranged between 118% and 360%. For 2017, the four laboratories reported a total of 563 gross alpha results to the groundwater monitoring program.

4. **Nitrite:** For all of the 2017 nitrite blind standard results, ALS and TASL reported recoveries <85%, with the two laboratories having a total of six nitrite recoveries less than the lower recovery limit. This is likely an indicator that the nitrite results from those two laboratories are biased low. ALS reported 9 nitrite results, and TASL reported 115 nitrite results to the groundwater monitoring program during 2017.

5. **Sulfide:** The sulfide results from TASL had 13 of 15 LCS recoveries less than the lower recovery limit and 13 of 15 MS recoveries less than the lower recovery limit. This means that the sulfide results generated at TASL are likely biased low. TASL reported 47 sulfide results to the groundwater monitoring program for 2017.

6. **2-Propanol:** The appearance of 2-propanol in field samples and FBs is primarily an artifact of blank preparation and field sampling operations, as 2-propanol does not likely occur in Hanford Site groundwater. An intermittent field contamination issue is likely affecting the FBs and field samples. For 2017, 106 results for detected values of 2-propanol were reported to the groundwater monitoring program. Section E9.5.1 provides for additional information.

7. **Polychlorodibenzo-p-dioxins and polychlorodibenzofurans:** SWRI and TAKN reported a total of 2,475 results for these analytes. The 17 split samples sent to these two laboratories resulted in 33 result pairs that met the evaluation criterion. Of the 33 result pairs, 32 pairs (97.0%) failed to meet the RPD limit requirement. The split failures had RPDs between 42.9% and 196%, and most of the out-of-limit RPDs were well above 100%. In general, when the split sample results for the polychlorodibenzo-p-dioxins and the polychlorodibenzofurans met the evaluation criterion, those results appeared to compare poorly between the two analytical laboratories. The split data indicate that when results greater than the detection limits are reported for these compounds, the results should be viewed with a great deal of skepticism. TAKN also reported a large number of method blank contaminations for these compounds, which further erodes confidence in the results.

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